Repairing the World

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When the Jewish Reconstructionist Congregation (JRC) of Evanston, Ill., decided to replace its synagogue, a guiding value was tikkan olam, Hebrew for “repairing the world.” The congregation committed to ethical architecture with the goal of demonstrating the benefits of sustainable building design to the larger community.

The synagogue, which incorporates sustainable materials such as concrete with fly ash and strategies such as light harvesting and water conservation, is the first religious institution to receive LEED® Platinum certification. The new shul, or synagogue, is 31,600 ft², which replaces a 21,400 ft² facility on the same site. The new building has three levels containing the congregation’s offices, early childhood program and chapel on the first floor; the education offices, classrooms and library on the second floor; and the sanctuary, social hall and kitchen on the third floor.

Land Use

Land use and storm water management are key environmental issues.
that influenced the project design. Situated in a mature, residential area of Evanston across from a city park and adjacent to the tracks of a commuter train, the design balances the limitations of a small site with an ambitious program.

The Evanston zoning ordinance limited the building to far less than the original plans for 42,000 ft². Specifically, the ordinance restricted the lot coverage and building height. The lot coverage requirements were instrumental in the final organization of the building.

The Congregation requested that all of the major components—the worship space, early childhood program and administrative space of the synagogue—be located on the ground floor. However, it was physically impossible to place all of these functions at grade, or even on the first two floors. A detailed analysis mapped space use hour by hour, day by day over a typical week to identify opportunities for flexibility and efficiencies, leading to a 25% reduction in space.

The design solution layered the building with the most frequently occupied areas on the first floor and the least used areas on the third floor. A major concern was locating the main sanctuary on the third floor. The issues included ease of access, especially for older congregation members, and creating a prominent pathway to the worship space.

The resolution was a wide linear stair on the south side of the building, which can be seen through the curtain wall of the main elevation. This design feature serves as a “spiritual ascent” to the most important space in the synagogue, the sanctuary. The space was made accessible by designing the stair with a shallow rise that is easily climbed and providing two elevators to the third floor. Per tradition, the bimah, a raised platform where the Torah scrolls are read, and ark, a cabinet where the Torah scrolls are kept, are located on the east wall of the chapel and the sanctuary. In addition, the congregation requested a strong connection to the natural environment. These two criteria posed another design challenge since the east side of the property faced an alley serving the garages of the nearby residences.

Placing the sanctuary on the third floor allowed the east wall to become a large picture window to the outdoors. The space looks into the trees of this mature neighborhood, creating a powerful, visual connection to the environment.

Locating the sanctuary on the top floor provided an economical way to create a large, long space with a high ceiling. The sanctuary symbolically rises above the rest of the building and has clerestory windows around the perimeter. The result is a light and airy worship space.
are composed of recycled gypsum board, 6 in. structural steel stud with recycled fiberglass insulation, Forest Stewardship Council-certified wood sheathing, 2 in. rigid insulation, and reclaimed cypress wood siding for a calculated R-value of 28.

Similarly, the roof is a metal deck covered with a minimum of 6 in. of polyisocyanurate insulation and a white, reflective thermoplastic.

Synergistically, the smaller building footprint created more open space on the site, enabling the project to meet storm water requirements. Pervious materials and landscaping comprise 43% of the building site, reducing the site detention requirements. These measures, combined with a below-grade storage structure controlled by restrictors, reduced storm water runoff by 25%. In addition, 30% of the site is landscaped with native and adapted species, creating small ecosystems for prairie plants, a rain garden, shade foliage and vines for the gabion site walls. Prior to demolition, congregation members saved plants and fostered them for replanting.

**Building Envelope**

Passive strategies implemented to reduce energy consumption include the building’s organization, volume and exterior enclosure. The early, careful consideration of sustainable measures integrated the architecture and building systems. For example, the HVAC concept mirrors the layering of the functional spaces by floor. In addition, coordination of the ductwork, fire protection, lighting, electrical and other building systems allowed the design team to reduce the floor-to-floor height to 12 ft, saving 25,000 ft³. Decreasing the volume translated into fewer building materials and reduced construction costs and energy consumption. Nearly all (95%) occupied spaces are on the building perimeter, maximizing views, daylighting and natural ventilation. The ceremonial stair, sanctuary/social hall, chapel and offices have glazed curtain walls with operable windows. The light-filled ceremonial stair can be ventilated naturally with air intake at the first floor and an exhaust fan in the ceiling of the third floor. The third-floor sanctuary has unobstructed views into the mature tree canopy of the neighborhood and is daylit with a clerestory and lightshelf.

