BAUER Group

P.T. BAUER Pratama Indonesia

FULL DISPLACEMENT COLUMN

An Optimum Geotechnical Solution to Support Embankment on Soft Soil

10th Business Forum

Road Engineering Association of Asia and Australia

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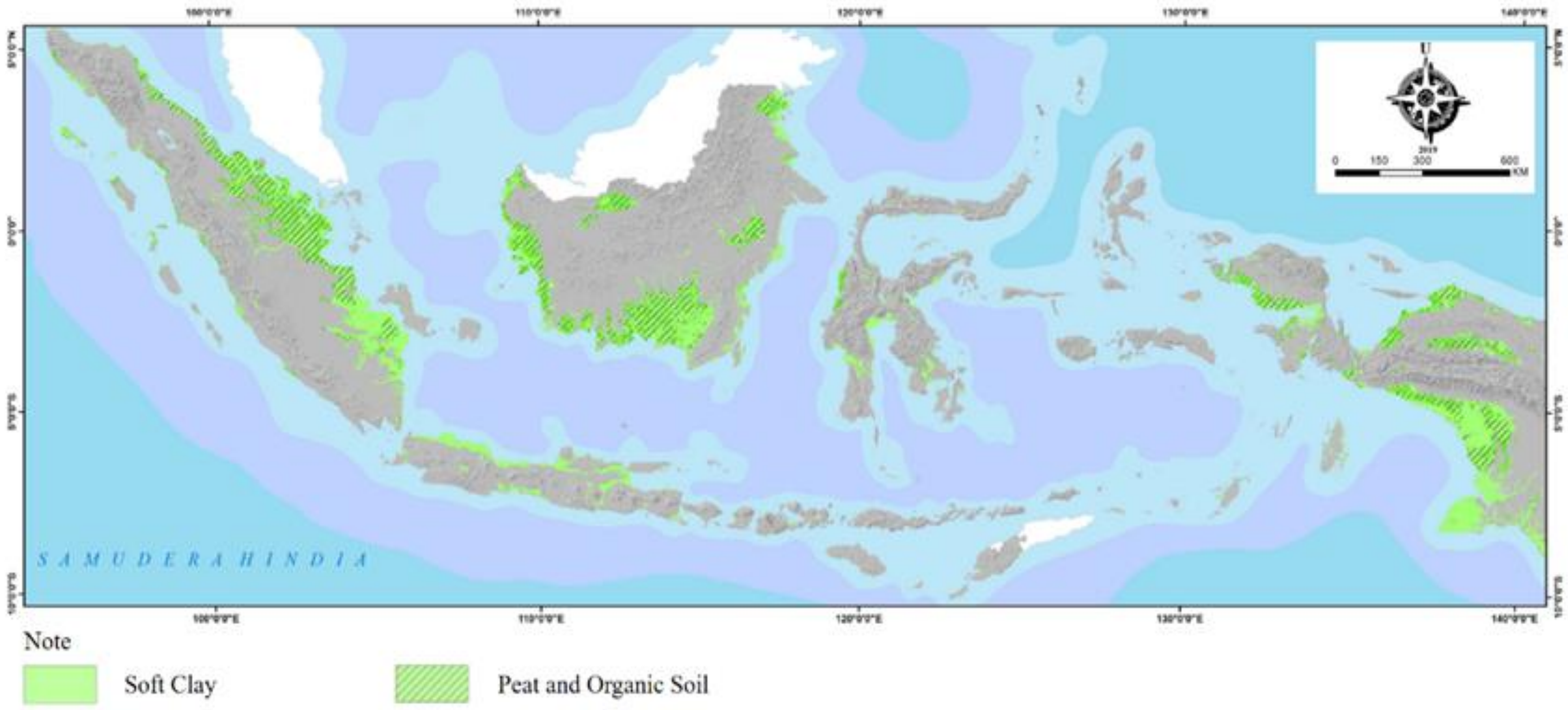
1

Introduction

Introduction

Distribution of Soft Soil in Indonesia (Wardoyo et al., 2019)

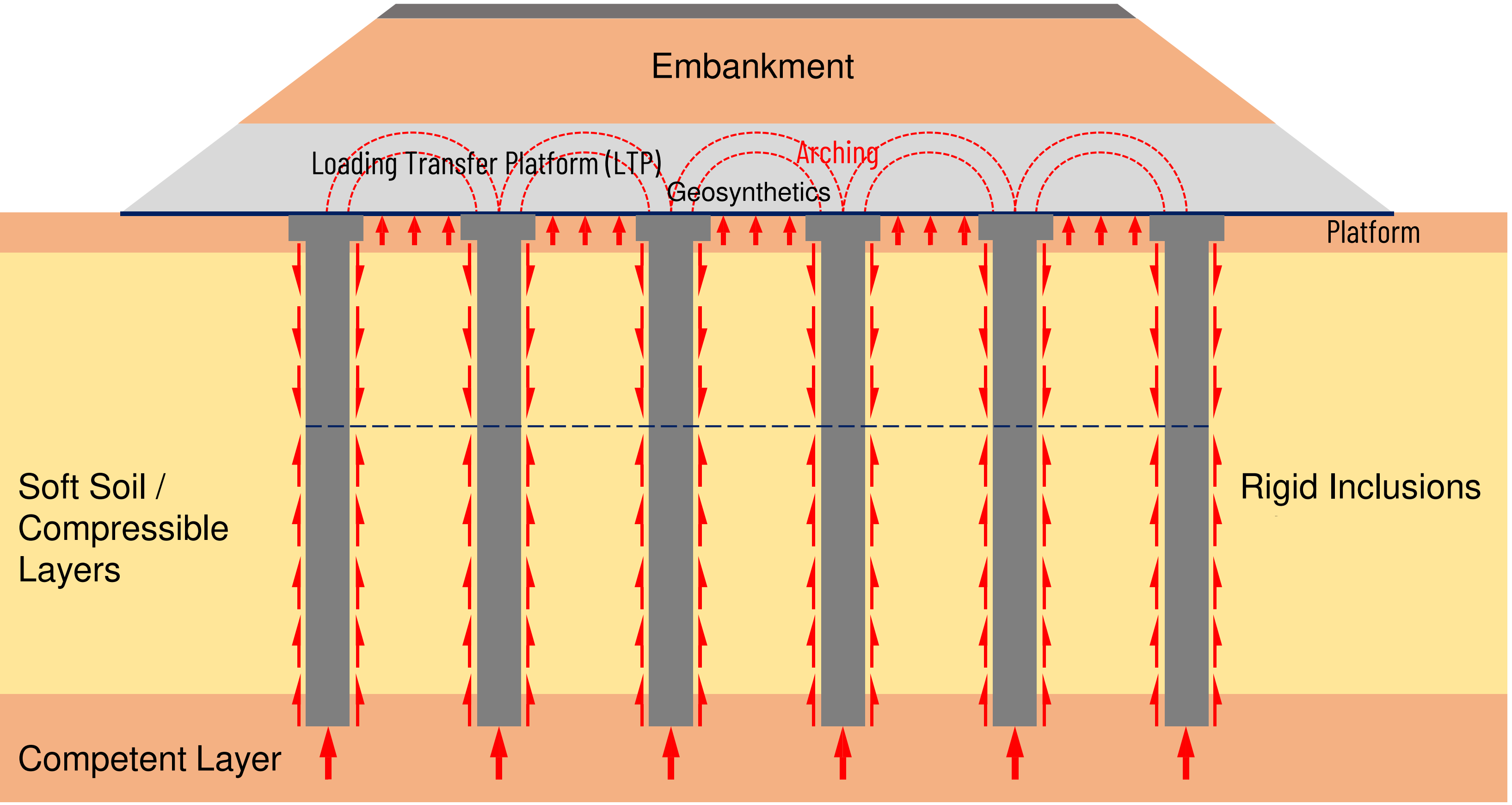


- Indonesia, as a tropical country, has a significant distribution of soft soil, including soft clay, peat, and organic soil, covering approximately 60 million hectares or about 30% of the country's land area.
- With around 20 million hectares consisting of peatlands and organic soil.

Introduction

- In Indonesia, embankment works such as roadways, runways, and flood control embankments, are still the most selected option for elevating infrastructure works.
- Constructing embankments on soft soil deposits poses a challenge:
  - Low shear strength
  - High compressibility characteristics.
  - Long-term consolidation of fibre in peat and organic soil, as well as pore compression resulting from loading.

Introduction

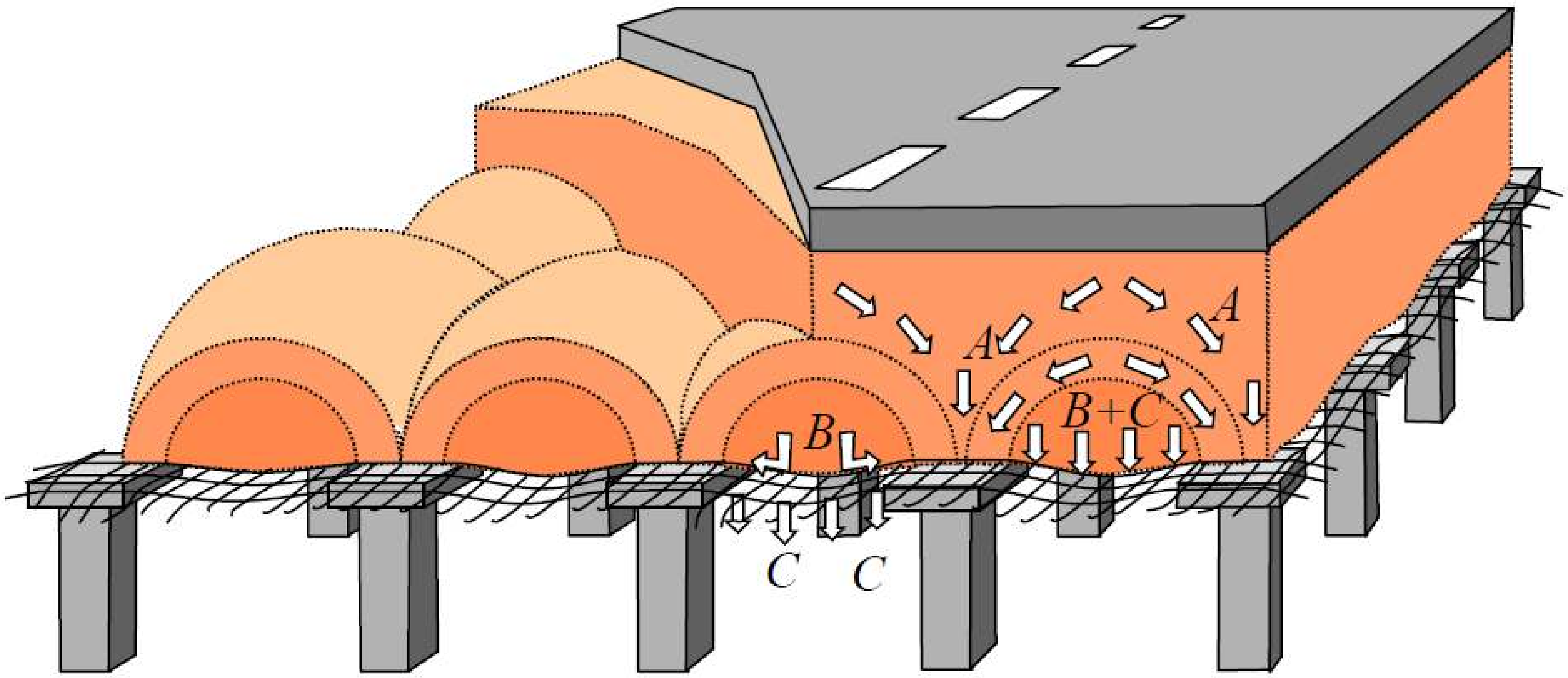


Concepts:

- The pile support method does not fundamentally improve the physical and mechanical properties of soft soil.
- A significant portion of the embankment load is transferred to the piles through a Load Transfer Platform (LTP) by arching mechanisms, while the remaining load is carried by the soft soil between the piles, resulting in consolidation settlement and negative skin friction (NSF) on the piles.
- Long-term settlement can be reduced.
- Further reduction in soil settlement can be achieved by incorporating high-tensile geotextiles

Introduction

Load distribution → **The vertical loads of the system are distributed into 3 load parts**



- **Parts A:** Load is transferred directly to piles
- **Parts B:** Load goes through the geosynthetics to the piles
- **Parts C:** Load is carried out by subsoils

(van Eekelen, 2015)

2

Full Displacement Column

Principles of Ground Improvement Technique

Ground improvement methods are used to improve unsuitable subsurface soils and/or to improve the performance of structures or embankments.

