Structural Shotcrete Specifications

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SHOTCRETE FOR AFRICA CONFERENCE
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Subject of Presentation

- Review of structural shotcrete specifications
- Shotcrete construction of:
  - In-ground parking structure, Calgary Alberta
  - Seismic retrofit of heritage masonry structure, Vancouver, British Columbia
  - Walls and pilasters in 50 storey hotel, Vancouver, BC
  - Whistler 2010 Olympics Bobsleigh/Luge Track
In-Ground Parking Structure, Calgary, Alberta

- 20 m deep soldier pile/timber lagging stressed channels tie-back evacuation
- Cloth/bentonite waterproofing membrane system
- Reinforced shotcrete perimeter walls
Calgary Parking Structure

- Preconstruction mock-up of typical structural steel wall
Calgary Parking Structure

- Shooting preconstruction mock-up
Calgary Parking Structure

- Finishing pre-construction mock-up
Calgary Parking Structure

- Core extracted from pre-construction mock-up for core grading to prequalify shotcrete nozzlman
Calgary Parking Structure

- Hoarding installed for cold weather shotcreting
- Shotcreting continued at ambient temperatures as low as -30°C
Calgary Parking Structure

- Structural reinforcing steel erected ready for shooting
- Note hoarding enclosure for cold-weather shotcreting
Calgary Parking Structure

- Start-up of shooting of structural walls using bench-gunning technique
Calgary Parking Structure

- Bench-gunning second lift
- Note blowpipe
Calgary Parking Structure

- Upper lift finished to line and grade
- Flash-shooting lower lift to shooting wires, ready for cutting, screeding and finishing
Calgary Parking Structure

- Trimming shotcrete with cutting rod to shooting wires
Calgary Parking Structure

- Finished structural shotcrete wall
- Finisher is cleaning top of wall and rebar to accept cast concrete suspended slab that will rest on structural shotcrete wall
Calgary Parking Structure

- Four levels of structural shotcrete walls completed
Calgary Parking Structure

- Close-up view of four levels of structural shotcrete walls
- Column conventional cast-in-place formed concrete (too heavily reinforced for shotcrete construction)
Calgary Parking Structure

- View of back-side of reinforced shotcrete wall with single-sided form removed
- Note complete lack of any shadows, voids or other defects
Calgary Parking Structure

- Core extracted from shotcrete wall for compressive strength testing
- Note dense quality of shotcrete free of voids or defects
Calgary Parking Structure

- Structural shotcrete walls approximately 50% completed
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- Façade of South Building
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- Façade of North Building
Pre-construction shooting of mock-up of column/wall connection, to prequalify shotcrete nozzleman for project
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- Completion of shooting of pre-construction mock-up of column/wall connection
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- View of back stripped face of mock-up column/wall connection
- Note complete lack of any voids, shadows or other defects
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- View of locations of cores to be extracted for core grading in pre-construction mock-up of wall/column connection
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- View of 5 cores extracted at locations of reinforcing steel from wall/column connection mock-up
- All cores were better than Grade 2
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- Interior of North building, gutted and braced
- Reinforcing steel installed in exterior walls, pilasters and columns, ready for shotcreting
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- L-bar anchors grouted into exterior stone masonry walls
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- Double mat of rebar installed on exterior masonry wall, ready for shotcreting
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- Nozzlman bench gun shooting 450 mm thick structural shotcrete wall
- Basement shotcrete left in natural shotcrete finish (since basement backfilled)
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- Bench gun shooting 1m deep pilaster through 4 layers of rebar
- Note nozzle inserted through first mat of rebar
Seismic Retrofit of Heritage Masonry Structure
Vancouver, BC

- View of above-grade perimeter wall being finished to line and grade
- Note shooting wire
Heavily Reinforced Structural Shotcrete Walls and Pilaster for New 50 Storey Hotel, Vancouver, BC

- Preconstruction mock-up of pilaster and wall
Heavily Reinforced Pilaster Mock-up with Two Sided Form

