Banking on Sustainability

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Cellular beams help Boise's Banner Bank Building achieve green goals and provide open, flexible office space, at tremendous materials and energy savings.

Photos: HDR Architecture, Inc.

EVERY CONSTRUCTION PROJECT HAS A WISH LIST FROM THE DEVELOPER, SOME MORE STRINGENT THAN OTHERS. In the case of the Banner Bank Building in Boise, the developer presented a unique list of three rules to his design team.

First, he wanted the building to achieve LEED Gold standards. Second, ultimate space-program flexibility was a mandate. Third, when it came to design rules… there were no design rules. The architect's Boise office assembled a team of local design professionals with a track record of collaborating to develop, test, and implement creative design solutions

The result is a state-of-the-art 180,000-sq.-ft, 11-story office building where structural framing decisions contributed in unique and unforeseen ways to ultimately help the building exceed the original LEED project goal and become a LEED Platinum project—the highest level of certification awarded by the U.S. Green Building Council (USGBC) .

Not-so-standard Procedure

Traditionally, when a building design team, principally the architect, begins to establish basic design elements such as space program requirements, building size and massing, building orientation, and fundamental building systems—including exterior cladding systems, shading elements, and wall fenestrations—the structural engineer is not consulted. Once a preliminary design is established the structural engineer is then typically asked to discuss the appropriateness and the pros and cons of various structural systems. In this "structure-after-design" scenario the structural engineer is asked to comment on the following:

- Based on a preliminary column grid, estimated floor-to-floor height, and myriad other metrics, which structural system makes the most sense?
- Should braced frames, shear walls, or moment-resisting frames be selected to resist lateral loads?
- What are the owner's project schedule expectations?
- Which construction contract delivery method has been discussed with the owner?
- What are the relative cost differences between various structural systems?

The Banner Bank Building design team asked these questions of its structural engineer, but with two key differences: the structural engineer participated in the design from the very beginning of the process; and Gary Christensen, owner and developer, posed no limitations in terms of building systems, materials, or construction methodologies. "There are no rules of thumb here," stated Christensen in an early team meeting. "In fact, cut off your thumbs!"

The design process kicked off with a two-day design charette, which involved discussing different approaches to structural design, mechanical and electrical systems, façade design, and the integration across all disciplines of sustainable design strategies and elements.

During the meeting, the structural engineer asked some unusual questions to test the team's and owner's commitment to cost-effective, efficient design. While structural design itself contributes very few possible points to a project's LEED "point total," it can result in increased points for other disciplines. Some of the questions were:

- How does the selection of a particular structural system affect a construction schedule or accelerate construction?
- How little structure is required to complete the structure?
- Which structural system augments the mechanical design—floor/wall mass for thermal benefit, structure depth as it relates to mechanical duct routing, acoustic damping, vibration mitigation, and so on?
- Which structural system will require the least amount of raw building materials?
- Which structural system will provide required strength with the least weight? (Note: Less structure mass results in lower foundation demand, lower seismic mass, smaller columns, lighter crane picks, lower cost, faster time to market, and thus less interest paid in the interim.)
- Can the choice of a particular structural system make repeated tenant improvements easier, faster, and less costly?

From these discussions the developer coined the phase "Use fewer pieces of larger sizes that bolt together faster." This has become Christensen's mantra for all of his projects. With the Banner Bank Building, he also directed the design team to allow the structural design to establish the underlying basis for the overall design, realizing that efficiency in structure can create cost-effectiveness without compromising the building's architectural look or spatial program requirements.

Building the Bank

The project site is a typical Boise quarter-block: 122 ft by 150 ft. The actual building footprint is 121 ft by 139.5 ft. The architect's concept was an open office plan with a typical central core containing two stairs, three elevators, an elevator lobby, and restrooms. The need for a highly flexible office floor plate did not fit well with the traditional 30-ft by 30-ft structural grid. The design called for a column-free floor plan with beams spanning just over 45 ft on the north and south sides of the core and 28-ft span members in the middle of the building defining the core area.

The 11-story Banner Bank Building features 45-ft clear spans for office layout flexibility.

The cellular-beam appearance is mimicked in structural steel details for the exterior entrance canopy.

A floor plan free of interior columns answered the challenge of creating an ultimately flexible floor plan for future tenant improvement. A steel gravity-framed structure was selected after a thorough investigation of numerous structural systems. Two interior central concrete shear elements at the outboard side of the stair enclosure resist lateral loads. However, spanning 45 ft with conventional wide flange beam framing would result in framing 2 psf to 3 psf heavier than necessary, including heavier beams, girders, and columns.

The structural engineer recommended cellular beams for the project, provided by CMC Steel Products. Also called castellated beams, they feature round or hexagonal holes created in the web through a unique fabrication process. Cutting through the web following a particular pattern about the beam center line, and offsetting each half of the beam results in a beam 50% deeper than the root beam. For example, a W18×35 root beam results in a CB 27×35 (cellular beam), a beam with an increased span capacity and lighter than a required conventional shape, all things being equal. The holes demonstrate the fact that the strength of a beam is not necessarily dependent on how much material makes up the member, but in fact, how the material is proportioned throughout. To further economize a floor framing design, asymmetric CB beams used in composite construction take advantage of smaller top flanges required in the transformed section and a larger bottom flange resisting tension stresses. First patented in 1937, cellular beams offer significant advantages:

- They are, pound for pound, stiffer than traditional wide flange beams.
- They result in a lighter structure.
- When CB beams are used in longer spans, less columns are required, resulting in fewer footings and less material handled overall. This design scenario can result in a stiffer floor.

