RC 2018 XVII Reunión del CONCRETO

El evento del Cemento, el Concreto y los Prefabricados

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El evento del Cemento, el Concreto y los Prefabricados

New Technology to Solve Quality Control Gaps in Concrete Production and Delivery

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Canada

Content

- Truck Probe
- Measurements
- Calibration
- Precision
- Systems
- Conclusion

Problem

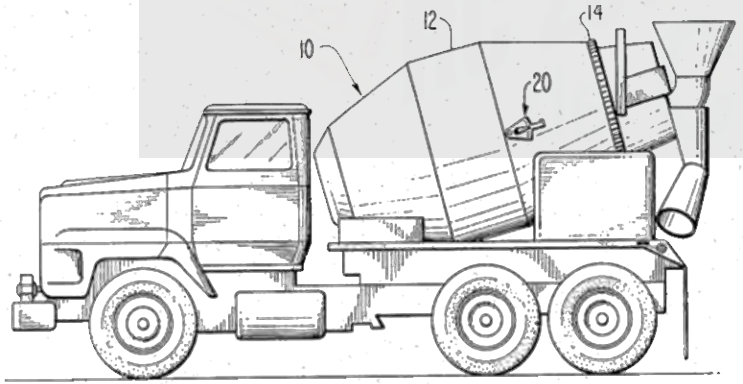
- The Ready Mix Producer is responsible for the final quality of a product, despite having very little control over quality after the product leaves the plant

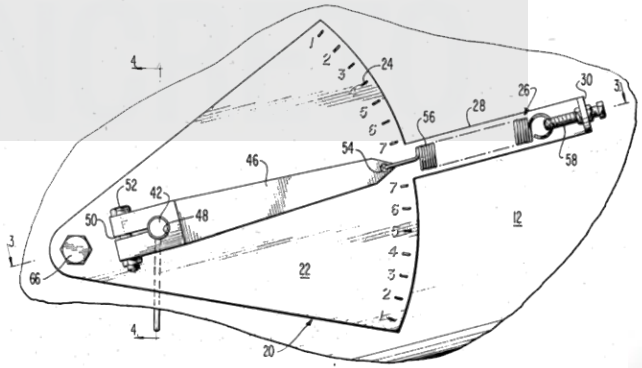
- Some ‘quality’ processes after batching actually don’t help assure quality, and slow down the delivery cycle

Historic

- Historically, there was many attempts to measure the properties of concrete directly into the drum of the ready mix which, is possible, have to solve some of the problems associated the delivery of a ever changing products.

- One of the first (1975) is described in US PAT 3,924,447)





Historic

- ACI Committee 238 technical note (in preparation) titled,

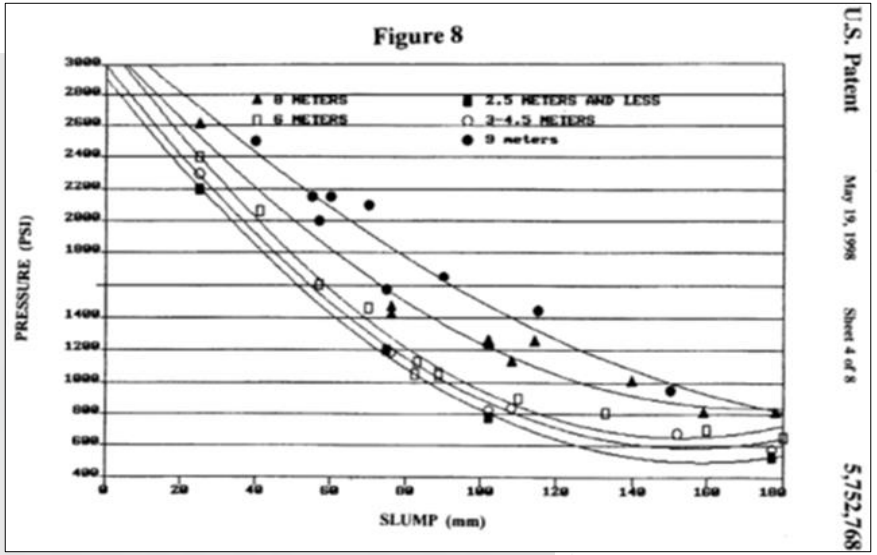
'Technical Note on Automatic Methods to Measure and Control Concrete Workability in Transit Mixers'

- Defines the following methods:
  - Indirect Method: Measurement of the hydraulic pressure in the drum's hydraulic system that rotates the drum.
  - Direct Method: Measurement of force acting on a sensor installed inside the mixer during drum rotations.

