Designing Sustainable Parking Structures

— Craig A. Shutt

Precast concrete components comprise the bulk of a parking facility's structure, making it easier to incorporate sustainable design concepts

Owners of all types of building structures are looking for ways to create sustainable designs, even if they aren't planning to apply for LEED certification. Precast concrete components can help meet those needs, especially on projects where the material serves as the structural framing, such as parking structures. But owners don't always realize the benefits that can be achieved by using precast concrete.

That lack of focus on recognizing the sustainable-design techniques for parking structures could result from their connection to automobiles, suggests Kathy Buck, project manager at Neumann/Smith Architecture in Southfield, Michigan. "In the world of LEED, sustainable design looks down on the automobile as detrimental to the environment," she notes. "But a very thoughtful way of handling automobiles in the built environment can be achieved with sustainable design, and it's a necessary concept. Certainly, the automobile isn't going anywhere—especially in the city of Detroit."

Detroit is where Buck and her design team created a 615,440-sq-ft, nine-story parking structure for Blue Cross/Blue Shield of Michigan that has been LEED certified. The total-precast concrete structure, with spaces for 1,808 cars, features decorative touches that include fin walls, cantilevered roof girders supported on a clerestory, and a green roof with a walking track. The planted area of the roof encompasses 52,307 sq ft, which is believed to be the second-largest green roof area in Michigan (behind the Ford Motor Co. Rouge Plant).

Green roofs are becoming more

Photo: Scott R. Booney

Fact Sheet

Project: *Blue Cross/Blue Shield Parking Structure*

Type: *Parking structure and campus improvements*

Location: *Detroit*

Designer: *Neumann/Smith Architecture, Southfield, Mich.*

Engineer: *Desai/Nasr Consulting Engineers, West Bloomfield, Mich.*

Contractor: *Turner Construction Co., Detroit*

Owner: *Blue Cross/Blue Shield of Michigan, Detroit*

Precaster: *National Precast Inc., Roseville, Mich.*

Precast Specialty Engineer: *I.E.S., Tecumseh, Ontario, Canada*

Parking Consultant: *Rich & Associates, Southfield, Mich.*

Project Size: *615,400 sq ft on nine stories*

Precast Components: *2,000 pieces, including double tees, roof beams, spandrels, inverted tee-beams, a K-wall structural system, square columns, rectangular columns, lite walls, stair risers and walls, and brick-clad wall panels.*

Project Cost: *$13.285 million*

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prevalent for precast concrete parking structures, as designers realize the benefits of adding greenery to a space that previously served only as protective cover. Precast concrete double tees can support these added loads easily, either by strengthening the tees or reducing the spacing between supports. For more on these designs, see the sidebar.

Even in non-LEED-certified projects, sustainable concepts make a great deal of sense, says Ron Cullen, principal at Cullen Architecture & Design in Helena, Montana. Prior to opening his own office this year, he helped design a 61,200-sq-ft, three-story parking structure in Helena's downtown historic district aimed at reducing long-term operating and maintenance expenditures.

"The in-ground cost was somewhat higher than other designs, but the precast-concrete design will save a considerable amount through the years in maintenance and repair costs," he explains. "The return on fees that the parking can generate won't sustain a high maintenance budget that would have been needed with other materials. Everything we did with this project was aimed at long-term maintenance needs." That includes a design that eliminated the need for a ventilation system and a computerized lighting system that controls lighting year round.

The Blue Cross/Blue Shield facility in Detroit is one of the first LEED-certified parking structures.

‘These simple elements combined to create an elegant—and inexpensive—cornice feature.’

The cantilevered double tees along the roof of the parking structure were finished with a metal fascia that helps create a distinctive roofline. Photo: Neumann/Smith Architecture.

LEED-Certified Parking

Officials at Blue Cross/Blue Shield of Michigan had a number of goals for their new facility, led by the need to consolidate a variety of off-campus parking locations to provide better access for employees. An existing 125-car surface site was used, adding considerable benefits by enhancing site development by maximizing open space. The new structure also houses the company's maintenance office, adding additional functionality.

