THE EASTON COLLECTION CENTER
A Sustainable Design Approach to Protecting Museum Collections

James A. Roberts, AIA, LEED-AP[1]

INTRODUCTION

The recently completed Easton Collection Center in Flagstaff, Arizona, is the latest addition to The Museum of Northern Arizona (MNA). The Museum of Northern Arizona is a private institution founded in 1928 with the mission to inspire a sense of love and responsibility for the beauty and diversity of the Colorado Plateau through collecting, studying, interpreting, and preserving the region's natural and cultural heritage. The new Easton Collection Center facility consists of just over 17,000 square feet of floor area. It was designed to house a significant portion of MNA's extensive and valuable cultural and natural science collections, providing appropriate indoor environmental conditions in a sustainable way and upon completion of construction was certified LEED Platinum by the United States Green Building Council.

The Colorado Plateau is a geographical province covering 130,000 square miles roughly centered on the Four Corners. Much of it is wild and inaccessible ranging from 5,000 to over 12,000 feet in elevation. This region possesses outstanding natural beauty and ecological diversity and is also home to some of America's most intact Native culture. The high altitude, arid climate of the building site for this project, as well as its cultural and historic context presented unique challenges and opportunities relevant to sustainable building design.

KEYWORDS

living roof, sustainable museum buildings, thermal mass, energy optimization, collaborative design, radiant cooling, rainwater harvesting, LEED, museum collections

BACKGROUND

The 200-acre MNA campus includes the museum exhibit building and research facilities as well as repositories for more than five million Native American artifacts, natural science specimens, and fine art pieces. Prior to the construction of this new 17,000 square foot Easton Collection Center those invaluable artifacts and specimens were housed in a variety of buildings scattered about the MNA campus. Those buildings were poorly secured, poorly insulated, not air-conditioned, and certainly not suited to house vulnerable museum collections. Prior to beginning the design effort the museum director, Robert Breunig, Ph.D., and the

[1]James A. Roberts is principal architect and president of Roberts|Jones Associates, Inc., 2525 East Arizona Biltmore Cir., Suite B-128, Phoenix Arizona, 85016; jimroberts@robertsjones.com.

building donors, Elizabeth G. and Harry K. Easton, expressed their commitment to creating a truly sustainable solution to this critical building need. We decided early on to seek LEED certification for the project from the USGBC, but had no preconception of what level of certification we might achieve. Our goal was to do everything in the way of sustainability that made sense and was attainable for this project, in this location, and not be drawn into the temptation to "buy points" by applying solutions that were not genuinely sustainable in this context.

Museum collection storage buildings have a reputation as being "energy hogs" primarily due to the need for these facilities to meet stringent indoor environmental parameters for temperature, humidity, and environmental stability. Good advice offered early on by National Park Service architect Richard Cronenberger, AIA helped guide us to a building that would take advantage of what the local climate had to offer in the way of solutions. The solutions described below are offered to illustrate this approach as an alternative to approaches that respond to the natural setting as an adversary to be overpowered.

In the end we were pleasantly surprised when the project earned LEED Platinum certification with 57 points—52 required—and was also honored as the National Best of the Best Green Building for 2009 by McGraw Hill Engineering News Record, as well as numerous other accolades.

Native American Influences

A highly significant portion of the valuable collections that are now housed in the Easton Collection Center are Native American cultural artifacts, both prehistoric and historic. These objects represent a very important cultural resource to those native peoples who reside on the Colorado Plateau, and because of this it was important that the design of the new facility respond to and respect those

