The Greening of the Samuel T. Dana Building: A Classroom and Laboratory for Sustainable Design

MAGGIE MCINNIS and ILENE R. TYLER

Rehabilitation of this 1904 building at the University of Michigan used green design to preserve its role as a center for learning and research.

The Samuel T. Dana Building, originally called the Medical Building, was constructed between 1901 and 1903 on the central campus of the University of Michigan in Ann Arbor to house the university's medical school (Fig. 1). This Beaux Arts–style building, designed by architects Frederick H. Spier and William G. Rohn, is located in the university's National Register Central Campus Historic District. In the 1960s the medical school vacated the building, which then became home to the School of Natural Resources and Environment (SNRE). At that time, the building was renamed after the founding dean of the SNRE college, Samuel Trask Dana. Between 1998 and 2003 the building underwent a comprehensive rehabilitation, including a complete infrastructure upgrade. The project had two goals: to use green-design principles for the upgrades while preserving the historic integrity of the building and to demonstrate SNRE's commitment to the environment by conducting the rehabilitation as an ongoing laboratory for learning about sustainability. This paper describes the treatments and the specific materials and systems used in the project.

Introduction

The Dana Building was constructed of solid brick masonry, typically exposed on the interior in classrooms and offices. Wooden floor and ceiling joists bear on the brick masonry. A timber-framed roof originally covered all but the center of the building, a courtyard, which covered an underground mechanical space. The courtyard allowed natural light into interior spaces.

When the university and the School of Natural Resources considered whether the school should remain in the Dana Building or relocate, it was important to consider the historical significance of the college's location on campus and the value of the building itself. The faculty, staff, and students unanimously supported the SNRE's current, prominent location on the campus plaza "diag" since the 1960s (Fig. 2). The faculty and staff also considered the expense and resources that would be required to build a new structure versus the cost to renovate the current facility.

Fortunately, the value of the Dana Building was recognized. In sustainability terms, it is clear that the sturdy structure and lasting materials had significant value and that the useful life of the materials was far from over. Since retaining the building meant that exterior walls did not need to be built from scratch using new resources, reusing the building gives the project additional green value; the land had already been cleared, and the soil excavated for the original building's foundations. Other land that would have been developed for a new building is preserved, hence reducing the depletion of resources and encouraging the reuse of resources already spent.

When built, the Dana Building was not richly appointed with beautiful plasterwork or ornate woodwork. In fact the original interior was very simple; plain plaster walls and ceilings and wood floors were the primary finishes. When the rehabilitation project began in 1998, the exterior was relatively intact as built, except for the replacement windows of the 1980s. A rehabilitation rather than a restoration approach was adopted because there were few significant interior features and that approach was in keeping with the original, utilitarian function of the building. There were a few important considerations, however. One character-defining feature of the original building is its "donut"

Fig. 1. Early-twentieth-century view of the Samuel T. Dana Building, originally the Medical Building. Photograph courtesy of the University of Michigan.

Fig. 2. Exterior view of the Dana Building today, facing campus "diag." Photograph by Christopher Campbell.

floor plan, with a double-loaded corridor serving faculty offices on each side and studios on four floors. The building has two entrances, the street side facing East University and the "diag" side facing the pedestrian interior of the historic campus. The simplicity of this plan provides flexibility for changing programs and teaching methods. When weighing the value of the building, it was relevant to consider this adaptability.

Another defining feature is the wood stile-and-rail doors of the long corridors. The design team determined that the building would lose its historic character if these doors were replaced to meet current code requirements. Therefore, extensive surveying was undertaken to document the door sizes, style, and hardware, and a plan was developed to reuse as many doors as possible (Fig. 3). Fortunately, the width of the doors complied with current codes in most applications, but significant hardware modifications were required in order to meet accessibility standards. Many doors were relocated to different masonry openings to accommodate program changes that resulted in different use of interior spaces. Despite significant labor costs to modify doors and bring them up to code, the material costs were substantially reduced. The embodied energy of this material is retained in the building.

All of the original wood windows were replaced in the 1980s with new aluminum windows that retained the traditional one-over-one, double-hung configuration and were placed within the original masonry openings. When the aluminum windows outlive their service life, the original openings can be restored with new wood windows.

