



# Ground Improvement Solutions for the new Cruise Terminal in Lisbon

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**Session S7 – Biogrout & Other Grouting Methods, 1<sup>st</sup> June 2012**



## OUTLINE

- ☐ **Introduction**
- ☐ Main constraints
- ☐ Quay walls refurbishment and underpinning
- ☐ Landfill foundations
- ☐ Design
- ☐ Monitoring and survey
- ☐ Quality control / quality assurance
- ☐ Alternative solutions
- ☐ Conclusion remarks





Lisbon

Tagus River



Tagus River

Site Location



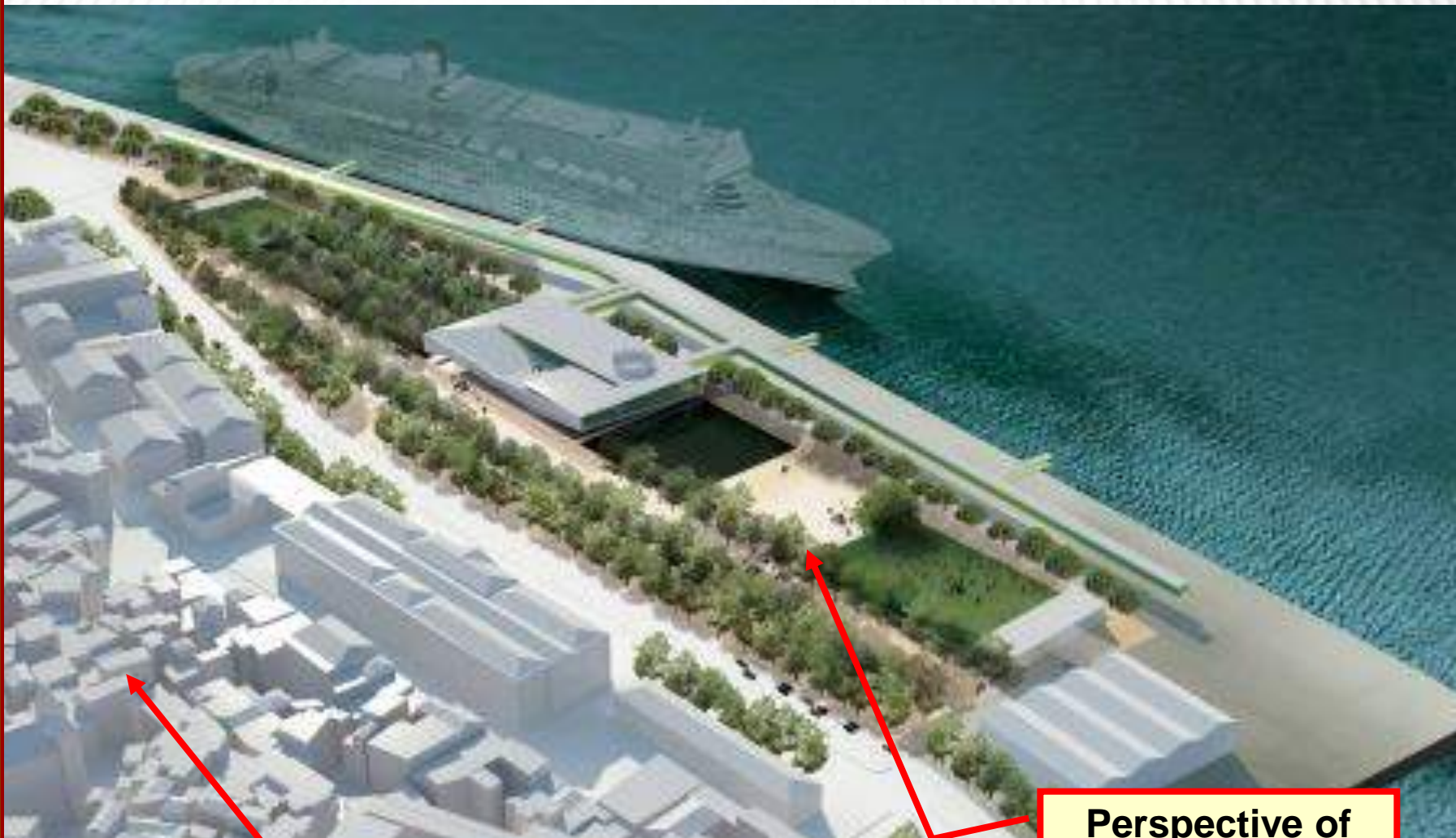




**Existent quay  
wall to be close  
and refurbished**

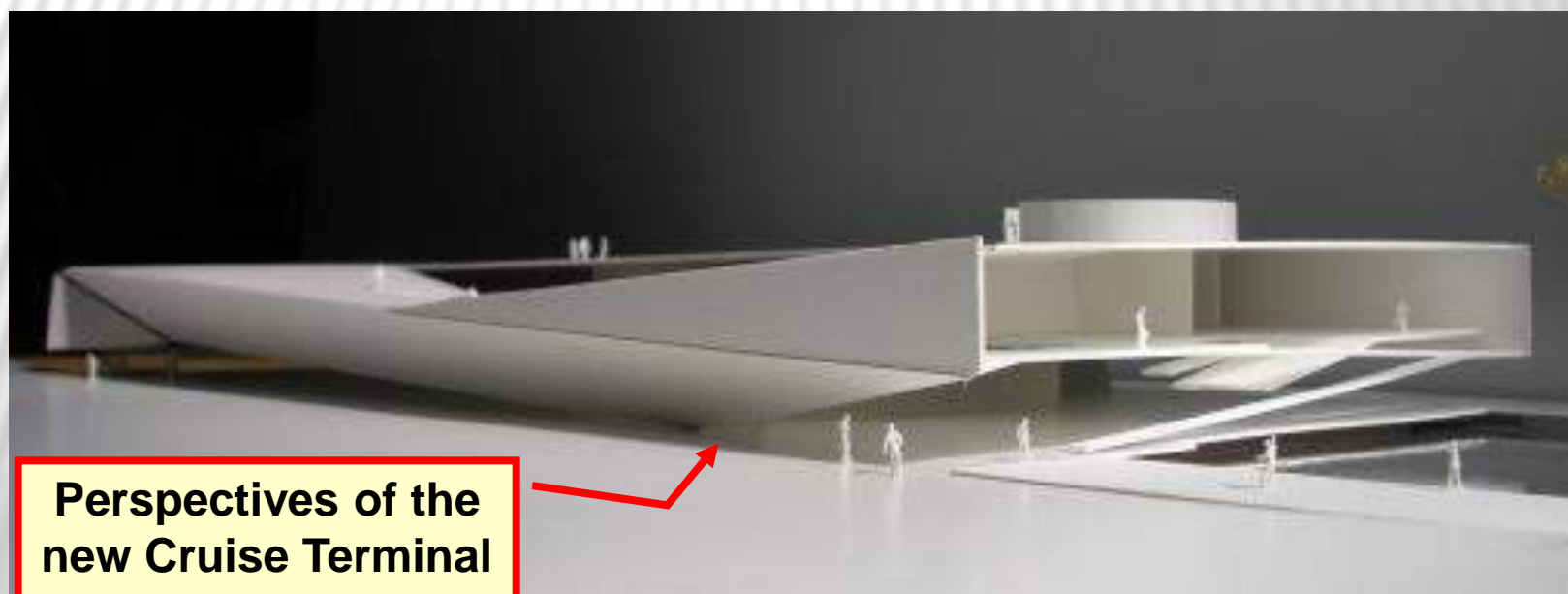
**Dockyard on  
high tide before  
the filling works**





