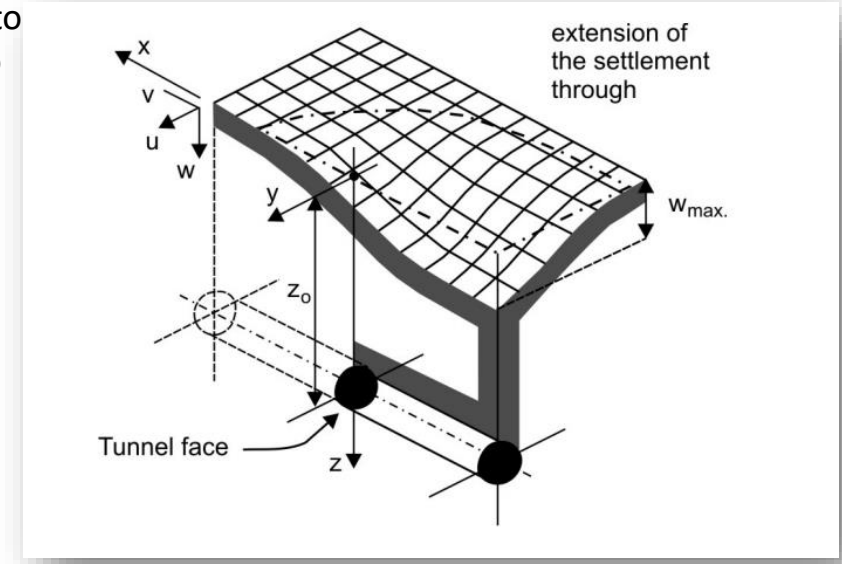
EUROPEAN NO•DIG 2023 Conference ITALY

HDD Horizontal directional drilling used in the construction of the new Metropolitan line in Warsaw, Poland

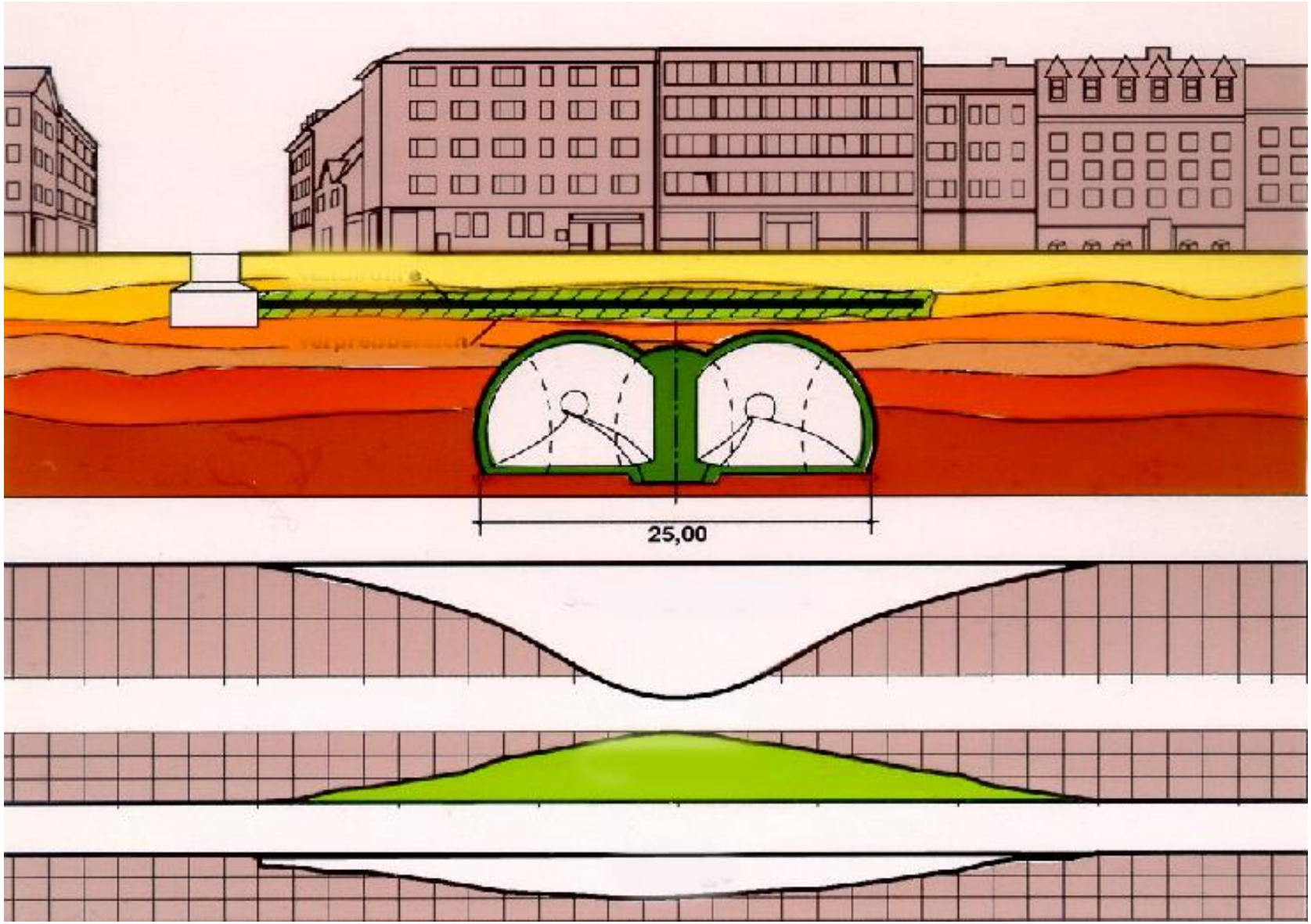
Lorenzo Pratico
Operations Manager
INROCK International Ltd part of SANDVIK Group

