Use of SCC in High Density Concrete Repairs

ACI Convention

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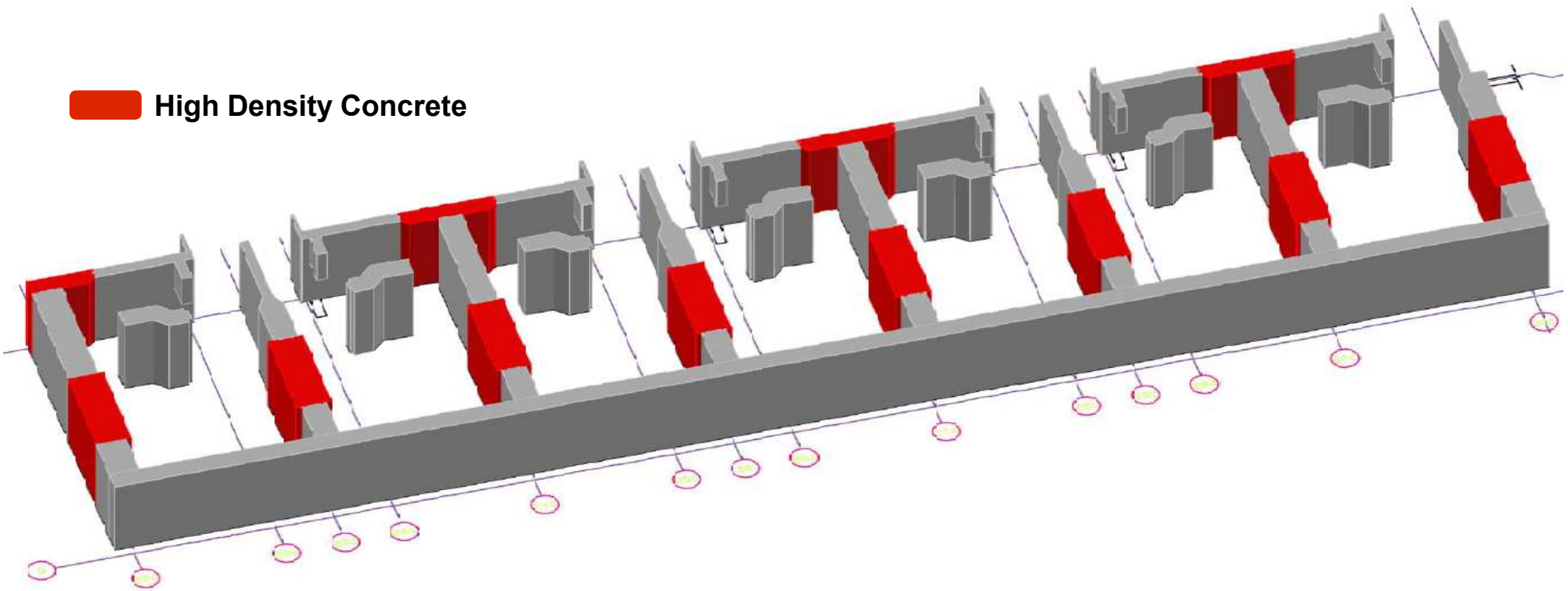
Use of SCC in High Density Concrete Repairs

- 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/m^3 wet and 3,850 kg/m^3) @ 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/m^3) 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 m^3 ($760 per yd^3) !!

Use of SCC in High Density Concrete Repairs

Here's the problem……


What's with all the honeycombing?
13/10/200

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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 ……..