- Note shooting wire
Shooting Wall Mock-up with Wet-Mix Shotcrete

24/10/2008
Shooting Pilaster Mock-up
Shooting Pilaster Mock-up

- Note use of blow-pipe to control rebound
Use of Pencil Vibrator to Help Consolidate Shotcrete in Wall Mock-up
Trimming Shotcrete to Line and Grade with Cutting Rod
Finishing Shotcrete with Rotary Disc
Final Finishing of Shotcrete
Diamond Saw Cutting Wall and Pilaster Mock-ups
Saw Cut Wall Section
Close-up of Saw-cut Wall Section
Saw-Cut Pilaster Section

- Note dense shotcrete
Close-up of Saw-Cut Pilaster Section

- Note excellent shotcrete consolidation around dense reinforcing steel
Cores Extracted from Pilaster

- Note excellent consolidation of shotcrete
Cores Extracted from Wall Section

- Note excellent consolidation of shotcrete around dense reinforcing steel
Whistler 2010 Olympics - Bobsleigh/Luge Track
Installation of Rebar and Cooling Pipes in Track
Stay-Form

Expanded Metal Lath
Correct and Incorrect Method of Encasing Reinforcing Bars with Shotcrete

Fig. 8.4—Correct (left) and incorrect (right) method of encasing reinforcing bars with shotcrete
Typical Reinforcing and Cooling Pipe Detail

- Note use of expanded metal lath in first sections of track
Note Use of Diagonal Spacer Bar
Note Congestion at Cooling Pipe Header
Track Ready for Shooting

- Note use of temporary plastic screed bars
Void and Coarse Aggregate
Trapped Behind Expanded Metal Lath
Stay-Form Removed and High Pressure Water Blasted
Void at Congested Area of Cooling Pipe Baffle and Diagonal Spacer Bar, After Hydro-blasting
Void at Cooling Pipe Spacer Bar After Hydro-blasting
Construction of Second Mock-up Using Stay-Form
Start of Shotcreting Shoot Cove
Between Wall/Floor First
Shoot Floor Next
Consolidate Shotcrete in Cove/Floor with Immersion Vibrator
Fully Consolidated Shotcrete In Cove/Wall
Blow out Rebound/Overspray with Blow-pipe
Shoot First Lift on Wall
Back Face of Wall

- Note lack of voids behind stay-form
Pumping Shotcrete into Header Beams for Subsequent Consolidation with Immersion Vibrators
Header Form Stripped off Still-Fresh Shotcrete
Finish Coat Applied to Flush with Screed Pipes
Screeding Shotcrete to Temporary Screed Pipes
Finishing of Shotcrete After Screed Pipe Removal
Broom Texture Finish (to aid ice adhesion)
Newly Finished Shotcrete Surface
being Moist Cured by Misting
Misting with Water Pressure Sprayer
Cut-out Section from Second Mock-up

- Note good consolidation around rebar, cooling pipes and stay-form
Close-up View of Cut-out from Second Mock-up

- Note good consolidation of shotcrete
Completed section of Track
Whistler 2010 Winter Olympics
Bobsleigh/Luge Track Finish Zone
Whistler 2010 Winter Olympics
Bobsleigh/Luge Track

Inspection of iced track prior to first run by Canadian World Champion Bobsledders Pierre Lueders and Justin Kripps

Photo Courtesy VANOC/ Photos: David McColm
Whistler 2010 Winter Olympics
Bobsleigh/Luge Track

Canadian bobsledders Pierre Lueders, pilot and Justin Kripps push off their two-man bobsled from a lower start for their first run down The Whistler Sliding Centre track

Photo Courtesy VANOC/ Photos: David McColm
Whistler 2010 Winter Olympics
Bobsleigh/Luge Track

Start of first run on track

Photo Courtesy VANOC/ Photos: David McColm
Whistler 2010 Winter Olympics
Bobsleigh/Luge Track

- First run on track

Photo Courtesy VANOC/ Photos: David McColm
Whistler 2010 Winter Olympics
Bobsleigh/Luge Track

- Air time at finish

Photo Courtesy VANOC/ Photos: David McColm
Whistler 2010 Winter Olympics
Bobsleigh/Luge Track

Photo Courtesy VANOC/ Photos: David McColm