SIMSG ISSMGE

International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE)

Time Capsule Project (TCP) – Kazakhstan Geotechnical Society (KGS) Report

GEOTECHNICAL INFRASTRUCTURES FOR MEGACITIES AND NEW CAPITALS

KGS

ISSMGE TC305
Technical Committee on Geotechnical Infrastructure for Megacities and New Capitals

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CONTENTS

RUSSIAN FEDERATION
European Russia
Asiatic Russia
KAZAKHSTAN
MONGOLIA
CHINA
JAPAN
N. KOREA
S. KOREA
UZBEK.
KYRG.
TURKEY
IRAN
AFGH.
PAKISTAN
INDIA
NEPAL
BHUTAN
BANGLADESH
IRAQ
SYRIA
LEBANON
ISRAEL
JORDAN
KUWAIT
BAHRAIN
QATAR
SAUDI ARABIA
OMAN
YEMEN
GEORGIA
ARMENIA
AZ.
CYPRUS
SRI LANKA
MALDIVES
MYANMAR (BURMA)
LAOS
THAI.
CAMB.
TAIWAN
PHILIPPINES
MALAYSIA
SINGAPORE
BRUNEI
INDONESIA
EAST TIMOR
AUSTRALIA
ICELAND
NORWAY
SWEDEN
FINLAND
DENMARK
UNITED KINGDOM
REPUBLIC OF IRELAND
FRANCE
SPAIN
PORT.
ITALY
GERMANY
POLAND
UKRAINE
BELA.
ROM.
GREECE
MALTA
ALGERIA
LIBYA
EGYPT
TUNISIA
MOROCCO
MAURITANIA
MALI
NIGER
CHAD
SUDAN
ERITREA
DJIBOUTI
ETHIOPIA
SOMALIA
NIGERIA
BENIN
C.A.R.
KENYA
UGANDA
DEM. REP. CONGO
GABON
TANZANIA
ANGOLA
ZAMBIA
MALAWI
ZIMB.
NAMIBIA
BOTS.
MOZAMBIQUE
MADAGASCAR
SOUTH AFRICA
SWAZILAND
LESOTHO
SEYCHELLES
COMOROS
MAURITIUS
ATLANTIC OCEAN
INDIAN OCEAN
Franz Josef Land
Novaya Zemlya
Severnaya Zemlya
New Siberian Islands
SVALBARD (to Norway)
JAN MAYEN (to Norway)


RUSSIA
New Capital
Kazakhstan
International boundary
Oblysy boundary
National capital
Oblysy capital
Railroad
Road
Astana
AQMOLA
SOLTÜSTIK QAZAQSTAN
BATYS QAZAQSTAN
SHYGHYS QAZAQSTAN
MANGGHYSTAU
ONGTÜSTIK QAZAQSTAN
ZHAMBYL
CHINA
UZBEKISTAN
TURKMENISTAN
KYRGYZSTAN
TAJIKISTAN
AZER.
Caspian Sea
Aral Sea
Lake Balkhash
Nizhniy Novgorod
Perm'
Nizhniy Tagil
Krasnoyarsk
Tomsk
Kemerovo
Novosibirsk
Novokuznetsk
Barnaul
Biysk
Omsk
Kurgan
Chelyabinsk
Yekaterinburg
Tyumen'
Izhevsk
Kazan'
Ul'yanovsk
Ufa
Penza
Samara
Saratov
Magnitogorsk
Orenburg
Volgograd
Astrakhan'
Makhachkala
Baku
Rasht
Tehrān
Petropavlovsk
Qostanay (Kostanay)
Rūdnyy (Rudnyy)
Kökshetaū (Kokshetau)
Pavlodar
Ekibastuz
Atbasar
Esil (Yesil')
Temirtaū (Temirtau)
Arqalyq (Arkalyk)
Semey (Semipalatinsk)
Öskemen (Ust'-Kamenogorsk)
Oral (Ural'sk)
Aqsay (Aksay)
Orsk
Aqtöbe (Aktobe)
Maqat (Makat)
Embi (Emba)
Shalqar (Chelkar)
Atyraū (Atyrau)
Beyneu (Beyneu)
Aqtau (Aktau)
Aral (Aral'sk)
Zhezqazghan (Zhezkazgan)
Balqash (Balkhash)
Saryshaghan (Saryshagan)
Ayaköz (Ayagoz)
Zaysan
Tacheng
Lepsi (Lepsy)
Taldyqorghan (Taldykorgan)
Qapshaghay (Kapchagay)
Zharkent
Almaty
Yining
Ürümqi
Korla
Kuqa
Bayqongyr (Baykonyr)
Qyzylorda (Kyzylorda)
Türkistan (Turkestan)
Zhangatas (Zhanatas)
Taraz
Shū (Shu)
Shymkent
Bishkek
Balykchy
Tashkent
Nukus
Uchquduq
Daşoguz
Urganch
Türkmenbaşy
Balkanabat
Buxoro
Navoiy
Samarqand
Qarshi
Khujand
Osh
Dushanbe
Ashgabat
Türkmenabat
Mary
Atamyrat
Termiz
Qurghonteppa
Khorugh
Mashhad
Volga
Syr Darya
Amu Darya
Irtysh
Ishim
Ob'
Ural
Zhaysang Köli

INTRODUCTION

High-rise buildings (buildings with a height of more than 75 m) pose new challenges for engineers, especially in the field of calculations and design of above-ground structures, bases and foundations. Therefore, designers of both above-ground and underground parts of the building are forced to resort to more complex methods of calculation and design. Especially this applies to geotechnics, who are involved in the design of foundations for high-rise buildings.

By complexity, problematic design, erection, operation, impact on the environment and people, high-rises can be attributed to the structures of increased danger and complexity.

Kazakhstan has its own modern experience in designing and erecting high-rise buildings above 75 m of unique structures, including the “Emerald Quarter” (210 m), “Northern Lights 1” (180 m) in Astana, Railways Building (174/156 m), Transport Tower (the building of the Ministry of Transport and Communications) (155 m), Khan-Shatyr (150 m) (see Figure 1).

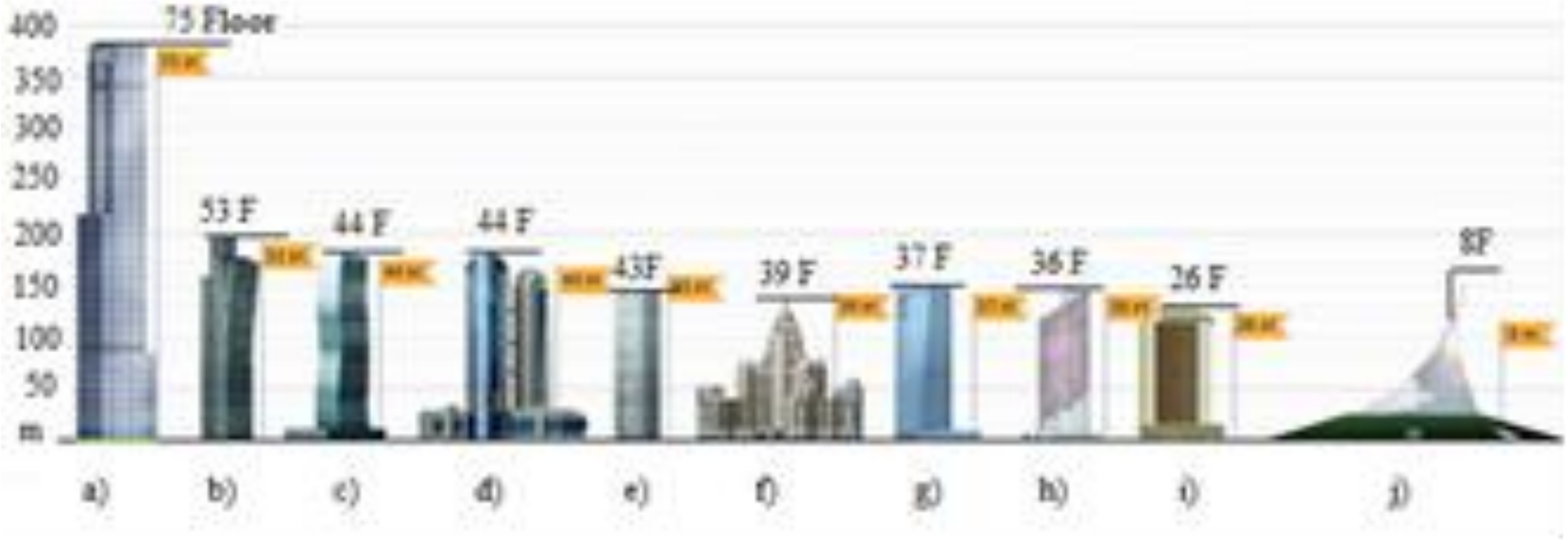


Figure 1 High-rise buildings above 75 m of unique structures in Nur-Sultan

Note: a) Abu-Dhabi Plaza; b) Emerald Quarter; c) Northern Lights 1; d) Railways Building Towers; e) Grand Astana Tower; f) Triumph of Astana; g) Astana Marriott Hotel; h) Transport Tower (the building of the Ministry of Transport and Communications); i) Hotel “Kazakhstan” (Almaty city) and j) Khan-Shatyr.

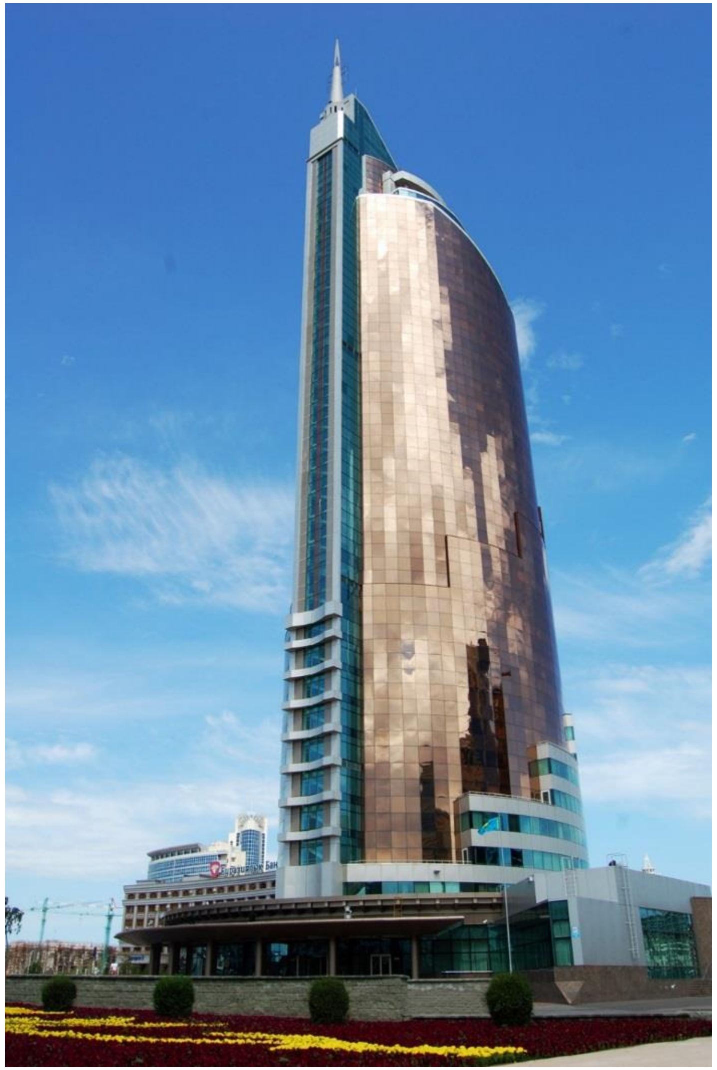

Abu-Dhabi Plaza

Downtown of Nur-Sultan

“Emerald Quarter”

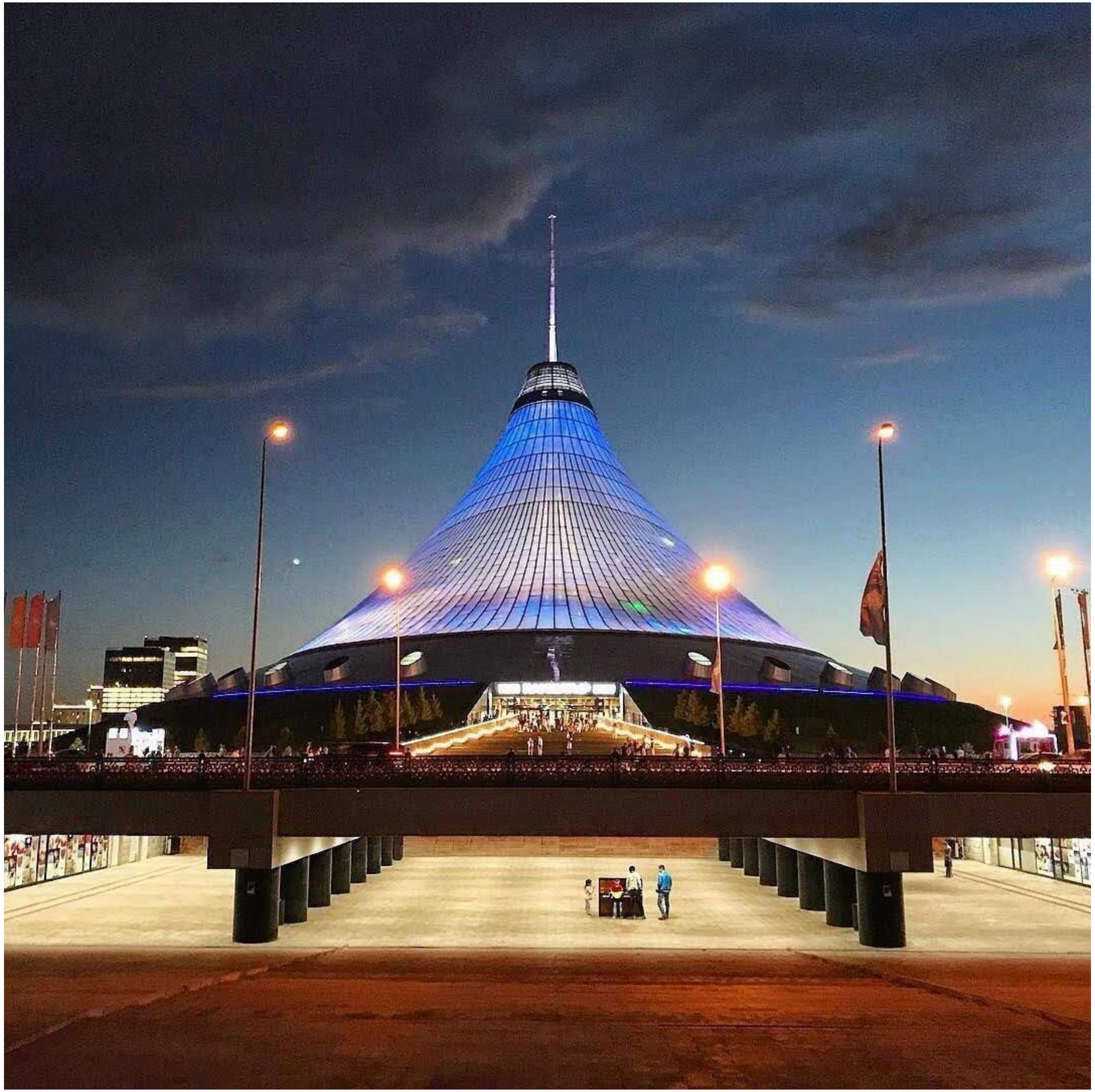
“Northern Lights 1”

Nur-Sultan, Railways Building



Transport Tower (the building of the Ministry of Transport and Communications)

Khan Shatyr Entertainment Center



New Railway Station of Nur-Sultan, Kazakhstan.

CASE STUDY:

Embassy of the USA in Astana

Overall building area of the EXPO complex – 173,4 Hectare

Overall building area of the EXPO Site– 25 Hectare

EXPO: ILLUSTRATED SITE PLAN

ABU DHABI PLAZA

ASTANA KAZAKHSTAN

Project Overview

Block H
14-Storey Hotel
190 Guest Rooms
100 Serviced Apts
32,000 sqm

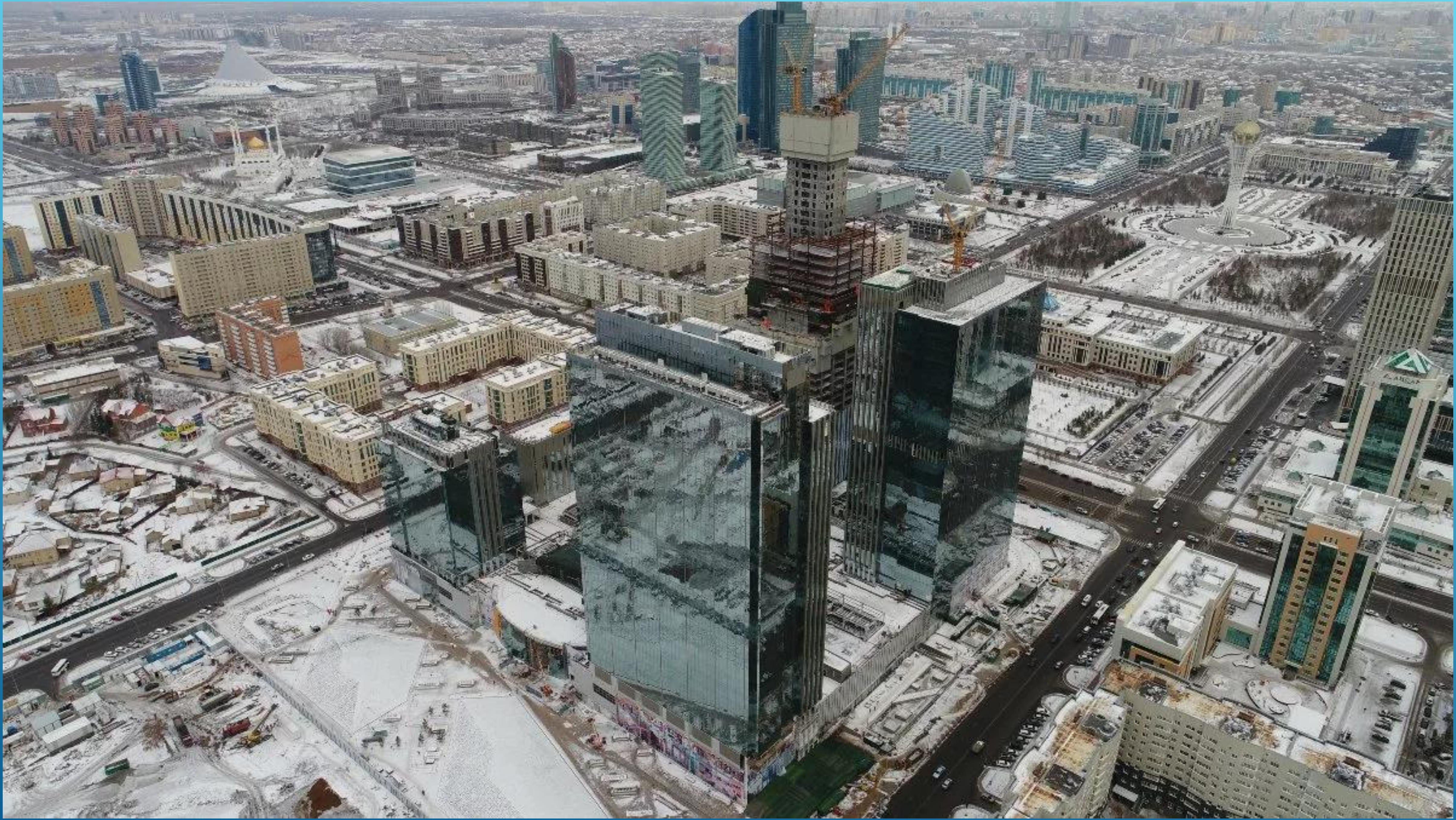
Block Z
17-Storey Residential
20,000 sqm

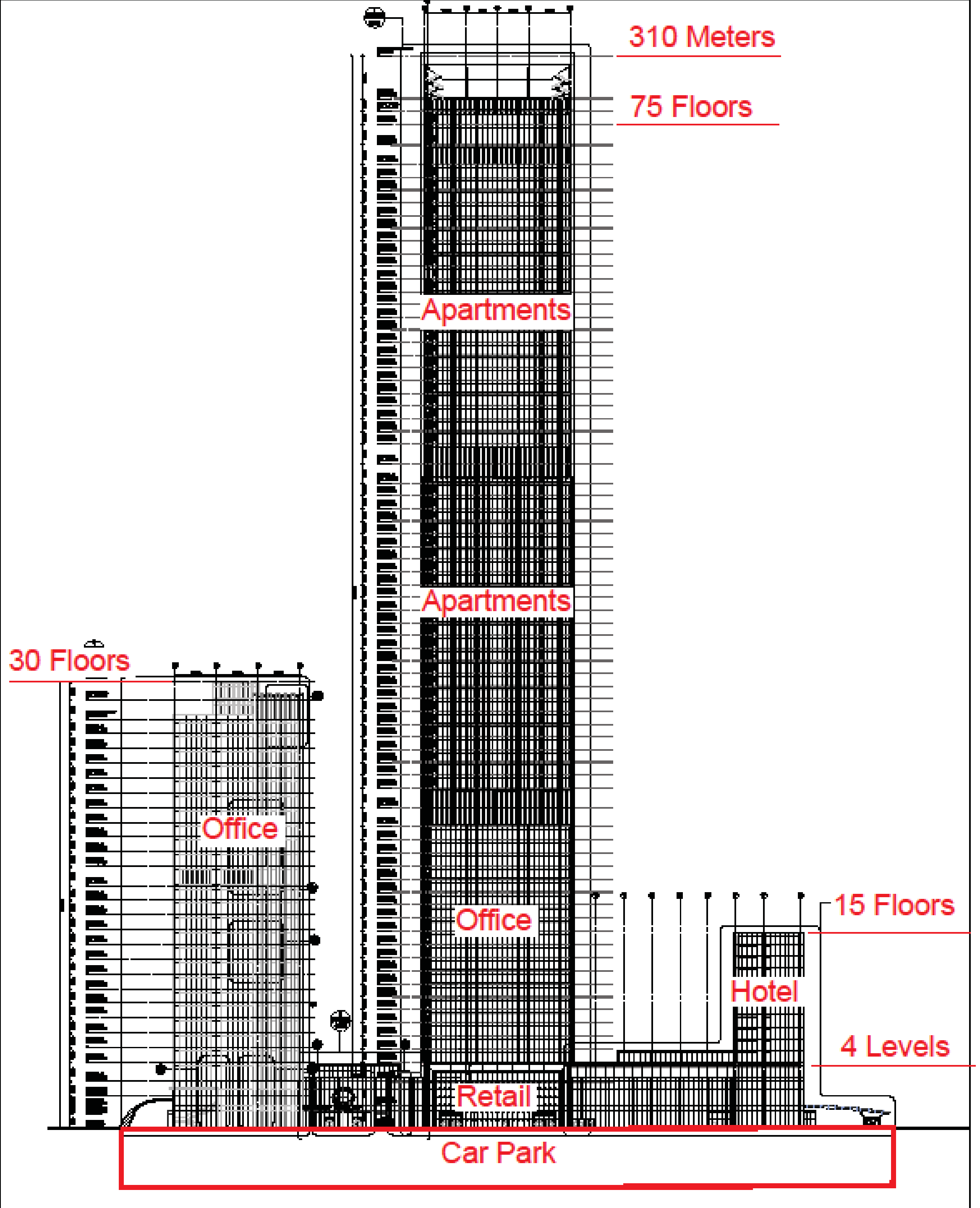
Block P
2-Storey
Podium Retail
50,000 sqm

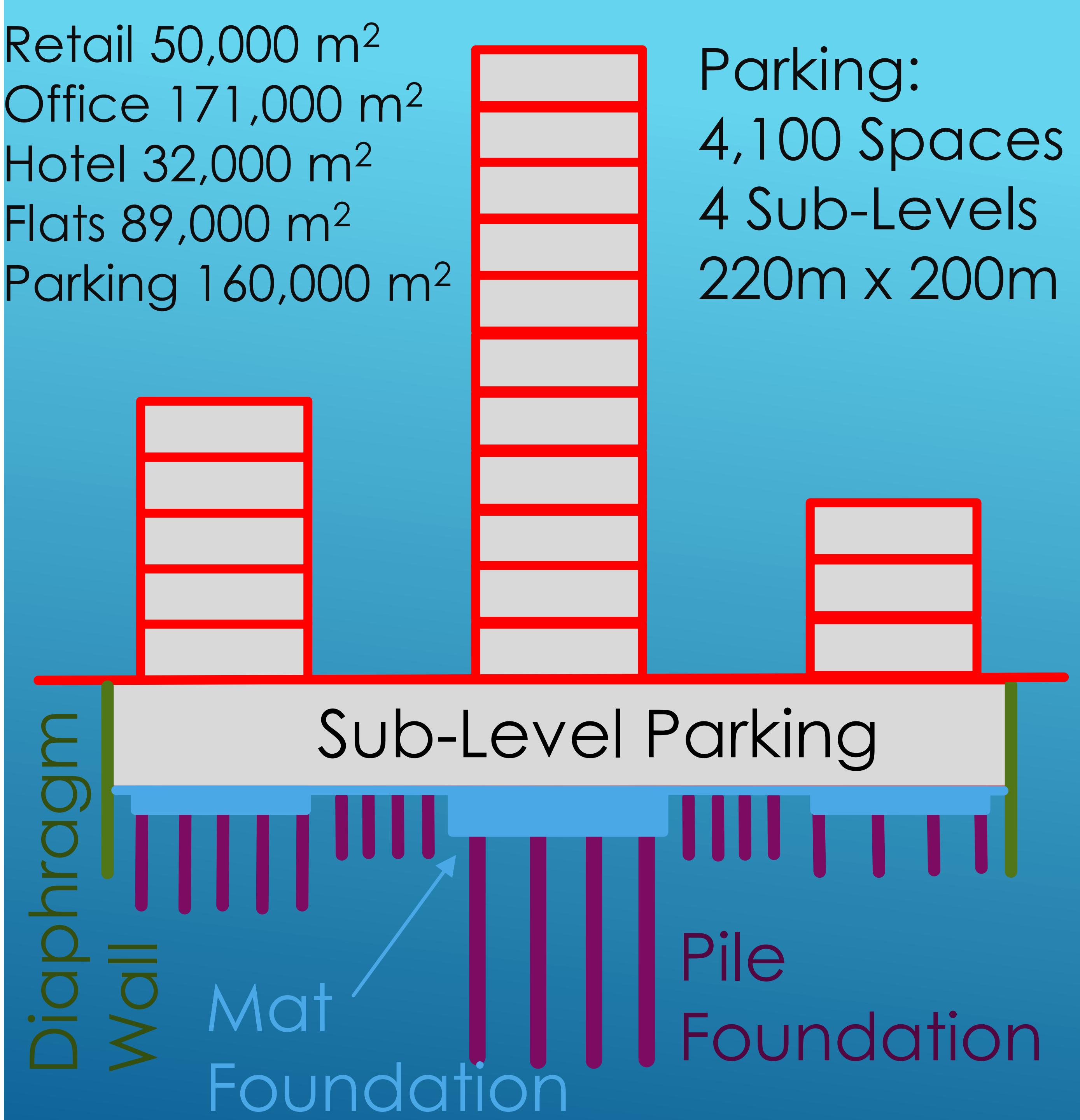
Block R
75-Storey
Mixed Use
450 Apts 69,000 sqm
Office 37,000 sqm

Block O
30-storey
Office 69,000 sqm

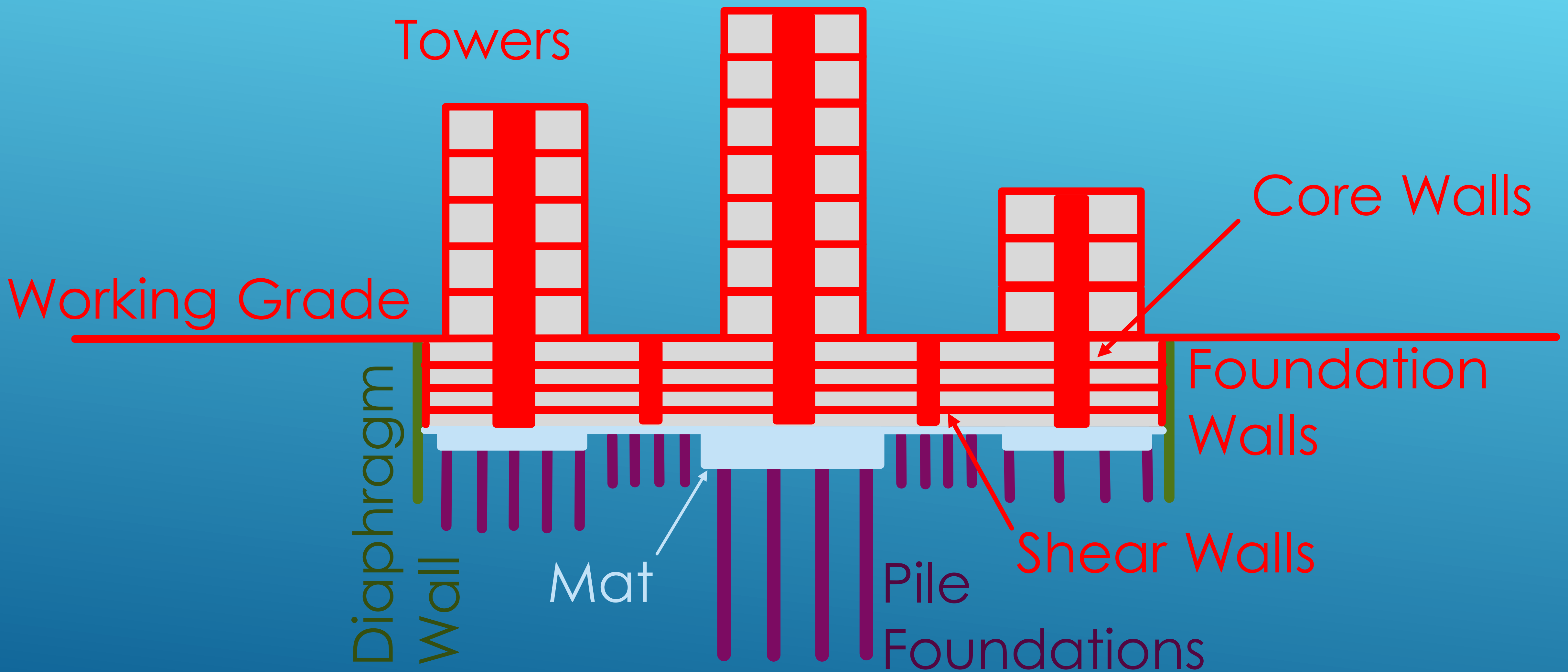
Block Y
31-Storey
Office 65,000 sqm


310 Meters
75 Floors
Apartments
Apartments
30 Floors
Office
Office
15 Floors
Hotel
4 Levels
Retail
Car Park


Retail 50,000 m²
Office 171,000 m²
Hotel 32,000 m²
Flats 89,000 m²
Parking 160,000 m²
Parking:
4,100 Spaces
4 Sub-Levels
220m x 200m
Sub-Level Parking
Diaphragm Wall
Mat Foundation
Pile Foundation

