



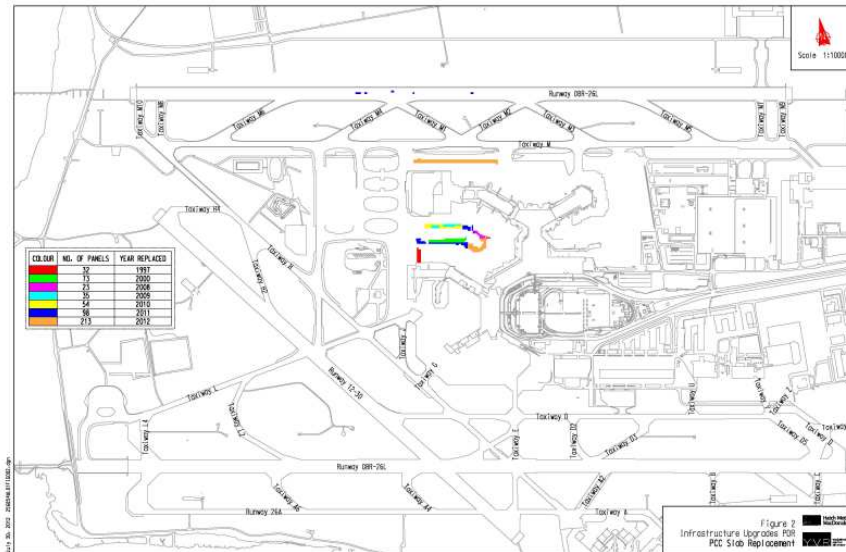
Runway Concrete Slab Replacement in Record Time at YVR

Lincoln Chan, P.Eng.
Principal Project Manager, Associate

Project Overview

- Vancouver International Airport (YVR)
Slab Replacement Program (Year 2010 – 2012)
- Focus on Pavement Distresses around Centreline of
 - **Runway 08L – 26R (North Runway)**
 - Taxiways JA, JB and JC
 - Apron VI “International Horseshoe”
- HMM’s Roles
 - Pavement Assessment
 - Planning and Coordination
 - Cost Estimates, Detailed Design and Construction Services

YVR PCC Slab Replacement Program



Challenges

- Ground Conditions
- Vancouver Weather
- Control of Foreign Object Debris (FOD) during Demolition
- Very Limited Gate and Runway Closure Windows



Strategies

- Minimize Excavation Depth to avoid Ground Water
- Separation of Base Course from Subbase:
 - Geotextile and Geogrid
- Base Layer:
 - 40mm-minus clear crush
- Stabilized Base Layer:
 - 4MPa to 10MPa Lean Concrete
- PCC Layer:
 - High Early Strength Concrete - 4.8MPa (700psi) fr in 7 days
 - **Rapid Strength Concrete – Lafarge Chronolia® 4H**
Target of 3.5MPa fr within 24hrs and 4.8MPa fr within 46hrs



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Lafarge Chronolia® 4H Concrete

- Proprietary concrete mix in accordance with CSA A23.1/A23.2
- Properties:
 - Maximum Aggregate Size: 40mm
 - Slump after 60min: 180mm to 230mm (2 hour workability)
 - Air Content: 4.0 to 6.0%
 - f'c: 30MPa in 24 hours & 37MPa in 46 hours
 - Target fr: 3.5MPa within 24 hours & 4.8MPa within 46 hours
 - Drying Shrinkage (ASTM C157): ~-0.028% Length Δ at 28 days – Low
 - Rapid Chloride Permeability (ASTM 1202): ~950 C at 28 days – Very Low
 - Hardened Air Void Test (ASTM C457): Spacing Factor of ~135 μ m - Satisfactory
 - Freeze-Thaw Cycles (ASTM C666): Weight Lost of ~-0.18% after 300 cycles
 - Alkali Aggregate Reaction (ASTM C1293, CSA A23.2-14A): ~0.0003 at 2 years