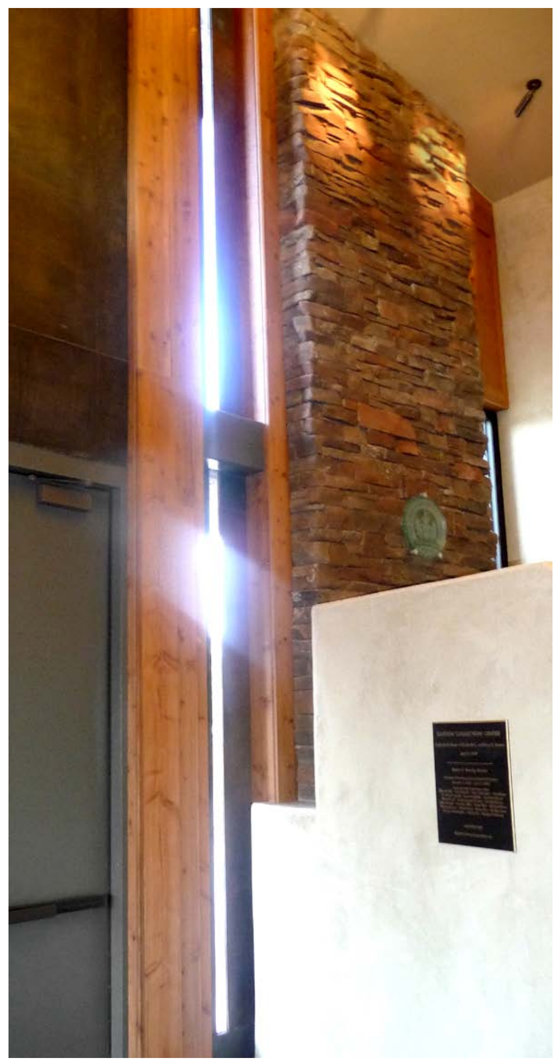
Prehistoric Native American ceramic urn from the Museum of Northern Arizona collection.

Rusting steel column with etched pictograph imagery.

people's values, many of which are philosophically environmental in nature. The design team consulted with a specially convened Native American Advisory Committee comprised of representatives from each of the major Native Tribes who inhabit the plateau and who helped guide the design team toward solutions that would be appropriate to their philosophies and sensibilities. Many of the cultural objects that were to be housed in the ECC are viewed as living entities by the native cultures who created them, and that belief implies that those objects need to be kept safe in a place that is intimately connected to nature and responds to daily and seasonal change. Keeping that concept in mind actually reinforced sustainable choices relating to building orientation, natural daylighting, building material selections, and even the appropriateness of incorporating a living roof.

Specific to orientation, the building entrance faces east and the building lobby captures dramatic views of the San Francisco Peaks—sacred to the native peoples. A 20′ tall solar-aperture slit window next to the main entry door casts rays of the vernal and autumnal equinox sunrise onto and through the inner door to the repository vault and will also mark the path between the summer and winter solstices on the inner wall of the building's vestibule. Although these features do not appear to be specifically related to sustainability, it is interesting to note that they reinforced rather than contradicted sustainable choices.

Glazed solar aperture in east elevation.



Equinox sunrise light on main door to Collections Room.

MUSEUM BUILDINGS AND SUSTAINABILITY

Because of the stringent indoor environment requirements of museum buildings, their design presents unique challenges relative to applying concepts of sustainability. Achieving sustainability often requires a flexible approach to design solutions that may be conceived as stepping outside the bounds of conservative museum design practice.

In reality though, a sustainable approach is the most conservative, primarily because a sustainably conceived building relies less on externally provided energy and, in terms of life cycle costs, is less of a financial burden. Most private, non-profit museums like the Museum of Northern Arizona are acutely under the threat of funding inadequacies, and it is just such inadequacies that present the greatest threat to the preservation of their collections. That is why it is especially important that these buildings perform efficiently with the minimum of resource consumption. Our goal with the design of the Easton Collection Center was to create a structure that could do a very good job of maintaining a stable environment for the stored objects even if no outside energy was consumed. That being said, much effort was applied in defining optimal and reliably achievable indoor temperature and humidity parameters.

An important part of the collaborative design effort that our team applied were in-depth discussions regarding what the indoor environmental parameters for temperature and relative humidity should be and how best to insure that those set-point parameters would be maintained. Those discussions included MNA administration and collections department staff, conservations specialists, mechanical engineers, energy modeling consultants, and architects. Points of discussion included:

- Optimum temperature and humidity levels for the various types of objects in the collection
- The unique properties of the high desert climate where the collection objects originated
- The environments that the collected objects had experienced in the past
- The impact of exposure to certain fixed temperature and humidity levels compared to the impact of sudden changes in those levels
- The effects of exposure to light at various wavelengths over time
- Reliability of alternative HVAC system approaches and the operational costs of those alternatives
- Operational complexity and maintenance requirements of alternatives

One key concept in optimizing energy efficiency was developing a consensus on allowing temperature set-points to drift with the seasons. In the end, the team settled on a temperature parameter that would allow summer set-point of 70°F that would be allowed to drift down to 60°F in the winter. This not only reduced heating and cooling loads, but also made maintaining RH levels more energy efficient. Interior temperatures were allowed to vary from set-points by a maximum of + or – 6 degrees in a 24-hour period. It was established that relative humidity levels could vary by no more than 8% from a 35% set-point in any 24-hour period.

