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Completion of Gronauer Lock
By Jonathan M. Leader

The Wabash and Erie Canal Lock #2 is a remnant of the Wabash and Erie Canal system. At one time, it was the longest canal system in the United States. Better known by the name of its gatekeeper, Mr. Gronauer, the Gronauer Lock is an historic artifact of local, state, and national significance. Found as part of a highway widening and improvement program, the lock's survival is nothing short of miraculous. It provides a dynamic link between the New Haven, Indiana area's riverine roots and a bygone technology vital to the growth of a nation. Successfully conserved, it will now be a source of educational enhancement and tourist revenue through the exhibit being constructed at the Indiana State Museum.

Built in the 1830's, the lock is a large complex, composite artifact. Approximately 90% of the original structure was still intact when it was found, with only the lock doors, attendant mechanisms, and portions of the upper lock walls missing. The surviving structure's timbers, planks, and sills remained in place and were composed primarily of red and white oak, and poplar. Iron had also survived very well in situ in the form of forged spikes, nails, and fittings.

The lock underwent a partial rebuilding during the mid-1800's further complicating the conservation efforts by ensuring a lack of uniform aging of components beyond the normal wear and tear of use or deposition.

The initial excavation of the lock was completed by a team under contract to the Indiana Department of Transportation from Ball State University located in Muncie, Indiana. The recordation and numbering of the lock's structural elements for disassembly and eventual reassembly was accomplished under the supervision of the SC Institute of Archaeology and Anthropology. As was usual, this portion was a joint venture of the Underwater Archaeology Division and the Office of the State Archaeologist.

The successful treatment of waterlogged wooden artifacts rests on a basic understanding of the nature of degraded wood and contemporary conservation techniques. Most people's understanding of wood and its properties are by direct observation of green or seasoned woods. Unfortunately, this experience does not prepare them for the realities of degraded woods from an archaeological context. Green wood is characterized by its recent removal from the living plant, its relative flexibility and density, its quantities of sap, and by its structural instability. Seasoned wood is produced by carefully drying green wood under controlled circumstances. This usually results in a relative loss of flexibility, density and volatile sap, and in a gain of structural stability. As an end product, structural stability is desirable in both modern and antique woods and is a goal of conservation. It is common for non-conservators to think of wet archaeological wood as being synonymous with green wood. If this were correct, the logical treatment would be to dry the wood under controlled circumstances and return it to its prior seasoned state. Unfortunately, this would be disastrous for the majority of waterlogged archaeological woods.

At the chemical level, all woods are composed of lignin and cellulose. Lignin is an amorphous polymer that is based on phenol. Its function is to support and preserve the cellulose...
component of the wood. Cellulose is a polysaccharide, or carbohydrate. It represents almost 75% of the wood and tends to form in long chains called fibrils. Fibrils group together and produce the cell walls and other structures. Both lignin and cellulose contain hydroxyl groups that allow water to bond to their surfaces. Fluids in the form of intracapillary water, incidentally absorbed water, and sap are also present. Wood sap is primarily composed of water, sugars, salts, and other metabolic materials. Tanins, resins, silica, and form of rays and tracheids in softwoods, and rays, fiber tracheids, and vessels in hardwoods. In both soft and hardwoods, valve-like intervacular pits connect the cells. Each pit has a valve membrane called a torus. The membrane opens and closes controlling the passage of fluids.

In addition to the chemicals and cellular structures already mentioned, green and seasoned wood both contain quantities of air. The air present in green wood means that it is not filled to maximum capacity by water. This in turn means that surface tension stresses are localized and more easily defused through the wall structures in the individual cell or smaller groups of cells. This is an important point, as the greatest damage to drying waterlogged archaeological woods that do not contain air occurs from an increase in the effect of surface tension on degraded wall structures. The green wood's excess water escapes through the small intervacular pits, which dramatically increases the pressure exerted on the cell walls, but not to the point that the sound wood can not achieve equilibrium and eventual seasoning. Some water, approximately 25% of the seasoned weight, remains chemically bound to the cellulose in seasoned woods.