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Runway 08L–26R PCC Replacement

- Replace eleven 7.5m x 6.0m x 380mm reinforced PCC slabs over five different areas along the centreline
- PCC slabs to be removed, replaced and cure within 59 hours
(April 15, 20:00 - April 18, 07:00)
- Rain or shine
(allotted timeframe, can not reschedule)



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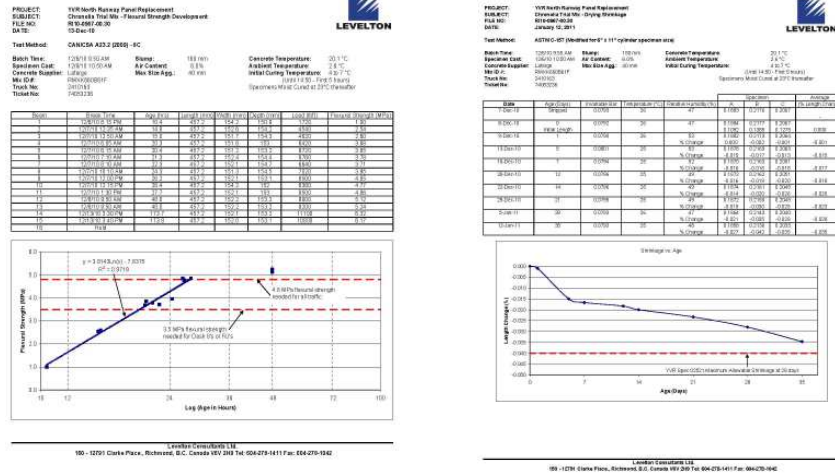
Concrete Trials

YVRAA, HMM and Levelton agreed on testing Lafarge Chronolia® 4H as a solution for rapid strength gain concrete for the project.

- First trial performed at Lafarge Kent Street batch plant on December 6, 2010
 - Air content: 6%
 - Slump: 180mm
 - Moist cured at 23°C after 5th hour
 - Flexural Strength: 3.5MPa at ~20hrs & 4.8MPa at ~26hrs
 - Drying Shrinkage: -0.028% at 28 days
 - Issue: segregation

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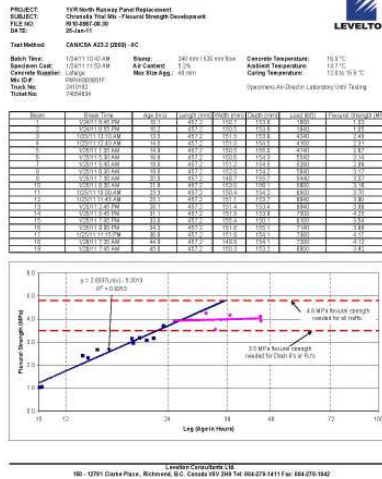
First Trial



Concrete Trials (cont'd)

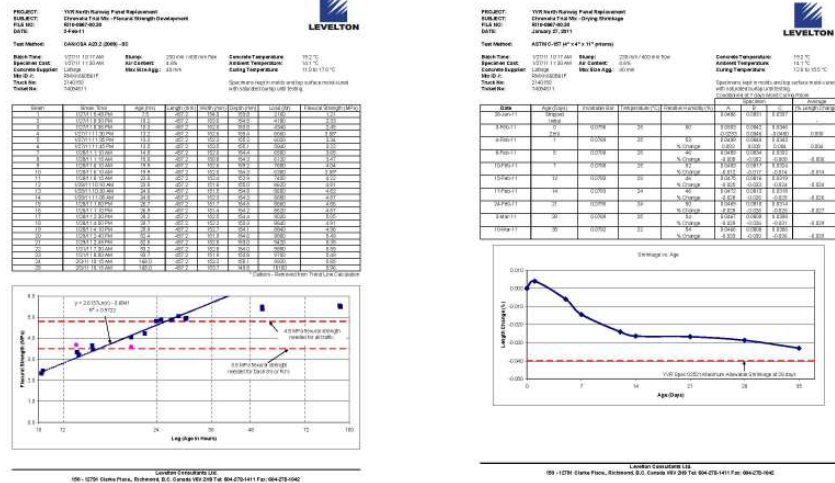
- Second trial performed at Levelton's laboratory on January 24, 2011 to simulate 30 – 40 mins of transit time
 - Air content: 5.2%
 - Slump: 240mm
 - Air-dried in laboratory until testing
 - Flexural Strength: 3.5MPa at ~23hrs & levelled off at 4.1MPa after ~36hrs
 - Issue: possible phenomenon known as "accelerator burn-out" of cementing materials (lack of supplementary water during air-dry conditioning in laboratory until testing)