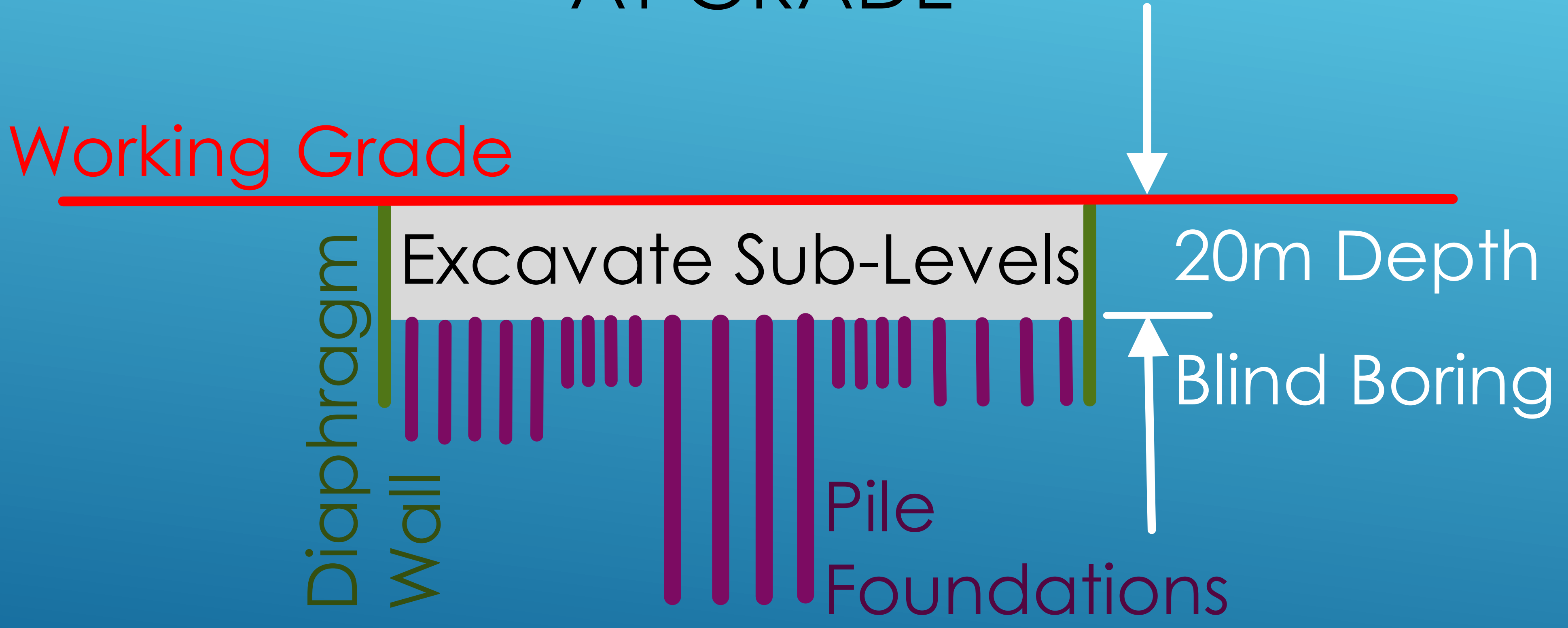
SUB-LEVELS AND SUPERSTRUTURE

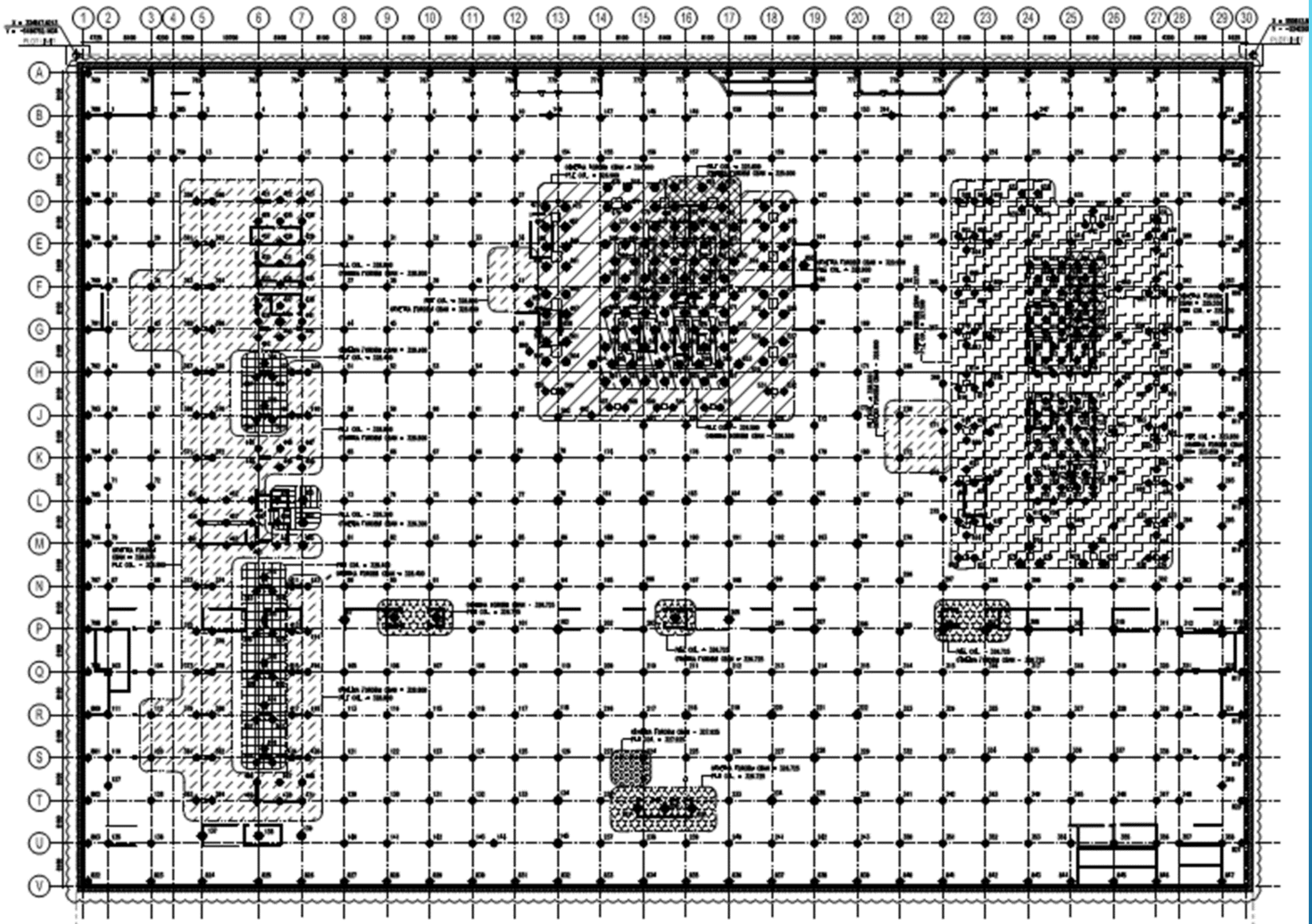


ABU DHABI PLAZA FOUNDATIONS

- 1,125 Auger Cast Piles
- 1.0 to 1.5 Meters in Diameter
- 13 to 25 Meters in Length
- 40 MPa Concrete with Severe Exposure Durability

INSTALLATION OF AUGER CAST PILES AT GRADE

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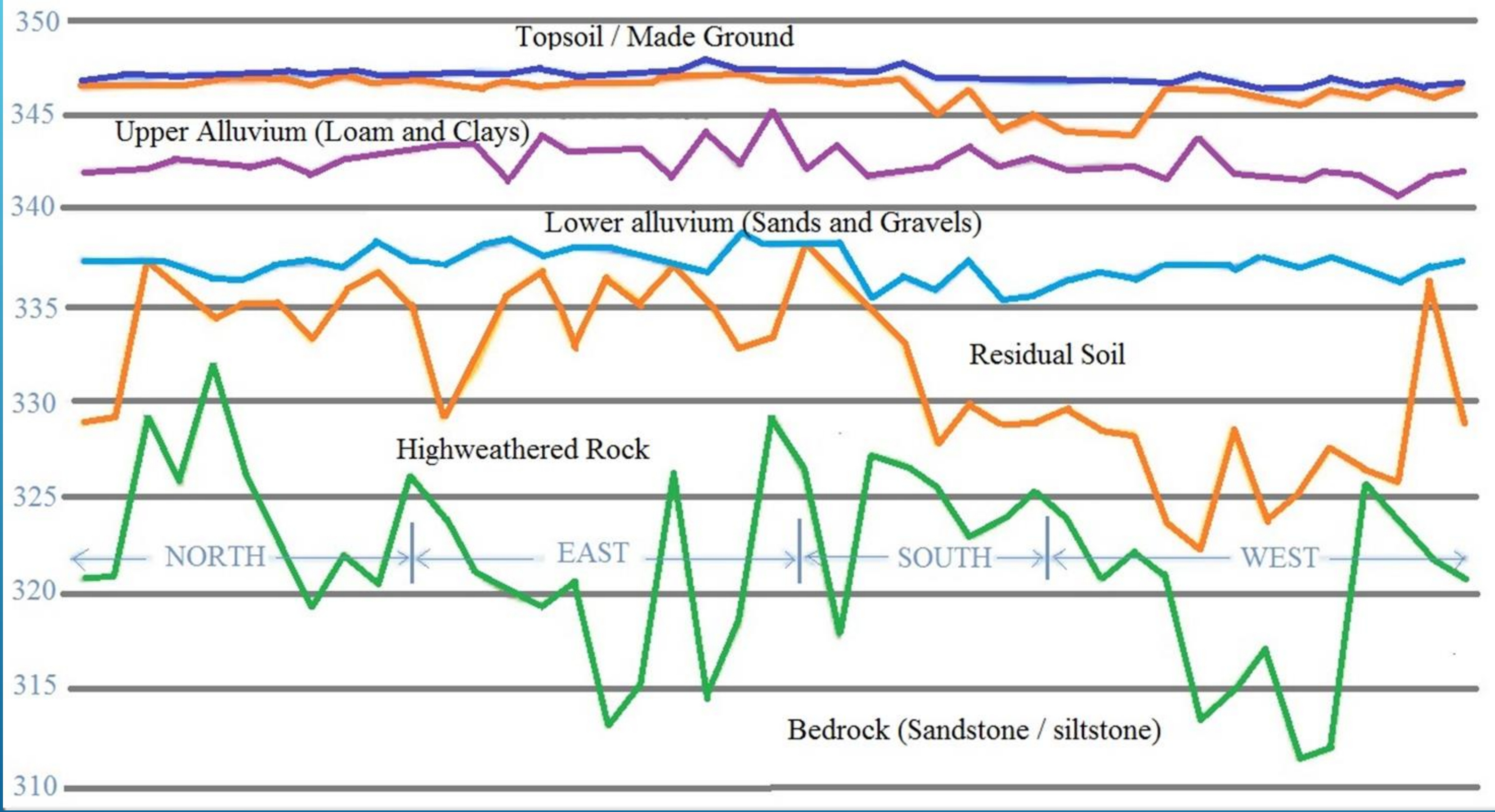


350
345
340
335
330
325
320
315
310
Topsoil / Made Ground
Upper Alluvium (Loam and Clays)
Lower alluvium (Sands and Gravels)
Residual Soil
Highweathered Rock
NORTH
EAST
SOUTH
WEST
Bedrock (Sandstone / siltstone)


09/11/2013

To confirm that the piles can withstand the weight of the proposed buildings, KGS company has conducted a number of pile tests, including 7 BDSLT (Bi-Directional Static Load Test) of piles with diameters 1000 mm, 1200 mm and 1500 mm, as well as cross hole logging test of 144 piles, integrity testing with the PIT method – 400 piles and a borehole diameter measurement for 151 piles.

After the completion, Abu Dhabi Plaza will become the tallest building in Kazakhstan and Central Asia, and the height of one of the blocks of the complex will be 320 meters.

The architectural concept is shows in Figure 2, which represents the construction site - in the Centre of which a skyscraper should rise.

This grandiose skyscraper will be the fourteenth tallest building in the world. The architect of the project is famous British architect Norman Foster.

Abu Dhabi Plaza is a High-rise buildings with a retail and leisure podium and a hotel cluster at the base that rises to form a series of office and residential towers to the north - creating a new landmark on Nur-Sultan's skyline.

Project of Abu Dhabi Plaza

Table 1 Geotechnical soil parameters

Soil	Clay / Loam	Sand & Gravel	Loam & Clay	Rock Debris	Sandstone	Hard Sandstone
Thickness (m)	4.0	4.5	5.5	1.5	2.0	Below
Natural Unit Weight Υ (kN/m³)	18.5	19	18.5	20.5	23.5	24.0
Internal Friction Angle φ' (°)	25	35	26	35	38	38
Cohesion c' (kN/m²)	1	1	30	1	40	50
Modulus of Elasticity E (MPa)	15	25	30	50	65	100
Permeability k, (m/day)	1x10E-5	1x10E-2	1x10E-5	1x10E-2	1x10E-5	1x10E-5

THE ANALYSIS OF THE DEFORMATION OF THE BASE FLAC3D

The analysis of the deformation of the base is based on the production of a load of its own weight of a single design in the horizontal plane of the vertical deformation, as shown below in the Figure 4.
The horizontal grillage plan is a form of a reference deformation and is used to estimate column drafts in various places.
The draft for each stage of construction is calculated using the ratio of the vertical reaction at each stage to the vertical reaction at the full design load.
The block R and the basement tile of the general basement are modelled taking into account the changes in thickness.
Model physical boundaries are set within the grid 9 to 21 and the grid from A to M. Figure 4 and Table 2 shows the settlement of the contour of the site using the program FLAC 3D.
The wind forces are based on the tower dynamic parameters, such as the natural frequency and damping of the tower. The wind loads indicated in the RWDI report were based on observational data over a 50-year period. Multiplication by a safety factor 1.4 was used to estimate the ultimate wind load.

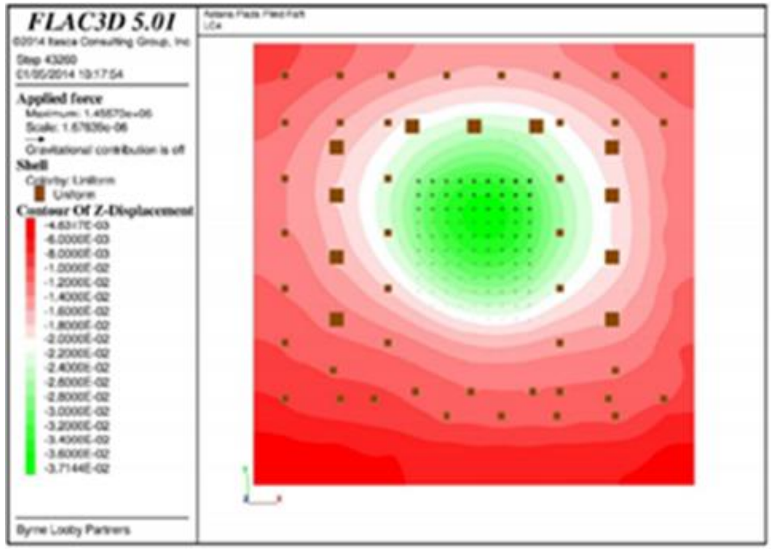
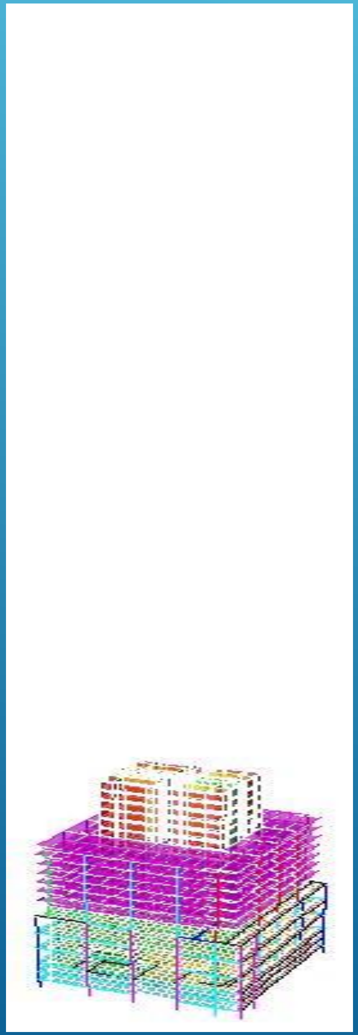
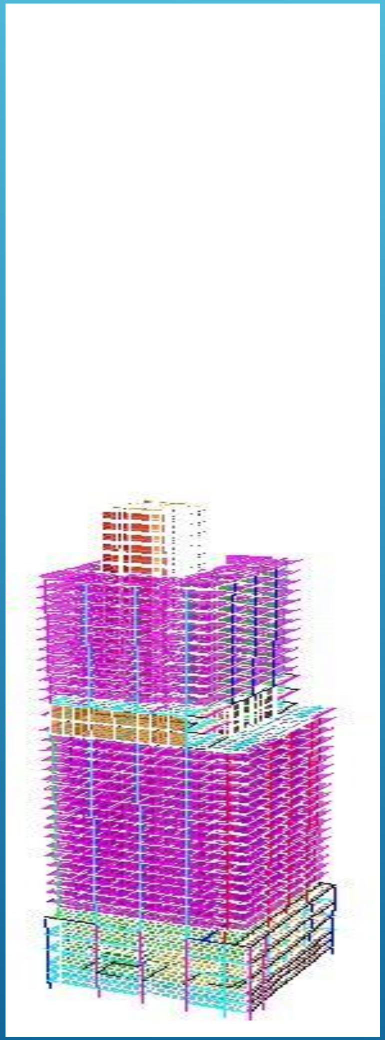
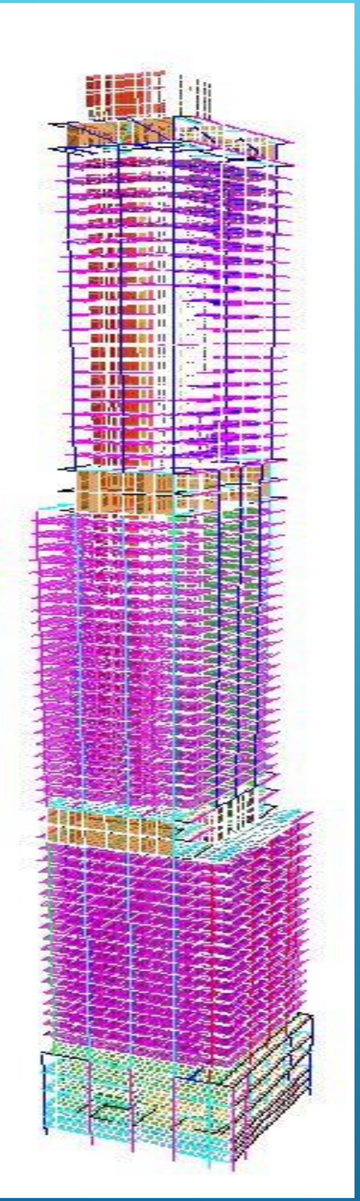
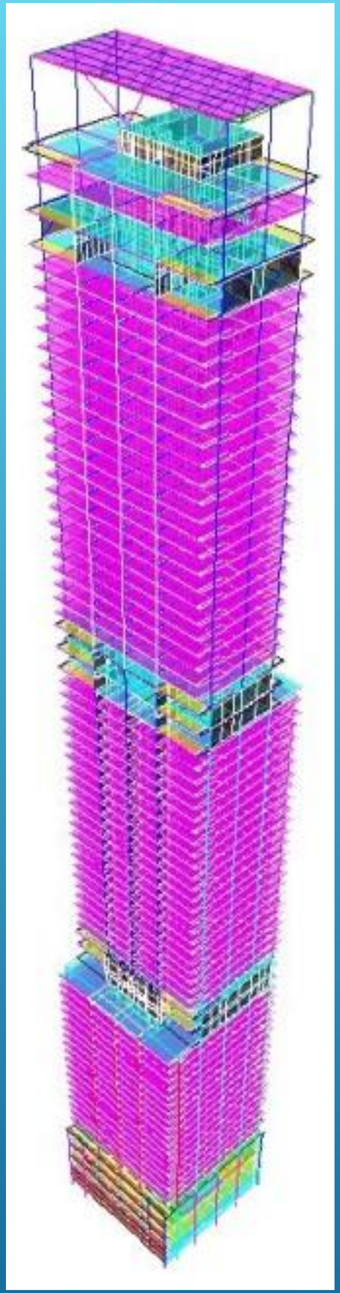


Table 2 Draft of the plate foundation under full fixed and movable loads

Location:	**Model (with software program FLAC 3D)**
Core of the building (core) (Block R)	37,4 mm
Column RC1 (Block R)	14 mm
Uneven settlement (Block R)	23,4 mm

The tower's wind loads fluctuate depending on wind speed, wind direction, and local effects such as swirls. The measurement of the wind shield for comparison with the model is not suitable, and will not provide any meaningful information for the purpose of building evaluation. Nevertheless, the effect of the measured wind speed and direction is considered when comparing the results of deformation with the computational model for gravity loads. Since the design of wind loads is based on the dynamic reaction of the building, the frequency of the natural oscillation and the estimate of the damping of the tower will be measured to compare the values used to calculate the wind strength. The effect of temperature on the final model will be limited to normalize the effect on the measured data. Recorded ambient temperatures at the time of measuring the settlements of the tower are necessary to ensure the normalization of the results. The measured data must be collected in order to minimize the effect of temperature effects throughout the tower, and also to limit the effect of localized heating, the effect of solar warm amplification, and the settlement of the sun during the day. Localized temperature control at specific work sites below the working front will be taken into account. The building models will take over the temperature of the structural elements within all the façade closed floors especially not heated to the same temperature throughout the tower. If inaccessible, an external ambient temperature sensor will be used during data collection. Structural elements in unloaded floors opened to the environment will be considered at ambient temperature during the collection of these readings. Hydrostatic pressure under the slab foundation was not considered.

Seismicity of the Region: Seismic loads are not taken into account for this project, since Nur-Sultan is not classified as an earthquake zone. Seismic risk distribution map of Kazakhstan is given in Figure 5. According to below map, Nur-Sultan is located in the region which has very low risk in terms of seismic hazard.

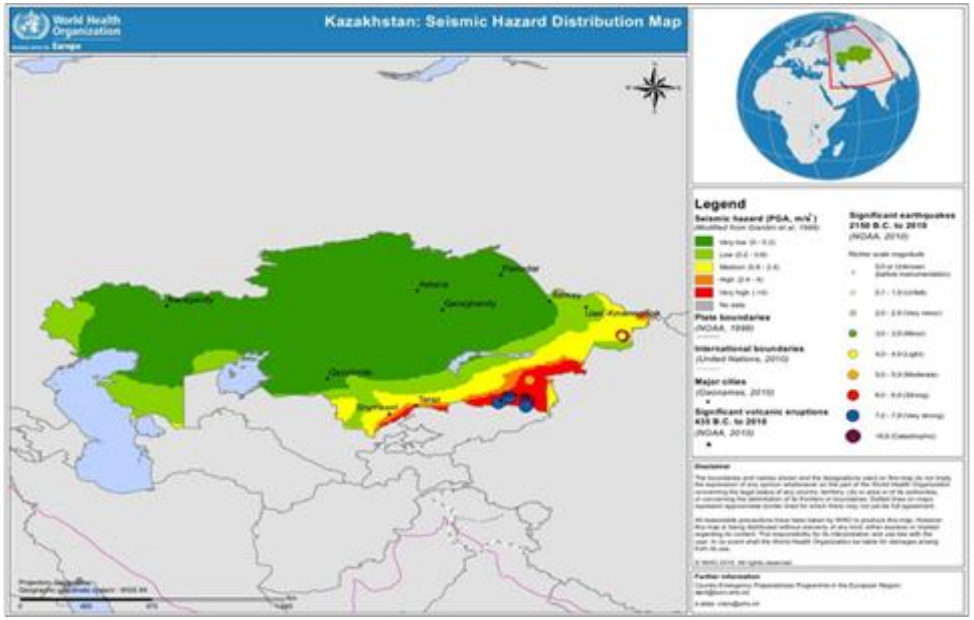
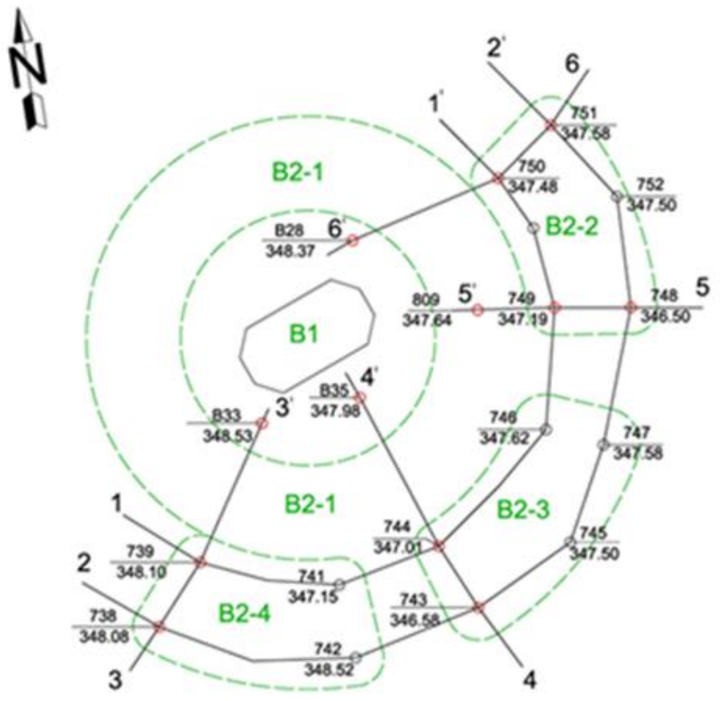


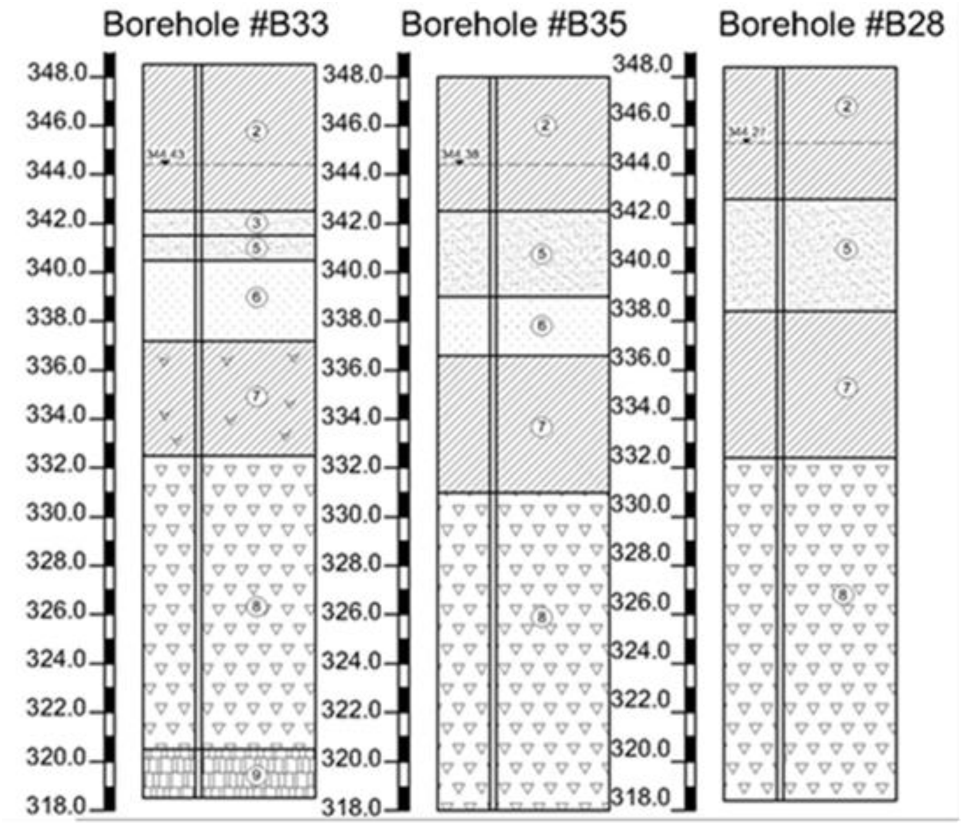
Figure 5 Seismic Risk Distribution Map

According to seismic risk distribution map, peak ground acceleration a_{max} should be taken a value between $0m/s^2$- $0.2m/s^2$ which is equal to 0.02g therefore could be ignored in structural design.

