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АНДАТПА

Бұл диссертациялық жобада Каспий теңізінде орналасқан “Қашаған” кен орнының гидрометеорологиялық сипаттамасы, теңіз мұнай-газ құрылымдарының түрлері және теңіз мұнай-газ платформаларын жел турбиналары арқылы қамтамасыз ету қарастырылған.

Көрнектік үшін Autodesk Maya программасында жел турбинының кеңістіктегі қатты денелі 3D моделі құрастырылды және анимациялық видео жасалынды. Берілген тапсырмаға сай Autodesk Inventor Professional 2014 программасында Солтүстік Каспий теңізінде орналасқан “Қашаған” кен орнына арнайы жоба бойынша мұнай платформасын энергиямен қамтамасыз ету үшін жел турбинының тірек фермалық бағанының есептік схемасы салынып, оған тұйықталған элементтер әдісін қолдануы арқылы өз салмағына, фермалық бағананың үстіңгі бөлігінен түсетін салмағына, циклондық ағын және мұз күштеріне байланысты есептеулер жүргізілген. Inventor 2014 жүйесінде жел турбинының тіректі фермалық бағаны, іргетасымен топырақ негізі кешенді түрде есептелген. Есептеулер нәтижелері бойынша құрылымның кернеулік-деформацияланған күйі зерттелген.

Экономика, еңбекті қорғау және тіршілік қауіпсіздігімен қоршаған ортаны қорғау салалары бойынша өндірісте жүзеге асыру ықтималдығына мол сілтемелер берілген.

Кілт сөздер: Autodesk Maya, Autodesk Inventor, 3D Modelling, AutoCAD, Жел Турбиналары.

АННОТАЦИЯ

В данном диссертационном проекте рассмотрены гидрометеорологические характеристики месторождения “Кашаган” расположенное на севере Каспийского моря, типы морских нефтегазовых сооружений, морская ветровая турбина для Каспийского шельфа в средних глубин и нагрузки, действующие на них во время эксплуатации на шельфе.

Построена пространственная твердотельная модель и создана анимационная презентация ветровой турбины в программе Autodesk Maya 2012. Создана расчетная схема опорной фермовой колонны ветровой турбины, проектируемой для месторождения “Кашаган” в средних глубин Каспийского моря. Проведен совместный расчет опорной колонн и надводной части строения на статические нагрузки – собственный вес сооружения и вес надводной части турбины, и ветровую нагрузку методом конечных элементов. По результатам расчетов изучено напряженно-деформированное состояние конструкции.

Освоена методика расчета методом конечных элементов с использованием программного комплекса Autodesk Inventor Professional 2014.

Результаты расчета могут быть использованы при проектировании морских ветровых турбин.

Также в работе приводится расчет базовой сметной стоимости строительно-монтажных работ опорной фермовой колонны и морской ветровой турбины и срока его окупаемости. В разделах охраны труда и окружающей среды рассматриваются потенциальные риски для персонала и возможные угрозы для окружающей среды, а также приводятся меры по их предотвращению и сокращению.

Ключевые слова: Autodesk Maya, Autodesk Inventor, 3D Modelling, AutoCAD, Ветряные Турбины.

ABSTRACT

In this thesis project examined meteorological characteristics of the field “Kashagan” located in the north Caspian Sea, the types of offshore oil and gas constructors, offshore wind turbine structure integrated for the middle depths of the Caspian shelf, and the load acting on them during operation on a shelf.

Dimensional solid 3D model and 3D animation presentation of offshore wind turbine is built in the program Autodesk Maya 2012. Created the design scheme of supporting jacket for offshore wind turbine. Jacket designed for the field in the middle depths of the Caspian Sea. Carried out joint account of supporting columns and turbine structure on the static load - own weight of construction and the wind turbine weight of the structure, and the wind load by finite-elements. Also the calculations studied the stress-strain state of the structure.

The finite element method are mastered and calculated by using a software package Autodesk Inventor Professional 2014.

The calculation results can be used in the design of offshore wind turbine structures for oil and gas platforms. Also, the thesis presents the basic calculation of the estimated cost of construction and installation works supporting truss design and offshore wind turbine, its payback period. Sections health and the environment are considered potential risks to personnel and possible threats to the environment, and provide measures for their prevention and reduction.

Key words: Autodesk Maya, Autodesk Inventor, 3D Modelling, AutoCAD, Wind Turbines.

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INTRODUCTION

This thesis discusses the design of offshore wind turbine structure. Over the past 20-30 years, the share of oil and gas in the global energy balance of the consumption greater than 70% in comprising of all other type of energy source.

Developing Caspian offshore fields is one of the major future objectives pursued by Kazakhstan's oil and gas industry. The strategy for developing Kazakhstan's offshore fields is aimed at ensuring the sustainable growth of the country's economy, improving the population's living standards by rational and safe development of hydrocarbon resources, and facilitating progress of the country's associate industries.

The Northern Caspian Sea currently represents one of the major hydrocarbon prospect areas in the world. It is including the oil and gas giant Kashagan, regarded as one of the world largest hydrocarbon findings during the recent years, as well as many other promising prospects currently being explored. Hence, extensive drilling campaigns are expected to be carried out in the near future. From an economical point of view the most critical aspect is related to maintaining operations throughout the heavy ice season in order to ensure continuous development of offshore hydrocarbon fields.

The aim of this work is to develop and design justification of offshore wind turbine structure. This goal is achieved the tasks that constitute the scientific novelty of the work.

To meet growing energy demands wind energy has become an important source of energy. In the last decade wind turbines have been installed offshore to accommodate even more wind power. The offshore wind resource is of a better quality, resulting in higher electricity output. On the other hand, the costs of constructing and installing support structures for these turbines offshore is higher than onshore. Therefore offshore turbines are being made larger to economize in the support structure and installation costs. As the technology for wind turbines improves, the industry has developed wind turbines with rotor diameters as large as 150 m and power ratings of 8.0 MW. It is the intention to build wind farms in water depths of even 60 meters. All of these factors pose significant challenges in the design and construction of wind turbine support structures and foundations.

The development of large offshore wind turbines has a lot to offer for future sustainable energy production. The calculation is carried out for all kinds of loads, which are determined by the deformation, compression, torsion. Selected the appropriate conditions the structure of H, the material meets all the requirements and standards of RK GOST.

1 GEOLOGICAL PART

1.1 Characteristics of the Caspian Sea

The Caspian Sea is the world's largest inland water body, which extends 1200 km from north to south and contains more than 40% of the inland waters of the world. It is located in a depression separating Europe and Asia between the latitudes 47°13' and 36°34' N and longitudes 46°38' and 54°44' E. The catchment area is 3.5 million km² which encompasses entirely or partially eight countries; the five littoral states Russia, Azerbaijan, Iran, Kazakhstan, Turkmenistan, and also Georgia, Armenia and Turkey that influence the Sea through river discharge.



Figure 1.1 – Map of Caspian sea

The water level of the Caspian Sea is currently positioned approximately 27 m below the mean sea level and the Sea has no surface outlets. A shipping route to the Black Sea is provided through the Volga-Don canal.

Table 1.1 - Main characteristics of the Caspian Sea

Name	Value	
1	2	
Surface area	378000 km ²	
Volume	78100 km ³	
Catchment area	3500000 km ²	
Coastline	7000 km	
Length	1200 km	
Width(min-max)	196-435 km	
Average depth(m)	North	5 (max 20) m

Table 1.1 - continued

1		2	
	Middle	190 (max 790) m	
	South	330 (max 1025)	
Average surface temperature (°C)	North	Winter: 0	Summer: 25
	South	Winter: 10	Summer: 26
Surface salinity(ppt)	North	0.1	
	Middle	10	
	South	13	

The Caspian Sea is commonly divided into three basins: the northern, middle and southern. The northern basin occupies 27% of the surface area of the Caspian Sea but is shallow, averaging only 5 m in depth (Table 1), and, as a consequence, retains only 0.6% of the total volume of the Sea. Progressing southward, the depth increases considerably. The middle basin is separated from the northern part by the Mangyshlack Shelf and occupies 38% of the surface area of the Caspian Sea and contains 36% of its volume. The remaining 39% of the surface area of the Caspian occurs in the southern basin which has a maximum depth of 1 025 m and, as a consequence, retains 63% of the total volume of water. The middle and southern basins are separated by the Apsheron Shelf, which is a continuation of the main Caucasus range.

1.1.1 The air temperature

The air temperature in different parts of the sea during the year varies differently. In the northern part of the sea throughout the coolest period is December - February, when the average monthly temperature ranges mostly from -1 °C in the island Chechen Island to minus 10 °C in the city of Atyrau. From October to early April frosts occur. The absolute minimum temperature of -38 °C (Atyrau, December - February).

The warmest period (June - August), the average monthly temperature is 22-26 °C. The absolute maximum temperature of 45 °C (Atyrau, July, August). In the middle of the sea winter is milder than in the north. The average temperature in the coldest months (December - February) varies from -3 °C in the north-east of the middle part to plus 7 °C in the south-west. Frosts are possible from late December to mid-February, and on the east coast - until early March. The absolute minimum temperature is minus 27 °C (coil Kendirli, December).

In the warmest months (July and August) the average temperature is generally 24-27 °C. The absolute maximum temperature of 45 °C (coil Kendirli, July, August).

1.1.2 Water temperature

Because a quite big extent of the sea along the meridian the water temperature is subject to sizeable latitudinal changes most distinctly expressed in the winter period, when the sea temperature changes from 0-0,5°C on an edge of ice in the north

to 10-11°C in the south, a difference of nearly 10°C. This difference decreases to 1-2 °C in the summer: In the north - 24-25 °C, In the south 25-26 °C. The temperature on the east coast is 1-2°C lower than on the west coast.

The most general characteristic of water temperature is the distribution of the annual average temperature during many years over the water area. Precisely these values reflect the influence of the researched reservoir on climate of the adjoining land, though it is more smoothed with regard to separate seasons. This smoothness is reflected in the form of annual average isotherms too. Far from the coast the accumulation of water heating in degrees changes from 11 °C in the areas adjoining the Caspian near steppes to 18°C on southeastern tip of the sea mirror. The greatest influence on the form of isotherms is the drain of the following rivers: Volga, Terek, Kura, and also prevailing winds. The influence of cold deep waters getting to the surface is great in eastern half of the water area.

Annual average differences of water temperature on the surface of up to 20 °C are observed in the northern areas. This is also observed near the east coasts of the South Caspian, but that depends on intensive warming up in summer and cooling down of shoals in winter. It is characteristic for central parts of the South Caspian that water temperature changes least during the year, which corresponds to small seasonal climatic distinction. The annual difference of surface temperature decreases to 14-15 °C near western and eastern coasts of the Middle Caspian in the upwelling areas.

1.1.3 Salinity

The salinity of Caspian Sea changes from the north to the south within a range of 1,0 to 13,5 parts per thousand. This difference is especially strongly present in the North Caspian. It is less obvious in other areas distinguished by self-relative homohalinity. It is apparent from Figure 4.2 that the difference of the value around the wellhead and the freshened Volga's part compared to the southeastern water area is about 12,5% (Figure 1.2).

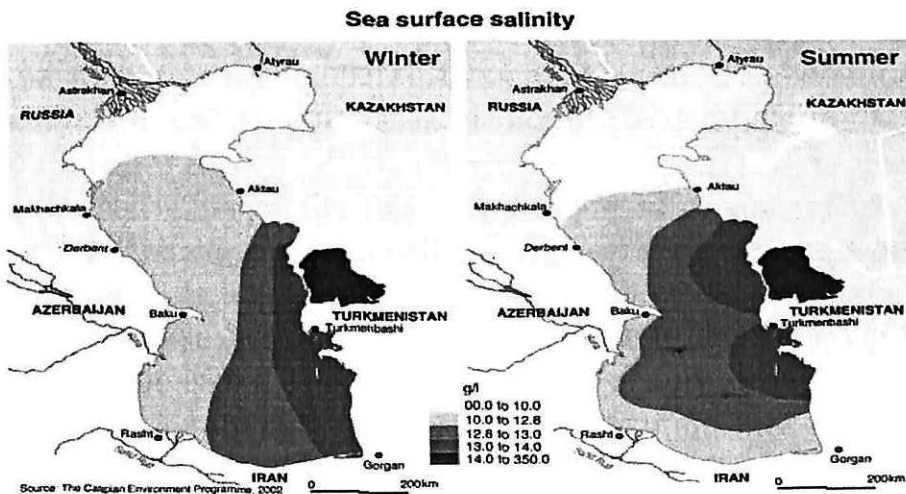


Figure 1.2 – Sea surface salinity

The isohaline 12,5% bending around the peninsula forms the ledge as if it moves more salty water masses to the east. This phenomenon is explained by freshening influence of the rivers' drain on the western coast of the Middle Caspian, which is allocated by branches of Main Caspian flow of cyclonic and anticyclonic directions. Practically all the rest space of superficial waters of the sea after 12,5 parts per thousand isohaline is defined by salinity of 13,0-13,5% . Almost complete absence of a hydrographic network in the south-east Caspian area has caused raised salinity (13,5%) of the water in that area.

The common increase of the salinity happening in the northern areas is observed in the whole area of the sea in winter months. Following this the main part of the water area is characterized by isohaline 13,0-12,5% and less change of values. In other parts of the sea extremes do take place. Like in the Gara-Bogas-Gol Gulf, where the salinity of the water reaches 300 parts per thousand.

1.1.4 Waves

Characteristics of waves in various areas of Caspian Sea strongly differ from each other. The main characteristics of the waves in the Northern Caspian sea are: height – 3 m, the period - 10 sec., length – 85 m. The waviness in southeastern and eastern direction has the largest repeatability in the western part of the Northern Caspian Sea. In the northeastern area of the sea the repeatability is biggest in western and eastern directions.

The waviness in various areas of Middle and South Caspian is characterized by the following features. Because of northern winds the greatest heights of 5% provision waves are 2-3 m in the coastal zone of Makhachkala - Derbent region, and are 4-6 m in the sea part of this area. The average periods and lengths of waves are accordingly 4sec and 16m at the coast, 5-7sec and 20-25m far from the coast. The wave size increases from the north to the south too.

The greatest wave heights are found around Absheron peninsula. During severe northwestern storms ($> 25\text{m/sec}$) in the epicenter the waves reaches heights of 7,5 - 8,0 m, and during extreme storms 9-10 m. The eastern winds with a speed of 5-9 m/sec cause waves with heights up to 1 m. The winds with speeds of 10-15 m/sec cause waves of up to 2m in height. The period of the waves is increased to 3,0 - 4,7 sec. With eastern winds of 16 - 20 m/sec the waves reach heights of 3-3,5 m with a period of 6 sec.

The whole southern Caspian Sea has a weak standard waviness (0,5-1m) due to the southeastern winds. Strong waves develop in case of northern and western winds on the east coast near the Cheleken region. The height of waves does not exceed 1 m in case of moderate and strong northwest winds (from 5 up to 15 m/sec) in the eastern area of the South Caspian. Storms of 16-20 m/sec cause waves of 2-3m, and heavy storms (21-25m/sec) waves of 3 - 4 m.

1.1.5 Currents

In order of importance the causes of the circulation in Caspian waters are:

- wind and its transversal unevenness;
- relief of the bottom forming some isolation between North, Middle and South Caspian;
- the shape of the coastal line;
- distinction of water temperature in different parts of the sea, an increase of temperature from the north to the south;
- drain of rivers flowing into the sea, especially of the Volga river.

The common circulation Caspian Sea waters may be explained as follows. (Figure 1.3) The drain of the Volga River forks in the North Caspian. The first branch goes to the southwest and further follows along the west coast. The other branch turns to the northwest and following the western, the eastern and the southern coasts of the North Caspian, forms anticyclonic (directed clockwise) circulation of waters. Further, the waters from the North Caspian enter into the Middle Caspian, moving along the west coast, flowing around Absheron peninsula, then going onward to the south and further turning according to the shape of the coast in eastern direction. The current is directed in opposite direction at the east coast, so from south to north. A branch separates from this stream near Cheleken peninsula, turns to the west and joins the stream which is going along the west coast of the South Caspian. As a result of this the cyclonic circulation of waters (directed counter-clockwise) is formed in the deep-water hollow of the South Caspian.

In its turn another branch also separates from the stream, which is going along the western coast of the Middle Caspian. After that it turns more to the north to the Absheron peninsula, where it turns to the east and joins the waters going along the east coast in northwestern direction. The main part of this stream turns to the left (to the west) at the south of Mangishlak peninsula and joins the waters going along the west coast of Middle Caspian, thus forming also the circulation of waters there. In this way the basic features of the currents' scheme show that there is a large external cyclonic circulation of the waters covering all parts of the sea, besides cyclonic whirlpools of the Middle and South Caspian waters.

General speeds of the current in the Caspian Sea are 20-30 mm/sec. The greatest values of current speed, which is reaching up 100 mm/sec, are observed in an area near Apsheron peninsula, between Jiloy Island and NeftDashlari.

1.1.6 Ice motion

The northern part of the sea freezes in the winter. Ice usually starts being formed in November. The whole northern part of the sea is covered with ice in severe winters. In soft winters ice is formed in shoals within the 2-3 m isobaths. The occurrence of ice in the middle and southern parts starts in December - January. Ice has its origin at the east coast, at the west coast it frequently is taken to by the currents from northern part of the sea.

The shallow gulfs freeze at the east coast of the middle Caspian during severe winters. Stacks of ice form shores and coves at formed at the coast in this period. The drifting ice is found up to Absheron peninsula at the west coast in abnormal cold winters

1.1.7 Humidity

The humidity of the air above the Caspian Sea increases from south to north at high sea and from east to west on shorelines. It also increases towards the high sea. The humidity of air does not change much in the cold period of year, making 80-87% on western coast and 75-80% on eastern coast. In the high sea it decreases from 90% at the central parts of Middle Caspian to 85% at center of South Caspian.

The highest humidity of air on western coast is marked in northern part of Azerbaijan coast (87%), the lowest - in Apsheron (75-77%). In the summer the driest site of western coast is an area of Apsheron up to the mouth of Kura River (55-66%). This period the humidity changes within 55-60% limits. On the Iranian coast the humidity is more than 70%. In the high sea it reaches value of 80%.

1.1.8 Precipitations

The amount of precipitation on the Caspian coast depends on interaction of originally different air masses with relief of the coast. Distribution of precipitation above water area is extremely uneven. It oscillates from 210 (NefDashlari) to 1250 mm (Lenkoran zone) of precipitation per year on western coast of southern part of the sea. To the north of Absheron peninsula the amount of precipitation makes 400-430 mm. Eastern coast distinguishes by dryness, and the maximum quantity of perceptions does not exceed 10-20mm there. On the Iranian coast it falls out about 1000-1200 mm of precipitation per year because of humid climate.

1.1.9 Cloud cover

The cloudiness above Caspian Sea is more in the winter than in other seasons of year and its value changes form 5,5 ball on the southeast to 8 balls on the northwest. Generally, the cloudiness on western coast of Middle Caspian is the greatest in all seasons that is connected with cyclonic activity in this area.

The spring range of cloudiness variation compounds from 3,2 to 6,8 balls, moreover it increases from the southeast to the northwest. Distribution of average cloudiness is more uniform in the summer. It changes within 2,4-3,9 balls limits over the most part of water area and over shoreline. The autumn distribution of cloudiness, which closes to the spring, is 3,6-6,7 balls.

The clear weather with cloudiness about 0-2 degrees prevails above the sea and the coast during a warm period of year; the cloudy weather with cloudiness about 8-10 balls has the largest repeatability during a cold period.

1.1.10 Wind

Direction and strength of wind blowing over Caspian are determined by three factors: distinctive general circulation of an atmosphere, field of temperature that is created by the sea itself and a relief of its coasts. (Figure 1.4) Despite significant physiographic dissimilarity the water area of Caspian and its shoreline may be divided into regions with relatively stable regime of a wind direction. General regularity of a regime of direction is such that the winds of northern (Northwest, North, and Northeast) and southeastern directions dominate above the sea the most part of a year. The probability of setting up wind fields of the northern rhumbs makes up on average 41% for one year; moreover their probability in the summer is more (48,7%) than in other seasons of the year. All eastern winds make up on average 35,9% per a year. More often they are observed in the winter (41,3%), when the stable cyclones form above areas of Kazakhstan and Central Asia.

The average speed within the water area of the sea is 5,7 m/sec. The greatest average speeds are observed in the middle part of the sea and are on average 6-7 m/sec per a year. Their values are 8-9m/sec in the area of Absheron peninsula. The wind speed sometimes reaches 40 m/sec there. In the cold part of a year (December-February), when the intensity of an atmosphere circulation above Middle and South Caspian increases, the average wind speeds reaches 7-7,5 m/sec.

The annual average wind speeds are 5,0-6,3 m/sec from northern and eastern coast of Caspian to Gara-Bogaz-Gol Gulf and increase up 7 m/sec around Mangishlag peninsula and capes.

The average wind speeds are sizably lower in South Caspian: in central areas - 4-5 m/sec, on eastern coast - 3,5-4 m/sec, on the outside southeast -2,5-3 m/sec. Low speeds (2,2-3 m/sec) is observed on south-western coast, in Iranian waters and on southern coast of Caspian.

Although the average wind speeds increases form the south to the north in warm period of a year as well as in cold period, the distinction between areas of the high sea and the coast is the least in this period: above the sea the average wind speeds change from 3 to 5 m/sec, above the coast - from 2 to 5 m/sec.

1.1.11 Water level fluctuations

One of the most important features of the Caspian is its changing water level, which has a significant effect on biodiversity in the extensive shallow areas. The level of the Caspian Sea is below that of the World Ocean, but may have been as low as - 64 m. Early in the last century (up to 1929), the sea level fluctuated around - 26.2 m, later decreasing to - 29.0 m in 1977 (Kosarev and Yablonskaya, 1994). This was the lowest level reached during the past 400-500 years. In 1978 a rapid rise began, the level reaching - 27.0 m by 1994. Since 1995 some regression has been observed in the sea level. At present the Caspian Sea level stands around the - 28.8 m mark. There are almost no tides. The factors causing these fluctuations are not well understood and the causes are hotly debated. One study (Aubrey et al., 1994)

suggests that 45 % of the change in the water level is due to an increase in river flow, 16 % to an increase in surface precipitation, 25 % to a decrease in evaporation rates, and 14 % to a decrease of flow to the Kara BogazGol, which has a water level lower than the sea. Other studies suggest (Kosarev and Yablonskaya, 1994) that a significant fraction of recent sea-level change is tectonic in origin. There is a clear need for better methods for predicting sea-level change. The Caspian Environment Programme has therefore established a regional centre for water fluctuation in Kazakhstan, which is addressing the main causes of the changing water levels and is working on the development of models to predict future changes in the water level.

1.1.12 Characteristics of wind waves of the Caspian Sea

The Caspian Sea is quite hectic, especially the middle and southern parts. In the northern part of the sea waves is limited by shallow water, and from November to March, in addition, the presence of ice, wave heights are usually no more than 4 meters, sometimes only in the south-western district of the northern part of the sea up to 8 m throughout the year, in the Caspian Sea is dominated by wave heights less than 2 m, their frequency ranges from 65 to 90%. Heights of repeatability waves' 2-4 m 10-30%.

In the middle and southern parts of the sea throughout the year can be celebrated wave height 6 feet or more. Are particularly turbulent area of the island and the Oil Rocks area, located to the north-west of it, is the height of waves up to 12 meters rough sea is almost universally observed with winds from the N, and only in the north-western region of the middle part of the Caspian Sea - with winds from the SE. In the region of the island of Oil Rock is most often cited the excitement of N, and in the cold time of the year - and from S.

In the open area of the central and southern parts of the sea often there is a strong swell from the N or NW, and the northern region - from E and SE. The Caspian Sea is often seen jostling.

1.1.13 Bottomset beds

The sediments are mainly Holocene sediments Novocaspian tier. On the periphery of the pool they are formed sands and coquina shell detritus. In the hollows and Borozdina accumulated silt, clay and calcareous siltstones. On relatively gentle slopes and hollows dominated by clay, limestone and calcareous silts. The most steep slope areas of basins adjacent to Dagestan and Kazakh-Turkmen coast, lack of recent sediments, and here come the bottom sediments of Pleistocene and even the Neogene. In the areas of active uplift near the bottom of the Apsheron coast out of older rocks observed on the shallow shelf.

1.1.14 The location and conditions of the Kashagan field

The Kashagan field is one of the largest fields in the world discovered during last 30 years.

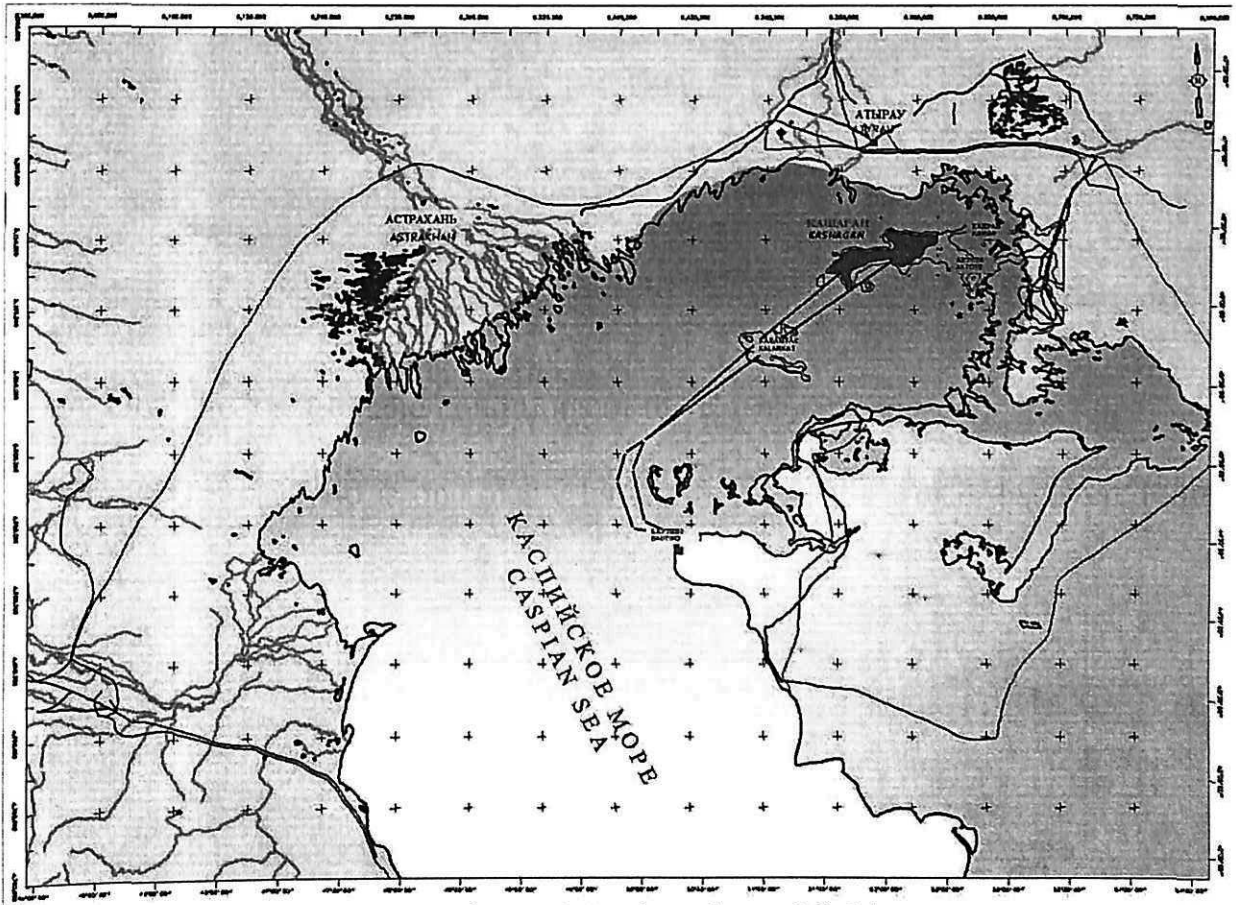


Figure 1.5 – location of field

Administratively, the Kashagan field, covers 820 km² in the north-eastern part of Kazakhstan sector of the Caspian Sea, located in the Atyrau region of Kazakhstan. Administrative center of the city of Atyrau, located 75 km north of the Kashagan field. The nearest settlement is a settlement Eskene, located at the junction 35 km from Atyrau.

