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Conservation of the Ancient Boat from the Sea of Galilee

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Introduction

From the outset, the Galilee or Kinneret Boat (dubbed the "Jesus Boat" by the media), which was found and excavated in 1986, introduced conservation challenges (Wachsmann and Raveh 1990:1–7; Wachsmann, Raveh and Amos 1990:9–14; Wachsmann 1993). A complicated and unconventional rescue operation was necessary to enable its excavation, packaging and transportation to the conservation site (Cohen 1990a:15–22; 1990b:9–16). One of the decisions made in the field that was essential for the future conservation process was not to take the boat apart. Dismantling the vessel would have made it easier to transfer as well as cheaper and faster to conserve, but the time and money saved would have been spent later on restoration. Moreover, the wooden parts would have been stored on flat trays during the conservation process and therefore would subsequently need to be reshaped for restoration. The choice to rescue the whole vessel was also based on the boat's construction (Steffy 1990:29–47): dismantling would have meant breaking all the tenon connections, and crushing the wood around the iron nails where the corrosion products had penetrated, solidified and formed an iron-wood continuum. The nails themselves are very fragile and many would have probably broken. The decision to keep the boat intact was endorsed by the Ministers of Tourism and Education, who promised that there would be financial support for the conservation process because of the massive public interest.

The boat was transferred to Kibbutz Ginnosar, about 500 meters to the north. The conservation facilities were organized in the vicinity of the Man in the Galilee Museum (Fig. 1). The museum team was involved in the technical and management aspects of the excavation and conservation process.[1]

The Conservation Treatment

Ancient wet wood finds are waterlogged. The inner structure of the wood cells has deteriorated as a result of bacterial activity, and drying such an object without conservation treatment

Fig. 1. The boat in the conservation pool, viewed from the stern. The heating elements are protruding from the wall along the length of the boat, and the circulation pipes are mounted at the ends of the pool.

will cause cell walls to collapse. As a result, the object will shrink, become deformed and crumble into pieces or even dust, depending on the level of deterioration. Careful application of a two-step polyethylene glycol (PEG) treatment (Pearson 1979:51–56), as modified by Hoffman (1986:103–113), has been found to produce good results. The PEG is gradually added to the pool, penetrating the wood and replacing the water. As the concentration of the PEG is increased the water evaporates until the required level is reached. During the first stage the small PEG molecules replace water bonds within cell walls and during the second stage the large PEG molecules coat the cell walls and fill some of the gaps. The period of time necessary for this process to take place depends on the size of the wood elements, the degree of deterioration and the species of wood.

In the case of the Kinneret Boat, the various degrees of deterioration of the wood, the wood species and the size of this vessel had to be factored into the choice of conservation method. Most of the frames are made of oak, whose dense inner structure makes penetration of any conservation material problematic. While experience and research have shown that a two-step PEG treatment can overcome this problem, conserving such a large complex vessel of different wood species in a single immersion bath was a task that had not been previously undertaken. Some of the woods such as carob, Christ thorn, hawthorn, sycamore, laurel, willow, plane tree and Atlantic terebinth are not generally used for boat construction and a conservation process for these types of timber had not been documented. The 12 different wood types and the iron components would probably all respond differently to the chemical compounds used for conservation.[2] Nonetheless, further experiments to determine optimal methods for conservation would have required sampling too much wood and would have resulted in a delay in bringing the boat to a stable state. This led to the decision to employ the two-step PEG treatment, as it seemed best suited to cover a large range of wood characteristics.

The Two-Step PEG Treatment

For the first stage, PEG 600 (Fig. 2) was used instead of PEG 200, as recommended in the literature, to prevent the treated wood from becoming too hygroscopic after the conservation. This would have affected the stability of the final result and could give the surface of the wood a wet appearance at the high relative humidity of the air in the museum. It might also cause leaking of the conservation materials, which would eventually result in destruction of the boat (Grattan 1981:243–252). In retrospect, we realize that PEG 200 would have been preferable to PEG 600, which froze in the barrels and required heating during winter to keep it liquid.

