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U.S. NAVY

FERRO-CEMENT BOAT BUILDING MANUAL

VOLUME II

NAVAL SHIP SYSTEMS COMMAND
WASHINGTON, D. C.

1972

FOREWORD

This volume of the Ferro-Cement Boat-Building Manual covers plastering tools and their use, preparation for plastering, plastering, steam curing and hull repair. It has been assembled to give guidance to the people planning and organizing a boat-building project and to the men physically doing the work.

Applying the mortar to a ferro-cement hull is hard work. The chemical action of setting cement waits for no man. The people undertaking this strenuous and exacting job must work hard and fast to properly apply the mortar to a hull. The mortar must thoroughly penetrate the mesh, and be smoothly finished both inside and out or all the good work preceding plastering can be destroyed.

Plastering is an extremely crftical stage of boat-building but the most rewarding. All that precedes plastering and follows is overshadowed by the plastering job itself. The skill of all the men working in the boatyard is on display by the finish, and water-tightness, of the completed hull. The skill of a good plasterer will result in not only a rugged but a smooth and fair ship which will be viewed with pride by all who see and use her.

TABLE OF CONTENTS

-END OF VOLUME II -

INDEX OF TRAINING FILMS CORRESPONDING TO THIS TEXT

TRAINING FILM SERIES NO. 5862-1-72

Film No.	Title
(10)	Meshing Hulls-Preparation For Plastering
(11)	Plastering Tools and Mixing Mortar
(12)	Plastering a 65' Hull
(14)	Steam Curing
(15)	Water Testing and Repairs
(16)	Moving and Rolling Hulls
	General Films
(17)	Building a 65' Patrol Boat Hull
(18)	Building a Fishing Fleet

PLASTERING TOOLS

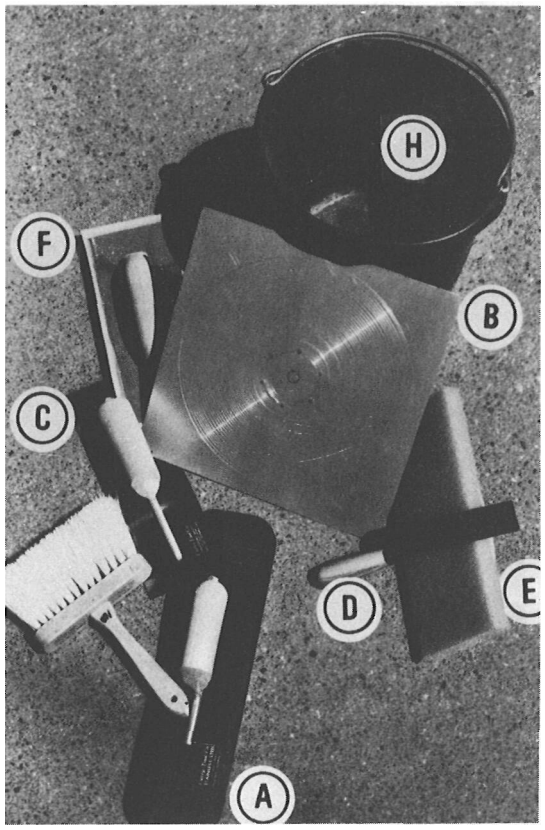
AND

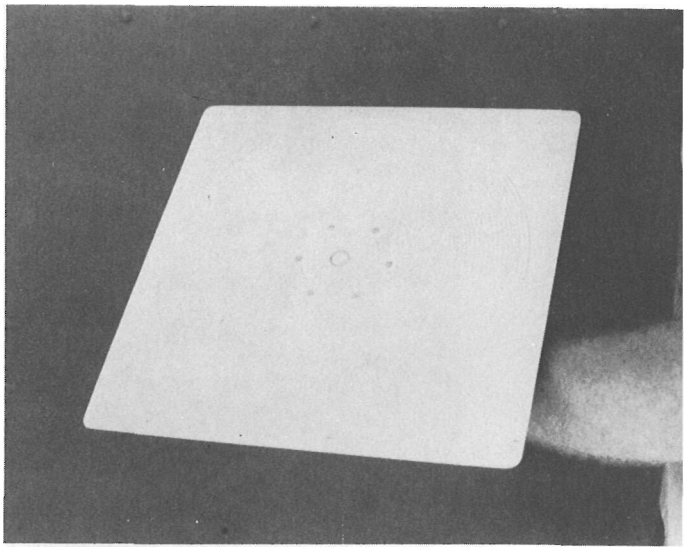
THEIR USE

PLASTERER'S TOOLS AND THEIR USE

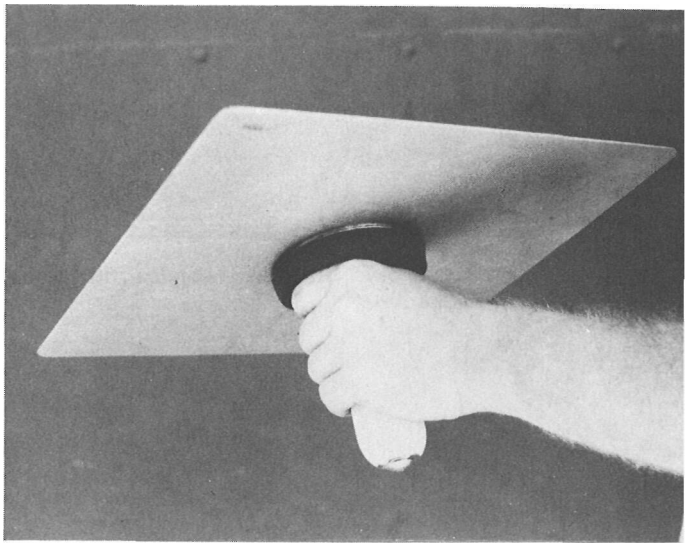
The basic hand tools required for applying the finishing mortar on cement hulls are:

A — Swimming pool trowel.
B - Hawk.
C - Standard 4" x 12" (101.6 mm x 304.8 mm) trowel for application and smoothing.
D - Edger.
E — Smooth sponge float.
F — Coarse sponge float.
G - Water brush.
H - Bucket





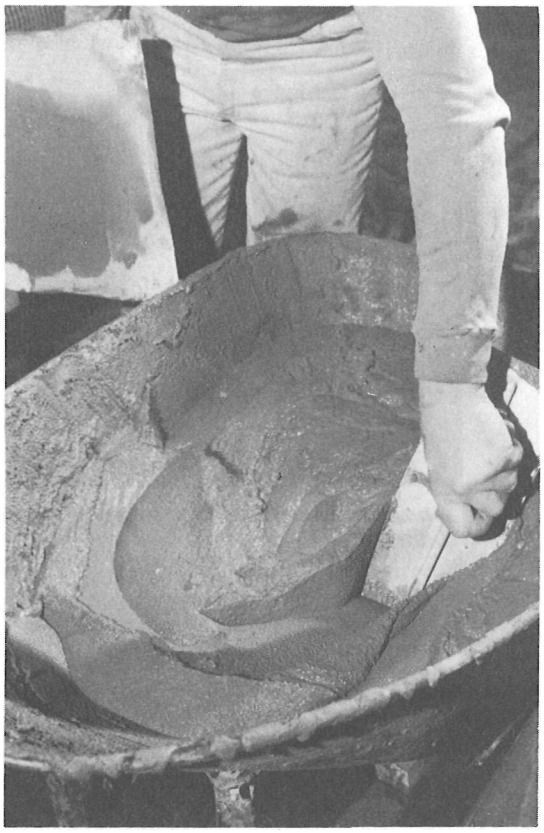
A hawk has a serrated top to stop mortar from sliding off.



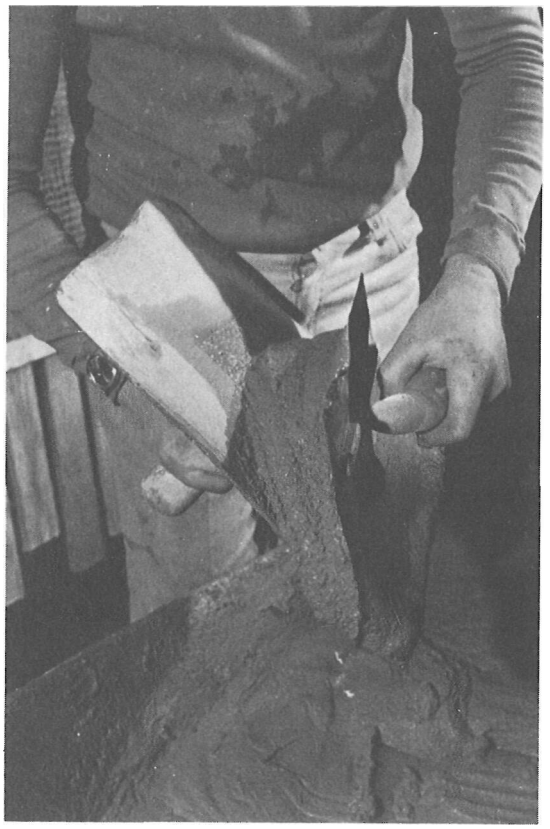
The hawk has a comfortable sponge cushion to make it more comfortable to hold.

THE HAWK AND HOW TO USE IT

A hawk consists of 12" square (304.8 mm square) aluminum plate with a wooden handle attached to the bottom center. The hawk is normally held by the handle in the plasterer's left hand. It is used to hold the mortar while the plasterer is applying it to the hull. The following sequence illustrates how to hold and use a hawk.

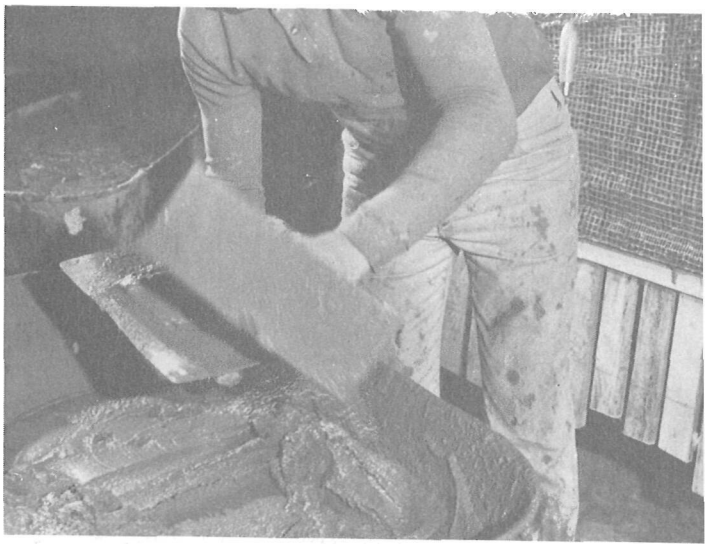


First, a quick stir to the wheelbarrow-load of mortar.

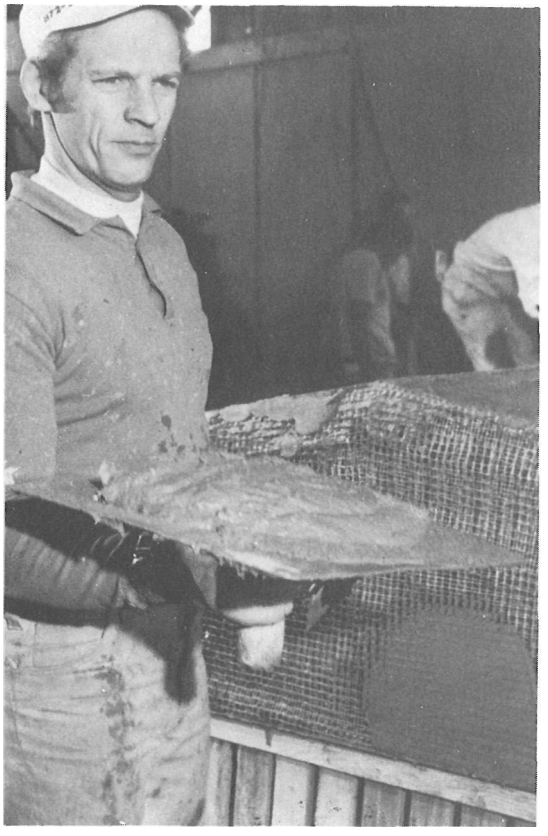


Scooping the mortar right onto the hawk.

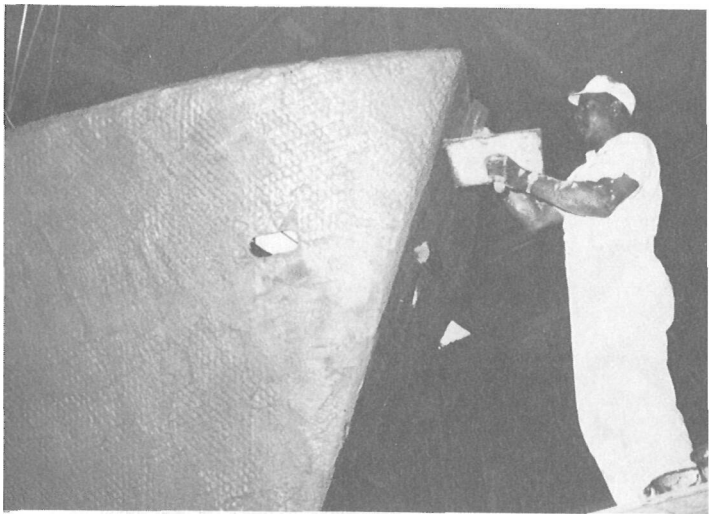
Use both the trowel and the hawk to load the hawk.



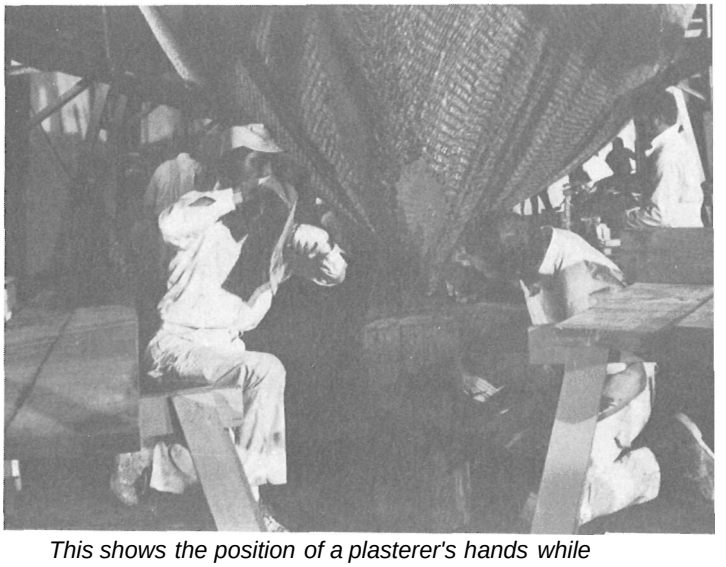
Trim the mortar off the edge of the hawk.



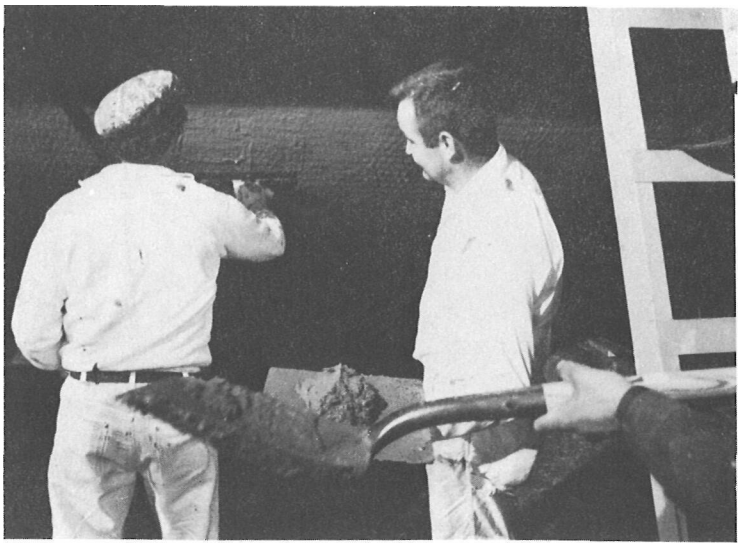
Don't load the hawk too full.



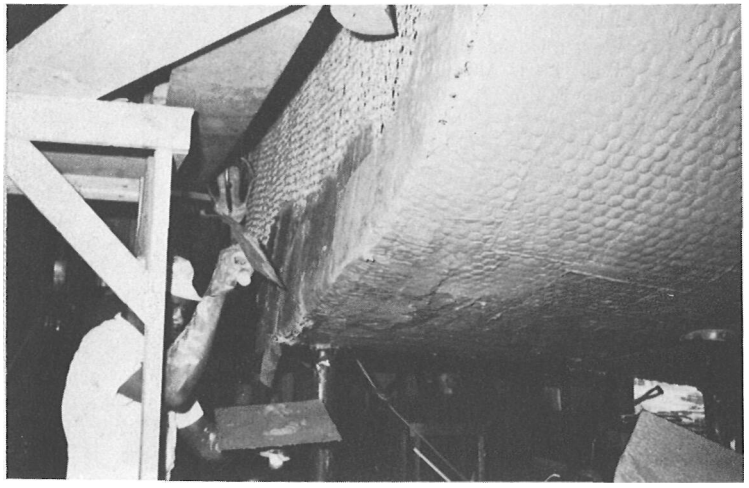
The mortar is scooped right off the hawk onto the hull.



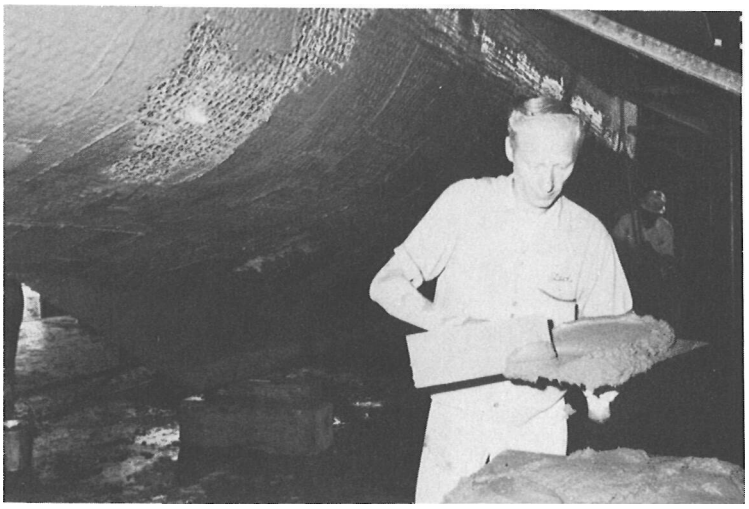
This shows the position of a plasterer's hands while effectively applying the mortar to the hull.



A helper loads a hawk with a shovel.



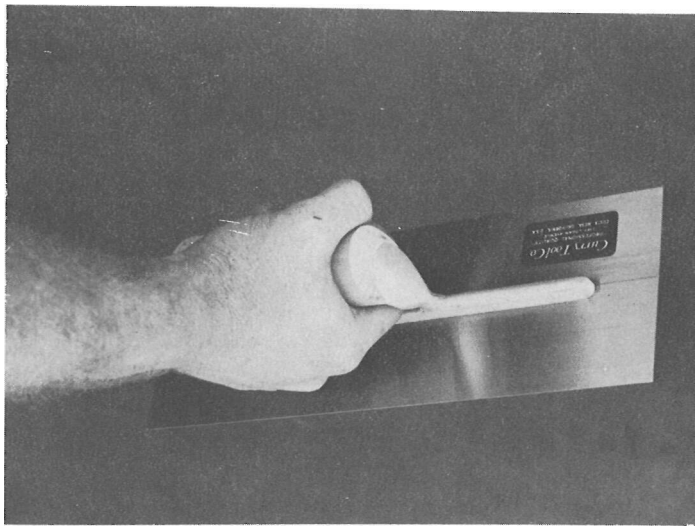
Hold the hawk under the work to catch the mortar which falls back.



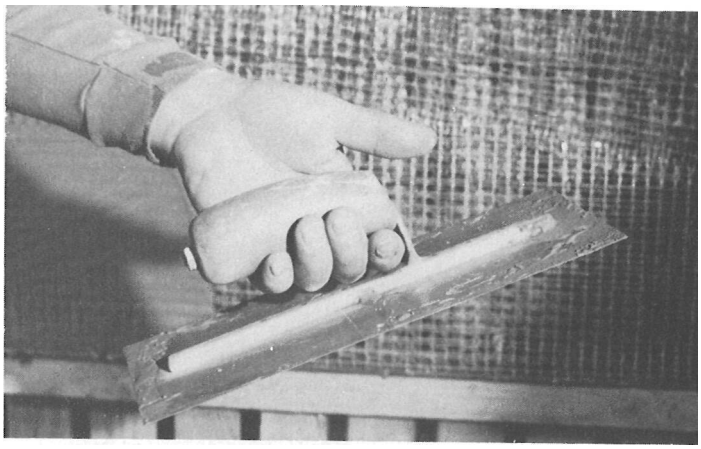
Loading a hawk from a mortar board.

STANDARD STEEL TROWEL

The standard steel trowel has a 4" x 12" (101.6 mm x 304.8 mm) stainless steel face. A wooden handle is attached to the back. The handle is bolted onto a casting which is riveted to the trowel blade. Care must be taken not to damage the sharp edge of the trowel. If the edge of the trowel is nicked, the nick will drag marks over the work as the mortar is being spread and smoothed. Care must also be taken to keep the trowel handle securely fastened. If the handle is allowed to become loose the plasterer will not be able to control the trowel. The following sequence illustrates how to use a trowel.

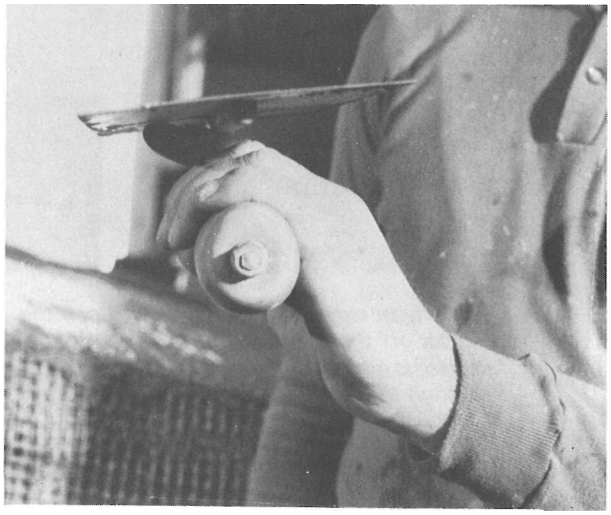


Standard trowel.



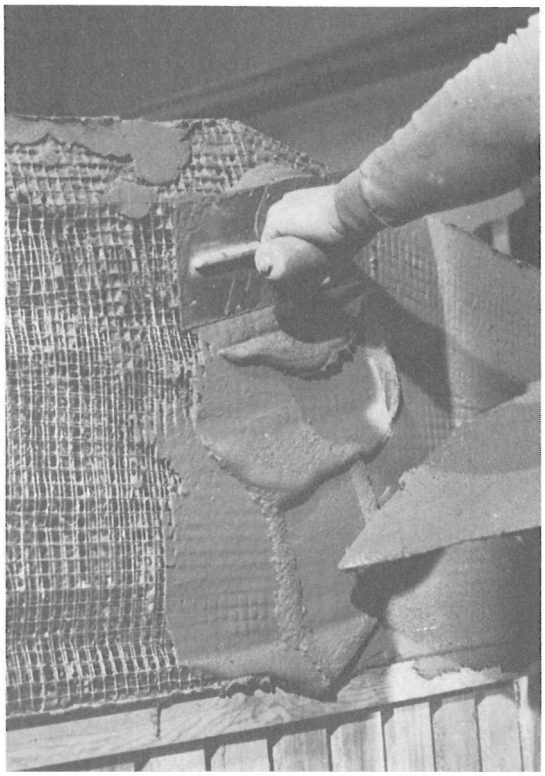
Balance the trowel in the hand.

Use the fingers in guiding the blade in overhead strokes. Be sure to keep the back of the trowel and the trowel handle clean. If mortar is allowed to build up on the back of the trowel the sand in the mortar will soon blister the hand of the plasterer

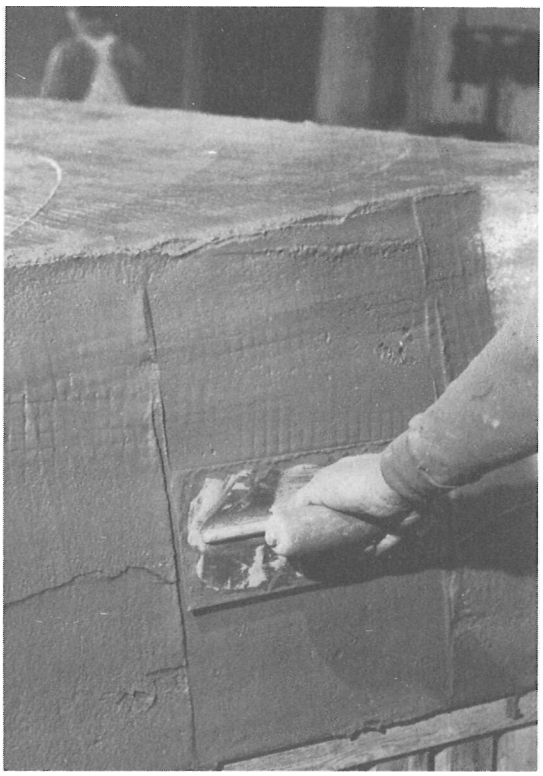


Always keep the nut on the back end of the handle tight thus preventing the handle from turning.

The front end of the trowel handle is recessed to receive the bolt which holds the handle. If the handle is allowed to become loose this wood recess may become damaged and it will not be possible to keep the trowel handle tight afterwards.

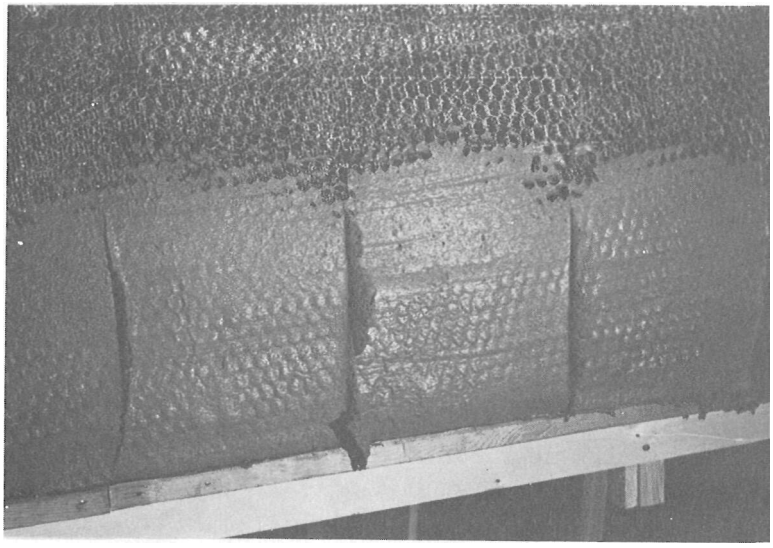


The proper way to apply mortar. Punch the mortar off the hawk against the hull. If the mortar is punched it will penetrate all the way through the mesh. Never spread the mortar off the hawk.

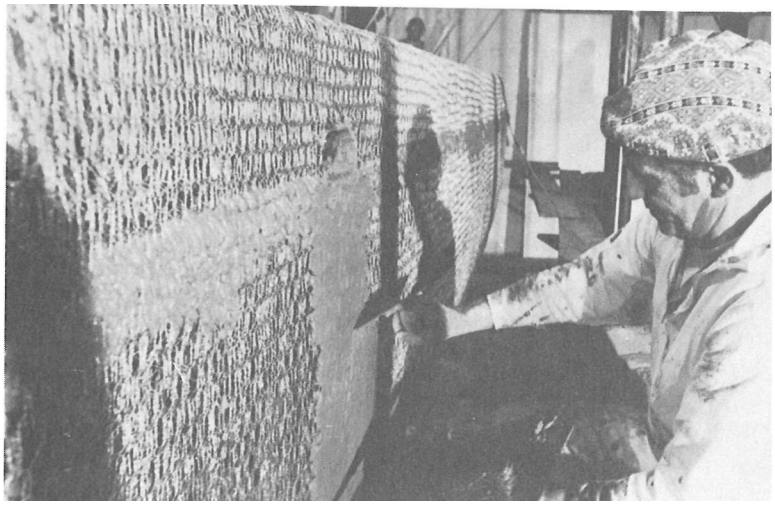


Only after mortar has been punched against the hull is it spread.

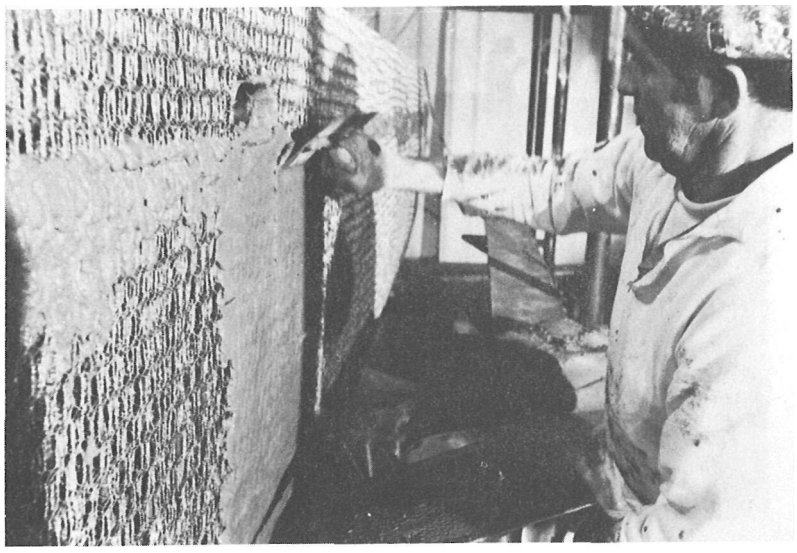
Mortar which has penetrated the mesh properly.



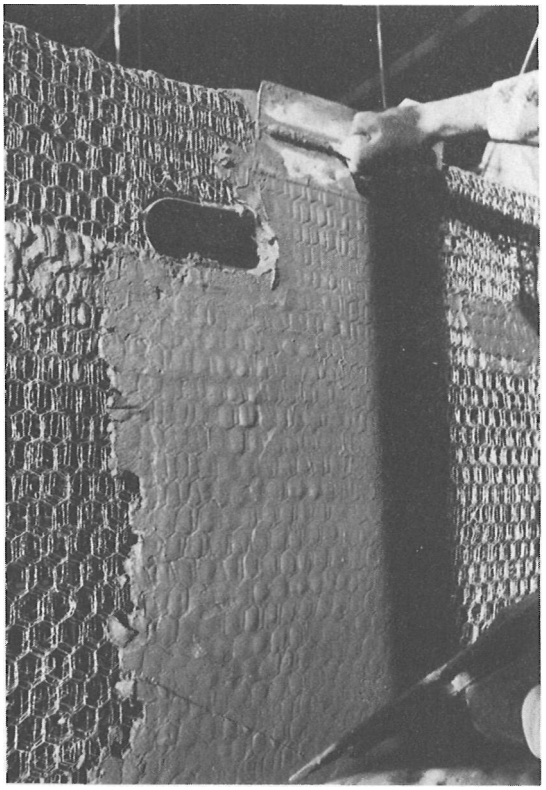
This illustrates a series of trowels of mortar which were punched on. After the whole area is gone over in this manner, the mortar will be spread.



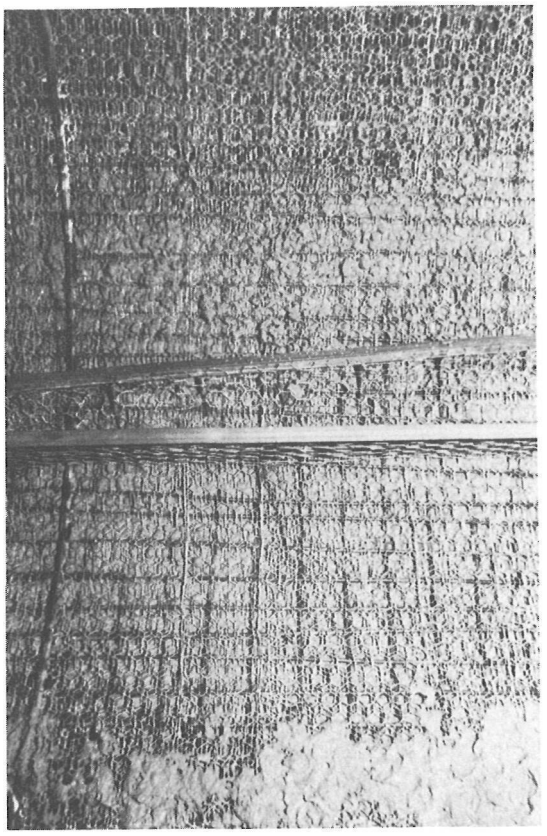
This man is illustrating how NOT to apply mortar.



He is applying a thin skin on the outside of the hull mesh and spreading it.



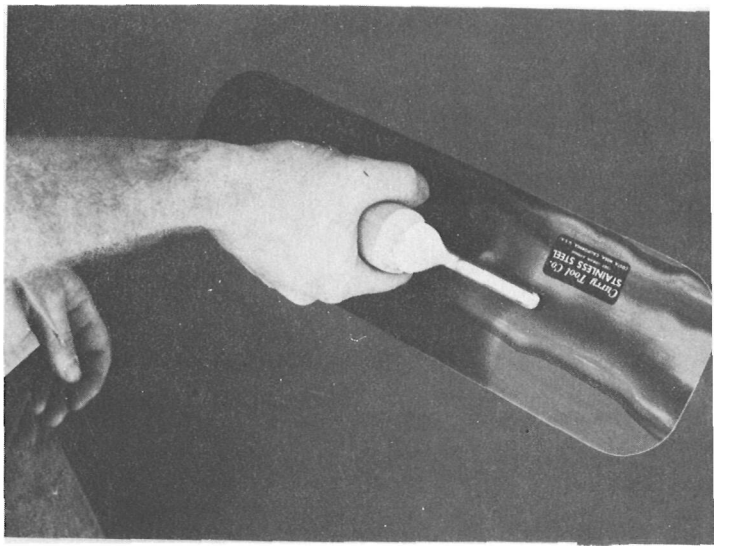
A thin skin of this type only penetrates the outer layers of mesh. If mortar is applied in this way from both inside and outside the hull a lamination will result between the two layers. There will be mortar on the mesh on both sides of the hull shell but air pockets will be formed against the rods. If this occurs these voids will eventually fill with water and could seriously damage the steel reinforcing thus considerably shortening the life of the hull.



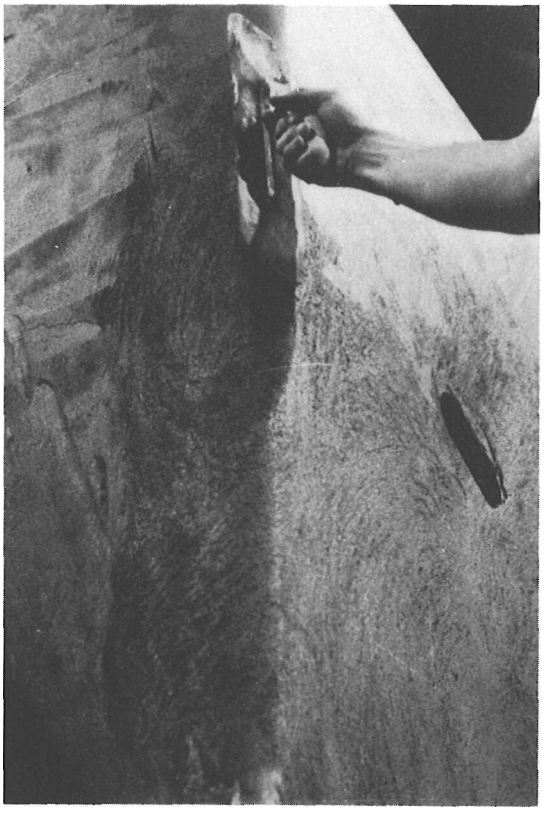
This is an area shown from the inside where the plasterer has merely spread the mortar rather than punched it against the hull. Mortar spreak like this will leave pockets of air in the reinforcing.