90 km south-east of the eastern boundary of the Kashagan field is located onshore giant Tengiz field.

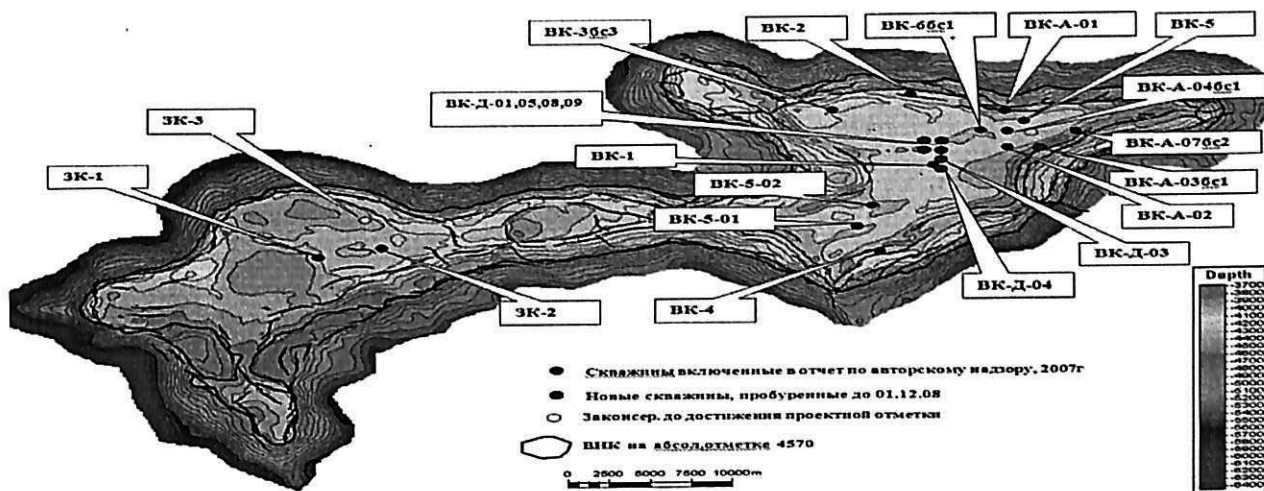


Figure 1.6 – Structure map on the roof of carbonates, reflecting horizon P2 (H-400)

Coastal areas of northern, north-eastern and eastern parts of the Caspian Sea, where the majority of oil fields (Tengiz, Royal, Karajanbas, Sev.Buzachi etc.), characterized by well-developed infrastructure. The closest a pipeline belonging to the CTC, is 80 km from the eastern circuit of the field.

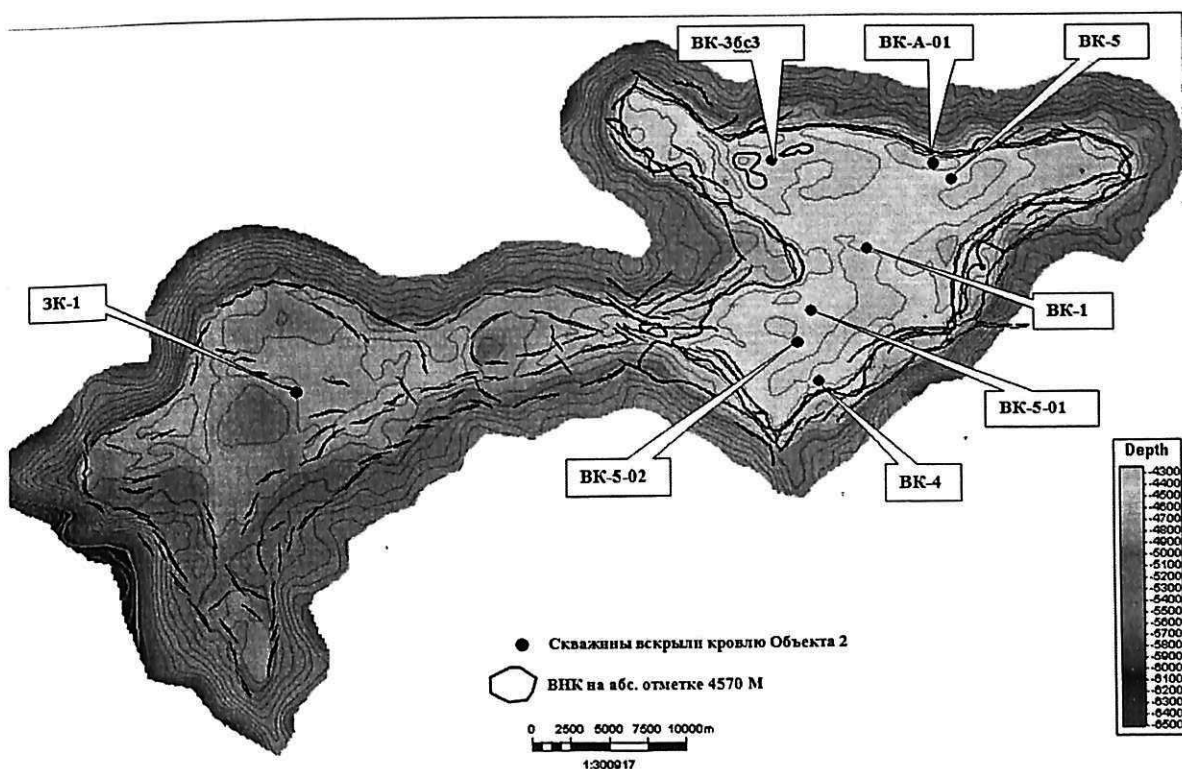


Figure 1.7 – Structural map of the collector on the roof of the object II, reflecting horizon P21 (H-700)

Climatic and biological characteristics of the territory of the activities have a significant impact on production.

The main features of the Northern Caspian region are:

- shallow water (0-10 m) in the licensed territory, and 3-4 m in most of the Kashagan;

- difficult to explain long-term changes in sea level;
- intermittent storms causing surge phenomena;
- the establishment of ice in the winter, progress and ridging of ice around offshore structures;
- High-seasonal variability of temperature;
- the presence of zones of high biological productivity, especially in the deltas of the Volga and the Urals, in the reeds on the northern coast and the vast coastal shallows;
- important spawning areas, feeding areas and migration of different species of fish, including valuable species of sturgeon;
- a large number of waterfowl using the adjacent sections of the coast during the breeding season in spring and summer, or migrating through the area in spring and autumn;
- a large part of the population of Caspian seals that live on this territory from autumn to early spring, and breeding on the ice in winter.
- In the project area, there are two distinct seasons. Summer period (May-October) is characterized by high temperatures, the winter (November-April) - low temperatures and the presence of ice. Solid ice cover near the coast periodically replaced with a period of discontinuity of ice on East Kashagan, as well as to the period of clean water and moving ice. The amplitude of the average daily temperatures on objects ranging from plus 30 to minus 30 °C, extreme unstable range is from plus 40 to minus 40 °C. Spring observed minimum sea temperature equal to, on average, 0.8 °C in March. The maximum values of the average, 24.7 °C, observed in September.

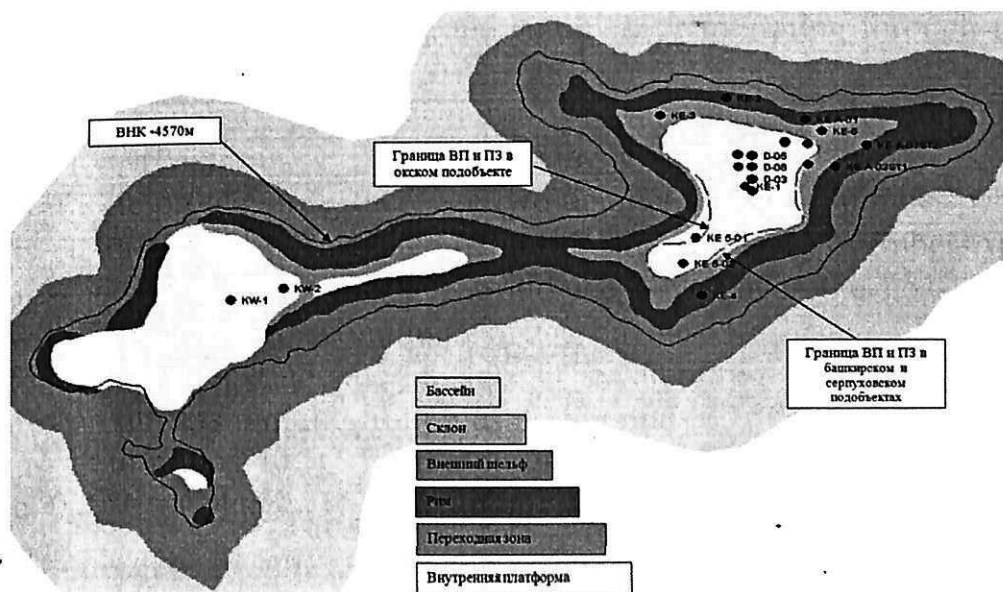


Figure 1.8 – Facial map

The annual average wind speed of 5-6 m/s. The greatest wind speed observed from January to April. According to historical records of the year, on average there are 30-40 days, when the wind speed exceeds 15 m/s. According to the literature, with the strongest storms north wind speed reaches 40 m/s.

East Coast of the North Caspian drier than other parts of the Caspian Sea, because of the weak penetration of humid air masses from the Atlantic Ocean, which provide the majority of precipitation falling in the region. Over the past 50 years, the average annual rate of precipitation was 210 mm. The duration of rainfall is higher in the winter months, when the total amount of precipitation is minimal, and the loss of dry sediments (eg during storms) peaks. In the summer rains short but strong. In the north-eastern part of the sea fogs occur most frequently in March and April due to the inflow of warm air from the continent to the cooler surface of the water. Average duration of fog is 7-8 hours.

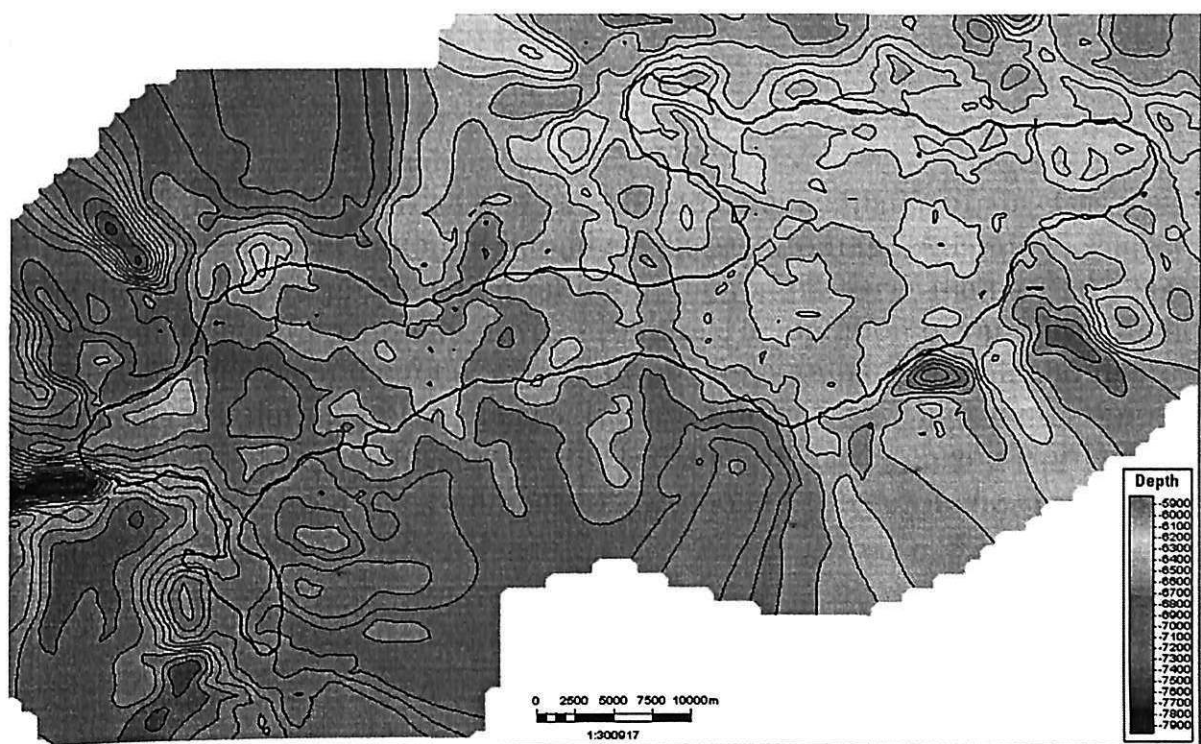


Figure 1.9 – Structural map of the underside of the Devonian carbonates, reflecting horizon P2d (H-990)

The seabed in the area of activity consists of the flat and smooth slopes. The sea depth in the area of small and unstable work, over 80% of the bottom of the entire northeast of the Caspian Sea does not reach the depth of 5 m. On the plot are the Kashagan East mark depth 3.6-4.8 m, the area West Kashagan - 7-8 m. There are significant long-term fluctuations mean sea level. The level of the Caspian Sea has fallen by nearly three meters from 1875 to 1977gg, but grew by 2.4 meters during the period from 1977 till 1994. The average level declined by nearly 0.2 meters a year in 1995-1996, but remained almost constant in 1997-1999. The average seasonal water level also varies. In the summer the water level by an average of 0.2 meters above average sea surface in winter - 0.1 meters below the water and covered with ice. Astronomical tides are almost nonexistent. Hold water level fluctuations occur typically in a period of 0.5 days to a few days, due to the influence of wind. Sudden rises or falls (rises in the south-westerly wind, fall in the north-east wind) on the East Kashagan in the range 0.3-0.4 m occur several times a year. Wave height is a direct

function of the wind field, water depth, angle of approach and the seabed. On the East Kashagan maximum wave height is estimated between 1 and 2 m, and in the West Kashagan, due to increased water depth, the maximum wave height is about 2 to 3 m.

During the winter season, from December to March, the northern part of the Caspian Sea is covered with ice. The thickness of ice floes moving determines the maximum load that they can make their way into obstacles. The ice thickness can be up to 0.5m (winter normal) and can form layers of ice floes greater thickness due to movement caused by the wind. The establishment of the ice cover prevents the wave formation. However, during warm winters can ice storms, in which the particles of broken ice coastal bear toward the shore. Such storms can produce a devastating effect on the morphology of the coastline.

North Caspian Sea contains important aquatic resources, including populations of commercial fish, flocks of waterfowl that live in the coastal zone, and most of the population of Caspian seals in the winter.

In 1974 the Council of Ministers of the Kazakh SSR announced its decision northern areas of the Caspian Sea conservation area. Subsequently, this provision was amended by the Presidential Decree of 1991, which allows subsoil user to conduct exploration activities in the above areas.

Development of the field will be carried out in difficult geological conditions with abnormally high reservoir pressure and high hydrogen sulphide content in the composition of formation fluids. In order to increase oil recovery and reduce the production of sulfur, the Consortium plans to pump crude produced gas back into the producing reservoir. In the development of the deposit provides for the construction of artificial islands and platforms, which will be located the mouth of the production and injection wells with vertical and directional trunks. All this imposes stringent requirements to all kinds of economic activities, carried out both within the sea and its coastal strip.

Therefore, oil operations in the territory should be performed with great care, so as to cause minimal impact on the fragile ecology and bio resources of the work area of great importance to public health and the economy of Kazakhstan, and is an international treasure.

2 TECHNICAL-TECHNOLOGICAL PART

2.1 Types of offshore constructions

Different types of offshore oil rigs and platforms are used depending on the offshore oil/gas field water-depth and situation.

Rigs are used for the drilling of the wells and platforms are installed in the field for extracting oil/gas operation. Main types of rigs and platforms are briefly explained as follows: Drilling for natural oil/gas offshore, in some instances hundreds of miles away from the nearest landmass, poses a number of different challenges from drilling onshore. With drilling at sea, the sea floor can sometimes be thousands of feet below sea level. Therefore, while with onshore drilling the ground provides a platform from which to drill, at sea an artificial drilling platform must be constructed.

2.1.1 Classification of offshore oil and gas constructions

The offshore structures built in the ocean to explore oil and gas are located in depths from very shallow water to the deep ocean. Depending on the water depth and environmental conditions, the structural arrangement and need for new ideas required. Based on geometry and behavior, the offshore structures for oil and gas development has been divided into following categories.

- 1) Fixed Platforms
 - Steel template Structures
 - Concrete Gravity Structures
- 2) Compliant tower
 - Compliant Tower
 - Articulated Tower
 - Tension Leg Platform
- 3) Floating Structures
 - Floating Production System
 - Floating Production, Storage and offloading System

2.1.2 Fixed platforms

In certain instances, in shallow water, it is possible to physically attach a platform to the sea floor. This is what is shown above as a fixed platform rig. The 'legs' are constructed of concrete or steel, extending down from the platform, and fixed to the seafloor with piles. With some concrete structures, the weight of the legs and seafloor platform that they do not have to be physically attached to the seafloor, but instead simply rest on their own mass. There are many possible designs for these fixed, permanent platforms. The main advantages of these types of platforms are their stability; as they are attached to the sea floor, there is limited exposure to movement due to wind and water forces. However, these platforms cannot be used in extremely deep water; it simply is not economical to build that long.

2.1.2.1 Template (jacket) platforms

This type of fixed platform is the one usually installed in the Persian Gulf, the Gulf of Mexico, Nigeria, and California shorelines and is made of steel. Template platforms mainly consist of jacket, decks and piles.

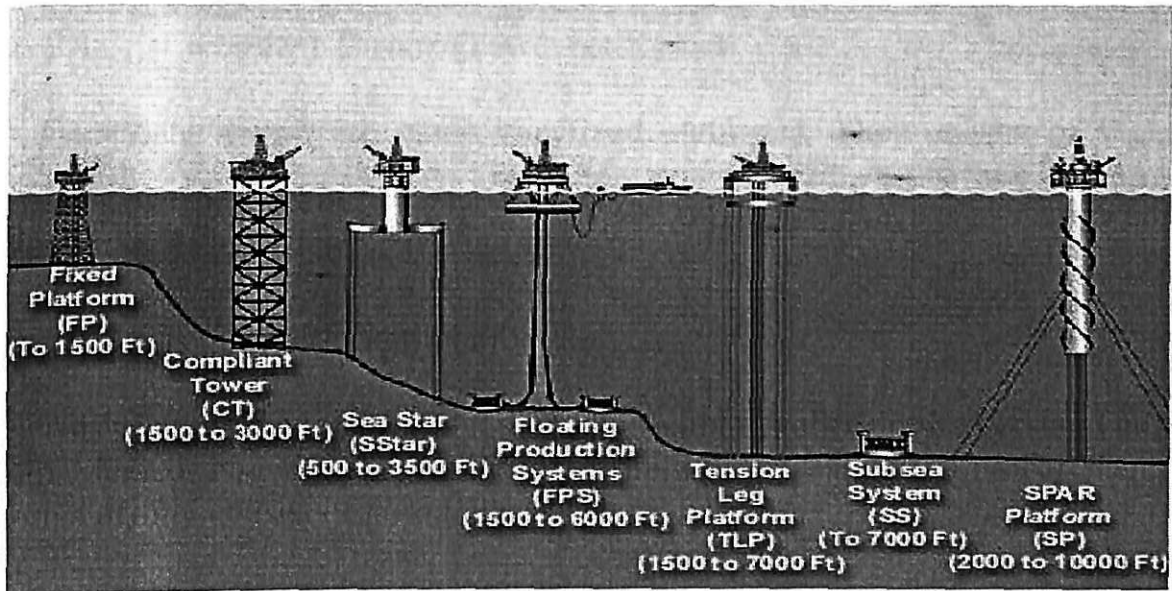


Figure 1.5 - Different types of offshore fixed platforms

All of the petroleum platforms installed in the Persian Gulf are of the Template (Jacket) type. At the present time about 145 template platforms belonging to Iran and about 130 template platforms belonging to Arabian countries are installed in the Persian Gulf. Figure 2 shows one template platform.

2.1.2.2 Concrete Gravity Platforms

Concrete gravity platforms are mostly used in the areas where feasibility of pile installation is remote. These platforms are very common in areas with strong seabed geological conditions either with rock outcrop or sandy formation.

Some part of north sea oil fields and Australian coast, these kind of platforms are located. The concrete gravity platform by its name derive its horizontal stability against environmental forces by means of its weight. These structures are basically concrete shells assembled in circular array with stem columns projecting to above water to support the deck and facilities.

Concrete gravity platforms have been constructed in water depths as much as 350m.

2.1.3 Compliant Structures

In addition to the developing technologies for exploration and production of oil and natural gas, new concepts in deepwater systems and facilities have emerged to

make ultra-deepwater projects a reality. With wells being drilled in water depths of 3000m, the traditional fixed offshore platform is being replaced by state-of-the-art deepwater production facilities. Compliant Towers, Tension Leg Platforms, Spars, Subsea Systems, Floating Production Systems, and Floating Production, Storage and Offloading Systems are now being used in water depths exceeding 500m. All of these systems are proven technology, and in use in offshore production worldwide.

2.1.3.1 Compliant Towers (Tower platforms)

Compliant towers are much like fixed platforms. They consist of a narrow tower, attached to a foundation on the seafloor and extending up to the platform. This tower is flexible, as opposed to the relatively rigid legs of a fixed platform. This flexibility allows it to operate in much deeper water, as it can 'absorb' much of the pressure exerted on it by the wind and sea. Despite its flexibility, the compliant tower system is strong enough to withstand hurricane conditions.

2.1.3.2 Seastar platforms

Seastar platforms are like miniature tension leg platforms. The platform consists of a floating rig, much like the semi-submersible type discussed above. A lower hull is filled with water when drilling, which increases the stability of the platform against wind and water movement. In addition to this semi-submersible rig, however, Seastar platforms also incorporate the tension leg system employed in larger platforms. Tension legs are long, hollow tendons that extend from the seafloor to the floating platform. These legs are kept under constant tension, and do not allow for any up or down movement of the platform. However, their flexibility does allow for side-to-side motion, which allows the platform to withstand the force of the ocean and wind, without breaking the legs off. Seastar platforms are typically used for smaller deep-water reservoirs, when it is not economical to build a larger platform. They can operate in water depths of up to 3,500 feet.

2.1.3.3 Spar Platforms

Spar platforms are among the largest offshore platforms in use. These huge platforms consist of a large cylinder supporting a typical fixed rig platform. The cylinder however does not extend all the way to the seafloor, but instead is tethered to the bottom by a series of cables and lines. The large cylinder serves to stabilize the platform in the water, and allows for movement to absorb the force of potential hurricanes. The first Spar platform in the Gulf of Mexico was installed in September of 1996. Its cylinder measured 770 feet long, and was 70 feet in diameter, and the platform operated in 1,930 feet of water depth.

2.1.3.4 Tension leg platforms

Tension leg platforms are larger versions of the Seastar platform. The long, flexible legs are attached to the seafloor, and run up to the platform itself. As with the 19 Seastar platform, these legs allow for significant side to side movement (up to 20 feet), with little vertical movement. Tension leg platforms can operate as deep as 7,000 feet.

2.1.4 Floating Structures

2.1.4.1 Floating production systems

Floating production systems are essentially semi-submersible drilling rigs, as discussed above, except that they contain petroleum production equipment, as well as drilling equipment. Ships can also be used as floating production systems. The platforms can be kept in place through large, heavy anchors, or through the dynamic positioning system used by drillships. With a floating production system, once the drilling has been completed, the wellhead is actually attached to the seafloor, instead of up on the platform.

The extracted petroleum is transported via risers from this wellhead to the production facilities on the semi-submersible platform. These production systems can operate in water depths of up to 6,000 feet.

2.1.4.2 Floating Production, Storage and Offloading System

Floating Production, Storage and Offloading System (FPSO) consists of a large tanker type vessel moored to the seafloor. An FPSO is designed to process and store production from nearby subsea wells and to periodically load the stored oil to a smaller shuttle tanker. The shuttle tanker then transports the oil to an onshore facility for further processing. An FPSO may be suited for marginally economic fields located in remote deep-water areas where a pipeline infrastructure does not exist. Currently, there are no FPSOs approved for use in the Gulf of Mexico. However, there are over 70 of these systems being used elsewhere in the world.

2.1.5 Subsea System

Subsea production systems are wells located on the sea floor, as opposed to at the surface. As in a floating production system, the petroleum is extracted at the seafloor, and then can be 'tied-back' to an already existing production platform. The well can be drilled by a moveable rig, and instead of building a production platform for that well, the extracted oil and natural gas can be transported by a riser or even undersea pipeline to a nearby production platform. This allows one strategically placed production platform to service many wells over a reasonably large area. Subsea systems are typically in use at depths of 7,000 feet or more, and do not have

the ability to drill, only to extract and transport.

2.2 Force effects on offshore construction

2.2.1 Loads

All of the loads acting on the structure or its individual components in the construction, transportation, installation, operation and decommissioning should be taken into account in the design. To comply with Canada, you should consider all the static and dynamic components of the effects of stress and strain, have a significant effect on strength, fatigue behavior, stability and buoyancy structures during construction and installation, as well as workability

2.2.1.1 Classification of loads

The forces acting on the structure, have different length and the probability of occurrence. Therefore, all the regulations on designing buildings emit several types of loads. All loads are divided into 4 groups:

- Dead load;
- Functional load;
- Live load;
- Environmental load;
- Accidental load.

2.2.1.2 Dead load

Dead load acting on the construction during the lifetime, for example, weight of the the platform structure and appurtenances, permanent equipment and pipes, dead weight of modules, cranes and helideck.

- For dead loads include:
 - Dead weight design and construction;
 - water pressure directly on the surface of the building and grounds, the force effect of filtered water, including body forces filtration and weighing in water-saturated parts of the buildings and grounds and back pressure on the border of the waterproof construction at normal water level corresponding to the maximum water flow rate calculated the probability of exceeding the design of the main event and normal operation and impervious drainage devices;
 - loads of prestressing construction;
 - weight of the soil and its lateral pressure, overburden pressure, soil pressure that occurs as a result of deformation of the base and structure, causes - Vai external loads and temperature effects;

2.2.1.3 Functional load

This variable loads associated with the normal functioning and operation of the facilities. For example, loads induced by platform operation like weigh *of the* liquids in pipes/tanks, thermal loads, drilling loads, loads induced by helicopter landing and vessel mooring, dynamic loads due to vibration of equipment and loads due to crane operation.

2.2.1.4 Live load

Live loads are the loads imposed on the platform during its use and which may change either during a mode of operation or from one mode of operation to another. Live loads should include the following:

- The weight of drilling and production equipment which can be added or removed from the platform;
- The weight of living quarters, heliport and other life support equipment, life saving equipment, diving equipment and utilities equipment which can be added or removed from the platform;
- The weight of consumable supplies and liquids in storage tanks;
- The forces exerted on the structure from operations such as drilling, material handling, vessel mooring and helicopter loadings;
- The forces exerted on the structure from deck crane usage.