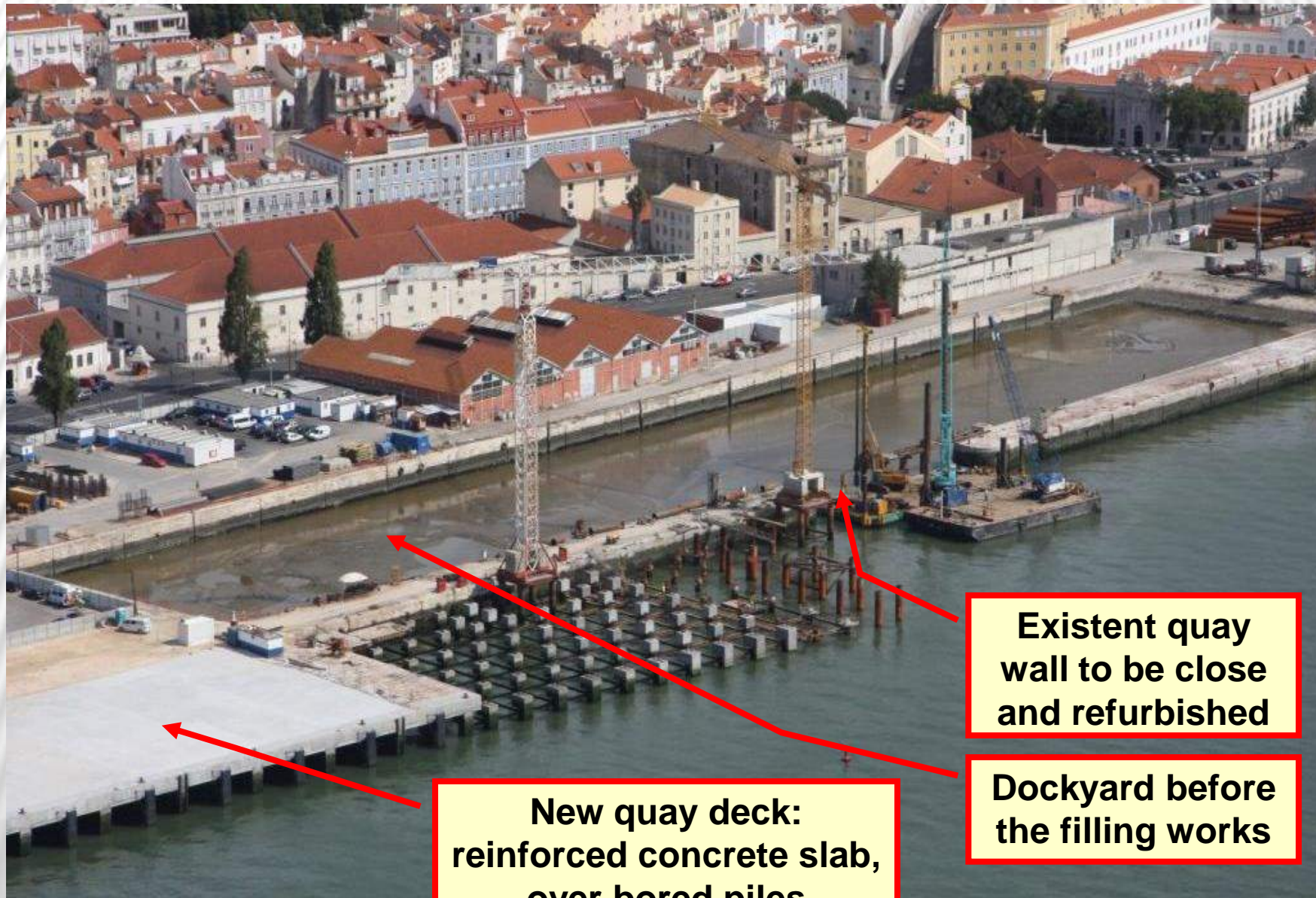
**Alfama Hill**

**Perspective of  
the new Cruise  
Terminal**



**Perspectives of the  
new Cruise Terminal**





**Existent quay  
wall to be close  
and refurbished**

**New quay deck:  
reinforced concrete slab,  
over bored piles**

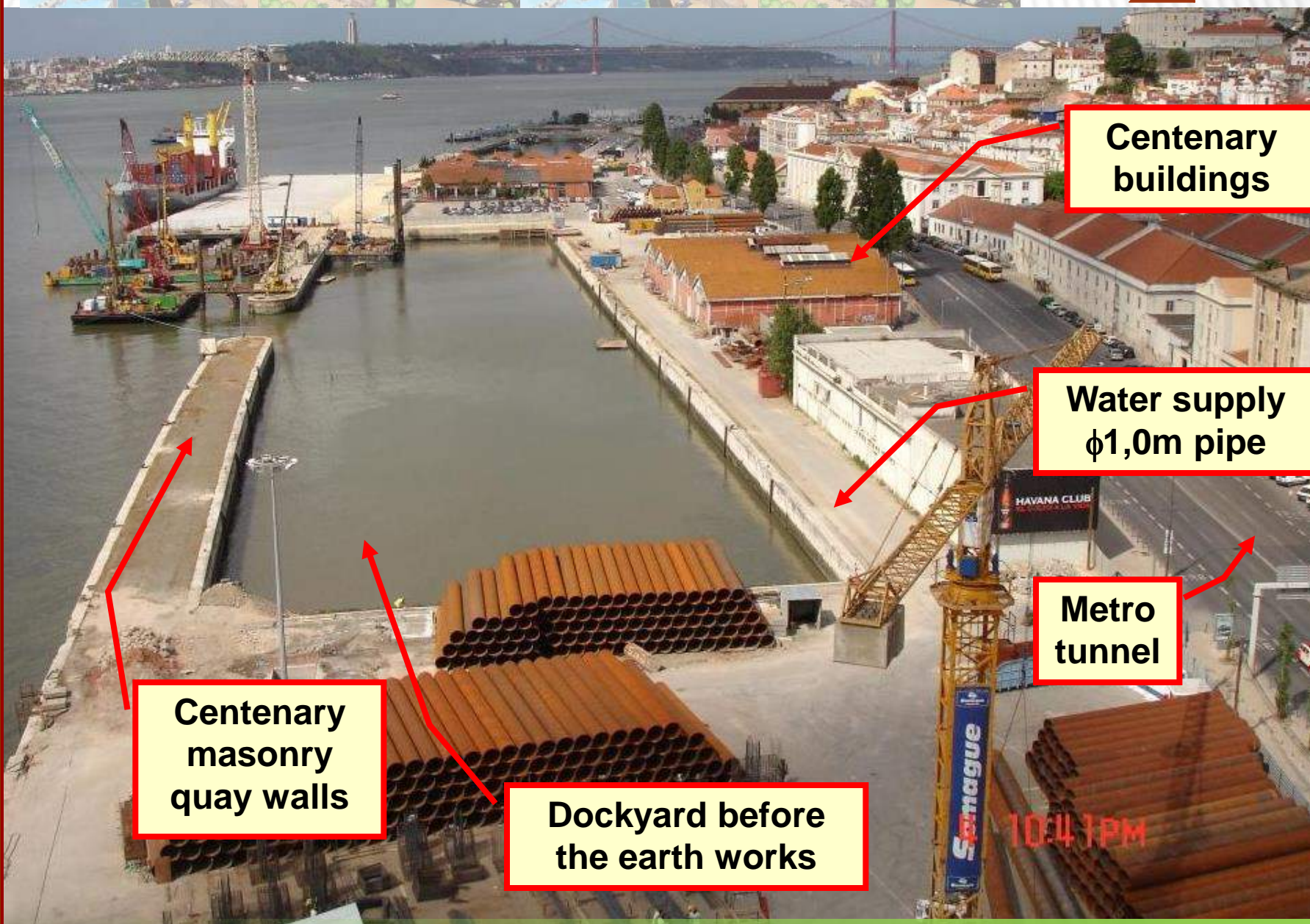
**Dockyard before  
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**Centenary  
buildings**

**Water supply  
φ1,0m pipe**

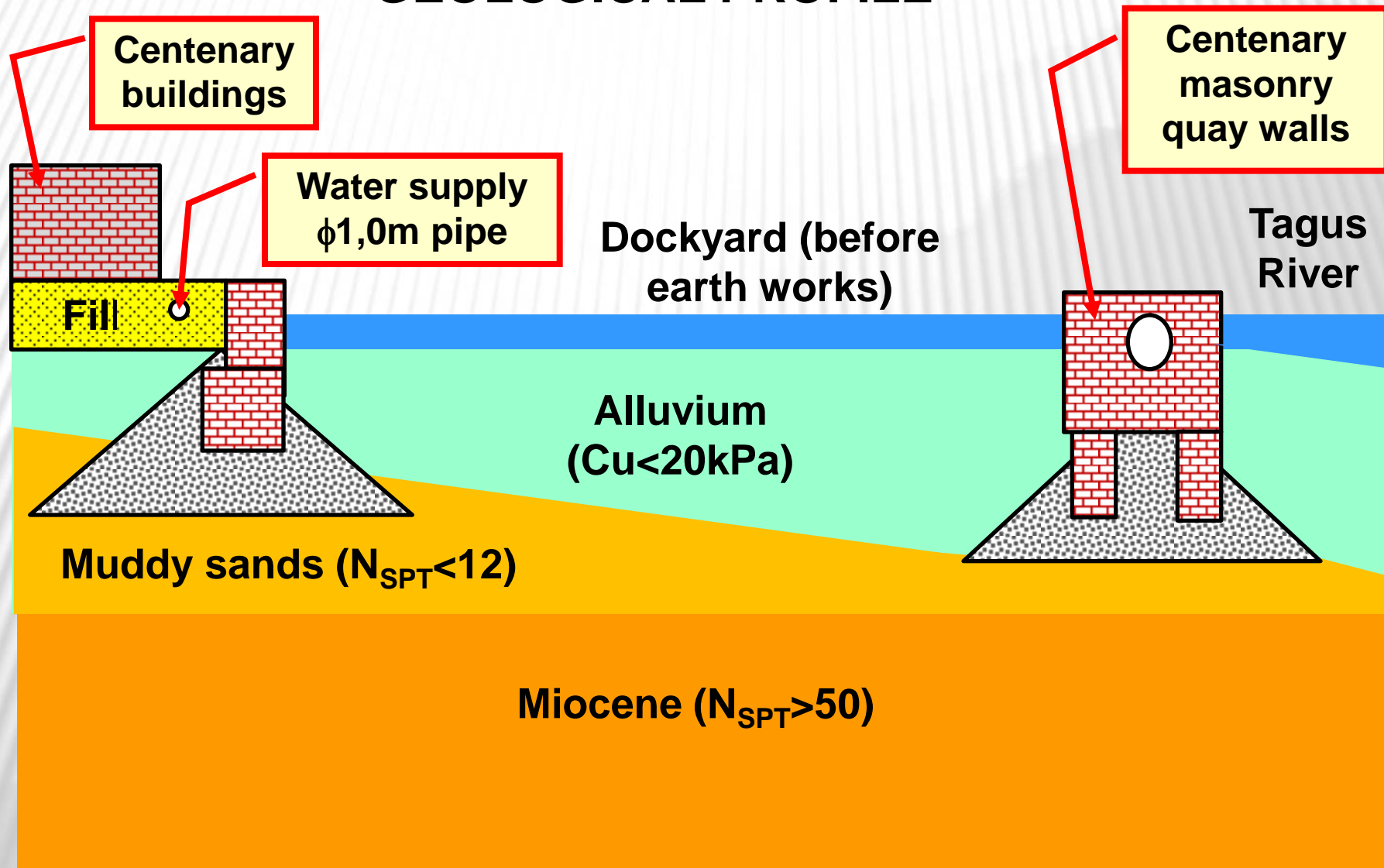
**Metro  
tunnel**

**Centenary  
masonry  
quay walls**

**Dockyard before  
the earth works**



# GEOLOGICAL PROFILE







**Earth works in  
difficult conditions**





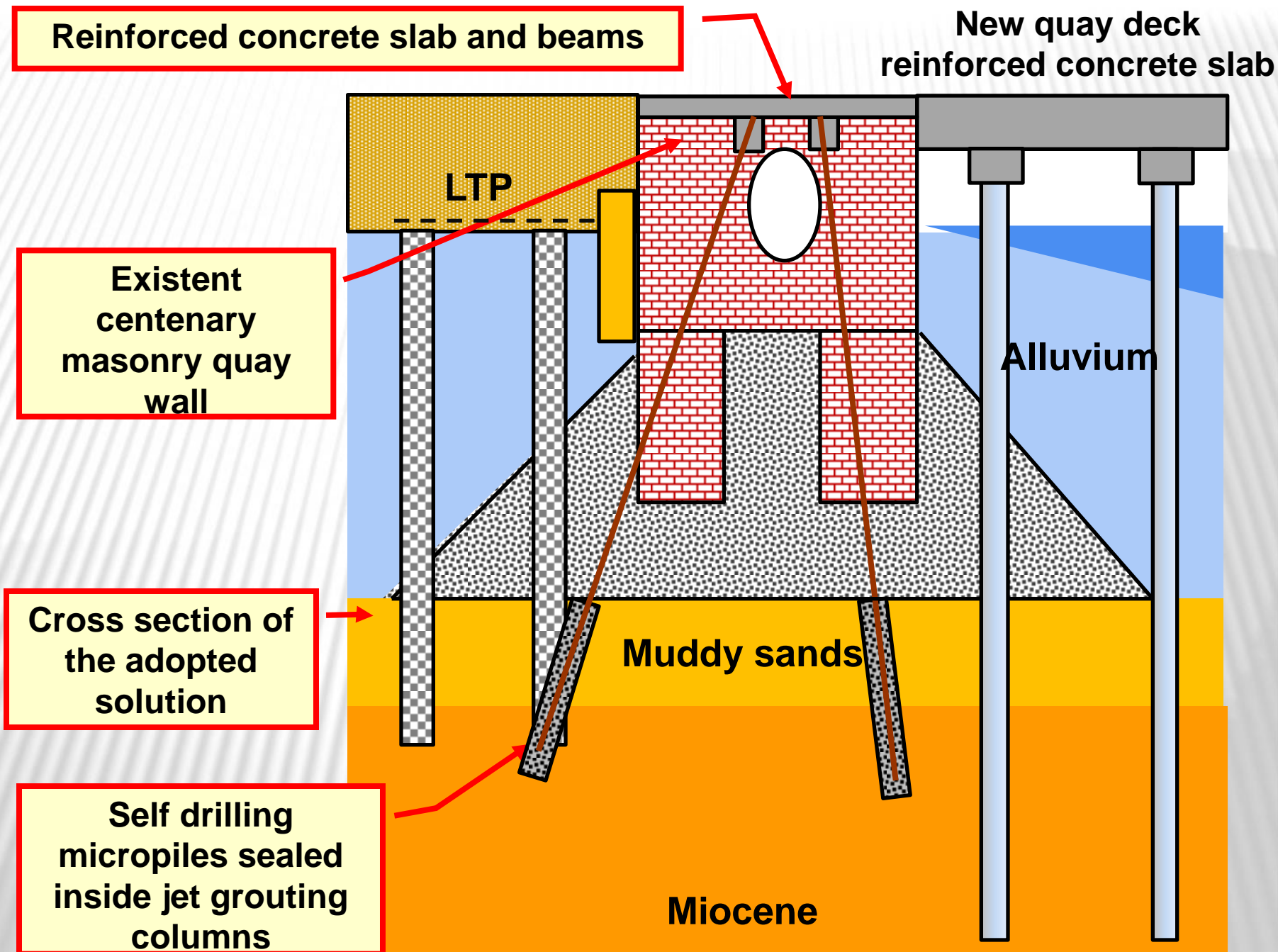
**Jet grouting works in  
difficult conditions**



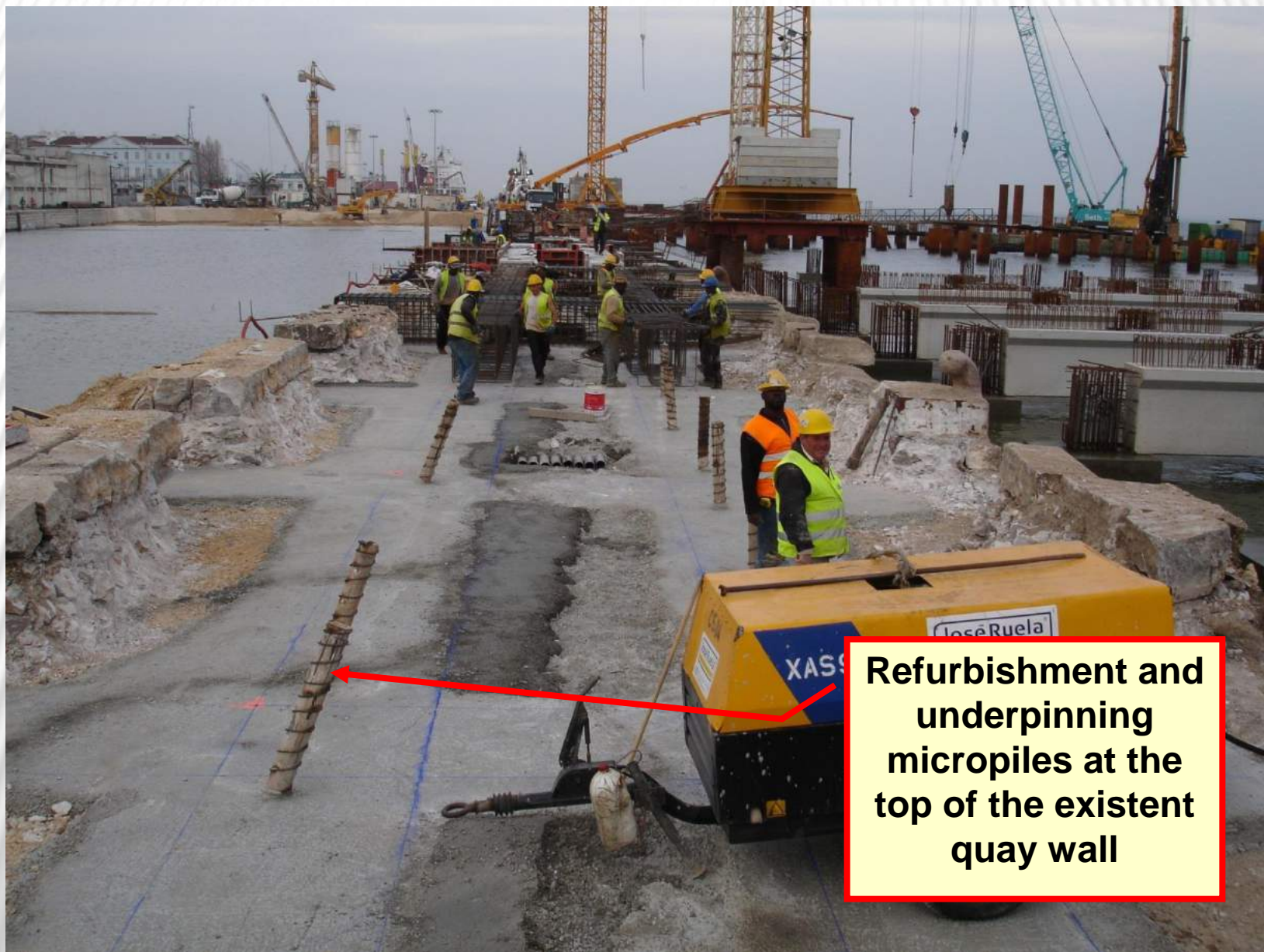


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**Refurbishment and underpinning micropiles at the top of the existent quay wall**





