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Integrated Deck Structures for Arctic Islands

Structures de planchers préfabriqués pour des îles arctiques

Integrierte Arbeitsdecks für Offshore-Bauten in der Arktis

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SUMMARY
This paper presents the results of a feasibility study of placing one or more integrated decks (I-DECKS) on a man-made island for drilling and producing oil and gas in Arctic waters. Separate drilling decks and production decks are proposed. Each deck and its facilities would be prefabricated, skidded onto a barge, towed to the site, and skidded onto the island. Deck footings provide positive compensation for settlements. The paper concludes that the concept is feasible and promises significant cost savings when compared to conventional modular facilities.

RESUME
Cet article présente les résultats d'une étude de faisabilité pour des dalles intégrées (I-DECKS) sur des plates-formes de forage de production de pétrole et de gaz dans les eaux arctiques. On propose des dalles de forage et de production séparées. Chaque dalle est préfabriquée avec ces installations, chargée dans une barge et amenée sur le site. Ensuite de quoi, elle est hissée dans la structure de la plateforme. Un système de réglage permet de compenser les tassements. Cette étude conclut que ce système est faisable et permettra des économies significatives par rapport aux autres systèmes conventionnels.

ZUSAMMENFASSUNG
Der Beitrag präsentiert die Ergebnisse einer Durchführbarkeitsstudie über die Anordnung eines oder mehrerer Zwischendecks auf einer künstlichen Insel für die Förderung und Produktion von Oel und Gas in arktischen Gewässern. Getrennte Decks für die Förderung und die Produktion werden vorgeschlagen. Jedes Deck mit seinen Einrichtungen würde vorfabriziert, auf einen Schleppkahn geschoben, an Ort geschleppt und auf die Insel geschoben. Um Setzungen auszugleichen, sind spezielle Auflager vorgesehen. Der Beitrag schliesst mit der Feststellung, dass das Konzept durchführbar und gegenüber vergleichbaren konventionellen Bauten kostengünstiger ist.

1. INTRODUCTION

1.1 Integrated decks for offshore platforms

In the past 40 years the search for oil and gas resources has extended offshore on a worldwide basis, and as the price of oil and gas has increased, the search has extended into deeper and deeper water and into the hostile environment of the Arctic region.

In conventional construction, separate modules for various drilling and production facilities are prefabricated onshore and then transported to an offshore platform and set on a deck substructure by a marine derrick barge. The modules are then hooked up and operations begin. In the North Sea, for example, 8 to 20 modules must be placed and hooked up, requiring an average of one million man-hours and ten months, at a cost of millions of dollars. To reduce these costs a new integrated concept was developed called HIDECK [1], in which the entire deck is prefabricated in one piece and all facilities are installed on the deck while onshore. The completed structure is then carried offshore on a barge (see Fig. 1) and mated with the supporting platform with an estimated savings of 90-95% of the offshore hookup. HIDECK was used for the deck structure of the Maureen Platform for Phillips Petroleum Company in the U.K. sector of the North Sea, with installation completed in 1984. Other integrated decks have also been used in the North Sea.

1.2 Man-made islands in the Arctic

When oil and gas exploration moved to the ice-covered waters of the Beaufort Sea, engineers were forced to design fixed and floating structures for the tremendous forces exerted by moving ice, sometimes of the order of 500 MN or more on a single structure. As a result the structural solution for most Beaufort Sea sites to date has been to build an artificial island of sand or gravel, and use drilling rigs and other facilities adapted from land-based operations. Modules of a convenient size and weight are prefabricated in Canada or the Lower 48 United States and generally shipped by barge to the island to be placed on the island and hooked up. The same problems of hookup time and cost are encountered on the islands as on offshore platforms, with even greater unit costs because of the severe environment and remote location. Therefore, the same economies as offshore would be achieved by integrating island facilities into a single unit, or several units, if they could be prefabricated, delivered, and installed successfully. This paper presents the results of a study of this specific topic by the Brown & Root Marine Engineering Division.

