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Optimization of retrofitting an anchored sheet pile quay wall using separated relieving platform

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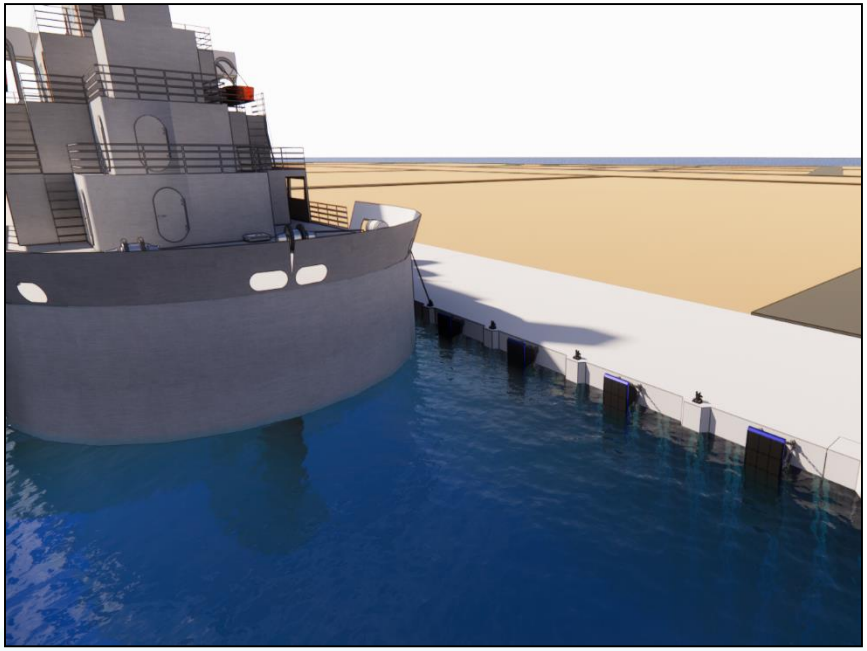
Introduction

- Quay walls serve as integral components of any functioning port, providing critical infrastructure for docking and unloading vessels.

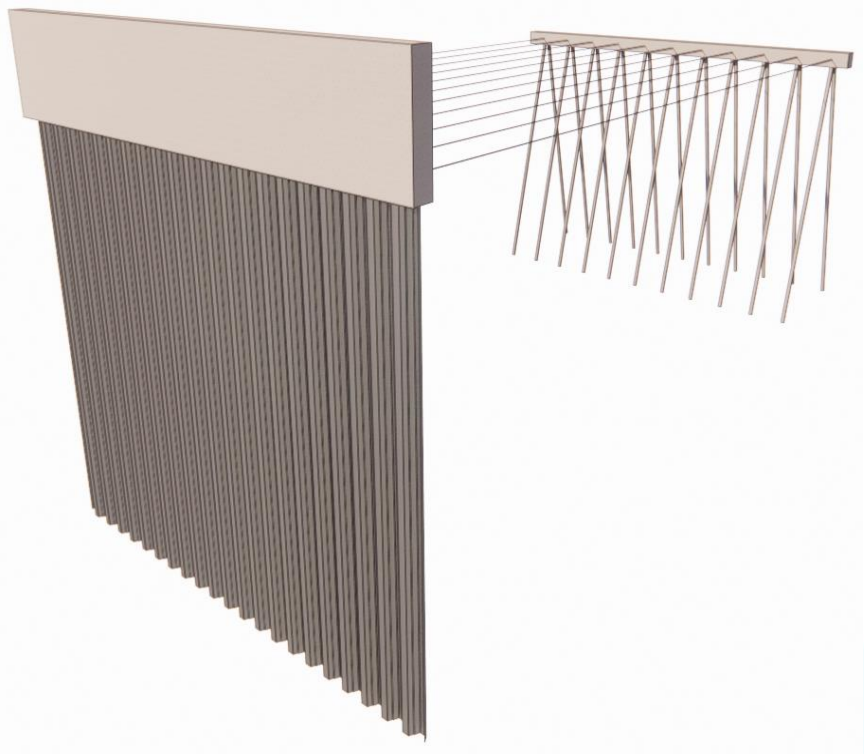
- Among the various types of quay walls, **anchored sheet piles** stand out as a common choice due to their durability and effectiveness in withstanding the forces exerted by the surrounding marine environment.



Introduction

- An **Anchored sheet pile** system typically consists of a front wall, a tying system, and an anchorage system.

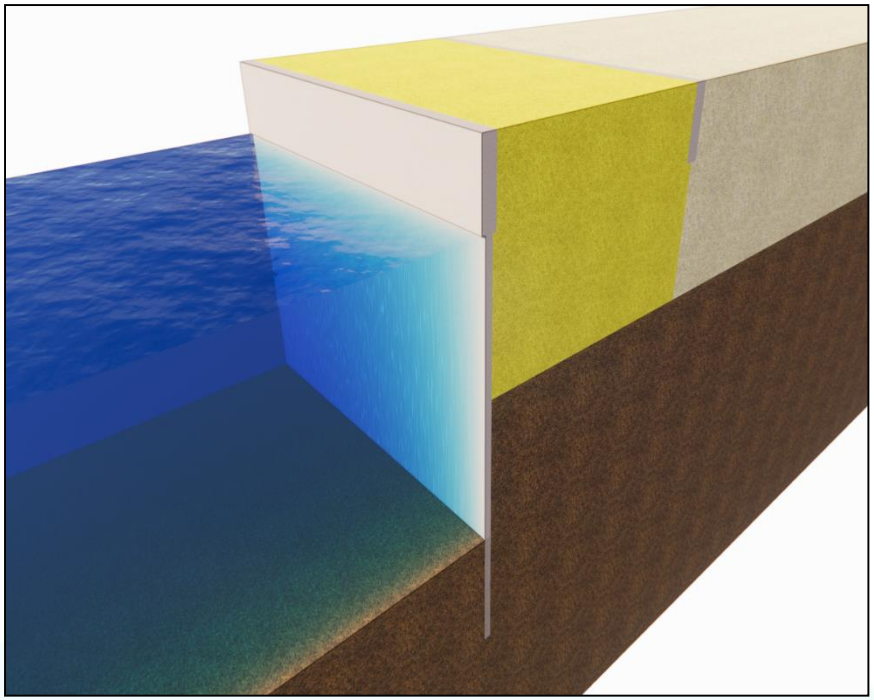
- Considering the swift evolution in the maritime sector, particularly concerning **vessel dimensions** and **tonnage**, the necessity to upgrade quay walls is undeniable in order to accommodate these advancements.



Introduction

- A prevalent method for upgrading a quay wall, often employed in **Egypt**, involves **constructing a new quay wall** in front of the existing one, designed to withstand the additional anticipated loads.