THE SWIMMING POOL TROWEL

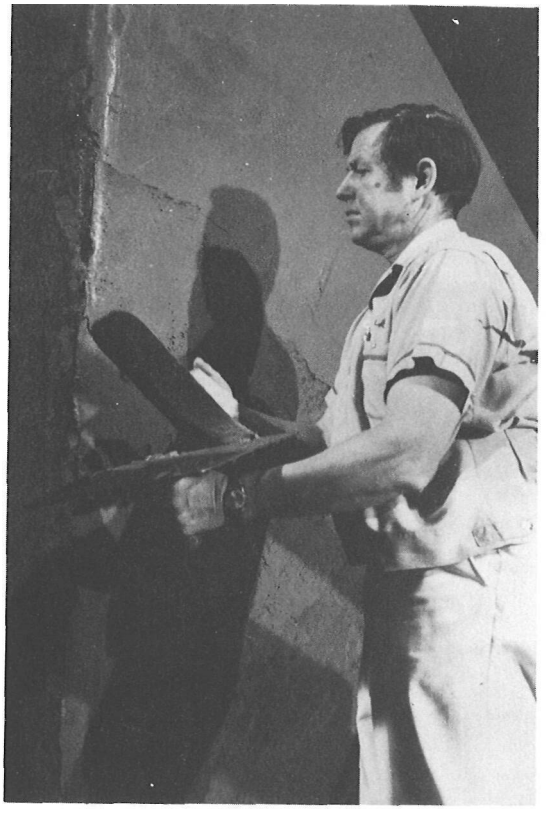
The swimming pool trowel is much the same as the standard plasterer's trowel except for its rounded corners. These rounded corners prevent the edge of the trowel digging into the surface of the concrete as the plasterer trowels the finish smooth. A boat hull consists of a series of compound curves which are difficult to finish with a standard plasterer's trowel without leaving ridges behind the trowel as it passes over the work.



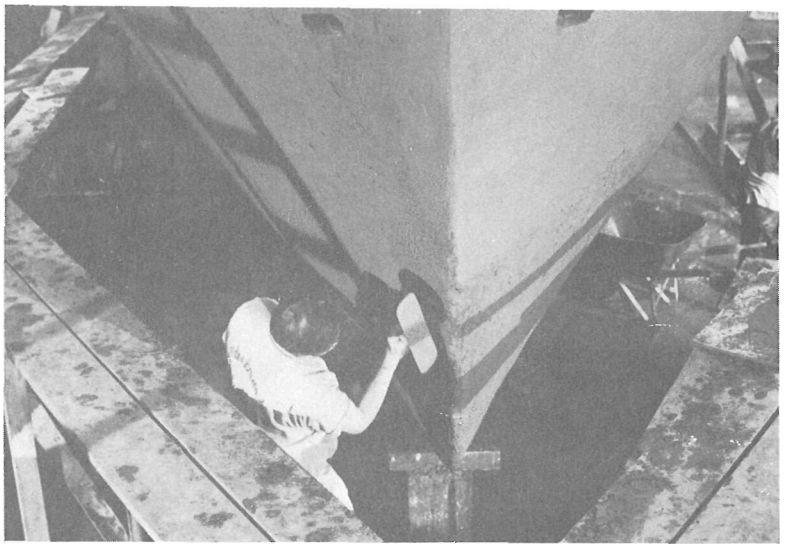
Swimming pool trowel with stainless steel blade.



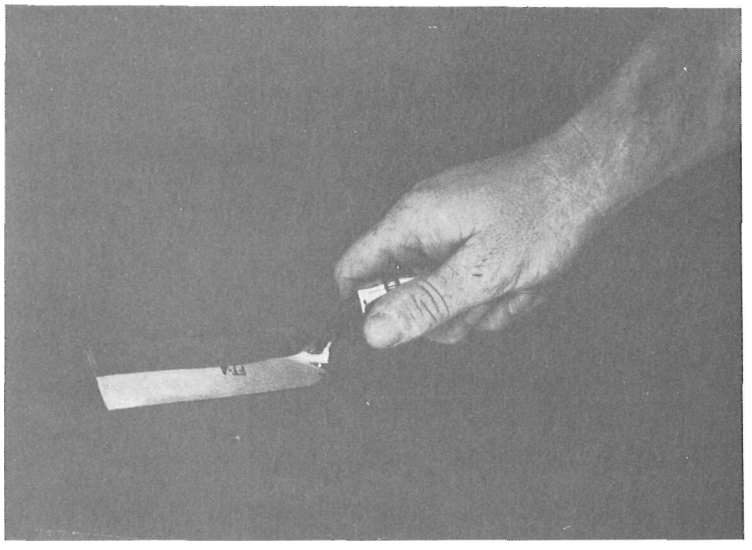
The swimming pool trowel is used for finishing work. Here the hull has just been sponge-floated and the plasterer is now starting the first part of steel troweling.



The swimming pool trowel is first used to apply the skin coat.



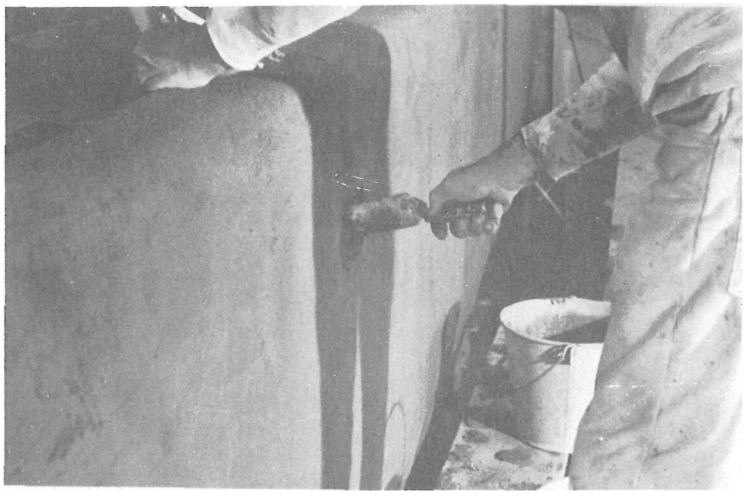
This illustrates the shape of the swimming pool trowel.



Theedger.

THE EDGER

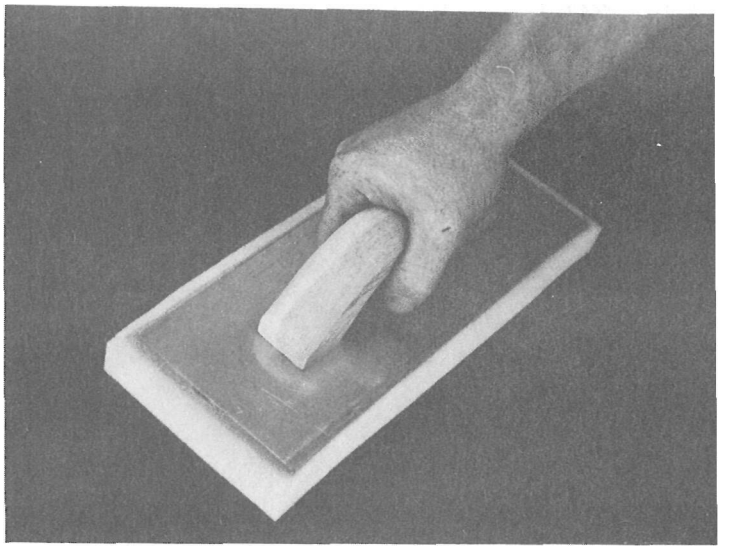
The edger is a small rectangular trowel used mostly for work in difficult corners. A plasterer customarily carries this tool in his hip pocket and uses it frequently for cleaning off the back of his trowel.



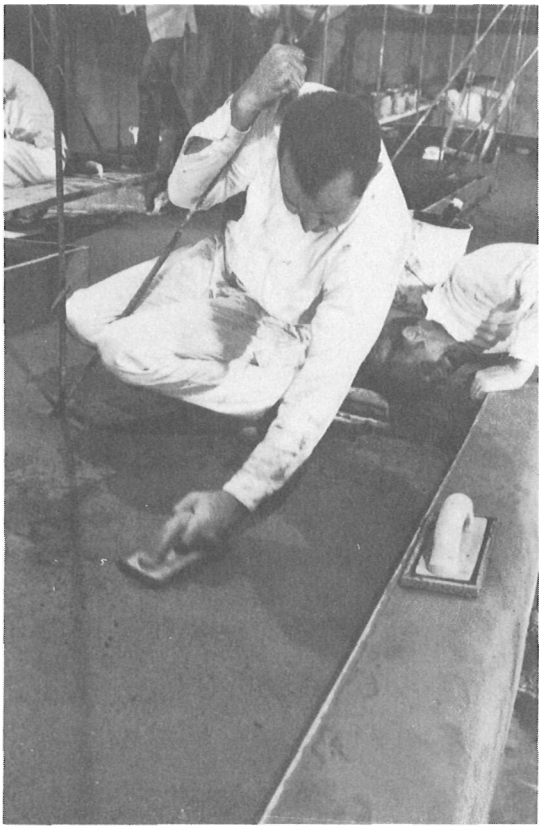
An edger being used to clean out a scupper hole.

SPONGE FLOAT

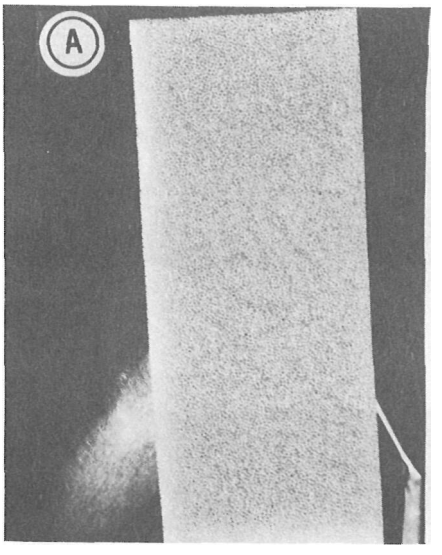
The sponge float is made on a wood or aluminum base. It has a wooden handle attached to the back and a sheet of approximately 1" (25.40 mm) thick sponge rubber is affixed to the base. The sponge rubber is obtainable in varying densities. The coarser sponge-face leaves a coarse finish. The finer face gives a smooth finish. The coarser-faced sponge float is used during sponge trowel when the mortar has taken its initial set. The fine-face is used for the finishing before steel troweling with the swimming pool trowel. The sponge trowel is used in a circular motion; it smooths the surface of the mortar by flattening out any ridges and by moving the surface mortar into the hollows. The sponge trowel can only be used when the mortar has started to set and there is no longer water on the surface.



Sponge float.

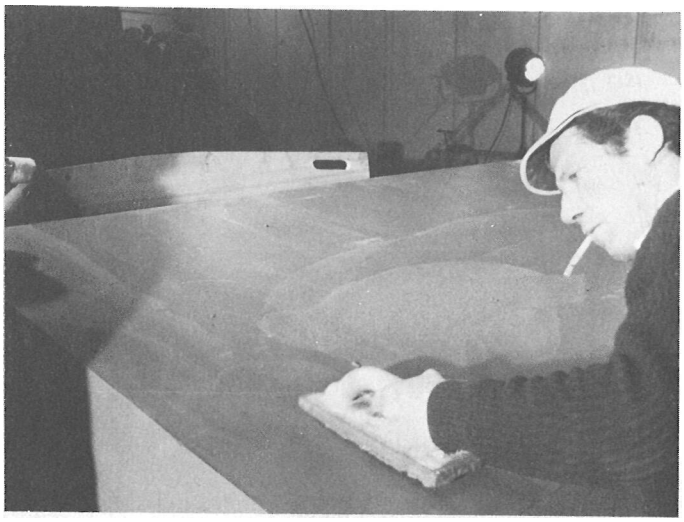


Here a coarse sponge float is being used to finish a deck.

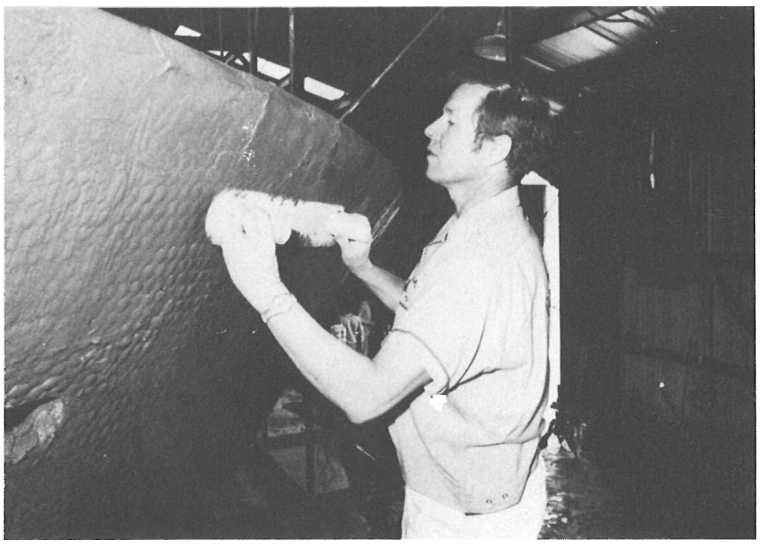


(A) Coarse-faced sponge float.
(B) Fine-faced sponge float.

Here the surface is still a little too wet for a sponge finish. Notice how the mortar is being left in ridges. On a large hull like this one, sponge floating has to be started fairly early as all of the hull mortar sets up at about the same rate.



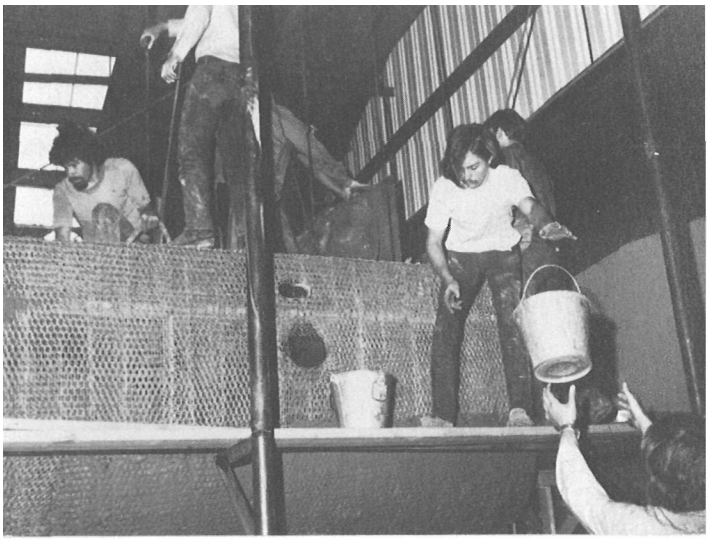
On a small hull with a small surface area sponge floating can be done throughout at just the right stage of mortar set. In this way the maximum smoothing effect may be achieved all over the hull.



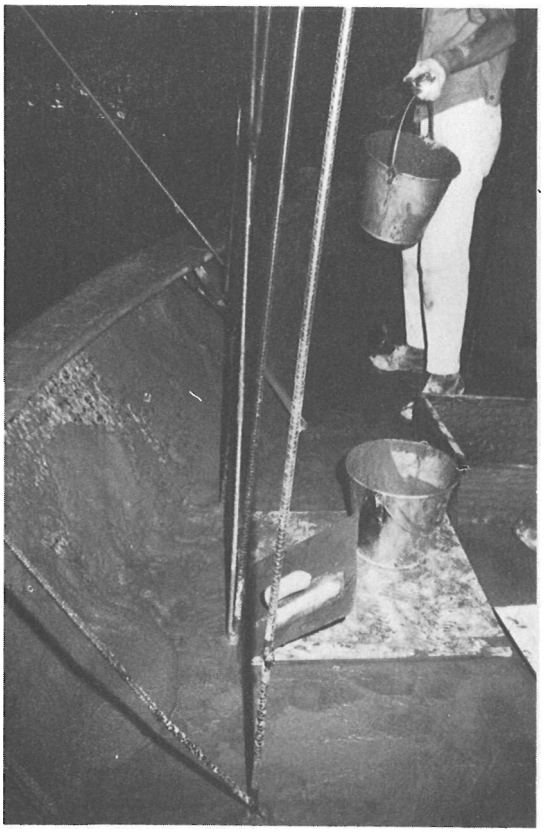
The darby is not an issue tool but some plasterers use them to assist in final fairing. The darby is being used here to check for lumps on the hull mortar.

GALVANIZED BUCKET

The $2^1/_2$ to 3 gallon (9.56259 liters to 11.355 liters) heavy duty galvanized bucket is the best size to use during plastering of a ferro-cement hull. The buckets must be strongly built to withstand the abuse received on plastering day.

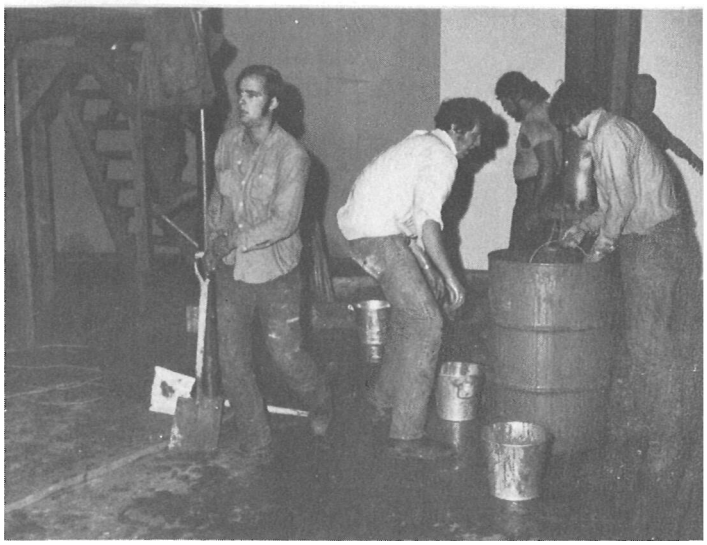


Buckets are often tossed around and get dented.



Wet mortar is heavy. A bucket of this capacity is the maximum the plasterer's helpers should be obliged to carry over all the obstructions which have to be negotiated on plastering day. These buckets are continually being lifted up to the deck from the floor.

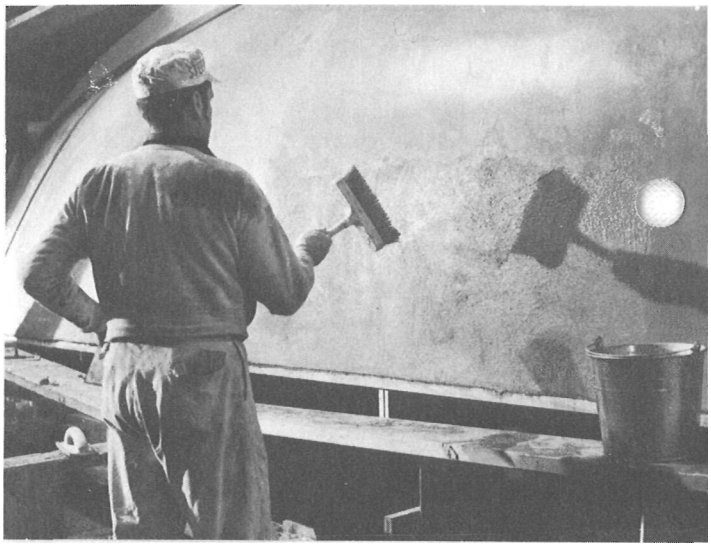
Always have a drum of water close to the mortar box so that the buckets can be rinsed after each loading. This will prevent the mortar from sticking to the bucket sides. If the buckets are not rinsed after each load mortar will tend to build up making the buckets heavy. This dead mortar may be inadvertently dumped onto the hull along with a load of fresh mortar, later causing problems.



WATER BRUSH

The water brush is a wooden-handled brush with long, soft bristles. Its basic use is to flick grout on the hull in final finishing. The plasterer uses this brush to assist in cleaning his tools throughout the day.

Water Brush.



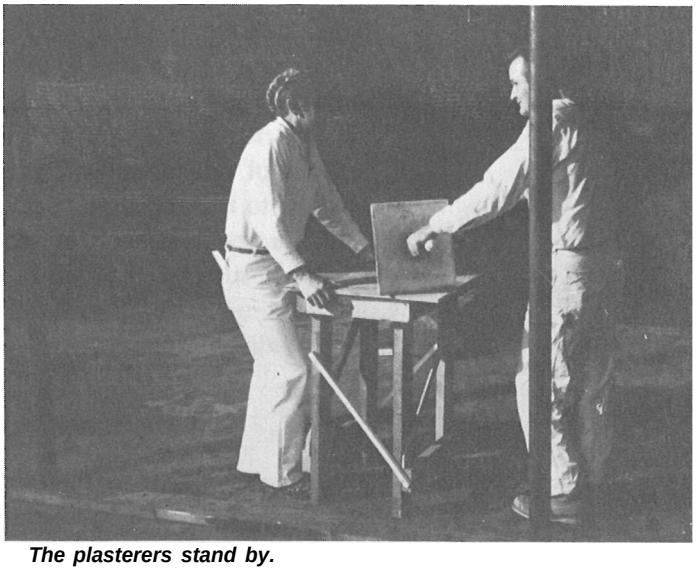
Here a plasterer is flicking grout onto the hull to assist in lubricating the surface of the mortar during final finishing. Note the edger in the plasterer's hip pocket.

The yard gets ready for plastering.

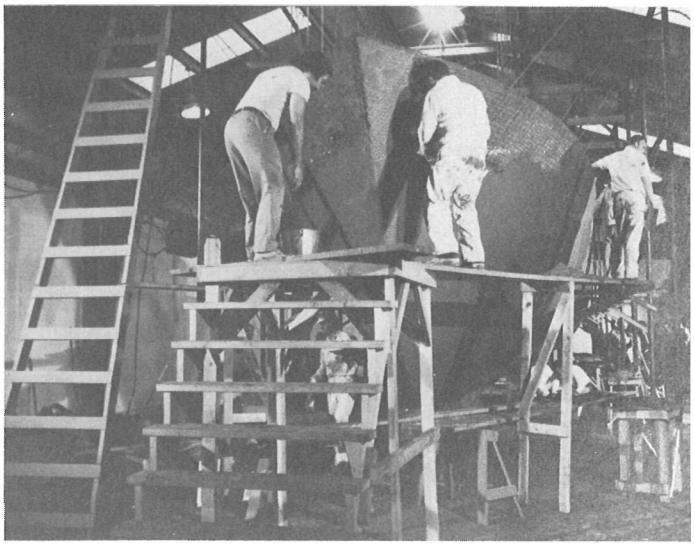
PREPARATION

FOR

PLASTERING



The plasterers stand by.



The scaffolding is prepared.

STAGE 3 - JOB 1
PREPARATION FOR PLASTERING

The plastering of a ferro-cement hull is a critical point of construction. Mortar only stays plastic for a few short hours before setting hard. Careful planning and preparation must precede the appointed plastering day. The following is a check list of details which must be attended to prior to plastering a hull.

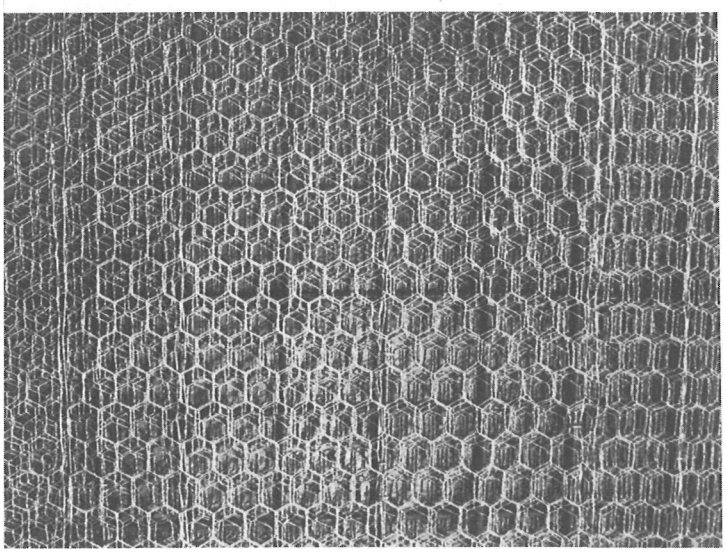
1. Mesh.

Is the mesh absolutely tight all over the hull? Special places to check are:

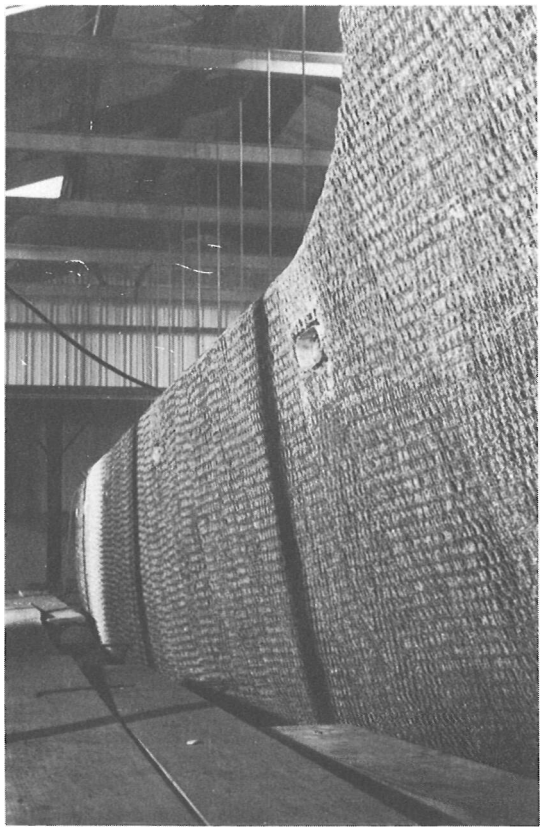
a. **The decks:** Check for tightness all over. Be sure all the mesh joints are well secured.

b. **The hatch coamings:** Check that there are no loose ends of mesh protruding at the top. Ensure the mesh is not rounded on the inside corners of the coamings but is laid in tight to the corner vertical rods. There is no stress on hatch coamings so ensure the mesh joint at the deck is square; do not let the mesh radius here.

c. The bulwarks: Ensure the mesh is laced back of the scupper holes. Check the mesh on the underside of the bulwarks cap. The mesh should be laced very tightly here. Loose ends of mesh should be bent in against the screed. If stanchions are used to support the bulwarks ensure that the drainage holes against the bulwarks are in place and that the mesh does not protrude around these holes. The mesh may form a straight radius at the bulwark and deck joint but this radius should be constant all around the deck edge. The mesh must lie below the level of the scupper holes so that the mortar may be matched with the bottom level of the scuppers to allow all the deck water to run out freely.



Deck mesh ready for mortar.



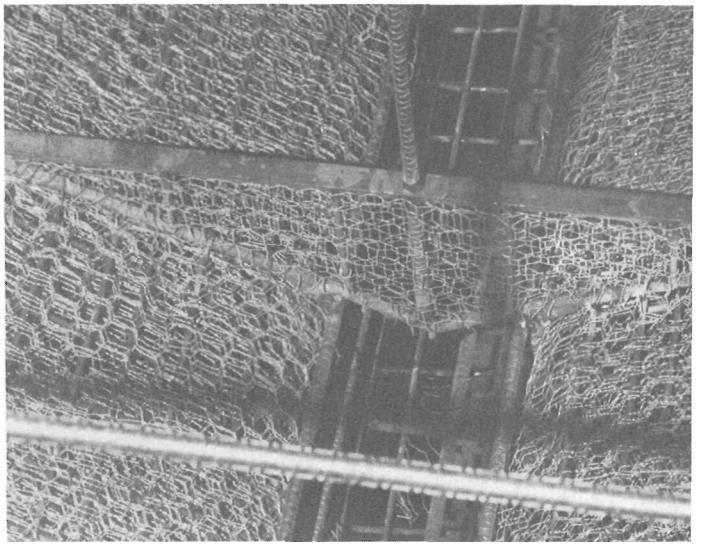
Hull meshed and faired, ready for mortar. Note how the scupper screeds project slightly beyond the surface of the mesh. These screeds will finish flush with the concrete surface.

d. Hull: Check to ensure that the mesh is tight and fair all over the hull. Be sure there are no loose hog rings or mesh ends protruding. Ensure the hull is absolutely fair.

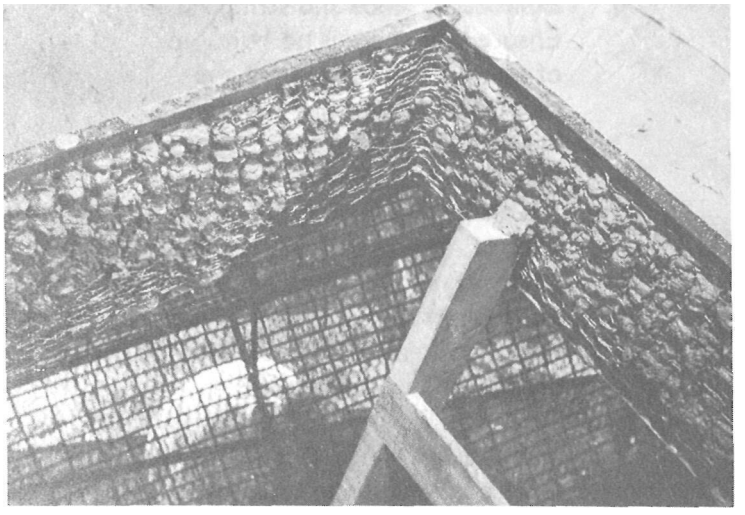
e. Transom: If the transom is designed flat ensure that it remains flat. Watch for build-up of mesh on the transom corners. If the mesh builds up too heavily on the corners of the transom voids will occur at this point. Better too little than too much mesh at the transom corner.

f. The Keel: Ensure that the mesh is laced tightly at the bottom of the keel. Do not allow the mesh to build up here. Two layers of mesh are sufficient at the bottom of the keel. These two layers will allow any mortar scraped or dropped off the inside of the hull during plastering to fall right through the mesh. A second, double strip of mesh may be added to the bottom of the keel after plastering the hull prior to plastering the keel bottom. Remember the keel is constructed like a concrete beam. The keel gets its strength from the heavy reinforcing rods used in this area. If the mortar which drops to the bottom of the keel during plastering is not allowed to fall right through it will remain there in the form of loose sand with no strength. This will always be a problem area later for the keel bottom will become a prime source of leaks. When the ballast is poured into the keel the fresh mortar cannot work itself around these lumps of old mortar. A concrete beam or keel only becomes strong when the fresh mortar completely embeds the steel rods.

g. Bulkheads, webs and stringers: Ensure that there is no build-up of mesh on the corners of the bulkheads where they join the hull. If the mesh builds up on these corners, there will nearly always be a hollow at the corner after plastering and this will be a second major source of leaks. Four layers of mesh are sufficient for these areas. The mesh should be trimmed at the corner; it should not lap over onto the hull mesh. Ensure that all the limber holes are in place on bulkheads, webs and stringers.



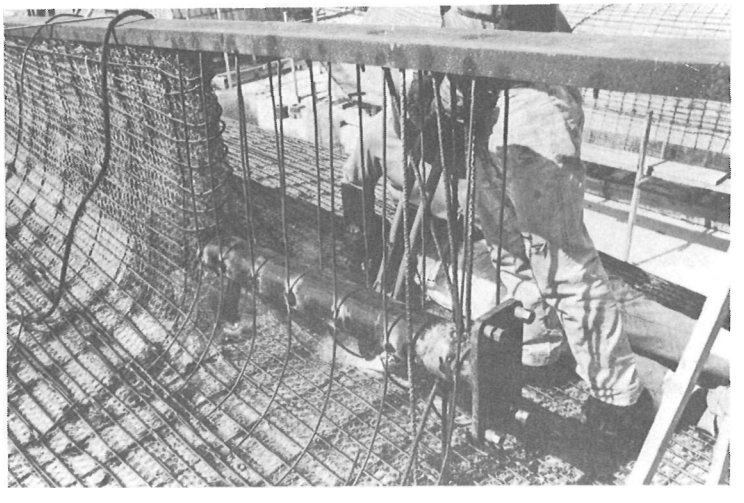
Mesh is not lapped at webs and bulkheads. Note: The heavy reinforcing in the keel box and how the mesh is left off the keel bottom to allow waste mortar to drop th ough.



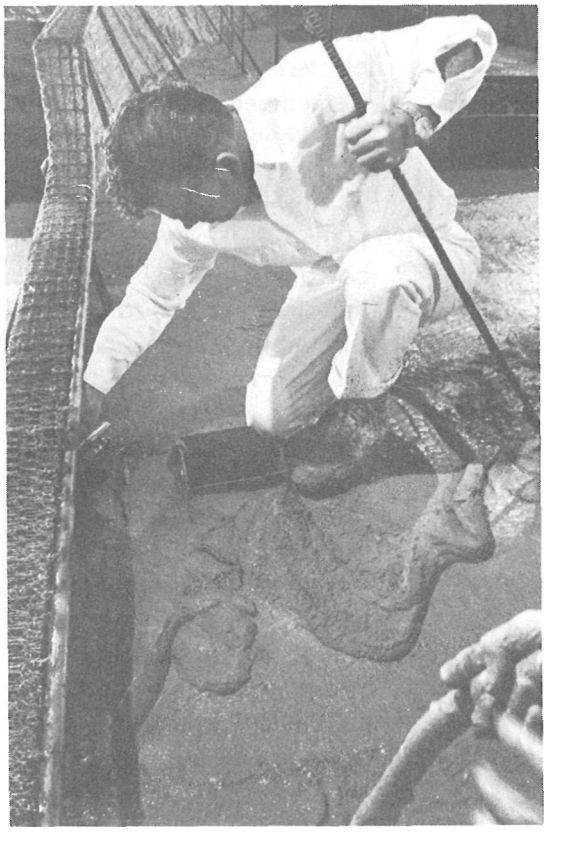
If the mesh is not laced in tightly it will bulge out when the mortar is pushed through.

h. Stern tube: Again, do not allow the mesh to build up here. Ensure that the design permits the deadwood cavity to be poured solid. This is normally a difficult area to pour mortar into, for the stern tube is nearly always as large in diameter as the width of the deadwood area inside. The deadwood is also built like a concrete beam. The vertical hull reinforcing rods will all be welded to the stern tube. The normal mesh lay-up should be terminated 6" (150 mm) above and below the stern tube in the solid deadwood area. Use only 2 layers of mesh here so that the mortar may be packed in tightly around the stern tube.

Only when all the above-mentioned areas have been prepared should a date be set for plastering. Too often the plastering crews are organized for a specific date, the meshing is not complete, and the above-mentioned areas are rushed through and not attended to properly. If these areas are not meshed properly, a rough plastering job will result and the hull will be full of voids around the keel, shaftlog, bulkheads, webs and stringers. Even in a production yard it is better to leave a finished hull sit for a week while plastering is organized rather than going into expensive overtime or not doing this last job properly. Remember that undoing mistakes and neglect after plastering is hard work and expensive.



Example showing stern tube of equal diameter to width of deadwood.



Mesh clipped in around the bulwarks cap screed.

2. Plastering Crew.

To calculate how many men will be needed use the following rule of thumb guide;

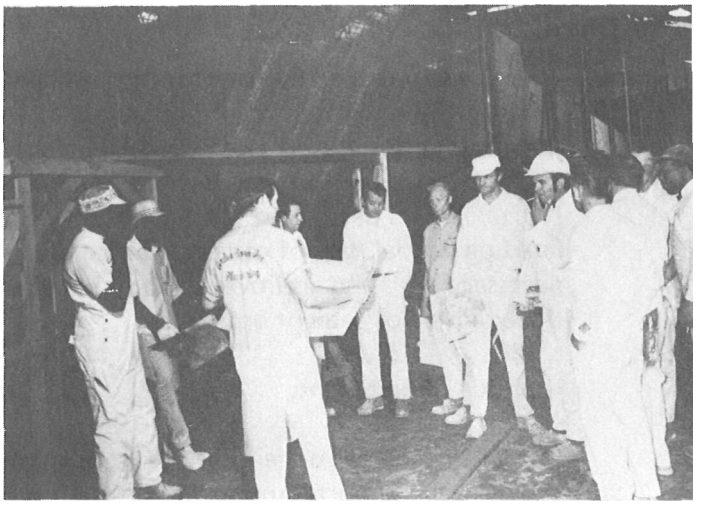
1 applicator—finisher and 2 laborers for every 200 sq. ft. (18 m^2) of hull surface to be plastered.

