University of Glasgow | School of Engineering

James Okwudili (2153307)
supervised by Prof Simon Wheeler

Ground Improvement using Stone Columns

PROJECT INTRODUCTION

With the presence of weak compressible soils causing large foundation settlements, effective and economic ground improvement methods have been developed to solve these issues. Stone columns provide an effective and economic ground improvement technique reducing final settlement and providing a cheaper alternative to pile foundations.

This project explores the methods used in analyzing the effectiveness of stone columns and compares these methods to see how their assumptions and calculation process affects their results .

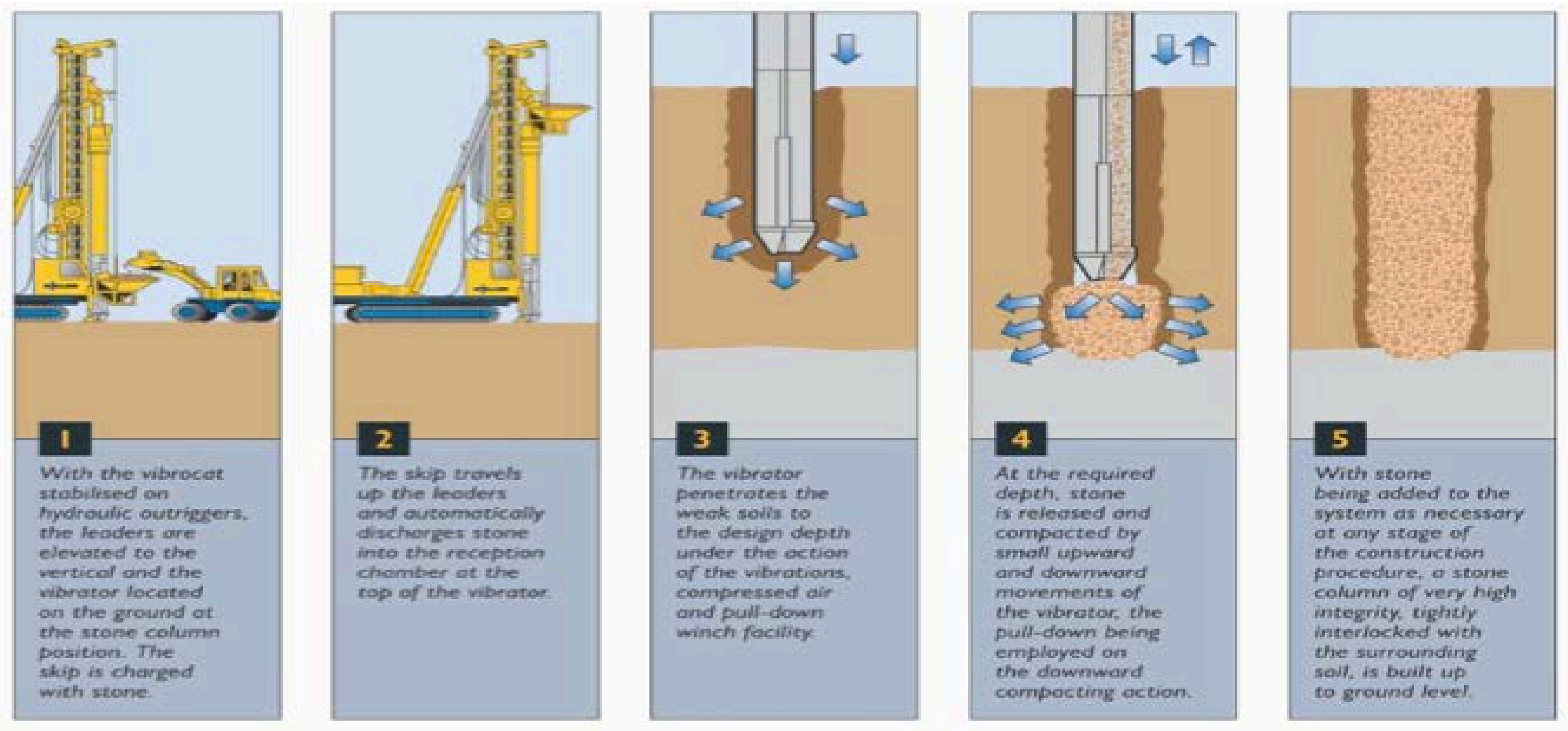


Figure 1 shows the construction of stone columns (Bryan et al 2007)

METHODS

When analyzing the effectiveness of stone columns 4 methods are used, they are

- Simple Elastic Method
- Balaam & Booker Elastic Method
- Priebe's Improvement Method
- Elasto-plastic Method

All methods use two factors to access the effectiveness of stone columns in reducing the final settlement, they are the:

$$\text{Improvement Factor}(\eta) = \frac{\text{Settlement without Stone columns}}{\text{Settlement with Stone Columns}}$$

$$\text{Reduction Factor}(\beta) = \frac{\text{Settlement with Stone Columns}}{\text{Settlement without Stone Columns}} = \frac{1}{\eta}$$