Second Trial



Concrete Trials (cont'd)

- Third trial performed at Levelton's laboratory on January 28, 2011
 - Air content: 4.6%
 - Slump: 230mm
 - Specimens kept in molds and top surface moist-cured with burlap
 - Flexural Strength: 3.5MPa at ~15hrs & 4.8MPa at ~24hrs
 - Drying Shrinkage: -0.029% at 28 days
 - Issue: none
- Success!



Project Requirements

- Construction Methodology
- Full-time QC Manager
- Minimum two mock-up panels
- Provision for inclement weather (tenting, hoarding, heaters, etc.)
- Redundant/standby equipment
- Backup batch plant

Price Tag

- Three bidders
- Awarded project in February 2011
- Construction cost: ~\$550K (or \$50K per panel)
- Lafarge Chronolia® 4H Concrete: \$1,100/m³



Project Team

client: **Vancouver Airport Authority (YVRAA)**

consultant: **Hatch Mott MacDonald (HMM)**

YVRAA's QA: **Levelton Consulting Ltd.**

contractor: **Jacob Bros Construction (JBC)**

subs:

- Lafarge Canada Inc. (Chronolia® concrete)
- Gastaldo Concrete Ltd. (concrete placing and finishing)
- CanWest Concrete Cutting & Sealing (sawcutting, drilling & dowels)
- LMS Reinforcing Steel Group (rebars)
- Sealtec Industries (sealant)
- True Colors Painting Ltd. (pavement paint markings)
- Baskin Associates Technical Services (contractor's QC)
- Pro-tech Surveys Ltd. (survey)



Construction Methodology

- Distinct crews and crew superintendent for each activity
- Mock-up to simulate worse case scenarios
- Double sawcut panel edges and relief cut (3 x 3 matrix) one day before runway closure
- 10.5m wide temporary tent structure on wheels for inclement weather and ensure curing environment
- Placement of PCC by line pump and triple roller screed
- Heat and wet curing
- Second batch plant on standby

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Redundant Materials & Equipment



Vancouver International Airport Authority
Contract CFC-11-8360-723
North Runway Slab Replacement 2011

Redundant Materials & Equipment

Equipment:

- Mechanics service truck
- Low-bed
- Tandem c/w flat deck trailer
- Haul crane truck
- Ambulance (to be used as mobile first-aid room)
- Water truck, hoses for pressure washers & curing
- Flat deck trailer with 500 gal water tank
- Portable trailer with portable toilets
- 2 – diesel light towers
- 1 – 550 excavator
- 1 – ZX35U excavator with breaker
- Skid steer
- JD 310 Backhoe with breaker & forks, Case 580 Backhoe
- Wheel loader c/w broom
- Pressure washer
- 6 – Workable lights
- 1 – radiant heater c/w 12' flex hose
- Gas power cut-off saws, circular saw with diamond blade, grinder with diamond blade & cup stone
- 5 – 5500W - 5000W generators
- 6 – 2" electric water pumps & hoses
- 2 – 1/4" puddle pumps & garden hoses
- 2 – burke bars for prying relief cuts
- 2 – TE72 chipping hammers with bits
- 1 – Terramite triple roller screed
- 1 – single roller screed
- 2 – power trowels, hand trowels, shovels, rakes, brooms, floats (too many to list)
- 1 – backpack concrete vibrator
- Shovels, brooms
- Cement finish tools for Set 45
- Gasoline & diesel – fuel in service truck
- Split kits

