BY CHARLES Q. CHALOEICHEEP, P.E.; CHRISTOPHER FLINT CHATTO, ASSOCIATE AIA; AND EDWARD CLARK

Echoing the ever-changing waterway that passes the Seattle district headquarters of the U.S. Army Corps of Engineers, the “oxbow” shape of the USACE’s new building represents the transformation from a “silo” office culture to an integrated community. In the Corps’ previous home—a former 1930s Ford Motor warehouse that was later converted to offices—tall cubic walls and limited access to daylight or exterior views did little to encourage interaction. Now, employees meet members of other departments when they take the open stairs. A variety of conference rooms, hybrid spaces and informal collaboration areas that are centralized in the daylit atrium support project teams as they grow and shrink. Nearly every space provides daylight and views of the restored 4.6 acre former brownfield site, including the Duwamish Waterway.

Design Competition
While the $72 million project provides a beautiful, collaborative workplace, its exceptional energy performance places it among the most elite class of high performance buildings in the U.S. It is the result of a guaranteed performance-oriented contract—a first for the U.S. General Services Administration and an emerging industry trend—which withheld a portion of the contract funds until the first year energy use was verified.

The project was shaped by government programs designed to spur innovative high performance design for federal buildings and stimulate the economy via the release of stimulus funds from the American Recovery and Reinvestment Act (ARRA) as quickly as possible. The GSA used the tight time line demanded by the stimulus dollars and the competitive bidding marketplace at the end of 2009, to experiment with a design-build competition.

A design-build contract meant that the money could be budgeted immediately, and the rapid three-year project time line allocated final funding two to three times faster than traditional design-bid-build contracts. During the three-month design competition in which proposals were developed to a schematic design level to express design intent, but also assess cost, schedule and performance criteria. In the midst of a struggling economic climate at the end of 2009, these three firms participated in an unfunded competition, each taking a substantial risk to secure a rare, fully funded project at that time.

As part of its Design Excellence program, the GSA specified a set of holistic sustainable performance criteria, required LEED Gold certification and encouraged the reuse of materials from the USACE’s existing on-site warehouse building.

The guaranteed energy performance target required the building team to meet an energy goal 30% better than the ASHRAE/IESNA Standard 90.1-2007 baseline model, or an effective EUI of 27.3 kBtu/ft² yr, with 0.5% of the overall contract award retained until the first year of performance was verified through a measurement and verification (M&V) process.

Performance Oriented Design
Peak Load Reduction and Form Optimization. It was a challenge in the three-month competition phase to develop a schematic design proposal that could meet the guaranteed budget and energy performance criteria,
Right: Information on local waterways and locational data are implemented as graphic views of the Duwamish Waterway.

The building’s diagrid structure, known as a diagrid, wraps the exterior of the building and is prominent at the ends of the oxbow. It is essentially an oversized truss comprised of diagonal column and bracing that resists lateral and gravity loads while addressing progressive collapse.

The steel and concrete deck, like stainless steel shingles that reflect varying light from shingle to shingle, vertical and horizontal sun-shading elements contribute detail and texture to the façade.

The building is clad in stainless steel shingles which vary in size from 1” to 3”, creating a unique pattern and texture to the façade.

An orientation-specific shading system, with vertical fins and a variable number of horizontal louvers depending on orientation, limits solar loading, reducing annual energy consumption and first cost through decreasing the required number of chilled beams and plant size.

Energy modeling, which was embedded in the design process, determined that triple glazing alone would not be sufficient to provide comfort for all occupied hours. So, perimeter fin tubes are used to provide the required heating.

**ENERGY AT A GLANCE**

- **Annual Energy Use Intensity (EUI) (Site):** 33.3 kBtu/ft² (25.7 kBtu/ft² adjusted)
- **Natural Gas:** 3.4 kBtu/ft²
- **Electricity (From Grid):** 29.9 kBtu/ft²
- **Annual Source EUI:** 103.4 kBtu/ft²
- **Annual Energy Cost Index (ECI):** $0.63/ft²
- **Savings vs. Standard 90.1-2007 Design Building:** 33%
- **ENERGY STAR Rating:** 99
- **Carbon Footprint:** 6.2 lb Co2e/ft²·yr
- **Percentage of Power Represented by Renewable Energy Certificates:** 71%
- **Number of Years Connected to Purchase RECs:** one year

**WATER AT A GLANCE**

- **Annual Water Use (Model):** 200,000 gallons building water use, 1.5 million gallons of irrigation water use, 2.2 million gallons of cooling tower water use.
- **Actual water use is not available due to insufficient data from meter readings.**

The site retains the 95th percentile rain event, and treats 99% of the annual runoff. Roof water is captured and reused in a 25,000 gallon cistern for reuse.