2. INTEGRATED DECKS FOR DRILLING AND PRODUCTION ON MAN-MADE ISLANDS (I-DECKS)

2.1 Requirements

In order to provide a realistic basis for this study, the assumption wasmade of a facility capable of producing up to 150,000 barrels of oil per day along with some natural gas.

2.2 Facilities design

The required drilling and production complex was studied in two configurations, one for a land-type operation with multiple modules on the island surface, and the other for four large structures in which the facilities could be grouped. Two such structures are devoted to production drilling and supporting facilities (Fig. 2), the others are devoted to production facilities for separation and processing (Fig. 3). For a variety of reasons, both the drilling and the production structure, during several design cycles, evolved into rather narrow, elongated structures with two main levels. The lower level would be completely enclosed while the upper level would support operations which could be individually enclosed as required. Certain items, such as personnel quarters, would be placed on the island separately. A comparison of the surface area of the islands, modular units vs. I-DECK, revealed that the I-DECK layout used only 46% of the area required by the modular units.

2.3 Structural design

The primary structural elements in both structures are full-depth trusses whose chords are part of the floor framing for the decks. On the drilling I-DECK (Fig. 2), longitudinal trusses lie along grid lines A and B, with transverse trusses on grid lines 3 and 7. Three major support points lie along line 3 and three more on line 7. The longitudinal trusses have a central span of 88 m and a cantilever at each end of 27 m, a condition which tends to equalize positive and negative bending moments in the trusses. On the production I-DECK (Fig. 3), longitudinal trusses lie along grid lines A, B, C, and D, with transverse trusses on line 2 and 5. Five major support points lie along each of lines 2 and 5. The longitudinal trusses have a central span of 85 m with a cantilever at each end of 30.5 m. In addition to supporting the live and dead loads for the in-place conditions described above, the structures were also designed to resist the loads that occur during construction, loading onto a barge, transportation on a barge, off-loading onto the island, and jacking to the proper elevation.

2.4 Fabrication

Large trusses such as these are normally fabricated flat on the ground and then rolled up into place for interconnection. Large items of equipment could be placed in each structure as it is built, if desired, or slipped into place later through the large openings in the main trusses before the exterior skin is attached. Fabrication would be performed at a site adjacent to water so that the completed structure could be loaded onto an ocean-going barge.

2.5 Transportation

The drilling I-DECK is estimated to require 3,900 tonnes of structural steel, to have a transport weight of 5,500 tonnes, and to have a total operating weight, in place, of 15,000 tonnes. Comparable figures for the production I-DECK are 4,100 tonnes of structural steel, transport weight of 8,200 tonnes, and an in-place, wet, operating weight of 14,000 tonnes. Using normal fabrication yard procedures, one structure could be skidded longitudinally aboard a barge, and the barge could be towed from the fabrication yard to the island. Computer analysis of transportation accelerations and stresses for a tow from either the West Coast of the United States or from the Far East indicated that the barge and the I-DECK would behave satisfactorily. For this study a barge was chosen with a length of 177 m, a breadth of 49 m, and a lightship displacement of 17,200 tonnes. Barge draft for the production I-DECK would be 3.7 m.

2.6 Installation

Fig. 4 shows the sequence of island construction operations in a schematic manner. The great structural strength of the deep longitudinal trusses is utilized not only in the in-place condition but also during installation. Because of the shallow slope of gravel islands (see Fig. 5), the bow of the barge must stand off a certain distance (estimated as 23 m) from the near edge of the skidways on the island. The I-DECK trusses have more than adequate strength and stiffness to cantilever off the bow of the barge until they touch down on the skidways. Skidding proceeds until the structure is in its final position with major support points directly over the permanent foundations (Fig. 6). A jacking mechanism is provided at each major support point to jack the structure to its final elevation.

The elevated position of the deck has several advantages (1) additional freeboard above the level of the sea and ice, (2) open space beneath the structure which allows the wind to sweep the snow away, and (3) ability to load consumables through a hatch in the lower deck from a vehicle below.