Pavilion of Kazakhstan (Sphere) is the only building in the world, which is a sphere finished form with a diameter of 80 meters. Possessing unique design features, a given shape of the building, as well as the functions of the exhibition building, it serves as a prime example of the use of renewable energy sources at the same time. The site chosen to accommodate Expo-2017 Nur-Sultan is located 8 km south of the old city of Nur-Sultan and just 4 km from the new government block on the southern bank of the Ishim River. The exhibition area with a total area of 25 hectares is surrounded by a territory of 149 hectares, intended for housing residential and mixed buildings, auxiliary exhibition facilities and transport infrastructure. The total area of the Exhibition Area is 174 hectares.

At the construction site, a complex of laboratory and field studies of the soil base was also carried out. Based on the field description of the soils confirmed by the results of cone penetration tests and laboratory tests, a division of the soils composing the site of prospecting for engineering-geological elements (EGE) in the stratigraphic sequence of their occurrence was carried out.





Number of engineering-geological element	Soil nomenclature
2	Loams
3	Sands
5	Coarse sands
6	Gravel soils
7	Loams inclusions of gruse
8	Gruse soils
9	Rock debris soils

Plan for the location of boreholes at the construction site (Build – B1)

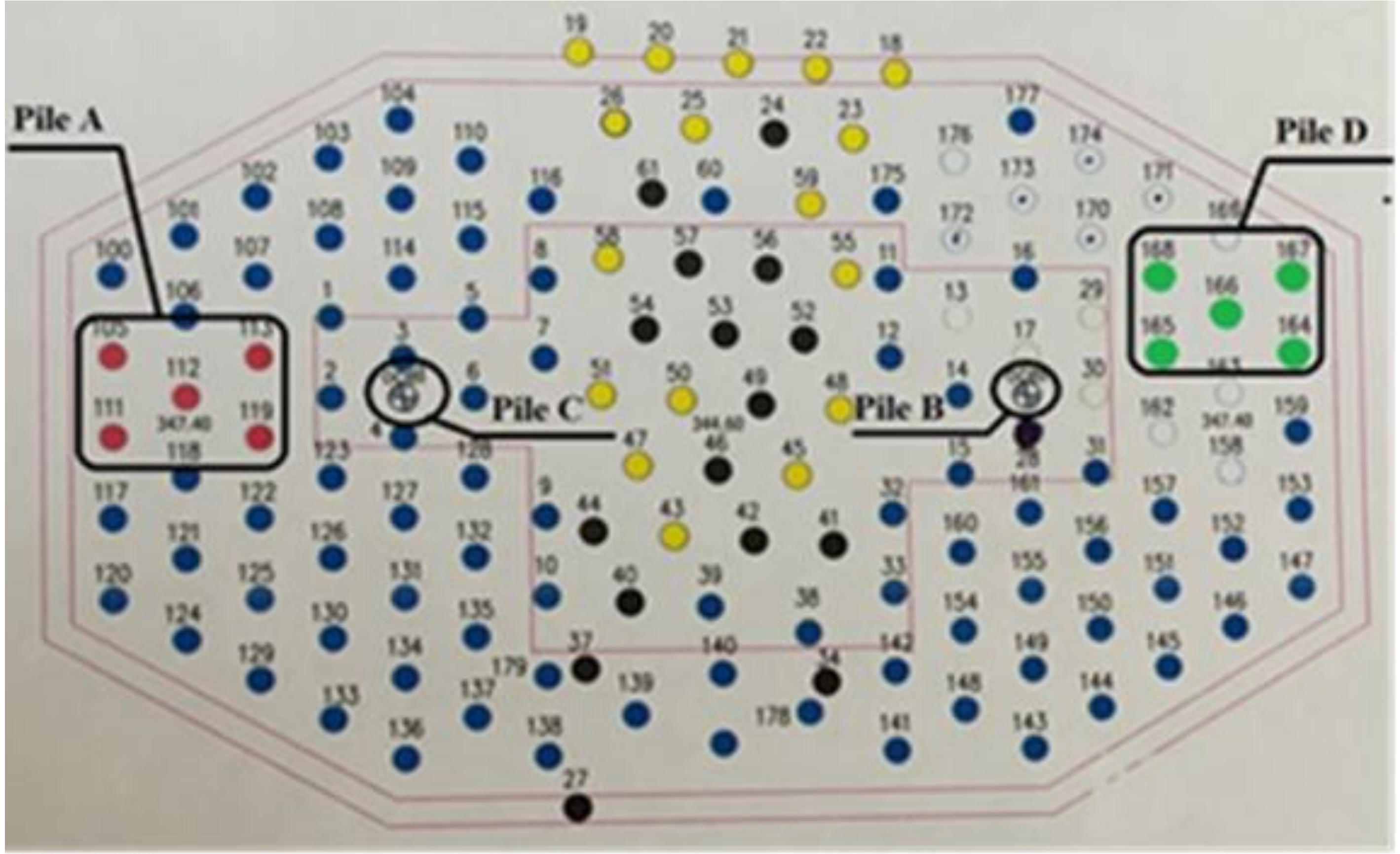
Boreholes B28, B33 and B35 cross-hole section

The physical and mechanical characteristics of the soils in Expo-2017

EGE	Soils	Design data soil soaking in natural state				
		E, Mpa	ρ, g/cm^3	c, kPa	f^o	R_o, kPa
2	Loams	12.5	1.91	38	19	-
3	Sands	17.0	1.92	2.0	35	-
5	Coarse sands	21.0	1.92	1.0	38	-
6	Gravel soils	23.0	-	-	-	300
7	Loams	14.0	2.04	27	27	-
8	Soils	36.4	-	-	-	400
9	Rock debris soils	-	-	-	-	450

Results Discussions of Pile Load Testing

Static testing with Osterberg method (O-Cell testing) was carried out for the test of deep foundations at the site of the construction of this object. Four bored piles were subjected to static tests (O-Cell testing- 2 piles and Static Compression Load Test (SCLT) – 1 pile and Static Load Test (SLT) by GOST-1 pile). The test pile was a 1000 mm diameter bore pile with 31.5m length. The target of this tests was obtaining of bearing capacity of piles on problematical soils ground of Expo 2017 using different test and standards.



Placement of tested piles according to the pile draft of Expo 2017 (B1): **Pile A** (SCLT by ASTM); **Pile B** (O-Cell-1); **Pile C** (O-Cell -2); **Pile D** (SLT by GOST)

Static Load Test (SLT) in accordance with the requirements of Kazakhstan Standard GOST

Static tests of soils for bored piles are carried out in accordance to GOST 5686-94. Test was carried out after the pile concrete strength had attained more than 80% of the design value.

Loading of the tested pile is made uniformly, without shocks, loading steps which value is set by the test program, but is accepted no more than 1/10 the greatest load, given in the program. When burying the lower ends of full-scale piles in coarse elastic rock, gravel and packed sands, and also clay soil of a solid consistence it is allowed to accept the first three steps of loading equal 1/5 greatest loadings.

At each step of loading of a production pile, take readings on all instruments for measurement of deformations in the following sequence: zero reading - before loading of a pile, the first counting - right after application of loading, then sequentially four counting with an interval of 30 min and further in each hour before the conditional stabilizing of deformation (relocation attenuation).

For criterion of the conditional stabilizing of deformation in case of test, take the speed of settling of a pile at this step of loading which isn't exceeding 0.1 mm:

-in the last 60 min observations if under the lower end of a pile sandy soil or clay soil from solid to low-plastic consistence;

-in the last 2 hours of observations if under the lower end of a pile clay soil from high-plastic to free-flowing consistence.

During the control, testing of piles during construction the maximum load should not exceed the design resistance of the pile in the material.

Unloading piles of produce after reaching the maximum load steps equal to double the value of speed of loading, with each stage of exposure of at least 15 min.

The bearing capacity of the tested piles with static vertical-pressing forces, at the above construction site, was 12000kN. It should be noted that even with a maximum test load of 12000 kN, only the elastic operation of the pile in the ground is manifested, as evidenced by a slight residual soil settlement after unloading, which is 1.4 mm. In Kazakhstan, a safety factor of 1.2 is adopted in pile design, if static load test are carried out on one pile in the construction site. Therefore, the design value of ultimate pile capacity, Qd, was estimated to be Qd= 12000/1.2=10000 kN.

Pile Static Compression Load Test in accordance with the requirements ASTM

Static compression loading testing was carried out in accordance to ASTM D 1143.

Vertical static loading of piles using the SCLT method is one of the most widely used field test methods for soil used to analyze pile-bearing capacity. In the first cycle, the experimental pile was loaded to 100% of the design load, in the second cycle to 200% (12 000 kN). The holding time of intermediate loading stages was 30 minutes, unloading - 20 minutes. The time for maintaining peak loads was 120 and 240 minutes, respectively.

The test pile was a 1000 mm diameter bore pile. the static load test is performed as per ASTM D1143. Test pile up to 12000 kN.

Reaction piles to be used No.164, 165, 167, 168. Reaction Piles Length: 31.5m and cross-section 1000mm. Tension Load per Reaction Pile 12000/4=3000kN. Friction force: 1.0m * 3.14 - 31.50m * 75kPa * 0.75 = 5563 kN/ FS=2.0, Fall=2782 kN.

Reaction pile weight:

31.5*1.0*2/4*3.14*25 = 618kN + 2782kN = 3400kN

3400kN>3000kN;

Static top-down load test in construction site

Following results are obtained from the mentioned static compression load test preliminary test pile:

a) the maximum settlement up to 6000 kN is 2.09 mm;

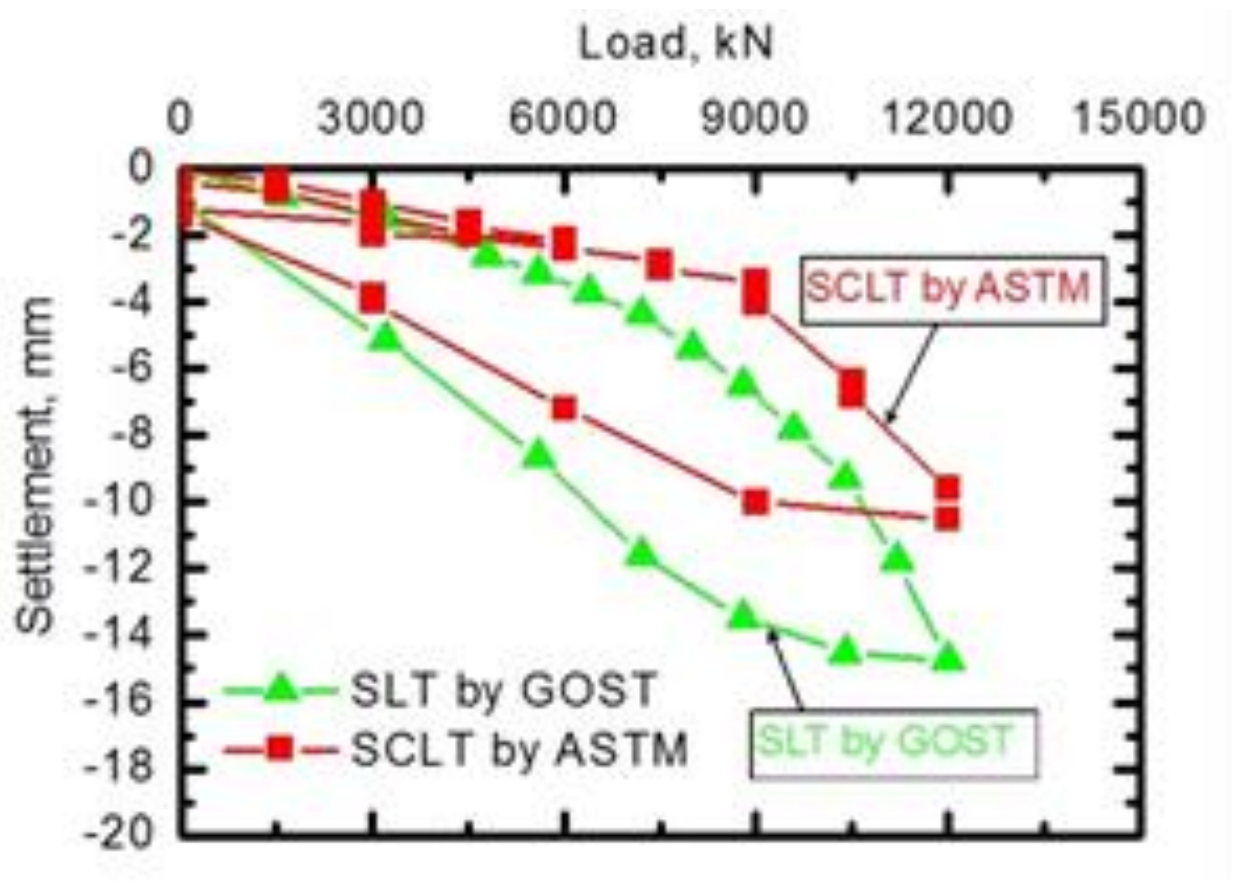
b) the maximum settlement up to 12000 kN is 10.51 mm.

The working test pile is loaded up to 200% of the working load and settlements of the pile under various load steps are recorded. Recorded settlements of 2.09mm (at 100% working load) and 10.51mm (at 200% working load) are observed to be within acceptable limits which calculated as below (1):

$$Uz = \left(\frac{PL}{AE}\right) + 0.01d$$

Uz=0.025m=25mm>10.51mm.

The Figure shows results of static compression load test by ASTM and static load test by GOST.



Results of static loading tests (methods: SCLT and SLT)

Bi-Directional Static Load Test in accordance with the requirements ASTM

Bi-Directional static tests of soils for bored piles are carried out in accordance to ASTM D8169. Bi-Directional static load tests by the Osterberg method are carried out at the pre-project stage, before the design and mass penetration of the piles begins. The method makes it possible to separately determine the bearing capacity of the ground along the tip and along the lateral surface of the pile. It is usually used for testing large or large drill or ramming piles.

When testing piles using the immersed jack, the O-cell power cell is installed directly into the body of the test pile. The power cell is a system of calibrated hydraulic jacks in a protective casing. It divides the test pile into two elements: the upper one, located above the power cell, and the lower one, located under the power cell.

The monitored load in the power cell (O-cell jack) is created by the hydraulic pressure from the oil station pump located on the surface and connected to the power cell by the oil pipe. The pressure is controlled by a precision electronic pressure gauge calibrated in the general scheme of the hydraulic system. In the process of increasing the load on the walls of the jack piston, the power cell opens. The result of this disclosure is the Settlement of the upper element of the pile upward and the lower element downward. The Settlement of the upper element is measured by rod strain gages mounted on the upper plate of the jack and by displacement sensors installed in the upper part of the steel pipe. The settlement of the lower element is measured by means of rod strain gages mounted on the lower plate of the power cell (O-cell jack).

The tests are continued until one of three conditions occurs: it will be that the limit of surface friction or lateral shear is reached; the ultimate load-bearing capacity will be reached; the maximum power of the power cell (O-cell jack) will be reached. Osterberg's method allows testing piles of large dimensions without the use of anchor piles, which reduces costs at the stage of geotechnical surveys.

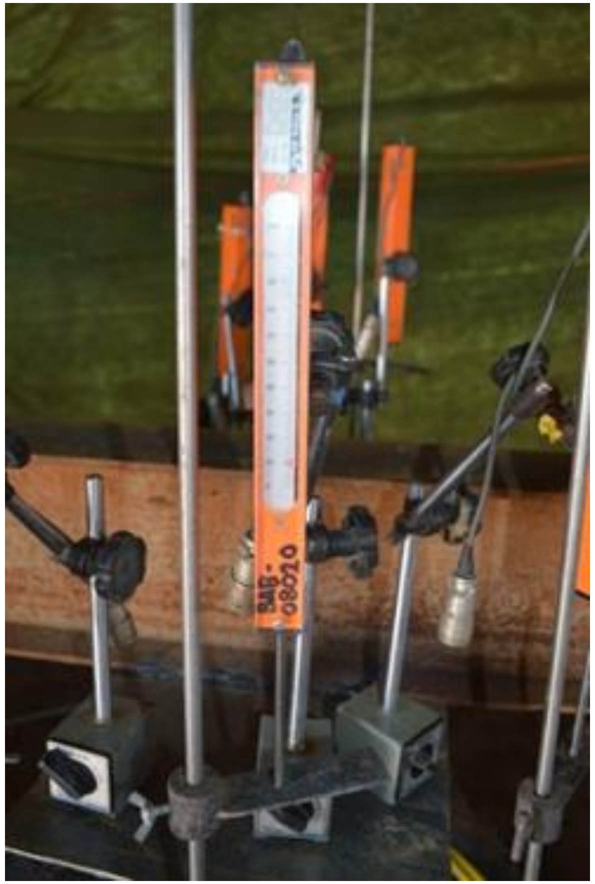
According to the results of engineering and geological surveys, bored piles 31.5 m long and 1000 mm in diameter were used as foundations. In order to control and evaluate the compliance of the bearing capacity of piles on the ground, the design loads were field static tests by the Osterberg method.

The hydraulic jack is installed at a depth of ½ the length of the pile - 16.8 m. The power cell is connected by hydraulic hoses to the hydraulic pump located on the ground surface.

When designing the O-Cell test, special attention should be paid to the study of the geotechnical structure of the soil massif of the construction site, since the location of the jack in the body of the pile depends on the accuracy of the survey data, in particular the results of assessing soil resistance. The correct decision to place the jack affects the quality of the tests carried out, since the differentiated determination of the load-bearing capacity components (along the lateral surface and below the lower end) is reduced to the correct selection of an equal ratio of the lateral resistance of the soil along the upper element to the resistance below the lower end of the lower element of the experimental pile.

Tested pile details (Bi-Directional static load test)

WL-(Working Load)	14500 kN
TL - (Test Load)	29000 kN (14500kN*2)
Reaction Type	O-Cell load test (Compression)
Hydraulic Jacks	3 (500-tonnes) hydraulic jacks
DG – (Displacement Gauges)	6 × TOKYO SOKKI Model SDP-100C 100 mm maximum stroke resistance-type displacement transducers (2 nos. for pile top, cell top and cell bottom).
PG – Pressure Gauge	GEOKON Model 4500HH-10,000 vibrating wire-type pressure transducer
SG – Strain Gauges	40 × GEOKON 4911 Sister bar strain gauges (10 levels)
Data Recording Equipment	1 × DATATAKER Model DT515 data logger (for pressure and displacement) 1 × DATATAKER Model DT80g data logger (for Sister bar strain gauges)
Data Recording Intervals	1 minute



Bi-Directional static load test in construction site

Results of field trials using the Static Load Test and Osterberg methods

Figure 7 shows a comparison of the test results: the "load-sludge" curve obtained by the SCLT method and the equivalent "load-settlement" curve determined by the O-cell method.

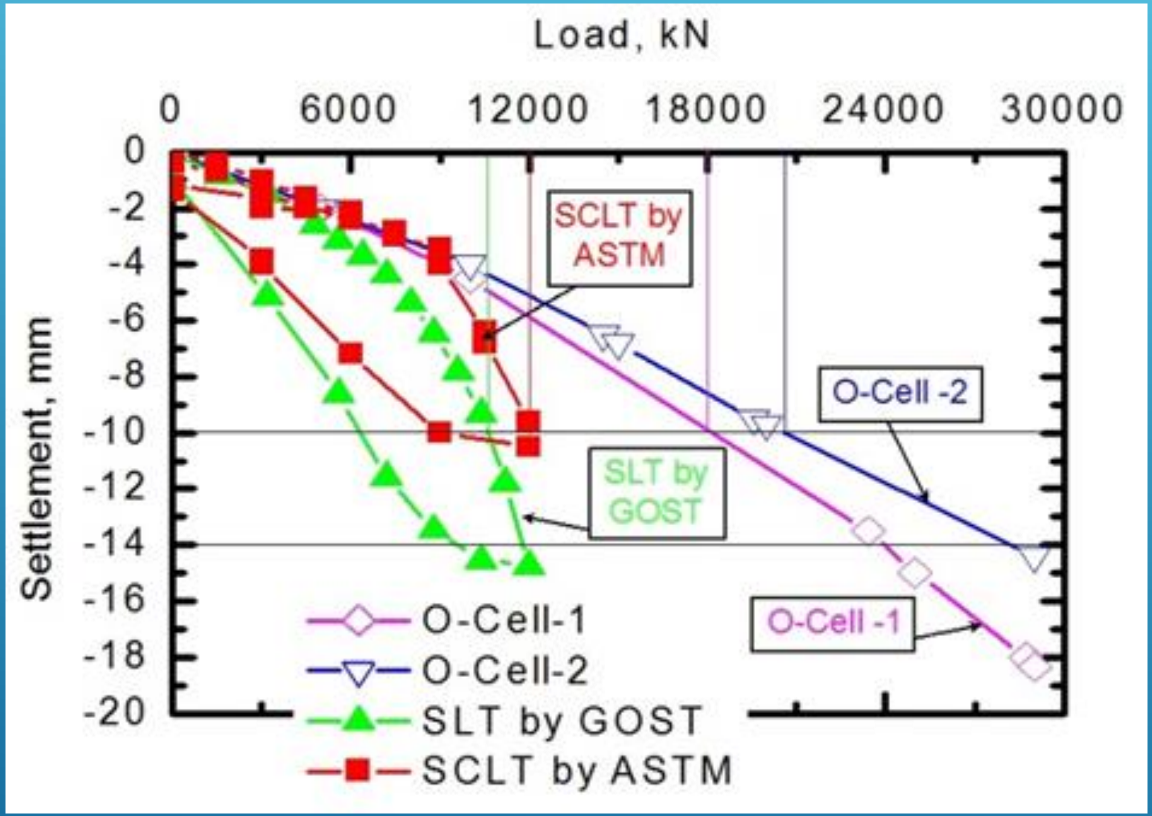
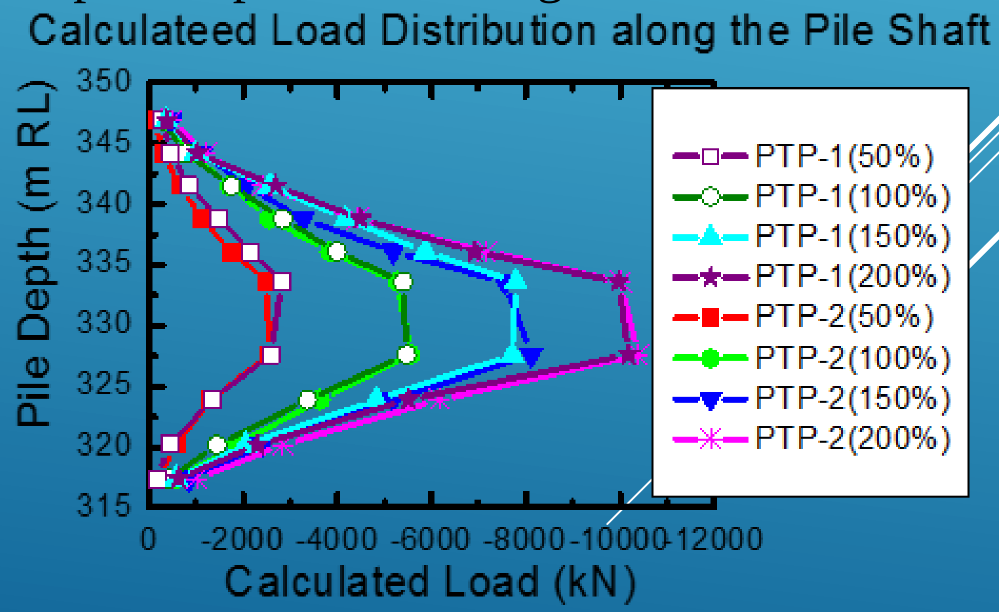


Figure 7 – Comparison of test results carried out by SCLT, SLT and O-cell methods

The figure 7.1 shows the results of strain-measuring transducers. This figure 7.1 presents the load distribution along the length of the piles. The graph shows that even at maximum load, the pile is kept by lateral resistance of the subsoil. Only a small part of the load accrues to the pile edge. The indicators of lateral resistance of the pile on the depth are presented in figure 7.1.



7.1 Calculated load distribution of piles (PTP-1 and PTP-2)

Results of field trials using the Static Load Test and Bi-Directional Static Load Test methods

On results, tests the charts of dependence were got settings of pile from loading and change setting on the stages of loading in time.

For a criterion maximum possible setting were accepted pointing regulated in SNIP RK 5.01-03-2002 - Pile foundations sub clauses:

- for the particular value of maximum resistance of pile Fu the pressing loading is necessary to accept loading under act of that the tested pile will get setting, equal S and determined on a formula (2):

$$S = \zeta S_{u,mt}$$

where $S_{u,mt}$ - maximum value of middle settings of foundation of the designed building or structure, for productive and civil one-story and multistory building with complete framework a 8cm (for reinforce-concrete constructions) is accepted by equal on pointing of SNiP RK 5.01-01-2002 – Bases and foundations;

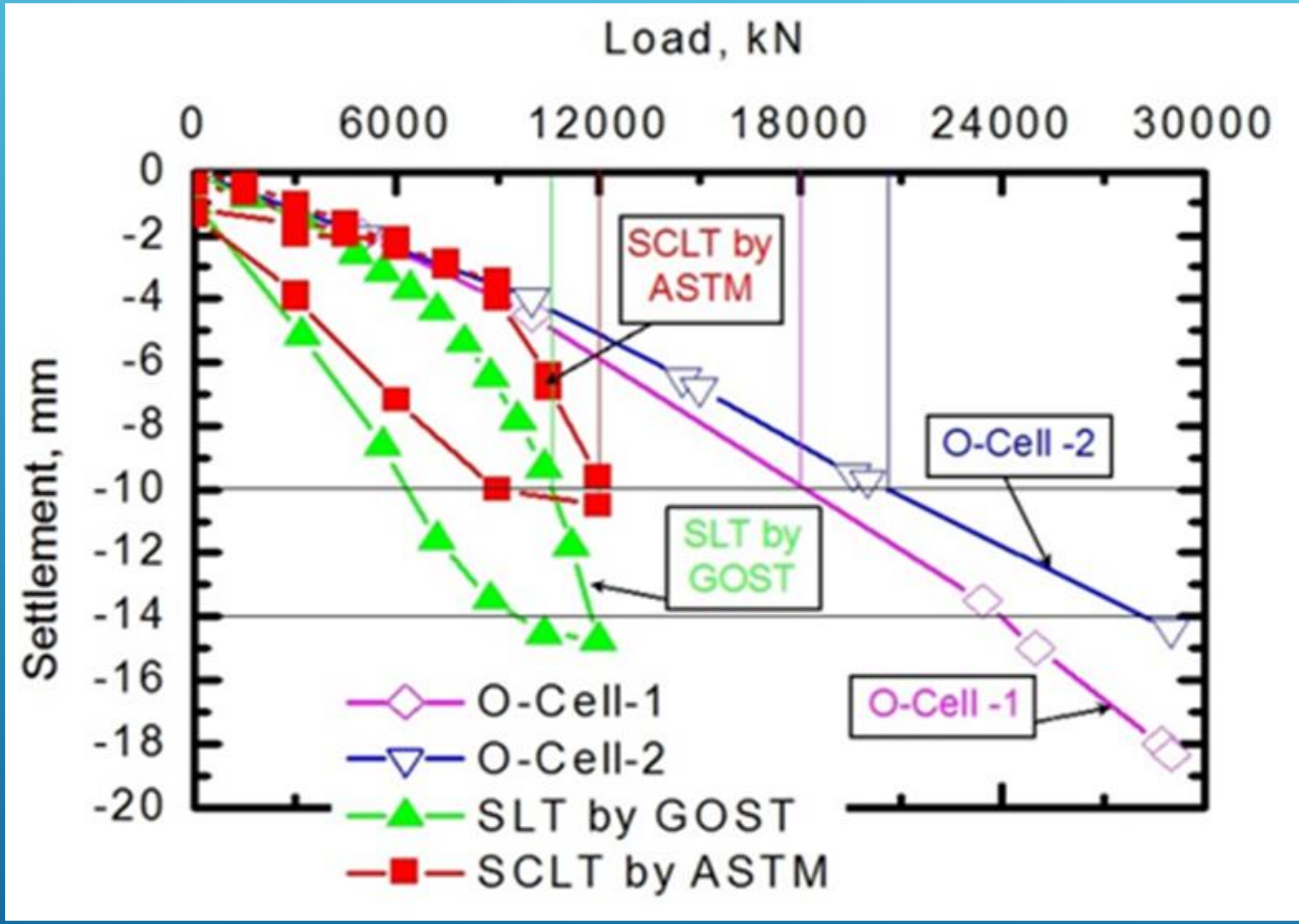
ζ - transition coefficient from a maximum value of middle settings of foundation of building or structure Su, mt to setting of the pile got at static tests with the conditional stabilizing (damping) of settings, accepted by equal 0,2 on pointing (by MSP 5.01-101-2003).