25th May 2023

Civil engineer projects generally affect the equilibrium of the ground conditions. In areas where the soil is inherently unstable or under the water table, they could even cause ground subsidence to overlying buildings.
During the last two decades the HDD technique helped on numerous civil engineering and tunnelling construction projects. It is one of the most accurate and reliable methods to install pipes into the ground and it can be used for many different applications, such as tube a manchettes (TAM) for compensation and treatment grouting, freezing pipes, drainage pipe for landslide, landfill remediation and Dam's renovation.
HDD technique helped to date designers and drilling contractors to expand the horizons of technical solutions previously thought too difficult and too expensive.
This presentation sets out to describe the HDD technique since it started and its evolution on tunnelling, environmental remedies and civil




ND BH 44


25,00

January 24, 2006, Warsaw City Council gave approval for the construction of the second Metro Line which extended for a length of around 31 kilometres extending from the east to the west of the city.

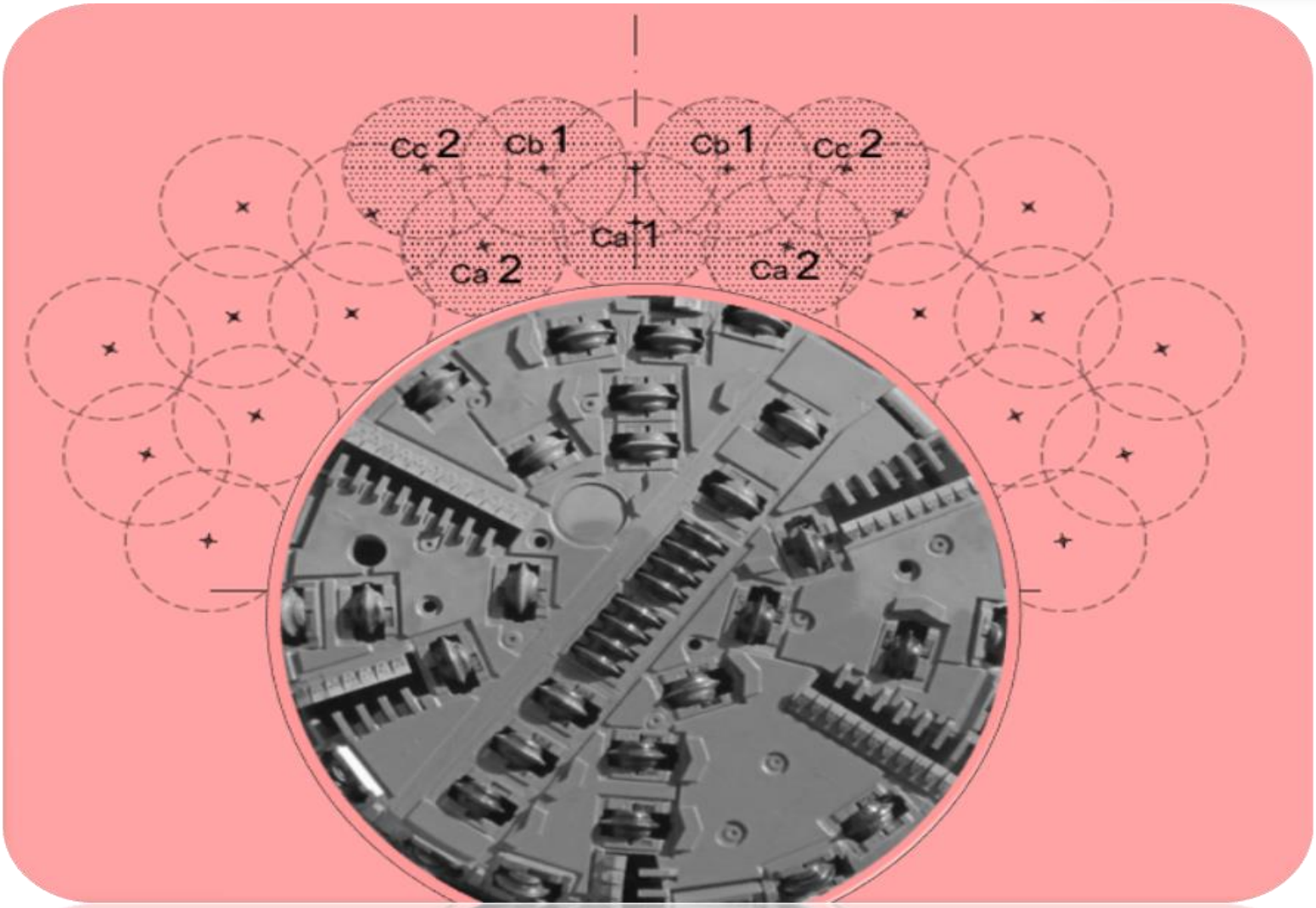
In late 2009 Italian construction company Astaldi won the contract for the Metro central line together with partners Gülemark (one of the largest Turkish construction design companies) and PBDIM (the largest national construction company of Poland).

The contract signed by AGP (Astaldi Gulemark PBDIM) with the city of Warsaw was for around 3.375 million Zloty (US$1.1 million) and will lead to the completion of the central metro line 2 at 6.3km long with seven stations between the two termini of Rondo Daszynskiego e Dwozec Wilenski.

The subcontractor for the AGP consortium was Icotekne Polska Sp z oo, a polish company established on 09.06.2011 by Icotekne spa.

The section of metro line that extends predominantly underground passes beneath and in between the stations of Powisle and Standion and underneath the Vistiola River.

In order to guarantee greater security the metro line will comprise a pair of tunnels each housing a single track. These tunnels will be bored using a fully automated tunnel boring machine of 6.32 metre diameter.


