IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 15, Issue 2 Ver. I (Mar. - Apr. 2018), PP 31-37
www.iosrjournals.org

Analysis for Failure Mechanism of Temporary Shoring Structure

H.N. Ramesh[1], K.N. Jayaprakash[2]
[1](*Professor, Department of Civil Engineering, U.V.C.E/ Bangalore University, Bangalore-560 056 India)*
[2](*Research Scholar, Department of Civil Engineering, U.V.C.E/ Bangalore University, Bangalore-560 056 India)*
Corresponding Author: H.N. Ramesh

Abstract : *In this study, a case history of temporary earth support collapse is illustrated briefly and mechanism of accident occurrences are introduced with the result showing that piles and anchors which are not provided with sufficient length cause collapse of structures. In deep excavation process there may be potential for circular sliding surface to propagate outside the anchor bond zone and the reduction in shear strength of soil due to increase in pore water pressure. Presence of seepage or ground water table in the backfill soil increases the pore water pressure,in turn increases the Bending moment with active earth pressure and anchor head becomes ineffective to bear the tensile forces, hence failure occurs.The failure mechanism can be overcome by the measurement of moment and pressure whichreveals valuable information for verifying the design assumptions.*

Keywords –*Bending Moment, Ground Anchors, Micro Pile, Pore Water Pressure, Active Earth Pressure*

Date of Submission: 24 -02-2018 Date of acceptance: 15-03-2018

I. Introduction

Accidents due to collapse occurs during ground excavation. There isa need to decrease these accidents is a major concern in the deep excavation sites. In this paper an attempt has been made to analyse the failure mechanism of temporary shoring structure from a case study.

The methodology adopted for retention of temporary shoring system was micro piling with tie back anchor system (passive ground anchors). It is five summit residential project at Whitefield, Bangalore. The temporary shoring system was recommended for deep excavation near property boundary having offset of 2.0 M and depth of excavation for 9.0 M. The length of shoring system for 45m along the property boundary wall and around 20.0 M length in the center portion of the shoring system failed due to excessive excavation and without taking seepage water in to account during design of shoring system.

This case studyhas been described with a temporary earth support which was collapsed and the ground behind the support failed. The total soil volume of 180 M^3 with the thickness of 4.0 M slide in to an excavation area and as a result construction was halted due to damage to the adjacent property.

II. Project Case Study

2.1 Materials and Properties

The properties of foundation soil used for analysis are listed as shown in Table1.0, properties of shore pile in Table 2.0 and properties of anchors in Table 3.0.

Table.1 Properties of Foundation soil

Properties	Values
Dry unit weight (γ_{dry})	17.3 kN/M^3
Bulk unitweight (γ_{wet})	19.15 kN/M^3
Permeability in horizontalDirection (k_x)	1 m/day
Permeability in Vertical Direction (k_y)	1 m/day
Young's modulus (E_{ref})	18000 kN/M^2
Cohesion (C_{ref})	35 kN/M^2
Friction angle ($\phi_{o)}$)	27^0

Table.2 Properties of Shore Pile

Diameter of the pile M.S. Pipe 6mm thickness	200mm
Spacing	0.6 M
Concrete grade	M_{20}

Table.3 Properties of Anchors

Diameter of the TMT Bar	25mm
Diameter of the Grout hole	150 mm
Grade of the steel	Fe415
Weight of steel (w)	3.85 kg/M

2.2 Case history of the temporary earth support system

The Construction site had 2.0 M set back from the property boundary for the deep excavation. The deep excavation was proposed for the two basement and foundation system was 12.0 M depth. Based on the soil investigation report, vertical excavation was not feasible for 12.0 M depth, hence shoring system of micro piling with tie back anchor system was proposed.

2.2.1 Outline of the construction work

This accident occurred at the building construction site which had an excavation done up to a depth of 12.0 M and length of excavation was 45.0M. The ground plan and location of geotechnical investigation, bore log of construction site are shown in Fig. 1 and Fig. 2 respectively.

