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Design of a Floating Berth

Conception d'un poste de mouillage flottant

Projekt eines schwimmenden Anlegeplatzes

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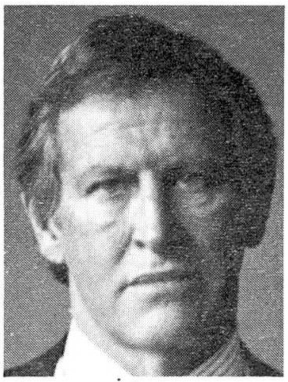
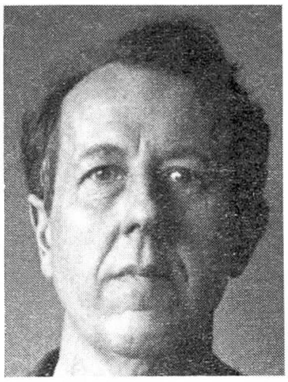
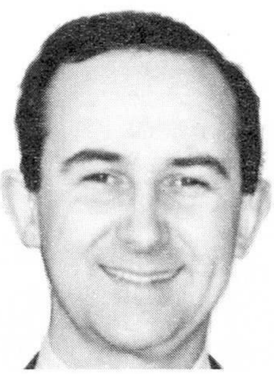






SUMMARY
The paper describes a covered berth for naval vessels, and the reasons underlying a novel and unique solution, which is a floating pre-stressed concrete twinhulled structure. The chosen geometry of the pontoons is discussed, model tank testing is described in some detail, together with the design procedures and an outline of the anticipated construction methods which contractors will adopt.

RÉSUMÉ
Cet article décrit un poste de mouillage couvert pour bateaux, et les raisons qui ont conduit à mettre au point cette solution unique entièrement nouvelle : celle-ci consiste en une structure flottante à double ponton en béton précontraint. La géométrie choisie pour ces pontons est expliquée et les essais de modèle en bassin sont décrits en partie. Cet article donne également un aperçu des études réalisées et un résumé des méthodes de construction prévues, qui seront utilisées par les entrepreneurs.

ZUSAMMENFASSUNG
In dieser Abhandlung wird ein überdachter Anlegeplatz beschrieben. Es werden die Gründe für eine neue und einzigartige Lösung, eine schwimmende Doppelrumpf-Struktur aus Spannbeton, angeführt. Es werden die gewählte Anordnung der Pontons diskutiert und die Modellversuche angesprochen zusammen mit den Konstruktionsvorgängen und einer Skizzierung der Vorgesehen und von den Unternehmern anzuwendenden Baumethoden.

1. INTRODUCTION

1.1 This paper describes the design of the main elements of a floating covered jetty for special naval vessels, which will provide craneage as well as support services for the vessels while moored in the berth. A floating structure was chosen as the most cost effective solution because the depth of water, 70 metres, and the sea bed-rock at a slope of 40° would have rendered conventional piling extremely expensive. However, the floating solution poses problems since it will permit dynamic motions caused by wind, waves and tides.

1.2 The jetty will comprise twin pontoons, each 200m long x 25m wide, separated by 30 m of water, having a draft of 7m and a freeboard of 5m, and displacing 70,000 tonnes. At one end, the pontoons will be connected by a rigid box link and at the opposite end by an underwater tubular steel brace allowing vessels with a draft of up to 13m to enter the berth. The enclosure to the berth will be about 60m wide, a maximum of 45m high at the ridge and composed of aluminium clad structural steelwork. Two overhead electric travelling cranes and a two leaf vertical lift vessel access door will be provided. The jetty will be permanently moored to the shore by articulating tubular steel booms and provided with steel box girder bridges catering for a maximum tidal range of about 4m.