**Quay wall  
refurbishment  
and underpinning  
beams**







Quay wall  
refurbishment  
and underpinning  
beams



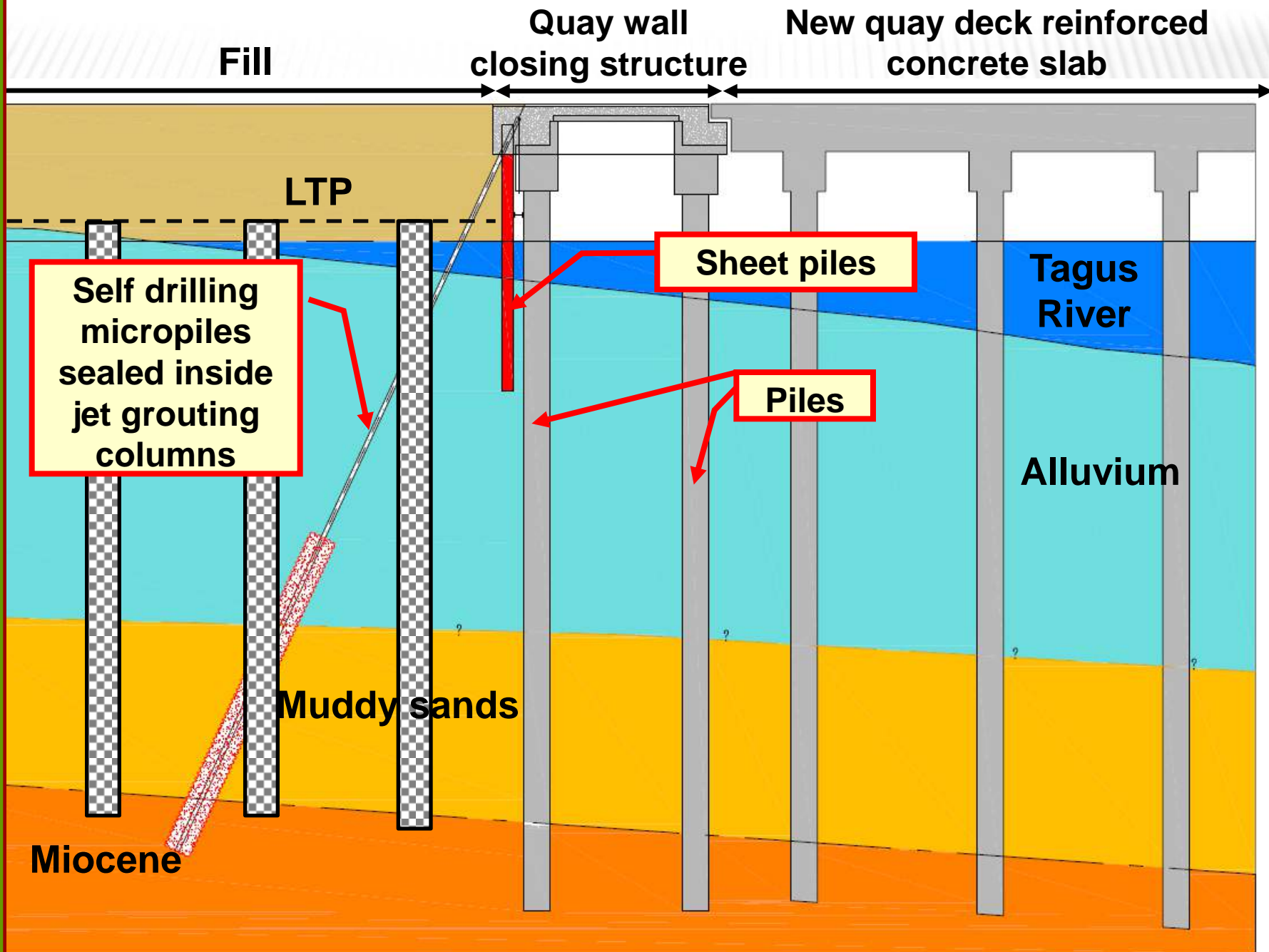


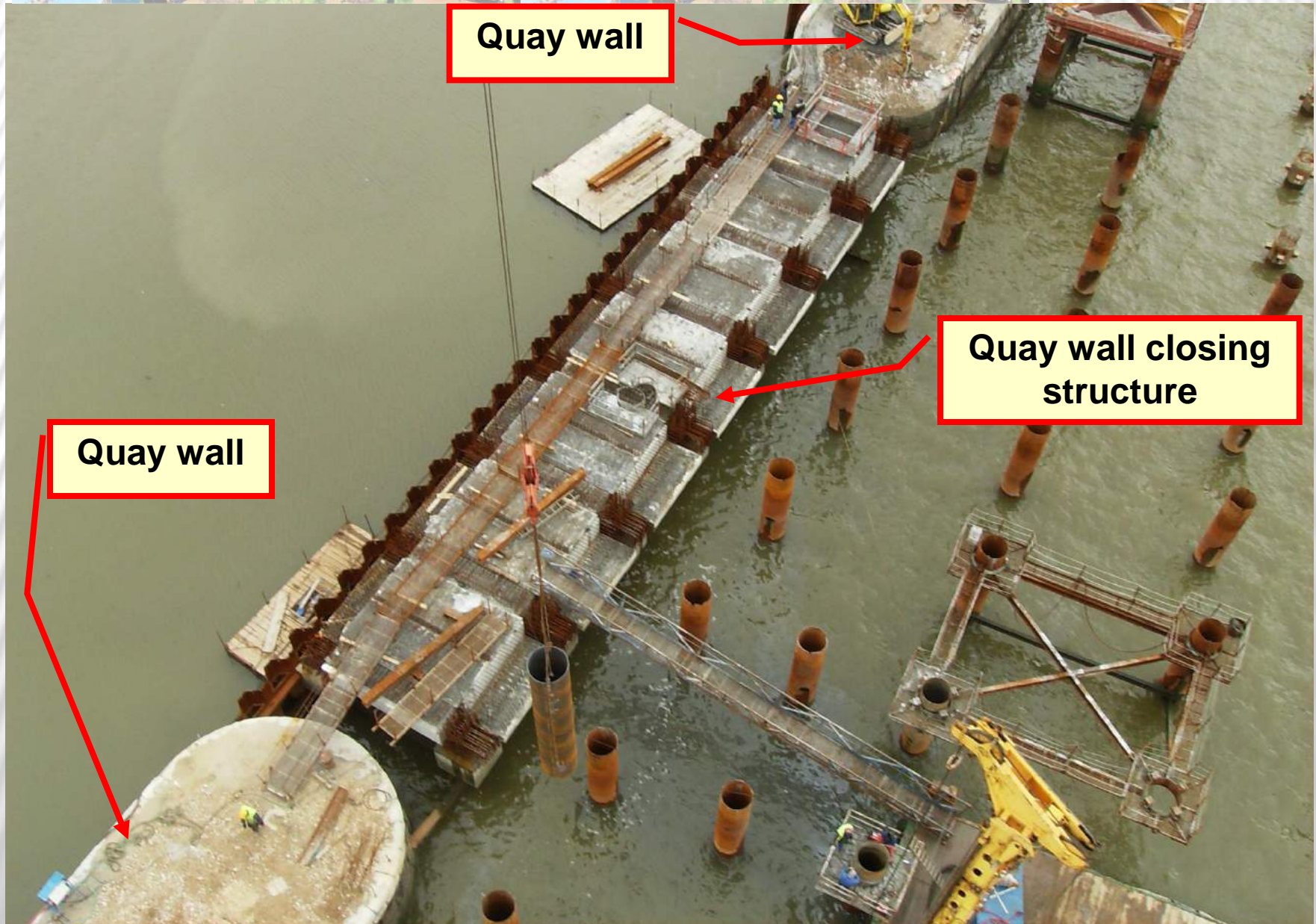


## OUTLINE

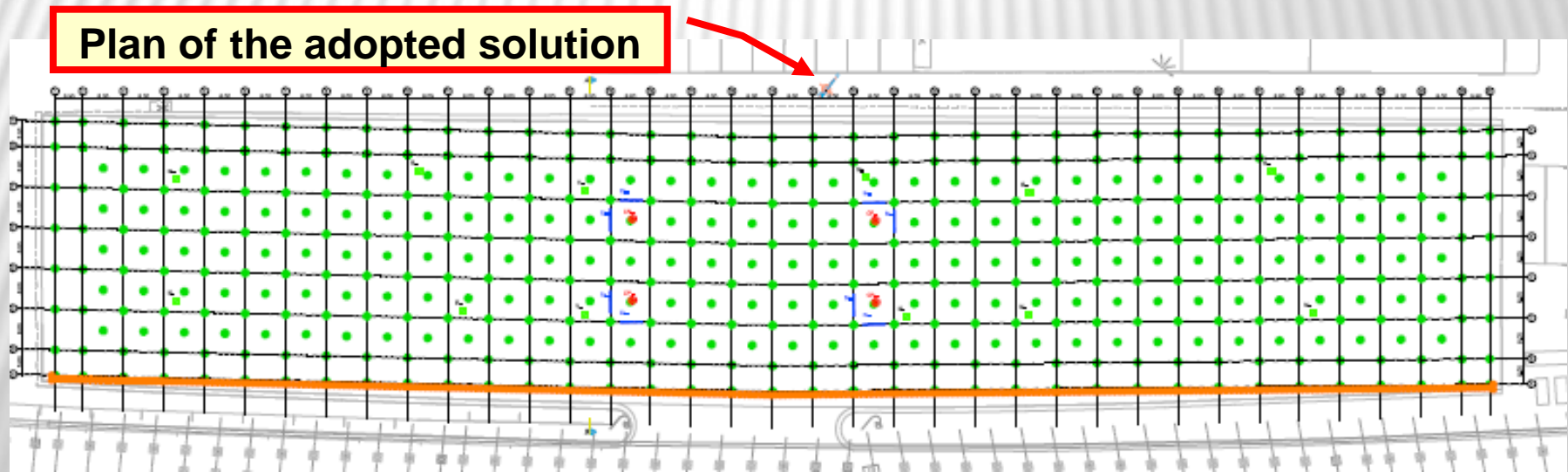
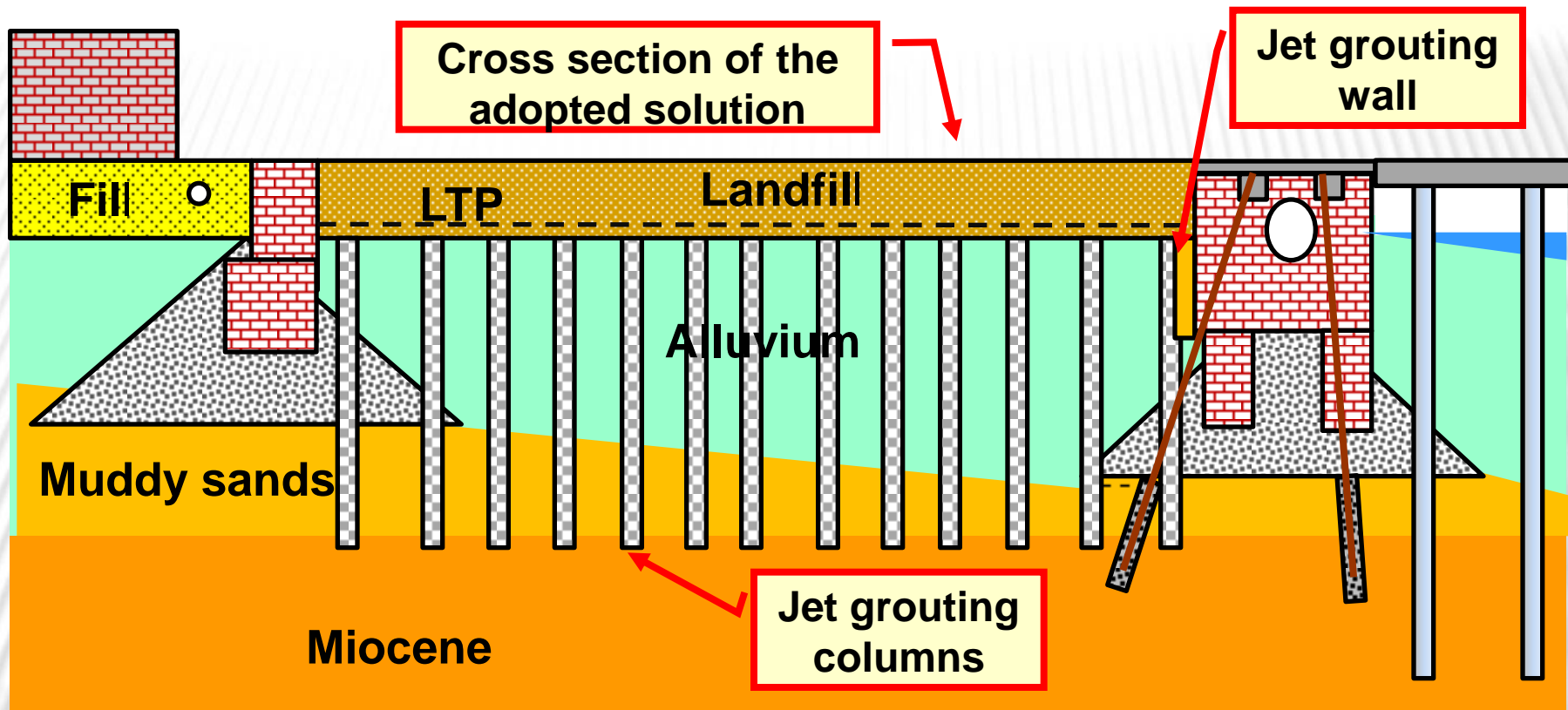
