BUILDING WITH
CONCRETE

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REVISED STRUCTURAL CONCRETE 'COOKBOOK' WILL FOLLOW A SIMPLER RECIPE

The ACI 318 building code is getting its biggest makeover since 1971 to make it easier for engineers to use.

BY CARY KOPCZYNSKI
CARY KOPCZYNSKI & CO.

When structural engineers reach for concrete building code documents late this year, they may be surprised at what they find.

ACI 318, the longstanding guide for structural concrete design and construction, has been completely reorganized in a way that, its writers hope, will be easier to use by the industry.

Every three years, the American Concrete Institute's building code committee updates ACI 318 — the code to which concrete buildings and other structures are designed and built. These changes are then adopted by the International Building Code, which is the document followed by all 50 states and several other countries as the standard building code. ACI 318's most recent changes — arguably the most dramatic since 1971 — is now available for review by the public.

New chapters

In recent decades, changes to ACI 318 have revolved primarily around updates in materials and design technology — revisions that reflect new materials, better knowledge of structural systems' behavior, and new construction systems and analytical approaches. The changes introduced in this version, however, revolve mainly around the organization of the code requirements, shifting the focus from a "force-based" to "element-based" format.

In other words, instead of chapters dealing with forces affecting concrete structures such as "shear" and "flexure," chapters will now be arranged by the building elements themselves, such as "slabs," "columns," and "beams." Within each chapter will be all the requirements necessary to design that particular element.

This will eliminate the need to flip through several chapters to comply with all of the necessary design requirements for a particular structural member, as was necessary with the old organizational format. The code's new design can be compared to a cookbook: all the ingredients for baking a cake such as eggs, flour, sugar, oil — along with the baking instructions — are in one chapter, instead of individual chapters on eggs, flour and sugar.

Changes were overdue

As the understanding of structural behavior and materials had increased over the years and design techniques had evolved and matured, existing chapters in the old code had been expanded to include the new information. The result was a complex document that had become confusing and often off-putting for its structural engineer users.

Depending on the structural member being designed, requirements from five or more chapters often needed to be met, requiring structural engineers to virtually memorize the location of key requirements due to the nonintuitive nature of the code's layout.

So, while the task of reorganizing a code that had grown from a small booklet years ago to a much larger and more extensive document today seemed somewhat overwhelming, the ACI 318 committee nevertheless decided six years ago to move forward. The consensus was that reorganization was long overdue and would ultimately benefit code users.

With the new ACI 318, struc-

WHAT DO YOU THINK?

The revised ACI 318 building code for structural concrete is available for public review and comment through June 17. (See the ACI website for details: bit.ly/1kdlMat.)

The ACI 318 committee will meet in August to address the comments and make any necessary revisions to the document. It will be published by ACI in November and incorporated into the 2015 edition of the International Building Code.

tural engineers will be able to access all necessary information for any structural element — beams, columns, footings, walls, etc. — in one convenient location. The exception will be design information that applies to multiple elements. This information will be contained in "toolbox" chapters and referenced from the others to avoid redundancy. For example, requirements for rebar bends, splices and detailing will be contained in one chapter and referenced by other chapters to eliminate the need to repeat it multiple times.

Some updates shelved

The code reorganization did not come without challenges. One of the most difficult was dealing with the need to update it and reorganize it simultaneously. As it turned out, the time required for reorganization was so significant that some proposals for updating technical and other code requirements were shelved until the next issue of the code.

While the revised ACI 318 code itself can't really be called simplified — it remains at about the same page count as its previous version — its reorganization should offer a code that's easier to use and more welcoming to current and future designers of concrete buildings.

Cary Kopczynski is CEO of Bellevue-based structural engineering firm Cary Kopczynski & Co. and a long-time ACI 318 committee member. His firm has designed numerous concrete buildings throughout the United States and beyond.

Structural engineers will use an updated code to design concrete buildings such as Premier on Pine, a 42-story tower under construction in downtown Seattle.

PHOTO BY SOUNDVIEW AERIAL

NEW CHAPTER WILL HELP WITH FUTURE RENOVATIONS

While most of the revisions to ACI 318 pertain to its reorganization, one new addition is a chapter on requirements for preparing construction documents.

Previously, ACI 318 was largely silent concerning information beyond structural design itself required to be included in construction documents. It was up to each design office and the permitting authorities they worked with to determine what constituted an adequate set of drawings and specifications.

ACI 318-14, however, spells out this additional information in considerable detail. For example, structural engineers must now include all loading assumptions, foundation design values, key assumptions concerning lateral analysis, and other related information. While many designers already include this in their drawings, others don't, or the information they include is overly rudimentary. The latest revision to ACI 318 will change that.

Such information is useful when a building undergoes any sort of renovation, addition or upgrade. With the design criteria clearly shown on the original design documents, engineers and contractors are better able to properly assess an existing structure for modification. Since well designed and constructed buildings can remain in service for many generations, future users of the original drawings will be well served by an accurate "road map" of the design.

ON THE COVER

The Chief Joseph Fish Hatchery was the grand award winner at the Washington Aggregates and Concrete Association's annual Excellence in Concrete Awards. The hatchery tied for honors in the civil projects category. The full list of winners is on page 5.