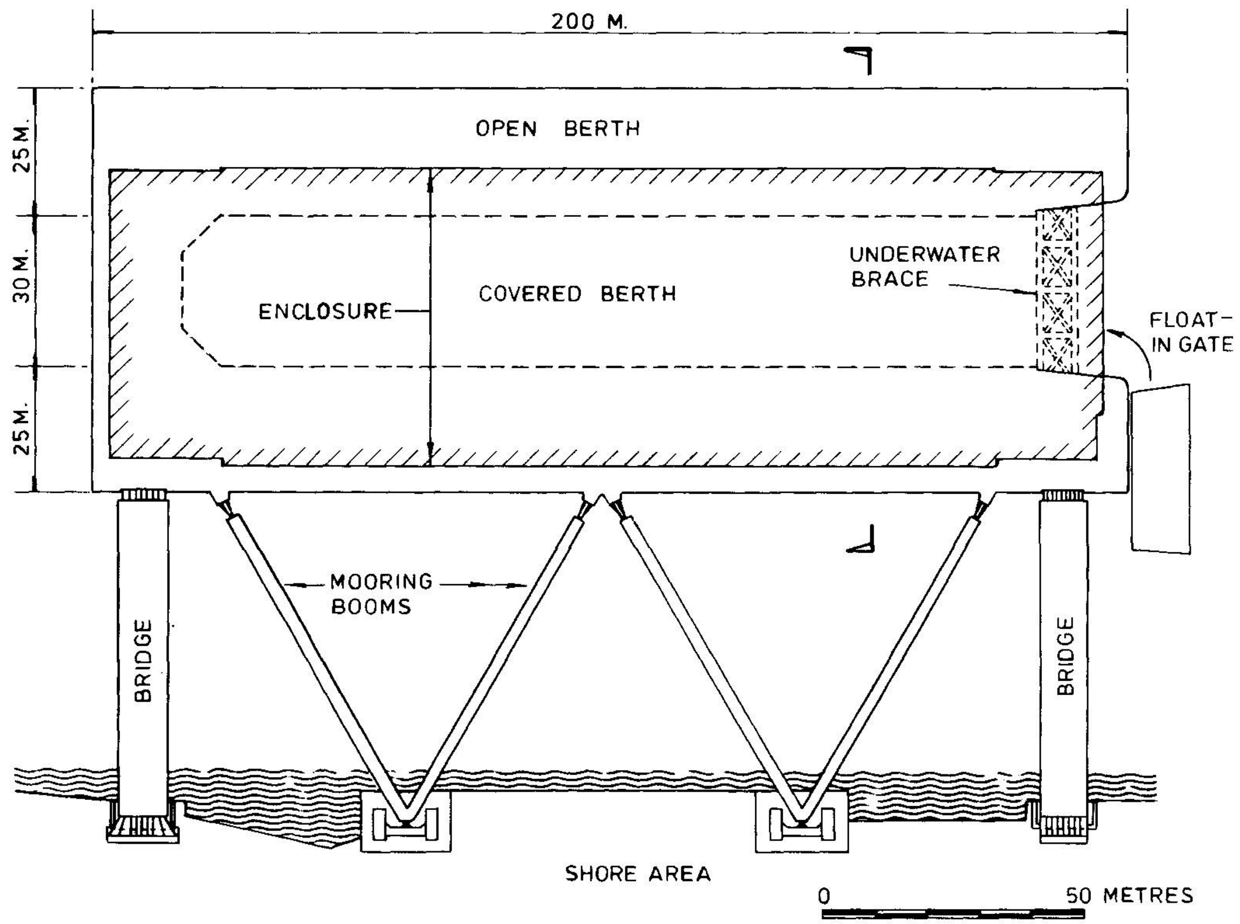


FIGURE 1 - PLAN

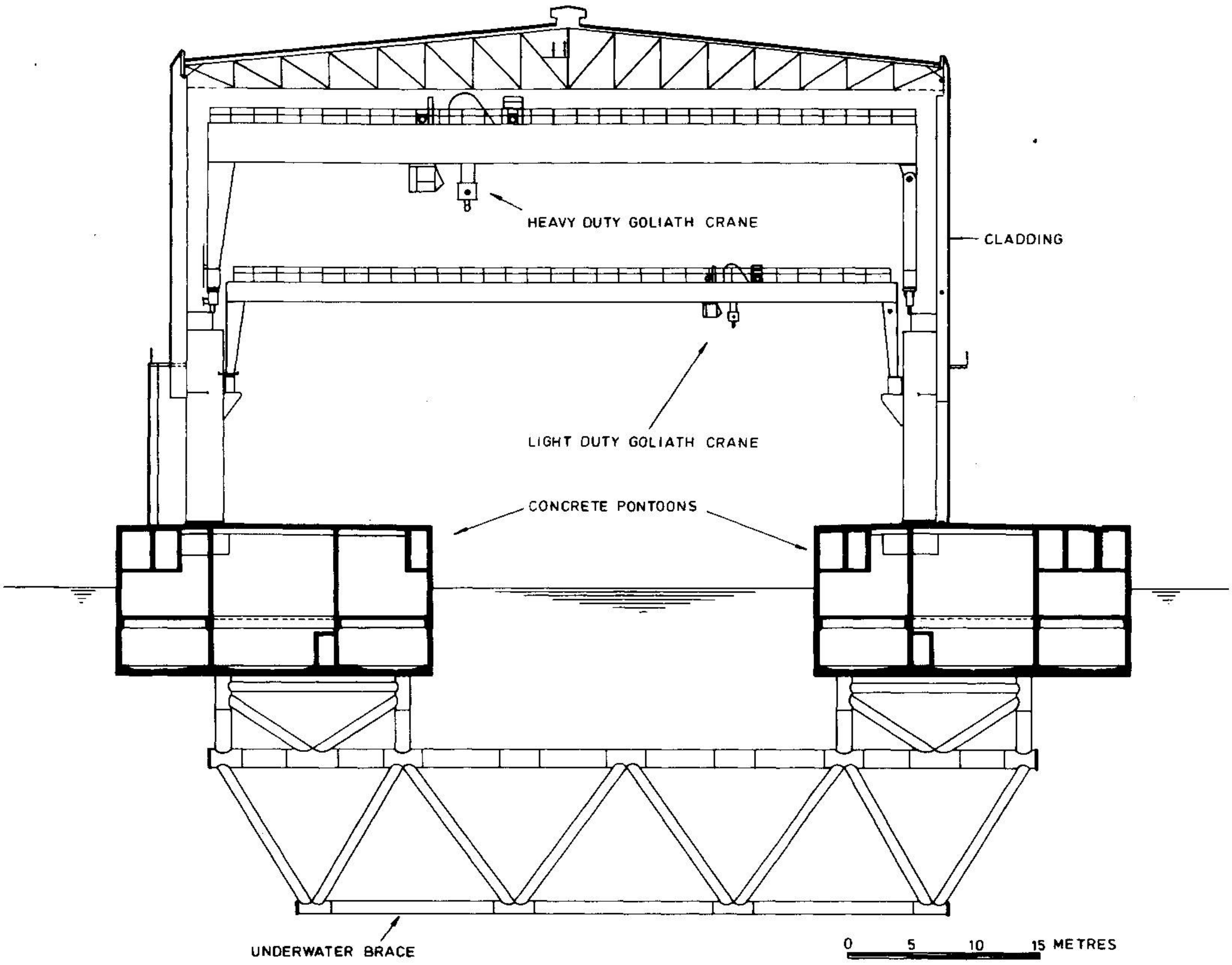


FIGURE 2 - CROSS - SECTION

2. STRUCTURAL FORM

2.1 The general layout of the jetty is shown in Fig. 1 and a typical cross-section in Fig. 2. The two longitudinal bulkheads in each pontoon are placed symmetrically to coincide with the eccentric enclosure column line on each pontoon. Spacing of the outer transverse bulkheads is limited by collision damage considerations, and is generally 30m. An intermediate deck is provided to support the outer walls against hydrostatic pressure, with internal transverse bulkheads at 15m centres, which both transfer the hydrostatic loads and add support to the bottom slab.

2.2 The hull girder bending moment, shear and torsion strength requirements strongly indicated that the pontoons should be longitudinally prestressed. A number of options were also considered for transverse and vertical prestressing, but for a number of reasons it was decided to use only unstressed reinforcement transversely. Local shear stresses were the major parameter in determining wall and slab thickness and haunching for the basic rectangular hull section.