The PEG 600 was added to the water in the conservation pool in which the boat was kept at an average rate of 2.2% w/v per month until the final concentration was 50% w/v (Fig. 2). Following this stage, the pool was emptied and filled with water overnight. The low molecular PEG solution had a cleaning effect. All the mud that had not been removed manually came off with this solution, revealing previously indiscernible details. The boat was photographed and all our observations were recorded.

The second stage, involving treatment with PEG 4000, began after about a year's delay (due chiefly to the 1991 Gulf War).[3] We added PEG 4000, with an initial concentration of 20% w/v, subsequently raising the concentration at an average rate of 2% w/v per month, until the final concentration was 80% w/v (Fig. 3).

The PEG was first dissolved in hot water in a tank and then transferred to the pool using a pump. The procedure was repeated 12 times to achieve the required concentration of 20% PEG in the pool. The rest of the PEG was added daily by emptying the bags directly into the pool where the heat and circulation dissolved it quickly. In this way the concentration of PEG in the pool was increased by about 2% w/v per month.

The Iron Elements

The nails connecting the frames to the hull and the U-shaped fastening staples (see Fold-out 2) cannot survive the PEG treatment because the mild acid solution attacks the metal (Cohen and Roman 1990:77–80). The heat and air in the circulating solution would have increased its corrosiveness. Following the research of the Canadian Conservation Institute (CCI) we

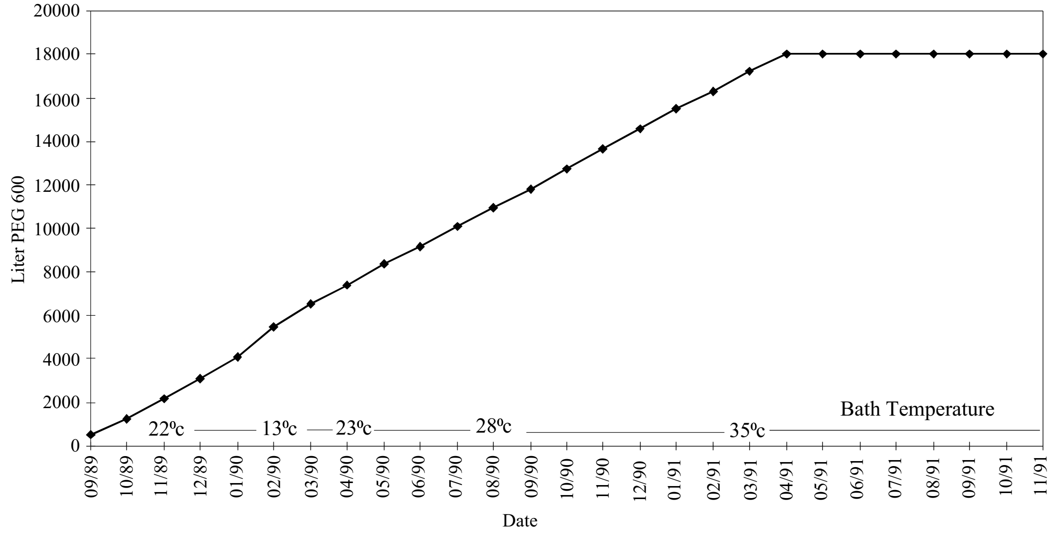

Fig. 2. Addition of PEG 600 to the pool. Average rate: 2.2% w/v per month, final concentration: 50% w/v.

