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KOROR, PALAU
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USE OF CONCRETE (1)

JAMES (UK) : The use of concrete in the marine field is certainly not new. Between 1917 and 1922 due to the shortage of steel during and just after World War I over 150,000 tons of concrete shipping was built on both sides of the Atlantic, ranging in size from 7,500 ton oil tankers to small tugs and lighters. The hull thickness on such vessels ranged from between 4 and 6 in (102 and 152 mm). A new material, a derivative of concrete has now been developed in UK in which the hull has a thickness of only 7/8 in (22.2mm). In this development all the data obtainable on concrete ship construction over the years has been utilized.

The basic raw materials are sand, cement, steel reinforcing and other special additives that give this material good properties.

Concrete boat construction requires no expensive moulds such as are required in glass-reinforced plastic boat construction and therefore one boat can be produced relatively cheaply, it not being necessary to recover expensive mould cost over a series of identical hulls.

All that is required is a suitable jig to support the keel, preferably capable of having wheels attached for easy movement and a set of wooden frames similar to wooden shams used in conventional wood boat construction. The steel reinforcement being built up around these frames. Any shape of hull may be produced in this manner. The stem mould and transom mould are removed to facilitate access to the reinforcement when the hull is cast. After the hull has been cast and is no longer "green", it is sprayed continuously with water for between 100 and 150 hours according to conditions. The other frames are then removed and the hull cleaned off internally.

During the laying-up of the reinforcement for a hull, it is not necessary to adhere to any strict temperature control, when the hull is cast, however, it is advisable to maintain a moderate temperature with a reasonable degree of humidity.

The ultimate tensile strength of this concrete material is 5,340 lb/in2 (390 kg/cm2) and because a mesh reinforcement is used, it will have this tensile strength in all directions. Most boats less than 100 ft (30 m) in length are now built of wood because it is cheaper than aluminium or glass reinforced plastic. Therefore, this concrete shall be compared with wood.

The tensile strength of wood is approximately 6,000 lb/in2 (422 kg/cm2) along the grain and negligible across the grain, also the tensile strength of a wooden hull is diminished considerably by the fastening and the fact that the grain often "runs out" whereas in concrete hulls there are no fastenings and the tensile strength is accordingly uniform.

The compressive strength of this concrete material without reinforcement is about 7,200 lb/in2 (500kg/cm2) after seven days and 12,225 lb/in2 (860 kg/cm2) 28 days and continues to increase with age far in excess of wood. Young's modulus of elasticity for this concrete material is 1.30×10^6 lb/in2 (91,400 kg/cm2).

The specific gravity of the concrete is 2.4, that of glass-reinforced plastic is 1.6, and of a wooden hull including fastenings 0.9. In spite of the weight of the material a concrete hull compares favourably in overall weight with both wooden and glass reinforced plastic hulls because a concrete hull requires no heavy internal frames or floors and a panel almost half as thick as timber is equally as strong.

Vessels shorter than 100 feet (30 m) do not have stresses upon the hull that are excessive. On a 75 ft (22.9 m) trawler displacing 110 tons the maximum stress at deck level or the bottom of the skeg, depending on whether the vessel is hogging or sagging will not exceed 1,000 lb/in2 (70 kg/cm2) if the thickness of the hull is approximately 1/2 in (12.7 mm) thick. Therefore with the tensile strength of the concrete material being 5,340 lb/in2 (390 kg/cm2) there is ample margin for safety.

A pertinent question is whether a concrete hull is sufficiently strong to withstand rough treatment such as abrasion against dock walls or rubbing against other craft. For such vessels concrete is immensely hard and shows great resistance to abrasion. It has distinct advantages over reinforced plastics in this sphere. Because of its greater thickness and the fact that even if the surface suffers abrasion it will not weep as is the case with a glass-reinforced plastic hull due to its internal porosity.

After exhaustive tests Lloyds Register of Shipping have intimated that they will give 100 A1 classification to a vessel with a concrete hull, also the British White Fish Authority will accept applications for grants.

A concrete hull is very strong and yet is also extremely flexible. A sample strip was tested by Lloyds Register of Shipping and the following results were obtained. Size of strip : 21.65 in (550 mm) long, 5 in (127 mm) side, and 0.65 in (16.4 mm) thick. The distance of the loading from one support point was 8.5 in (216 mm). Normal stress levels + 700 to -600lb/in2 (+ 49.2 to -42.2 kg/cm2). It was flexed for 2 x 10^6cycles without fracture.

STIFFENED BY METAL

The concrete hull is stiffened by the insertion of metal frames spaced in accordance with the size of the hull and to these frames are attached lugs to take bulkheads, etc. James' firm has also devised a method of casting into the hull, floors and engine beds in concrete and these strengthen the main structure to a considerable degree.

