IMPROVEMENT OF UPLIFT CAPACITY OF TRANSMISSION TOWER FOUNDATION

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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: UOM Verified Signature Date: 11/03/2024.

D.V.T Amarakoon

The above candidate has carried out research for the Masters thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

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Abstract

Electricity transmission is carried out by conductors attached to the lattice tower structures, mostly supported by a shallow spread footing foundation, associated with around 40-45 percent of the total project cost.

The uplift capacity is one of the main factors when selecting the size of a transmission tower foundation. The current design practice considers the weight of the concrete foundation and the soil as an inverted frustum that contributes to resisting forces. However, it is noted through literature that the actual behaviour of the uplift capacity of the foundation does not exactly depend only on the weight of the soil inverted frustum shape and concrete. Instead, it depends on the soil properties, such as friction and cohesion. Global research has been carried out on cement soil stabilization, insertion of fiber to the cement sand backfills, and use of geo-grids as improvement techniques for uplift capacity.

This study aims to assess different techniques and propose suitable techniques to improve the uplift capacity of transmission tower foundation construction. To commence this process, soil samples with low SPT values were collected from five tower locations of ongoing transmission lines in the western province of Sri Lanka. Most of the remoulded samples are tested and identified as Clayey Sand according to the USCS classification. The tri-axial test on remoulded soil resulted in an undrained cohesion value of 5.6 kN/m^2 to 10.4 kN/m^2.

Then, modified soil samples are prepared, adding 1 percent and 3 percent cement by soil weight, cured for 7 days, and tested. Uniaxial compressive tests (UCS) are performed on the mixed soil samples. The UCS on samples of 3 percent cement shows a significant improvement of cohesion, resulting in values between 20 to 60 kN/m^2.

Then a 3D finite element model is developed and verified by using the values of the research carried out by (Consoli, Ruver, & Schnaid, Uplift Performance of Anchor Plates Embedded in Cement-Stabilized Backfill, 2013). Then, the actual foundation is analyzed for various area configurations. Hence, a series of models are developed incorporating different configurations of foundation depth, improvement angle, and cohesion for full-depth, layer-wise, and partial-depth types of improvement.

In conclusion, the uplift capacity of the transmission tower foundation can be increased significantly by adding 3 percent cement to the existing clayey sand backfill. The uplift capacity increases with the angle of improvement and cohesion of the backfill material. The uplift capacities were compared as a percentage of the remoulded soil backfill at a foundation with a depth of 3.0 m.

When considering full-depth improvement cases, a minimum of 100 and 120 percentages resulted for the foundation depths of 2.0 and 2.5, respectively, with a cohesion value of 40 kPa and a 25-degree angle. However, it is 150 percent for the foundation depth of 3.0 m, even with a cohesion of 20 kPa.

Also, the uplift capacities of layer-wise depth improvement and the total layer improvement of the practical excavation are similar.

Further, improvement as a partial depth with a layer thickness of 1.5 m (starting from the bottom of the foundation) results in 120 and 150 percentages for depth of foundation 2.5 and 3.0 m, respectively, with a cohesion value of 40 kPa and 25-degree angle.

Keywords: - Improvement, Uplift capacity, Foundation, Cement, Cohesion

DEDICATION

I dedicate this thesis to the exceptional individuals who have been instrumental in shaping my life and academic pursuit.

First, I express profound gratitude to my parents, A.D. Theodore and P.D.M. Elizabeth. Their boundless love, unwavering support, and continuous encouragement have propelled my achievements. Their steadfast belief in my capabilities has been an unwavering source of motivation, and I am forever grateful for their countless sacrifices.

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I also extend this dedication to all individuals who tirelessly pursue knowledge and self-improvement. May this thesis, in some small way, contribute to your enriching journey of growth and discovery.

To everyone dedicated to learning and self-improvement, I also dedicate this thesis to you. May it play a small part in your journey of growth and discovery. Your commitment to learning is inspiring, and I'm grateful to share this work with you.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Abbreviations

USCS	Unified Soil Classification System
CEB	Ceylon Electricity Board
UCS	Unconfined Compressive Strength
3D FE	Three-Dimensional Finite Element
CWR	Completely Weathered Rock
SC	Clayey Sand