2.7 Foundation design

Most gravel islands to date have been intended only for exploratory drilling and have been classified as "temporary", with a short design life and no need for permanent foundations. For a production island, however, a longer useful life requires the provision of permanent foundations. Since settlements in man-made Arctic islands can be very large, these must be accommodated in some manner. Some of the basic characteristics of the I-DECK make it ideally adaptable to these difficult foundation conditions: (1) the long span between major supports makes it possible for the drilling I-DECKS' foundations to move away from the areas of greatest settlement due to thaw of the permafrost around the wellbore, and (2) the small number of support points and the provision of a separate jacking device at each of these makes it possible to relevel each of the support points as often as necessary to accommodate foundation settlement.

Spread footings are proposed for the permanent foundations. Two strip footings would suffice for supporting one I-DECK. Since each support can be jacked indefinitely, settlement is not a problem, and therefore the most important limitation for allowable bearing pressure on cohesionless soils is completely bypassed, and we observe that the unit bearing capacity of the footing goes up in direct proportion to footing width. Hence for any reasonable footing size such as we would have, there would be a large factor of safety. Also, with spread footings, we have avoided the problems of driving and maintaining piles in fill material and in frozen ground, with associated downdrag and uplift at various times. Finally, if we wish to make one further provision for the worst imaginable circumstances of surface settlement and tilting in the fill supporting the footings, each separate support point in a row of supports could be provided with a separate spread footing. This would allow the load to be taken completely off one footing, if it should, for example, tilt too much, with the transverse truss redistributing the load along that line of footings while the tilted footing itself is reset and releveled. The transverse truss and individual footings would have to be designed for this possibility of course. It should be noted that the footings and skidways could be prefabricated, possibly of steel, and transported to the island, to be installed during the island construction.

3. CONCLUSIONS

The complete scenario for the design, fabrication, transportation, and installation of an integrated deck (I-DECK) on a man-made Arctic island has been studied and has been determined to be feasible. A number of advantages of an integrated deck over the conventional practice of using a large number of small modules have been identified and include the following items:

- hookup man-hours, time, and cost can be tremendously reduced
- island size can be reduced
- number of sealifts can be reduced, thus improving the probability of finding a satisfactory summer "weather window" for installation
- the number and length of utilidors connecting various facilities can be reduced
- the small number of support points and the provision of a separate jacking device at each of these makes it possible to relevel each of the support points as often as necessary
- if we choose, we can provide a separate spread footing at each support point, thereby making possible the resetting and releveling of individual footings, one at a time, in the event of extreme settlement or tilting
- an integrated deck would make possible an easy removal of facilities after the field is depleted.

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REFERENCES

1. ABBOTT P.A., FARMER L.E., BLIGHT G.J., OSBORNE-MOSS D., A New Integrated Deck Concept, Offshore Technology Conference Paper No. 3879, May 1980.