Cc 2
Cb 1
Cb 1
Cc 2
Ca 1
Ca 2
Ca 2

The construction of this new metro system will obviously affect the equilibrium of the local ground conditions. In areas where the soil is inherently unstable and/or composed of loose material works could even cause ground subsidence resulting in significant damage to overlying buildings.

For this reason, in the area around the stadium it was necessary to carry out remedial works to prevent subsidence and damage to any surface construction infrastructure.

The subsidence prevention application in focus is located close to the hub near the station, which is an area marked C14, which comprises the stretch of metro linking Stadio station with Treno Vilnius station.

Of particular concern was the area between Zamoyskiego and Targowa roads, an area comprising historic and preserved listed housing.

In this section the TBM needed to pass around 10m below the street level. Moreover the presence of sandy soils ensured that consolidation of the formation was necessary in this area to prevent surface building construction failures.

For the ground consolidation – which needed to be performed under the building foundations without disturbing the surface or cause a worsening of already difficult ground conditions – it was necessary to conduct a detailed technical analysis to assess the potential damage to buildings caused by the construction process.

As a precaution, certain operations were implemented to minimise risk to overland structures.

The consolidation process, which consisted of treating the soil with cement and chemical injections, was utilised to limit the settlement of buildings
In particular, what was required was to build a boundary/barrier around the tunnels approximately 3m in thickness using high pressure valve tubing.

The object of the process is to consolidate the ground, providing soil stiffness that allows the formation of a stabilised arch formation in the immediate vicinity of the excavation surface which prevents the spread of tension strain damage in the buildings above.

