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Briefing: Analysis of piled stabilisation of landslides

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In this briefing the author presents some corrections arising from his experience of use of the pile analysis method outlined in Viggiani's paper 'Ultimate lateral load on piles used to stabilise landslides'.

1. INTRODUCTION

Viggiani's paper[1] suggests a simple and concise method for calculating restraining forces applied to a landslide by unrestrained stabilising piles (i.e. piles not fixed, connected to or restrained against a structure or other piles) and bending moments in the piles themselves. The simplicity of the method explains the fact that despite its considerable age it is (in the author's experience) still used by practitioners in the field of stabilisation of landslides.

The analysis method is based on the assumption that lateral pressures acting on piles are only dependent on the direction of the relative movement between a pile and cohesive soil and on the soil strength but not on the amount of the relative movement. The value of interface stress is always assumed to be equal to the ultimate value, which can be different for the body of landslide and for the underlying intact soil, but it is assumed to remain constant with depth in each of these two layers. A simple calculation of the balance of forces allowed creation of a set of formulae for the three main design cases identified in the paper—with yielding of the pile–soil interaction either in the landslide body, or in the underlying intact soil mass, or in both layers simultaneously. The last case implied that the deflected shape of pile would have two points of contraflexure—one above and one below the slip plane. Additional sub-cases were also examined for the last design case, when bending moments in piles would reach their ultimate value.

The analysis method did not include a detailed analysis of pile–soil interaction and it was expressly not applicable for non-cohesive soils.

The author of this briefing would like to highlight some errata which he encountered in his personal experience of use of the equations published in the original paper, as outlined below.

2. ERRATA

Errors have been encountered in the formulae published in the paper. In particular, equations (5) and (9) in the paper need to be rewritten as

$$\frac{M_2}{k_1 c_1 dl_1^2} = \frac{1}{\chi}\left(\frac{k_1 c_1 d\lambda l_1 - \chi T}{2 k_1 c_1 dl_1}\right)^2 = \frac{1}{4\chi}\left(\lambda - \frac{\chi T}{k_1 c_1 dl_1}\right)^2 \quad (5)$$

$$\frac{T}{k_1 c_1 dl_1} = \frac{\lambda}{(2+\chi)} \times \left\{\sqrt{\frac{(2\chi+2)}{\chi} + \frac{(2+\chi)}{\lambda^2}\left(\frac{4M_Y}{k_1 c_1 dl_1^2}\right)} - 1\right\} \quad (9)$$

Note the addition of χ as a multiplier for T in the second part in the parentheses in equation (5) and the replacement of λ with χ in the denominator in the first part under the radical in equation (9), compared with the published formulae.

The suggested corrections imply that the bending moments calculated using the original equation (5) would normally be underestimated. Indeed, for a common design case in the typical design conditions the author's experience indicates that M_2 may increase by around 50%.

It should be added that the design modes represented by original equations (5) and (9), namely Viggiani modes B and B_1 respectively, may not necessarily be critical. However, the corrected equation (5) may increase the criticality of the design mode B from the original paper.

The effect on the restraining forces calculated using the original equation (9) would be dependent on the particular values of input parameters and on the geometry of the problem.

3. CONCLUSIONS

Engineers using the paper for design of piled stabilisation of slopes should take note of the corrected formulae in this briefing.

The author of this briefing would also like to note that the paper has routinely been used for a considerable period of time without some errata having been noticed, which would further underline responsibility of designers to employ utmost rigour in the assessment of accuracy of methods which they use.

REFERENCES

1. VIGGIANI C. Ultimate lateral load on piles used to stabilise landslides. *Proceedings of 10th International Conference on Soil Mechanics and Foundation Engineering, Stockholm*, 1981, 3, 555–560.

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