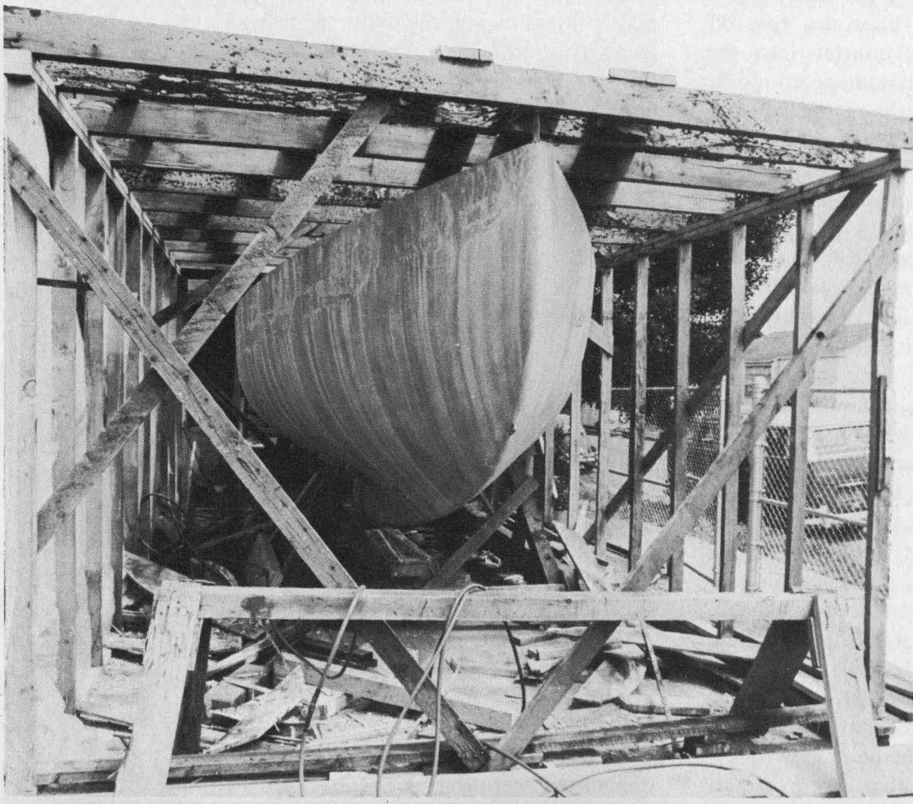
HOW TO BUILD FLICKA



PART FIVE · CURING

COMPLETE PLANS/ILLUSTRATIONS BY BRUCE BINGHAM

□ Many people assume that the hardening of concrete is simply a matter of its drying out, but this is incorrect. Cement hardens and gains its strength through a process known as hydration—the development of a crystalline formation or ion complex created by the restructuring of the elements within the mortar. This chemical reaction is activated and maintained only through the presence of water, which in effect acts as a catalyst much in the same way as with those of polyester resins. This chemical reaction is one of the most important elements in your boat's eventual strength and longevity. Because hydration occurs on a rapidly decelerating scale, it is during the initial life of the mortar that this process is most critical and during which it may achieve as much as 95 percent of the final strength (Portland Type 1).

There are several basic factors that readily affect the rate and success of hydration. The continuous presence of water moisture is imperative and must not be taken lightly. If any portion of the plastered hull is allowed to dry out prior to the completion of the curing cycle, hydration will be almost completely arrested. Hydration cannot be re-activated and the strength of the concrete at the time of drying will be increased only slightly during the remainder of the vessel's life. Let's examine the vast difference in finished strengths between properly cured concrete and that of dry-cured concrete. In Chart I, I have compared not only wet and dry cured compression strengths but that of steam cured as well. Heat has a tremendous effect not only on the rate of strengthening but on shrinkage, too. You can see that the time required to reach maximum compression yield may be reduced substantially by inducing a higher temperature but this must be done very deliberately to prevent blistering and cracking. Conversely, extremely low temperatures slow down the hydration process and at freezing temperatures, curing ceases and severe damage may result from ice crystal expansion. This can be alleviated by using several space heaters within the curing chamber.

