Use of SCC in High Density Concrete Repairs

ACI Convention
Minneapolis, Minnesota
April 15, 2013

Robert Quattrociocchi, EllisDon
Use of SCC in High Density Concrete Repairs

- Construction began in 2004 for the Lakeridge Health Centre – North Wing Expansion (Oshawa, Ontario)
- New cancer treatment facility housing 7 radiation therapy bunkers
Use of SCC in High Density Concrete Repairs

- 12 Segments of bunker walls were comprised of high density (HD) concrete (3,950 kg/m³ wet and 3,850 kg/m³) @ 25 MPa
- Thickness of high density walls ranged from 800mm (31”) to 1,500mm (59”)
- Required to attenuate gamma ray radiation from linear accelerators
- Remainder of walls were regular density concrete (2,400 kg/m³) to be poured concurrently with HD walls
Use of SCC in High Density Concrete Repairs

- Hematite aggregate from Brazil
  - Specific Gravity = 5
  - 20mm (3/4”) nominal

- Benificated Hematite sand from Quebec, Canada
  - Specific Gravity = 4.9
  - FM = 1.8

Cost for HD Concrete = $1,000 per m³ ($760 per yd³) !!
Use of SCC in High Density Concrete Repairs

Here’s the problem......
What’s with all the honeycombing?
Use of SCC in High Density Concrete Repairs

Why all the honeycombing?

- Low slump (well below target)
- High slump (well above target)
- 3rd party testing took way too long
- Improper consolidation
- HD concrete poured in alternating 6” lifts with RD concrete (extended pour duration)
- Issues integrating HD concrete with RD concrete
- Yada yada yada ……..
Use of SCC in High Density Concrete Repairs

Improper consolidation between pour lifts
Use of SCC in High Density Concrete Repairs

HD concrete not integral with RD concrete
DANGER
DUE TO
CRAZY-BRICKIES
LAZY
06/07/2005
HD Concrete Repair

Procedure:

Take #1

“The Conventional Approach”
Use of SCC in High Density Concrete Repairs

- High density grout to a “dry-pack” consistency
- Steel shot used as coarse aggregate (SG=7.8)
- Hematite sand used for fine aggregate (SG=4.9)
- Shrinkage Compensating Admixture
- Latex bonding agent
- Mixed in 30L mortar mixer
Use of SCC in High Density Concrete Repairs

- Affected zones chipped out to sound material
- Perimeter areas benched to provide min ½” ledge
- Exposed base substrate washed with high pressure sprayer

- Tapcons with tie-wire set into base substrate for transfer of shrinkage strains at bond line
- 10m rebar added for shrinkage restraint if depth of repair permitted
Use of SCC in High Density Concrete Repairs

- Mortar “thrown” at the surface in layers
- Highly labour intensive / time consuming
- Issues with weight of material for use in a vertical repair
- Issues with achieving complete filling around rebar
There has to be a better way.....
Use of SCC in High Density Concrete Repairs

- Sounding or tapping process indicated potential for voids
- Ultrasonic Pulse Velocity (corelated to results from cores) used to verify integrity of patches
- Results indicated that several patches had delaminated / contained voids
- We needed another approach.........and fast!!!
HD Concrete Repair

Procedure:

Take #2

“The SCC Approach”
Use of SCC in High Density Concrete Repairs

- We couldn’t get it wrong a 3rd time!
- Decided to apply “SCC Technology” to solve our problem
- Some recent experience with SCC, but never in repair applications
- Our new mix had to:
  - Be pourable
  - Have high flow properties
  - Optimize density
  - Be stable (no segregation)
  - Prevent or mitigate shrinkage
  - Reduce the overall labour component / schedule
Use of SCC in High Density Concrete Repairs

- Targeted 4,000 kg/m³ wet density
- Steel shot (SG=7.8)
- Hematite sand (SG=4.9)
- Type 10 cement
- HRWR - polycarboxylate based (ASTM C 494 Type A & F)
- VMA - liquid cellulose based
- Shrinkage Compensating Admixture
- Latex bonding agent
Use of SCC in High Density Concrete Repairs

- High paste volume required:
  - due to shape and gradation of Hematite sand
  - due to void ratios of both the sand and steel shot
  - to act as carrier for high density aggregate
  - for filling around rebar

- 720 kg/m³ of Type 10 used for flowable mix
Use of SCC in High Density Concrete Repairs

- Preliminary trials performed in the field
- Initially targeted 650mm (26”) slump flow
- We were achieving the flow we needed, but mix was unstable
- Experienced segregation issues at this slump flow level
Use of SCC in High Density Concrete Repairs

To increase stability while maintaining our spread we:

- Reduced water content
- Increased HRWR
- Increased VMA
- Trial & Error process
- The results............
560 mm (22”)
Use of SCC in High Density Concrete Repairs

**High Density SCC Recipe:**
- 5 liter batch
- Butter mixer with blend of steel shot, sand, cement and water
- Add steel shot
- Add cement and blend
- Add sand to mixture
- Add 90% of water & SRA
- Add HRWR and 5% of water
- Add VMA and remainder of water
- Mix until consistency achieved
- Check slump flow (if not min. 560mm, temper with HRWR)
- Forms installed with a beak extending 75mm (3”) above patch
- Perimeter of forms and joints sealed with caulking
- Drainage hole with plug installed at bottom of form to check for watertightness and for preconditioning
Use of SCC in High Density Concrete Repairs

Placing:

- SCC poured in 3 uniform lifts to reduce drop
- Formwork tapped after each lift to remove air bubbles
- Filled to min. 75mm (3") above patch
- Larger patches formed in segments
- After first lift was placed, another panel was installed above
Curing:

- Forms left in place for 3 days after placing
- Curing compound sprayed on patch upon form removal
Use of SCC in High Density Concrete Repairs

Verification of Patches:

- Grout cubes taken at the beginning and end of each day to monitor strength
- Surfaces tapped with rebar to determine if hollow sounds present
- Ultrasonic Pulse Velocity testing performed once more after 7 days
High Density Bunker Walls:

- From October 2006 – July 2007
- 4000 kg/m³ high density SCC concrete for radiation therapy bunkers
- SCC required to provide full consolidation between rebar and to flow beneath block-outs cast-in for mechanical ductwork sleeving
- Technology transfer to local readymix producers in the Caribbean
- Concrete trials performed in lab (Toronto) and in field to prove the viability of the mix
- Series of mock-ups cast on site to verify performance and constructability
National Oncology Centre
Mount Hope, Trinidad & Tobago