Redefining Net Zero

BY DIRK KESTNER, PE, AND KILEIGH SHEA

Dirk Kestner (**dkestner@walterpmoore.com**) is a principal and **Kileigh Shea** (**kshea@walterpmoore.com**) is an associate, both with Walter P Moore's Austin office.

HOUSTON HAS UPPED its sustainability game with a new environmental research center.

The Houston Advanced Research Center (HARC) is a not-for-profit research facility that provides analysis on energy, air and water issues in buildings. Its mission is to contribute to a "sustainable future in which people thrive and nature flourishes." HARC collaborates with universities, private organizations, governmental agencies and community groups to develop solutions to environmental issues and affect policy related to sustainability.

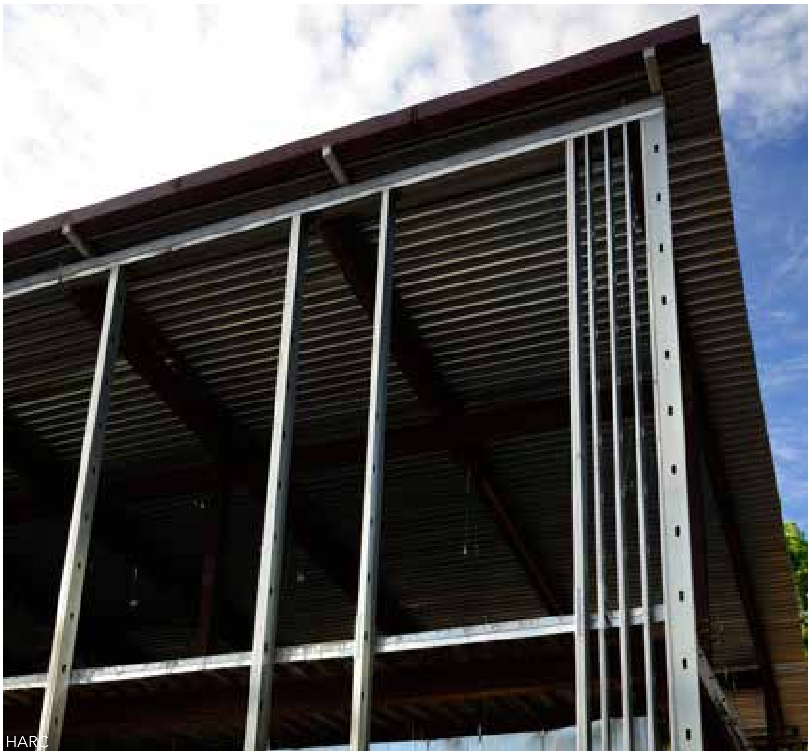
HARC's original campus, built in the 1980s, no longer supported this mission. Furthermore, many of its offices did not have access to daylight and it did not provide an inspiring work environment. HARC sought to build a new headquarters that directly reflected its mission and serve as a living example for regionally appropriate sustainable design in the Gulf Coast region. It was also essential that the design respect the financial realities of a not-for-profit research institution. Gensler was selected as the prime architect and from the earliest stages of design, facilitated fully integrated planning sessions with the full ownership and design team, including structural engineer Walter P Moore.

These sessions illuminated HARC's project goals and focus not only on operational energy efficiency, but also on minimizing environmental impacts due to the materials used within the building. The team chose to pursue certification under the then current LEED 2009 rating system and set Platinum certification as its goal. While LEED 2009 did not include a whole-building life-cycle assessment (WBLCA) in the main body of the rating system, based on the owner's interest in reducing embodied impacts the team elected to pursue a LEED Pilot Credit that allowed for application of the LEED v4 WBLCA language in LEED 2009. HARC's new headquarters opened last year.

A New Design Tool

A WBLCA is a quantitative tool for measuring the environmental impacts of a project through the entire lifespan of the project—from design, material sourcing, construction,

A Houston research facility successfully implements a whole-building life-cycle assessment to reduce embodied emissions and push toward a "zero-carbon" building.



Baldinger

HARC

HARC is a not-for-profit research facility that provides analysis on energy, air and water issues in buildings.

operations and maintenance to end of life. Though WBLCAs are relatively new to the buildings industry, consumer product manufacturers have used life-cycle assessments (LCAs) for some time to determine the environmental impacts of their products.