PHOTO COURTESY OF THE BONNEVILLE POWER ADMINISTRATION

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PUBLIC WORKS: CIVIL PROJECTS TIE

A concrete office building and colored concrete plaza were built for the new hatchery, which involved four different construction sites.

PHOTO COURTESY OF WACA

CHIEF JOSEPH FISH HATCHERY

Location: Bridgeport
Owner/developer: Bonneville Power Administration
Project team: PCL Construction Services, general and concrete contractor; Tetra Tech, architect and structural engineer; Godbey Red-E-Mix, ready-mix supplier

GRAND AWARD

The Chief Joseph Fish Hatchery involved four different construction sites spread out over 40 miles in rural north-central Washington.

The state-of-the-art hatchery is fully sustainable from a fish culture standpoint and can raise 2.9 million chinook salmon per year.

The facility was designed and constructed with two focuses: automation and low-maintenance durability. Various systems can be monitored remotely with minimal staff and were designed to survive harsh summers and winters.

Ready-mix concrete was used throughout the project.

Nearly 9,000 cubic yards of concrete were used during construction. Concrete elements included two separate in-water pump stations on the Okanogan River; a fish ladder and broodstock facility in the Columbia River; two banks of 20 fish raceway cells; five fish acclimation and rearing ponds with concrete inlet and outlet structures; a concrete tilt-up hatchery building; a waste facility; a storage building with cast-in-place walls; a process water headbox; an office building with exposed concrete beams, walls and polished concrete floor; a colored concrete plaza; and an intake bulkhead 50 feet below water at Chief Joseph Dam.

Although concrete was necessary throughout the entire facility for its durability, concrete was essential for one technical element. Approximately 60 percent of the water supplied to the facility was to be from a gravity-fed pipeline with a steel intake bulkhead. However, divers discovered that the adjacent riprap embankment was unstable and had the potential to damage the steel gate and break the watertight seal of the system.

With the project already under construction when this was discovered, the project team worked together quickly to design a concrete intake wall that could be constructed underwater in lieu of the original steel intake bulkhead.

Using concrete eliminated the fears about riprap damaging the intake area. It also eliminated the need to inspect the intake system with divers on a regular basis. (The U.S. Army Corps of Engineers requires yearly inspections for underwater steel structures). Concrete solved the immediate construction needs and reduced substantial long-term maintenance costs.

Placing a concrete intake wall underwater did however present a significant number of challenges that the team needed to work through.

While the engineer worked on the design of the permanent structure, the general contractor worked with the project divers to design a formwork system as well as a protective shield to keep divers safe from the riprap that rolled down into the area during construction of the wall.

The wall was placed using bottom-up concrete placement with a one-of-a-kind concrete mix specially designed for the project. Additionally, a Fuko water stop system was cast into the wall and injected after curing with a hydrophilic water stop compound.

With large concerns about this kind of placement (from the concrete mix to the underwater pumping method) and achieving proper consolidation, the team constructed a mock-up wall in one of the fish raceways. A test wall was cast underwater using the same size pump truck and attachment systems that would be used on the actual wall. Thanks to everyone's effort and teamwork, the wall placement went off with no issues and provided a watertight seal that exceeded expectations.

TILT-UP STRUCTURES

PROVIDENCE MEDICAL OFFICE BUILDING AT HAWKS PRAIRIE

Location: Lacey
Owner/developer: Marvin Road LLC
Project team: BPCI, general and concrete contractor; TGB Architects, architect; Shutler Consulting Engineers, structural engineer; Miles Sand and Gravel Co., ready-mix supplier

The Providence Medical Office Building at Hawks Prairie has 30 decorative colonnades around its exterior. The unique quality of these colonnades or "pilasters" is that they are concrete tilt panels.

The colonnades were originally intended to be steel framing. After analysis, it was determined that the desired look could be achieved at a better value using the concrete tilt method.

Each colonnade is 3 feet wide, 28 feet tall and 6.5 inches thick. They share a common footing with the building's panels and are connected via embeds and welds. Installation required "bucking out" a small section of the tilt panel walls at each colonnade for an added cable connection.

While the colonnades were picked by the crane, the additional cable pulled the colonnade to its final position. The colonnades stand half an inch from the tilt panel walls.

The top of each colonnade interfaces a foam and acrylic cornice system that wraps the entire perimeter of the building. Many subtle architectural features (such as precast concrete sills, brick veneer pilasters, and stained concrete panel sections framed by reveal strips and the tilt-panel colonnades) create a building with strong architectural appeal, yet maintain the cost efficiency and durability of ready-mixed concrete tilt construction.

The team saved money by building decorative colonnades with concrete tilt panels.