These methods are used when replacement of the in-situ soils is impractical because of physical limitations, environmental concerns, or other conventional methods are costly.

Functions:

- ☑ Increase bearing capacity, shear, or frictional strength,
- ☑ Increase density,
- ☑ Control deformations,
- ☑ Increase or provide lateral stability,
- ☑ Form seepage cutoffs or fill voids,
- ☑ Transfer embankment loads to more competent layers, and
- ☑ Increase resistance to liquefaction.

Principles of Ground Improvement Technique

Inclusion / Reinforcement
Techniques that introduce foreign elements to improve in situ soil

Consolidation
Techniques that drain and reduce voids

Compaction
Techniques that densify soil by compaction

Principles of Ground Improvement Technique

Improvement by Inclusion/Reinforcement

- Vibro Stone Column
- Vibro Concrete Column
- Cutter Soil Mix
- Soil Cement Column
- Dynamic Replacement
- Full Displacement Column
- Grouting

Improvement by Consolidation

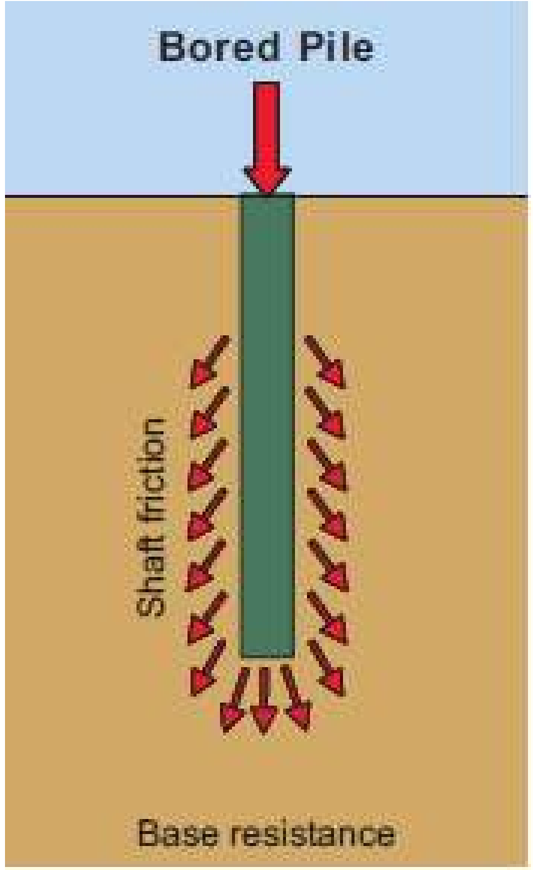
- Prefabricated Vertical Drain

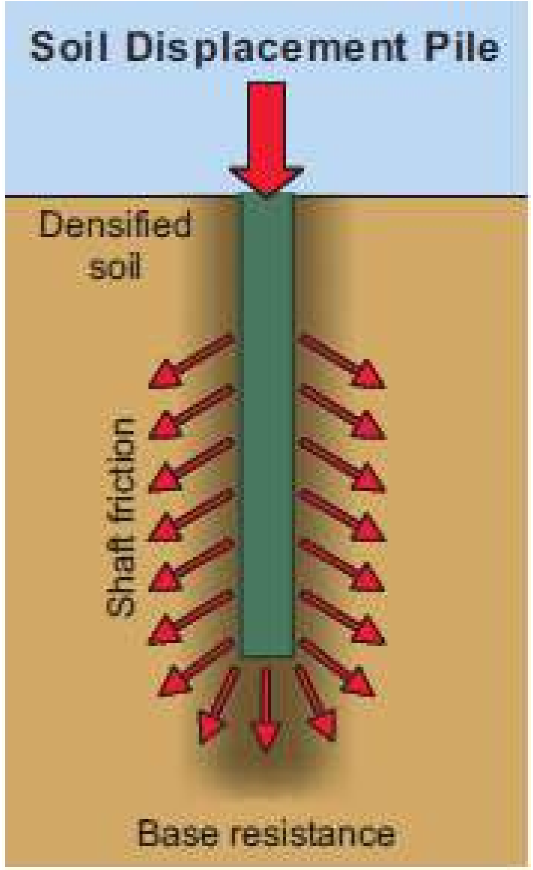
Improvement By Compaction

- Vibro Compaction
- Dynamic Compaction

The Technique

Advancement of a displacement boring tool into the ground with a rotary drilling rig using both torque and crowd force





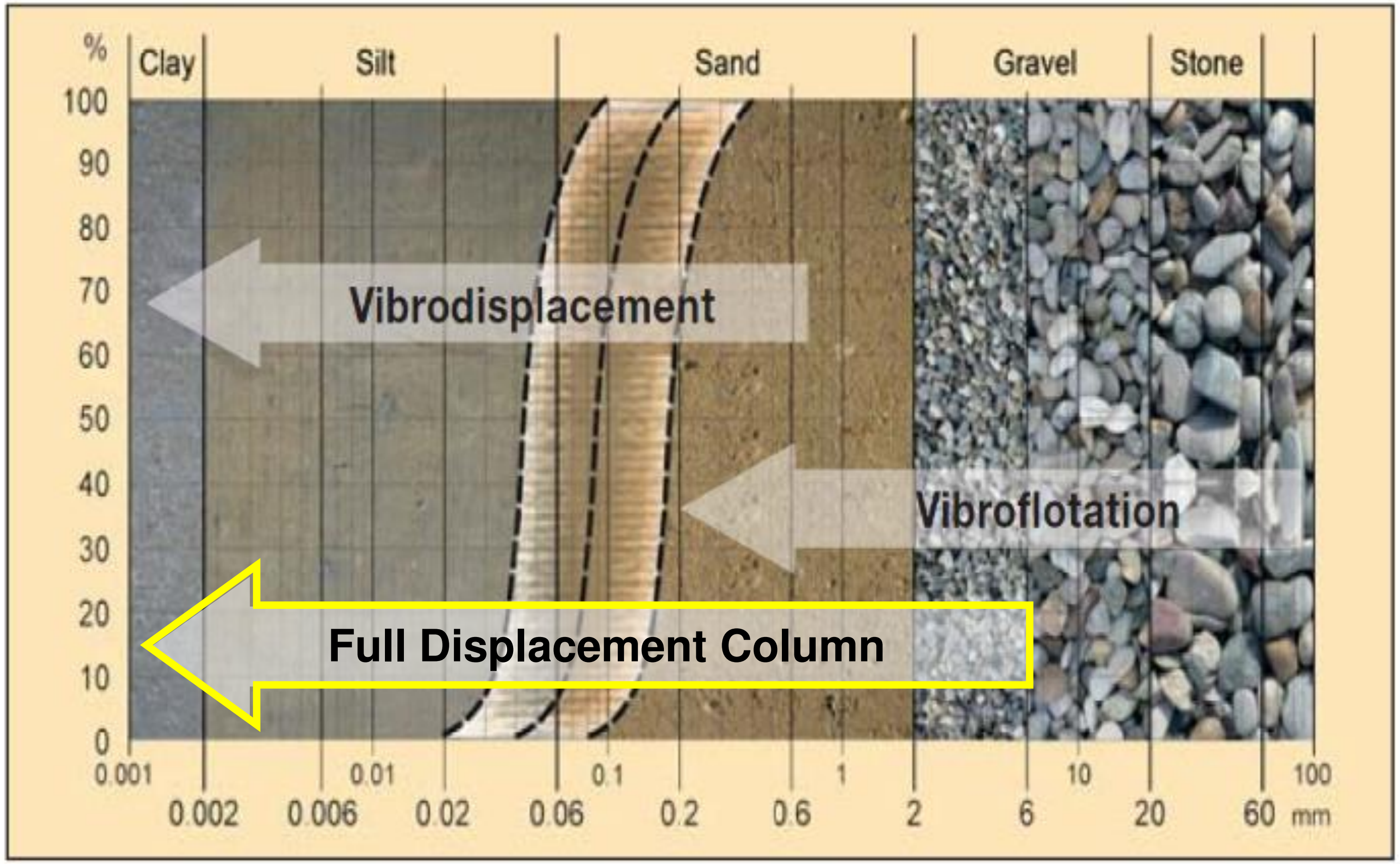
Full Displacement Column

Full Displacement Column (FDC) is a rigid inclusion method developed by BAUER.

This ground improvement method is constructed through introducing the displacement tool to the soft soil formation and injecting a rigid material to be formed as a column by cast-in-place mortar grout which is constructed by a rotary drilling technique that is installed in certain grids (square or triangular pattern).

Full Displacement Column

Range of application

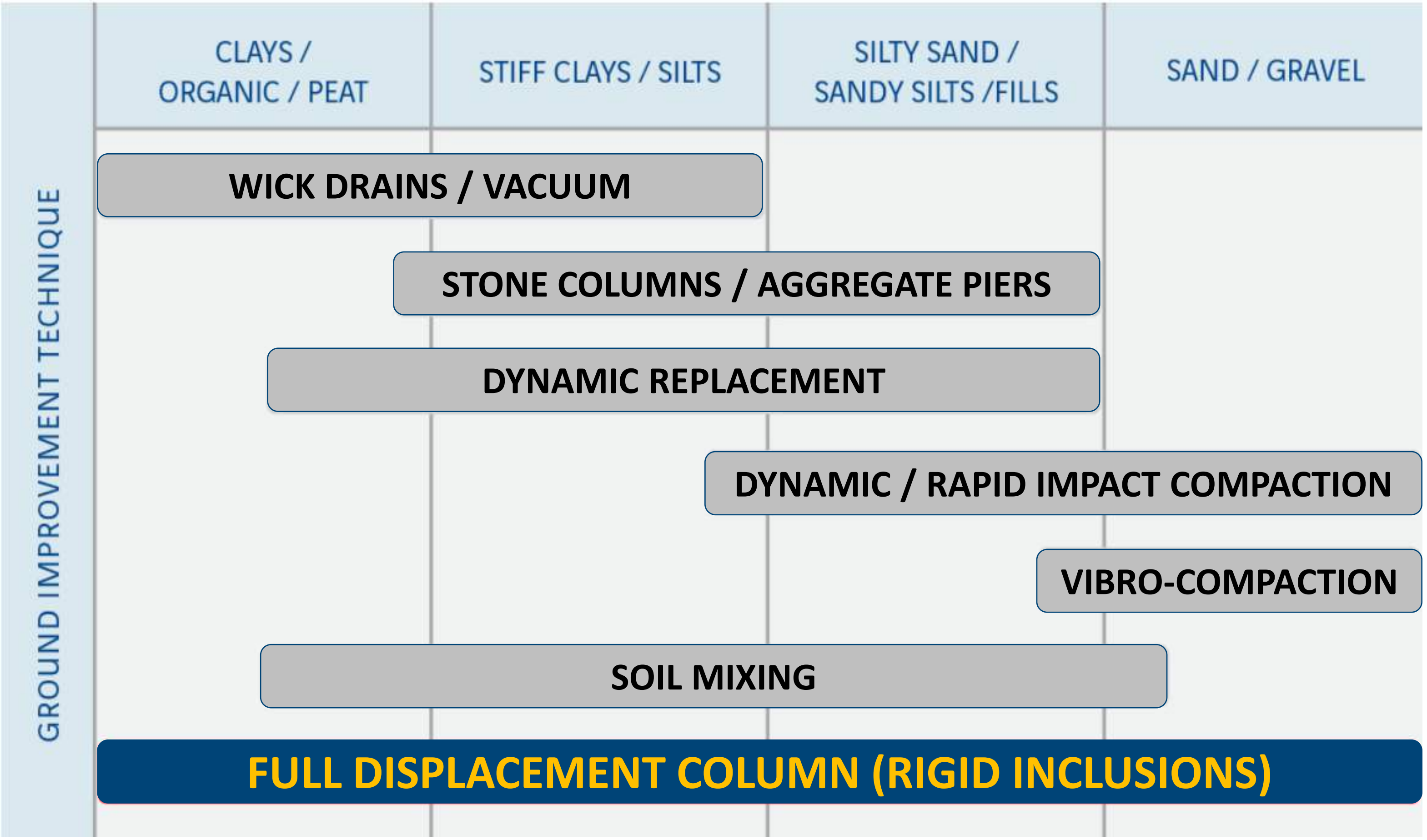


Full Displacement Column

Range of Application

Compared to other ground improvement technique, FDC has wider range of application. It perform very well in soil conditions ranging from sand/gravel, silt and clay to soft organics soils, as long as the soil is displaceable.