These forces are derived from consideration of the suspended load and its movement as well as dead load.

2.2.1.5 Environmental load

Environmental loads are loads imposed on the platform by natural phenomena including wind, current, wave, earthquake, snow, ice and earth movement. Environmental loads also include the variation in hydrostatic pressure and buoyancy on members caused by changes in the water level due to waves and tides. Environmental loads should be anticipated from any direction unless knowledge of specific conditions makes a different assumption more reasonable.

- the weight of people, materials in the areas of maintenance and repair, the load on the ceilings of residential and public buildings, the stress caused during manufacturing, transportation and installation; suspended load and overhead cranes, snow and wind loads.
- pressure of the ice, determined by its long-term average thickness;
- loads from ships (weight, bulk, mooring and percussion) and on floating bodies;
- snow and wind loads;
- load hoisting and other mechanisms (and hanging bridge cranes, etc.);
- pressure from hydraulic shock during normal operation;

- dynamic loads at the admission costs of free-surface flow and pressure tunnels at normal water level.

2.2.1.6 Accidental loads

Accidental loads induced by accidental vessel collision, fire, explosion, waveslam and dropped objects. Accidental loads are loads, ill- denied with respect to intensity and frequency, which may occur as a result of accident or exceptional circumstances. Examples of accidental loads are loads due to collision with vessels, fire or explosion, dropped objects, and unintended flooding of bouyancy tanks. Special measures are normally taken to reduce the risk from accidental loads. For example, protection of wellheads or other critical equipment from a dropped object can be provided by specially designed, impact resistant covers.

All loads must be calculated with a certain security. This parameter depends on the frequency of occurrence of class load and reliability of structures. According to Russian regulations, offshore facilities should be designed according to the requirements for Class I installations of security as you burn them may result in the loss of life and serious environmental pollution. Canadian standards allow classification of certain offshore facilities in the second class reliability.

2.2.2 Design loads

To improve the reliability of the determination of loads in the design of structures introduce the concept of the design load. Approach to the determination of the design load is more conservative than the definition of the regulatory burden (i.e., load, regulated methods of calculation laid down directly in the rules). To determine the design loads regulatory burden is multiplied by a safety factor (more or less than one.) For example, the weight to be multiplied by the structure factor greater than unity when calculating the bearing capacity of the base structure and a lower unit for calculating a shift along the bottom surface structure.

2.2.3 Load combinations

The construction works multiple loads. The simultaneous achievement of their maximum values is unlikely. Therefore, the calculation is made on a variety of adverse combination of them, with the introduction of factor combinations.

There are two types of combinations:

- the basic combination;
- special combinations;

The basic combination consisting of a permanent, long-term and short-term loads, special combinations consisting of a permanent, long-term, the possible short-term and one of the special loads.

If the ground is only one combination of short-term load factor combinations is taken as a unit, taking into account two or more short-term loads are multiplied by the recent 0.9.

2.2.4 Forces due to water pressure

Exposure to water in any structure, partly or wholly in the water depends on the water: if it is in rest or in motion.

Dormancy is called a state in which the liquid (water) is not moved in both the horizontal and vertical directions.

The liquid is in a state of rest, the primary driver of all hydrostatic solutions, is the hydrostatic pressure.

Hydrostatic pressure has two important characteristics: first - the pressure always acts normal to the site under consideration at any point of the volume of liquid, the second - the value of the pressure p at any point does not depend on the angle area in which this point is found. It is called the two properties allow us to determine the hydrostatic force on any part of the body that is completely or partially in the liquid. Here are a few important cases OOGC to determine the power of water pressure.

In Figure 1.7 shows the area, located in the water. We denote the center of gravity of the figure by the letter C , the figure is inclined to the horizontal at an angle α . The water pressure at the point will be determined by the formula:

$$p_C = \gamma_p \times h_C \quad , \quad (2.1)$$

where γ_p - the proportion of the liquid;

h_C - the distance from the surface to the point S .

Further, in view of this relation, we determine the total water pressure to the entire surface area of ω :

$$P = p_C \times \omega \quad (2.2)$$

Condition (1.2) allows the hydrostatic pressure found on any surface of anybody that is permanently or partially in water.

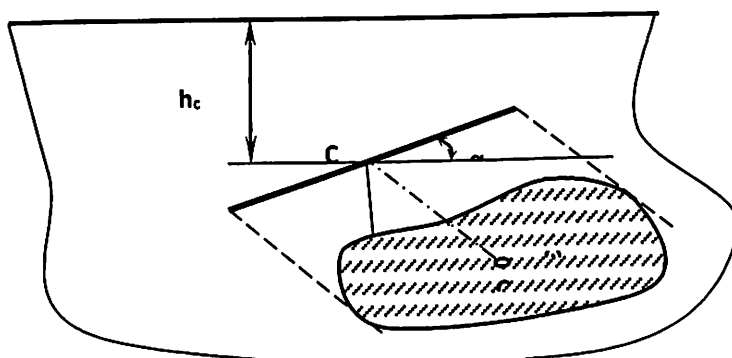


Figure 1.7 - Diagram of the definition of pressure to the site

In Figure 1.8 shows the underwater part of an offshore platform. The pressure at points 1, 2 and 3 are in accordance with the Formula (1.1):

$$p_1 = h_1 \times \gamma_p; \quad p_2 = h_2 \times \gamma_p; \quad p_3 = h_3 \times \gamma_p \quad (2.3)$$

As seen from (2.2) despite the fact that the pad $\omega_1, \omega_2, \omega_3$ inclined at different angles to the horizontal, all the product p is the specific weight of water γ_1 for each point corresponding to the depth of water.

Having determined the position of the center of gravity of each of the areas, you can find the full amount of pressure on each of the areas.

We next consider the curved surface (Figure 1.9). The water pressure at any point in the envelope of curved surfaces will be determined by the condition (2.2). As for the total amount of water pressure, it consists of two components: the vertical and horizontal (P_z and P_x). Horizontal P_x is equal to the area of the triangular diagrams of pressure and etc.

$$P_x = \frac{\gamma_w \times H^2}{2} \quad (2.4)$$

For both figures because the depth is the same for drawing diagrams 1.8 and 1.9.

Vertical (total) volume of the liquid pressure power in the hatched region, multiplied by the specific weight of water, i.e. weight of water contained in the shaded area.

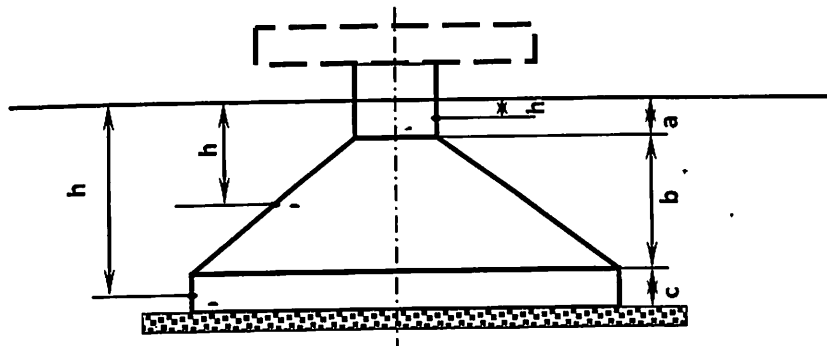


Figure 1.8 - Diagram of the definition of water pressure on the underwater part OOGC

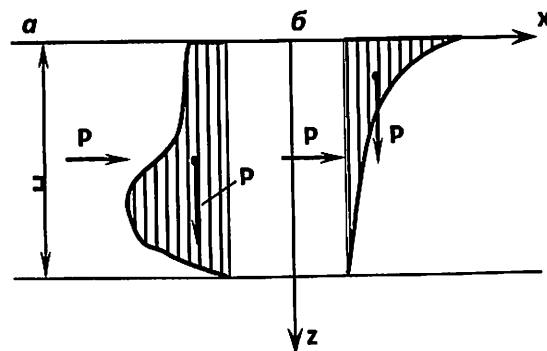


Figure 1.9 - Scheme to determine the water pressure on a curved surface

2.2.5 Force action on construction of the moving water

At rest, the water is in very rare cases. Even in closed containers is a constant movement of fluid under the influence of changes in temperature, change the position of containers, etc. In open waters as the more water is in constant motion. Therefore, when designing OOGC necessary to account for force effects of water as it moves.

Hydrostatic fluid pressure and the force effect of the moving fluid, enables to determine the forces that are constant values. Given the values of the flow velocities, the depth of the body, its shape - the value of the pressure forces will be maintained during the whole preservation of constancy effects of liquid.

In addition to the permanent effects of wind forces and fluid flow may, under certain conditions, result in unstable power impacts of variables, both in magnitude and direction.

Power flow hydrodynamic pressure P has two components: the so-called drag force P_x (horizontal direction) and lift component P_z (vertical component).

The values of the force F depends on many factors: the shape of the body wrap, the roughness of its surface, the velocity and viscosity of the liquid and some other values. In general, the strength of the hydrodynamic pressure of the flow are determined by the formulas:

horizontal component ("drag"):

$$P_x = 0,5 \times C_x \times \rho_s \times \omega \times v^2 \quad (2.5)$$

where C_x - the drag coefficient of the surface, subjected to a stream of moving with speed v ;

ρ - density of the liquid;

ω - area (frontal) surface.

The vertical component (lift):

$$P_z = 0,5 \times C_z \times \rho_s \times \omega \times v^2 \quad (2.6)$$

where C_z - lift coefficient.

This force occurs when the body is at the bottom or near the bottom.

Coefficient $C_x > 1$, and C_z are within 0.3 - 0.5 times the values of C_x . The coefficients C_x and C_z are determined on the models or empirically using data obtained from similar tests of the designed object.

Ocean currents, which are progressive movement of water masses, whose impact on OOGC be taken into account, can be divided into the following types:

- Tidal, at which the velocity vector passes close to the normal to the coastline, the vector direction is changed to 180° in the tidal cycle (for the shore and off shore);

- Stock - for the mouths of rivers, is directed generally toward the sea;

- Wind - the flow caused by the wind;

- Gradient - flow arising under the influence of temperature changes.

However, the greatest practical interest in relation to the assessment of the impact on OOGC is wind and tidal currents.

2.2.6 Loading from the effects of wind

Wind load on structures OOGC is due to the movement of air masses field of air pressure, variable both in space and in time. However, in the calculation, for example, using a stability value generalized real wind load, namely, the estimated wind pressure force representing the resultant wind load F , attributable to any area. For example, the total value as shown in Figure 1.10 and diagrams of wind load can be replaced by the resultant of F_v , the line of action which passes through the point (Figure 1.10). In reality there is no such power, and no real point on, but it is possible to use calculations and call it "force" wind impact. This is an imaginary force, representing the sum of the diagrams of wind load, distributed over the area V . This force is applied through the center of gravity of the diagrams.

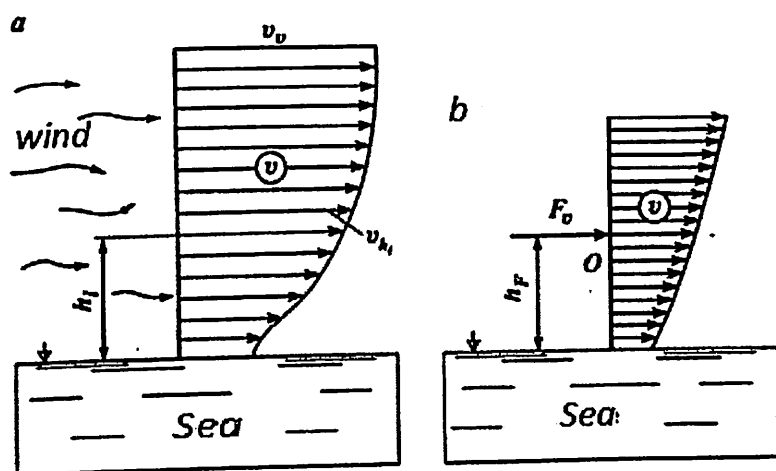


Figure 1.10 - Wind load and its resultant of representation

Meaning of the wind load and thus "forces" the wind pressure is determined according to the aerodynamic measurement. For facilities OOGC the horizontal component of the force F_v is given by:

$$F_v = C_v \times \omega \times 0,5 \times \rho_v \times v^2 \quad (2.7)$$

where C_v - coefficient of drag;

ω - sail area of the object, ie the area of that part of the object, which is subjected to wind action;

v - velocity of the wind;

ρ_v - the calculated density of air

$$\rho_v = \frac{3,5 \times 10^{-3} \times p_v}{273^\circ + t}; \quad (2.8)$$

where p_v - atmospheric pressure at the location of the facility;
 t - the air temperature.

Under the square sail ω means the projection of all surfaces of the object on the vertical plane. If the structure is composed of several parts, between which there is free space, the total sail area is defined as the sum of the individual areas. But you cannot ignore one important fact. Since each element can have a different contour design (rectangle, square, circle, etc.), then the total force on the object OOGC should be determined as the sum of the impacts of wind power on the individual elements are defined with regard to the shape of their outer contours. Accounting for the streamlined shape of the object or the wind OOGC individual element is the introduction of the corresponding drag coefficient C_v (sometimes called a shape factor). This coefficient is determined only by experimentation. Produced blowing shapes in wind tunnels or model tests are carried out in field conditions, and based on the results of the tests are determined by the values of coefficients of the form (drag). The values of drag coefficients for the most common forms are shown in Figure 1.11. The arrows on the various forms of sections stand for the wind direction.

For high-rise elements (drilling rigs, support columns, the design of beams, trusses, etc.) is defined as the total sail area of ω of all the details of the corresponding element. The value assigned to the form factor of the element as a whole, ranging from $C_v=1$ and $C_v=1.8$. Assign C_v should in each case for a particular element. Thus, for a derrick of tubular structures $C_v \approx 1.6-1.8$; truss $C_v=1.3$; platforms supporting column square $C_v=1.0-1.3$; cylindrical column $C_v=0.7$. Wind pressure creates two main types of impacts on OOGC: horizontal and tilted. The first determines the horizontal movement of the object, the second - its slope.

In determining the wind tilting moment M_w relative to the line surface of the water is taken into account the horizontal component of the wind "power", i.e. F_v :

$$M_v = h_F \times F_v \tag{2.9}$$

where h_F - shoulder application of the resultant load F_v relative to the surface of the water line (Figure 1.10, b).

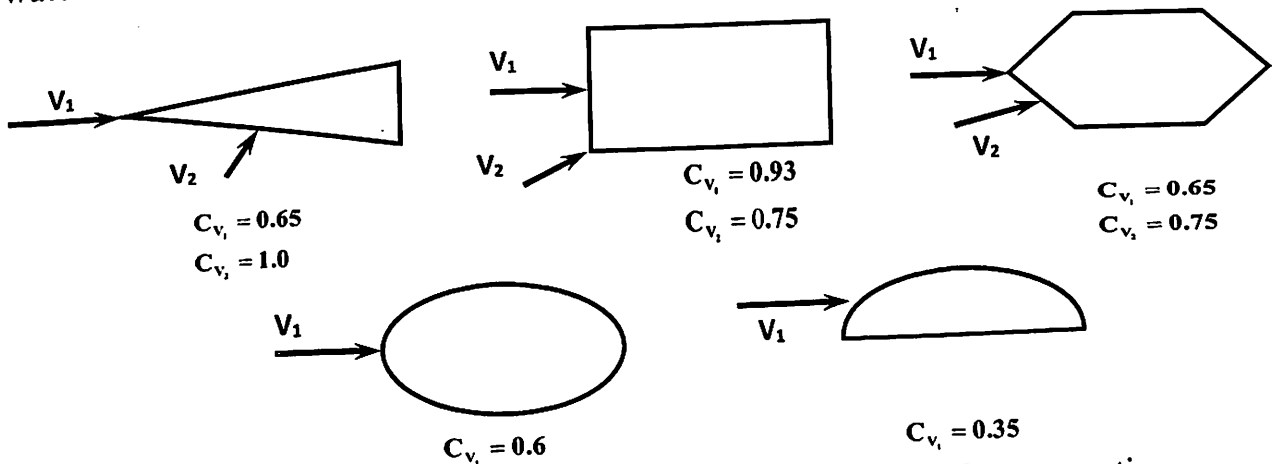


Figure 1.11 - The drag coefficient for various forms of cross-section

It is further noted that in the formula, the velocity V_v average wind speed V_v meant 10 meters above the sea surface over a time interval 10 minutes. The diagram of the distribution of wind speed with height is calculated using the formula:

$$\frac{V_{h_i}}{V_v} = 1 + 2.5 \times \ln 0.1 \times h_i \sqrt{(0.71 + 0.71 \times V_v) \times 10^{-3}}, \quad (2.10)$$

where V_{h_i} - the wind speed at the height h_i .

Table 1.2 presents data on average wind speeds, which happen once in 50 years in various seas (period - 10 minutes).

Table 1.2 - Average wind speeds

Sea	Average velocity of wind m/sec	Sea	Average velocity of wind m/sec
Caspian	45	Barents	46
Black	43	Okhotsk	48

In reality, the wind can blow the building from different angles, changing its direction within 360 °. OOGC object will experience a variable (depending on the wind direction) force action F_v . Thus, even at a constant wind velocity v value F_v will vary depending on the direction of the velocity vector.

In the calculations for wind loading facilities located at high altitude relative to the surface of the sea (a helipad, a drilling rig, etc.) must take into account the dynamic component of wind load velocity fluctuations, as well as lift with the wind blowing horizontal and slightly inclined surfaces.

2.2.7 Waves and their impact on OOGC

The waves are the most difficult for the theoretical and practical assessment of their impact on the structure of physical and mechanical phenomena that periodically appear and disappear at any open water. It is known that the waves have great destructive force. This is particularly evident in the incessant change of coastlines, their erosion. As the offshore oil and gas facilities are installed in the marine waters, it is necessary to know how and with what force of wave action on these structures, the nature of their origin.

2.2.8 Overview the theory of wind waves

Waves - is generated by the wind alternating shafts of water (hills), and depression on the free surface of the sea.

The waves are divided into "running" and "standing." By "running" refers to a wave moving in the direction of the wind that caused their formation, under the "standing" refers to the waves without forward motion. Travelling waves do not occur with counter (reflected) waves, so they are moving in the direction of the wind; standing waves are formed by the interaction (collision) waves traveling and counter.

The shape and size of waves depend on the length of the acceleration wave-type body of water (sea area), the wind speed. Therefore, when considering the wave process is necessary to consider these options.

In seamanship are four zones of the reservoir at a depth of water:

The first zone - Deep within which the impact on the bottom of the wave process is absent, the depth of water - $H > 0,5 \lambda$.

The second zone - shallow affecting the wave process, and in this area $0,5\lambda \geq H > H_{kr}$ - the depth at which to start the destruction of the waves.

The third zone - surf, within which begins and ends with the destruction of the waves - $H < H_+$.

The fourth zone - priureznaya, which completely destroyed by the waves run (is rolled) on shore or slope construction. Thus, we can say that the slope of the function of the shore facilities at the end of the existence of each of the waves lapping on it.

The main parameters of the wave process required for the design:

- Defined wave parameters - length λ , the height (amplitude) h and h_{gh} (greatest height) with the maximum wind velocity v (m/s) with a probability of occurrence times 50 (for OOGC);

- Is determined by the rate and duration of the wind in different directions (compass points), are so-called "wind rose" and identifies the most dangerous wind rumba for specific objects OOGC.

Very important for the formation of waves, especially their size, is the so-called acceleration wave length. By the length of acceleration waves or mean length of the part of the sea, which begins and ends with a wave process.

Height offshore wind waves decreases as one moves from the surface to the seafloor. According to the classical theory of wave height decreases with depth exponentially

$$h_z = h \times \exp\left(\frac{2\pi z}{\lambda}\right) \quad (2.11)$$

where z - depth from the surface of the sea; h_z and h - height of waves at depth z and at the sea surface, respectively.

The results of field studies show that the reduction in the height of the surface waves with depth to water the depth of which is twice the wavelength correctly assessed by the formula:

$$h_z = h \times e^{\left[-5.5 \left(\frac{z}{\lambda}\right)^{0.8}\right]} \quad (2.12)$$

However, for engineering calculations such updates are insignificant. On these waters approximately calculate the wave height h_z at depth z can be based on simple rules: if the depth increases in arithmetic progression, the wave height is reduced to geometric (Table 1.3).

Table 1.3 - Reducing the height of the waves with the depth of the sea.

The relative depth of the sea z/λ	The wave height h_z (as a fraction of h)	The relative depth of the sea z/λ	The wave height h_z (as a fraction of h)
0	1	5/9	1/32
1/9	1/2	6/9	1/64
2/9	1/4	7/9	1/128
3/9	1/8	8/9	1/256
4/9	1/16	9/9	1/512

Wind waves are divided into forced arising and being under the influence of wind pressure and the free occurring after the cessation of the wind, or released for the zone of action. Loose waves are also called swell. The results of numerous wave observations in natural conditions show that for deep water areas where the bottom does not affect the shape and size of wind waves, we can assume that $\lambda \approx 20h$ for wind waves and $\lambda \approx 30h$ to swell waves. Encountered obstacles in the way of the waves are hydrodynamic loads. According to modern concepts of hydrodynamics major components of the total force of pressure waves at any cylindrical obstacle is the drag force, inertial force and the force of the water hitting the barrier.

The drag force is proportional to the square of the linear velocity of the orbital motion. Its maximum value is achieved by passing mono support at the crest of the wave. Drag force due to the fact that the surface of the barrier at its thick liquid flow occurs, but under certain conditions, periodically separates the boundary layer of the vortex structure. The energy expended in the formation of vortices and to overcome the friction of the water barrier, creates a drag force.

However, for engineering calculations such updates are insignificant. On these waters approximately calculate the wave height h_z at depth z can be based on simple rules: if the depth increases in arithmetic progression, the wave height is reduced to geometric. Very important for the formation of waves, especially their size, is the so-called acceleration wave length.

The appearance of the inertial force due to the fact that the wave mode in the variable obstruction flows about the rate of water flow. The time variation of the velocity of the water creates a force whose magnitude is directly proportional to the acceleration of the flow. The maximum value of this force is achieved at the points of the wave, the position of which roughly corresponds to the undisturbed portion of the sea. Thus, against the force of the drag force is the inertia phase offset equal to $\pi / 2$.

Table 1.4 - Scale degree wind waves (the numerator) and swells (the denominator)

Seaswell	Level of wave and swell	Size of wave			The minimum water depth (m) at which valid the above relations
		height, mm	length,	period, sec	
Weak	1	$\frac{< 0.25}{< 0.25}$	$\frac{< 5.0}{< 10}$	$\frac{< 2.0}{< 2.0}$	$\frac{2}{5}$
Light	2	$\frac{< 0.25-0.75}{< 0.5}$	$\frac{5-15}{15}$	$\frac{2-3}{3}$	$\frac{3}{7}$
Moderate	3	$\frac{< 0.75-1.25}{< 1.0}$	$\frac{15-25}{30}$	$\frac{3-4}{4}$	$\frac{7}{15}$
Significant	4	$\frac{< 1.25-2.0}{< 2.0}$	$\frac{25-40}{60}$	$\frac{4-5}{6}$	$\frac{12}{30}$
Strong	5	$\frac{< 2.0-3.5}{< 3.0}$	$\frac{40-75}{90}$	$\frac{5-7}{8}$	$\frac{20}{45}$
Large	6	$\frac{< 3.5-6.0}{< 5.0}$	$\frac{75-125}{150}$	$\frac{7-9}{10}$	$\frac{35}{75}$
Storm	7	$\frac{< 6.0-8.5}{< 7.0}$	$\frac{125-170}{210}$	$\frac{9-11}{11}$	$\frac{60}{110}$
Hardcore	8	$\frac{< 8.5-11.0}{> 7.0}$	$\frac{170-220}{> 210}$	$\frac{11-12}{> 12}$	$\frac{80}{> 110}$
Hurricane *	9	> 11.0	> 220	> 12	> 80

* The swell is calibrated by only 8 points.

Impact strength caused by sudden loss of flow and supporting surge. This force is proportional to the square of the flow rate. Its maximum value is achieved in phase with the maximum drag forces.

The role of the individual components of a total force of the waves and obstacles of various parameters are different. For a relatively small waves, not accompanied by a surge, the most important role played by the inertial component. For large steep waves, especially in the burst, the major role played by the drag force and stroke.

2.2.9 Calculation of wave loads on braced frame construction

Many offshore structures are composed of core elements arranged in horizontal, vertical and oblique. These elements include a variety of props, piles, the rods connecting the pillars of the fixed platforms collectively, and the cross-cutting.

Under certain conditions, the frequency change of wave pressure and the natural frequency of the vertical supports can be matched. This will increase the oscillation amplitude of support that can be extremely unfavorable for support for its intended purpose.

As the wave passes through the support (rack rod) value of the wave of pressure on it will vary from the positive to the negative, and the magnitude of the resultant pressure is defined as the total value of the pressure diagram constructed by the height of the support. It should be borne in mind that the pressure itself q includes two components: q_s - speed and q_i - inertia, i.e.

$$q = q_s + q_i \quad (2.13)$$

Speed and inertial components of q depends on the water depth H , the length and height of the waves, the height of the support (the rod) and the size and shape of its cross section. The account of all the factors is very complicated and does not always solve the problem in a finite form. Therefore, in practice methods, including theoretical and experimental data, and the data obtained experimentally.

For calculations of the strength and stability of vertically standing pillars necessary to have a quantitative value and the point of application (conventional "applications"), the resultant forces distributed Q and q_s , q_i . On the recommendations of D.D. Lappo speed component of the resultant force

$$Q_c = \gamma \times \frac{b \times h^2}{12} \alpha_c \times \beta_c \times k_v^2 \quad (2.14)$$

and inertial

$$Q_H = \gamma \times \pi \times \frac{b^2 \times h}{4} \alpha_H \times \beta_H \times k_v \quad (2.15)$$

where α_s and α_i - factors that depend on the ratio of water depth H and elevation supports (bar) above the bottom, i.e. H / λ and length λ and the wave height and h , i.e. λ / h ;
 γ - bulk density of the liquid.

The values of these coefficients obtained from experiments and field measurements are determined by the data graph drawing 1.25. It should be borne in mind that α_s is not dependent on the above relations with $H \geq 0,5 \lambda$, and $\alpha_i = 1$ for $H \geq 0,3 \lambda$.

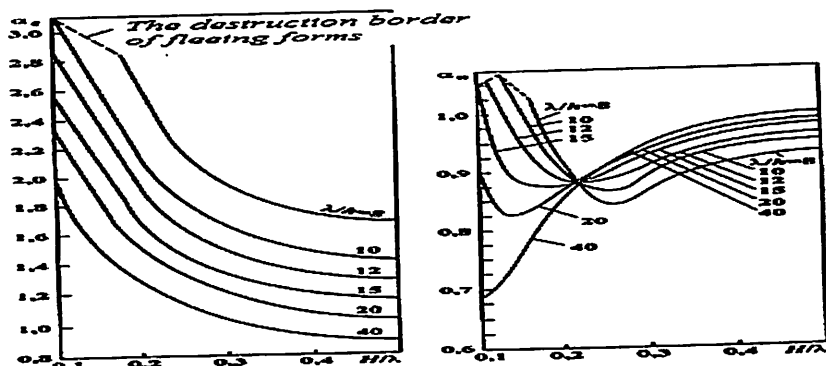


Figure 1.13 - Schedule of coefficients α_s and α_i

The coefficients β_s and β_i are taken on schedule drawing 1.14 for circular cross-sections support (rod) $\beta_s = \beta_i = 1$.