Materials:

- 4 boxes 1/2" clear crushed gravel for fill of voids in CSB and topping up to maintain 380mm thickness of PCC
- Reinforcing – 20m straight bars – 48 - 7.3m, 88 - 5.8m
- 1 pallet (50 bags) Set 45 for repair of chips in adjacent PCC
- Spare epoxy dowels (100)
- Spare poly. lumber for protection & wash-out
- Rubber conveyor belts for moving track machines

April 15, 2011



Vancouver International Airport Authority
Contract CFC-11-8360-723
North Runway Slab Replacement 2011

- Spare tarps for hoarding
- 6 – 100lb propane bottles
- Killy litter for damming
- Ropes
- Straps
- Hardwood wedges
- Dimension lumber (2x8, 2x10) for bracing & temp bulkheads
- Full height (380mm) bulkhead with notches for dowels

April 15, 2011

Lessons Learned from Mock-up

- Placement of first truck was at 90mins from batching to simulate worst case scenario for concrete delivery → lost slump very quickly
- Due to high slump of concrete, placement crew had difficult time building the material up to top of the form → cold joint formed between first and second loads
- Finishing crew reported the mix was very “sticky” → required significant amount of water and power pan float to finish the surface
- Entire form was not filled due to shortage of material → wet material not completely discharged from batch plant
- Average temperature of 20°C was maintained in the tent and slab was 25°C warmer than temperature outside the tent → risk of cracking due to thermal shock in the concrete when tent is removed

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Lessons Learned from Mock-up

FIELD REVIEW REPORT (Continued)			
PROJECT:	No.	PROJECT No.	DATE:
2011 North Runway Repair Project	1	8013-9897-00-30	08 April 2011
 <p>Photo 1: Lead 1 - Note build-up of Leading Edge</p>			
 <p>Photo 2: Leads 1 and 2 - Note Hardened Concrete from the First Load</p>			
 <p>Photo 3: Surface Finish After Pass with Triple Roller Screen</p>			
 <p>Photo 4: Power Floating the Surface</p>			

Page 3 of 6 Per David Smith, MScE, P.Eng. Levelton Consultants Ltd.

Lessons Learned from 2nd Mock-up

- Uninterrupted supply of compliant concrete allowed continuous placement without the occurrence of cold joint
- Two mats of steel reinforcement in each direction (consistent with design) aided in preventing the concrete from self-leveling and allowed crew to build concrete up to the top of formwork to facilitate strike off with triple roller-screed
- Power trowel and water by fog-misting the surface worked well to close the surface

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Lessons Learned from 2nd Mock-up

FIELD REVIEW REPORT (Continued)			
PROJECT: 2011 North Runway Repair Project	No. 2	PROJECT No. R110-0907-00-30	DATE: April 11, 2011
LOCATION: Batch Plant Grounds			



Photo 2: Concrete consistency and rebar facilitate build-up of concrete to top of formwork.



Photo 3: Concrete consistency past extent of rebar is self-leveling.

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Per *[Signature]*
Levelton Consultants Ltd.

FIELD REVIEW REPORT (Continued)			
PROJECT: 2011 North Runway Repair Project	No. 2	PROJECT No. R110-0907-00-30	DATE: April 11, 2011
LOCATION: Batch Plant Grounds			



Photo 4: Power trowel with pan float and fog misting of the concrete surface.



Photo 5: Application of broom texture finish.

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Per *[Signature]*
Levelton Consultants Ltd.