The design features a total-precast concrete structure that includes double tees, roof beams, spandrels, inverted tee-beams, square columns, rectangular columns, lite walls, stair risers and walls and brick-clad wall panels. National Precast of Roseville, Michigan, cast nearly 2,000 precast concrete components for the project.

In addition to helping achieve sustainable-design goals, the precast concrete design also was used due to economics and timing, Buck says. The precast option proved most economical especially when looking at the long-term benefits, she notes. “Overall costs, including future maintenance, were all factored into the equation when reviewing different designs. The total-precast design ultimately was chosen because of its inherent concrete qualities and method of connectivity, which ensures positive water drainage. Both are key factors that will aid longevity and cost efficiency of operating and maintaining a well-functioning parking deck.”

Erecting the project through harsh winter weather also meant precast concrete offered the best choice. “Pouring a purely cast-in-place concrete structure in the field was not feasible due to likely delays caused by possible inclement weather,” she says. Even so, timing was critical, as the owner wanted decks topped with concrete in the field instead of using pretopped double tees. The first half of the precast levels was erected through the winter, and then they were topped once the weather warmed up as crews continued erection of the top half of the structure.

Aesthetics were a key requirement as well, and the designers incorporated a number of distinctive design features adopted from the adjacent Blue Cross/Blue Shield office tower that was constructed in 1970 and clad with architectural precast concrete panels.

To visually relate the new structure to the adjacent Bricktown District of Detroit, the parking structure also features inset brick soaps or half-bricks on its wall panels, interspersed with flat spandrel panels to create contrast. “The benefits of inserting brick soaps into precast concrete is a very effective way to add a variety of materials and scale to soften stark parking facilities,” she says. The half-bricks, with half of the center cores in each brick included, provide highly irregular, dovetail backing that provides secure anchorage of the brick to the precast concrete.

“The combination of using load-bearing precast panels with precast columns and spandrels allowed the project to respond to both the original precast concrete office tower as well as the brick-clad buildings in the neighborhood,” she adds. “The freedom of precast concrete permitted a lively façade with a wide variety of whimsical openings of variable sizes within the punched grid of the opening.”

Embedded brick also was used to create fin walls that extend beyond the structural grid for the height of the building. The fins appear as thin blades of perforated masonry matching earlier BC/BS projects on campus, Buck explains. “These special corners help break down the boxy mass normally found in parking decks.”

Cantilevered Roof Edges

Another attractive element was added at the roof line, where double tees create a dramatic cantilevered projection about 30 in. beyond the structure. The brick-clad, load-bearing walls terminate at the ninth floor to create a tall clerestory that defines and emphasizes the cantilevered roof from below.

“Cantilevering the ends of the double-tee stems and flanges allowed the design to turn a utilitarian design into one featuring an honest and direct use of the technology,” she says. Decorative aluminum endplates, installed by the precaster prior to erection, conceal the steel reinforcing at the tee ends. These were attached to the tees with three $\frac{1}{2}$-in.-diameter threaded stainless-steel dowels that were embedded into each tee. A crisp, vertical metal fascia disguises the sloped edges of the double tees. “These simple elements combined to create an elegant—and inexpensive—cornice feature for the deck.”

The owners also were concerned that the aesthetic details of the exterior be continued inside, she notes. “So adamant was the owner of the critical nature of the concrete finishes on the interior that we decided to change the mixture to a self-consolidating concrete. The end result was a more uniform concrete finish with fewer bug holes and voids, thus enhancing the durability factor and overall appearance.”

Many of the interior surfaces also were painted white, including the underside of the roof tees, creating a bright appearance.

Roof Goes Green

The most dramatic aspect of the project, however, and the one that contributes significant sustainable features (and employee benefits) is the vegetated rooftop, which contains a 1/10th-mi. walking track, made of recycled materials, as well as locker and shower facilities at the ground level of the deck. "Blue Cross/Blue Shield wanted to make a statement about their commitment to fostering healthy lifestyles and their role as a health advocate," she explains. "This design reflects that dedication."

