Международная научно- практическая конференция “ Свайные фундаменты: Тенденции , проблемы и перспективы развития “, 7-8 июня 2018 года, Москва, Российская Федерация

Geotechnical Construction and Testing of Piling Foundations on Problematical Soil Ground of Kazakhstan

Askar Zhussupbekov, Abdulla Omarov, Ashkey Yergen, Karlygash Borgekova , Gulshat Tleulenova

SEAGS
Southeast Asian Geotechnical Society

CONTENTS

1. **About Kazakhstan , Astana and INTRODUCTION**
2. **ENGINEERING-GEOLOGICAL STRUCTURE OF THE CONSTRUCTION SITE**
3. **STATIC COMPRESSION LOAD TEST (SCLT)**
4. **DYNAMIC LOAD TEST WITH PDA**
5. **RESULTS OF ESTIMATION ANALYSIS OF BEARING CAPACITY**
6. **CONCLUSION**

SEAGS
Southeast Asian Geotechnical Society

SEAGS
Southeast Asian Geotechnical Society

Introduction

General minerals of Kazakhstan

N	Minerals	Reserves	Place in a World
1	Chromium	350 million ton	1
2	Lead	14.8 million ton	1
3	Zinc	34 million ton	1
4	Uranium	900,000 ton	2
5	Copper	40 million ton	4
6	Oil	2.7 billion ton	7
7	Iron	17 billion ton	7
8	Gold	1,900 ton	9
9	Natural gas	1.830 billion. m^3	15

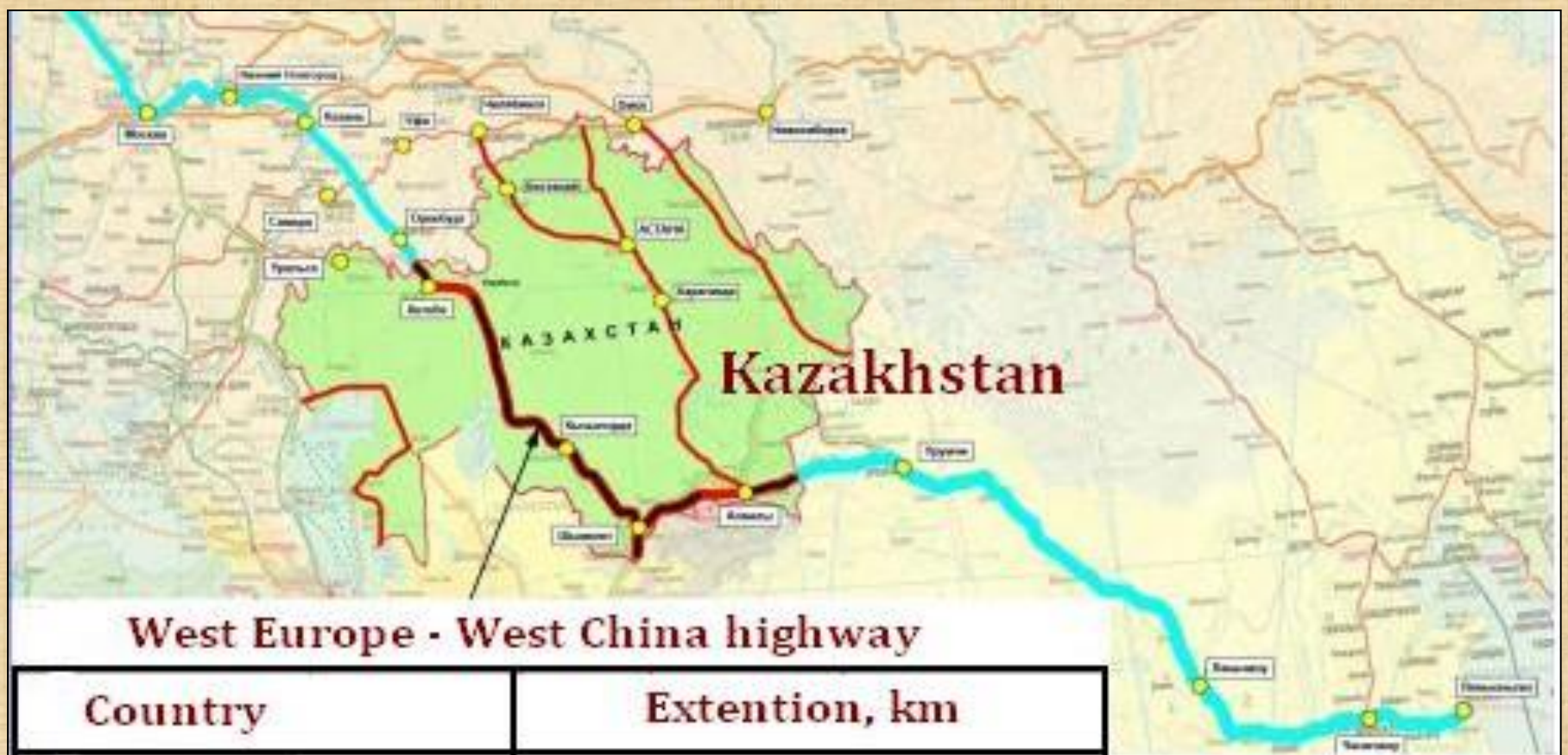
Nuclear Industry of Kazakhstan

In 2009 Kazakhstan come to the first place in world on mining the Uranium (it was mined about 13 500 tons)

Rank	Country	Production (tU)	Uranium Resources (tU)* <US$80/kg
1	Kazakhstan	14 020	344 200
2	Canada	10 173	329 200
3	Australia	7 982	714 000
4	Namibia	4 626	145 100
5	Russia	3 564	172 400
6	Niger	3 234	44 300
7	Uzbekistan	2 429	55 200
8	USA	1 453	99 000
9	The Ukraine	840	126 500
10	China	750	44 300
11	SA	563	205 900
12	Brazil	345	157 400
13	India	290	-
14	Chez	258	600
15	Romania	75	-
16	Pakistan	50	-
	Total	**50 772**	**2 438 100**