Completed in 1998, Phase I of the project filled in the courtyard of the original floor plan. The old roof timbers were removed, and a new fifth floor was constructed with a skylight over the courtyard and a framed, hip roof. This floor is not visible from the ground because it was designed to fit within the new hip roof. Over 20,000 square feet was added to the building, creating a light well that directed natural light into newly enclosed spaces (Figs. 4 and 5).

Fig. 3. Original door salvaged and reused at SNRE's landscape studio. Photograph by Maggie McInnis.

The goal of the Phase II work, which commenced in 1999, was to rehabilitate the entire structure using as many green features as possible. The university supported the initiative to seek Leadership in Energy and Environmental Design (LEED) certification, yet to carry out the comprehensive rehabilitation work in a manner that retained the essential character-defining features of the structure.[1] Recently, the Dana Building rehabilitation project was awarded a Gold-level LEED rating from the U.S. Green Building Council for implementing green features in the building. The LEED program recognizes projects that demonstrate use of sustainable design features and, depending on the extent of sustainable design, awards Basic, Silver, Gold, or Platinum ratings.

The Philosophy of Sustainability

The practice of preservation and sustainable design have a shared goal: conserving natural and cultural resources for future generations. By preserving buildings, fewer resources are used than when building new. This approach is inherently green on an environmental and economic level. The Dana Building rehabilitation retained 100 percent of its shell and 50 percent of its interior structural floors and major load-bearing walls, preserving materials in good condition and reducing costs of new material.

Preserving is also green on a cultural level. The SNRE community has strong

Fig. 4. Second-floor plan illustrating the building's original donut-corridor configuration and center courtyard partially filled in with additional classroom space and light well. Drawing by Quinn Evans I Architects.

historical ties to the building's location on campus and recognition by the greater university community. By rehabilitating the building, the cultural ties linked to the site were preserved. The relationships between the cultural and natural resources are undoubtedly intertwined, and both ideas strongly influenced the future of the Dana Building. One could not be considered without the other.

Managing the By-products of Construction and Demolition

Waste management. Construction and demolition practices in the United States generate huge quantities of waste each year, estimated to be as much as 25 to 45 percent of the waste stream destined for the landfill. Waste materials are potentially recyclable, e.g. carpet, lumber, steel and scrap metal, porcelain and ceramics, acoustic ceiling tiles, glass, concrete, and brick. At the Dana Building, as much material as possible was diverted from the landfill, either through recycling or through salvage and reuse, but only after much training of the subcontractors. Three large dumpsters were placed on site for recyclable materials, to be sorted by metals, wood products, and other materials, such as carpet and paper packaging. Removed brick was stacked in another location on site so that it could be reused within the building. Chutes went down to dumpsters so contractors could direct the recyclable materials to the appropriate receptacle. Despite the watchful eye of the job superintendent and designated student representative, named Green Coordinator by the college's dean, many materials went in the wrong dumpster and had to be resorted. Other materials could not be recycled because there were only small amounts. For instance, many suspended acoustic ceiling tiles and grids were removed, but they could not be recycled because, according to ceiling manufacturers who collect recycled ceiling products, there simply was not enough to warrant someone's time.

The local recycling center, Recycle Ann Arbor, picked up many items that were potentially reusable and sold them through their reuse center. These items included modern cabinetry, doors, millwork, furniture, and a select number of aluminum windows that were no longer needed at the interior courtyard. The university did not benefit monetarily from these sales, but the reward lay in saving items that would have otherwise been dumped in a landfill. The contractor did not have to pay dumping fees, which provided an incentive to take this extra step.

Approximately 25 percent of the construction waste was recycled — not enough to gain a LEED credit in construction-waste management. However, in rehabilitation work this was still an accomplishment, as there is often more building material removed than during construction of a new building. In a new building the primary wastes are packaging materials and scrap from installed products. A new building would not be removing walls, doors, and ceiling material, unlike a rehabilitated building that gets modified for current needs. Much of the removed material was non-original to the historic building, consisting of modern finishes from the 1970s and defunct mechanical plumbing and ductwork systems.