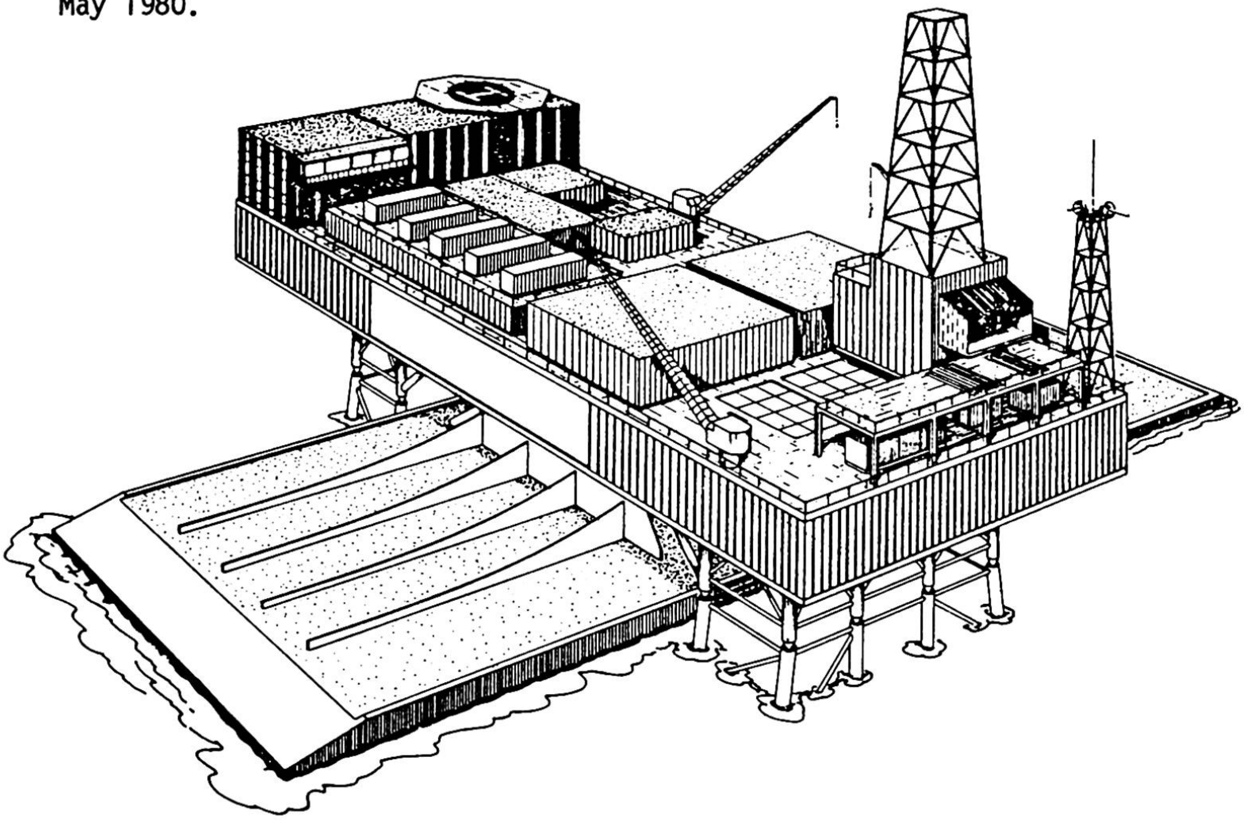

FIGURE 1- HIDECK - INSTALLATION BY BARGE

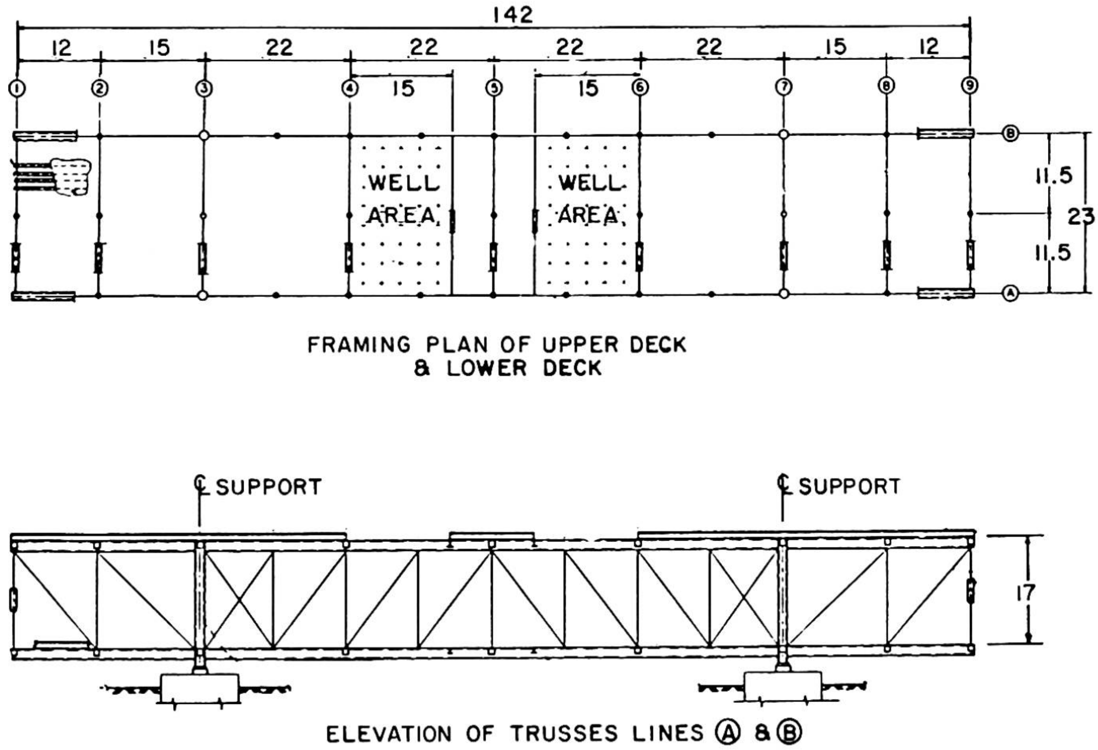

