REINFORCED CONCRETE SHIPS*

By A. Alban H. Scott
Vice-President, Society of Architects

STEEL shipbuilders look upon reinforced concrete as a very complex matter, chiefly owing to the large number of small rods and the overlap required to get continuity, but in comparing the form of jointing in reinforced concrete work to the riveting in steel ships and the caulking required one would perhaps be justified in thinking that it might be impossible to get a comparatively water-tight ship with steel plates, when it is considered that for a ship to, say, 1,000 tons D.W. for the hull alone there would be approximately 2,500 separate sheets and angles of steel used and somewhere in the neighborhood of 110,000 rivets.

The approximate number of bars in a reinforced concrete vessel (same D.W.) would be 52,000.

Testing of Materials is Important

The testing of materials for reinforced concrete ships is one of extreme importance, and the Concrete Institute's report on this subject should be carefully studied. The whole of this report is applicable to shipwork, except that the maximum size of the coarse material requires, in the opinion of the writer, to be reduced to ⅜ in.

Additional tests are desirable as to the impermeability of concrete, and also as resistance to shock.

In several references to reinforced concrete ships one notices the phrase that "concrete is poured in," and in the opinion of the writer the loose application of this term should be combated. To obtain the best results, concrete should be *placed* into position as dry as possible, and after the concrete has been so placed, and sprinkled with water the result is a material much stronger and much more waterproof than a wet, sloppy mixture, or even a mixture which might be termed plastic; for this reason one would much sooner adopt the method of elevating the practically dry, mixed material in preference to delivery by gravitation.

Materials Required

A good deal of discussion has been taking place as to the suitability of various sites for the construction of reinforced concrete vessels. It is necessary to consider first the materials involved. If we take a boat of, say, 1,000 tons D.W., we find we shall require approximately 40 tons of clean, fresh water, free from injurious foreign matter, 564 tons of aggregate, 234 tons of sand, 125 tons of cement, 160 tons of steel, and 138 tons of material for equipment in the way of machinery, etc. It is clear, therefore, that the combined weight of the sand and aggregate is 66 per cent. of the total required, including equipment. It would consequently appear desirable, so as to save the cost of freightage and the difficulties of transport, that waterways for these shipyards should be looked for in the neighborhood of suitable stone quarries, where crushing plants could be put down and trolley-ways or rope-ways for transporting the material from the quarry to the shipyard could be arranged. It is also possible that cement could be obtained in the immediate district. If concrete in a relatively plastic condition be finally chosen such a method of transport from the quarries to the vessel obviously suggests that the material should be lifted above the ships, and after being mixed at a convenient level the concrete should be transferred by gravity to each particular vessel and part of the vessel requiring concrete at the moment. This method, however, the author suggests, requires too great a percentage of water.

With this new form of construction for vessels the temptation to depart from true ship lines must be resisted. For many years investigations have been carried on to ascertain the lines which give the least resistance to a ship passing through water; and because a different material is proposed to be used for certain boats it is submitted a great mistake would be made by departing from proper and regulated lines of the ship in the expectation of securing economies in construction in reinforced concrete. Safety and efficiency in running must be the first considerations. To depart from proper ship lines would involve extra expenditure on the running costs, which would quickly neutralize any saving on the capital outlay of the ship when constructed. No doubt it would be found that if five or six boats were built with the same set of centering there would be no additional cost by having what is known as "circular circular work." It has been stated that it is more difficult to get the reinforcement into position by following the true ship lines than if straight lines are adopted. The obvious reply to this is, that it is more difficult to construct upper stories to a building than lower stories, therefore we won't have any upper stories, or if it is more difficult to provide for hatchways, leave them out.

"Flour" Should Be Eliminated

The importance of testing each individual material used in reinforced concrete cannot be too strongly emphasized.

The following results of tests might be of interest:—

By kind permission of the publishers the following extracts are given from my previously published book, "Reinforced Concrete in Practice."

"It is important that 'flour' should be eliminated from the sand. The actual size of the grains of sand in the concrete has a material effect on the strength of the work. Table No. 15 indicates the amount of surface to be covered by the cement."

Materials passing through a mesh of the following diameters.			Approximate total surface area of the particles contained in each cubic foot of material.
	Inches.		Square inches.
Sand.	0.0066	Should not be used for R.C. work.	1,530,000
	0.013		792,000
	0.025		412,000
	0.04		268,000
	0.06		194,000
	0.13		98,000
	0.25		45,000
Aggregate or coarse material.	0.37		28,000
	0.5		21,000
	0.62		16,000
	0.75		13,600

These areas are taken on the assumption that the grains have smooth and even surfaces, and no allowance has been made for irregularities of any description; they should therefore be considered as the minimum area.

Grading the Material

The amount of voids in the aggregate and sand when mixed renders it necessary to exercise the greatest care in grading the material. To ensure good compact concrete the voids should be reduced to the lowest percentage com-

*Abstracted from paper read before the Concrete Institute, May 9th, 1918.