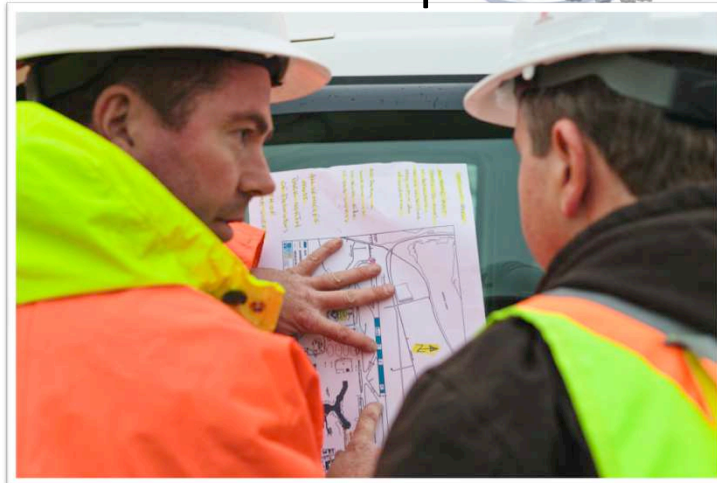
The Big Day – April 15, 2011



Time 18:30 - Safety Huddle

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Time Lapse



Time 19:00 – Superintendent Confirming Plan with Project Director

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Time Lapse



Time 19:55 – Equipment Queuing for 20:00 Start Time

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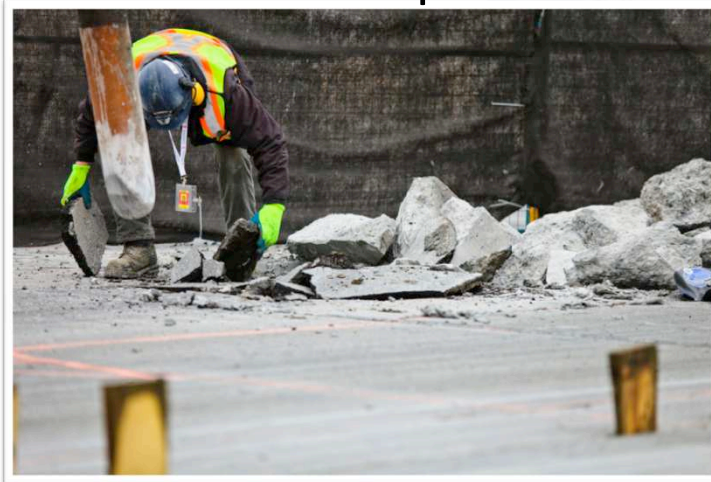
Time Lapse



Time 20:10 • (Area A) • PCC Demolition with Hydraulic Hammer

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Time Lapse



Time 20:20 • (Area A) • Separation of Asphalt Patches from PCC

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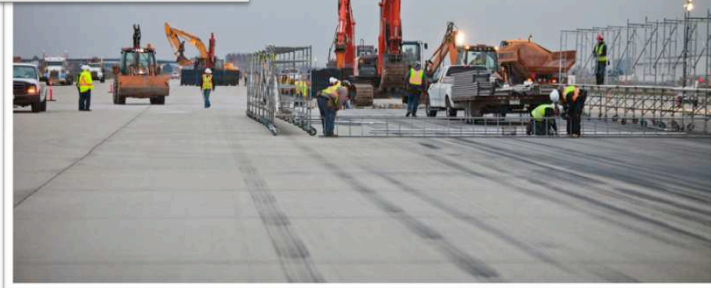
Time Lapse