PHOTO COURTESY OF WACA

WASHINGTON AGGREGATES AND CONCRETE ASSOCIATION 2014 EXCELLENCE IN CONCRETE CONSTRUCTION AWARD WINNERS

GRAND AWARD
Chief Joseph Fish Hatchery
Bridgeport

Tilt-up structures
Providence Medical Office Building at Hawks Prairie
Lacey

Cast-in-place parking structures
Clearwater Casino parking garage
Suquamish

Cast-in-place structures
Husky Stadium renovation
Seattle

Public works: Bridges/renovations
Satus Creek Bridge replacement
Toppenish

Public works: Civil projects (tie)
Chief Joseph Fish Hatchery
Bridgeport

Public works: Civil projects (tie)
Lower Baker Unit 4 Powerhouse
Concrete

Residential decorative concrete
Diamond S Ranch
Bellevue

Residential ICF
Hendricks residence
Anacortes

Architectural decorative concrete
Grand Ridge Plaza blocks 2, 3, 17 and 18
Issaquah

Pervious concrete
Estancio I
Bellevue

Concrete paving
Liberty Lake roundabout
Liberty Lake

Special applications: Technical merit
The Martin apartments
Seattle

Sustainable merit
Cascade Middle School
Sedro-Woolley

CAST-IN-PLACE PARKING STRUCTURES

CLEARWATER CASINO PARKING GARAGE

Location: Suquamish
Owner/developer: Port Madison Enterprises (Suquamish Tribe)
Project team: Korsmo Construction, general contractor; Rice Fergus Miller, architect; Coughlin Porter Lundeen, structural engineer; Turnstone Construction, decorative concrete contractor; Conco, concrete contractor; Hard Rock, ready-mix supplier

The Suquamish Clearwater Casino Resort is undertaking a major five-year expansion, including a 700-space parking garage that was completed earlier this year.

The seven-level, 214,500-square-foot long-span structure is supported by post-tensioned beams. Shear walls are positioned around the perimeter.

Interior concrete surfaces have a swirl finish.

The exterior walls have sculpted shotcrete murals that express the tribe's heritage and connection to the waterways of Puget Sound.

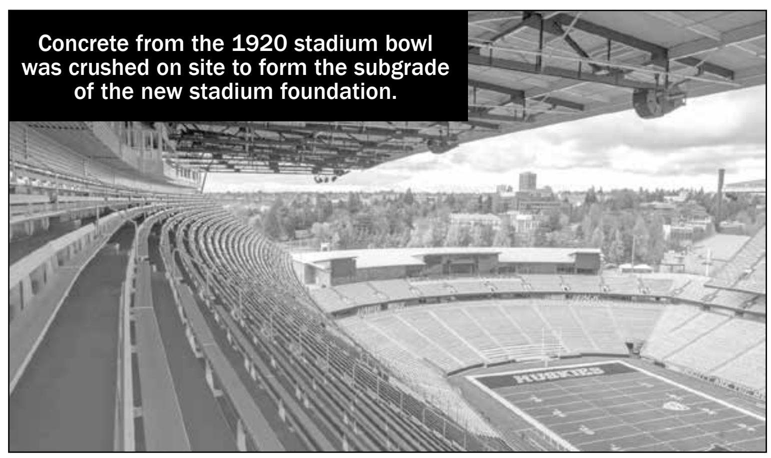
Sculpted shotcrete murals depict tribal canoeing scenes.

PHOTO COURTESY OF WACA

CAST-IN-PLACE STRUCTURES

HUSKY STADIUM RENOVATION

Location: Seattle
Owner: University of Washington
Project team: Turner Construction, general and concrete contractor; 360 Architecture, architect; Magnusson Klemencic Associates, structural engineer; CalPortland, ready-mix supplier



Concrete from the 1920 stadium bowl was crushed on site to form the subgrade of the new stadium foundation.

PHOTO COURTESY OF WACA

When Husky Stadium was first built by the Puget Sound Bridge and Dredging Co. in 1920 the construction material of choice was concrete. It was selected for its durability, economy and constructability.

Fast-forward more than 90 years when the latest stadium renovation was being planned. Even though the lower concrete bowl was crumbling in spots, it was a no-brainer to replace this iconic Northwest structure with the same material.

The existing concrete had held up well past its life expectancy and was an integral part of countless memories. In fact, the stadium's nearly century-old recycled concrete — 26,300 cubic yards in all — demonstrated its sustainability by being demolished and crushed on site to form the subgrade of the new stadium foundation.

After the old stadium was demolished, construction on the new one began. A total of 37,200 cubic yards of concrete was poured in the main structure as well as 1,800 cubic yards of site concrete around the stadium.

