8. COMPOSITE HULL DESIGN

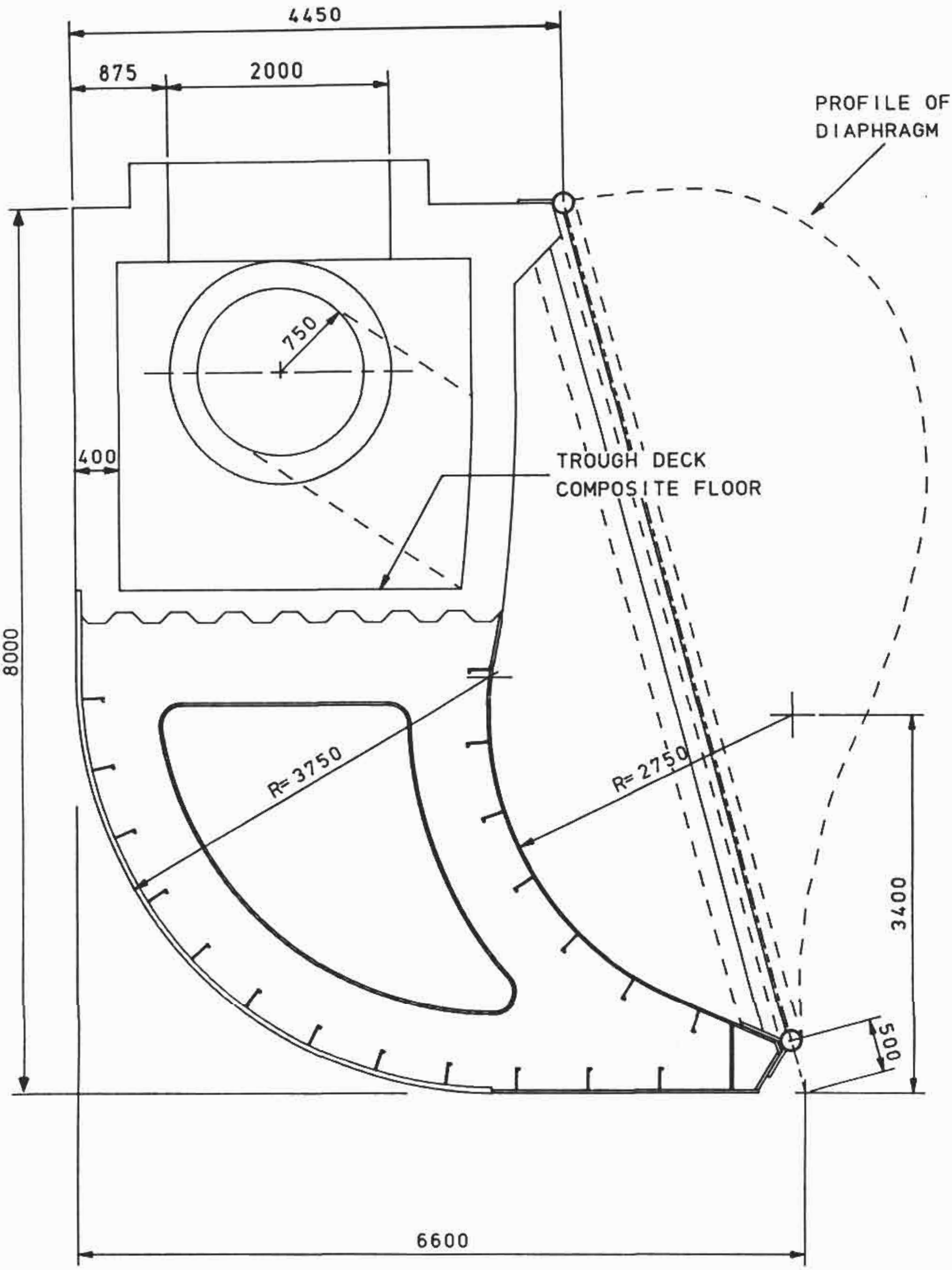
8.1 General

The hull is conceived as a means of using concrete ballast structurally to replace structural steelwork while retaining the constructional advantages inherent in the steel option. Two schemes are considered; the first being a hybrid structure in which the lower section of the device is fabricated steelwork and the upper section concrete and the second being a true composite scheme in which the concrete acts compositely within an outer steel shell. The hybrid scheme is shown in Fig 8. In both cases the steel section would be constructed in a shipyard in the same manner as the steel hull option and then moored at a concreting jetty for completion of construction.

8.2 Hybrid Scheme

In this scheme the lower section, up to the mid deck, is fabricated, complete with bag separation panels, in a shipyard and launched. The half completed structure is then moored up to a concreting jetty where the upper section is completed in prestressed concrete. The mid deck is constructed in concrete on troughed deck steel permanent formwork so that continuity of reinforcement into the wall can be provided. Thicker wall panels than are used in the concrete design can be economically employed because of the light displacement of the lower section.