The micro piles were used as a temporary earth support system with the vertically bored MS pile method. The length and spacing of micro piles were 12.0 M and 1.0 M respectively. The first row of the ground anchor was 150mmdiameter; the length was 8.0 M at an angle of 45^0installed from 2.0 M depth from the existing ground level. The second and third rows of anchors were installed at 5.0 M and 8.0 M respectively from the existing ground level, having 150mm diameter, 5.0 M long and inclined at an angle of 60^0.

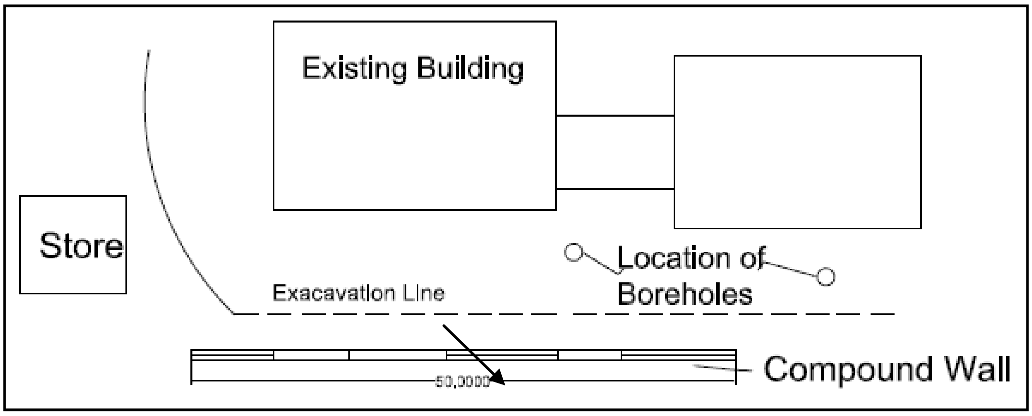

Fig 1. The ground plan and location of geotechnical investigation

2.2.2 Situation relating to the accident occurrence

The workers at the construction site at around 8.30 am had noticed that the connection between the capping beam on the top, some piles on the east side corner had disconnectedand a hair line crack was observed on the surface behind the micro pile. In addition, wet patches were observed on the micro pile wall due to seepage due to the drain adjacent to the excavation boundary. The engineer had predicted the danger of a collapse and made necessary arrangements to provide additional weep hole to drain the seepage coming to the shoring system from the drain and back fill the soil to achieve passive resistance.

However, at around 3.30 p.m., the east side 12.0 M of the temporary earth support structure collapsed gradually with the ground behind the support. The ground sliced into the excavation area along with the compound wall for a thickness of approximately 4.0m. The sudden collapse of the entire temporary earth system occurred and the mechanism of collapse is due to excessive excavation without adhering to the design as shown in Fig 3.0.

Due to this collapse, thirty-eight MS piles were toppled. All machines and accessories were buried. As a result, this accident made a huge damage to property.