The general rule of thumb applies: SPT < 30 or CPT <10 Mpa, undrained shear strength cu > 15 kN/m2, and non-displaceable layer with thickness <1.50 meter.



(Messe, 2017)

Full Displacement Column

Main Equipment

DISPLACEMENT TOOL

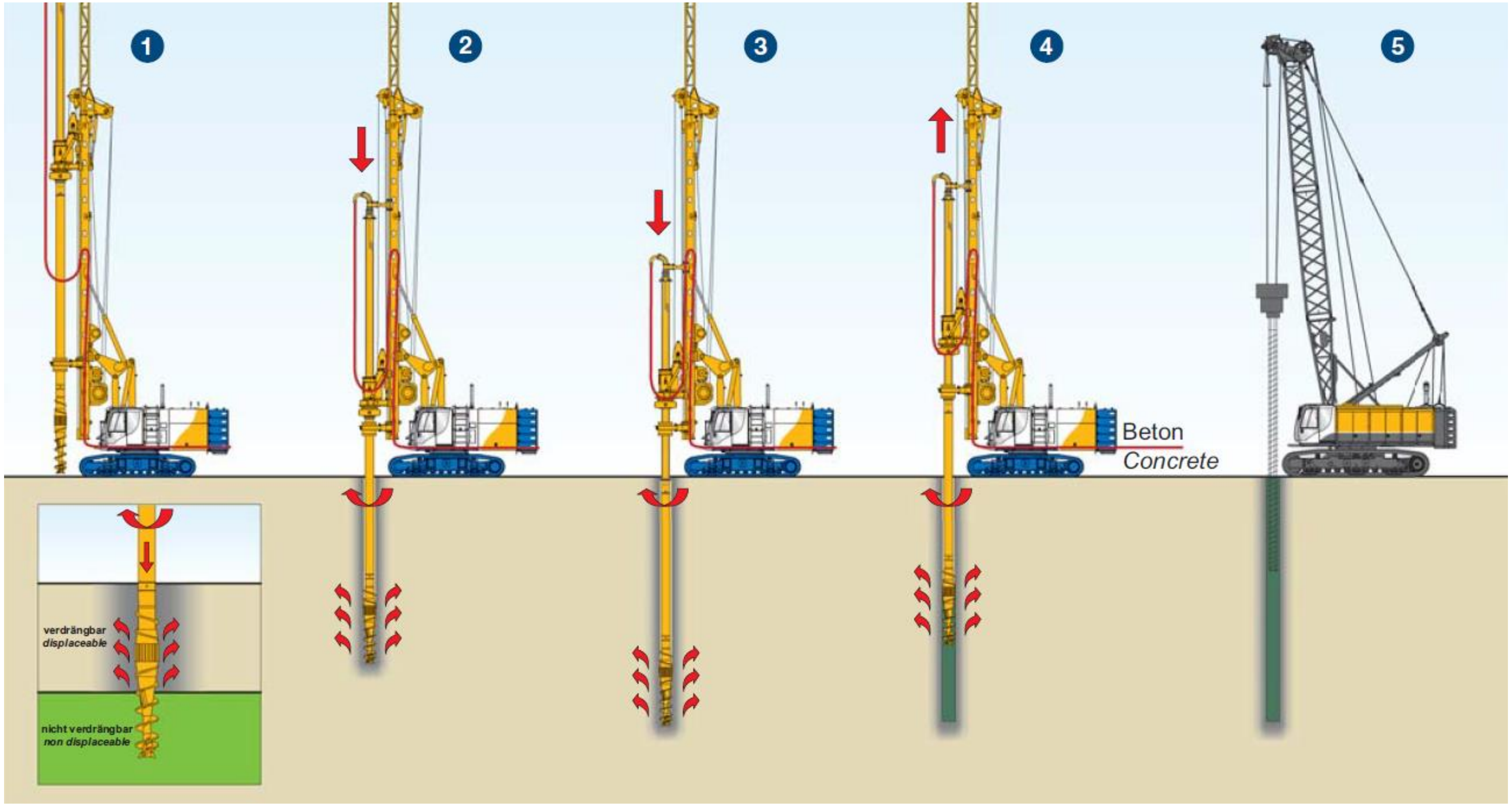
FDC Rig

EXCAVATOR

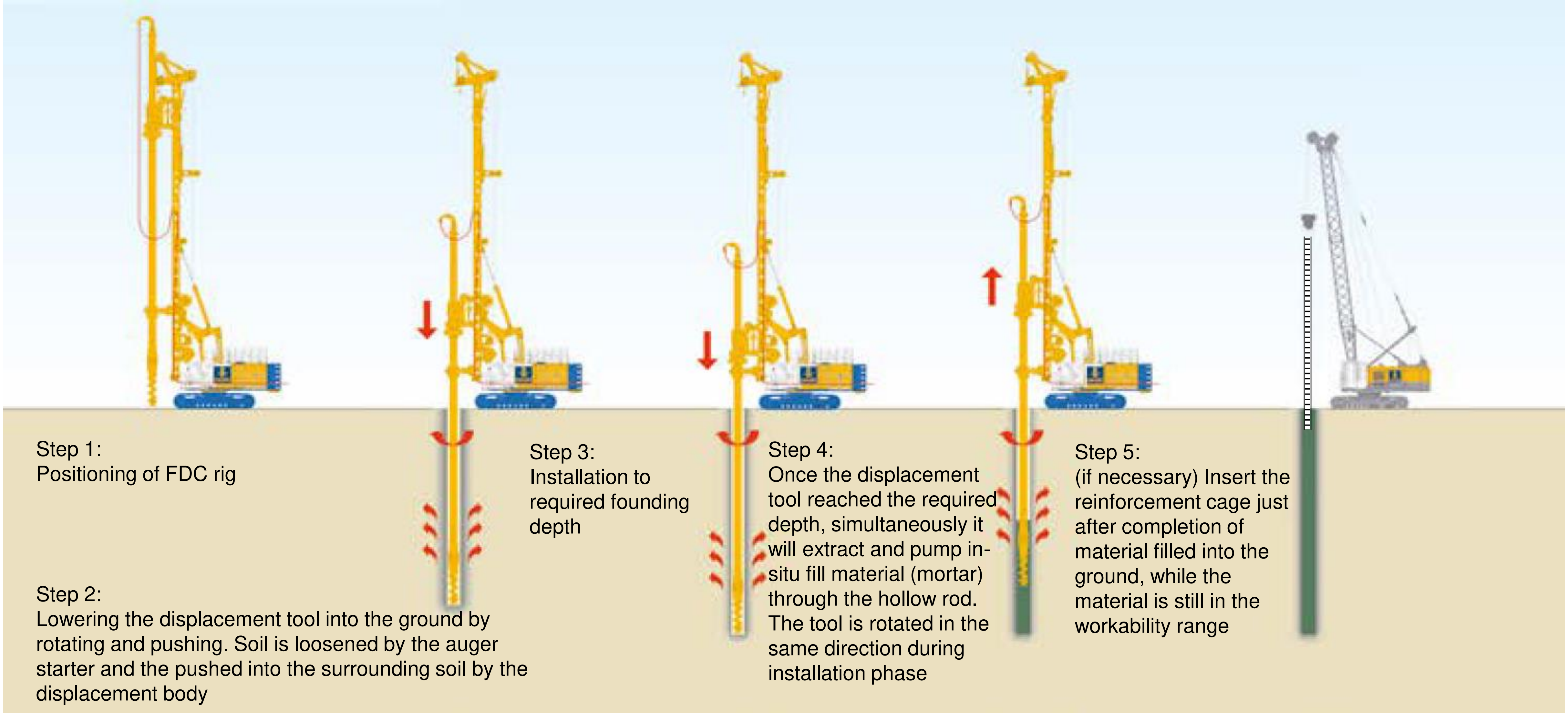
MORTAR PUMP

Full Displacement Column

Construction Sequence



FDC - Sequence of Works



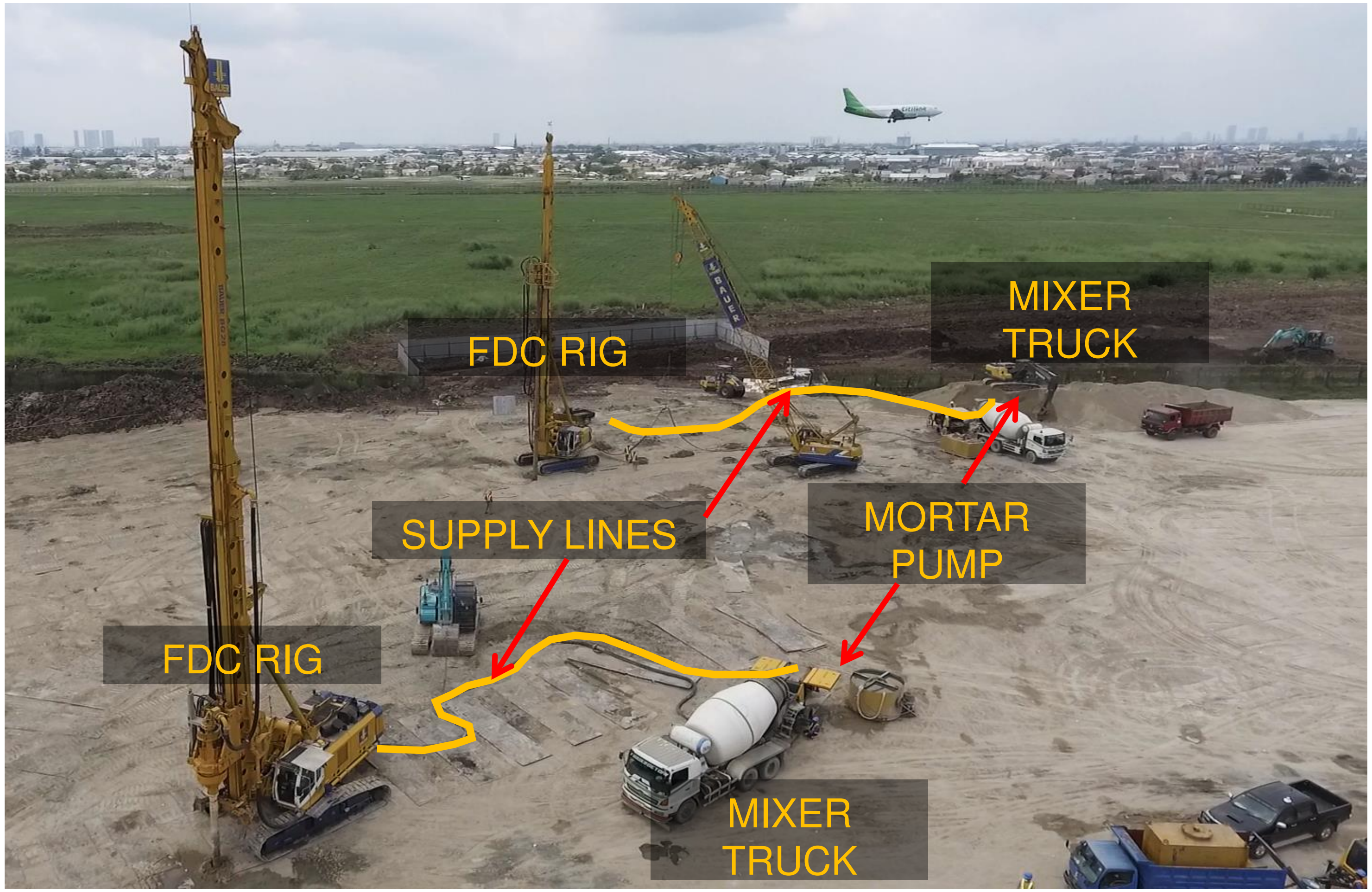
FDC - Sequence of Works (animation)

Full Displacement Column

Typical Site Setup

Rigid material (concrete or mortar) is pumped using moveable concrete pump through the supply lines which is connected to the hollow rods and discharged at the outlet on the bottom of displacement tool.