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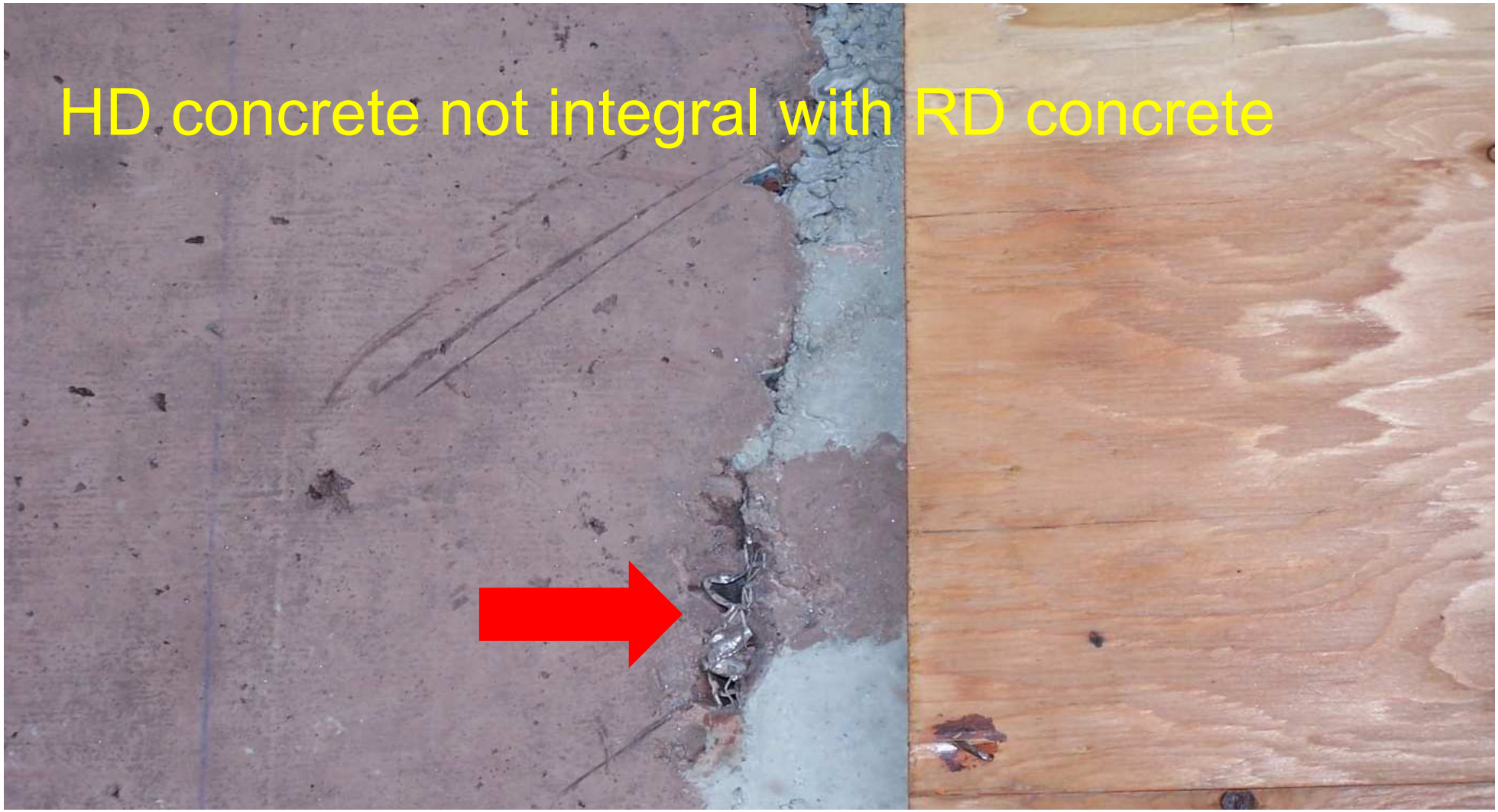