Table presents a numerical comparative analysis of the bearing capacity of piles, obtained by different methods in this research from Figure. It is shown in this figure, a comparison of the test results graphical curve obtained by the SCLT method and the equivalent "load-settlement" curve determined by the O-Cell method. For the comparative purposes a criterion of Pile A (SCLT by ASTM), Pile B (O-Cell-1), Pile C (O-Cell-2) and Pile D (SLT by GOST), a settlement of 10mm and 14 mm has been taken to denote the similarity of load capacity for all pile. These two values were chosen base on Kazakhstan technical specification on determining the limiting value of acceptable which is given as 16mm settlement for any loading.

For the comparative criteria of Pile A (SCLT by ASTM), Pile B (O-Cell-1), Pile C (O-Cell -2) and Pile D (SLT by GOST) results fixes settlements of 10 and 14 mm had been taken.

Table 1 presents a comparative analysis of the bearing capacity of piles, obtained by different methods in this research.

ID	result fixes settlement 10 mm	result fixes settlement 14 mm
Pile A (SCLT by ASTM)	11 788 kN	-
Pile B (O-Cell-1)	18220 kN	23985 kN
Pile C (O-Cell -2)	20535 kN	28385 kN
Pile D (SLT by GOST)	10 630 kN	11814 kN



LRT (Light Railway Transport)

LRT is 100 % an overhead road (bridge) with two railway lines;

First stage of construction include - 22,4 km overhead road and 18 stations;

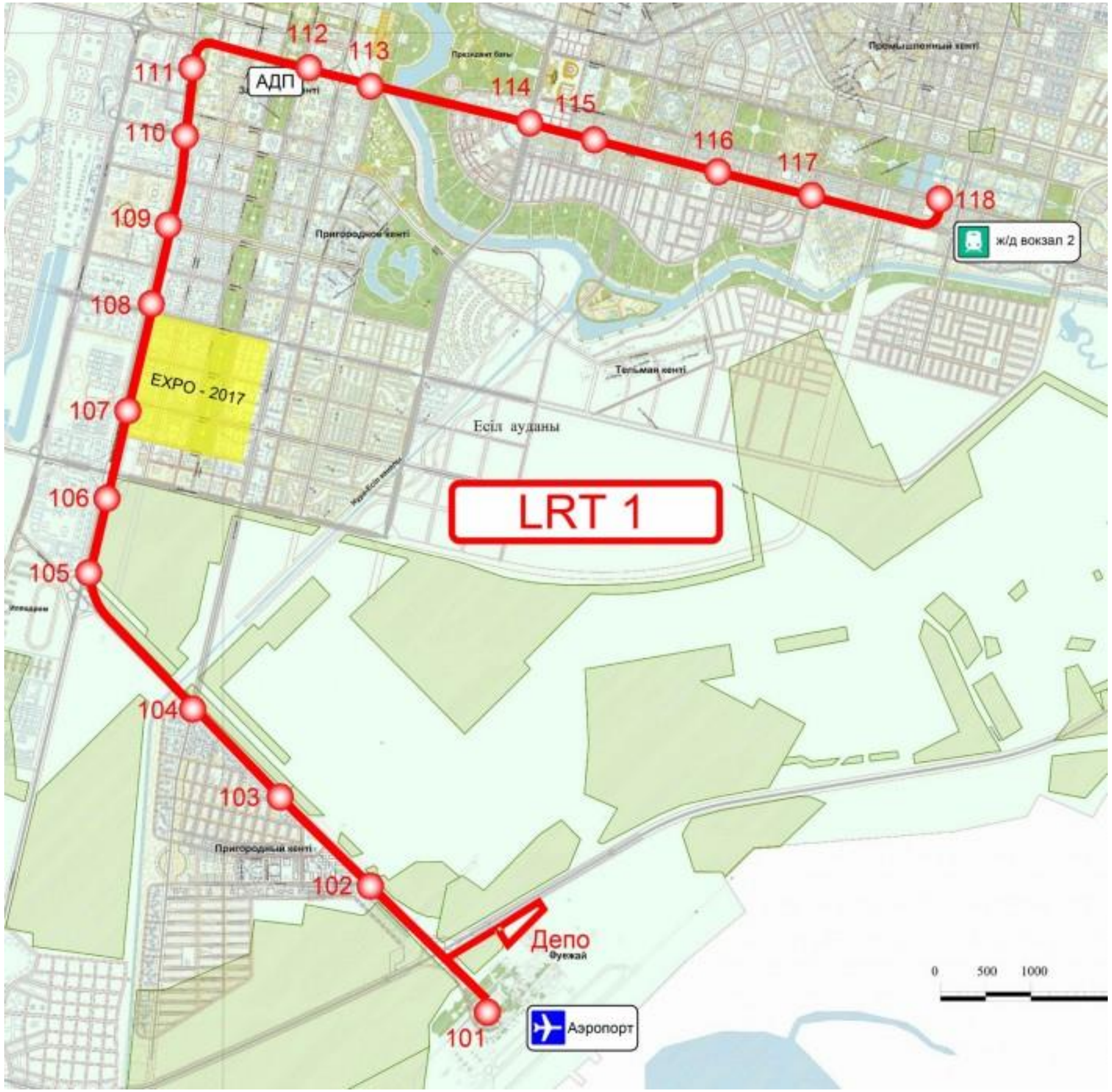
Height of the bridge is 7÷14 m above the ground;

Start construction works - spring of 2017 year;

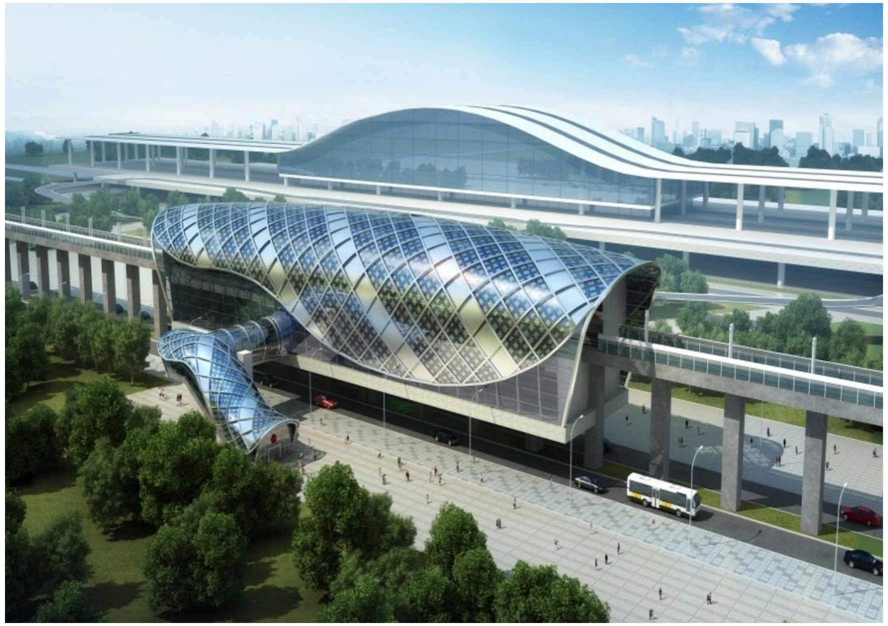
The cost of the project is about 1.9 billion dollars;

Construction work produce a Chinese state-owned company «China Railway Asia-Europe Construction Investment Co».

LRT MAP first stage





Perspective view of LRT near New Railway Station of Astana, Kazakhstan

Foundations of Overhead Road

Overhead road based on columns every 30 meters.

The foundation of each column is include 4 or 6 bored piles with cross-section 1.0÷1.5 m and length 8÷55 m.

Design bearing capacity of each bored piles is from 4500 to 12000 kN.

Foundations of Overhead Road

Overhead road based on columns every 30 meters.

The foundation of each column is include 4 or 6 bored piles with cross-section 1.0÷1.5 m and length 8÷55 m.

Design bearing capacity of each bored piles is from 4500 to 12000 kN.

In these conditions, very important to control integrity of concrete body of each bored piles.

For checking integrity of bored piles applying two methods:

- Low Strain Method

- Cross-Hole Sonic Logging.

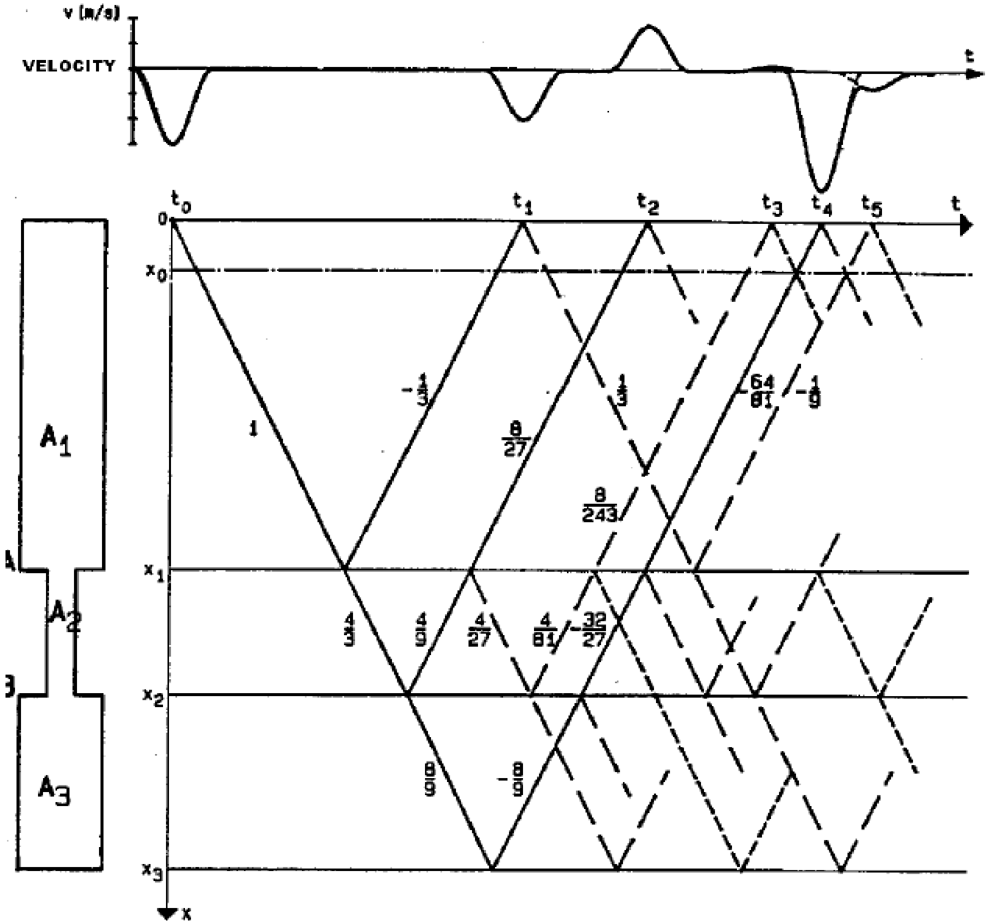
Low Strain Method

To perform this test, a sensor (usually accelerometer) is pressed against the top of the pile while the pile is hit with a small hand-held hammer. Output from the sensor is analyzed and displayed by a suitable computerized instrument, the results providing meaningful information regarding both length and integrity of the pile.

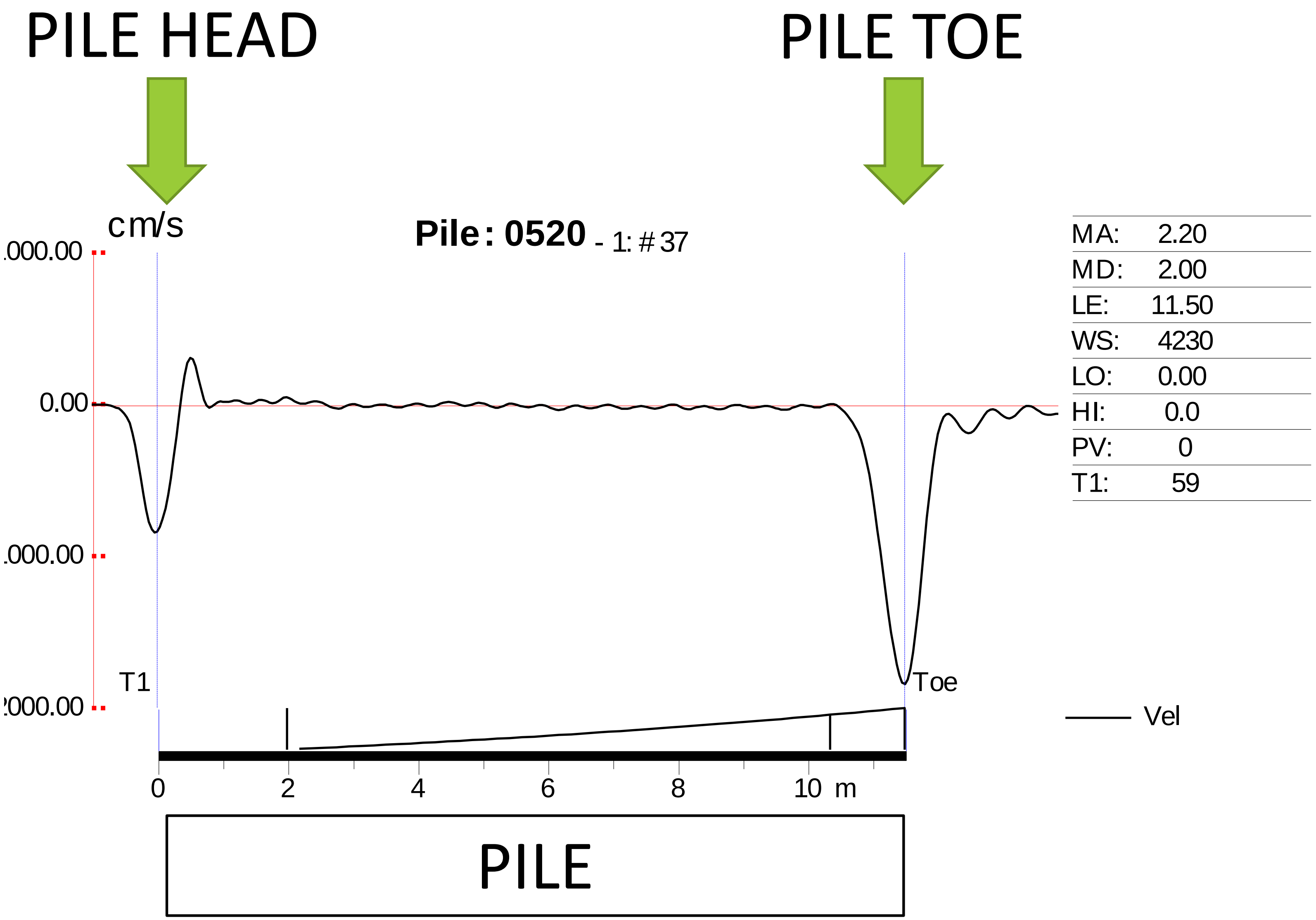
PILE INTEGRITY TESTER SIT
(Profound BV, NETHERLANDS)

PILE INTEGRITY TESTER - PIT-QV
(PILE DYNAMICS INC., USA)

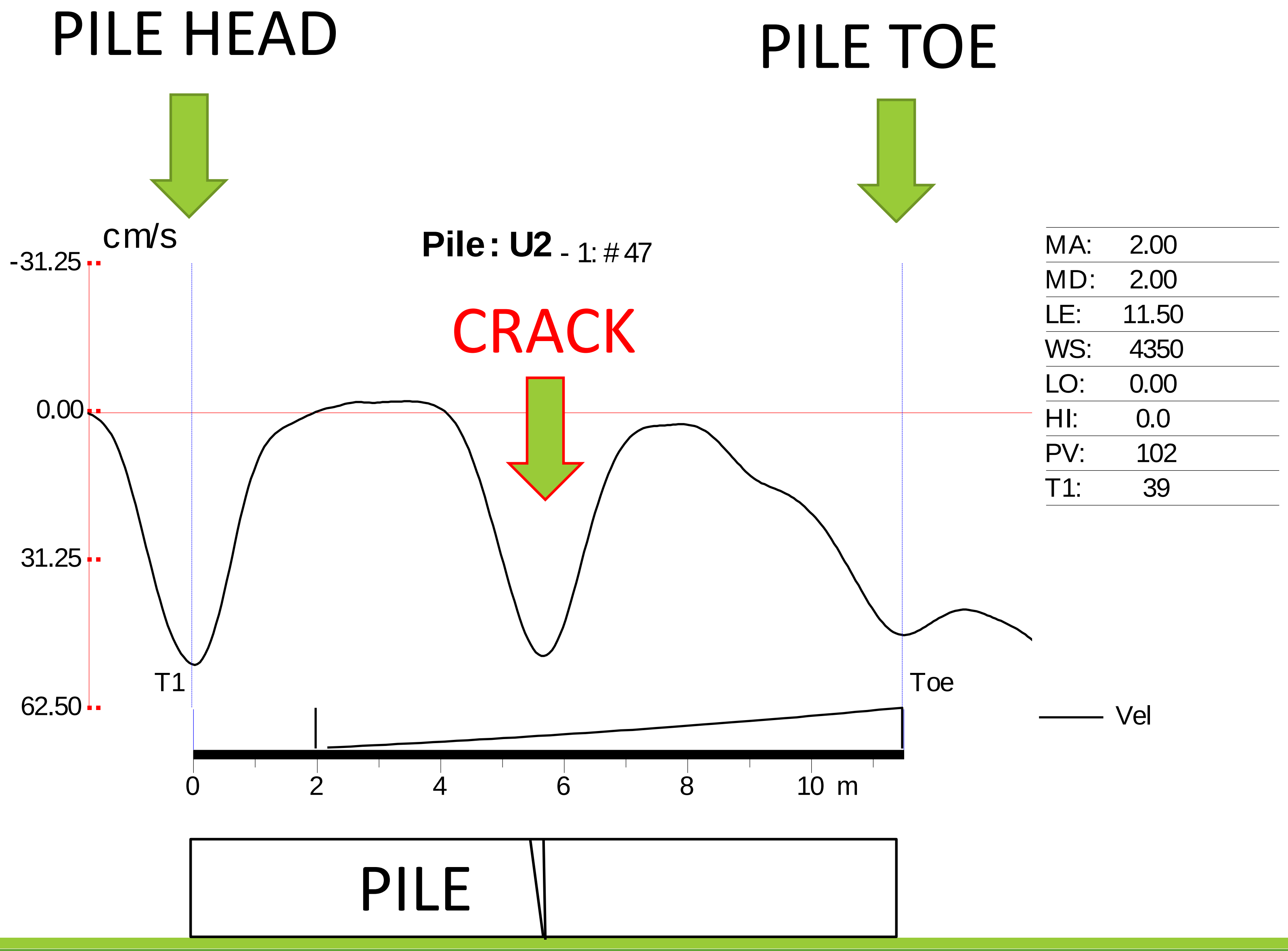
Schematic diagram for a rod with a reduced cross-section



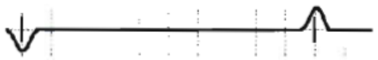
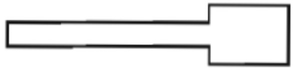
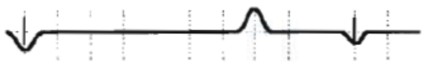
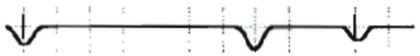
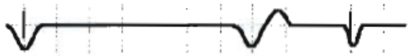
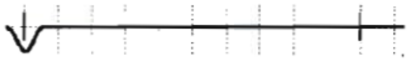
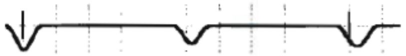
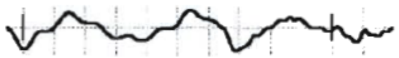
Results of PIT – “good” pile



Results of PIT – “bad” pile



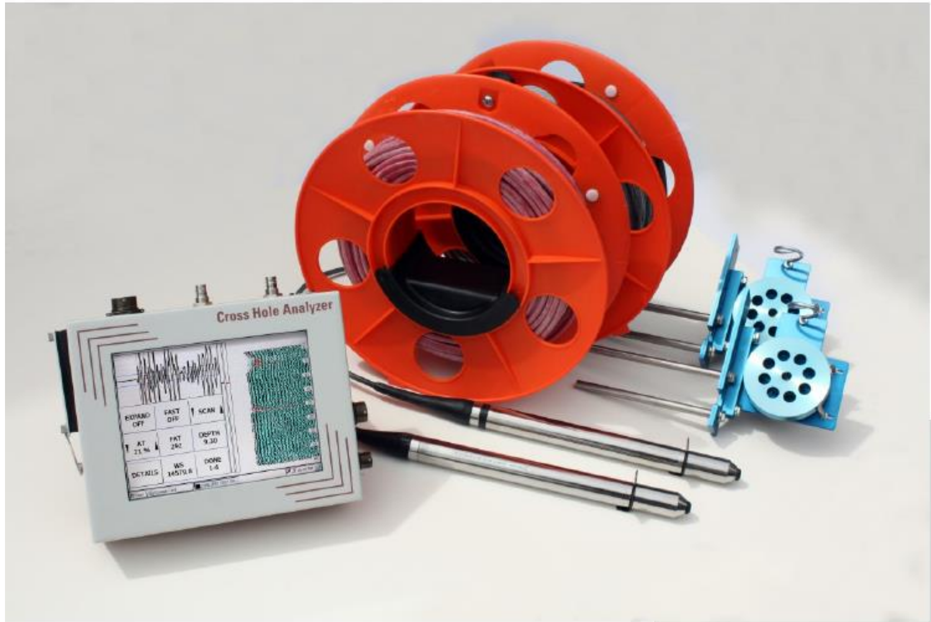
Typical Pile Profiles with Respective Reflectograms

PILE PROFILE	DESCRIPTION	REFLECTOGRAM
	Straight pile	
	Straight pile	
	Straight pile	
	Increased	
	Decreased	
	Locally	
	Locally	
	High L/D ratio	
	Multipole reflections from	
	Irregular profile	

Cross-Hole Sonic Logging

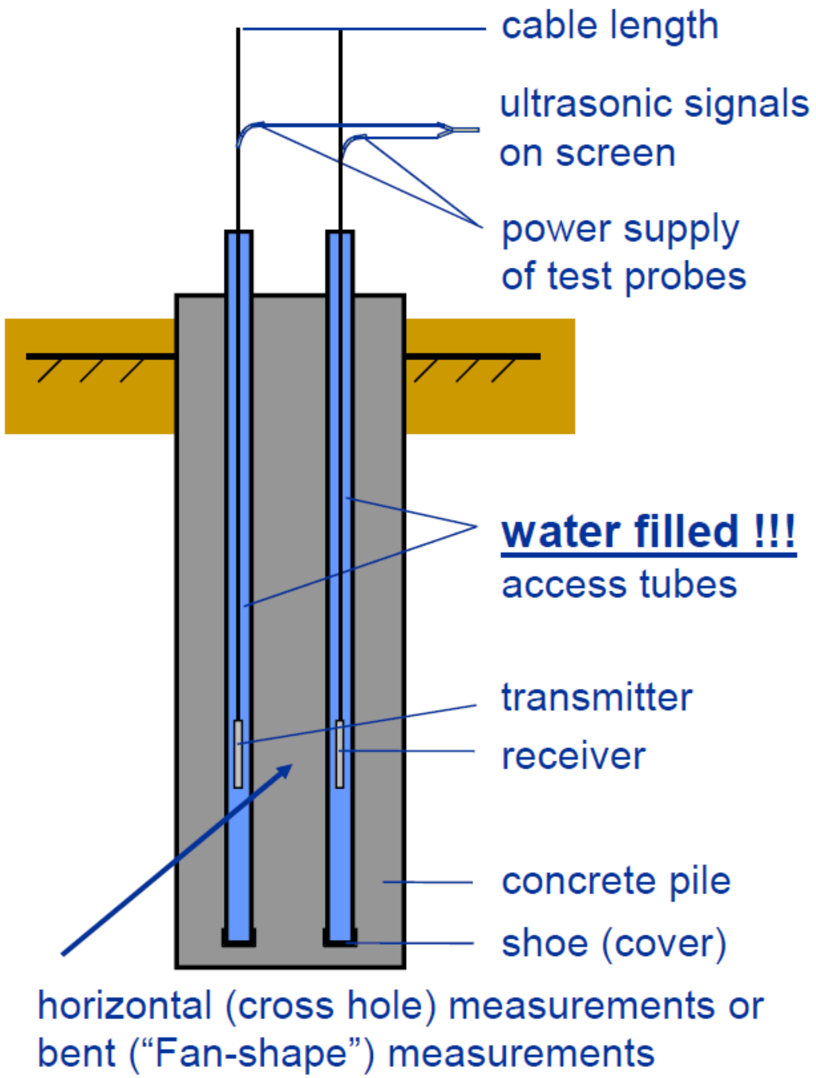
Sonic logging is intrusive and necessitates the prior installation of access tubes (usually two or more) in the pile. Before the test they have to be filled with water (to obtain good coupling) and two probes are lowered inside two of the tubes. One of these probes is an transmitter and the other a receiver of ultrasonic pulses. Having been lowered to the bottom, the probes are then pulled simultaneously upwards to produce an ultrasonic logging profile. The transmitter produces a series of acoustic waves in all directions. Some of these waves do eventually reach the receiver.