Time 20:35 • (Area A) • Removal of 2.5m x 2.0m PCC Slabs with 2nd Excavator

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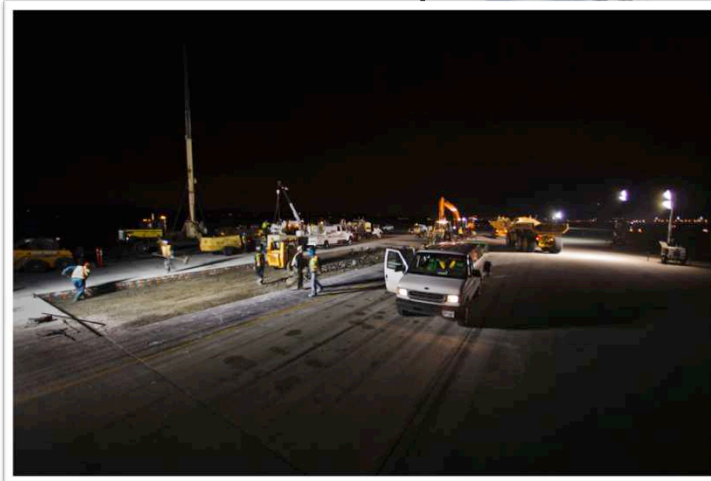
Time Lapse



Time 20:50 • (Area A) • 10.5m Tent Structure

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Time Lapse



Time 21:30 • (Area A) • Completion of PCC Demolition

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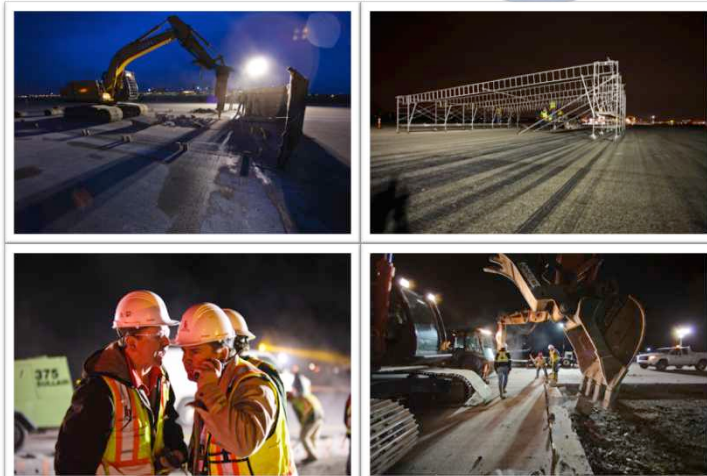
Time Lapse



Time 21:40 – 02:00 • (Area A) • Gang-drilling PCC for Dowel Placement
(30mins Ahead of Schedule)

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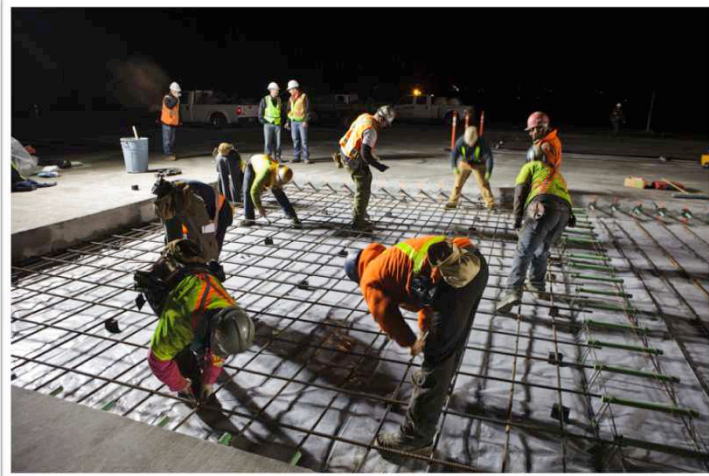
Time Lapse