FIGURE 2- DRILLING I-DECK

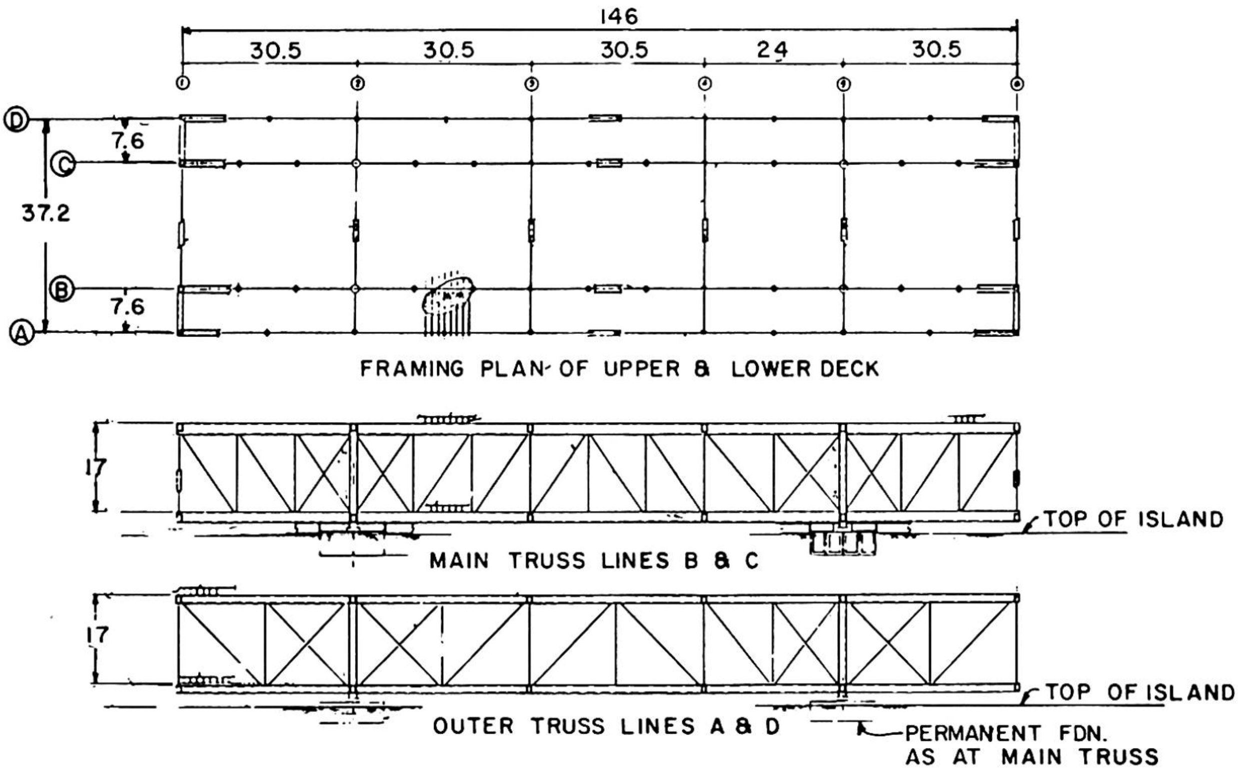

FIGURE 3- PRODUCTION I-DECK