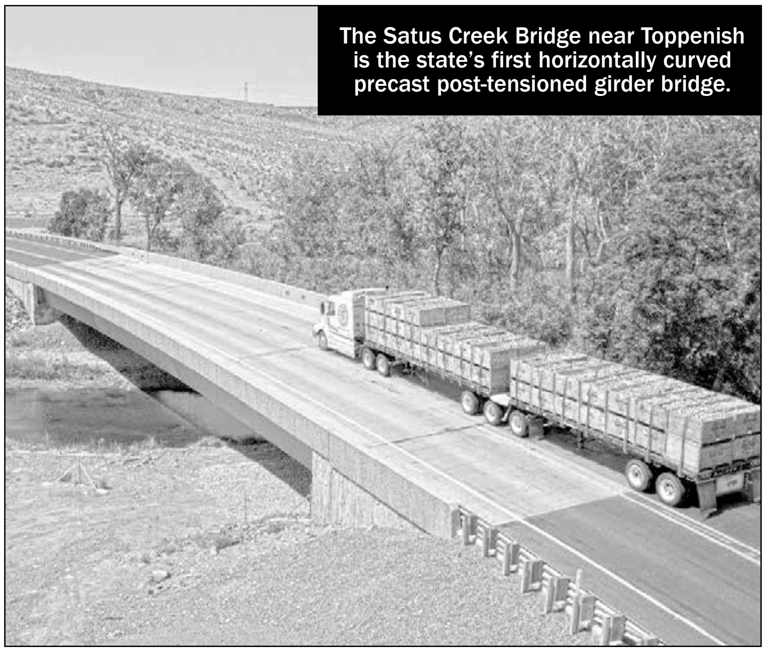
Cast-in-place stadium seating risers were formed and poured in 450- to 1,500-foot lengths over 140 consecutive work days.

More than 11,000 linear feet of vertical walls were formed and poured. Many of these concrete walls included encased structural-steel columns to assist in resisting uplift of the cantilevered roof system for the south stands.

Concrete was also used for the buckling-restrained brace frames (concrete-filled steel tubes), which married the great compressive strength of concrete with the tensile strength of steel, resulting in an economical way to handle any future seismic forces. The use of these critical elements throughout the stadium will also help with fan-induced accelerations during the games.

Cast-in-place concrete was an integral part of the stadium design because of its aesthetics, durability, constructability and overall sustainability for this iconic building.

PUBLIC WORKS: BRIDGES/RENOVATIONS



The Satus Creek Bridge near Toppenish is the state's first horizontally curved precast post-tensioned girder bridge.

PHOTO COURTESY OF WACA

SATUS CREEK BRIDGE REPLACEMENT

Location: Toppenish
Owner/developer: Washington State Department of Transportation
Project team: Franklin Pacific Construction Co., general contractor; WSDOT, architect and structural engineer; Concrete Technology Corp., concrete contractor; Hood River Sand, Gravel & Ready-Mix, ready-mix supplier

The Satus Creek Bridge is located in Yakima County 25 miles southwest from Toppenish along U.S. Highway 97 at Satus Creek. It was built as part of a $13.4 million project completed in 2013.

The 180-foot-long simple-span bridge replaced an old, load-restricted timber bridge built in 1942. The new structure corrects design deficiencies with the old timber bridge, including vehicular impact and seismic resistance.

Several unique features were incorporated into the design, including horizontally curved and spliced precast girders.

A long, single-span bridge was necessary to satisfy environmental constraints related to crossing the wide creek. The bridge deck is conventional cast-in-place concrete. The shallow foundation also consists of conventional cast-in-place concrete.

The superstructure is composed of open precast concrete box girders, or "tubs," which are horizontally curved and tipped to match the 8 percent cross slope of the bridge. To achieve this long, simple span across Satus Creek, each girder line consists of three precast girder tub segments.

Falsework towers were used to temporarily support the segments while the deck was cast and splice sections were assembled. Each tub web has three post-tensioning tendons. After post-tensioning was applied the temporary falsework towers were removed.

Composite provided the ability to have an increased span capability, eliminating the need for an intermediate pier. This was a great cost savings and it satisfied the environmental constraints.

Another added benefit that came with the spliced girders concept is the reduced shipping costs. The segments are easier to handle and more shipping routes become available to the girder fabricator at the time of delivery due to shorter and lighter girders.

The Satus Creek Bridge is the first horizontally curved precast post-tensioned girder bridge to be built in the state of Washington. It is a cost-effective, durable and resilient structure that is pleasing to the eye and satisfies the geometric and environmental constraints of the site.

The bridge was a testing ground for the state Department of Transportation's Bridge and Structures Office. The team did not encounter significant issues during the design and construction phases of the project, but several design issues could present challenges for projects requiring smaller horizontal curvatures.

PUBLIC WORKS: CIVIL PROJECTS TIE

LOWER BAKER UNIT 4 POWERHOUSE

Location: Concrete
Owner/developer: Puget Sound Energy
Project team: PCL Construction Services, general and concrete contractor; Black & Veatch, structural engineer; Concrete Nor'west, ready-mix supplier

The Lower Baker Unit 4 Powerhouse is a subterranean 30-megawatt hydro turbine generator powerhouse connected by a new 15-foot-diameter tunnel.

The project is located on the Baker River in Skagit County, partially within the town of Concrete.

Design and construction was split into four phases.

Phase I consisted of site utility relocations to make way for the new powerhouse. Following utility relocations a series of secant wall piles were installed into bedrock to form a watertight (lean mix concrete curtain) wall around the powerhouse construction.

Once the secants were completed excavation began in the area within the walls. The east secant wall provided the "turn under" location (portal) to begin the tunneling work included in the construction of Phase II.

