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ABSTRACT

This paper describes one of the most challenging off-shore artificial islands construction in the North of Caspian Sea, Kazakhstan. Two 130 m by 90 m artificial island where sheetpiling was employed were constructed for oil exploration. The islands are closed box structures whose front walls are composed of 15 m long sheetpiles and tied to the back sheetpile wall. Sheetpile driving is done by the aid vibro-hammers with low-pressure water jet assistance.

The proposed construction site is extremely sensitive environmental area, known as "Special Ecological Zone" and "Specially Protected Zone". For this reason very strict environmental regulations are implemented in addition to the safety and quality control programs during the construction works. The local water depths at the construction site are in the range of 1 to 2 meter and also subjected to unpredictable annual and seasonal changes mainly due to the very strong wind effect.

The logistic works for the site have been carried out from the main office, established in Bautino, which is the only closest urban village in the region and is approximately 350 km away from the construction site. Transportation to the construction site is carried out by ships and usually takes 28-30 hours in case weather conditions permit. The construction of two islands was completed successfully in a period of less than 96 days before the scheduled construction period. The oil exploration works are projected to commence in 2003.

INTRODUCTION

An off-shore construction project which was completed in the North of Caspian Sea, Kazakhstan, that is among the world`s most promising for the search for hydrocarbons. (Figure 1.)

The proposed site is located within the Kazakhstan sector of the Northeast Caspian Sea and is characterized by shallow waters between 1 and 9 meters in depth with an average of approximately 6.2 meters.

Sheetpiling was employed in the construction of both artificial islands (130 m x 90 m) so as to explore oil. The islands are closed box structures whose front walls are composed of 15 m long sheetpiles (Larssen 605) and tied to the back sheet pile walls by tie-rods. Sheetpile driving is done by the aid vibro-hammers with low-pressure water jet assistance.

GEOTECHNICAL and SOIL CONDITIONS

Geotechnical site investigations were carried out in the north-eastern part of the Caspian Sea. The investigation consisted of in-situ testing and sampling, followed by both offshore and onshore laboratory testing of the samples. In-situ testing included piezo-cone penetrometer tests (PCPT). Results from the field investigation and laboratory testing revealed that soil profiles consisting mainly overconsolidated clay overlain by a very dense sand stratum and a soft clay layer.

The age of the marine deposits at the proposed site vary from recent Novocaspian (top 3.0 to 5.5 m) to Late/Early Khavalynian (down to final boring depths).

Of the two islands; Island 1 and 2; only one of the geotechnical profile of the site, that is Island 1 is presented in Figure 2 and a summary of the soil properties for Island 1 is given in Table 1.

The geotechnical properties of the top layers of the subsoil are essential for the engineering design of an artificial island. Tests on samples of the soft clay layer encountered between about 0.1 m and 1.8 m reveal typical undrained shear strength values of 20 kPa. The sands from the shallow strata contain a substantial fines content (silt/clay fraction).

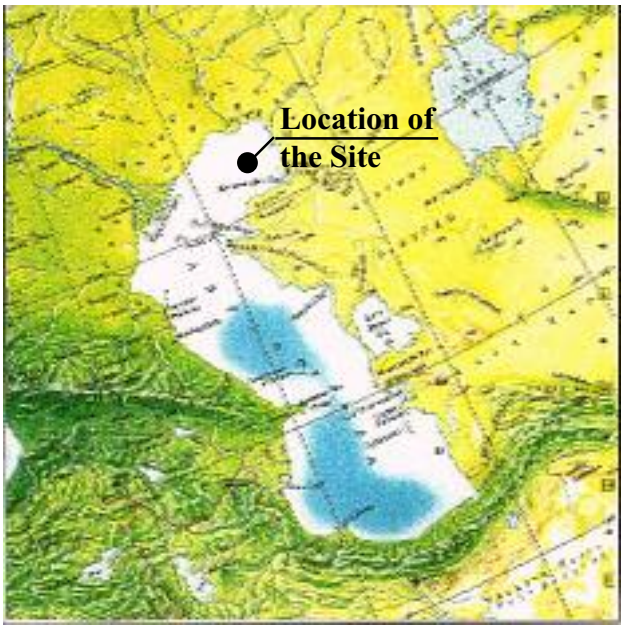

Figure 1. Geographical Map of the Caspian Sea

The site is marked by a generally flat sea bed topography, with a water depth between 2.5 m and 2.9 m. At the top of the soil profile a thin layer of soft clay and silt is observed, which extends to a depth between 0.8 m and 1.4 m below seabed. Towards the south-west of the site the soft clay largely wedges out and is replaced by a loose silica sand. Below the soft clay a very dense, silty silica sand occurs, which may reach a maximum thickness of 4.8 m. Gypsum crystals are commonly observed in the sand. Below the sand stiff clay occurs which extends to the final borehole depth at 19.6 m below seabed. Between 10.7 m and 13.5 m, an interbedded very silty very dense silica sand occurs, with abundant gypsum crystals. Gypsum crystals can also be found in the top of the clay stratum.