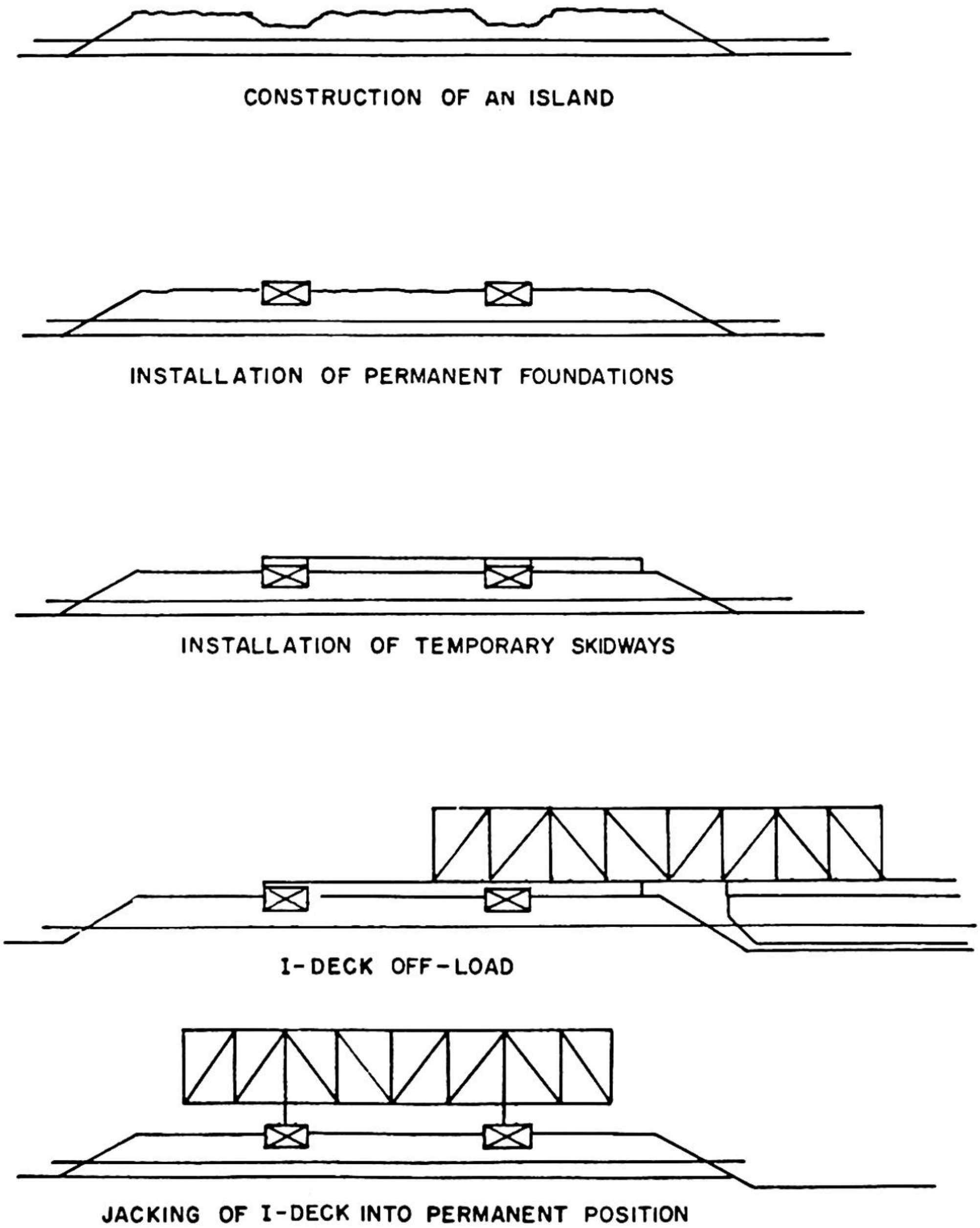

FIGURE 4– ISLAND CONSTRUCTION SEQUENCE (SCHEMATIC)