Other materials were salvaged for reuse within the building. Timber beams

Fig. 5. An atrium light well and classroom addition was created in the original courtyard. A skylight tops the entire addition. Exterior masonry walls facing inward were preserved. Photograph by Christopher Campbell.

from the removed roof framing were salvaged and remilled, then used as wood-slat ceiling material, railing supports, and furniture for the building. The timber roof was removed to make way for the fifth-floor construction and courtyard skylight. Most original doors were refinished and reassigned, instead of being replaced. The original doors were high quality stile-and-rail and were of solid oak construction of higher value than most commercial doors on the market today. Hardware changes required plugging of old holes and drilling new ones, but the design team felt it was important to retain the doors because they were identified as a defining feature of the building.

Indoor air-quality control. How well the indoor air quality is maintained during construction affects both the health of building occupants and the lifetime of the building's ventilation system long after the contractors have departed. Construction dust and debris typically pollutes the interior of a building and can contaminate the ventilation system if it is not protected during construction. Once the ventilation ducts were installed, the open ends and vent locations were sealed with plastic to prevent the infiltration of dust and volatile organic compounds. The plastic seals were removed at the end of construction. Existing and new ductwork was also vacuum cleaned to flush out potentially harmful particles that may have slipped through at vent locations.

Low-VOC paints and adhesives and water-borne finishes were used to prevent lingering "paint smells" during and after construction.[2] Given that the building was partially occupied during the entire construction phase, the concern for strong odors was a special concern. Natural wool-fiber carpets were installed to avoid the off-gassing common in new synthetic carpets.[3] Off-gassing of products can contribute to the ill health of building occupants even after construction is complete. This phenomenon is commonly referred to as sick-building syndrome.

Sustainable Technology

Solar panels. The Dana Building supplements its energy load by harnessing solar power and converting it into electricity. An active solar-power system supplies energy through the direct conversion of sunlight into electricity. The building has a photovoltaic (PV) array that supplements the electricity supplied by the university's cogeneration power plant. A 20 kW PVL (laminate-style PV) system and a 10 kW monocrystalline-panel system were installed on the standing-seam, Kynar-finished metal roof.[4] An inverter converts DC power to AC power. The panels were originally designed to be mounted on the courtyard skylight, with the expectation that translucent-panel technology would be available. However, when the time came, PV-system manufacturers indicated that this type of panel was not yet available. The installed panels are, therefore, mounted on top of the roof instead, matching its slope. They are not visible from the ground nor do they detract from the historic appearance of the building. The array does not generate enough electricity to meet all of the building's demands, but it serves as an educational tool for students and faculty at the SNRE. Computer software interfaces with the system to monitor its performance and provides data for research projects. The array is the first installed on the University of Michigan campus.

Fig. 6. Typical floor layout of composting-toilet "shaft" that is used as a unisex toilet room on three floors of the building and sandwiched between larger toilet rooms. Drawing by Quinn Evans I Architects.

Energy-efficient lighting. User comfort in individual offices was a key component of the project agenda. Dual uplight/downlight fixtures were specified, providing overall ambient light and task lighting.[5] Because the original, high ceilings were retained, pendant fixtures were used, as they would have been originally. Many existing, linear-type fixtures already in the building and in good condition were reused, saving costs of new fixtures and reducing waste going to the landfill. The fixtures use long-life fluorescent, rather than incandescent or halogen, bulbs. In addition, natural daylight penetrates the building through the central skylight and large perimeter windows, thus reducing the need for artificial lighting during daylight hours. No historic fixtures remained in the building at the beginning of the rehabilitation, and photographs of early lighting schemes have not been located. Remodeling in the 1960s, 1970s, and 1980s eliminated these fixtures and replaced them with lay-in fluorescent lighting. The rehabilitation project called for the removal of these modern lay-in fixtures. Although modern pendants and linear lighting fixtures were installed, they do not diminish the historic spaces because they are suitable for high ceilings.

Occupancy sensors. The faculty at the Dana Building wanted to have individually controlled lighting and temperature conditions in offices, classrooms, and conference rooms. Lighting fixtures can be manually controlled, but if a room is unoccupied, sensors will turn off the lights. Temperature can also be manually adjusted in individual spaces; however, if humidity conditions increase to the point where the radiant-cooling panels become inefficient, adjustments are automatically made to the room conditions.