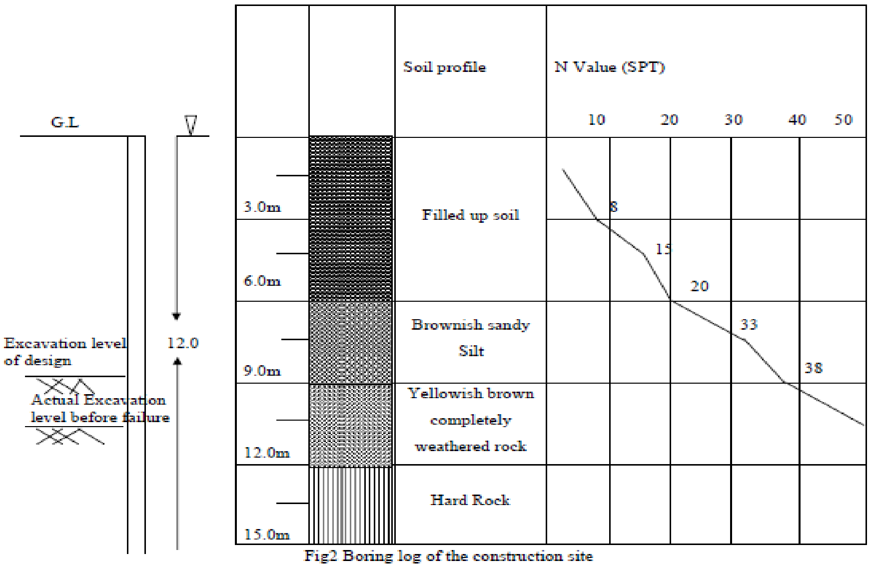

Fig2. Boring log of construction site

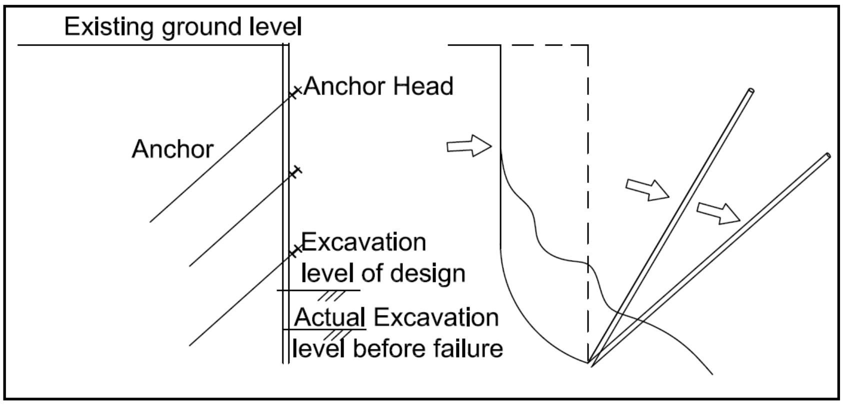

Fig.3 Estimation Mechanism of Collapse

2.2.2 Sequence of Failure

Fig. 4 shows the progression of the shoring collapse just before the accident. During the excavation process, the penetration depth of the micro pile wall decreased step by step. Failure occurred when the penetration depth of the micro pile reached about 3.0 M and failure continues with a small displacement emerged with excavation step. Fig. 5 shows the total collapse of the micro pile. The failure occurred suddenly when the embedment depth of the micro pile reached about 2.5 M.

Fig 4. The position of shoring system just before the incident (East corner side)

Fig 5. The scene of the collapsed accident (East corner side)

III. Analysis Of Failure Mechanism

3.1 Design consideration of the temporary earth support system

Fig 6 shows construction of temporary shoring structure as per design considerations. The Design was made for actual site condition. Considering the depth of excavation and existing ground soil parameter, Micro pile was provided with embedded length of 2.0 Mand grouted nail wall designed for 8.0 M length providing the inclination of 45^o for top layer and 60^o for bottom two layers. While designing shoring for this particular site, there was no consideration of water table for design.