A few of the hundreds of Native American textiles now protected within the ECC.

Considerable effort was expended in reaching an informed consensus on these parameters with the understanding that such collaborative decision making was key to a viable sustainable solution. Additionally, the team understood that temperature and humidity spikes resulting from failure of overly complex systems could easily do significant damage to objects as compared to a slow drift out of range that might occur with less technically intensive or aggressively controlling systems.

THE BUILDING SITE

Selection

The area of The Museum of Northern Arizona campus where the Easton Collection Center has been constructed, the Harold S. Colton Research Center, was built on agricultural land once known as the Antelope Valley Ranch but is now well within the city limits and less than two miles from downtown Flagstaff. Selecting a building site within the 200 acres of mostly vacant green land that was available for such a project presented a unique environmental challenge.

Considerable master planning effort was expended in selecting a building site that would both support the mission of MNA and support a sustainable future for both existing and future improvements. The 200-acre MNA campus is divided by an important highway that is the route from Flagstaff to the Grand Canyon 75 miles to the north. The eastern portion of the campus, known as the Harold S. Colton Research Center, was the best place for the ECC. However, the many buildings that existed on this campus were scattered and variously oriented

Stone clad southeastern aspect of the Easton Collection Center showing living roof, stepped planters, and sacred San Francisco Peaks to the north.

with little discernable organization that might guide site selection. Lanes for automobile traffic and parking seemed to fill in every void between buildings. Constructing an important new building in this context presented an opportunity to create sustainable order.

Ultimately, a location for the ECC was selected that would allow it to buttress a new pedestrian core and bring order to the helter-skelter campus. That open space pedestrian core would be flanked on three sides by historic structures. We believed that the investment of an important new building in their midst would ensure the vitality and usefulness of these historic structures into the future. Placing the new building in this location would, however, require the removal of four small substandard buildings. It required a leap of faith on the part of the MNA Board of Directors to approve of the removal of those buildings, especially with so much open land available, but in the end the larger environmental benefits of a well-conceived master plan prevailed and those building were "deconstructed." All salvageable materials were diverted from the landfill; and even cinderblock walls and concrete foundations and slabs were crushed for reuse in the base of the new building. Several mature Ponderosa Pine trees inhabited the site area, but all of those were protected and saved by careful placement of the new building and protection throughout construction activities.

Orientation

Beyond relating to the surrounding historic buildings, and responding to Native American traditions, other important environmental factors influenced the orientation of the building. The viability of a comprehensive commitment to a living roof concept required a south sloping arrangement of the overall building mass. Regularly inhabited work spaces within the building were all configured to be located along the south side where access to daylight and passive solar heating could be assured.

Stormwater

Many details of the site design of the ECC contribute to mitigating the impact of storm water runoff. The extensive living roof system plays a big part in this mitigation and more is said about the details of that system later. However, a key factor in its effectiveness is its ability to absorb peak flows and release excess water slowly. This run-off mitigation capacity has been witnessed during several intense thunderstorms that have occurred since the building was completed.

Main pedestrian walkway is clad in pervious an interlocking paver system.

The broad pedestrian walks that approach the building are constructed with a porous paver system that allows water to quickly permeate between the paving stones and into the porous base, which consists of a layered combination of filter fabric, clean crushed rock, and coarse sand made entirely of recycled glass.

All new parking spaces on site were constructed with a very porous system that used a GravelPave grid system with interstices filled with fine crushed gravel for the top surface that would allow stormwater to percolate through to sub-grade soils and not run-off. The number of new automobile parking spaces on site were kept at or below local zoning code minimums. With such a large campus, divided by a highway, it made good sense to provide an electric vehicle charging station for shuttle vehicles.

Parking spaces paved in pervious GravelPave® system.

Open Space

One of the major benefits of reworking the campus master plan as part of this project was the reorganization of vehicular traffic and parking areas. This reorganization resulted in the elimination of many driveways and scattered parking spaces that were located around the area where buildings were removed to create the site for the new Easton Collection Center. All of that space that did not fall under the new building footprint was converted to landscaped open space and planted with sustainable native species. This conversion to landscaped open space together with a building that is completely sheltered under a living roof significantly mitigates any heat island effect for this new project.