DANGER
DUE TO
CRAZY-BRICKIES
LAZY
P022
06/07/2005

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

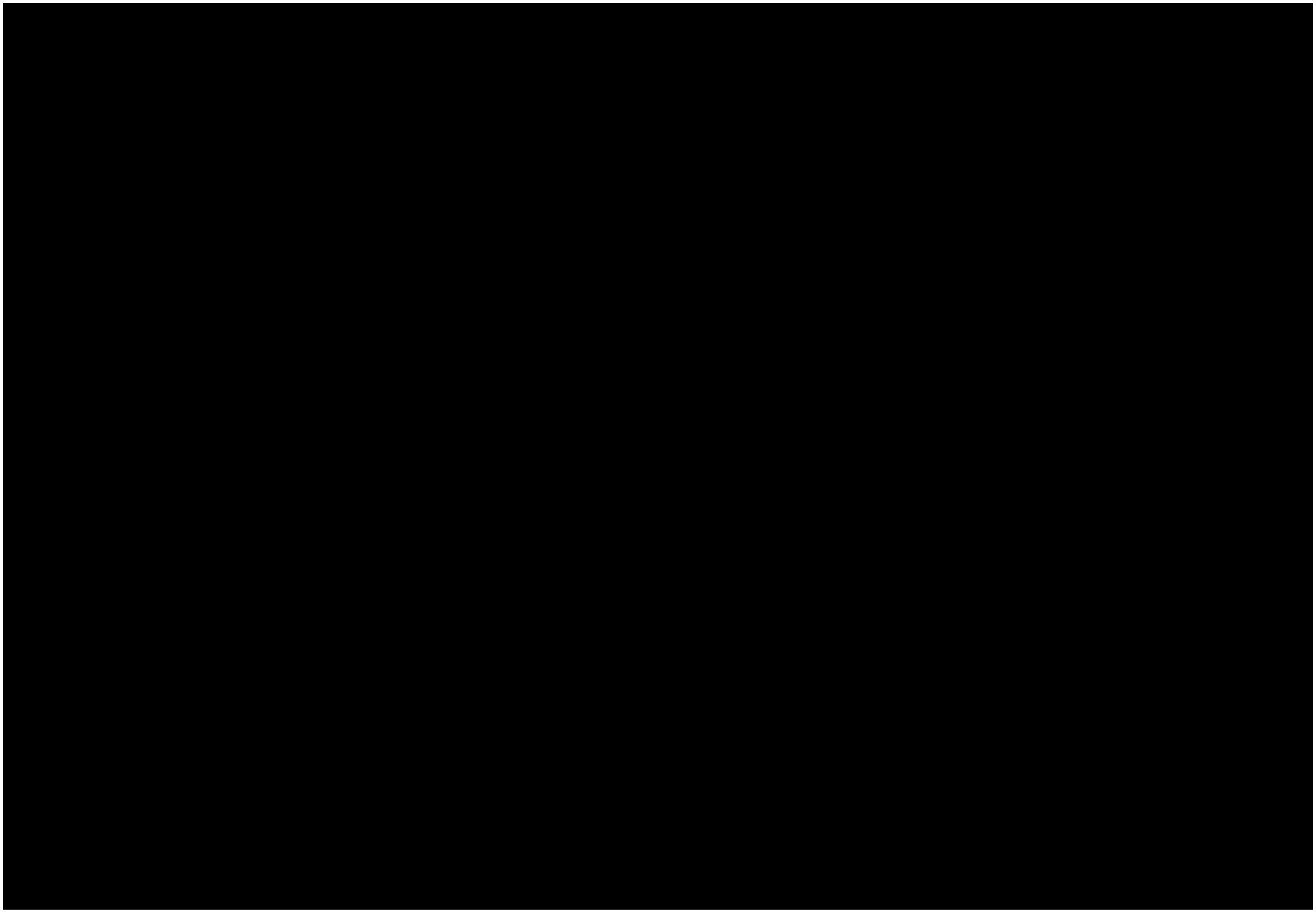
Use of SCC in High Density Concrete Repairs