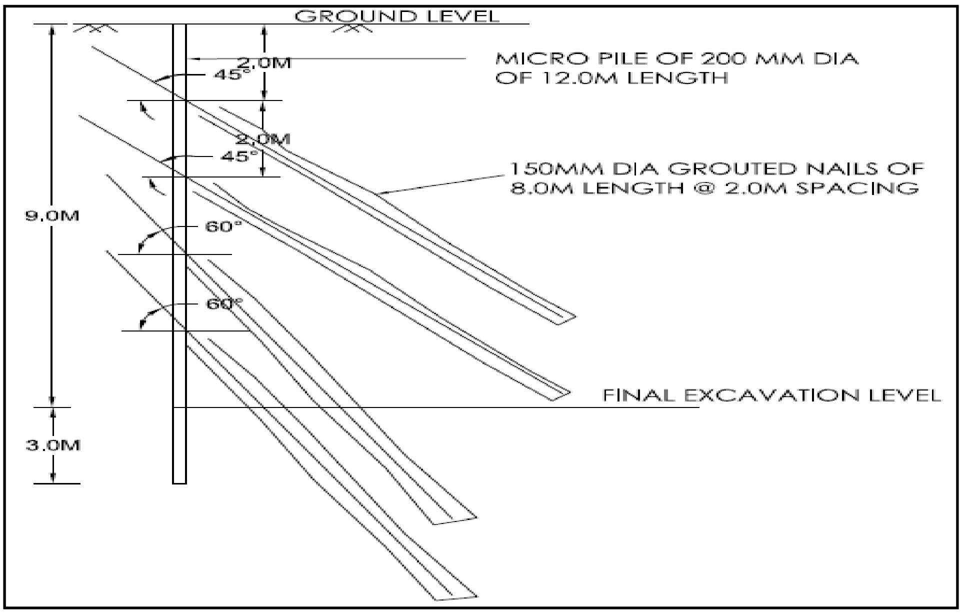

Fig 6. Model according to the design consideration

3.2 Monitoring

Instrumentation is usually required to monitor the performance of a micro pile structure during construction. Measurement of moment and pressure furnish valuable information for use in verifying design assumptions. The pressure distribution diagram is shown in Fig. 7.0. Most importantly, the data may predict the potentially dangerous situation that could affect the stability of the structure. In this construction site, however, only visual inspection was used, such as checking for unusual surface signs. The maximum bending moment was found to be 20.4 kN/M to 20.11kN/M up to 3.0 M depth as shown in Fig. 8.0.