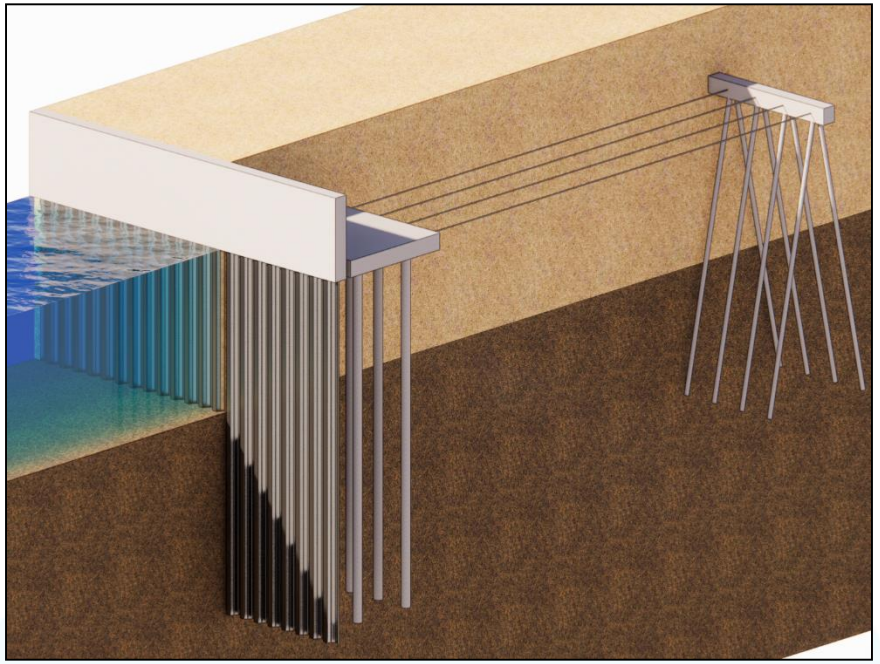
- While effective and straightforward, this approach comes with **substantial costs** and **reduces** the available **basin area** within the port.



Introduction

- An alternative method for **upgrading** an **anchored sheet** pile quay wall is to install a platform supported by piles, known as a **relieving platform**, along the apron side, **separated** from the existing quay wall.

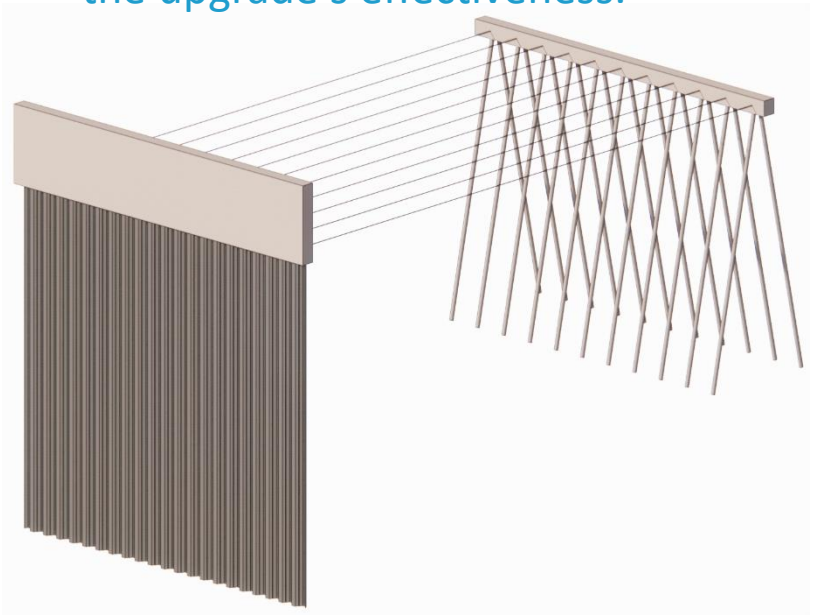
- The effectiveness of this added platform in **upgrading** the existing quay wall to allow for deeper basins and elevated loadings was demonstrated by **Roushdy *et al.*, (2023).**



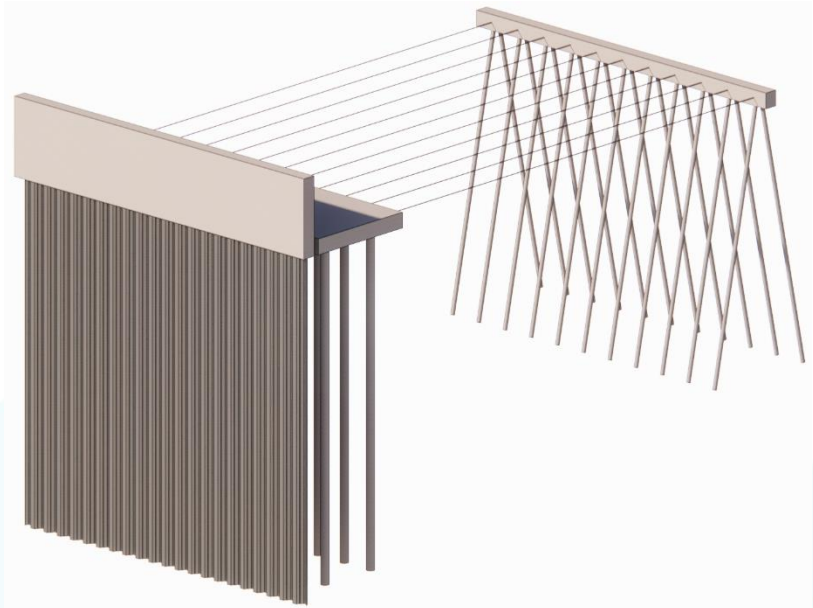
Roushdy, M. , Naggar, M. , Abdelaziz, A.. "**Numerical Investigation on Anchored Sheet Pile Quay Wall with Separated Relieving Platform**". World Academy of Science, Engineering and Technology, Open Science Index 204, International Journal of Geotechnical and Geological Engineering (2023), 17(12), 182 - 200.

Objective of the Study

- This study focuses on analyzing the added **platform supported on piles as an upgrade** to the existing quay wall, aiming to determine the **optimal dimensions** for maximizing the upgrade's effectiveness.



- Before upgrade



- After upgrade

Research Methodology

- The methodology employed in this study involves numerical investigation to achieve the study's objectives, utilizing finite element analysis with PLAXIS 3D Software.
- This methodology comprises of:

Verification Phase

Carried out through the utilization of **field measurements** conducted by **Endley *et al.*, (2000)**, the output of this step is a validated model.