3. MODEL TESTING

3.1 To prove the operational acceptability of the jetty, model tests were commissioned at the laboratories of Hydraulics Research Ltd. Initial tests identified the motion characteristics of the structure, in operational, and extreme wind, wave and current environments. Later tests were undertaken to assess accurately the absolute and relative motions of the prototype jetty and vessel moored within the enclosed berth. The test tank and model jetty are shown in Plate 1.

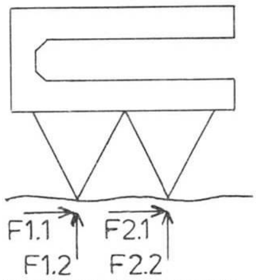
3.2 Surge, sway and yaw of the structure were measured using metal probes, fixed to the floating jetty, positioned between electrodes in fluid filled pots supported on a rigid platform within the enclosure. Heave, pitch and roll motions were obtained by ± summation of the outputs from twin wire resistance probes fixed to the jetty. Axial boom forces were measured by strain gauged proof rings. Typical maximum motion and force figures for an extreme 1 : 100 year return wind case are shown in Table 1.

Table 1

100 year return conditions - typical maximum force and motion figures

	Tonnes Max	Tonnes Min
F 1.1	621	507
F 1.2	565	445
F 2.1	759	573
F 2.2	562	432

		Max	Min
Surge,	m	0.28	0.19
Sway,	m	0.08	0.16
Heave,	m,	0.05	0.04
Yaw,	degrees	0.13	0.11
Roll,	degrees	0.11	0.05
Pitch,	degrees	0.14	0.11