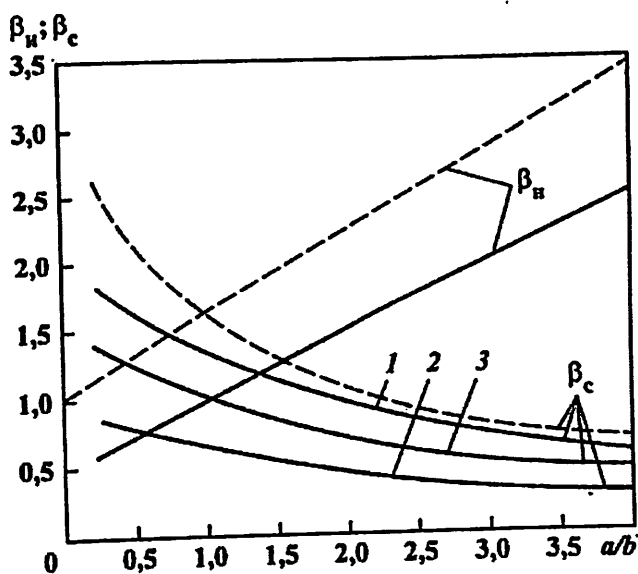


Figure 1.14 - Schedule of coefficients β_s and β_i

Table 1.5 is a cross-sectional dimension of the element (props rod) in the direction of the wave. The coefficient k_v taken from the data shown in Table 1.5.

Table 1.5 - The coefficient k_v

a/λ	0,05	0,1	0,15	0,2	0,25	0,3	0,35
k_v	1,0	0,97	0,93	0,86	0,80	0,70	0,60

2.3 Selection of rational basis

2.3.1 Influence of environment's characteristics for the choice of a OOGC

We present only the main characteristics which are independent from desire or reluctance of designers and builders are responsible for deciding on the form and design parameters OOGC that best meets the requirements to ensure the life of the object in the database of climatic conditions.

2.3.1.1 The surface condition of the sea area

The state of the surface area of the sea will be possible to understand the condition of the water at the sea surface at different times of the year: the sea could be ice-free or freezing. The "ANTI-FREEZE" will be called the sea, the surface of which in the area of accommodation OOGC not freeze ever. This means that the marine structures will never be exposed to ice.

"Freezes" will be called the sea, the surface of which in any period of time is frozen. In this case necessarily OOGC design and build using the ice conditions (ice thickness, while it is standing, possible shifts, etc.). Under ice-sea commonly used lightweight construction because they are not exposed to ice.

2.3.1.2 The depth of the sea

From the depths of the sea in the placement OOGC significantly affect the choice of constructive forms OOGC. In the practice of offshore oil and gas construction has developed three major titles depths of the sea: large, medium and small.

Immediately, we note that there are different interpretations of these depths - household, that is employed in everyday practice and based on the hydrological interpretation. Hydrological interpretation divides the sea areas in the deep, shallow and coastal depending on the changes that occur in waves, when the depth of water.

The notion of depth, relating more to the simplicity or complexity of construction work at sea, there are tips like this:

great depth $H > 50\text{m}$;

average depth of $15\text{m} < H \leq 50\text{ m}$;

shallow depth $H < 15\text{m}$

Of course, such a gradation of the depth of conventional, but still allows you to start designing and building OOGC appreciate the complexity of works and tentatively, given the existing experience of marine oil and gas construction, select one or more design concepts OOGC to the area of the oil or gas. So, at depths of 10-20 m is most advisable to take OOGC stationary species at depths up to 50 m OOGC can be both fixed and floating objects. At greater depths OOGC floating species may be the most appropriate, which allows to simplify and reduce the volume and complexity of work directly into the sea.

2.3.1.3 Geological structure of the seabed in the area of construction OOGC

Ground floor area of the sea in the placement OOGC may have a different bearing capacity. As is known from soil mechanics, strength characteristics of soils can be from several Newton's per square centimeter (for example, sludge) to several thousand Newton's per square centimeter (for rock). Accordingly, there will be different requirements for the foundation part OOGC.

Depending on the type of soil is decided constructive design of the bottom supporting structure. Thus, in the case of low bearing capacity under construction pile foundation supports. For high load-bearing capacity of soils can be used piling and weakly deepened foundations.

For the rocky ground does not matter what type of foundation will be selected: load-bearing capacity of the rock to provide a reliable fixing of any foundation.

2.3.1.4 The hydrodynamic characteristics of the sea

The impact of waves and currents on the structure OOGC are very important in the appointment of their shape and size. Sea level change requires a very sound approach to the appointment of the height of the sea surface platforms placed on it technological equipment.

The impact of waves and currents greatly destabilizes the overall stability of the platform. To prevent this requires appropriate design of the reference solutions and application platforms complex mooring systems.

2.3.1.5 The wind characteristics in the area of construction OOGC

Wind as a factor of the dynamic effects on structures OOGC is of critical importance. The impact of the wind in two main parts: the first - just strong pressure on all open items OOGC and second - perturbation of the surface of the sea that gives rise to waves and currents of the time, which in turn leads to a hydraulic effect on all objects that are in the water.

2.3.1.6 The seismic characteristics of the zone placement OOGC

Seismic effects on OOGC are very significant factor in the architectural and construction layout designs OOGC. Seismic effects are characterized by the intensity and frequency of occurrence for a period not less than 100 years.

The main feature of the design OOGC calculated by taking into account the seismic activity is to ensure the strength of structures in general and their components, as well as maintaining a steady state of marine oil and gas facilities in the whole and its individual elements. It is allowed deformation and displacement within the elastic state of structural elements.

2.3.1.7 Temperature Environment

Under temperature control means regularity of possible temperature changes of the environment by season, year, and decade. This will set the maximum and minimum temperatures. The value of the temperature regime of the environment allows you to design and construct OOGC individual components so that there was no violation of due process of freezing water or fluids. Insulated areas related to

human activities, in addition, they are provided with work clothes for the appropriate temperature (weather) conditions.

The impact on the design and construction as a whole could have a possible icing and structural elements at temperatures close to 0 °C and the rain. This can significantly heavier construction, and under certain conditions lead to a shift Calculated centers of gravity, which in turn can reduce the stability and overall stability OOGC.

3 SPECIAL PART

3.1 The calculation model, the method of calculation and recommendations for the design

3.1.1 Justification of the choice of the method of calculation tasks

This problem is solved in a linear formulation. In linear problems there is a direct proportionality between the loads and displacements due to the small displacements, as well as between strains (effort) and deformations in accordance with Hooke's law. Therefore for linear problems the best choices are the principle of superposition and the independence of the forces.

In physically non-linear problems there is no direct proportionality between stress and strain. Material of construction is subject to the law of the non-linear deformation. Deformation law can be symmetric or asymmetric - with a variety of outside resistance to tension and compression. In geometrically nonlinear problems there is no direct proportionality between strains and displacements. In practice, the most widely used is the case of large displacements at small strains.

This problem cannot be solved by any analytical method. In this regard, it is advisable to use one of the most effective methods for the approximate solution of engineering problems - the finite element method (FEM).

For engineering practice the great importance have approximate methods of calculation, the importance of which is constantly increasing due to the inability to obtain accurate solutions to complex engineering problems.

Suppose that the state of the system is described by a function. Let this function be the only solution of a mathematical problem, formulated on the basis of physical laws. The solution is to find an infinite set of functions, one that satisfies the task. For complex tasks, rather than to look for the desired function of an infinite set of features, the problem is simplified. We consider a family of functions defined by a finite number of parameters. As a rule, among the functions there is no exact solution of the problem. However, the appropriate choice of parameters can try to approximately satisfy the equations of the problem and thereby build an approximate solution. This general approach is not unique to the FEM, but also for other approximate methods. Specific to the finite element method is to construct a family of functions defined by a finite number of parameters.

We note several important advantages of FEM

a) The finite element method allows us to construct a convenient scheme of formation of the system of algebraic equations for the nodal values of the unknown function. Approximate approximation solutions with simple polynomial functions and all the necessary operations are performed on the individual data element. Next, the association of elements which leads to the desired system of algebraic equations. This algorithm is a separate element from the transition to their full range is particularly suitable for physically and geometrically complex systems.

b) Every single algebraic equation obtained on the basis of FEM contains a small part of the nodal unknowns of the total number. In other words, many of the coefficients in the equations of the algebraic system is zero, which greatly facilitates the solution.

c) The tasks that describe the functions that satisfy the functional equations, is called the continuum. In contrast, the decision of the so-called discrete tasks accurately defined by a finite number of parameters which satisfy the corresponding system of algebraic equations. FEM, as well as other numerical methods, essentially replacing the continuum approximation to the discrete problem. In FEM the whole procedure of such replacement has a simple physical meaning. This allows you to more fully imagine the whole process of solving the problem, avoid the many possible errors and to properly assess the results.

d) In addition to the continual problems finite element method is used to connect the elements and the formation of algebraic equations for solving discrete problems directly. It extends the scope of application of the method.

Active introduction to the theory and practice of design of computer technology and the latest information technology also contributes to the wide application of approximate methods of solutions, including the FEM.

There are software packages that solve engineering problems using finite elements, such as:

- Autodesk Maya 2012;
- MSC NASTRAN for Windows2006;
- Autodesk Inventor Pro2014;
- SolidWorks2008;
- LIRA 9.6;
- FEM Models etc.

FEM can be solved with a high degree of accuracy virtually any engineering problem. The solution to this problem is also possible boundary element method, however, it is limited to in sufficient provision of commercial programs.

3.2 Fundamentals of the finite element method

The method of finite elements, substantially lies in its name: the system being studied (rod or continuum) is divided into a large number of individual parts of the final sizes (finite element) having the same physic-mechanical characteristics, as given year. After that exactly or approximately investigate the stress-strain state of each finite element known methods of structural mechanics and the theory of elasticity: strength, movement, or a combination in order to determine, depending on the adopted method of analysis effort or movement, or both of them at the points of connection between the finite elements themselves (nodes). These factors make the unknowns of FEM. To find the unknown and algebraic equations are solved, usually of a very high order.

In practical calculations of structures and facilities engineering is currently the most common version of the finite element method, a method based on the idea of

movement, so will restrict the study only this form of the method. The Finite Element Method movements was very much geared to the use of computers, as in the analysis of individual finite elements have to deal with simple geometric objects such as standard fixed on a path. The matrix of the system of algebraic equations is symmetric and positive definite band. Such a system is relatively easy to solve. Using the same example of an embodiment in the form of a mixed finite element method or force does not always lead to a system of equations with symmetric positive definite matrices. For their solutions usually require special more complex algorithms.

When implementing the finite element method in displacements as unknowns take necessary translational movement, and in some finite element models and optional angles nodes.

Approach to strength calculations, based on the finite element method in displacements, is a single rod for both systems, and for continuum: plates, shells, massive bodies. The difference lies only in the applicable basic types of finite elements: core, flat triangular and rectangular, similar to the shell, curved shell and volume.

The core elements can be hinged at the ends, working only in tension and compression, flexural flat and spatial, and general appearance, experiencing all kinds of deformation: tension, compression, bending and shear in two planes, and torsion.

Plane elements can be deformed in the plane (plane problem of elasticity) or plane (the problem of bending the plate).

Flat shell elements combine both types of deformation: in its own plane and out of plane, but do not include the mutual influence of these kinds of deformations. The curved shell elements allow for interaction between the two types of strains, rather describe the geometry of a given system being studied, but in the realization they are more cumbersome. Three-dimensional finite element models have the form of pyramids, prisms, parallelepipeds, or appropriate curved objects. They are commonly used in the calculation of massive bodies: dams, piers, arrays, soils, etc., that is where the bulk of the problem requires a decision by the theory of elasticity.

3.3 Software systems are used for the calculation of the problem

Autodesk Inventor, developed by software company Autodesk, is 3D mechanical CAD design software for creating 3D digital prototypes used in the design, visualization and simulation of products.

Autodesk Inventor uses Shape Manager, their proprietary geometric modeling kernel. Autodesk Inventor competes directly with SolidWorks and less directly with Creo Elements/Pro, CATIA, and NX (Unigraphics).

3.3.1 Integrated Motion Simulation and Assembly Stress Analysis

Inventor includes an integrated motion simulation and assembly stress analysis environment. Users can input driving loads, friction characteristics, and dynamic components, then run dynamic simulation tests to see how a product will work under

real-world conditions. The simulation tools can help users optimize strength and weight, identify high-stress areas, identify and reduce unwanted vibrations, and size motors and actuators to reduce energy consumption. Finite element analysis (FEA) lets users validate component design by testing how parts perform under loads (using actual load information instead of estimates).

Inventor's Parametric Studies and Optimization technology lets users modify design parameters from within the assembly stress environment and compare various design options, then update the 3D model with the optimized parameters.

3.3.2 Functionality

Layout circuits combine individual parts and assemblies. Users can check the possibility of assembling an object; add new parts and position, as well as to correct the interference between the parts of the project.

Molds and tooling. The program automates key aspects of the design of injection molds under pressure. Users can quickly create and validate the design of forms and then export them to the Autodesk Moldflow.

Information sheet. Special design environment flat products automate many aspects of the work. Users can create parts sweep formed shapes, to form the flanges by 3D-modeling and paste the details of specialized fasteners.

Frame Generator is used to design frames (frames) based on the standard profiles. The frames are created by placing standard steel sections to the frame. Formation of the final conditions is simplified thanks to the standard options for the corner joints and butt joints. Users can create their own profiles and add them to the library.

Cable and pipeline systems. A framework for creating piping helps to design them in such a way as to fit into a complex assembly or confined. It includes a library of standard fittings, pipes and hoses, and provides the creation of assembly drawings, which are updated as changes to the original 3D-model.

3.3.3 Data Interoperability and Exchange

Inventor uses specific file formats for parts (IPT), assemblies (IAM), and drawing views (IDW or DWG). Files can be imported or exported in DWG format. Design Web Format (DWF) is Autodesk's preferred 2D/3D data interchange and review format.

Inventor includes a Building Information Modeling (BIM) Exchange tool, used to create and publish simplified 3D representations, intelligent connection points, and additional information in native file formats for AutoCAD MEP software. Users can export 3D geometry to AutoCAD Architecture, Revit-based software, and AutoCAD software, and exchange data with industrial design software such as Autodesk Alias Design. Inventor is also used to design mechatronic systems since it is interoperable with electrical software applications such as AutoCAD Electrical and Eplan.

Inventor can exchange data with applications such as CATIA V5, UGS, SolidWorks, and Pro/ENGINEER. Inventor supports direct import and export of CATIA V5, JT 6, JT 7, Parasolid, Granite, UG-NX, SolidWorks, Pro/E, and SAT files. The Inventor Construction Environment provides fault-tolerant import of large STEP and IGES data sets.

3.4 Creating a three-dimensional model of a jacket of wind turbine

On the PC, Autodesk Inventor Professional 2014 was created a solid model of offshore wind turbine components and constructed the jacket, which is shown in Figure 2.1.

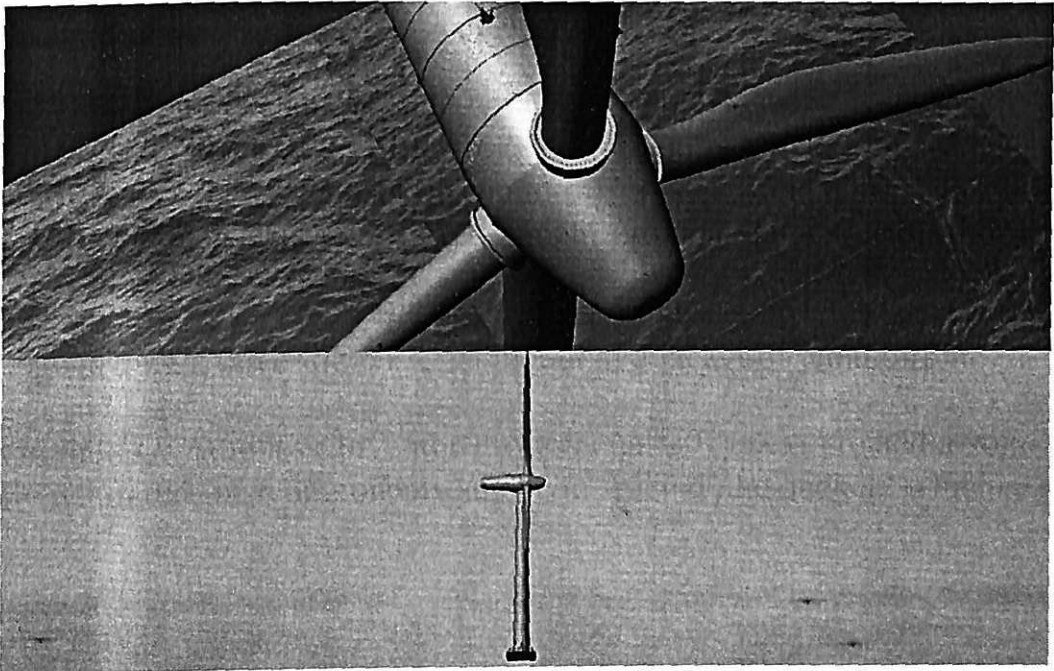


Figure 3.1- Solid model of wind turbine body

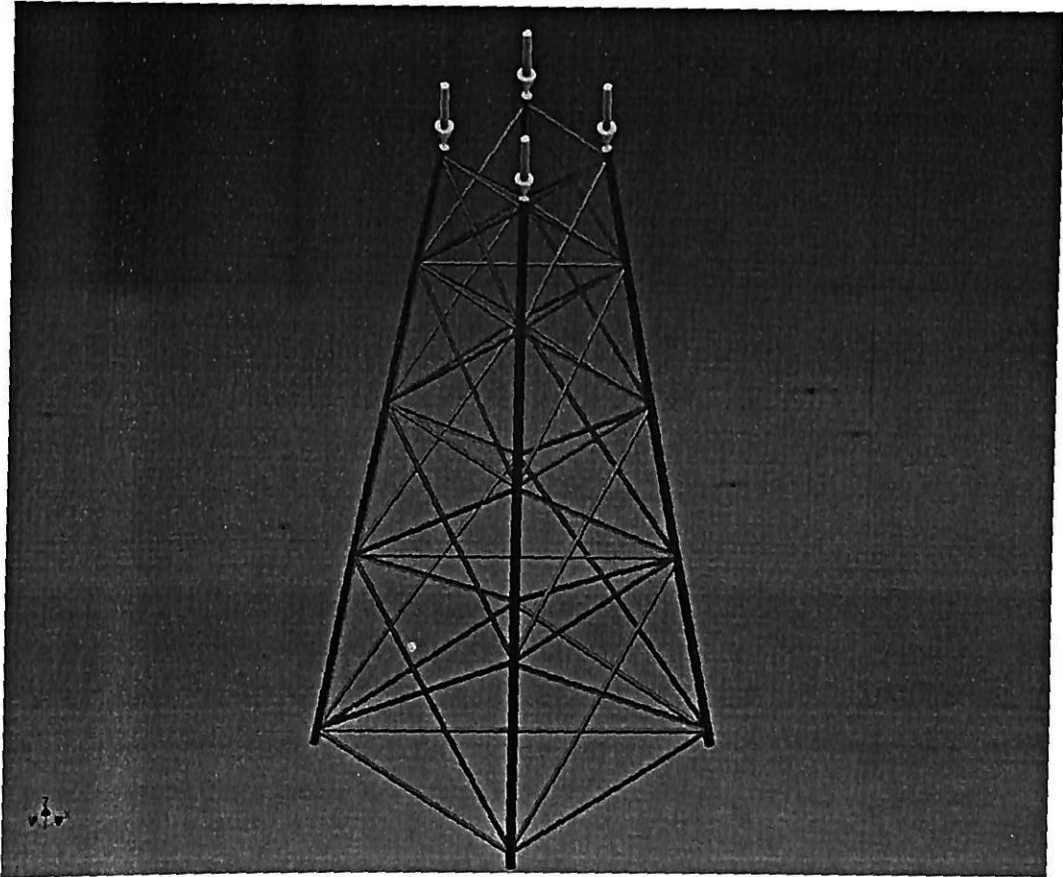


Figure 3.2 - Solid model of jacket



Figure3.3- Solid model of constructed wind turbine

Table 2- Main data for 3.6 MW wind turbine (without tower)

Power	3.6 MW
Rotor orientation	Upwind
Number of blades	3
Control	Variable speed, collective pitch
Turbine diameter	126 m
Rated rotor speed	0,20 Hz
Blade passage frequency	0,59 Hz
Rated tip speed	78 m/s
Blade weight (each)	18,8 ton
Hub weight	53,6 ton
Rotor weight	110 ton
Nacelle weight	240 ton
Tower top weight	350 ton

Trends in geometric size and rated power capacity of offshore wind turbines. Figure 1(a) shows the main components of an OWT system, including a typical monopile foundation, the substructure, transition piece, tower, rotor blades and nacelle (hub). Modern OWTs are installed with either pitch-regulated blades or variable rotational speed systems in order to allow optimization of power production over a wide range of prevailing wind speeds. The rotational speed of the main rotor shaft is typically between 10 and 20 rpm. The nacelle contains key electromechanical components of the wind turbine, including the gearbox and generator. The gearbox may cause efficiency losses for the wind turbine and is a particular source of noise. Recent developments in the design of permanent magnet generators have made it possible to construct some types of wind turbines without the requirement for a gearbox. In this case, the rotor is connected directly to a low speed multi-pole generator that rotates at the same speed, termed a direct-drive unit. Removing the gearbox removes one of the key components requiring more maintenance and that is prone to failure. The substructure connects the transition piece or tower to the foundation at seabed level. In Figure 1(a), a monopile is shown as the foundation system, although other foundation types, discussed later in the paper, may also be used. Together the tower, substructure/support structure and foundation maintain the turbine in its correct operational position. The transition piece provides a means of correcting for any vertical misalignment of the foundation that may have occurred during its installation. In some cases, the foundation can extend to above the water surface, thereby also serving as a substructure by connecting directly to the transition piece or tower.

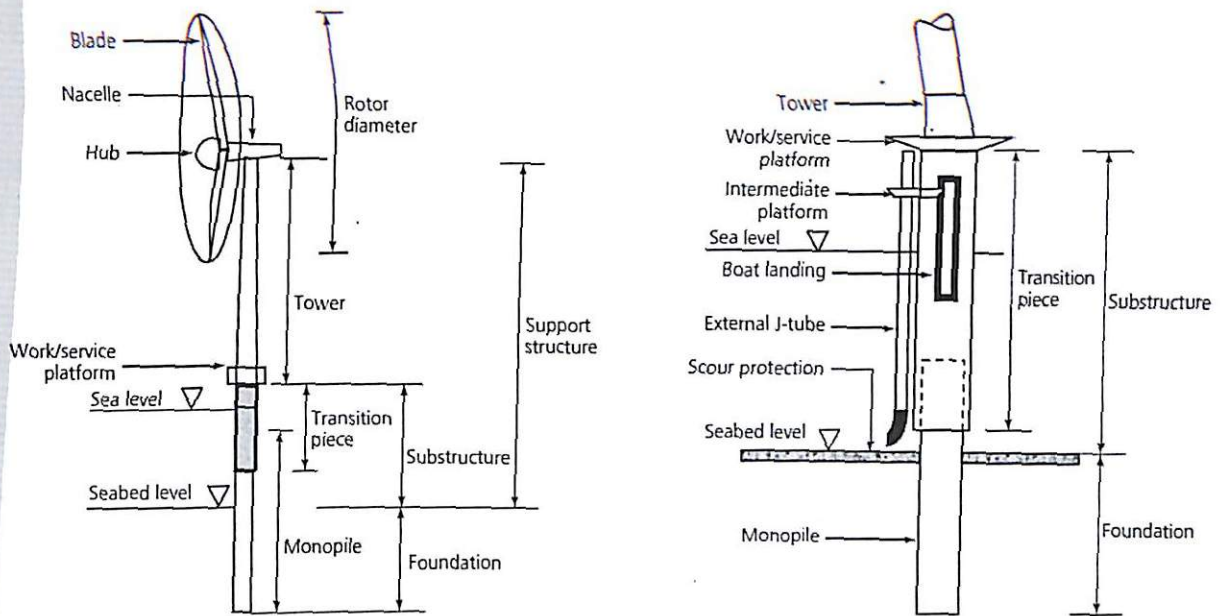


Figure 3.3- Major components of OWT system.

3.5 The calculation model of supporting of a wind turbine

This manual provides basic conceptual information to help get you started. It provides examples that introduce you to the capabilities of Stress and Modal Analysis in Autodesk Inventor Simulation.

Built on the Autodesk Inventor application, Autodesk Inventor Simulation includes several different modules. The first module included in this manual is Stress Analysis. It provides functionality for Structural Static and Modal analysis of mechanical product designs.

This chapter provides basic information about the stress analysis environment and the workflow processes necessary to analyze loads and constraints placed on a part or assembly.

Calculation of the wind turbine support on the stress analysis is carried out in several stages:

- To create three-dimensional model of an wind turbine;
- To create the calculated scheme of the jacket support;
- To put necessary dependences of the jacket's support. Dependence of the fixings is enclosed on the bottom of the jacket support;
- To set the own weight and distributed load on the deck of an wind turbine on an axis Z;
- In the conclusion we count the jacket bases owing to what we receive results on the SSS.

The calculation model of supporting rod columns and the foundation of an wind turbine was created in Autodesk Inventor Professional 2012.

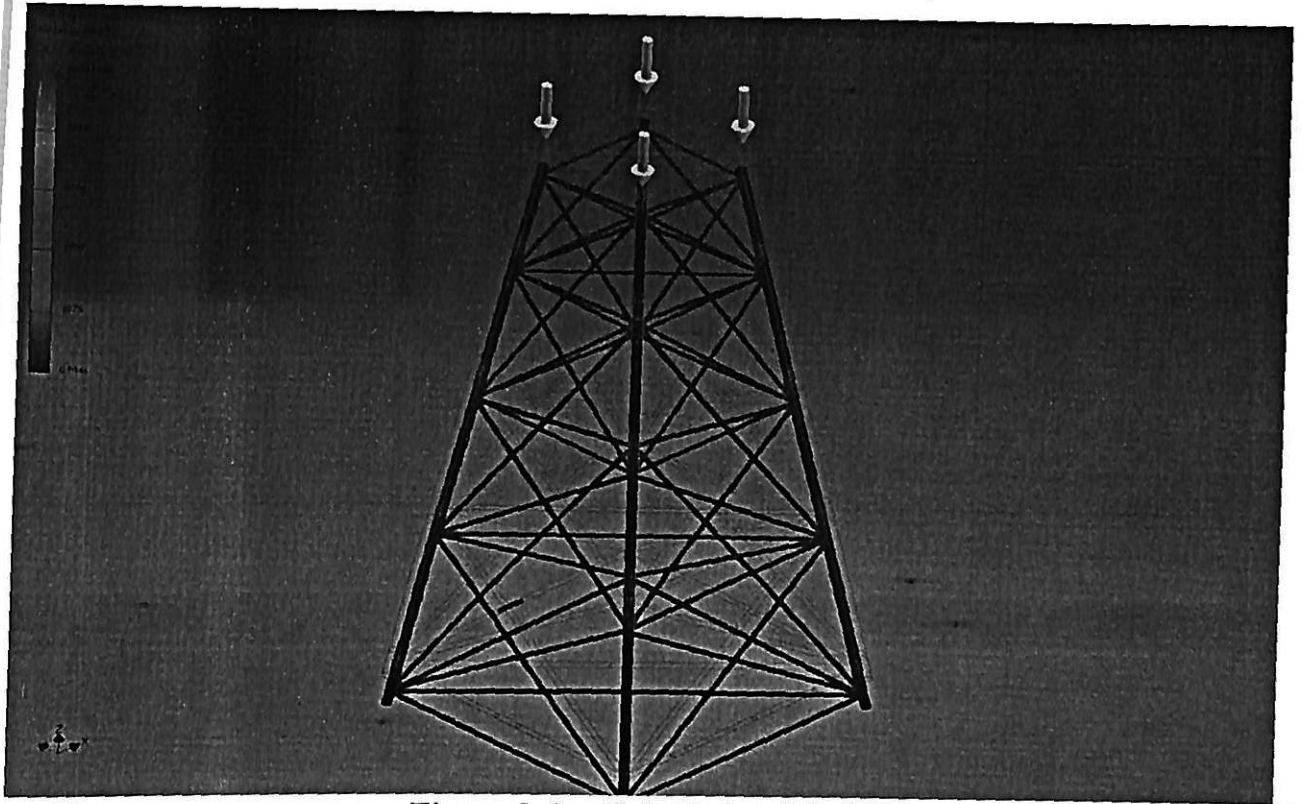


Figure 3.4 - Calculation Model

The results interpretation phase is where the most critical thinking must take place. You compare the results (such as the numbers versus color contours, movements) with what is expected. You determine if the results make sense, and explain the results based on engineering principles. If the results are other than expected, evaluate the analysis conditions and determine what is causing the discrepancy.