A Good Investment

Beyond providing structural benefits, using cellular beams can have other positive effects on a building as well:

Construction schedule. By removing columns from the floor plate, the field erection time is significantly reduced due to fewer, larger parts that bolt together faster ,and less foundation elements to support the loads of the building above. The results are reduced labor cost and a reduction in overall schedule, which when offset by the premium paid per pound for the cellular beams (due to increased fabrication effort), can make cellular beams very cost-effective. This was the case with the Banner Bank project.

Mechanical and electrical benefits. A "hidden" benefit that was not realized until well into the design of Banner Bank: Web penetrations create a continuous plenum space from the ceiling to the underside of the structural floor above, resulting in a reduced number of smoke detectors required in the plenum. In fact, at Banner Bank, there are no smoke detectors in the ceiling plenum at all. The beam web holes allow air to freely flow throughout the plenum, thus allowing smoke detection to be accomplished right at the return air intake of the air handler on each floor. The result: only one smoke detector required per floor. This single benefit of cellular beam framing saved the owner close to $100,000 in up-front costs.

By aligning CB web penetrations from beam to adjacent beam, the openings can be used for routing ducts, fire sprinkler piping, conduits, and cabling. Pre-planning amounts to orienting columns in the same direction so that one beam does not frame into a girder web and another into a column flange. If columns are oriented with their strong axis parallel to the girder span, then the column web and girder web are only offset by the thickness of the girder's shear plate connection. This will result in good alignment of all beam web penetrations.

In addition, the CB beams are deeper than they would have been as conventional shapes, resulting in a stiffer floor structure and reducing footfall vibration perceptibility.

Tenant space planning flexibility. Banner Bank has 16,880 (gross) sq. ft of column-free floor plates. Composite floor beams are spaced up to 12 ft, 3 in. on center. The floor framing supports a 14-in.-high raised access floor. Mechanical supply air distribution is accomplished in the underfloor space, as are power and data lines. The developer selected a modular wall system for tenant space build-out. Walls can be easily deconstructed and moved to suit a new tenant. This virtually eliminated the need for gypsum partitions within the rentable floor area.

Structural Synergy

While reducing materials also reduces negative impacts on the environment, there are other sustainable benefits to the owner and to the building occupants as well; the sustainable advantage of cellular beams doesn't stop with the structure itself. As noted above, the cellular web allows air ducts, fire sprinkler piping, and telecommunications to penetrate through the beam rather than beneath it, thus saving vertical space. This in turn provides several sustainable benefits:

Increased daylight harvesting. By no longer having to run ductwork beneath a beam, the acoustic ceiling can be raised. Raising the acoustic ceiling allows exterior windows to be taller, which in turn provides more daylight further into the floor plate.

Reduced building materials. Using cellular beams can significantly reduce the total amount of building materials required in a multi-story building envelope, or allow for more floor area within the same envelope, than when using conventional wide flange beam framing. If the ceiling-to-floor space saved is 8 in. to 9 in. per floor, a building with a 14 ft floor-to-floor height will result in one additional floor of rentable space for every 18 to 21 floors. In the case of Banner Bank Building, the total floor-to-floor vertical height reduction, even with the use of a 14-in. raised floor system, was 8 in. per floor, compared to conventional framing and overhead HVAC distribution; this saved over seven vertical feet of building envelope materials and cost.

Energy conservation. Cellular beams weigh, on average, 35% to 50% less than wide-flange beams capable of carrying the same loads with the same span and tributary area. Since the cellular beams reduced the building envelope by over seven vertical feet, there was a reduction of 59.4 cubic yards of precast concrete exterior skin. According to a Portland Cement Association study published in *Building Green*, 1.7 million BTUs of energy are consumed to produce one ton of concrete by the time it is delivered to a job site.

Less steel. Banner Bank Building's structural frame required 12% less steel than using traditional wide-flange beams. This number might not sound too significant until you realize that 117 tons of steel was conserved, and 1.2 billion BTUs of energy was conserved by reducing the amount of steel required for fabrication

Cellular beams weigh 35% to 50% less than wide-flange beams capable of carrying the same loads with the same span.

Continuous Sustainability

The structural system of Banner Bank Building is a model of efficiency. Its light, resource-efficient design supports the functionality of the building beyond what a wide flange system would be capable of, while reducing the amount of material needed to produce the structure and envelope. It conserved energy during construction and it will continue to enhance the building's energy performance for the life of the building. The many win-win sustainable solutions that resulted from the early inclusion of the structural engineer, and their decision to investigate cellular beams, are both dramatic and promising. MSC

Cellular beam web penetrations were aligned from beam to adjacent beam, allowing services to be easily run in the ceiling cavity.

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