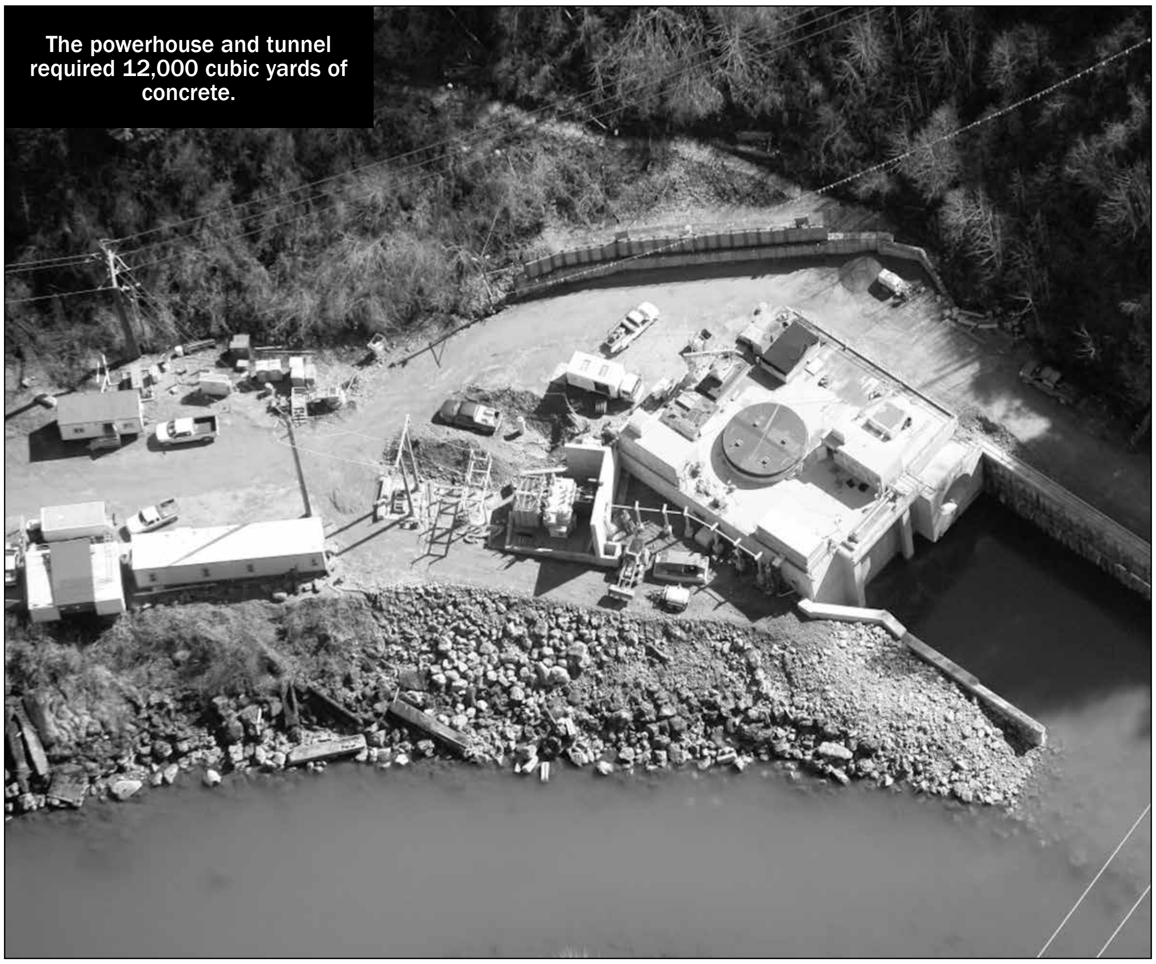
Phase III construction included the concrete powerhouse structure, and Phase IV construction included the permanent secant concrete tailrace entry to the Lower Baker River.

The concrete powerhouse included four main below-grade levels with the lowest level reaching 20 feet below the river. The footprint of the powerhouse was approximately 6,000 square feet, yet the project consumed 12,000 cubic yards of concrete between the powerhouse structure and tunnel.

The concrete floors and perimeter walls of the powerhouse are 36 inches thick. The perimeter walls were single-side formed against the secant piles with a PVC water stop and keyway at each construction joint to reduce water seepage. The walls and floors remained exposed as a finished product.

Due to the precision required of the turbine and generator components, placement of concrete required specialized methods and mix-design engineering to counteract potential alkali silica reactivity (ASR) of the aggregate and cement in the mix. Over time, ASR in concrete has potential to move embedded components, which can be counteracted by use of fly ash.

The ready-mix supplier worked with the design-build team to develop this specialized mix utilizing the aggregates available in the region, ultimately resulting in mix containing 30 percent fly ash.



The powerhouse and tunnel required 12,000 cubic yards of concrete.

PHOTO COURTESY OF WACA

Additionally, concrete was placed in 1-foot lifts every eight hours around critical embedded components as a method to further control and minimize the effects of buoyancy and heat of hydration moving the embed. The largest embed, in excess of 60,000 pounds, was the scroll case, the foundation for turbine component erection.

This pressure vessel embed was pressurized prior to concrete encasement to reduce skin friction and simulate operating pressures of the component during use. The vessel remained pressurized at 150 pounds per square inch with circulated reservoir water through the use of two high-pressure pumps over a three-week period until all the lifts were cast around the scroll case within 0.0196 inches of tolerance.