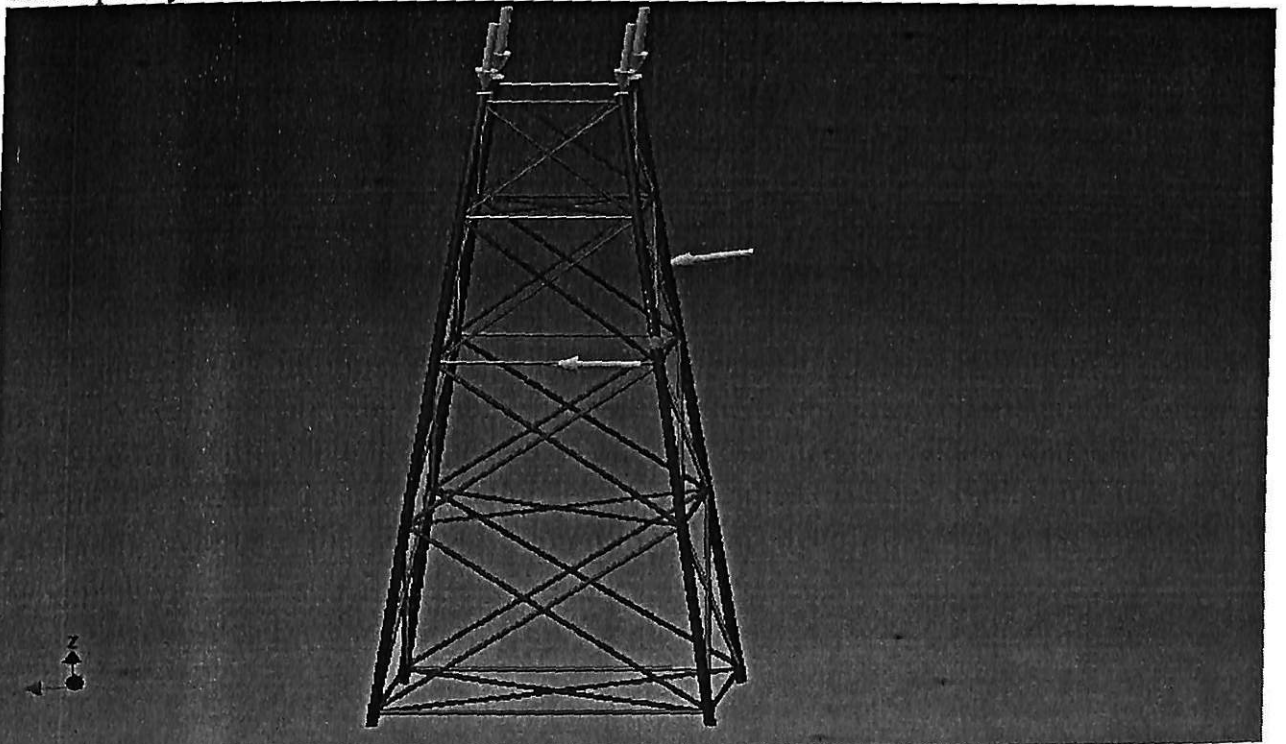


Figure 3.5 - Dependence of fixings

3.6 Collecting of loads

In the calculation of the base jacket to take into account the strength

- Own weight;
- Payload;
- Cyclonic flow;
- Ice load.

Below is a brief description of the data load, calculation of their values and way of application to the design scheme.

The collection and selection of the environmental criteria for the design of offshore structures are the owner's responsibility. Statistical models are essential to adequately describe environmental conditions. All environmental phenomena of importance should be considered, such as wind, waves, currents, and tides. In general, environmental conditions as follows need to be considered in design:

- wind forces;
- current forces;
- wave loads;
- ice loads;
- wave impact forces;
- earthquakes;
- accidental loads;
- fire and blast loading.

The design conditions of offshore structures in the Northern Caspian Sea are primarily driven by: extreme shallow water, water level fluctuations, ice regime in wintertime and hydrodynamic regime during the fall season. The ice and hydrodynamic regimes are considered to adversely exclude each other. The wave and current loads compared to the ice loads at the assumed location can, due to the restricted water depth, be expected to tend to small ratios. For Kashagan oil field the most important load from environmental loads is ice loads. Hence, potential impacts of ice on the structure constitute the global design load condition.

3.6.1 Dead weight

In the program sets the value of the density of the material (concrete) for the base jacket. Net weight of the structure is determined by the program and is applied to the nodes of the finite element as a distributed load

3.6.2 Payload

Useful load created by the weight of equipment, residential blocks, pipes and other objects which are directly on the jacket deck. Accept payload on the top plate of the building is 20,000 tons

3.6.3 Hydrostatic pressure

The impact of water on any structure, partly or wholly in walking in the water, depending on water conditions: whether it is at rest or moving.

Dormancy is called a state in which the liquid (water) is not moved in both the horizontal and vertical directions.

Hydrostatic pressure is a major determinant of all hydrostatic solutions for the fluid in the rest.

Hydrostatic pressure has two important characteristics: first - the pressure always acts normal to the site under consideration at any point of the volume of liquid, the second - the value of the pressure p at any point does not depend on the angle area in which this point is found.

In Figure 2.3 shows the area, located in the water. We denote the center of gravity of the figure by the letter C , the figure is inclined to the horizontal at an angle α . The water pressure at the point will be determined by the formula:

$$p_C = \gamma_G \times h_C \quad (3.1)$$

where γ_G - the specific gravity of the fluid;

h_C - the distance from the surface of the water to the point C.

Diagram of the definition of pressure to the site

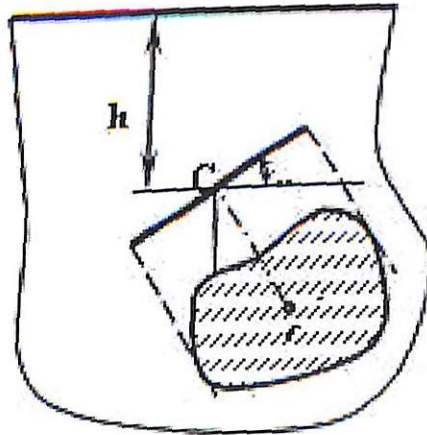


Figure 3.6

Further, in view of this relation, we determine the total water pressure to the entire surface area of ω :

$$P = p_C \times \omega \quad (3.2)$$

This formula allows to find the hydrostatic pressure on any surface of anybody that is permanently or partially in water.

In this project, the calculation of the base jacket to Autodesk Inventor hydrostatic pressure on the inclined base (Annex A, Figure A3) is given as an uneven

load on the nodes that varies from 0 at the surface of the water to the value $P_{n.osn.}$ at a depth $h_1 = 24$ m P value found by the formula:

$$P_{n.osn.} = \frac{4 \times \pi \times ((h_1 \times (R + R_1) + h_2 \times (R_1 + R_2)) \times \gamma_w)}{38} = \frac{4 \times 3,14 \times ((21 \times (9 + 6) + 14 \cdot (6 + 7)) \times 10055,25)}{38} = 31851,34H / \text{узел} = 31,85m / \text{узел}.$$

3.6.4 Impact of current

At rest, the water is in very rare cases. Even in closed containers is a constant movement of fluid under the influence of changes in temperature, change the position of containers, etc. In open waters as the more water is in constant motion. Therefore, when designing MNGS necessary to account for force effects of water as it moves.

Hydrostatic fluid pressure and the force effect of the moving fluid, enables to determine the forces that are constant values. Given the values of the flow velocities, the depth of the body, its shape - the value of the pressure forces will be maintained during the whole preservation of constancy effects of liquid.

Flowing water exerts on anybody placed in it, the various types of force action. As in the case of wind load concentrated force, the resultant load from the moving water, is a conventional (estimated) strength. Computational methods allow us to determine the magnitude of this force, the direction of its action and the point of application.

Although these values are relative, their use in the calculation of permissible and simplifies them, as it allows you to operate one, but not a lot of strength. The results of calculations quite reliable. The strength of the hydrodynamic pressure of water flow P has two components: the so-called drag force P_x (horizontal direction) and lift component P_z (vertical component).

The values of the force F depends on many factors: the shape of the body wrap, the roughness of its surface, the velocity and viscosity of the liquid and some other values. For objects MNGS most often rectangular, cylindrical, lattice shape streamlined surfaces. Significant impact on the size and shape of water exerts pressure diagrams and position relative to the surface of the body of water: a body floats in the water body, the longitudinal axis vertical, horizontal or inclined at an angle to the water surface.

In this problem, ignore the value of the vertical component of the force of flowing pressure stream of water and consider only the horizontal component, which is determined by the formula:

The drag coefficient is equal to the surface of the circular cross-section 0.6, the frontal surface area equal to half the area of the lateral surface of the structures under water - 87.85 m^2 .

Substituting these data into (2.6.4.1), we obtain:

$$P_x = 0,5 \times 0,6 \times 1025 \times 87,85 \times 1,0^2 = 27013.875H.$$

The obtained value of the pressure force of the water flow is divided by the number of nodes semi zone on water level:

$$27013,875 / (9,81 \times 20) = 1376.8539 \text{ kg / node}$$

This load is applied to the nodes located on semi zone water level. In depth, the load varies from 1.376 t/node on the line of the water level to 0 at the bottom.

3.6.5 Ice load

Ice load value depends on many factors, some of which are characterized by ice, and part - structure.

Ice load is determined by the deformation or the view, the type of damage and cleaning the ice prior to the construction or external driving forces. In both situations, the load value is not constant in time. This is especially true in cases where the rate of ice large enough to cause it to brittle fracture. Then the ice load reaches a peak and then decreases rapidly and starts to increase again. Traditional now is to determine the maximum peak load and its treatment as a quasi-static design value.

The most important parameters influencing the ice load are:

- The type of ice formation;
- Properties of ice;
- Scenario of interaction; - Geometry of the building;
- The scale effect.

Due to the use of different scenarios for the output used to calculate the loads of empirical formulas (e.g., type of ice formations, the type of interaction, the strength of the ice, etc.) there is wide variation in the ice load assessment by experts from different countries and companies.

Thus:

- Ice load is stochastic in nature, and only the use of probabilistic methods can give more or less reliable results;
- For the development of probabilistic methods need to understand better the correlation between the different parameters affecting the load. Existing knowledge is incomplete.

In determining the ice load is usually the following types of ice formations:

- Level ice;
- Rafted ice;
- Hummocks;
- Hummocks;
- Icebergs.

Level ice is often used as a prototype, both in theoretical and laboratory studies. Many of the regulations considered as the basis of level ice load estimation for the majority of ice formations. Share the one-year and multi-year ice. Multi-year ice stronger than one year old and therefore creates great stress in the interaction with

the structure. Annual level ice thickness varies during the winter and spring, as well as from year to year. It depends on the temperature, waves, currents, etc.

The average ice loads for buildings taken from the table 6.31 the original data. The dimension of the load, $F_i = 50.0 \text{ MN}$.

3.6.6 Cranes

Most wind turbine assembly operations are performed with mobile cranes, which may be either of crawler type or truck-mounted. Crawler cranes are often the preferred choice, however, they have the drawback of needing quite wide tracks for travel between the turbine sites within a wind park. Of the cranes mentioned below, the LR 1400 needs a 9 m wide track and the LR 1800 needs 12,5 m. In order to avoid excessive costs for roads etc, the crane may be dismantled between use at the successive turbine sites in a wind farm, although such dismantling also involves a cost. Cranes in general have benefits of a short installation time per turbine and a relatively small crew. Disadvantages are the areas needed for the lifting operation, need for wide roads inside parks, rigging between turbine sites, wind restrictions (maximum 5 – 8 m/s during lifting) and the cost for mobilization and hire, especially of the largest units.

Approximate costs for mobilization and hire are depicted i. In the calculations of the report, the cost of 300 km of land transportation from Swedish port has been added.



Figure 3.7- Lifting of the 340 t hub section for Enercon E-126 7,5 MW wind turbine. The Terex Demag CC9800 crawler crane is formally rated 1600 t and in this configuration can lift 360 t

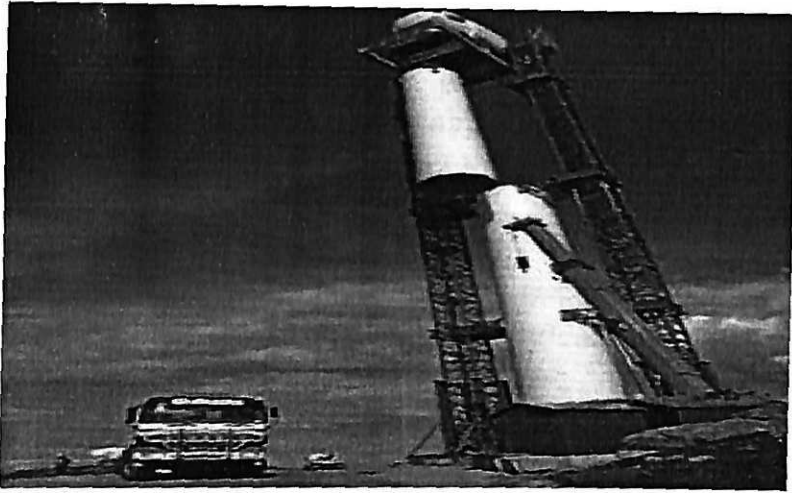


Figure 3.8- Lifting towers in use for assembly of Scanwind 3 MW wind turbine at Hundhammerfjell, Norway. Lifting operation performed by SarensTransrig AS. Note that the wind turbine tower is used for stabilizing the lifting towers and that a small mobile crane is used for assisting lifts

3.7 Calculation of the foundation base of the jacket, taking into account the physical and mechanical properties of soils Caspian shelf

Without exception, the construction of oil and gas industry are: on the natural ground surface, below the surface, i.e. deepened into the ground in mounds on mounds, arranged for the placement of any structures.

In all cases, the ground base is a medium carrier and the load bearing or impact on the structures as a whole or individual elements. And the belief that the construction work will be the expected period of exploitation may only be provided to ensure the strength and stability of the soil environment (or mass). How many would not have been strong structure and elements of oil and gas properties emergence of the so-called deformation of soils that are not included in the design and construction, may lead to the inevitable emergencies.

Facilities have on the ground vertical and horizontal actions, ie compacted soil or destroy or seek to move him. These external forces are transmitted to the ground through a special design called foundations various types, in turn, installations have reactive impact soil.

Considering the strong interaction between soil and structure, we note that both the ground and the contact surface of the soil-structure appear normal (compressive) and tangential (shear) stress. For soils main operating voltages are compressive, tensile stresses as soils, especially unrelated, do not hold. These are the ones you need to determine how to evaluate the stress state of the soil and the plant.

Soil Mechanics, as a scientific discipline can solve all the problems that inevitably arise in the design and construction of oil and gas industry.

Here are some basic laws of soil mechanics.

In soil mechanics have stringent computational models and methods for solving the elasticity and strength of materials, mathematics and physics, hydraulics and other scientific disciplines. But this also applies characteristics obtained

empirically so-called field or in laboratories special instrumentation. These characteristics, soil mechanics called physical or physic-mechanical, i.e. characterizing the properties of the soil, its ability to receive external forces to hold them for a long time, the variability of different properties in a short or long period of time, etc.

Physical and mechanical properties are divided into two groups: the characteristics determined by direct measurement using the devices in laboratory or field conditions, and the characteristics obtained by calculation using data from the first group.

The first group gives an idea of the physical properties of soils. The second group of models used in the calculation of soil mechanics as defining values or relationships that identify certain sections is estimated to soil mechanics.

A short list of the characteristics of the first and second groups:

- The first group (for soils in their natural state): bulk density, moisture content, compressive strength and shear coefficient of permeability, deformation modulus, adhesion, and particle size distribution;

- Second group: porosity, bulk density of dry soil skeleton and water-saturated soil densities and soil consistency, ductility indices, compression properties, etc.

Solve the main problem - ensuring a sustainable and long-term work on the building or in the ground can only be having the most reliable physical and mechanical characteristics of the soil and using the most appropriate model of the real conditions of soil structure interaction.

The objectives are to determine the soil mechanics of vertical displacements (pellet) and the stress state of the soil.

It should be noted that the determination of the stress state is even elastic bodies of homogeneous material on the decisions of the theory of elasticity is a very difficult task. Especially difficult is the determination of the stress state of the soil, the properties of which vary quite widely. Therefore, one of the most important problems in the theory of the stress state of soils is sketch a settlement of the strength and deformation properties of soils. They must be designed in such a way that can be used in soil characteristics Calculated models. In turn, the estimated model should be suitable for use in soil mechanics.

As a result of scientific work of outstanding scientists in the field of soil mechanics and the theory of elasticity established two approaches to the modeling of the stress state: the model linearly deformable medium model and the theory of maximum stress state of the soil.

The model line-deformed environment it is assumed that at any point of the material under stress do not occur inelastic deformation, ie does not appear the phenomenon of plasticity. With a single load is applied, as is the case for the structures erected on the ground, you can use Hooke's law.

Model Theory maximum stress ground condition implies that all points of the ground under the influence of internal or external forces arise plastic deformation, i.e. the soil is in the extreme tension. In this case the soil is sometimes referred to as "ground mass."

For this application the first condition of the ground (elasticity) of the model is unacceptable. By setting the scope of use of the first or second.

Models must be sufficiently reliable data on the state of the volume of soil or parts thereof.

Thus, the calculated stress state of the soil model can be applied only under certain conditions, namely: soil is either elastic body or plastic. In the first case arising voltage must be less than the limit, and the second - that's the limit. Such a condition in the soil may be only under certain conditions. The conditions for the design of structures shall be pre-installed.

For the calculation of the subsoil and in particular the determination of the contact stresses on the sole of the method of construction of the bedding coefficient. In this method, it is assumed that the soil (or other base) can be represented as a plurality of springs unrelated to each other, i.e. a compression of the springs concentrated force its neighboring springs do not react to compression. This shows the name of the coefficient "bed": spring mattress just combines as many unrelated elastic foundation springs.

Even without going into the details of the method, we can say that this idea of the ground is very conditional. However, the method gives quite good results. Its simplicity allowed to provide a method widely accepted in engineering practice. This method is available to most professionals involved in the design of structures such as oil pipelines, storage tanks for crude oil and petroleum products, the calculations of the strength of the ice fields in the development of oil and gas offshore the North Sea.

In this thesis project of the foundation calculation was carried out in an wind turbine PC Autodesk Inventor. We took into account the absolute position of the mark of the foundation and the physical and mechanical properties of soils Caspian shelf.

The pressure force on the soil was determined by summing the effect of static loads its own weight, and the payload with the influence on the value of the Archimedes force. The resulting load is distributed over the area of the base plate.

The buoyancy has been found by the formula:

$$F_A = \rho_v \times (V_{п.ч.} + V_{н.п.}) \quad (3.5)$$

$$F_A = 1025 \times (84,589 + 12800) = 13206704kg = 13206,704m$$

where ρ_v - the density of sea water;

VP.CH. - The total volume of all the rods of the support rod coluSmn, immersed in water;

VN.P. - Displacement of the bottom plate.

Load on the ground equal to:

$$P = \frac{P + P - F_A}{A_{н.п.}} = \frac{50851815 + 20387360 - 13206704}{80 \times 80} = 9068kg / m^2 = 9,068m / m^2 \quad (3.6)$$

where P - weight of the structure;

R_{pol} - Payload;

AN.P. - The area of the bottom plate.

So, when calculating the soil was specified load on the base plate which is equal to 9,068 tons/m².

Wind turbines work by converting the kinetic energy in the wind first into rotational kinetic energy in the turbine and then electrical energy that can be supplied, via the national grid, for any purpose around the UK. The energy available for conversion mainly depends on the wind speed and the swept area of the turbine. When planning a wind farm it is important to know the expected power and energy output of each wind turbine to be able to calculate its economic viability.

Problem statement

With the knowledge that it is of critical economic importance to know the power and therefore energy produced by different types of wind turbine in different conditions, in this exemplar we will calculate the rotational kinetic power produced in a wind turbine at its rated wind speed. This is the minimum wind speed at which a wind turbine produces its rated power.

Mathematical model

The following table shows the definition of various variables used in this model: Under constant acceleration, the kinetic energy of an object having mass m and velocity v is equal to the work done W in displacing that object from rest to a distance s under a force F , i.e.:

$$E = W = F \times s \quad (3.7)$$

According to Newton's Law, we have:

$$F = m \times a \quad (3.8)$$

Hence,

$$E = m \times a \times s \quad (3.9)$$

Using the third equation of motion:

$$v^2 = u^2 + 2 \times a \times s \quad (3.10)$$

we get:

$$a = \frac{v^2 - u^2}{2 \times s} \quad (3.11)$$

Since the initial velocity of the object is zero, i.e. $u=0$, we get:

$$a = \frac{v^2}{2s} \quad (3.12)$$

Substituting it in equation (1), we get that the kinetic energy of a mass in motions is:

$$E = \frac{1}{2} \times m \times v^2 \quad (3.13)$$

The power in the wind is given by the rate of change of energy:

$$P = \frac{dE}{dt} = \frac{1}{2} \times \frac{v^2 \times dm}{dt} \quad (3.14)$$

As mass flow rate is given by:

$$\frac{dm}{dt} = \rho \times A \times \frac{dx}{dt} \quad (3.15)$$

and the rate of change of distance is given by: $\frac{dx}{dt} = v$
we get:

$$\frac{dm}{dt} = \rho \times A \times v \quad (3.16)$$

Hence, from equation (3), the power can be defined as:

$$P = \frac{1}{2} \times \rho \times A \times v^3 \quad (3.17)$$

A German physicist Albert Betz concluded in 1919 that no wind turbine can convert more than 16/27 (59.3%) of the kinetic energy of the wind into mechanical energy turning a rotor. To this day, this is known as the Betz Limit or Betz' Law. The theoretical maximum power efficiency of any design of wind turbine is 0.59 (i.e. no more than 59% of the energy carried by the wind can be extracted by a wind turbine). This is called the "power coefficient" and is defined as:

$$C_{pmax}=0.59$$

Also, wind turbines cannot operate at this maximum limit. The C_p value is unique to each turbine type and is a function of wind speed that the turbine is operating in. Once we incorporate various engineering requirements of a wind turbine - strength and durability in particular - the real world limit is well below the Betz Limit with values of 0.35-0.45 common even in the best designed wind turbines. By the time we take into account the other factors in a complete wind turbine system - e.g. the gearbox, bearings, generator and so on - only 10-30% of the power of the wind is ever actually converted into usable electricity. Hence, the power coefficient needs to be factored in equation (4) and the extractable power from the wind is given by:

$$P_{avail} = \frac{1}{2} \times \rho \times A \times v^3 \times C_p \quad (3.18)$$

The swept area of the turbine can be calculated from the length of the turbine blades using the equation for the area of a circle:

$$A = \pi \times r^2 \quad (3.19)$$

where the radius is equal to the blade length as shown in the figure below:
We are given the following data:

$$\text{Blade length, } l = 52 \text{ m}$$

$$\text{Wind speed, } v = \frac{12 \text{ m}}{\text{s}}$$

$$\text{Air density, } \rho = 1.23 \frac{\text{kg}}{\text{m}^3}$$

$$\text{Power coefficient, } C_p = 0.4$$

Inserting the value for blade length as the radius of the swept area into equation (8) we have:

$$l = r = 52 \text{ m} \quad (3.20)$$

$$A = \pi \times r^2 = \pi \times 52^2 = 8495 \text{ m}^2 \quad (3.21)$$

We can then calculate the power converted from the wind into rotational energy in the turbine using equation (7):

$$P_{avail} = \frac{1}{2} \times \rho \times A \times v^3 \times C_p = \frac{1}{2} \times 1.23 \times 8495 \times 12^3 \times 0.4 = 3.6 \text{ MW} \quad (3.22)$$

This value is normally defined by the turbine designers but it is important to understand the relationship between all of these factors and to use this equation to calculate the power at wind speeds other than the rated wind speed. Having knowledge of how a turbine behaves in different wind speeds is critical to understand the income lost by any down time of the turbine. It is also useful to understand what power a turbine should be producing so that if there is a problem with the turbine this can be picked up on due to lower than estimated energy values. Predictions of how much energy will be produced by a turbine are important to the energy market, as energy is sold before it is actually produced. This means that accurate calculations of the energy are very important to balancing the energy in the market and to forecasting a company's income.

3.7.1 General Analysis

As final output data we can get wide range of resulting figures:

- Von Mises Stress;
- 1st Principal Stress;
- 3rd Principal Stress;
- Displacement;
- Safety Factor;
- Stress;
- Displacement;
- Strain;
- Contact Pressure;
- Modal Frequency.

Analyzing displacements we should conclude, if this level of construction displacement is acceptable for structure stability or we need to change the design of an island.

Comparing stresses with the yield point of structure's material, we should find out, if any destruction will occur. Also from the stress picture we can define the weakest areas of construction and take the actions to reinforce it.

Displacement values for all the examined calculations are insignificant which assures the stability of the islands under all types of ice conditions. This is quite obvious, because the island area, its own weight and material characteristics are sufficient enough to prevent big displacements.

Table 3.1 Physical parameters:

Weight	708631 kg
Area	3,92534E+009 mm ²
Volume	7,08631E+011 mm ³
The center of the mass	x=79359,6 mm y=79465,8 mm z=-39220,4 mm

Table 3.2 Design parameters of the base jacket:

		Steel
Material General	Mass density	7,85g/sm ³
	Yield point	207 MPa
	Ultimate tensile strength	345 MPa
	The Young's modulus	210 GPa
Tension	Poisson's ratio	0,3 br
	Shear Modulus	80,7692 GPa
	Expansion factor	0,000012 br/C
	Thermal stress	47 W/(m K)
	Specific heat	420 J/(kg C)

In general, all the stress pictures show the distribution of increasing stress towards the edges of construction. Analyzing the figures we can conclude, that the main body of the island can withstand all the forces without any destruction, whereas the corners of the structure are subjected to the stresses, which are higher than the yield point value for the given construction (see Figures 2.6; 2.7; 2.8;2.9). The decision on reinforcement of the edges with the iron sheets was made by designers.