A cylindrical consolidation zone around the consolidation tubing was designed to be horizontal and extend below the planimetric footprint of surface buildings to avoid the spread of tension-induced deformation at surface due to the advancement of the tunnel excavation below.

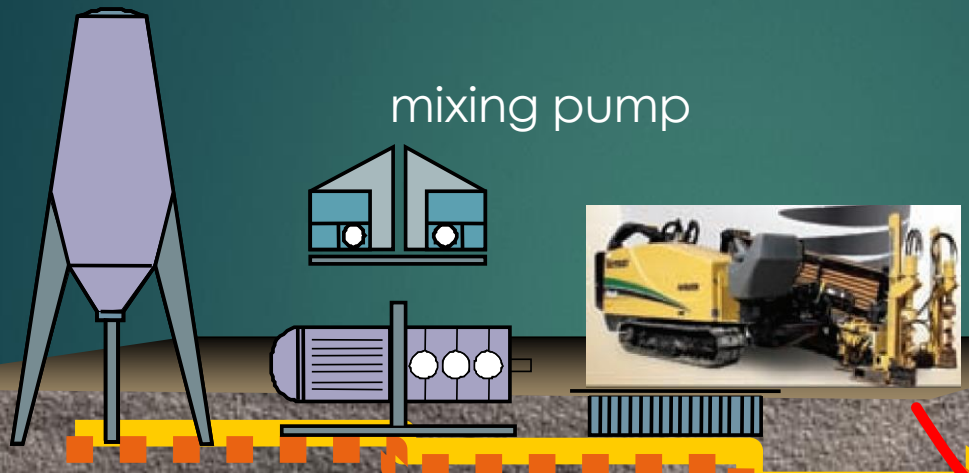
The injection mixture and methodology suitable for this type of ground treatment was assessed by careful analysis of the particle distribution curve of the soils and its physical and mechanical characteristics.

The soil conditions, which are predominantly loose sands, were deemed favourable for consolidation by cement and chemical injections.

The chemical mixture is required to impregnate even the smallest inter-granular gaps, giving the ground both stronger mechanical features as well as a degree of increased impermeability due to the close proximity of the Vistiola River.

HDD COMPENSATION GROUTING

Cement - Filler



The pre-treatment process involves:

•Installing grout injection tubes TAM's to a pre-determined pattern.

•Injection of grout through sleeves with careful process control to reduce the settlement of the area above.

OPERATIONS

The directional drilling / stabilization process was the most delicate and demanding phase throughout this project.

The design solution proposed consisted of making 48 sub horizontal drillings, (24 for each tunnel gallery) each of approximately 250 meters length spread over three rows with a maximum distance of about 1 meters between each other.

The directional drilling / stabilization process has been the most delicate and demanding phase throughout this project. The design solution proposed consisted of making 48 sub horizontal drillings, (24 for each tunnel gallery) each of approximately 250 meters length spread over three rows with a maximum distance of about 1 meters between each bore hole.