- **Roof water is captured and retained off. Roof water is captured and retained.**
- **Building’s  rounded form enclosing a 20 21.
- **Envelopes**
- **Heating and Cooling:**
- **Pumps:**
- **Elevators:**
- **Plug Loads:**
- **Unitary System:**
- **Interior Lighting:**
- **Model:**

The former offices for the U.S. Army Corps of Engineers (USACE), Seattle district headquarters were grossly inadequate. The history of the site dates back to the 1930s and Ford Motor’s “famous assembly line,” which produced the “new V-8 cars.”

In 1940, Ford released the site to the U.S. Army, which remained at the location until 1956. From 1957 to 1970, the Boeing Airplane Company Missile Production Center was located in the nearby 1201 building.

With the complex returning to the U.S. government in 1973, the original Ford Factory and former 1202 warehouse were converted from industrial to office use. The structure featured sawmill dere-stories that were still painted black from wartime security concerns, and tall interior partitions limited daylight and views. Many employees expressed the desire to move from the sprawling, run-of-the-mill single-story complex in industrial south Seattle to more modern downtown facilities. But the existing site had its merits. Not only was it already owned by the GSA, but it was located on the banks of the Duwamish Waterway (although it was not visible from the USACE’s former offices). The waterfront represents the legacy and the future of the USACE; the river’s channel was established by the army decades ago, and now the river is undergoing a renaissance of environmental remediation and naturalization, a direct response to its long history of industrial pollution.

**NEW LIFE FOR INDUSTRIAL SITE**

The building serves as a collaborative workplace, combining of workplace flexibility and promoting connection and collaboration through more encounters among staff in this dynamic space.

High Performance Office.

The structure wrapping the commons pool conference rooms and other specialized and shared functions into the center of the building. Through sharing, the number of meeting rooms for the headquarters’ 19 departments was reduced, while promoting connection and collaboration through more encounters among staff in this dynamic space.

Collaborative Workplace.

The atrium and centralized commons pool conference rooms and other specialized and shared functions into the center of the building. Through sharing, the number of meeting rooms for the headquarters’ 19 departments was reduced, while promoting connection and collaboration through more encounters among staff in this dynamic space.

The building is clad in stainless steel shingles that reflect varying light from shingle to shingle, vertical and horizontal sun-shading elements contribute detail and texture to the façade. **MONTHLY ENERGY USE BREAKDOWN, 2013**

**Domestic Hot Water**

**Fans**

**Heat Rejection**

**Pumps**

**Heating and Cooling**

**Interior Lighting**

**Unitary System**

**Elevators**

**Plug Loads**

**Envelopes**

**Elevators**

**Plug Loads**

**Ductwork**

**Fans**

**Heat Rejection**

**Pumps**

**Heating and Cooling**

**Interior Lighting**

**Unitary System**

**Elevators**

**Plug Loads**

**Model**

Note: A spike in the heating and cooling energy use for December was due to a broken fluid cooler. Benjamin Benschneider
A system of stairs and bridges connects the commons to perimeter work spaces, which overlook the area. Timber reclaimed from the previous non-historic $1202 warehouse on the site is a focal point of the commons. The atrium commons functions as the social and cultural heart of the project. Timber provides the primary structure and enclosure of this space, reclaiming approximately 200,000 board feet of structural timbers and tongue-and-groove decking from the existing warehouse on the site.

To make the structure work with the limited amount of timber, the team’s structural engineers developed the first application of a composite beam. Lag bolts in the top of structural timbers engage the concrete topping slab, providing additional effective depth for the beam, reducing the number of beams by providing greater spanning capacity. In the conference rooms, hydronic variable air volume terminal boxes triggered by CO$_2$ sensors provide the capacity and control to manage thermal comfort and ventilation associated with intermittent occupancy.