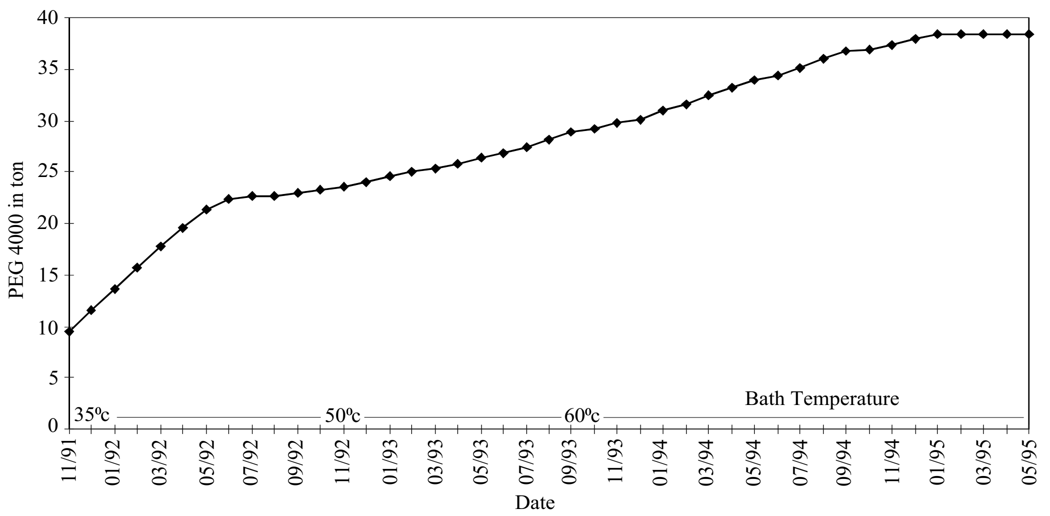

Fig. 3. Addition of PEG 4000 to the solution. Average rate: 2% w/v per month, final concentration: 80% w/v.

added the corrosion inhibitor, Hostacor-KS1 (200 liter) during both stages of PEG treatments to protect the iron (Starling 1987:215–219; Gilberg, Grattan and Rennie 1987:265–270; Argyropoulos, Degrigny and Guilminot 2000:253–264). The iron elements retained their shape and their rusted surface did not dissolve in the solution.

Another additive, the oxidation inhibitor hydroxianisol (130 liters), was also added to the PEG 4000 solution to maintain the stability of the PEG polymer chains, and to prevent them from breaking into shorter ones. This would have made the conserved wood more hygroscopic and weakened the boat (Geymayer, Glass and Leidl 1990:83–89). This phenol solution had an unpleasant odor that disturbed the workers and visitors. However, the conservation facilities were in a separate building and when the wood dried at the end of the treatment, the smell ceased to be a problem.

Biological and Bacterial Problems

During the waiting period, while testing and preparing the equipment needed for the chemical conservation process, red larvae spread in the water around the boat in the pool. There were so many that they changed the color of the water. We did not know if they had affected the wood but they prevented the visitors from viewing the boat. The problem was solved by adding three fish (each approximately 10 cm long) to the water—initially goldfish, which were replaced by Saint Peters fish (the native fish in the nearby lake). The fish were used instead of toxic chemicals that might have harmed the workers.

Bacterial activity was not encountered during the preparation for the chemical treatment, but three weeks after adding 560 liters of PEG 600, the liquid in the pool became dark and bubbly, with foam on the surface, and a bad odor developed. Samples were taken and the pool was washed out and filled with fresh water. Laboratory tests showed that there were bacteria present that were breaking down cellulose into glucose, thus increasing the activity of other types of bacteria. Wood particles, products of the wood breakdown, were found in the foam. Laboratory tests also showed that both the tap water and the PEG were contaminated with bacteria. In order to solve this problem Dr. Ayala Barak tested a number of products (Dawson 1981:269–276) and found that the best disinfection was achieved with isothiazoline (Kathon). This chemical compound breaks down within a few months, so that any spill would become harmless in a short time. This was an important factor because the conservation pool was in an unstable seismographic area on the edge of a lake that is the main source of fresh water in Israel. The boat was treated with 250 liters (800 ppm) of Kathon WT (13.9% active agent) (Rohm and Haas). This penetrated the wood structure and subsequent tests showed that the wood was free from bacterial activity. After the first disinfection, the solution was treated to destroy residual isothiazoline and replaced with fresh water, to minimize the amount of breakdown products remaining in the conservation tank. The Rohm and Hass product breaks down into the inorganic salts magnesium nitrate and magnesium nitrite.