Vessels constructed of this concrete material up to 40 ft (12m) in length are slightly heavier than an equivalent vessel constructed in wood, glass-reinforced plastic or steel. Larger power-driven hulls are lighter than steel or wooden hulls and yet have the same strength and are equally rigid. It should also be noted that vessels up to 60 ft (18 m) in length can be constructed of 7/8in thick (22.2 mm) material. This thickness weighing only 11 lb/ft2 (52.8 kg/m2). However, the thickness of a glass-reinforced plastic hull is greatly increased as the hull sizes increase. Thereby, adding to the cost of materials.

A concrete hull is fire resistant and in this respect has considerable advantage over wooden hulls and glass-reinforced plastic hulls. Test panels have withstood 3,100ºF (1,700ºC) for 1½ hours with no effect on the material.

It is quite possible to construct decks and superstructure in the concrete material, using the same form as the hull skin. By doing so one produces a very strong and rigid hull due to it becoming a complete monolithic structure. On smaller vessels this is not advisable due to the weight factor.

It is not necessary to protect a concrete hull with paint, but any normal good quality marine paint will be quite adequate for decorative purposes and anti-fouling. A concrete hull requires no maintenance. It is a homogeneous structure, therefore it cannot leak, cannot corrode and is immune to marine borers. Barnacles and algae will attach themselves to a concrete hull below the water line in the same manner as a timber or metal hull, but they may be easily removed with a powerful detergent which will have no effect on the hull. Concrete cannot be attacked by marine borers and hulls built in this material will not deteriorate as is the case of hulls built of wood where a very short life span may be expected.

A tremendous advantage of a concrete hull over other forms of hull material is that it can be so easily repaired. If a concrete hull is damaged in a collision, it can be repaired in about one-tenth of the time taken to repair a wooden hull. The procedure for repairing is as follows : The damaged area is broken away until the surrounding concrete material is undamaged and solid. It should be remembered that when a hull is damaged, the damage is completely localized and is confined to the area where the impact took place. Once the broken concrete has been removed any broken mesh reinforcement is replaced and knocked back into its original position.

SIMPLE REPAIR KITS

A suitable repair kit is supplied by the makers and the ingredients mixed in accordance with the instructions and is then applied to both the interior and the exterior of the damaged section. The exterior is left slightly rough and finally "ground off". The hull is then painted and finished as it was before damage. Normally a repair can be effected in one ordinary working day. Whereas it is comparatively simple to repair a concrete hull even in tropical conditions, the same does not apply to glass-reinforced plastic hulls where materials if stored tend to deteriorate and it is not always possible to maintain the correct working temperatures that are all important in effecting a satisfactory repair.

Hulls built of the concrete material are relatively cheaper than wood and steel and are cheaper than reinforced plastic hulls over 30 ft (9m) in length. The main labour involved in producing a hull is in setting up and forming of the reinforcement. Consequently larger hulls are proportionately cheaper than smaller hulls. It must also be realized that to produce a reinforced plastic hull cheaply a number of hulls have to be produced from the same mould whereas in the case of a concrete material hull it is quite possible to produce a single hull to a particular shape economically.

Above 34 ft (10.35m) concrete hulls can compete with wooden, steel and reinforced plastic hulls. For example, a 24 ft (7.3 m) hull complete with floors and engine beds is sold for £700 ($ 1,960), a 28 ft (8.5 m) hull complete with floors and engine beds for £ 800 ($ 2,240), a 34 ft (10.3 m) hull for £ 1,000 ($ 2,800) and a 45 ft (13.7 m) hull for £ 2,100 ($ 5,880). Concrete hulls are dry, durable and more easy to repair than hulls made from other materials . Concrete is relatively cheaper than any other form of construction.

Concrete hulls do not absorb any amount of moisture and therefore there is no risk of contamination by fish in fishing boats, moreover, it is a very good insulator having a thermal conductivity of 68.88 BTU/ft2/º/F/hr (335 kcal/m2/º/C/hr), consequently there is little or no risk of condensation in concrete hulls. Furthermore, such a hull is completely odourless.

Due to the built-in framing and strength inherent in the material, it is possible to obtain 11 per cent more space in a concrete material-hulled craft than in a similar sized hull constructed in any other material. It must also be stressed that concrete-hulled craft may be cast into practically any form to meet the particular requirements of the purchasers, rather than the purchasers having to accept a standard design as in reinforced plastic hulls, or prohibitive costs as in wood and steel hulls.

It has already been stated that the basic raw materials for the construction are sand and good quality cement. Both these items are usually readily available in most countries. This is, of course, of paramount importance particularly in under-developed territories and countries that lack their own steel mills and accordingly have to import the raw materials for other forms of construction, often using valuable foreign exchange.

It is also important to note that apart from one trained technician, it is quite possible to construct vessels in this concrete using intelligent but unskilled labour.

Finally the advantages may be summarized as follows : continuous and monobloc structure, smooth surface, perfectly watertight, no maintenance costs, easily repairable, extremely strong but without losing a marked degree of elasticity.

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(1) Extracted from "FISHING BOATS OF THE WORLD", Vol. 3, published by arrangement with the Food and Agriculture Organization of the United Nations by Fishing News (Books) Ltd., LONDON, 1967.

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