Time 22:00 • (Areas B to E) • Activities in Other Areas

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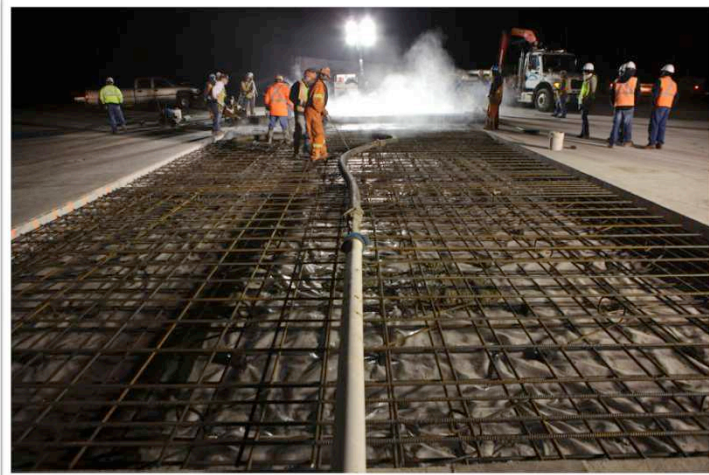
Time Lapse



Time 23:15 – 02:30 • (Area A) • Rebar Placement
(On Schedule)

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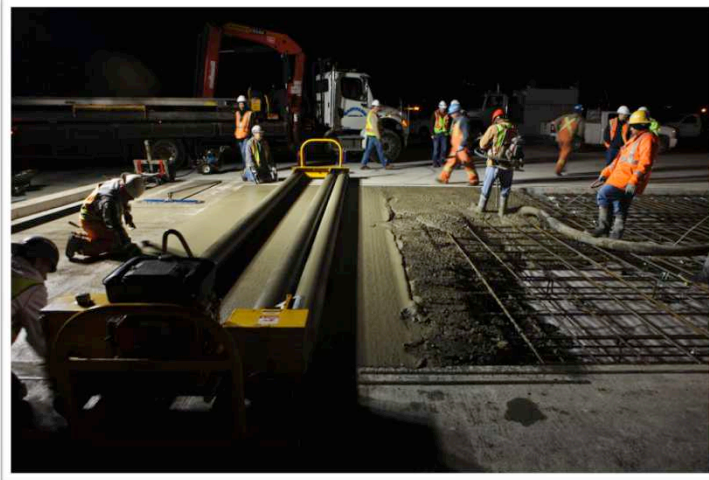
Time Lapse



Time 03:00 – 05:00 • (Area A) • PCC Placement Line Pump

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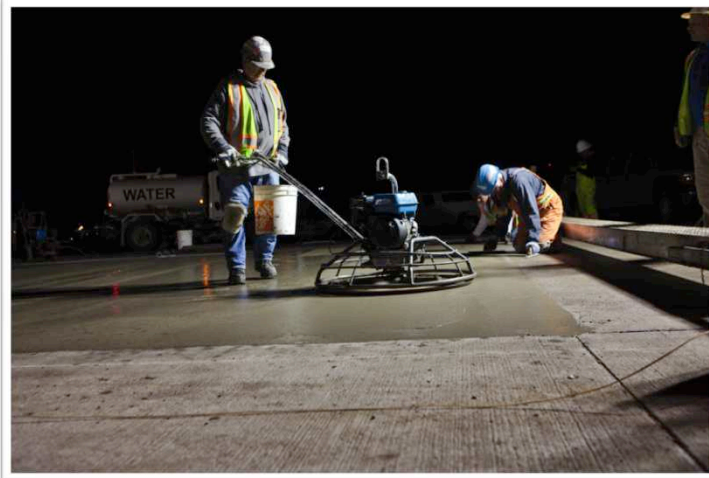
Time Lapse