Brome Chemicals Co. had a novel formulation of isothiazoline,[4] which is based on organic salts that leave no residue, and we also used this during the PEG 600 treatment, but this experimental formulation did not become commercially available. After the first disinfections the liquid in the pool was changed, and the PEG treatment was resumed. A concentration of 2–12 ppm Kathon in the solution kept it clean. About four liters of Kathon were added every 4 months. To increase the efficiency of the Kathon 1 liter of quat, an organic salt of ammonia (80% active agent), was added during the PEG 4000 treatment.

Concluding the Chemical Process

When the concentration of PEG 4000 in the solution had reached the desired level (80% w/v) the boat was kept in the solution for six months to ensure that the PEG had penetrated the wood. Samples of wood were taken for examination: liquid was extracted from a core sample and the concentration was found to match that in the pool; a few samples of wood were dried under controlled conditions and measured for shrinkage and deformation. The results showed that the wood had absorbed the two PEGs and the maximum shrinkage was 1%. We hoped that the results of these tests reflected the state of all the different woods in the boat.

The PEG solution can be reused for conservation of waterlogged wood so it was decided to collect it in small containers, which would be easy to handle (see Technical Aspects of the Conservation Process, below). A flexible plastic pipe system connected to the conservation circulation pumps was installed for drainage. The heating was turned off as soon as the drainage began and there was danger that the PEG solution would freeze in the pool or in the pipes. Therefore, the drainage of 40 cubic meters of solution had to be completed within a few hours.

Six years after the beginning of the PEG conservation process, the moment finally arrived to remove the solution from the pool. Our foremost worry was whether the boat had survived undamaged during the almost four years that it had been hidden from our sight by the dark fluid. There was also a risk that, once the supporting liquid was removed, the vessel might fall apart or become warped. To our relief, the draining of the solution revealed an intact and stabilized boat (Fig 4).

Fig. 4. Removing the solution from the pool at the end of the conservation process viewed from the prow.

Controlled Drying

Before the pool was emptied, an environmental control system was installed in the conservation hut consisting of two air-conditioners, a humidifier and monitors for temperature and humidity. The roof and walls were insulated with polyurethane foam to protect the inner environment from the extreme heat outside, which frequently exceeded 40º C. This setup permitted controlled drying of the boat. Stable temperature and relative humidity are essential for dimensional stability of the wood.

At the conclusion of the PEG treatments the boat was dried in a controlled environment for almost a year. The relative humidity was gradually decreased from more than 90% to 60%. During this period the timbers of the boat were measured for shrinkage: in various positions on the planking, frames and keel, marking pins were inserted at distances of 2–5 cm. Every week measurements were made to detect dimensional changes and the boat was examined for deformations and cracks.

TECHNICAL ASPECTS OF THE CONSERVATION PROCESS

The Conservation Pool

The reinforced concrete pool was lined with porcelain tiles and insulated with a 5 cm thick layer of Styrofoam on the outside. The pool measured 3.5 × 9.2 m and was 1.6 m deep. It was almost completely below ground level. It answered all our requirements: there was no evidence of leaking or heat loss and it provided an excellent working environment, which was stable, clean and capable of bearing a heavy load of workers and equipment. A lower depression should have been left on one side of the pool, to help drainage. Two of the pool corners were used for shelves for parts of wood that were found with the boat when it was excavated. Plastic containers filled with water and pebbles were placed in the other two corners to reduce the quantity of conservation solution needed.

Pool Cover

Polyethylene foam sheets were used to cover the pool for thermal insulation and evaporation control. The 2.5 cm thick sheets were fitted to the pool (9 sheets of 1.0 × 3.5 m) and floated on the solution. They were easy to handle and could be removed by one or two people. 'Windows' were cut at their edges for inserting heating elements, pipes and detectors. When the evaporation was excessive, another layer of foam sheets (2 cm thick) was added to the cover and fitted over the edge of the pool.

Heating the Solution

Heating was achieved with 47 stainless steel electrical heating elements, each 1 m long, immersed in the pool along the edges. To prevent burning of the PEG by extended contact with the heat source, the solution was kept constantly circulating and the elements heated alternately. During the conservation process they became corroded and burnt out and each one was replaced about three times. At first L-shaped elements were used (to achieve good heat dispersion), but they tended to corrode more at the elbow and they were replaced by U-shaped elements. In order to detect damage to any one of the elements, each was connected separately to a control board. Ceramic heating elements should be considered for future projects.