WATER EFFICIENCY

Water scarcity is a major limitation to growth in northern Arizona. Even so, native cultures have lived sustainably for centuries with this scarcity. Not only is the climate very dry, but the geology of thousands of feet of layered porous sedimentary rock that underlie the Colorado Plateau—think Grand Canyon—means that water does not flow on top of the land to fill lakes, and wells are typically more than a thousand feet deep.

Through the incorporation of waterless urinals, dual-flush toilets, and flow limiting valves we were able to reduce potable water use by more than 50% for the ECC. Landscape approaches present another opportunity to conserve. The high altitude extremes of radiation, heat, cold, and drought have exerted powerful natural selection forces to favor the unique plant species that currently thrive in the local ecosystem. A truly sustainable approach to planting meant that an entirely indigenous landscape palette be selected. The benefits of relying on native plants for this purpose include water conservation, symbiotic integration with the surrounding natural ecosystem, and reduced maintenance. Several minor site grading features like swales with rock check dams and porous weir walls were configured to support natural water collection near larger plants and trees. An interim irrigation system was installed to irrigate plants during plant establishment periods only, one or two growing seasons at most—after which plantings would be capable of living with what the climate would provide them.

The irrigation system for the living roof includes a significant water harvesting component and thus uses no potable water. That system is described in more detail in the following section.

THE LIVING ROOF

The entire roof area of the Easton Collection Center is constructed as an extensive living roof and is planted in native species, mostly drought tolerant grasses like Blue Grama (*Bouteloua Grasilis*); however, many species of drought tolerant plants and cacti are intermixed to simulate the native plant ecosystems that exist in open meadows around Flagstaff.

Even though plant species that are abundant in northern Arizona are all very drought tolerant, it was understood that we would need to provide a reliable source of moisture for plants to survive in an extensive living roof application through the driest months. Those hot, dry months occur in late spring and early summer, before the monsoon thunder showers can be expected to arrive in early July. This supplemental water requirement is driven primarily by shallow soil depth on the roof and increased wind and sun exposure on the elevated, south-sloping roof surface.

To address this need in a sustainable way, our team created an extensive snowmelt and rainwater harvesting system. The entire roof area drains through a gutter system to fall into a series of stepped planters at the south end of the building that filter run-off and convey it to a sump at the low end where it is pumped to a 20,000 gallon cistern located upslope from the building. This cistern was sized according to calculations prepared by our living roof consultants and is based on data gleaned from local climate statistics.

Our principal living roof consultant, Paul Kephart of Rana Creek, understood that the ability for the soil mix used in the living roof assembly to hold water was as important as its mineral and biologic content. He therefore spent considerable effort in formulating and testing various soil mixes. The volcanic cinder soils that are abundant in the Flagstaff vicinity had the advantage of being lightweight, high in mineral content, and also very porous and thus made an excellent foundation for the selected mix.

The choice of roofing system can play a significant role in the energy performance of a building envelope, especially low profile buildings like the Easton Collection Center. In addition, considering the vulnerable nature of the building contents in a museum collections building, a reliable watertight barrier is essential.

Stepped planters at the south edge of the building capture and filter snowmelt and storm run-off, which is then pumped to a 20,000 gallon cistern for use in irrigating the living roof in dry months.

Other than the stormwater mitigation benefits already mentioned, the sustainable attributes of living roofs are perhaps understated in most descriptions. The benefits that attracted our design team to this living roof option were several. Placing a living roof over a museum collection storage facility is perhaps counterintuitive, but such concerns were found to be unfounded. The thermal mass benefits of 6+ inches of soil material fit well with our overall building envelope concept. Placing this layer of soil along with drainage mats, root barriers, and insulation layers above the roof waterproofing membrane provided significant protection to that membrane and will in fact significantly extend its life. Heat, ultraviolet radiation, ice, and physical impacts are all major threats to the life of a roof membrane, and a living roof system isolates the membrane from all of those threats.