- 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

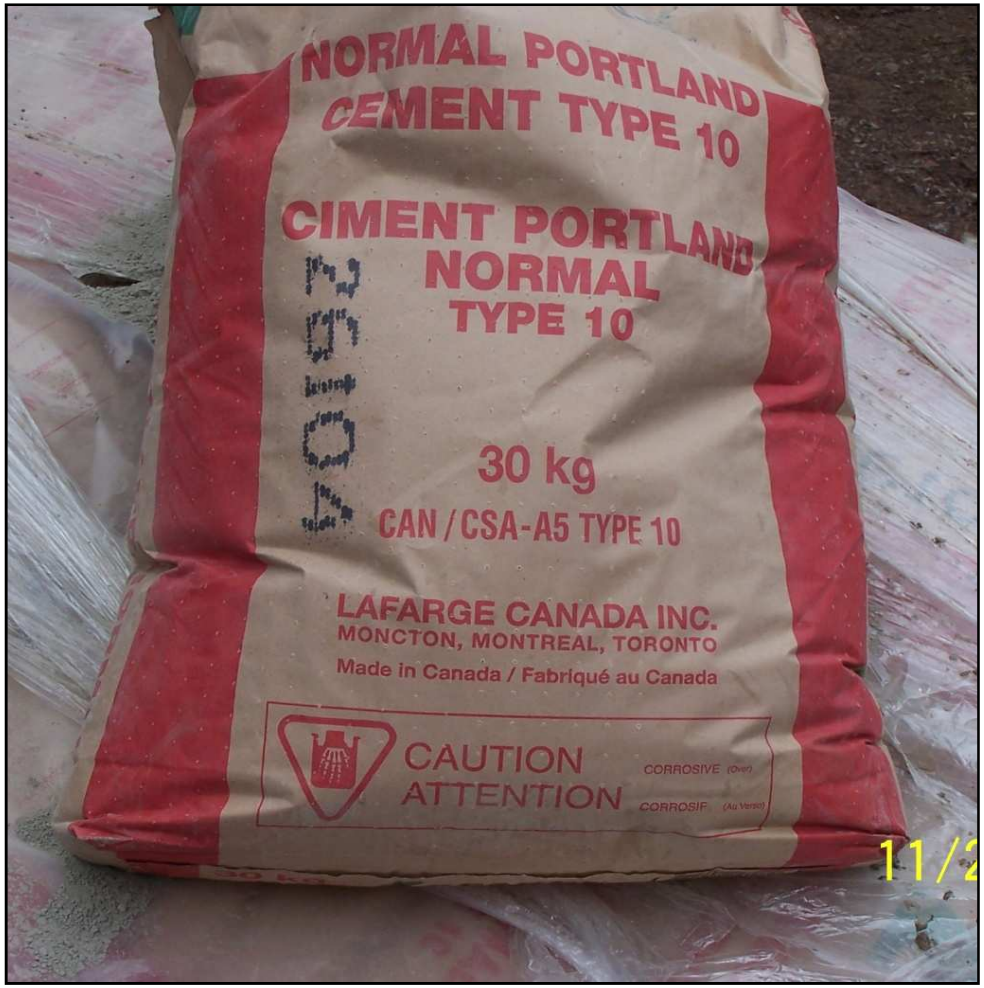
Use of SCC in High Density Concrete Repairs

- Targeted 4,000 kg/m^3 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/m^3 of Type 10 used for flowable mix