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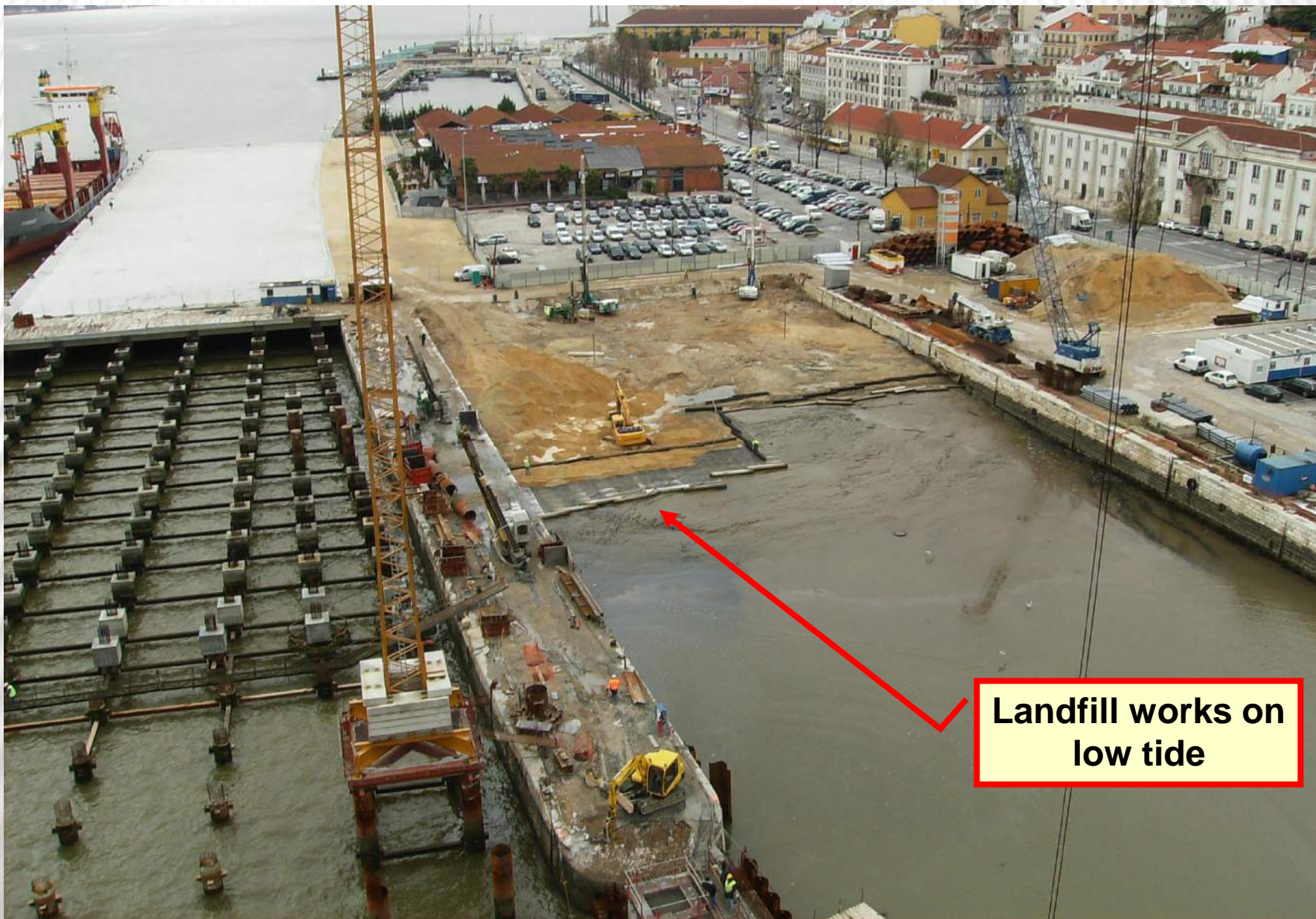
Installation of geogrids





Installation of geogrids





**Landfill works on  
low tide**





**Landfill works on  
low tide**





**Landfill works  
after conclusion**

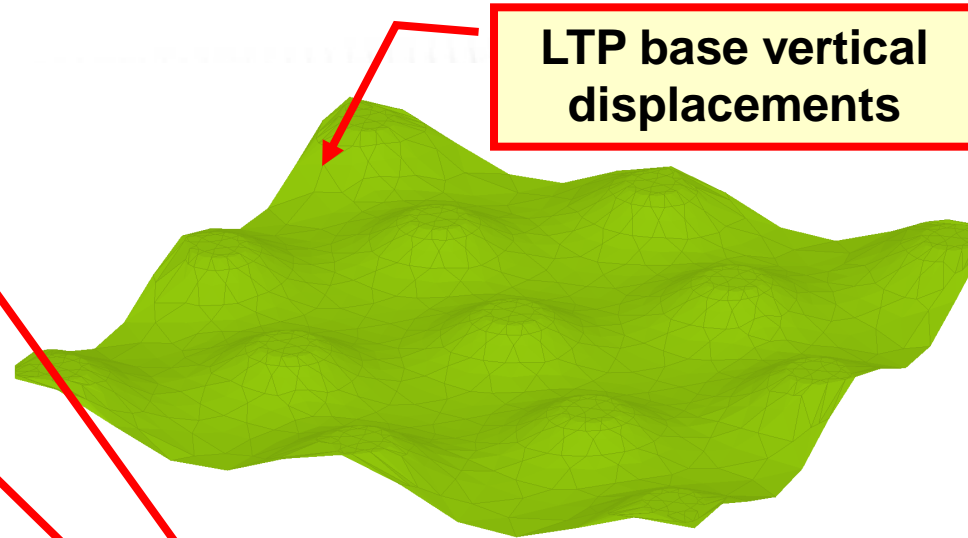
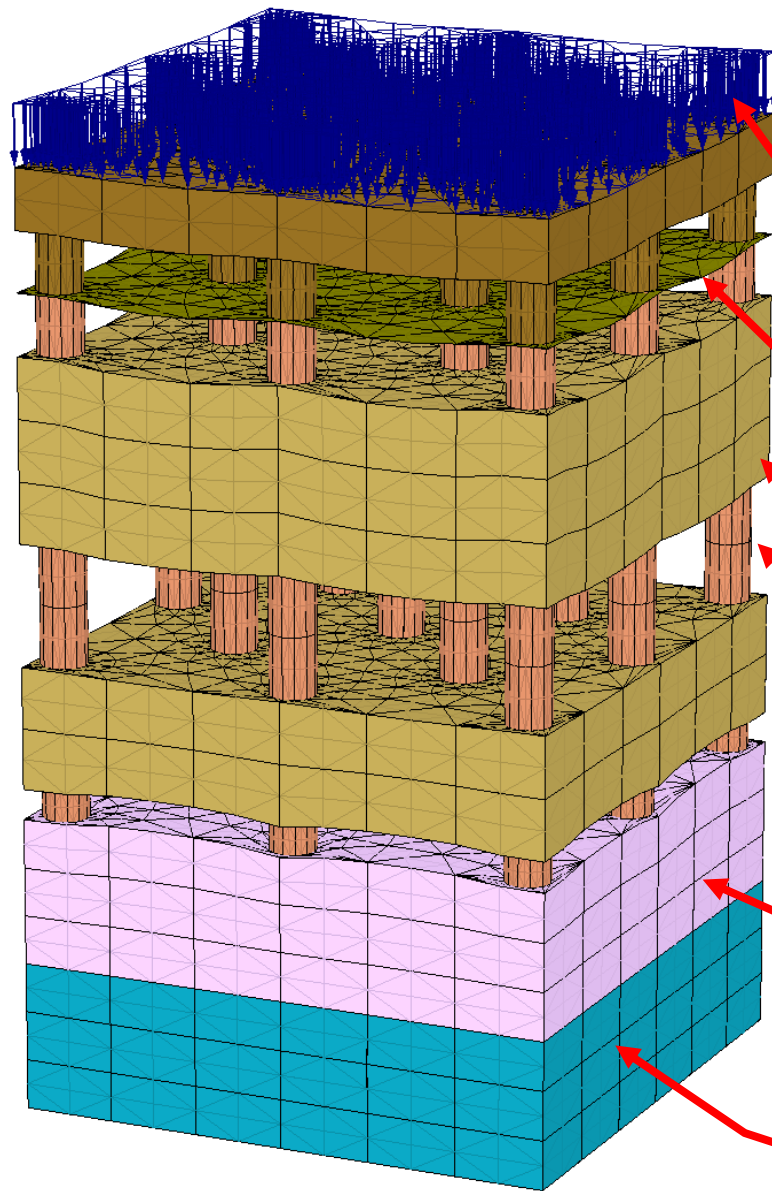