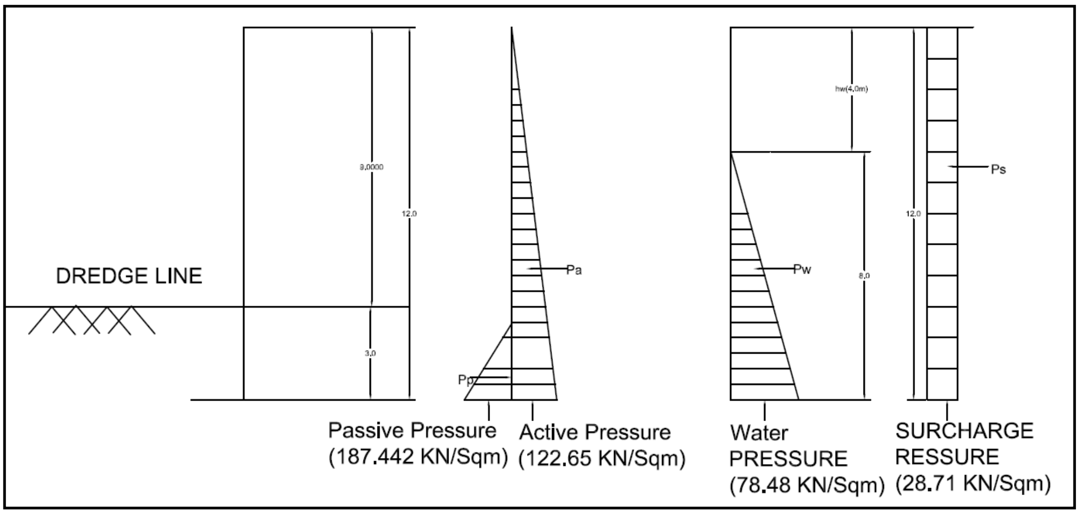

Fig7. Pressure diagram for the load acting on micro piles

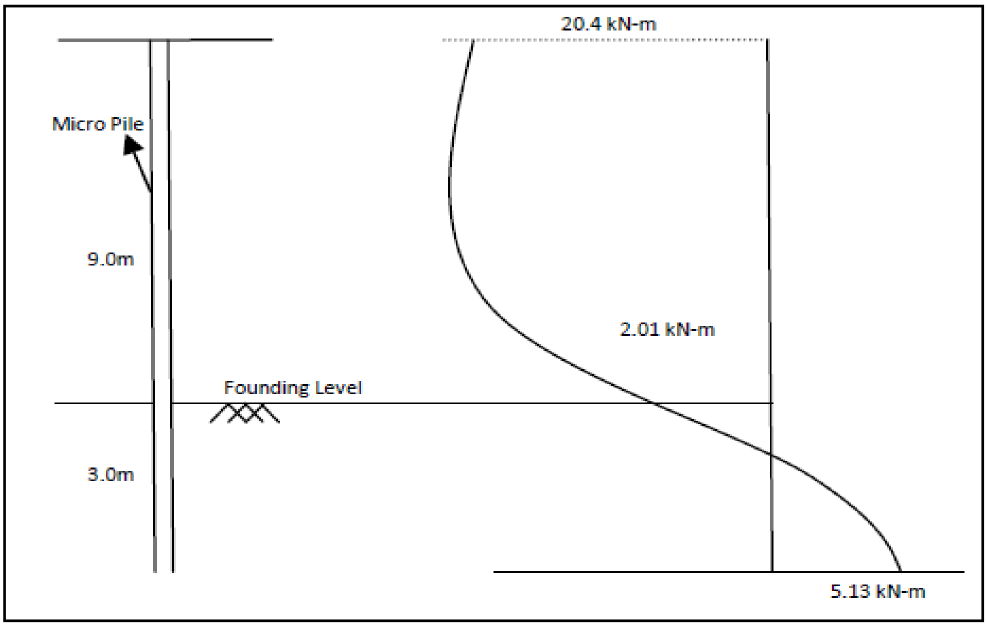

Fig. 8. Bending moment diagram from the load acting on micro piles

3.3 Earth pressure and bending moment on retaining system

The earth pressure on the micro pile together with depth during excavation process is shown in Fig 7. The active earth pressure increases and passive earth pressure decreases as the excavation depth increases beyond 9.0 M. that is from final excavation level or founding level.

The variation of bending moment with the depth of wall is shown in Fig 8. The bending moment increases as the earth pressure increases on the other hand, during excavation, the moment at the middle of the pile rapidly increases while the moment of the pile at the excavation surface decreases as the excavation increased. Therefore, the pile was bent significantly as the upper part of the pile struck out while the pile at the excavation surface did not move much. This suggested that the anchor head suffered severe tensile force due to the bending of pile.

3.4Tensile force acting on anchor:

The Figures7 and8 show the pressure diagram and bending moment diagram for micro pile. It is shown that the active earth pressure increased during the excavation and increase in the depth of excavation makes critical slip lies further away from its actual position in terms makes insufficient length of grouted nails to bear the forces. Hence caused the anchor failed to support pile due to large tensile force, as a result temporary structure is collapsed.

3.5 Estimation of the mechanism of the collapse

The sequence of collapse is shown schematically in Fig. 3, the mechanism of collapse is summarized as follows;

a. Initially clients haddecided to excavate up to 9.0 M depth, later as per revised structural design excavation was done up to 10.0m depth.Due to change in structural design consideration, critical slip circle moves away from the excavation line hence due to increase in critical slip circle, provided embedment length of grouted nail as per design becomes inadequate. This in turn, the embedment length provided of the anchor bar was insufficient. Fig 9 shows the variation in critical slip according to the depth of excavation. When the excavation was done up to 9.0m depth critical slip lies away from the vertical cut. When the excavation was continued up to 10.0m depth, critical slip circle further moves away around 840mm from the vertical cut.

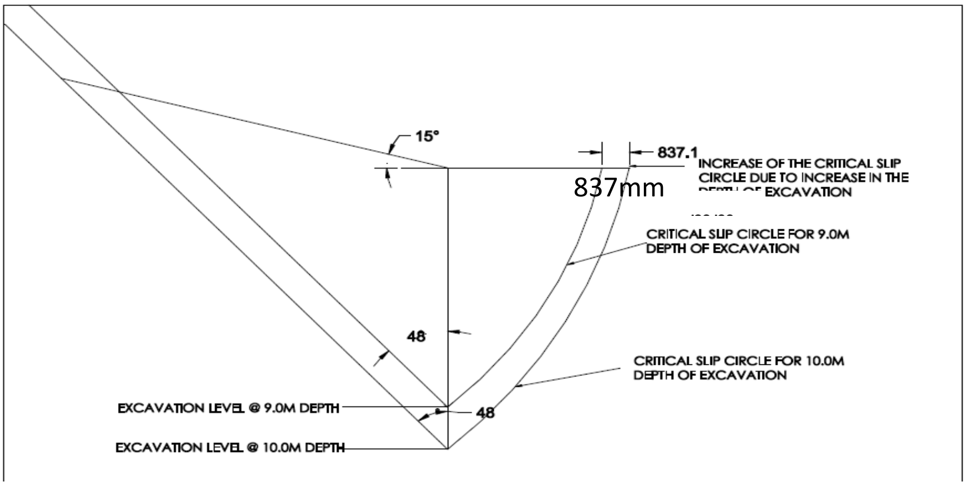

Fig9. Variation in critical slip circle according to depth of excavation

b. Fig 10 shows the slip circle before the occurrence of failure. Due to absence of water table during the investigation stage, no water table effect was taken in to account during the design stage. After the construction of shoring system, due to heavy rainfall, water flow choked in the adjacent drain due to improper drainage facility caused the seepage of water into shoring area. As aresult, increase in the pore water pressure increases in earth pressure to the existing temporary shoring system and there was decrease in the shearing resistance of soil thereby making tie back anchor bars ineffective. Hence the temporary shore structure starts losing its capacity to stabilize the vertical cut.

