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Civil Engineering

Elixir Civil Engg. 88 (2015) 36479-36482

ISSN: 2229-712X

Using of Finite Element Analysis for Evaluating the Effect of New Construction onto the Bridge Pile Foundation

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ARTICLE INFO

Article history:
Received: 14 April 2015;
Received in revised form:
15 November 2015;
Accepted: 20 November 2015;

Keywords
Bridge foundation,
Numerical analysis,
Finite element,
Landslide analysis.

ABSTRACT

This paper is organized such as, it is based on the study of an industrial factory building to the bridge pile foundation construction stability, and it investigates the effect of a new building to the bridge pile foundation internal force by the finite element analysis software ANSYS. Matching the data of numerical examination with the one of monitor measurement, we achieve that a new building has a small influence on the deformation under load action and the stress difference of a bridge pile foundation. Besides, the bridge pile foundation is safe and stable under load action.

Introduction

Since the capital construction increasingly develops and improves in China, more and more new buildings are built on their neighboring existing buildings which has a certain influence on existing buildings. All these situations, including a foreign-style house on the shallow tunnel, a tunnel under high-rise construction, or a deep foundation ditch around the bridge, require a strict computational analysis to provide reliable data for the influence extent of new buildings to existing ones and estimate the force change of building structure.

Engineering Situation

The new industrial factory is located on a high slope, part of the tectonic denudation hilly topography. According to the original relief map, the terrain is flat in the lows, with a gradient of 35. And the slope is a little steep, with a gradient of 15 or 20. Due to a consequent bedding rock landslide, a 25-meter-high and 30-meter-long fill slope is formed on the section of 10-10' ~ 15'-15, whose interface obliquity is about 20 degree, consistent with the dip angle of rock stratum.

Currently, support reinforcement has been applied to the slope by a pile sheet wall. The length of the slope retaining wall is 587.54 meters. Fifty piles are arranged in the middle of the slope, including the bridge pile foundation support and bolt structure beam protection. Specific plans are shown in Figure.1.

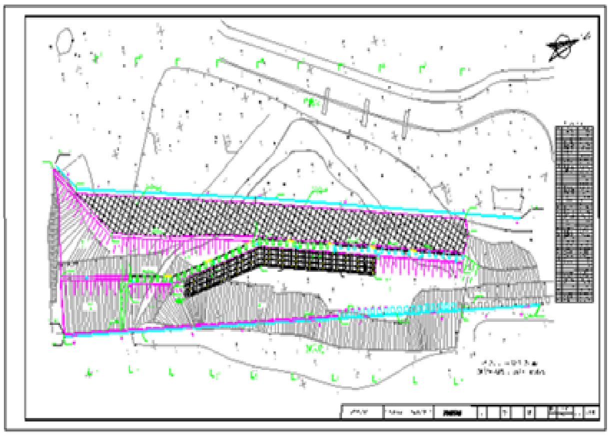

Figure 1. Master plan

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Analysis of the Finite Element Model

Computation Module

To reduce the boundary effect and guarantee the accuracy in computation, the model size is that: length along slope to the factory building (X-direction) is 120 m. Width along slope to Y-direction is 50 m. Height from the lower boundary to the surface (Y-direction) is 58 m.

The whole computation module is simulated with a total of 56326 planar units and 10659 nodes in the finite element grid. And the finite element grid is divided as below.