In addition to its role as collaborative commons, the atrium is integral to the building’s high performance strategies. Return air from the office is collected by the atrium; buasoy energy drives the air, as 70% efficient flat plate heat exchangers arranged at the top of the atrium precondition incoming ventilation air.

The atrium also daylights half of the office’s 60 ft floor plate, in addition to the conference rooms and circulation space. Plants and landscaping within the space, in concert with exposed wood, changing daylight conditions, and views to the river, reinforce a biophilic design approach that emphasizes a connection to nature.

Office Daylighting Strategies. The climate of the Pacific Northwest presents challenges to using daylight as the primary illumination source. Cloudy skies are the predominant sky condition, but clear sunny days occur sporadically in winter, and are most frequent during the summer, when peak cooling conditions occur. A balance had to be struck between opening up to the cloud skydome and protecting from the direct beam condition. Exterior windows optimize their daylight contribution by maximizing window head height and using orientation-specific shading. The shading system reduces heat gain and assists with visual comfort. Internal venetian blinds at all exterior windows offer additional glare control, allowing occupants to adjust to their comfort.

Collaborative Commons. Some 61% of the building’s occupied floor plate is daylight. Task lights at all exterior windows offer additional glare control, allowing occupants to adjust to their comfort.

Daylight is also provided to inboard occupants by the atrium, where a variable frit pattern, ranging to a maximum density of 66%, is strategically deployed on the atrium skies, based on individual work spaces’ exposure. Light colored interior surfaces as well as 42 in. tall partitions topped with 6 in. glazed strips help facilitate daylighting. Light-colored interior surfaces as well as 42 in. tall partitions topped with 6 in. glazed strips help facilitate daylighting. The partition walls are oriented parallel to the façade to provide views to the skydome and protecting from the direct beam. Electric lighting is provided via high efficiency, direct/indirect fluorescent fixtures, which are used throughout the office spaces. Fixtures are controlled through a combination of zoned daylight sensors, occupancy sensors and the building management software. The 66% frit was not dense enough to protect occupants on the atrium side of the northern office plate, and roller shades were retrofitted to protect them from direct beam and the associated glare. Due to peer pressure from those deeper in the plate, perimeter office workers are encouraged to raise the shades so views to the atrium are preserved once the discomfort has subsided.

Central Systems. The hydronic system allowed for the efficient integration of ground source heat and the inclusion of a phase change material (PCM) tank for thermal storage. Polyethylene tubing was run into...
135 hollow structural steel piles that were driven an average of 160 ft deep through the sandy riverbank soil to find bedrock.

The PCM tank, a large cylindrical tank filled with stacked containers of eutectic salts that change phase at 55°F, acts as a direct source of chilled water for the chilled beams and as a source of heat for the heat recovery chillers to deliver 120°F heating hot water. The PCM tank, in theory, operates similarly to a ground source system, but with a daily, rather than a seasonal, cycle.

The building’s “oxbow” design creates an open, collaborative workplace environment for the U.S. Army Corps of Engineers. The indoor campus environment enhances the concept of creating a collective community and identity by centralizing all common services and conference rooms within the “commons” or social heart of the building.

Water Systems. This 4.6 acre site, transformed from 100% impervious to 50% pervious, is surrounded with infiltration and evaporation swales that manage and cleanse storm water flows prior to discharge into Duwamish Waterway. The storm water system eliminates the need to connect to the already overtaxed municipal sewer system.

Native and adaptive plantings reduce irrigation demand and provide habitat opportunities along the industrial waterway and complement ongoing efforts to restore ecosystems as the Duwamish enters the Puget Sound. High efficiency fixtures and a rainwater harvesting system help reduce potable water demand. Rainwater is collected from the roof and is reused for toilet flushing, irrigation and cooling tower makeup water. The rainwater system, which offsets the remainder of loads are met with a traditional boiler and the heat recovery chiller acting as a traditional chiller.