Composting toilets. A composting-toilet system was installed on four stories of the building. They are unisex facilities and are adjacent to the main toilet facilities on each floor.[6] Compliance with a one-hour fire separation between floors resulted in the design of a "whole room" shaft through the building (Fig. 6). Since the 14-inch-diameter chutes could not be fire-rated, the chutes were designed to extend through the building, through this "whole room" shaft. Minor reframing of the original wood joists was required to create the code-compliant shaft. The system is simple in operation and self-contained. Chutes empty directly into a composter

Fig. 7. Chilled ceiling panels were installed in a historic space. The original masonry window openings are visible. Photograph by Ilene Tyler.

at the basement level, which is maintained on a monthly basis. Establishment of the composter enzymes took time. However, the system is now odor-free and operational. There has been some reluctance by building occupants to use the composting toilets, despite initial enthusiasm, perhaps because the adjacent conventional toilets are convenient. The system did require substantially more space, particularly with a single composting toilet on each building floor. However, it serves as an educational tool for water-saving concepts.

Water-saving plumbing fixtures. Waterless urinals were introduced as part of the rehabilitation project.[7] Using a patented blue "fluid" that is lighter than water, the fixtures require no water-supply line — only a sanitary line — to function. Unlike the composting toilets, the urinals and low-water-use toilet fixtures were relatively straightforward installations, and water use in the building has been significantly reduced. Training of maintenance staff was necessary for proper cleaning of waterless urinals. Touchless faucets also reduce water waste.

Radiant-cooling system. The corridors facing the courtyard had long been used as a conduit for mechanical- and electrical-system piping. All classroom spaces and offices were accessed from the corridor. Therefore, it made sense that the piping for a new radiant-cooling system be placed in the corridors and feed spaces directly from this loop. A cold-water loop was added for the new cooling system, one of the first of its kind to be used in the United States, but readily available technology.[8] It is a quiet, simple system that eliminates extensive ducting. Without large duct runs, the high ceilings could be retained, thus preserving the tall windows (Fig. 7).

Radiant cooling is a passive system of copper pipes fixed to a metal shroud. Heat transfer occurs between the space and the panels. The panels absorb thermal energy radiated from people and convection currents. A minimal exchange of ventilation air controls the moisture load. The air-handling unit for ventilation air dehumidifies outdoor air, and dry air is brought into the spaces. A desiccant system dehumidifies the air. If windows are opened, the system shuts off. A sensor on the panel controls condensation by regulating the flow and temperature of water in the copper pipes.

The chilled water in the radiant-cooling system is about three times more efficient than air as a heat-transfer medium. A detailed analysis of the system determined that it reduces energy costs by 30 percent. In fact, six LEED credit points were earned in the Energy and Atmosphere category for this system. The chilled panels were installed in classrooms, offices, and meeting rooms. Because the various-sized panels use much of the available ceiling area, detailed coordination with lighting, data grids, historic columns, and varying ceiling heights was critical (Fig. 8).

Building-perimeter insulation (consisting of a 1-inch air cavity), insulation between stud walls, and a vapor barrier behind a layer of gypsum wallboard control condensation and air-filtration affecting the efficiency of the radiant-cooling system. Because this upgrade was applied to an existing masonry structure with many difficult-to-access situations, the system does not achieve a completely air-tight and water-tight building envelope, but it does improve the efficiency of the cooling system.

Sustainable Materials

With natural resources diminishing at an ever-increasing pace, it seems responsible to specify new products that have reduced impact on forests, oil reserves, and water. If certain materials that have

Fig. 8. Integrated cooling and lighting systems and a data grid are installed in the ceiling above student workspaces in the landscape-architecture studios. Photograph by Christopher Campbell.

Fig. 9. Designed to be a demonstration space of sustainable materials, this fourth-floor conference room showcases bamboo flooring, certified wood, and wheat board. Photograph by Christopher Campbell.

Fig. 10. The large lecture hall features soy-based, biocomposite ceiling panels, recycled/refurbished fixed seating, natural wool carpet, and low-VOC paint products. The original steel columns were retained. Photograph by Christopher Campbell.

Fig. 11. New office casework and doors in the Dean's Suite were constructed from certified wood. Photograph by Maggie McInnis.

already been manufactured, such as plastic and glass bottles and car tires, can be diverted from a land fill and reused in the form of a new product, then there is less demand to make new plastics, glass, and rubber, which is an oil-demanding process. Also, the use of rapidly renewable resources can replace such products as lumber from slow-growing trees and offer the equivalency in performance and cost.