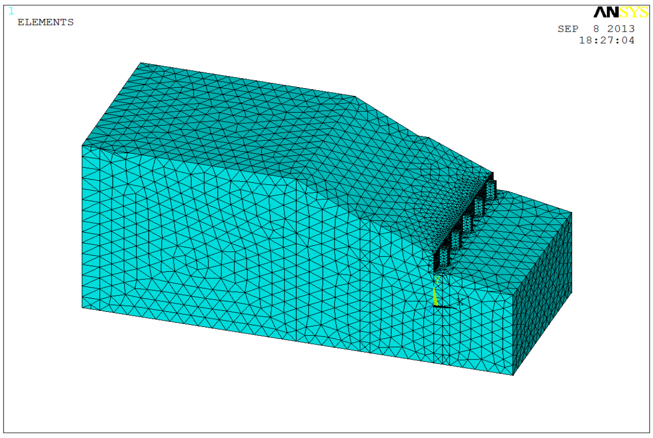

Figure 2. The finite element computation and analysis module

Design Conditions

The model is calculated and analyzed by using Drucker-Prager Yield Criterion in ANSYS , and material parameters are determined based on data from geological survey report. The results are shown in Table.1. The finite element simulation is computed under the load of self-weight stress and additional stress respectively. We divide the jump into two phases:

Step 1: self-weight stress loading

Step 2: factory loading

Because the factory loading in process is subject to banded model, these loads are equivalently applied to the whole area of industrial buildings in the worst situation, and the force is $250\ KN/m^3$.

Results are shown in Figure.3.

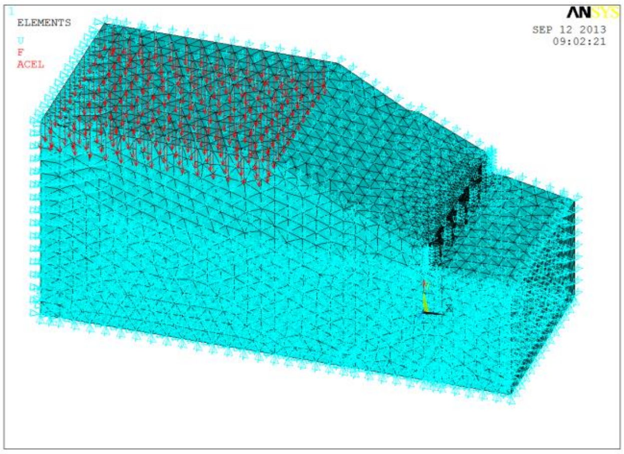

Figure 3. The loading model

Results

Analysis of self-weight stress to the bridge pile foundation

Maximum displacement and stress values in all directions of the bridge pile foundation under self-weight stress are shown in Table.2. The nephogram of maximum displacement and stress values in all directions of the bridge pile foundation under self-weight stress are shown in Figure.4 - Figure.9.