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**Building Envelope**

<table>
<thead>
<tr>
<th>Component</th>
<th>Type</th>
<th>Reflectivity</th>
<th>Overall R-value</th>
<th>Glazing Percentage</th>
</tr>
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<tbody>
<tr>
<td>Roof</td>
<td>Fossil bituminous asphalt roofing, polyisocyanurate insulation, metal deck</td>
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<td>19</td>
<td>62%</td>
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<tr>
<td>Walls</td>
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<td>Basement/Foundation</td>
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<td>Windows</td>
<td>Effective U-factor for Assembly</td>
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<tr>
<td></td>
<td>Solar Heat Gain Coefficient (SHGC)</td>
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<tr>
<td></td>
<td>Visual Transmittance</td>
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<tr>
<td>Location</td>
<td>Latitude 47.6° N</td>
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</tr>
</tbody>
</table>
Large rocks within the atrium serve as water features, inspired through the office plate and occupants of the energy-efficient features of the building. Small kitchens are distributed throughout the office plate and occupants can be quite cost effective at a building operations level, provided on-site renewable generation. The roof is designed to allow the building to be tuned from operating level. • The adjustments to the building water flows through stream channels chiseled in the stones, providing a direct tie to the climate and surrounding environment.

Measured Performance

Measuring the performance of the building started in January 2013, less than three months after substantial completion of the project. The first few months of M&V required coordination between the designers, builders, controllers, contractor and building operator—the M&V team—to ensure that the building was being properly measured and that the measured data could provide information on how the building was running and how it could be improved. During the first quarter of operation, the M&V team tuned the building’s HVAC systems, which were running outside of building operating hours, improved thermal comfort in select spaces, improved acoustics and identified glare issues. The team also identified opportunities for the USACE to reduce plug loads by shutting computers off at night, and controlling the server’s 24/7 loads.

Renewable Energy Evaluation

The integrated design was developed to meet energy goals without the need for on-site renewable generation. Initial life-cycle cost analysis of a solar domestic hot water system and supplemental photovoltaic system were outside the range of acceptable return. The roof is designed to allow the installation of a photovoltaic array in the future should the life-cycle cost benefits improve.

Conclusion

Even with its low operating energy, its integrated systems, and attractive interior spaces, arguably the most noteworthy aspect of this project relates to its performance-oriented design delivery. The GSA’s use of a guaranteed energy performance contract coupled with the Design Excellence Program pushed the team to deliver not only a beautiful building, but also one that performs as promised. This project demonstrates the success of performance-oriented contracting, an emerging industry trend, as well as the value of M&V. The substantial amount of money at risk incentivized the team to create a thorough approach, and for a project of this scale, the effort proved to be quite cost effective at a building operations level.

400,000 gallons of potable water use annually, is highlighted for occupants and visitors a true window facing the atrium.

LESSONS LEARNED

Trust and Risk Go Hand In Hand.

The GSA’s guaranteed performance contract was quite unusual; this was the first time the design team committed to such a process. Certainly, the dire economic climate contributed to the willingness to undertake a project of this nature, but the team also recognized the opportunity to be leaders in this industry trend, as more owners, designers and code officials are starting to address this critical aspect of energy-efficient design.

The past relationships of the team members was critical in taking the risk, creating an air of trust that allowed free, outside of the box thinking where all had an opportunity to put forth ideas. The pride associated with meeting the performance target as a team may have been a greater driver than the fear withheld and was fed by the trusting relationship of all of the players.


Rather than measuring energy performance during the building’s first year of occupancy, the project was commissioning and break-in period of a minimum of six months before the performance period begins would allow for more thorough commissioning.

A tuning phase was even more critical for this project with the innovative and integrated mechanical systems that required seven different operational modes depending on exterior and interior conditions. As it was, the team met the energy performance target, but only because the HVAC systems were designed to perform substantially better than the guarantee, made up for early months when the building was still not operating optimally.

Curved Floor Plan Created UFAD Challenges.

Underfloor air distribution (UFAD) was chosen on the basis of its energy performance and potential cost savings. However, this choice also required a thorough approach, and for a project of this scale, the effort proved to be quite cost effective at a building operations level.

After one year of operation, the building was tuned from operating at 10% over the target in the first quarter, to 12% below the target in the fourth quarter. The first full year of M&V was 25.7 kBTU (adjusted for plug loads and operations outside of the hours of operation agreed upon during the design); the project’s metered EUI (without adjustment) in 2013 was 33 kBTU. The adjustments to the building operation from M&V save the GSA and the USACE up to $40,000 per year in energy costs and have dramatically improved comfort. Meeting the energy performance target allowed the design build team to receive the 0.5% of the construction contract retained for proof of performance—nearly $400,000.

ABOUT THE AUTHORS

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