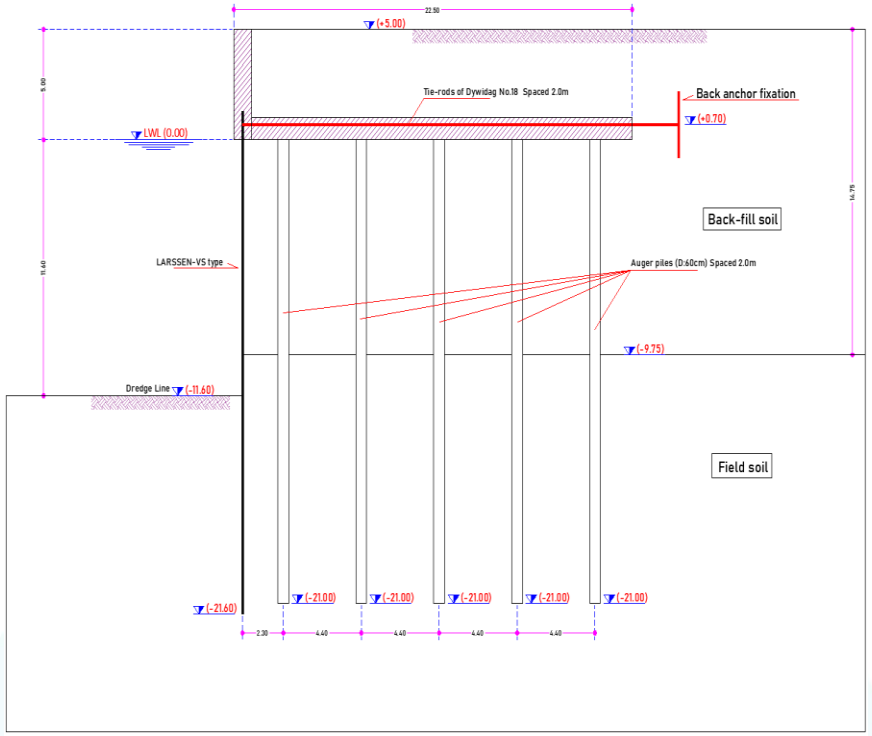
Parametric study Phase

The **validated model** is expanded in a **parametric study** to encompass a series of models with variations in the **number of piles supporting the platform**, **different pile sections**, **varied spacing between piles**, **piles at different bearing levels**, and **platforms positioned at different elevations**.

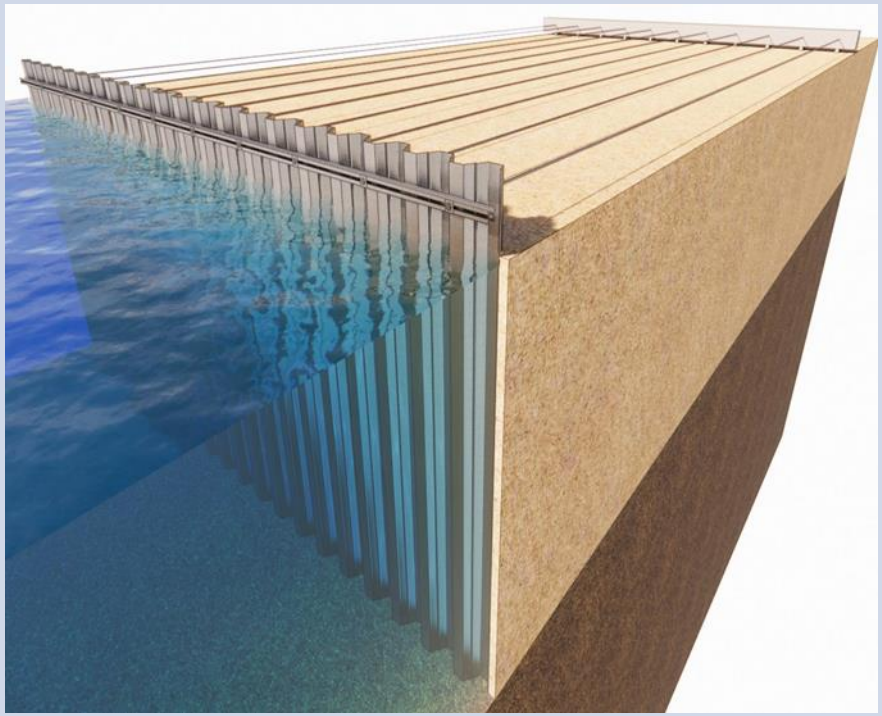
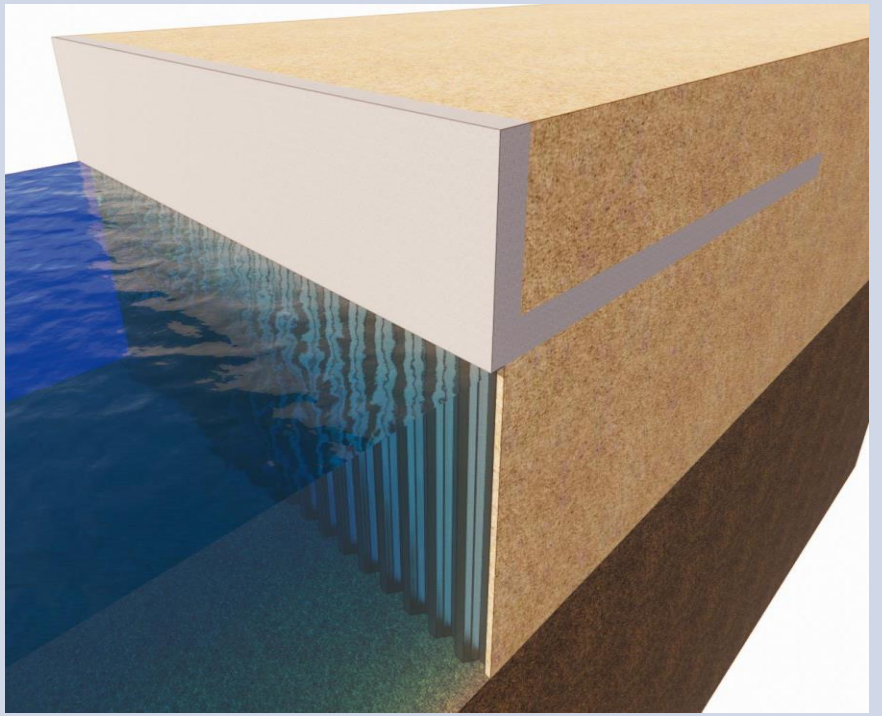
Endley, S. N., Dunlap, W. A., Knuckey, D. M., & Sreerama, K. (2000). **Performance of an Anchored Sheet-Pile Wall**. In Geotechnical Measurements. Geo-Denver 2000. American Society of Civil Engineers. https://doi.org/10.1061/40518(294)14

Verification Phase

- The actual **quay wall** was a **general cargo type** situated in the Port of Freeport, Texas, USA.
- The soil encountered in the field at the vicinity of the quay wall consisted of **overconsolidated clay**, located approximately **9.75 m** below the **mean water level (MWL).**
- The **measurements** were conducted for two phases: **after backfilling** (October 1986) and after **finalizing the superstructure** (November 1987).