Serious drying can result from failure to protect the hull from direct sunlight or wind. This, of course, not only arrests hydration but also causes hairline cracks to develop. Another detrimental effect is that direct sunlight or wind may cause one side of the hull to heat or cool at a different rate than the other. This produces a differential in the shell expansion which can break down the structure of the concrete, resulting in spalling or flaking of the mortar skim coats. This is a very common sight and is often the result of lackadaisical preparation.

Polyethylene sheets are used as vapor barriers to cover the hull or the entire scaffold during curing and are available in opaque white and colors. While it is a little more expensive and less frequently available than clear poly, the opaque is well worth the time and extra effort to avert possible disaster. The polyethylene covering not only protects the hull from sun and wind, but also serves to hold the humid air around the vessel and to stabilize the curing temperature. The more air-tight the polyethylene chamber, the better.

The Wet Cure

Preparation of the curing system must be completed well in advance of plastering day and should be thoroughly tested before being actually put into service. The most popular and successful method of wet curing is to lay several lengths of garden soaker hoses along the vessel's sheer (upright construction) or keel centerline (inverted construction). Because the water pressure is higher at the input end of the hoses, it is better to route the flow through manifolds rather than connecting them in a continuous series. The hoses may be held in position with weights or sheet metal brackets and an even water distribution is created by laying burlap strips or old blankets on the concrete surface. The important thing here is to keep every inch of the vessel wet.

The poly sheets may be pre-attached to enclose the entire scaffolding (upright construction) or A-frame staging before plastering day, then rolled out of the way. The best fastening method is to tack pieces of scrap battens over the poly against the scaffold timbers. The longer the batten, the better, as this lessens the possibility of strong winds tearing the poly sheets. As soon as the finishing strokes have been completed, roll the poly sheets to the closed position, seal the seams with plenty of tape and pack sand or dirt around the base.

If the hull is being constructed on natural ground, excessive water collection may create a serious problem by causing the vessel to settle into the muck. This rarely occurs evenly, thus straining and twisting the shell dangerously. Many builders have found it wise to rig a polypropelene sump under the boat to catch the drippings. A heavy duty submersible bilge pump is then used to route this water back to the soaker hoses, thus devising a partially recirculating water system. Keep in mind that this pump must not only be strong enough to lift the water up to the soaker hose again but to pressurize the system as well.

Before allowing the fresh mortar to harden, poke a 1-in. hole through the side of the armature at the lowest portion of the keel (upright construction) and in any other area where standing water may collect. This prevents an excessive weight buildup which could cause bulging of the hull and possible cracking. Do not depend on siphons