The company sponsors weight-loss programs that utilize the roof in good weather, and the walking track encourages employees to increase their activity. The rooftop vegetation also provides a dramatic perspective from the office tower, which overlooks the deck rooftop. Eight varieties of sedum plants, which are drought-tolerant and require little maintenance, are planted on the roof.

The roof consists of a composite vegetated roof system by XeroFlor America LLC, in which the sedum plants were installed like conventional sod over a drainage fabric that allows water to be collected above a membrane rubber roof adhered to the precast concrete roof double tees. Rainwater is collected and filtered by the vegetation and drainage-filter layers and stored in a 10-ft-diameter, 164-ft-long underground precast concrete cistern. Rainwater from other nearby BC/BS structures also are collected into the cistern and used to irrigate the campus landscaping.

The only adaptations needed to install the roof garden was to ensure the double tees could support the 100-psf live load required for the assembly space on the roof. This support was accomplished by spacing the tees closer than on other levels, she notes. The roof-level double tees were pretopped.

The ability to use one supplier for so many portions of the project was a big help to speeding construction and ensuring no responsibilities fell through the cracks, she notes. "The design of this parking structure showcases fresh and uninhibited concepts for using standard industry material in an application that is not standard and to emphasize their intrinsic beauty."

Enhanced Parking Design

The Jackson Street Parking Structure in Helena also used nonstandard design techniques, says Cullen. The precast concrete design helped the project team achieve a variety of sustainable-design goals, such as incorporating recycled/recyclable materials and using locally gathered materials for locally manufactured products. About 85% of the structure is concrete, with the rest consisting of recyclable steel for doors and grillwork, he notes. "All of the materials were locally produced, except for the elevator."

The three-story, 166-car structure features precast double tees and precast concrete beams, columns, and spandrels, with cast-in-place structural walls. The panels were cast in two groups, with nondecorative ones cast in four different configurations, while decorative panels were cast in 10 different configurations. High-performance concrete that attained 7,000-psi before delivery, using steam curing sped the casting process and created a durable composition.

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The roof of the Blue Cross/Blue Shield parking structure features a 1/10th-mi walking track and planted vegetation. Photos: Neumann/Smith Architecture

Rooftop Gardens Grow

Vegetated roofs have become well established in Europe and are beginning to take hold in America for both commercial and residential applications, according to the Portland Cement Association. The systems include waterproofing, drainage, a filter layer, a lightweight growing medium, and plants.

An "extensive" green roof has a relatively shallow soil profile (1 to 5 in.) and is planted with ground-cover plants that are adapted to the rooftop microclimate, the group says. "Intensive" green roofs have deeper soil (6 in. or more) and are typically planted with shrubs and trees as well as ground cover.

Modeling by Environment Canada has estimated that with grass in less than 4 in. of soil, a one-story building can reduce summer cooling needs by 25%. Field studies in Ottawa, Ontario, Canada, found that a 6-in.-thick green roof reduced heat gains by 95% and heat losses by 26%, PCA reports.

Other precast concrete parking structures have incorporated green roof gardens and other sustainable concepts. The 915 Walnut Street parking structure, a seven-story, 106,000-sq-ft facility in downtown Kansas City, Missouri, features a 16,000-sq-ft roof garden, the largest such garden in the city.

The project won the award as Best Sustainable Design in PCI's 2007 Design Awards competition. For more details on the project, see the Fall 2007 issue of *Ascent*.