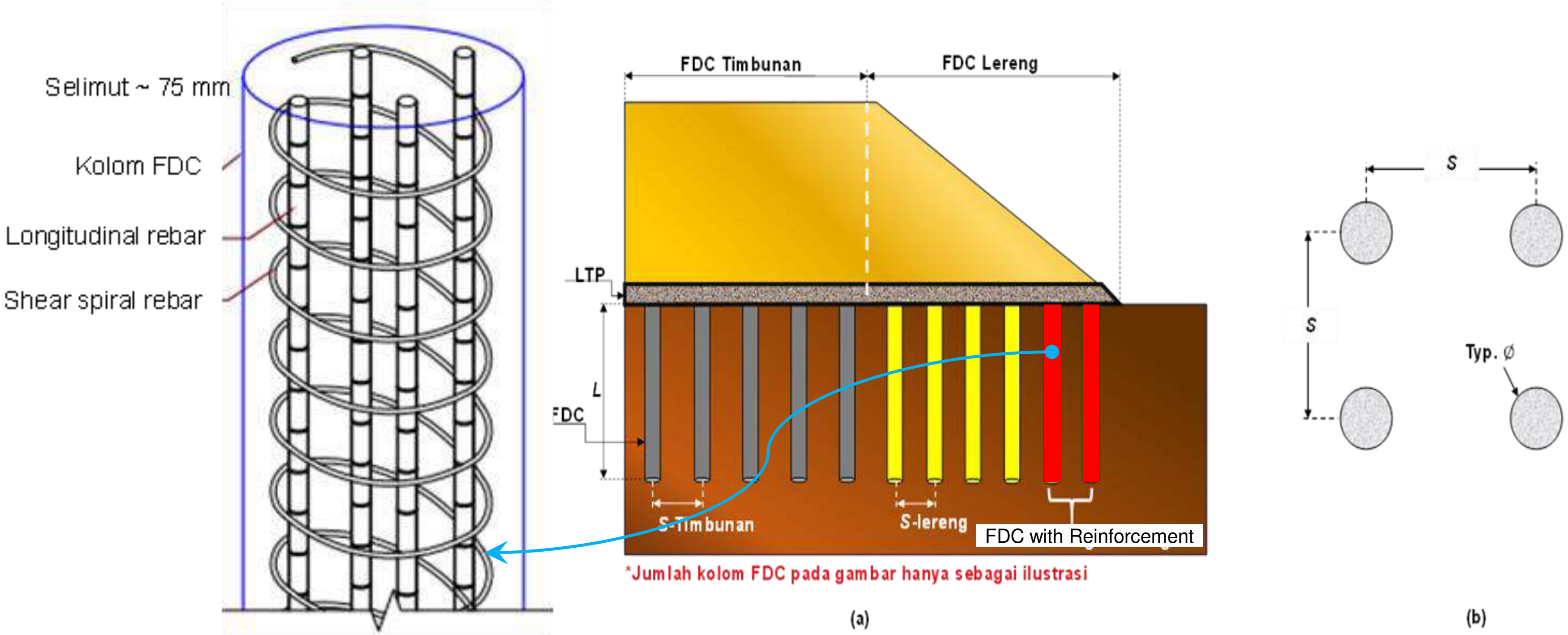
Workability of concrete/mortar normally within 55-70 cm (slump flow)



Full Displacement Column

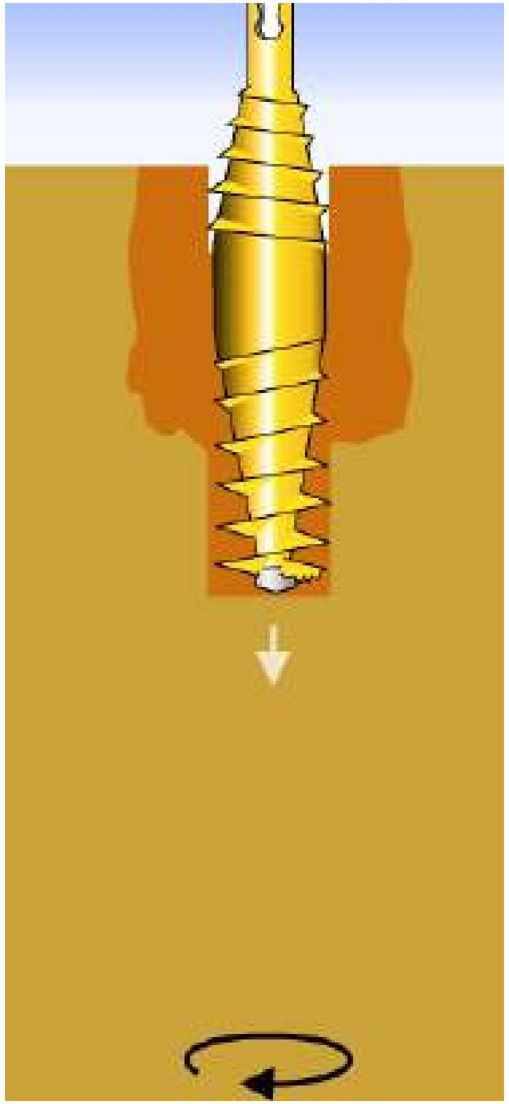
Reinforcement in FDC

- In the nature of ground improvement design (i.e. to improve bearing capacity and settlement control), reinforcement is not necessary to be installed.
- Reinforcement is needed when the FDC designed to counteract uplift or mitigate excessive lateral forces impacting the specific footings of embankment or any other structures.
- Installation of reinforcement is conducted immediately after mortar is pumped into the column.



Advantages

- Increase of skin friction and toe resistance due to compaction
- Vibration free installation method
- High daily performances
- Negligible spoil carriage
- No surcharge required

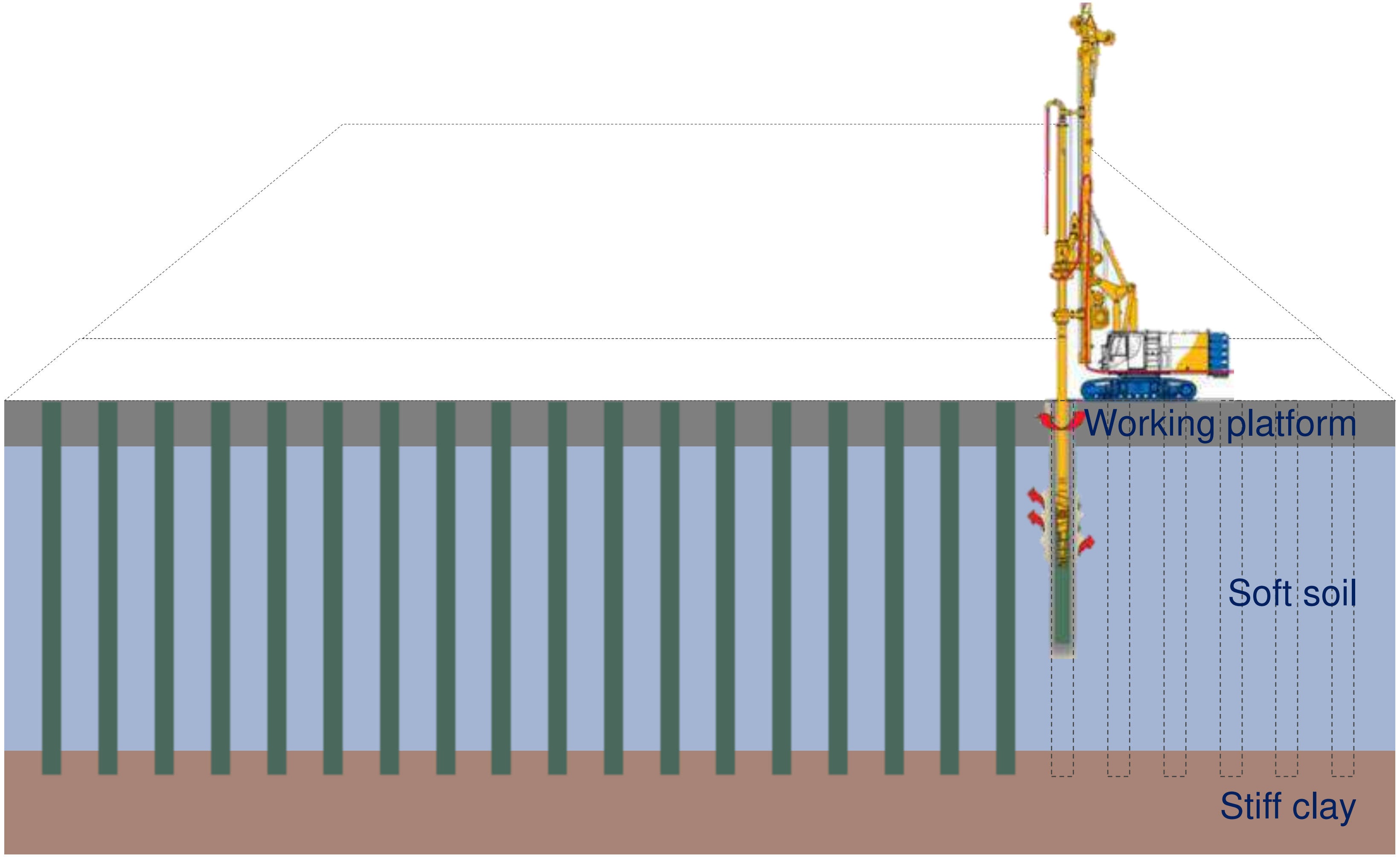


3

Illustration Stages of Construction an Embankment Supported by Full Displacement Columns