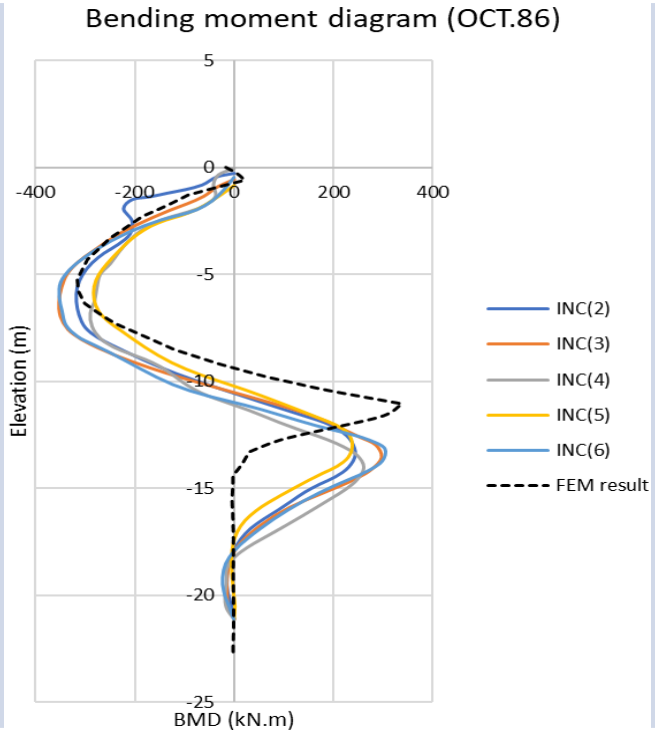


Verification Phase – Date of Field Measurements

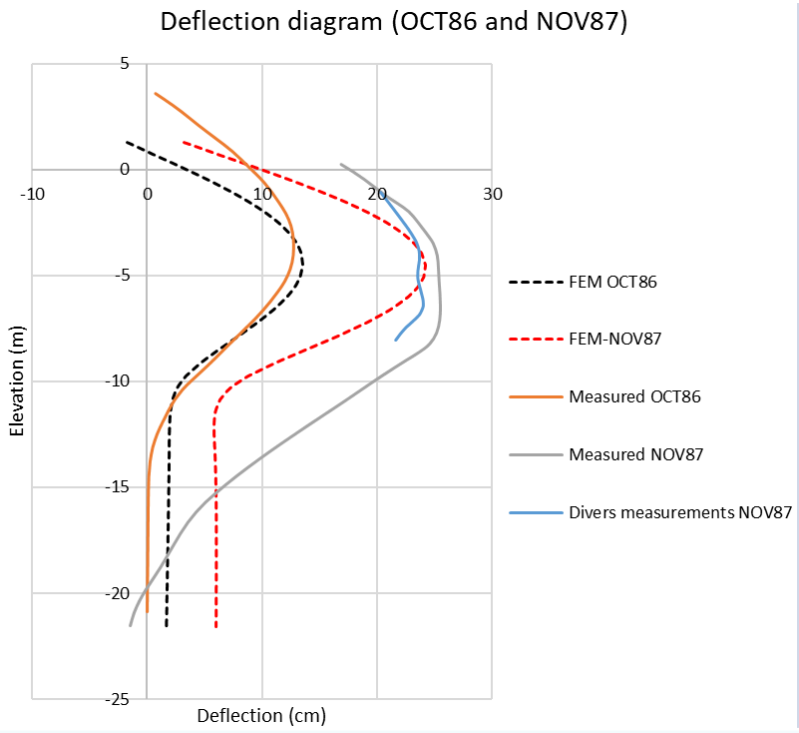
After backfilling (OCT, 86)	After superstructure finalizing (NOV, 87)
	

Verification Phase – Front wall

Verification of bending moment

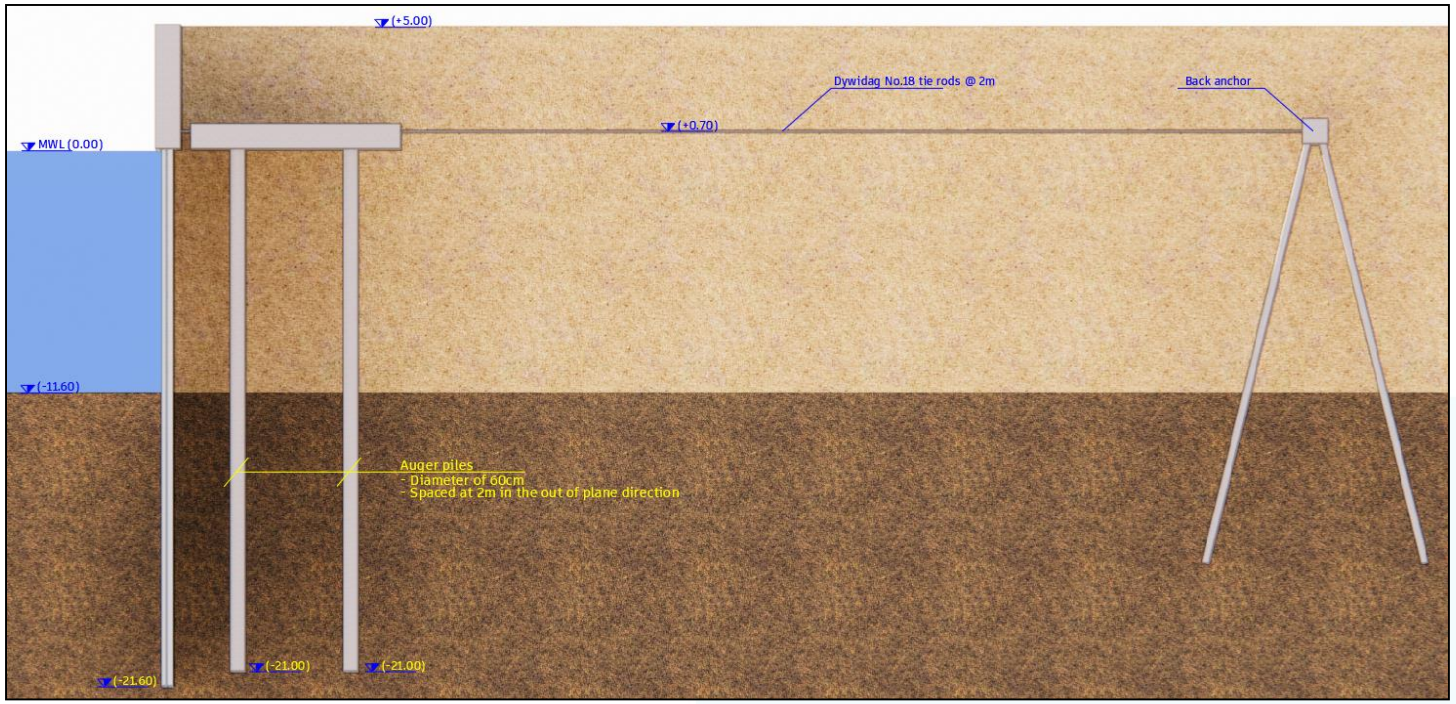


Verification of displacement



Parametric study Phase

- The **validated model** was expanded to include **two basic reference models**, each featuring **distinct retained soils**: **sandy fill** and **overconsolidated clay**.