Utilizing these practices, the design-build team met these significant tolerances, providing a high-quality concrete product for the client.

RESIDENTIAL DECORATIVE CONCRETE

DIAMOND S RANCH

Location: Bellevue
Owner/developer: Nick and Patricia Coluccio
Project team: ACS Custom Homes, general contractor; Mark Muir, architect; Absolutely Fine Concrete, concrete contractor; Stoneway Concrete, ready-mix supplier

The concrete contractor was initially asked to revive more than 10,000 square feet of existing concrete at Diamond S Ranch in Bellevue.

"It would be tough to bring it back to life," the contractor says. "I encouraged the client to tear it all out and start fresh."

The concrete design followed a ranch theme, including use of a wood-plank stamp.

Wherever there was vehicle traffic, Roman slate bands and ribbons were installed for aesthetics and crack control.

Horse stamps were added to the mix to enhance the rustic feel. A carpenter even created a custom 6-by-6-foot horse stamp for both entrances and the main foyer.

There were a couple of advantages to using stamped concrete and ready mix instead of wood. Concrete doesn't rot, and it holds up to vehicle traffic, including dump trucks, motor homes and commercial vehicles.

Textured stamped concrete can also develop character over time. If resealed biyearly the product will look good and sustain its class for a very long time.

Concrete is stamped with a wood-plank design to follow a ranch theme.

PHOTO COURTESY OF WACA

RESIDENTIAL ICF

The Fidalgo Island house was constructed with ICFs to insulate it from strong winds off Skagit Bay.

PHOTO COURTESY OF WACA

HENDRICKS RESIDENCE

Location: Anacortes
Owner/developer: Hendricks family
Project team: Bell Construction, general and concrete contractor; Concrete Nor'west, ready-mix supplier

The owners and contractor planned from the start to use insulated concrete forms for the construction of an 11,000-square-foot house on the shores of Skagit Bay on Fidalgo Island.

The project also included a 1,000-square-foot ICF guest house and a 1,900-square-foot ICF shop building.

There were several considerations that made concrete construction the right choice the for project.

A major factor was that the site is on the bay and gets hit from heavy south winds all winter and a strong west wind in the summer. Wind loads, load capacity, window sizing and insulation were all part of the design. Noise, comfort and durability all played into the selection of ICF.

For the exterior finishing a stucco-type product was applied to the ICF system.

Concrete that resembles limestone was used for the living room fireplace surround and the kitchen range hood. Using concrete for this application gave the homeowners the look of Old World craftsmanship.

Patio areas were constructed in concrete with a hand-trowel finish on a pan deck-type form. This allowed the area underneath to be used for storage as well as for spa mechanical equipment.

Ceilings were sprayed with a closed cell foam and then drywall was applied for an inside-looking finish. The 12-person spa was craned on to a reinforced footing and then backfilled with controlled density fill. The concrete slab then caps over the rim of the spa with a pool-type edge detail.

The landscaping and driveway were major focuses for the project. A 200-foot-long concrete wall was placed along the property line to allow for the site to be leveled off. The lower parking area has a black slate stamp border with a colored broom finish body.

The main drive down to the house is a 22-foot-wide natural broom finish with mono-poured curbs. The home also has a half-basketball court finished in concrete.

The guest house has a patio at grade with a fire pit in the center. The finish on this patio is colored concrete with a sand finish.

The home also has a gun safe that is ICF-constructed with reinforced slab footings, ICF walls, concrete ceilings and a 3-by-7-foot safe door. The property also has a 14,000-gallon underground concrete water storage vault that provides groundwater and rainwater collection for irrigation.

ARCHITECTURAL DECORATIVE CONCRETE

GRAND RIDGE PLAZA BLOCKS 2, 3, 17 AND 18

Location: Issaquah
Owner/developer: Grand Ridge Plaza II LLC
Project team: Robertson & Olson Construction, general contractor; Hewitt, architect; Magnusson Klemencic Associates, structural engineer; Turnstone Construction, decorative concrete contractor; Kulchin Foundation Drilling and Emil's Concrete Construction Co., concrete contractors; Cadman, ready-mix supplier

In developing a segment of the Issaquah Highlands called Grand Ridge Plaza, Regency Centers employed Hewitt to meld the built environment into the natural landscape. Various artistic expressions utilizing concrete were included in this effort.

- **Artistic shotcrete retaining wall along 10th Avenue Northeast:** This wall was originally built as a decorative gabion-basket retaining wall, however the owner wanted the wall to be deepened to accommodate the design of a large commercial store and improve the appearance of the existing wall.

To accomplish this Kulchin Foundation Drilling installed a soil nail-supported shotcrete wall that was textured to resemble large blocks of stone in an ashlar pattern. This pattern was carved into the shotcrete before it set and stained to prompt the wall to appear as carefully stacked individual stones.

Texturing and staining was performed by Turnstone Construction. The result is a beautiful adornment to a street that leads to a residential neighborhood, and it was additionally a cost-effective means of supporting 18 feet of earth behind a commercial building.