Circulation

Two separate systems were installed to gently stir the solution in order to achieve even temperature and concentration and to prevent prolonged contact of PEG with the 47 heating elements. Three to four exchanges of the liquid per hour were initially planned, without knowledge of how such a massive volume of PEG solution would behave. In fact, we found that one exchange of solution per hour was sufficient to maintain the required circulation. The use of two smaller pumps rather than one large pump meant that if problems occurred in one system they could be solved without interrupting circulation in the pool. Stainless steel screw pumps (Mono Pumps, U.K.) were attached to stainless steel 4 inch pipes. The pumps performed well, but after about five years the pipes started to rust around the joints that had been soldered. One of the piping systems was replaced with a crossed polyethylene (PAX) system. These pipes are easier and faster to build and are more resistant to chemicals.

Filtering

Three filter cylinders were installed on one of the circulation piping systems, using 2μ bag filters. The principal reason for these filters was to keep the solution clean, mainly for tourists, who were allowed to view the boat in the pool throughout the process. However, despite the filters, visibility decreased as the concentration of PEG in the solution increased because the PEG extracted brown-colored chemical compounds from the wood.

Monitoring and Control

Sensors for temperature, level and flow of the solution were connected to a computer that controlled the heat level and operated an alarm whenever there was a failure in the system. There were separate controls for the heating elements so that a problem in any one of them would be readily detected.

Energy Source

We decided to use electrical energy because solar energy is not reliable throughout the year, and therefore needs a back-up support system; fuel energy was not permitted because of ecological control regulations in the vicinity of the Sea of Galilee.

A heat loss of 2° C only was measured during a 5-hour electricity stoppage, when the liquid temperature was 60° C, thereby indicating that the insulation was good, and that the volume of 40 cubic meters of PEG solution lost heat relatively slowly.

Storage of Used PEG

Cardboard boxes lined with polyethylene bags were used to collect the PEG at the end of the process. These standard agricultural boxes (40 × 30 × 25 cm) hold about 25 kg PEG, a reasonable weight to handle for future use. Once the PEG was solid and dry, the edges of the bags were closed and stored on wooden platforms.

The Working Platform in the Conservation Hut

The boat is too fragile to carry the weight of a worker and it is not possible to reach all parts from the outside. A bridge of iron running on wheels along the edges of the pool was built in order to enable workers access to all parts of the boat (Figs. 5, 6).

Fiberglass-Polyester Frames

The frames built during the excavation and rescue operation in the field supported the boat within and without. Once in the conservation pool, fiberglass legs were fixed to the outer frames to stabilize the boat on the ground. The frames performed excellently for the rescue, but the outer frames were too thin under the bottom of the boat in the center. During the conservation process there was always some liquid in the pool, which supported the bottom of the vessel. At the end of the chemical process, as the pool was being emptied, some small movements were noticed in the boat's lower structure (Fig.7).

Maintenance

During the conservation process there were a number of unexpected problems: electrical short circuits, leaking pipes and valves, engine and pump failure, a flood from the nearby lake that threatened the conservation hut, rain leaking from the roof and even a fire. It was essential that a responsible person check the process every day because the monitors were not sufficiently reliable. Since the part-time conservator lived a few hours drive away, the conservation facilities were in a separate building from the museum and the regular staff kept changing, we insisted that the maintenance staff add PEG to the pool daily in the hope that during this process they would discover any problems that had developed overnight.

Fig. 5. The working bridge.

Fig. 6. The bridge wheels that ran along the pool's edge.

Fig. 7. The outer supports at the conclusion of the treatment.