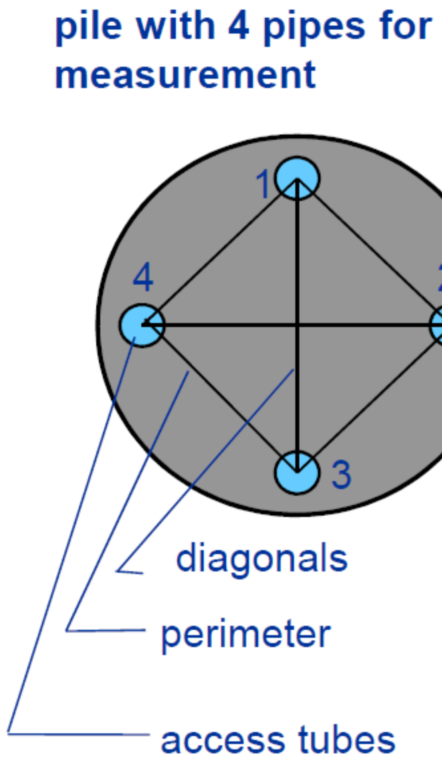
Cross Hole Analyzer
(Pile Dynamics Inc., USA)



TRANSMITTER RECEIVER

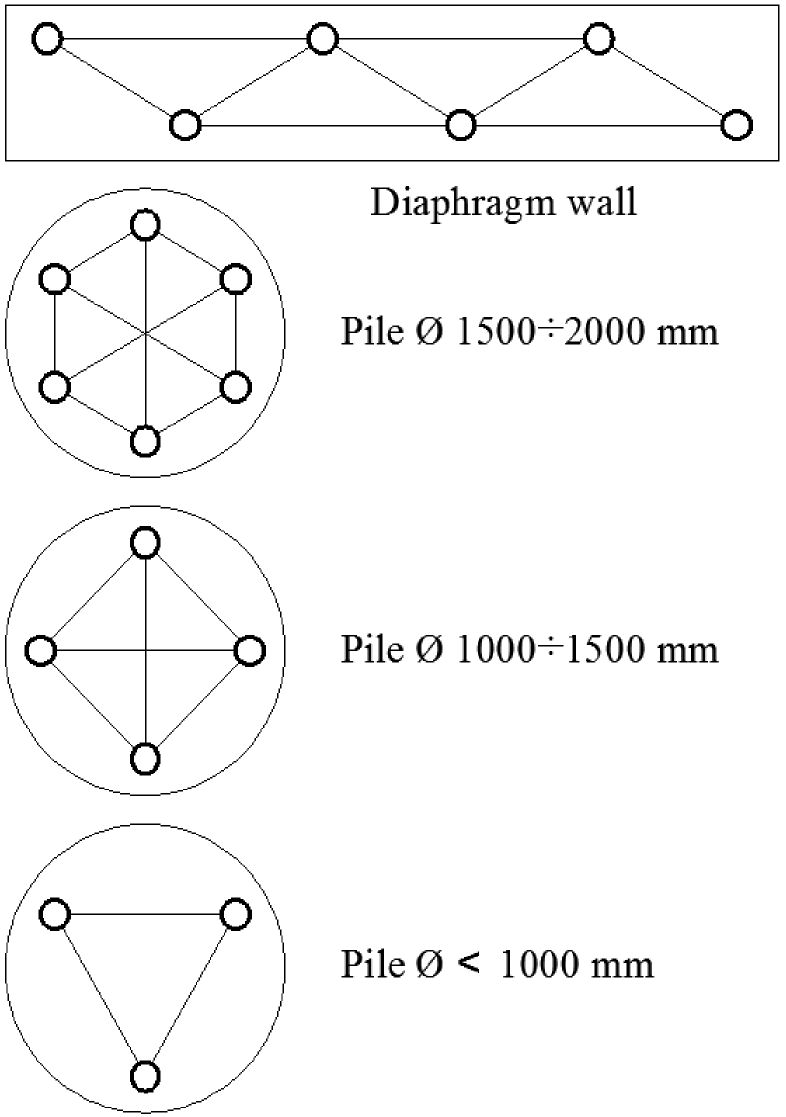
Cross-Hole Sonic Logging - Principle



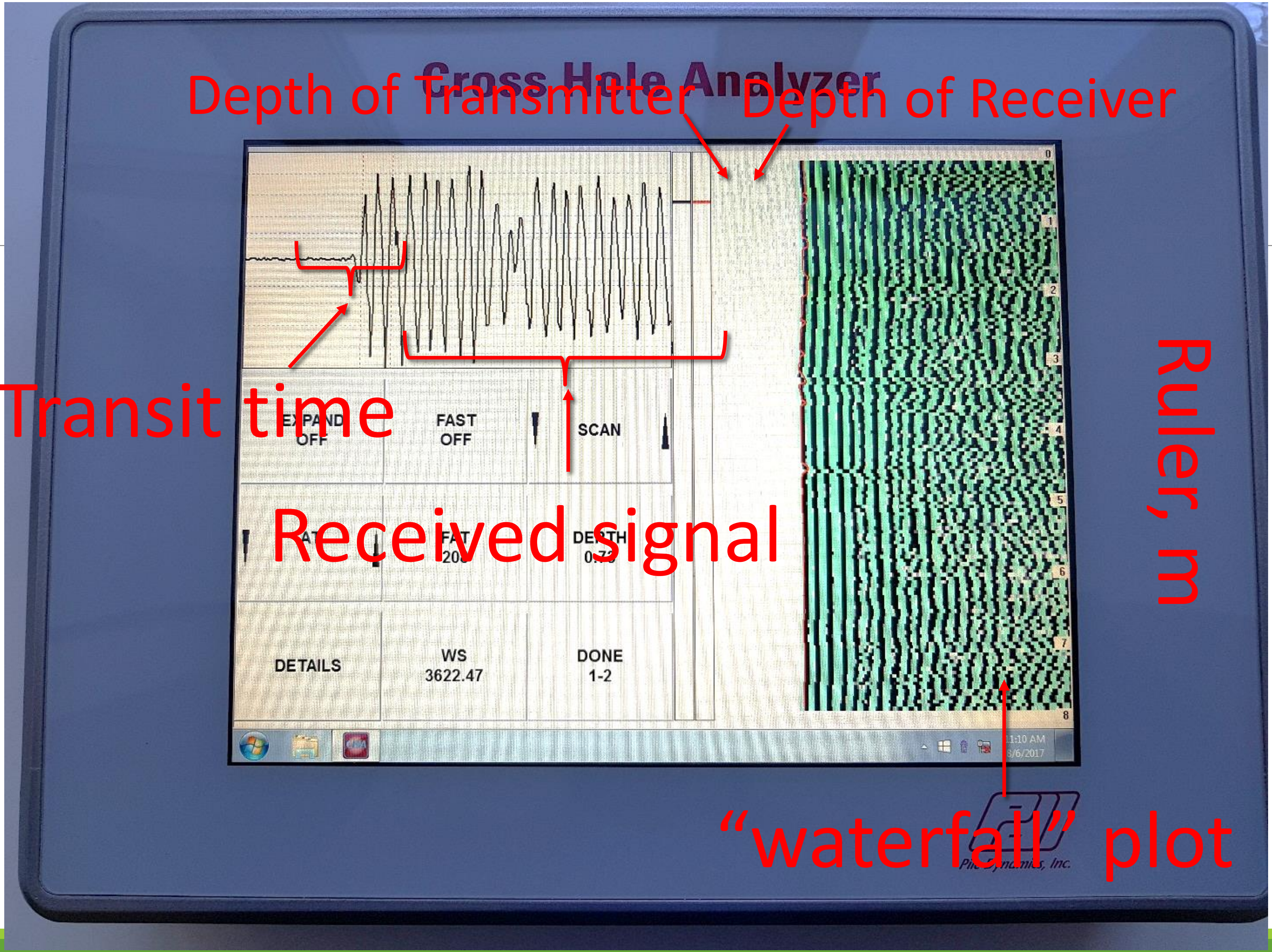


Stress Waves, emitted in one tube are received in another one if concrete quality is satisfactory

Typical Access Tube Configurations

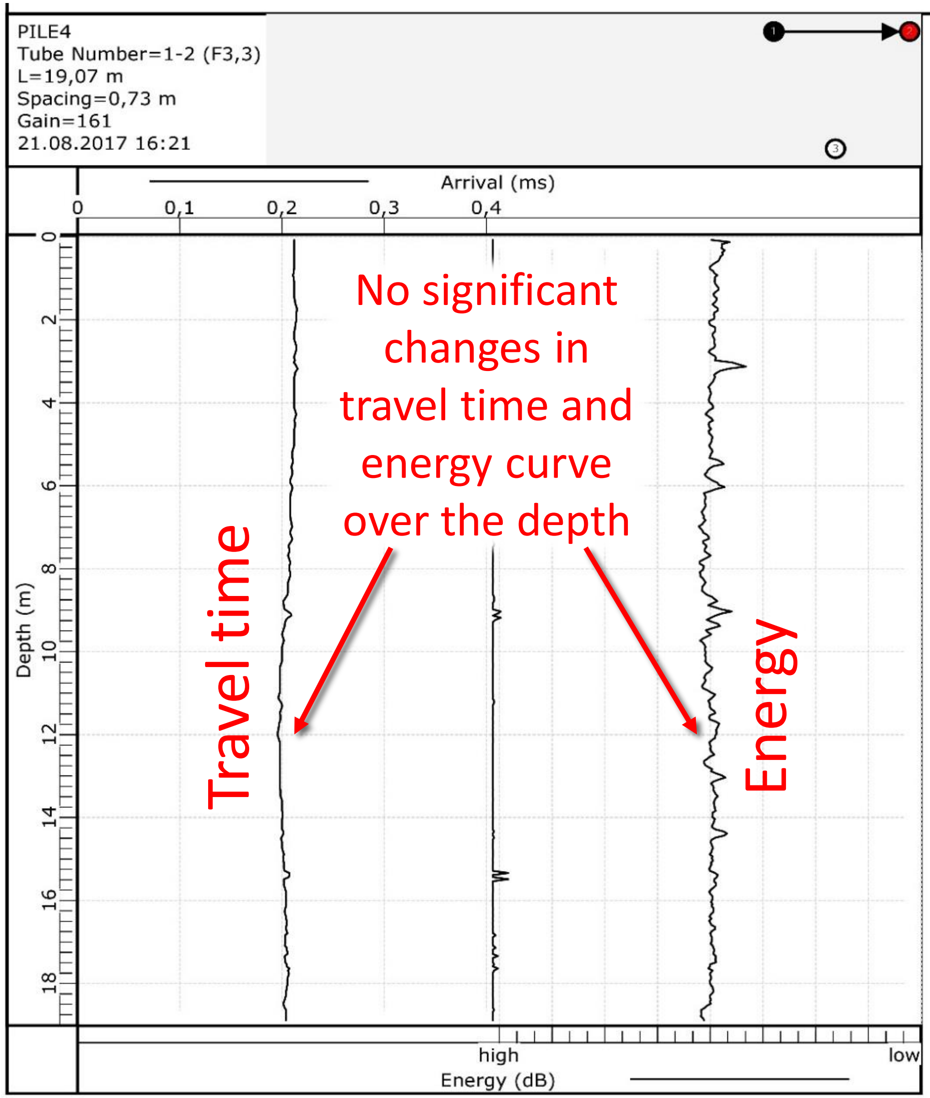


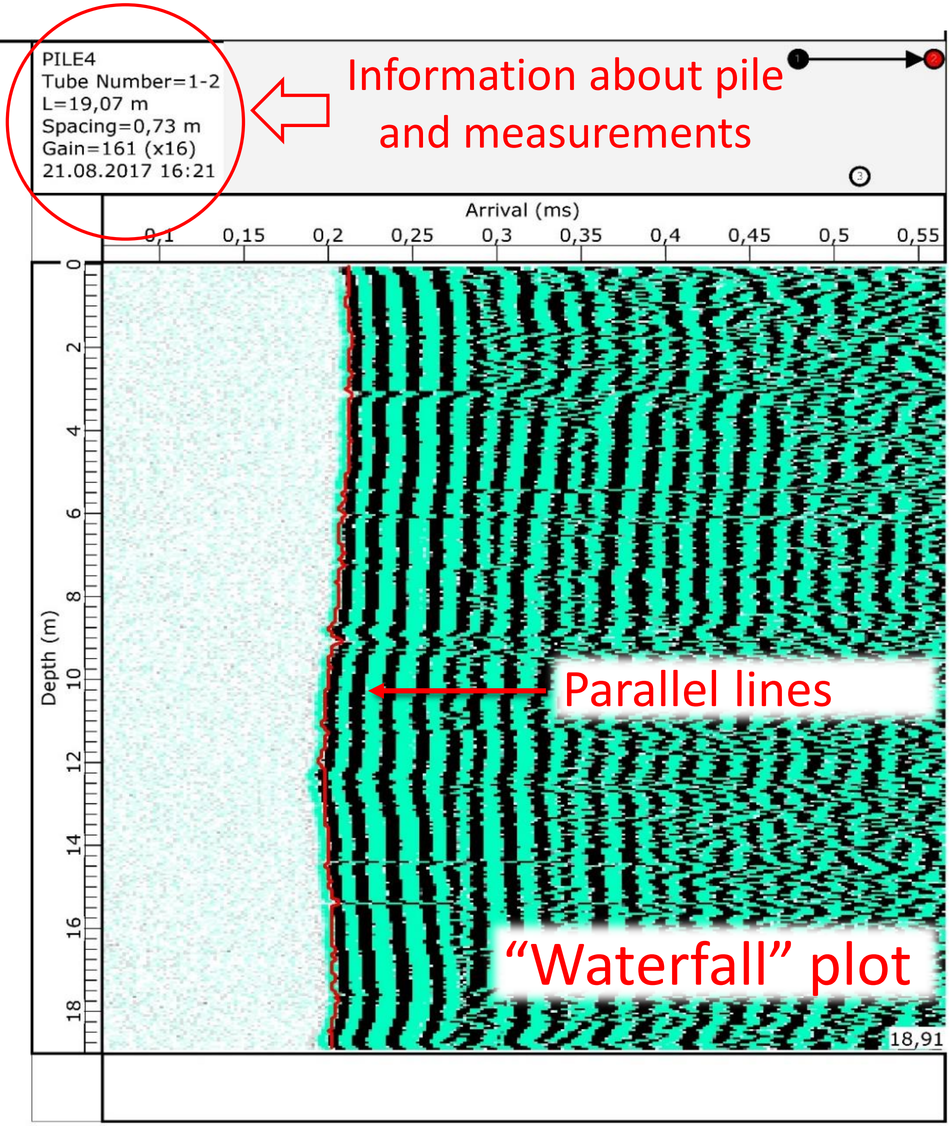

ACCESS TUBES



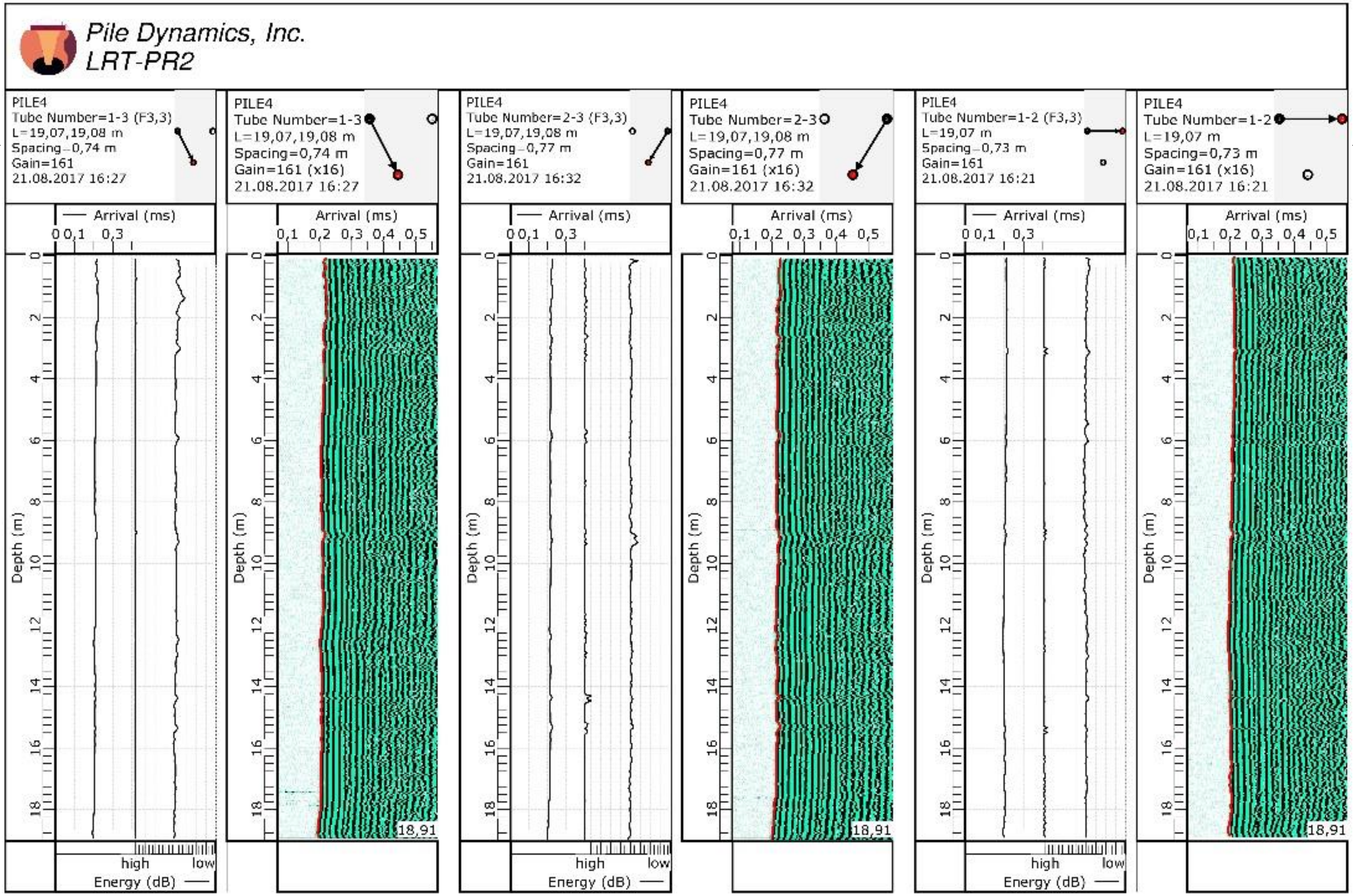
Cross Hole Analyzer
Depth of Transmitter
Depth of Receiver
Transit time
EXPAND OFF
FAST OFF
SCAN
Received signal
DETAILS
WS 3622.47
DONE 1-2
Ruler, m
"waterfall" plot
Pile Dynamics, Inc.

Results of “good” pile

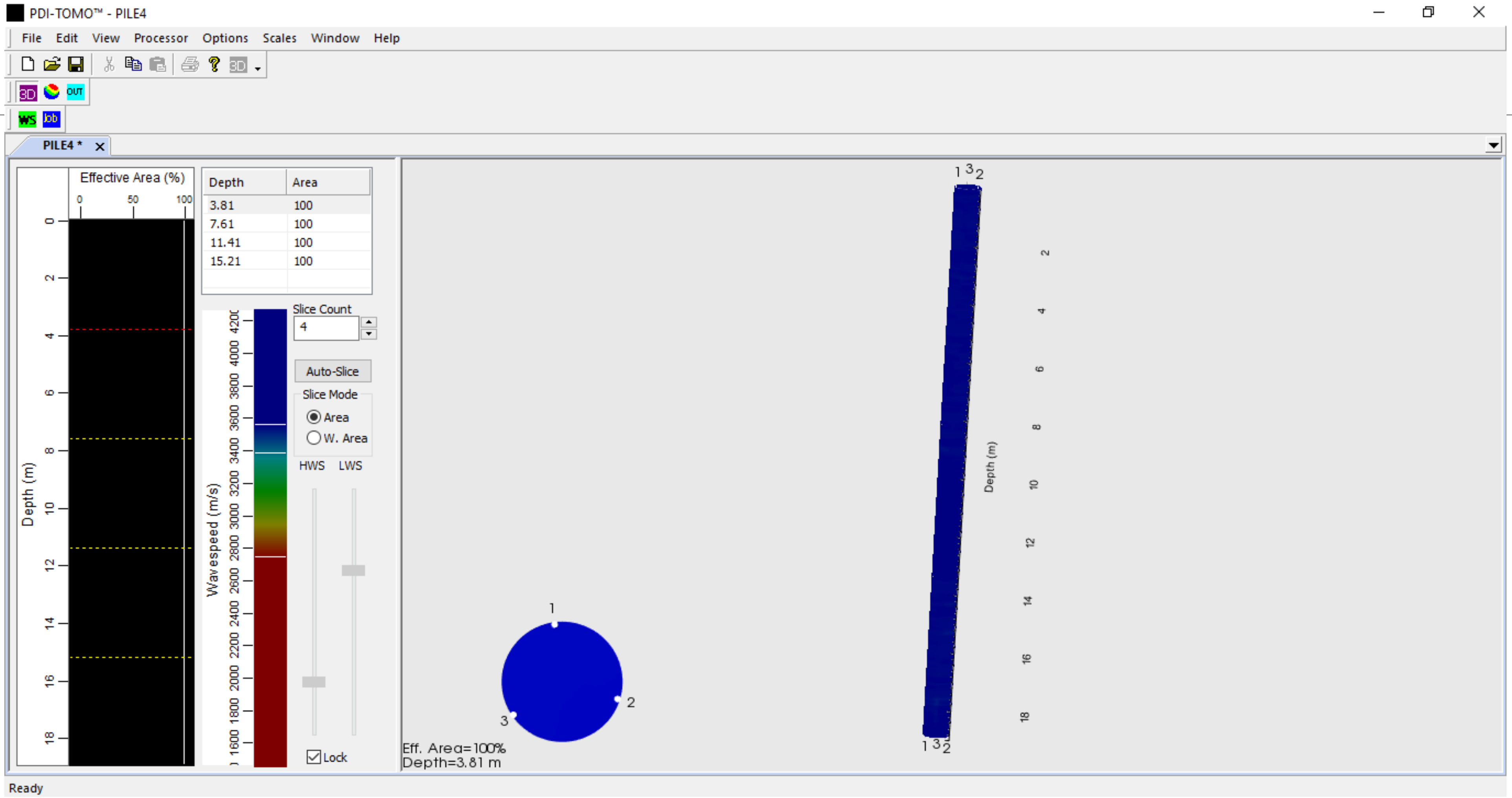




Results of “good” pile

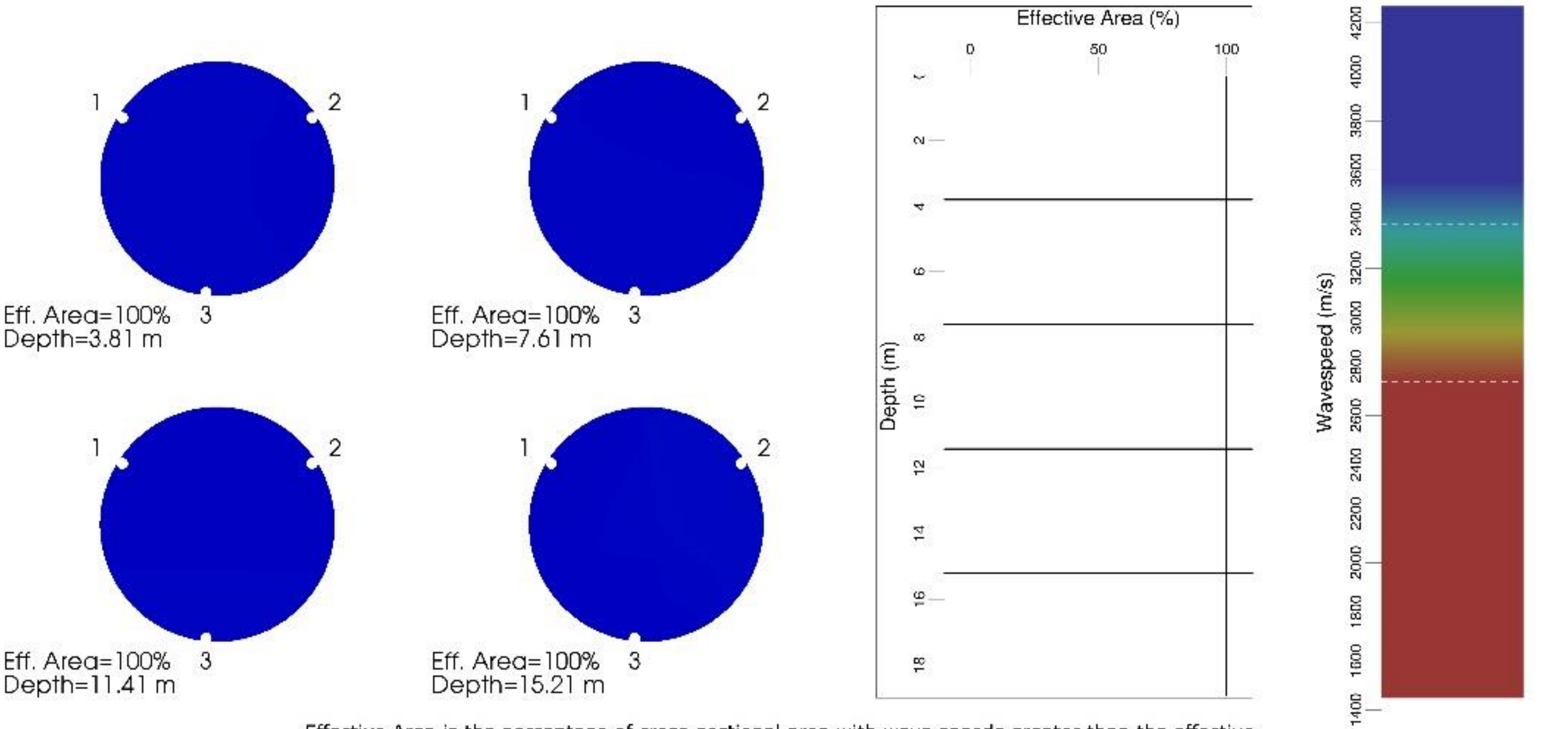


Results of "good" pile



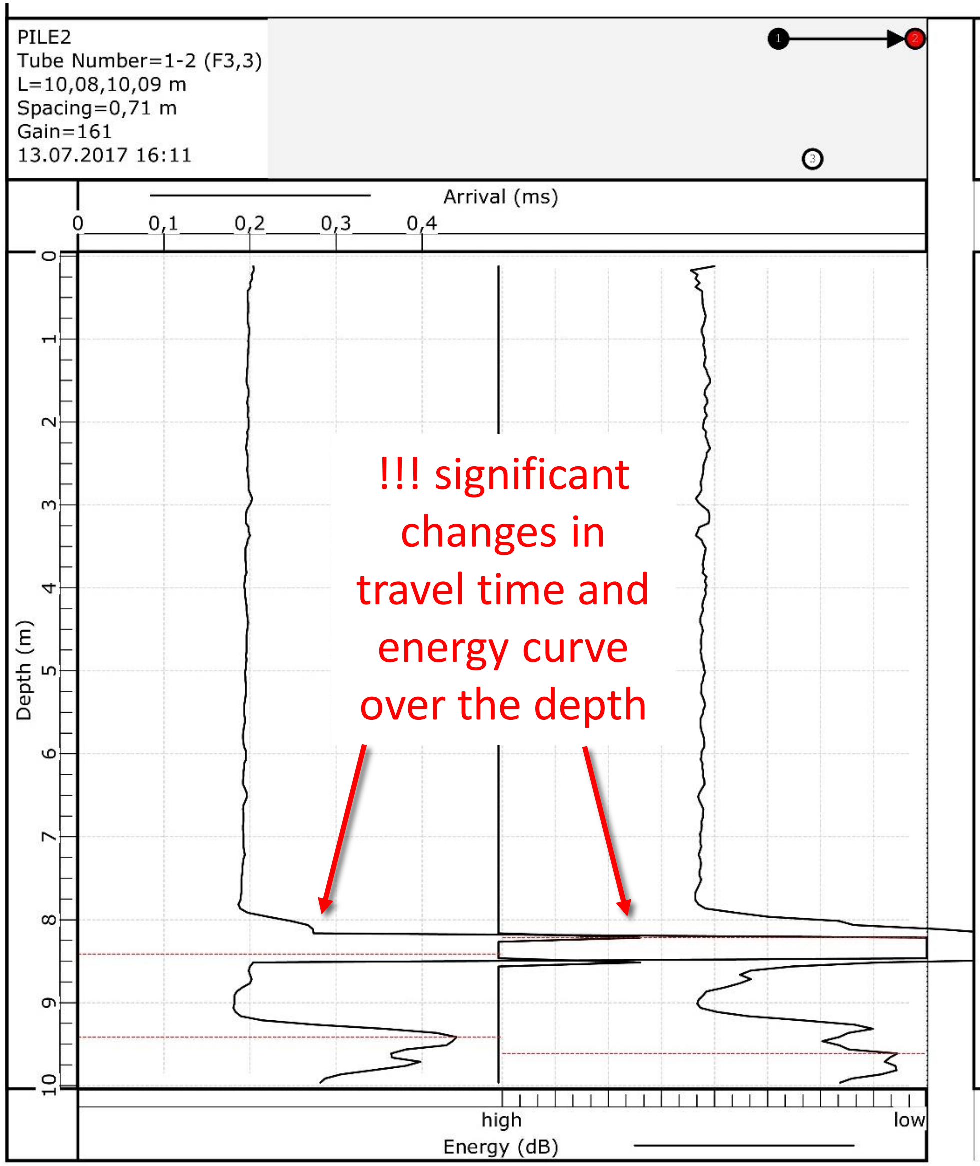
Results of a "good" pile

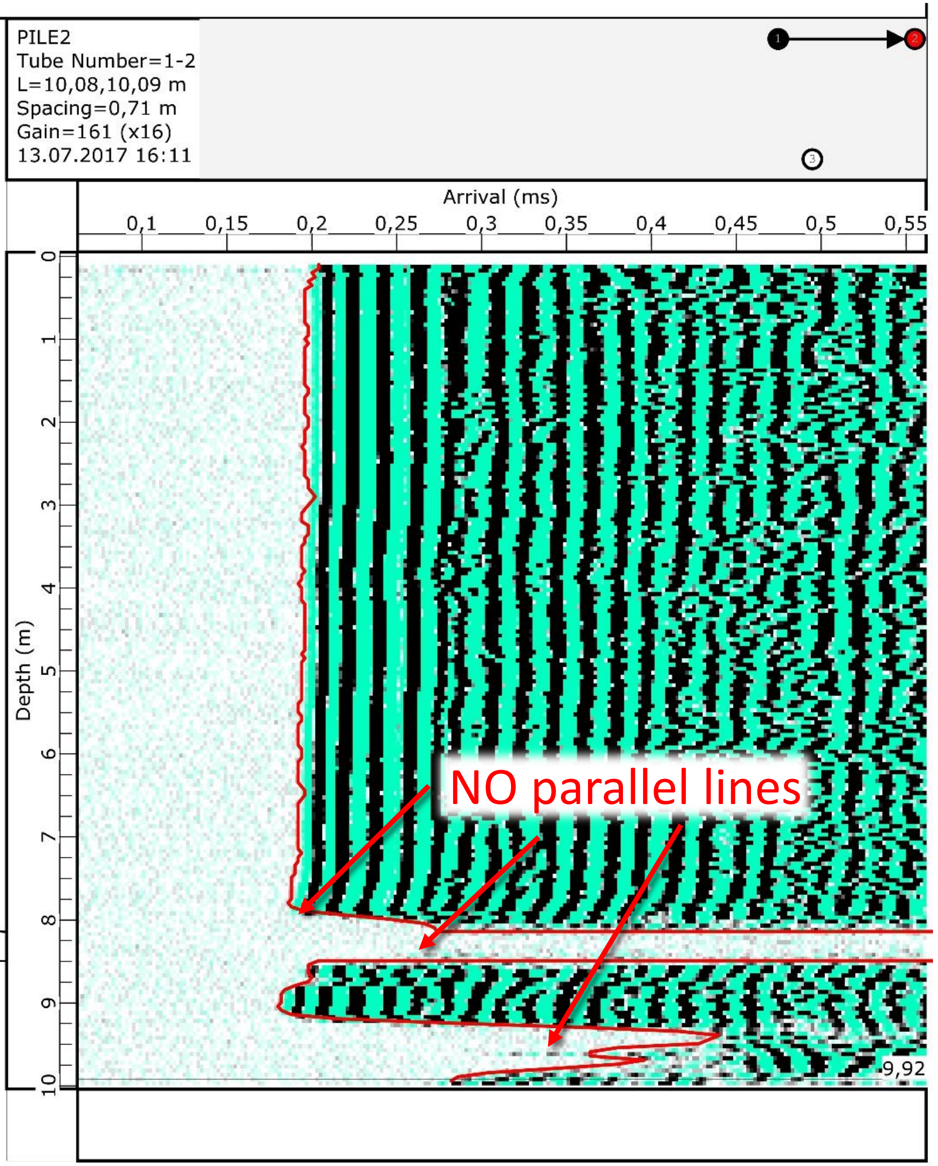
Company Name: Pile Dynamics, Inc.
Project Name: LRT-PR2
Pile Name: PILE4
AUG 21, 2017
Pile Length=19.1 m / Pile Diameter=1.2 m