- **Blowdown Plaza:** The green space adjacent to one of the site's wetland buffers presented an opportunity to employ concrete in an artistic expression.

Concrete "blowdowns," cylinders of concrete in varying diameters and lengths, represent abstract log forms and are signature elements of the pedestrian plaza.

The blowdowns were poured in an integrally colored concrete that was then sandblasted on the sides and polished on the ends. These blowdowns serve as low site walls for retaining soil, informal seating opportunities, spatial definers, and as the transitional edge to the protected wetland buffer.

The interlaced geometric layout of the concrete cylinders creates clean, long lines that often fracture and overlap. Where these overlaps and fractures occur gathering spaces and areas of unique planting are formed.

The sandblasted finish weathers to emulate timber forms, and the polished ends reveal the natural beauty of the concrete. These cylinders were designed by Hewitt, formed and poured by Emil's Concrete and set in place by Turnstone Construction.

- **Artistically embossed textured and colored sidewalks:** The pedestrian walks throughout the project are poured with integrally colored concrete that incorporate impressions of sword ferns that are naturally stained to produce color contrast and beauty. This approach represents a subtle but important tie to the surrounding natural landscape using concrete.

These three elements demonstrate that an artistic application to common built architectural forms can enhance the experiential quality of these destinations for the residents and visitors to the Issaquah Highlands and Grand Ridge Plaza.


Concrete cylinders designed to look like logs serve as seating and site walls in this Issaquah plaza.

PHOTO COURTESY OF WACA

PERVIOUS CONCRETE

ESTANCIO I

Location: Bellevue
Owner/developer: Crossmark Homes
Project team: Crossmark Homes, general contractor; Jeffrey J. Hummel Architects, architect; Peltola Concrete Construction, concrete contractor; Cadman, ready-mix supplier

Pervious concrete has long been appreciated for its sustainability, high recycled content and ability to limit stormwater runoff.

But the project team was looking to boost demand for the product by drawing attention to another of its qualities: its aesthetic value.

At a single-family residential infill project in Bellevue, a colored pervious pathway was designed to beautify the property.

Instead of using pea gravel, the pathway was paved with much smaller aggregate. A small amount of color was added, and rubber stamps were used to create a design.

A few more benefits of using pervious pavement include lower maintenance costs, a reduction of the heat-island effect, and use of recycled materials to replace 30 percent of the cement.


Pervious concrete has a practical side, but it can also be appreciated for its looks.

PHOTO COURTESY OF WACA

SUSTAINABLE MERIT


The bus lane was paved with an 8-inch-thick section of pervious concrete, selected for its cost, durability and ability to control runoff.

PHOTO COURTESY OF WACA

CASCADE MIDDLE SCHOOL

Location: Sedro-Woolley
Owner/developer: Sedro-Woolley School District
Project team: Colacurcio Brothers Construction, general contractor; Harthorne Hagen Architects, architect; 2020 Engineering, structural engineer; PCS Structural Solutions, civil engineer; LangCo NW, concrete contractor; Concrete Nor'west, ready-mix supplier

Cascade Middle School in the Sedro-Woolley School District recently underwent a $20 million renovation.

Priorities included protecting the environment and providing safe access for buses, faculty and staff, and parents dropping off students.

When considering sustainable stormwater management strategies for the site, infiltration was identified as the preferred method. Several infiltration methods were evaluated, and ultimately it was decided to install permeable pavement because of the large amount of infiltration area beneath the pavement.

Other infiltration strategies concentrate the stormwater in smaller facilities, which require deeper sections to provide enough stormwater storage prior to infiltration. Pervious pavement meets two needs by providing a pavement surface as well as a stormwater management facility.

Of the types of permeable pavements currently available, pervious concrete has the highest level of durability and structural integrity, especially for the heavy bus traffic. It also has a light reflective surface, which helps to mitigate the heat-island effect. Because the pervious pavement areas did not need any conventional stormwater components (such as catch basins, pipes and vaults) it was also the most economical choice.

Pervious concrete has been shown to provide several pollutant-removal mechanisms inherent to the paving structure. These mechanisms include stomwater volume reduction (through infiltration and evaporation), reduced spray and vehicle washoff, biological degradation, filtration, absorption and volatilization. Through these mechanisms, the typical pollutants removed include hydrocarbons, metals, sediment, nutrients, chloride, bacteria and polycyclic aromatic hydrocarbons.

All of these characteristics help the project earn credits under the Washington Sustainable Schools Protocol, the green building standard for school construction in Washington state.

Pervious concrete covers nearly 4 acres of the site. Parking areas were constructed with a 6-inch-thick section, the bus lane was constructed with an 8-inch-thick section, and the sidewalks were constructed with a thickness of four inches, totaling 3,500 cubic yards.

The pervious concrete mix includes admixtures and Fibermesh 150 for added durability and hydration control. The increased thickness as well as the fiber and admixtures in the bus lanes give additional strength to accommodate the heavy axle loads of the buses.

In the specifications for the project, it was stated that the installer must be certified through the National Ready Mixed Concrete Association's Pervious Concrete Contractor Certification Program, which ensured that the installer was experienced and knowledgeable in the field.