CLEANING, STORING AND STUDYING THE BOAT

Further examination and assessment of the boat's condition necessitated lifting the vessel from the bottom of the pool to which it was glued with excess (residue) PEG. The fiberglass supports that had been built during the excavation were first cut to make them narrower and a temporary iron support was gradually built; the original fiberglass supports were then removed. The new support was constructed from segments of iron 3–4 cm wide and 2 mm thick, joined by small screws and bent to the shape of the boat. The end result was a set of modular strips connected to telescopic legs that could be gradually elevated (Fig. 8). This was suitable for the prow and stern, but in the center a different solution had to be used: a strip of iron 1 mm thick and 4 cm wide was inserted between the floor and each fiberglass frame. The strip's end was heated to allow it to penetrate the PEG residue. These strips were connected to the pool's walls on both sides by steel wires and turnbuckles (cable tension device; Fig. 9). The boat was elevated millimeter by millimeter by adjusting each telescopic leg and tightening the turnbuckles. Gradually the boat was lifted (2–3 mm at a time) to 20 cm above the floor of the pool. All the fiberglass supports were replaced with metal supports on 130 telescopic legs, which enabled the boat to be raised so that it could be cleaned and studied from below. The excess PEG was cleaned from the wood surface using a hot-air gun and absorbent paper tissue.

At this stage some of the deformation in the wood was repaired using pressure and heat. Small parts of the boat, which had become detached during the excavation and treatment, were reattached using 1 mm diam. stainless steel wire drilled through the wood core.

For the first time, after 2,000 years, the vessel could be examined thoroughly. The boat was first measured with a laser theodolite and the

Fig. 8. Telescopic legs comprising bolt bars and nuts inside iron pipes.The pipes were gradually lengthened by slowly tightening the nuts.

Fig. 9. The turnbuckles that lifted the middle of the boat from the floor.

drawings completed by hand. Detailed maps of the boat were prepared and samples of wood were taken to complete identification (see Plans 1, 2 in rear pocket; see Werker, this volume). These maps will also serve as a guide for future restoration should there ever be any breaks due to transportation of the boat or any other cause.

A study of the boat revealed that the wood came from three different sources: wood from which the bulk of the boat was built, wood taken from older boats (e.g., the prow and part of the keel) and wood used for repairs. Samples of wood from all three sources were taken for ^{14}C dating in an attempt to obtain more information about the age of the boat than the previous examination had yielded (Carmi 1990:127–128). Unfortunately these tests did not supply us with more information.

The appearance of the boat's surface, the wooden repairs and the iron staples that were used to replace and strengthen disintegrating parts of the boat enabled us to estimate that it had been in use for about twenty years.

PREPARATION FOR EXHIBITION

The boat was to be exhibited in a special addition[5] to the Man in the Galilee Museum, at Kibbutz Ginnosar, only 20 m from the conservation pool. The exhibition stand, which also served as part of the transportation apparatus, was built at the conservation pool while the hall was under construction.[6] The stand's design and engineering had to take into account aesthetic, structural and conservation requirements, all of which were at variance. Eventually, the team produced a strong support with a light appearance, which was suitable for this extraordinary artifact.

The stand is constructed of stainless steel with a matt surface (Fig. 10). A long elliptic base supports 18 frames which transverse the boat, 5–40 cm from its surface (Fig. 11). The wood is gently supported by 400 'fingers' that are attached to these frames. This specially-developed device can be adjusted to any angle and length along the frames. In delicate areas, mainly at the bottom and along the keel, 1 mm metal strips were attached to the wood, and these are mostly invisible to visitors. The metal areas touching the boat were covered with balsa wood 1 mm thick (Figs. 10, 11).

The exhibition hall was fitted with an efficient environmental control system based on two parallel systems supported by a generator in case of electricity failure. Since the correct environmental conditions are essential for the safety of the boat, failure in one system is corrected by the second, an alarm is automatically sounded and a warning signal appears on the operator's home computer (Cohen 1998:182–187).

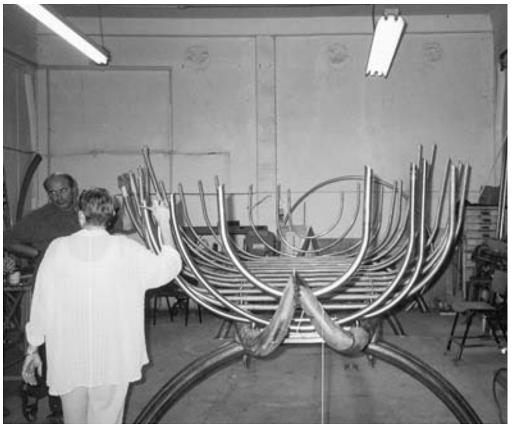

Fig. 10. The stand at the factory.