When selecting commercial plasterers to do the application and finishing be sure they understand that the mortar has to be punched against the mesh when applying it and not spread over the mesh as in normal plastering work. If the vessel has over 1500 sq. ft. (140 m^2) surface area employ a plastering supervisor who will specifically keep an eye on the consistency of the mortar mix as well as assign the plasterers' duties and check each individual's work. A second man should be in charge of coordinating the helpers; he will work closely with the plastering foreman.

Ten hours is the maximum length of time men will be able to work effectively on the job. There is a certain amount of energy required to plaster a hull properly so be sure there are enough men on hand to complete the job totally in this time and clean up afterwards. If too few men have been employed, two areas will normally reveal this deficiency. They are (1) the inside of the hull will be poorly finished, requiring much work later to make it presentable, and (2) the work site will be left in a mess. The area under the hull, mortar boxes, buckets, etc., will be encrusted with hardened concrete, left there by men who became too tired to pay proper attention to cleaning up at the end of the plastering day.

Sufficient manpower must be employed but they must be effectively deployed. Proper supervision of the men is as important as the willing workers themselves.

A second rule of thumb may be used. This is that the work must be laid out so that all the mortar is applied to the hull within the first 3 hours of starting the job. If all the mortar is not applied within this time, the men will become too tired to finish the job properly. An experienced crew will normally have the job finished and cleaned up within eight or nine hours after starting, allowing one hour for breaks.



The Foreman Plasterer assigns his men to their respective sections of the hull.

The bagged sand and cement stored on pallets.

3. Materials.

For specific information on sand and cement refer to Task 2, page 28.

As a guide, order one 94-lb. (42 Kg) bag of cement for every 15 sq. ft. (1.3 m^2) of hull surface area to be plastered. When considering surface area add the total ferro-cement surface area of the hull which includes deck, webs, bulkheads, coamings and floors. One 94-lb. (42 Kg) bag for every 15 sq. ft. (1.3 m^2) of surface area allows a good margin for wastage and ensures that there is ample cement to complete the job. Extra quantities of cement will be required for filling in the keel, engine bearers, etc., at a later date. Remember that labor is by far the most expensive factor during plastering. If the job is delayed for lack of materials, the delay will be costly.

Cement is the key factor for calculating the material quantities required for it is the normal practice to batch sand and additives at a proportion of so much per bag of cement. It is unwise to design mortar barches calculated on partial bags of cement. Order the necessary sand and additives to combine with the quantity of cement ordered.

4. Equipment.

If a vessel has under 1500 sq. ft. (140 m^2) surface area, 1 mortar mixer will have sufficient capacity to do the job. Two mixers will be required for jobs over 1500 sq. ft. (140 m^2). Do not attempt to plaster hulls of over 3000 sq. ft. (280 m^2) in one day but go into a multi-stage plastering operation. (See page 75 on multi-stage plastering.)

In conjunction with every mortar mixer use 3 rubber-tired construction wheelbarrows. Three 55-gallon (208 L) water drums will also be required beside every mixer.

For every 200 sq. ft. (18 m^2) of hull surface area 1 plasterer is needed.

A good rule of thumb calculation for each plasterer's hand equipment is the following:

2 — 3-gal. galvanized buckets.
1 - 2' x 2' x 1/2" (600 mm x 600 mm x 13 mm) plywood mortar board.
1 — 3' (900 mm) high mortar stand.
2 — standard steel trowels.
1 — swimming pool trowel.
1 — hawk.
1 - edger.
2 — sponge floats.
1 — darby.
1 — water brush.
2 — pair gloves.

(Note: The extra trowels, floats and gloves may be used by the helpers who may do the sponge floating inside the hull once the major work of applying the mortar is complete. See page 50. Three 4' x 8' (1250 mm x 2400 mm) mortar boxes will be required for each mixer. Each mortar box and wheelbarrow should be supplied with a long-handled, square-mouth shovel.

If steam curing is anticipated, steam distribution pipes should be ready. A steam tent should be prepared and material should be on hand for making a structure to support the steam tent. Steam generators should be ordered. (See Volume III, Job 9.)

Two vibrators should be used if the hull is to be built on the open cage method in the manner of the 65' (19.5 m) power boat hull with a deck mold. Four vibrators will be required if the hull is to be built over a wooden mold.

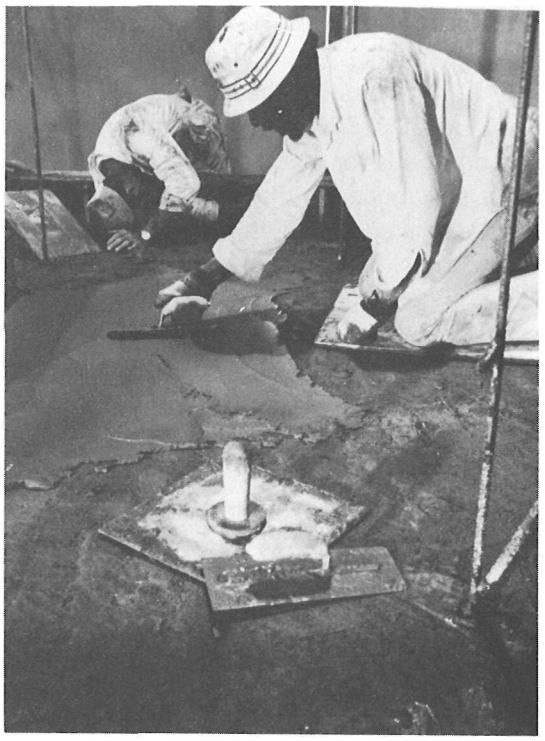
Sufficient water hoses will be needed to reach the nearest source of water. If 2 mixers are to be used have a separate hose and water supply to each mixer.

All the above-mentioned equipment should be organized well in advance of plastering day.

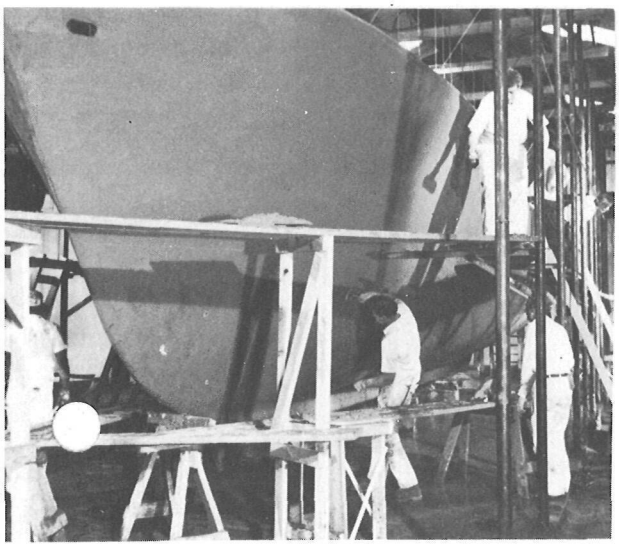
5. Scaffolding.

Scaffolding planks should be of a good quality lumber which is nearly knot free. 2" x 10" (50 mm x 250 mm) fir makes an ideal scaffold plank. 14' (4.3 m) lengths are the handiest to handle. If scaffolding is to be set up only one plank wide the plank should be supported every 6' (1.8 m). If two planks wide scaffolding is used, these planks will safely span 12' (13.6 mm) with 2 men working on it at once.

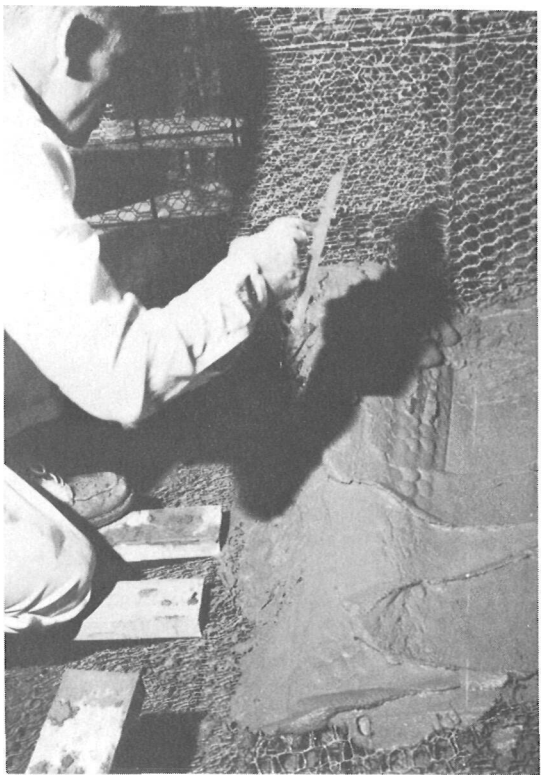
A 65' (19.5 m) hull will require a total of 36 2" x 10" x 14' (50 mm x 250 mm x 4.3 m) fir scaffolding planks. These will probably have been ordered earlier in the job and will already be on hand.



A kneeling pad to distribute the plasterer's weight.



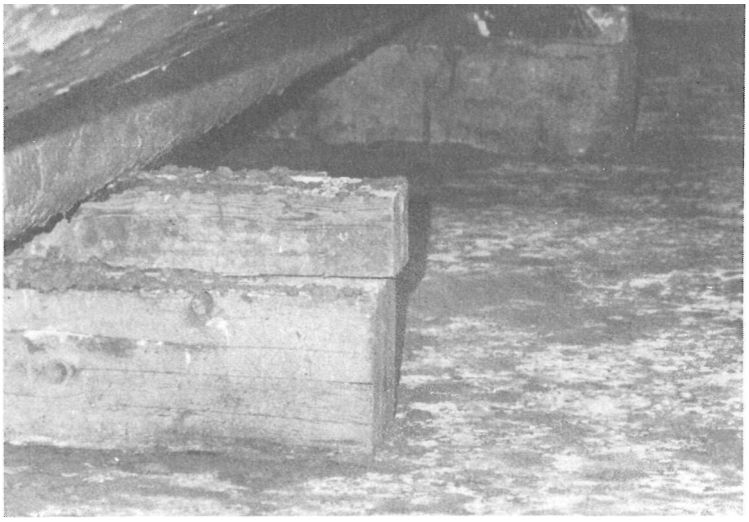
Scaffolding with steps and ladders.



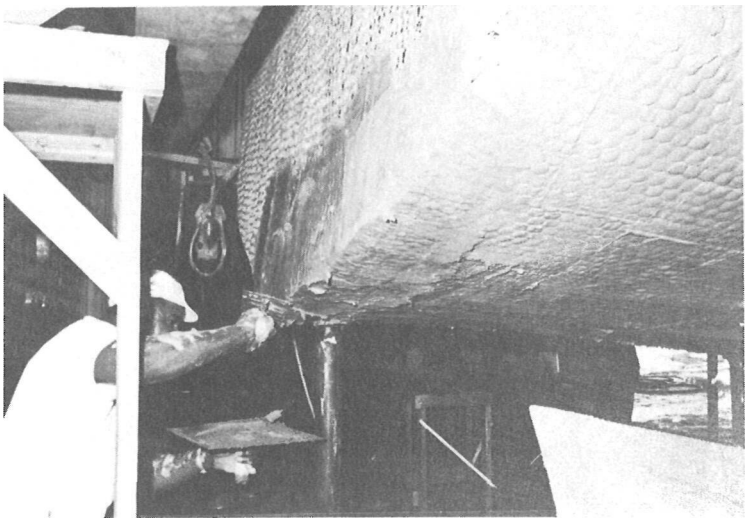
Short 2"x 4" 's (45 mm x 90 mm) timbers for the

Inside scaffolding will vary with each vessel. Each watertight section should have 2" x 10" x 7' (50 mm x 250 mm x 2.1 m) lengths of scaffolding in it for the men to adjust as they require. Some short lengths of 2" x 4" (45 mm x 90 mm) should be put into the awkward fore and aft sections.

Each section of the hull should have two 2' x 2' x 1/2" (600 mm x 600 mm x 13 mm) plywood pads for standing on. This will give a plasterer a means to distribute his weight should he have to step on the hull in reaching an awkward corner. If these pads are not supplied a man will be obliged to step on the hull framework anyway to reach awkward corners and he will bend the reinforcing rods in doing so, thus throwing the hull out of fair.



Keel blocks.



Pipe supports under the stern.

8 — 3' (900 mm) high saw-horses should be on the job. These will be used for gaining access near the stem and on the stern where it is awkward to reach from a scaffold.

1 — a ladder should be placed in each watertight section of the hull for access to the compartments.

1 — set of stairs should be erected at each end of the hull. These stairs should be strong enough to allow two people to pass on them while carrying material on and off the boat.

Each set of stairs should have a landing stage at the top. The normal run and rise for stairs is 7" (175 mm) high and 11" (275 mm) run. However, in a work shop this may be changed to 8" (200 mm) high by 8" (200 mm) run. If a ramp is to be used it should be made three times as long as it is high, with cleats nailed across it for steps.

6. Hull Supports.

The last item to check before plastering are the hull supports. If the hull is built upright using overhead supports the supports should run plumb to the overhead beam. If the beam is spanning more than 12' (3.6 m), as they do on most hull support structures, additional diagonal supports should be taken to the corner of the support to prevent the beam sagging.

Keel blocks should be prepared. Keel blocks should be a minimum of 12" x 12" x 4' (300 mm x 300 mm x 1.2 m) long for the bottom block and blocks of similar dimensions used up to the final wooden wedges driven under the hull. Keel blocks should be set up under structural bulkheads and large floors.

If the stern overhangs the keel, pipe supports should be set up under this area to take the weight of the stern section. If a hull is designed to be a completed 20 tons dead weight, it will attain a weight of nearly 30 tons during plastering, taking into account the weight of the water in the mix plus that of the men walking around on deck. The hull must be well braced from as many points as possible so that no movement will occur when the men start to work on it. The overhead structure must be well braced to support this additional hull weight until the concrete sets hard enough to bear its own weight.

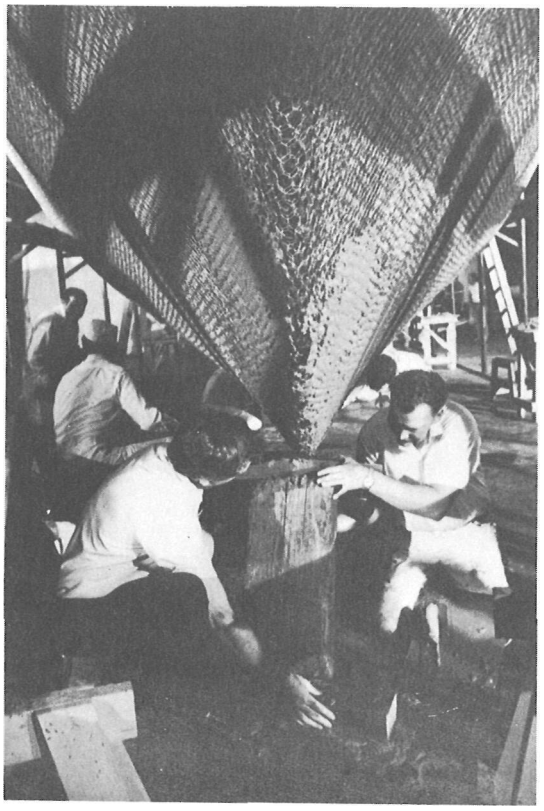
LAYING OUT MEN

The mesh is now laced tight over the entire hull.

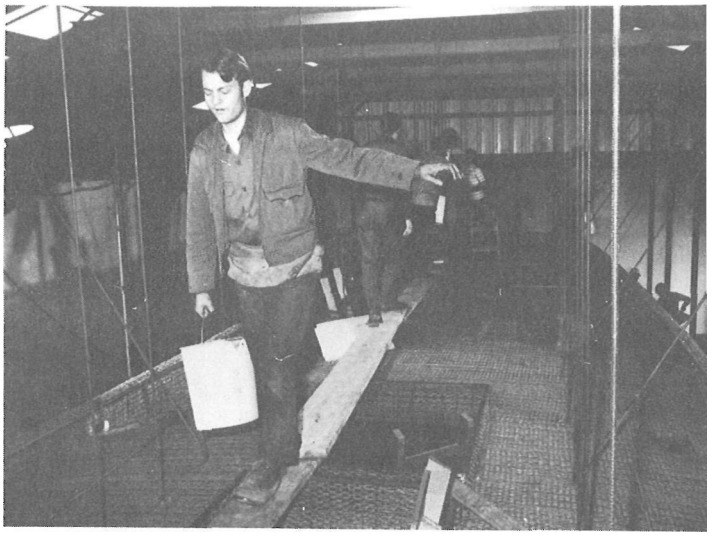
The materials and equipment required are all on hand.

The scaffolds are all erected and the hull is well braced.

The next stage is to plaster the hull.



Applying mortar under keel blocks, then replacing the blocks.

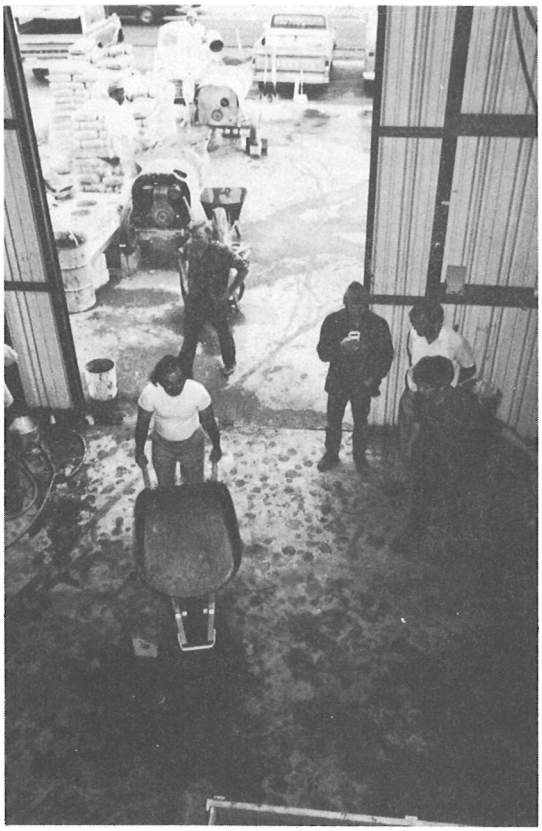


The deck is plastered first The bucket brigade moves into action.

TASK 2 - Plastering Day

If plastering is scheduled to start at 8 a.m. have the plasterers and the helpers report for work at 7:30. This will allow the plasterers a few minutes to browse over the job and familiarize themselves with their day's work. By allowing an extra 1/2 hour at the start of the job for the men to relax and examine the hull and the equipment lay-out, they will all become familiar with the work and the supply system before the seeming confusion of the mortar application begins. This also allows a little lead time to get the mortar mixers fueled and checked, the water drums full, and the first batches of mortar mixed ready for the start. Further, electrical extensions for the vibrators and trouble-lights will have to be prepared, and the buckets, shovels and wheelbarrows lined up.

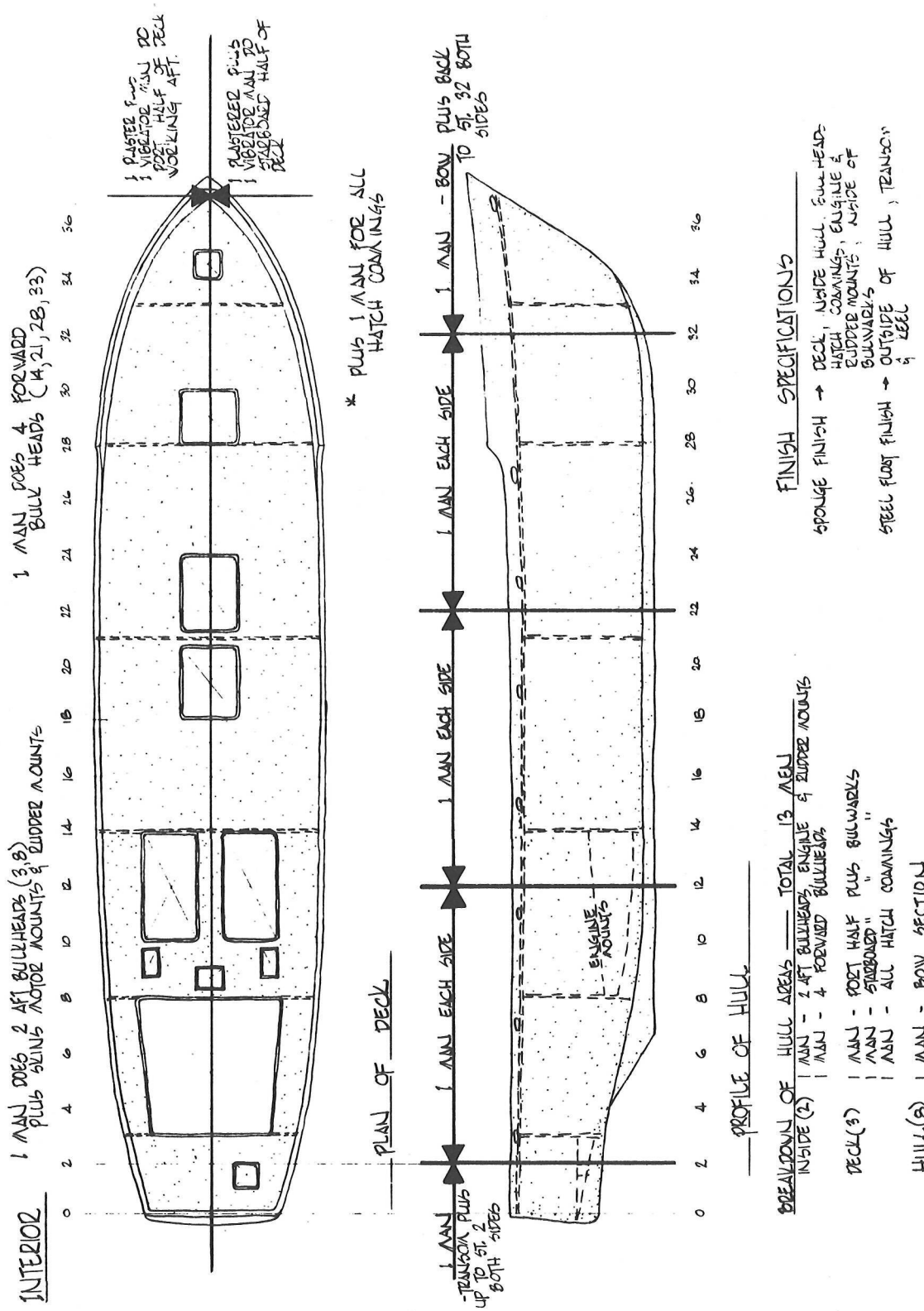
At 7:45 call the plasterers into a group and explain to them the basic difference between boat plastering and construction plastering. How they should concentrate on punching the mortar against the hull rather than spreading it as they would in the regular plastering of a wall or ceiling. Normal plaster lath is only one layer while the average ferro-cement lay-up is from eight to twelve layers of mesh and two layers of rods.



Loaded wheelbarrows are wheeled in.

A chain of buckets being filled and passed up to the deck.

The bucket brigade dumps the mortar directly onto the deck; it is vibrated immediately.



BREAKDOWN OF HULL AREAS —— TOTAL 13 MEN

INSIDE (2) | MAN - 2 AFT BULKHEADS, ENGINE & RUDDER MOUNTS
| MAN - 4 FORWARD BULKHEADS

DECK (3) | MAN - PORT HALF PLUS BULWARKS
| MAN - STARBOARD " "
| MAN - ALL HATCH COAMINGS

HULL (8) | MAN - BOW SECTION
| MAN - STERN "
6 MEN - HULL SIDES

FINISH SPECIFICATIONS

SPONGE FINISH → DECK, INSIDE HULL, BULKHEADS, HATCH COAMINGS, ENGINE & RUDDER MOUNTS, INSIDE OF BULWARKS

STEEL FLOAT FINISH → OUTSIDE OF HULL, TRANSOM & KEEL

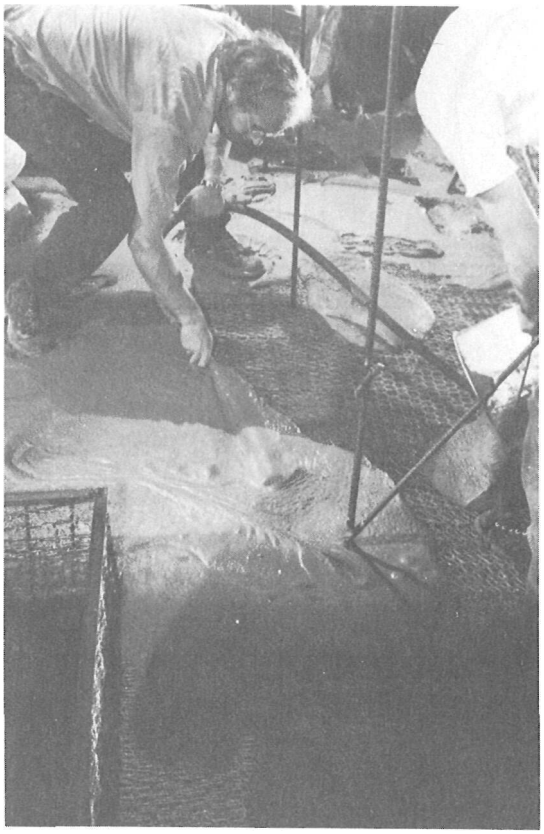
Diagram showing where to assign the plasterers.

Next, detail each plasterer to his appointed area of the hull (see diagram on page 25). The diagram shows how the 65' (19.5 mm) power boat hull has been divided into approximately equal areas of 200 sq. ft. (18 m^2) per man. The plasterers working the deck have a slightly larger area to cover, and the plasterers working the bulkheads and floors have a smaller area, because the inside of the hull is more difficult and time-consuming to plaster.

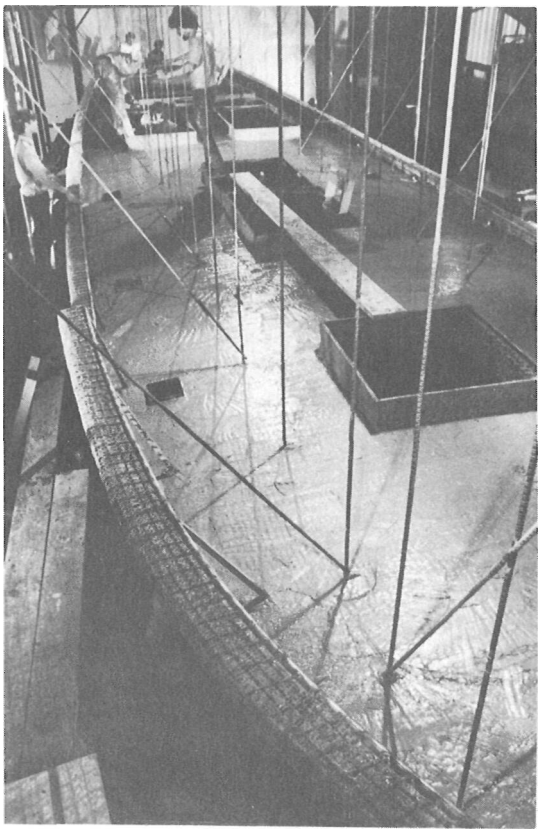
The wheelbarrows line up for fresh mortar.

Meanwhile, have the helpers standing to one side in a group by themselves. First, detail off one man for each vibrator. Next, detail off one man for each wheelbarrow. Next, detail off as many men as are required to start a bucket brigade working along the deck.

While the first helpers are being sent to their various duties, several plasterers should remove the keel blocks, plaster the areas under the keel formerly in contact with the blocks, then replace them and drive the wedges up tight against the keel.



Starting at the bows the men work aft, to port and starboard



The deck after one hour.

The first large area to tackle is the deck. The deck will be plastered quickly. It should take only one-half hour to apply all the mortar to this area. The vibrators will be running constantly while the deck is being plastered. It is difficult to plaster any other part of the hull while the vibrators are running for the mortar will tend to fall off.

As soon as the deck is plastered the men on the bucket brigade will be free to assist the plasterers starting work on the hull. Detail the helpers off one at a time. Stay with him until he demonstrates that he has understood what he is to do and whom he is to work with. Appoint an area off to one side where men who have finished a specific job can collect and be given a new job as the work progresses. On a hull the size of the 65' (19.5 m) power boat, thirteen plasterers were required for application and finishing. Two mixer men and one foreman plasterer were also employed making a total of sixteen men on the plastering crew. Thirty-two additional helpers were used; that is to say, two helpers for every one plasterer. With forty-eight men scrambling all over the hull, two mortar mixers roaring away and three vibrators adding to the din, the job will quickly take on a semblance of absolute confusion. The job will quickly develop into real confusion unless the men are given good leadership and constant guidance.

As soon as the plasterers have finished spreading the mortar on the deck horizontal surfaces they should start plastering the bulwarks and the bulwarks' cap which is a difficult and time-consuming area. Meanwhile the rest of the plasterers are working to get all the mortar applied to the hull before the hour of 10a.m.

Next, the plasterers move to inside the hull to work on the appointed areas. While they are working these interior sections, some of the helpers will be scraping off the mortar on the deck and the hull right back to the mesh. When the concrete starts to harden, some of the men can go inside the hull with sponge trowels and finish off this area. The helpers working inside should keep a sharp eye on the keel area to watch for loose scraped-off mortar and spillage. This loose mortar should be cleaned up regularly and dumped.

Meanwhile, as the demand for mortar decreases, some men and their wheelbarrows should be detailed to shoveling up the scraped-off mortar and heaping it into individual piles which are easily picked up once they begin to harden.

Send men off for breaks and for lunch only in small groups so that work on the hull will carry on without interruption. Pay particular attention to keeping the work site and the equipment constantly cleaned as the job progresses. If it is warm weather keep plenty of water cooling the floor beneath the hull so as to avoid having the hull mortar harden too fast. But, most important of all, the man in charge should be continually inspecting the hull and the work area, trying to anticipate problems before they arise. The man in charge should be constantly available to make quick decisions. It is a hectic day but there is only one day for plastering the hull.

The following points should be borne in mind when selecting sand for use in ferro-cement construction:

1. Never use coral sand or salt-water beach sand.

2. Never use sand crushed from limestone shell.

3. River sand is generally the best type for ferro-cement. Generally it will have been deposited over many centuries, created originally from igneous rocks, quartz, basalt, granite, etc., and borne down by the river current.

4. Pre-bagged commercial sand is the most convenient to use, if available economically, for these reasons:

   a. The sand normally comes from natural deposits which are large enough and of sufficiently high quality to justify commerical exploitation.

   b. It is washed, graded, weighed and bagged.

   c. Therefore, more easily stored and handled than bulk sand.

   d. Therefore, easy to batch with cement. For instance, three 100-pound (45 Kg) bags of sand and two 80-pound (36 Kg) bags of cement make a good, one-batch mix in a standard size paddle-mixer.

   e. Bagged sand is dry. Consequently, the water-cement ratio may be more easily controlled than by using bulk river sand which is likely to contain a varying amount of moisture.

   f. Commercial sand-packaging plants can supply accurate information on their gradings of sand. It may be necessary to mix 1, 2, or 3 grades of bagged sand together to arrive at the required sand grading mixture.

WHAT TO LOOK FOR WHEN SELECTING SAND

1. Grading Size of Sand Particles

The accompanying chart shows what is considered a desirable variation of particle sizes in sand. The predominant particle sizes are for those sands which will pass through a No. 8 sieve and yet be retained by a No. 50 sieve. The designations "No. 8" and "No. 50" refer to the aperture sizes in the wire screens of the sieves; No. 8 being 1/8 of an inch (3.2 mm) and No. 50 one-fiftieth of an inch. If a grain of sand is more than 1/50th of an inch in any one direction it will not pass the sieve. Long thin slivers of sand are an exception and this is the second factor to avoid.

2. Sand Shape

The ideal shape is the diamond, flat-sided, bulky, yet tapering. Long, slivery sand should be avoided. Sand is the strength agent of mortar. Cement is the part which binds the sand particles together. A diamond shape will not shatter as easily as a long, thin section. Diamond shapes naturally interlock and compact more easily than do other forms of sand particles. Varying shapes and sizes will interlock around a predominant mass of diamond-shaped particles if each particle is completely surrounded by cement paste, a high-strength concrete will result.

3. Cleanliness

What is meant by clean sand is a sand which is free from earth, humus, grass roots, clay, silt, or any particles which are not minute stones. If there is silt present in the sand it will mix with the cement paste and weaken it. Silt has no bonding power.

BULK SAND

In many areas it is uneconomical to obtain commercially bagged sand. If bulk sand is used it should be:

1. Stored within a retaining wall. This will stop the pile of sand spreading out and getting mixed with foreign matter.

2. Bulk sand should always be screened to remove the coarser particles. It should be shoveled through a No. 8 sand screen.

3. Screened sand should be kept separated from the unscreened sand.

4. A cover should be kept over the sand pile to keep out airborne foreign matter.

5. Avoid sand from crushed rock. It may be used if there is no other type of sand available.

6. Avoid sand which has been dredged out of tidal river beds or harbor basins. This is generally used for fill on construction sites but will not serve for cement.

SUMMARY

Sand should be clean and well graded. One hundred percent should pass a No. 8 sieve, 30 percent a No. 50 sieve, 5 percent a No. 100 sieve. Larger particles of sand tend to make the mix bind and wilt hang up on the mesh, thereby causing pockets behind each large sand particle. Coarse particles of sand also drag to the surface when finished and scratch the hull surface. Too fine a sand requires too much cement paste to bind it together. This tends to make a weaker concrete as the exact grading and particle shape forms the strength member and the cement is the glue or paste which holds it together.

Suitable sand will generally be found in most countries with mountain ranges or old high hills, or in those with rivers which flow from high hills and mountains.

CEMENT

There are four common types of Portland cement available:

Type 1 — Standard cement, most commonly used in construction.

Type 2 — Sulphate resistant and slightly retarded, this cement takes longer to set.

Type 3 — High, early-manufactured type so that it will gain a high strength quickly.

Type 5 — Sulphate resistant. When this cement is manufactured a special rock is chosen which will make the resulting concrete resistant to sulphates.

All four types of Portland Cement have been successfully used in ferro-cement construction. Choose the type of cement which is most readily available locally. Choose only freshly-kilned cement and avoid using cement which has been stored for long periods.

THE COMPOSITION OF CEMENT

Portland Cement is a predetermined and carefully proportioned chemical combination of calcium, silicon, iron and aluminum. Crushed rocks of these elements are burned in a kiln resulting in a cement powder so fine that a sieve capable of holding water will allow the cement to pass. The powder is so fine that one pound (1/2 Kg) of cement powder will contain approximately 150 billion grains.

HOW TO STORE CEMENT

Cement will retain its quality indefinitely if it does not come into contact with moisture. If it is allowed to absorb moisture it will set more slowly and its strength will be appreciably reduced. In storing sacked cement, the warehouse or shed should be as airtight as possible.

MIXING MORTAR

The ratio of water to cement will vary considerably according to each particular job. There are many factors which determine how much water should go into the mix. Some of these factors are:

1. The water content of the sand.

2. How much old mix remains in the mixer from the previous mix.

3. The sand-cement ratio designated.

4. How the mix is to be applied: A mix which is to be used over a wooden mold and vibrated should be a little wetter than a mix which is to be troweled over a mesh and reinforcing lay-up with no mold to back it. (See photo.)