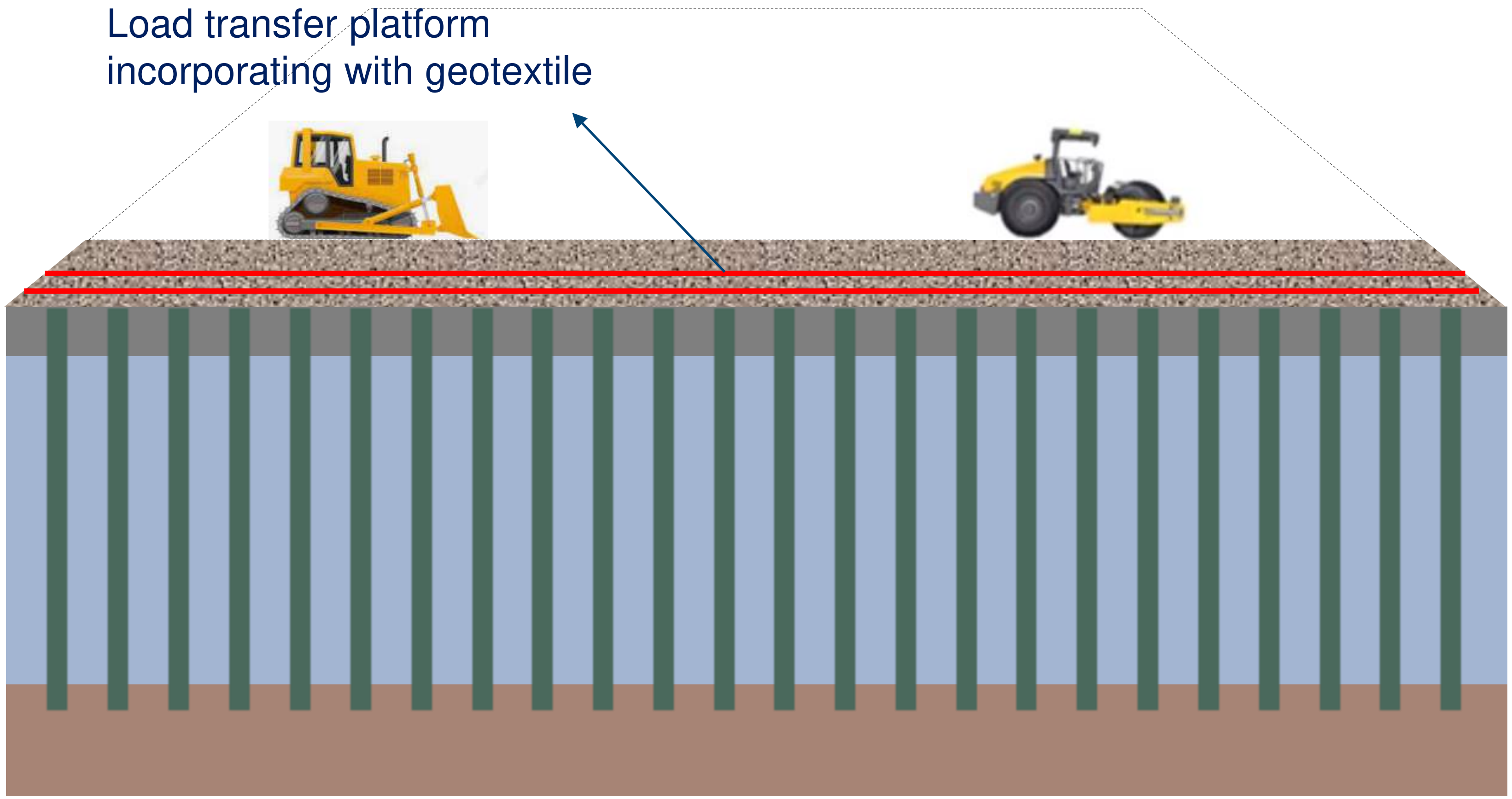
Stages of Construction

FDC Installation



Stages of Construction

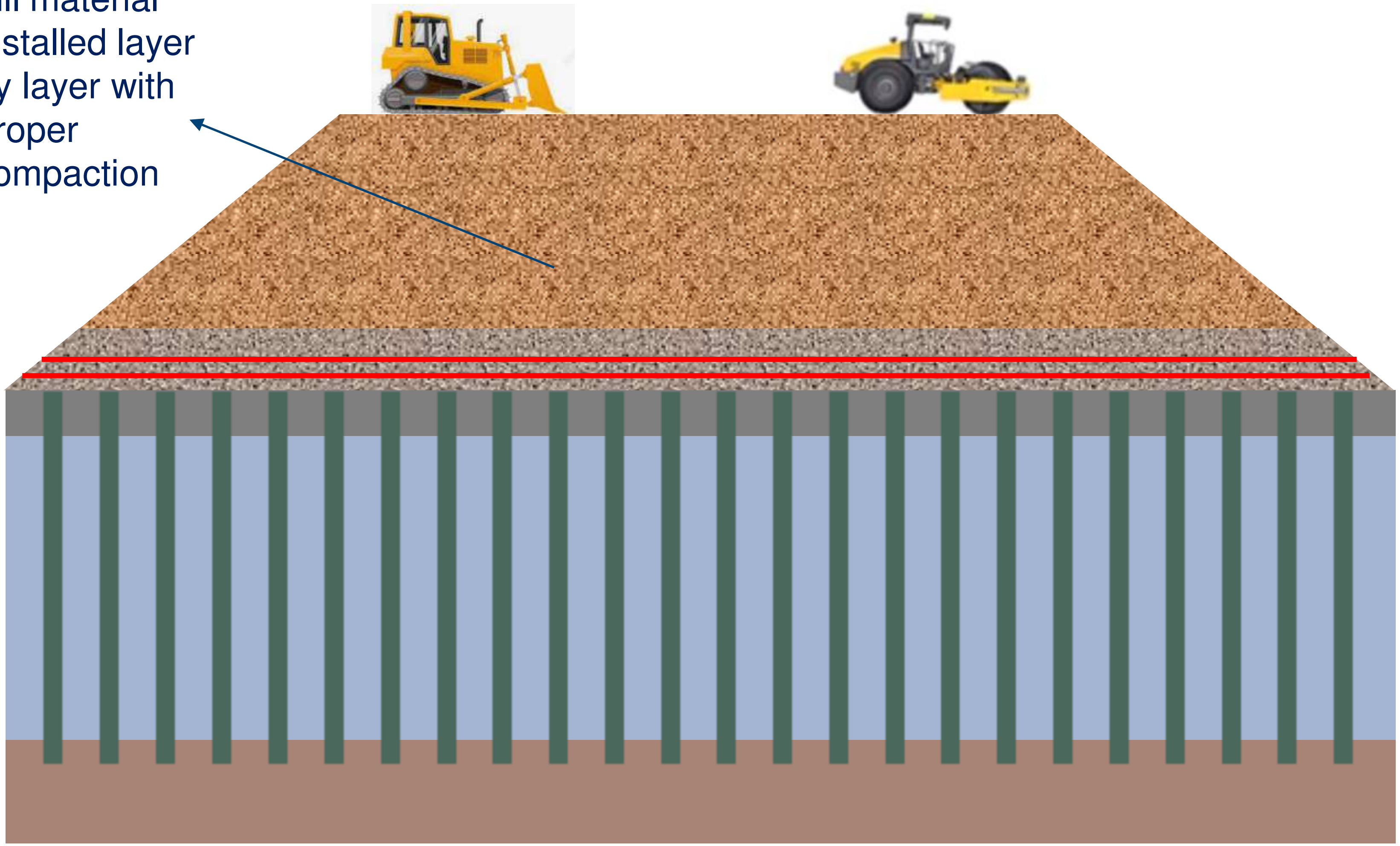
Installation of Load Transfer Platform



Stages of Construction

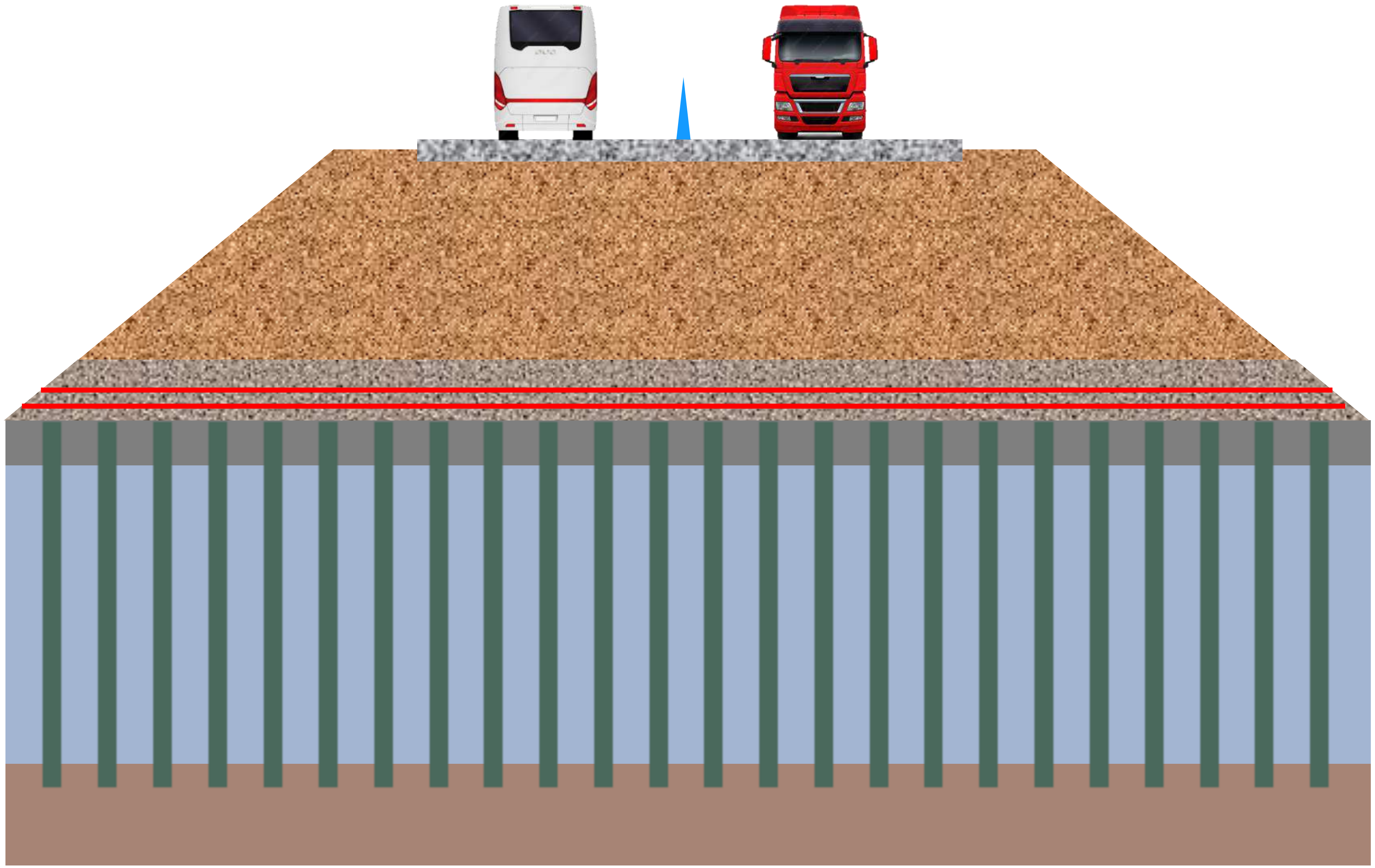
Installation of Fill Embankment

Fill material installed layer by layer with proper compaction



Stages of Construction

Completed Embankment and Pavement

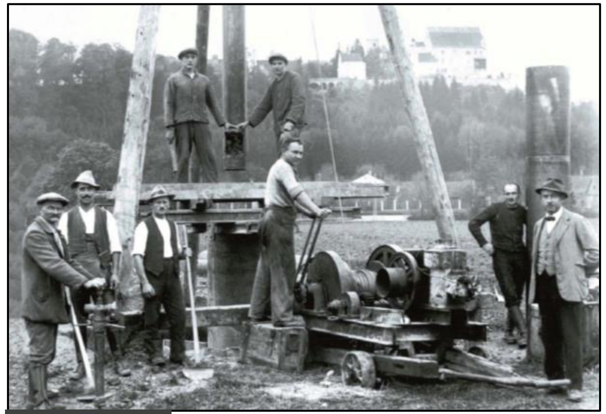


4

Innovation in BAUER and Implementation Technology 4.0

Innovation in BAUER

1790	Foundation as a copper forge in Schrobenhausen, Germany
1870	Artesian well for the new Schrobenhausen railway station, start a drilling work
1976	First hydraulic rotary drill rig BG 7
1984	First diaphragm trench cutter BC 30
2014	New generation machine with EEP