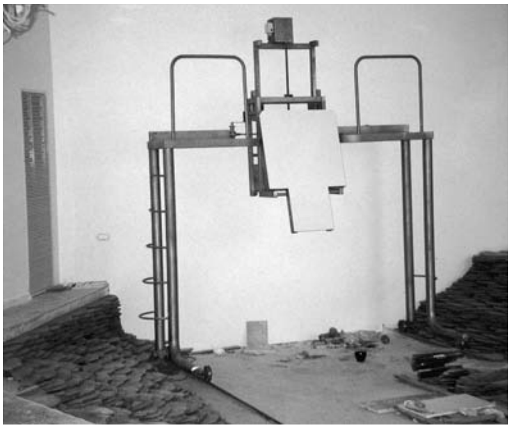

Fig.12. Working bridge at the museum.

Fig. 11. Adjusting the stand to the boat.

A working bridge was installed at the exhibition, which will be necessary for future restoration and maintenance of the boat (Fig. 12). Unfortunately, there was no space to hide it from view and it became part of the exhibition.

TRANSPORTATION

Transportation of the hull was extremely hazardous. The wood had been stabilized by the conservation treatment but the boat was still very fragile and careful packaging was necessary. All the frames of the stand were locked together with metal strips along and above the boat. The wood was covered with polyethylene sheets and 1 cm thick sponges. All the gaps between the boat and the metal supports were filled with Styrofoam boards that were glued together with dabs of polyurethane foam. The inside was padded with cushions made of polyethylene foam, held in place with metal strips.

The boat was transported by a crane. Two transverse iron beams were placed below the stainless steel support and connected to the display leg sockets. The roof of the conservation facilities and part of the wall of the exhibition hall were removed. An iron framework was lowered by the crane into the pool and attached with screws to the two beams below the boat (Fig. 13). The crane slowly raised the boat, turned it around, and moved it 24 meters away into the exhibition hall (Fig. 14). It was then lowered into position on jacks that were built for this purpose (Fig. 15). The iron framework was dismantled and the two legs were attached to the boat. They were connected to the floor with chemical screws. A layer of rubber one-cm-thick was laid between the metal construction and the cement floor as a shock absorber.

The following day, the environmental conditions were stabilized and the packing materials removed. The transportation had not damaged the boat and for the first time it could be viewed in an open space. Exactly 14 years after the first day of the excavation, the boat was secure (Fig. 16).

RESULTS

The boat retained its shape during the conservation process, although there were slight movements at the center, and fragments fell out in two places. These were reshaped and restored. No cracks or deformation due to shrinkage were observed. Dimension measurements conducted at the stern and prow where access was available indicated that shrinkage of 0–4% had occurred.

Fig. 13. The crane attached to the packaged boat for transportation into the exhibition hall.

Fig. 14. The crane carrying the boat through the eastern wall.

Fig. 15. Lowering the boat to its final position.

