SEISMIC ANALYSIS OF WEAKENED SLOPES REINFORCED WITH TIEBACK ANCHORS

Abolfazl RIAHI NOURI
PhD Candidate, IIEES, Tehran, Iran
a.riyahi@iiees.ac.ir

Abdollah ROHANI HAJIAGHA
M.Sc., Hormozgan University, Bandar Abbas, Iran
sasanrohani@gmail.com

Mohammad Ghasem VETR
Assistant Professor, IIEES, Tehran, Iran
vetr@iiees.ac.ir

Keywords: Seismic Stability, Slope, Tieback, Plaxis, Earthquake

Over the past decades some slopes were created inadvertently without considering any analysis and design criteria. Consequently, such slopes faced sliding problem due to service and other probable loads. In order to revitalize their stability and prevent catastrophic events, especially in public gathering places such as parks, reinforcing those slopes was considered an inevitable solution. Due to the fact that reinforcing by using tieback system could decrease the plastic displacement of a slope, this type of anchoring system was chosen to handle slope instability problem. However, an essential question is that whether reinforced slopes have proper safety factor during a severe earthquake or not?

In this paper, three slopes with different geometries in a park in Tehran are considered as case studies. After the slopes experienced sliding, they were reinforced with tieback anchors. Their stability situations have been examined by employing the finite element method. At first, position of circular slip surface is obtained by means of Geo Slope software (Krahn, 2004). Then, reinforcing of the slope with a weakened layer (above-mentioned slip surface with residual soil strength parameters) is simulated by Plaxis to gain an allowable safety factor in static loads. Finally, the seismic stability of the reinforced slope was investigated for adopted horizontal component of two earthquake records at SLE, DBE and MCE intensity levels.

In table 1 two types of anchor were applied to reinforce a slope is shown. The geometry and location of anchors were depicted in Figure 1 and the distance between anchors is 4m and 2m in vertical and horizontal respectively. For each anchor the static factor of safety was calculated, it is worth mentioning that initial safety factor for the slope before sliding was about 1.69.

Table 1. Types of anchors were applied to stabilize slopes

No.	Anchor	EA(kN)	Maximum Force (kN/m)	Pre-stress Force (kN/m)	Static Factor of Safety in slope with anchor
1	A125	1.03e5	125	90	1.15
2	A210	2.14e5	210	150	1.69

The anchors average axial forces in dynamic analysis in the slope are 173 kN and 122 kN for A210 and A125 respectively. It is evident that A125 is not appropriate to stabilize the slope, because anchors are near plastic state and slope will fail. This issue represented in Figure 2 , after the time 4s the anchors dose not play any role in stabilizing the slope. On the other hand, A210 plays key role in the total stability of slope, as it can be said that the behaviour of reinforced slope is similar to slope before sliding (Figure 2).

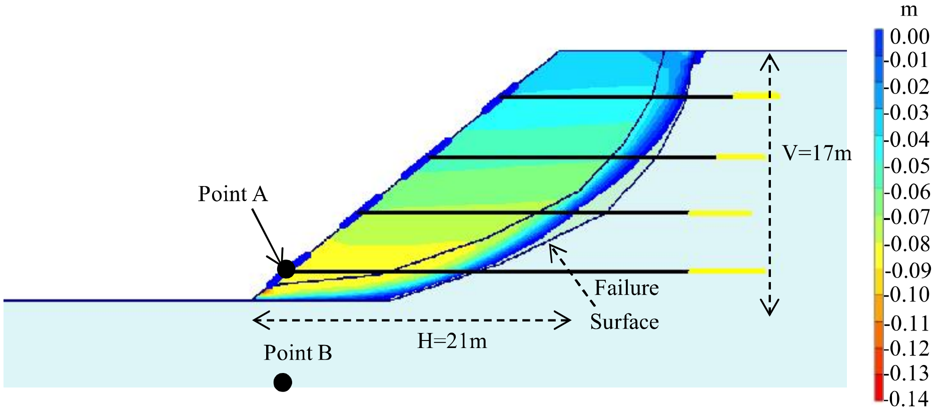

Figure 1. Horizontal displacement of reinforced slope with A125 at the end of dynamic analysis

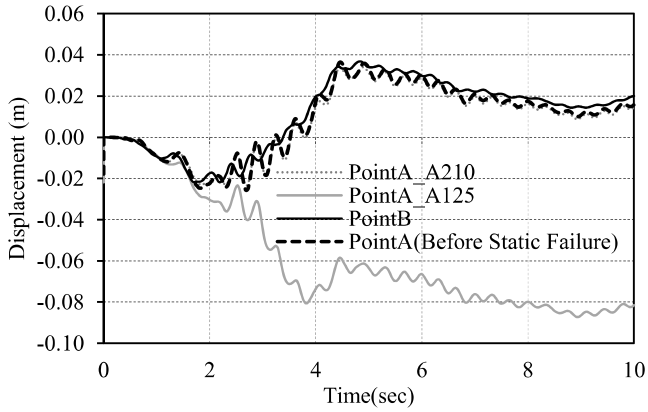

Figure 2. Horizontal displacement of various points in slopes reinforced with A125 and A210

REFERENCES

Brinkgreve RBJ (2002) Plaxis finite element code for soil and rock analysis: Manual, Balkema, Rotterdam

Kramer SL (1996) Geotechnical Earthquake Engineering, University of Washington, Prentice-Hall, ISBN 0-13-374943-6

Krahn J (2004) Stability modeling with Slope/W An Engineering Methodology, Calgary, Canada, Geo-Slope/W international LTD

Sabatini P J, Pass D G and Bachus Robert C (1999) Ground anchors and anchored systems, US Department of Transportation, Office of Bridge Technology

Trandafir AC, Kamai T and Roy CS (2009) Earthquake-induced displacements of gravity retaining walls and anchor-reinforced slopes, *Soil Dynamics and Earthquake Engineering*, 29(3): 428-437