Секция 12
АРКТИКА И ЕЕ ОСВОЕНИЕ
(доклады на английском и немецком языках)

TYPES OF ARCTIC OFFSHORE PRODUCTION PLATFORMS

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There is current widespread and intensive interest in the Arctic, driven primarily by the discovery of significant oil and gas reserves and the recognition of the very large sedimentary deposits which hold the promise for even greater discoveries. The Arctic marine environment, especially the continental margins, has become a focal point for scientific and technological exploration.

The interest is centered in three areas: the Canadian Beaufort Sea, where Dome Petroleum and Gulf Canada have announced major discoveries; the Alaskan Beaufort Sea, where recent leases in the Diapir Basin of Harrison Bay sold for over two billion dollars; and a sub-Arctic offshore region of New-foundland, where Mobil Canada and its partners have announced the discovery of the world's second largest offshore oil field. Over the next few years, there are additional lease sales scheduled for the Bering and Chukchi Seas west of Alaska. Major gas discoveries have been made in the Arctic Islands, north of Canada, and geologically favorable conditions for offshore petroleum exist in Labrador and Davis Strait.

In the shallow water of the Beaufort Sea, many sand and gravel islands have been built, either by hauling the fill material out over ice roads in the winter and dumping it through holes cut in the ice, or by a combination of dredging and barge haul in the summer. Because of the scarcity of suitable materials, sand has been hauled by trailer suction hopper dredge up to 80 km and more. Early sand fill islands were characterized by very flat slopes, for example, 1:15, and loosely consolidated fills. More recent innovations in discharging through pipes at the sea floor, and separation of the sand and water, have resulted in slopes as steep as 1:5 and 1:6, with relative densities of 60 %.

Erosion of the slopes by waves and gouging by ice has required the installation of extensive armoring, usually in the form of filter cloth overlain by 2-cy and 4-cy sand-filled polyethylene bags. Slope protection still remains one of the most significant areas for improvement in technical adequacy, speed of deployment, and cost reduction.

In deeper water, Canmar has successfully carried out exploratory drilling operations from ice-strengthened drillships, operating during the summer season in the Canadian Beaufort Sea. The operating season has been extended through October by the use of icebreakers to break up the sea ice as it approaches the ship.

As an alternative to the very high costs associated with floating operations, Dome Petroleum built a caisson-retained island at Tarsiut, in 23 m (75 ft) of water. This island structure has been highly instrumented in order to develop the maxima amounts of data needed for future designs. Among the principal findings from the Tarsiut island has been the importance of providing proper freeboard and seawall wave deflectors to prevent over-topping and excessive spray during summer storms. In winter, massive rubble piles have built up around Tarsiut, grounding on the underwater embankment, yet still exerting high ice forces on the caissons.

In 1982, Dome Petroleum converted a very large crude carrier (VLCC) to a drilling platform, strengthening the sides by a 1-m-thick (3.3 ft) concrete composite wall, and the internals by heavy steel plates and shapes. The deck has been insulated. This vessel, the SSDC-1, was founded on an underwater sand embankment and has been given augmented protection against the sea ice by artificially constructed rubble piles, also grounded on the embankment.

There has also been some exploratory drilling carried out from the fast, relatively stationary ice between the Arctic islands. The ice platform has been built up by progressive flooding and freezing, and insulation has been provided to slow down its thawing.

The preceding constitutes the experience in actual platform construction and operation in the Arctic. However, several additional platform concepts are being constructed now. Esso Resources of Canada has built and delivered an octagonal steel caisson, consisting of eight individual segments, with articulated joints. This will be installed on prepared underwater embankment in summer of 1983, and filled with sand, so as to form a caisson-retained island similar in concept to Tarsiut. Also, in summer of 1984, Gulf Canada will receive delivery of a steel caisson vessel, designed to float to a site, then be seated on the sea floor by ballasting, and finally filled with dredged sand.

In 1983, Gulf received delivery of a floating caisson, circular in plan, designed to break ice downward. This caisson is moored by a heavy spread mooring to extend the drilling season until 2 m of sea ice arrive.

