Slag Cement Association 2013 Project of the Year Awards

The Slag Cement Association (SCA) presented the 2013 Project of the Year Awards during the meeting of ACI Committee 233, Ground Slag in Concrete, on March 25th at the ACI Spring 2014 Convention in Reno, NV. The awards recognize projects for excellence and innovation in concrete using slag cement. Nine projects received 2013 Awards in the categories of architectural design, durability, green design, high-performance, innovation application, and sustainability.

Architectural Design

Pérez Art Museum Miami

The Pérez Art Museum Miami (also known as the Miami Art Museum), a public private partnership with the city of Miami, FL, and Miami-Dade County, was designed by Pritzker Prize-winning architects Herzog & de Meuron and has transformed the Museum Park into a central destination on Miami's cultural map. The three-story building has 200,000 ft^2 (18,600 m^2) of programmable art display space and sits on an elevated platform beneath a canopy that provides shaded verandas and a plaza.

A portland cement replacement level of 50% slag cement was selected to meet the architect's color requirements for the finished exposed concrete, provide required design strength, and reduce the environmental footprint of the concrete.

Project credits: Pérez Art Museum Miami, Owner; Herzog & de Meuron, Architect; Baker Concrete Construction, Engineer; Suffolk Construction, Contractor; Central Concrete Supermix and Titan America, Concrete Suppliers; and Lehigh Hanson, Slag Cement Supplier.

Durability

Ohio Department of Transportation Jefferson County Maintenance Facility

The Ohio Department of Transportation (ODOT) Jefferson County Maintenance Facility and a similar Wayne County project represent a new prototype for future ODOT facilities. The owner selected a 6 in. (150 mm) concrete pavement alternative to asphalt for the project, and a total of over 4000 yd^3 (3060 m^3) of concrete was placed in pavements, floors, and walls during July and August of

Pérez Art Museum Miami, Miami, FL

Ohio Department of Transportation Jefferson County Maintenance Facility, Wintersville, OH

2013. Ternary concrete mixtures containing slag cement, portland cement, and microsilica were used to increase strength and durability.

Slag cement was used at 20% and 40% replacement levels. The 40% slag cement ternary mixture achieved 28-day strengths in the 9000 psi (62 MPa) range and was used in salt storage facility walls. The 20% slag cement ternary mixtures provided 28-day strengths in the 6500 psi (45 MPa) range for project paving applications. The use of slag cement in ternary mixtures improved the placement, setting, and finishing characteristics of the concrete; increased strength; and reduced permeability for improved durability.

Project credits: Ohio Department of Transportation, Owner; MWA/JMSA JV, Architect; Sands Decker, Engineer; LW Associates, Contractor; D.W. Dickey & Son Inc., Concrete Supplier; and Essroc Italcementi Group, Slag Cement Supplier.

Green Design

San Francisco Public Utilities Commission Headquarters

San Francisco Public Utilities Commission Headquarters plans originally called for a steel-frame building, but plans were changed to a concrete structure to reduce costs by $10M and add an additional floor within the same zoning envelope. The 13-story, 277,500 ft² (25,780 m²) structure incorporated six different concrete mixtures using slag cement or combinations of slag cement and fly ash to reduce CO_2 emissions in pursuit of a LEED Platinum rating.

San Francisco Public Utilities Commission Headquarters, San Francisco, CA

A ternary mixture of 40% slag cement and 30% fly ash was used for mat slab, column, and core wall concrete mixtures, which had a specified compressive strength of 8000 psi (55 MPa) at 90 days. The elevated post-tensioned floor slabs used a 65% slag cement mixture with no fly ash to achieve 4500 psi (31 MPa) in 3 days to allow for stressing and stripping. This mixture met the 56-day, 6000 psi (41 MPa) specified compressive strength criterion for post-tensioned slabs at earlier ages, enabling a rapid speed of construction. Innovative structural design, concrete mixture development, and construction techniques all support the goal of achieving a LEED Platinum rating on this project.

Project credits: City and County of San Francisco, Owner; San Francisco Department of Public Works, Project Manager/Developer; KMD Architects and Stevens + Associates JV, Architects; SOHA Engineers and Tipping Mar Structural Engineering, Engineers; Webcor Builders/ Webcor Concrete, Contractor; Central Concrete Supply Co., Inc., Concrete Supplier; and Lehigh Southwest Cement Company, Slag Cement Supplier.

High-Performance

One World Trade Center

One World Trade Center is a world-class structure of symbolic importance. At 104 stories tall with an antenna reaching 1776 ft (541 m), New York's tallest skyscraper pushed the boundaries of what can be achieved with concrete. High-performance concrete criteria included heat reduction in the mass concrete placements, high strength for structural performance and blast resistance, superior rheology for pumping, and a reduced environmental footprint to achieve sustainable design objectives. A unique design aspect of the structure is a high-strength concrete center core with specified strengths of up to 14,000 psi (97 MPa). This core is designed to withstand explosive and high-impact forces, while maintaining structural integrity to allow a safe exit passage for building occupants.