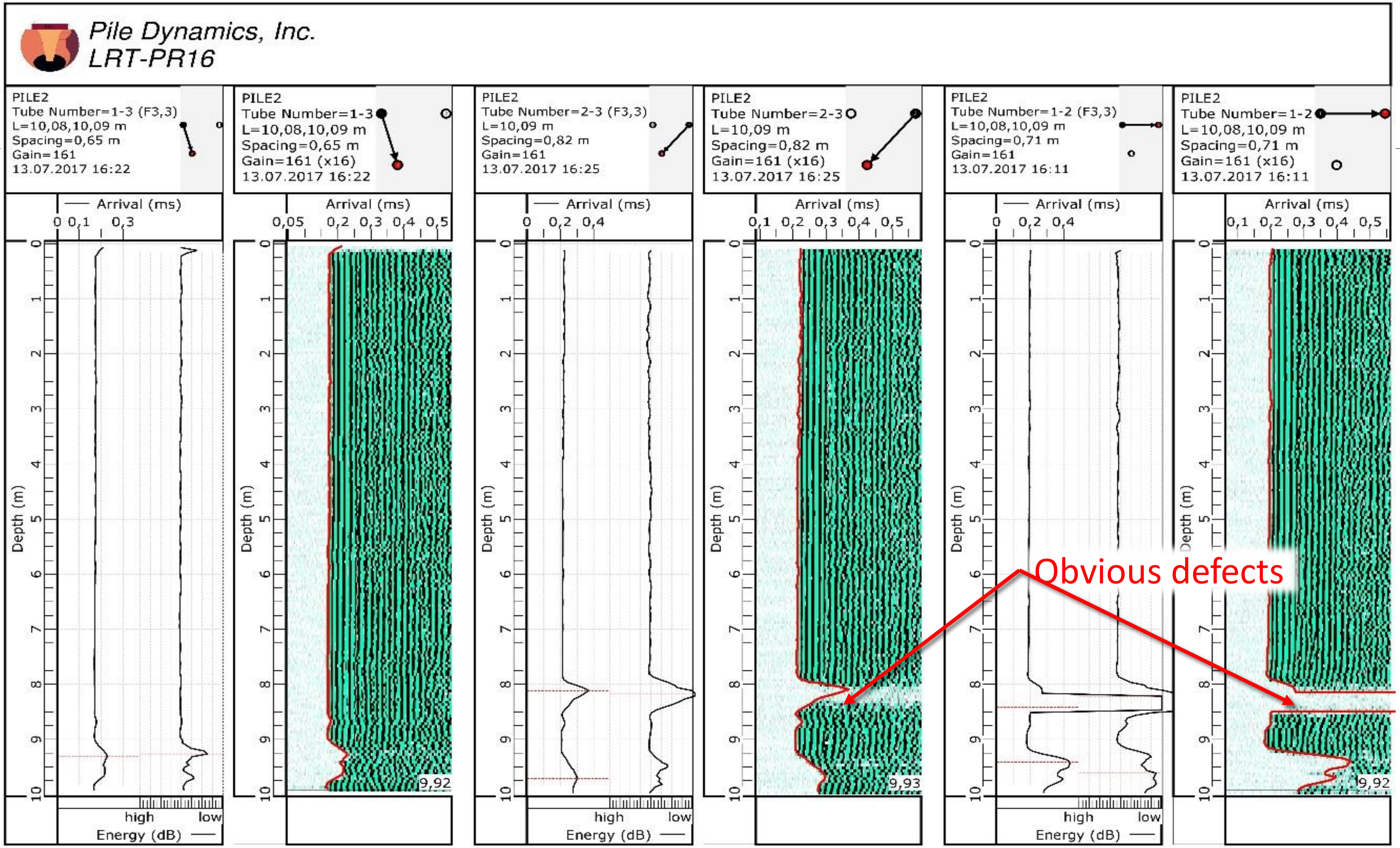
Effective Area is the percentage of cross-sectional area with wave speeds greater than the effective wave speed (EWS) selected by the user, 3378 m/s

Results of "bad" pile

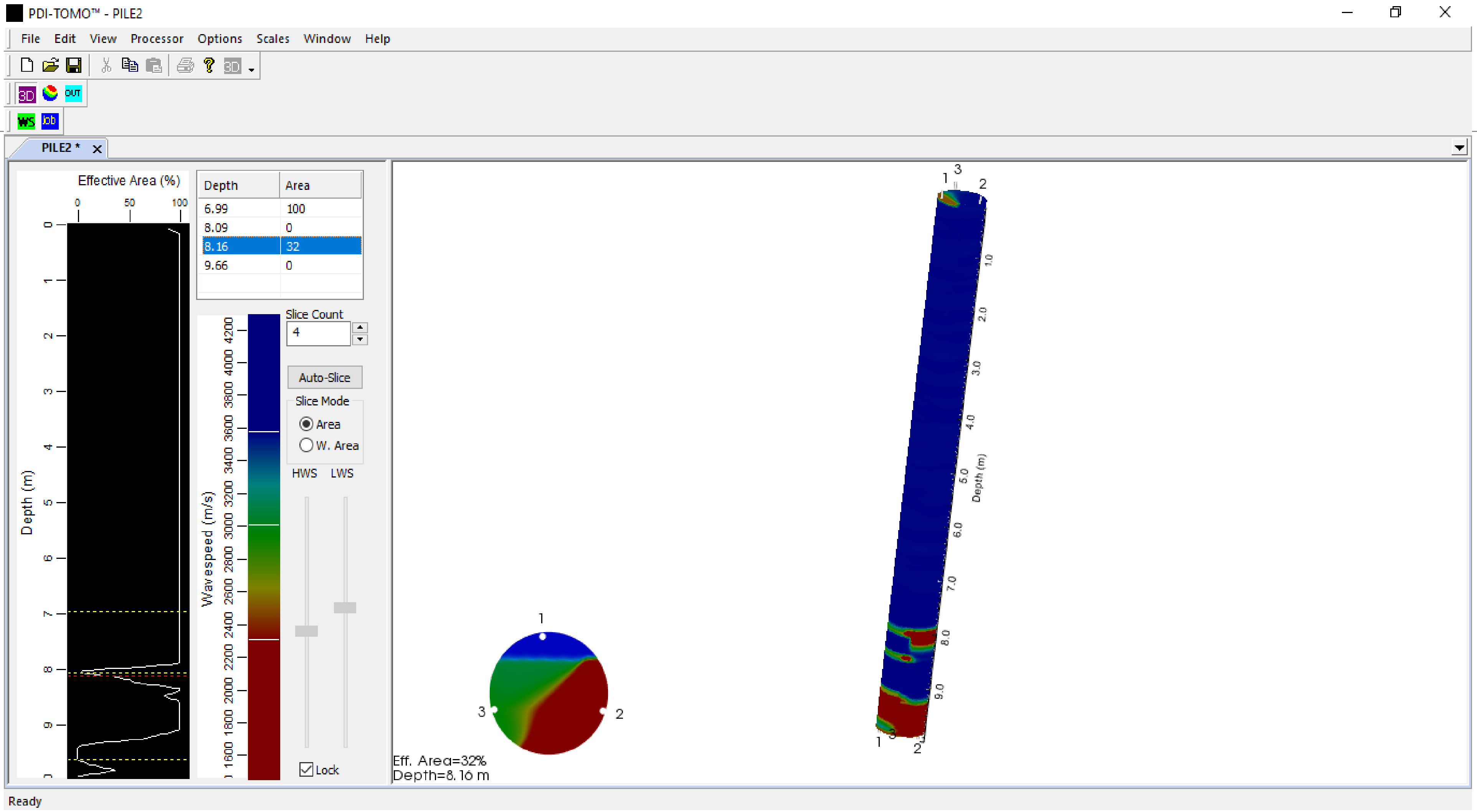




Results of "bad" pile

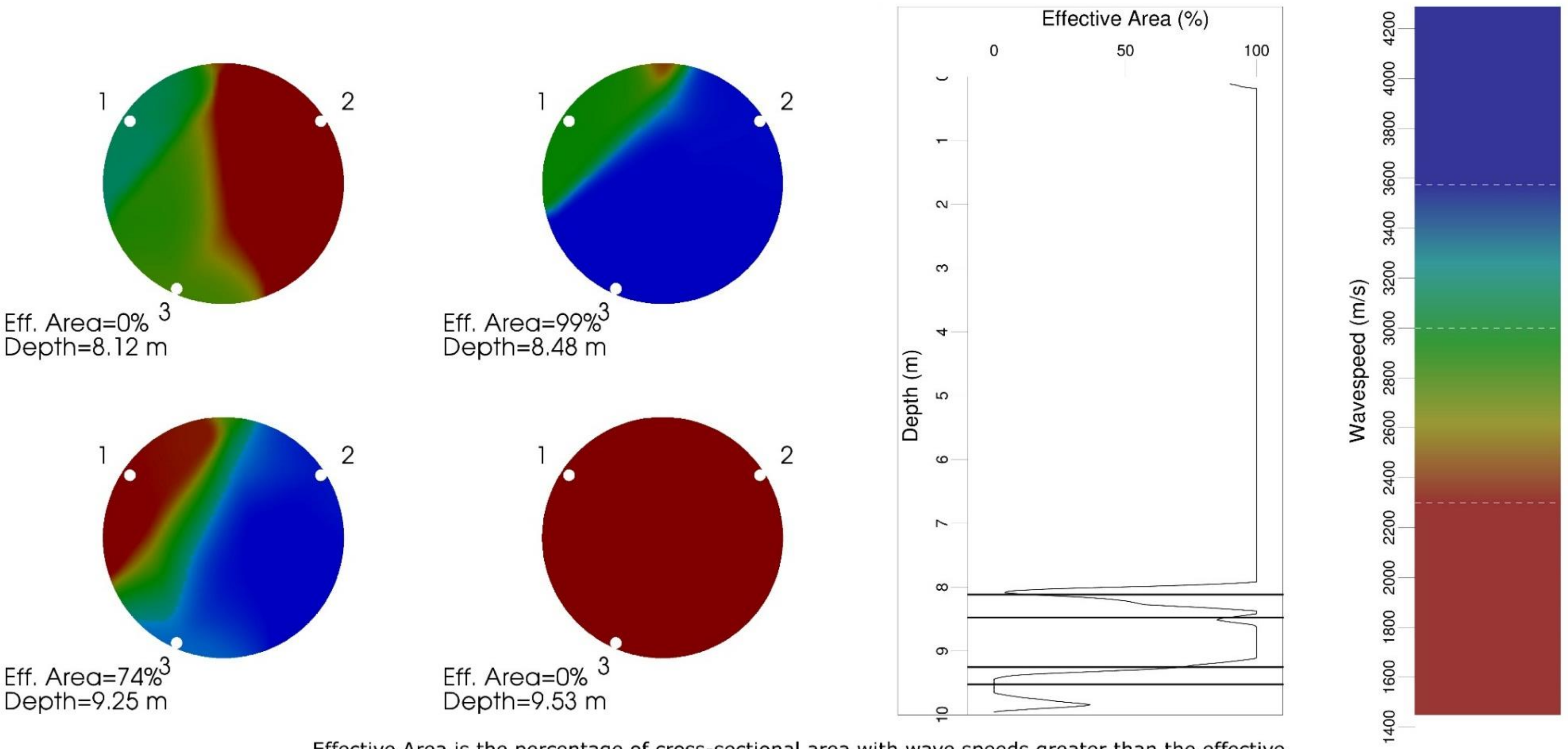


Results of “bad” pile



Results of “bad” pile

Company Name: Pile Dynamics, Inc.
Project Name: LRT-PR16
Pile Name: PILE2
JUL 13, 2017
Pile Length=10.1 m / Pile Diameter=1.2 m



Effective Area is the percentage of cross-sectional area with wave speeds greater than the effective wave speed (EWS) selected by the user, 3000 m/s

Pile Dynamics, Inc.

Low Strain Testing Constraints

The following items may often be detected:

- Pile length.
- Inclusions of foreign material with different acoustic properties.
- Cracking perpendicular to the axis.
- Joints and staged concreting.
- Abrupt changes in cross section.
- Distinct changes in soil layers.

Sonic test will normally not detect the following items:

- The toe reflection when the L/D ratio roughly exceeds 20.
- Gradual changes in cross-section.
- Minor inclusions and changes in cross-section.
- Impedance changes of small axial dimension.
- Small variations in length.
- Features located below either a fully-cracked cross section.
- Debris at the toe.
- Deviations from the straight line and from the vertical.
- Load-carrying capacity.
- The consistency of concrete cover.
- The length of reinforcement.

Cross-Hole Sonic Testing Constraints

The Cross-Hole Sonic Test will normally detect the following items:

- Finds multiple defects.

- Finds “soft bottoms” if tubes go to bottom.

- Finds voids better than soil inclusions.

- Finds larger defects easier than small defects.

- Waterfall, FAT (First arrival time), & energy all help find defect.

The Cross-Hole Sonic Test will normally not detect the following items:

- Cannot find diameter changes or bulges.

- If too few tubes, can miss a defect.

- Can find defect on direct path.

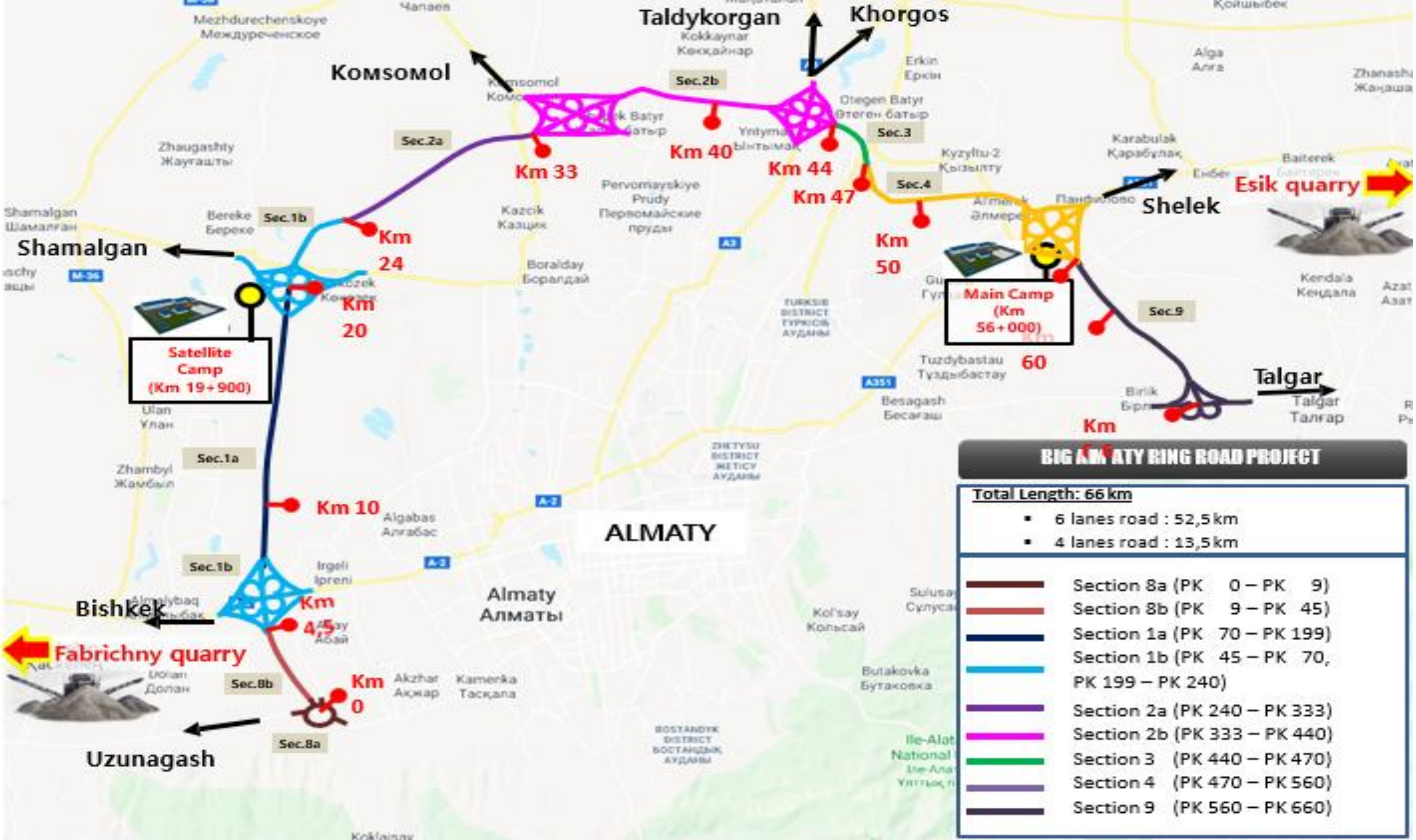
- Cannot find defect outside cage.

- Major diagonal defects more difficult to find.

- Need more than 4 tubes for 1500 mm pile (recommend 6 tubes for shaft this size).

INFORMATION ABOUT THE PROJECT

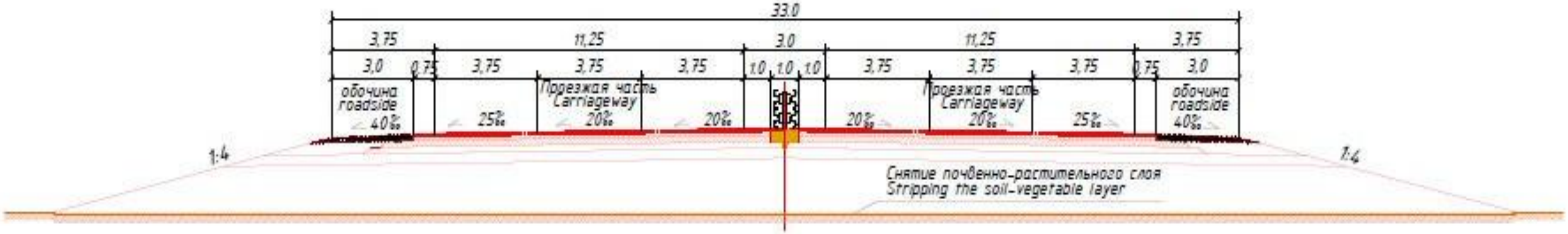
- **Project Name** : Big Almaty Ring Road (BAKAD) Project
- **Employer** : Ministry for Industry and Infrastructure Development of the Republic of Kazakhstan
- Total Length of the road (66km) + 7 Interchanges / 20 Bridges (1,377 m) / 14 Overpasses (1 677 m) / 6 Underpasses (131 m) / 1 retaining wall/ 13 toll points, 228 pcs of utility networks (167 km), 152 culverts (6,7 km) / 26 million m^3 of excavation works, Paving works (Sub-base – 816 thousand m^3, base layer made of crushed stone and sand mixture – 625 thousand m^3, asphalt pavement – 644 thousand m^3).



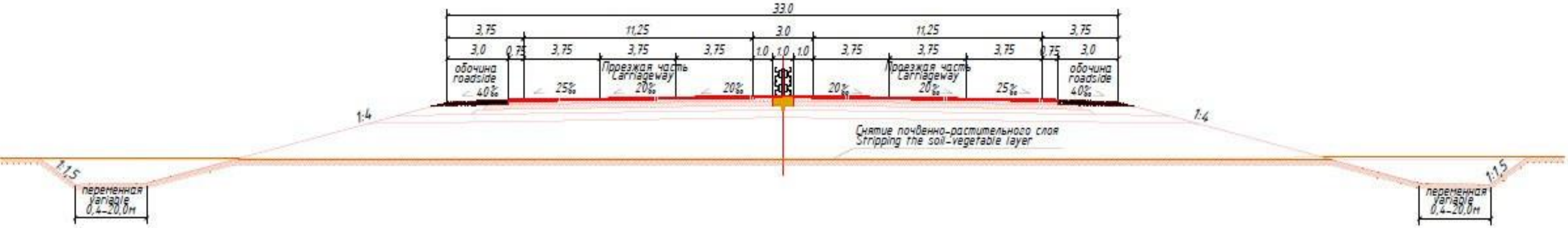
Taldykorgan
Khorgos
Комsомоl
Sec.2b
Sec.2a
Sec.3
Km 33
Km 40
Km 44
Km 47
Sec.4
Esik quarry
Shelek
Sec.1b
Km 24
Shamalgan
Km 50
Km 20
Main Camp (Km 56+000)
Satellite Camp (Km 19+900)
Sec.9
Km 60
Talgar
Sec.1a
Km 10
ALMATY
Sec.1b
Km 4,5
Bishkek
Fabrichny quarry
Sec.8b
Km 0
Sec.8a
Uzunagash
BIG ALMATY RING ROAD PROJECT
Total Length: 66 km
6 lanes road : 52,5 km
4 lanes road : 13,5 km
Section 8a (PK 0 – PK 9)
Section 8b (PK 9 – PK 45)
Section 1a (PK 70 – PK 199)
Section 1b (PK 45 – PK 70, PK 199 – PK 240)
Section 2a (PK 240 – PK 333)
Section 2b (PK 333 – PK 440)
Section 3 (PK 440 – PK 470)
Section 4 (PK 470 – PK 560)
Section 9 (PK 560 – PK 660)

SOIL IMPROVEMENT

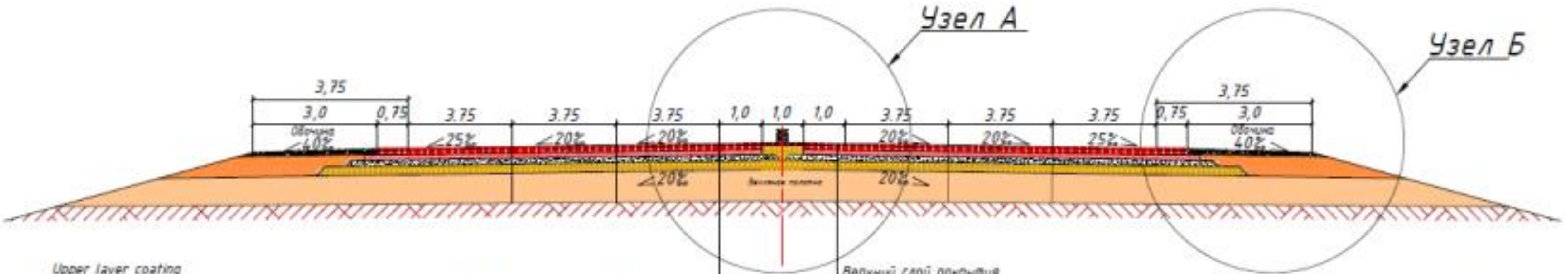
Тип 1. Насыпь высотой до 3,0 м
Type 1. Embankment up to 3.0 m high



Тип 1А. Насыпь высотой до 3,0 м с кювет-резервами с одной или двух сторон
Type 1A. Embankment up to 3.0 m high with ditch reserves on one or two sides



ROAD PAVEMENT DESIGN

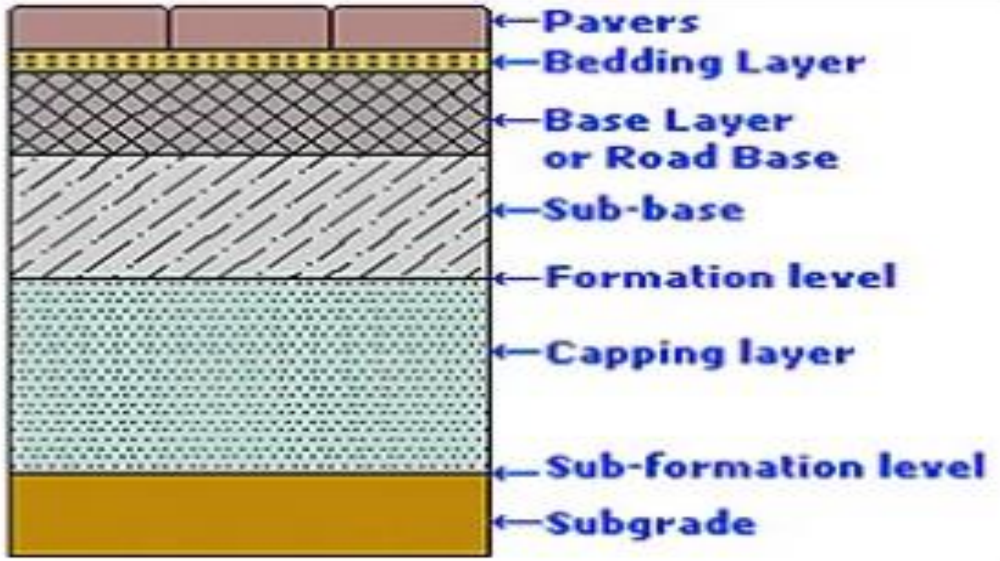


Upper layer coating Polymer asphalt according to CT PK 1223-2013 hot laying tight, I mark, from crushed stone mixture of type A according to CT PK 1225-2013, modified bitumen according to CT PK 2534-2014.	- 5 cm
Bottom layer of coating Dense-graded coarse-graded asphalt concrete I of a brand, type A to CT PK 1373-2013, brand of bitumen БНД-70/100 to CT PK 1225-2013.	- 10 cm
Upper layer coating Coarse-graded coarse-graded asphalt concrete I of a brand to CT PK 1373-2013, brand of bitumen БНД-70/100 to CT PK 1225-2013	- 13 cm
Lower layer coating Stone sand mixture C5 - 40 mm (for reasons) ГОСТ 25607-2009.	- 25 cm
Underlying layer Natural sand and gravel mix ГОСТ 3735-2014	- 30 cm
Subgrade soil - light loam	

Верхний слой покрытия Полимерный асфальтобетон по СТ РК 1223-2013 горячей укладки плотный I марки, из щебёночной смеси типа А по СТ РК 1225-2013, битум модифицированный по СТ РК 2534-2014.	- 5 см
Нижний слой покрытия Асфальтобетон горячей укладки плотный I марки, из крупнозернистой щебёночной смеси типа А по СТ РК 1225-2013, битум БНД-70/100 СТ РК 1373-2013	- 10 см
Верхний слой покрытия Асфальтобетон горячей укладки пористый II марки из крупнозернистой щебёночной смеси СТ РК 1225-2013, битум БНД-70/100. СТ РК 1373-2013	- 13 см
Нижний слой покрытия Смеси щебёночные с непрерывной гранулометрией С5 - 40 мм (для оснований) ГОСТ 25607-2009.	- 25 см
Подстилающий слой Природная песчано-гравийная смесь ГОСТ 3735-2014	- 30 см
Грунт земляного полотна - суглинок легкий	

PROPOSED CAPPING LAYER

- **Capping Layer** - A capping layer is installed to reduce the effect of a weak subgrade on the structural performance of a ground supported roadway.
- A capping layer is laid over a poor quality subgrade, ensuring that it will provide stiffer resistance to the loads from the roadway above. It also reduces the chance of differential settlement in the layers above it by supporting them more homogeneously than an unimproved subgrade, which may contain 'soft spots'.
- The materials most commonly used in a capping layer are crushed rock, hardcore or a hydraulically bound mixture. Because the grading of the material in a capping layer doesn't need to be particularly tightly controlled, the material can usually be sourced locally. This means that capping layers are usually relatively inexpensive to install.



Capping layers are constructed by

- Laying a relatively thin layer of material (max. 250 mm).
- Thoroughly compacting the layer.
- Repeating until the required thickness has been reached.

RISKS WHEN OPERATING THE BAKAD ROAD

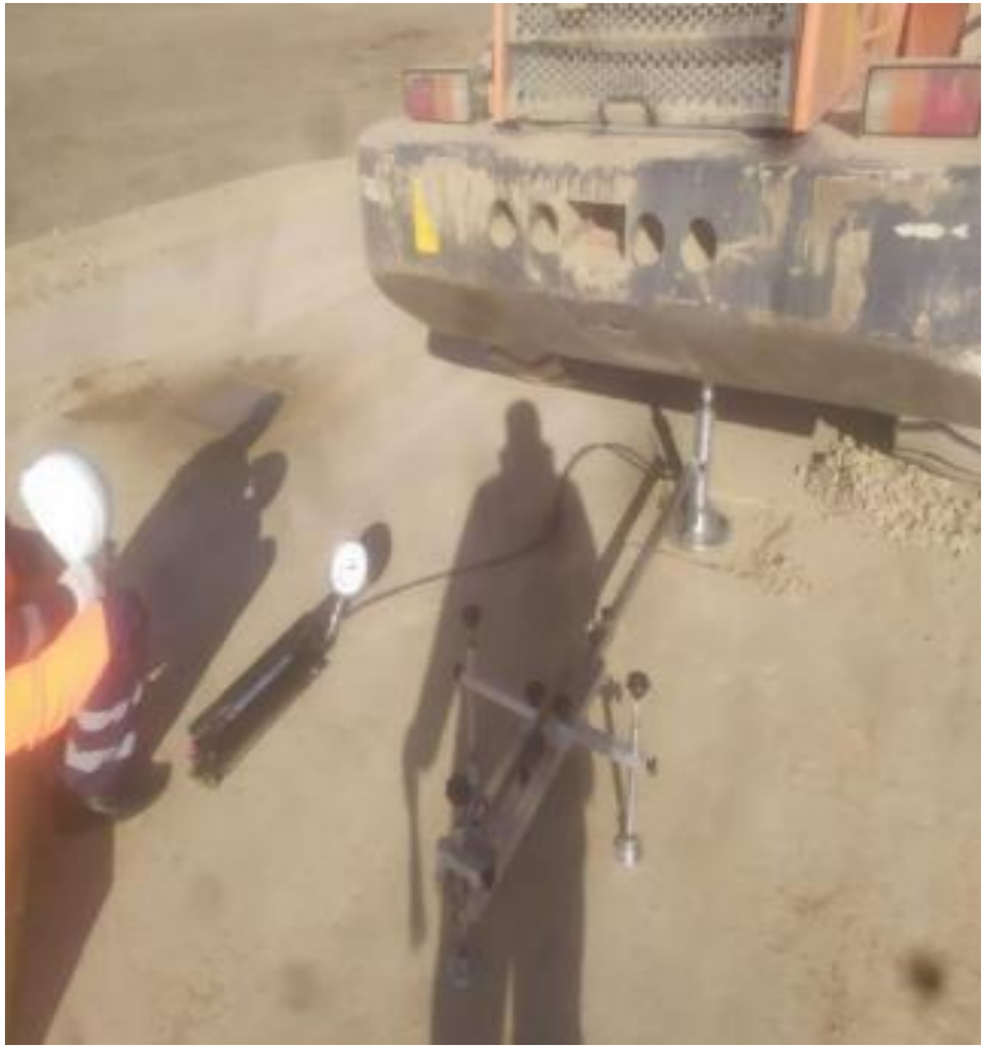
- Excessive soil settlements are possible in some areas because IGE-4 soils are relatively compressible.
- Possible flooding of the basement soils at 1) the overpass through Aksenger (CH 207 + 00 to- CH 217 + 00) and, 2) the bridge over the Aksai river (CH 152 + 00 to CH 156 + 00)
- These locations are prone to potential flooding because of the relatively close proximity of groundwater to the ground surface.
- During the period of the engineering-geological investigations (i.e., August 2018), the groundwater was found at a depth of 0.6 m (in well 10n PK 211 + 61) to 14.7 m.