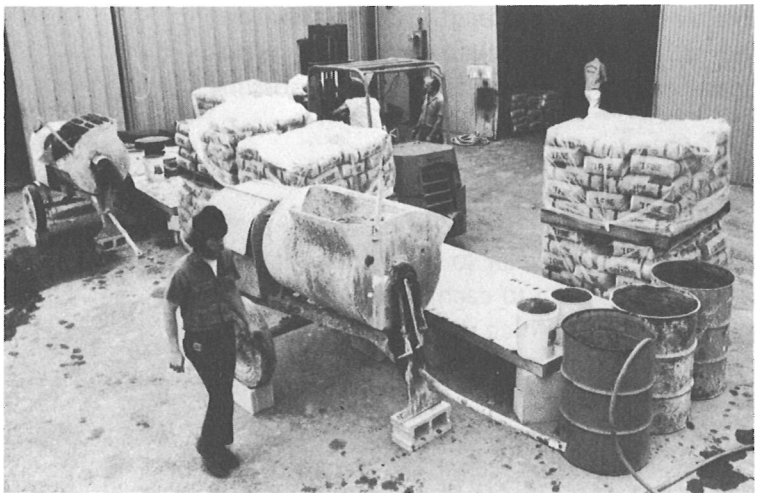
5. Ambient temperature.

Consequently, there can be no exact quantity of water given which will prove correct for all mixes for all applications. A trial batch should be mixed at the start of operations so an approximation of water quantity per mixer load can be made and followed for the rest of the day.

HOW TO OPERATE THE MORTAR MIXER (GASOLINE-POWERED):

1. First, inspect the mixer drum and paddle blades. Ensure that there is no dried mix left on them from previous use. Check that the mixer blades have not been worn too badly.

2. Once the mixer is clean, start the engine and let.it run for a couple of minutes until it warms up.



The mixers mounted on blocks prior to starting mixing. By having the mixer mounted on blocks a wheelbarrow can be filled directly from the mixer.

Place approximately 80% of the estimated amount of mixing water required in the mixer.

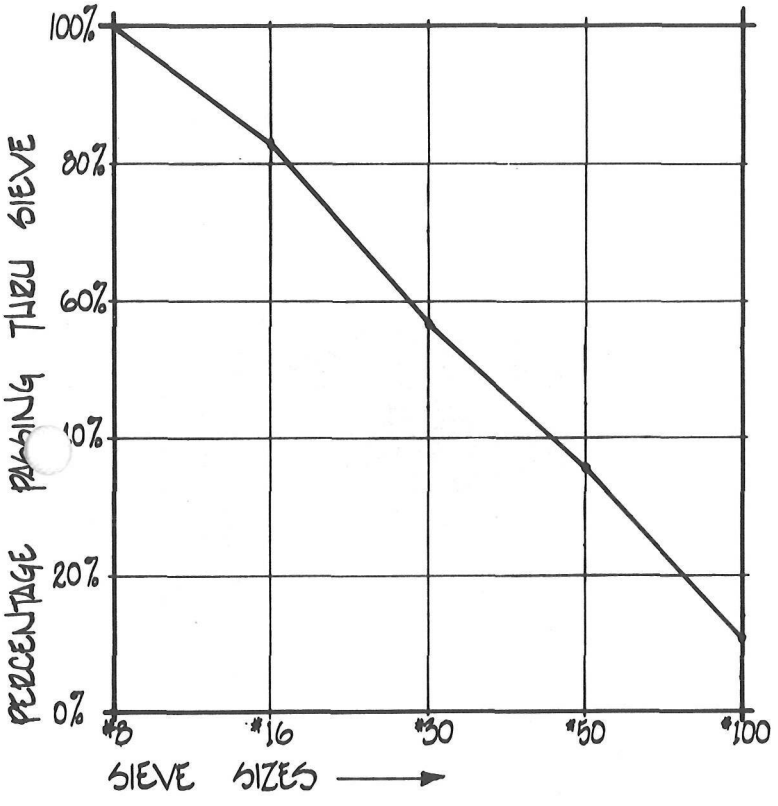
Next, dump in the cement. Let the cement mix with the water for at least one minute. Ensure that there are no lumps in the cement.

Last, dump the sand into the mixer. The mix will appear very stiff at first. Be careful not to make it too dry or the mixer motor will stall. Slowly add water to the mix until the desired consistency is reached. Let the batch mix for two minutes.

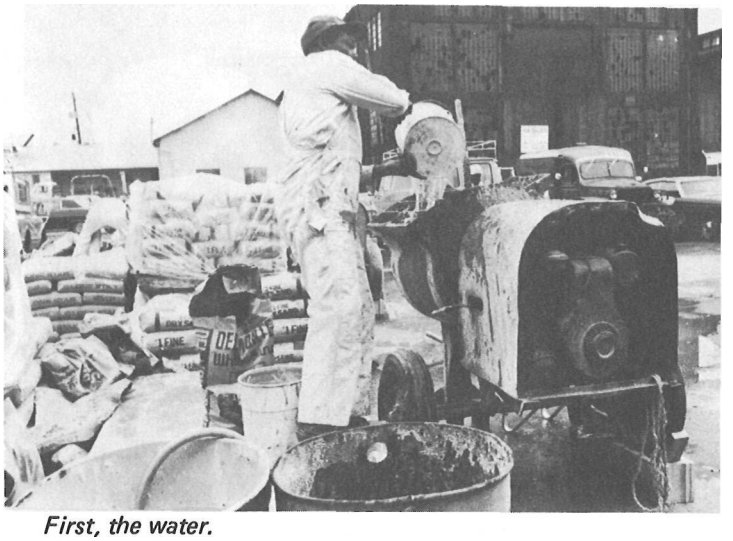
Keep the mixer revolving and dump the mortar carefully into the wheelbarrow.

Do not let the mix revolve too long in the mixer. Do not leave any mix in the machine longer than 15 minutes after first mixing. Once the water has come into contact with the cement the hydrolysis process will begin. As the hydrolysis process goes on, the mix will stiffen. The paddle wheel will keep the mix liquid, thus making it lose some of its strength. Further, there is a certain amount of time required to transport the mix from the mixer and dump it into a distribution box and from the box to its application to the hull. Any mortar over one-half hour old should not be applied to the hull but dumped. Mortar is not expensive. Weak concrete is.

After every third mix the mixer should be well washed out and cleaned prior to starting to mix a new batch of mortar. A water hose with a strong jet will be sufficient to clean the mixer at every trial batch.

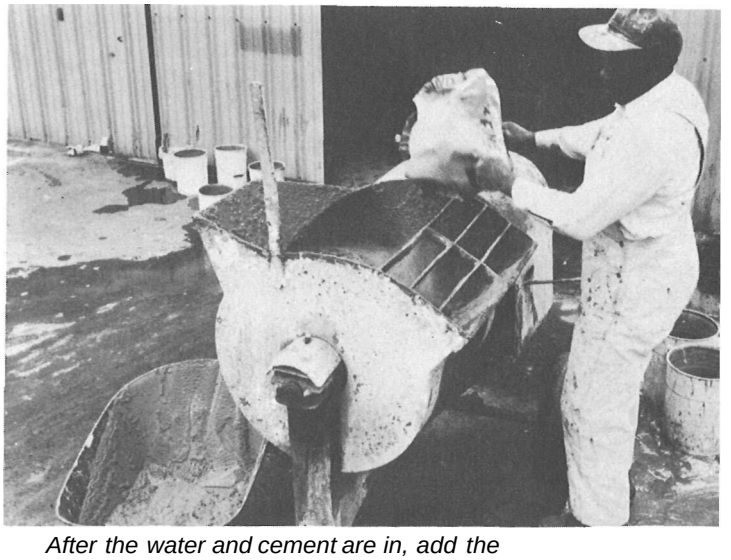


Sand *analysis graph.*

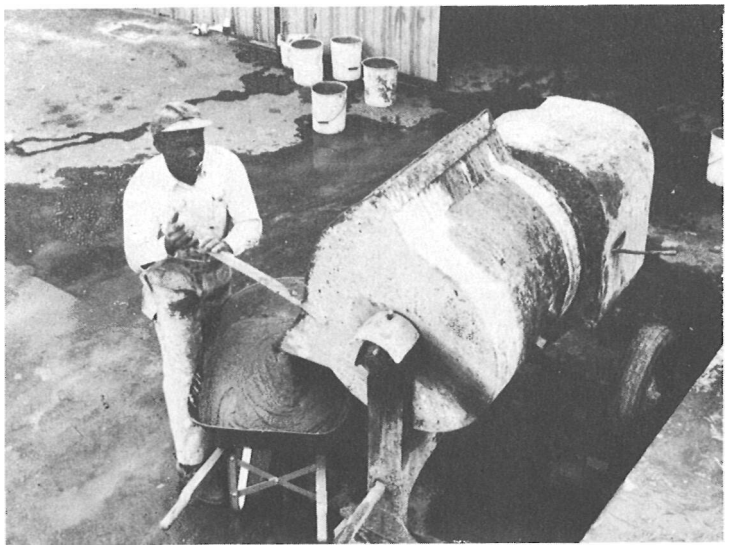


First, the water.

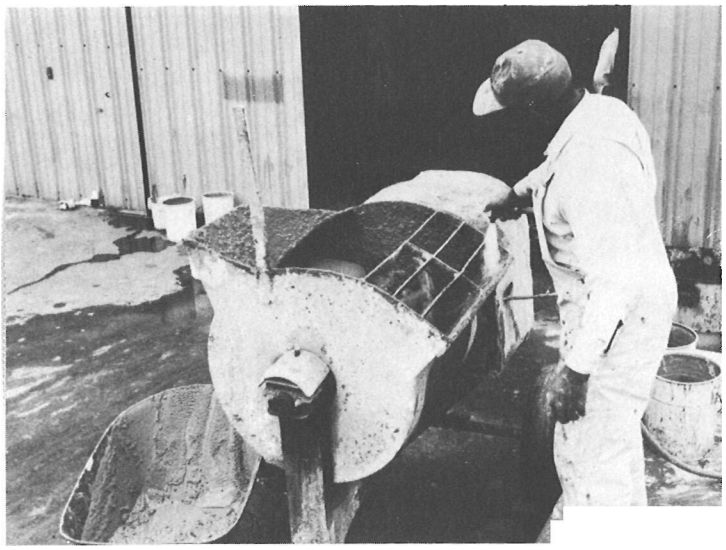
Next, the cement.



After the water and cement are in, add the sand.

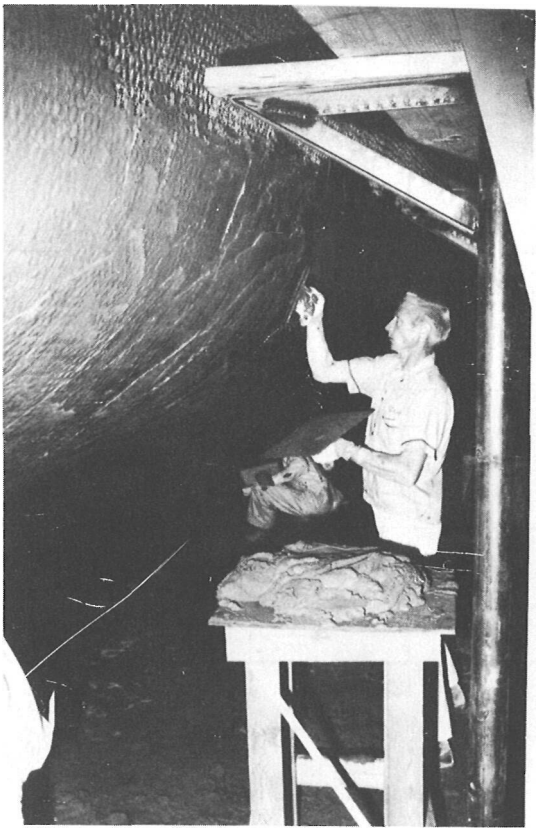


Dumping the mortar into a wheelbarrow.



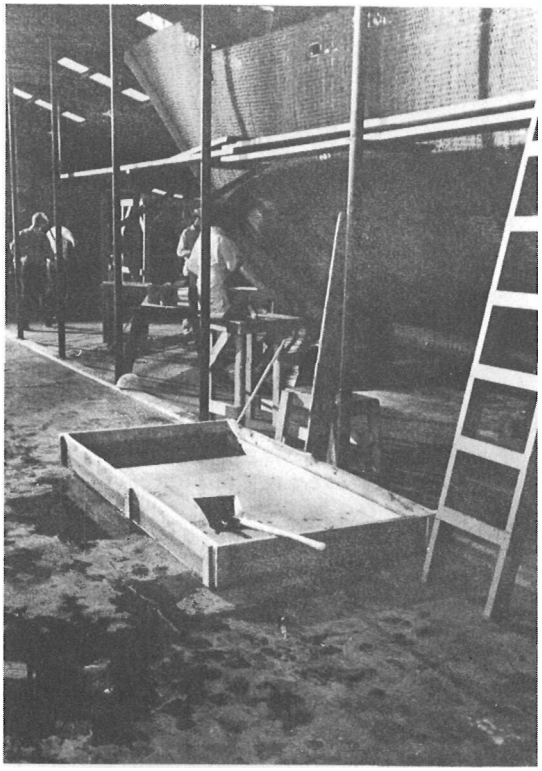
wash out the mixer after every third batch.

A wetter mix to be used over a mold.

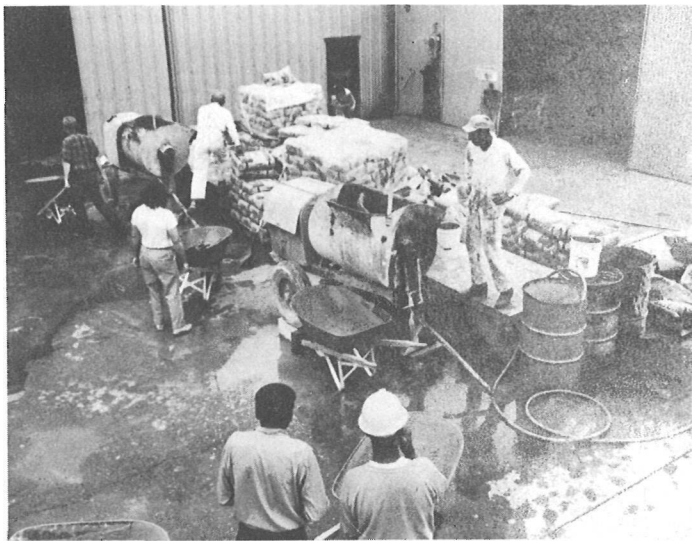


Mix consistency where no mold is to be used.

DISTRIBUTING MORTAR

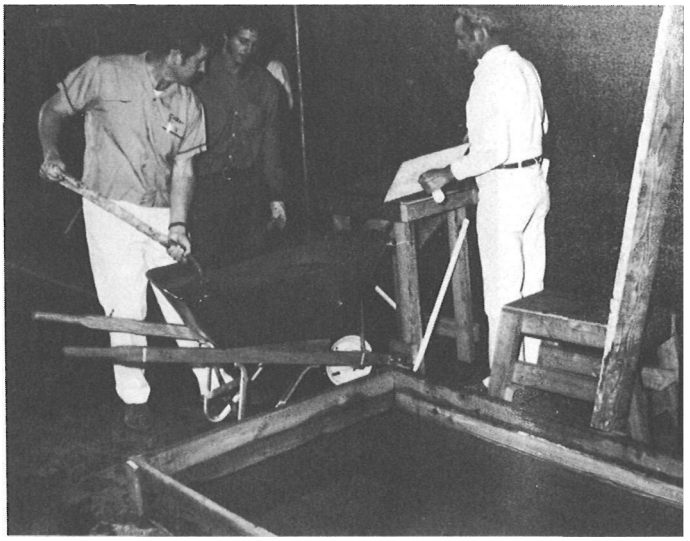


1) Set up mortar boxes at strategic points around the hull.

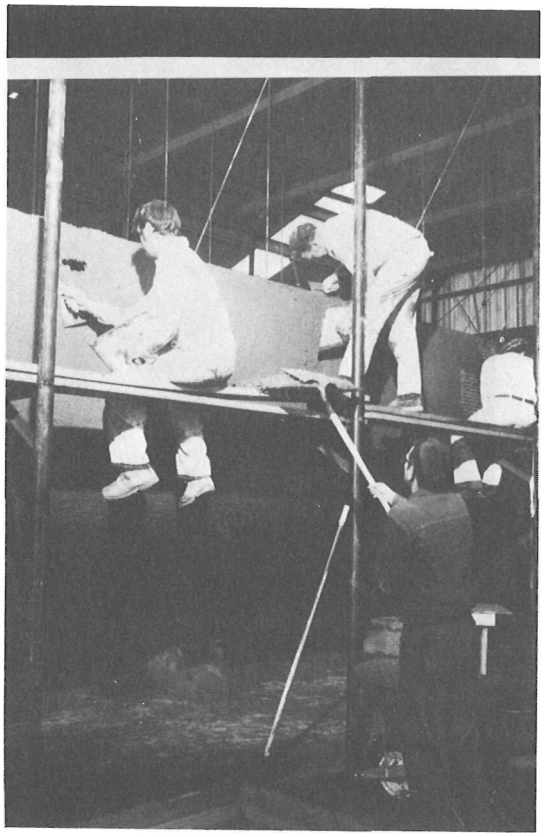


2) The wheelbarrows should follow an orderly procedure for filling. Have the traffic flow in one direction only around the hull.

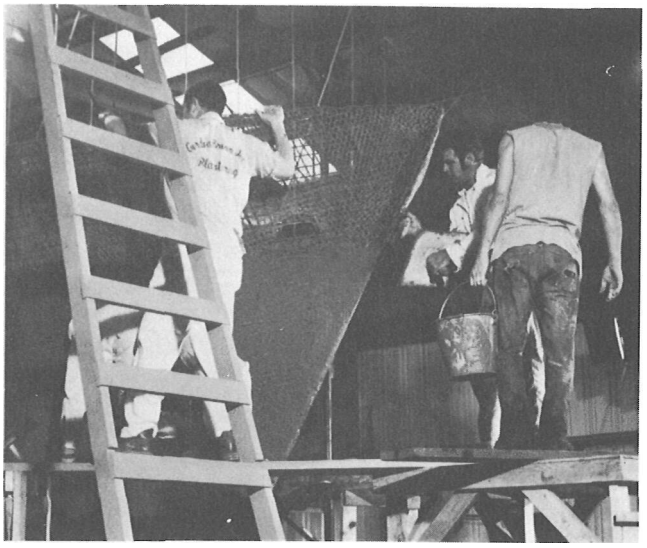
3) A contractor's wheelbarrow full of mix is heavy. Be sure that there are no holes or bumps in the path which may cause a



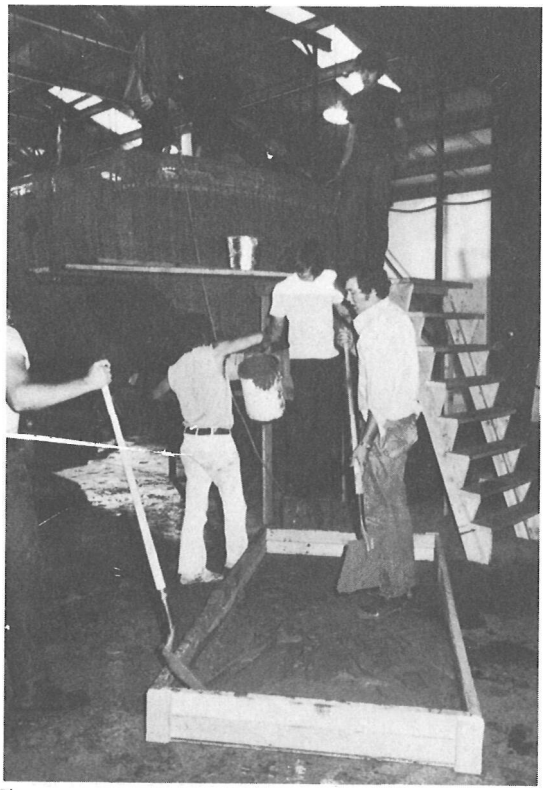
4) The foreman plasterer shows a helper how much mortar to put on the plasterer's mortar stand.



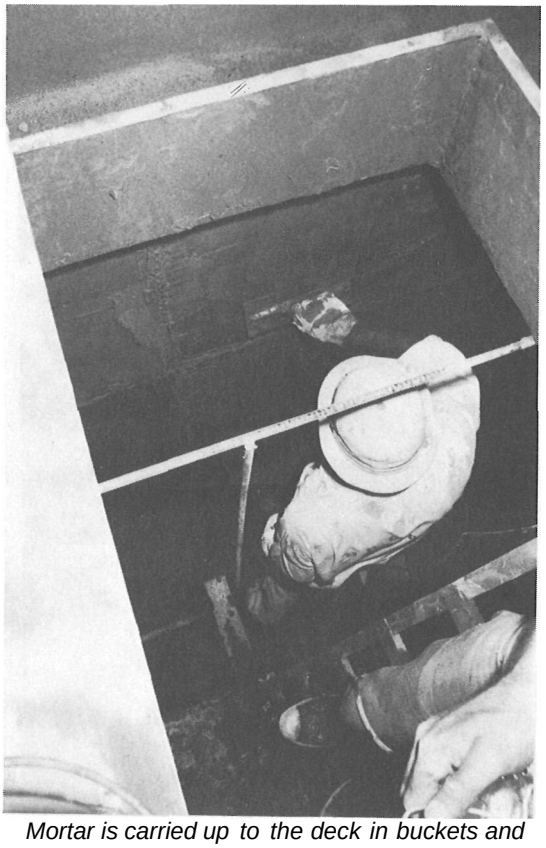
5) *Once the plasterers are working above ground level, they place their mortar boards right on the scaffolds beside them.*



7) *Here a helper stands by with some mortar. The helper's main job is to have mortar always ready for the plasterers without obliging the plasterers to move too far to get it.*



6) *The mortar buckets are only partly filled. The returning buckets are dipped into a tub of water and rinsed prior to refilling with fresh mortar.*



Mortar is carried up to the deck in buckets and passed down to the men working in the hull.

MORTAR APPLICATION

To do a good job of applying and finishing the mortar on a ferro-cement hull there are seven distinct stages of application and finishing. If one step is not done properly and in proper sequence a poorly finished vessel may result. Again, using the 65' (19.5 m) power boat hull as an example, the plastering steps are as follows:

Step 1 — Application; deck.

Step 2 - Application; outside hull.

Step 3 — Application; inside hull and bulkheads.

Step 4 - Scrape back to mesh hull and decks.

Step 5 — Skin coat.

Step 6 — Sponge trowel hull.

Step 7 - Steel float hull.

STEP 1 - APPLICATION OF DECK MORTAR

Application Time — 1 hour.

3 — plasterers-applicators required

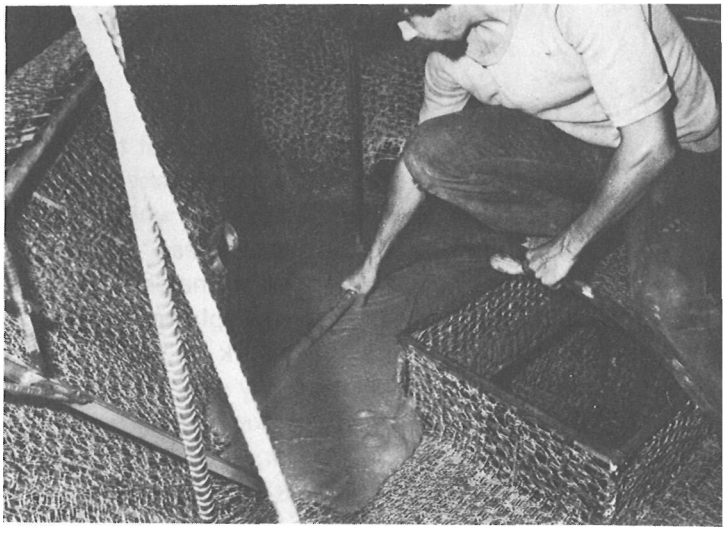
2 — vibrator operators.

Sufficient labor to transport the mortar quickly from the mortar mixer to the area of deck being plastered.

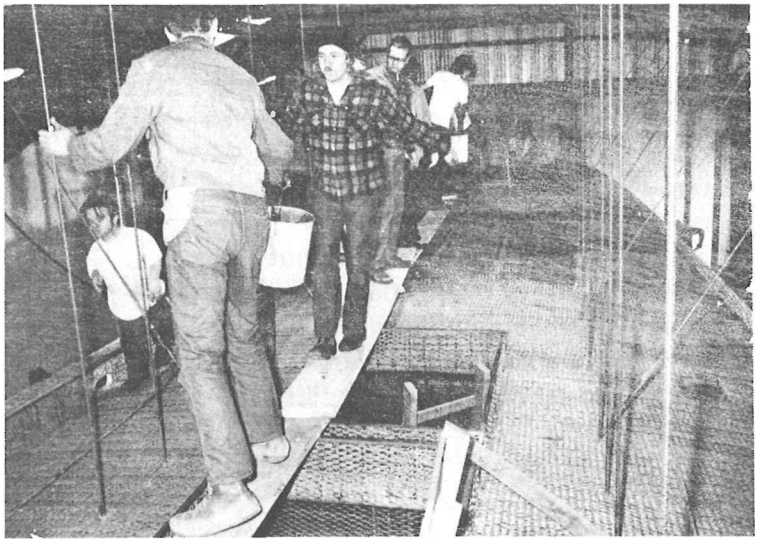
1) Start at the stem. Dump the mortar out of the buckets into piles on the deck. Insert the vibrator head into the mortar piles and vibrate until the mortar disperses into the mesh. Do not attempt to spread the mortar over a large area with the vibrator. Instead, shift the excess mortar with a trowel.

2) Work aft along the deck. The plasterers following the men dumping the mortar onto the mesh and vibrating it. The plasterers apply mortar to the hatch coamings as they work back along the deck. They spread the mortar as they go, scraping up excess mortar and putting it into the piles being vibrated.

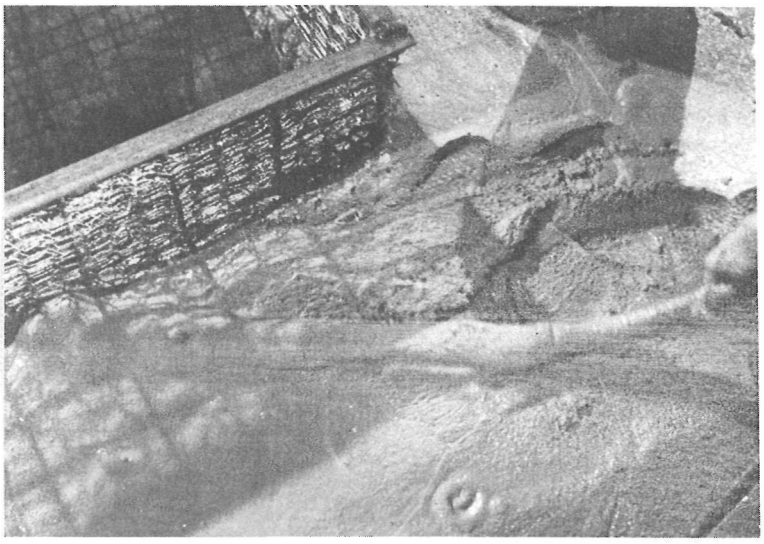
3) The men operating the vibrators pay particular attention to the joint between the deck and the hull. Allow the vibrator to rest a few moments at all spots along the deck edge. Vibrate this point until the V-gap is completely filled. When vibrating ensure that there is plenty of mortar stacked up on deck above the vibrator. If the layer of mortar above the mesh does not at least equal the thickness of the mesh to be filled voids will occur. While vibrating the deck edge have one man check the outside of the hull. It is easy to see when mortar has completely filled this joint as it will emerge in an even, thick band through the hull mesh along the deck sheer line.



Start applying mortar to the deck at the stem.



Working along the central gang-plank the bucket brigade rapidly brings up mortar.



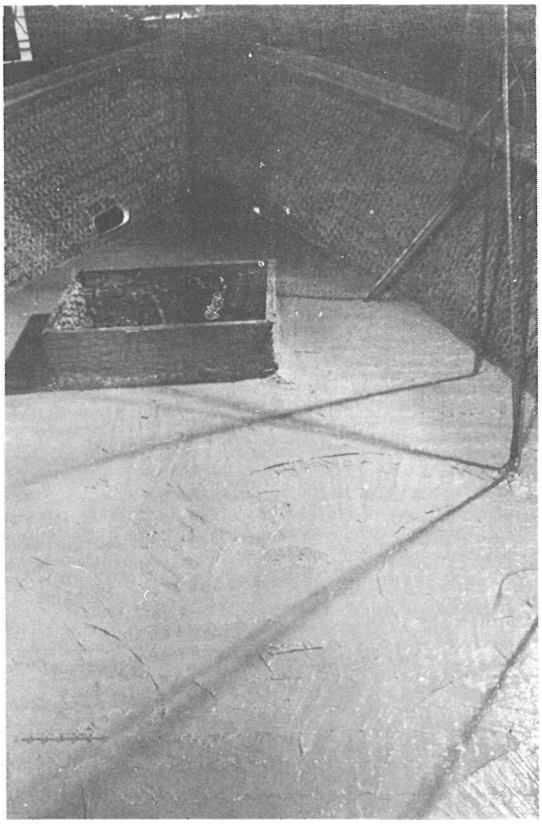
Be sure there is excess mortar over the area being vibrated so the mortar will flow into all air pockets.

4) Do not plaster the bulwarks at this time. The bulwarks and bulwarks cap take a lot of careful attention. There is not time while the deck is being vibrated to do these areas. It is vital that the mortar is applied to the deck as quickly as possible so that the other plasterers may start work on the hull. Work on the hull cannot be carried out satisfactorily while vibrators are being used anywhere on the structure as the mortar applied to the horizontal planes will tend to fall off the mesh.

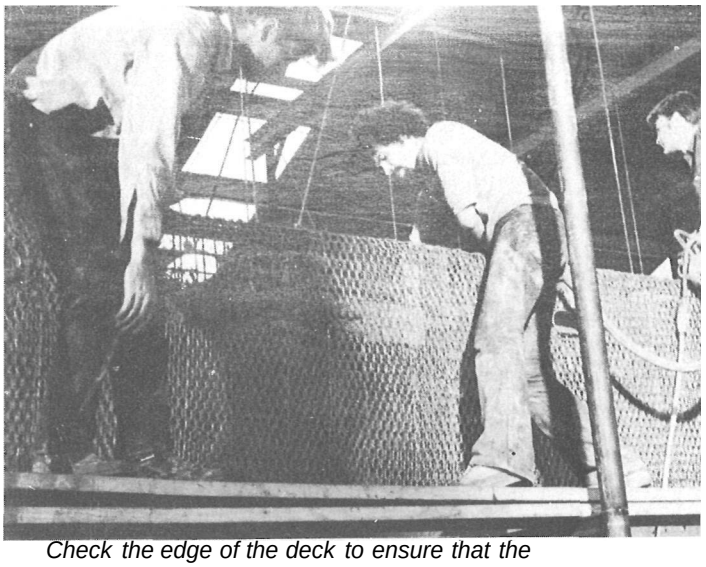
5} Continue working back along the deck until all the mortar is applied. Spread any of the excess mortar scraped up.

6) After all the mortar is applied to the deck, the plasterers assigned to the deck concentrate on applying the mortar to the bulwarks and the underside of the bulwarks cap. This is an awkward area to get at with a trowel. Mortar will have to be forced up under the bulwarks cap in the best way possible. The mortar will be punched through the bulwarks from the decks. The men working upwards on the outside of the hull will finish the outside of the bulwarks off. Once the bulwarks are finished from the inside the hatch coamings will be attended to.

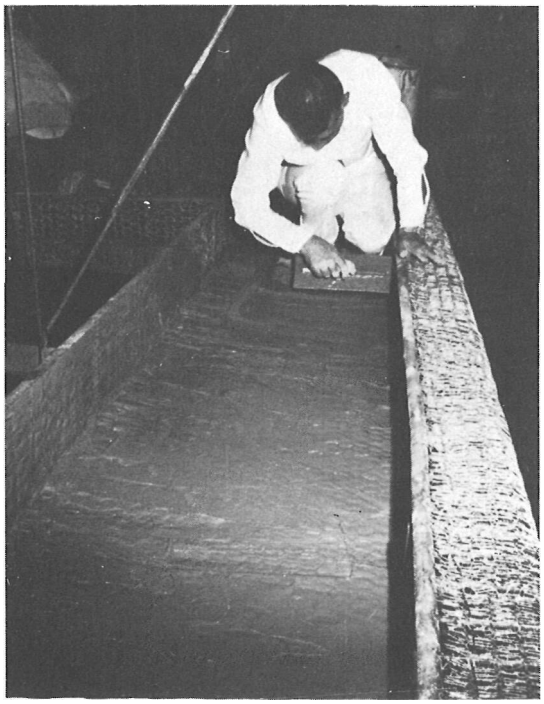
Dump the mortar directly on deck.



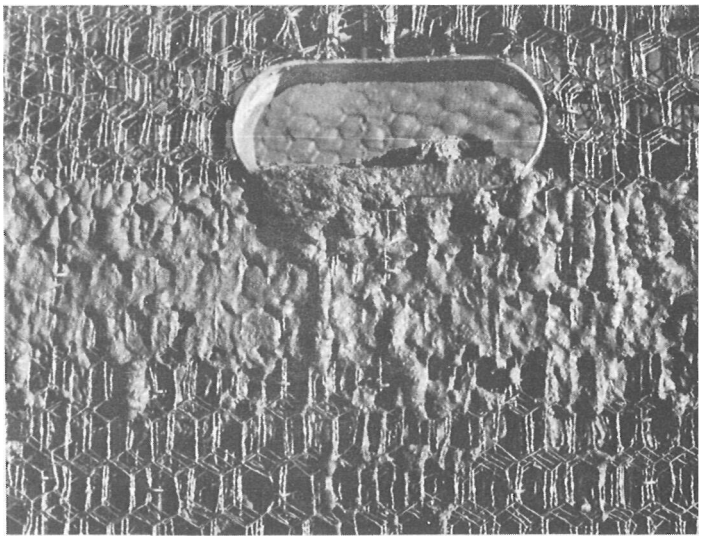
Foredeck once initial mortar has been applied and prior to scraping excess mortar back to the mesh.



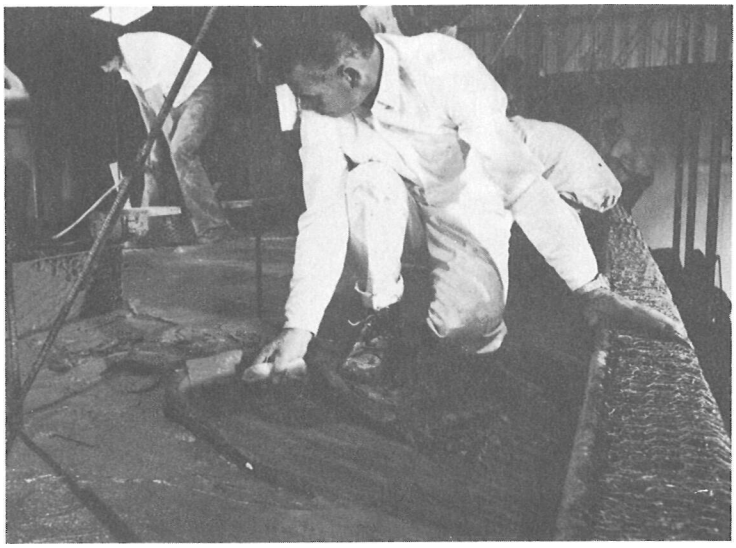
Check the edge of the deck to ensure that the mortar is penetrating this "V" joint properly.



The plasterers apply mortar to the hatch coamings as they work along the deck; they do not plaster the bulwarks at this time.

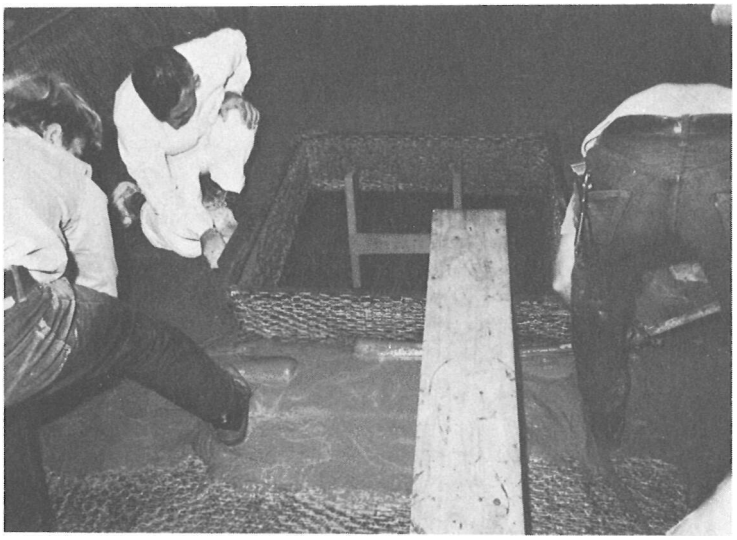


The deck mortar, well vibrated, being forced through the hull exterior mesh after filling the "V"-groove between deck and hull.