Potential LEED Points For Precast Concrete Parking Structures

LEED Category: Sustainable Sites

Credit	Pt.	Title and Precast Contribution
5.1:	1	**Site Development**—Protect or restore habitat. *A precast building design can obtain this credit by limiting the site disturbance to prescribed distances from the building. Less dust and waste is created at construction site because only needed precast concrete elements are delivered; there is no debris from formwork and associated fasteners. Fewer trucks and less time are required for construction because concrete is made offsite; particularly beneficial in urban areas where minimal traffic disruption is critical. Precast concrete units are normally large components, so greater portions of the building are completed with each activity, creating less disruption overall. Less noise at construction sites because concrete is made off-site.*
5.2:	1	**Site Development**—Development footprint. *Mixed-use precast buildings and parking structures are particularly good for this credit, as they are capable of exceeding the local open space zoning requirement by 25%.*
6.1:	1	**Stormwater Management**—Limit disruption of hydrology. *Reducing impervious cover by specifying mixed-use precast buildings and free-standing parking structures. The footprint will be smaller than asphalt parking lots. Vegetated roofs can be used on free-standing parking structures.*
6.2:	1	**Stormwater Management**—Reduce or eliminate water pollution *Storm water can easily be recaptured in a precast parking structure for non-potable uses (landscape irrigation; toilet and urinal flushing; and custodial).*
7.1:	1	**Heat Island Effect**—Non-roof. *The requirement is met by placing a minimum of 50% of parking spaces under cover (defined as underground, under deck, under roof, or under a building). This is easily achieved through mixed-use precast structures with parking under or free-standing parking structures.*
7.2:	1	**Heat Island Effect**—Roof. *Light colored concrete reduces heat island effect in urban areas. This means using materials with reflectance greater than 0.3. Concrete typically has reflectance between 0.35 and 0.8. Asphalt typically has reflectance less than 0.3 and does not meet the criteria. Thermal images taken with digital infrared thermometer showed an average 40-degree temperature difference between new concrete and new asphalt.*
8.0:	1	**Light Pollution Reduction**—Minimize site lighting where possible. *Structured precast parking will require fewer fixtures to produce the same level of lighting compared to asphalt parking lots. Other benefits are reduced light trespass from the building, improved night sky access, reduced development impact on nocturnal environments, and reduced energy demand.*

LEED Category: Materials & Resources

Credit	Pt.	Title and Precast Contribution
1.1:	1	**Building Reuse**—Maintain 75% of existing shell. *Precast concrete's durability helps it to maintain its appearance, so shells will remain in place longer. Precast buildings can be recycled after building life cycle. Components can either be dismantled and reused or the components can be crushed and used for road base or construction fill after the structure's life cycle.*
1.2:	1	**Building Reuse**—Maintain 95% of existing shell. *Same as above.*
2.1:	1	**Construction Waste Management**—Divert 50% by weight or volume. *Precast is made off-site in a controlled production environment, construction site waste is automatically eliminated. Construction waste is also reduced at the plant by producing products in reusable steel forms for standard sections. Many precast producers recycle water and materials at their plants.*
2.2:	1	**Construction Waste Management**—Divert 75% by weight or volume. *Same as above.*
4.1:	1	**Recycled Content**—The post-consumer recycled content plus one-half of the preconsumer content constitutes at least 10% (based on cost) of the total value of the materials in the project. *A significant amount of industrial by-products can be used in precast concrete products to replace and supplement some of the cement in the mix. These products are called supplementary cementitious materials or SCMs for short.* *ASTM C 618 provides standards for fly ash. Fly ash is used in quantities of 5 to 65% to replace the Portland cement. ASTM C 989 is for blast furnace slag. Slag is used to replace 20 to 70% of cement in the mix. ASTM C 1240 is for silica fume. Silica fume is used in quantities of 5 to 12%. Using silica fume will also increase concrete strength and provide exceptional durability.*
4.2:	1	**Recycled Content**—An additional credit is available if the project uses 20% post-consumer recycled content. *Same as above.*
5.1:	1	**Local/Regional Materials**—Use a minimum of 10% (based on cost) of the total materials value. *Most precast components use local material (sand, water, aggregates) and are made at a plant close to the site, saving transportation costs.* *Precast concrete components are usually transported and erected within 200 miles of the plant and easily meet the 500-mile requirement. Most precast products are also manufactured with materials extracted, harvested, or recovered within 500 miles such as aggregates, cement, sand, reinforcing steel and additives.*
5.2:	1	**Local/Regional Materials**—Use a minimum of 20% (based on cost) of the total materials value. *Same as above.*