The majority of the occupied spaces have 9.5 ft ceilings to enhance daylighting and natural ventilation. In each classroom, the windows are at four heights to provide a variety of views for toddlers to adults. The operable windows located near the floor and near the ceiling encourage buoyancy ventilation. Operable windows in these spaces take advantage of the prevailing winds to provide cross ventilation. The location of the punched windows on the inside face of the exterior wall provides integral shading.

The synagogue’s three-story ceremonial stair is strategically placed on the south exposure to act as a thermal buffer zone. An exterior sensor opens a window on the first floor and turns on an exhaust fan at the roof level when the outside air is at an appropriate temperature. This allows for passive cooling of the entire south face.

The building’s exterior envelope construction enhances its energy-conscious layout. From the interior to exterior face, the walls are composed of recycled gypsum board, 6 in. structural steel stud with recycled fiberglass insulation, Forest Stewardship Council-certified wood sheathing, 2 in. rigid insulation, and reclaimed cypress wood siding for a calculated R-value of 28.

Similarly, the roof is a metal deck covered with a minimum of 6 in. of polyisocyanurate insulation and a white, reflective thermoplastic.
The parking lot lights are powered by individual solar panels.

**Lighting**

The interior lighting integrates the architectural planning and the latest lighting technology to reduce energy consumption and improve the quality of the indoor space. The building plan places more than 90% of the occupied spaces on the exterior with access to daylight and views. Solar tubes help illuminate the third-floor kitchen and reception spaces.

To complement the natural sources, more than 90% of the fixtures use T5 fluorescent lamps, and more than 50% are indirect/direct pendants. The project also incorporated other long-life, energy-conscious light sources including cold cathode and LED.

Lighting controls include a combination of occupancy sensors, photocells, mesh shades, dimming and dual lamp switching. The artificial lighting in the sanctuary and ceremonial stair is controlled by photocells. In the sanctuary, full dimming capability and photocells work together to maximize daylight harvesting. In most other spaces, occupancy sensors control the lights. In the classrooms, two dual-switched lamp fluorescent fixtures provide a simple, cost-effective means to respond to the natural light.

The site lighting around the building consists of only four exterior fixtures, all with full cutoff optics to eliminate light pollution. In addition, the interior fixtures are located so that their maximum candela falls within the building. For example, an embedded fluorescent fixture in the center room of the ceremonial stair only illuminates the risers and treads.

Limited on-site solar power is used in both a practical application and as a symbolic gesture for lighting. First, the congregation’s 24-car parking lot is illuminated by three pole-mounted 32 W fluorescent fixtures with a solar panel, storage battery and controller. Polycrystalline silicon photovoltaic (PV) modules that convert sunlight into electricity compose the solar panel. Sealed gel batteries store the electricity for nighttime use by parking lot lights. A built-in controller manages the electricity flow from the panels to the batteries. In addition, the controller operates the lamp by sensing and remembering when dusk and dawn occur, or it can be programmed to turn the fixture on and off at preset times.

Second, electricity from a solar panel located on the synagogue’s roof continuously illuminates the ner tamid, or eternal light, located in both the chapel and sanctuary. Like the parking lot lights, a battery in the solar panel stores enough energy to keep the ner tamid on even during the shortest days.

**Flexible, Efficient Equipment**

The mixed-use facility includes worship spaces, a daycare, classrooms, a social hall with a kitchen, and private and open offices. Highly efficient, flexible HVAC equipment contributes to a large part of the energy savings. For example, a 94% ultra-high-efficiency gas-fired condensing boiler heats the synagogue, rather than an 80% conventional or even a 91% condensing boiler. Also, the synagogue is not a 9-to-5 operation, further complicating the energy modeling. In fact, the spaces used vary daily, weekly and seasonally. In response, seven 15-ton modular chiller units, which can adjust to the synagogue’s occupant load, cool the building. This high-efficiency air-cooled chiller has a peak power consumption of 1,212 kW/ton, rather than 1,256 kW/ton per ASHRAE Standard 90.1-2001.

In addition, the chiller has a 14-to-1 turndown ratio (14.3 integrated part-load value [IPLV]) as compared to a conventional air-cooled chiller’s 4-to-1 (3.05 IPLV). The higher chiller turndown ratio allows the chiller to provide cooling capacity to exactly match the building demand. This prevents the compressor from short cycling and allows the chiller to reduce energy consumption and extend the lifecycle cost.