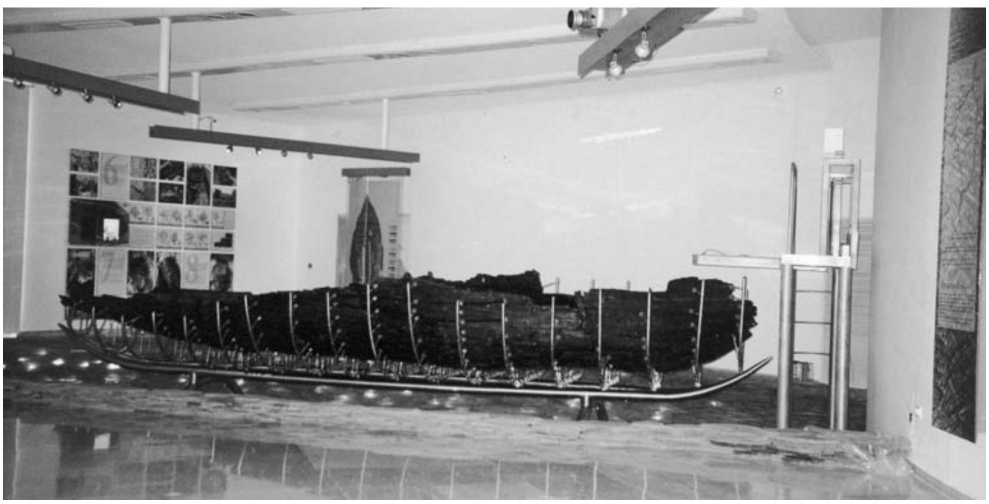

Fig. 16. The boat in the new exhibition hall.

It is possible to see details on the surface of the wood such as tool marks and indications of use, which are well preserved. Illumination of the boat in the pool for tourists caused growth of algae on the wood, especially in one part where the light bulb was only 20 cm from the wood surface. This gave the wood a rippled appearance.

The success of the conservation treatment was surprising considering that the boat was not built from high quality wood—12 different wood species were used (see Plan 2 in rear pocket), some timbers having been taken from older boats. The Kinneret boat had a full life, underwent various repairs and was eventually abandoned on the shore. Some of its parts had been removed in antiquity, possibly for use in other boats. When it was found after about 2000 years its condition had deteriorated—roots had penetrated the timber and it had many cracks and holes. Despite this, the boat survived transportation from the site to the shore and then to the conservation pool. The move to the new exhibition hall at the end of the conservation process was also successful.

The stern starboard part that fell off the boat during the excavation, and another part that was discovered while digging, were conserved with the rest of the boat on shelves located in a corner of the conservation pool. The stern starboard was restored to its original position when the boat was in the museum.

The iron elements that were protected by the corrosion inhibitor are more fragile than they were before the conservation process, and could create a problem in the future. The relative humidity appropriate for wood stability (50–60%) is too high for iron, which ideally needs an RH of 30%.

Today the boat is in a controlled environment with a relative humidity of 60% and a temperature of 22° C and is stable. It is hoped to lower the relative humidity to 50% to protect the iron nails. This will be done only if the wood does not suffer any shrinkage during the process.

CONCLUSION

The decision to conserve the boat intact proved correct. The danger that it would fall apart during transportation or conservation treatment was overcome.

Eleven years passed from the excavation to the end of the conservation treatment. It took three more years to plan and prepare the boat for exhibition, construct the final metal support, build the new exhibition hall, arrange the display and set the boat in its place. Throughout the process, tourists were able to visit the conservation facilities, and this justified the effort involved, adding interest in the project and contributing to public awareness of the boat as part of the world's cultural heritage. Our aim was to complete the project by the year 2000, when many pilgrims were expected to visit the area touring sites and remains from the beginning of the era.

The relatively high cost of the environmental control and maintenance of the boat require public interest in this project, and visitors to the museum are essential to help support preservation of the boat in the future.[7]

NOTES

[1] This project was executed under the auspices of the Israel Department of Antiquities and Museums (at that time part of the Ministry of Education; today, the Israel Antiquities Authority), with the financial support of the Ministry of Tourism.

[2] Before the conservation process, when about 40% of the wood had been examined and only 7 of the 12 types of wood had been identified, it was already assumed that more species had been used in the boat construction (Werker 1990; this volume).

[3] PEG with an average molecular weight (AMW) of 3350 had been ordered, but the material that arrived was PEG with an AMW of 4000. We decided to use it, in order to prevent further delay and expense. The bags of PEG 4000 flakes were much larger in volume than the dissolved PEG. When the 40 tons of PEG reached the conservation site, it seemed to be 4–5 times the volume of the conservation pool and a large storage area was prepared.

[4] Donated by I.M.I. Haifa.

[5] Architect: Chanan Havron—A.B. Planning; Curator: Rene Sivan; Designer: Dorit Harel—Harel Designers.

[6] Engineer: Uri Harmel.

[7] The total project cost $2,600,000 (conservation: 1,807,235 NIS; permanent exhibit: 3,588,055 NIS).

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