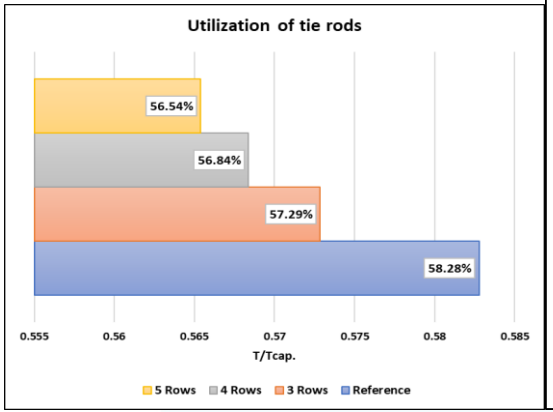
Parametric study Phase

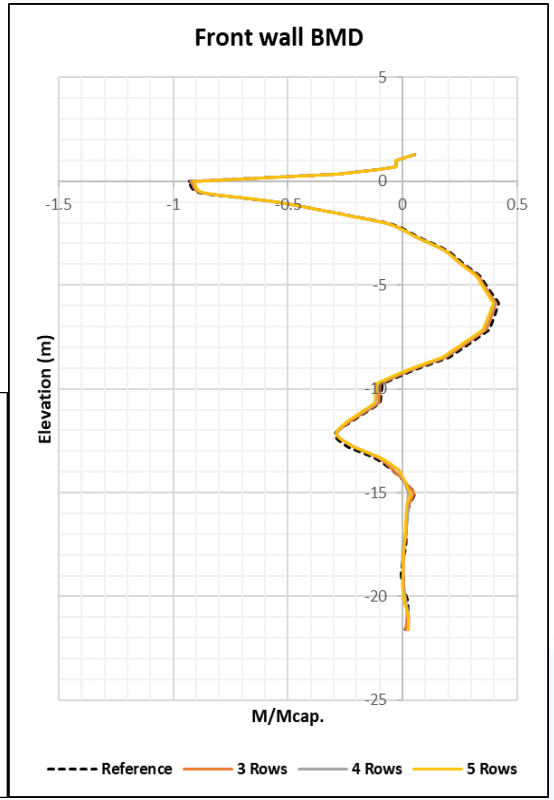
- The **parametric study** involves **comparing** the **reference models** to the **refined cases of the platform with varying pile setups** in order to achieve **optimization** using both of the retained soil types.

Findings and Interpretation

1) Effect of **increasing Number of piles** supporting the platform (**Sand fill**):

- **Front wall** exhibited **Negligible** effect. ✘
- **Lateral deformation** was **reduced** by up to **8%** when increasing number of piles. ✓
- **Tie rods** tension slightly **reduced** with the **increase** in number of piles. ✓

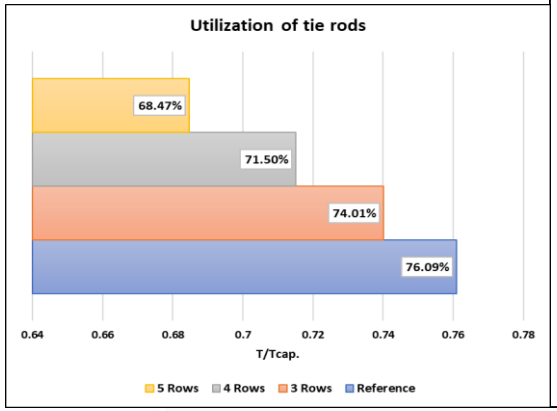


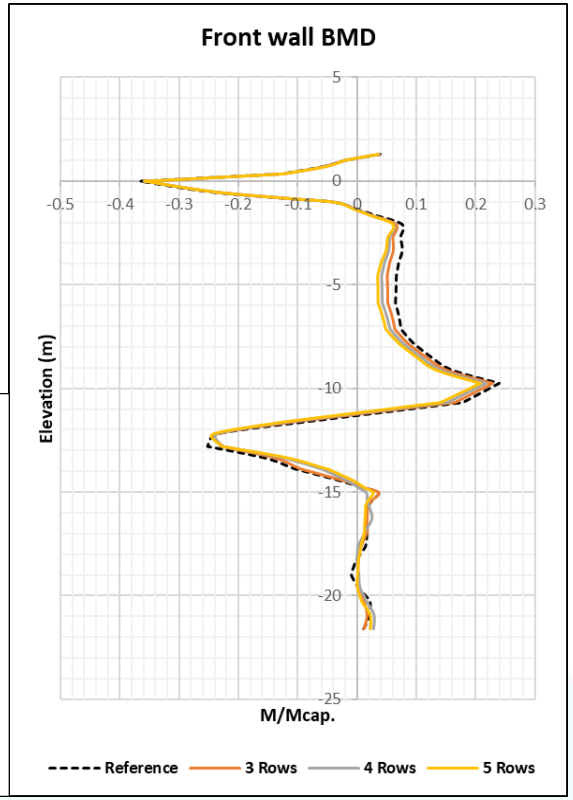


Findings and Interpretation

1) Effect of **increasing Number of piles** supporting the platform (**Overconsolidated clay fill**):

- **Front wall** exhibited **Negligible** effect at the maximum bending zone. ✘
- **Lateral deformation** was **reduced** by up to **14%** when increasing number of piles. ✓
- **Tie rods** tension was **reduced** with the **increase** in number of piles. ✓

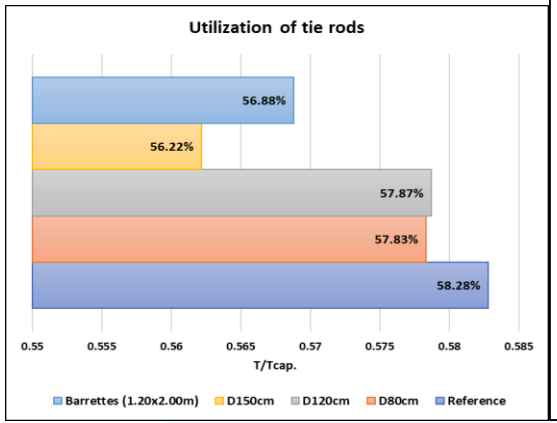


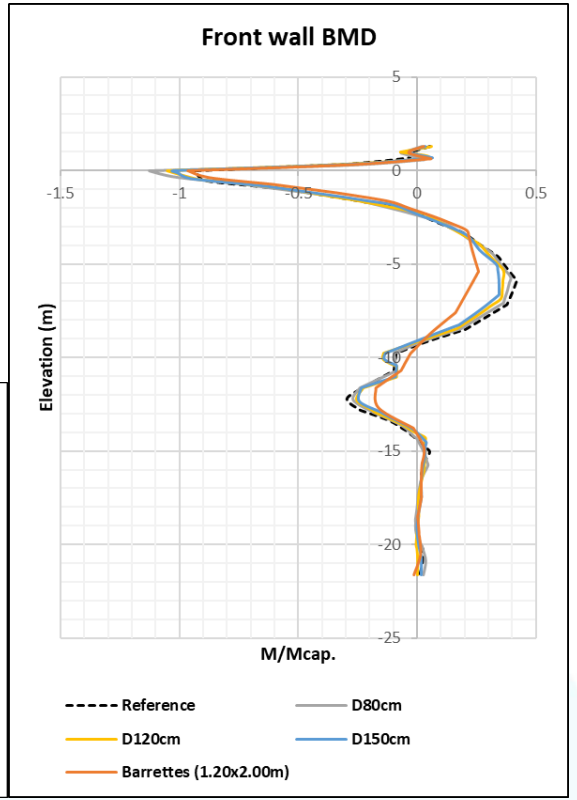


Findings and Interpretation

2) Effect of **increasing Stiffness of piles** supporting the platform (**Sand fill**):