In addition to the benefits listed above, the pervious concrete provides an educational opportunity for the students of Cascade Middle School. By understanding why the pavement is pervious, and what benefits it provides, the students have an opportunity to learn about stormwater management and how their actions can affect the health of our communities, watersheds and ecosystems.

The parking lots and sidewalks actually act as outdoor classrooms for teachers to engage the students in discussions about pollutant removal, infiltration rates, and the science behind the stormwater management system.

CONCRETE PAVING


The roundabout was completed in fewer than 35 working days.

PHOTO COURTESY OF WACA

LIBERTY LAKE ROUNDABOUT

Location: Liberty Lake, Spokane County
Owner/developer: City of Liberty Lake, Washington State Department of Transportation
Project team: Wm. Winkler Co., general and concrete contractor; Michael Terrell–Landscape Architect; Central Pre-Mix, ready-mix supplier

A new roundabout was built in Liberty Lake at the westbound Interstate 90 off-ramp to Harvard Road and Mission Avenue.

Work involved removing the existing pavement, modifying utilities, excavating over 2,500 cubic yards of roadway, installing a new stormwater biofiltration system, constructing the roundabout, and installing a masonry wall, sign and over 2,000 plants and trees.

The roundabout was operationally complete in fewer than 35 working days, earning the maximum early completion incentive.

The project required coordination with 14 subcontractors and numerous suppliers.

Approximately 600 cubic yards of fast-setting concrete was used to allow traffic on the newly constructed pavement less than 24 hours after placement.

Additionally, there were two separate concrete suppliers: One supplier provided the concrete for the pavement and the second provided the concrete for the curb and sidewalks. The project included use of colored and textured concrete.

Although the project specifications allowed for temporary closures of the I-90 off-ramp and Mission Avenue, the closures were avoided by revising the traffic-control plans, building a ramp bypass road and adjusting the project phasing.

Extensive communication with local business owners helped ease their initial apprehension regarding the project and its impacts to their customers. Businesses were able to remain open during the entire construction process, and business owners welcomed the avoidance of the road closures.

Throughout construction, more than 18,000 vehicles traveled through the core of the project daily, along with pedestrians and bicyclists.

Over the course of more than 9,000 man-hours (including prime, subcontractor and inspectors) there were no accidents, injuries or near misses — no small task considering the traffic, weather and round-the-clock working hours at times.

SPECIAL APPLICATIONS: TECHNICAL MERIT

THE MARTIN APARTMENTS

Location: Seattle
Owner/developer: Vulcan Real Estate
Project team: Exxel Pacific, general contractor; Callison, architect; Cary Kopczynski & Co., structural engineer; Conco, concrete contractor; Cadman, ready-mix supplier

The 24-story Martin apartment tower in Seattle's Belltown neighborhood became the first building in North America to use steel fibrous reinforced concrete as a rebar replacement for shear wall link beams in a high-seismic region.

The result was a simple and buildable link beam detail that eliminated rebar congestion, facilitated faster construction and reduced steel tonnage. This innovative approach saved significant time and money.

Reinforcing congestion has long been the bane of reinforced concrete construction in high-seismic regions. The most difficult and congested reinforcing is in shear wall link beams.

Shear walls provide lateral stability to a building. The strength and stiffness of a wall are compromised, however, by penetrations required for doorways and mechanical openings. The elements above the openings become highly stressed "link beams" that are critical in maintaining coupled wall behavior. Seismic strength and ductility demands in link beams are high.

Traditionally, diagonal bars are used to reinforce these link beams, combined with high quantities of tightly spaced stirrups and ties. This traditional approach is costly and time-consuming to build and causes major conflicts in rebar placing since the diagonal bars conflict with rebar in the adjacent wall boundary elements.

Steel fibrous reinforced concrete (SFRC) replaces the diagonal bars and much of the remaining steel that is required in conventional designs, providing improved strength and ductility. Further, it eliminates the serious constructability challenges contractors face in placing rebar and concrete in what are typically highly congested zones.

With SFRC, the strength and ductility of link beams is maintained even though a significant quantity of reinforcing steel — including the unwieldy diagonal bars — is eliminated. SFRC in link beams can result in up to a 40 percent rebar reduction and a 30 percent net cost savings compared with traditional link beam construction.

SFRC is not addressed by ACI 318 or the International Building Code for use in seismic link beams, so the Seattle Department of Planning and Development required two peer reviews by independent structural engineers before granting approval. SFRC link beams without diagonal bars would achieve equal or better performance compared with those in a traditional code-compliant design.

While SFRC has so far been targeted for use primarily in shear wall link beams, the success of The Martin created a springboard from which to extend SFRC into entire shear walls. SFRC as a partial rebar replacement throughout a shear wall would improve the entire wall's constructability and increase its seismic strength and ductility.

The steel fibers were mixed into the concrete at the batch plant. After workability was confirmed at the site, a tower crane and bucket were used to place the link beam concrete while a pump simultaneously placed the adjacent shear wall concrete.


Steel fibers were mixed into the concrete at the batch plant.

PHOTOS COURTESY OF WACA


The Martin was built using steel fibrous reinforced concrete in place of rebar for the shear wall link