Self-Consolidating Concrete Solves Challenging Placement Problems

SCC fills 100-ft-high columns at new airport terminal

BY MICHEL LESSARD, BRIAN SALAZAR, AND CAROLINE TALBOT

Pearson International Airport in Toronto, ON, Canada, is in the midst of a $4.5 billion (CAN) upgrade including a new terminal, parking structure, and pavement. The design of the new terminal incorporated 180 hollow steel composite columns that were 101 ft (31 m) tall. The columns contained a cage of 12 to 30 reinforcing bars and an electrical cable conduit in the center. A dog bone-shaped steel plate at the top of the column later connected to the roof trusses (Fig. 1).

HOW TO SUCCESSFULLY PLACE THE CONCRETE

The dog-bone plate, coupled with the airport's restriction of cranes above the upper terminal level, led the concrete team to pumping the concrete from the bottom of the column. Pumping 101 ft (31 m) vertically presented unique challenges such as finding the proper mixture proportions, the proper pump, the connection at the bottom of the columns, and the proper sequencing of the concrete trucks so that each column would be continuously filled. Self-consolidating concrete (SCC) appeared to be the best choice for this process; the concrete had to be homogenous, with little tendency to bleed and segregate.

Fig. 1: This steel plate was located at the top of the columns in the new Pearson airport terminal and provided a location to connect to the roof trusses

The concrete team, design group, and testing authorities agreed to use SCC and proceeded to develop appropriate mixture proportions to achieve 30 MPa (at 28 days) strength and a slump flow between 650 and 750 mm. Air entrainment was not required because this concrete would not be exposed to freezing and thawing conditions. The only concern with setting time was that it allow a sufficient time of plasticity to ensure ease of pumping the approximately 12 m^3 of concrete in each column. The concrete producer's facility confirmed proper SCC characteristics, setting time, and slump.

To ensure subsequent success on the project, the concrete team scheduled a test placement for November 1999. A Schwing BPL 900 pumped the concrete through a 125-mm-diameter pump connection, located 400 to 800 mm above the base plate, using a sliding guillotine plate. Workers conducted the test placement using two truck mixers, each containing 6 m^3 of concrete. Concrete was placed continuously, with an observer in a skyjack above the column communicating with the pump operator to avoid overfilling (Fig. 2).

The trial placement went very well with the pump pressure never exceeding 7 MPa. When the first truck was approximately 2/3 empty, the second truck started supplying concrete to the pump hopper to ensure a smooth and even flow of concrete into the pump.

Fig. 2: Workers observe SCC placement in the test column to avoid overfilling

After the successful test placement onsite, the concrete team established the placing schedule of the remaining 179 columns. Workers typically placed concrete in four columns per day. Slump flow was maintained between 600 and 750 mm throughout the column placement. High-range water-reducing admixture stored at the job site was used occasionally to keep the slump flow between 600 and 750 mm when inevitable onsite delays caused a slump flow reduction.

The 30 MPa mixture contained a combination of admixtures to achieve the target slump flow and proper setting time. Any early stiffening and initial set had to occur after the columns were filled. A high-range water-reducing admixture (Type F); a water-reducing admixture (Type A); a water-reducing, retarding admixture (Type D); and a viscosity-modifying admixture were used to achieve and maintain the specified slump flow throughout the pumping process. The maximum coarse aggregate size was 1/2 in. (10 mm). The slump flow averaged 660 mm and the average compressive strength was 45 MPa at 28 days.

PROBLEM SOLVED

SCC was clearly the proper choice for this difficult concrete placement. SCC is currently being specified and used in North America for architectural concrete, heavily reinforced members, and difficult repair projects. This successful project expands the use of SCC in providing a solution for an otherwise very difficult project. A traditional placement method, which involved filling the column through side ports at different levels, caused great concern over uniformity of mixture proportions, potential segregation, and setting problems. That method would have incurred significant additional cost and required a longer placing window for each column. SCC not only delivered uniform, high-quality concrete without bleeding and segregation, but did so at a lower overall cost.

Selected for reader interest by the editors.

Project Credits

Structural Engineer: Yolles Associates
General Contractor: PCL/BFC Joint Venture
Forming Contractor: J.J. McGuire
Concrete Supplier: Dufferin Concrete Group
Admixture Supplier: Euclid Admixtures Canada

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Brian Salazar is a graduate of Seneca College in Toronto, ON, Canada, where he received his CET (Certified Engineering Technician) in 1978. He worked in the ready-mixed industry before joining Euclid Admixture Canada, Inc., in 1987, where he works with admixture and construction product applications in Ontario. As the National Business Development Manager with Euclid, Salazar is active with the ACI Ontario Chapter, the Ready Mix Concrete Association of Ontario, and is a member of CSA S-413, Technical Committee on Parking Structures.

Caroline Talbot received her BS (1990), MS (1992), and PhD (1996) in civil engineering from Laval University in Quebec City, QC, Canada. Her master's work included the durability of shotcrete repairs. Talbot's doctorate was on various aspects of deicer salt scaling, including the influence of supplementary cementing materials. She has worked with Euclid Chemical Co. for the past 7 years as a product development engineer and a research and development manager in the repair products and admixtures area.