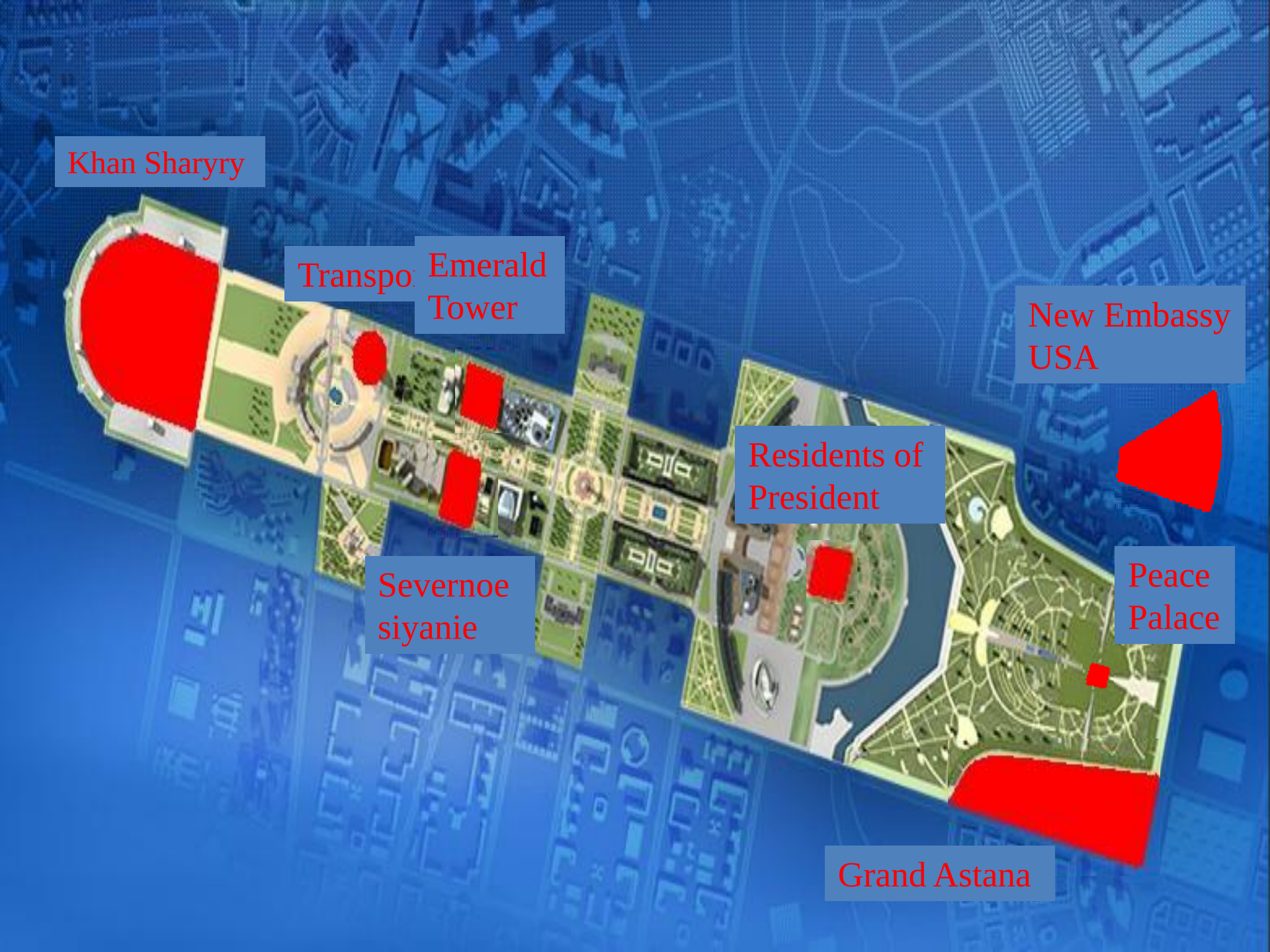
The data according report of **World Nuclear Association**

West Europe – West China Highway



West Europe - West China highway

Country	Extention, km
Russia	2233
Kazakhstan	2767
China	3225
Total	8445


Khan Sharyry
Transpo
Emerald Tower
New Embassy USA
Residents of President
Severnoe siyanie
Peace Palace
Grand Astana