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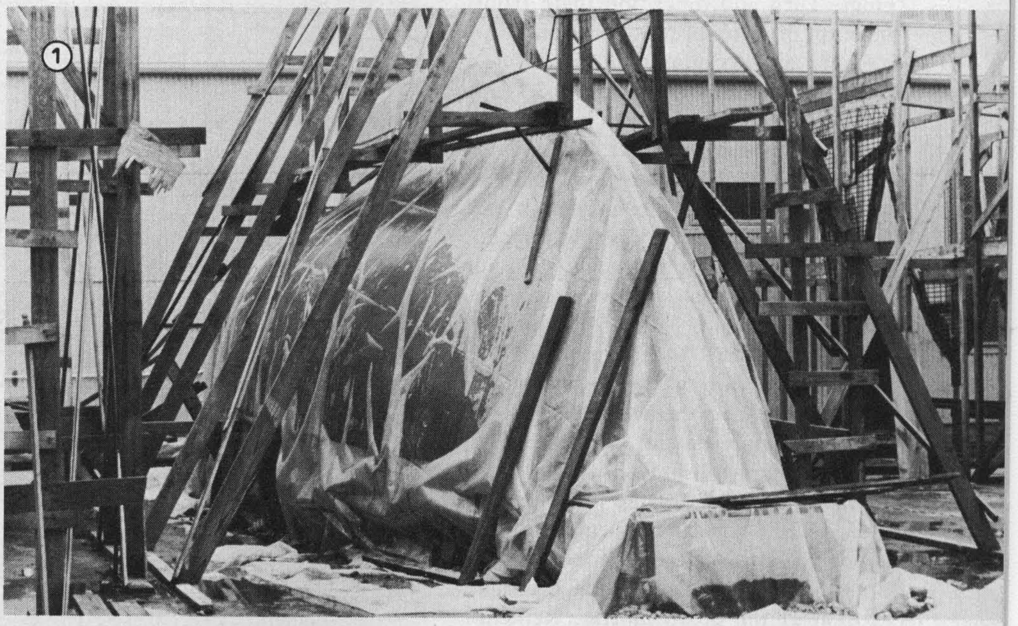
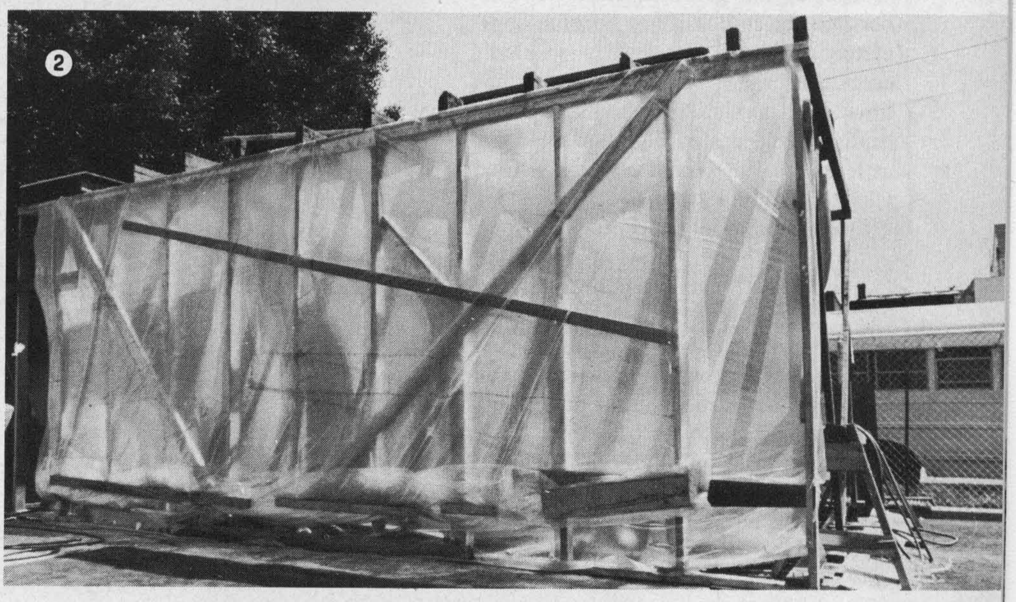
An inverted hull (1) can be shrouded with polypropelene plastic sheeting, but it must be checked frequently to insure even distribution of the water. When the hull is built upright in a scaffolding (2), the entire scaffold is covered with plastic to create a "hot house" effect.





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or pumps to carry off this water, as they inevitably become jammed or clogged with concrete chips and loose aggregate. Once the hull has fully cured, the drain holes can be easily filled with an epoxy grout with no loss of hull strength.

The wet curing cycle should not actually begin until four to eight hours after the completion of plastering. To start before this time would wash away the outer cement and dislodge the surface aggregate. If, however, hydration is delayed for more than 10 to 12 hours after plastering, you will run the risk of drying the hull and incurring hairline cracks. Don't forget to cure your test panels. They may be wrapped in burlap and placed under the hull to take advantage of the drippings. Turn and reposition them from time to time to prevent erosion. Remember also to photograph every detail of your curing operation and keep accurate records of your inspections and chamber temperatures. These documents will help to provide a graphic history of your boat's construction for future certification or possible buyers.