Recycled materials. Many new products used in the project contain a percentage of recycled content. They include plastic-resin toilet partitions and lavatory countertops, glass-based floor and wall tile, rubber flooring made from recycled rubber tires and post-industrial colored rubber, and polyester upholstery fabric made from PET (polyethylene terephthalate).[9] Twelve percent of the new materials specified contained post-consumer recycled content, and half of those contained post-industrial recycled content. Two LEED credits were earned for the use of recycled-content material.

Renewable materials. Materials produced from rapidly renewable resources are considered renewable materials. Their appearance is often unusual and therefore provides an opportunity to be used as "showcase" elements.

Bamboo flooring and bamboo-veneered applications were used throughout the building. Areas of the new fourth floor have bamboo flooring made up of thinly sliced and laminated bamboo strips (Fig. 9).[10] Several varieties of biocomposite board were used for cabinetry, ceiling tiles, non-wet countertops, and as ceiling panels throughout the building (Fig. 10). They include wheatstraw, sunflower-seed hulls, soy flour, and waste newspaper and are all readily available and formaldehyde-free.[11] At that time biocomposite boards were slightly higher in cost than cabinetry made from particleboard and plastic-laminate materials. However, with the growing interest in products made from renewable resources, more companies are producing this type of product, which should drive the costs down to be competitive with traditional cabinetry materials.

A product that has been around since 1949 and that is seeing resurgence in use is Tectum, a wood-based panel. This product was used as an acoustic treatment on walls and ceilings throughout the building. The wood fibers used in Tectum come from self-propagating aspen trees that are purchased from companies that are part of the Sustainable Forestry Initiatives (SFI) program. The aspen is air-dried naturally, without the use of any chemicals, to produce the wood fibers, and only natural materials such as magnesium oxide mixed with magnesium sulfate (Epsom salt) and sodium silicate (sand) mixed with calcium carbonate (limestone) are used as binders. All of the water used in the manufacture of Tectum is captured and recycled.[12]

Another traditional product used at the Dana Building is linoleum, a mixture of linseed oil and natural resins, cork and wood flour, and organic pigments. Now available in rich new colors, linoleum was installed as a floor surface in laboratories and research spaces, at building entries, and in lower-level spaces on concrete slab, as tack board. It was also used as countertop material.[13]

New dimensional lumber and glued laminated material came from managed forests, certified by the Forest Stewardship Council. At new door openings the casings and door frames were constructed of certified oak or ash, depending on whether it was adjacent to original wood trim where matching was necessary (Fig. 11). There was a long lead time to obtain certified wood, and costs were substantially higher than non-certified wood. However, the number of managed forests certified by the Forest Stewerdship Council is increasing. This should make certified products more available and drive the costs down in the future.

Cork flooring, a rapidly renewable resource, was installed in feature conference rooms.[14] Its soft, absorptive quality acts as a sound deadener. The cost per square foot of cork material was comparable to conventional wood flooring material.

Carpeting used throughout the building consists of 100 percent wool fibers. It was selected over other types of carpet because of the concern for off gassing, especially since the building was continuously occupied throughout construction. Carpeting was used in corridors, classrooms, and offices over wood-framed floors. The cost per square foot of carpet was comparable with other commercial carpets.[15]

More than 12 percent of all new materials used on the project came from rapidly renewable resources, and two LEED credits were earned for the use of these materials. The broad use of new green materials is blended with the building's original wood doors, trim, and plaster walls by careful selection of color schemes and textures that give the interior a warm atmosphere, enhancing the original features.

Reused materials. When the original roof structure and attic were removed to make way for the addition of a fifth floor, the roof timbers were salvaged and milled into custom-dimensioned lumber for reuse. The old pine timbers were long, straight members, 5- to 6-inches wide, and were used as ceiling boards in a large student commons and conference rooms and railing fins for a top-floor reading room. Other boards were used to make custom furniture pieces for public spaces throughout the building.

Bricks removed to create mechanical shafts and modify bearing walls were reused to fill in wall construction where necessary. The exposed brick is a character-defining feature of the building, and by reinstalling brick material to match retained brick walls, rather than infill with gypsum wall material, the warmth and character of this natural material is retained.