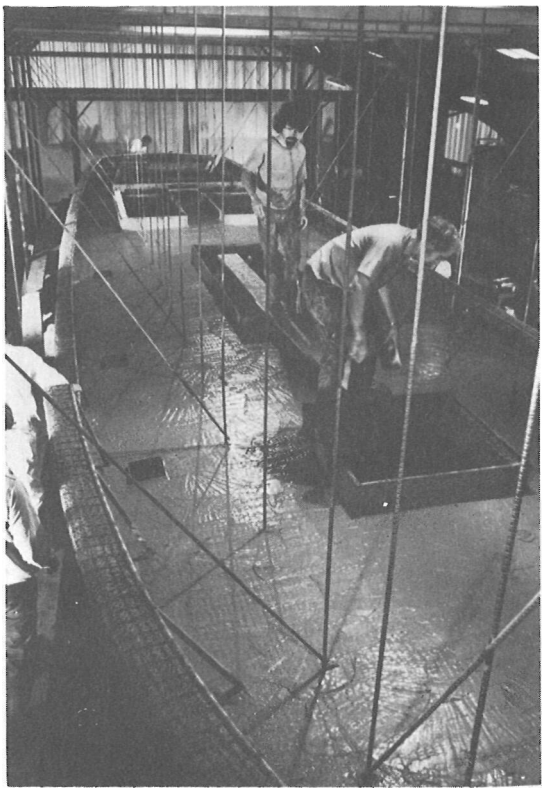


The plasterers scoop up excess mortar and push it back to the areas being vibrated.

Mortar is dumped directly into holding boxes for redistribution.



The helpers hold their feet on the vibrator heads to stop the heads from prancing around the deck and splattering mortar over the men nearby.



As soon as the deck mortar is applied the men transfer to the hull exterior.

STEP 2 - APPLICATION OF HULL MORTAR

Application Time — 2 hours.

1 - plasterer per 200 sq. ft. (18 m^2) of surface area.

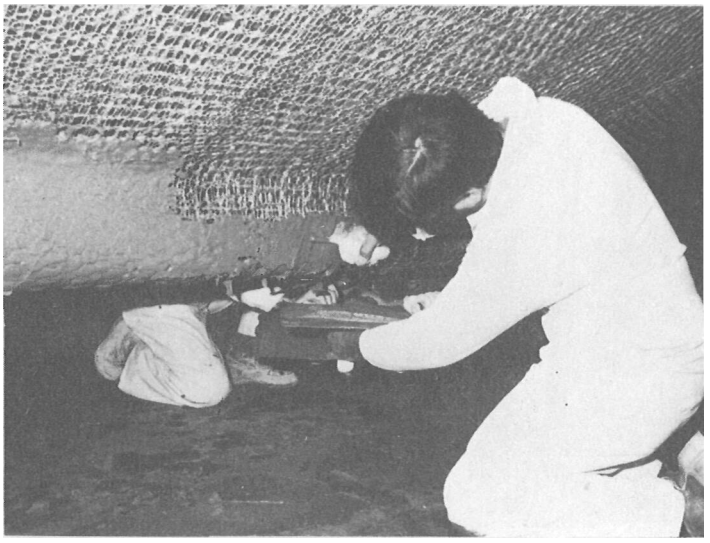
Helpers as required.

1) The keel area in contact with the keel blocks should be plastered prior to plastering the deck. The weight of mortar placed on the deck will have caused the hull to settle on the keel blocks making them difficult to remove if these areas over the keel blocks have not been plastered prior to plastering the deck. Once the keel block areas are plastered the keel blocks should be replaced and wedged firmly in place.

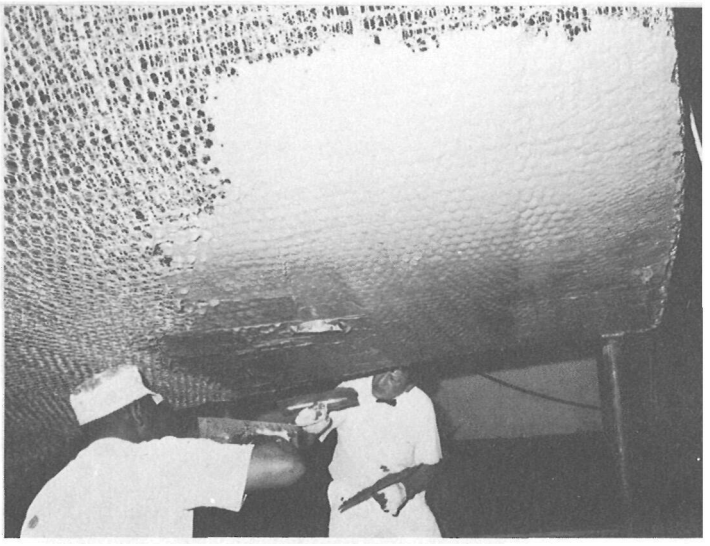
2) After the deck is plastered the plasterers assigned to the hull start applying the mortar to their appointed areas. Work starts at the bottom of the hull at the keel sides and the men work up the hull to the bulwarks cap. The men apply the mortar by scooping the mortar off the hawk and punching it hard against the hull mesh. The entire hull is worked over in this way. As the mortar is punched through a small area the plasterer spreads the excess mortar over the surface pushing hard. The mortar is applied from the outside of the vessel, and from the bottom to the top, for the following reasons:

a) A lot of work is saved by applying the mortar from the outside. If the mortar was applied from the inside of the hull it would all have to be lifted up to the deck and passed down to each hull section being plastered.

b) It is more awkward to work inside the hull than outside. By applying the mortar from the outside large areas are covered more quickly.

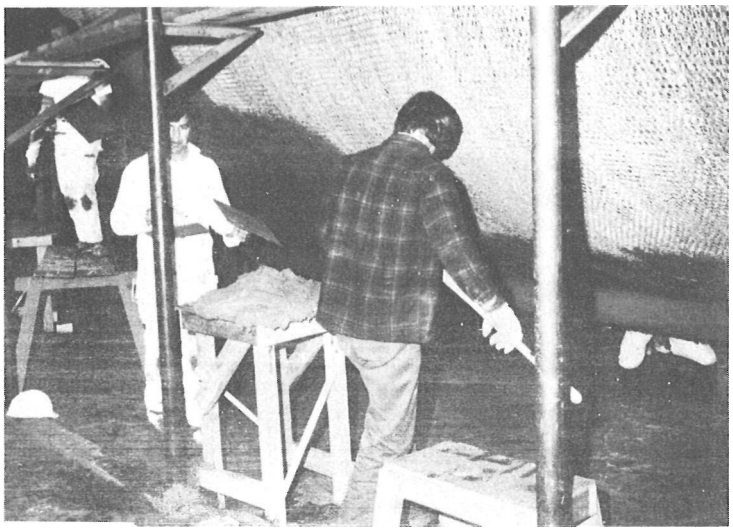


Application of the hull mortar starts at the keel side.



The horizontal surfaces of the hull require hard punching to get the mortar to penetrate the mesh properly.

After the mortar is punched into the mesh it is spread.



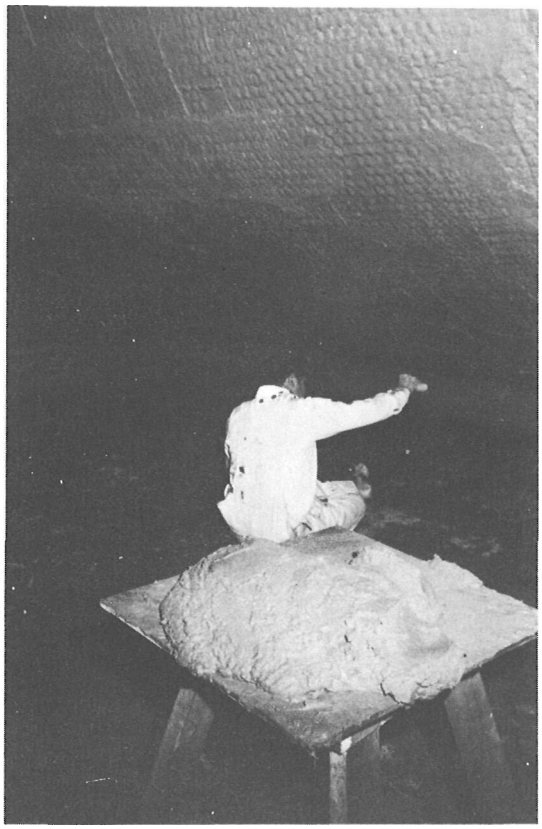
Helpers keep the plasterers supplied continually with mortar.

3) When large amounts of mortar are handed down into the hull there is a certain amount of spillage. This spillage generally gets trampled into the mesh and sets quite rapidly through being small quantities by themselves. It is difficult to work mortar past an area which has had mortar spilled on it previously and has already started to set. Any mortar which spills from the outside of the hull merely falls to the floor or is caught by the plasterer on his hawk to be pushed back onto the mesh immediately.

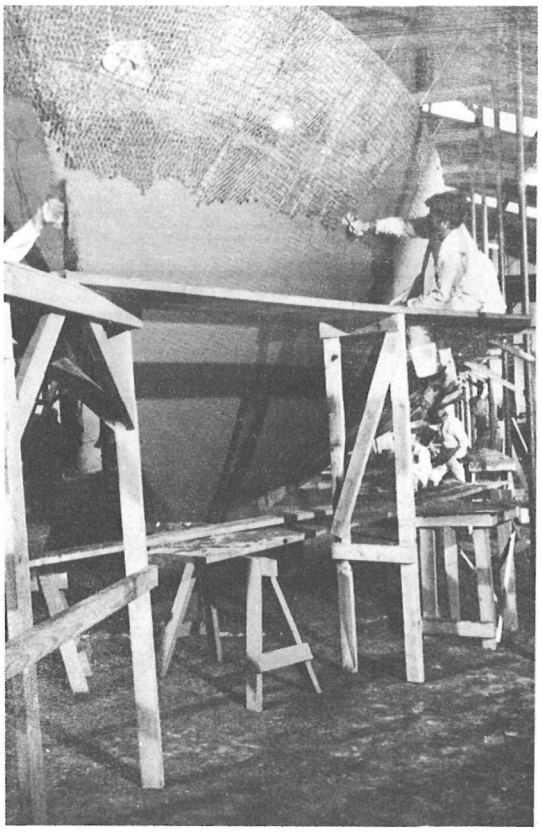
4) Some of the horizontal surfaces of the hull are difficult to plaster from the outside, especially under the stern of the vessel and up under the bilges. However, these difficult areas are generally not so large and the plasterers should resist the temptation to plaster them from the inside for the following reasons:

a) Excess water in the mortar is carried by gravity downwards. This excess moisture will collect on the bottom surface of the horizontal mortar layer. This wet surface makes mortar pressed against it difficult to adhere. Mortar applied overhead has to rely on friction to keep it in place until it sets. If there is moisture on the mesh, the mortar will not hang in place.

b) Once the mortar applied on the horizontal surfaces from the outside of the hull takes its initial set, mortar can be forced against it from the inside with no danger of the outside layer falling off. Working from the inside of the hull the plasterers can work it down hard and force the mortar against the outside layer more easily than doing it in reverse. Adequate penetration of the mortar into the mesh will be ensured.

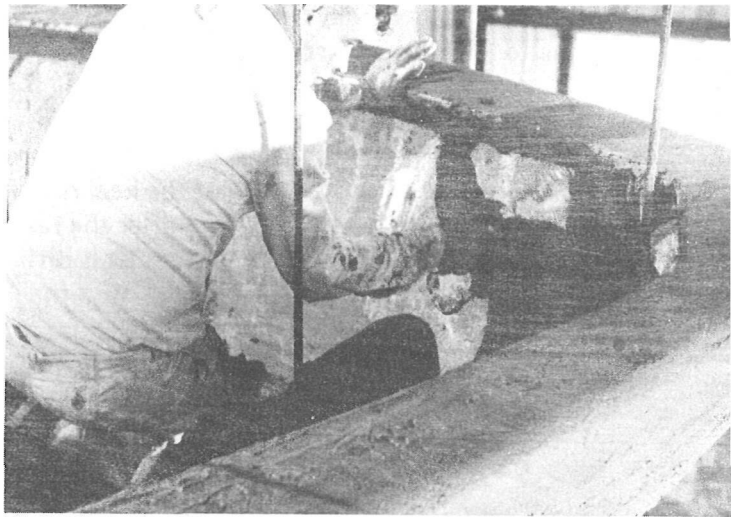


A plasterer checking over his work and applying more mortar to an area where penetration was not perfect.

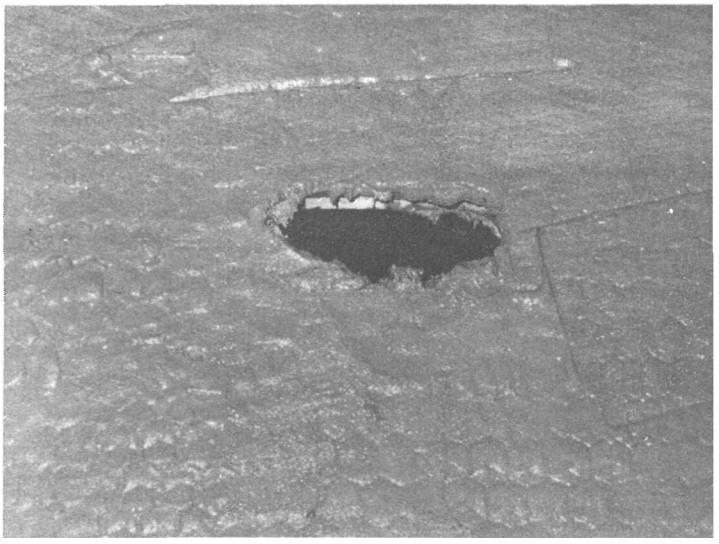


Good scaffolding makes work easy.

c) If there are insufficient staples on the outer layer of mesh in any square foot area of the hull, the weight of the mortar applied to the mesh will cause the mesh to sag away slightly from the hull framework. If the mortar has already been applied from the inside a layering effect will result. A void will be left in the center of the thin concrete shell where the two layers of mortar have separated. Water will find its way into a void of this type, which cannot possibly be advantageous, especially when the total thickness of the finished hull is less than one inch (25 mm).



The inside of the bulwark being finished.



This mortar will be scraped back to the scupper screed.

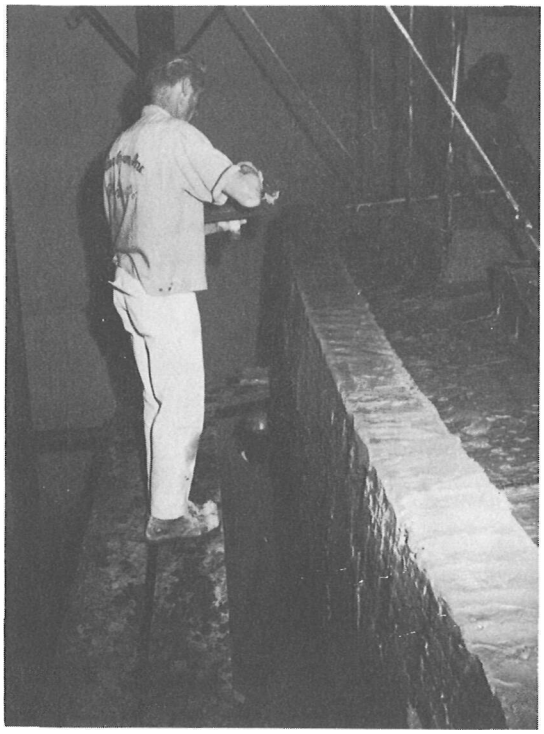
A plasterer punching the mortar against the hull.

5) The keel bottom is not plastered at this time for two distinct reasons:

a) Again, the water in the mortar runs by gravity down to the keel. The area around the bottom of the keel remains moist for several hours after the rest of the hull mortar has set. It is difficult to get mortar to hang onto the under surface of the keel bottom until the excess moisture from the hull has disappeared.

b.) During Step 3, while plastering inside the hull, a certain amount of mortar inevitably falls into the keel cavity. This waste mortar must find a way out through the bottom of the keel or serious consequences will result. On all hulls inspected in service which were plastered with no way of dispersing the mortar which falls into the keel cavity, the keel concrete was found to have little strength and was often riddled with voids for the first several inches up from the bottom. A large majority of hulls plastered this way experience weeping up through the keel bottom due to this section being filled with lumps of loose mortar. The only remedy for this weeping once it has occurred is to pour bucket of watery grout into the keel and vibrate it thoroughly once the hull is cured and prior to ballasting. Keep pouring grout until it is to the level of the top of the waste mortar in the keel. This grout will seal any cracks in the bottom of the keel. Do not use more than is necessary to ensure that the bottom of the keel becomes solid. There is a lot of shrinkage in the grout itself and little strength except as a form of glue to bind the lumps of mortar already in place solidly together.

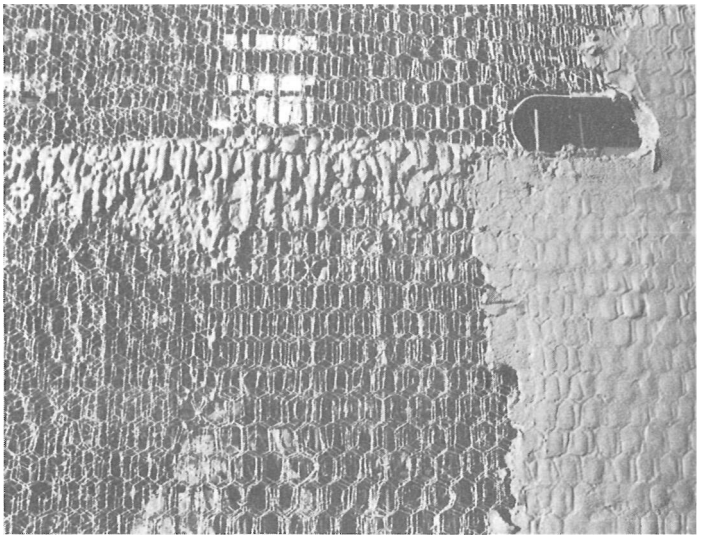
6) Continue applying mortar in an upwards direction on the hull to the bulwarks cap, working the mortar in hard to obtain maximum penetration of the mesh.



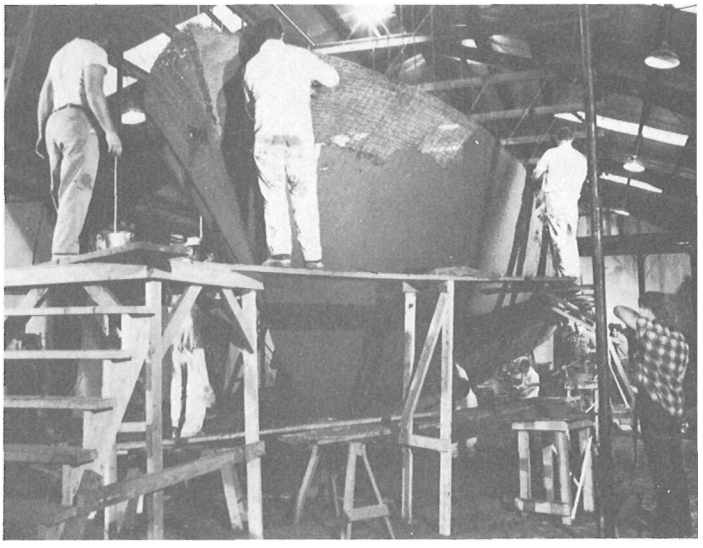
The hull during application looks a mess.

7) As the plasterers work up the hull sides, some of the helpers should go inside to inspect how much mortar is being forced through the mesh. A good applicator will push the mortar right through the inner side of the hull mesh. An average applicator will leave some of the inside layers of rods exposed with the outside rods covered, while a poor plasterer will leave some of the outside rods still visible from inside the hull. A poor plasterer is one who spreads the mortar like house stucco. Where an applicator has accidently not achieved good penetration, the helper should poke a 6" (150 mm) long U-shaped tie wire through the hull as an indicator to the plasterer for him to go over that area again. The plasterer will poke the wire back when he has re-done the particular area. The helpers should not be more than 5 minutes application time behind the plasterer in advising poor penetration for the mortar will start to set and no more mortar can be pushed against that area.

This photo graphically illustrates what happens when a plasterer adds water to old mortar and applies it to a hull. It is a great temptation to a plasterer to scoop up a lump of semi-hard mortar which is laying on the floor or in a wheelbarrow, rejuvenate it with water and patch up a small area during final finishing. It will be easier to do this than restart the mixer but the results will be disastrous.



Mortar punched onto the hull mesh from the outside merges with the well-vibrated deck mortar. (Inside, barely discernible through the mesh, is a helper checking for penetration.)



All the good welding and mesh work is being finally buried in mortar.

STEP 3 - PLASTERING INSIDE THE HULL

After the plasterers have applied the mortar to the outside of the hull they should immediately go inside and spread mortar over the exposed mesh. While inside they should also apply mortar to webs, bulkheads and knees.

1) Inside plastering should start at the deck and work downwards. The plasterer should load the mesh with plenty of mortar and work over a selected area, working from it in several directions. While troweling he should press the mortar firmly into the mesh, endeavoring to get maximum penetration of the mortar into the mesh and filling all voids.

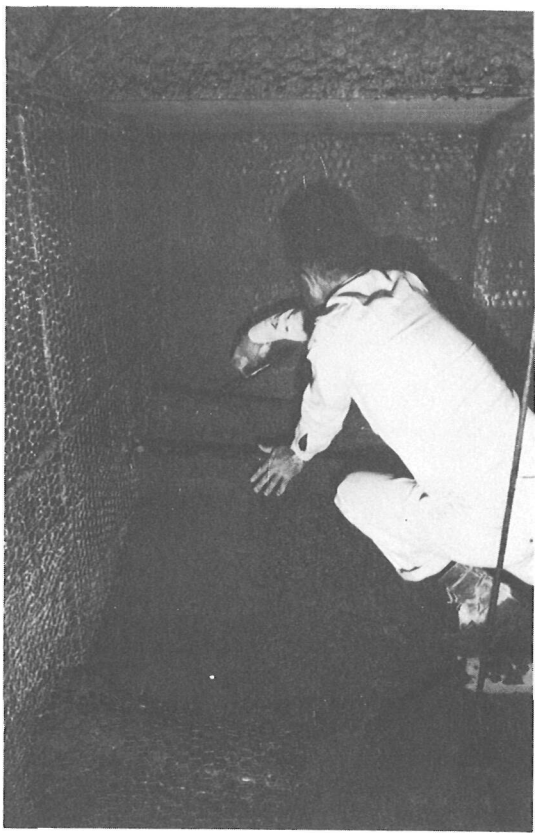
2) **Knees**

First apply the mortar to the hull around the knees ensuring that the hull outer mortar behind the knees is solid before plastering the knees themselves. Force the mortar into the knees and bring it level and even with the T-bar screed. Do not make the knees thick where they join the hull. Maintain them at a maximum 1" (25mm) thickness throughout.

3) **Stringers**

Do not plaster the stringers until the inside of the hull has been skimmed to the stringers. Plaster the stringers in the same way as the knees.

The mortar is applied at the top of the bulkheads and the plasterers work downwards.



The hull is skimmed prior to applying the mortar to the bulkheads.

Pay particular attention to the corners of the stringers where they join the bulkheads. Work the mortar well into this joint. Do not cover the drain holes left in the stringers which allow water to run into the bilge.

4} **Webs and Sole Supports**

Plaster the webs and sole supports next. While skimming the inside of the hull, work the mortar well into the base of the webs where they join the hull. Again, keep the thickness down to 1"(25mm).

5) **Bulkheads**

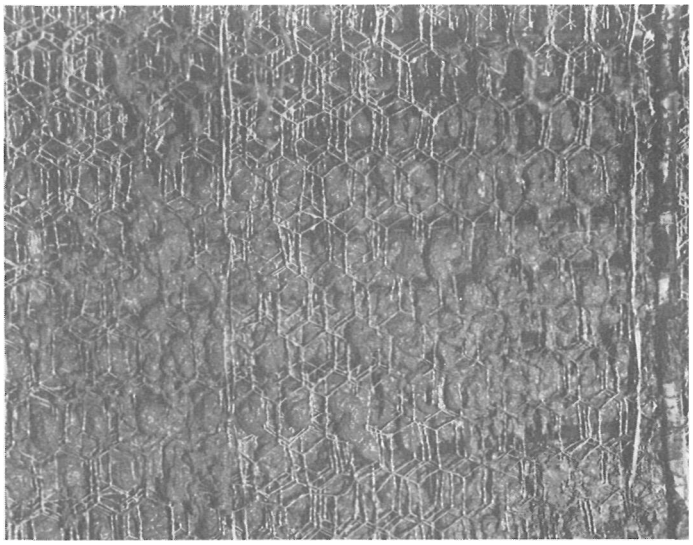
Plaster the bulkheads last. They are plastered in the same manner as the hull. Be careful to straighten out any bulges in the bulkheads once all the mortar is on. A bulkhead spreading 13 ft. (4 m) and 8' (2.4 m) high will easily develop a bulge of 2" (50 mm) or more in its center area, outwards from the side which was plastered last. Concrete bulkheads are very stiff bulkheads once the mortar has set but they are quite flexible until this time.

6) Once all the plaster is applied on the inside of the hull the balance of the work here will be left to the helpers who will now be finished supplying fresh mortar. Allow 1 hour for the mortar to set then have the helpers take scrapers inside the hull and scrape the mortar back to the mesh over the entire inner surface. A good plastering job should show a mesh pattern all over the inside of the hull. Once the excess mortar has been scraped off the interior mesh of the hull send in buckets to clean out all the old mortar spilled into the keel cavity, or have the helpers poke it through the keel mesh with rods.

7) Next, the helpers sponge trowel the entire inside of the hull. There are a lot of corners to smooth out and a lot of area to cover. The 65-ft. (19.5 m) power boat requires 16 helpers with sponge trowels for 2 hours to dress up the inside properly.

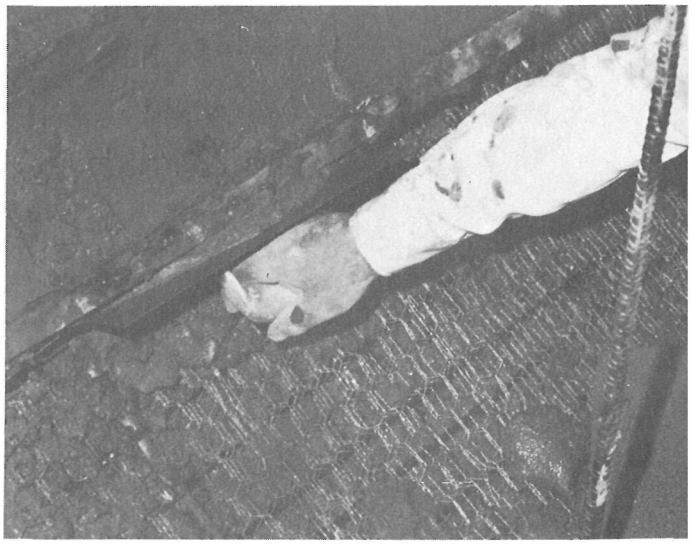
8) **Engine Beds and Rudder Stuffing Box Supports**

Plaster a thin skin coat over the outside of these structures. Do not apply the mortar hard here but merely spread it thinly over the mesh to create a form to contain the mortar which will be poured and vibrated into these structures once the hull has been cured.

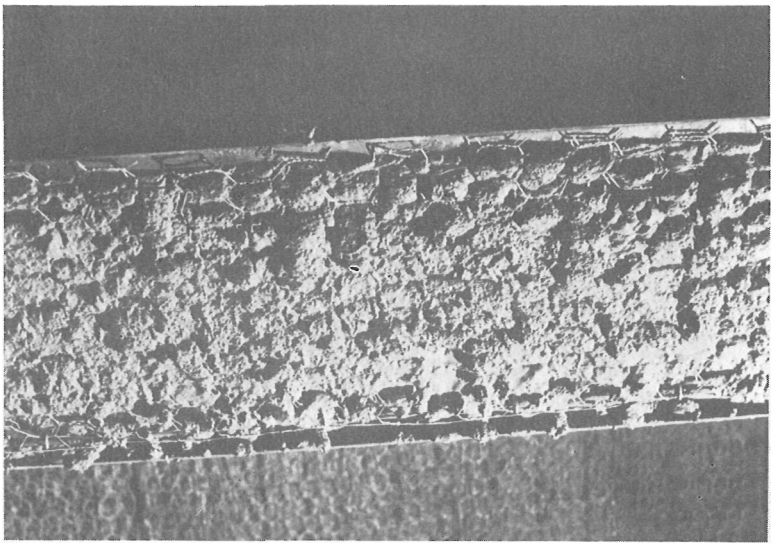


A sample of average penetration.

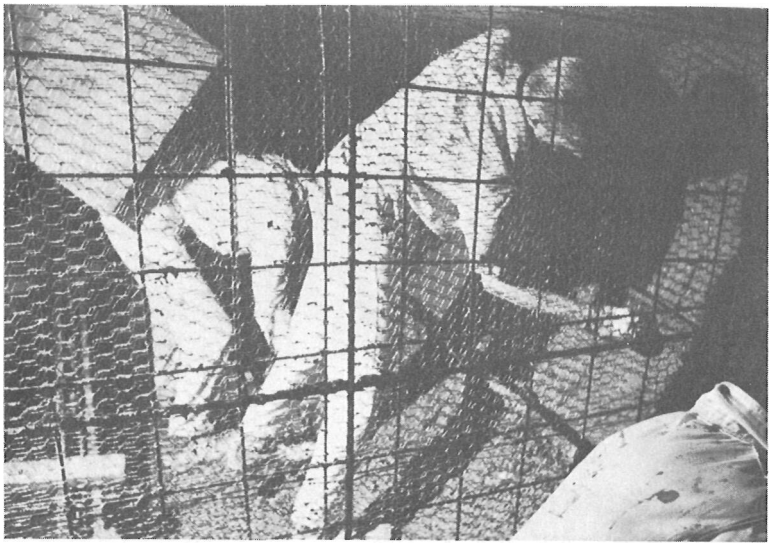
Using the hawk inside the hull.



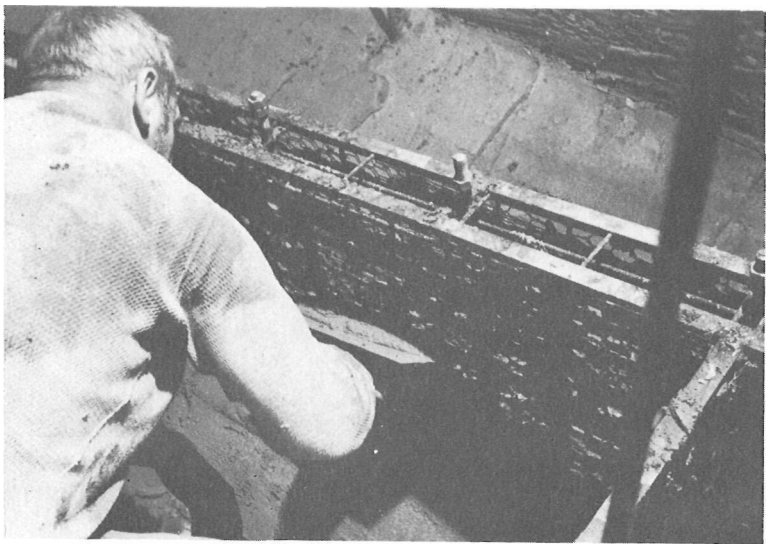
Applying mortar to a stringer.



Mortar penetrating to the inside of a hatch coaming.



Men working inside the hull (seen through a bulkhead).



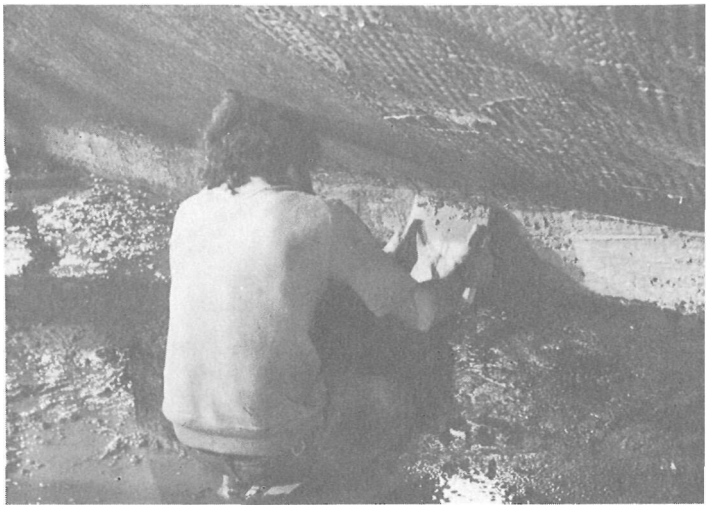
Skin coating the engine beds.

STEP 4 - SCRAPE THE HULL OUTSIDE MORTAR BACK TO THE MESH

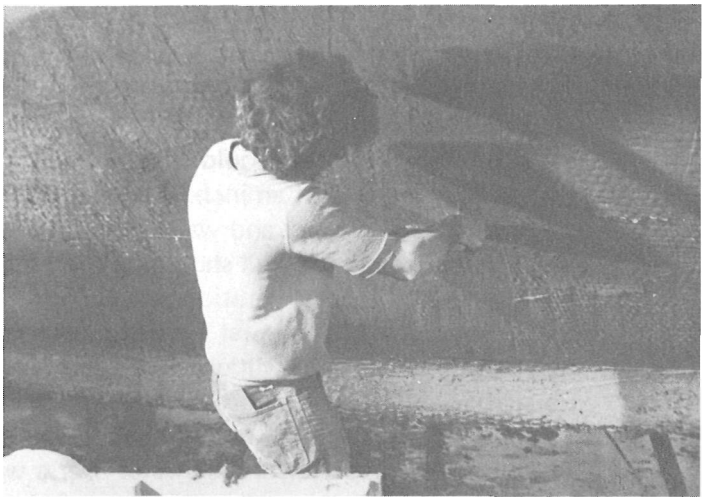
While the plasterers are working inside the hull a crew of helpers should be detailed off to scrape the excess mortar off first, the decks, then the hull. Simple steel scrapers may be made up or 1' x 6" x 1/2" (300 mm x 150 mm x 13 mm) plywood boards will serve. Scrape the mortar back until the surface mesh is exposed over the entire outside surface of the hull. The mortar is scraped back for two reasons:

1) Weight. It is difficult to gauge the thickness of the mortar over the mesh if surface mortar is not scraped back after application. Extra weight does not mean extra strength. The principle of ferro-cement is to leave as thin as possible a layer of mortar covering the mesh. By scraping the mortar right back a skin coat of new mortar may be applied to a controlled thickness.

2) Key. A doubtful bond may occur between mortar which has nearly set and fresh mortar applied several hours later. Cured concrete seems to bond better to new mortar than does semi-hard mortar to new mortar. The exposed wire mesh gives an additional key between the layers of fresh and older mortar, as does the rough surface left by the scrapers.

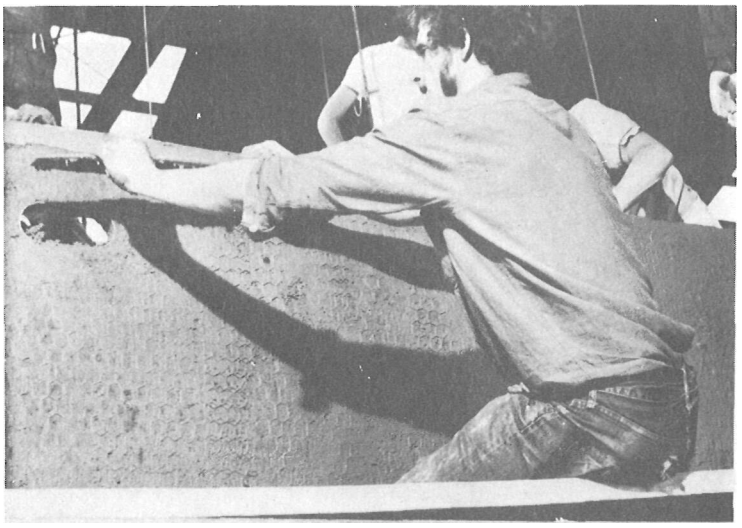


A helper uses a board to scrape excess mortar off the hull mesh inside and outside.