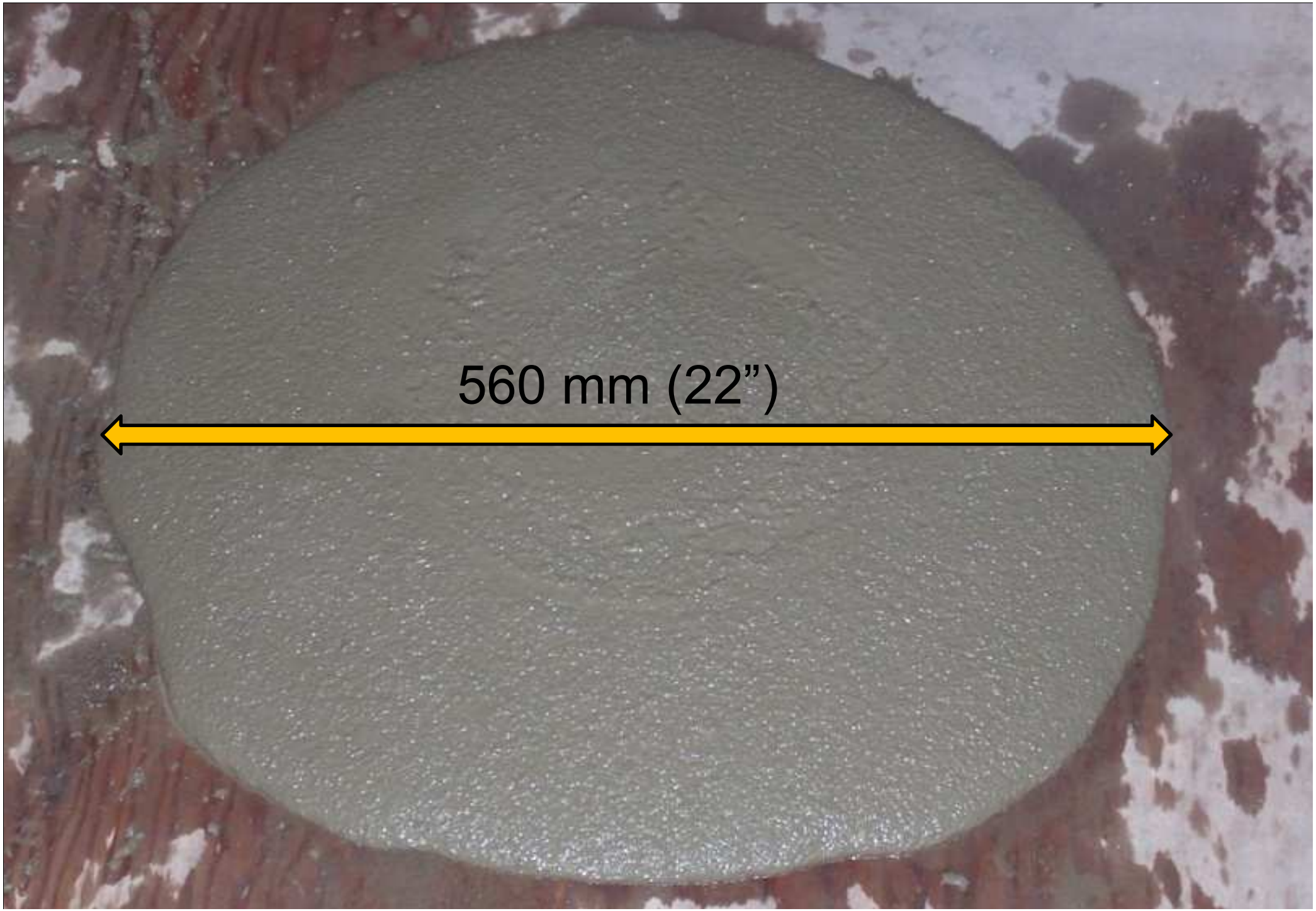
Use of SCC in High Density Concrete Repairs

- 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

<u>High Density SCC Recipe</u>:

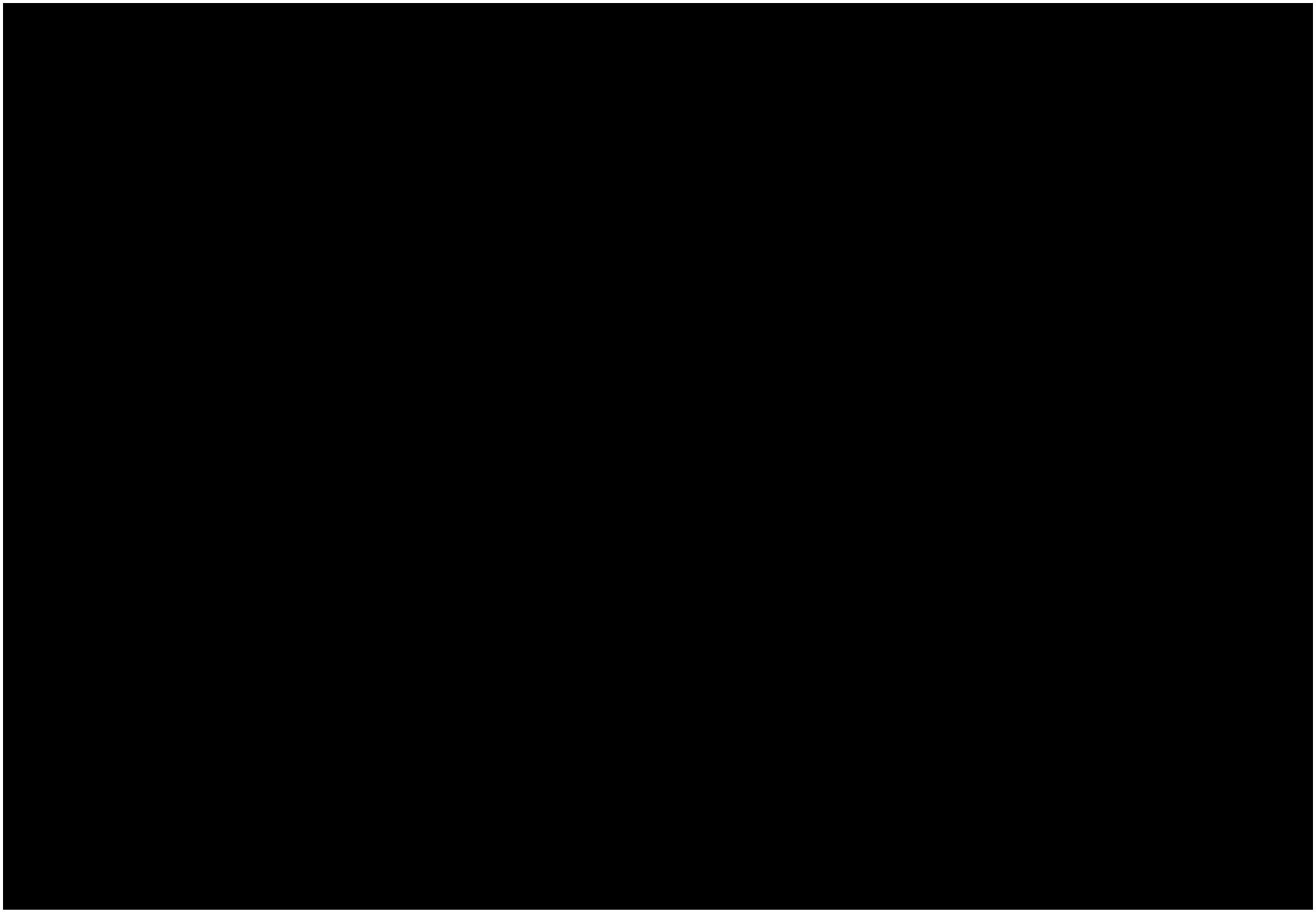
- 5 liter batch
- Butter mixer with blend of steel shot, sand, cement and water
- Add steel shot
- Add cement and blend
- Add sand to mixture
- Add 90% of water & SRA
- Add HRWR and 5% of water
- Add VMA and remainder of water
- Mix until consistency achieved
- Check slump flow (if not min. 560mm, temper 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 water tightness 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

National Oncology Centre

Mount Hope, Trinidad & Tobago

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

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