The ventilation system also reacts to the building’s ongoing activities. The air-handling unit, return fan, chiller fans, chilled water and hot water pumps are equipped with variable frequency drives. In addition,
overhead bifold door normally used for aircraft hangars.

Integrated Construction

The interior wood slat construction in the synagogue’s worship spaces is an integrated solution addressing the ventilation, material use, acoustical needs and daylighting of these spaces. Reclaimed cypress was milled into 1¾ in. slats that compose the interior north and south walls of it above the human breathing zone. In contrast, a conventional overhead air distribution system provides 55°F supply air at the ceiling level at high velocity. The supply air mixes with the contaminated room air to maintain a uniform room temperature throughout the entire space.

Using displacement ventilation eliminated the HVAC equipment and ductwork from above the high ceiling in the sanctuary. The advantages of this system include reducing the required overhead maintenance and decreasing the structural load on the 50 ft long space. The system also influenced the choice of an operable partition to divide the sanctuary and social hall. Almost the entire north and south walls of the space were needed for perimeter supply diffusers. When open, a traditional operable partition stores panels against the walls. In this case, this was undesirable since the panels would block some of the clerestory windows, and more importantly, impede delivery of the supply air to the space. The solution was an overhead bifold door normally used for aircraft hangars.

Displacement Ventilation

The displacement ventilation system serving the sanctuary and social hall provides many benefits including lower installation cost, reduced energy consumption and improved indoor air quality. Six fan-powered boxes deliver 63°F air at a low velocity, resulting in decreased fan power. Displacement ventilation is distributed near the floor, employing stratification to heat or cool only the first 3 ft of the 18 ft space.

In simple terms, the clean, uncontaminated air travels along the floor until it encounters a warm body and rises by natural buoyancy effect. The air continues to wash over the occupants as it picks up more heat, and the air-handling system returns it above the human breathing zone.

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The 6 R’s: Reduce, Reuse, Reclaim, Recycle, Renewable and Regional

Reduce Reducing floor-to-floor heights to 12 ft eliminated an estimated 10,400 ft² of materials. In addition, polished concrete structural slabs eliminated unneeded floor coverings, and most walls are composed of recycled drywall with low-VOC paint.

Reuse Some 96% (2,700 tons) of the demolition and construction waste was recycled and diverted from landfills, including the concrete and masonry that was crushed on site and used as engineered fill for the building’s foundations. Finally, waste brick and concrete were used to fill the gabion site walls.

Recycle The building includes many products manufactured with recycled materials, including concrete with fly ash, synthetic drywall, structural and miscellaneous steel, fiberglass insulation, toilet partitions, ceiling tile, carpet and playground mulch.

Reclaim Eighteen thousand square feet of reclaimed cypress was used as exterior siding and for interior slat walls. Four crimson maple trees on the site that could not be saved were cut down and milled to clad the ceremonial door. The bimah floor was milled from storm-felled black walnut trees from local park districts.

Renewable The synagogue also features products made with rapidly renewable materials, including millwork made with Dakota Burl, a board made from sunflower seed husks; carpet with bio-based polymer fibers; linoleum tackboards; and rubber mulch made from discarded tires.

Regional Overall, 47% of the building’s materials were regionally manufactured with an additional 14% of the raw materials extracted locally.
the sanctuary as well as the walls and ceiling of the chapel. The walls and ceiling provide both acoustic absorption and diffusion. First, the cypress slats obscure the fiberglass batts, made of recycled material. The 0.5 in. gaps between the slats make the walls and ceiling acoustically transparent, allowing sound to travel through the wall and hit the sound-absorbing material, which dampens the sound waves. Second, the wood walls and ceiling provide diffusing surfaces, which reflect sound waves in multiple directions to ensure that the quality of the sound is pleasing and reaches a greater number of listeners.

The wood slat surfaces undulate in and out of plane in 4 ft sections to create large-scale diffusion, while the 0.5 in. gaps create small-scale diffusion in response to various wavelengths or frequencies. The wall design also integrates the displacement ventilation system. The wood slats screen the supply and return ventilation, making them essentially invisible to the users while still permitting the supply air to stratify in the room. In addition, the design takes advantage of the composite walls’ thickness by incorporating a lightshelf at the top of the wood slats and bottom of the clerestory windows, bouncing daylight farther into the 50 ft-wide sanctuary and social hall.

Resource Use Summary
In its first year of operation the Jewish Reconstructionist Congregation has met or exceeded expectations concerning the building’s use and consumption of water, gas and electricity. Interviews with the synagogue staff and members indicate that the facility is being used more intensely than projected. More large events have been scheduled in the sanctuary/social hall with an average increase in participants from 250 to 350 persons. The new building also has allowed the congregation to significantly expand their adult education program. An unanticipated occupant load is the almost weekly tours of the synagogue given by more than 25 volunteer members who have been trained as docents.