Because of the rapid early gain in strength, the first week of curing is the most vital. Do not walk on the hull or jar it in any way. Keep the vessel totally soaked during this period, then gradually reduce the water flow to a uniform dampness for the last few days. This will prevent a sudden drying and change of the hull temperature. Make sure that no water flows or drips onto any one concentrated area, as this may cause the eventual erosion of the green mortar. Remember that the hull will not become completely hard until it is dry so don't erect the cradle or shoring until that time. For maximum strength, the hydration cycle should be maintained for at least the full period indicated. (See Chart II) While 28 days of wet curing has been commonly accepted as a general rule of thumb, it has been conclusively proven that extending this period to any degree increases the strength as well as the shell's protection against its corrosive environment. Don't be concerned about stains and streaking on the sides of the vessel as these are normal mineral deposits which will disappear when the hull is acid-etched before sealing.

Ideally the hull should be inspected several times a day and periodic shifting of the hoses or burlap may be required from time to time. Spray down any area of the vessel which is not getting its full portion of the water flow. Jay Benford suggests rigging a timing mechanism on the water supply, which is a great idea. His system is to salvage a solenoid valve actuated by a micro-switch from an automatic dishwasher. The micro-switch is operated by a cogged wheel attached to an old

EFFECTS OF HYDRATION ON MORTAR STRENGTH

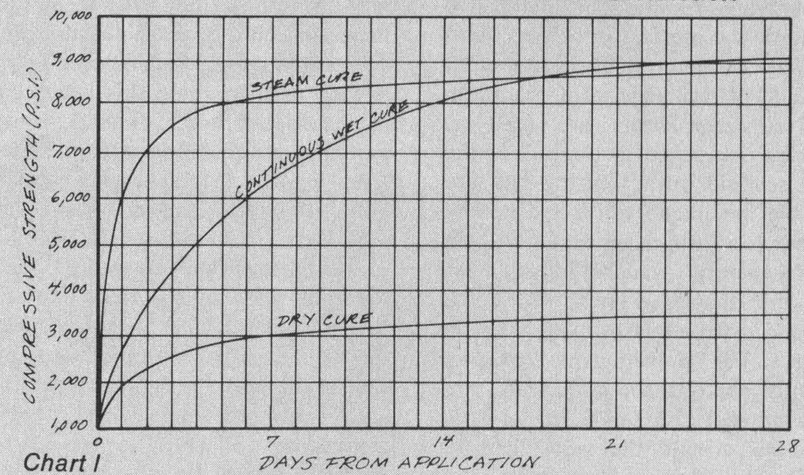

Chart I

MINIMUM RECOMMENDED WET CURING TIME

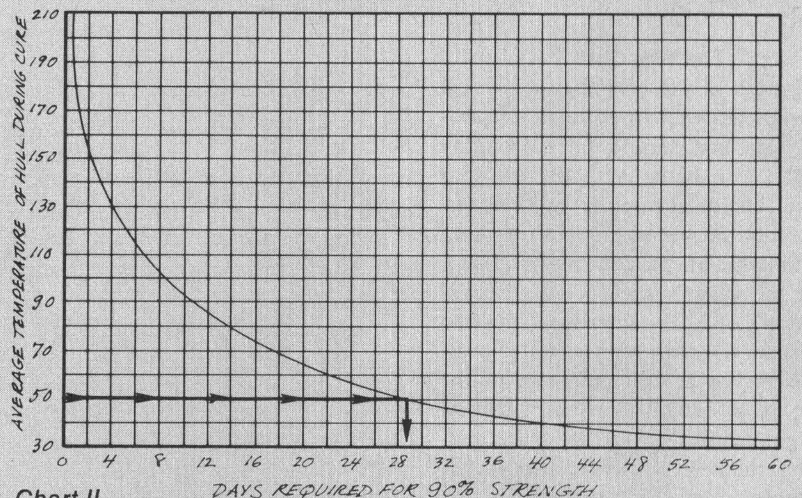

Chart II

MINIMUM RECOMMENDED STEAM CURING TIME

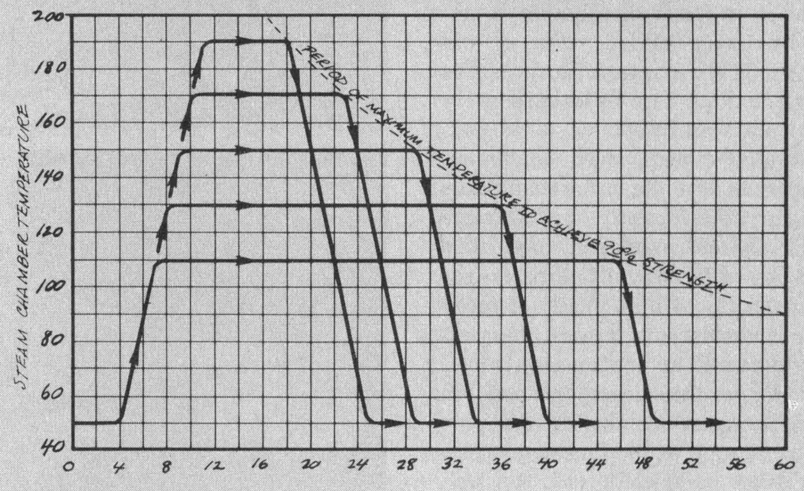

Chart III

Continued on page 72

FLICKA Continued from page 64

clock motor. The notches in the wheel are cut so that the water will be turned on for one minute out of every three. This has the effect of reducing the water bill.

Grinding and Grouting

Carborundum stones (available from any concrete supplier) are extremely effective in knocking down moderate high spots that may have eluded you on plastering day and will do the most good while the shell is still soft. When sanding with Carborundum, a mushy substance will develop on the surface and this will actually aid in sanding, but be sure you rinse this stuff off as you move to a different area of the vessel, as it will set up, filling the microscopic pores of the mortar (this reduces the bond of the epoxy sealer to be applied later). Some fashioning of sculptured detail may also be accomplished.