The steps of increasing consistencies observed in the soil profiles are considered to be related to sedimentary breaks caused by the sea level fluctuations of the Caspian Sea. The occurrence of gypsum in the sediments is also considered as a stratigraphical marker related to evaporation in very shallow water and mud flat conditions.

This area is an extremely sensitive environmental location, known as “Special Ecological Zone” or “Specially Protected Zone Border”. The shallow waters and coastal reed beds spark high levels of biological productivity and supports a wide range of fish and waterfowl species. Activities within this region are subject to stringent controls during the periods April 01 to July 15 and the whole month of October. During the winter months, the majority of the Caspian seal population conducts their breeding season on the ice.

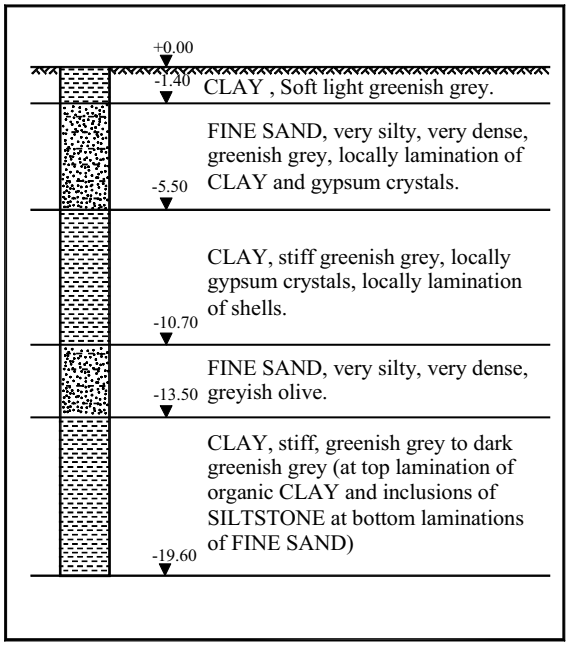

Figure 2. The soil profile for Island 1

METEOROLOGICAL CONDITIONS

The average overall air temperatures at the North Caspian Sea Region varies between 8 to 10^{o}C. The mean air temperature in winter is between -7 and -10^{o}C, with the arrival of the Arctic air masses, it drops to -30^{o}C. During the summer months (June to August) the mean air temperature is 24 – 26^{o}C, reaching to 42 – 44^{o}C with a south wind.

Water temperatures vary as much as air temperatures depending on the time of year. During the summer, water temperatures can rise above 26^{o}C in shallow areas.

However, in the beginning of November, ice starts to form in protected areas of the Northeast and with the onset of winter, the ice cover increases and spreads west and south. (Fig.3) Depending on the year, the ice pack can reach both shores of the extreme north Caspian Sea. Again depending on the year, ice cover can last until April.

Table 1. Summary of Soil Properties at the proposed Island 1

Depth (m)	**Soil Type**	γ kN/m^3	**I_P (%)**	**w (%)**	**c_u** (kPa)
0.1-1.4	Clay	-	13	-	20
1.4-5.5	Fine Sand	20.0	-	17	-
5.5-10.7	Clay	18.5	36	25	85
10.7-13.5	Fine Sand	20.0	-	22	-
13.5-19.6	Clay	19.5	24	18	80

PROJECT DESCRIPTION

The project consists of construction of two artificial islands to explore oil in Caspian Sea. (Fig.3) Each island is surrounded by sheetpile wall. The outer walls are anchored to the back sheet pile walls by tie rods. The dimension of islands is 130 m. x 90 m.

The length of perimeter sheetpiles varies within the range of 13 to 15 m. The total area of perimeter sheetpiles is 6,000 sq.m. wheras the total area of 5 m long anchor piles is 1,900 sq.m. (Fig. 4)

Figure 3. The panoramic view of the construction site

The summarized work phases at the project site are as follows:

Earthworks

All fill and core materials are supplied from Bautino Base for island construction. Materials were loaded from loading jetty to barges. Barges could not reach to island with full load capacity due to shallow water conditions. Therefore fill material was divided into half at the transfer point where the water depths are considerably deep and only half loaded barges could reach the island. Fill or core materials were dumped into the sea by excavators from the barges.

After preparation of sufficient area, excavators were moved form the barge onto the dumped material by the aid of special ramp for leveling operations. Earthwork operations continued until the island reached its designed level and dimensions.

When the installation of the tie rods was completed, backfilling and compaction works were started. The geomembrane was layered and sheets of membrane were welded to each other. The quality of the welding was tested against permeability defects since it would prevent the contaminated water, oil, the products of oil and other material harmful for the Caspian Sea environment leaking into the Caspian Sea. Over this membrane compaction works continued until the specified level. Soil compaction test results were taken regularly to ensure the quality of the work.