Time 03:00 – 05:00 • (Area A) • Striking off PCC with Triple Roller Screed

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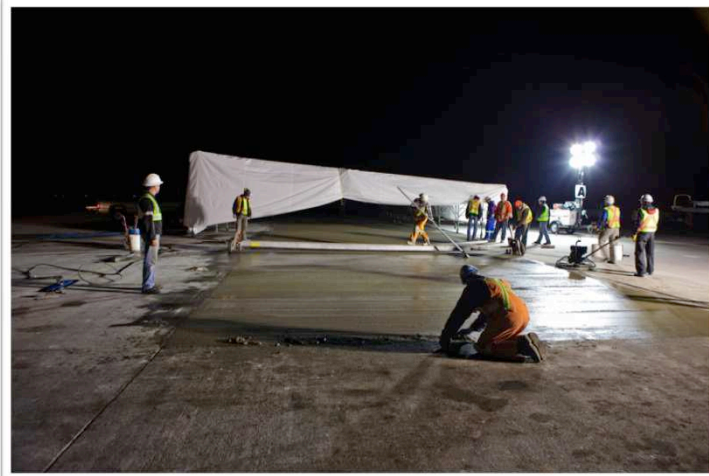
Time Lapse



Time 04:00 • (Area A) • Power Trowel PCC to Close the Surface

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Time Lapse



Time 05:00 • (Area A) • Rolling Tent in Place for Curing
(On Schedule)

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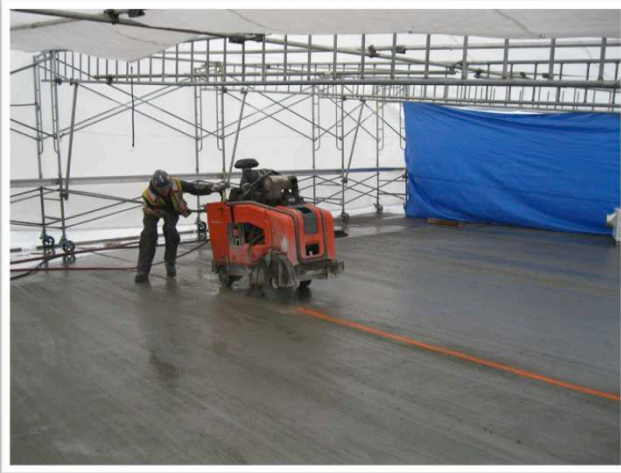
Time Lapse



Time 05:30 • (Area A) • Wet Curing at 20-25°C
(On Schedule)

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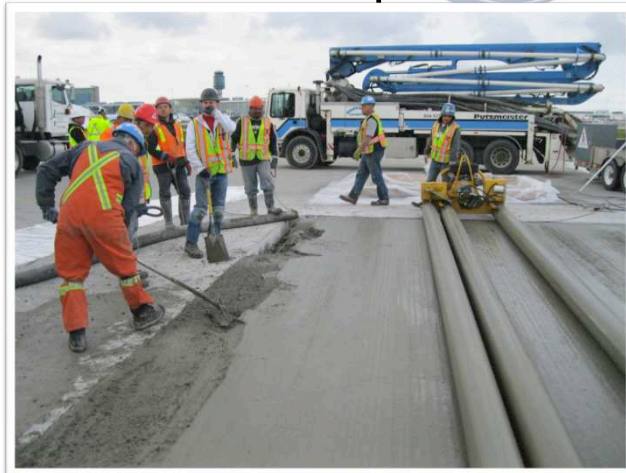
Time Lapse



Time 06:15 • (Area A) • Green Cutting of PCC

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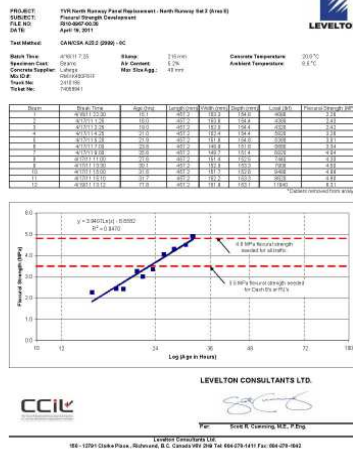
Time Lapse



Time 09:10 • (Area E) • Last PCC Slab
(On Schedule)

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Flexural Strength Results



4.8MPa (700psi) fr after 32hrs (at 15:00 on April 17, 2011)
(Runway Opened 13 hours Ahead of Schedule)



Questions?