- The indirect method has many drawbacks but, even though, it has been around for long time, even as a basis for automatic adjustment in transit (1990, US PAT 4,900,453).

Indirect Methods

- Among the drawbacks, there are:
  - Varies with the size of the load
  - Varies with the speed of the drum
  - Varies with the mixtures
  - Not accurate for small load
  - Not accurate for fluid concrete
  - Need to calibrate every truck on regular basis
  - Is affected by the speed of the temperature of the oil
  - No direct measurement in slump

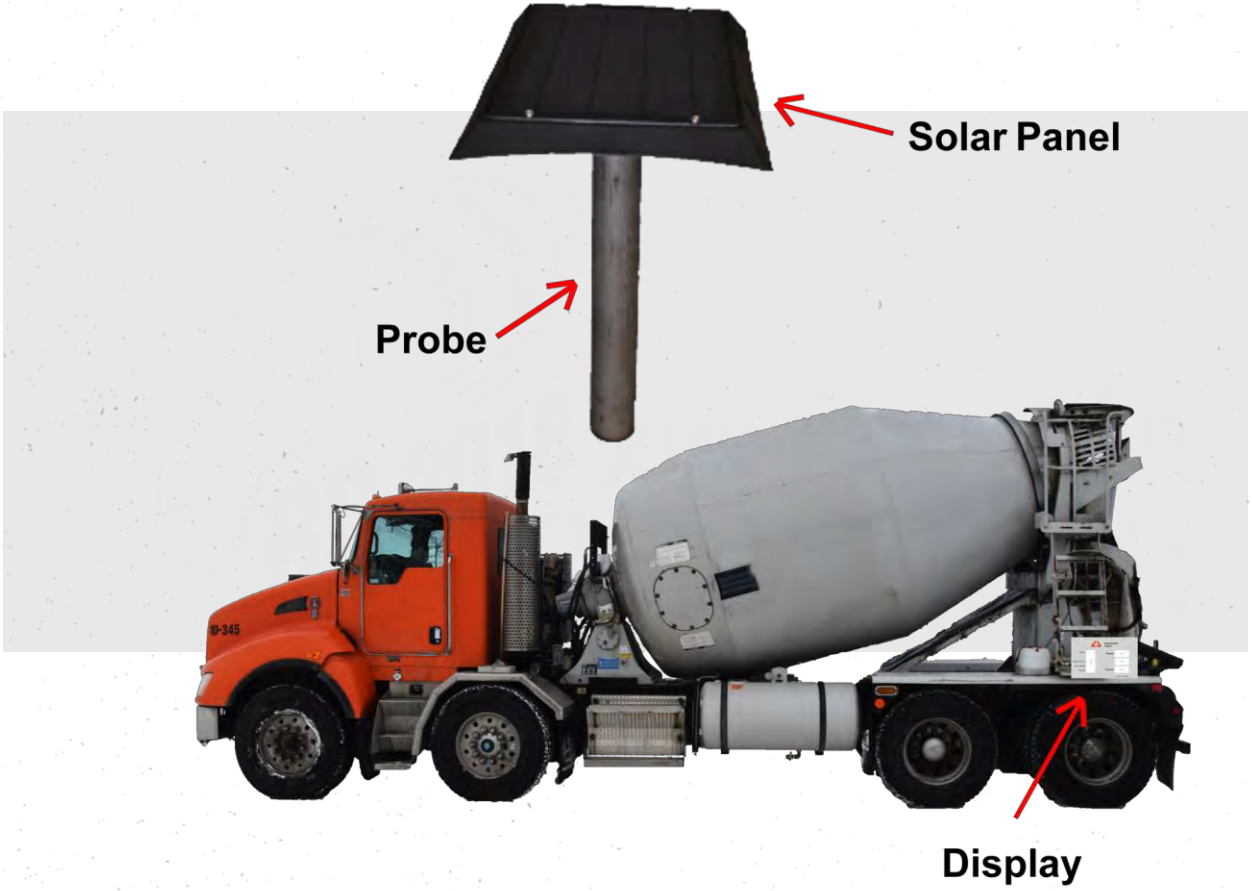


Solution

- An innovative in-Drum measurement device that can asses, among other, the properties of concrete in real time without sampling and human error: ‘The Truck Probe’.

- When integrated with other devices or systems, such as flow meters, GPS system, batching plant data etc., this Probe can be the most powerful tool to control the concrete quality.