It is a straightforward exercise to calculate the R-value based insulating properties of a living roof assembly. However, there are other thermal benefits that should be considered, even though they are not easily quantified. During the warm or even hot growing months of the year moist soil and the evapo-transpiration driven energy absorption of the plants themselves can help reduce the cooling load. In the winter months, especially on windy days that are common in Flagstaff, the projected structures of the plants themselves, for instance the dried, curled blades of the grasses, play a role in holding an insulating boundary layer of air at the surface rather than letting it be constantly blown away as it would from a smooth roof surface. This effect is similar to what the multitude of tiny hairs that cover a human body do to help it preserve heat on a cold day.

The Museum of Northern Arizona is currently involved in botanical research regarding native grassland restoration, and the Easton Collection Center's living roof will serve as a living, evolving experiment in native landscape evolution.

THE BUILDING ENVELOPE

For building design, discussions of how to achieve exemplary building energy efficiency would best begin with the subject of defining the nature of the building envelope. Should it be conceived as a thermos bottle or a cave? In our effort to create a building that would take best advantage of what the local climate had to offer our team chose the "cave" approach.

Thermal Mass

Perhaps the most important aspect of the design of the building envelope of the Easton Collection Center was providing very high thermal mass inside the thermal envelope. This feature alone provides for a thermally stable environment for the collection objects and also allows mechanical equipment to be sized and configured to work against something closer to average daily temperature rather than against the extreme high and low temperatures of a typical day in the high dry climate of Northern Arizona where swings of 40°F common.

Exterior walls, key interior walls, and floors are constructed of high-thermal-mass materials that are directly exposed to the interior atmosphere. Walls are constructed of 12″ thick, solid-grouted concrete masonry with an unpainted lime plaster finish. All interior floors are constructed of reinforced integrally colored concrete that has been densified and polished.

Most of the interior ceilings are exposed steel structure. The presence of all of this thermal mass in direct contact with the interior atmosphere prevents any sudden changes in temperature that could damage objects. It also prevents the effects of a particularly hot day

Interior of main Collections Room showing four directions patterning in polished concrete.

from putting a strain on the building's HVAC because it effectively dampens and delays (offsets) such thermal peaks to the evening hours when equipment can operate more efficiently. A similar "thermal flywheel" offsetting and dampening effect is felt during cold weather spikes.

Thermal Insulation

To perform most effectively, all of this internal mass must be isolated from the exterior climate by a continuous envelope of insulation—under slab, on exterior of walls, and just above roof deck. The building's living roof includes 5″ of rigid polyisocyanurate (PIR) insulation above the membrane. All exterior walls have a minimum of 4″ of PIR on the exterior side, and floor slabs have 2″ of PIR underneath. This effectively isolates the building's interior from the exterior thermal environment.

For window construction, "thermally-broken" aluminum frames were selected. Thermally broken refers to the fact that the interior and exterior aluminum frame components are isolated from each other by a thermally resistant connector. Typical one-piece aluminum frame components act as an unwanted thermal bridge compromising the effect of insulated glazing. We selected insulated, dual-pane, low-E glazing with UV barrier to further isolate the building's interior from undesirable outdoor elements. The UV barrier did reduce the solar heat gain potential of south facing glass, but its use was dictated by the need to protect collections objects from harmful radiation.

Vapor Sealing

One other consideration was key in optimizing the performance of the building envelope. Achieving an airtight envelope is important to interior environment control, especially when it comes to maintaining specific humidity levels. Our humidification target for the interior was 35% RH +/– 8% with a maximum change of 6% in any 24 hour period. The high-altitude, arid climate of northern Arizona often results in dew point temperatures in the single-digit or even negative degree range and outdoor RH levels in the low single-digit range. In these conditions, vapor diffusion pressure will unrelentingly push moisture out of the interior of a building through any escape route available, and mechanical energy will be required to replace it. Maintaining such an RH level in even a moderately leaky building can consume a lot of energy and may not even be attainable with any sort of stability.

Since smoke infusion from either wildfires or controlled burns was a concern relative to protection of artifacts, it was decided that the interior should be slightly pressurized to prevent unfiltered air from entering the building. The need to pressurize the interior without introducing too much outside air further emphasized the need to tightly seal the building.