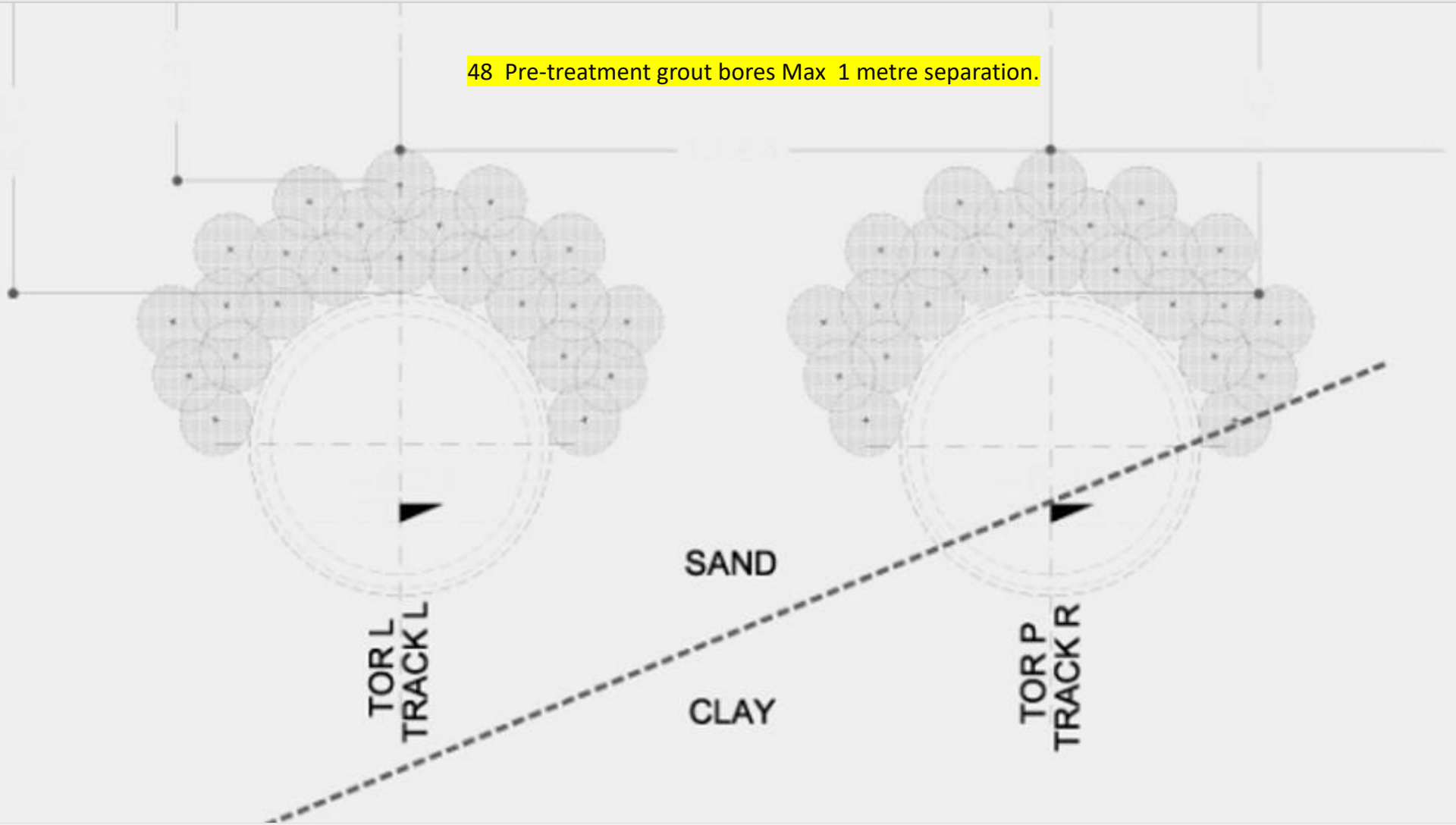
The geometric pattern of the stabilization bore holes made is basically divided into three sections:-

1) A combined curved section from entry to approximately 40 metes away distance with a radius of curvature of 100 meters.

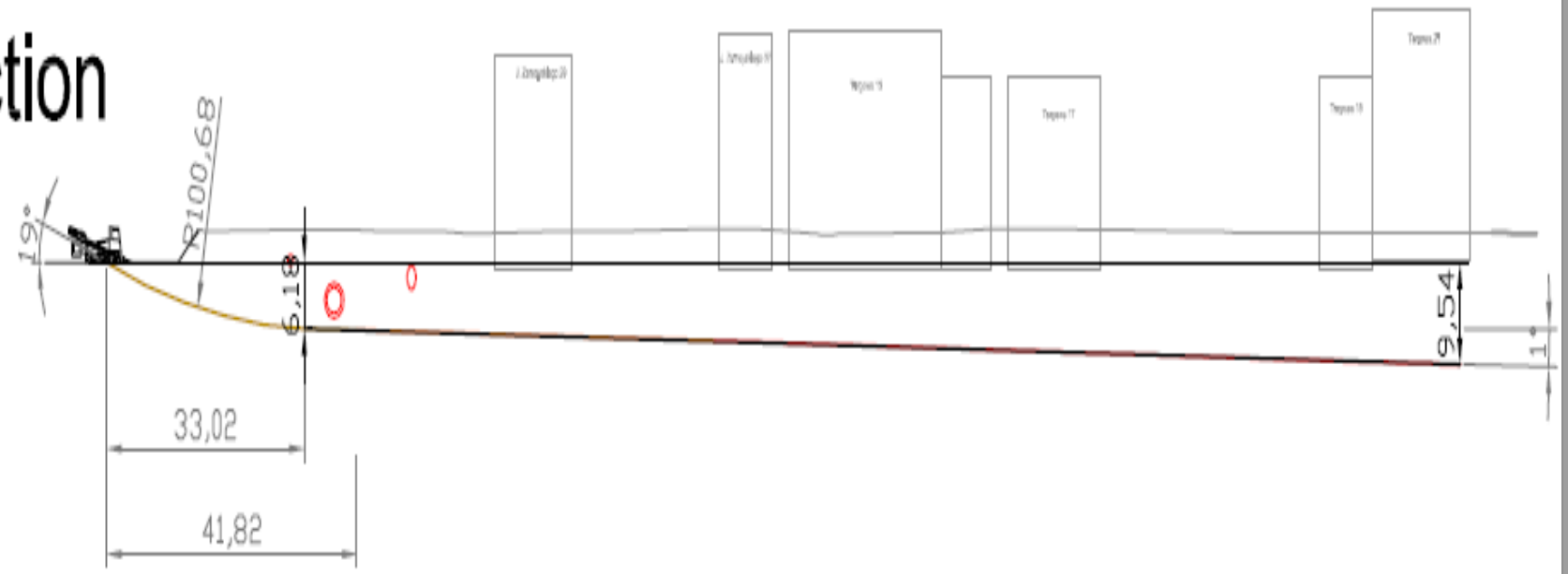
2) A central straight section from approximately 40 meters to approximately 70 meters away from entry