The mortar is scraped back to the surface mesh. This will enable the plasterers to control the thickness of the skin coat which is applied last.

A man scraping mortar off near the bow.



The mesh is left exposed.

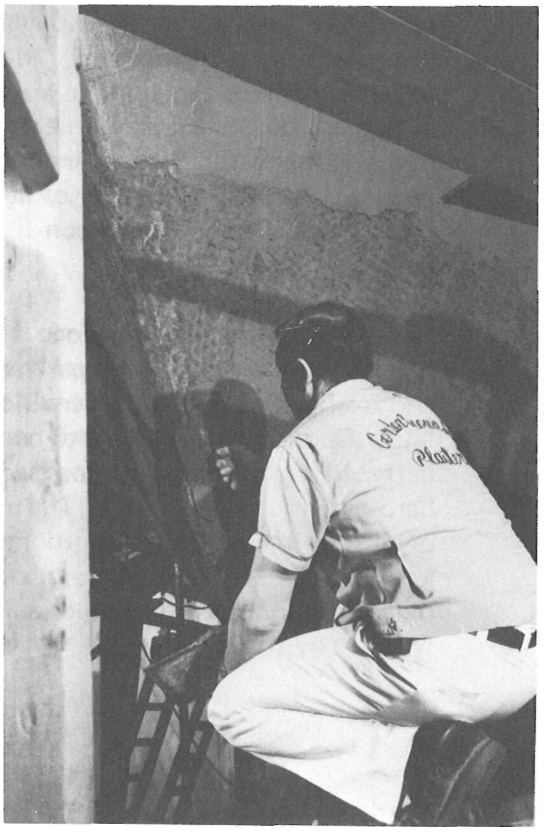
1) Mortar may have to be built up for such critical points as the bulwark sheer line or rail cap. The edge of the transom must also be built up so that a constant radius may be molded onto it.

2) Hatch coamings should be squared off neatly at all corners.

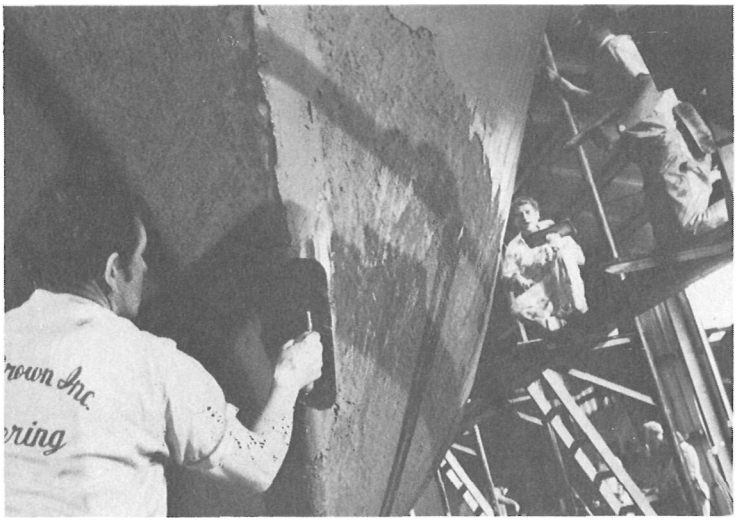
3) Scuppers should be faired into the deck and bulwarks.

STEP 5-SKIN COAT

When the mortar on the outside of the deck and the hull has taken its initial set a thin skin coat of fresh mortar should be spread over the surface. This skin coat should be troweled on smoothly about 1/8 of an inch (3 mm) thick. Mortar of the same mix and water content as was used previously on the hull should be used for the skin coat. As the hydration process is advancing rapidly in the first applied mortar at this stage the skin coat will only take about one hour after application before it can be worked. The skin coat is applied with the same plastering technique as is used to spread plaster over a wall.

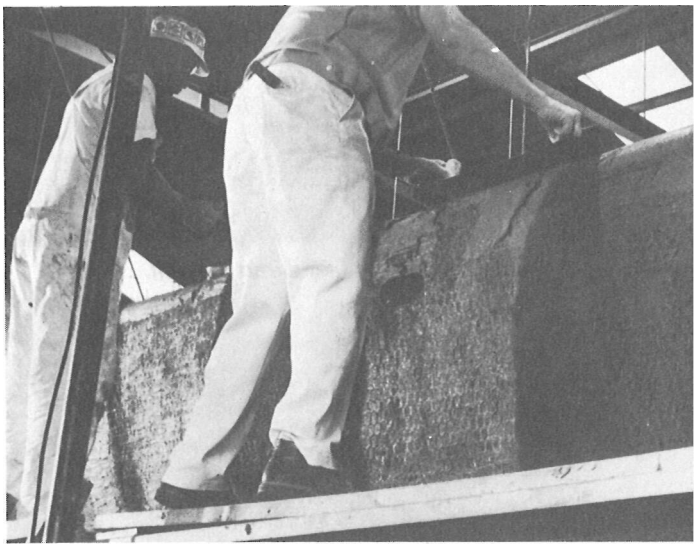


The mesh pattern' makes a good key for the skin coat.

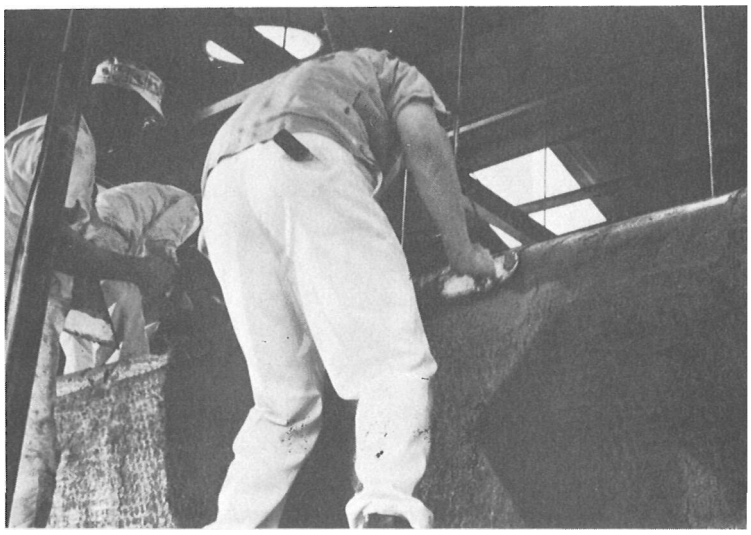


Applying the thin skin coat at the bow.

Building up mortar on the bulwark cap edge.

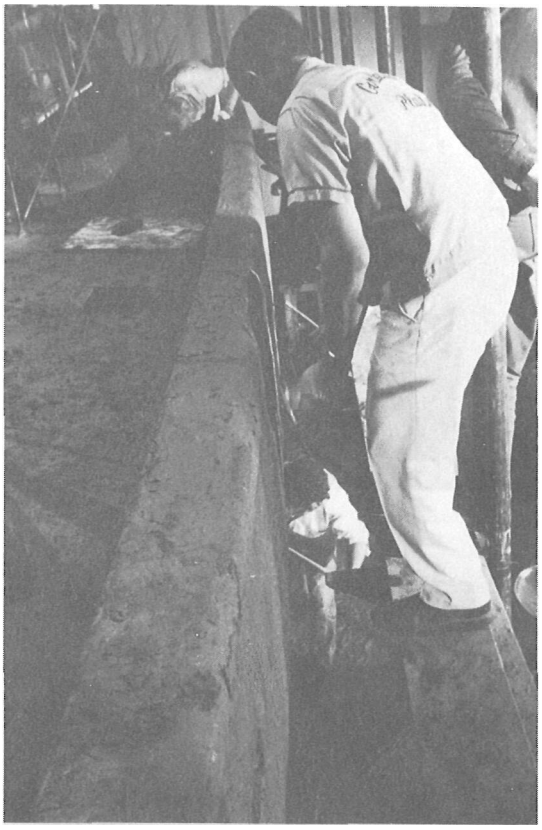


The darby is used to fair this critical area.



Mortar is stacked on the bulwarks cap and worked around the sheer-line.

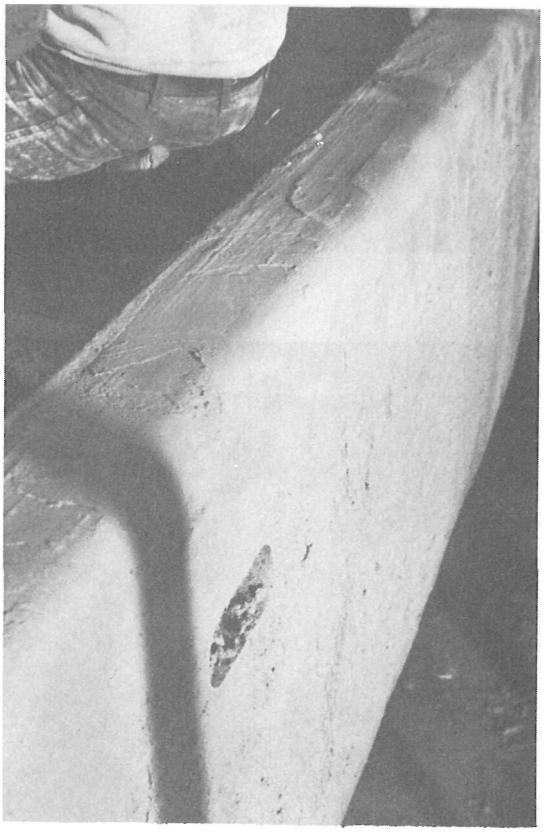
STEP 6 - SPONGE TROWELING DECK AND HULL



The mortar is faired into the hull.

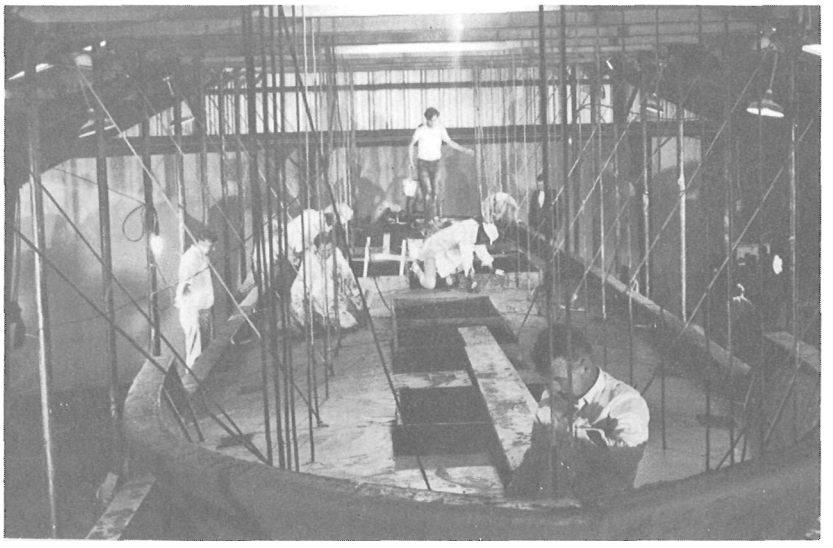
The deck is given a sponge trowel finish. This finish is carried up the inside of the bulwarks and under the cap. The hatch coamings are also sponge troweled inside and outside.

1) Sponge troweling should not be started until the mortar has taken its initial set. The sponge trowel is worked in a circular motion, the idea being to smooth out the ridges and shift the top layer of mortar into any hollows. As the mortar begins to set hard sponge troweling becomes more difficult. Resist the temptation to keep dipping the sponge trowel into a bucket of water in order to shift the surface mortar more easily. Rather, have all available men take up sponge trowels while the surface is still easily workable.

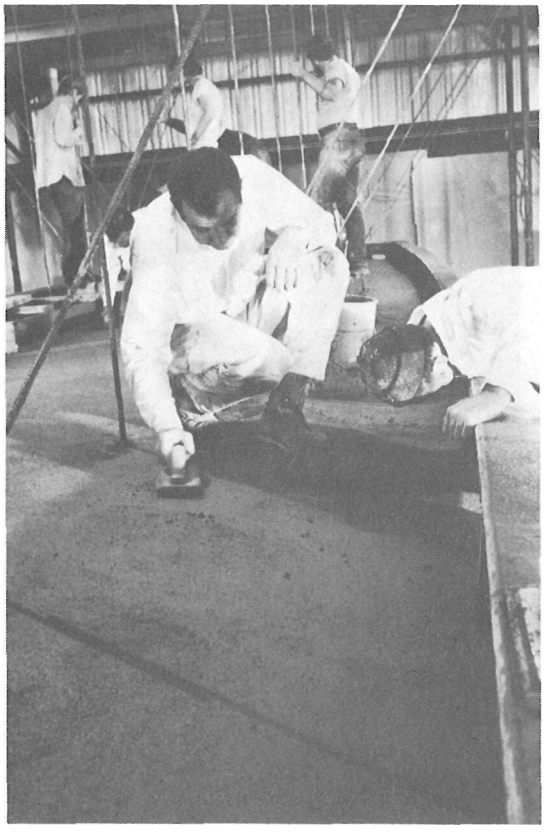


The built-up mortar is allowed to set prior to finishing.

Skin coating the deck.



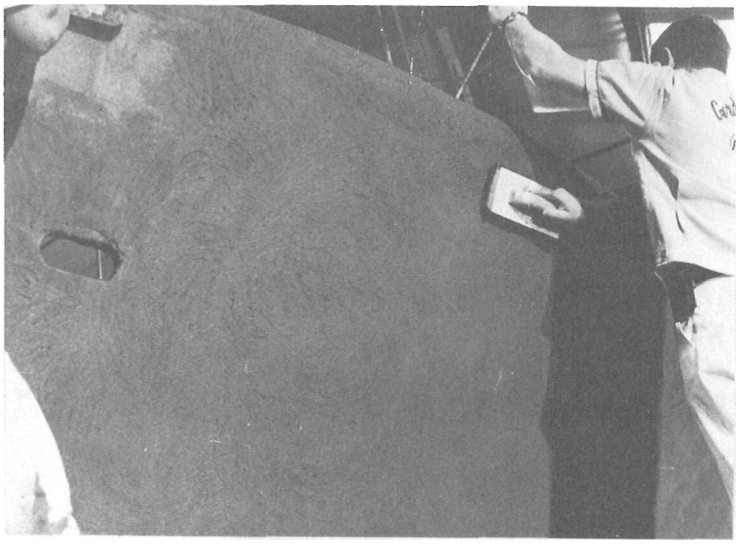
Overall view of deck being finished.



Sponge troweling the deck.

Fairing up a scupper.

2) The hull is sponge troweled in the same way as the deck. However, a good finisher with a steel swimming pool trowel should work right behind the man who is working the sponge float. He will trowel the hull to a glossy smooth finish immediately after the pass with the sponge float.



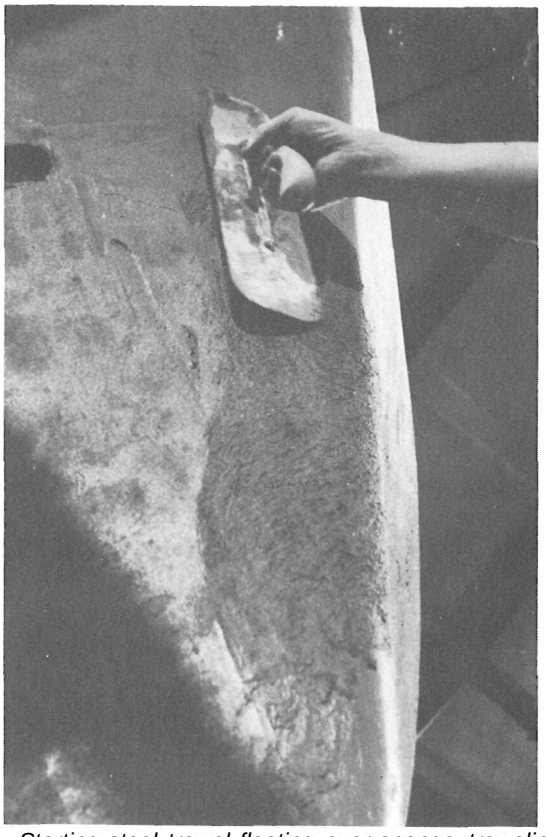
Sponge troweling.

Sponge trowel being used in a circular motion.

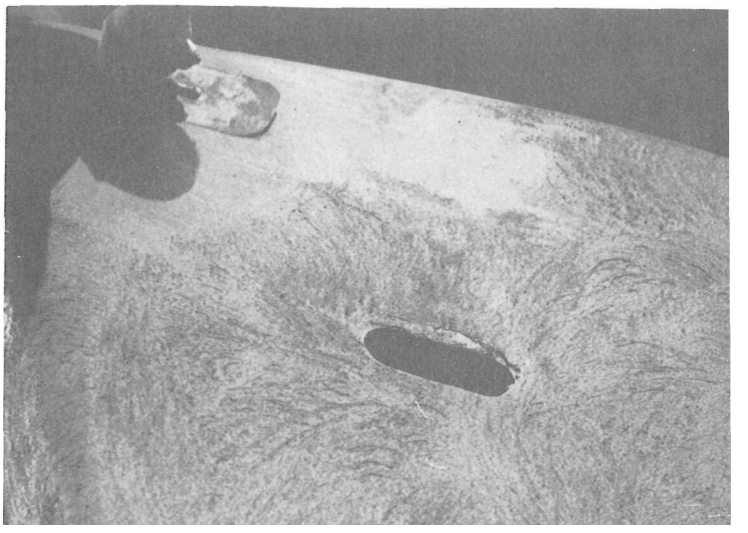
STEP 7 - STEEL TROWELING

The hull is gone over at least twice, first with the sponge floats, then with the steel trowels. If the hull mortar can still be worked have the men go over it for a third time. The more troweling and finishing the better the resulting hull finish. If the mortar has set too hard before the troweling pass is completed the plasterer may flick a little water cement grout over the surface to be worked. This grout will help lubricate his trowel. The grout should be used sparingly for it will turn to powder once the hull cures and has to be cleaned off before paint will adhere to the hull surface.

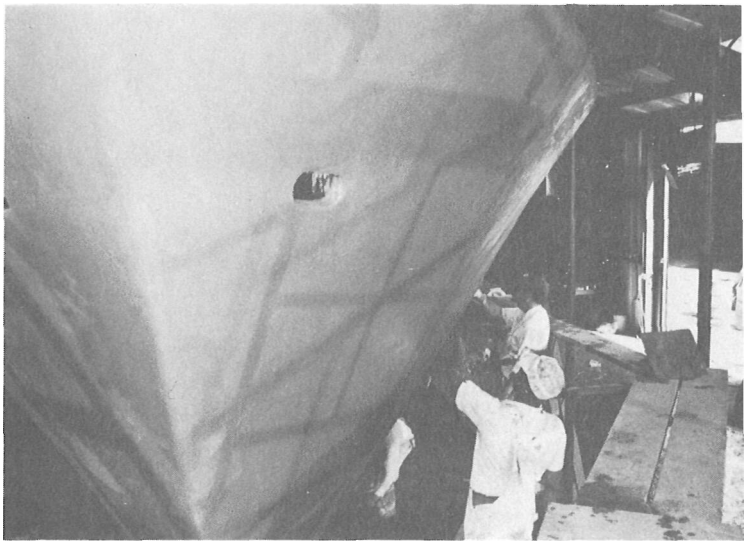
Finally, when the hull and decks are finished, the inside is neat and all spilled mortar cleared up, skin coat the bottom of the keel.



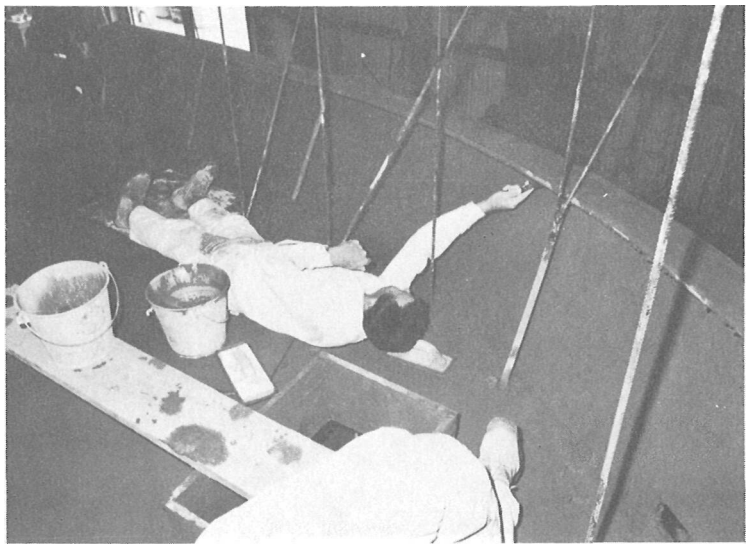
Starting steel trowel floating over sponge troweling.



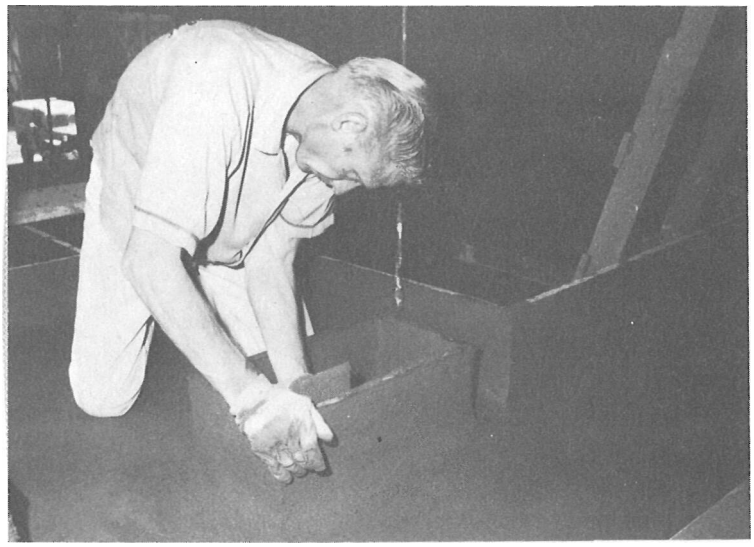
Steel float presses the surface sand back into the hull mortar.



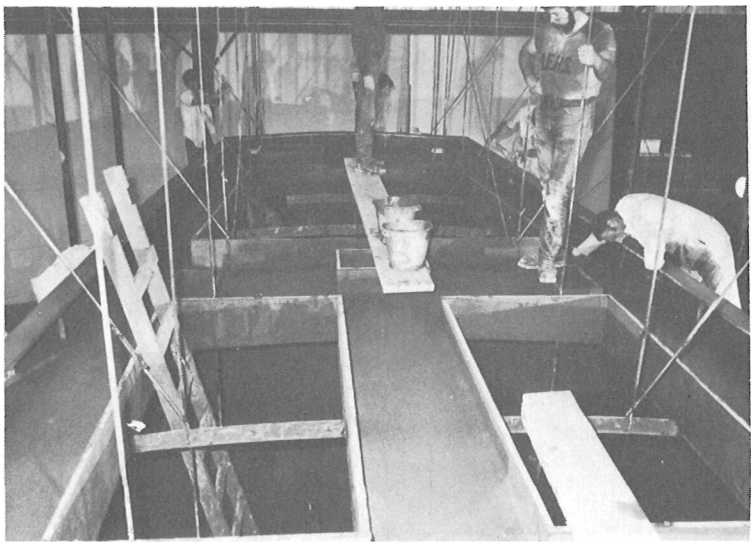
Result of the first pass of the steel trowel on the hull.



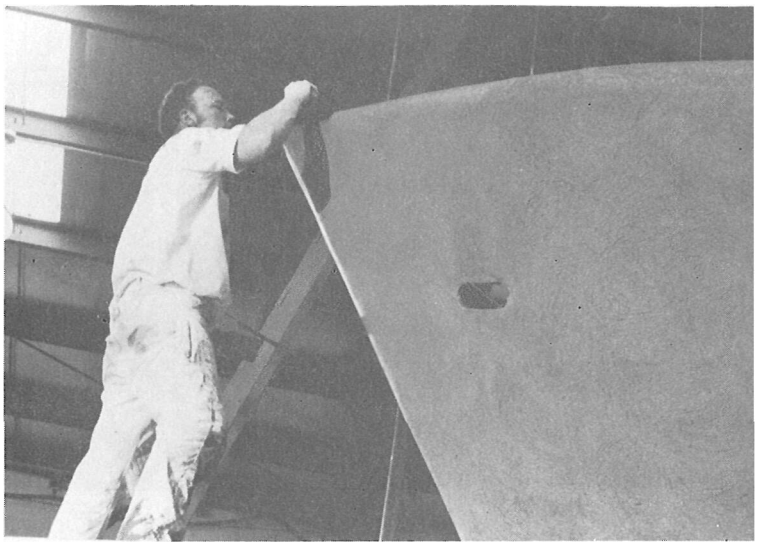
Packing the mortar under the bulwarks cap with the edging tool. An awkward area to work.



Sponge finishing the inside and the outside of the hatch coamings to conform to the T-bar screed.

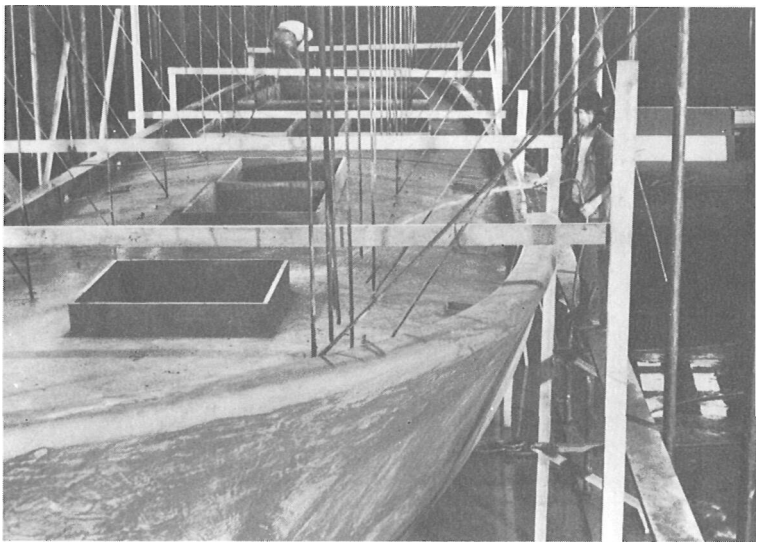


Decks, coamings and bulwarks sponge finished and looking trim.

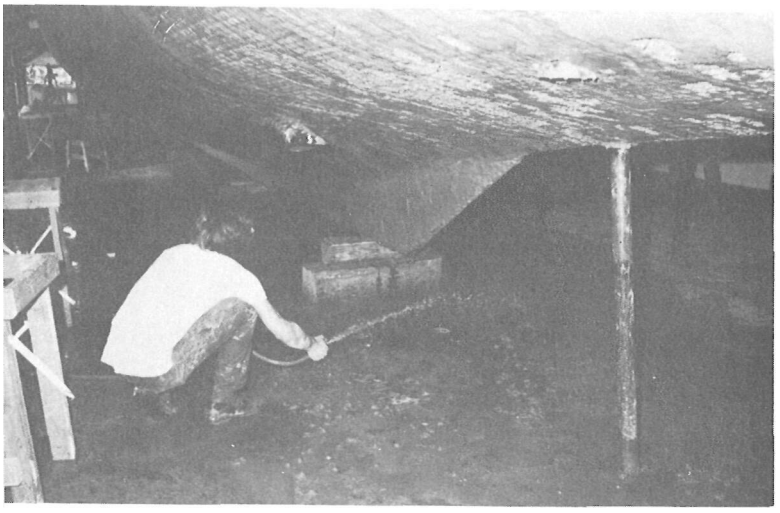


Putting a steel trowel finish to the stem-head.

A final touch to the steel trowel finish at the stem-head edge with a piece of plastic sheeting.

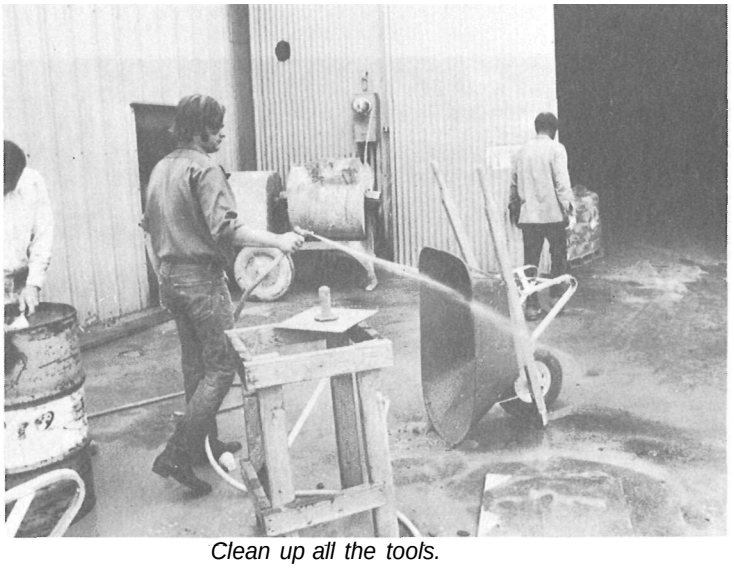


The morning after plastering day; wetting the hull surfaces down as the steam tent framework is being erected.



On a hot day spray water under the hull to stop flash setting.

At the end of the day clean all mortar boxes, etc.



Clean up all the tools.

CLEANING UP

Plastering a ferro-cement hull represents a long, hard day's work. The tired men will naturally want to go home as soon as their work is finished. Their work cannot be considered finished until the cement on every article of equipment used during the day has been thoroughly cleaned off. As well as cleaning off the equipment, the whole area must be hosed down and cleaned.

1) Washing Hand Tools

Collect all the hand tools used during the day. Place them conveniently close to a hose with a group of men detailed to ensure that all the dried concrete is thoroughly cleaned off. Supply several stiff brushes and scrapers to assist in their work.

2) Washing Equipment

Rinse the mixer out and clean it thoroughly. Again, use a stiff brush and a scraper to get any hardened mortar off the paddle blades and out of the drum corners. Hose and brush off the outside of the mixer. Attend to the mortar boxes, mortar stands, etc. Clean them off and leave them ready for another day's work.

3} Clean up the general work areas around the mixer, under the hull, and around the mortar boxes. Be careful that the man washing down the floor does not spray water on the fresh plastered hull. Have one man work with the man on the hose. He should use a long-handled scraper to remove dried lumps of mortar off the floor. Leave a good-sized pool of water lying under the hull. The evaporation of this water will raise the humidity around the hull and prevent it from drying out prior to steam curing.

4) Finally, wash off all the scaffolding planks. Pick up all the empty sand and cement bags and generally make the whole area tidy.

Nail battens on plastic joints.

Light framework for steam tent.

Steam tent erected.

ERECTING THE STEAM TENT

The steam tent should be large enough to clear the hull surface. No part of the tent should come in contact with the hull once steaming commences. The tent should also be as air-tight as possible. At the same time the tent should only be large enough to just contain the hull. Each additional cubic foot of the steam tent has to be heated to the required temperature, thus demanding extra steam heat from the generator.

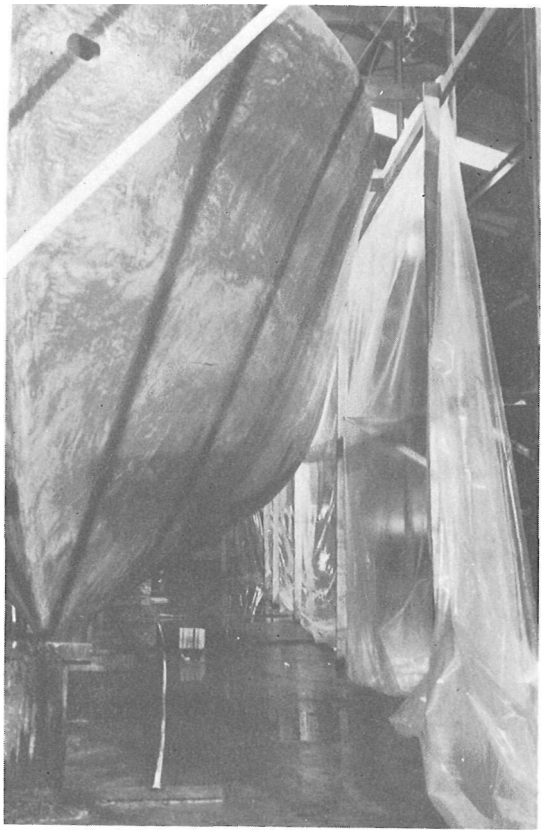
Plastic sheeting, 4 mil thick, makes an adequate cover for a steam tent in those cases where only a few boats are to be produced.

If many hulls are to be made, a more permanent steam tent made from rubberized canvas should be purchased.

There is little weight to the steam tent so a light 2" x 4" (45 mm x 90 mm) wooden frame (see photo) will be sufficient. Be sure to use some diagonal braces on the structure to prevent it collapsing. A heavier structure will be required if the hull is to be steamed out of doors. Furthermore, if the hull is to be steamed out of doors in cool weather a double layer of plastic sheeting should be used. One layer fastened under the wooden support structure and one layer over the support structure. This will form a closed air pocket between the layers of plastic sheeting and assist in maintaining the temperature in the tent. Battens should be nailed over all the sheeting joints if steaming out of doors for the wind may come up and rip the steam tent open during steaming.

Start erecting the steam tent first thing in the morning after plastering. A hull should be allowed a minimum of 12 hours after finishing before steam curing begins. The hull may be steam, or accelerated, cured for up to 4 days after plastering provided the hull has been kept damp during this period.

Finally, before commencing curing, knock a couple of drain holes in the bottom of the hull to let any condensed steam water trapped inside run out. Avoid shock loading the hull at any time prior to steam curing. Do not hammer wedges under the bilge. Do not cut main suspension braces; intermediate braces may be cut with caution. Do not jump down into the hull or jump onto the decks, at this time. Treat the hull as being fragile until after curing.



Keep plastic clear of the hull.

TASK 4 — Steam, or Accelerated, Curing

Steam curing is preferred to the 28-day cold water wet curing for the following reasons:

1) Steam curing is completed in 24 hours. Other work on the hull may then start.

2) Hulls which have been steam cured do not normally have shrinkage cracks to the extent of most hulls which are 28-day wet cured,

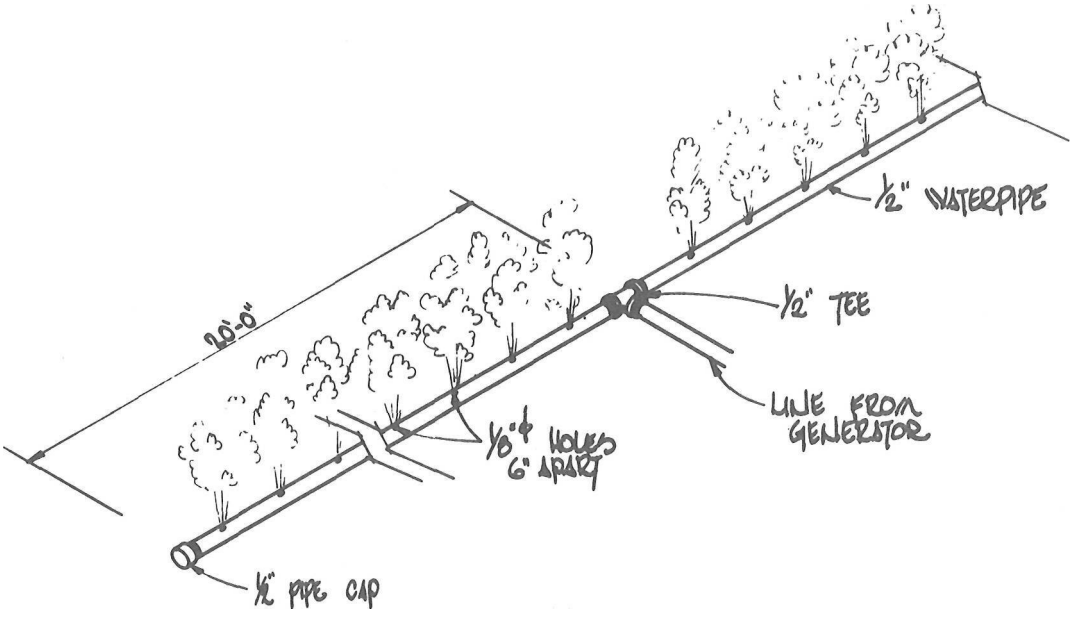
3) There is far less mess with steam curing than with wet curing.