To perform an LCA, manufacturers study the processes from the time raw materials are extracted from the earth until the useful life of the product is complete and the material is recycled into a new product or is returned to the earth. Quantifying the energy input and emissions at each stage of the process, manufacturers can make quantitative analyses of a product's impact on the environment and determine where improvements can be made to minimize those impacts. For example, AISC has performed LCAs on various types of steel, including hot-rolled steel sections, plate steel and HSS that measure the impacts on the environment due to a specific volume of each material. The results of these LCAs are published in environmental product declarations (EPDs), which are short reports summarizing the environmental impacts in each material. Steel EPDs can be accessed at **www.aisc.org/epd**.

A WBLCA uses the same principles applied to consumer products, but at a whole-building level. WBLCA allows design teams to model all the materials in a building using specialized software—in this case, the Tally Environmental Impact Tool—and then compare multiple design scenarios based on their environmental impacts (there are currently several WBLCA software packages on the market, ranging in price and complexity). WBLCAs go beyond comparing steel buildings to concrete buildings; they allow designers to compare various types of steel, adjust concrete mix proportions and investigate various enclosure design options to make informed design decisions. Additionally, WBLCAs are now part of many sustainability rating systems, including LEED v4, which puts a much greater emphasis on quantitative comparisons of the impacts caused by building products.

As is typical for most projects, HARC's structural design team investigated different structural systems during the project's schematic phase. However, unlike typical projects, the team also used a WBLCA tool (Tally) to compare several structural systems and investigate which assemblies and subassemblies contributed the most to each environmental impact indicator, and used those results to drive the design.

Understanding the Environmental Impacts of Design

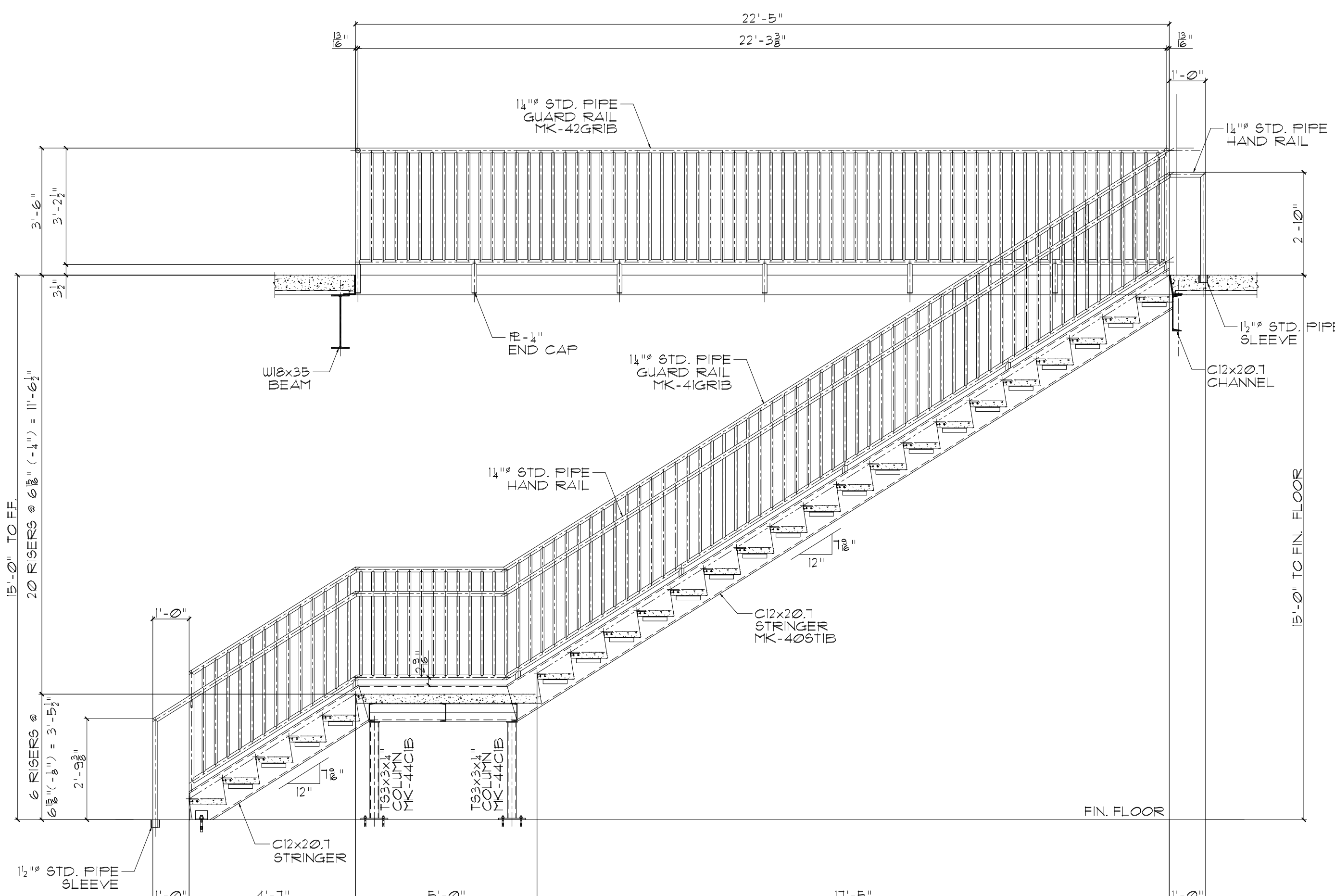
As part of the schematic design, and to establish a benchmark, the design team first considered what would constitute a "typical" structural system for this type of building located in this region. In suburban Houston, a building of this size—two stories and 20,000 sq. ft—is frequently constructed of site-cast concrete perimeter bearing walls and interior steel framing. Insulation is either placed on the inside of the concrete panel or within a "sandwich" panel, and the exterior is either left exposed or sometimes partially clad to achieve the desired exterior aesthetic. The plan dimensions of the building were set at 240 ft by 62 ft based on programming requirements and the desire to ensure that all spaces could effectively have access to natural light. For the bearing wall case, this resulted in a single row of columns down the middle of the building, with composite steel framing at the second level and steel bar joists at the roof. Belled drilled footings, bearing 15 ft below grade, were recommended in the geotechnical report, and the bearing wall scheme required three lines of drilled footings.