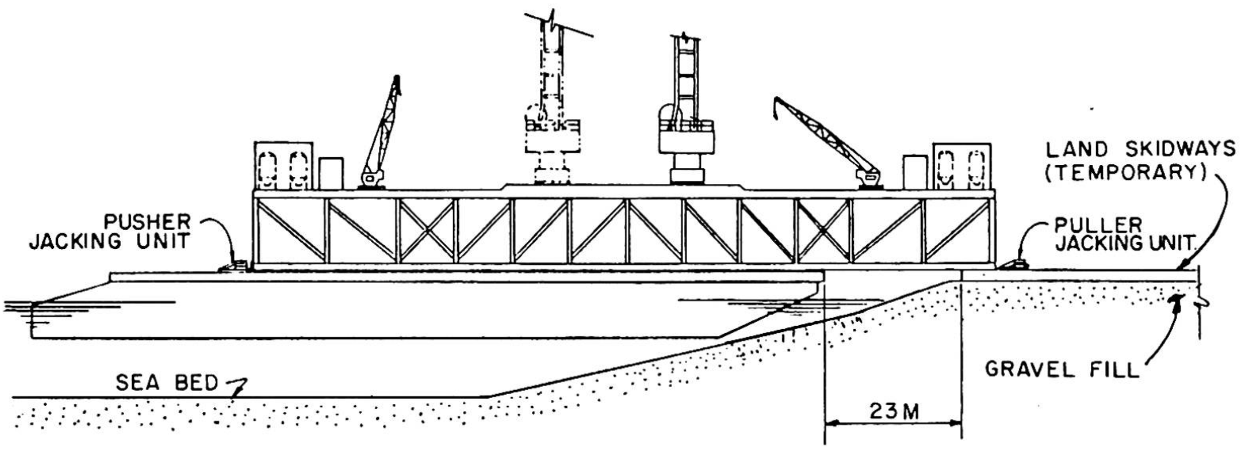

FIGURE 5- TRANSFERRING I-DECK TO ISLAND

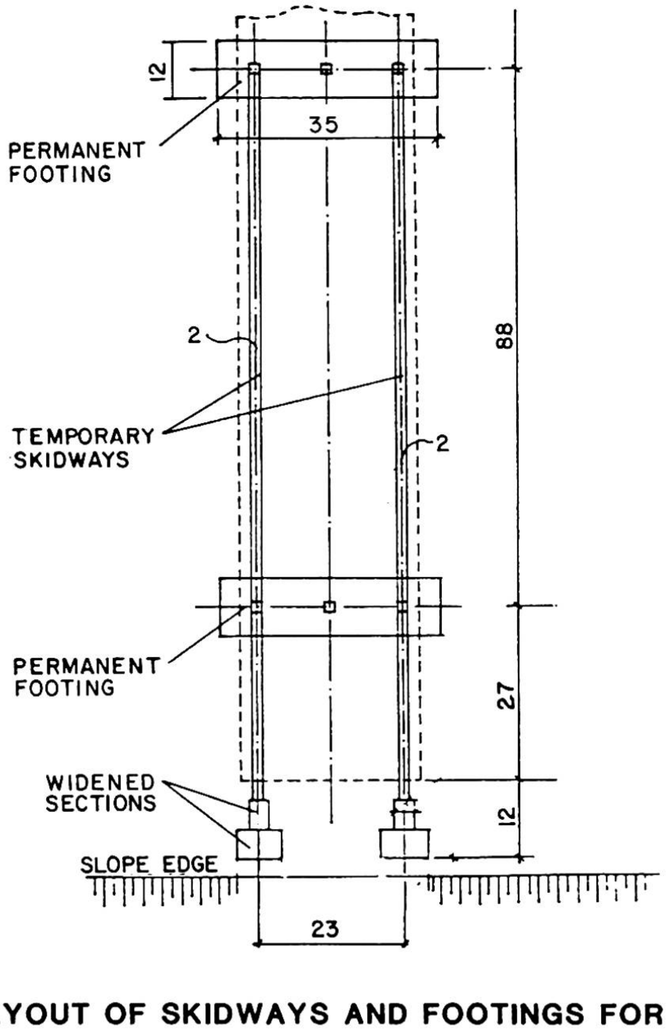

FIGURE 6- LAYOUT OF SKIDWAYS AND FOOTINGS FOR DRILLING I-DECK