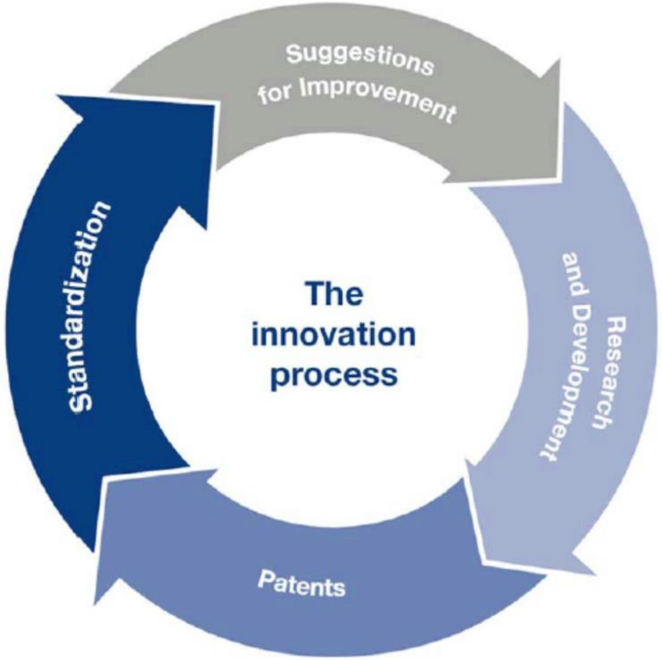


1870

1976 1984

2014

Research and Development



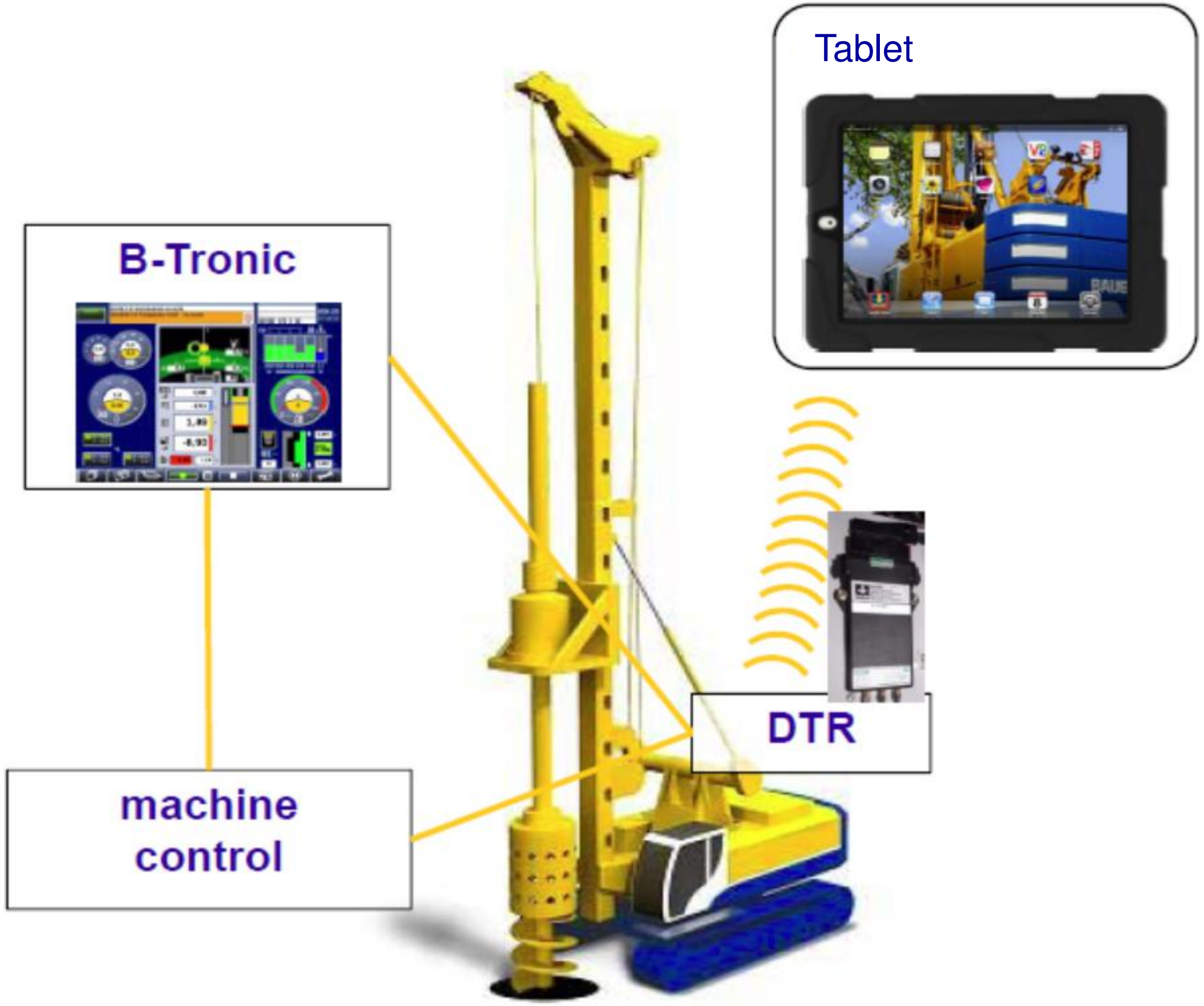
Bauer Assistant Systems

- *Extended assistant and automatic systems offer numerous advantages for many different drilling techniques*
- *Reduction in wear on both machine and drilling tool*
- *Increase in productivity*

Communication Technology

- *Bauer B-Tronic system with high-resolution touch screen for display of main parameters*
- *Tablet with standard Internet connection for accessing the drilling rig. The operator's screen can be mirrored live on the tablet and the operator has the option to access manuals, machine management data and more*
- *Due to machine networking, production data, locations and detailed reports of drilling operations can be retrieved from isolated machines as well as the entire machine fleet*

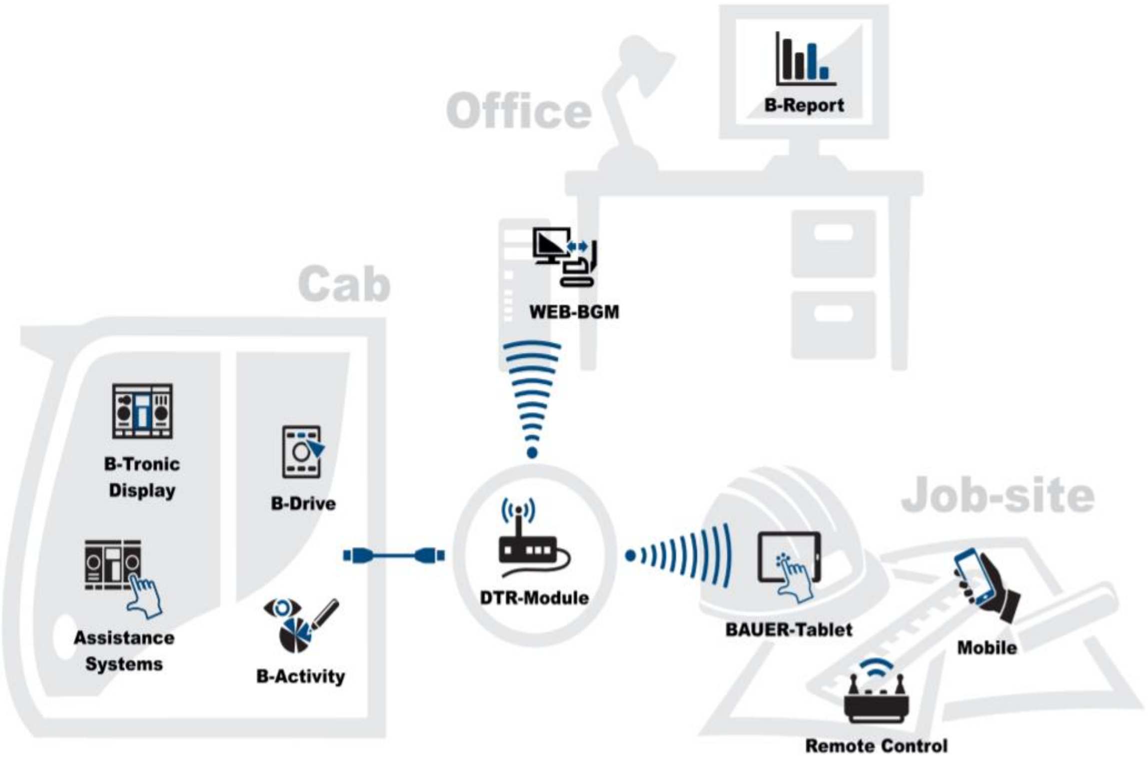
The Intelligent Rotary Drilling Rig



B-Tronic
The B-Tronic system delivers a complete system that goes far beyond the electronic control of the machine.

The B-Tronic system assists to complete the construction activities reliably and accurately.

B-Tronic



The high-performance B-Tronic system based on dozens of sensors that positioned at all critical points in the machine. These sensors continuously collect data which are centrally logged and processed.

B-Tronic

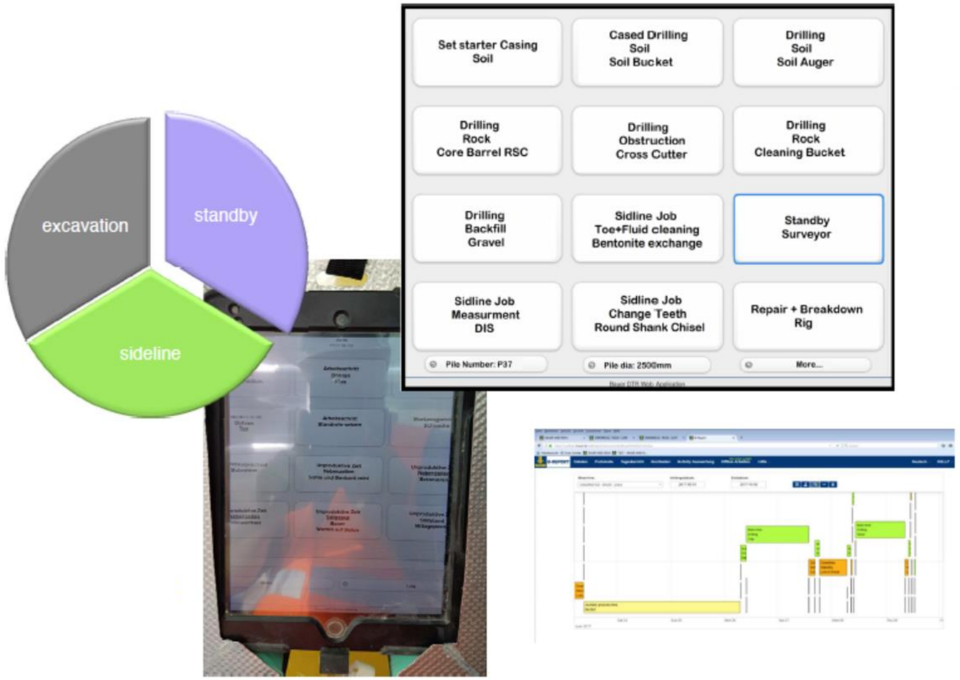
A high-resolution touch screen with a range of different display modes inform the operator about the status of the machine and provide details for its optimum use.

Data transmission system such as WLAN, USB, or the DTR communication module, allow the machine and production data to be transmitted locally and globally to any point via the internet.

Tracking of Process Data
Using B-Tronic Activity (B-Report)

B-Tronic Activity is a software program that records the activity of drilling rigs and combines it with equipment data already captured.

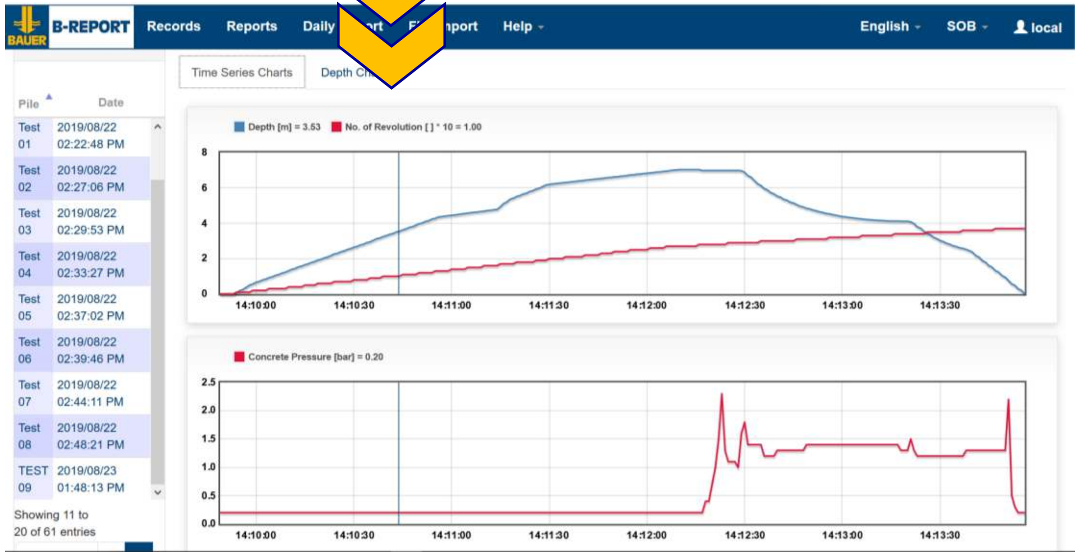
B-Tronic Activity (B-Report)



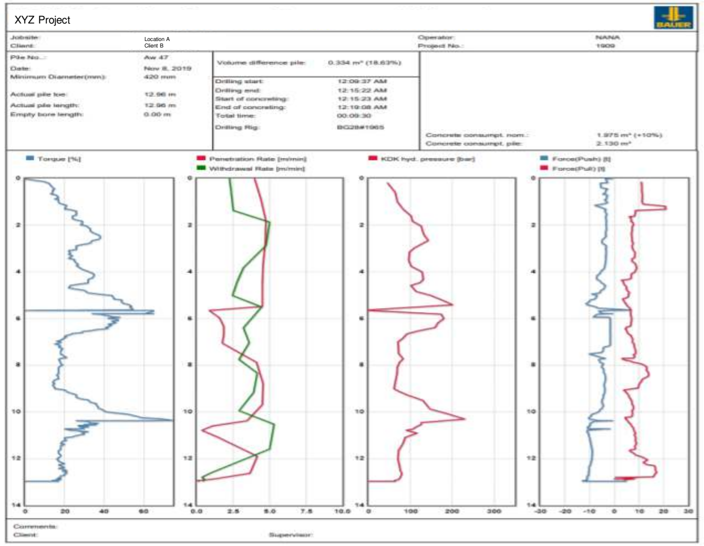
The entire production process no longer has to compiled using individually recorded work steps assembled from equipment data and manual logging
→ **a time consuming and complex tasks**.