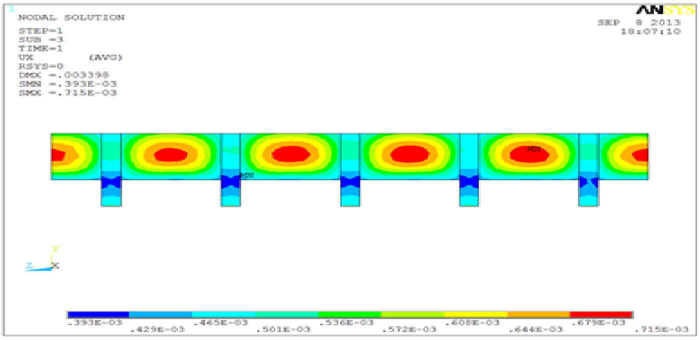

Figure 4. Displacement diagram under self-weight stress in X-direction

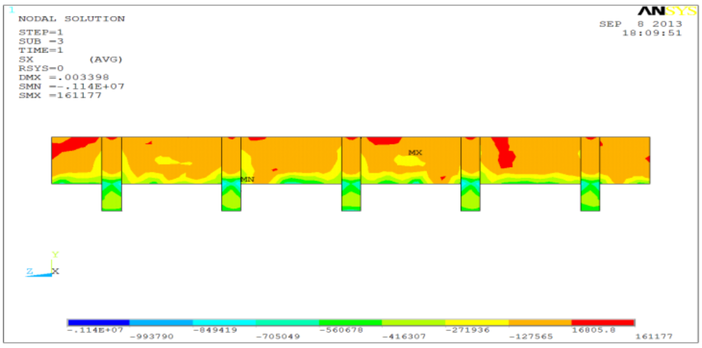

Figure 5. Stress diagram under self-weight stress in X-direction

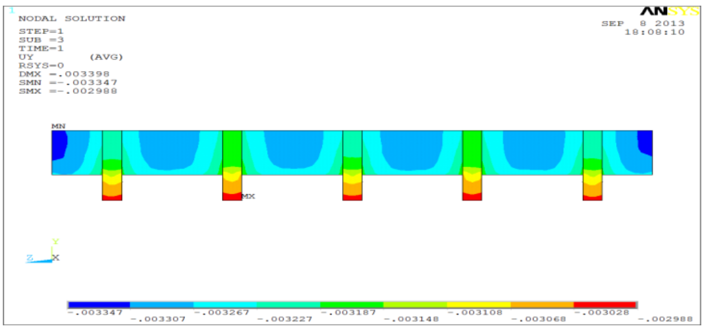

Figure 6. Displacement diagram under self-weight stress in Y-direction

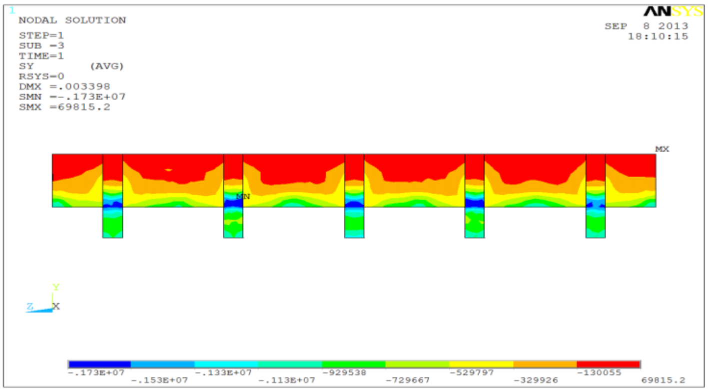

Figure 7. stress diagram under self-weight stress in Y-direction

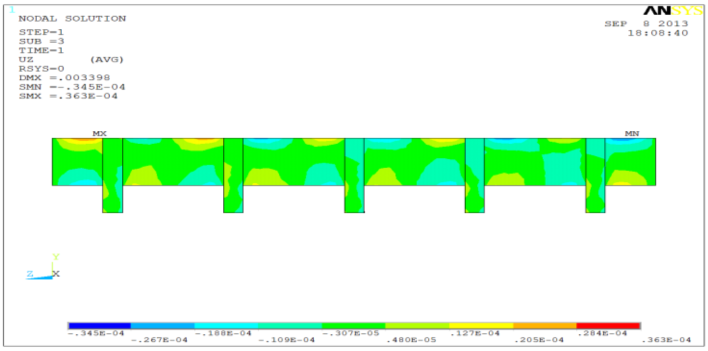

Figure 8. Displacement diagram under self-weight stress in Z-direction

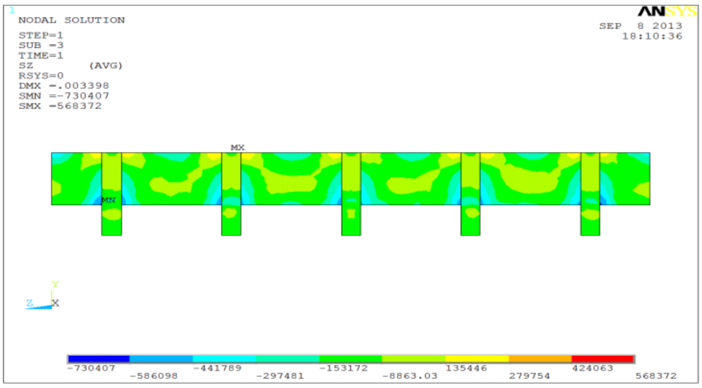

Figure 9. Stress diagram under self-weight stress in Z-direction

Analysis of load action to the bridge pile foundation

Maximum displacement and stress values in all directions of the bridge pile foundation under load action are shown in Table.3. The nephogram of maximum displacement and stress values in all directions of the bridge pile foundation under load action are shown in Figure.10 - Figure.15.