Depending on the archaeological environment, large quantities of the wood may be lost. In waterlogged woods, the extra water from the outside environment mechanically stresses the wood through swelling and bulking the fibers. It also effects the wood's chemical composition. The interaction of water and cellulose over time results in a process called acid hydrolysis. Acid hydrolysis causes the breakdown of the cellulose into its component simple sugars. This results in damaged cells and the loss of necessary support structures. Needless to say, adequate support is essential for the waterlogged wood to survive the effects of evaporation. During evaporation, the sequence of wood cells that become water free is somewhat random. This shift from cell to cell in differing locations of the wood focuses the tension stresses, and in conjunction with the lack of air in the waterlogged wood, maximizes the effects of surface tension on the degraded cell walls. As in sound woods, intervacular pits enhance the situation by channeling the evaporating water through tiny apertures. The resulting damage to a sufficiently degraded wood is usually rapid and devastating. In addition, once the cell walls collapse, and the inner surfaces of the cell come in contact with each other, they cannot be separated.

Bacteria and fungi also play a significant role in the degradation of archaeological waterlogged woods. Under normal conditions cellulose, hemicellulose, and cell sap are a feast for these organisms. Archaeological waterlogged woods, in oxygenated surroundings, provide these entities even easier access to these nutrients.

The conserved sill going out the door and back to the Indiana State Museum. (SCIAA photo by Jonathan Leader) Tyloses are waste and preservative chemicals commonly found in redundant cells and in the dead heartwood.

At the microscopic level, wood can be seen as being composed of interconnecting capillaries. The function of these capillaries is to move sap containing nutrients and waste to and from the cells. It is not surprising that the majority of wood cell structures are oriented from the root to the crown of the tree. Hardwoods, such as oak, are more complex in their cell structure than softwoods, such as pine. Similar structures exist in both woods in the
In both cases, the result is a loss of support structures. As a general statement, hardwoods tend to be more resistant to this form of attack than softwoods, and heartwood is more resistant than the sapwood.

The most common conservation technique for dealing with waterlogged archaeological wood is the replacement of the water with some form of bulking agent. Success or failure for this technique rests on the wood's permeability and degree of degradation. As a general statement, the more degraded the wood, the more likely it is to be permeable. Unfortunately, archaeological waterlogged woods can be extremely variable when it comes to permeability, even within a single artifact. It is not uncommon for the tori valves in the intervacular pits to survive in a closed position. This can occur even in badly degraded wood, thus rendering the wood difficult to permeate. In addition, the survival of large quantities of tannins, resins, and tyloses can also drastically affect the ability of the wood to take up fluids. Mitigation of these factors requires a thorough knowledge of the wood being treated.

Determining the wood's moisture content and specific gravity gives the conservator an idea of the quantity of undamaged wood that remains. Microscopic inspection of the wood provides information concerning the actions of bacteria, fungi, and the presence of closed tori and tyloses. Once these factors are known, conservation can proceed.

The most commonly used agent for conserving archaeological waterlogged wood is polyethylene glycol (PEG). Polyethylene glycol is a polymerized form of ethylene oxide and has been used to preserve archaeological wood for almost 50 years. It is considered to be non-toxic and biodegradable. PEG solutions tend to become acidic with PH ranges of 4.9 to 7.2, and will attack most metals with the exception of stainless steel. This can make the PEG treatment of composite wood and metal artifacts difficult, as the metal component can be damaged or entirely destroyed. Buffering agents can be added to PEG to mitigate its effect on metal.

Large pieces of waterlogged archaeological wood are often treated with PEG in a variety of ways. Spraying, brushing, and tank immersion are the most common techniques. Past decisions to spray or brush large pieces of waterlogged archaeological woods, rather than to immerse them, have been tied to expedience rather than to conservation science. There is no question that immersion provides the best chemical and environmental control, the most successful impregnation of difficult woods, and the most responsible approach to worker safety during a large-scale wood conservation project. Nonetheless, the cost constraints of building large immersion tanks for each project made the lesser techniques viable in the past. Conservation ethics requires that the best possible treatments be selected.