THE RESULTS OF SOIL COMPRESSION AND SHEAR TESTS BY KAZAKH PROMTRANSPROEKT LLP

№	Characteristics	Unit of measure	2019г. FII LLP «Kazakh Promtransproekt»	
			embankment	groove
1	Specific cohesion	kPa	71,5	58,8
2	Angle of internal friction	degrees	37	31
3	Modulus of Deformation	MPa	9.5/2.9*	13.6/1.7*

THE RESULTS OF FIELD SOIL TESTS

№	Point name	Modulus of deformation, (Mpa)	Modulus of elasticity, (Mpa)	Compression ratio
1	CH- 10+260	46,74/ 10,75*	39,65/ 39,65*	0,99/ 0,94*
2	CH- 10+220	30,64/ 5,54*	37,08/ 37,08*	0,99/ 0,9*
3	CH- 10+110	25,05/ 5,42*	41,18/ 31,15*	0,99/ 0,9*



RECOMMENDATIONS

1. Provide protection against flooding(drainage system).

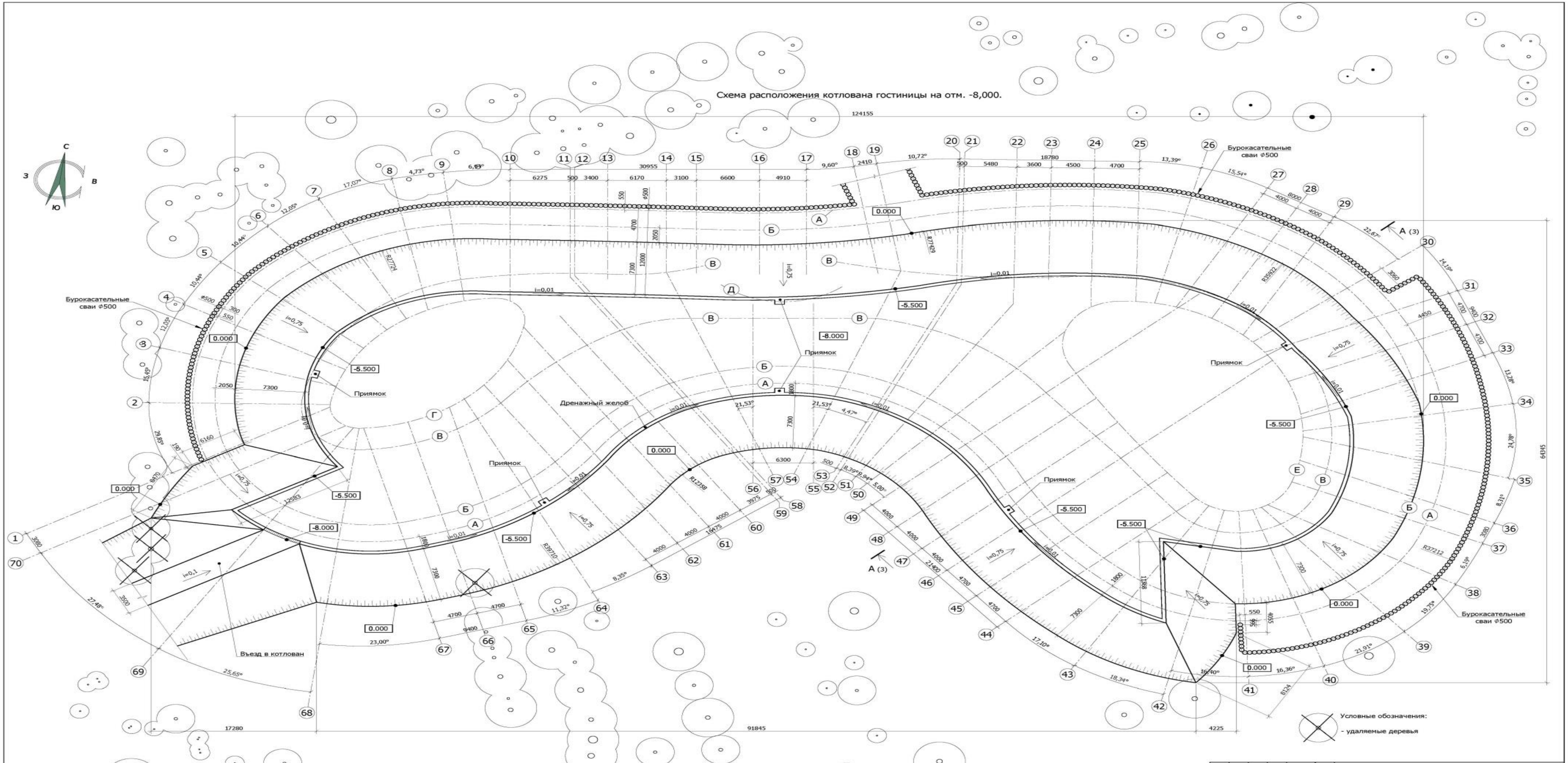
2. Provide regulating discharge outlets and watercourses structures and measures to prevent flooding and under-flooding of joining to non-regulated small and medium rivers as well as for protection of crossings under roads.

3. When designing structures on subsiding soils, consideration should be given to the possibility of increasing their humidity due to: soaking the soil from above external sources (rainwater, snowmelt water). Given this, it is necessary to provide a set of measures, including the elimination of drawdown properties. Water protective and constructive measures.

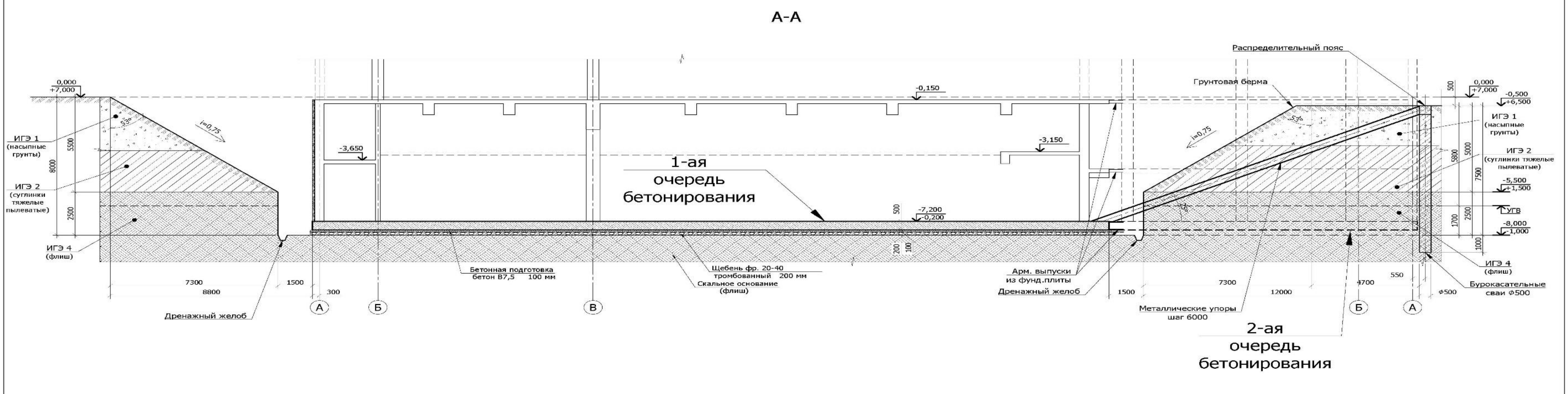
4. In areas where the groundwater level is close to the bottom of the embankment, apply a «capping layer» for more rigid resistance to loads from the structure located above. It also reduces the chance of differential settlement in the slab by supporting it more homogeneously than an unimproved subgrade, which may contain ‘soft spots’.

5. Lean clay can be used as an artificial embankment, if it is well compacted and a large amount of water is not allowed into the soil body. In this project, the groundwater level is low, therefore, an artificial structure can play the role of a water seal for surface waters.

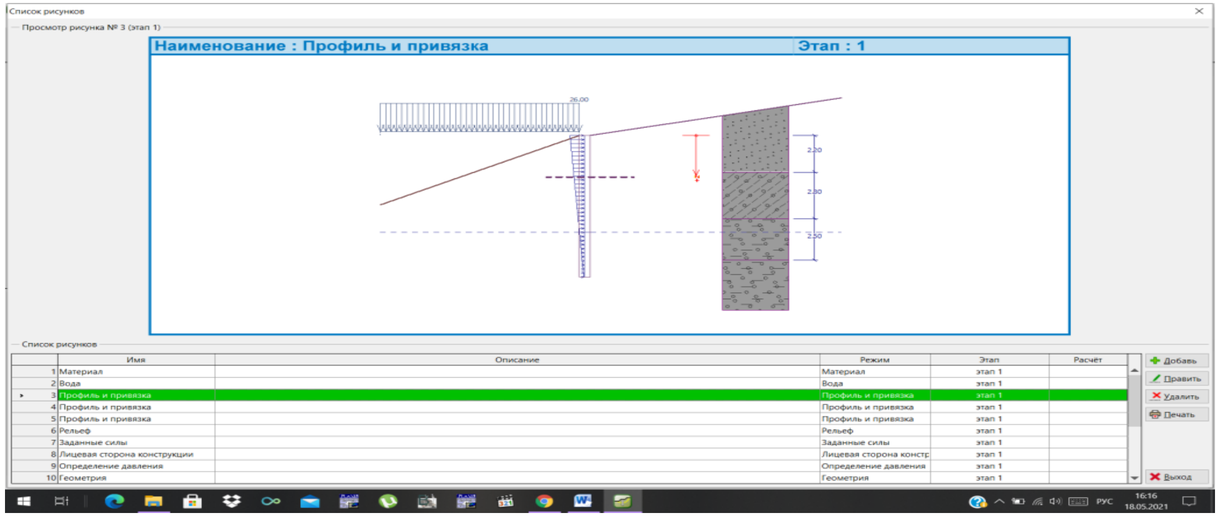
6. To analyze the mechanical properties of the earth embankment, it is necessary to use the results of field tests as more reliable information on the mechanical properties of the soil. (The obtained results of field tests are: for soil at natural moisture - deformation modulus Ed = 34.14 MPa, for water-saturated soil - deformation modulus Ed = 7.24 MPa).

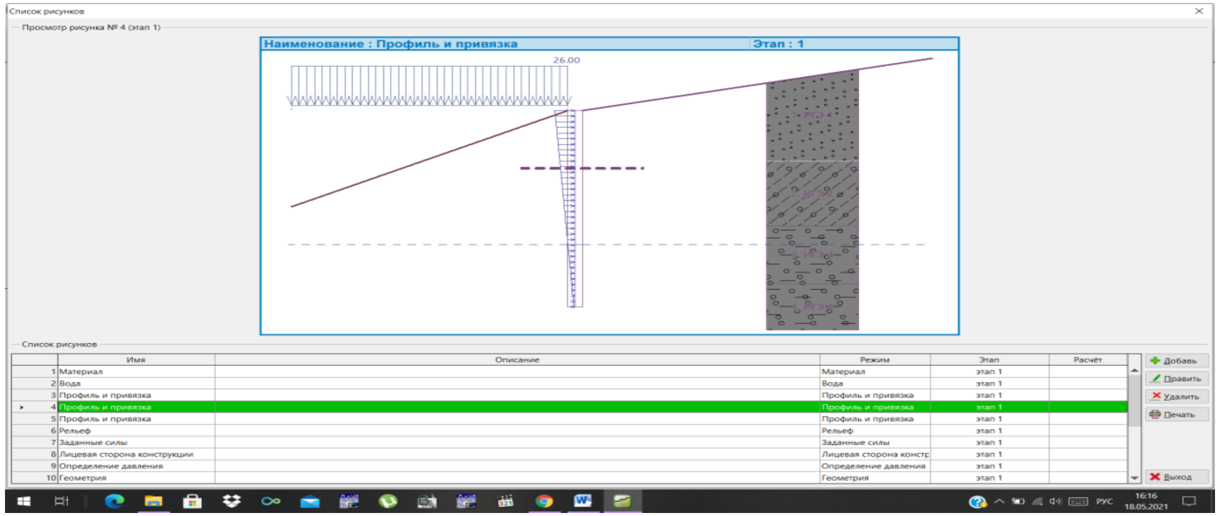


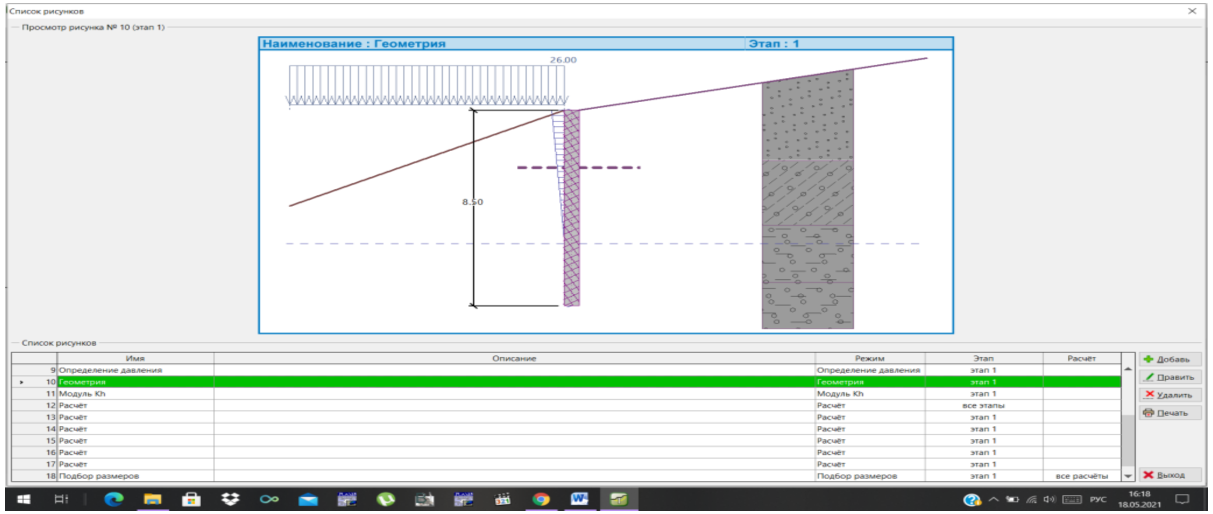
						АКБ - 01/20- КЖ.0			
Изм.	Кол.уч.	Лист	№Док.	Подпись	Дата	Краснодарский край, г. Геленджик, ул. Туристическая, д. 27. Комплекс Голубая Волна.			
Разработал	Кузнецова					Корпус Гостиницы	Стадия	Лист	Листов
Проверил	Григорьева						ПП	1	
Гл. констр.	Гузовский					Схема расположения котлована гостиницы на отм. -8,000.	ООО "АКБ "ТРАДИЦИЯ"		
Н.контроль									

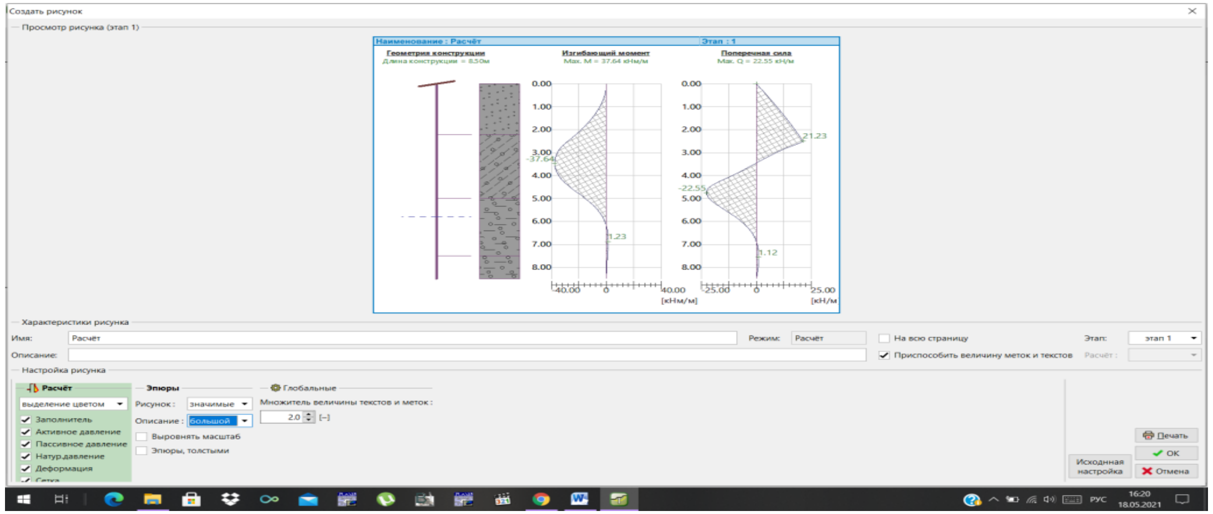


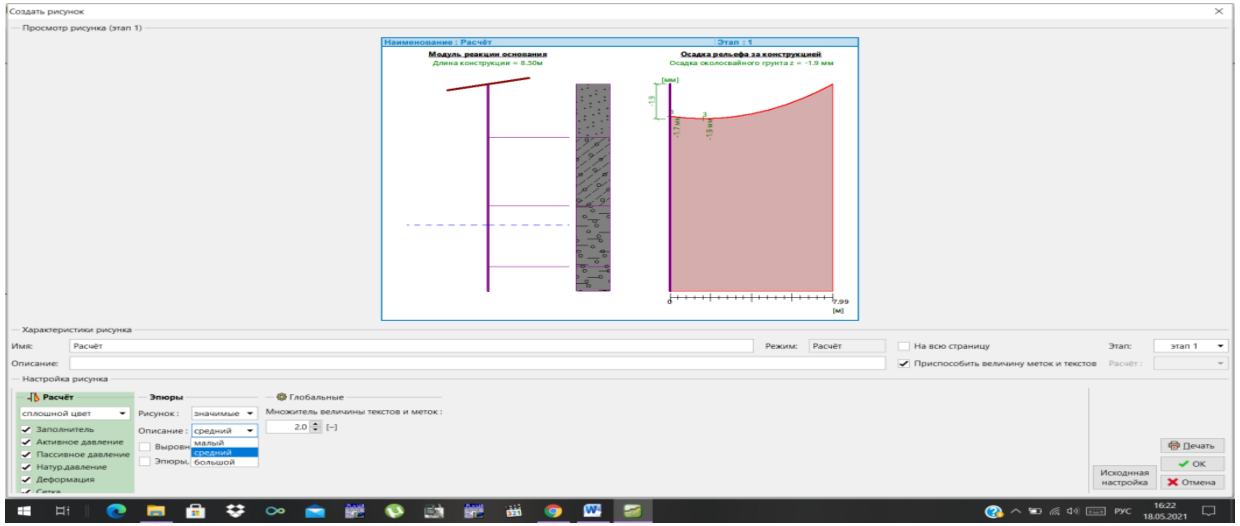
						АКБ - 01/20- КЖ.0			
						Краснодарский край, г. Геленджик, ул. Туристическая, д. 27. Комплекс Голубая Волна.			
Изм.	Кол.уч.	Лист	№Док.	Подпись	Дата				
Разработал		Кузнецова				Корпус Гостиницы	Стадия	Лист	Листов
Проверил		Григорьева					ПП	3	
Гл. констр.		Гузовский							
Н.контроль						Разрез А-А	ООО "АКБ "ТРАДИЦИЯ"		

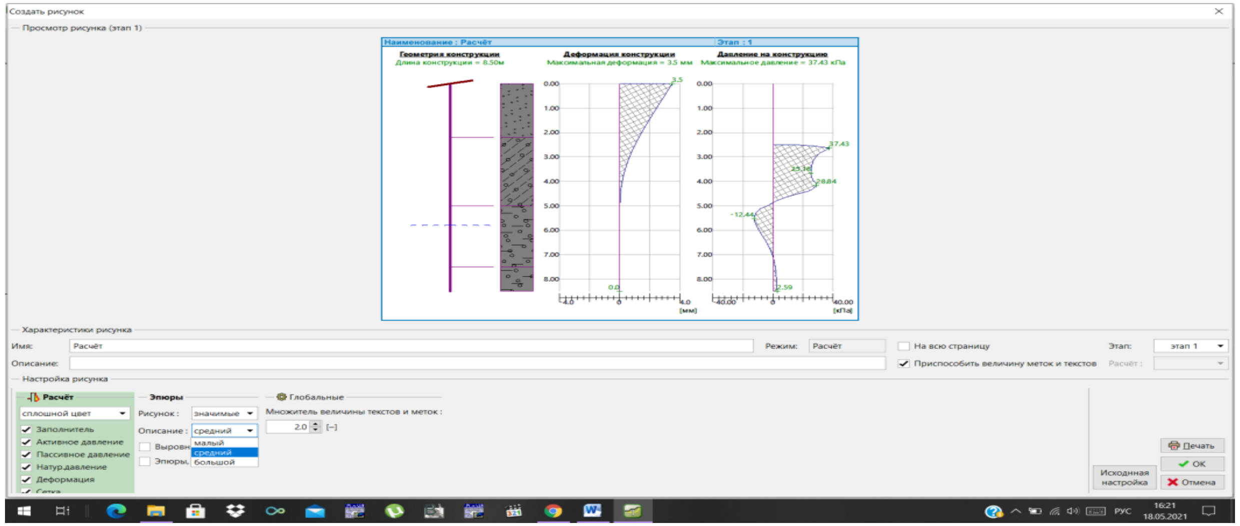

Список рисунков
Просмотр рисунка № 3 (этап 1)
Наименование : Профиль и привязка
Этап : 1
Список рисунков
Имя
Описание
Режим
Этап
Расчёт
1 Материал
2 Вода
3 Профиль и привязка
4 Профиль и привязка
5 Профиль и привязка
6 Рельеф
7 Заданные силы
8 Лицевая сторона конструкции
9 Определение давления
10 Геометрия
Добавь
Править
Удалить
Печать
Выход

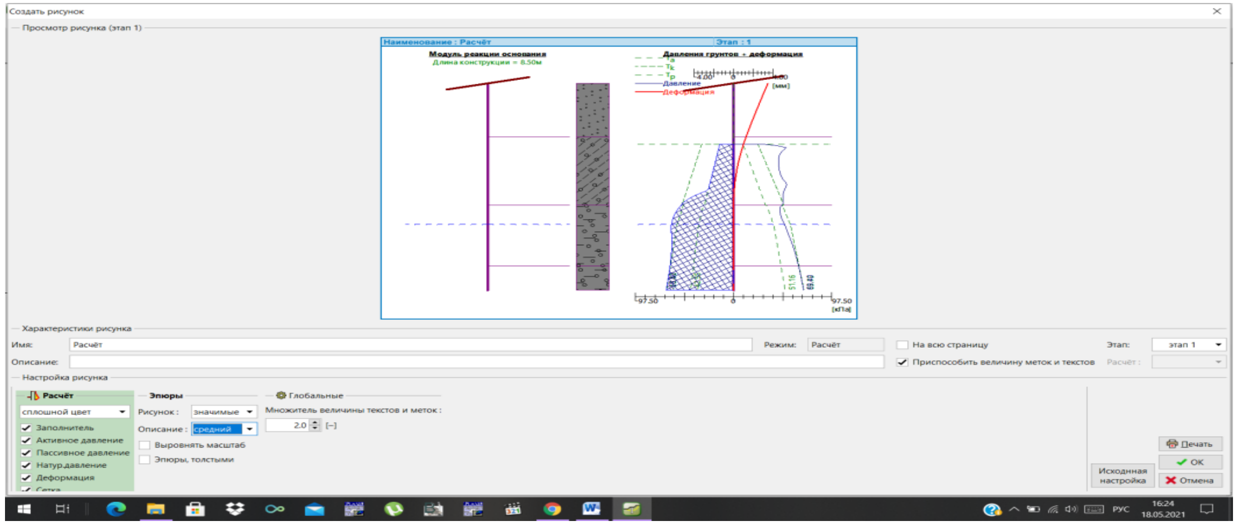

Список рисунков
Просмотр рисунка № 4 (этап 1)
Наименование : Профиль и привязка
Этап : 1
26.00
Список рисунков
Имя
Описание
Режим
Этап
Расчёт
1 Материал
2 Вода
3 Профиль и привязка
4 Профиль и привязка
5 Профиль и привязка
6 Рельеф
7 Заданные силы
8 Лицевая сторона конструкции
9 Определение давления
10 Геометрия
Добавь
Править
Удалить
Печать
Выход

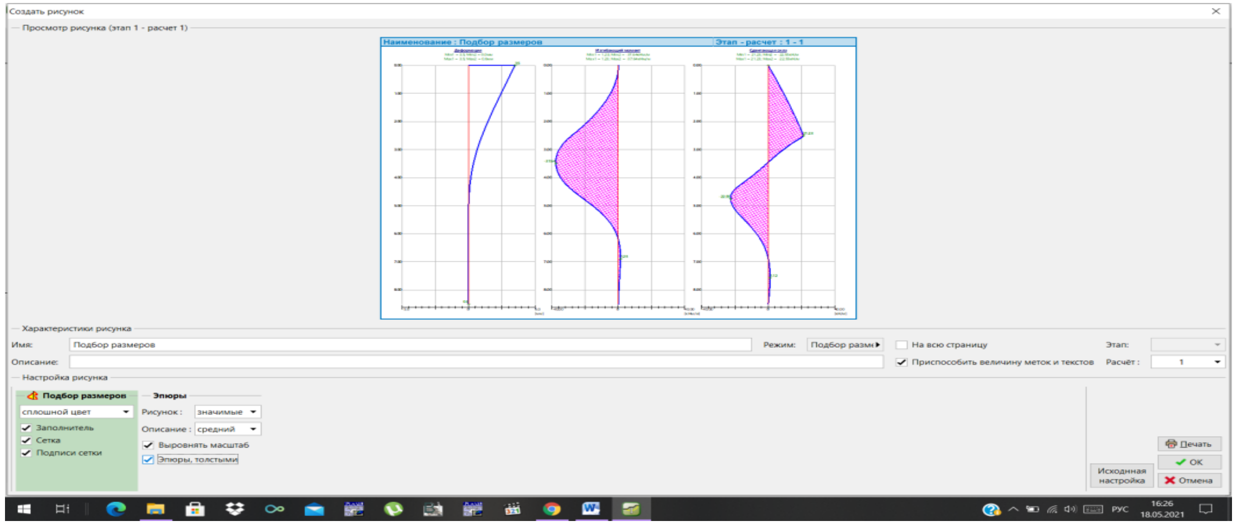

Список рисунков
Просмотр рисунка № 10 (этап 1)
Наименование : Геометрия
Этап : 1
26.00
8.50
Список рисунков
Имя
Описание
Режим
Этап
Расчёт
9 Определение давления
10 Геометрия
11 Модуль Kh
12 Расчёт
13 Расчёт
14 Расчёт
15 Расчёт
16 Расчёт
17 Расчёт
18 Подбор размеров
все этапы
все расчёты
Добавь
Править
Удалить
Печать
Выход