Much research was undertaken and several concrete mixtures containing slag cement were developed to meet performance criteria for various One World Trade Center foundation and structural elements and for the World Trade Center Memorial and Museum mass concrete placements. Concrete mixtures included a quaternary mixture used in lower elevations that contained 52% slag cement with portland cement, fly ash, and silica fume. This combination was used to control heat gain and at the same time achieve the 14,000 psi (97 MPa) strength requirement. This was such a large project with many phases that it included multiple concrete suppliers and two slag cement suppliers.

One World Trade Center, New York, NY

Willamette River Bridge, Eugene, OR

Project credits: Port Authority of New York and New Jersey, Owner; Skidmore, Owings and Merrill, Architect; Cantor Seinuk, Engineer; Tishman Construction, Contractor; Eastern Concrete, Empire Transit Mix, Ferrara Bros. Building Materials Corp. and Quadrozzi Concrete, Concrete Suppliers; and Holcim (US) Inc. and Lafarge North America, Slag Cement Suppliers.

Willamette River Bridge

The Willamette River Bridge provides a critical link on the I-5 corridor near Eugene, OR. In 2002, shear cracks found in the original 1961 structure prompted installation of a temporary bridge and plans for permanent northbound and southbound bridges. Construction of the new bridges began in the summer of 2009. By mid-2013, both the 1985 ft (605 m) long northbound and the 1759 ft (536 m) long southbound bridges were completed.

Slag cement was used to reduce heat of hydration in the large mass concrete footings and to achieve Oregon Department of Transportation performance-based "alternate" high-performance concrete requirements for the bridge decks. For the mass concrete, a 60% slag cement replacement met heat and strength requirements, and yielded 56-day strengths exceeding 6200 psi (43 MPa). Where the bridge arches met in the middle of the river (dubbed "The Ice Breaker"), the steel reinforcement was extremely congested and the concrete could not be vibrated. A self-consolidating mixture using slag cement was developed that enabled filling the forms without leaving any voids. For the bridge decks, Knife River was able to produce a 30% replacement slag cement concrete mixture that achieved less than 1000 coulombs when tested at 90 days according to AASHTO T 277, "Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration." This concrete mixture provided outstanding quality, durability, strength, finishability, and pumpability.

Project credits: Oregon Department of Transportation, Owner; OBEC Consulting Engineers, Engineer; Hamilton Construction Company and Slayden Construction, Contractor; Knife River Corporation-NW-Eugene Division, Concrete Supplier; Cal Portland, Portland Cement Supplier; and Ash Grove Cement, Slag Cement Supplier.

Cedar Point Amusement Park GateKeeper Roller Coaster, Sandusky, OH

Innovative Application

Cedar Point Amusement Park GateKeeper Roller Coaster

GateKeeper is the first roller coaster ride that visitors see when entering Cedar Point Amusement Park in Sandusky, OH. In fact, each person entering the park must walk between the two massive columns that support GateKeeper. These columns were constructed using up to 50% slag cement and measure 6 ft (1.8 m) wide by 20 ft (6 m) deep by 24 ft (7.3 m) high. They support the tower section of the tallest wing roller coaster in the world.

The massive columns were constructed using monolithic placements so heat of hydration was a major concern. In addition, the concrete near the bottom of the columns had to gain sufficient strength during the placement to avoid overloading the formwork. To accomplish these two objectives, slag cement was used in three different mixtures. Type III cement was used with 25% slag cement for the first

6 ft (1.8 m) of each column, Type III with 50% slag cement was used from 6 to 12 ft (1.8 to 6 m), and Type I cement with 50% slag cement was used for the last 12 ft (6 m) of the columns. To avoid thermal cracking in the massive columns, a maximum temperature of 158°F (70°C) was specified with a maximum temperature differential of 36°F (20°C) from the interior to the exterior concrete.

The 28-day strength requirement was 4000 psi (28 MPa) and the three mixture proportions achieved an average of 5800 psi (40 MPa). The speed of construction was also of the essence because of the tight construction timeline to have the entire project completed prior to the amusement park reopening in the spring. The use of slag cement for thermal heat control allowed for time and cost savings because cooling pipes were not required to cool the interior of the concrete.

Project credits: Cedar Fair Entertainment Company, Owner; Tony Ravagani Architects, Architect; Bowser-Morner, Inc., Engineer; AA Boos & Sons Inc., Contractor; Elite Concrete Industries, Concrete Supplier; and St Marys Cement, Inc., Slag Cement Supplier.

Mechanical Dynamics and Analysis High-Speed Balance Facility (MD&A "Spin Cell")

The MD&A "Spin Cell" was built in early 2013 in south St. Louis, MO. Large rebuilt electrical turbine generators (such as ones at coal-fired power plants) are railed into the approximately 100 ft (30 m) long test chamber, connected to a drive shaft powered by external motors and tested to well beyond rated capacity. The chamber interior is evacuated of most air, oil is sprayed as lubrication and coolant, and the electricity generated by the unit being tested is dissipated through an extensive grounding system. The minimum 5 ft (1.5 m) thick and heavily reinforced and armored concrete chamber is designed to contain shrapnel from any generator explosion/disintegration. The mass concrete construction used a high slag cement content self-consolidating mixture.