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# 3D FEM MODEL



LTP base vertical displacements

Loads at the surface

LTP

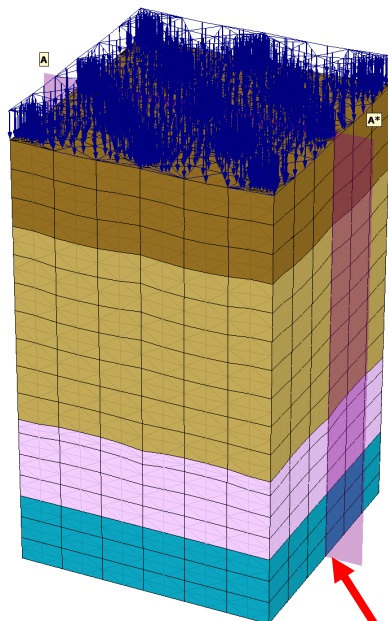
Muddy alluvium

Jet grouting columns

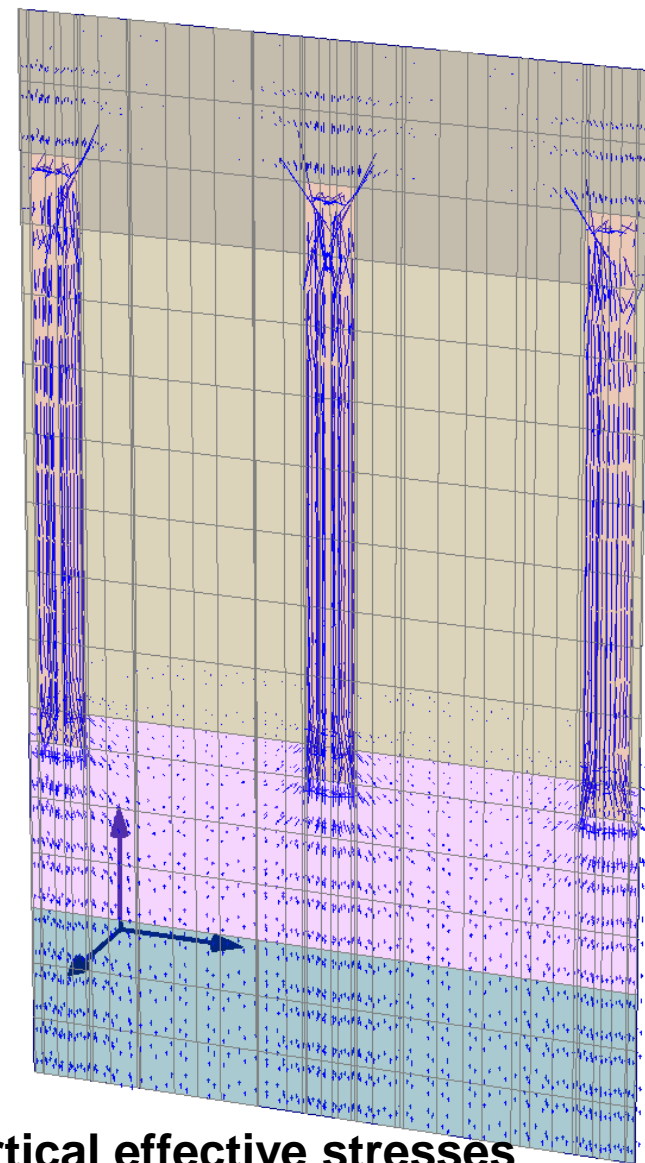
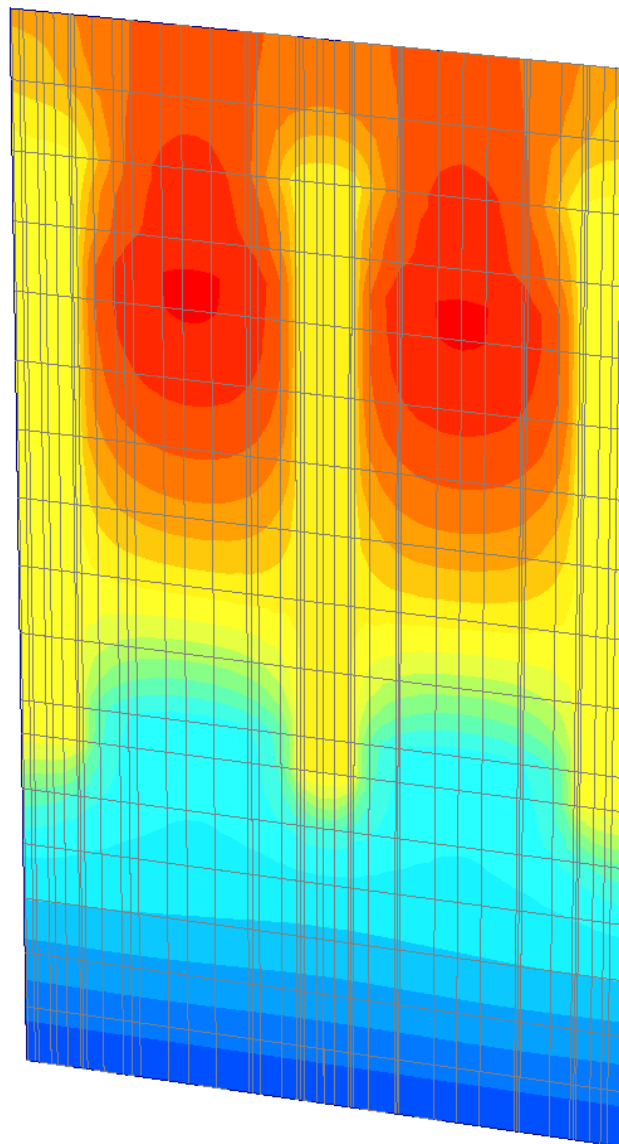
Sandy alluvium

Miocene: dense sand and sandstone





Plan where the results were obtained



Vertical displacements: max 76mm

Vertical effective stresses



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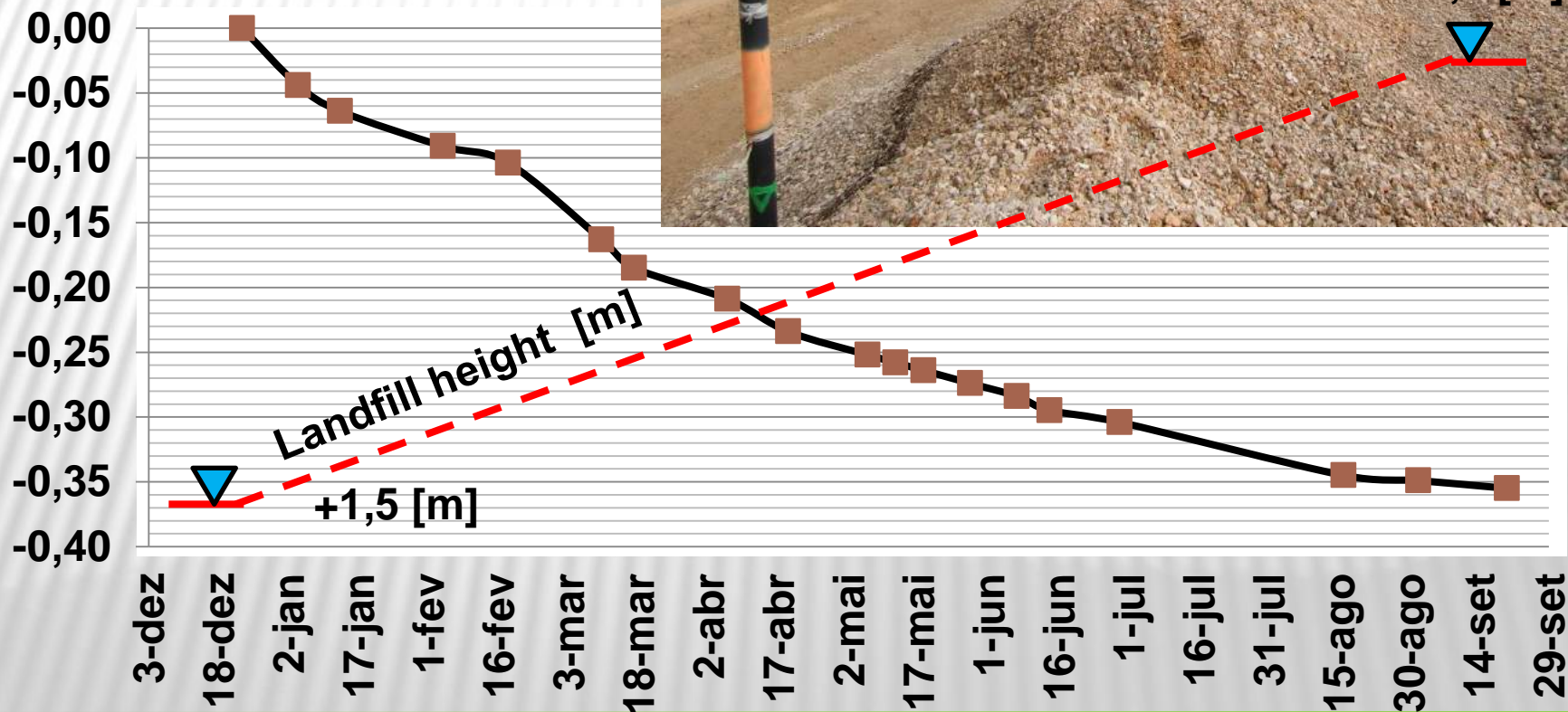


Topographic mark

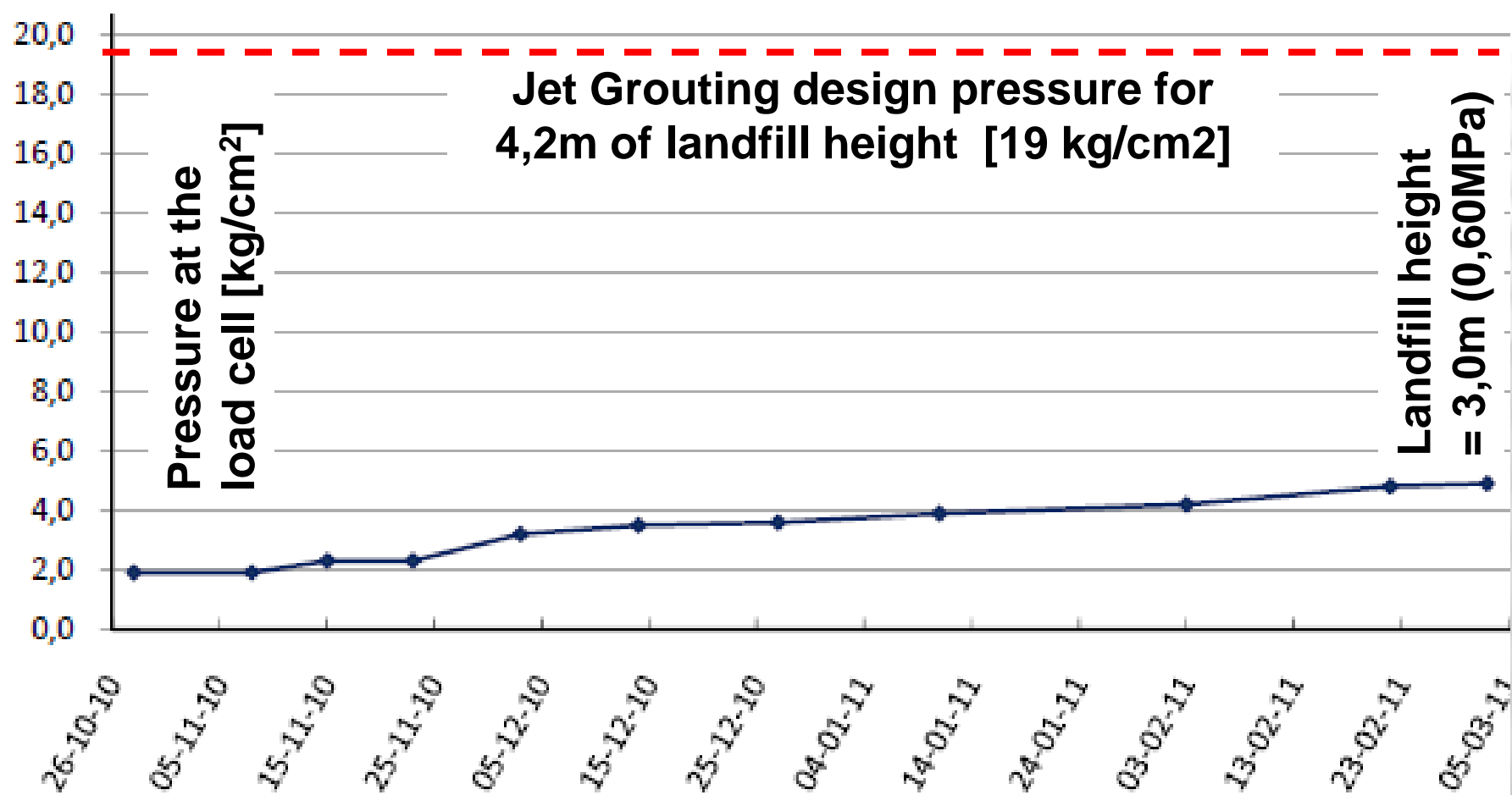
Topographic marks at the landfill base



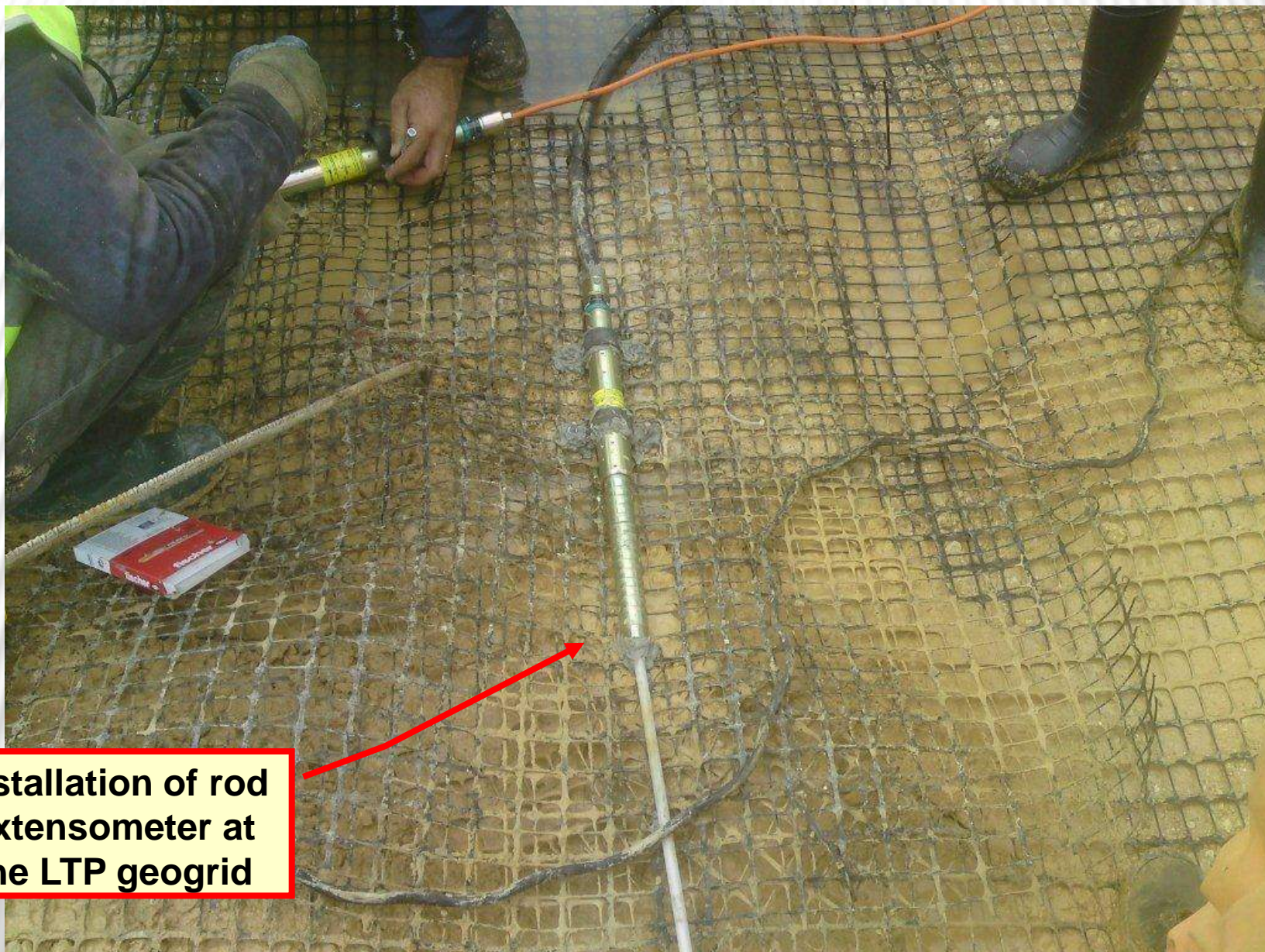
Vertical displacements at the landfill base [m]