- **Front wall** exhibited **Increase** in the maximum bending zone with the increase in piles stiffness. ✘
- **Lateral deformation** was **reduced** by up to **19%** when increasing stiffness of piles. ✓
- **Tie rods** tension negligibly **reduced** with the **increase** in stiffness of piles. ✘

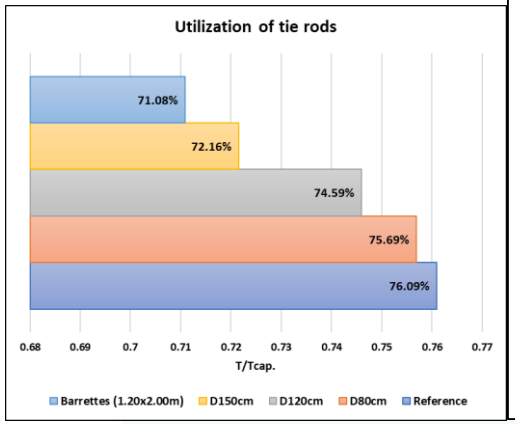


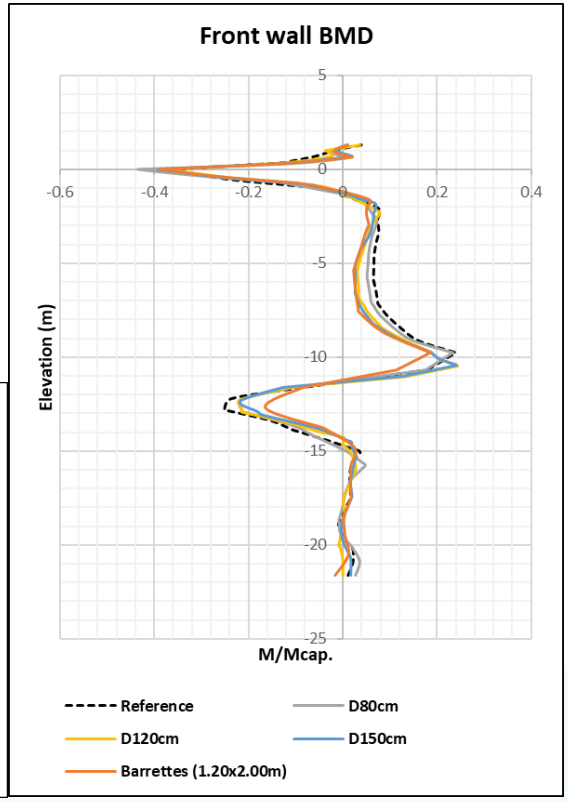


Findings and Interpretation

2) Effect of **increasing Stiffness of piles** supporting the platform (**Overconsolidated clay fill**):

- **Front wall** exhibited **Increase** in the maximum bending zone with the increase in piles stiffness. ✘
- **Lateral deformation** was **reduced** by up to **14%** when increasing stiffness of piles. ✓
- **Tie rods** tension marginally **reduced** with the **increase** in stiffness of piles. ✓

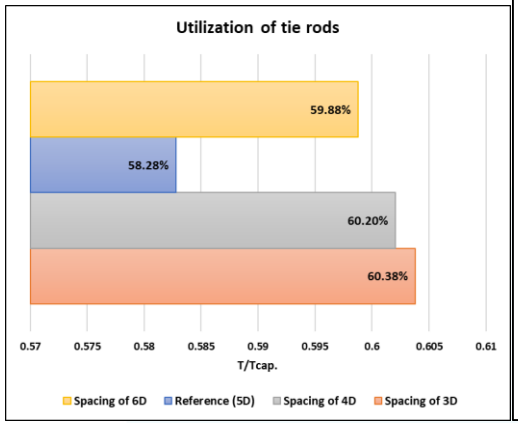


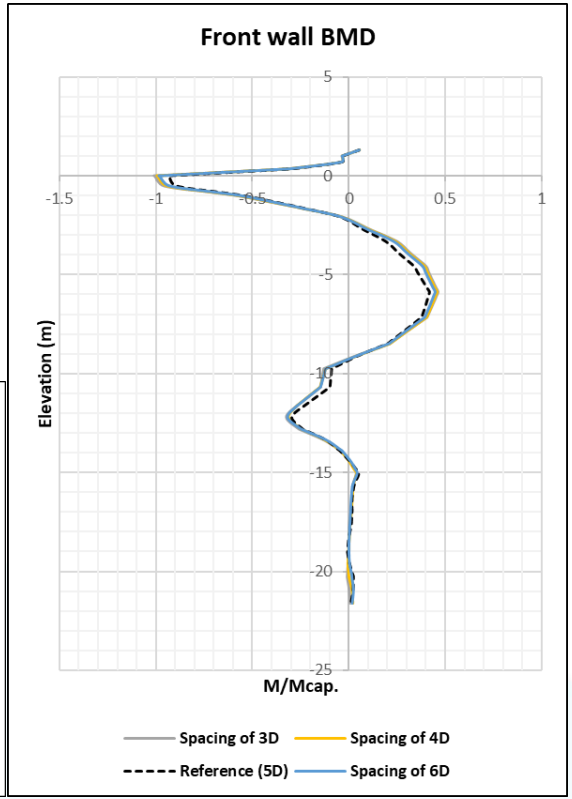


Findings and Interpretation

3) Effect of **increasing Spacing of piles** supporting the platform (**Sand fill**):

- **Front wall** exhibited an **Increase** in the maximum bending zone with an **increased** spacing of piles. ✘
- **Lateral deformation** was **Increased** by up to **4%** when **increasing** spacing of piles. ✘
- **Tie rods** tension negligibly **reduced** with the **increase** in spacing of piles. ✘