Fill shallow divots while the hull is wet as a good bond is created at the earliest stage of cure. This filling is done with "grout" which is simply pure cement and water. It should be mixed on the basis of workability (a creamy paste) according to the particular circumstances, but I must advise caution to avoid building a grout thickness in excess of ⅛-in. Grout has very little strength in itself and may have a tendency to crack or flake if built up to an unreasonable volume. A rubber squeegee or flexible wooden batten will work beautifully as an applicator. If grouting is done within the first week of hydration, it will then receive almost the full benefit of the cure cycle.

Steam Curing

As I noted earlier, the temperature of the water, air and hull have a tremendous bearing on the rate of strengthening of concrete. In essence, the higher the temperatures, the faster the cure. Theoretically, submerging your vessel into boiling water would result in the most successful hydration but, unfortunately, theory and practice are often worlds apart. The most successful alternative to submersion is the use of steam which envelopes the freshly plastered hull at normal atmospheric pressure. Steam curing has also been proven to have the marked effect of reducing the harmful electrolitic time required of wet curing, as well as de-

Continued on next page

FLICKA

Continued from page 72

terring corrosion through a more effective and dense crystal growth within the matrix. The proper use of steam hydration may have the effect of producing up to 90 percent of final concrete strength within a period of only 24 hours. Compared with the time, labor and mess of the 28-day wet cure, it is clear that there are many benefits to be derived.

The equipment used for steam curing varies widely. The most popular steam generator is the type used for cleaning car underbodies and may usually be rented from special machinery outlets. Regardless of equipment used, it is imperative that you make provisions for a back up system capable of completing the cure in the event your primary system fails. This may even require shifting to a wet cure system right in the middle of the cycle, after the hull has cooled sufficiently. Don't let yourself be caught short without sufficient recourse.

Covering the hull for steam curing differs widely from wet curing. Because polypropylene is affected by high temperatures, canvas or heavy fabric serves far better. This chamber should be as airtight as possible and should be sealed as soon as the vessel has been plastered. It is not recommended, however, that you enclose the entire scaffold or A-frame stage, as this would require steaming a tremendous volume. It is far better to construct a smaller framing with wood or steel hoops so as to encompass an area only slightly larger than the hull itself. When building this frame, try to avoid large free spaces above the hull as these areas could become "hot spots" of stagnant hot air.