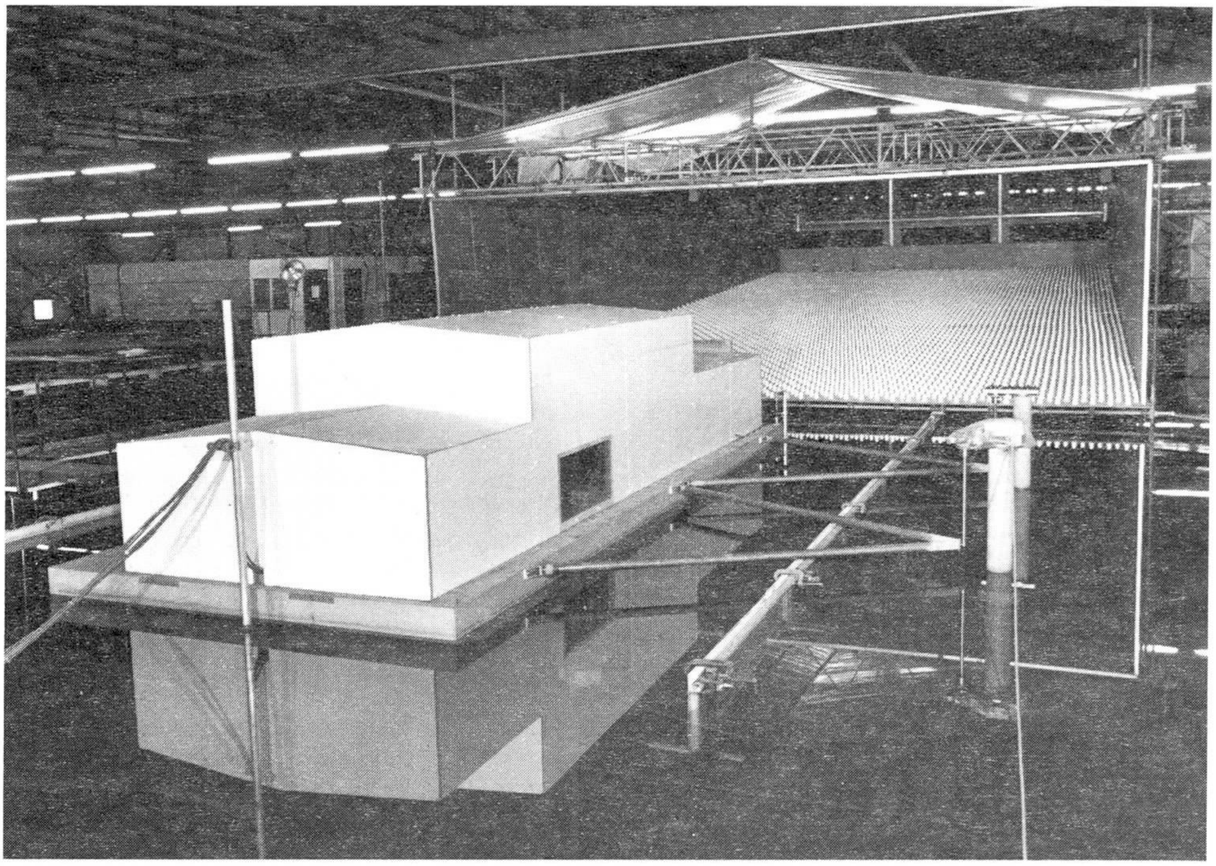


PLATE 1

4. DESIGN PROCEDURES

4.1 Preliminary design of the jetty was carried out using a simplified global model consisting of a detailed tubular brace structure with the two pontoons and the south link represented by line elements. From this it was possible to obtain stresses and deflections for the main pontoons and the brace. Although grillage analysis has been shown to be capable of giving accurate results for this type of structure, the finite element membrane method was chosen for the detailed analysis because of its flexibility. In particular, a detailed model of the closed end could be used with a relatively coarse model of the straight pontoon sections. Support conditions were modelled by using springs and restrained freedoms to give the correct mooring boom articulation and by distributed vertical springs representing buoyancy stiffness. Static loading was applied to simulate wave loads, wind loads, dead load, ballast tanks, prestressing, damage cases and collision forces as well as 8 different combinations of live loads giving maximum hogging, sagging, torsion and racking at key sections.

4.2 The structure is aseismically designed and can also be subjected to accidental collision forces. It is also necessary to ensure that certain sensitive plant items such as the crane load pendulum, the vessel access door and cantilevered service booms are not dynamically coupled to the pontoon motions.

4.3 After the finite element membrane analysis of the global loading had been first run, an approximate hand analysis was made to check on the magnitude and disposition of the prestress. Adjustments were made to achieve the most economic and effective use of the prestress and then the final part of the analysis was rerun. Post processor plotting of the envelopes of the membrane tensions, compressions and shears due to global loading then followed.

