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Khashayar Hemmati
Asil sazan abnieh Co., Iran

Seyed Vahid Masoomi
Asil sazan abnieh Co., Iran

Javad Nazari Afshar
Asil sazan abnieh Co., Iran

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Khashayar Hemmati
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Tehran-Iran

ABSTRACT

This paper presents a case study example of appropriate method selection of stabilization and reinforcement of slope by introducing engineering and economical aspects. Introduced slope is located in science and research campus of Islamic Azad University (IAU) in north of Tehran with height of 4-29 m and length of 370 m. A big building with 9 floors and total area of 70000 square meters is located upper and near edge of slope, so that existence of this building has increased sensitivity of projects design and construction method. Slope is located in vulnerable area with a high risk of seismicity based of 6th Iranian building code. In addition primarily geotechnical site investigation is reported existing of 13 different geotechnical zones of rock mass with R.Q.D less than 10% and slope wash and fill material. A second expanded series of site investigations program have been performed to obtain better geotechnical resolution and information about slope. In this project, in addition of stabilization of slope, architectural aspects of slope's stabilization system was very important, so that, capability of green face for slope and vegetate of small trees and grass in berms introduced in design, in addition slope should have a compliance with vicinity of existing project. By introducing of seismicity of project location and economy, stabilization and reinforcement of slope by geogrid material is selected for this project in comparison other excising methods. More detailed information about geological and geotechnical of site condition are presented in paper.

INTRODUCTION

This paper presents a case study example of appropriate method selection of stabilization and reinforcement of slope by introducing engineering and economical aspects. Introduced slope is located in science and research campus of Islamic Azad University (IAU) in north of Tehran. The trench has a variable height about 4 to 29 meters and 370 meters length. There is a large 9 floors building above the trench with 70000 square meters area close to the edge of trench. The existence of this building forces a considerable surcharge in the trench. So this matter increases the sensitivity of the design and implementation method of this choice. According to the part sixth Iranian building code, the mentioned trench in that region is at the high risk seismicity. The required aim of this design is developing on appropriate place around the building (on the top slop) for mechanical equipment as campus of university. Architectural view of visual effects which is in accordance to the environment is of high importance. Developing vegetation in that area provides us a beautiful view plus stability. In figure 1, shows the related slope with project that building is on the top of slope. Fig.1 presents location of slope (highlighted) with buildings on top of the slope.

Fig.1. Location of slope

SITE INVESTIGATION

In the present project, achieving a good design directly depends on suitable program of site investigation and required

parameters for designing. Provided information about geological parameters by employer was very brief and incomplete. Therefore, the first step in achieving a proper survey about local investigation is determining more accurate parameters in geology and geotechnical design. The main structure by the trench from geological view is from highly weathered rocks (with RQD less than%10) which were unstable due to different pressure and variations in geological period and human intervention in excavation embankment. In General, the number of layers and geotechnical parameters of project is very various that part of project which has a highest height was of a very loose slope-wash that its depth is not specified in different places. In this regard, after boring several bore holes in different places and vast survey on geology and summarizing between achieved parameters in geotechnical parameters of rock units and soil, they categorized to 13 geological sections with special shear strength parameters for each zone.

Table.1. Parameters of rock units and soil

ROCK AND SOIL UNITS	PHI PDEGREE	C Mpa	E Mpa
SW	33	0.006	25–30
R1	30	0.083	648
R2	35	0.11	1027
R3	33	0.1	864
R4	36	0.12	1125
R5	32	0.090	770
F ZONE	11	0.014	145
R6–1	22	0.048	335
R6–2 (KM200–250)	26	0.054	447
R6–3 (KM250–300)	28	0.045	447
R7–1	25	0.035	335
R7–2 (KM350–400)	27	0.027	335
R7–3 (KM400–450)	32	0.018	335

Based on obtained soil logs from bore holes, the thickness and placement of each layers, in order to do the necessary analysis regarding computing slop stability and displace and finally achieving a general scheme. In order to realization of this matter, four vertical bore holes in depth of 25 meters have excavated in the eastern area of this site which the results affect in the following items:

- Determine the physical quality of rock mass and its blocks.
- Determining thickness and type of surface layer.
- Determining the material properties of the fault zone.

ANALYSIS

After completing the geological studies and required geotechnical testing, regarding the shown layers of soil logs and trench outcrops, have been specified that there are many changes in geometry layers of trench in depth and length which is prepared cross section perpendicular on trench at interval of 10 meters along the project appropriate to the geotechnical layering in each section for analysis of present slope. Limit equilibrium program (slide V.6) was applied for stability analysis. After reviewing all of the sections, it was specified that failure surface in most cases are in weak layer of slope wash (e.g. Blue layer in Fig. 2) and this layer should be removed for stabilizing of trenches.

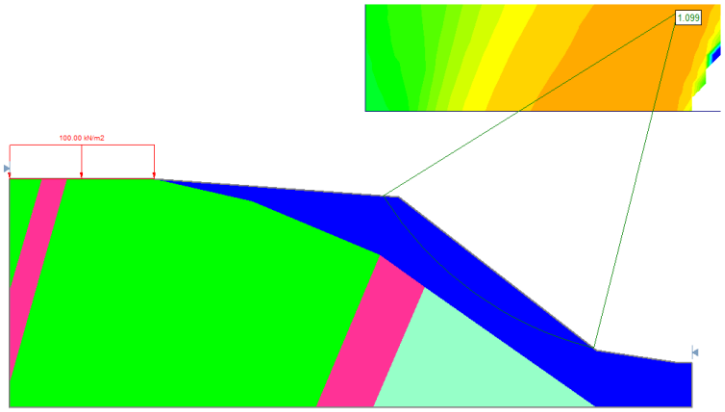

Fig.2. Stability analysis of slope before excavation

By introducing comprehensive site investigation program and gathering good information about geometry and direction of layers, it found that existing of slope wash layer has an essential effect on failure surface and FOS. Second series of analysis were performed on the slope by removing slope weak wash layer in all analysis. In Fig. 3 distribution of FOS along slope is presented.