Gallery of Astana City Megaprojects

View of City

Bayterek Tower

Twin Towers
Zwillingstürme

International Airport
Internationaler Flughafen

Lighter - Feuerzeug

Nur Astana Mosque

Taban Astana Stadium
Sportstadion

Khan Shatyr Entertainment Center

Freizeitzentrum

Night Astana

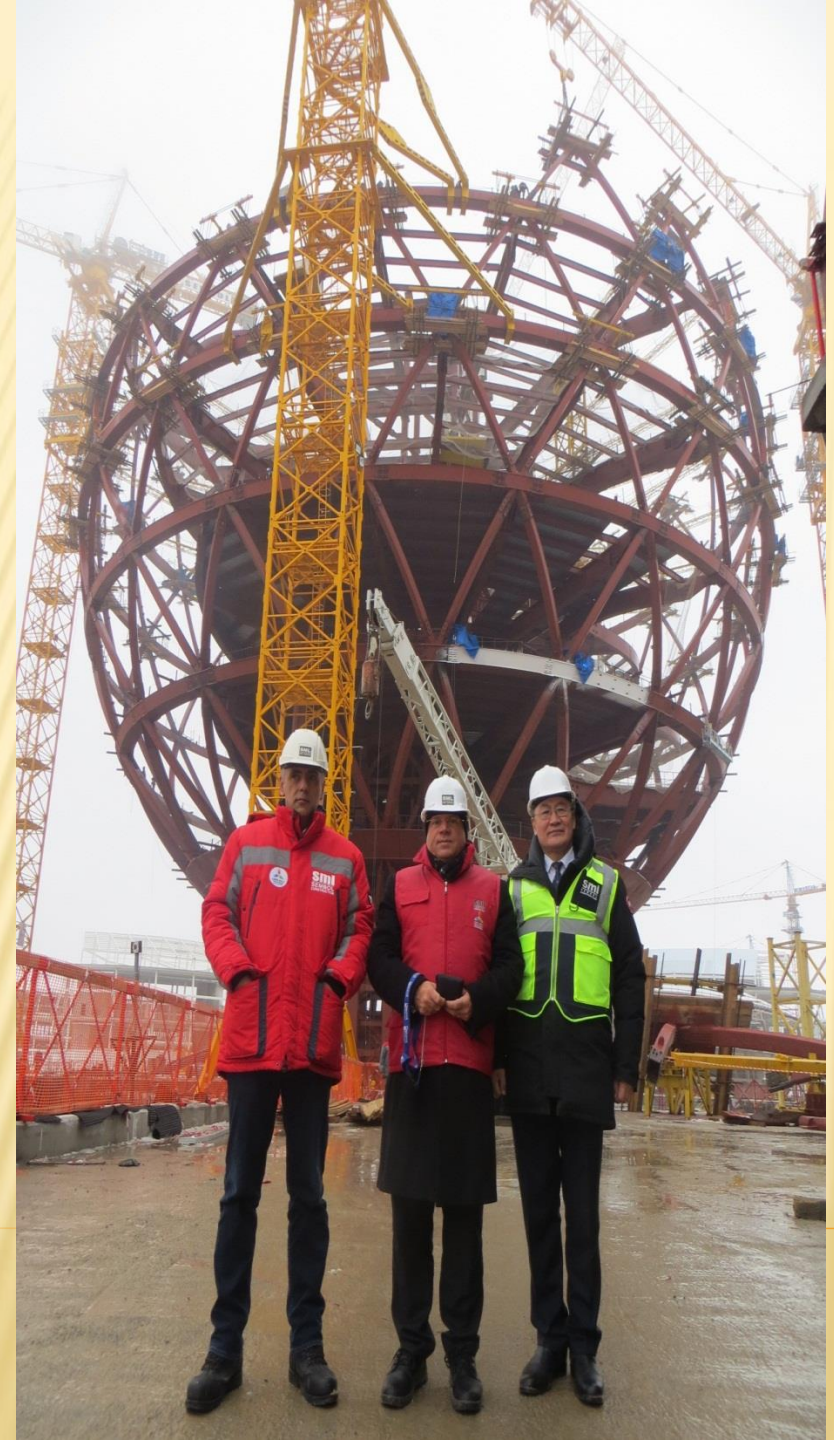
Night Astana

Transport and Emerald Towers

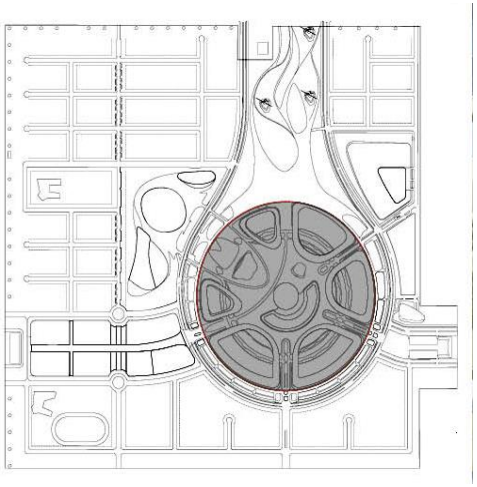
淡江大學
Tamkang University

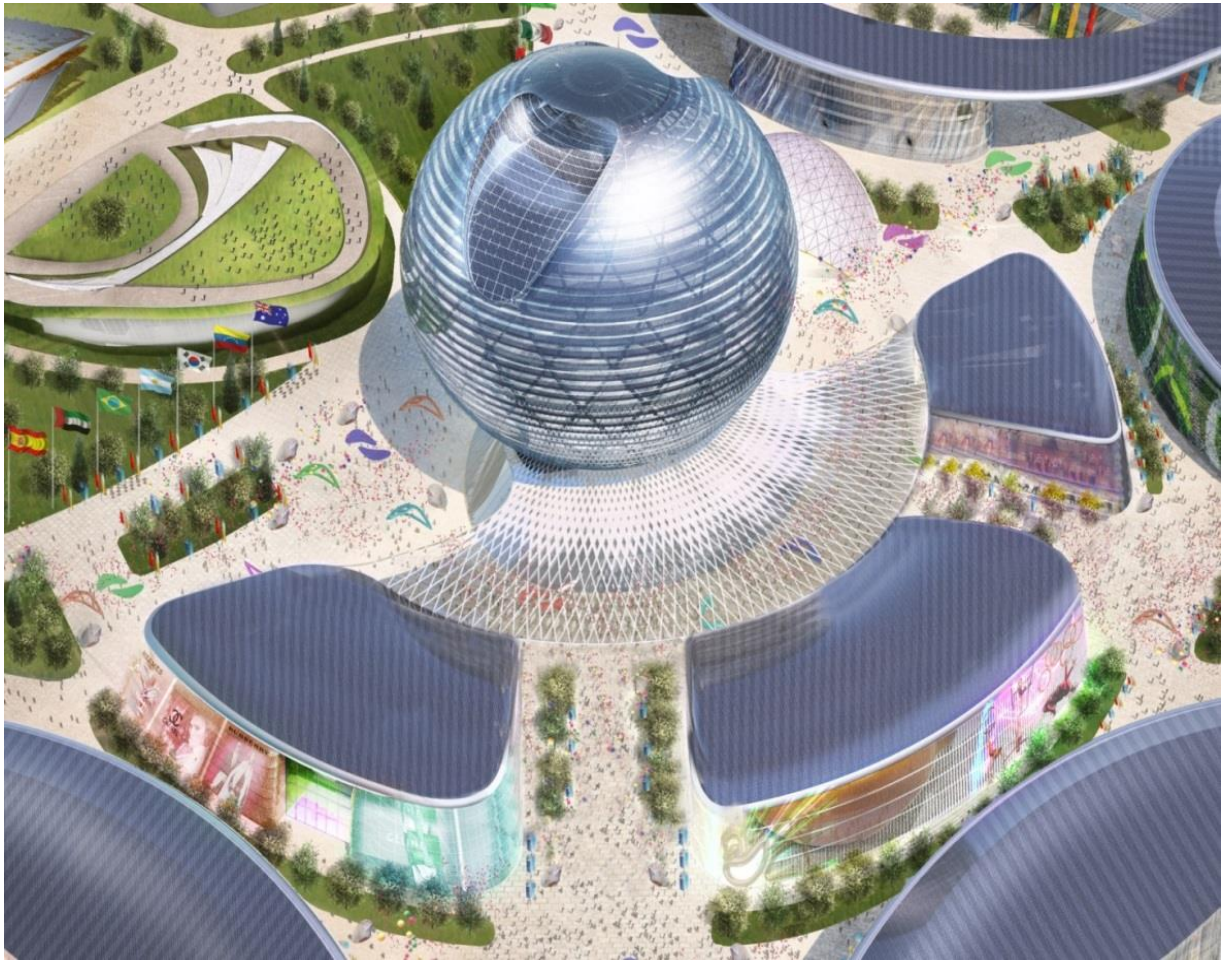
EURASIAN NATIONAL UNIVERSITY

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



Technical visit to the construction site of EXPO-2017





Overall area of the Sphere complex (above ground) - 19998 m2

The Sphere - 14898 m2

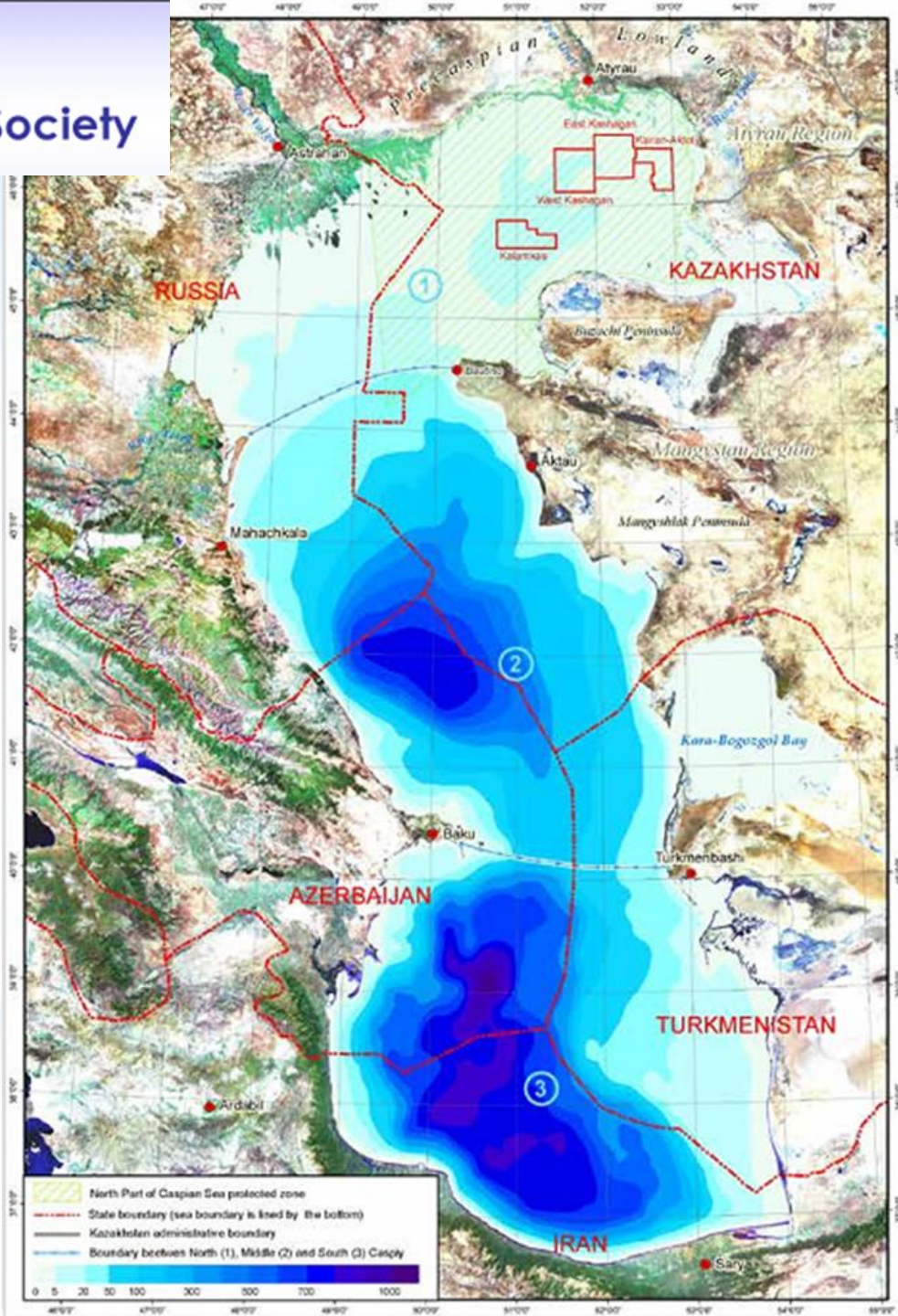
National Pavilion – 5100 m2

SEAGS
Southeast Asian Geotechnical Society

Prorva- Sea Port

Приморско-Эмбинская нефтегазоносная область 2008 г.
Кашаган
Кайран
Актоты
Жемчунина
Исатай-Сункар-Толкын
Тажигали
Каратон
Королев
Маткен
Тенгиз
Морское
Прорва
Южная
TENGIZ
PORT PRORVA
Приморско-Эмбинская (Кашаган-Тенгизская) нефтегазоносная область
Начертил: Adaykz