3) A combined curved section from approximately 70 meters to 250 meters with a radius of curvature of approximately 330 meters.

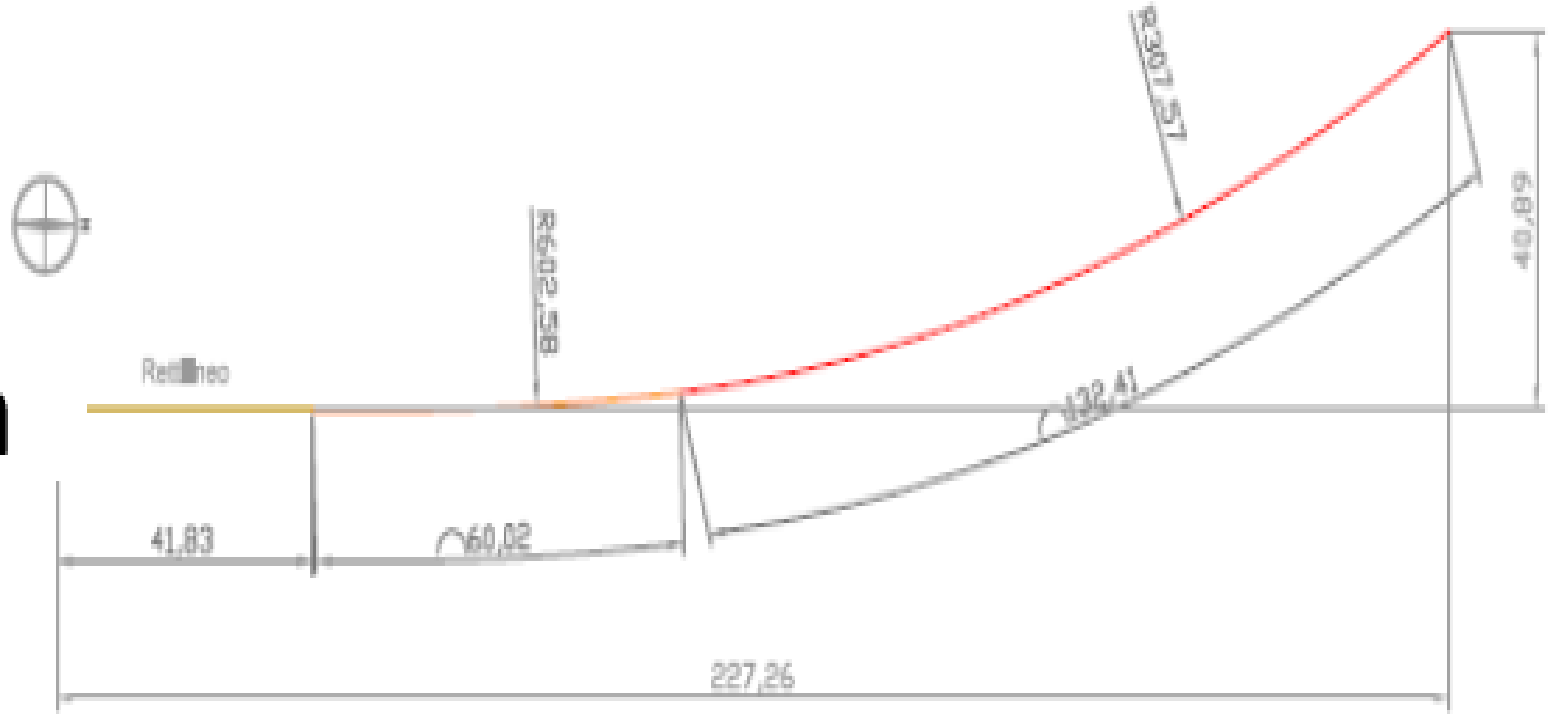
48 Pre-treatment grout bores Max 1 metre separation.