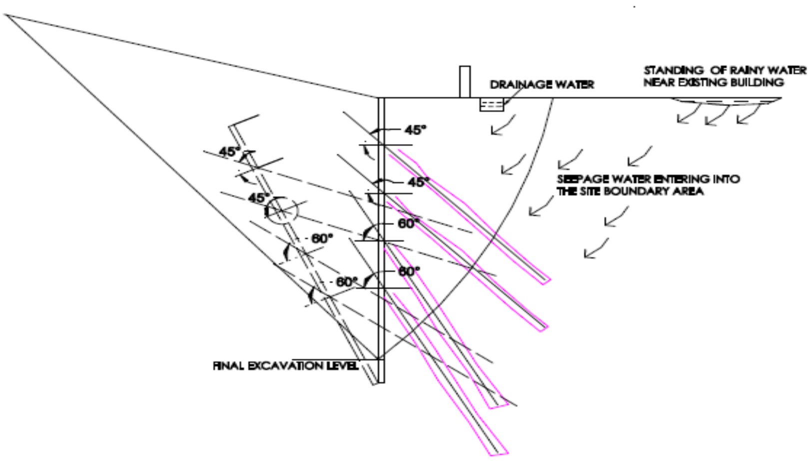

Fig10. Failure of supporting system due to entering of seepage water

c. It was noticed that there was existing building 6.0m away from the site boundary.The surcharge pressure initially considered for no water table conditions, but due to seepage of drain water and reduced shear resistance, excess surcharge pressure acting over the micro piles along with less embedment depth of micro piles caused over turning of the micro piles.

d. Finally, the unstable earth support structure led to a huge-volume soil collapse.

IV. Conclusion

In this study, the case history of the temporary shoring structure failure mechanism is analyzed and following conclusions are drawn,

- The water table condition plays an important role in the design of temporary shoring system. The presence of adjacent structures, drains are to be considered during the design.
- As the factor of safety for temporary shoring design is less than 1.5, careful planning of excavation and future excavation planning to be considered during the design period so that such accidents can be prevented.
- Proper ground movement monitoring system should be placed after installation of the shoring system so that any adverse conditions can be foreseen and can prevent any probable accidents.
- Good lined drainage facility should be mandatory around the shoring system so that seepage of water can be prevented and provide adequate weep hole in the shoring system as a preventive measure.

Acknowledgement

The author acknowledges M/s. Piramal Group, Bangalore for carrying out the field work.

REFERENCES

[1]. Bolton, M.D. and Powrie, W., (1987), "Collapse of Diaphragm Walls Retaining Clay," *Geotechnique, 37 (3), 335-353*

[2]. Madabhushi, S.P.G. and Chandrasekaran, V.S., (2005), "Rotation of Cantilever Sheet Pile Walls," *ASCE Journal of Geotechnical and Geo-Environmental Engineering, Vol.131, No.2, pp 202-212.*

[3]. Gopal MadabhushiS. P. * and V. S. Chandrasekaran (2008)" Centrifuge Testing of a Sheet Pile Wall with Clay Backfill" *Indian Geotechnical Journal, 38(1), 2008, 1-20*

[4]. ViswanadhamB.V.s., Gopal Madabhushi (2008)"Modelling the failure of a cantilever sheet pile wall" *International Journal of Geotechnical Engineering 3(2):215-231*

[5]. Kazuya Itoh, NaotakaKikkawa& Yasuo Toyosawa(2011)" Failure mechanism of anchored retaining wall due to the anchor head itself being broken" *International Symposium on Backward Problems in geotechnical Engineering, 2011, 13-18*

H.N. Ramesh. "Analysis for Failure Mechanism of Temporary Shoring Structure." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 15, no. 2, 2018, pp. 31-37