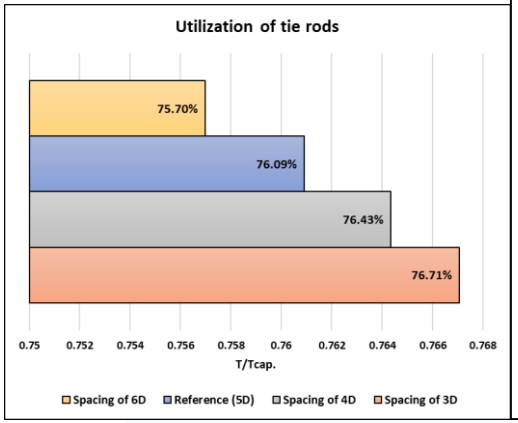


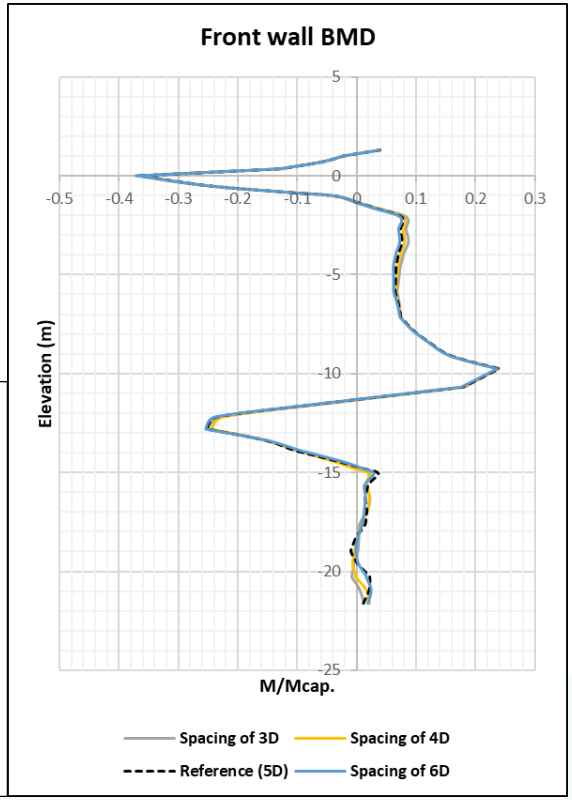


Findings and Interpretation

3) Effect of **increasing Spacing of piles** supporting the platform (**Overconsolidated clay fill**):

- **Front wall** exhibited an **Increase** in the maximum bending zone with an **increased** spacing of piles. ✘
- **Lateral deformation** was Negligibly **Increased** by up to **2%** when **increasing** spacing of piles. ✘
- **Tie rods** tension negligibly **reduced** with the **increase** in spacing of piles. ✘

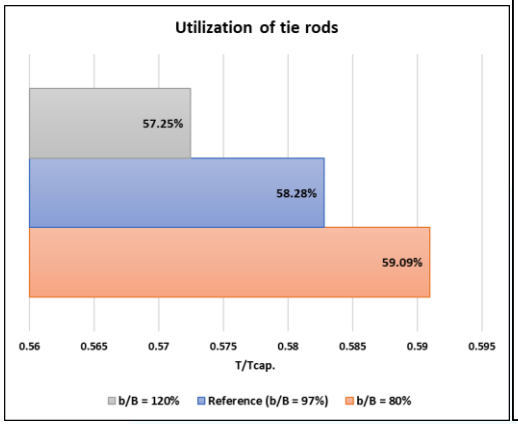


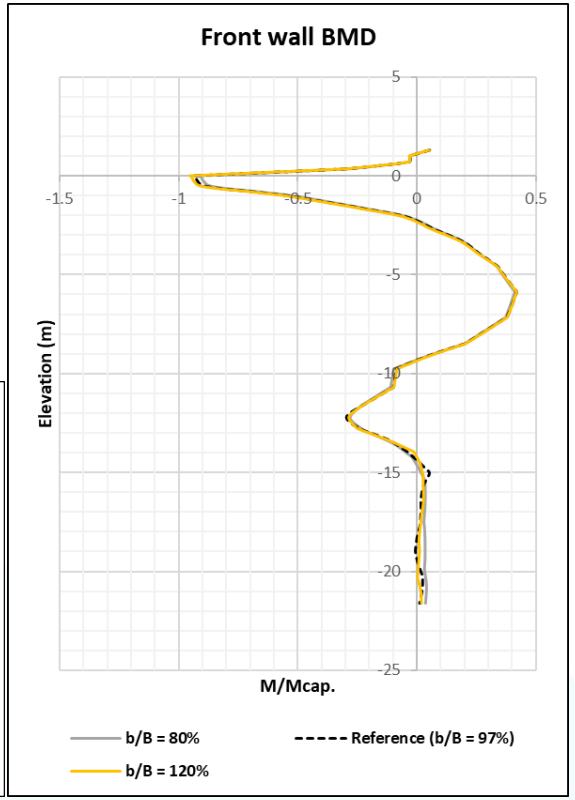


Findings and Interpretation

4) Effect of **adjusting bearing level of piles** supporting the platform (**Sand fill**):

- **Front wall** exhibited **Negligible decrease** and **increase** when **increasing** and **reducing** bearing level of piles by 20% respectively. ✘
- **Lateral deformation** was almost **Unaffected** by modifying bearing level of piles by ±20%. ✘
- **Tie rods** tension slightly **reduced** with the **increase** in bearing level of piles. ✓

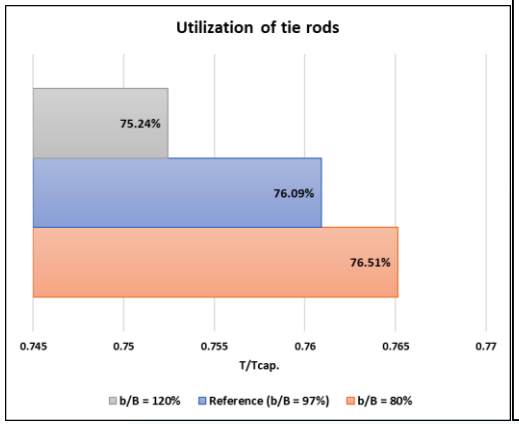


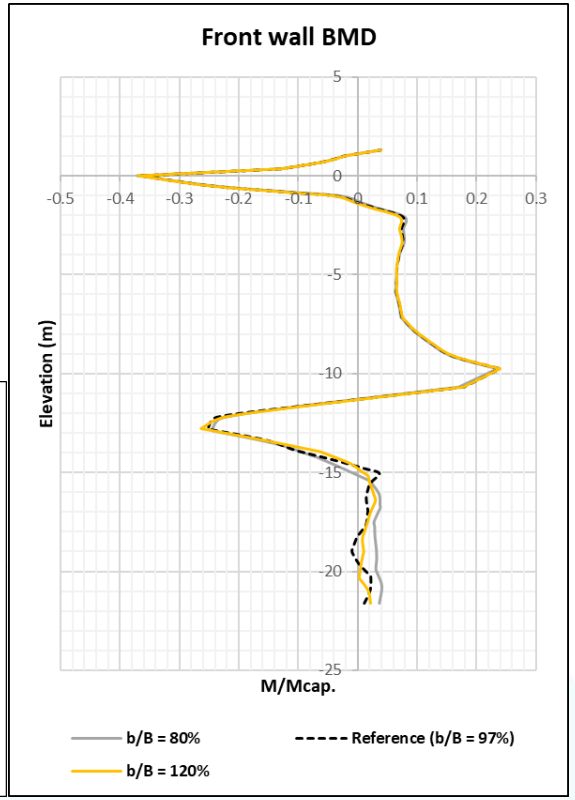


Findings and Interpretation

4) Effect of **adjusting bearing level of piles** supporting the platform (**Overconsolidated clay fill**):