Routing of the steam exit piping must be planned to develop the most even temperature gradient around the hull. Because the steam pressure is higher near the generator, it is best to pass the steam through a manifold, then into various separate pipes rather than connecting them as a continuous series. When curing an inverted hull, two pipe routes must be laid to provide for steam both on the inside and outside of the shell. If you steam only under the vessel, the vapor will simply rise to the keel area where it becomes stagnant without benefiting the outside of the hull. This must be avoided at all costs as it would cause an unevenness in the strength of the finished vessel.

The uniformity of the temperature and humidity around the hull is vital for proper steam curing. Simply filling the chamber with hot vapors will not do at all and many potentially good boats have been ruined in this manner. My suggestion is to install several fans fitted with vapor-proof motors within the chamber and hull to keep the air in motion and well mixed.

After the vessel has been plastered and the chamber closed, allow the mortar to set for three to four hours before beginning the steaming process. Keeping in mind the effects of thermal shock, slowly raise the temperature of the chamber with steam to 150° over a four to six-hour period. Once this temperature is reached, it must be maintained for at least 12 hours but preferably a full 20 hours. Then gradually lower the chamber temperature over four to six hours

Continued on page 76

FLICKA

Continued from page 74

until the ambient (outside) temperature is reached. Do not open the chamber right away, but give the hull plenty of time to cool and dry. If you are steam curing your hull under very cold ambient conditions, the heating and cooling periods should be lengthened. If your system is unable to produce the recommended 150° buildup, your maximum heat period will have to be lengthened, providing, of course, that the chamber air is water saturated. Chart III will show variations in the steam cure cycle. Keep a very close watch as the hull cures and accurately record the hourly chamber temperature. Above all, don't assume that your system will tend itself because it will inevitably go on the blink the instant you drop your guard.

Leaching and Curing Agents

There has been a lot of talk about chemical curing in lieu of hydration, but results are inconclusive at this writing so I will leave it to time to prove. There are curing agents, however, which do add significantly to finished strength, as well as contributing other important attributes. One such popular product among ferrocement builders is Crete-Seal manufactured by Tri-Col Products of Bakersfield, Cal. Crete-Seal is a colorless, watery solution which may be swabbed onto the hull while it is still wet after the full cure cycle, and left to soak into the concrete. It is most effective if applied to both sides of the shell as possible with the open mold construction systems. Its benefits are:

1). It literally seeps into the concrete through osmosis, thus filling the microscopic voids of the mortar caused by entrapped air. This results in a denser concrete shell.

2). The binding properties of Crete-Seal enhance the internal adhesion of the mortar components, thus creating an increase in shell strength.

3). The increased density of the concrete skim coat caused by Crete-Seal enhances the waterproof properties of the shell, as well as its resistance to oil penetration and armature corosion.

4). Crete-Seal retards the formation of "hot spots" caused by uneven drying of the cured hull, thus lessening the possibility of forming hairline cracks.

5). Hairline cracks may be sealed and bonded by the saturation of Crete-Seal.

6). Crete-Seal neutralizes and helps leach alkalis and lime which may exist within the cured shell. This one factor, alone, aids greatly the adhesion of epoxy sealers and paint.

Crete-Seal must be used directly out of the can without dilution. When applying to the hull, literally saturate the shell surface. Allow this solution to stand for about four hours, then rinse it away with fresh water. It generally takes 12 to 14 hours for Crete-Seal's chemical reaction to occur and about six days for the solution to completely harden within the concrete. Once the hull has completely dried, a white powder will appear on the hull surface which is simply a deposit of lime which has been leached out of the interior of the shell. This residue is easily rinsed away with fresh water. Successive applications of Crete-Seal are very desirable as it will cumulatively add to the benefits of the first washing. When, at last, no lime dust remains upon drying, you may confidently proceed with hull finishing. □