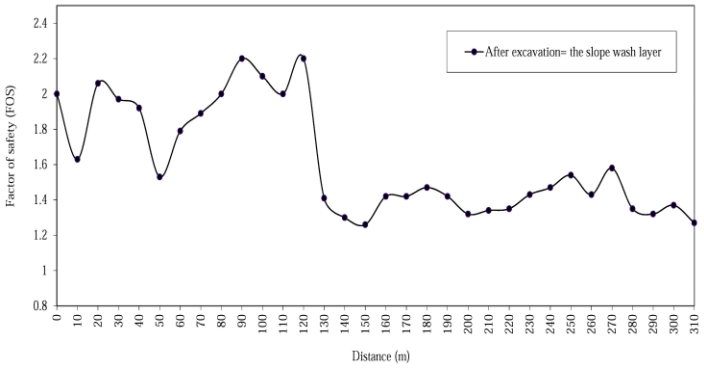

Fig.3. Distribution of FOS along slope length after excavation

METHODOLOGY & DESIGN

After specifying geometric & geotechnical properties of different parts of trench, it was required to survey different alternative for having a proper scheme that meet all the need of employer, in terms of stability & aesthetics and preserving the environment. After surveying of various options like retaining wall, anchor, nailing, the reinforced soil system is applied for stabilizing and embellishing the existence of slope. Regarding variation of safety factor in length of slope after removing slop wash layer, the project categorized to 3 section of geometrical reform of slope, making façade and reinforced soil system and mixture of those parts. Since embankment part is more determined than other parts, the main part of design allocated to this section and develop this part to others part. One of the benefit of reinforced soil system is that the major parts of soil which is as result of removing slop wash layer, is applied in reinforced soil system as a basic material. This matter is of vital important for reducing cost of soil displacement, fuel and damage to environment. It can be described the benefit of reinforced soil system in a summery as follow:

A) Reinforced soil system is more economical in comparison to other retaining walls when average height of wall is greater than 3 m.
B) Retaining wall of the reinforce soil system is so faster and easier to perform than other ways and there is no need to more labors and specialized equipment. Many components are prefabricated construction and lead us to a fast and exact performance.
C) Regardless to the height and length of wall, the structure of reinforced soil system is completely stable during performance.
D) Reinforced soil system is more flexible in comparison to cantilever walls. So they are well known to more flexible retaining and can bear deformations and large settlement. While these kinds of displacement are anticipate embedding vertical joints facilitate any movement & displacement of wall. In this case of applying reinforced soil retaining, safety factor of soil bearing capacity will be reduced in comparison to conventional rigid retaining wall.
E) Regarding the flexibility and property of energy absorbing integrated soil mass behind the wall; the seismic operation of reinforced soil system is better than rigid retaining walls. Totally, soil slippage of reinforced soil elements should be more considered in seismic design of reinforced soil retaining than their tensile strength.

After choosing reinforce soil system as a selected design, regarding the limitation of the bottom & top slop of project and height variation, the 4 meters height and proper berm chosen for performing the reinforced soil retaining (Figure. 4) for green space and lighting.

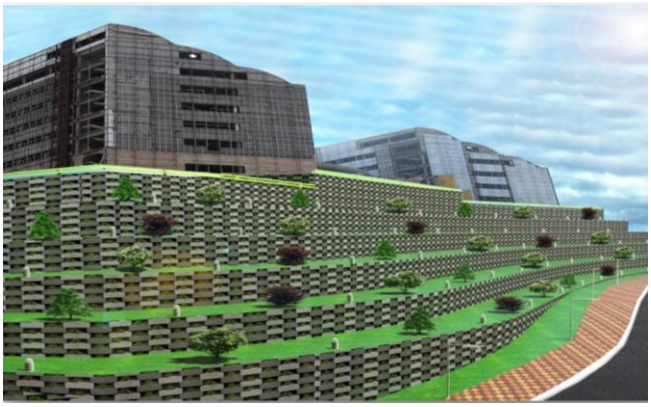

Fig.4.Veiw of Final design for slope

CONCOLUSION :

The real aim of this article was to convey this matter that taking more time on site investigation and obtaining more complete data by a supplementary test on geology and geotechnical, will be highly worth for engineers to choose the best options.
In this project, achieving accurate data and taking a decision for replacing weak layer with a reinforced soil structure causes that the trench will be better in limited time from technical and engineering point of view.

REFERENCES

FHWA. [2009]. "*Design and Construction of Mechanically St*abilized Earth Walls and Reinforced Soil Slopes – Volume I ". U. S. Department of Transportation Federal Highway Administration, Publication No. FHWA-NHI-10-024.

FHWA. [2009]. "*Design and Construction of Mechanically St*abilized Earth Walls and Reinforced Soil Slopes – Volume II". U. S. Department of Transportation Federal Highway Administration, Publication No. FHWA-NHI-10-025.

Bowles, J. E. [1988]. "*Foundation Analysis and Design*". 5th Ed., McGraw-Hill International Editions, Singapore.