4.4 The cross-section including the service passageway walls and floors and

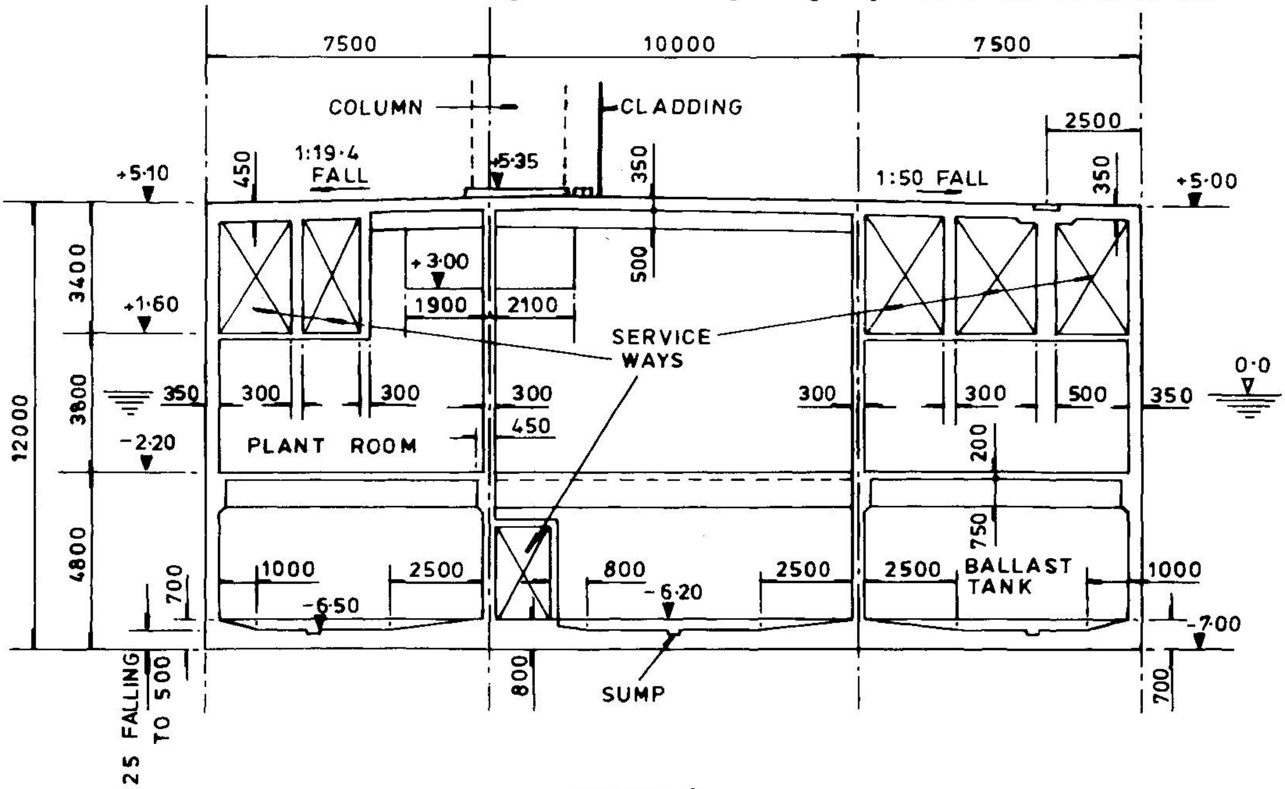


FIGURE 3

intermediate deck is illustrated in Fig 3. About 70 A1 size drawings have been produced to show the concrete outline and prestressing arrangements by computer aided draughting

4.5 The individual panels and loaded areas of the structure were analysed by conventional hand methods for the various local load conditions such as water pressure and plant loads. These were then combined with the stresses obtained from the global analysis, already adjusted to combine the membrane shears into direct membrane stresses. The areas of high external load such as mooring boom connection points, brace connections, bridge supports, and column bases were analysed by hand. Concrete member thickness has been minimised but is sufficient to ensure that the use of shear reinforcement in slabs and walls is not required. The deck is designed to carry heavy vehicles, cranes and stacked loads.

5. SERVICEABILITY

5.1 It is anticipated that the draft of the structure will be slightly lower than that required for operational requirements. Some of the cells in the lower part of the structure have been designated for water ballast and provided with a ballast water pumping system. It will be possible to trim the jetty fore and aft and athwartships.

5.2 Great attention has been paid to durability of the structure for minimum maintenance. The concrete specification is aimed at producing high strength impermeable concrete of 50 N/sq.mm characteristic strength. The minimum cement content will be 400 Kg/cu.m and at least 30% pulverised fuel ash or 50% blast furnace slag will be incorporated. Cover to reinforcement in the splash zone and exposed deck is 75mm, 50mm for submerged surfaces, and 30mm for internal surfaces except the ballast tanks which are 50mm.

5.3 Although a bilge pumping system will be installed it is expected that the structure will be virtually watertight. Construction joints will be carefully detailed with waterstops, and the longitudinal prestressing will assist in maintaining watertightness.

6. CONSTRUCTION

6.1 At the mooring site there is no land available or suitable for a construction yard, and therefore the jetty will be built elsewhere and towed to the Site.

6.2 The jetty is in effect a vessel without propulsion and construction is foreseen as being very similar to ship construction. Fitting out the jetty with plant, services, bilge and ballast systems, accommodation units and steel superstructure should be completed within the construction yard.

6.3 After the tow, mooring of the jetty in the permanent position will be a routine operation. The Contractor will have positioned the mooring booms on shore connections, with the outer ends supported on pontoons. Once the jetty is connected to the booms, the bridges can be placed and commissioning of the on-board plant will commence.

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