The preliminary WBLCA run of a single bay of the building indicated that a significant amount of the environmental impacts, particularly global warming potential (measured in tons of CO_2 and also known as a "carbon footprint"), were attributed to the concrete panels and foundations. Walter P Moore then developed an alternate steel-framed scheme with wide-flange girders spanning the 62-ft direction of the building and 24-ft composite steel beams spanning between the girders. This allowed the girders to be supported on two column lines with a 35-ft central span and two 13-ft, 6-in. cantilevers to the inside of the exterior walls. This framing system, while slightly increasing the steel tonnage, allowed for the perimeter wall to be non-load-bearing and framed from cold-formed steel studs that spanned continuously from the top of the perimeter grade beam to the underside of the roof. The continuity of the steel studs allowed for a more efficient stud design and eliminated joints in the building envelop at the second floor.

The perimeter wall supported exterior insulation and a rain screen enclosure that uses an exterior panel slightly offset from the insulation plane. This system allows warm air to vent vertically outside of the insulation plane. Together, the continuity of the envelope and the rain screen system were key components of the building's net-zero energy strategy.

The steel system also permitted the removal of one line of drilled footings. Drilled footings were only required below the interior column lines and the non-load-bearing perimeter wall was able to be supported on a perimeter grade beam—a strategy that resulted in a

Wide-flange girders span the 62-ft direction of the building, and 24-ft composite steel beams span between the girders.



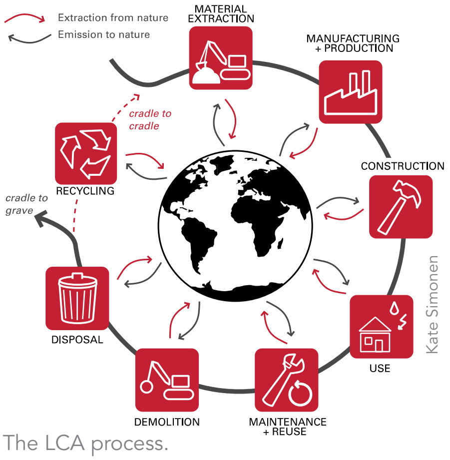
A detail of the main stairs and railings.

significant reduction in the project's total concrete volume. However, the double-cantilever girder scheme resulted in a condition that could be susceptible to floor vibrations. This required Walter P Moore to perform a time-history vibration analysis on the double-cantilever to optimize the steel framing while not compromising occupant comfort.