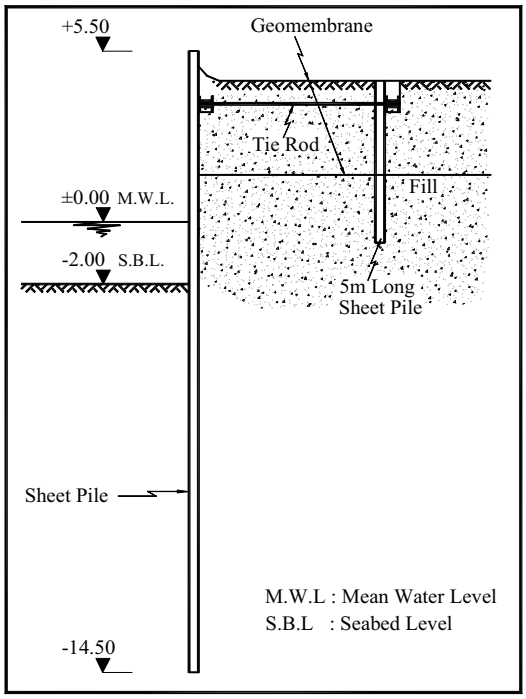

Figure 4. Cross section of the sheetpile walls

Sheet Piling Works

The project contains sheet pile driving works with length of 13 and 15 meter double sheetpiles and 5 meter single anchor sheetpiles. Sheetpiles are to be driven down to a depth of –10 meter. The top level of 13 meter and 15 meter long sheetpiles are + 4.4 meter at two sides and + 6.4 meter at other two sides respectively. The reason for this difference in the elevations is to form a curtain against prevailing wind action.

Water jetting pipes are fixed to sheetpiles within the stocked area before driving. A special guide was used in driving the long sheetpiles in vertical and horizontal alignment.

Water Jet Assisted Sheetpile Driving

Since the soil is hard to very hard at the proposed site, it could not possible to drive unless water jetting, therefore all of the double sheetpiles for the main front walls were driven by use of water jet. The method was realized by a water pump via one pair of pipes connected to the sheetpiles by means of welded clamps. After completion of driving, water jet pipes could be taking out by pulling with a crawler crane.

Anchor Pile Driving

Anchor piles (L=5 meter) were driven without using water jetting. During driving of anchor piles, the guide was used in order to align the piles.

Waling Beam and Tie-rod Installation

Each waling beam was 12 m in length and consisted of two U320 beams with U spacers. After driving the piles, the holes were opened for tie rods & bolts. After installation of waling beam tie rod and bolt installation were started. (Fig.5)

Two parts of tie rods were fixed before installation. A crane was used to install tie rods between anchor piles and main wall. After installation, nuts were tightened behind anchor wall and main wall. Each corner of island is supported by waling beams (corner frame) inside the structure against ice action during winter season.

Capping Beam

The final stage of sheetpiling construction was the installation of capping beam. After the island was surrounded with sheet piles and anchor wall and tie rod installation finished capping beam works were started. Two sides of the top of main wall were covered with L beams and these beams welded to each other.

Figure 5. Installation of tie-rods

Logistic of the Project

The logistic works for the site have been carried out from the main office, established in Bautino, which is the only closest urban village in the region and is approximately 350 km away from the construction site. Therefore the transportation to the construction site is carried out by ships and usually takes 28-30 hours depending on the weather conditions. Two freighters realized transportation between island and the base.

Since water level in the vicinity of the island is very low, the accommodation ship could not reach the island and had to anchor far away from the island. Therefore the journey by a small boat from the accommodation ship to the island takes maximum 2 to 2.5 hours depending on the weather conditions.

WORK SCHEDULE & PERFORMANCE

Sheetpiling works were started in May, 2002. The installation of sheetpiling works for the main wall and the anchor wall with tie-rods were completed in July, 2002.

The construction of the two islands was completed successfully in a period of less than 96 days.

JOB HAZARD ANALYSIS & PERSONNEL TRAINING

The sheetpiling works were executed by fully complying with the very strict HSE regulations stipulated in the project and achieving the "Safety Excellence and the Zero Accident Philosophy". All works were conducted by using PPE (Personnel Protective Equipment); such as hard helmet, gloves, safety glasses, life jacket for all personnel on site and by using safety belt for the workers on guide.

Personnel Training

Since the offshore works show big differences and contains more dangerous stages when compared to any other construction work, all workers are trained about the sea survival. Sea survival training contains sea survival techniques, basic first aid and fire fighting. Therefore applicants are trained about what they will do to survive in case of emergency on sea. In case of transportation by helicopter, it is also necessary to have Helicopter Survival Training and H2S Training. In Helicopter Survival Training, applicants learn how to escape from a helicopter that has fallen to sea.

CONCLUSION

The project site consisting of installation of sheetpiles in an adverse weather conditions is one of the most challenging off-shore construction project completed recently. During the installations the piling crew have always been faced with the difficulties caused by the adverse weather conditions; such as being capsize during the journey between the accommodation ship to the site or being stuck at the island, working on an island that could be flooded anytime, or struggle against strong winds and snow storms.

The project was completed successfully in September 2002 before the target scheduled completion date while overcoming all the obstacles and difficulties caused by the adverse weather and working conditions.

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