LEED Category: Innovation & Design Process

Credit(s)	Pts.	Title and Precast Contribution
1.1 — 1.4:	1-4	**Apply for other credits demonstrating exceptional performance** (must be submitted and approved). *Precasters can help create innovative systems that achieve key sustainability goals, (e.g., use of thin brick reduces material and transportation costs).*
2.1:	1	**LEED Accredited Professional.** *Some precasters have LEED Accredited Professionals on staff.*

Two colors, three textures and inset brick produced a look for the Jackson Street parking structure that helped it fit into its neighborhood. Photo: Cullen Architecture & Design.

Fact Sheet

Project: *Jackson Street Parking Structure*

Type: *Parking structure*

Location: *Helena, Mont.*

Designer: *Karhu-Cullen Architects, Helena, Mont.*

Engineer: *Morrison-Maierle Inc., Helena, Mont.*

Contractor: *Diamond Construction Inc., Helena, Mont.*

Owner: *City of Helena, Mont.*

Precaster (panels, columns, beams, spandrels, trim): *Missoula Concrete Construction, Missoula, Mont.*

Precaster (double tees): *Montana Prestressed Concrete, Billings, Mont.*

Project Size: *60,000 sq ft on three levels*

Project Cost: *$3.16 million*

Photo: Missoula Concrete Construction.

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The 88 double tees were pretopped, so no topping will need to be maintained, he notes, cutting long-term costs. The deck units were 67 ft long and 10 ft wide. "The precast deck units gave the general contractor flexibility in scheduling," Cullen explains. "The units were delivered to the site so they facilitated construction sequencing with the other precast elements."

Aesthetics on this project also were a key consideration. The surrounding buildings were constructed of brick, granite and sandstone from local quarries in the late 1800s, Cullen explains, and the new structure had to blend with them. "We accomplished this by designing precast concrete panels with two colors of concrete, three design textures and thin brick," he says.

In addition to the sustainable attributes provided by the use of locally made precast concrete components, several other design elements contributed to the low long-term operating and maintenance costs, he notes. The hill behind the parking structure was cut away and supported by a retaining wall built with concrete masonry units. The 300-ft-long wall, with an average height of 28 ft, is held in place by a series of fabric layers and local soils.

"Setting this wall 8 ft away from the structure into the hillside created natural ventilation that pulls fresh air through the facility," Cullen explains. "As a result, no fans or exhaust system was needed, so there will be less maintenance cost through the building's lifetime." Cutting into the hill also cost less than installing an exhaust system would have cost to achieve the same result.

In addition, a computerized lighting system controls the fluorescent-lighting fixtures throughout the structure. During the day, the system monitors sunlight and exposure and turns off lights when they aren't needed. At night, motion sensors detect cars passing through levels and turn lights on ahead of the flow and turn them off behind it. In addition, the system energizes the lighting at a low level during winter months, as coming on from being off for some time in the cold Montana temperatures would damage the tubes, he explains.

"This was by far the most sustainable parking structure I've ever done, and it worked beautifully," he says. "I have used a number of these sustainable-design techniques on office buildings and other facilities, but this was the first time that a parking structure emphasized sustainability."

It most likely won't be the last time, as owners are becoming more aware of the potential, long-term savings, and architects are encouraging the approach. "I'd love to do more projects like this," says Buck. She already has looked at other projects of several building types that may be able to incorporate the roof garden. "The most remarkable thing about this project is to stand on the roof and see the downtown city skyscrapers around you and the river in the distance, but you're surrounded by a field of grass. And you can hear the crickets chirping." ■

For more information on this or other projects visit *www.pci.org/ascent.*

The roof of the Blue Cross/Blue Shield parking structure features a 1/10th-mi walking track and planted vegetation. Photos: Neumann/Smith Architecture

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Project Cost: *$13.285 million*