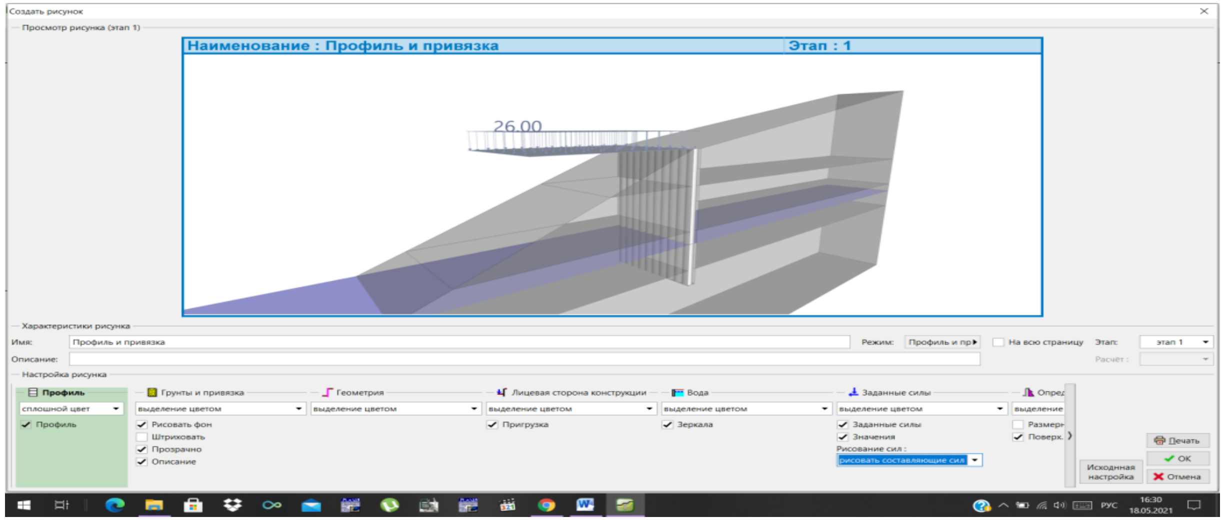

Создать рисунок
Просмотр рисунка (этап 1)
Наименование : Расчёт
Этап : 1
Геометрия конструкции
Изгибающий момент
Поперечная сила
Характеристики рисунка
Имя:
Расчёт
Режим:
Расчёт
На всю страницу
Этап:
этап 1
Описание:
Приспособить величину меток и текстов
Настройка рисунка
Расчёт
Эпюры
Глобальные
выделение цветом
Заполнитель
Активное давление
Пассивное давление
Натур.давление
Деформация
Рисунок:
значимые
Описание:
большой
Выровнять масштаб
Эпюры, толстыми
Множитель величины текстов и меток:
Печать
OK
Отмена
Исходная настройка

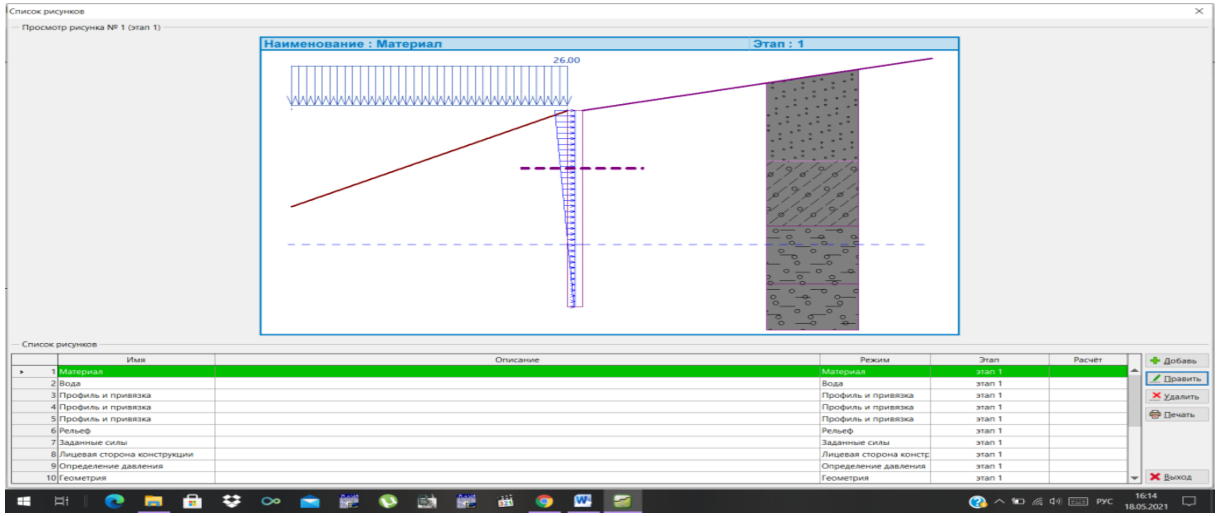

Создать рисунок
Просмотр рисунка (этап 1)
Характеристики рисунка
Настройка рисунка

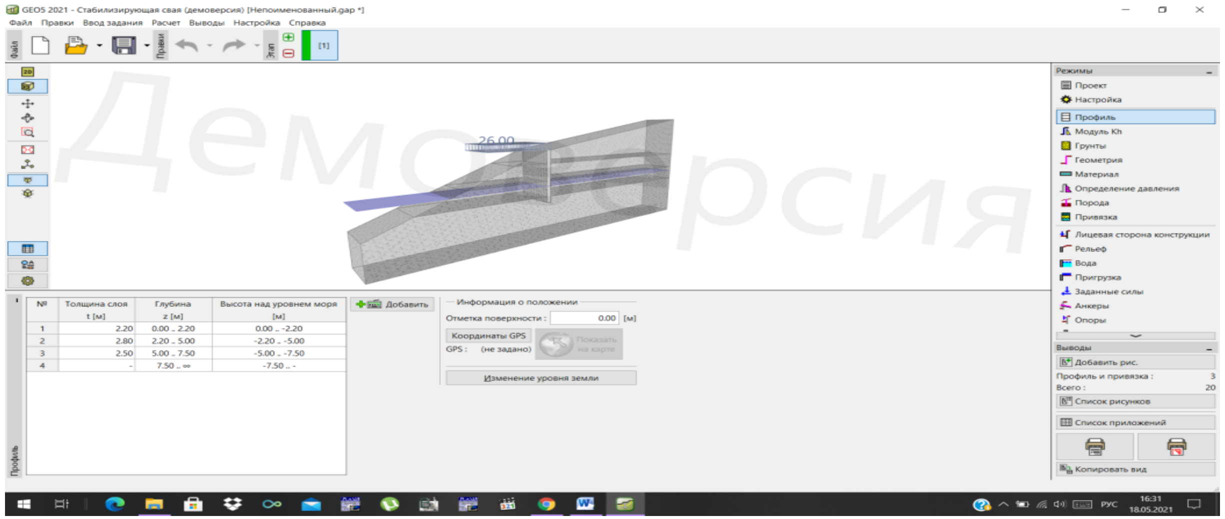

Создать рисунок
Просмотр рисунка (этап 1)
Характеристики рисунка
Настройка рисунка

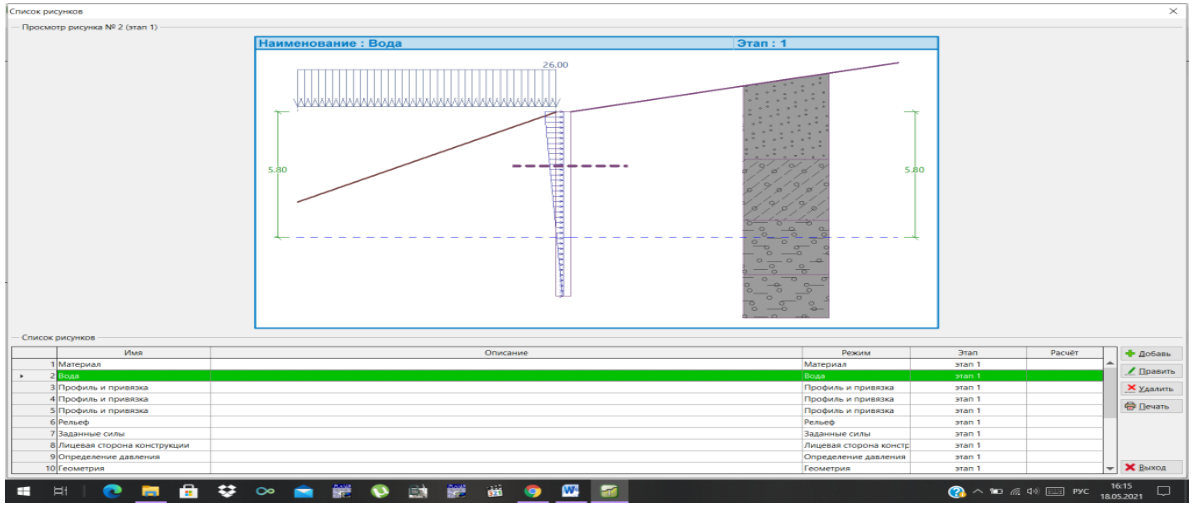

Создать рисунок
Просмотр рисунка (этап 1)
Характеристики рисунка
Настройка рисунка

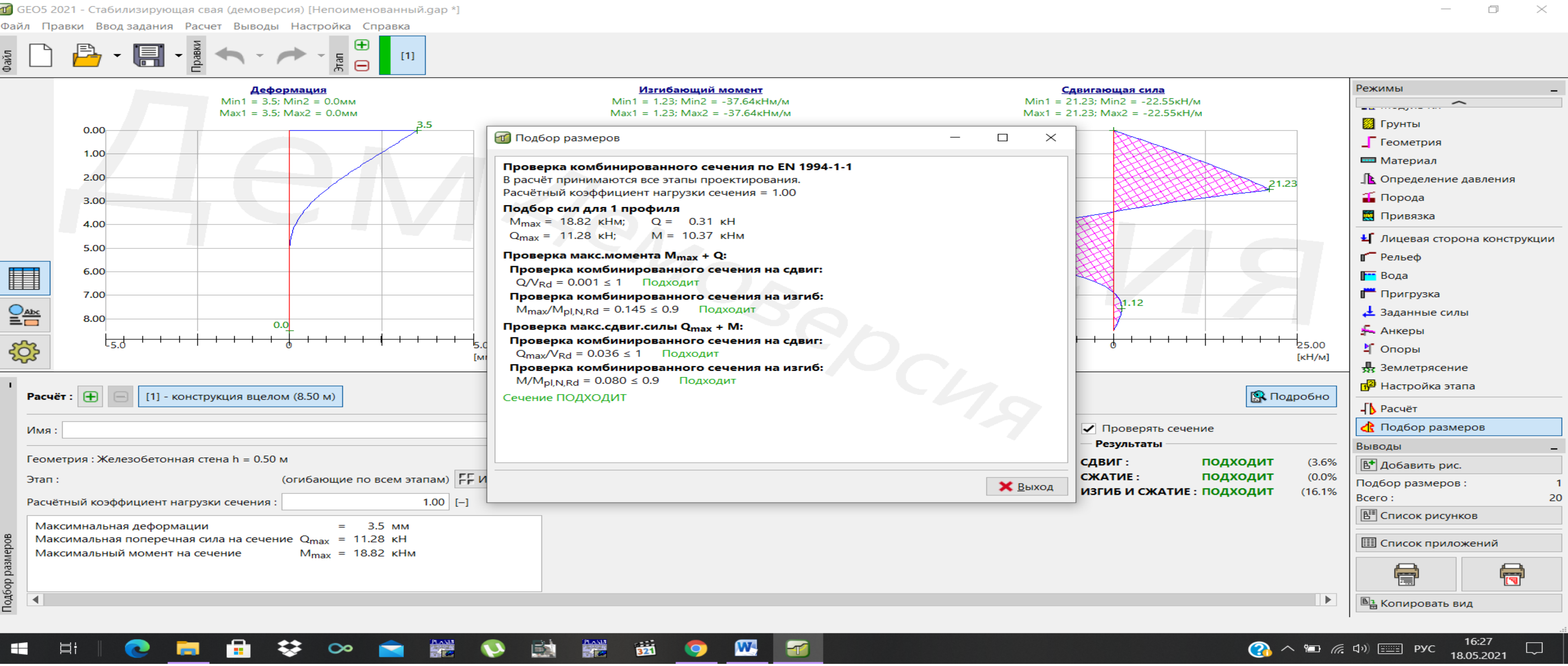

Создать рисунок
Просмотр рисунка (этап 1 - расчет 1)
Характеристики рисунка
Настройка рисунка


Создать рисунок
Наименование : Профиль и привязка
Этап : 1
26.00


Список рисунков
Наименование : Материал
Этап : 1
26.00


GEO5 2021 - Стабилизирующая свая (демоверсия) [Непоименованный.gap *]
Демоверсия
26.00


Список рисунков
Наименование : Вода
Этап : 1
26.00


GEO5 2021 - Стабилизирующая свая (демоверсия) [Непоименованный.gap *]
Файл Правки Ввод задания Расчет Выводы Настройка Справка
Деформация
Min1 = 3.5; Min2 = 0.0мм
Max1 = 3.5; Max2 = 0.0мм
Изгибающий момент
Min1 = 1.23; Min2 = -37.64кНм/м
Max1 = 1.23; Max2 = -37.64кНм/м
Сдвигающая сила
Min1 = 21.23; Min2 = -22.55кН/м
Max1 = 21.23; Max2 = -22.55кН/м
Подбор размеров
Проверка комбинированного сечения по EN 1994-1-1
В расчёт принимаются все этапы проектирования.
Расчётный коэффициент нагрузки сечения = 1.00
Подбор сил для 1 профиля
Mmax = 18.82 кНм; Q = 0.31 кН
Qmax = 11.28 кН; M = 10.37 кНм
Проверка макс.момента Mmax + Q:
Проверка комбинированного сечения на сдвиг:
Q/VRd = 0.001 ≤ 1 Подходит
Проверка комбинированного сечения на изгиб:
Mmax/Mpl,N,Rd = 0.145 ≤ 0.9 Подходит
Проверка макс.сдвиг.силы Qmax + M:
Проверка комбинированного сечения на сдвиг:
Qmax/VRd = 0.036 ≤ 1 Подходит
Проверка комбинированного сечения на изгиб:
M/Mpl,N,Rd = 0.080 ≤ 0.9 Подходит
Сечение ПОДХОДИТ
Выход
Режимы
Грунты
Геометрия
Материал
Определение давления
Порода
Привязка
Лицевая сторона конструкции
Рельеф
Вода
Пригрузка
Заданные силы
Анкеры
Опоры
Землетрясение
Настройка этапа
Расчёт
Подбор размеров
Выводы
Добавить рис.
Подбор размеров : 1
Всего : 20
Список рисунков
Список приложений
Копировать вид
Расчёт : [1] - конструкция вцелом (8.50 м)
Подробно
Имя :
Геометрия : Железобетонная стена h = 0.50 м
Этап : (огибающие по всем этапам)
Расчётный коэффициент нагрузки сечения : 1.00 [–]
Проверять сечение
Результаты
СДВИГ : ПОДХОДИТ (3.6%
СЖАТИЕ : ПОДХОДИТ (0.0%
ИЗГИБ И СЖАТИЕ : ПОДХОДИТ (16.1%
Максимнальная деформации = 3.5 мм
Максимальная поперечная сила на сечение Qmax = 11.28 кН
Максимальный момент на сечение Mmax = 18.82 кНм
Подбор размеров
РУС
16:27
18.05.2021

CONCLUSIONS

- 1) Having studied the experience of road construction in Kazakhstan and the CIS countries, as well as the design data and geological conditions of the project "Construction of the Big Almaty Ring Road (BAKAD) 1 section (start-up complex) PK 45 + 00 - PK 240 + 00" (provided by the customer). We can conclude that it is possible to build a road without using the capping layer. This conclusion is justified by the fact that in the project, the height of the embankment and pavement is sufficient for this region and it ensures the stability of the pavement and embankment, and protects against the effects of freezing and melt water.
- 2) It is necessary to ensure the quality of compaction of the soil embankment and pavement and their geometric parameters according to the project.
- 3) It is especially necessary to pay attention to the compaction of the central part and the slopes of the embankment, which will provide protection from the influence of melt water into the body of the embankment, the penetration of which will lead to a deterioration in the mechanical properties of the embankment and the corresponding subsidence.
- 4) It is necessary to carry out high-quality protective measures against flooding (drainage system).
- 5) It is necessary to inspect the "Big Almaty Ring Road (BAKAD)" during its construction and operation.

CONCLUSIONS

Existing pile foundation standards practiced in Kazakhstan are out-of-date and are in urgent need for modernization. This paper presented very short descriptions of coming changes to the concept of Kazakhstan pile foundation design.

The overlay of the curves showed that the convergence of the graphs is observed only at the initial stage of loading, then a change in the trajectory of the SLT curve, characteristic of the creeping stage of soil resistance, is observed, whereas the O-cell curve (at this stage of loading) is more characteristic of the elastic resistance of the soil.

When testing piles using the SLT method "from top to bottom", a design load of 6000 kN corresponds to a draft of 2.09 mm, a maximum test load of 12000 kN is a draft of 10.51 mm. It should be noted that even with the maximum test load, only the elastic operation of the pile in the ground is manifested, as evidenced by a slight residual soil sediment after unloading, which is 1.4 mm.

When testing piles using the O-cell test, a maximum test load of 29000 kN corresponds to a draft of 18.35mm (for the PTP-1 pile) and - 14.40 mm (for the PTP-2 pile). During the testing of the piles, both elastic and plastic deformation of the soil was observed, due to a greater test load on the pile than in the SLT method.

The cost of a quality control program for each construction site is very reasonable, and in any case much lower than the potential loss caused by an undetected defect of foundation.

The Low Strain test is a powerful quality-control tool, not so expensive and need about one minute for application but we must never forget that it is not omnipotent. Since the sonic method is based on the use of stress-waves, it can identify only those pile attributes that influence wave propagation and have a fairly large size.

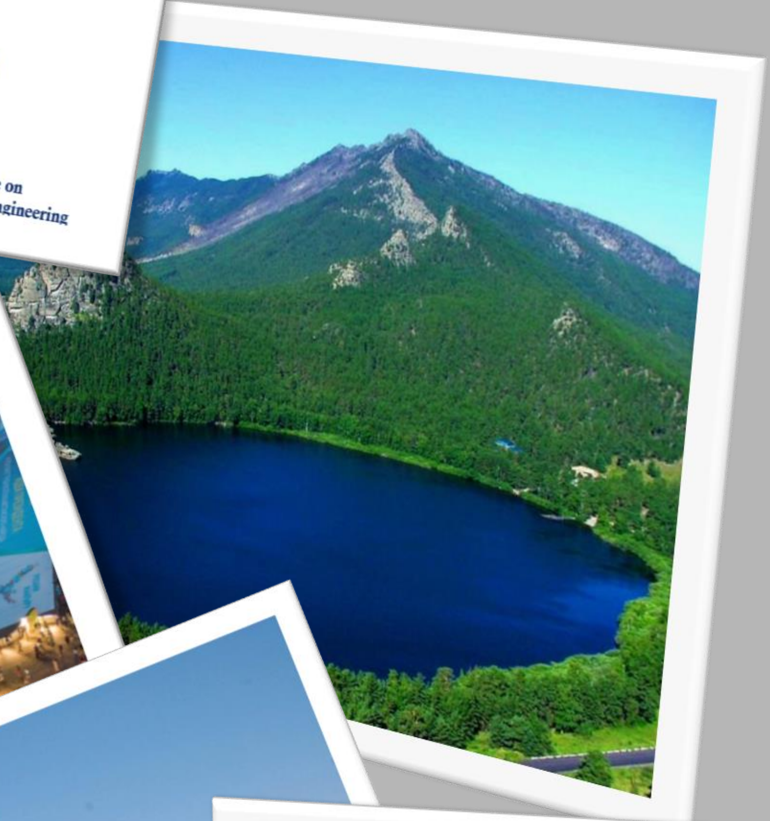
The Cross-hole logging testing is most accurately and quality for field observation of deep pile foundations.

Proposal for hosting of the 17ARC

Asian Regional Conference on Soil Mechanics and Geotechnical Engineering

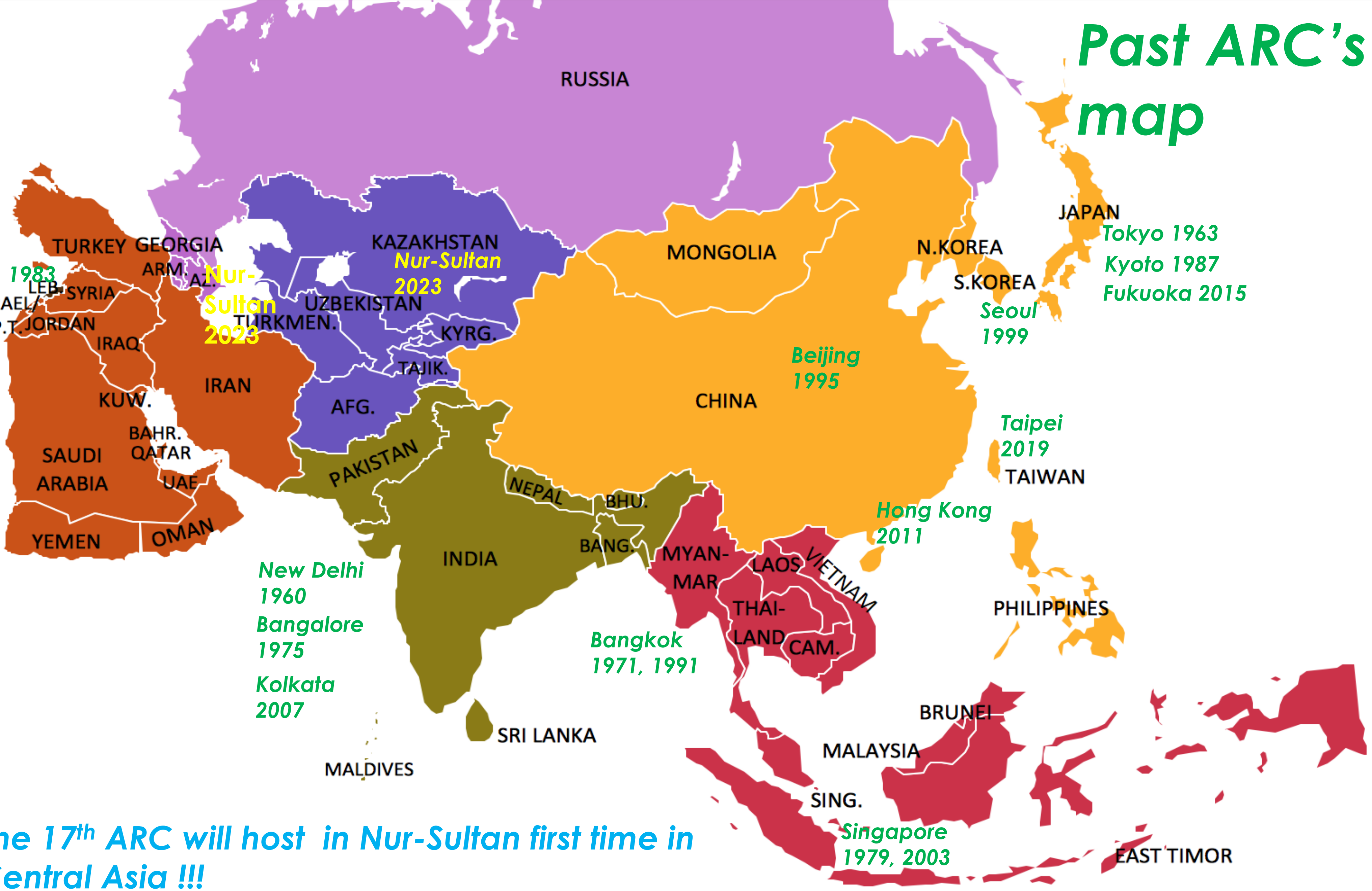
ARC
17th
Asian Regional Conference on
Soil Mechanics and Geotechnical Engineering

Proposal for hosting
the 17ARC
Asian Regional Conference on Soil Mechanics and Geotechnical Engineering



Kazakhstan Geotechnical Society

Past ARC's map



The 17th ARC will host in Nur-Sultan first time in Central Asia !!!

KGS

CONFERENCE INFORMATION

ARC
17th
Asian Regional Conference on
Soil Mechanics and Geotechnical Engineering

✓ Introduction

- ✓ **Proposed Host Organization:** Kazakhstan Geotechnical Society (KGS)

  More than 100 active members.

  KGS reached the experience in hosting of **local seminars**, **workshops** and **international conferences** (including the 1th, 2th, 3th Central Asian Geotechnical Conferences , 8 AYGEC, etc.)

- ✓ **Proposed Congress President:**

  Prof. Askar Zhussupbekov (L.N. Gumilyov ENU, President of KGS)

- ✓ **Proposed Congress Dates:**

  August 14-18 (Monday-Friday), 2023, www.issmge.org

- ✓ **Proposed Congress Venue:**

  EXPO Congress Hall, Nur-Sultan city, Kazakhstan

KGS

CONFERENCE INFORMATION

ARC
17th
Asian Regional Conference on
Soil Mechanics and Geotechnical Engineering

Main Theme

Smart Geotechnics for Smart Societies

Subjects

(1) Soil characteristic and properties
(2) Underground space and deep excavations
(3) Tunneling
(4) Slope, debris flow and embankment
(5) Dam
(6) Shallow and deep foundation
(7) Soil dynamics and geotechnical earthquake Engineering
(8) Soil improvement
(9) Geoenvironmental engineering
(10) Geotechnical reliability, risk assessment and management

engineering
(13) Forensic engineering
(14) Offshore and harbor geotechnics
(15) Geotechnical training and education
(16) In- situ testing and monitoring
(17) GeoEnergy
(18) Case History
(19) Investigation of foundations of structures historical buildings and monuments
(20) Numerical analysis of soil – structure interaction

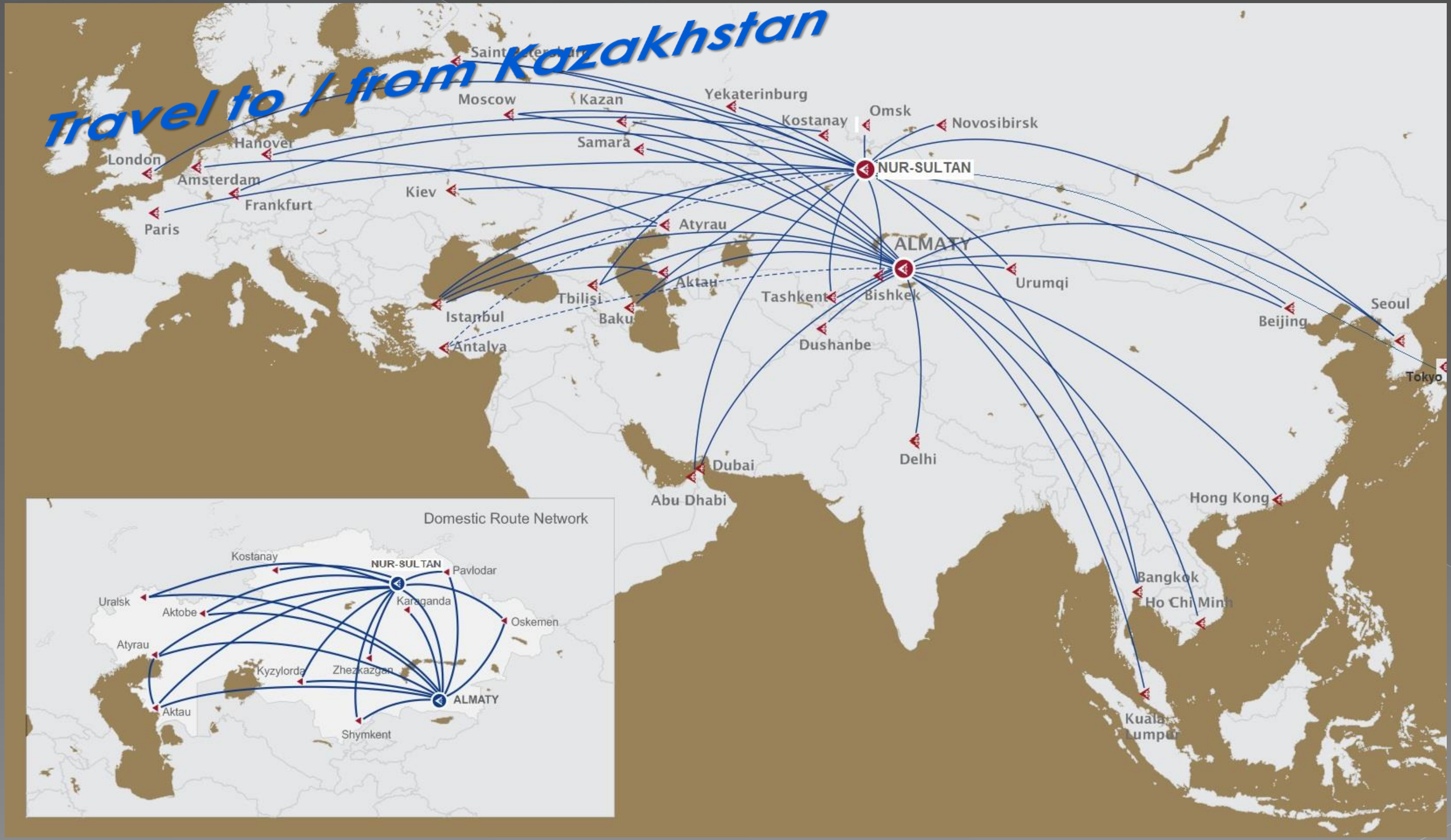
ABOUT VENUE
EXPO Congress Hall

- ✓ **Area**
  - 43 220 m^2
  - 3 floors above the ground, as well as underground Parking for 179 m/place
- ✓ **Height**
  - 29 m
- ✓ **Main hall** with a total area of 2,659 m2 is designed for 2,214 people (including telescopic stands for 1,610 seats, mobile seats for 492 seats and seats for persons with disabilities – 22 seats), 4 conference halls (each hall with an area of 700 m2)

The building is located in the area of EXPO-2017 exhibition complex and has a unique design of transparent roof

About KAZAKHSTAN

ARC 17th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering



2 international airports: Nursultan Nazarbayev airport and Almaty airport

2,000+ flights to 75 major cities around the world:

from the Nursultan Nazarbayev Airport, there are regular flights of 6 domestic and 14 foreign airlines to 18 domestic destinations and 35 international destinations.

Central Asia

You can visit amazing places in Central Asia 1-1,5 hours distance by plane

Almaty – Apples' Motherland !

GROUP PHOTO WITH KGS MEMBERS


THANK YOU
FOR
ATTENTION!