The Caspian Sea is the largest enclosed inland body of water on Earth by area, variously classed as the world's largest lake or a full-fledged sea. It is in an endorheic basin (a basin without outflows) located between Europe and Asia. It is bounded by Kazakhstan to the northeast, Russia to the northwest, Azerbaijan to the west, Iran to the south, and Turkmenistan to the southeast.



1. INTRODUCTION

The use of pile foundation is popular in Kazakhstan. Precast concrete joint piles are applied for Cargo Offloading Facilities (hereinafter – COF). Field tests of the soil by pile were carried out at the site construction of COF of Cargo transportation route of the North-East part of the Caspian Sea. Facilities were designed for offloading cargo handling bulky and general cargo in the north-east coast of the Caspian Sea near the Prorva oilfield delivered by river / sea transport.

Dynamic tests were conducted by PDA (Pile Dynamic Analyzer) and traditional methods, also static test by the requirements of the American Society for Testing Materials.

Static and dynamic tests were carried out on precast concrete joint pile with a total length of 27.5 m. It is composed of two segments with cross-section 40 cm x 40 cm: the bottom segment with length of 16.0 m and upper segments lengths: 9.5 and 11.5 m (see Figure 1).

Figure 1. Installation of precast concrete joint pile

SEAGS
Southeast Asian Geotechnical Society

SEAGS
Southeast Asian Geotechnical Society

SEAGS
Southeast Asian Geotechnical Society

SEAGS
Southeast Asian Geotechnical Society

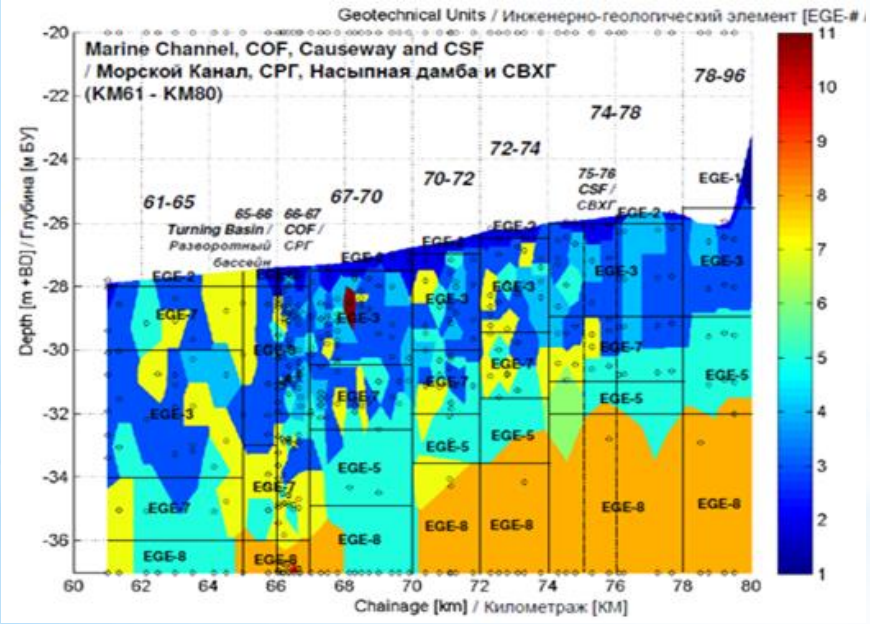
Wood with thickness of 10 cm and nylon with yield stress 72 MPa and thickness of 6 cm was for driving bottom segment between pile head and hammer helmet pile. Wood was used for driving upper segment was used wood with thickness 20 cm. Also pile is applied by corrosion protection material (bituminous) and marked every 0.25 m. The purpose of testing is estimation of the bearing capacity and comparison of the results of different tests by four piles (pile numbers: TP-02, TP-03, G-26 and B-38).

Static compression load tests were performed on precast concrete joint piles No. TP-02 and TP-03, which driving in COF Area with depth 23.00 and 26.75, from ground level Baltic datum -25,609 m and pre-augering with auger dia. 330 m, depth 11.40 m before driving.

Pre-augering with auger diameter 330 m, depth 11.40 m

2. ENGINEERING-GEOLOGICAL STRUCTURE OF THE CONSTRUCTION SITE

The project area is situated in the Northern Caspian Shelf. Right now the North Caspian Sea has a limited water depth (maximum 5 to 8 m). The water level in the Caspian Sea depends on a balance between the inflow of river water and evaporation.



Geotechnical profile based on Lab Results

This has resulted in large variations in sea level in the past. This explains the sequence and soil characteristics of the deposits. Table 1 shows engineering-geological structure of the construction site. Ten engineering-geological elements (units) are identified based on the geological setting and the borehole logs.

Major Caspian sea level fluctuations are closely related to Pleistocene glacial and interglacial periods. Warmer periods caused melting of glaciers and cut-off to the north flowing rivers causing rivers to flow southwards into the Caspian sea. The transition of Pleistocene to Holocene is identified with the start of the current warm period, i.e. around 11,700 years B.C.

Table 1 Engineering-geological elements

(EGE) Soil type	**General consistency**	**C**	**φ,** deg	**$\gamma_{natural}$,** kN/m^3	**Su,** kPa	**E***oed ;ref*
(**EGE-1**) FILL: SAND, clayey, calcareous	loose to medium dense	0.7	29.4	19.4	25	2,800
(**EGE-2**) SILT, slightly organic, calcareous	soft to firm	0.7	29,4	19.3	15	2,750
(**EGE-3**) SAND, silty, calcareous	medium dense to dense	2.7	31.5	19.0	-	30,000
(**EGE-7**) CLAY, silty, calcareous	stiff	20.8	24.7	19.1	80	2,000
(**EGE-8**) SAND, silty, calcareous	very dense	2.4	31.8	20.0	-	40,000
(**EGE-9**) CLAY, sandy, calcareous	very stiff	22.7	23.8	20.6	150	4,000
(**EGE-10**) CLAY, silty, calcareous	very stiff	25	24.7	20.2	150	2,000