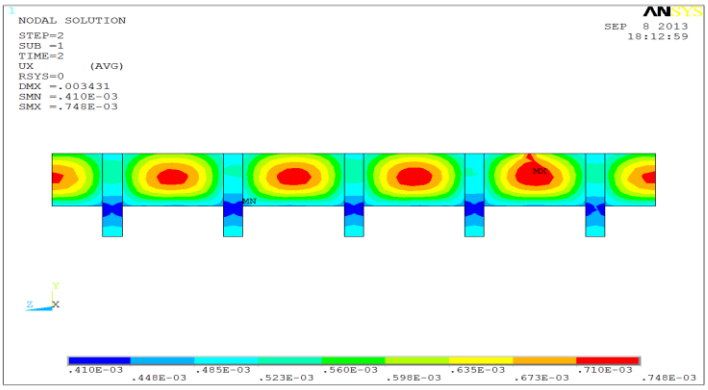

Figure 10. Displacement diagram under load action in X-direction

Table 1. Physical property parameter of material

Name	Multiplicity γ Kg/m3	internal frictional angle Φ /°	elasticity modulus E /GPa	Poisson ratio μ
Backfill	2000	28	1.7e-3	0.35
Mudstone	2200	35	0.2	0.23
Concrete	2400	—	30	0.20

Table 2. Bridge pile foundation displacement and stress values under self-weight stress

		X-direction	Y-direction	Z-direction
Displacement （mm）		**0.715**	**-3.347**	**-0.345**
Stress (MPa)	Maximum	0.161	0.070	0.568
	Minimum	-1.140	-1.730	-0.730

Table 3. Bridge pile foundation displacement and stress values under load action

		X-direction	Y-direction	Z-direction
Displacement （mm）		**0.748**	**-3.354**	**-4.360**
Stress (MPa)	Maximum	0.265	0.720	0.596
	Minimum	-1.160	-1.750	-1.190

Table 4. Bridge pile foundation displacement and stress values under load action

		X-direction	Y-direction	Z-direction
Computed stress （MPa）	Maximum increment	0.104	0.650	0.028
	Minimum increment	-0.020	-0.020	-0.460
Computed displacement value increment （m）		0.033	-0.007	-0.091
Measured displacement value （m）		0.030	-0.005	0.082