Table 3.3 - Results of the stress-strain state

Name	Minimum	Maximum
1	2	3
Volume	7.08632E+011 mm ³	
weight	5562760 kg	
Mises stress	0,135837 MPa	136656 MPa
1st principal stress	-6594,46 MPa	147227 MPa
3rd principal stress	-149814 MPa	6339,7 MPa
Displacement	7989,13 mm	14194,7 mm
Assurancefactor	0,00151475 br	15 br
Strain XX	-85745,1 MPa	84145,2 MPa
Strain XY	-64480,4 MPa	63370,6 MPa
Strain XZ	-1492,49 MPa	2213,39 MPa
Strain YY	-84893,3 MPa	83534,4 MPa
Strain YZ	-1443,41 MPa	2300,63 MPa

Table 3.3 - continued

1	2	3
Strain ZZ	-6607,91 MPa	6355,27 MPa
X-axisoffset	-1583,48 mm	-947,518 mm
Y-axisoffset	-1509,55 mm	-937,441 mm
Z-axisoffset	-14026,6 mm	-7865,27 mm
equivalentDeformation	0,000000657115 br	0,586002 br
1-stmainDeformation	-0,0000647379 br	0,662781 br
3-rdmainDeformation	-0,674211 br	0,0000324466 br
Deformation XX	-0,277594 br	0,272277 br
Deformation XY	-0,399164 br	0,392294 br
Deformation XZ	-0,00923923 br	0,013702 br
Deformation YY	-0,272321 br	0,268497 br
Deformation YZ	-0,0089354 br	0,014242 br
Deformation ZZ	-0,209279 br	0,212303 br

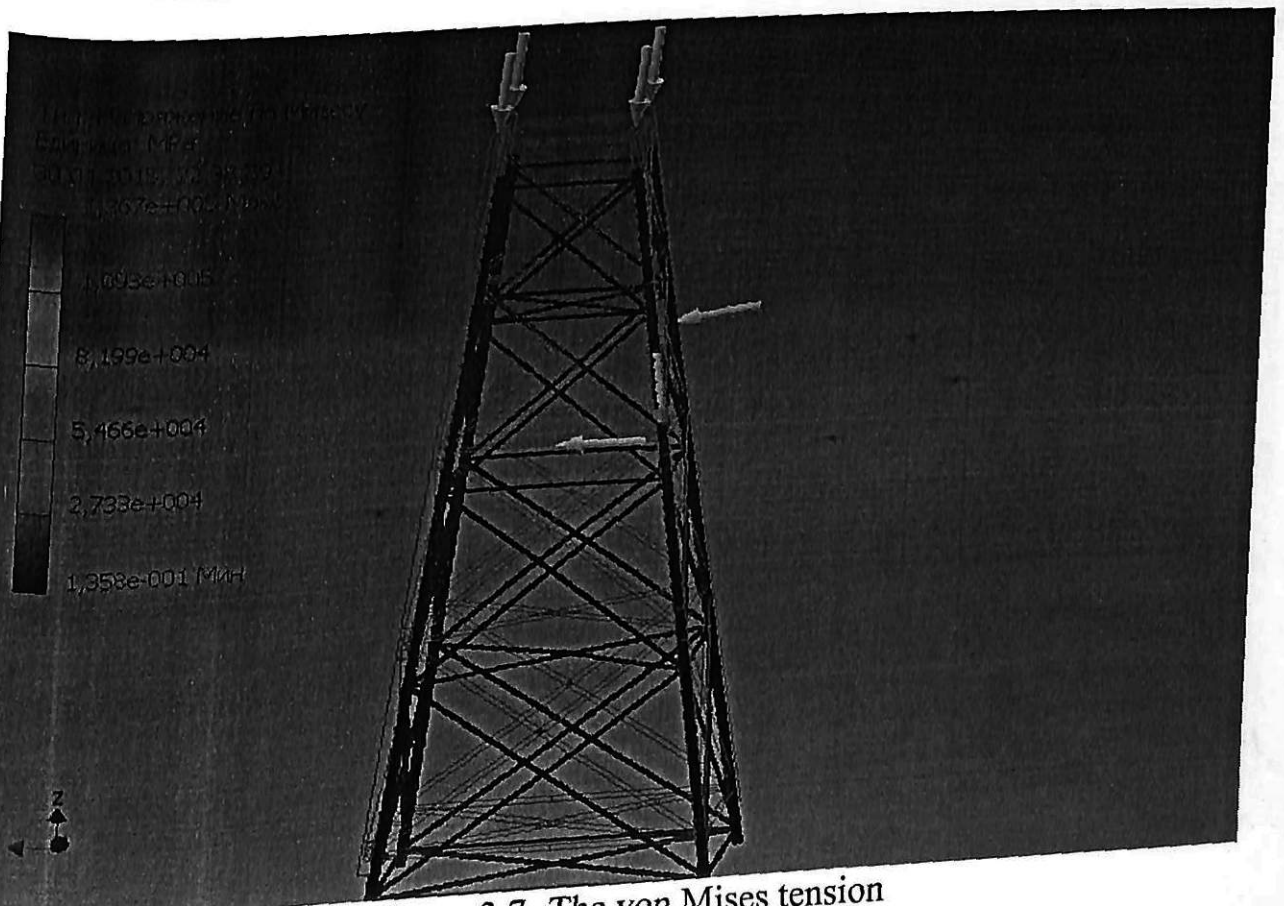


Figure 3.7- The von Mises tension



Figure 3.8- First principal stresses

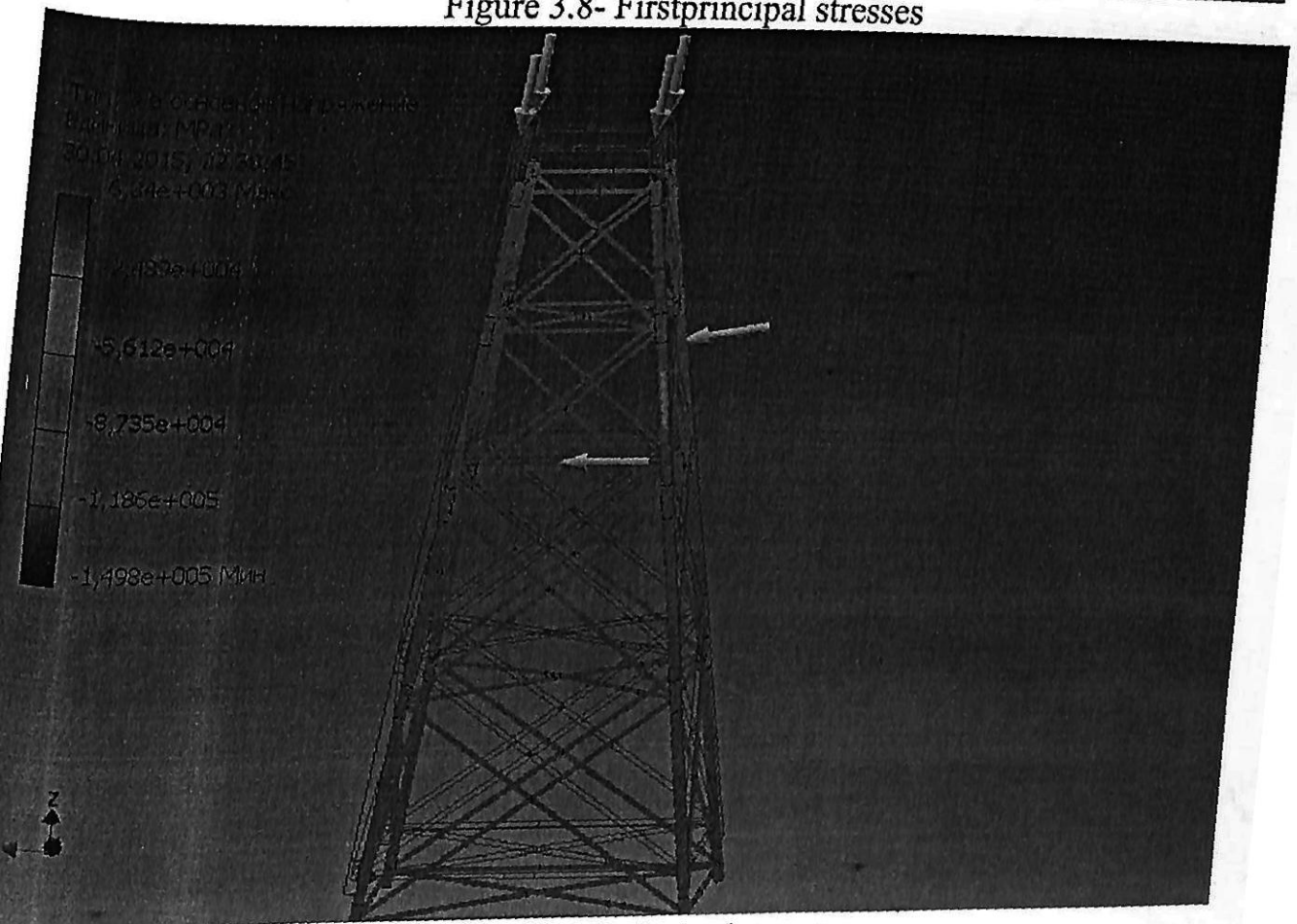


Figure 3.9- Third principal stresses



Figure 3.10- Displacement



Figure 3.11- Displacement in the X axis

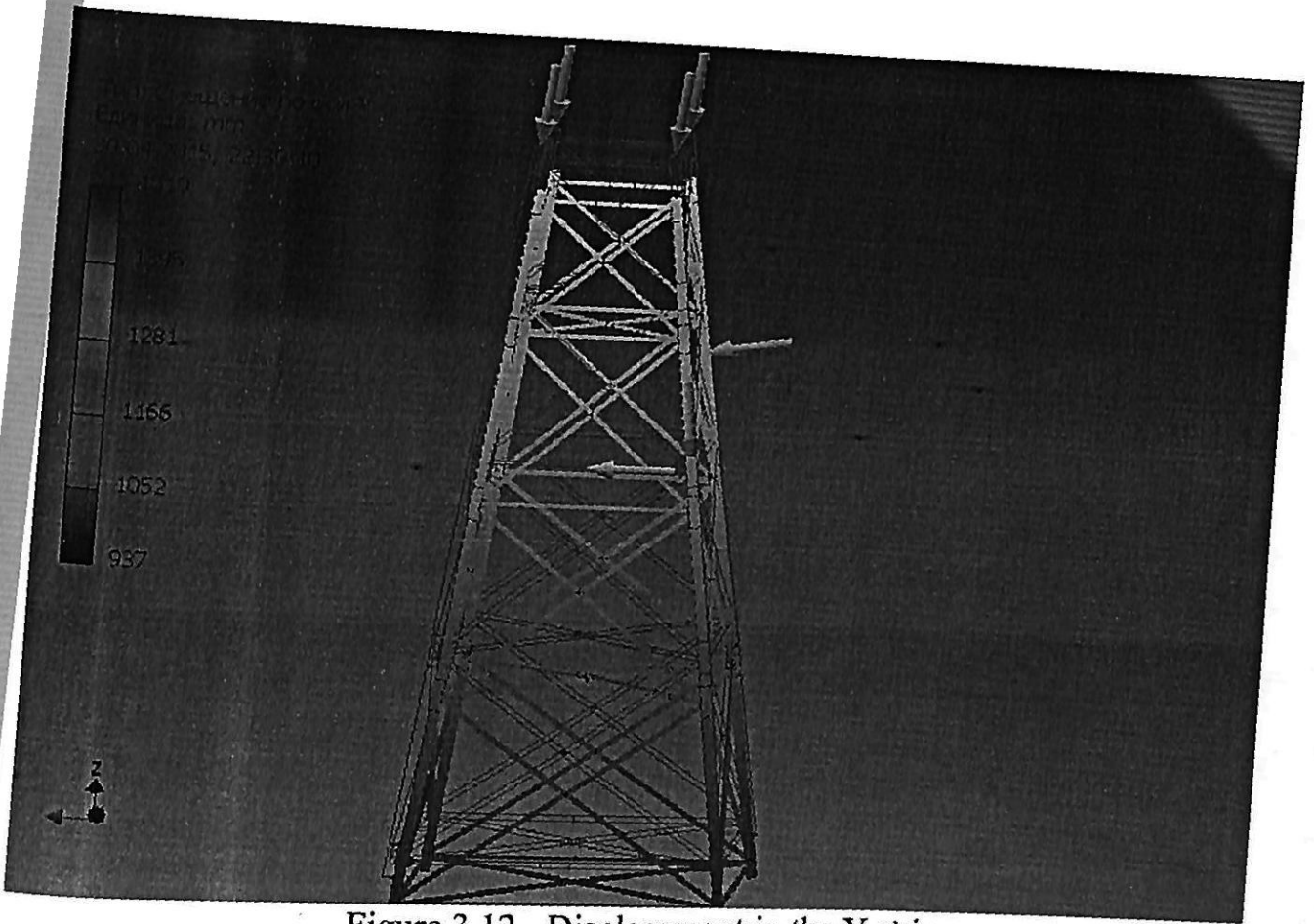


Figure 3.12 - Displacement in the Y axis

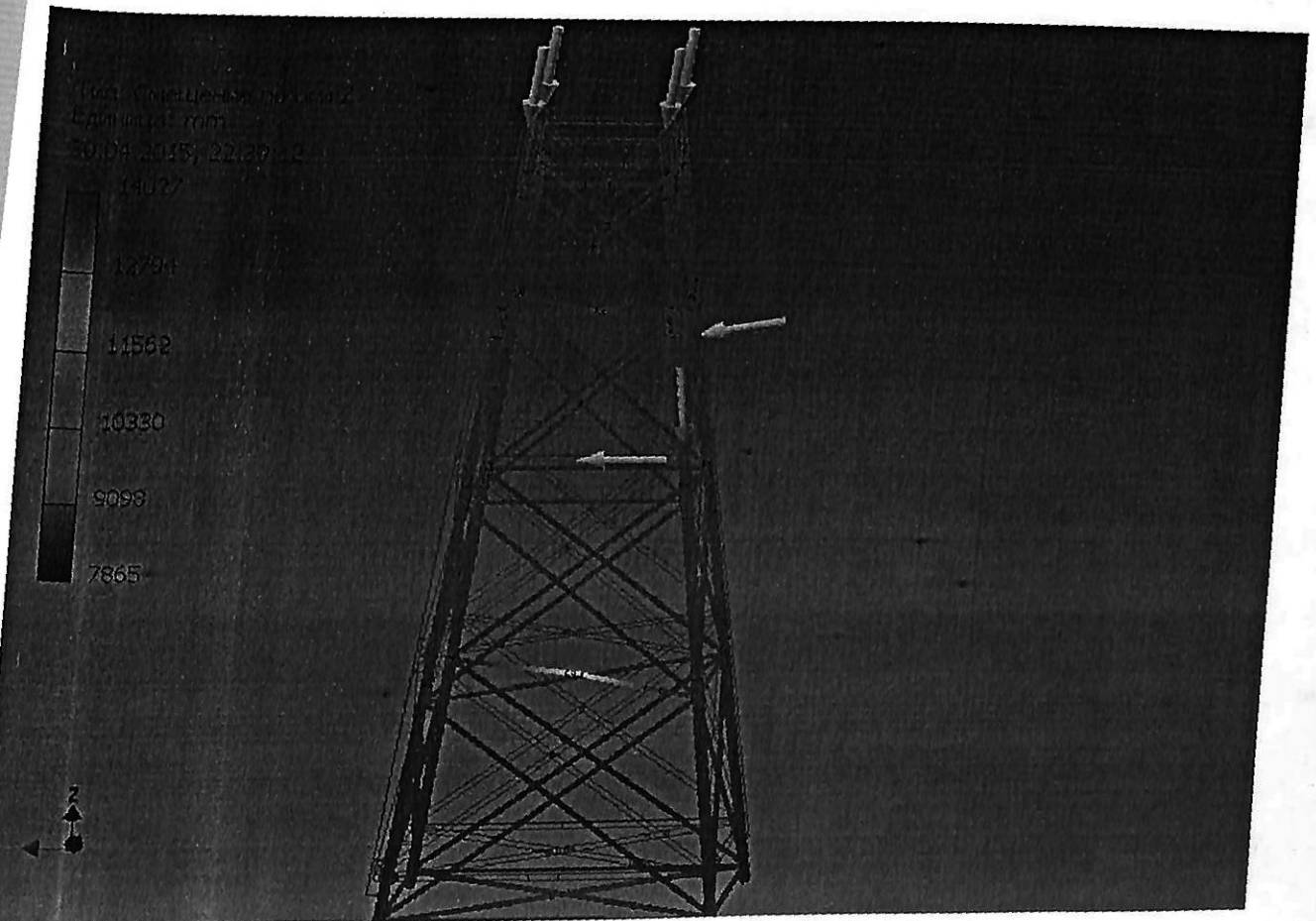


Figure 3.13- Displacement in the Z axis

4 ENVIRONMENTAL PROTECTION

The purpose of this section is to describe the environmental aspects of the development of fields in the Caspian Sea and to identify technical problems in order to reduce the impact of new projects on the environment.

Technical Regulations of environmental protection for construction offshore production facilities, related to petroleum operations

4.1 Basic requirements for environmental protection

1) When placing the drill sites must be ensured compliance with the requirements of environmental protection, restoration of the natural environment, rational use and reproduction of natural resources, environmental safety.

2) Accommodation drilling sites in protected areas and protection zones is allowed in cases stipulated by law, subject to the application pitiless drilling method.

3) The structure of environmental protection measures should include design solutions for:

- engineering reclamation (across the road);
- special engineering remediation (in areas with slopes hazardous natural processes);
- ground remediation (on sections of the route within the farmland in accordance with the requirements of the regulations);
- the protection of surface and groundwater from pollution;
- bioremediation (across the road, with the exception of sections of the route within the agricultural land);
- Eco-labeling (across the road - for the period of construction, for particularly important areas - the period of operation);
- environmental monitoring.

4) Engineering reclamation should be designed and implemented to perform basic types of construction works to prevent any dangerous natural processes outside of areas that existed prior to construction.

5) Special engineering reclamation should be designed and implemented so as to activate or occurrence of natural hazards have been eliminated or minimized in the range projected in the assessment of the impact on the environment and public health areas of disturbance.

6) Land reclamation should be designed and implemented so as to ensure the restoration of soil fertility of agricultural land, which existed prior to construction.

7) Biological reclamation should be designed and implemented so that reclaimed land had the self-healing properties after remediation.

8) Environmental labeling (environmental layout of the route) should be designed and implemented so that the implementation of construction work could be identified particularly important ecological sites: sites that require remediation of

various types. Marking critical environmental sites should provide for the design and construction period.

4.2 The Republic of Kazakhstan's Environmental Code

Article 264. Environmental requirements for the exploration and production of the sea

1) Drilling of wells should be based on proven principles and best practices of the international practice in the field of environmental protection in the oil operations.

2) Slots for offshore drilling platforms within the contract area are chosen based on the maximum possible preservation of marine areas that have long-term significance for fisheries, conservation and reproduction of fish and other water harvesting facilities.

3) Drilling operations with the drilling barge or platform under the ice cover in the area available for shipping, should be a constant presence icebreaking ship with the equipment necessary for the localization of a possible spill of hydrocarbons. Requirement referred to in this paragraph shall not apply to drilling, with the ongoing man-made islands.

4) Prohibited conduct in heavy ice conditions at sea drill-horizon pre-salt layer and the test wells with the alleged extreme pressure and high hydrogen sulphide content.

5) To ensure the sustainable existence of the ecosystem state conservation area in the northern part of the Caspian Sea in the design exploration and production in the sea as limited construction of drilling grounds, well testing and shipping.

6) In conducting petroleum operations subsoil user must provide measures for the prevention, control and spill response.

Changes IP «§» the Environmental Code

Article amended by paragraph 7, in accordance with the Law of RK of 03.12.11, № 505-IV

7) In carrying out the sea of oil extraction operations subsoil user is obliged to monitor the production process through observation and measurements at wellheads in the manner specified by the Government of the Republic of Kazakhstan.

4.3 The uniqueness of the Caspian Sea

The Caspian Sea is the world's largest inland reservoirs. That sea level salt content which is three times lower than in most of the seas, is the residue of a large ocean shoaled millions of years ago. Climate change brought influx of fresh water, and thereby contributed to the reduction of mineralization.

Isolated for millions of years, many residents of the Caspian Sea is not evolved. Some species are unique, for example, is the smallest seals - the Caspian seal, a rare sturgeon fish - beluga.

Apart from the fact that the Caspian Sea is home to non-migratory species, it is part of an extended Flyway between Siberia and Asia.

On the banks of the semi-desert surrounding the Caspian Sea, live and migrate along the ancient routes rare species of animals such as antelope (a rare species of antelope). Prey species include wolf and fox.



Figure 4.1 - The Caspian seal



Figure 4.2 – Sturgeon

4.4 Environmental problems of coastal pond

Negative impact on the ecology of the sea is provided by oil and gas industry (exploration, production, transportation, refining).

The greatest adverse environmental impacts in the North Caspian Sea associated with the development of the Kashagan oil and gas field, which has a high content of sulfur impurities, which often leads to gross violations⁴ of environmental requirements. In this case, derived from agricultural use large areas of land, also into the atmosphere thousands of tons of hazardous substances are released, including sulfur dioxide and hydrogen sulfide. After cleaning oil, sulfur stored in the open air, under certain climatic conditions, it can be transformed to many harmful chemicals and have a negative impact on the environment.

4.5 Environmental sensitivity

Special environmental sensitivity of the northern Caspian Sea is determined by several factors:

- Closure of the pool;
- Shallow water areas;
- Sharp fluctuations in water level;
- Rapid warming of the water column;
- High biological productivity;
- Endemism of species;
- Focusing on the local area almost all spawning sturgeon. All this leads to some limitations in the operations in the Caspian Sea.

In the most common species of regional sensitivity is defined as the coincidence of periods of high sensitivity of the life cycle of the biota (nesting, breeding, molting, migration), and the location of habitats of high sensitivity (spawning, nesting, breeding, molting, migratory routes). It is in these times and in

these places the main biological resources are limited in their movements and the most vulnerable to the physical effects.

4.6 Specifics of the impact on the environment of offshore oil and gas construction (OOGC)

Offshore oil and gas construction (OOGC) is a set of technical means and structures intended for hydrocarbon reserves of natural seabed. Offshore oil and gas construction feature is a great diversity of their component structures, vessels and floating equipment. For example, facilities for the exploration and development of offshore oil and gas field include: artificial island (AI), dams, culverts, drilling units (DU), drilling platforms (DP).

All structural components of offshore oil and gas construction have technological impact on the environment, including:

- The direct impact of different physical fields (mechanical, thermal, radiation, electromagnetic, etc.), or toxic chemicals (volatile aromatic oil, assistive technology solutions, etc.);
- Indirect effects through changes in the physical properties of the medium (turbidity and color of sea water, sea bottom topography, velocity field of water flows, etc.) or chemical properties of sea water (pH, dissolved gases, salt content, etc.);
- A disturbing influence on the representatives of the marine flora and fauna, which forces them to adapt or to migrate to other areas, etc.

OOGC impact on the environment leads to getting into the various pollutants, the greatest danger from crude oil and natural gas, which can enter the marine environment and drive atmosphere in large quantities, causing adverse changes in living and non-living components of the environment. For example, a ton of crude oil in contact with the sea surface can be spread in a continuous oil slick pollution area to 30 km.

Offshore oil and gas construction feature is a great diversity of their component structures, vessels and floating equipment. It should be noted that although the direct toxic effects of oil pollution of the marine environment on the biota of marine ecosystems and health in contact with the sea rights is relatively small, but the indirect influence of such changes in the physical and chemical properties of water, the sea bed and shoreline land may cause a significant adverse changes in the conditions living organisms.

Among the main causes of pollution in the environment include:

- Regulations' violations of production processes;
- Sea dumping of untreated or poorly treated drilling and municipal wastewater;
- Emergencies.

Among these reasons are the most dangerous for the environment are accidents:

- Accident on the operational drilling platforms (especially accompanied by the formation of fountains, fires and explosions);

- Oil spills during the transportation of produced (leading to contamination of vast marine and coastal stretches of continents)

4.7 Protection of the environment in the design and production stages

Based on the above material, and the available data on the ecology of the Caspian region to reduce the environmental impact to a minimum include the following areas of research:

- Contamination during drilling operations;
- Pollution of formation waters;
- Contamination of ballast water from storage and swimming funds;
- The choice of chemicals;
- Loading operations;
- Transportation of oil by ship;
- Possible oil spills;
- Treatment of waste;
- Emissions to the atmosphere.

4.7.1 Contamination during drilling operations

The drilling mud and cuttings are the largest portion of emissions during the development and operation of oil and gas fields. Because of low depth waters of the North Caspian Sea ice conditions and slow the rate of decomposition of organic material in the area the best solution would be to re-injection of drilling fluid into the formation. Re-injection of oily waste - a common practice in the North Sea.

4.7.2 Treatment of formation water

Produced water contains high concentrations of dissolved oil, inorganic salts, heavy metals and chemicals. The concentration of various substances in different fields varies. Conventional treatment for formation waters offshore oil removal means (40 mg/l) using separators, hydro cyclones or centrifuges, etc. This technique can not remove dissolved substances, so it is acceptable only if water draining with its subsequent significant dilution.

When working in the fields of the Caspian Sea produced water must be pumped into the ground. This requires a back-up pressure system. This technology is widely used on land and offshore, as well as in new fields' Norwegian continental shelf.

4.7.3 Ballast water of tanks and tankers

It should minimize the discharge of ballast water tanks and tankers. Based on experience in the North Sea oil concentration in such water is usually less than 5 mg/l. As little as possible to use the water in the ballast tanks, otherwise you have to install special cleaning systems.

There should be no discharge of ballast water from ships. The solution to this problem is to use permanent ballast.

4.7.4 Selection of chemicals

Chemicals must be not only highly efficient but environmentally (low toxicity, rapid neutralization of the environment). Data on such chemical agents should be used in planning for the environment.

4.7.5 Loading operations

The designs of the loading equipment have to ensure reliability and environmental friendliness during loading operations without any oil leaks and spills.

4.7.6 Tanker transport

Particularly threatening to leak oil tankers are transporting. It is necessary to conduct a risk analysis of such work to make improvements in design and technology use tankers. Only double-hull tankers can be used with the.

4.7.7 The probability of oil spills

An important task in the development of the Caspian Sea - reducing to a minimum the likelihood of oil spills. The Northern Caspian conventional mechanical methods of eliminating impurities can be effective in the summer / fall of the ice-free period. At other times, the collection of oil will be extremely difficult because of the ice. Currently, research is underway to develop alternative methods. Proven methods - are mechanical methods, local burning, bio treatment, etc. However, an effective method has yet to be found. The project must follow such research and to support them, even though the main focus should be on reducing the likelihood of oil spills.

4.7.8 Waste

In the area of the Caspian Sea opportunities to eliminate / waste disposal are very limited. It is therefore necessary to reduce the waste to a minimum. For processing must install special equipment.