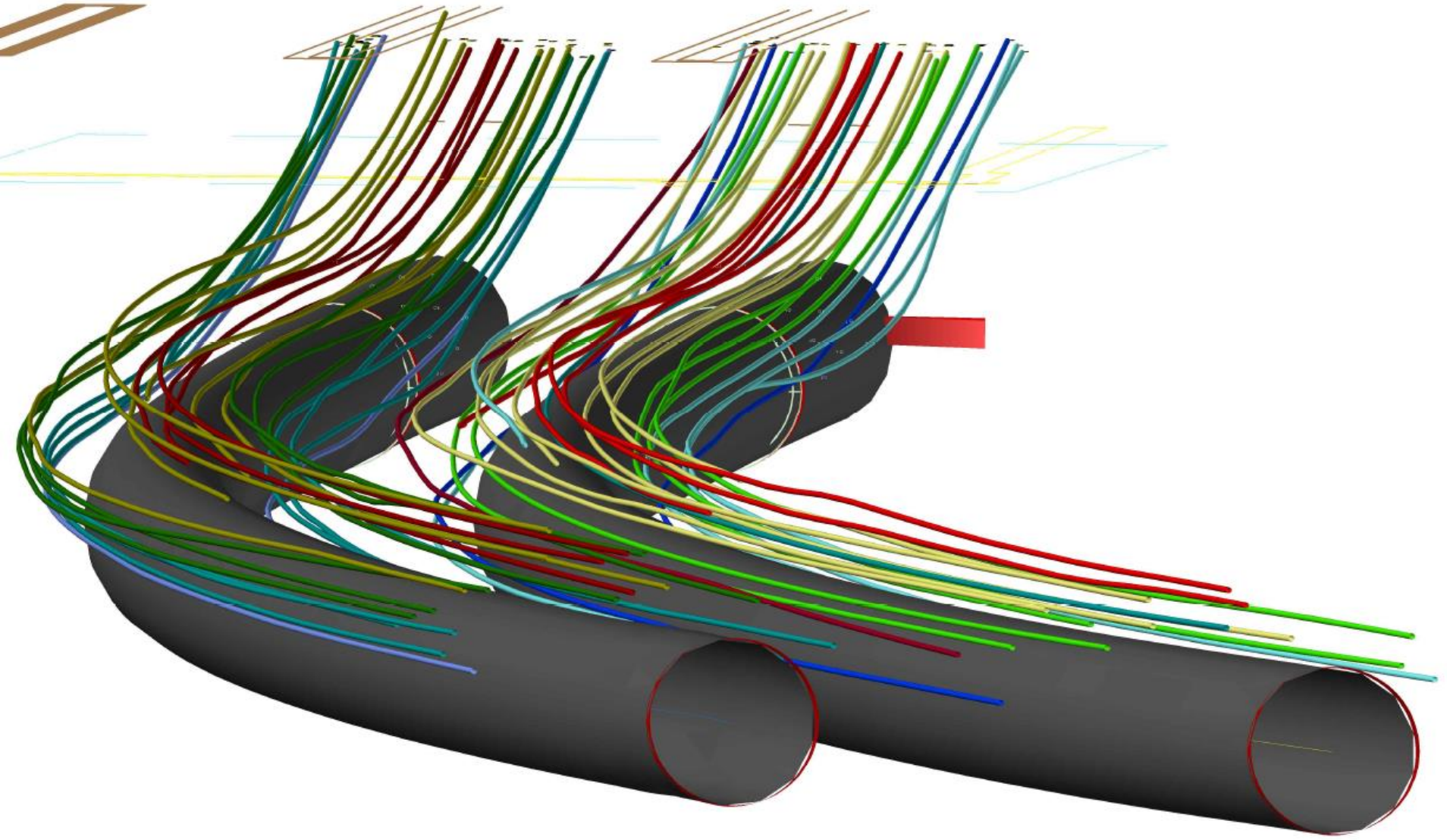


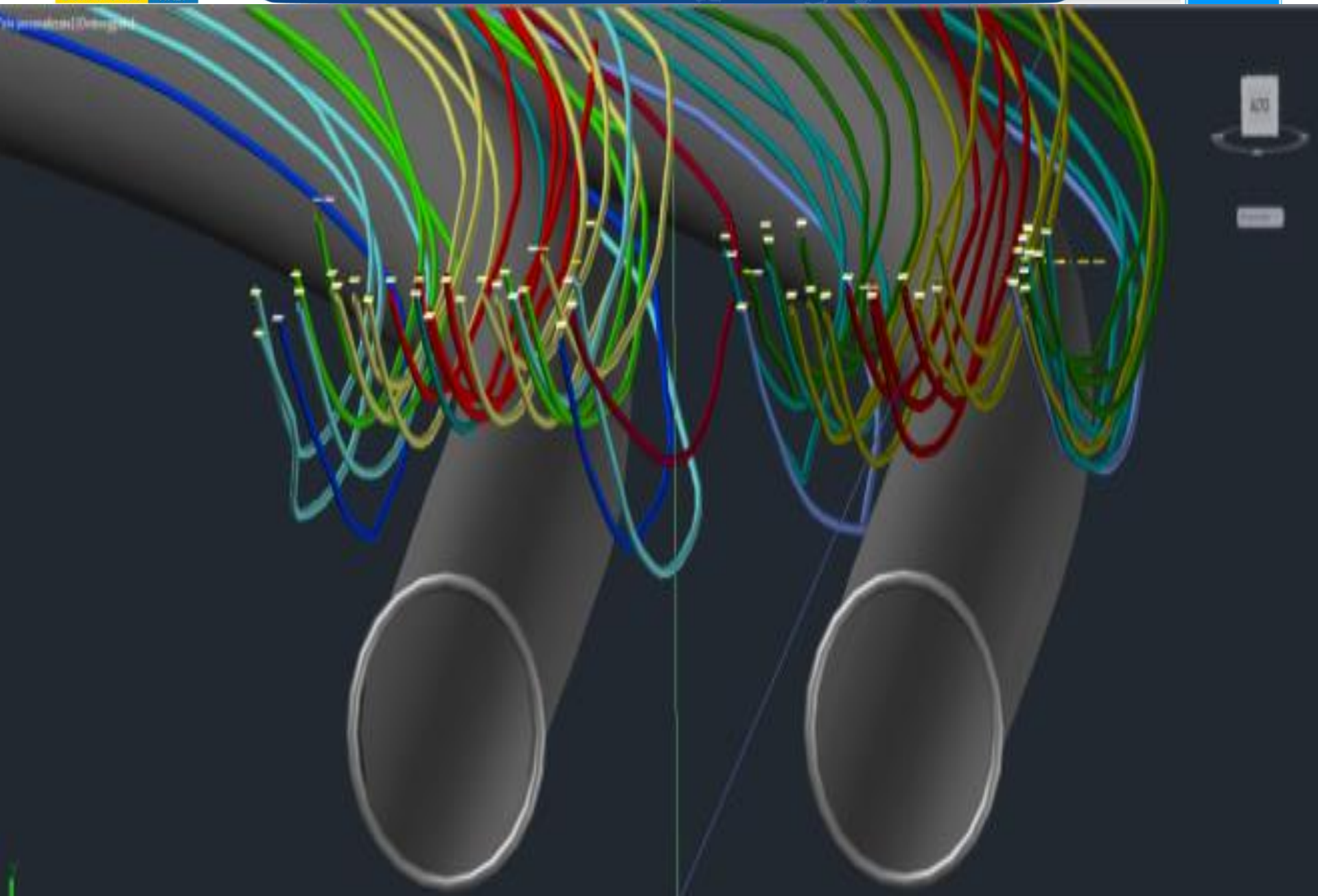
Section



Plan







THANKS for your attention

Eng. Dipl. Lorenzo Pratico

INROCK INTERNATIONAL
part of Sandvik Group