As an aid in assessing the condition of the lock prior to treatment, 28 borings from 14 locations throughout the structure were obtained. In addition, five loose structural members were also analyzed. The moisture content of the oak samples ranged from a low of 129% to a single recorded high of 433%. Fourteen of the samples were identified as Class III woods. A Class III wood has a moisture content of less than 185% and is considered to be minimally degraded. Four of the remaining samples were identified as Class II woods, with moisture content between 185% and 400%. These woods are considered to be degraded, but retain significant cell structures. The single Class I wood sample was all but destroyed during extraction. The specific gravity of the samples ranged from 0.20 to 0.51. If the specific gravity of the Class I wood sample is excluded, the other two classes of wood yield a mean specific gravity of 0.31 for the Class II and 0.43 for the Class III woods. Sound oak has a general
specific gravity of 0.59. Both moisture content and specific gravity tend to reflect the degree of degradation in the cellulose component of the wood.

Stereo microscopic examination of the remaining samples showed embedded debris in the form of fine clay and silts in the degraded exterior portions. This was not surprising due to the nature of the surrounding soils and the feeder spring that supplies the lock area.

Oxidation of the woods’ surfaces was in most cases pronounced, although several samples retained natural coloration after the first inch of penetration. This is due in part to oaks natural resilience and to the anaerobic conditions obtained under the silt in some locations. Minimal evidence of bacterial or fungal attack was visible.

A national carrier transported slightly more than 50 tons of wood to the SCIAA Conservation Laboratory. The costs of the transportation and the choice of carrier were determined by the people of New Haven, Indiana. The carrier chosen was a reputable company with experience in moving perishable, time sensitive materials. They did an excellent job. The wood was swaddled in burlap that was kept soaked with water and under taps to minimize evaporation and subsequent damage. The Crane Company accomplished the loading and unloading of the wood. This firm has been a valued support to large wood conservation projects throughout the state. Not only did this firm move the Brown’s Ferry Vessel into the laboratory at the start of that project, but also successfully transported the completed 1740s coastal merchantman to the third floor of the Rice Museum located in Georgetown, SC. Their work on this project was equally professional and smooth.

The lock was initially treated with a lower molecular weight of PEG to ensure maximum penetration of the oak and poplar timbers. This was followed by higher molecular weights of PEG to ensure cellular support. Careful monitoring of the PEG’s uptake by the wood through microscopic examination was essential for determining the treatment’s end point. Once this was reached the wood was slowly dried in a carefully controlled humid environment.

No long-term public conservation project exists in a state of isolation. Public awareness, interest, and approval are all necessary to the successful completion of these types of programs. Fortunately, this project had Mr. Craig Leonard, a historic architect, on site in Indiana to act as liaison and outreach coordinator.

While the lock was being treated at the SCIAA Conservation Laboratory, exhibit consultation continued with Indiana State Museum. The Indiana State Museum had outgrown its original building and was in the process of a complete renovation. This provided for a very interesting progression of exhibit plans for the completed lock structure. The same national carrier returned the conserved lock elements to Indiana. The pieces were placed in secure storage while the new museum took shape. The groundbreaking for the new building took place on August 30, 1999. Indiana Governor Frank O’Bannon cut the ribbon on the new facility on May 22, 2002.

The Indiana State Museum is now a 270,000 square-foot structure. This includes a three-story, 130,000 square-foot museum, a four-story, 100,000 square-foot administration building that is joined by a 200-foot bridge spanning the Central Canal, as well as a 40,000 square-foot IMAX Theater. The Office of the State Archaeologist is very pleased that this new museum will now house, as one of its primary exhibits, the Gronauer Lock.