We began by encapsulating all of the exterior walls with a vapor barrier that was fluid applied directly to the exterior face of the masonry walls, from footings to roof deck. The specified vapor barrier, W. R. Grace, Perm-A-Barrier® was spray applied as a thick, elastic, continuous membrane. All joints between walls and penetrating elements such as door and window frames were sealed with a continuous flexible flashing of self-adhering membrane tape. A vapor barrier was also placed under the floor slab insulation and bonded to the perimeter walls. Many details were addressed to insure that we would have a tight building envelope. Once the shell was complete, a blower door test was conducted to see just how much outdoor air would be needed to effectively pressurize the building. The attention to vapor seal detailing showed up when we got the blower door test results indicating that only 230 CFM would do the job. This low outdoor air requirement goes a long way toward reducing energy consumption and making RH targets achievable and stable. To insure air quality for human occupancy without introducing an unwanted excess of outside air, fresh air supply dampers are controlled by CO_2 sensors.

HVAC SYSTEMS

Design Intent

As mentioned, our intent in conceptualizing the HVAC system for the building was to take the greatest advantage of what the local natural environment would give us. A key factor in that regard was recognizing that even though the daily temperatures in the high, dry air of northern Arizona can be extreme, the “average” daily temperature is moderate. Very cold nights are often followed by sunny days, and periods of very cold or very hot weather do not typically last long. 40°F+ degree diurnal temperature swings are common. Mitigating these extreme peaks and valleys with a high mass, thermal-flywheel functioning structure allowed us to explore simpler, slower acting HVAC system concepts. We also learned that museums and museum collections environments are best served by systems that do not rely so much on air movement to control indoor climate. This is because of the tendency of air based systems to constantly stir up dust and other pollutants. For these reasons we chose to explore various radiant heating and cooling approaches.

Conveniently, the hottest weeks of the year in Flagstaff are also the driest, and we discovered that a simple evaporative cooling tower could produce cooling water close to the dew point temperature which is often in the 40–50°F range at that time of year. Nighttime cooling tower water can be very cold, and the daily peak offset afforded by the high mass structure could make efficient use of it.

Solution

To put these physical realities to use, we configured a simple in-floor radiant system that uses PEX tubing cast into the exposed concrete floor slabs—nearly three miles of it—so that we could use the concrete floor as a radiator to absorb heat from the interior. Cold cooling tower water cools the water in the floor loops via a heat exchanger, and that water is circulated through the floor slabs via a series of separately controlled loops or zones, each with its own small circulating pump. The main air handling unit for the collection storage space is also configured with a cooling water coil economizer and a water-source heat pump for backup in the event of extreme weather periods.

Heating needs are addressed with a pair of very high efficiency condensing boilers that provide heated water to these same radiant floor loops. The boilers are configured to operate in a "lead-lag" sequence for redundancy and added emergency capacity. Lead-lag refers to programming of side-by-side equipment to operate singly, but alternating to extend service life and provide redundancy, with the added benefit of being able to run both at the same time if extreme conditions occur.

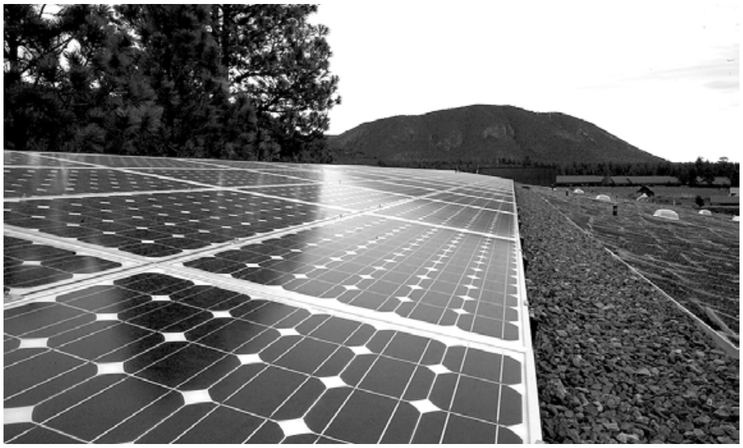
PEX in-floor cooling/heating loops being installed.

ELECTRICAL AND LIGHTING SYSTEMS

Electrical service to the site was upgraded to 408V, 3-phase power so that high efficiency equipment could be used. Also, in keeping with the environmental policies of the museum of Northern Arizona, the service agreement with the local electrical power provider stipulates that 50% of any power purchased will be from renewable resources.

