These disadvantages may, however, be overcome by the creation of storage reservoirs to regulate the flow and by settlement in the district. As the district becomes thickly populated and towns spring up transportation facilities will be greatly improved and a market created for the power.

CONSTRUCTION OF CONCRETE SHIPS FOR EMERGENCY FLEET CORPORATION*

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THE reinforced concrete ship can be built structurally equal to any steel ship.

The available information indicates with all the certainty possible, short of actual experience under service conditions, that the concrete ship will be durable for several years, ensuring satisfactory service throughout the probable duration of the present war.

The cost of the reinforced concrete ship complete will vary between $100 and $125 per dead-weight ton, depending upon the number of ships built and the conditions of construction. The cost of the hull alone will be between $30 and $40 per dead-weight ton.

The construction of concrete hulls will not interfere with the present program for the construction of steel and wood hulls, insofar as labor or materials are concerned.

The concrete-ship department has completed the detailed plans for a 3,500-ton concrete ship, so that construction can start immediately. The vessel proposed is of the same size, dimensions, and form as the 3,500-ton standard wood ship, except that the sheer-line amidships has been altered slightly and no outer keel is fitted. The general arrangement follows closely that of the above wood ship, including the number and position of bulkheads. The propelling machinery designed for the wood ship has been provided for without essential change in this vessel. The principal characteristics follow:

Length, 268 ft.; beam over shell, 46 ft.; depth amidship (at side), 28 ft. 3 ins.; draft, 23 ft. 6 ins.; full-load displacement, 6,175 tons.

Comparative Weights in Tons, Concrete, Wood and Steel Vessels

	Concrete.	Wood.	Steel.
Hull	2,500	2,300	1,160
Fittings, outfit and equipment	191	191	180
Propelling machinery	206	206	200
Margin	75	80	60
Ship (light)	2,972	2,777	1,600
Reserve feed	80	80	80
Ordnance	23	23	23
Fuel	300	300	300
Stores	40	40	40
Cargo	2,760	2,180	3,057
Total dead-weight	3,203	3,123	3,500
Full-load displacement	6,175	5,900	5,100
Proportion dead-weight to full-load displacement, per cent.	52	53	68.6

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*Abstracted from special report made to United States Shipping Board.

Metacentric Height

The metacentric heights in the light (ship without cargo) and full-load conditions are, respectively, 2.15 and 2.2 ft. The best practice at the present time places these values between the limits of 1 and 3 ft. for vessels of this type and size.

Range of Stability and Righting Arm

The maximum righting-arm occurs at 51.5° and 46.5° for the vessel light and fully loaded, respectively, the extreme ranges being 89° and 81.5°, respectively.

Freeboard

The freeboard amidships at side is 4 ft. 9 ins. This is satisfactory to the representatives of Lloyd's Register of Shipping.

Period of Roll

An attempt to investigate this theoretically is a laborious operation and of doubtful value. It is seldom attempted in the design of steel vessels. It is considered safe to say, however, that the concentration of relatively great weight in the decks and shell in the concrete vessel should aid materially in increasing the period of roll.

Girder Strength or Strength of Vessel as a Whole

The strength of the ship as a girder supported on the crest of a wave amidship, hogging, and also on the crests of two waves, one at each end, sagging, was calculated for five conditions. The same basic assumption as to length, depth, and form of wave and the same method of procedure that is standard practice in calculating the strength of steel ships was followed throughout.

Condition	Maximum bending-moment, foot-tons	Maximum tons per square inch fibre-stress in Deck-reinforcement	Keel-reinforcement	Lbs. per sq. in. fibre-stress in concrete
Ship without cargo, hogging	25 175	5.53	*2.80	728
Ship fully loaded, hogging	37 000	5.63	*2.95	766
Ship without cargo, sagging	14,400	1.28	†2.63	270
Ship light with enough cargo in forward hold to trim, sagging	11,960	1.07	†2.19	210
Ship fully loaded, sagging	9,400	0.84	†1.72	70

*Keel. †Deck.

Good practice in steel merchant-ships for a boat of this type gives a maximum stress in the outer fibre of from 5 to 8 tons per square inch, figured on the same basis as given above for the concrete ship. In addition to the stress due to the ship acting as a girder, there is local stress between frames where the plating must act as a beam over that space. This stress is seldom considered in steel ships, but has been computed in the design of the 268-ft. concrete ship.

Transverse Strength

Only for naval vessels is it the practice to compute the transverse strength with accuracy. Either the sizes of frames are taken from the books of the classification societies, or the frames are figured as beams supported or fixed at keel, bilge, or deck, as the case may be. The complete ring in the concrete boat is figured with numerous cases of loading and heeling for every frame. The strength of the transverse frames for the vessel was investigated for a large number of conditions of loading and for various immersions of the vessel. The transverse frames are designed to stand the outside water-pressure with water to the gunwales and with minimum cargo-load, for maximum cargo-load and a sagging draft of 16 ft. 6 ins., and for listed positions with loading slight and heavy.

The bulkheads have been designed to carry a head of water on either side to the deck. The collision-bulkheads,

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