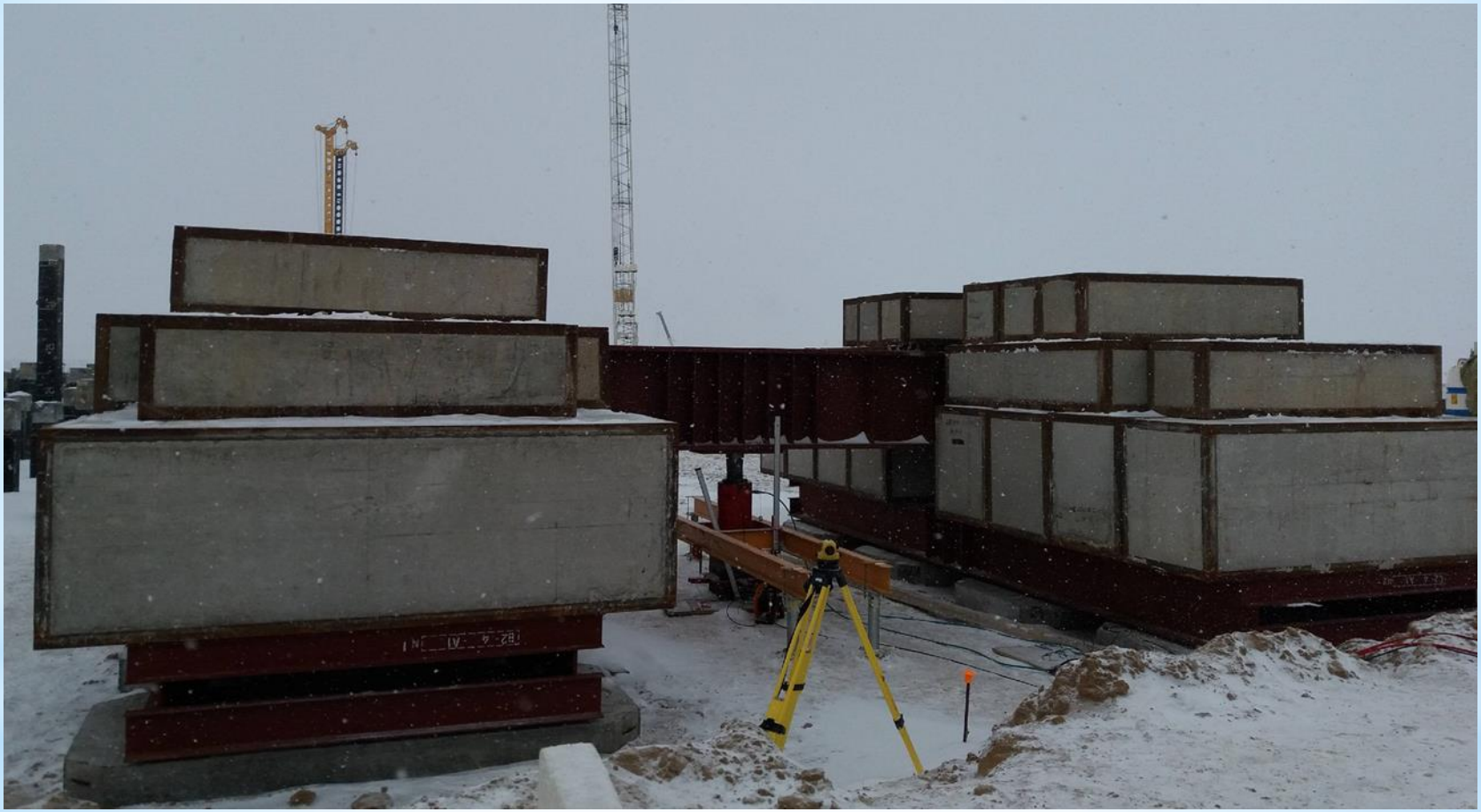
s_u – undrained shear strength [kPa]
$E_{oed\ ;ref}$ -Elastic unloading/reloading [kPa]

3. STATIC COMPRESSION LOAD TEST (SCLT)

Static compression load tests were performed on precast concrete joint piles No. TP-02 and TP-03, which are driving in COF Area with depth 23.00 and 26.75, from ground level Baltic datum -25,609 m and pre-augering with auger dia. 330 m, depth 11.40 m before driving.

Platform system is made of steel, which consists of metallic beam and 2 platforms located on equidistant distances from the centre main beams (see Figure 3).

Concrete blocks are used for platforms, and one platform can pack total weight of 200-205 tons. The vertical load creating with hydraulic jack DG500 G250. The pressure in the jack was creating with using electro-hydraulic pump NER-1,6A40T1, with manual distributor. The pressure controlled with pressure gauge MA100BU100 has value of the scale division 0 to 1000 bar. For reference beams using two H-beams with h=20 cm and length 5.3 m which bolted with clamp to screw piles BAU 114*4*2000 drilled in soil with depth 1.5 m. SCLT is a purpose designed system for monitoring static pile test in accordance with Eurocode7. Figure 4 shows the results of SCLT testing .



SEAGS
Southeast Asian Geotechnical Society

SEAGS
Southeast Asian Geotechnical Society

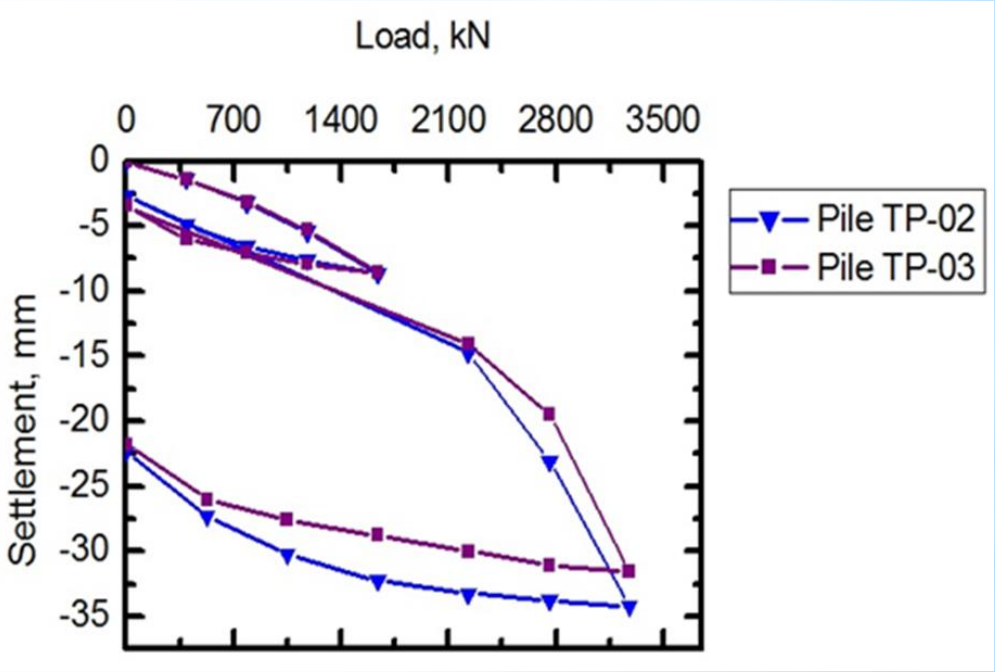
SEAGS
Southeast Asian Geotechnical Society

HITACHI

The loading and unloading can be carried out in stages as shown in Table 2.

Table 2 Load stages of the for preliminary pile

#	Percentage of Working Load	Load, kN	Minimum time of holding load
Load			
0	0	0	0
1	30	393	1 h
2	60	786	1 h
3	90	1179	1 h
4	125	1639	1 h
Unload			
5	90	1179	10 min
6	60	786	10 min
7	30	393	10 min
8	0	0	1 h
Load			
9	170	2229	6 h
10	210	2756	1 h
11	250	3278	6 h
Unload			
12	210	2756	10 min
13	170	2229	10 min
14	125	1639	10 min
15	80	1049	10 min
16	40	525	10 min
17	0	0	1 h



Load-settlement graphs from the SCLT methods

SLT is a highly accurate and robust system that enables you to monitor static pile tests whilst also ensuring the safety of site operatives.

Davisson's Offset Limit Method (ultimate load) offers the benefit of allowing the engineer, when proofing a pile for a certain allowable load, to determine in advance the maximum allowable movement for this load with consideration to the length and size of the pile.