The upper concrete structure will be prestressed circumferentially in the same way as the all concrete hull. In this case the prestressing force will also induce stresses in the steel bottom section resulting in a stress gradient within the concrete. This effect may give some slight benefit and allow the prestress to be reduced slightly.



HYBRID COMPOSITE SECTION

SCALE 1:50

FIG 8.1

However, the concrete works will have to be a high tolerance and will require accurate steel fixing and shutter erection in an exposed position over water. This will increase the price of concrete works substantially. Two different construction teams will be required and two different establishment costs will be incurred. Being a hybrid device it is unlikely that a production run of devices could be made less expensive than the cheaper of the steel or concrete schemes. Nevertheless there may be some saving over the concrete hull design for a single prototype device since the steel lower section will be relatively easy to launch into the water and will provide a good construction platform thus obviating the need for an expensive facility.

8.3 Composite Scheme

In this scheme the complete steel hull will be fabricated in a shipyard but with reduced plate thicknesses in certain areas. The additional hull strength required for the operation stage is then provided by a layer of heavily reinforced concrete acting compositely with the lower hull section and forming part of a larger volume of concrete ballast occupying roughly 60% of the lower hull cross section. The reinforcing bars will be positioned before float-out and the concrete will be installed at an inshore concreting jetty.

The placing costs of the concrete are minimised since very little formwork is required and there is no steel fixing while afloat.

Nevertheless, the volume of concrete required is substantial and adds approximately 25% to the cost of the steel hull. This cost is not offset by the saving in steel fabrication cost.

8.4 Conclusion

Neither scheme is considered to offer a cost advantage and both have an external steel hull section requiring maintenance. By substituting fixed ballast for water ballast, both scheme are more difficult to maintain than the all steel hull since they cannot be trimmed to allow the external hull to be painted. Consequently neither scheme has been developed further although the hybrid scheme may conceivably be worth pursuing for a prototype since it may reduce the fixed costs for a one-off device.

9. CONCLUSIONS

1. There is sufficient stability in the structure in the event of accidental damage causing either flooding of the power tube or flooding two adjacent compartments.

2. The device has been designed for extreme bending moments of 53 MNm in surge and 23MNm in heave with a maximum torsion of 11.5MNm.

3. Moments were calculated using development of the method used in the 1986 RPT report.

4. Torsions and the effect of unsymmetrical bending were calculated using a small finite element model.

5. The tubular space frame option was considered to be less efficient and more expensive to fabricate than an equivalent steel hull structure and was not developed further.

6. The all steel hull cross section was found to be very similar in layout to the side buoyancy space of a suction hopper dredger and therefore well within the capacity and experience of a number of shipyards.

7. The steel hull design was found to be governed by the fatigue wave spectrum. The critical sections of the steel hull for fatigue were found to be the welds at the corners between adjacent device segments. A minimum life of 25 years was achieved but a study showed that the life was very sensitive to the exact wave spectrum used.

8. The steel hull was designed to be ballasted with inert water. This allows the device to be deballasted to give good access for bag change-out and hull maintenance.

9. The concrete hull design required a slightly wider section than the steel scheme to provide sufficient buoyancy to support the additional self weight.

10. The optimum prestressing system turned out to be a system commonly used on circular tanks which avoids anchor blocks within the concrete. The design was found to be governed by the serviceability limit state.

11. A variety of types of construction facilities were examined. Three types of existing facility and a purpose built casting basin were found to be economically viable. It was not possible to select one single preferred construction facility since prices proved to be similar, within estimating tolerances. Individual facilities were marginally preferred for a greater or lesser number of devices. Since there are only a limited number of suitable existing facilities market forces are likely to determine the most economical method of construction at the time of tender.

12. The concrete hull is expected to require minimal maintenance but since there is little variable ballast it is not possible to raise a concrete device out of the water for bag change-out.

13. Two composite schemes were briefly investigated but neither was expected to be less expensive than the cheaper of either the all concrete or steel hull schemes and they were not therefore developed further.

14. The structural hull cost per device for a production rum of 10 or 12 devices at 2nd quarter 1991 prices was estimated to be in the range:

Steel Hull	£1.23m - £1.60m
Concrete Hull	£1.25m - £1.88m

These costs include launching but not towing to site and exclude moorings, mechanical and electrical plant and design costs. The costs for the two different materials have been estimated in completely different ways. The concrete estimate includes a small design contingency to allow for additional costs due to design development. The steel price does not include this and much of the detailed design would be carried out by the shipyard. The contract risk associated with the two estimates is therefore not directly comparable.

References

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