Conclusion

The rehabilitation of this 1904 university building applied green-design principles to preserve its historic use as a center for learning and research. Project initiatives were documented throughout the construction process. In cooperation with the university, the design team completed an application for certification through the U.S. Green Building Council's LEED evaluation program, and the building was awarded a Gold-level rating for the project. The program allows a third party to evaluate the accomplishments of a project and objectively determine whether goals have been met. The process pushes designers and owners to follow through on their sustainable-design intentions and may motivate them to expand these goals. For instance, the university elected to make some site improvements in order to capture additional LEED credits that would not otherwise have been available. The site improvements included landscaping with native plants and removing concrete areas to increase porous ground surfaces. The design team also went through an appeal process to successfully defend the energy model, demonstrating a projected 30 percent reduction in annual energy costs. Although the appeal process increased the time commitment for the LEED submission, it proved to be worthwhile once the final rating was awarded.

MAGGIE MCINNIS, AIA, LEED AP, is an associate at Quinn Evans | Architects in Ann Arbor, Michigan, and has been practicing architecture in the field of historic preservation for 14 years. She was the project manager for the Samuel T. Dana Building.

ILENE R. TYLER, FAIA, FAPT, is director of preservation at Quinn Evans | Architects in Ann Arbor, Michigan. A graduate of the University of Michigan, she also teaches preservation technology at Eastern Michigan University. From 1995–99, she served on the APT Board of Directors.

Notes

1. LEED Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.

2. Benjamin Moore's Pristine EcoSpec paint products were used throughout the building. This line of paint contains less than 50 grams/liter of VOC.

3. Godfrey Hirst carpet was specified. The carpeting consists of 100 percent wool fibers, containing no chemical treatments.

4. United Solar Ovonics, LLC, and Kyocera manufactured the photovoltaic panels installed on the building's metal seam roof. The inverter installed is manufactured by Ballard Power.

5. Linear Lighting and Zumtobel Lighting, both uplight and downlight linear light fixtures, provide versatile lighting conditions for the occupants of offices and classrooms.

6. Clivus Multrum composting toilets were installed on three floors with a composter at the basement level.

7. Waterless Urinals, one of two major manufactures of this type of plumbing fixture, were installed in all men's toilet facilities.

8. Sterling, of Ontario, Can., produced the cooling panels used at the Dana Building. Sizes were custom made to fit each room's unique configuration.

9. Yemm & Hart, from Columbia, Md., manufactured the recycled plastic products used throughout the Dana Building. TerraTraffic and TerraClassic floor and wall tiles from Terra-Green ceramic and glass tiles of Richmond, Ind., were installed in all restrooms. The tiles contain a minimum of 55 percent recycled-glass material. Gerbert Ltd. rubber flooring was installed in basement corridors over a concrete substrate. Gilford of Maine Fabrics, of Grand Rapids, Mich., were used for upholstered seating in the large lecture room.

10. Architectural Forest Products, Two Rivers, Wisc., manufactured the bamboo-veneer products that were used on the project. Round column covers were made from this product. Mintex Bambtex Flooring was installed in conference rooms.

11. The products "BioFiber Wheat," "Dakota Burl," and "Environ" are all produced by Phenix Biocomposites, Mankato, Minn. No out-gassing solvents are added during the manufacturing process, and therefore the material emits no volatile organic compounds into the atmosphere. BioFiber Wheat is created from a rapidly renewable resource, wheat-straw. Dakota Burl exhibits the beauty and elegance of traditional burled woods. Environ utilizes recycled paper products and rapidly renewable agricultural resources. From manufacturer's Web site, www.environbiocomposites.com.

12. Tectum, Inc. Environmental Statement, publication No. 902, pp. 3, 4. The text used in this article is quoted directly or summarized from the manufacturer's published environmental statement found online at http://www.tectum.com/products/Environmental%20Statement.pdf

13. Armstrong's Forbo and Marmoleum linoleum surfaces were installed as flooring, countertop surfacing, and tackboards.

14. Cork by Gerbert Ltd. was installed as flooring in small conference rooms.

15. The carpet used was manufactured by Godfrey Hirst.