The concrete thickness meant the entire test chamber above the belowground oil reservoir and pump facility is mass concrete. The minimum concrete thickness is 5 ft (1.5 m), and the underside of the barrel-like chamber is 8 ft (2.4 m) thick. Slag cement was used to lower the heat of hydration, better ensure that the self-consolidating concrete remained workable and could flow through the thick and tightly spaced three-dimensional array of reinforcing steel, and achieve strength reliably.

Although the specified compressive strength was 5000 psi (35 MPa), a considerably higher-strength mixture was requested and supplied. A 25:75 ratio of portland cement to slag cement was used with 3/8 in. (10 mm) limestone, natural fine aggregate, and steel fibers. The portland cement was a Type I/II low-alkali product, and the slag cement was Grade 100. The 28-day strengths exceeded 7300 psi (50 MPa).

Project credits: Mechanical Dynamics and Analysis, Owner; Fox Architects, Architect; Feld, Kamineski & Cohen P.C. and Swim Schuchat & Cornett Engineering Inc., Engineers; Tarlton Corporation, Contractor; Metro Materials, Inc., Concrete Supplier; and Holcim (US) Inc., Slag Cement Supplier.

Mechanical Dynamics and Analysis High-Speed Balance Facility "Spin Cell," St. Louis, MO

Sustainability

ODOT Project 10-0281

Ohio Department of Transportation (ODOT) Project 10-0281 was an upgrade to the IR-75/IR-475 interchange. The project included the construction of a new interchange at ProMedica Parkway, rehabilitation and reconstruction of six bridges, construction of four new bridges, and construction of 3700 ft (1130 m) of cast-in-place concrete retaining walls, four noise walls, and complete pavement replacement for 2.1 miles (3.4 km) of IR-475 pavement. Eighteen separate deck placements were conducted on the project, totaling 6649 yd^3 (5080 m^3) of slag cement concrete. In addition, approximately 6000 yd^3 (4590 m^3) of slag cement concrete were placed in the substructure of the bridges.

A ternary mixture was used with portland cement replacement levels of 25% slag cement and 25% fly ash. Specifications called for 4500 psi (31 MPa) at 28 days, 6% ± 2% air entrainment, a 4 to 8 in. (100 to 200 mm) slump, and maximum permeability rating of less than 1500 coulombs. Results of 390 performance tests run on 12,650 yd^3 (9670 m^3) showed an average of 7910 psi (45 MPa) compressive strength, 6% air entrainment, and 6-3/8 in. (160 mm) slump. The mixture tested at 752 coulombs under ASTM C1202, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration." An average of 5650 psi (39 MPa) was reached after more than two hundred 7-day strength tests were completed. The use of slag cement in this concrete mixture provided a very consistent, workable mixture that exceeded strength and durability criteria, and this performance was achieved at a reduced environmental footprint.

Ohio Department of Transportation Project 10-0281 ProMedica Bridge Deck, Toledo, OH

U.S. Coast Guard Headquarters, Washington, DC

Project credits: Ohio Department of Transportation, Owner; HNTB, Engineer; ES Wagner, Contractor; Kuhlman Corporation, Concrete Supplier; and St Marys Cement, Inc., Slag Cement Supplier.

U.S. Coast Guard Headquarters

Constructed on the west campus of the former St. Elizabeth's Hospital site in Washington, DC, the U.S. Coast Guard Headquarters project includes an 11-story office building for 3860 workers, a nine-story 800,000 ft^2 (74,320 m^2) parking garage, a central utility plant, and a National Operations Center. Clark Concrete Contractors placed 220,000 yd^3 (168,200 m^3) of concrete and 15,000 tons (13,600 tonnes) of reinforcing steel on this $435 million project. Clark placed an average of 3500 yd^3 (2675 m^3) of concrete every week for 42 consecutive weeks. The largest single placement required 2800 yd^3 (2140 m^3) of concrete over a 14-hour period for an 8 ft (2.4 m) thick mat foundation. Clark placed nearly 12 miles (19 km) of foundation walls and 523,000 ft^2 (48,590 m^2) of mat foundations.

The use of slag cement contributes toward the goal of achieving LEED Gold certification for this building. Some other green design features include a 400,000 ft^2 (37,160 m^2) green roof, a vegetative wall panel system, and an orientation that minimizes solar heat gain and maximizes the opportunity for daylighting. This project had to meet stringent blast resistance requirements. Designs required high-strength 3 ft (0.9 m) tall hanging perimeter turndown walls off most elevated slabs. Slag cement was also used to mitigate potential expansion due to alkali-silica reactive aggregate.

Project credits: General Services Administration, Owner; WDG Architecture, Architect; Cagley & Associates, Engineer; Clark Concrete Contractors, Contractor; Concrete Mixes Inc., Concrete Supplier; and Lafarge North America, Slag Cement Supplier.

The SCA represents companies that produce and ship over 90% of the slag cement (ground-granulated blast-furnace slag) in the United States. Through a program of continuous research, promotion, and education, SCA communicates the performance and sustainable benefits of this cementitious material to stakeholders throughout the construction industry. More information is available at **www.slagcement.org**.