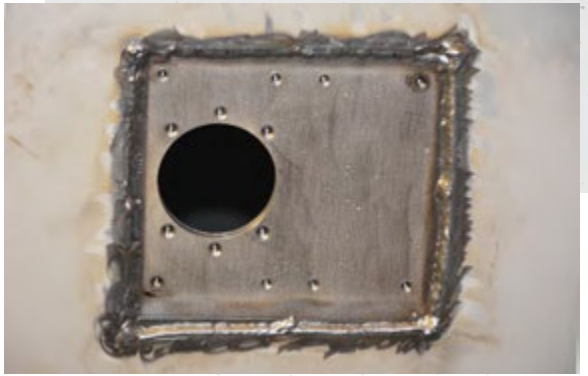
Description



Installation

- Installation (Probe only) takes less than 1.5 hours

- A hole must be made in the drum or the trap and a support plate must be welded. The rest is very easy work



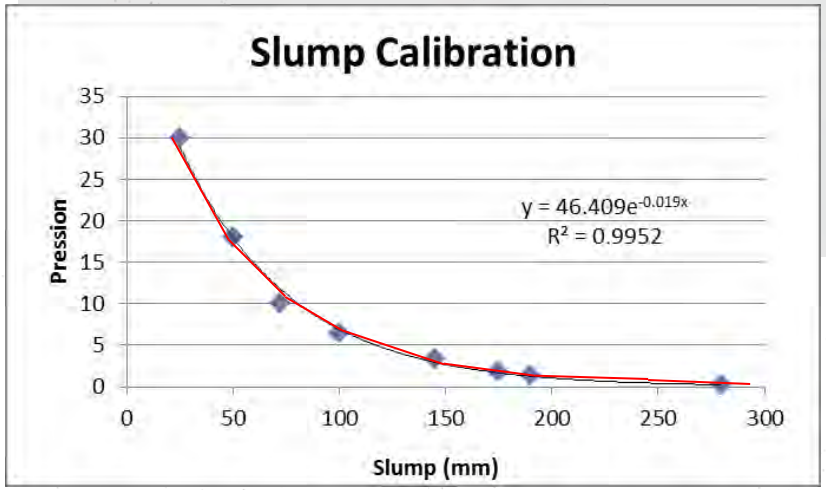
Measurement

- The Probe has many sensors:
  - Time
  - Angle
  - Temperature
  - Lateral pressures

- By combining these inputs:
  - Drum speed (Angle + Time)
  - Bottom Pressure (Angle + Drum speed + Lateral pressure)
  - Slump (Bottom pressure + Calibration)
  - Etc.

Calibration - Slump

- One way to establish a calibration (slump - pressure relationship) is to make a progressive addition of water and measure the slump after each addition while recording the pressure: when the slump goes up, the pressure goes down.