4) A better control of the cure can be maintained with steam curing. It is difficult during wet curing to keep the entire hull wet. Dry spots will normally develop where a sprinkler does not quite reach. Strict watches should be maintained for 24 hours, during steam curing while a similar watch system would be very expensive to maintain for 28 days.

5) If a hull is built in a wooden building a 28-day wet cure could probably ruin the building. Floor joints will start to rot from the prolonged dampness, materials stored in the building will become soggy and possibly damaged. All in all, the 28-day wet curing method has many drawbacks.

TEMPERATURE

Raise the temperature slowly and try to maintain it between 140 and 160 degrees fahrenheit (60 to 72 degrees centigrade). Avoid going over 160° F (72°C). The enclosed steam curing chart, as used on the 65' (19.5 m) boat hull, is a good example of the steaming temperature curve to try to strive for. The term, "to try and strive for," is used because steam generators have been found to be temperamental. They may sometimes break down 3 or 4 times during the 24-hour operation due to one reason or another. That is why two generators should always be made ready. Two generators will ensure getting the temperature up to the proper level and, if one breaks down, the other should maintain the temperature until the broken one can be repaired.



Steam distribution pipes.

THIS CHART REPRESENTS A TYPICAL STEAM CURING OPERATION

TIME	TEMPERATURE	NO. 1 STEAMER PSI.	TEMPERATURE	NO. 2 STEAMER PSI.	THERMOMETER NO. 1 STB. DECK	NO. 2 STB. DECK	NO. 3 PORT DECK	NO. 4 PORT DECK	NO. 5 FOC' SLE	NO. 6 TENT TOP	NO. 7 TENT BTM.	AVERAGE TEMPERATURE °F
4:30 started	Started at 4:30		Started at 4:30									
5:00	–	–	–	–	105	95	110	95	85	100	102	98.8
5:30	350	100	275	50	115	100	115	110	95	114	115	109.7
6:00 *T.F.	350	100	275	50	125	115	120	120	105	120	125	118.5
6:30	355	100	275	50	133	122	130	125	120	125	127	126.0
7:00	355	100	275	80	140	130	140	135	135	130	134	134.8
7:30 *T.F.	355	100	275	50	145	140	145	140	145	134	137	140.8
8:00	350	100	270	80	145	150	150	150	150	140	133	145.4
8:30 *T.F.	350	100	210	50	140	150	150	150	150	125	150	145.0
9:00	355	100	225	50	150	150	150	150	150	130	140	145.7
9:30 *T.F.	355	100	220	50	150	150	150	150	150	132	140	146.0
10:00	350	100	210	50	150	152	150	155	155	130	145	148.1
10:30 *T.F.	355	100	220	50	150	150	150	150	155	130	145	147.1
11:00	345	100	260	50	150	155	152	155	158	138	142	150.0
11:30 *T.F.	345	90	260	50	155	160	155	160	160	150	156	156.5
12:00	350	100	245	50	155	155	155	160	160	156	140	154.4
12:30 *T.F.	350	90	–	35	155	160	155	160	165	146	147	155.4
1:00	352	90	– BROKEN	–	150	155	151	154	158	138	142	149.7
1:30 *T.F.	355	90	– DOWN	–	148	150	150	150	155	135	141	147.0
2:00	340	90	–	–	148	150	148	148	155	130	135	144.8
2:30 *T.F.	340	90	–	–	148	150	148	148	150	134	140	145.4
3:00	340	90	–	–	148	150	148	148	152	134	138	145.4
3:30 *T.F.	340	90	–	–	146	149	148	148	152	132	138	144.7
4:00	330	85	–	–	146	148	146	146	149	138	132	143.5
4:30 *T.F.	336	80	– REPAIRED	–	140	145	140	140	145	130	135	139.2
5:00	335	80	200	40	135	145	138	140	146	138	135	139.7
5:30 *T.F.	335	80	215	45	141	148	142	144	147	138	137	142.4
6:00	342	95	222	45	144	153	146	149	153	135	137	145.2
6:30 *T.F.	348	95	220	45	144	154	147	150	154	134	137	145.7
7:00	348	95	221	45	147	156	150	152	155	136	138	148.0
7:30 *T.F.	348	95	220	45	149	158	151	155	157	137	139	149.4
8:00	346	90	222	45	150	158	152	155	158	137	140	150.0
8:30 *T.F.	339	90	223	45	152	160	153	157	160	137	141	151.4
9:00	336	90	220	45	152	161	154	158	162	138	142	152.4
9:30 *T.F.	333	88	222	45	153	163	155	160	162	139	142	153.4

10:00		300	45	222	45	154	162	155	160	164	139	143	153.5
10:30	*T.F.	295	45	222	45	153	161	156	160	165	138	142	154.0
11:00		–	–	222	45	150	156	151	152	157	133	136	148.0
11:30	*T.F.	333	72	220	45	150	159	153	156	158	136	139	150.1
12:00	No. 2 Shut Down	310	60	214	45	153	160	155	158	161	139	142	152.5
12:30	*T.F.	325	53	SHUT OFF		153	160	155	157	160	138	143	152.4
1:00		325	70	–	–	155	160	155	158	160	140	144	153.1
1:30	*T.F.	343	83	–	–	154	160	155	157	160	138	142	152.4
2:00		348	90	–	–	154	160	155	157	160	138	143	151.5
2:30	*T.F.	345	80	–	–	152	158	155	157	158	139	143	152.5
3:00		332	75	–	–	155	160	155	158	158	139	143	153.2
3:30	*T.F.	342	85	–	–	157	160	157	158	160	139	142	154.0
4:00		342	85	–	–	157	160	155	157	159	138	142	152.0
4:30	*T.F.	342	90	–	–	150	160	155	150	155	135	142	149.5
5:00***		130	40	–	–	150	157	150	150	155	130	134	146.5
5:30		200	40	–	–	145	140	145	145	140	125	130	141.4
5:45		Shut Down Generator No. 1		–	–	–	–	–	–	–	–	–	–
6:00		–	–	–	–	140	145	140	140	143	124	125	136.7
10:00		–	–	–	–	102	105	105	100	100	95	98	100.7

*T.F. - Tanks Filled

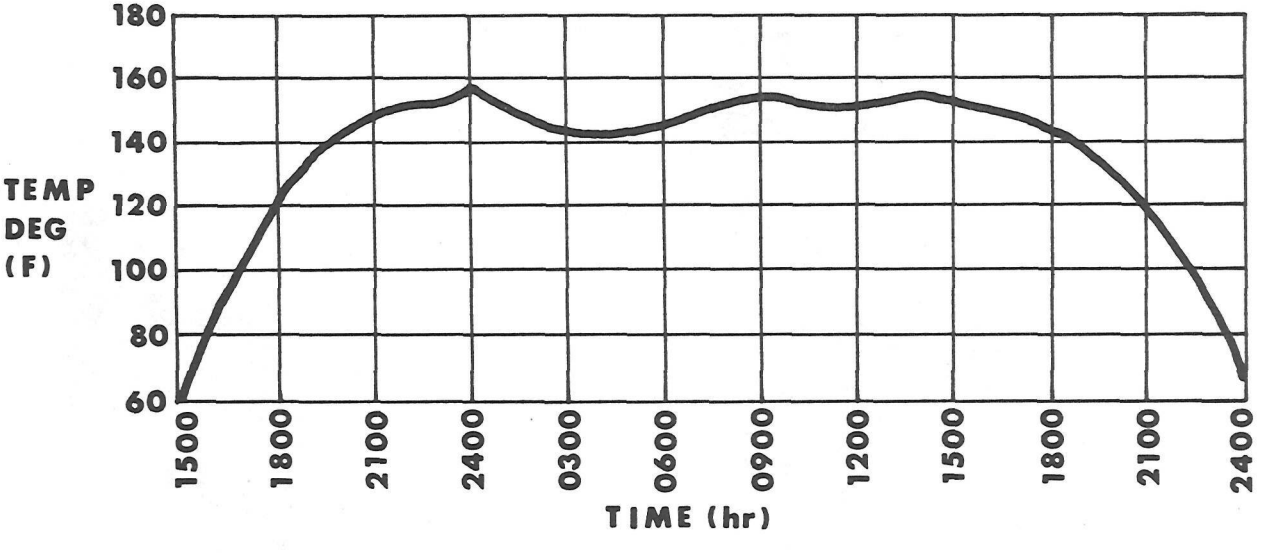
**0pened water valve cut-back fuel.

220 U.S. gallons of kerosene was consumed during steam curing.

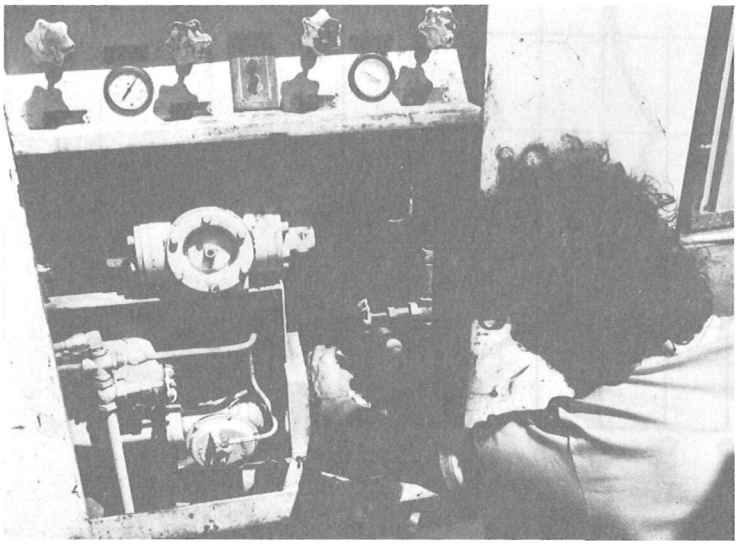
NOTE: One generator broke down during the night. The temperature fell off while the generator was being repaired. However, the second generator maintained the hull temperature at an acceptable temperature to ensure a good cure.

The peak and the hollow on the graph reflect this breakdown.

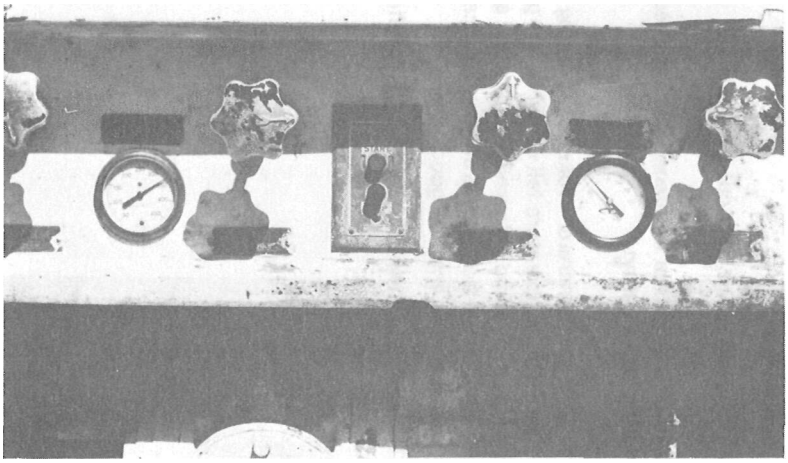
STEAM CURE GRAPH



Steamers, fuel, lights and tools.



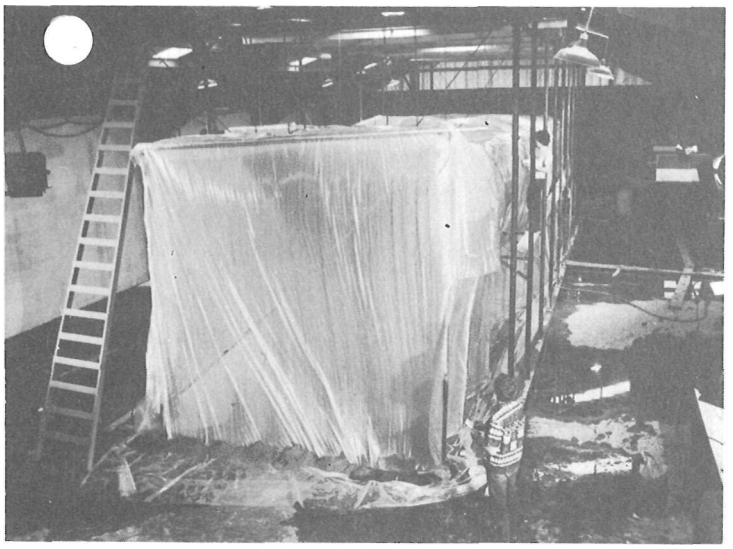
Adjusting fuel to steam generator.



Pressure and temperature gauges on the steam generator.

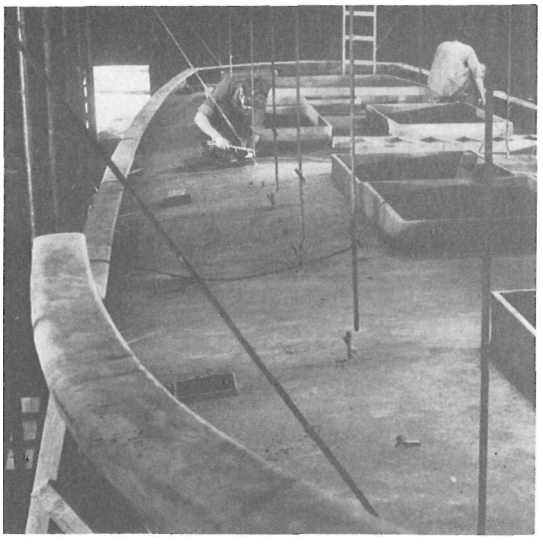
If the temperature cannot be raised over 120°F (50° C), maintain this temperature for 48 hours to ensure adequate curing.

Little accurate scientific information is presently available on the optimum temperature to be used during the steam curing of ferro-cement hulls. However, if the hull is cured under temperatures similar to those of the enclosed table a good job will result.

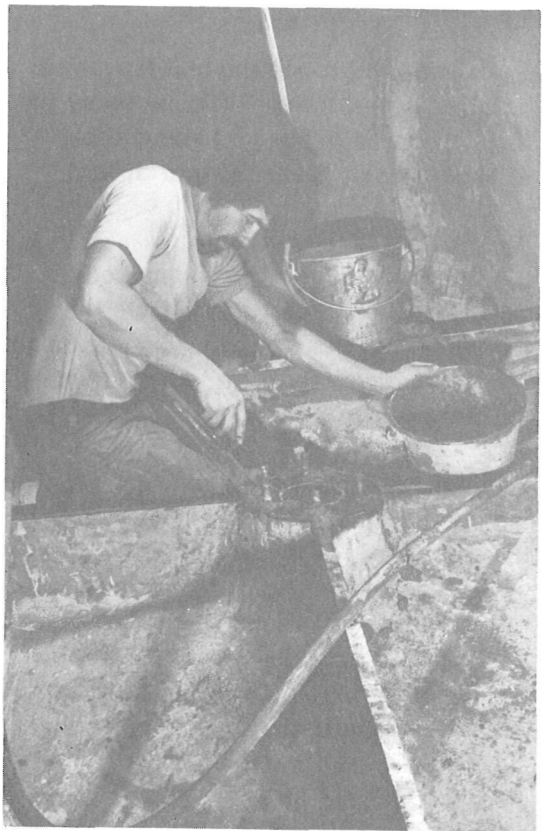


Steaming in progress.

Thermometers reaching into the hull to register hull temperature at various points.



Cutting susoension rods.



Filling shaft housing.

Casting Keel, Engine Beds and Rudder Housings

After the steam tent has been removed and the hull has cooled off, the keel, engine beds and rudder housings may be plastered.

1) Mix. Use the same mix for plastering the above-mentioned areas as was used for the hull itself. A slightly higher water-to-cement ratio may be used to make the mix more fluid so that it will fill up the cavities completely.

2) Start at the stem interior and sprinkle water over the stem. This will stop the hardened concrete from drawing too much moisture out of the fresh mortar.

3) Pack the stem cavity with mortar, vibrating it where possible. Fair the mortar into the hull concrete.

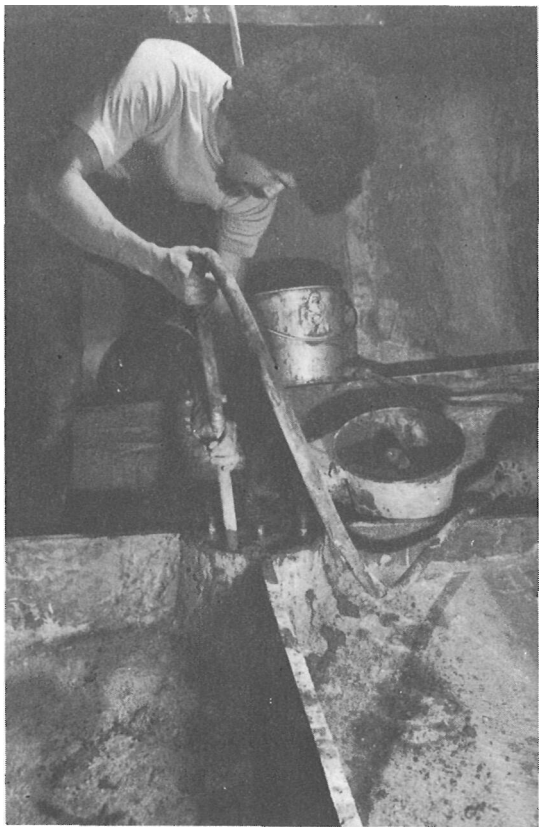
4} Work aft through the hull repeating the same process. Fill completely the keel cavity to a height above the gar-board line. Taper the mortar into the hull.

5) Pour mortar into the engine beds. Insert the vibrator and vibrate this area well. Stack the mortar to a height above the screeds and leave it to start setting.

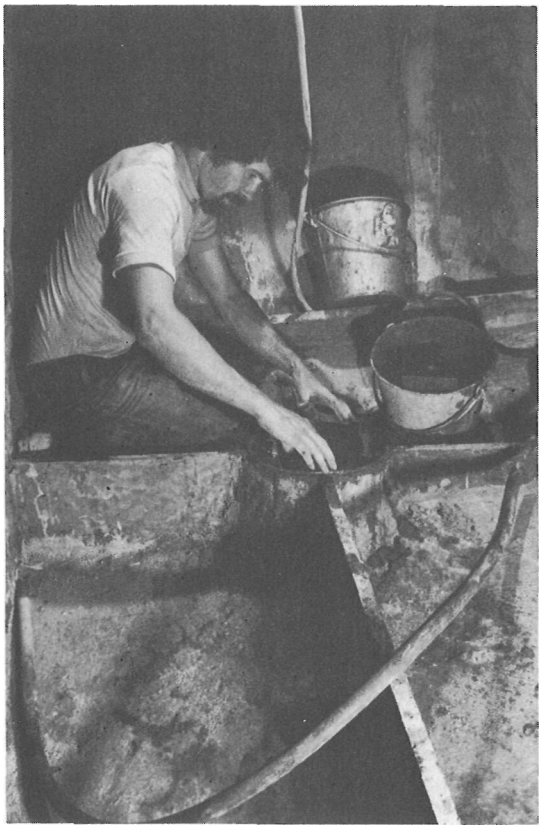
6) Check the rest of the engine room compartment. If there are any rough areas apply more mortar and round off the corners. When this mortar stiffens it will be steel-troweled smooth to give the concrete surfaces around the engines a slick smooth finish which will later be easier to keep clean than would a sponge trowel finish.

7) Remove the plates off the rudder stuffing box housing. Pack these full of mortar. Vibrate them well. Add more mortar until the housing is over-full. Replace the top plate and tighten up the bolts until the mortar squeezes out from all around the rim. This will form a good seat for the rudder stuffing box gland which will later be installed in this housing. As the nuts are tightened up, use a spirit level to ensure the top of the plate is finally level in all directions. This will ensure that the stuffing box gland will not bind on the rudder shaft when it is installed.

8) Go back over the stem and keel and sponge trowel finish all the newly applied mortar.



Vibrating mortar in rudder housing.



Fitting rudder housing plate.

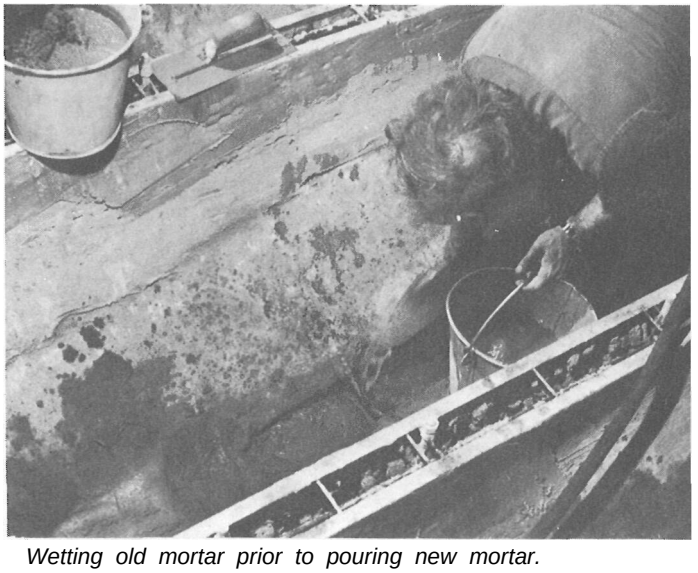
9) Carefully finish the top of the engine beds. Smooth the mortar absolutely level with the top surface of the T-bar screeds. Clean off any mortar from the bolts which protrude. Steel float the rest of the mortar.

10) Clean up the tools and equipment.

Mortar is dumped into keel bottom.

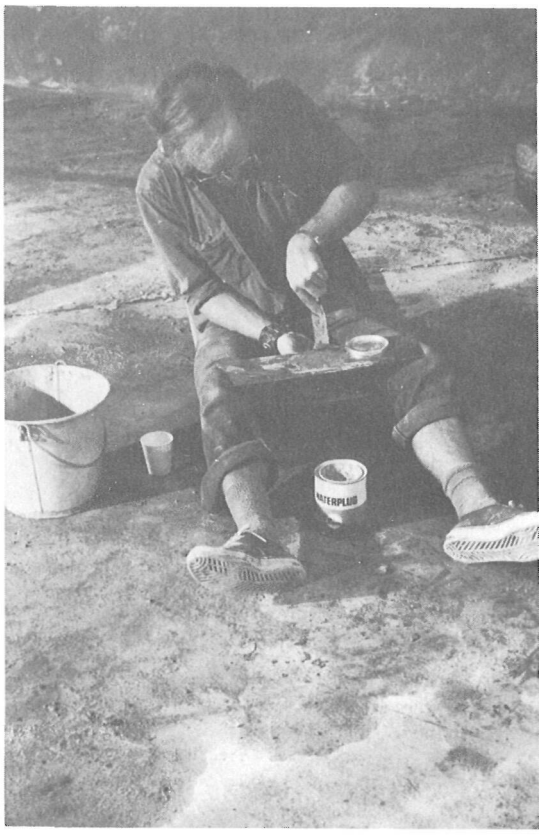
Then thoroughly vibrated.

Passingmortarinforthekeel.

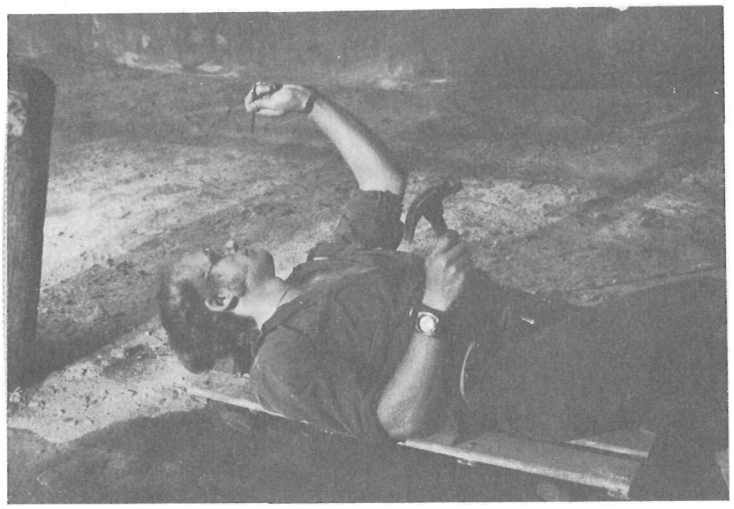


Wetting old mortar prior to pouring new mortar.

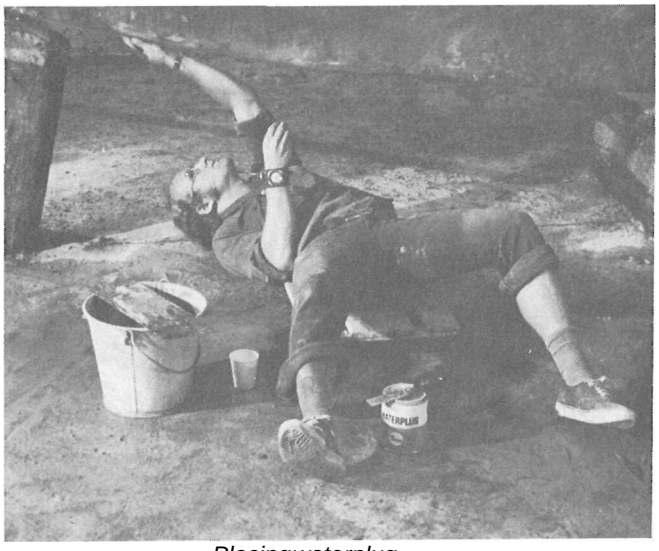
Mortar is faired into hull.



Mixing waterplug.



Chipping out hair-line cracks.



Placingwaterplug.

Engine beds are well vibrated.

Water Testing

If a concrete hull will hold water in, it will hold water out. This is the basic principle of the water test.

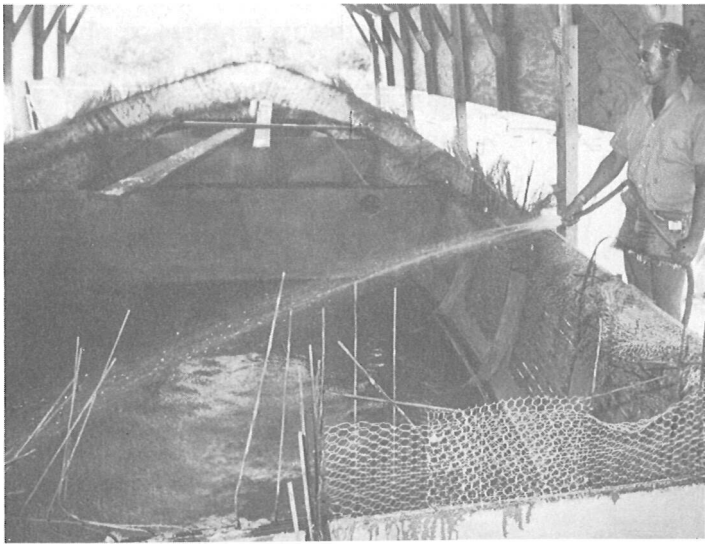
Even with the most conscientious workers, and the best supervision, voids can occur in the hull shell and keels of concrete vessels. These voids, if present, should be tracked down and repaired prior to proceeding further with construction. The best way to date of detecting leaks or potential leaks is to brace the hull well and fill it with water above the load water line. Water will leak out of those same small cracks or voids which will leak when the vessel is in service. These leaks can be marked on the hull and repaired once the water is pumped from the hull.

1) Use a fast-setting cement such as "Quick Plug" (see section on repair) and plug up the drain holes which were punched in the bottom of the hull prior to steam curing.

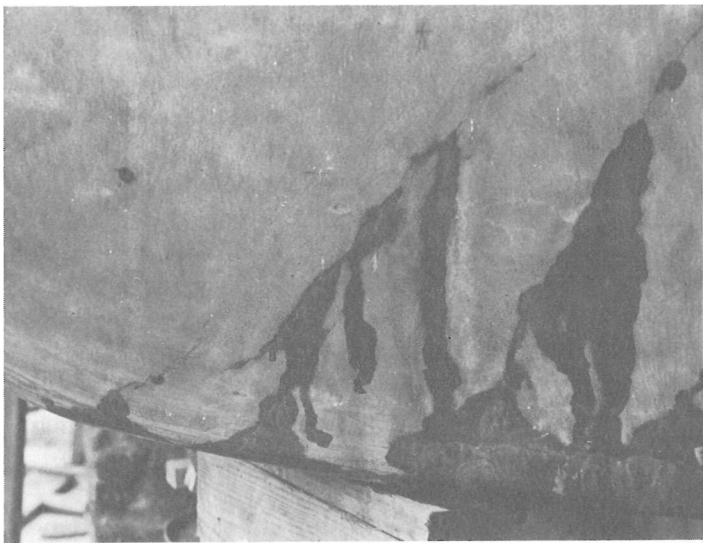
2) Block off the rudder shaft apertures and the propeller shaft apertures. The best way to do this is to install and bed the stuffing boxes into these apertures. Next, insert the shafts themselves and tighten up the stuffing box packings.

3) Block any thru-hull fitting holes. Again, the best way to block these is to install the thru-hull fittings and close the sea cocks. (Note: By installing the shafts and thru-hull fittings prior to water-testing, these fitting installations are also tested.)

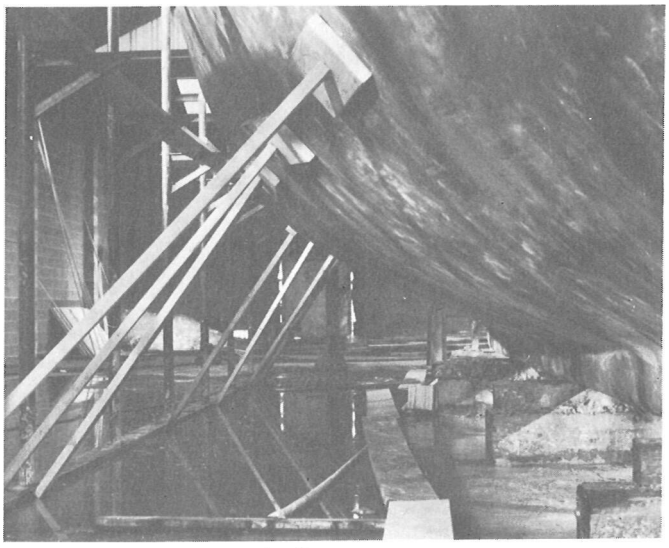
4) Shore up the hull. If a hull is designed to displace 25 tons when outfitted, it will hold nearly this amount of water when filled up to the load water line. Be sure the hull is well supported so that no damage occurs to the hull or the boat shed floor when this extra weight is placed inside the hull.



Filling hull compartments.



Crane-dropped hull showing damage, cracks leaking and sealing with sodium silicate.



Shoring up for water testing. testing

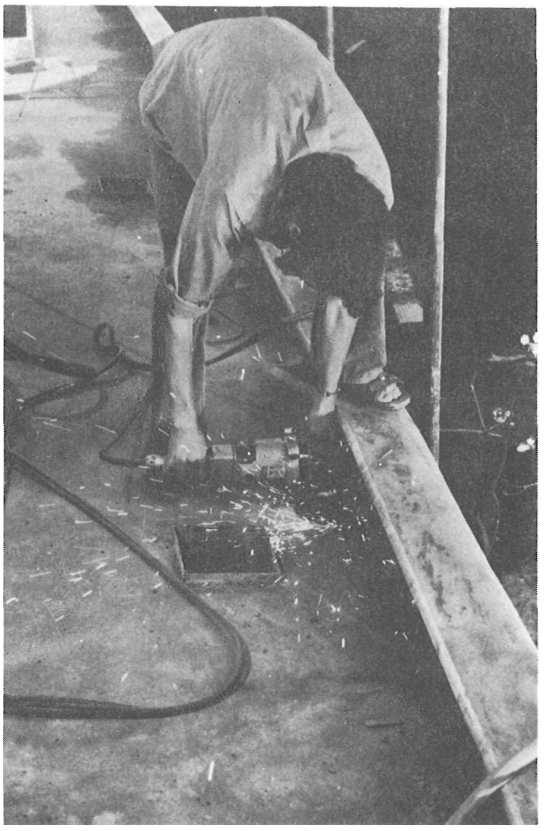
5) If the hull contains water-tight compartments fill these compartments one at a time. This will test if the compartments themselves are truly water-tight.

6) Pump the water from one compartment to the next, carefully checking for leaks and damp spots on the outside of the hull.

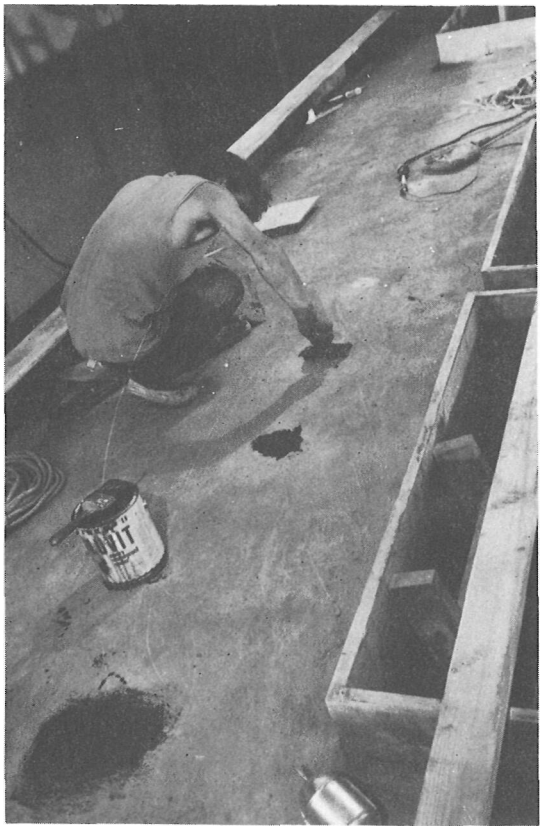
7) If small weeps or damp spots occur and the source cannot be recognized, then pour 5 gallons of sodium silicate for approximately every 1000 gallons of water into the hull test water. Stir the sodium silicate (water glass) to be sure that it becomes well mixed with the test water. As water leaks out of a crack it will carry some of this chemical with it. When sodium silicate comes in contact with the concrete at the inside edge of a small crack, it will form crystals which usually effectively seal minor cracks in about three days.

8) If larger, more persistent, cracks appear repair them. (See section on repairs.)

9) Once the hull is proven water-tight, pump or siphon all the water out. Mop up any standing water and allow the hull to dry out for two days before commencing outfitting.



Grinding rod ends below the surface.



Putting suspension rod ends.

Repair

Part 1 — New Construction Voids and Leaks.

Part 2 — In-service Damage.