Sohio is undertaking the construction of a gravel island in 15 m (50 ft) of water in Harrison Bay. This appears to be about the depth limit for this type of construction.

Arco is currently constructing a waterflood facility to service their onshore fields near Prudhoe Bay. One key component of this system is the Salt Water Treatment Plant, currently under construction on a large steel barge in Korea. The entire plant and integrated barge will be towed to Prudhoe Bay, where it will be seated on an underwater embankment, accurately screeded to receive the barge hull.

In the design and planning stage are a number of existing concepts for exploratory platforms, most of them based on the use of prestressed lightweight concrete. These caissons are de-signed to be constructed on the Pacific Coast or possibly in Japan, towed across the North Pacific and Bering Sea to Point Barrow, and thence into the Beaufort Sea. They are designed for multiple use, generally relocating each summer, with drilling being carried out in the winter season. These structures are generally known by acronyms: among them are the Zapata BWACS, and Sohio SAMS, the Exxon-Shell-Chevron ACES, and the Global Marine CIDS. They are designed to support the exploratory drilling operations of one to three wells at each site. The ice loads will be transferred through the structure into the seafloor soils--occasioning some innovative geotechnical and structural designs, since global ice loads may reach as much as 150 000 kips (75 000 tons) on a typical exploratory structure.

Special interest and concern exist about the impact of large multiyear floes or, in the case of Eastern Canada, icebergs, against a fixed structure. Masses of ice are very large, and their velocity may reach 1 to 1.5 knots, hence developing very large kinetic energy. What is currently being studied in great detail is the impact phenomena and the dissipation of energy.

The ice feature has not only its own mass but its hydrodynamic mass moving with it. As it nears the structure, the sea floor usually becomes shallower, and the ice feature slows, transferring more momentum to the water.

As it nears the structure, water is trapped and its pressure rises, preloading the structure but further slowing the ice, with considerable dissipation of energy hydrodynamically. Lateral thrusts may develop.

On impact, the ice crushes, with its apparent strength constantly changing due to multi-axial stress conditions and the contact area.

The structure, with its associated hydrodynamic and soil mass, is accelerated. As strains build up in the soil in shear and bearing, the structure and the ice feature are brought to a stop. The elastic strain in the soil now forces the structure and ice back; however, there is a great deal of damping and plastic deformation so this part of the process is minimized.

This entire interaction takes place over a very short period, perhaps two to eight seconds, with peak forces typically being of extremely short duration. Because of this short duration, the response of the most heavily loaded structural elements may be enhanced, with higher apparent yield and lower permanent deformation.

Under continuous crushing or multiple impact from floes, a sufficient number of peak stress conditions may occur to raise the question of low-cycle/high-amplitude fatigue. Prestressed concrete has excellent behavior in this regard. For steel structures, especially those subject to flexure, such as a monopod, the S - N limitations may become important.

The extremely severe conditions for site work in the Arctic, the short summer season with its frequent storms, and the high logistical costs give great incentive to accomplishing maxima fabrication and hookup in the temperate areas, then towing to the site. Minimum site installation requirements are desirable, especially those involving the use of auxiliary equipment such as derrick barges. Hence the emphasis is on self-containment insofar as practicable.

It is well known that the ecology of the Arctic is extremely fragile. Considerable study has been given to the problems of marine mammals, fish, and wild fowl. Noise is believed to adversely affect the bowhead whale at close range; hence consideration is being given to shrouding propellers to reduce cavitation noise. Pile driving and drilling noises in the water may be reduced by compressed air curtains.

The Arctic requires a multidisciplinary approach, involving not only the man y engineering disciplines--structural, ice mechanics, coastal hydraulics, mechanical system, instrumentation, geotechnics, marine architectural, etc, but also interaction with the biological, sociological, economical, and political aspects of any development. Properly integrated, the Arctic can be a tremendous boon to mankind. This, as much as the extreme physical environment, is the challenge facing us today.

References

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