Pile section area, A=0.16 m^2; Approximated pile dia., D=45.0 cm; Load, P=3000 kN;

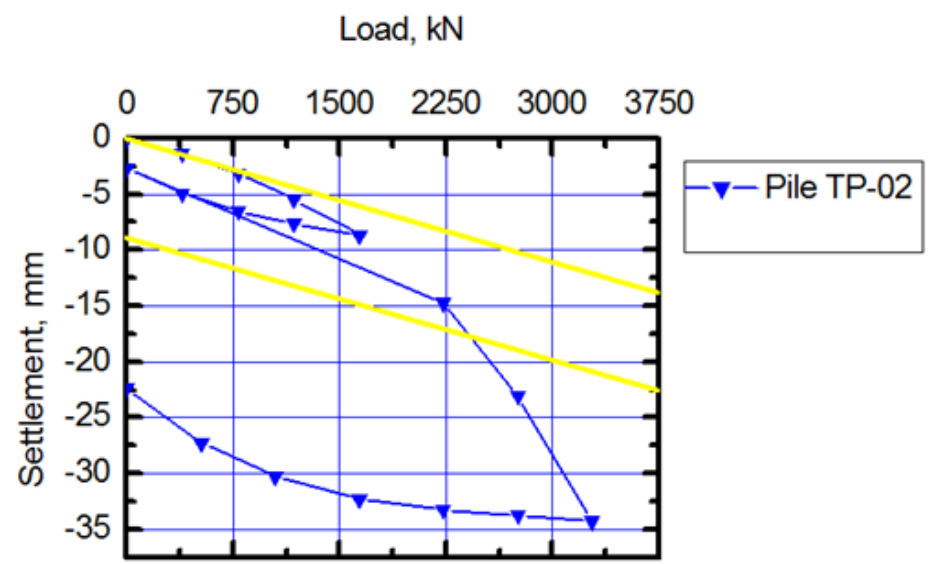
Pile number TP-02; pile length L=26,75 m; Young's (B 40), E_{con}= 45 000 000 kPa; Elastic line=(P*L)/(A*E)=0.011 m= 11 mm; Davisson (ASTM) offset: Δ=D/120+0.4=0.78 cm= 7.8 mm;

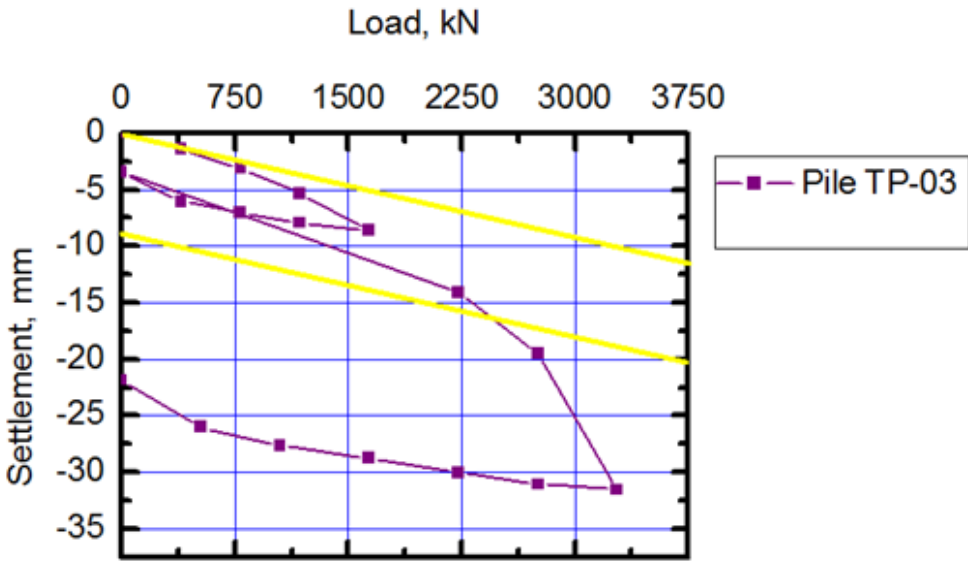
Pile Ultimate Capacity (pile number TP-02) Fu = 2480 (see Figure 5);

A primary advantage of this method is that the actual limit line can be drawn on the load movement diagram already before starting the test. The offset limit load criterion is primarily intended for interpretation of quick testing methods, but it can also be used when interpreting results from the slow methods.

Pile number TP-03; pile length L=23,00 m; Young's (B 40), E_{con}= 45 000 000 kPa; Elastic line=(P*L)/(A*E)=0.0096 m= 9.6 mm; Davisson (ASTM) offset: Δ=D/120+0.4=0.78 cm= 7.8 mm;

Pile Ultimate Capacity (pile number TP-02) Fu = 2450 kN (see Figure 6)





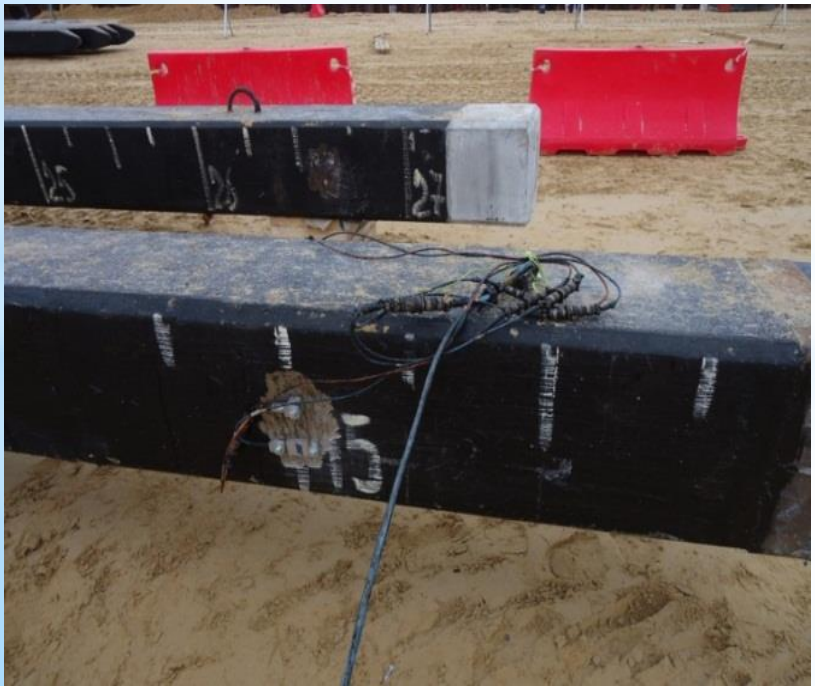
Ultimate failure load according to Davisson for piles No.TP-02 and TP-03

According to Kazakhstan Standard 0.1% of constructed piles on construction site must be tested by SLT, but at least 2 SLTs in a site must be done.