Once the digital information for a sufficient number of projects has been entered in a central database, it can serve as a valuable basis for costing purpose or handling follow up work.

B-Tronic Activity (B-Report)

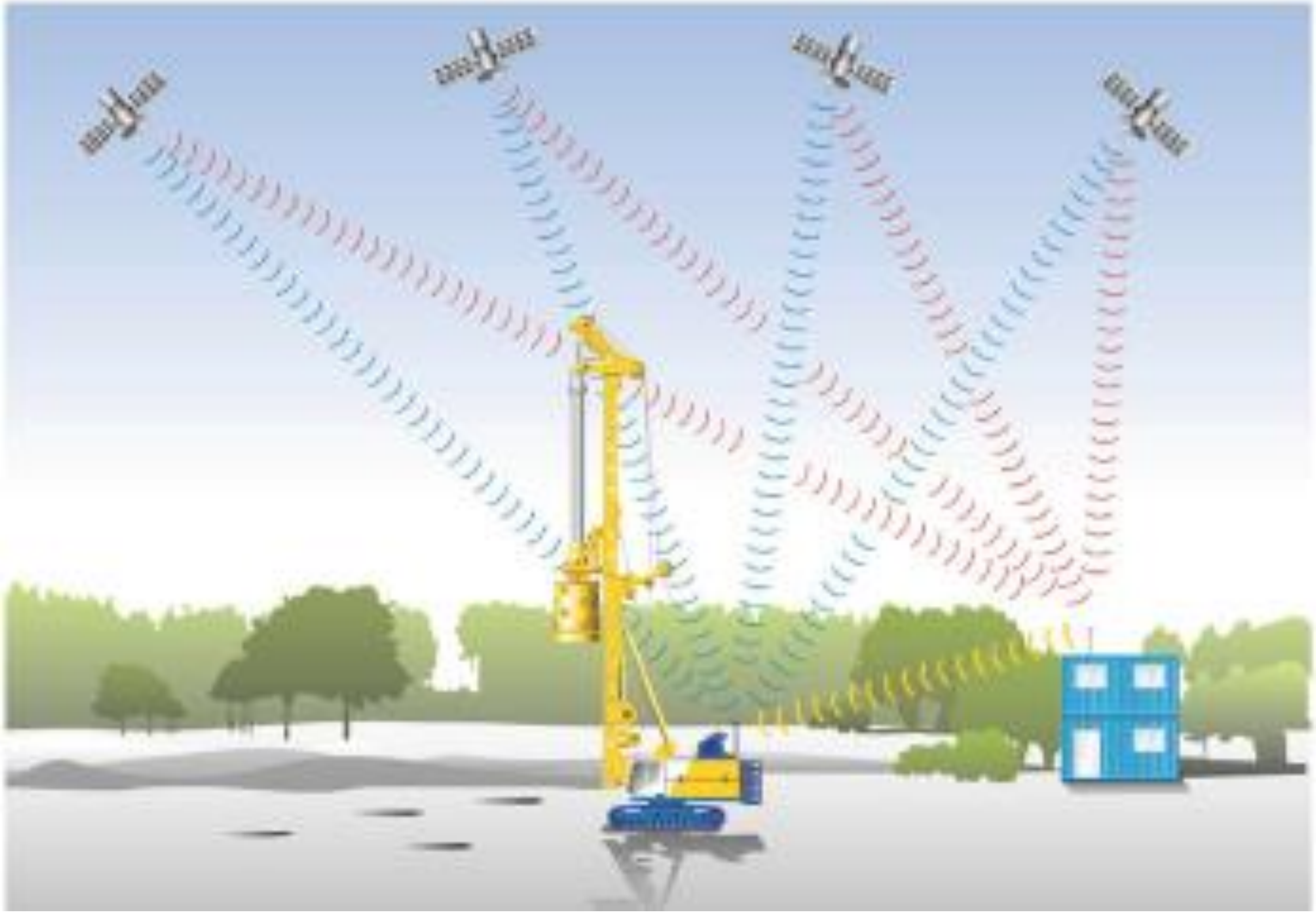


Analyzing



Print out / Report

B-APS (Assistant Positioning System)



GPS positioning in specialist ground improvement / foundation engineering,

GPS has now also found its way into specialist ground improvement / foundation engineering and facilitates the accurate positioning of drilling rigs in the respective drilling points.

36

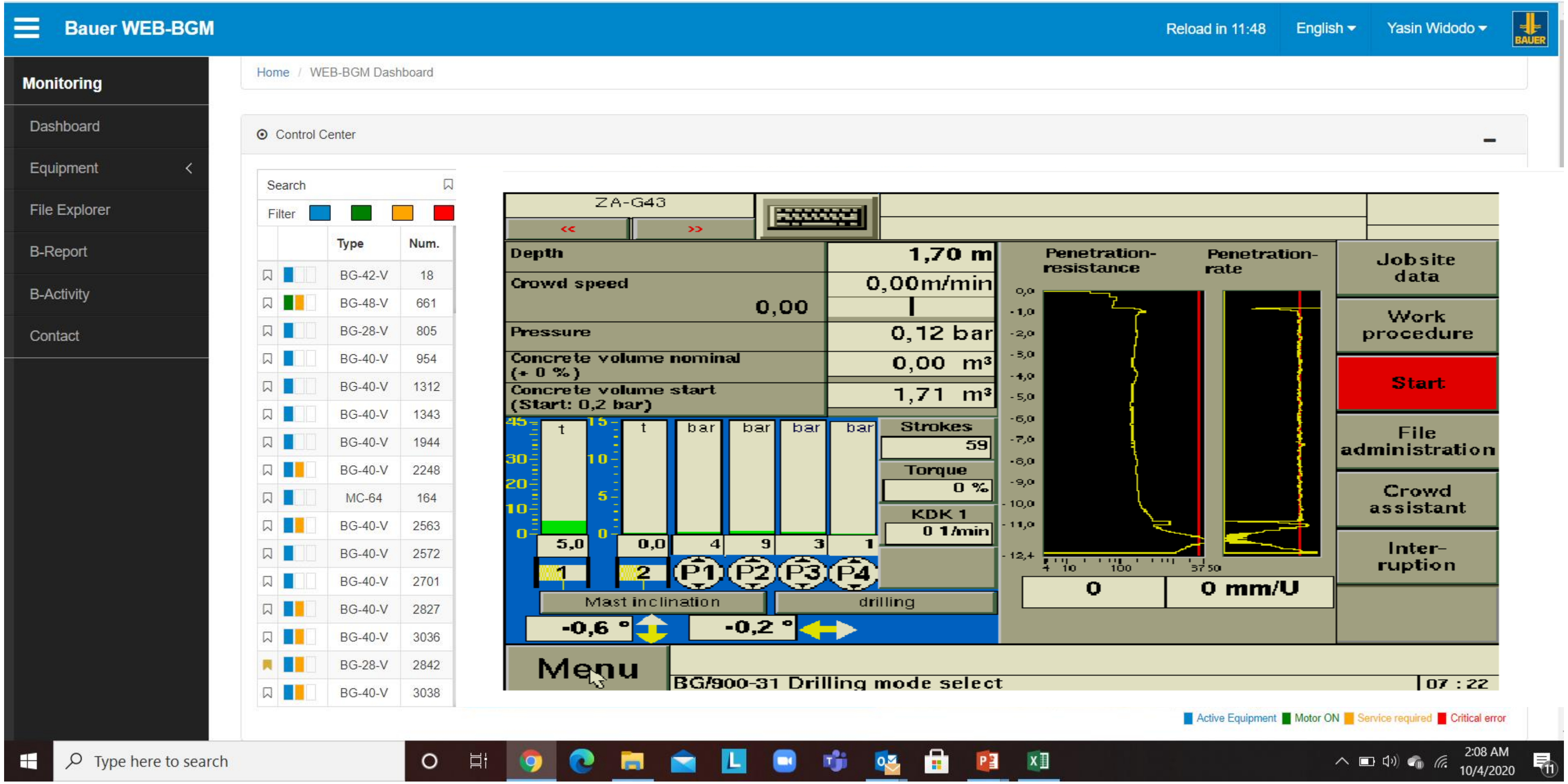
B-APS (Assistant Positioning System)

B-APS, the Assistant Positioning System uses two GPS antennas to detect the current position of the drilling rig and the display then guides the operator to the planned drilling sites.

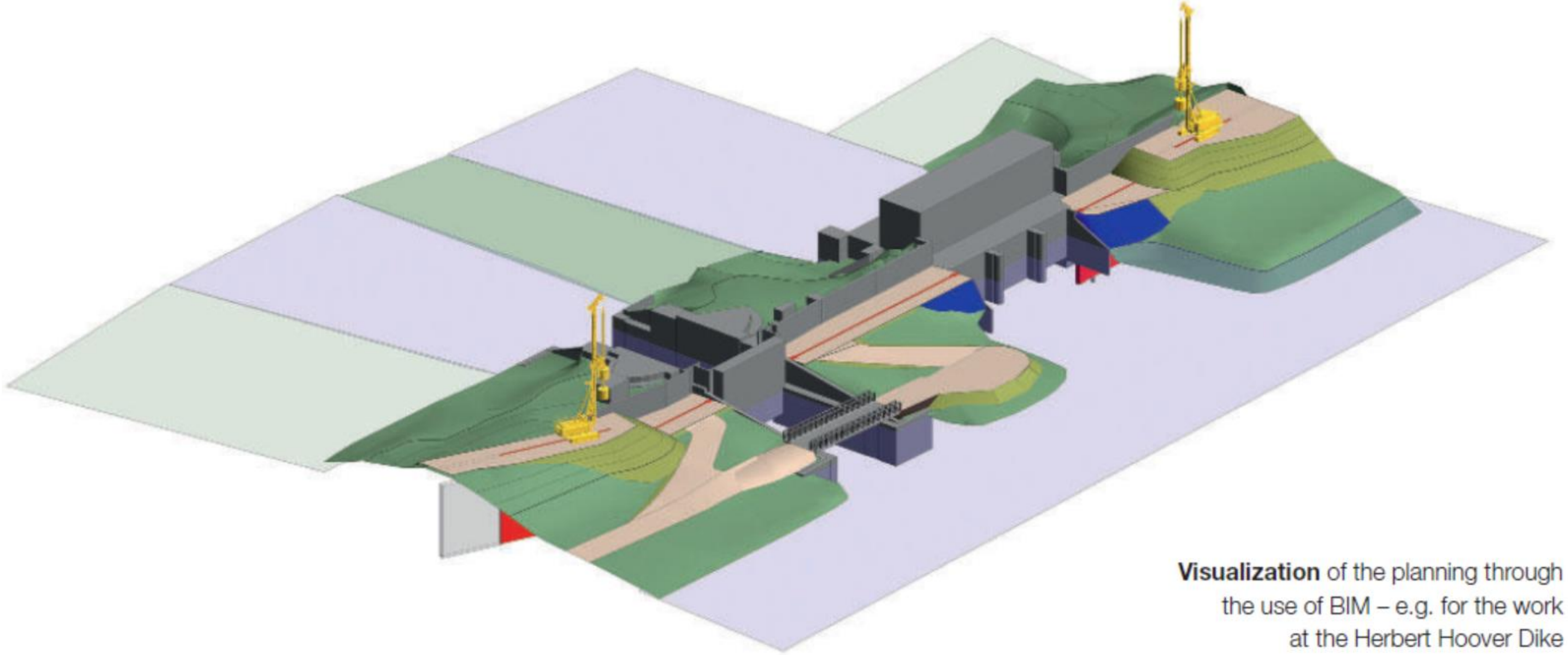
The simple and fast process increases the device’s productivity and brings additional time and cost savings.