Modifying the structural and enclosure system, and also refining the concrete mixes to use less cement, resulted in impact reductions in most categories and a 20% reduction in the carbon footprint without increasing the construction cost or schedule. Perhaps more significantly, these carbon savings occurred immediately unlike operational energy savings that build incrementally over the life of a building.

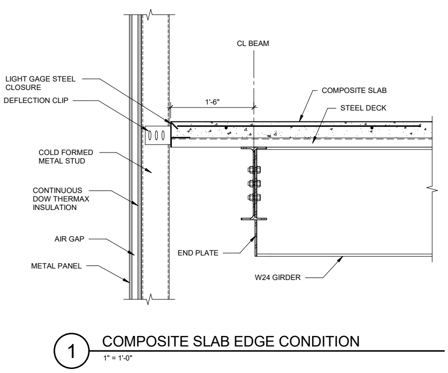
Approaching True Net-Zero

The use of a WBLCA to inform the structural and enclosure design of HARC's headquarters provided the team additional insight regarding material sourcing and structural system choices and allowed the full design team to better understand the



Kate Simonen

The LCA process.



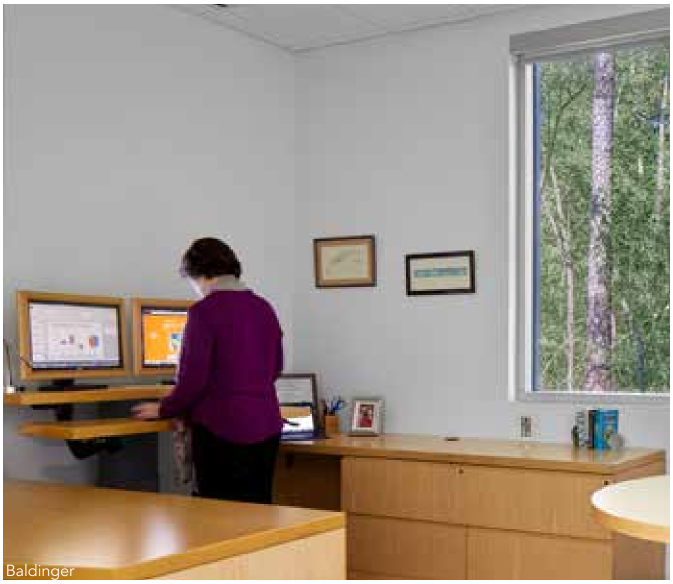
A slab edge detail.

Baldinger

The steel-framed stairs, installed.

Baldinger

A whole-building life-cycle assessment was employed to optimize the structural framing system for HARC's new headquarters.



A whole-building life-cycle assessment was employed to optimize the structural framing system for HARC's new headquarters.

project's environmental impacts. It also provided lessons that can be employed by other teams wanting to use WBLCAs to minimize the impacts of their designs.

For this WBLCA, the structural system was the focus of the optimization, and Walter P Moore performed the WBCLA in parallel with their other analyses. This both allowed the WBCLA analysis and findings to immediately inform structural design choices and more importantly, the professional performing the WBLCA understood what modifications to the structural system were most realistic.

WBLCAs show that reducing embodied impacts is more complex than comparing two building materials and following through with standard design choices. System selection should be considered in combination with analyses of the largest contributors to each environmental impact for each system. Following selection of a system, other elements such as framing schemes, foundation systems and material-specific sourcing decisions should be made.

Finally, the WBLCA allowed the team to understand the full impact of the building and push as close to a zero-carbon building as possible. In fact, HARC recently received a grant to place additional photovoltaic panels on the roof, an added capacity that is projected to more than exceed the building's annual electrical demand. The surplus renewable energy will be fed back into the grid and allow the project to begin offsetting emissions associated with the building materials, bringing the zero-carbon goal closer than ever. ■

The HARC project is the focus of the session "Redefining 'Net Zero': Design + Operate + Educate" at the 2018 Greenbuild conference in Chicago, November 14-16. See ***www.greenbuildexpo.com*** *for information.*

Owner
Houston Advanced Research Center

General Contractor
Brookstone

Architect
Gensler

Structural Engineer
Walter P Moore

Steel Fabricator and Erector
Sanco Steel (dba) Southern Steel Fabricators and Erectors, La Blanca, Texas (AISC CERTIFIED FABRICATOR)