4.7.9 Emissions to air

Power equipment should be designed so as to minimize the emissions of CO₂, NO_x, SO_x and VOC (for loading equipment and tankers)

4.8 Emergency blowouts from a well on OOGS and fighting against them

The greatest danger to environment is constituted by massive blowouts (open spouting) oil, natural gas or condensate at accidents on OOGC. Thus open spouting is understood as the uncontrollable expiration of formation fluids from the well as a result of absence, collapse or a leakage of the corresponding locking equipment. By the form thrown-out fluid fountains are sectioned on gas, oil and water. Very often in the course of open spouting the mixture of fluids jumps out of wells. Then fountains can be classified by the form components of thrown-out mixtures: gas-oil, gas-water, water oil, etc. In such cases use more generalized term – gas, oil and water entry (GOWE). Such fountains are the most severe accident outgrowing often during a natural disaster, demanding for elimination of considerable material inputs and time. Spouting is often accompanied by ignition, long fires and the explosions having very serious consequences, sometimes with losses of human lives. For prevention of emissions of oil, gas or water fountains and sealing of hole annulus at cementation of upsetting columns, implementation of the return circulation and other operations in the course of drilling the special blowout preventer equipment – the preventer which is mounting in case of blowout on a seabed is used. It serves as a guarantee that at an emergency situation inevitably entailing the halt of the boring drilling and departure of ship, a mining hole will be left in the safe state.

Blowout preventer stack is a system of valves, consisting of a combination of universal and spot preventer type enclosed in a roll cage. Blowout preventer seal the wellhead during drilling without rotating the drill string, and in reciprocation. Spot preventers are designed for sealing of wells being drilled and prevent ejection. After closing the BOP rams move the drill string is either prohibited or limited by the distance between the bushes. Manifolds preventer installations allow to carry out well through the issue of discharge of liquid or gas through the two discharge lines (emergency and labor), circulation of the solution with an adjustable back pressure on the formation, injecting a solution into the well (in the shell side) or mud pump cementing unit.

Completely avoid situations where the reservoir pressure is greater than downhole, with the existing technology of drilling is impossible. For taking of the kicking well under control the method of the balanced formation pressure, being characterized in that during the process of eliminating manifestations maintained constant bottomhole pressure slightly above reservoir. As a result, prevented the formation fluid flow, and in the well does not create too much pressure. Complications of GOWE leading to unusual situations and the need for non-standard solutions, occur frequently. Therefore, you should always be prepared for the possibility of their occurrence and the implementation of response measures.

4.9 Elimination of oil spills procedure

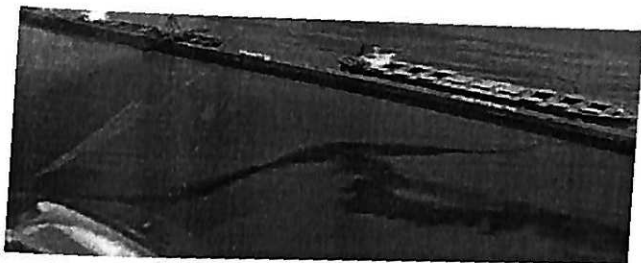


Figure 4.3 - Oil Spill

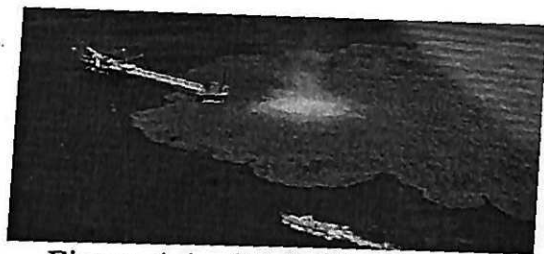


Figure 4.4 - Oil Spill volume of more than 500 tons

Strategy choice spill will depend on the economic and environmental resources that may be affected and the scale of the oil spill incident. In the decision making process considered all reasonable options for responding to oil spills.

When you select the following aspects are taken into account:

1) Localization and recovery of spilled oil - usually the preferred option that is practical only for small oil spills. There are a number of different kinds of devices to collect the spilled oil (skimmers) from the surface water use threshold, the vortex and of vacuum skimmers and skimmers, based on the principle of the sorption (brush, belt and drum) to remove oil from the water surface. After the spilled oil is collected, it must be pumped by pumps and hoses for temporary storage until proper disposal / destruction. As a result, an effective system of mechanical extraction of oil spilled requires proper equipment and trained staff, and an environment conducive for holding, collecting, pumping, pumping and storage of oil and oily waste. In the end, all the collected spilled oil must be properly disposed of in accordance with applicable requirements and regulations.

2) If the environmentally sensitive resources such as seabird populations, affects spilled oil on the sea surface, the most appropriate option is the use of oil dispersants, provided its location on the allowable depth. Dispersants are a group of chemicals that are sprayed or applied to oil slicks to accelerate the natural process of dispersion of oil in the water under the action of waves and currents. They do not remove oil from water, and are designed to "break up" oil, which forms a film on the surface of the water or the shoreline, through the translation of such oil in the emulsion phase, repeatedly accelerating, thus, the natural processes of decomposition of oil. Dispersants are served with spray nozzles, pumps and hoses and can be sprayed from a vessel or aircraft. Operations using dispersant is usually controlled by air (plane) in order to ensure efficiency and accuracy of spraying. Dispersants have a limited efficiency, requiring immediate, precise hit chemical on the spilled oil, and their application should be adjusted according to the type of oil, emulsification mechanism, salinity, weather and sea conditions. It is necessary prior approval of the technology with the elimination plan of oil spill.

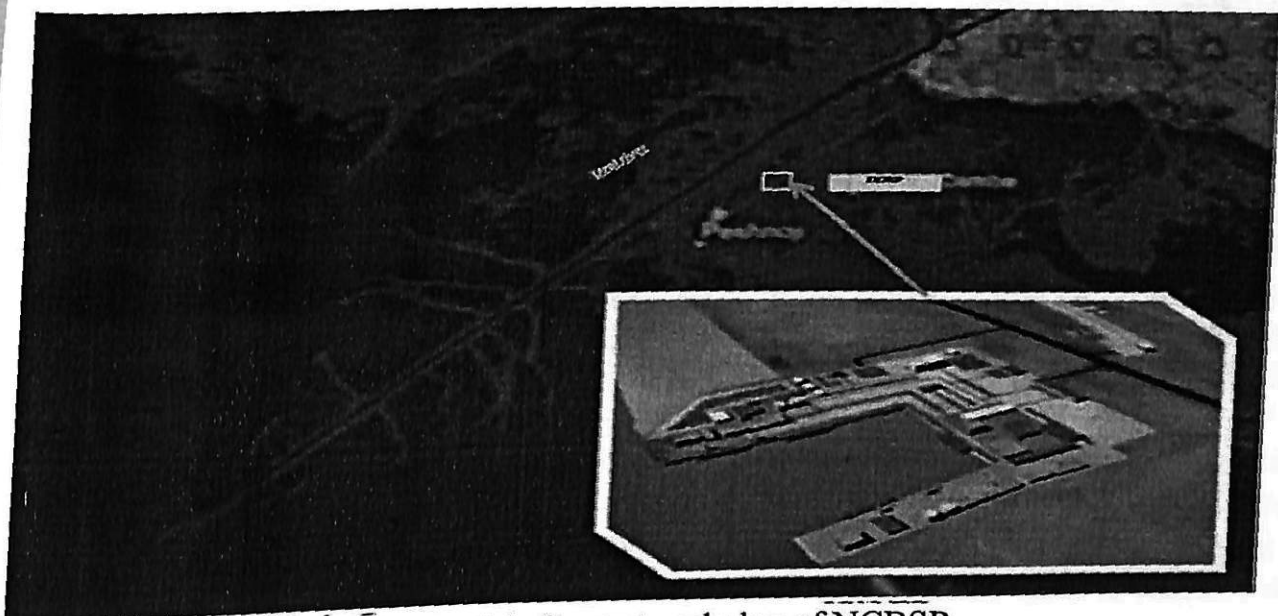
3) In other scenarios of oil spill the suitable variant of reacting there can be setting of boom barrages for especially sensible resources. At mechanical collection the poured out oil holds out through a boom barrage and gathers with the use of oil skimmer from the surface of water for temporal storage and subsequent utilization.

Boom barrages are opened out from courts or fastened to stationary building, or fastened ashore.

4) In-situ burning of spilled oil on the water surface, provides for controlled burning of oil floating on the surface of what is possible to a certain minimum thickness. Inflammation by releasing oil is oil, usually from a helicopter with gelatinous fuel or ignition device to release the vessel or the other point. In case of successful ignition of some or all the oil is burned from the surface of water or ice. However, some residual oil left after burning anyway. These residues can remain afloat or settle to the bottom, or have neutral buoyancy (depending on the type of oil spilled and the fire conditions.) Select your response to the oil spill should be based on the principles of analysis of the actual environmental benefits (AFEP) - identify possible responses with all the opportunities and constraints, and comparing the result with the overall benefits and risks of policies to eliminate spills.

4.10 North Caspian base of Spill Response

At present, the dam near the village of Atyrau region, a project of the North Caspian ecological base for oil spill response, which would protect the sensitive ecosystem of the North Caspian Sea.



Figures 4.1- Layout and plan of NCBSR

The main purpose is to store the response base, maintenance of equipment for oil spill response, ecological and meteorological monitoring, wildlife rehabilitation, education and training of technical personnel. The structure includes the following main NCBSR objects - berth mooring basin, storage capping, marine equipment, hangar for storage of air-cushion vehicles, the main warehouse storage equipment for liquidation of emergency oil spill products (OSR), the station of environmental and meteorological monitoring, rehabilitation center wildlife, utilities and facilities, gas station, helicopter pad needed for oil spill level 2 (they will also provide a measure of

the "first response" to the spill level 3), and the base and the Court to respond to the spill level 3.

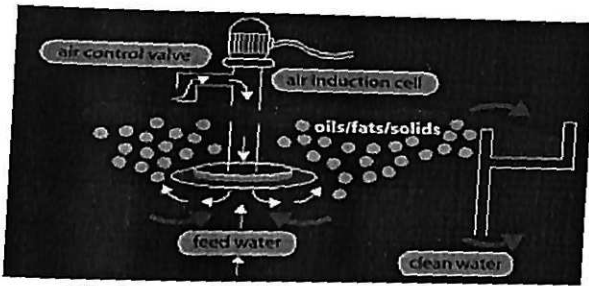


Figure 4.5 - Circular and cable

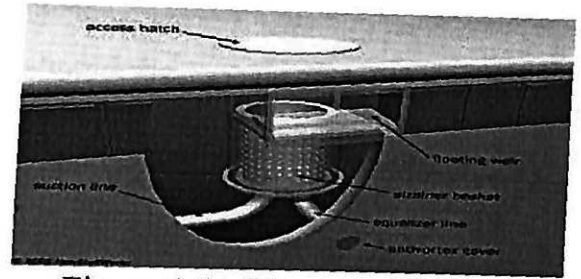


Figure 4.6 - Vacuum skimmers

Response Base is a nature reserve since its activities are aimed at ensuring environmental safety during offshore operations and the availability of response base is mandatory for operators of offshore oil fields. Therefore, the development of oil operations in 2 Zone Comprehensive Development Plan for the coastal strip of the Kazakhstan sector of the Caspian Sea (DPKCS)(on Kalamkas Sea, Zhemchujina structures, Tub-Karagan Kurmangazy, etc.) necessary to create databases quick reaction (QR) to emergency and oil spills of 2 level in the area.

Advisable to create a QR in Bautino Tupkaragan on the east coast of the bay. Due to the fact that the free areas on the coast of the Gulf of almost there, and to the base was conveniently located and well protected from the waves breakwater (separately for the construction of which would be expensive QR event), the possibility of combining with the current placement of the QR fueling ships.

Under the proposed arrangement QR estimated cost of its construction is the total area of the territory of 0.6 hectares and a length of 50 m quay wall is estimated at \$ 1.4 million on the QR should be created parking for specialized vessels in standby mode and has modular storage and office space. To ensure full preparedness for possible emergencies and oil spills level 2 in zones 1 and 3 DPKCS also recommended to create another new database to respond quickly to the Gulf Coast Sartas where there is free for posting area and where to artificial islands in the fields of the UPC Kashagan Aktoty and Kayran much shorter distances.

Construction of the rapid response to the coast near Kuryk is directly related to the success of the ongoing exploration and drilling operations in the oil and gas structure of the "H" in zone 3 DPKCS. In the case of an expected major commercial discovery was the beginning of the forced development of the oil field development operations, it is necessary to immediately start building providing these oil operations in the Gulf of QR Alexander Bekovich-Cherkassky.

5 LABOR PROTECTIONS AND SAFETY ENGINEERING

5.1 Occupational Health and Safety

Occupational health and safety issues should be considered as part of a comprehensive hazard or risk assessment, for example, a hazard identification study [HAZID], hazard and operability study [HAZOP], or other risk assessment studies. The results should be used for health and safety management planning, in the design of the facility and safe working systems, and in the preparation of safe working procedures. Health and safety management planning should demonstrate that a systematic and structured approach to managing offshore health and safety will be adopted and that controls are in place to reduce risks to as low as reasonably practical.

Offshore facilities should be designed to eliminate or reduce the potential for injury or risk of accident. In addition, the following issues should be considered in the design of offshore facilities:

- Environmental conditions at the offshore location (e.g. seismicity, extreme wind and wave events, currents, ice formations);
- Adequate living accommodation appropriate to outside environmental conditions;
- Temporary refuge or safe havens located in a protected area at the facility for use by personnel in the event of an emergency;
- A sufficient number of escape routes leading to designated personnel muster points, and escape from the facility;
- Handrails, toe boards, and non-slip surfaces on elevated platforms and walkways, stairways and ramps to prevent man overboard incidents;
- Crane and equipment laydown area positioning to avoid moving loads over critical areas and reducing the impacts from dropped objects. Alternatively, structural protection measures should be provided.

Occupational health and safety risk management should include hazard identification and communication, conducting work activities in a safe and skillful manner, appropriate staff training and maintaining equipment in a safe condition. Safety cases for offshore facilities should be developed where appropriate.

A formal Permit to Work (PTW) system should be developed for offshore facilities. The PTW will ensure that all potentially hazardous work is carried out safely and ensures effective authorization of designated work, effective communication of the work to be carried out including hazards involved, and safe isolation procedures to be followed before commencing work. A lockout / tagout procedure for equipment should be implemented to ensure all equipment is isolated from energy sources before servicing or removal.

Offshore facilities should be equipped, at a minimum, with specialized first aid providers (industrial pre-hospital care personnel) and the means to provide short-term remote patient care. Depending on the number of personnel present and complexity of the facility, provision of an on-site medical unit and doctor should be considered.

In specific cases, telemedicine facilities may be an alternative option.

An alarm system should be installed which can be heard throughout the offshore facility. Alarms for fire, gas leak and man overboard should be provided.

The formation of a health and safety committee for the facility is recommended. Health and safety inductions should be provided to the entire workforce prior to mobilization to the offshore facilities.

Occupational health and safety issues for further consideration in offshore oil and gas operations include:

- Fire and explosion prevention and control
- Air quality
- Hazardous materials
- Personnel transfer and vessels
- Well blowouts
- Ship collision
- Emergency preparedness and response

5.1.1 Fire and Explosion Prevention and Control

The most effective way of preventing fires and explosions in offshore facilities is by preventing the release of flammable material and gas, and the early detection and interruption of leaks. Potential ignition sources should be kept to a minimum and adequate separation distance between potential ignition sources and flammable materials should be in place. Offshore facilities should be classified into hazard areas, based on international standards, and in accordance with the likelihood of release of flammable gases and liquids.

Appropriate fire and explosion prevention and control measures for offshore facilities should include:

- Provision of passive fire protection on the facility to prevent the spread of fire in the event of an incident:
- Passive fire protection on load-bearing structures and fire-rated walls should be provided and fire-rated partitions should be provided between rooms
- Design of load-bearing structures should take into account explosion load, or blast-rated walls should be installed
- Design of items and structures against explosion and the need for blast walls should be based on an assessment of likely explosion characteristics
- Blast panel or explosion venting should be considered, and fire and explosion protection should specifically consider wellheads, safe areas, and living areas
- Accommodation areas should be protected by distance or by fire walls. The ventilation air intakes should prevent smoke from entering accommodation areas;
- All fire systems (for example, firewater pumps or control room) should be located in a safe area of the facility, protected from the fire by distance or by fire walls. If the system or item is located within a fire area, it should be passive fire protected or fail-safe;

- Explosive atmospheres in confined spaces should be avoided by making spaces inert;

- For unmanned facilities, occurrence of fire or explosion should be signaled to the remote control center to ensure that appropriate action is taken;

- A combination of automatic and manual fire alarm systems should be available on offshore facilities. Active fire protection systems should be installed on offshore facilities and should be strategically located to enable rapid and effective response. A combination of active fire suppression mechanisms can be used, depending on the type of fire and the fire impact assessment (for example, fixed foam system, fixed fire water system, CO₂ extinguishing system, and portable fire extinguishing equipment). The installation of halon-based fire systems is not considered current good practice and should be avoided. Firewater pumps should be available and designed to deliver water at an appropriate rate. Regular checks and maintenance of firefighting equipment is essential.

- Fire safety training and response should be provided as part of workforce health and safety induction / training, with advanced fire safety training provided to a designated firefighting team.

5.1.2 Air Quality

Due to the risk of gas releases at offshore oil and gas facilities caused by leaks or emergency events, adequate ventilation in closed or partially closed spaces is required. Air intakes should be installed to ventilate facility safe areas and areas that should be operable during emergency situations. If necessary, means to detect dangerous gas concentrations in the intakes, and automatic shut-down in the event of dangerous gas levels should be installed. A dangerous concentration of flammable gas can be considered to be a fraction (approximately 20 percent) of the Lower Explosive Limit of the substance.

The facilities should be equipped with a reliable system for gas detection that allows the source of release to be isolated and the inventory of gas that can be released to be reduced. Blowdown of pressure equipment should be initiated to reduce system pressure and consequently reduce the release flow rate. Gas detection devices should also be used to authorize entry and operations into enclosed spaces.

Wherever hydrogen sulfide (H₂S) gas may accumulate, monitors should be installed and set to activate warning signals whenever detected concentrations of H₂S exceed 7 milligrams per cubic meter (mg/m³). Personnel should also be provided with personal H₂S detectors and response training in the event of a leak. A self-contained breathing apparatus should be provided and the apparatus designed and conveniently located to enable personnel to safely interrupt tasks and reach a temporary refuge or safe haven.

5.1.3 Hazardous Materials

The design of the offshore facilities should reduce exposure of personnel to

chemical substances, fuels, and products containing hazardous substances. Use of substances and products classified as very toxic, carcinogenic, allergenic, mutagenic, teratogenic, or strongly corrosive should be identified and substituted by less hazardous alternatives, wherever possible. For each chemical used, a Material Safety Data Sheet (MSDS) should be available and readily accessible on the facility.

A procedure for the control and management of radioactive sources used offshore should be prepared along with a designated shielded container for storage when the source is not in use. The container should be locked in a secure store that is exclusively used for this purpose.

In locations where naturally occurring radioactive material (NORM) may precipitate as scale or sledges in process piping and production vessels, facilities and process equipment should be monitored for the presence of NORM at least every five years, or whenever equipment is to be taken out of service for maintenance. Where NORM is detected, a NORM management program should be developed so that appropriate handling procedures are followed. Procedures should determine the classification of the area where NORM is present and the level of supervision and control required. Facilities are considered impacted when surface levels are greater than 4.0 Bq/cm^2 for gamma/beta radiation and 0.4 Bq/cm^2 for alpha radiation.¹⁰ The operator should determine whether to leave the NORM in-situ, or clean and decontaminate by removal for disposal as described in Section 1.1 of this Guideline.

5.1.4 Personnel Transfer and Vessels

Personnel transfer to and from offshore facilities is typically by helicopter or boat. Specific safety procedures for helicopter and vessel transport of personnel are required and a safety briefing for passengers should be provided systematically along with safety equipment.

Helicopter decks (helideck) onboard offshore facilities should follow the requirements of the International Civil Aviation Organization (ICAO). Facilities for mooring boats during the transfer of personnel should consider adverse sea conditions to protect the boat and the facility structure from heavy impacts.

If personnel are transferred from the boat to the facility by crane, only cranes, cables, and baskets certified for personnel transfer should be used.

Support vessels should have the relevant permits and certifications to comply with the requirements of the International Maritime Organization. A Vessel Safety Management System should be implemented.

5.1.5 Well Blowouts

A blowout can be caused by the uncontrolled flow of reservoir fluids into the wellbore and will result in an uncontrolled release of hydrocarbons to the sea.

Blowout prevention measures should focus on maintaining wellbore pressure by effectively estimating formation fluid pressures and strength of subsurface formations. This can be achieved with techniques such as: proper pre-well planning,

drilling fluid logging; using sufficient hydrostatic head of weighted drilling fluid or completion fluid to balance the pressures in the wellbore; and installing a Blow Out Preventer (BOP) system that can be closed rapidly in the event of an uncontrolled influx of formation fluids and which allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained. The BOP should be operated hydraulically and triggered automatically, and tested at regular intervals. Facility personnel should conduct well control drills. Blow out contingency measures should be included in the facility's emergency response plan.

5.1.6 Ship Collision

To avoid accidental collisions with third party and support vessels, offshore facilities should be equipped with navigational aids that meet national and international requirements. Navigational aids include radar and lights on facility structures and, where appropriate, on support vessels. A 500 meter radius facility exclusion zone, at a minimum, should be implemented around permanent offshore facilities. The facility should monitor and communicate with vessels approaching the facility to reduce the risk of vessel collision.

The relevant maritime, port or shipping authority should be notified of all permanent offshore facilities as well as exclusion zones and routine shipping routes to be used by project related vessels. Permanent facility locations should be marked on nautical charts. The maritime authorities should be notified of the schedule and location of activities when there will be a significant increase in vessel movement, such as during facility installation, rig movements, and seismic surveys.

A subsea pipeline corridor safety zone (typically, 1,000 meters wide) should be established to define anchoring exclusion zones and provide protection for fishing gear. In shallower waters with high shipping activity, consideration should be given to burying the pipeline below the seabed.

5.1.7 Emergency Preparedness and Response

Offshore facilities should establish and maintain emergency preparedness to ensure incidents are responded to effectively and without delay. Potential worst case accidents should be identified by risk assessment and appropriate preparedness requirements designed. An emergency response team should be established for the offshore facility that is trained to respond to potential emergencies, rescue injured persons, and perform emergency actions. The team should coordinate actions with other agencies and organizations that may be involved in emergency response.

Personnel should be provided with adequate and sufficient equipment that is located appropriately for the evacuation of the facility. Lifeboats should be available in sufficient numbers for the entire workforce. These lifeboats should be enclosed fire-resistant crafts with trained lifeboat operators. Ice vehicles should be available for evacuation from facilities in frozen waters. Sufficient lifejackets, lifebuoys, and survival suits should also be provided.

Evacuation by helicopter should not be considered as the primary means of escape.

Exercises in emergency preparedness should be practiced at a frequency commensurate with the project risk. At a minimum, the following practice schedule should be implemented:

- Quarterly drills without equipment deployment;
- Evacuation drills and training for egress from the platform under different weather conditions and time of day;

- Annual mock drills with equipment deployment;

- Updating training, as needed, based on continuous evaluation.

An emergency response plan should be prepared that contains the following measures, at a minimum:

- A description of the response organization (structure, roles, responsibilities, and decision makers);

- Description of response procedures (details of response equipment and location, procedures, training requirements, duties, etc.);

- Descriptions and procedures for alarm and communications systems;

- Precautionary measures for securing the well(s);

- Relief well arrangements, including description of equipment, consumables, and support systems to be utilized;

- Description of on-site first aid supplies and available backup medical support;

- Description of other emergency facilities such as emergency fueling sites;

- Description of survival equipment and gear, alternate accommodation facilities, and emergency power sources;

- Procedures for man over board;

- Evacuation procedures;

- Emergency Medical Evacuation (MEDIVAC) procedures for injured or ill personnel;

- Policies defining measures for limiting or stopping events, and conditions for termination of action.

5.2 Community Health and Safety

Impacts to community health and safety from typical offshore oil and gas facility operations relate to potential interaction with other sea users, primarily ship operators and fishermen.

Activities such as offshore drilling and construction, pipeline installation, seismic operations, and decommissioning may result in temporary impacts to other users of the sea. Permanent installations and structures, including production and drilling facilities and sub-sea pipelines, have a potential long-term impact, at least until the end of the life of the field. Notification of the location of offshore facilities (including sub-sea hazards) and timing of offshore activities should be provided to local and regional maritime authorities, including fishery groups. The position of

fixed facilities and safety exclusion zones should be marked on nautical charts. Clear instructions regarding access limitations to exclusion zones should be communicated to other sea users. Sub-sea pipeline routes should be regularly monitored for the presence of pipeline spans and identified spans repaired.

In areas where significant impacts to fishermen are anticipated, a fisheries liaison officer should be appointed to provide a direct link with the fishing community. Arrangements for the management of potential community or amenity impacts resulting from shoreline impacts caused by oil, chemical, or fuel spills are to be included in the spill response plans.

5.2.1 Security

Unauthorized access to offshore facilities should be avoided by means of gates located in the stairs from the boat landings to the deck level. Means for detecting intrusion (for example, closed-circuit television) may be considered, allowing the control room to verify the conditions of the facility.

5.3 Personal Protective Equipment (PPE)

The planning and assessment of work activities will take account of any hazards and where practicable, the risk from these hazards will be eliminated or reduced. A residual risk may remain, but we can often reduce this further by wearing appropriate PPE. It is Subsea 7's policy to ensure that suitable PPE is available to everybody and always used in work activities.

Your full compliance with safe, well proven working procedures should prevent accidents and consequential injuries. PPE is the last personal line of defense, but may not protect you if you fail to behave safely.

Every person on a worksite must wear (unless in a designated safe zone):

- Hard-hat;
- Coveralls with high visibility reflective stripes or a high visibility tabard ;
- Safety boots/shoes;
- Safety glasses;
- Gloves (unless deemed unfit for task)

Additional Personal protecting equipment must be used when required and may include:

- Hearing protection;
- Fall protection harnesses;
- Respiratory protection equipment;
- Lifejackets (offshore applications including in harbor use);
- Burning goggles or clear goggles ;
- Gloves with specific hand protection (cut/thermal/chemical) ;
- Welding hood;
- Full faces shield

5.4 Occupational Health and Safety

5.4.1 Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV) occupational exposure guidelines and Biological Exposure Indices (BEIs) published by American Conference of Governmental Industrial Hygienists (ACGIH), the Pocket Guide to Chemical Hazards published by National Institute for Occupational Health and Safety (NIOSH), Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration (OSHA), Indicative Occupational Exposure Limit Values published by European Union member states,¹⁴ or other similar sources. Particular attention should be given to the occupational exposure guidelines for hydrogen sulfide (H₂S).

For guidelines on occupational exposure to Naturally Occurring Radioactive Material (NORM), readers should consult the average and maximum values published by the Canadian NORM Waste Management Committee, Health Canada, and the Australian Petroleum Production and Exploration Association or other internationally recognized sources.

5.4.2 Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive).

5.4.3 Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents.

6 ECONOMIC PART

One of the most important economic benefits of wind power is that it reduces the exposure of our economies to fuel price volatility. This benefit is so sizable that it could easily justify a larger share of wind energy in most European countries, even if wind were more expensive per kWh than other forms of power generation. This risk reduction from wind energy is presently not accounted for by standard methods for calculating the cost of energy, which have been used by public authorities for more than a century. Quite the contrary, current calculation methods blatantly favor the use of high-risk options for power generation. In a situation where the industrialized world is becoming ever more dependent on importing fuel from politically unstable areas at unpredictable and higher prices, this aspect merits immediate attention.

