GLASS REINFORCED PLASTIC BOATS

For the past ten years the Royal Navy has been evaluating the use of glass reinforced plastic for boats under thirty feet in length, as a result of which G.R.P. construction up to this length is now contemplated where numbers will justify the mould cost. The design of larger boats in G.R.P. is under consideration.

Trials carried out with glass reinforced plastic boats during the last ten years have covered craft from 9 feet to 27 feet in length, operated at speeds of from six to 16 knots. Experience has been gained with resin and reinforced material on G.R.P., composite, sandwich, round bilge and hard chine designs. Exhaustive testing of boats using both cold-set and hot-set construction has been carried out all over the world in H.M. ships.

One of the great advantages and financial saving accruing from the use of G.R.P. boats in the Navy is the resultant release of manpower which would otherwise be engaged in H.M. dockyards on the removal and maintenance of timber used in traditional wooden boats. A further saving would be made with G.R.P. by abolishing the present need for sheathing of wooden boats used in tropical waters to combat worm and microbe attacks. Apart from the obvious savings of men and money on maintenance, the adoption of G.R.P. in small boat construction in the Navy would mean resultant increases in the speed and ease with which boats can be repaired both on board and at shore bases, compared with the wooden boats, where removal of considerable amounts of planking is often necessary.

One of the main disadvantages was the decline in appearance of the G.R.P. boats after considerable use in Fleet service, but recent paint tests carried out by Admiralty research establishments have established that this can be overcome for all except the fast planing boats by traditional brush painting.

Admiralty experience of G.R.P. boats began in 1951 when two commercial dinghies were purchased. The first was a 9 ft 3 in. boat weighing 96 lb, using resin bonded glass and diagonal mat cold lay-up construction, and the other a 7 ft 7½ in. boat weighing 90 lb, and using resin bonded glass and swirled mat hot-set construction. These were tested initially over a period of six months by Captain, Coastal Forces, who reported that there had been no difference in their ultimate strength and no repairs has been needed. One dinghy was carried by an R.N. yacht for the New York-Bermuda Race in 1952.

To gain further experience with cold and hot-set constructions, two 20-ft motor dories (landing craft personnel, small) were ordered and successfully tested by the Amphibious Warfare Services. One was constructed using the brush-on method over a female mould, the other using the heated pressure bag hot-set method over an aluminium female mould. These, and further trials, showed that although there was nothing to choose from an operational point of view between cold and hot-set construction, in view of the small number of boats required by the Navy the expensive hot-set method was not justified. Further evaluation was therefore concentrated on cold-set techniques.

The next boat acquired by Admiralty, and now on Port Auxiliary Service duties at Portsmouth after seven years' use, was a 25-ft medium speed motor boat of cold-set construction using shell and frames of G.R.P. with gunwale, hog, keel and stem of timber, through bolted. The first five months' service with the trials cruiser H.M.S. *Cumberland* in hot weather in the Mediterranean showed that the hull stood up ' moderately well ' to naval handling and withstood impact equally as well as wooden hulls. The surface tended to crack and craze, especially along the waterline, and was susceptible to damage by abrasion when coming alongside. From the naval viewpoint a major disadvantage was that the appearance of the boat soon deteriorated, where a wooden boat would still have been ' smart '. It was painted in an attempt to improve appearances but paintwork peeled off below the waterline and rubbed off easily. The G.R.P. continued to abrade easily and the corners of the transom became jagged.

The boat was later issued to the Royal Fleet Auxiliary *Fort Rosalie* and after two-and-a-half-years' service it was surveyed (total service 4-5 years) with the result : better condition than wooden boat of comparable age ; abrasions and deep scores of the hull did not show evidence of ingress of water, delamination or leaching out of the resin ; through-bolting of wooden members was not a good feature ; impact resistance of glass mat reinforcement was satisfactory for Service use ; appearance was poor.

From 1959 onwards it was used experimentally for repair and other tests. Large areas of the skin and framing were cut out and repaired by various schemes, bilge keels and spray chines attached by differing resin/glass systems, several paint schemes applied and a new rudder of novel construction was fitted. The boat is still perfectly sound.

Direct comparisons between composite and all G.R.P. construction were made with four 27-ft motor whalers obtained in 1957/58. Two were of composite construction and two of monocoque construction. One of each type was issued together with a whaler of timber construction to the aircraft carrier H.M.S. *Victorious*, and the other two were issued to the frigates H.M.S. *Puma* and H.M.S. *Llandaff*.

A summary of their trials evaluation is as follows :—

H.M.S. Llandaff

Boat used in all climates in Icelandic, Home, Mediterranean, Persian Gulf and Far Eastern waters. Hull superior to conventional hull. Other than slight surface deterioration, G.R.P. hull satisfactory.

H.M.S. Puma

Boat used extensively and well tried under adverse conditions. G.R.P. hull superior to conventional hull, and boat satisfactory in every way. Damage received would have been much more severe in conventional hull and in one instance resistance quite remarkable. Main difficulty experienced in keeping boat smart and avoiding patchwork effect of repairs.