Photo: Neumann/Smith Architecture

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Photos: Justin Maconochie

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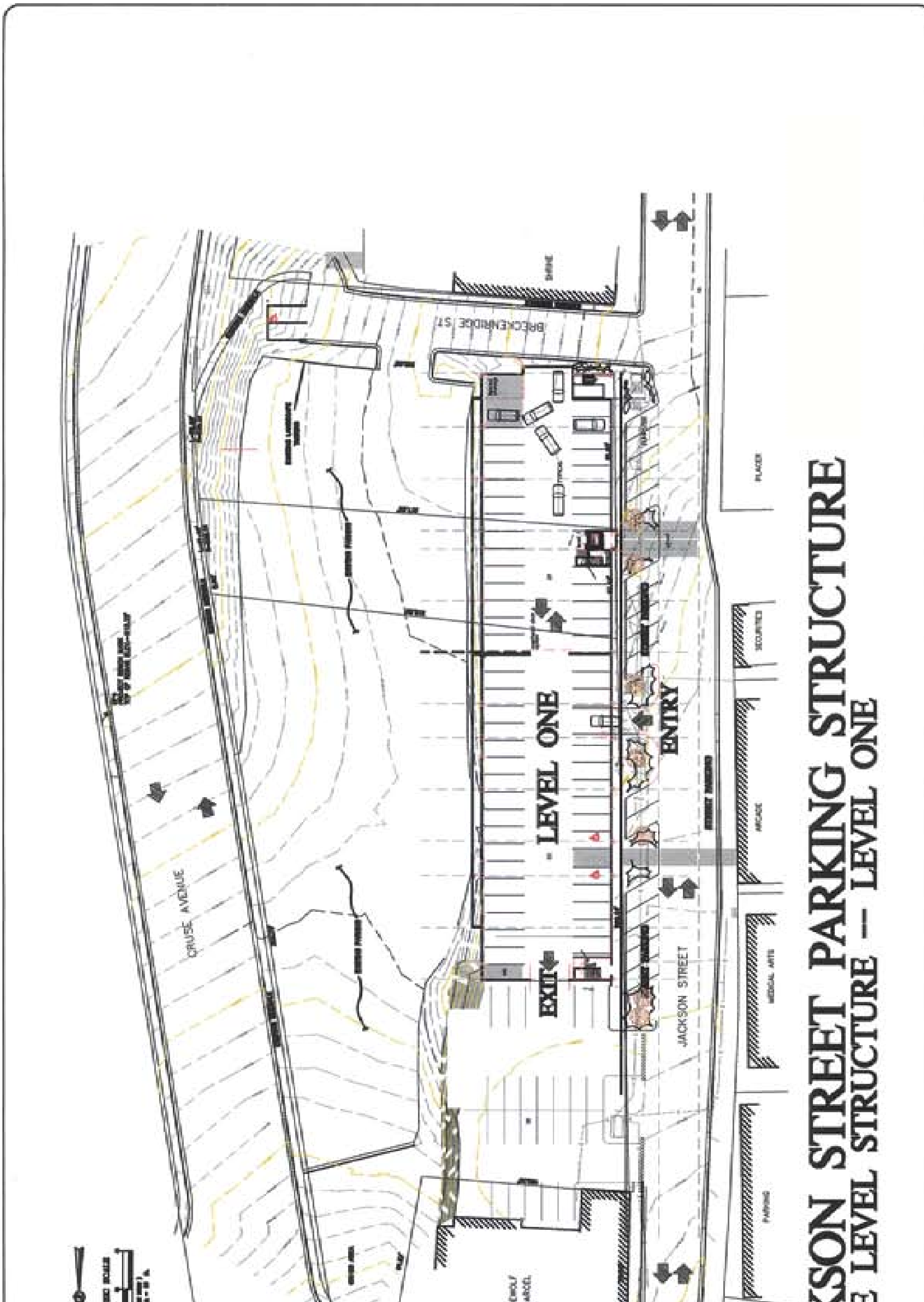
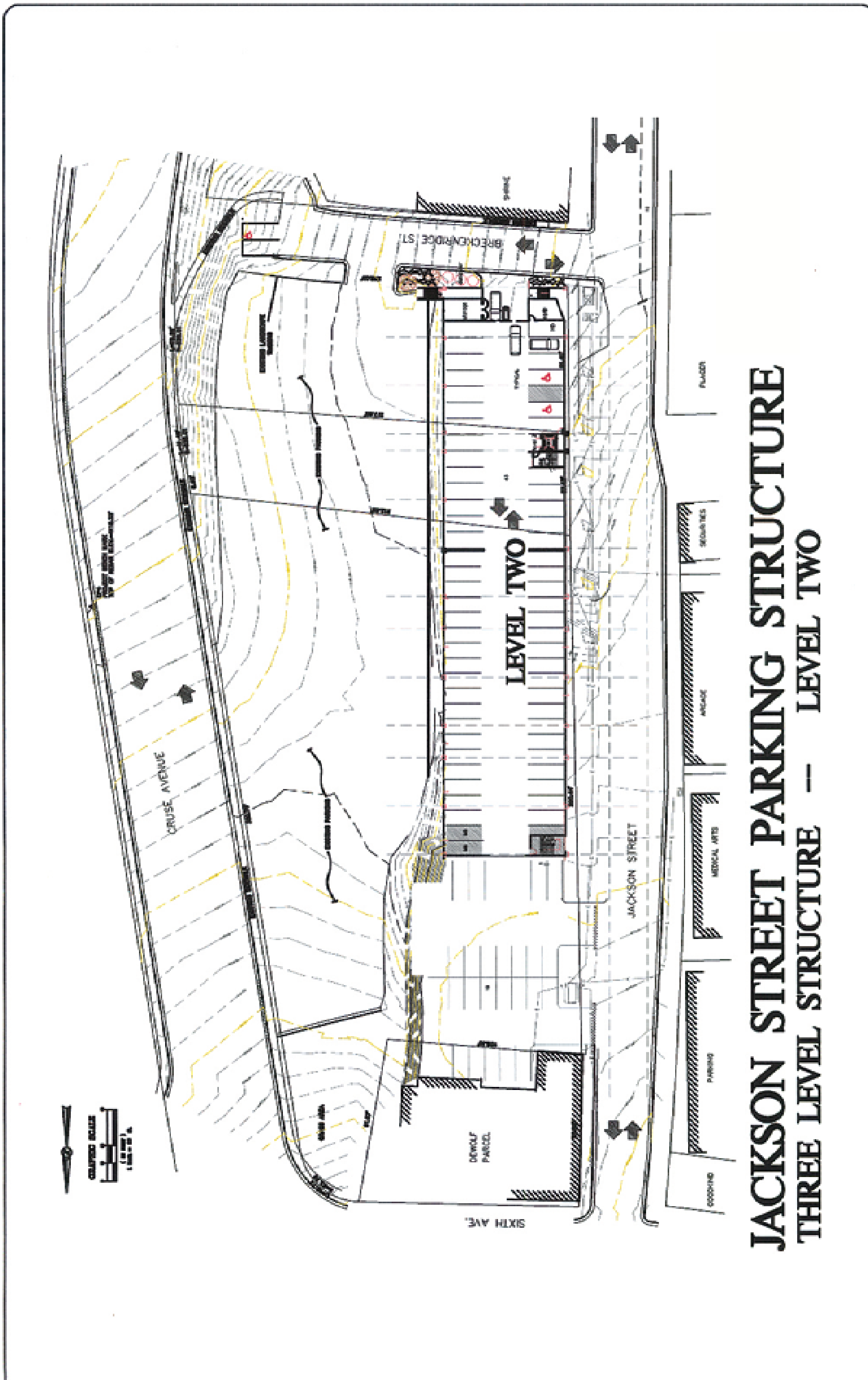


Photo: Cullen Architecture & Design.



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