Oil companies conduct economic evaluation in order to determine to what they should concentrate their efforts and resources in the development and exploitation of natural hydrocarbons. Such estimates are always based on the principle of profit (income turnover of capital).

Investment decisions are among the most important decisions you have to make a company. This is due to the fact that the projects of investment in oil companies are usually very capital intensive. In addition, many of these investments are sunk. Therefore it is important, before making an investment decision, to analyze alternative investment projects.

As mentioned earlier, the main goal of many offshore oil and gas projects - achieving optimal economic performance. If the final stage of the design are set high enough economic performance, it is necessary to return to the initial stage of designing and adopt a modified version. Economics, not technology - the main limiting factor in the implementation of many projects.

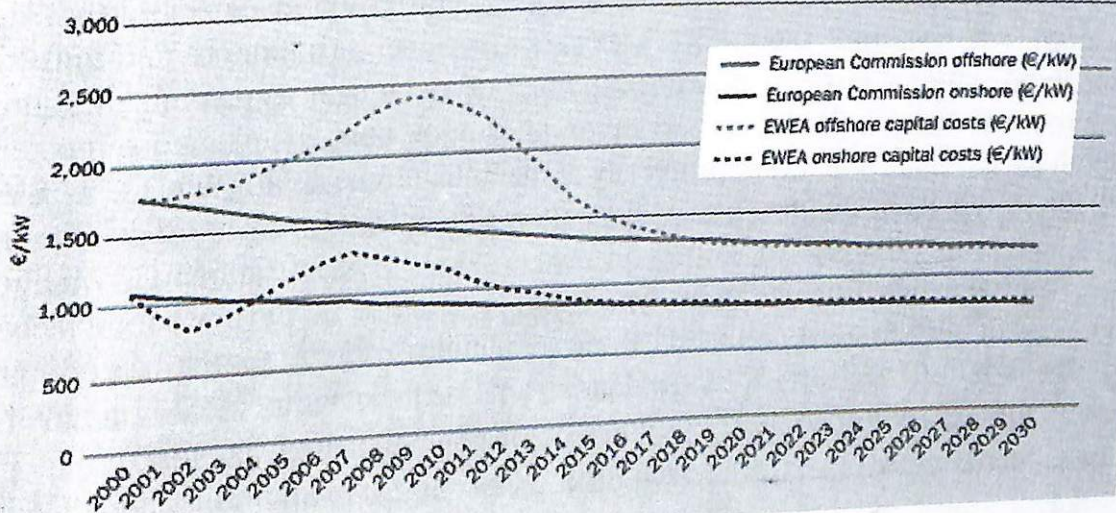


Figure 6

Basic cost of wind energy. Approximately 75% of the total cost of energy for a wind turbine is related to upfront costs such as the cost of the turbine, foundation,

electrical equipment, grid-connection and so on. Obviously, fluctuating fuel costs have no impact on power generation costs. Thus a wind turbine is capital-intensive compared to conventional fossil fuel fired technologies such as a natural gas power plant, where as much as 40-70% of costs are related to fuel and O&M. Table 0.1 gives the price structure of a typical 2 MW wind turbine.

Full cost of the project includes the costs of construction works, the cost of the purchase and installation of equipment and other costs:

$$C_{fc} = C_{de} + C_{rk} + C_m + C_l, \quad (6.1)$$

where C_{de} - the cost of the main and auxiliary equipment;

C_{rk} - spending for design license and jacking systems also include leg components, anchor winches, cranes, and certain components for the cantilever and spud cans;

C_m - spending, including the cost of products, structures, steel, engines, other necessary equipment and the materials needed for construction and installation work;

C_l - the spending for wages and salaries of workers to construction and installation works for buildings, platform and etc., spending for covering the costs of the construction organizations associated with the creation of the general conditions of production and its service organization and management:

6.1 Estimate calculation of the cost of manufacturing wind turbine jackets

Prices are determined by the demand for jacket construction services and the number of shipyards capable of supplying these services. Contractors demand new build jackets when day rates and utilization rates make investment criteria positive. But only a small number of shipyards around the world are capable of building jackets; and during periods of high demand, the supply of jacket construction services saturates the market, leading to backlogs and price increases.

During the contracting process, shipyard personnel estimate the costs of construction to develop a bid price. Jacket construction requires capital, labor, and materials, and a budget for each cost component is developed. Capital is recovered thorough a profit margin assessed on each jacket built; labor and material costs are estimated with an engineering-based approach and quotes from industry suppliers.

Capital. The capital costs of construction operation are minimal and consist of open land with access to a waterway, enclosed work spaces for welding and fabrication, several cranes, and a launching system. In Asia, launching is frequently conducted via dry-dock, while in the US, launching is performed via slipway or "walking."

Labor. Labor is required to fit, weld, and assemble steel components, and certify, inspect, and manage construction. Major work requirements during jacket-building include welding of steel components, assembly of piping systems, installation of equipment, outfitting, material-handling, engineering, and management.

Materials. Materials include steel, the jacket kit, engines and generators, and various other manufactured goods. Steel is used in jacket construction because of its strength, durability, corrosion resistance, weld ability, and price. The jacket kit includes the jacking systems, design license, and other components sold by the design firm. In the case of wind turbine jackets, kits typically include leg components, cranes, and capstans. Engines and generators provide the power and electricity to power a jacket. Other material includes outfit material, piping, electrical system components, pumps, and safety equipment.

6.1.1 Cost estimation and adjustment

Wind turbines under 100 kilowatts cost roughly \$3,000 to \$8,000 per kilowatt of capacity. A 10 kilowatt machine (the size needed to power a large home) might have an installed cost of \$50,000-\$80,000 (or more).

Wind turbines have significant economies of scale. Smaller farm or residential scale turbines cost less overall, but are more expensive per kilowatt of energy producing capacity. Oftentimes there are tax and other incentives that can dramatically reduce the cost of a wind project.

CAPEX cost breakdown for a wind turbine

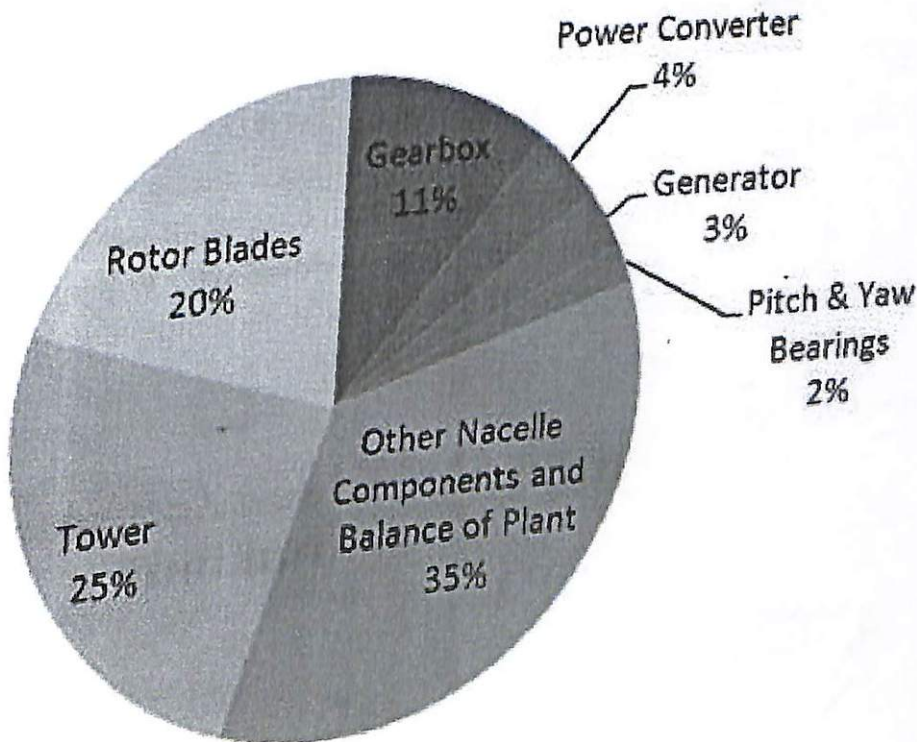


Figure 6.1.1

Commercial wind turbines. The costs for a utility scale wind turbine range from about \$1.3 million to \$2.2 million per MW of nameplate capacity installed. Most of the commercial-scale turbines installed today are 2 MW in size and cost roughly \$3-\$4 million installed.

Total costs for installing a commercial-scale wind turbine will vary significantly depending on the number of turbines ordered, cost of financing, when the turbine purchase agreement was executed, construction contracts, the location of the project, and other factors. Cost components for wind projects include things other than the turbines, such as wind resource assessment and site analysis expenses; construction expenses; permitting and interconnection studies; utility system upgrades, transformers, protection and metering equipment; insurance; operations, warranty, maintenance, and repair; legal and consultation fees. Other factors that will impact your project economics include taxes and incentives.

Table 6.1.1a - Jacket construction cost estimation modules

Module	Sub module	User input	Module assumptions	Adjustment factor
Labor		Capital cost	Productivity, hourly wages	Shipyard earnings index
Material	Steel	Lightship weight	Weight distribution, steel price	Steel mill products index
	Generators/engines	Installed power	Price per kw	Machinery and equipment index
	Other materials	Capital cost	Fixed percentage	All finished goods
Jacket kit			Fixed price	Ship and boat building index

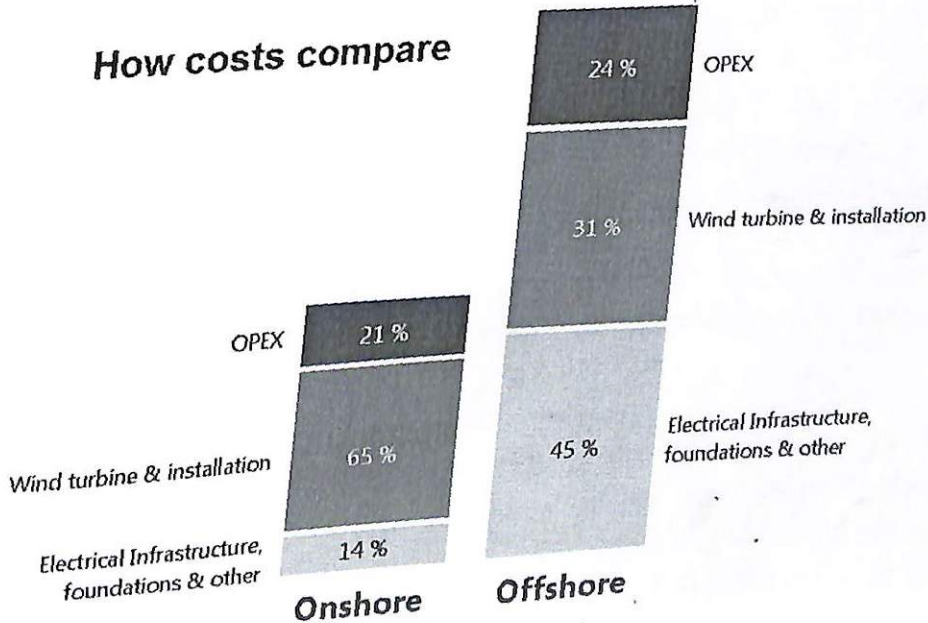


Figure 3.3 - Comparing

6.1.2 Labor cost module

Labor cost is determined as the product of the number of man-hours required and the average hourly wage. The number of hours required is estimated from the capital costs divided by the productivity. The labor cost relation is thus:

$$\text{Labor cost} = \text{Productivity} \times \text{Wage}$$

where capital costs are measured in dollars, productivity is measured in dollars of value produced per hour of labor (\$ output/hour labor), and wages are measured in dollars per hour (\$/hour). Capital cost is a user input. Wages and productivity are input on the basis of empirical data.

Table 6.1.2 - Cost of labor (OPEX)

Year	Number of employer	Staff salaries	\$/employee	Inflated \$/employee	Inflated \$/hour
2018	50	6.641.650	75.689	75.689	37,8
2024	15	1.000.710	66.714	70.263	35,1
2031	15	957.195	63.813	69.795	34,9
2036	15	899.295	59.953	68.398	34,2
Year	Rent	Light	Heat	Social projects	Total
2016	21000	7000	9000	15000	52000
2024	15000	1000	2000	50000	68000
2031	17000	1200	2500	55000	73700
2036	17000	1500	3000	60000	81500

Hourly wages in jacket building are expected to be similar to the shipbuilding industry because of the commonalities in the work requirements. In Table 6.1.2, the costs of labor at shipyards including fringe benefits are depicted in inflation-adjusted terms. The inflated dollars per hour (the last column of Table 6.1.2) is calculated under the assumption that all employees work an average of 2,000 hour/year.

The number of man-hours required to construct a wind turbine jacket depends on the jacket type, nation of build, preassembly status, and shipyard Steel weight or compensated gross tonnage has been used to represent the man-hours required to construct a ship; however, wind turbine jackets are structurally different from other ship types, and their compensated gross tonnage factors are not well defined.

6.1.3 Material prices

Building a jacket requires steel, labor, drilling, and other equipment. The manner in which cost is distributed across these categories determines the variation in construction cost by jacket class, complexity, and time. Shipyard location plays a key

role. Steel costs are highly variable over time, and when prices are high, the percentage values will tend to reside at the upper end of their ranges.

Steel is the main component of jackets, and material prices impact new build costs. On a proportional basis, wind turbine steel is usually a larger component of cost (10 to 20%) than in floaters (<10%). Steel prices are specified on a per ton basis and vary regionally with steel quality and shapes. Jackets are constructed using a variety of steel strengths, and no single steel price reflects costs for all jackets. However, the vast majority of jackets are built in Asia, and the Asian steel price index is a reasonable proxy for the jacket construction market. Both jacket prices and the steel index grew over the course of the decade at approximately the same rate, and are correlated. The steel price index explains 70% of the variation in average wind turbine jacket prices.

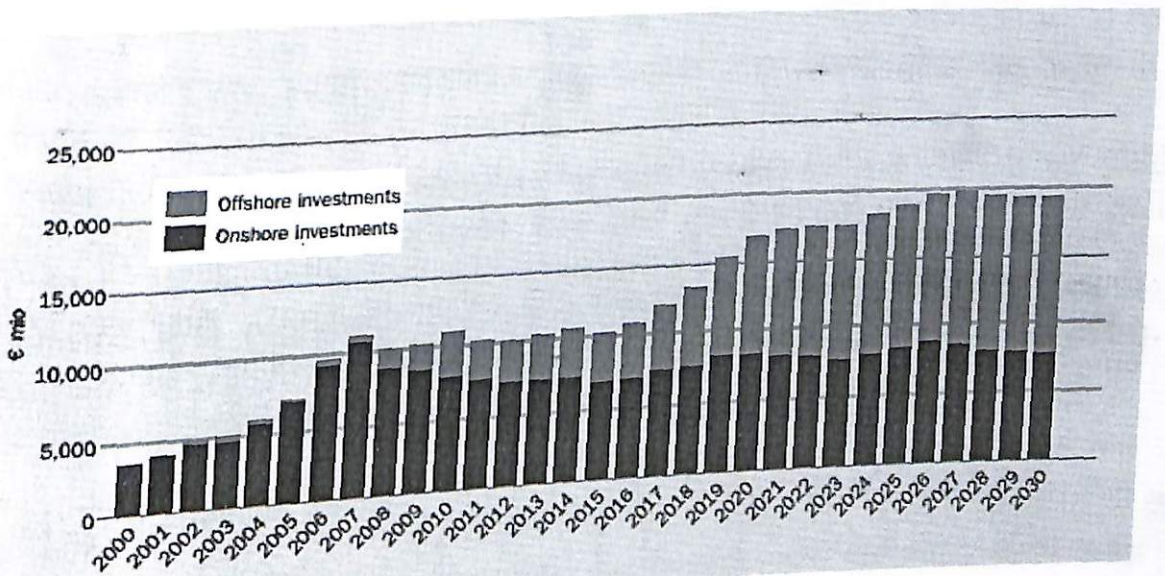


Figure 6.1.3

6.1.3.1 Steel submodule

The two grades of steel typically used in jacket construction include low-carbon steel for structural elements such as legs, decks, railings, walkways, and deck plating and high-strength, low-alloy steel for critical components and extreme conditions. Toured categorizes of steel components are considered: hull steel (typically 34-51 ksi), leg steel (typically 100 ksi), and miscellaneous steel (typically 72-90 ksi).

Steel costs are estimated separately for each component (x = hull, legs, miscellaneous) and summed. Costs are calculated as the weight of steel (in tons) multiplied by the price per ton. Each component is assumed to be a proportion of lightship displacement:

$$\text{Steel cost}_x = \text{Percent weight}_x \times \text{Steel price}_x \tag{6.1}$$

Lightship displacement is a user input. The proportion of lightship displacement attributable to the leg, hull, and miscellaneous steel is estimated from known weight distributions of a sample of jackets. Although the sample size is small and based on both generic and actual jackets, interval ranges are not expected to vary significantly across jackets. Approximately 20-30% of a jacket weight is made up of steel in the legs and spud cans, while 40-60% is made up of steel in the hull, jacking houses, and cantilevers.

Table 6.1.3.1 - Steel grade distribution for 300 ft wind turbine

Steel grade, ksi	Weight tons	Percent of total weight
34 to 51	130	30
72 to 90	152	35
100	154	35
Total steel weight	436	

Steel prices vary with changing market conditions and depend on yield strength, shape, and quantity ordered. Leg steel costs \$4,000-7,000/ton, hull steel costs \$700-1,100/ton, and miscellaneous steel costs \$1,000-1,500/ton. Hull steel costs are estimated with confidence because prices for shipbuilding steel are widely reported, although highly variable over time. Prices for leg steel are less certain because they are not widely tracked. Miscellaneous steel is a minor cost component.

6.1.3.2 Equipment prices

Engines, cranes, generators, drilling equipment, and dynamic positioning systems are significant components of jacket cost. These are all third-party materials purchased by the jacket builder and assembled onsite or at another location.

The steel price index was a poor predictor of floater costs while the equipment index explained 82% of the variation in prices, suggesting that equipment costs are a larger factor in overall prices than steel costs for floaters. The equipment and steel indices are themselves strongly correlated, and are likely to be influenced by many of the same global factors. However, their influence on jacket cost is largely independent, since each index impacts a separate shipyard budget category.

Table 6.1.3.2 - Cost of selected wind turbine

Equipment	Unit cost, \$ 1,000	Typical number	Total cost, \$ 1,000
Wind Turbine	14000	1	14000

6.1.4 Jacket kit module

Jacket kit costs depend on the jacket design and the scope of the kit and are purchased separately. All kits include a design license and jacking systems. Jacket

kits also include leg components, anchor winches, cranes, and certain components for the cantilever and spud cans, but the precise components are negotiable.

Table 6.1.4 - Jacket kit costs

Year	Kit cost, million \$	Number of kits	Jacket cost, million \$	Kit percent of cost	Inflated kit cost, million \$	Builder
2014	92	1			98	Petrobras
2008	40	1	180	22	47	Petro Vietnam
2007	60	1	175	33	66	Keppel AmFELS

6.1.5 Profit module

Profit margins are the proportion of revenue attributable to net income. The US wind turbine construction industry competes with international markets with lower labor costs and higher productivity; as a result, profit margins are expected to be low on a relative basis. Low profit margins do not adequately protect a firm from the risks of cost overruns, and this analysis assumes that profit margins below 5% are unsustainable. Profit margins above 10% are unlikely due to international competition.

6.1.6 Costs, profits

Capital costs. Application of the capital cost model requires the user to substitute the operational water depth, drilling depth, and environmental design into the capital expenditure regression model described previously to obtain \$164 million. Capital cost is the primary input in the labor, material, and profit modules.

Labor costs. Labor requirements are determined by the product of the capital cost and the inverse productivity metric. For hourly compensation of \$34-38/hour and productivity of \$90-100/hour, labor costs range from \$51 million to \$69 million.

6.1.6.1 Material costs

The water depth, length, and breadth of the jacket are substituted into an empirically derived weight relation:

$$D=49,316-3,233WD+0,563WD^2+0,12LB \quad (6.2)$$

yield 1100 tons. Table 3.7 partitions this mass among jacket components based on the assumed weight distribution described for leg steel (20-30%), hull steel (40-60%), and miscellaneous steel (5-10%).

Installed power is assumed to range from 3 Mw to 3.6 Mw and is multiplied by the unit cost (\$400-600/Kw) yielding generator costs of \$4-6 million. Other material costs are assumed to range from 20% to 25% of capital costs, or \$33-41 million.

Table 6.1.6.1 - Steel costs

Total weight, tons	Component	Proportion of lightship weight, %	Unit cost, \$/ton	Cost range, million \$
1100	Legs	20-30	4.000-7.000	0.8-1.4
	Hull	40-60	700-1.100	0.5-0.3
	Misc, steel	5-10	1.000-1.500	0.6-1.8
	Total			1.9-3.5

Jacket kits re assumed to cost \$25-45 million. Drilling equipment is assumed to cost \$20-50 million. Profits are assumed to be 5-10% of capital costs, or \$8-16 million. Capital costs. Application of the capital cost model requires the user to substitute the operational water depth, drilling depth, and environmental design into the capital expenditure regression model described previously to obtain \$164 million. Capital cost is the primary input in the labor, material, and profit modules. Low profit margins do not adequately protect a firm from the risks of cost overruns, and this analysis assumes that profit margins below 5% are unsustainable.

Labor costs. Labor requirements are determined by the product of the capital cost and the inverse productivity metric. For hourly compensation of 34-38 \$/hour and productivity of 90-100 \$/hour, labor costs range from \$51 million to \$69 million.

Table 6.1.6.1a - Budget effectiveness of the deposit as a whole

Year	Social tax	Tax on energy production	Rent tax	Export customs duty	Equipments	Property tax	Other taxes	Total
	\$	\$	\$	\$	\$	\$	\$	\$
				19181,56	10609,43	56,79	899,36	90834,94
2016	1439,86	19780,86	38867,08	19181,56	10843,43	46,65	913,76	92289,36
2018	1483,05	20176,48	39644,43	19181,56	11082,12	38,77	928,47	93775,79
2020	1527,55	20580,01	40437,31	19181,56	11325,58	32,59	943,51	95294,28
2022	1573,37	20991,61	41246,06	19181,56	11573,91	27,71	958,86	96845,04
2024	1620,57	21411,44	42070,98	19181,56	11827,20	23,82	994,97	100492,27
2026	1669,19	21839,67	44955,85	19181,56	12085,56	20,69	1011,39	102149,90
2028	1719,27	22276,47	45854,97	19181,56	12349,09	18,15	1028,14	103841,85
2030	1770,84	22722,00	46772,06	19181,56	12617,89	16,06	1045,23	105568,66
2032	1823,97	23176,44	47707,51	19181,56	12892,07	14,32	1084,80	109564,95
2034	1878,69	23639,96	50873,55	19181,56	13171,73	12,86	1103,05	111408,03
2036	1935,05	24112,76	51891,02	19181,56				

6.2 Cost distribution

Hub heights 125 - 175 m not possible with 4,5 m diameter limitation

Approximately one third of costs are associated with shipyard labor, and over half of costs are associated with materials, mostly in the drilling equipment package and jacket kit. The total expected costs range from \$14.5 million to \$23.7 million with an average of \$19.1 million.

Table 6.2 - Weight and cost of 3.6 MW wind turbine with welded steel shell tower

	Hub height, m
Tower	80
Diameter, top/base m	3,8/4,5
Plate thickness, min/max mm	52
Weight t	278
EigenfrequencyHz	0,35
Stiff/soft	Soft
Towertotal 1000 €	638
Transportation	
Blades, hub, nacelle 1000 €	90
Tower 1000 €	43
Transportationtotal 1000 €	133
Lifting	crane
Heaviestlift t	240
No crane hours (6 hours/lift) h	36
Liftingtotal 1000 €	81
Foundation	
Foundationweight t	2693
Foundation total (inclreinf., transp. moulds) 1000 €	296
Powercableintower 1000 €	66
WTG price (less 80m ordinary steel shell tower) 1000 €	4640
Windturbineinstalledtotal 1000 €	5855
Relativewindturbineinvestment*)	100%
Specific investment cost per MWh/year €	737
Relativeenergyproductioninvestment**)	105%

* Ref. 80 m tower

** Ref. 3.6 MW, 80 m welded steel shell tower

Estimated cost of wind turbine construction:

Material cost:

Steel costs: $130 \text{ tons} \times 5000\$ + 152 \text{ tons} \times 1000\$ + 154 \text{ tons} \times 1200\$$
 $650.000 + 152.000 + 184.800 = 986.800\$$

Engines costs: $3.6 \text{ Mw} \times 514\$/\text{Kw} = 1.850.400 \$$

Total cost of materials: $986.800 + 1.850.400 = 2.837.200\$$

Jacket kits cost: 1 unit cost 8.000.000 \$. Production Petro Vietnam.

Equipment cost: 14.000.000\$

Labor cost: in 100% productivity the total cost of labor is 2.641.650 \$

Total cost of construction of wind turbine:

$986.800 + 1.850.400 + 8.000.000 + 9.000.000 + 2.641.650 = 22.478.850\$$

6.3 Wind turbine market size

The price of wind energy depends very much on the institutional setting in which wind energy is delivered. This is a key element to include in any debate about the price or cost of wind energy, and it is essential in order to allow for a proper comparison of costs and prices with other forms of power generation.

Table 6.3- Net profit

Year	Annual delivery value Million \$	Net profit
2018	33	11.53
2026	37	45.8
2031	41	49.7
2036	43	51.3
Average	37,8	

Gross margin: $37.8/25.478=1.518$

Net profit margin: 2018 $11.53/43=0.268$

2026 $45.8/47=0.975$

2031 $49.7/51=0.974$

2036 $51.3/53=0.967$

The price of wind energy is different from the cost of wind energy described above. The price depends very much on the institutional setting in which wind energy is delivered. This is a key element to include in any debate about the price or cost of wind energy, and it is essential in order to allow for a proper comparison of costs and prices with other forms of power generation.

Wind power may be sold on long-term contracts with a contract term (duration) of 15-25 years, depending on the preferences of buyers and sellers. Generally speaking, wind turbine owners prefer long-term contracts, since this minimizes their investment risks, given that most of their costs are fixed costs, which are known at the time of the commissioning of the wind turbine.

CONCLUSION

In this thesis project designed offshore wind turbine with jacket structure by Autodesk Inventor 2014 and Autodesk Maya 2012.

In carrying out degree project:

- A review of the relevant literature in which studied meteorological characteristics of the Caspian region and the load acting on the offshore oil and gas facilities during their operation on the shelf, and the main requirement when choosing a rational type base turbines.

- Built dimensional solid model and calculation method selected and successfully implemented by means of calculation software package Autodesk Inventor Professional 2014.

- Creation of the methodological basis of the main version of choice of wind turbines, with enhanced functional responsibility

- Identify and justify the composition of the criteria design optimization wind turbine options, taking into account the technical, technological, industrial, environmental, economic and other aspects of the design, construction and operation of infrastructure facilities;

- Take into account the legal and regulatory requirements of the Republic of Kazakhstan;

- Choose the method of calculation and successfully implemented calculations using the software package Inventor 2014.

- A review of the economic part of the project for the construction of the wind turbine, tower, hug, jacket.

- Practical recommendations for planning health and safety of life and the environment.

- Applied Materials studied courses: "The Finite Element Method in Structural Mechanics", "Structural Mechanics", "Marine engineering structures and platforms", "Development of offshore structures", "Computer Design" , "Environmental management" and "Health and safety".

Based on the results of calculation of wind turbine for the oil and gas platform and jacket can be concluded that the conditions of strength and stiffness are fully implemented, therefore, you can begin to build the structure.

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