Installation of rod  
 extensometer at  
 the LTP geogrid





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UCS tests



Cores gathering for UCS tests





**Jet grouting columns full length core samples**

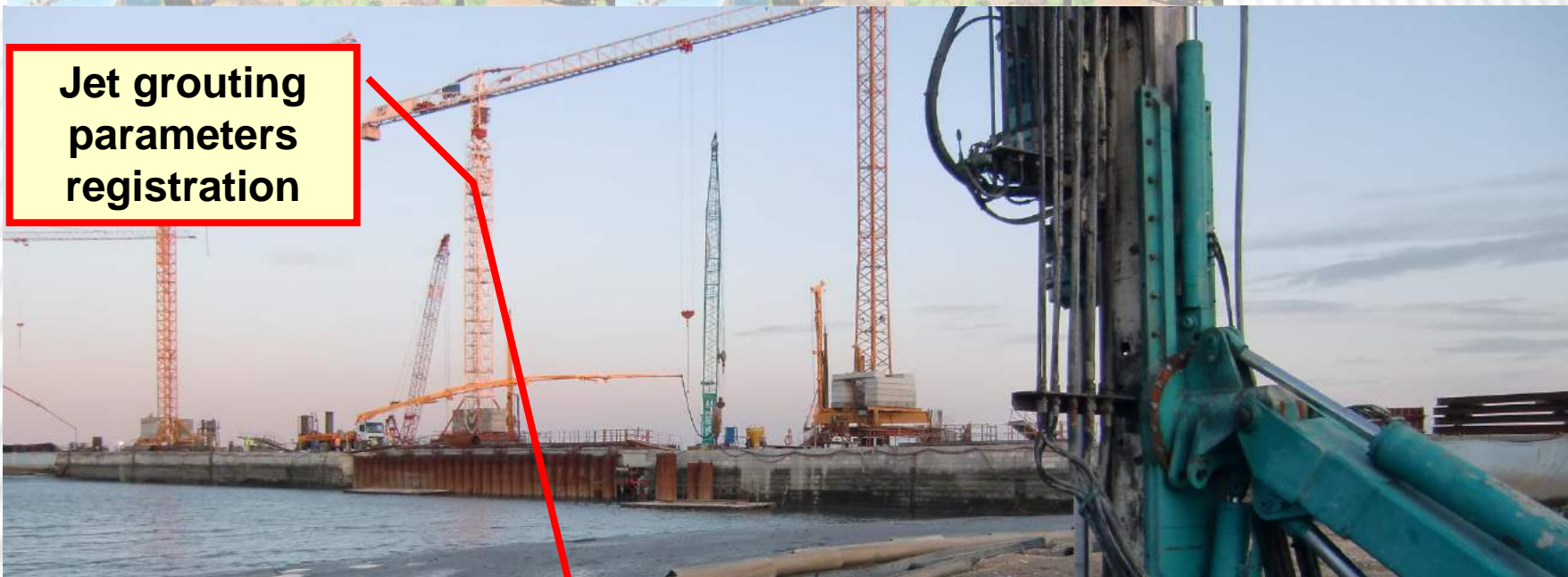


**Jet grouting columns core collection**

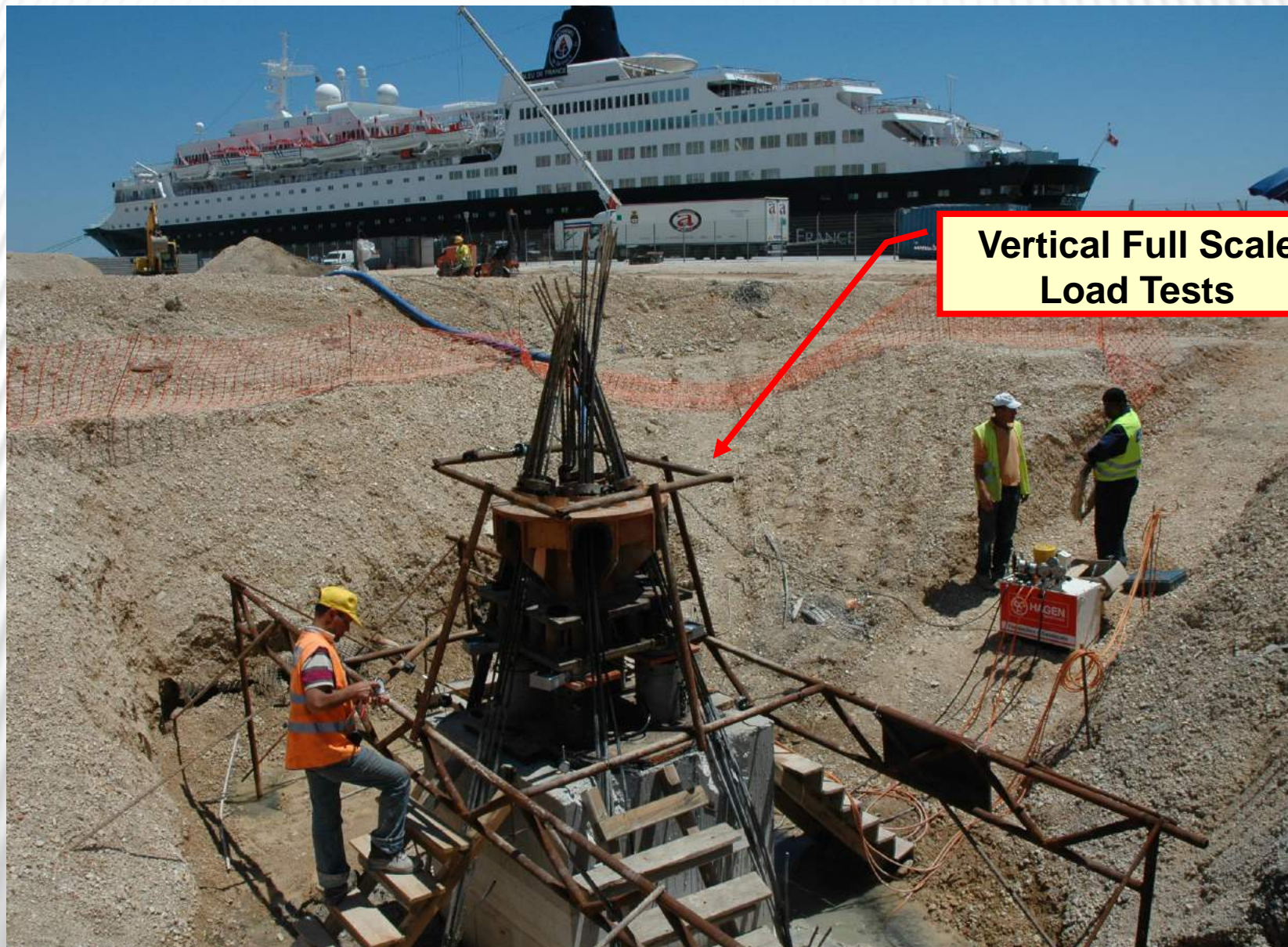




Jet grouting parameters registration

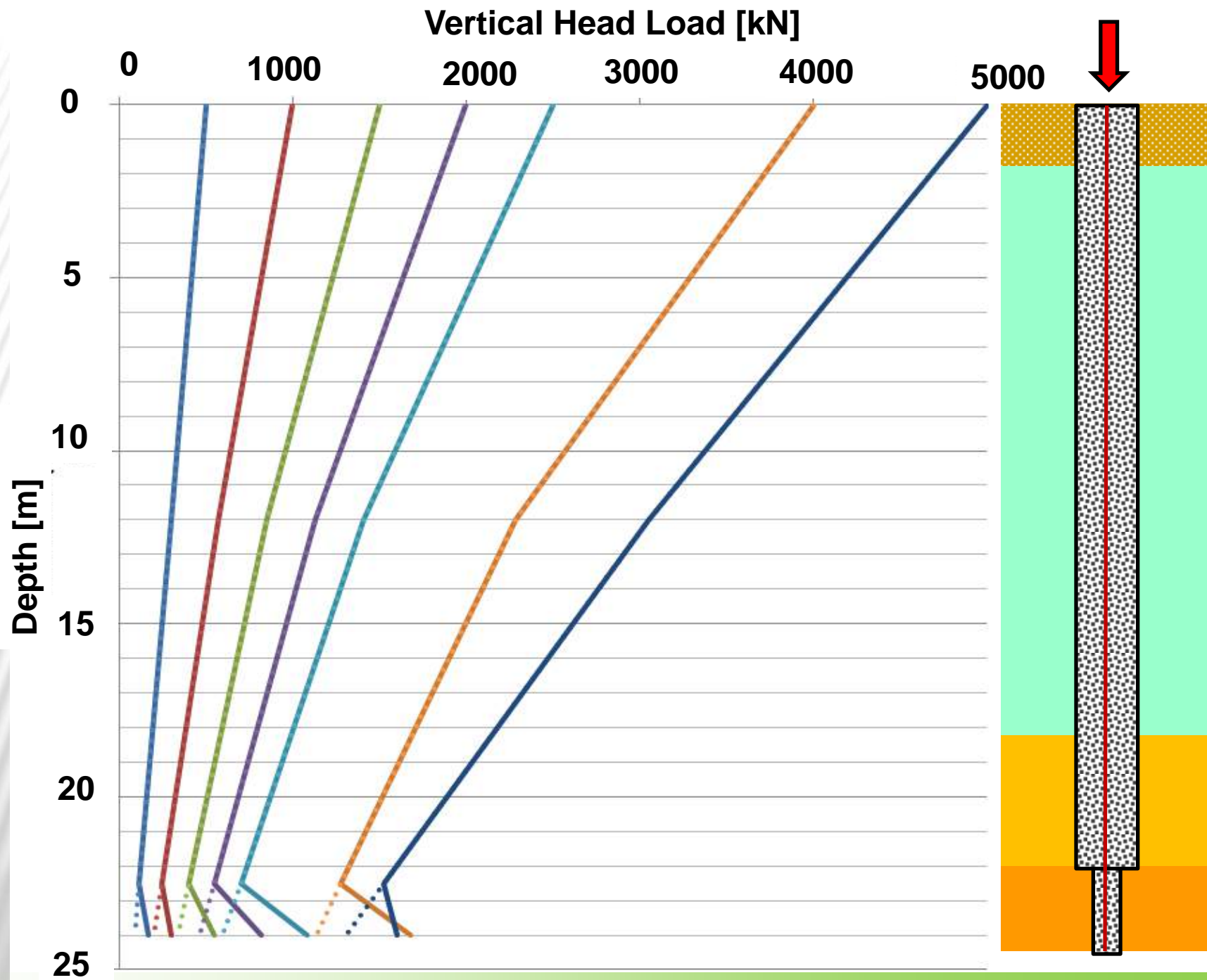




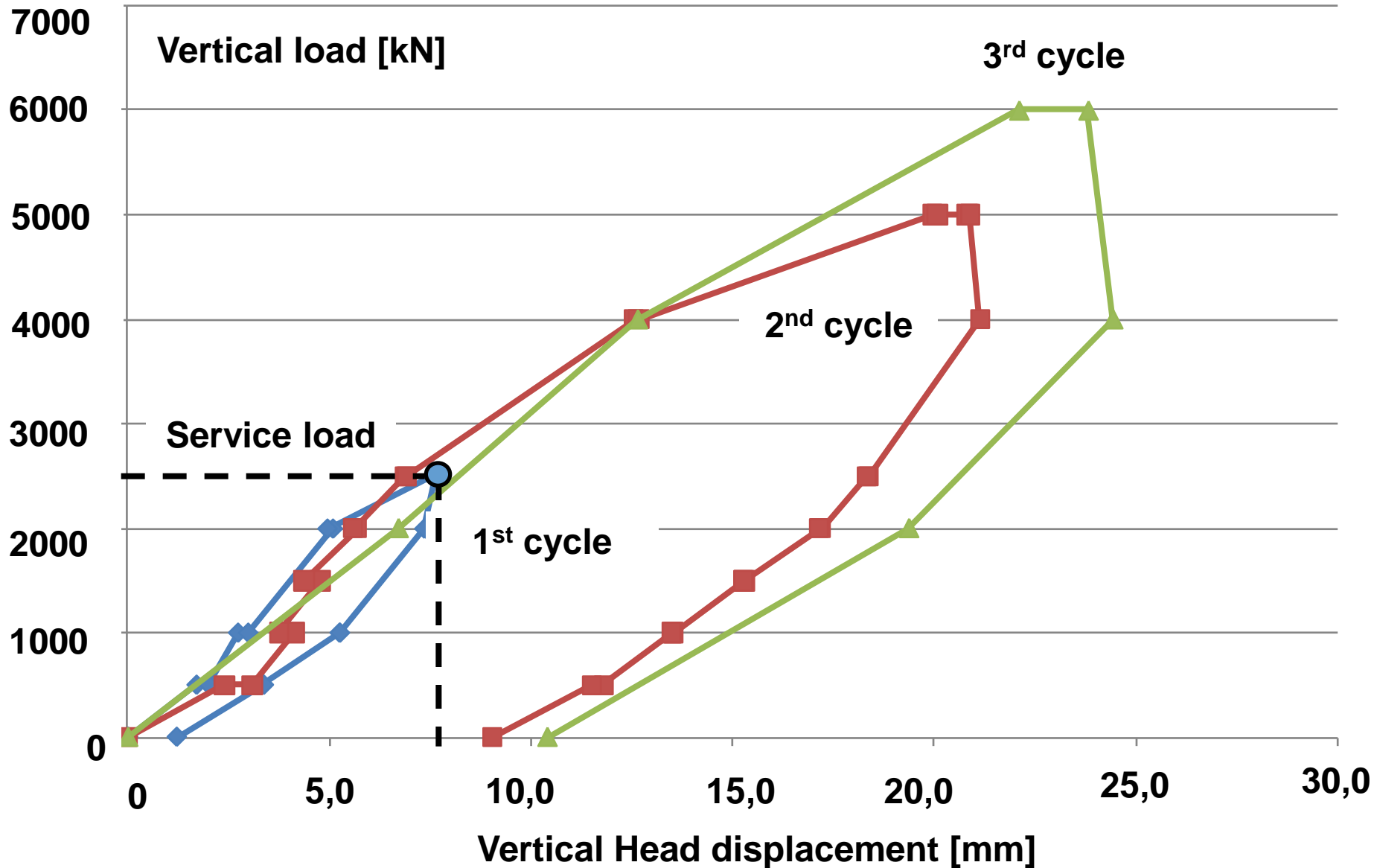


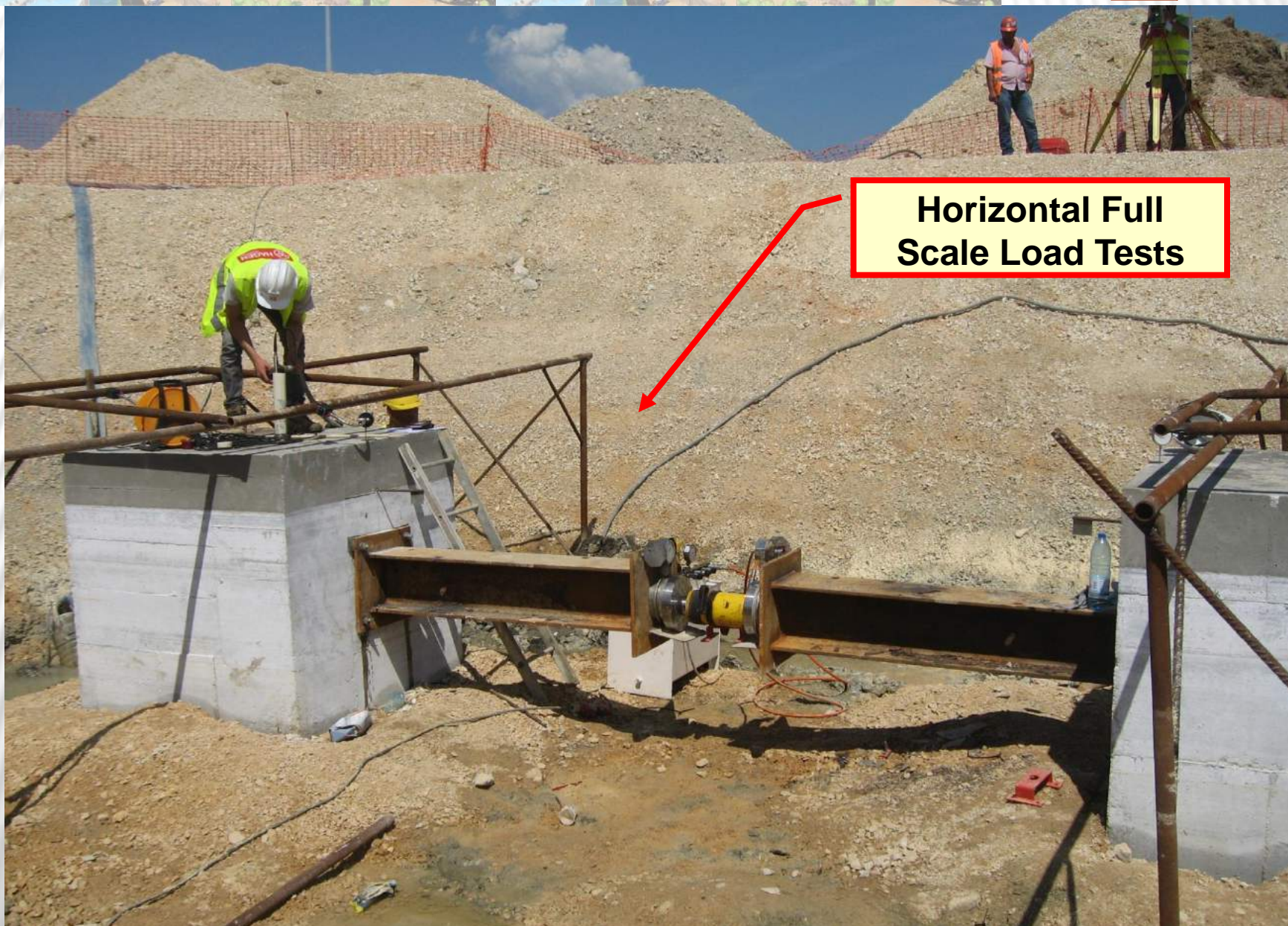
**Vertical Full Scale  
Load Tests**





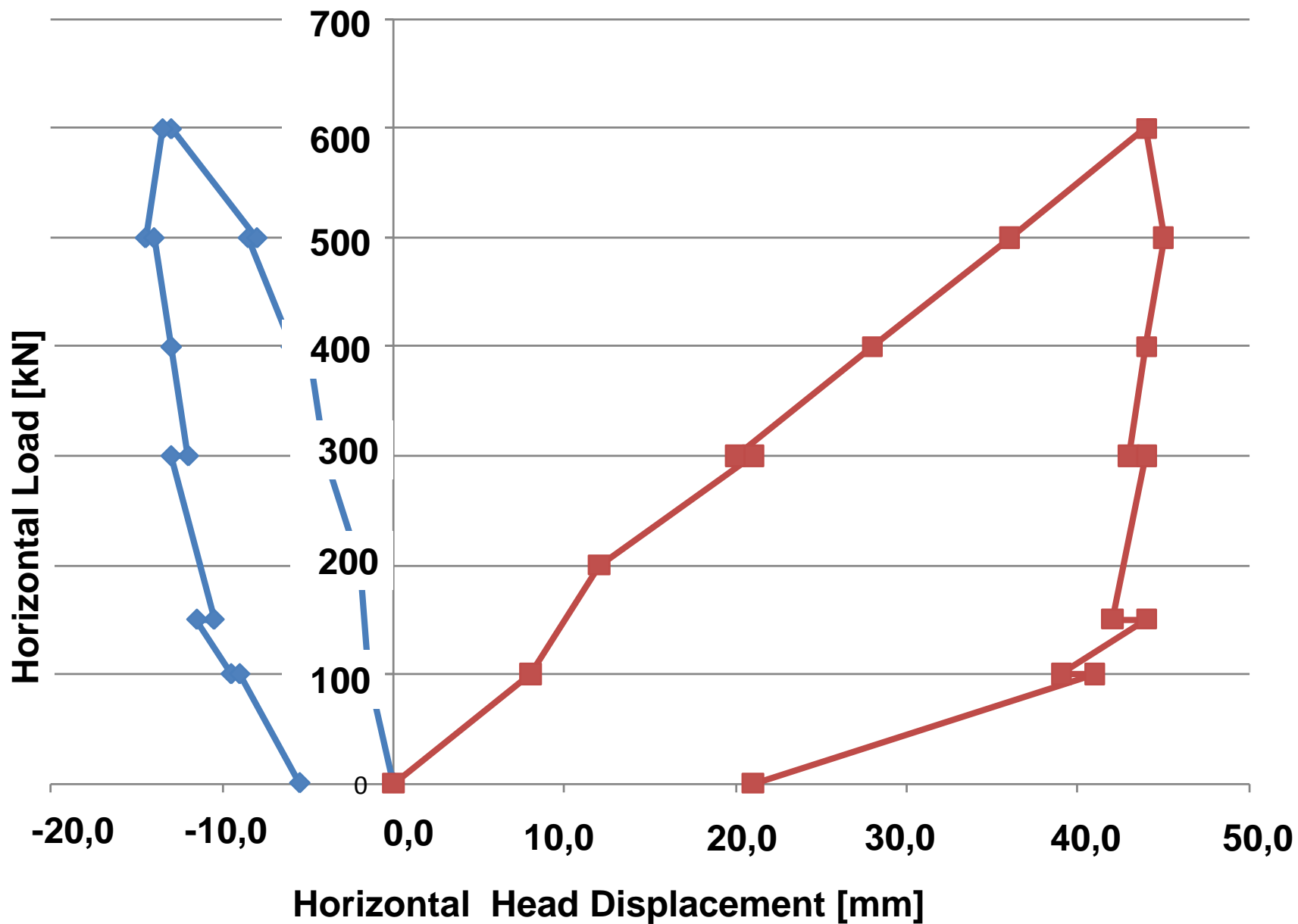


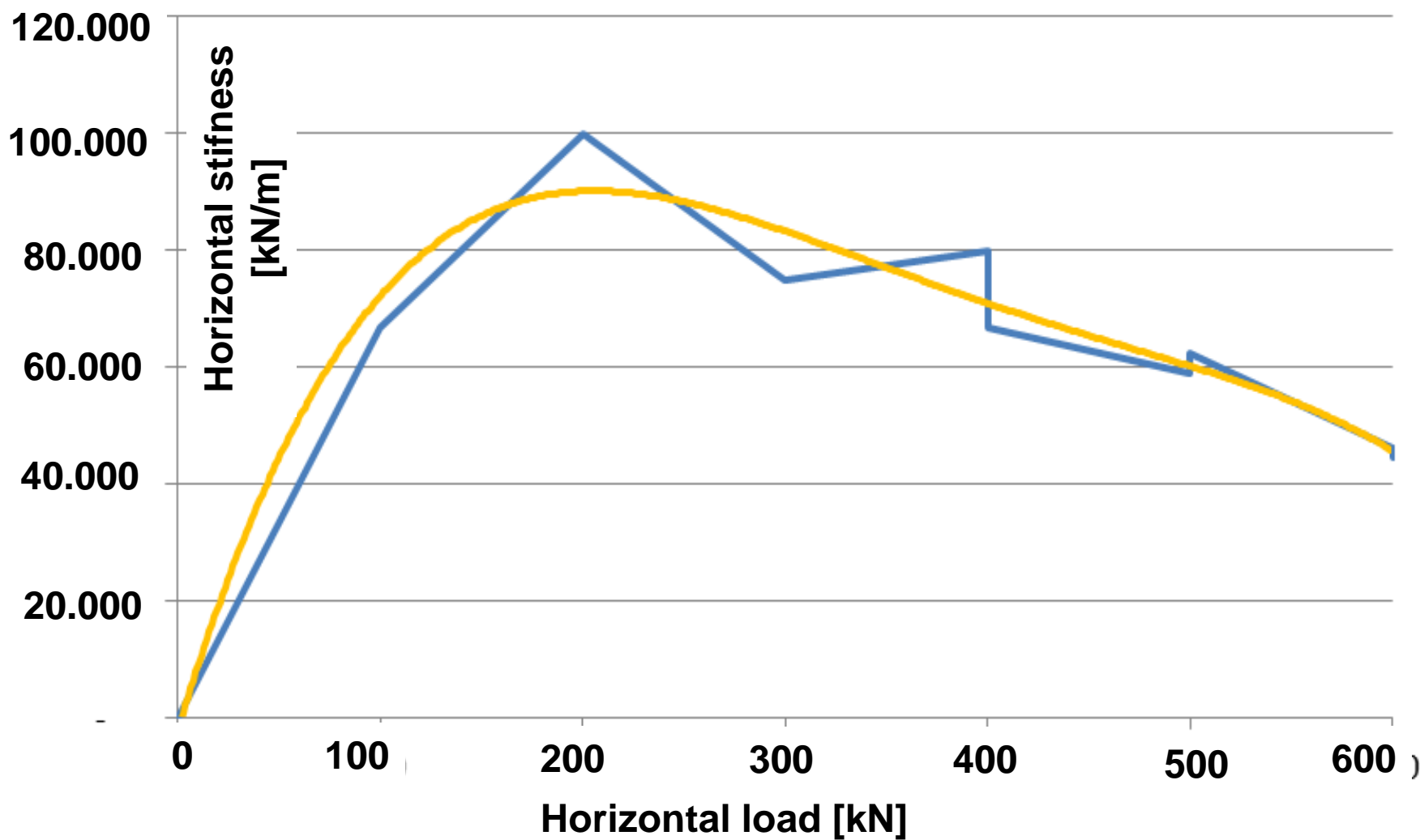




**Horizontal Full  
Scale Load Tests**