The energy modeling was originally performed using Standard 90.1-1999, but was recently revised using Standard 90.1-2004. Using the latest calculations, the baseline building’s energy use was 120,970 Btu/ft² and the design case was 73,350 Btu/ft² for a proposed savings of 35%. However, after tabulation of the gas and electric bills from drought-resistant plant species eliminate the need for an irrigation system. The water consumption tabulated from the first year’s water bills is 131,657 gallons, a 37% improvement over the baseline building. The difference from the design case and actual use is due to a larger occupant load during the year.
March 2008 to February 2009, the actual energy consumption was 51,979 Btu/ft², a 57% improvement over the estimated energy consumption. We encountered avoidable delays due to late submission of specialty items with one viable source. Examples on this project included stainless steel piping associated with a 94% efficient boiler, the 50 ft x 1.5 ft galvanized aluminum overhead door, and the solar-powered compact fluorescent parking lot lights.

High performance buildings often use new, innovative technologies and materials that are still developing a market. In addition, they often have few competitors. Submittals and shop drawings for these items should be reviewed within the first 60 days of construction regardless of their installation in the construction schedule. We encountered avoidable delays due to late submission of specialty items with one viable source. Examples on this project included stainless steel piping associated with a 94% efficient boiler, the 50 ft x 1.5 ft galvanized aluminum overhead door, and the solar-powered compact fluorescent parking lot lights.

Reducing the building’s volume to save on materials and energy consumption required more coordination between the architects and engineers. But that was only half the battle. Coordination of the subcontractors’ work during construction was equally important to ensure the building systems fit into the tight interstitial space above the ceilings. One important lesson is to install the largest systems first (i.e., ductwork, VAV boxes, etc.) For example, the boiler intake and exhaust piping was one of the last components to be installed, but could not be placed as designed due to interference from other building components. Eventually, after an exhaustive effort, a new path for the piping was found that did not affect the 9.5 ft ceiling heights in the perimeter spaces. However, the piping could have been installed as shown on the drawings while other less bulky systems, such as sprinkler piping and electrical conduit, could have easily been routed.

Combining two different innovative ideas can have unanticipated consequences. Our firm researches new technologies and materials before using them in a project. The synagogue design included polished concrete floors with a high percentage of fly ash. The concrete polishing subcontractor encountered difficulties grinding the concrete, and indicated that the floor was much harder to polish than normal. During subsequent discussions, it was discovered that the subcontractor had never worked with concrete containing fly ash. In addition, after occupancy, the congregation discovered that liquid staining was much harder to remove than anticipated. Though not proven, it was hypothesized that the fly ash content increased the concrete’s hardness and porosity, leading to these issues.

For example, the chiller master controller may determine that it is more energy efficient to run all six modular chillers at 50% part load than running three chillers at 100% full load. Another factor is the inability to account for all of the energy saving strategies incorporated into the building, such as occupancy sensors, solar tubes, displacement ventilation and natural ventilation. In addition, the combination of the reduced building volume, the effectiveness of the thermal envelope, the high-efficiency flexible HVAC equipment, energy-efficient lighting, the air distribution system, and HVAC and lighting controls that respond to occupancy and outdoor conditions may create a synergistic effect.

The large difference between the design case and actual numbers could be due to a number of factors. First, the energy model follows strict guidelines established under Standard 90.1-2004, Appendix G, to benchmark a building's performance. However, the energy model algorithm may not accurately represent the highly variable occupant load and the corresponding modular chillers’ part-load performance.

Opportunities The project team, even after design completion, should look for opportunities to incorporate sustainable strategies. The western portion of the synagogue site was lined with four mature cypress maple trees that would have provided great shading for the new building. Unfortunately, once site work commenced, the project team realized that the root systems would not survive the foundation and utility work. We researched the possibility of milling the maple locally to finish the ceremonial entrance door. This led to an awareness of the urban forestry industry as a source of environmentally friendly hardwoods and incorporating storm-felled black walnut trees into the project as the bimah flooring.

Designing the final documentation, the building fell about 4% short of the metric. To avoid this on our next project, we developed a spreadsheet to calculate the minimum amount of glazing required for each space to meet the daylight criteria. This tool was successfully applied to the Commodore Barry Elementary School in Philadelphia (LEED Gold certified) when developing the elevations during schematic design.