High altitude, abundantly clear skies, and cool temperatures make the building site for the ECC ideal for solar energy applications. The project includes a 23.1kW photovoltaic array which consists of a bank of collector panels along the upper, north, edge of the living roof. In that location, the panels are kept clean by the wind, and they shed rain and snowmelt runoff directly onto the living roof. Convection drafts from the lower areas of the roof help to clear snow from the panels as quickly as possible. It is projected that this array will provide nearly 27% of the building's electrical energy needs.

Several design features are aimed at reducing energy use for lighting of interior spaces. First and foremost is the effective use of natural daylighting. To begin with, all regularly occupied workspaces were placed along the south exterior side of the building. Carefully sized roof overhangs along that edge combined with adjustable translucent shades on the windows there allow for effective use of the natural daylight that the arid local climate abundantly provides. Central circulation spaces are lit by a series of 20″ diameter Solatube devices that penetrate the



The photovoltaic array located along the entire top edge of the living roof is capable of providing 27% of the building's energy requirements.

living roof. Well engineered acrylic lenses that cap these units are very effective at gathering daylight, even from an overcast sky, and transmitting it to the interior. These lenses result in much more luminosity than a typical un-lensed skylight provides and also function as highly effective UV filters—an essential attribute in museum applications. In fact, all of the glazing units for windows in the building included UV filtering films, which block more than 99% of that damaging high energy radiation.

Wherever Solatubes are used to light spaces where collection objects might be exposed for periods of time, especially in the main collection storage room, those Solatubes are equipped with electrically controlled shutters so that they can be closed whenever the spaces are unoccupied or darker conditions are desired. In the main collection storage room, these shutters are controlled by occupancy sensors that are programmed to close them when no occupancy is sensed after a 10-minute delay.

The Solatube daylighting devices that illuminate the main collection storage room are arranged in three separate zones. The occupancy sensors for those zones are programmed to open the shutters on those devices the instant that occupancy is detected. The intent is that whenever the system senses a person entering the space that an adequate level of illumination is provided for access through the space without turning on any additional electric lighting source. When a higher level of task lighting is required in an area, then artificial lighting can be intentionally switched on. That artificial lighting is programmed to be automatically switched off by the lighting control panel if no occupancy is sensed after a 10-minute delay.

Artificial lighting consists primarily of very efficient T8 fixtures arranged in functional, user-controlled zones throughout the building so circuits can be switched on and off as needed by the building occupants. Wherever appropriate, as in offices, hallways, and restrooms, occupancy sensors detect occupancy and turn on and off lights.

MATERIAL SELECTIONS

The key phrases in a sustainable approach to material selection that guided our design team were:

- Regionally harvested and manufactured
- Recycled/reclaimed content
- Reduced embodied energy
- Low maintenance
- Non-polluting/non-emitting

There are both subtle and obvious synergies in these different expressions like regionality and the transportation component of embodied energy; and the relationship between low maintenance and the natural durability of local materials.

Structural Materials

Since we were looking for a mass intensive building envelope that was inorganic and inert, it seemed a natural choice to rely on concrete products. The bulkiest component, aggregates, are easy to come by in Arizona, and coal fired power plants on the Colorado Plateau offer an abundant supply of fly ash to help offset the embodied energy downside of Portland cement. We used concrete design mixes with as much as 35% of the Portland cement content replaced with fly ash for all sub-grade concrete and grout for concrete masonry walls. Due to finishing concerns for the exposed floors, that ratio was reduced to 15% in slabs on grade. Concrete masonry units are a staple throughout Arizona, and local plants produce them in abundance, so that choice for structural walls was easy. Twelve-inch thick reinforced and solid grouted concrete masonry provided very cost effective mass and impenetrability.

Light gage steel trusses are typically manufactured from steel that is high in recycled content and several regionally located plants were available to provide the needed products. Their inorganic and fireproof qualities were also advantageous in this application.

Finish Materials

One very important consideration in the design of the ECC was that maintaining the structure itself should not take away from resources that could be better used in maintaining the museum collections. The extremes of the northern Arizona climate with strong ultraviolet radiation, extreme daily temperature swings, and the mechanical forces exerted by deep snow and ice can quickly degrade exterior materials, especially organics like wood, plastics, and paints. Because of this concern we chose exterior materials that were inert and presentable in their natural form without added coatings or finishes. Exterior walls finishes are either unpainted oxide, tinted hydraulic lime plaster, or natural dry stacked native stone, specifically Navajo Sandstone from a northern Arizona quarry. Accent panels and trim details are constructed of natural weathering steel. The bulk of these materials were readily available regionally and require little or no maintenance at all to retain their intended function and aesthetics.