- **Front wall** exhibited **Negligible** effect when modifying bearing level of piles by ±20%. ✘
- **Lateral deformation** was almost **Unaffected** by modifying bearing level of piles by ±20%. ✘
- **Tie rods** tension negligibly **reduced** with the **increase** in bearing level of piles. ✘

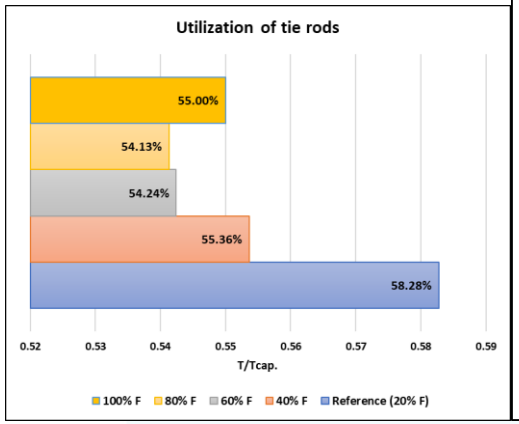


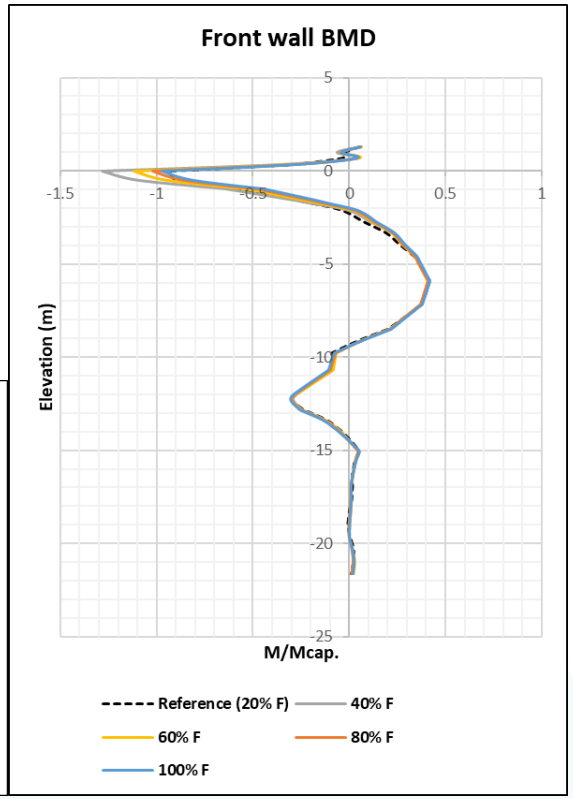


Findings and Interpretation

5) Effect of **adjusting elevation** of the **Platform** supported on piles (**Sand fill**):

- **Front wall** exhibited a **significant increase** when changing the level of the platform from the typical location (Lining with capping beam). ✘
- **Lateral deformation** was slightly **increased** by adjusting level of the platform by up to 4%. ✘
- **Tie rods** tension marginally **reduced** with the **modification** in platform level. ✓

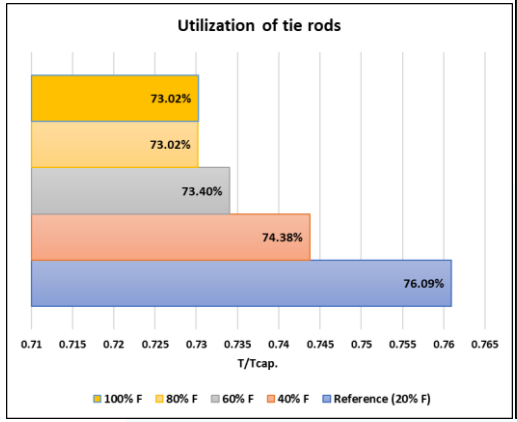


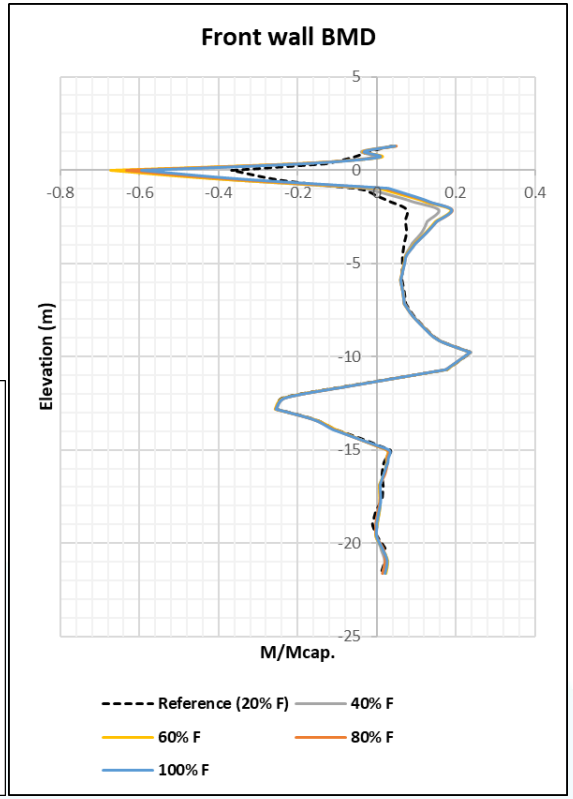


Findings and Interpretation

5) Effect of **adjusting elevation** of the **Platform** supported on piles (**Sand fill**):

- **Front wall** exhibited a **significant increase** when changing the level of the platform from the typical location (Lining with capping beam). ✘
- **Lateral deformation** was negligibly **increased** by adjusting level of the platform by up to 1%. ✘
- **Tie rods** tension marginally **reduced** with the **modification** in platform level. ✓





Conclusion and recommendation

Increasing number of piles supporting the platform	•**Unfavorable** to the front wall (Negligible effect). •**Slightly favorable** to the tie rod tension. •**Recommended** to use **only two piles rows** to support the platform.
Increasing stiffness of those piles	•Unfavorable to the front wall (**Increased** forces). •**Slightly favorable** to the tie rod tension. •**Recommended** to use reduced pile stiffness to support the platform in accordance with the design.
Increasing spacing of those piles	•Unfavorable to the front wall (**Increased** forces) •**Slightly favorable** to the tie rod tension. •**Recommended** to use spacing of **maximum 5*piles diameter (5D)** to support the platform.
Adjusting bearing level of those piles	•**Unfavorable** to the front wall (Negligible effect). •**Slightly favorable** to the tie rod tension, **slightly decreased tension** with the **increase** in bearing Lv. •**Recommended** to use the bearing level which is only **suitable for the design**.
Adjusting the elevation of the platform	•Unfavorable to the front wall (**Severely increased forces**, i.e., **Sensitive** to the platform location). •**Slightly favorable** to the tie rod tension. (**marginal decrease** effect with the adjustments). •**Recommended** to **align** the **bottom level** of the platform with that of the **capping beam**.

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