Part 1

A. Sealing Stern Tubes and Rudder Stock Housings

Where steel pipe is used for propeller shaft stern tubes and rudder stock housings the following procedure should be adopted:

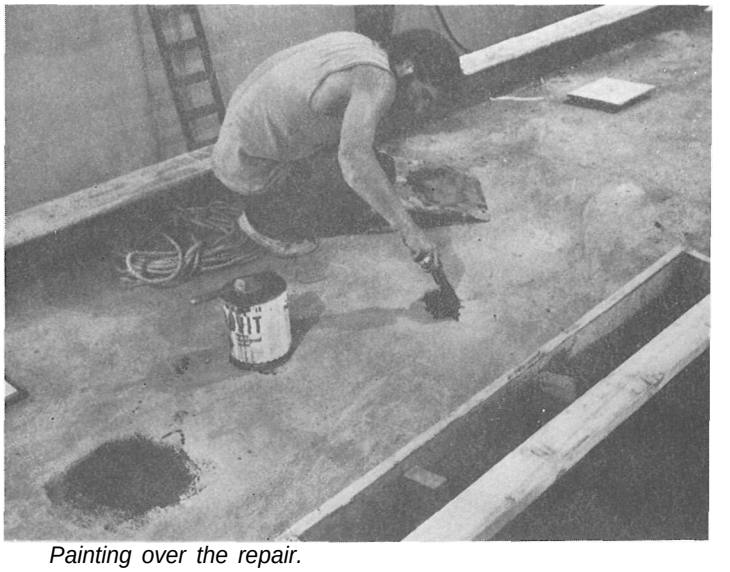
1) Chip out the concrete around the entire circumference of the outside end of the steel pipe in a "V." The "V"-shaped groove should be approximately 1" (25 mm) deep and 1/2" (13 mm) wide at the hull surface. Use a small, cold chisel to do this. Do it carefully so that the "V"-shaped caulking seam is reasonably neat. Avoid breaking large chips out of the hull when making the caulking seam.

2) The builder rolls an even-sized rope of tarred oakum on his knee in a strip about as thick as a factory-rolled cigarette.

3) Using a caulking iron or a cold chisel, hammer the oakum into the "V"-shaped crack. Pound the oakum in tight. Fill the crack to a height of approximately 1/4" (7 mm) from the surface.

4) Mix up a batch of sealing compound. Use epoxy resin and cement powder mixed together into a stiff consistency. Paint the seam with resin. Then fill it out with the prepared sealing compound. The sealing compound can be smoothed level by the builder wetting his thumb and rubbing it over the surface.

5) When the sealing compound starts to set paint the area with a coat of the same epoxy resin.



Painting over the repair.

Calking shaft log aperture.

B. Sealing Shrinkage and Stress Cracks

If there are any shrinkage cracks which are obvious to the eye they should be repaired in the following manner:

1) Use a small cold chisel and chip out the crack in a "V" shape down to the outer layer of mesh.

2) Mix a batch of Roplex, fine sand and cement powder, one part sand, one part cement, and enough Roplex to make the mix into a stiff paste or putty.

3) Paint the crack with Roplex. Apply the putty to the crack with a putty knife or trowel. Paint the surface of the crack with Roplex.

4) If the crack is a large one, it may need two coats of putty as this mixture will shrink if used in too large an amount. For the second coat of putty repeat the same process as for the first. Note: Only mix small quantities of putty at one time as this mixture has a short pot life.

C. Sealing Holes

To seal holes such as drain holes, also small voids found under keel support blocks, use the following procedure:

1) Chip away inside the hole so that it becomes larger than at the surface.

2) Mix up a batch of "Quick Set" or some other fast-setting and expanding patching compound. Roll the compound into a ball and stuff it into the hole. Smooth out the surface and hold it in place for a couple of minutes until the compound sets. The plug will expand in the hole and fill it tightly.

3) Paint over the top of the "quick" plug with epoxy resin. Note: A good epoxy resin to use for patching is a thiokol-base epoxy. "Gluvit" is a recommended brand.

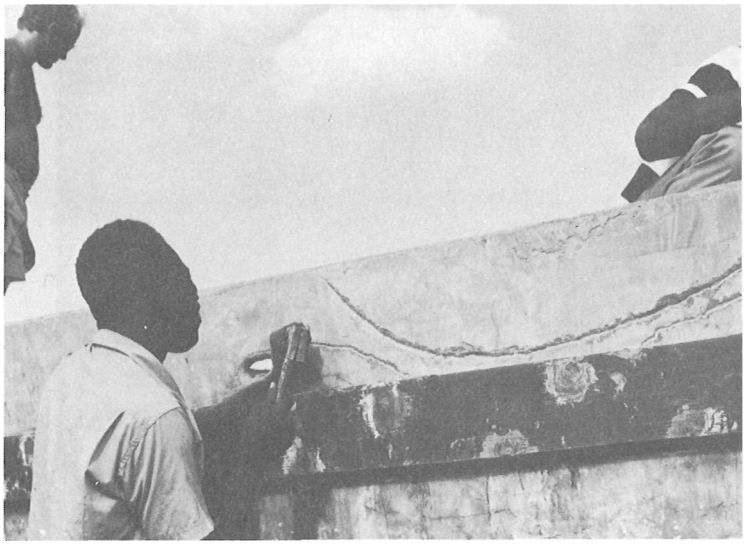
D. Sealing Suspension Rod Ends

Where a hull has been suspended from an overhead support during construction, and suspension rods pass through the deck, the rod ends will remain exposed and level with the deck. These places should be treated in the following manner:

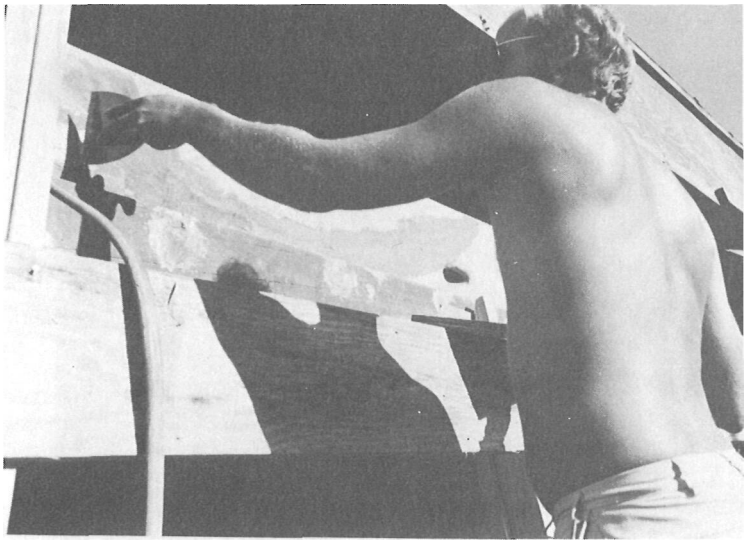
1) Clean off the concrete at the base of the rods. Use an oxy-acetylene cutting torch and cut the rod off as close to the deck as possible. (Note: heated concrete will pop and explode. Be sure to wear protective eye-pieces and clothing.)

2) Use a grinder with a carborundum disc and grind the end of the steel rod until it is 1/4" (7 mm) under the surface. Use a lot of pressure and the grinding will not take long even though it does make a lot of dust.

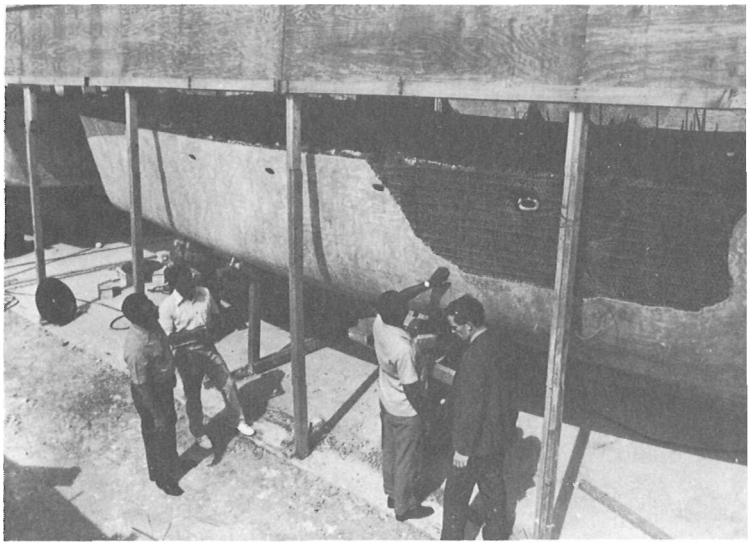
3) Mix up a compound of epoxy and cement (the same as was used for the rudder and stern tubes). Fill the gouges left in the deck by the grinder, first painting the gouge with resin, then filling it with putty. Paint the areas with resin to smooth the compound level with the surface of the deck.



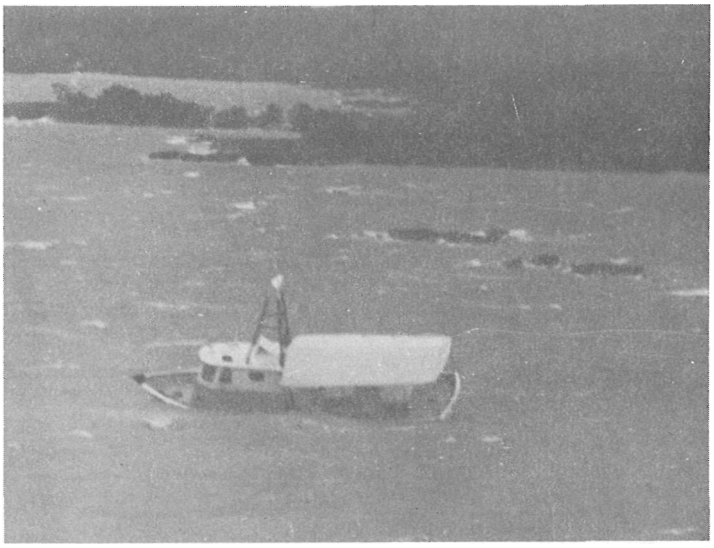
Damage cracks to the hull sheer are deepened with hammer and chisel into a V-shaped groove.



The V-shaped repair groove is first coated with Roplex, then filled and smoothed with a fine sand, cement and Roplex putty.



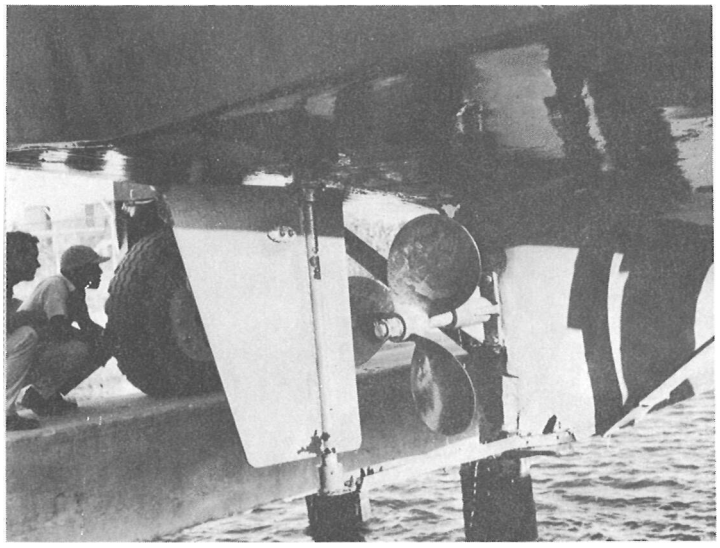
A large, damaged area to a crane-dropped hull has the broken concrete pounded out completely and the reinforcing steel and mesh faired prior to repair.



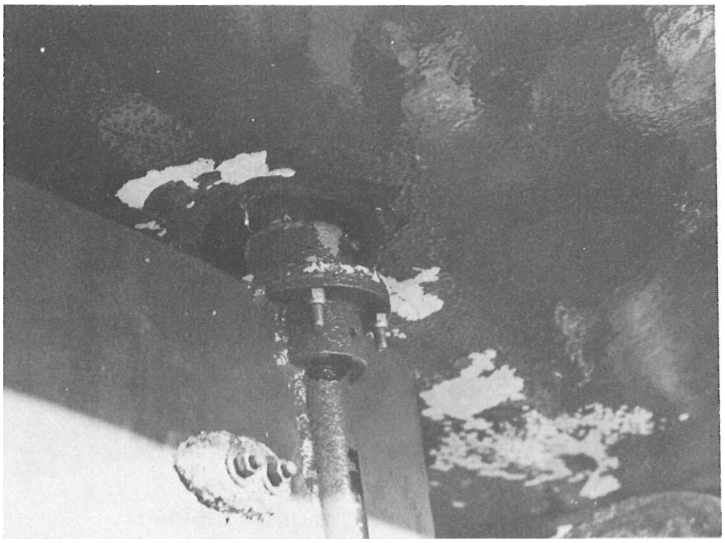
The reef-bound vessel from the air.

REPAIRS IN SERVICE

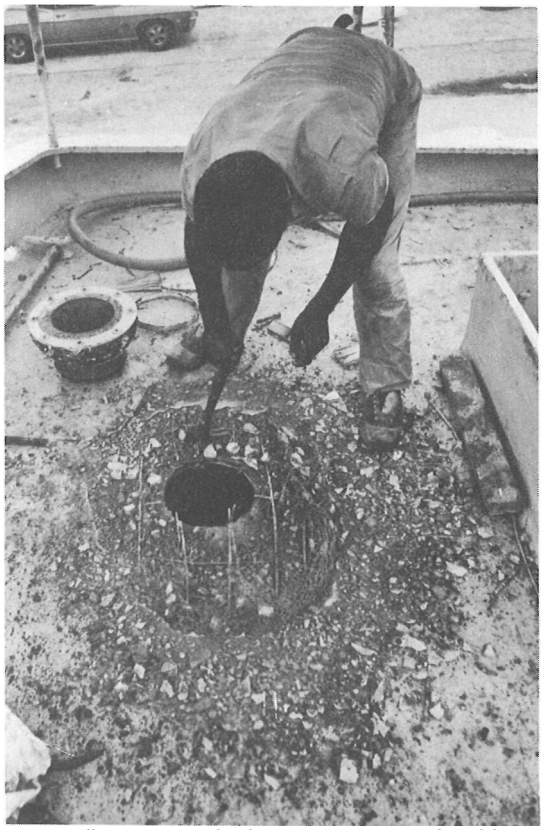
An unattended fishing vessel is driven onto remote Bahamian reefs in a storm. Before finally wedging herself on the reef the vessel, her anchor chain parted, pounded her rudder shoe severely on the rocks. She lay for two weeks on the reef. Later it was found that the propeller shaft, due to the ferro-cement deadwood having been poured solid with concrete, was as true as the day installed. Photos reveal the damage.



Damaged steel keel. Minimal damage to ferro-cement deadwood.



Rudder shaft housing driven upwards tnrougn hull shell. The only leak.



Pounding out cracked cement at top of rudder shaft housing.

Part 2

Repair to a Vessel in Service

If a concrete hull receives major structural damage while in service it may be repaired as follows:

1) The vessel should be put into dry dock and blocked up in such a way as to free the area under repair from stress.

2) All interior fittings should be removed from behind the area of damage.

3) The damaged concrete should be pounded out from the mesh and steel reinforcing. One man should be stationed inside the hull holding a heavy sledgehammer head against the area of the hull to be repaired. A second man outside the hull will use a 2-lb. (1 kg) sledgehammer and pound out the damaged concrete at the point against which the first man is holding his sledgehammer head. This will pulverize the already damaged cement leaving the mesh and rods bare.

4) The mesh and rods should be pounded back into fair. If rods are broken or badly twisted they should be cut out and new rod lap-welded to the stub ends which protrude from the edge of the damaged area. If the mesh is badly damaged it should be cut out in this manner:

   The outside layer of mesh both inside and outside the hull should be cut back 3" (75 mm) from the damaged area. Each successive layer should be cut back 3" (75 mm) further away from the edge of the repair. New mesh should then be cut to the shape of each panel and clipped in place. Be careful not to lap the joints for this will make the penetration of the repair mortar difficult if too many layers of mesh are built up. Fair the repaired rod and mesh to the lines of the hull.

5) Paint the edge of the repair with a sloppy grout mixture (water and cement with no sand). While the grout is still wet, plaster the repair with a standard hull mix of mortar. Finish the repair in the same way as the hull was plastered originally. Lay wet sacks on the inside of the hull and paint the outside of the repaired area with a concrete sealant. Keep the sacks continually damp for 7 days. Paint as with new concrete.

6) Replace the interior fittings after the repair has had 7 days to cure. If the damaged area is extensive, do not move the hull for 28 days by which time the cure will be complete.

Two-Coat Plastering

Two-coat plastering is an alternative method to complete plastering in one day or to cold-joint plastering. Essentially, it consists of giving the entire hull a skin coat of mortar on the outside all in one day. This outer coat of concrete will be cured and the hull interior plastered at a later date.

The advantages of this method are as follows:

1) If the plasterers are not accustomed to ferro-cement work, in particular, the technique of punching the mortar through the mesh, then this method gives the men an opportunity to do the work in two stages. If penetration was not good enough on the application of the outer coat, a chance remains to succeed with the inner coat.

2) Fewer men are required for the work of applying a single outside coat. It is probable that a higher standard of finish will be obtained with this method than with one-day complete plastering. The work is that much less arduous and the men, consequently, that much more disposed into putting their energies into obtaining a good finish.

Step 1:

The same mixture of mortar is used in two-coat plastering as for other methods. Plastering procedure for the hull is also the same with the exception that the plasterers must take special care in the hull interior to clean up and remove all mortar which has fallen through the mesh. A stiff broom should be used to brush projecting mortar back into the mesh leaving the inner layer of reinforcing rods exposed.

Step 2:

Steam cure the outer coat.

Step 3:

After the outer coat has been steam cured the inner coat may be applied at the builder's convenience. For application of the second coat supply each plasterer with a bucket of watery grout. The grout is for flicking onto the immediate area he is about to plaster with mortar. The plasterer must force the mortar well into the mesh, working it thoroughly in all directions, to ensure that every crevice and air pocket between the inner mesh and outer coat becomes filled. When preparing the mortar mix for the inner coat use only medium and fine grades of sand with a ratio of 100 lbs. of cement to 125 lbs. of sand. A slightly wetter mix is recommended for the inner coat than the mixed used on the outer coat.

Step 4:

The mortar should be scraped back to the mesh and sponge trowelled.

Step 5:

Steam cure the inner coat.

The "Two-Week Plastering Schedule" would beessentially:

Hull - 2 days

Deck - 1 day

Fish-hold - 1 day

Water tanks and keel — 1 day

Bulkheads - 1 day

Skin coat — 1 day

Water test and curing — 1 day

Repair — 1 day

Reserve 1 day for contingencies, totaling ten working days in a two-week rotating schedule. The above operation refers to a multi-stage plastering operation except for the hulls. If the hulls themselves were to be plastered in stages the following procedure should be followed:

1) After hull meshing and fairing is complete divide the hull into two equal sections. Each section should have approximately the same surface area. The dividing line chosen would be approximately the waterline for the purposes of this example.

2) Cover the area which is not to receive mortar with 4 mil plastic. Fold the plastic at the edge into a neat straight joint and staple it to the hull wooden mold. This is done to prevent mortar falling on the mesh which is not to be plastered that day. It will also leave a clean joint for the new mortar when it is applied later.

3) Apply the mortar to the section above the waterline which is to be plastered first (the hull is inverted; therefore, the area of the hull which lies closest to the ground). Plaster right over the edge of the folded plastic. Cure the area finished on the first day by brushing on a concrete sealing compound (any brand name product will do) and allow this to sit for three consecutive days while the hull cures.

4) After three days remove the plastic sheeting. A neat, clean tapered joint will be found underneath it. The joint in horizontal areas will taper under the plastic. In vertical areas it will taper away from the plastic. The hull will have gained sufficient strength to carry a man's weight at this time but not sufficient strength to be moved. (Note that the men working on the hull should always wear rubber-soled shoes.) Do not steam cure at this time for there is a danger of warping the rest of the wooden mold.

5) Wet the joint thoroughly. Apply the mortar to the remainder of the hull vibrating the joint thoroughly. Be careful not to damage the joint. A sloppy cement grout may be brushed over the joint just ahead of the plasterers if the builder so desires. It is not necessary to use any other type of joint compound other than plain grout. Sufficient information is still not available to prove that commercial brands of joint compound placed between old and new concrete is especially advantageous in ferrocement work. Grout is cheap and it works well.

6) Finish the joint carefully. When the entire hull has been plastered proceed with steam curing. The four-day interval after applying mortar to the first section and steam curing does not appear to effect the resulting cure. The steam will wash off most of the curing compound. Sandblasting prior to painting will remove the remainder.

Multi-Stage Plastering

The major disadvantage to multi-stage plastering is that the plastering equipment encumbers the yard for several weeks. With one-day complete plastering, on the other hand, the application, finish and curing is all over in 72 hours. Other work on the hull cannot be carried on satisfactorily while plastering is in progress. Prefabricated components, however, can be made during a drawn-out plastering period. From information gathered to date there is no apparent structural weakness in multi-stage plastering providing that the mortar is applied and cured properly. Multi-stage plastering is more expensive in a commercial operation than is the one-day plastering operation. However, multi-stage plastering may prove to be more economical to a "one boat off" project. It enables the builder to do a majority of the work himself with the assistance of a few, relatively unskilled laborers. In this way the builder need not employ expensive mortar applicators and finishers.

The main advantage of multi-stage plastering is quality control. If only a small area is to be worked on in any given day by a small crew, better control of the mortar penetration into the mesh may be maintained.

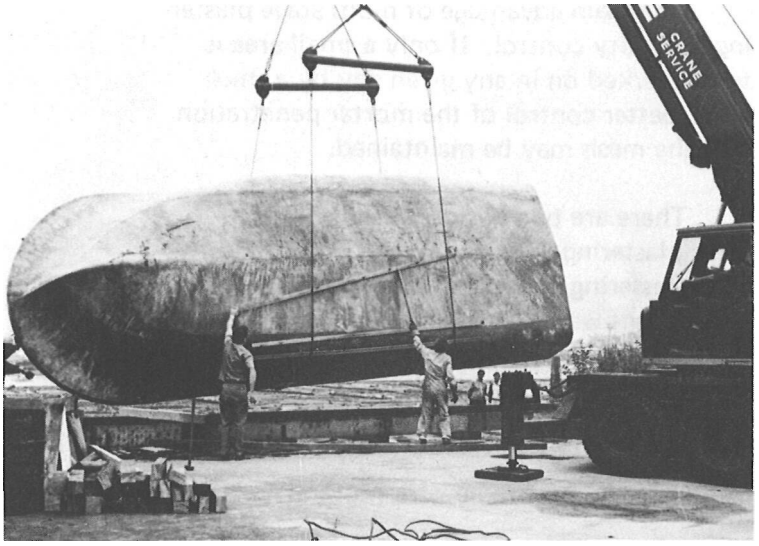
There are two basic methods of multi-stage plastering. They are: cold joints and two-coat plastering. Cold joints should be handled in different ways depending if the hull is being built over a wooden mold or with the open, welded framework method.

COLD JOINTS: Framework Method

To best illustrate cold joint plastering refer to Volume II, Task 2, page 23, which describes how a 65-ft. (19.5 m) power boat hull was plastered completely in one day. Alternatively, this same hull could have been plastered using cold joints as follows:

1) The mesh would not have been applied to any of the interior members, such as engine beds, webs and bulkheads until after the hull itself had been plastered and cured. The welding work would be done in these areas, however, prior to plastering. The started rods would all be fabricated into the appropriate webs, engine beds, rudder mounts, etc., so that the hull would receive support during plastering from these members.

2) The hull itself would be plastered first, leaving the deck and interior work until a later date. It would be plastered inside and out. The area of the hull which extends above the deck to form the bulwarks would only receive a skin coat from the outside. The inside of the bulwarks would be plastered and finished at the same time as the deck. The areas inside the hull where the starter rods are fabricated into structural members would be finished with a sponge trowel. Then a stiff broom would be drawn along the side of the starter rods to form ridges in the hull mortar. The ridges then formed would act as a mechanical bond



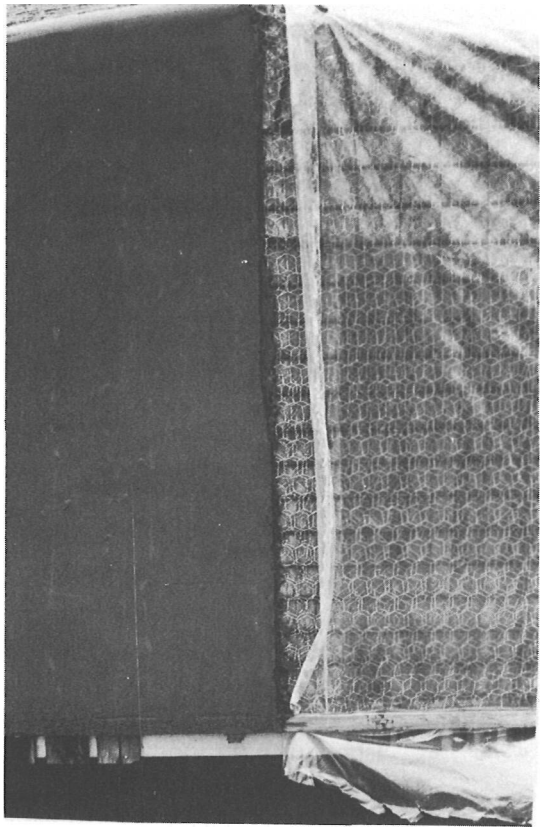
Houseboat hull built expressly to test multi-stage plastering method. Cold joint is just discernible at the hull waterline.

between the hull concrete and the web and bulwarks concrete. The brooming must be done before the hull mortar becomes too stiff to work. When finishing was complete, standard steam or wet curing procedures should follow.

3) The deck should be plastered at the second phase. This would include finishing the inside of the bulwarks and the hatch coamings. One hour before plastering commences the inside of the bulwarks and deck edge would be thoroughly soaked from a water hose. The water should be sprayed under pressure to ensure the mortar along the deck edge becomes thoroughly wetted. Then the mortar may be applied and vivibrated. Particular attention should be given to vibrating the mortar in the deck joint thoroughly. Once the deck is finished it should be steam or wet cured.

4) After the deck has been cured then the mesh can be applied to the interior structural members. Once the interior of the hull has been meshed, the webs, bulkheads, stringers, knees, engines bearers, floors and rudder mounts may be plastered and finished and the keel cast. Before plastering begins hatch covers should be prepared for all the deck openings in order to retain the moisture from the new mortar curing inside the hull.

Before applying new mortar to the joint of the hardened hull cement it should be thoroughly wetted. The same mortar mix may be used for the hull, decks and the interior. The same mix as was used in Task 2, page 23, will prove adequate.



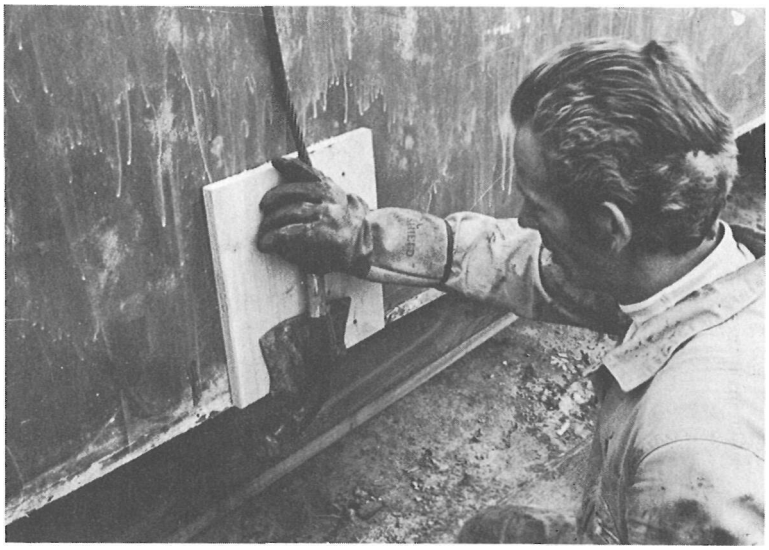
Use plastic sheeting to protect the mesh while plastering the first hull section.

COLD JOINTS: Inverted Wooden Mold Method

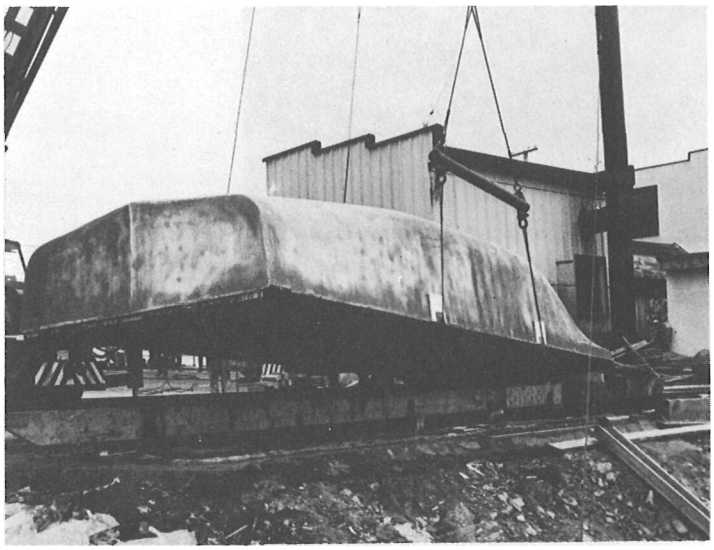
Refer to Volume III where 10 ferro-cement fishing vessels were constructed simultaneously. On a commercial operation such as this, plastering could have been carried out successfully using a different method, had a continuous production line operation been set up and completed. The boats were scheduled to be launched, one every two weeks, on a year-round operation. The operation could, altenatively, have employed two good plasterers permanently rather than maintained an eight-man crew which worked one day at a time, then was laid off until the next hull became ready to plaster.

If two plasterers were to be permanently employed, several hulls could be worked upon simultaneously. Stripping, meshing interior, deck lining, etc., would be programmed to coincide with plastering dates. The plasterers and their laborers would transfer from hull to hull daily as each became ready to plaster.

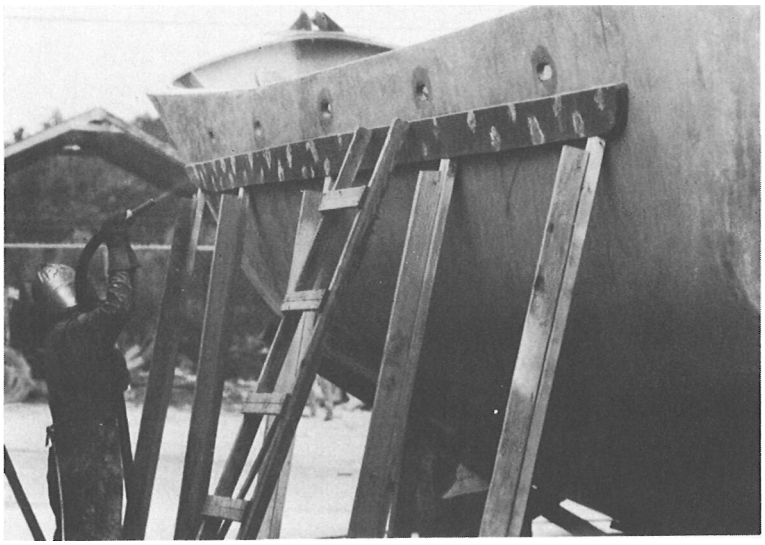
Example of cold-joint plastering, inverted wooden mold method.



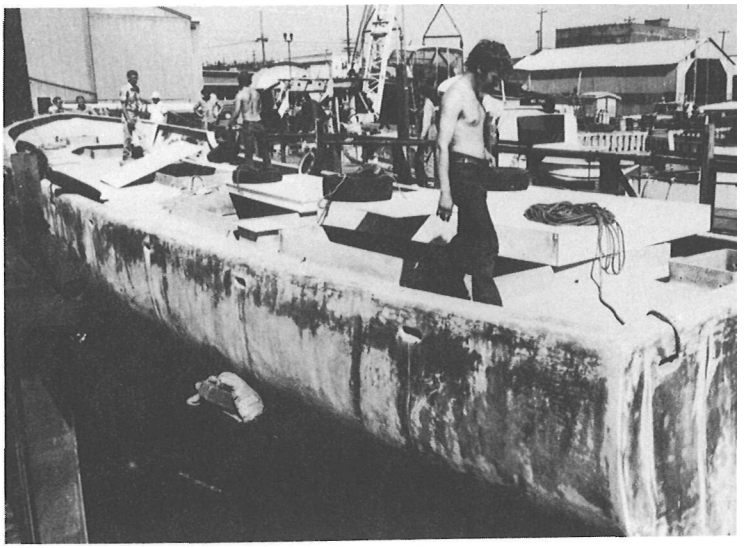
Preparing to roll a hull plastered on the multi-stage method. Note streaks of curing compound on hull which were used to cure the first section plastered. After the second section was plastered, the entire hull was steam cured.



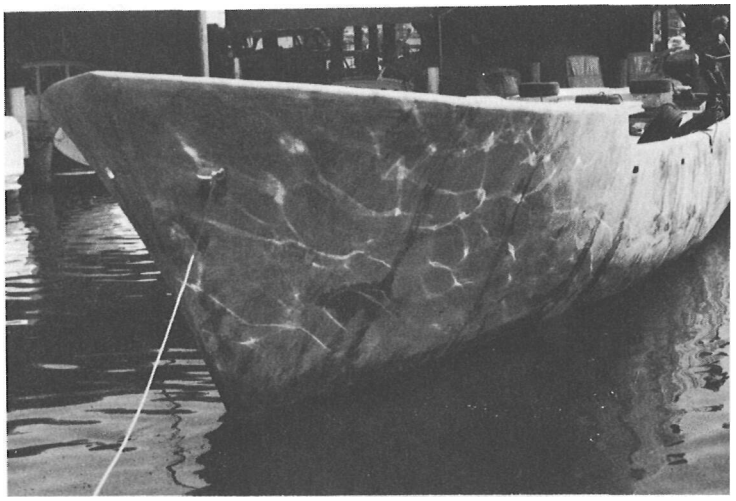
The multi-stage plastered hull shows no sign of stress cracks at the joints after rolling.



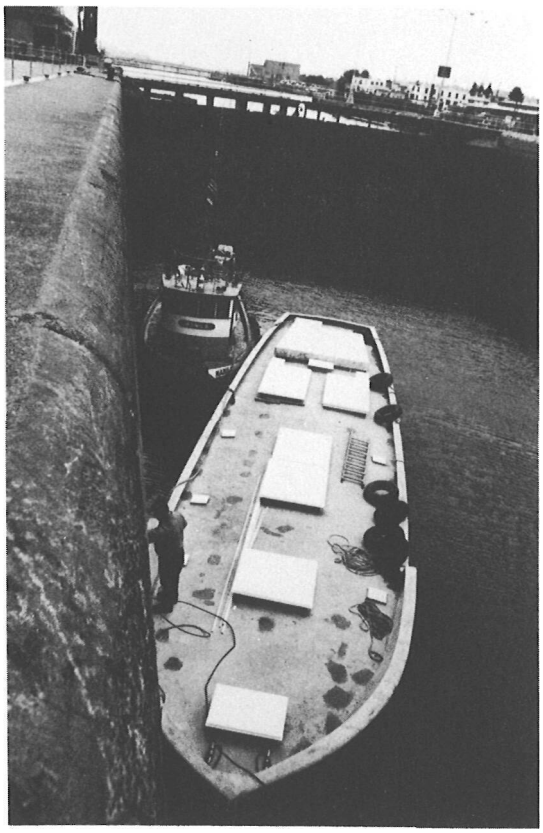
A light sandblasting being given to a hull prior to painting. A better bond is given to the surface after the polished steel trowel finish has been removed.



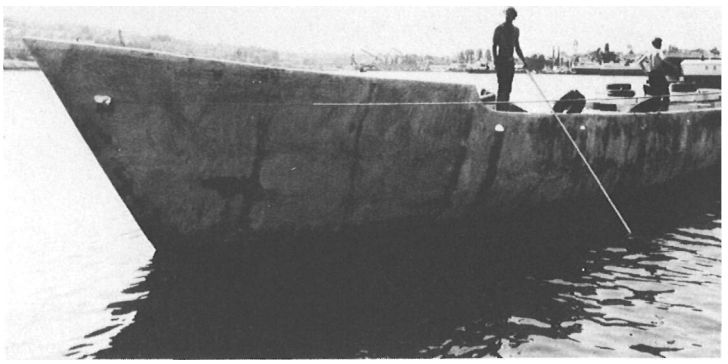
Right:
A quick tour of the hull satisfies the men that there are no leaks. Water-testing prior to launching pays off.



Hull afloat: Ferro-cement does not look handsome until painted. The water reflection pattern is an indication of smooth finish.



The 65-ft. (19.5m) hull being towed through the locks on her way to out-fitting.



The careful use of screeds in fairing the hull sheer is justified when the vessel is seen on the water.

-END OF VOLUME II -