Relative to the building's interior, concerns regarding sustainability not only included life-cycle expenditure of resources but also included very real concerns about pollutants that might be introduced through regular maintenance activities.

Hardened and polished integrally colored concrete floors throughout the building are a good example. These floors exhibit their thermal mass effect best when exposed, and the permanent finish system selected means that keeping them looking good will require no more than damp mopping with clean water. Walls in the main collection repository and in many other locations are finished with a hard-troweled, integrally-colored hydraulic lime plaster that requires no paint.

Wherever wood products were incorporated into the project they were either reclaimed or FSC certified materials. Countertops were constructed from a Paperstone product fabricated from 100% post-consumer recycled content.

Construction Waste Management

Our design team and especially our construction team, KCS Construction Services, took the issue of construction waste management very seriously. This effort required educating subcontractors early in the process and making sure that facilities were available to separate, store, and collect waste materials. In the end we were successful in diverting 79% of construction generated waste from landfills.

INDOOR AIR QUALITY

In a museum collections storage environment, with literally millions of objects to be cared for, the air needs to be kept clean. This is also an environment where people work, and insuring the quality of the atmosphere they live and breathe in is critical. The first line of defense in each of these concerns is in not introducing materials that will contribute to pollution, this includes both particulate and volatile pollutants.

Descriptions of the interior finish material choices given earlier highlight important attributes that support clean air. Additionally, wherever materials were specified that have the potential to contain pollutants such as VOCs in adhesives, paint products, carpet, etc., as well as urea-formaldehyde in composite panel materials, great care was taken to insure that products with very low or no VOC content were selected.

All spaces that are regularly occupied in the ECC were generously equipped with screened operable windows so that occupants can effect their own fresh air supply. Additionally, the outside air supplies for the air handlers for all spaces are controlled via CO_2 sensors. Thermostatic controls are located throughout the facility so that occupants can control settings for individual zones. It should be noted that one benefit of an in-floor radiant heat delivery system is that comfort is less dependent on air temperature.

A major source of pollutants in buildings are those that are left over from the construction process. Concealed spaces, especially ductwork, are typical repositories for such pollution. In the design of the ECC we made an effort to eliminate as many concealed spaces as possible, by exposing roof structure, eliminating soffits, and building solidly filled walls. We also worked with our building team to implement a Construction IAQ Management Plan, a key feature of which was sealing all ductwork as it was installed and maintaining that seal throughout construction activities. A two-week long purge of the building, which involved pumping 100% filtered outdoor air through the building, was conducted prior to occupancy to insure that any residual pollutants were cleared. Pre-filters and primary filters were installed on all forced air components.

CONCLUSION

The sheer number of determinants, influences, and stakeholder concerns affecting the design of this project made its execution a somewhat daunting task. When approaching such a multifaceted design effort it is often a concern that dissimilar goals will come into conflict, and it is also easy to confuse means and ends. However, a clear focus on sustainability provided direction and resolved many potential conflicts. Sustainability lies at the heart of the issue of preservation of museum collections, and it is also at the core of the Native American cultural philosophies that needed to be respected in this instance. A building designer is constantly confronted with choices to be made. Our team found that by defining those choices in terms of sustainability, we very often presented a clear best choice and had the additional benefit of providing positive grounds for consensus.

Simplicity is not easily achieved, and it certainly was not in this case. As building designers, we use this goal of simplicity as a way of testing, at least intuitively, whether we are on the right track with our ideas. We view overly complex solutions with a skeptical eye. An interactive team approach, coupled with allowing adequate time to investigate alternatives in the decision making process, is essential to achieving a meaningful simplicity. If a solution feels too complex or confused then it is probably best to start again from a new perspective. Technical simplicity also has value. Whenever possible we chose low-tech solutions, and that of itself gives confidence that result will be sustainability for the long term.

In the end, we believe that the completed Easton Collection Center does present a fairly compact, simple solution to a complex set of challenges. Although our design team had no preconceptions whatsoever regarding building form or aesthetics, we were encouraged that an approach focused so tightly on sustainability yielded such an aesthetically pleasing solution—and one that fit gracefully into its context.

Prehistoric Native American ceramic bowl from the MNA collections.