H.M.S. Victorious

Only limited use of boats available during trials. Monocoque construction using G.R.P. throughout preferred from cleaning and appearance aspects. Other than slight surface blemish and deterioration G.R.P. satisfactory, repairs quicker and maintenance easier.

Experience has also been gained by Admiralty with the use of plastic sandwich construction on a 16-ft fast motor boat. The hull consisted of expanded P.V.C., $\frac{7}{8}$-inch thick, sandwiched between laminations of G.R.P. This provides inherent buoyancy, a clean internal surface and a degree of rigidity sufficient to allow frames to be dispensed with. The boat was finished in G.R.P. throughout, including canopy, deck and engine case. Service with H.M.S. *Cumberland* showed some lack of adhesion of G.R.P. laminates to P.V.C. core (attributed to constructional techniques) but it was considered that the rigidity of the shell and elimination of frames given by the sandwich method of construction was a sound technique for small boats. There was the usual decline in appearance of the boat and although the abrasive resistance of outer laminate was better than in earlier G.R.P. boats it was still not good enough for Service use.

Following extensive prototype evaluation and modification, the boat was allocated to H.M.S. *Tyne* for further trial as a result of which it was found that the G.R.P. showed no sign of surface deterioration ; the non-skid surface of the G.R.P. deck was not adequate ; a reasonable appearance could be maintained by washing with water and detergents.

Other trials or consideration have been, or are still being, given to 52$\frac{1}{2}$-ft harbour launches, 8 ft 6 in. and 12-ft heavy duty dinghies, 18-ft motor boats and 29-ft survey boats.

As a result of this 10-year trial period the Admiralty has formulated a standard repair kit for plastic repairs, which may also be used for semi-permanent plastic repairs to wooden boats.

Due to the reported ' fall off ' of appearance of G.R.P. boats, Central Dockyard Laboratory, Portsmouth, are carrying out further tests of numerous paint schemes to ascertain the most suitable for G.R.P. application. As yet, a paint scheme for fast planing hulls cannot be recommended.

The conclusions reached by the Admiralty as a result of these exhaustive trials of G.R.P. boats are as follows :—

Materials

Glass

1. Low alkali glass is more suitable for marine work.
2. The glass reinforcement prior to use must be dry.
3. Glass mat, although not so strong as glass roving and cloth, is quite satisfactory for boat hulls up to 30 feet in length of low or medium speed with inboard engines.
4. The introduction of glass woven roving between layers of glass mat should be considered for craft above 30 ft.

Resins

Polyester resins :

1. Selected resins suitable for marine application should be used.
2. Clear resin for all other than the gel coat of a laminate aids inspection.

3. A proportion of flexibilizer (or a specially prepared resin) is necessary for gel coat resins to prevent surface crazing, etc.

Epoxide resins :

1. Should be used for securing items after the hull has cured.
2. Are most suitable for use as a repair resin.

Fillers :

Fillers in the resin mix, in general, increase water absorption properties and, with particular reference to the gel coat, produce a rigidity resulting in star shakes and other surface blemishes. Their use is not therefore recommended.

Construction

(*a*) Cold set hand lay-up techniques are satisfactory, provided that they are carried out under temperature-controlled conditions.

(*b*) Resin tends to crush around fastenings and it is necessary to place wood, metal pads or special ' plastic ' washers under the heads and points of through fastenings.

(*c*) Use of through fastenings to be kept to a minimum because of seepage along the fastenings. It is preferable to bond resin/glass angles or lugs, etc. on inside of G.R.P. hull for securing purposes.

(*d*) Wooden engine bearers are more economical than G.R.P. for Service boats because of alterations often required when re-engining is undertaken.

(*e*) Timber and plywood should be used in a G.R.P. hull where it proves to be satisfactory and economic.

(*f*) Monocoque construction, i.e. side benches, thwarts, flats and bulkheads, etc. all of G.R.P., should, because of the numerous moulds needed, be considered only where large numbers are required.

(*g*) G.R.P. hulls up to at least 16 feet in length can, by use of sandwich construction, be given sufficient rigidity to dispense with longitudinal and transverse framing and buoyant material can be efficiently incorporated.

(*h*) G.R.P. decks having a non-slip pattern incorporated in the outer resin layer do not exhibit sufficient non-skid characteristics.

Service Characteristics

(*a*) G.R.P. boats up to at least 30 feet in length, are adequate for Service requirements in respect of strength, impact strength and watertightness.

(*b*) Not being subject to rot, microbe attack or shrinkage the maintenance of G.R.P. boats is appreciably less than that required for wooden boats.

(*c*) Tropical service of a G.R.P. boat does not necessitate the fitting of outer bottom sheathing.

(*d*) Although G.R.P. does not possess anti-fouling properties, marine growth is easily removed.

(*e*) Repair of G.R.P. boats, both shore-based and shipborne, is simple and quicker than repair of wooden boats.

(*f*) ' Fall-off ' of appearance that has been experienced with G.R.P. boats can be overcome, for other than fast planing craft, by painting.

Comment

A progressive scheme of manufacture and repair of G.R.P. has now been incorporated in the training syllabus of shipwright apprentices at H.M.S. *Caledonia.*