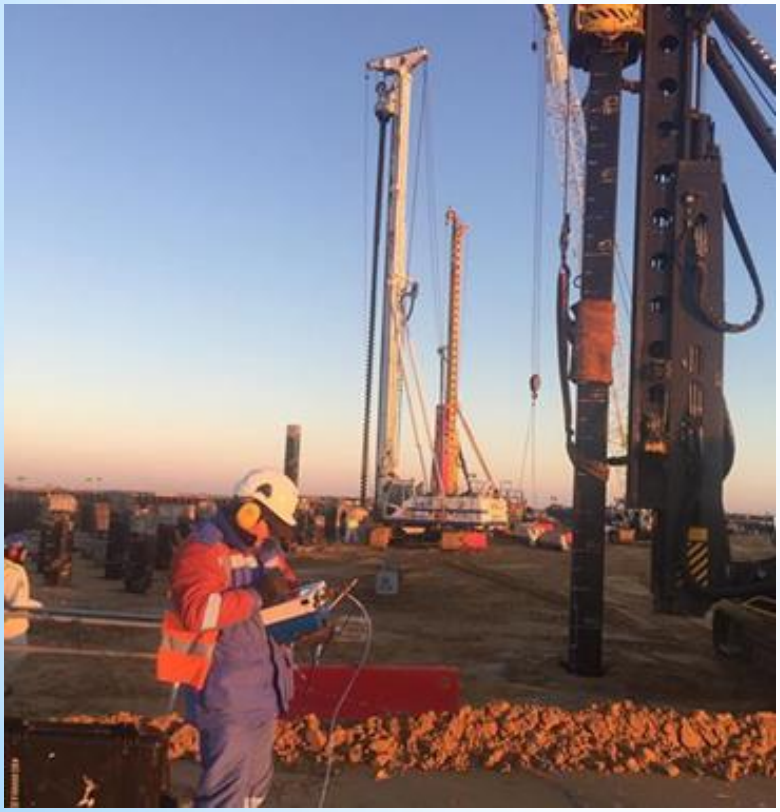
The Davisson Offset Limit is very sensitive to errors in the measurements of load and movement and requires well-maintained equipment and accurate measurements. However, it is easy to apply and has gained wide acceptance.

4. DYNAMIC LOAD TEST WITH PDA

Pile Dynamic Tests were performed on precast concrete joint piles No. G-26 and B-38. Piles were tested with PDA (Pile Driving Analyzer – Model PAX) using hammer JUNTTAN PM25LC with a hydraulic hammer HHK-9A of 9 tons of weight and a head-cap of 990 kg (Geotechnical Interpretation Report. (2014)). On the tested pile a pair of accelerometers and at least a pair of strain transducers are attached at least two pile diameters below pile head (see Figure 7, Figure 8 and Figure 9).



The energy delivered to the pile is directly computed as the work done on the pile from the integral of force times incremental displacement which is easily evaluated as force times velocity integrated over time. Maximum compression stresses at the pile top come directly from the measurements. The measurements also allow direct computation of the compression stress at the pile toe and the tension stresses along the shaft.



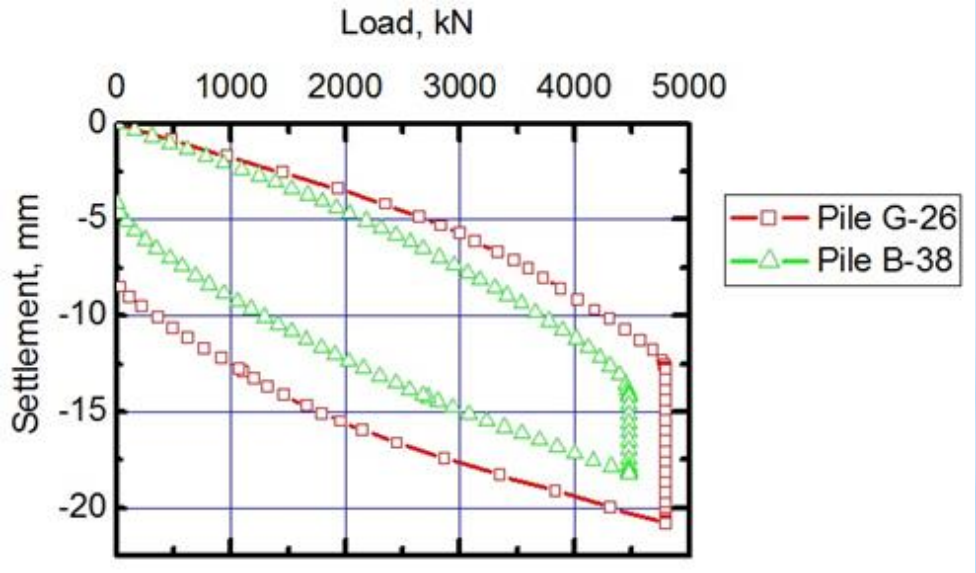
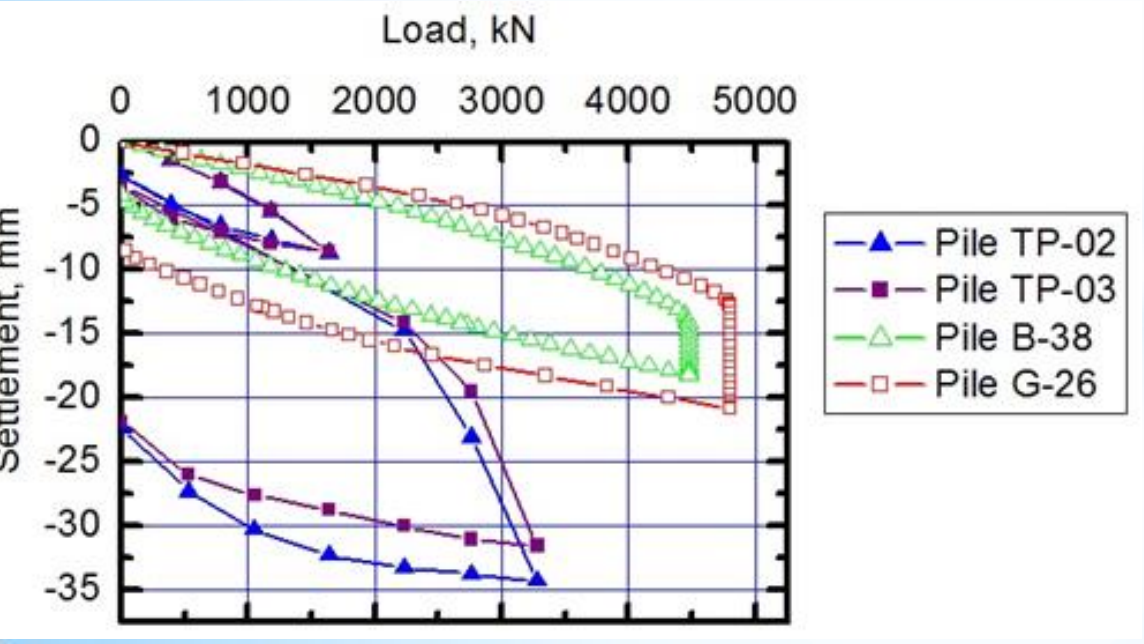


Figure 10 presents the monitoring results of PDA test. The results showing pile dynamic compression and tension stresses, static pile capacity and blow counts versus pile penetration depth. The Figure 11 presents CAPWAP analysis results that include plots of measured pile head data obtained under the hammer blows from the end of driving and associated simulated pile head and toe static load-settlement relationships.

Difference between performed SCLT and DLT test could be explained partly because time gap between DLT and SCLT is 9 days and also because of driving nearby piles before SCLT test, what produce additional pore pressure and less friction at the time of SCLT. Since high bearing soil layers have large permeability it could be assumed that pore pressure effect and pile set-up are quicker.



We have to be aware that simulation of static load test with CAPWAP (or DLT) does not include any long term effects like creep or long term settlements. This is why in almost all cases CAPWAP load-set curve is little higher than load-set curve from static load test, especially for higher loads and toe bearing piles.

6. CONCLUSION

The purpose of testing is determination of bearing capacity and the penetration depth of immersion of composite piles in problematical ground soils of Atyrau region, Kazkhstan.
According to the results of DLT with PDA of driven piles (40×40 cm and lengths of 23 m and 26.75 m) the bearing capacity of the piles amounted to be 2143 kN. The bearing capacity of driven piles according to the results of SCLT amounted to be 2067 kN and 2042 kN.
The disadvantage of the offset limit load lies in the difficulty of determining the modulus of elasticity E for concrete piles and concreted pipe piles. Davisson's method needs the pile to be loaded to failure to be applicable.
We have to be aware that simulation of static load test with CAPWAP (or DLT) does not include any long term effects like creep or long term settlements. This is why in almost all cases CAPWAP load-set curve is little higher than load-set curve from static load test, especially for higher loads and toe bearing piles.