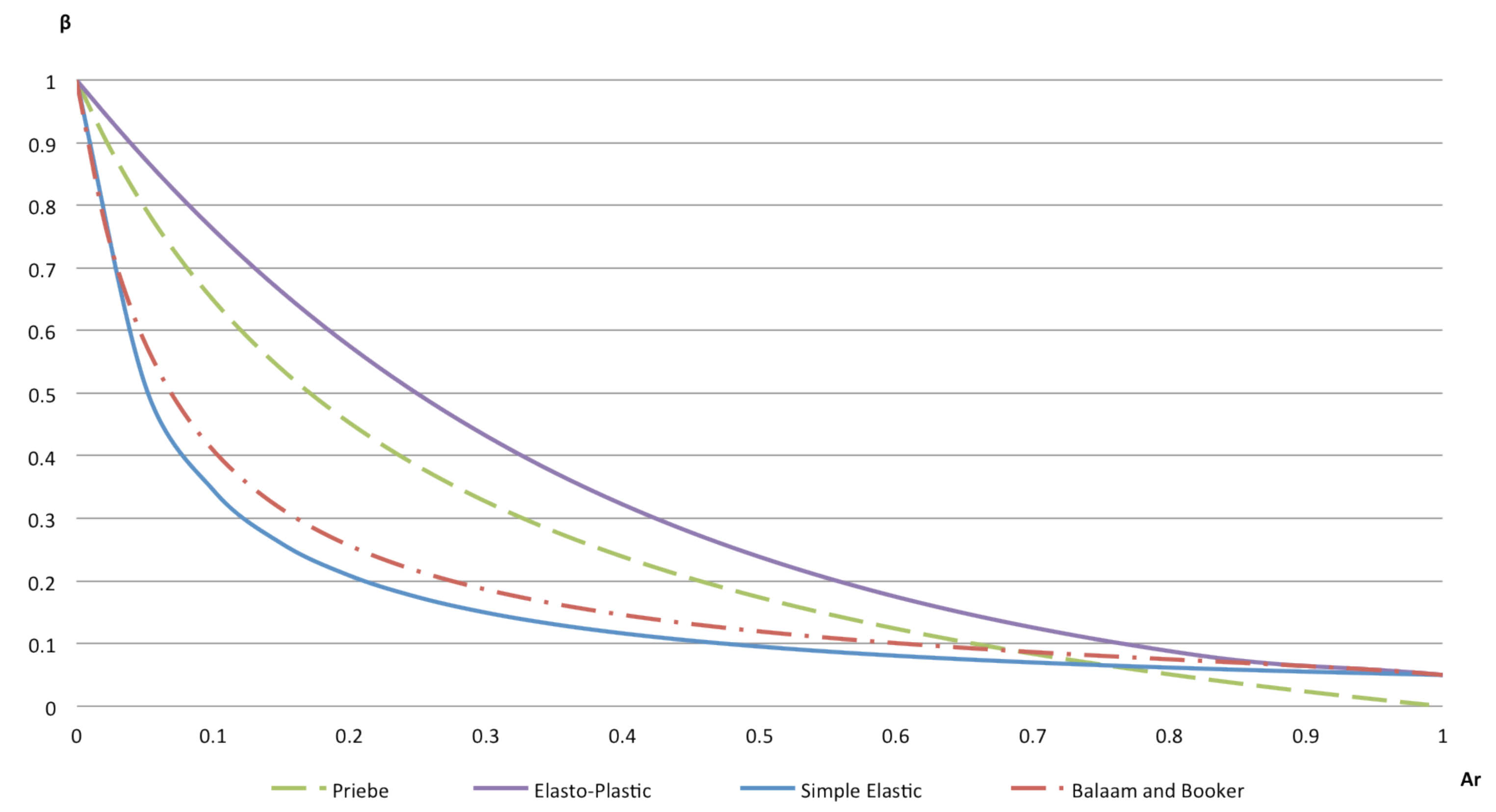
METHOD ASSUMPTIONS

Simple Elastic Method	• Stone column and soil act as elastic materials • Stone column and soil do not strain laterally (εrc and $\varepsilon rs=0$)
Balaam & Booker Elastic Method	• Stone column and soil act as elastic materials with the consideration of lateral strains
Priebe's Improvement Method	• Soil both act as an elastic materials • Stone column acts as a plastic material which yields as a frictional material • Soil and stone column have zero bulk density • Stone column has a dilation angle of zero
Elasto Plastic Method	• Soil acts as an elastic material • Stone column acts as an elasto-plastic material which yields as a purely frictional material • Stone column has constant dilatancy during plastic shearing • Both soil and stone column have bulk densities greater than zero

RESULTS

The various methods make varying assumptions which leads to the derivation of effectiveness factors (η & β) that have different variables. To solve this discrepancy the various methods have been re-expressed in terms of 8 dimensionless parameter (some methods not using all 8 parameters). The re-expressed equations are then assigned average values to see how the various methods compare to each other.

The reduction factor (β) for all 4 methods are plotted on the same graph (shown below) using average values for the independent parameters.



It should be noted that the area ratio (Ar) has a practical range between 0-0.2, looking closely at this range we see the reduction factors produces more conservative results as the methods move from the Simple Elastic to the Elasto-Plastic method. This is caused primarily by improved assumptions made as new methods are introduced.

CONCLUSION

Stone columns provide an effective and economic ground improvement technique. The four methods explored have both their strengths and weakness but they all help broaden our understanding on how stone columns improve weak soils. The 4th method which provides the most complete closed-form analysis neglects the effect(s) consolidation has on the improvement and reduction factors. This issue provides further research opportunity to develop an even better analysis for stone column design.

References
Bryan M, James M and Jonathan B. (2007). *GROUND IMPROVEMENT USING THE VIBRO-STONE COLUMN TECHNIQUE.* Available: https://www.engineersireland.ie/EngineersIreland/media/SiteMedia/groups/societies/geotechnical/Ground-Improvement-using-the-Vibro-Stone-Column-Technique.pdf?ext=.pdf. Last accessed 3/06/2015