View of plaza looking west (WJE Photo).

Teak Window Restoration

Material Issues at the Salk Institute

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Located on a Southern California bluff overlooking the Pacific Ocean, the Salk Institute for Biological Studies (1965) is one of architect Louis Kahn's finest works, comprised of laboratories, study towers, and offices flanking the iconic plaza. Among the major architectural elements of this unique complex are, the pre-fabricated teak windows set within the concrete structures. After fifty years of marine environment exposure, the window assemblies weathered to a non-uniform appearance, experiencing surface erosion and insect damage that were exacerbated by unfortunate maintenance practices. Restoring these assemblies, which are prime examples of custom exterior millwork important within Kahn's larger body of work, presented unique challenges. Rather than implement programs of minor aesthetic repairs, the Salk Institute embarked upon a conservation-based approach to address the issues on a long-term basis.

In 2013 the Salk Institute partnered with the Getty Conservation Institute (GCI) to develop this approach. Working in tandem with GCI, WJE performed a detailed investigation and analysis of these assemblies and materials. Three different treatments were developed to address the varied degrees of distress, ranging from in situ cleaning and refinishing to selective repair and replacement. WJE developed contract documents specifying the treatments. While the majority of the teak windows (historic fabric) were retained, several assemblies necessitated more extensive intervention including the replacement of the teak and underlying materials. This article discusses material-distress issues and the challenges of selecting materials for in-kind renewal/ replacement.

Assemblies and Distress Mechanisms

The windows are comprised of exterior teak millwork, interior oak finishes, and pine subframing with transite panels, an asbestos containing material (ACM). The teak millwork includes tongue and groove panels, frames, and adjustable sliding glass and louvered sash to modify interior light and natural ventilation. This window structure relies on an indeterminate load path that utilizes the subframing,

West elevation prior to conservation project (WJE Photo).

transite panels, and teak millwork to resist the coastal wind forces.

Distress conditions included erosion of tongue and groove teak panels where over 1/4 inch of thickness had been lost, exposing the ferrous metal nails which had corroded as a result of the sea salt from the coast. Teak damage was attributed in part to ultraviolet ray degradation, where lignin breaking down over time undermined the bond of the cellulous, resulting in gradual surface erosion. However, the majority of the section loss was attributed to abrasive cleaning methods that utilized wire brushing and harsh chemicals with refinishing. Frequency of teak cleaning was greatly influenced by mildew growth prevalent on the site from local vegetation. Though not detrimental to the wood, the biofilm has been an aesthetic concern since the original construction. Consequently, gentile

View of study tower after conservation project (WJE Photo).

cleaning and possible refinishing approaches, balanced with practical expectations related to mildew re-accumulation, were scrutinized.

Drywood termites, notorious along the southwest coast, were another source of damage. In particular, the open nature of the study towers proved particularly vulnerable to these insects. Unlike subterranean termites, drywood termites can enter through open windows and do not require shelter tubes or high-moisture content within the wood; although a preference for the warmer south and west building facades was apparent. As the transite panels and teak are well suited for this environment, termite damage was primarily at the pine subframing. In isolated areas, bore holes through the teak cladding were apparently created by termites to access the subframing.

Excluding the glass and interior oak finishes, three primary materials needed to be addressed: the transite, subframing, and the teak.

Eroded teak and termite damaged subframing at transite panel to teak supports (WJE Photo).

Substructure Material Selections: With the exception of being an ACM, the transite panels performed well over the life of the structure. In order to gain a comfort of retaining these elements, abatement and air monitoring protocols were followed to ensure asbestos fibers were contained when these panels were manipulated. Initial temptations to eliminate the ACM were discussed; however, panel removal would have created a greater hazard and burdened landfills. Testing demonstrated that friable asbestos fibers could be managed without extensive effort by the contractor, thus the majority of the panels were salvaged.

Where they could not be salvaged, numerous transite panel replacements were studied, including metal and precast cementitious materials. Budget and detailing steered us toward a wood product, and panels fabricated with 2x6 Accoya were selected. Accoya is manufactured by Accsys Technologies located in Arnhem, the Netherlands, and is a treated radiate pine. The process, initially studied in Germany in 1928, with continued research at the Forest Products Lab in Madison, Wisconsin and Europe, utilizes an acetic acid treatment that modifies the wood cells on a molecular level. The modification increases acetic anhydride molecules, replacing hydroxyl molecules (hydroxyl molecules facilitate the wood moisture content fluctuation under changes in humidity) creating cell walls that are more fully swollen, with reduced hygroscopic tendencies. The equilibrium moisture content of the treated material is around three percent and experiences approximately one percent change between a saturated to a fully dry condition. The result is a non-toxic more dimensionally-stable material. Long-term testing has demonstrated decay and termite resistance and a 50-year warranty is available in above ground applications. In addition to selective transite panel replacement, Accoya was used for subframing reinforcement. The 100 percent wood treatment allowed for tooling and notching of members without concern of exposing underlying untreated wood common in other treatments.

Teak Issues

Teak distress was proportional to the degree of environmental exposure. For example, UV degradation and abraded finishes were more prevalent at areas along the west elevation and at locations facing south along the main plaza, while window systems that are well sheltered or face north and away from the plaza were observed to be in better condition. As part of the preservation approach to maintain as much of the original teak wood windows as practical, a series of trial mock-ups were prepared as part of the study to help evaluate the appearance and efficacy of different interventions. Though salvaging existing teak remained a project objective, areas of teak replacement were unavoidable. The acquisition of teak material presented a new set of obstacles.

There were generally three options for acquiring teak material, including plantation-grown, old-growth First European Quality (FEQ) material, and reclaimed sources. The plantation-grown teak tends to be less dense material as it is harvested from younger trees on varied soils. Although heartwood obtained from plantation-grown material may be of good quality, it can result in smaller usable pieces that would not be feasible for the project requirements. Reclaimed teak, though a viable option for procuring the desirable old-growth material, introduced a new challenge in confirming the material was legally obtained and tracking chain of custody from legal and responsible sources. Accurately tracking the chain of custody, of paramount concern, was not always achievable.

The FEQ teak matched original building specifications and was selected. This material (Burmese teak) is obtained through the Myanmar Timber Merchants Association (MTMA) from forests managed by Myanmar Timber Enterprise (MTE). Limited annually to maintain sustainable forestry practices, the teak must be purchased by parties licensed through the U.S. State Department. Thus, chain of custody was carefully inspected to ensure legal practices were followed. Additionally, an independent wood scientist was retained by the Salk for inspection and selected testing of the imported teak material prior to shipment to ensure material satisfied project specifications.

Exterior finish applications were also examined, including various cleaning and coating systems that were exposed to UV and weathering conditions. Non-film-forming coatings were mocked-up and located on the rooftop for over a year, followed by laboratory analyses which demonstrated that varied maintenance cycles for different exposures would be appropriate. The finish review provided the basis for recommended long term maintenance for stewardship (cleaning and follow-up applications) in the future. While teak is considered a very durable material, regular maintenance will be required to maintain the appearance of the teak.

Credits: *Work was performed as joint effort with Getty Conservation Institute, Salk Institute, WJE Los Angeles, CA and WJE Northbrook, IL. Kyle Normandin, AIA (Associate Principal - Los Angeles office) served as project manager for WJE.*

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