B-APS (Assistant Positioning System)

Real time to tracking the position of each machine and its activities such as current position, daily sequence, and activity inside the operator's cabin.



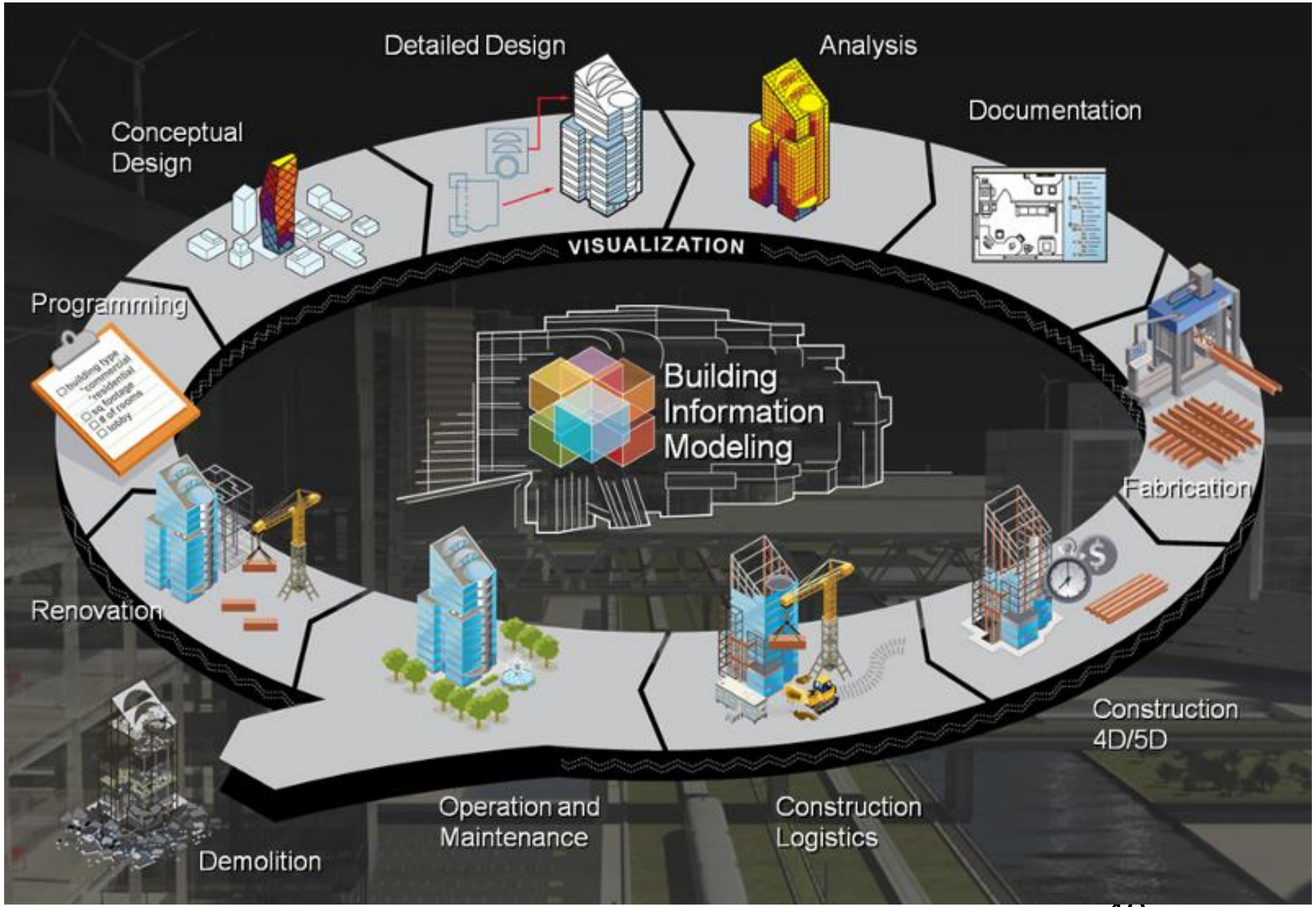
Digitization of construction site processes with BIM



Visualization of the planning through the use of BIM – e.g. for the work at the Herbert Hoover Dike

Complex construction projects are nowadays digital right from the beginning. A fact that lead to fundamental changes in the process not only in structural engineering but also in specialist foundation engineering.
Lengths, widths, and heights are recorded.
Likewise: when will something be built and what does it cost?
All of this together called Building Information Modeling or BIM

Further Development

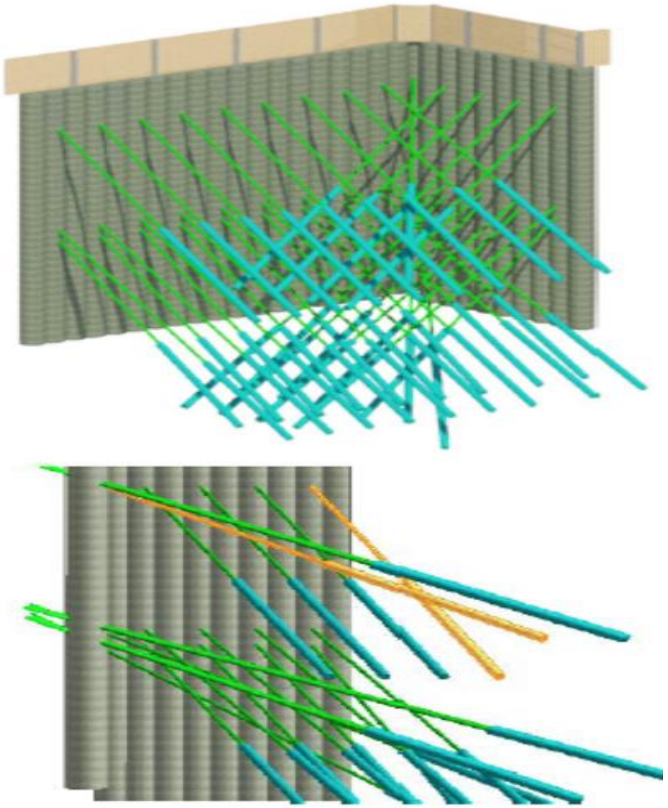


Source: aproplan.com

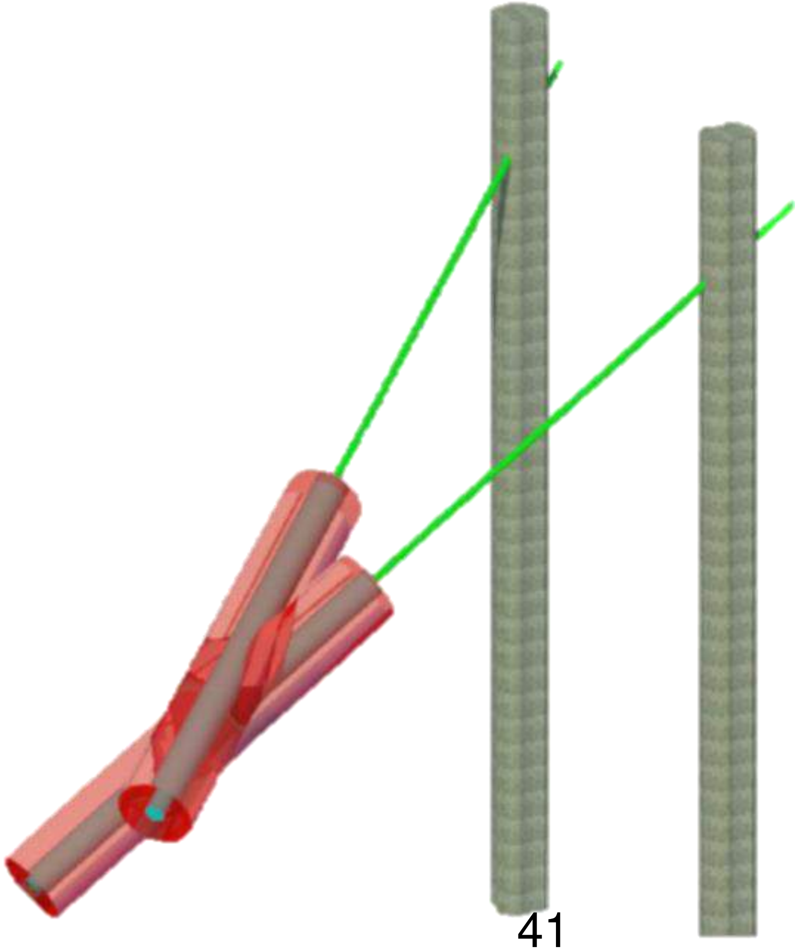
40

Further Development

Identified of critical part



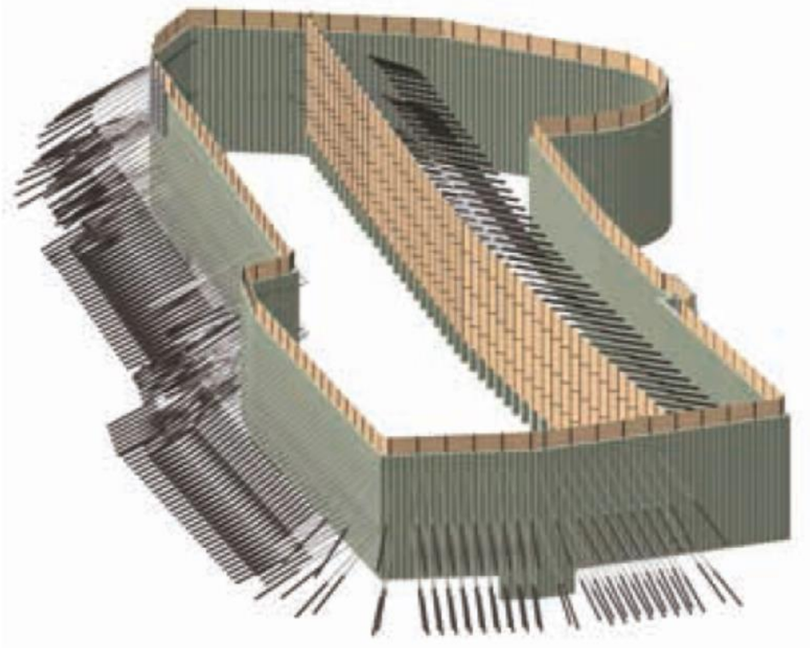
Clash detection warnings

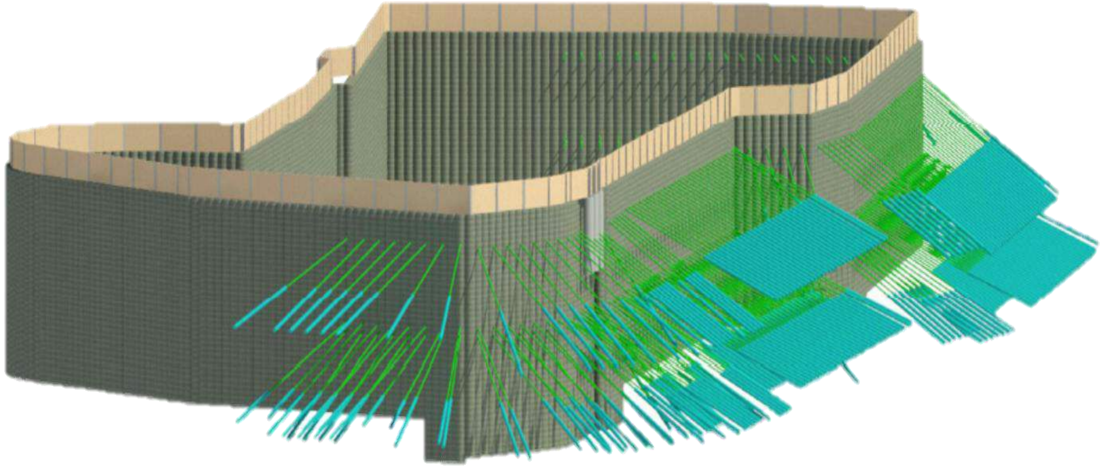


41

Further Development

Quantity survey, time schedule and cost estimation





42

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Jakarta Airport, Indonesia

PASSION for PROGRESS

Thank you

Questions?

Contact

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