ISSMGE TECHNICAL COMMITTEE REPORT
TC 305 Geotechnical Infrastructure for Megacities and New Capitals

October 2013 – June 2018

Chair: Askar Zhussupbekov

Vice-Chair: Hoe Ling

Secretary: Der-Wen Chang

Nominated Member: 28

Corresponding member: 1

Total: 32

TC 305 Geotechnical Infrastructure for Megacities and New Capitals MEMBERSHIP LIST

1	Chair	Askar Zhussupbekov	Kazakhstan
2	Vice Chair	Hoe Ling	United States
3	Secretary	Der-Wen Chang	Chinese Taipei
4	Nominated Member	Tadashi Hashimoto	Japan
5	Nominated Member	Rolf Katzenbach	Germany
6	Nominated Member	Makoto Namba	Brazil
7	Nominated Member	Luljeta Bozo	Albania
8	Nominated Member	Skënder Allkja	Albania
9	Nominated Member	ALEJO OSCAR SFRISO	Argentina
10	Nominated Member	Argimiro Ferreira	Brazil
11	Nominated Member	Helen Reeves	United Kingdom
12	Nominated Member	Ozer Cinicioglu	Turkey
13	Nominated Member	Viktor Popov	Kazakhstan
14	Nominated Member	Gennady Sultanov	Kazakhstan
15	Nominated Member	Mahendra Singh	India
16	Nominated Member	Massimo Ramondini	Italy
17	Nominated Member	T.G. Sitharam	India
18	Nominated Member	Nikolaos Klimis	Greece
19	Nominated Member	Baris Trak	Turkey
20	Nominated Member	Kazuhito Komiya	Japan
21	Corresponding Member	Hirokazu Akagi	Japan
22	Nominated Member	Rupert Leung	Hong Kong
23	Nominated Member	Axel Ng	Hong Kong
24	Nominated Member	Dipanjan Basu	United States
25	Nominated Member	Manuel Matos Fernandes	Portugal
26	Nominated Member	Eugeniusz Dembicki	Poland
27	Nominated Member	V.A. ILYICHEV	Russia
28	Nominated Member	Saeed Heidari	Iran
29	Nominated Member	Patrick Ganne	Belgium
30	Nominated Member	Fabrice EMERIAULT	France
31	Nominated Member	Masyhur Irsyam	Indonesia
32	Nominated Member	Sebastiano Rampello	Italy

TC 305 Geotechnical Infrastructure for Megacities and New Capita
TERMS OF REFERENCE

- Disseminate knowledge and practice on design and practice of geotechnical technologies at megacities and new capitals to the members of ISSMGE.
- Establish guidelines and technical recommendations on design and practice of geotechnical technologies at megacities and new capitals.
- Assist with technical programs of international and regional conferences organized by ISSMGE to present the impact of relevant technologies.
- Interact with industry and other organizations working on design and practice of geotechnical technologies at megacities and new capitals.

TC 305 Geotechnical Infrastructure for Megacities and New Capita
ADMINISTRATIVE MEETINGS

- 27 October, 2013, Taipei, Taiwan
- 13 December December, 2014, Astana, Kazakhstan
- 8 July, 2015, Astana, Almaty, Kazakhstan
- 28 March, 2015, San Antonio,Texas, USA
- 10 November, 2015, Fukuoka, Japan
- 13 September, 2015, Edinburgh, Scotland
- 15 February, 2016 , Phoenix, Arizona, USA
- 7 August, 2016, Astana, Kazakhstan
- 2 October, 2016, Astana, Kazakhstan
- 4 November, 2016, Taiwan
- 14 November, 2016, South Korea
- 12 December, 2016, Astana, Kazakhstan
- 19 June, 2017, Astana, Kazakhstan

TC 305 Geotechnical Infrastructure for Megacities and New Capita
ORGANIZED EVENTS

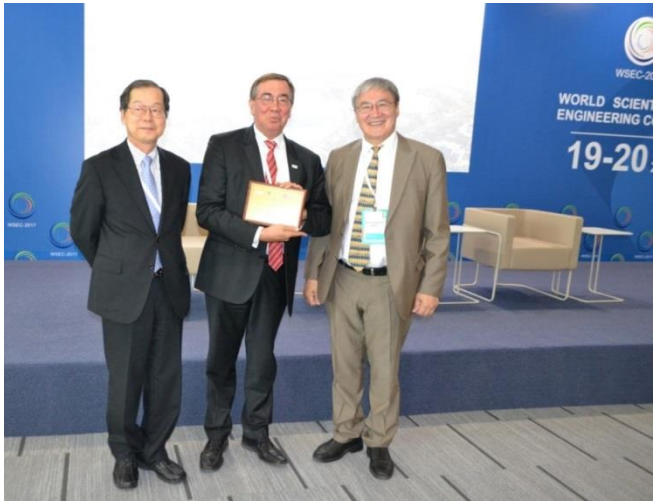
- The First Taiwan-Kazakhstan Joint Workshop in Geotechnical Engineering, October 27, 2013, Taipei, Taiwan
- The First Eurasian Congress of Construction Industry on TC 305, (participations are Professor Christos Tsatsanifos, Hellenic Society for Soil Mechanics and Geotechnical Engineering, Athens, Greece, Dr. Fujii Yukiyasu, Japanese Geotechnical Society, Gifu, Japan, Professor Michael Lisyuk and Professor Aleksey Shashkin, Russian Geotechnical Society, Saint-Petersburg, Russia and members of Kazakhstan Geotechnical Societies), 2-3 December, 2014 , Astana, Kazakhstan, (about 2022 participants);
- Kazakhstan-Japan Joint workshop on TC 305, (lecture of Prof. Tanaka Tadatsugu, Prof. Yoshi Iwasaki, Fujii Yukiyasu), 12-13 December , 2014,

TC 305 Geotechnical Infrastructure for Megacities and New Capita
ORGANIZED EVENTS

- Astana Economic Forum (AEF), panel session “Next Generation Cities”, Astana, Kazakhstan (Invited Lecturers: Prof. Eun Chul Shin, Incheon University, South Korea, Prof. Askar Zhussupbekov, Eurasian National University), 21 -22 May, 2015, Astana, Kazakhstan (about 4000 participants from)
- The First Kazakhstan-American Geotechnical Workshop «Transport systems and energy geotechnics» at the Summer school «Geotechnical Infrastructure for Mega Cities and New Capitals», July, 2015, Astana, Almaty, Kazakhstan

TC 305 Geotechnical Infrastructure for Megacities and New Capita
ORGANIZED EVENTS

- The Roundtable discussion on «Innovation and Challenges in the Construction of the Ground and Foundations of Renewable Energy Facilities» within the World Scientific and Engineering Congress «Energy of the future: innovative scenarios and methods of their implementation» WSEC-2017, Astana, Kazakhstan, 2017.



TC 305 Geotechnical Infrastructure for Megacities and New Capita
FUTURE ACTIVITIES

- The second GI-KGS joint workshop TC 305 within the International Foundations Congress and Equipment Expo, March 5-10, 2018, Orlando, Florida
- The 16th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering (16ARC), October 14-18, 2019, Taipei, Taiwan

TC 305 Geotechnical Infrastructure for Megacities and New Capita

THANK YOU FOR ATTENTION!