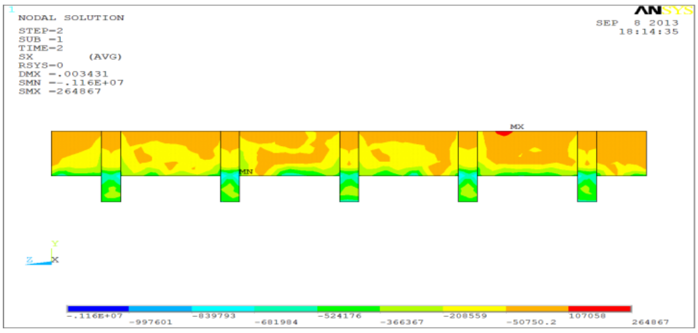

Figure 11. Stress diagram under load action in X-direction

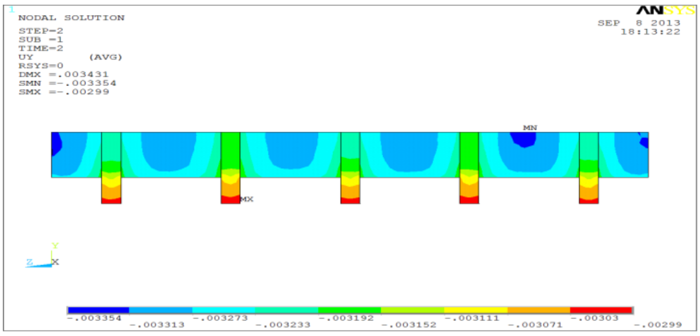

Figure 12. Displacement diagram under load action in Y-direction

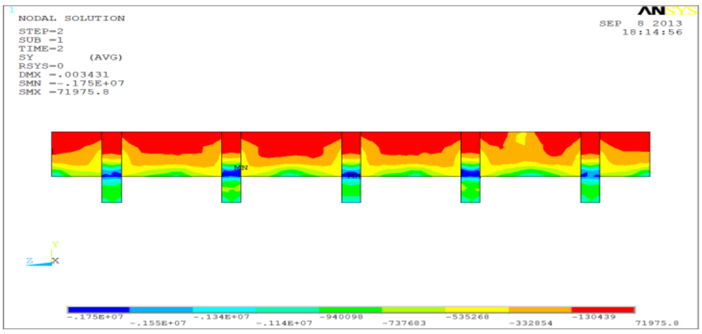

Figure 13. Stress diagram under load action in Y-direction

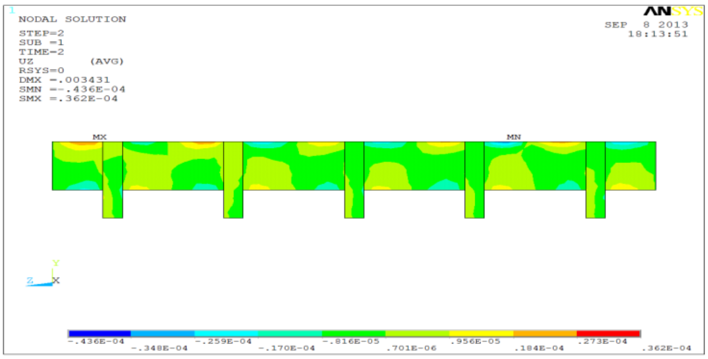

Figure 14. Displacement diagram under load action in Z-direction

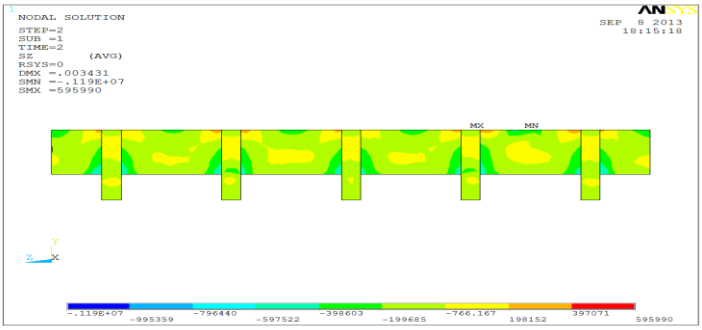

Figure 15. Stress diagram under load action in Z-direction

Relative analysis of the numerical computation and monitor measurement

Since the only data we can measure is the bridge pile foundation deformation, we compare the data of numerical simulation with that of monitor measurement to verify the reliability of the numerical simulation. Computed and measured values are shown in Table.4. The main displacement is that in X-direction (horizontal direction) under load action, and it differs by 0.003 m. The maximum stress change of the bridge pile foundation is 0.65 MPa in Y-direction (vertical direction).

Conclusion

Stress and displacement principles of supporting construction are computed and analyzed by the finite element software ANSYS. The evaluations between computed and measured values are demonstrated as below.

1) There is little change between computed and measured standards in all directions of the bridge pile foundation under load action, mostly in the key displacement (X-direction), which differs by 0.003 m. It indicates that the load we applied about 250 KN/m^3 is rational and the computed values are consistent.

2) The supreme stress alteration of bridge pile foundation under load action is 0.46 MPa in Z-direction, less than concrete density strength. From now the bridge pile foundation meets the load bearing requirements.

3) The all-out tensile stress alteration of bridge pile foundation under load action is 0.65 MPa in Y-direction (vertical direction), less than tensile strength of concrete. Later the bridge pile foundation meets the load bearing necessities.

4) Analysis above shows that the influence on the displacement and stress alteration of bridge pile foundation under load action is small. The bridge pile foundation assembly under load action is safe and constant.

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