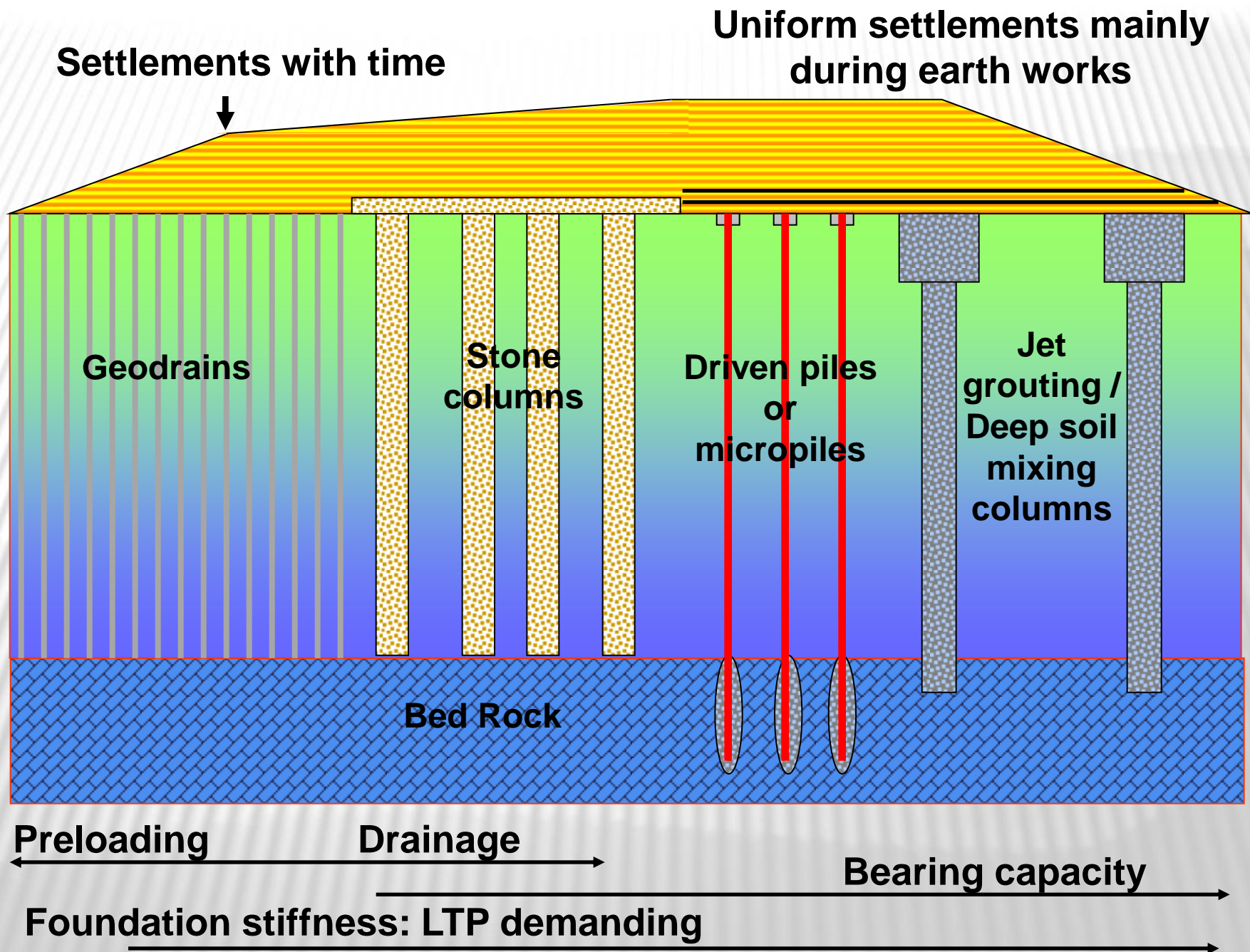






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## CONCLUSION REMARKS

 **BIG VERSATILITY**





## CONCLUSION REMARKS

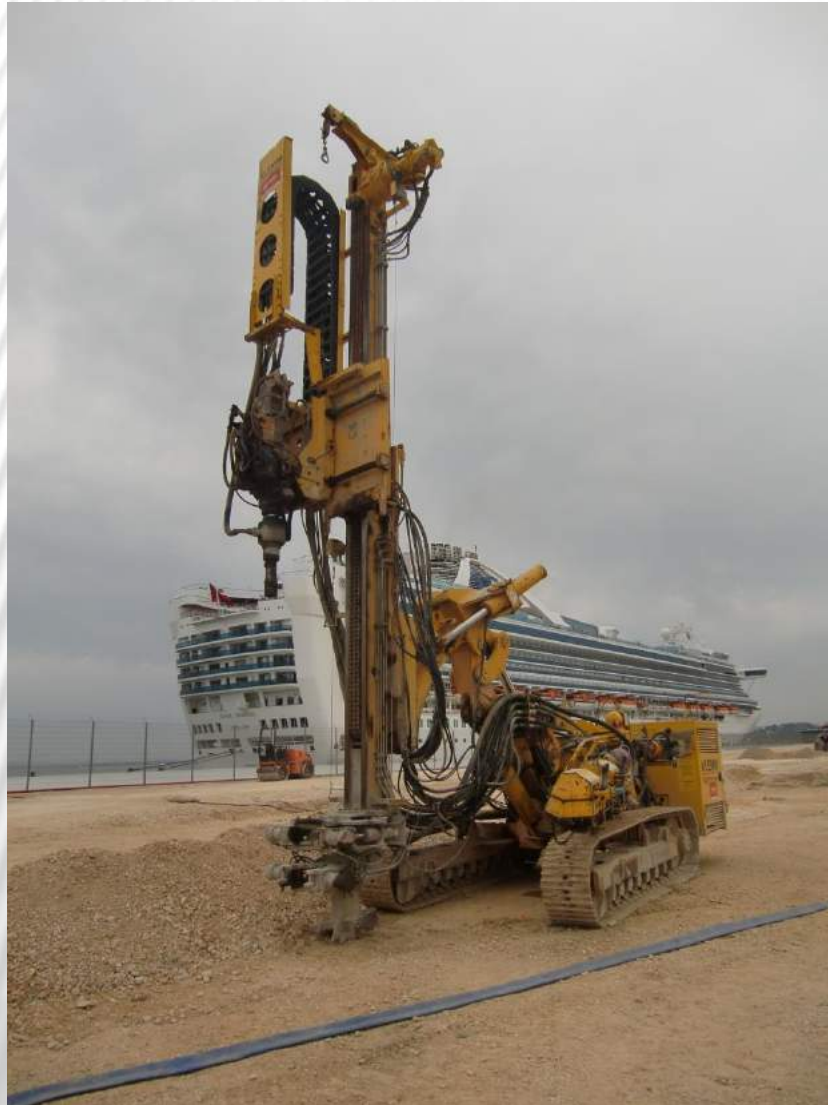


- ❖ **BIG VERSATILITY**
- ❖ **POSSIBILTY TO REINFORCE  
THE COLUMNS WITH STEEL  
PROFILES / MICROPILES**





## CONCLUSION REMARKS



- ❖ **BIG VERSATILITY**
- ❖ **POSSIBILITY TO REINFORCE THE COLUMNS WITH STEEL PROFILES / MICROPILES**
- ❖ **NO NEED FOR PRELOADING ON SOFT SOILS**



## CONCLUSION REMARKS

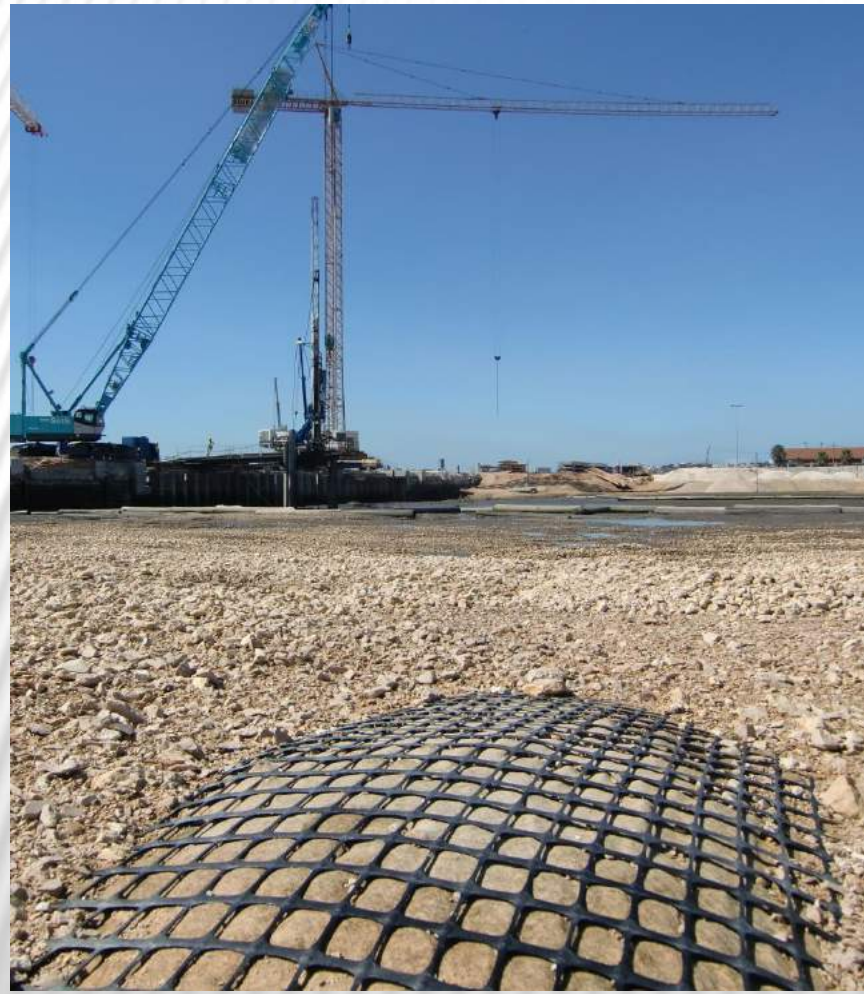


- ❖ **BIG VERSATILITY**
- ❖ **POSSIBILITY TO REINFORCE THE COLUMNS WITH STEEL PROFILES**
- ❖ **NO NEED FOR PRELOADING ON SOFT SOILS**
- ❖ **ENVIRONMENTAL ADVANTAGES**





# CONCLUSION REMARKS



- ❖ **BIG VERSATILITY**
- ❖ **POSSIBILTY TO REINFORCE THE COLUMNS WITH STEEL PROFILES**
- ❖ **NO NEED FOR PRELOADING ON SOFT SOILS**
- ❖ **ENVIRONMENTAL ADVANTAGES**
- ❖ **CONFINEMENT EFFECT ON SOFT SOILS**



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- ❖ **BIG VERSATILITY**
- ❖ **POSSIBILTY TO REINFORCE THE COLUMNS WITH STEEL PROFILES**
- ❖ **NO NEED FOR PRELOADING ON SOFT SOILS**
- ❖ **ENVIRONMENTAL ADVANTAGES**
- ❖ **CONFINEMENT EFFECT ON SOFT SOILS**
- ❖ **EXECUTION CONTROL: QC / QA**





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