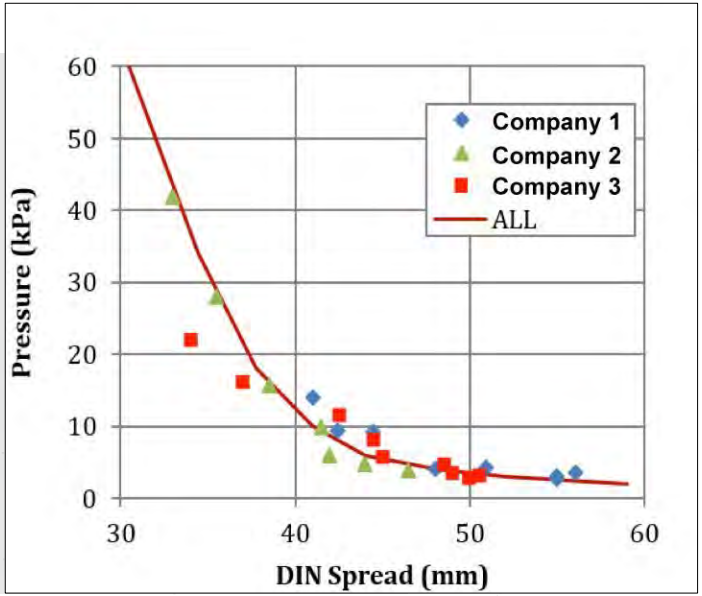


Pressure	Slump
30	30
18	50
10	80
4	14
…	…
…	…
…	…
0.01	290

Calibration - Slump

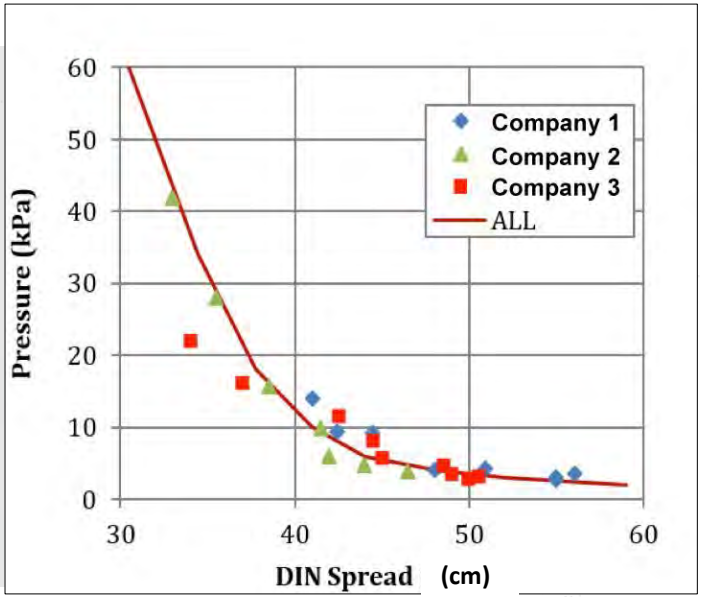
- Another way is to wait for the concrete to get stiff and take serval sample during that time while recording the pressure

- This can be done for different test method like German flow table or the slump flow



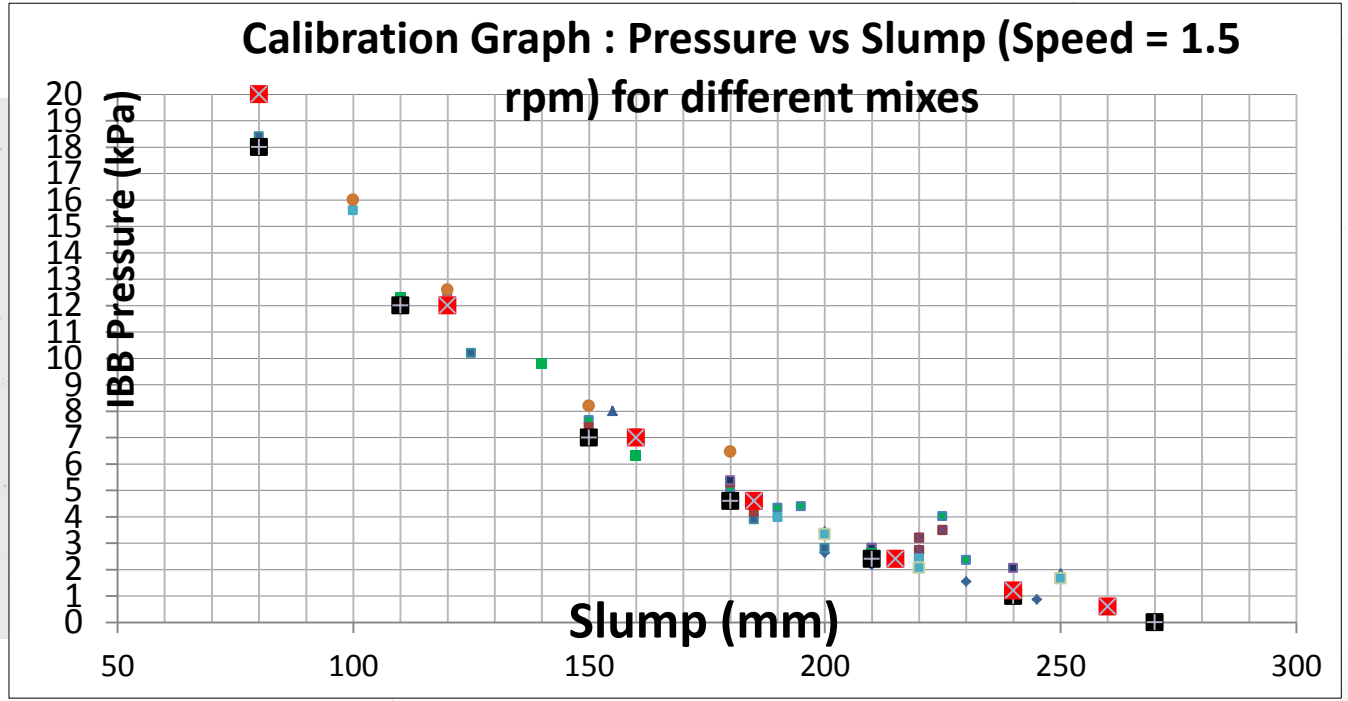
Calibration – (German Flow Table)

- Workability calibration can also be established for other test such as German Flow Table or Slump Flow (SCC).

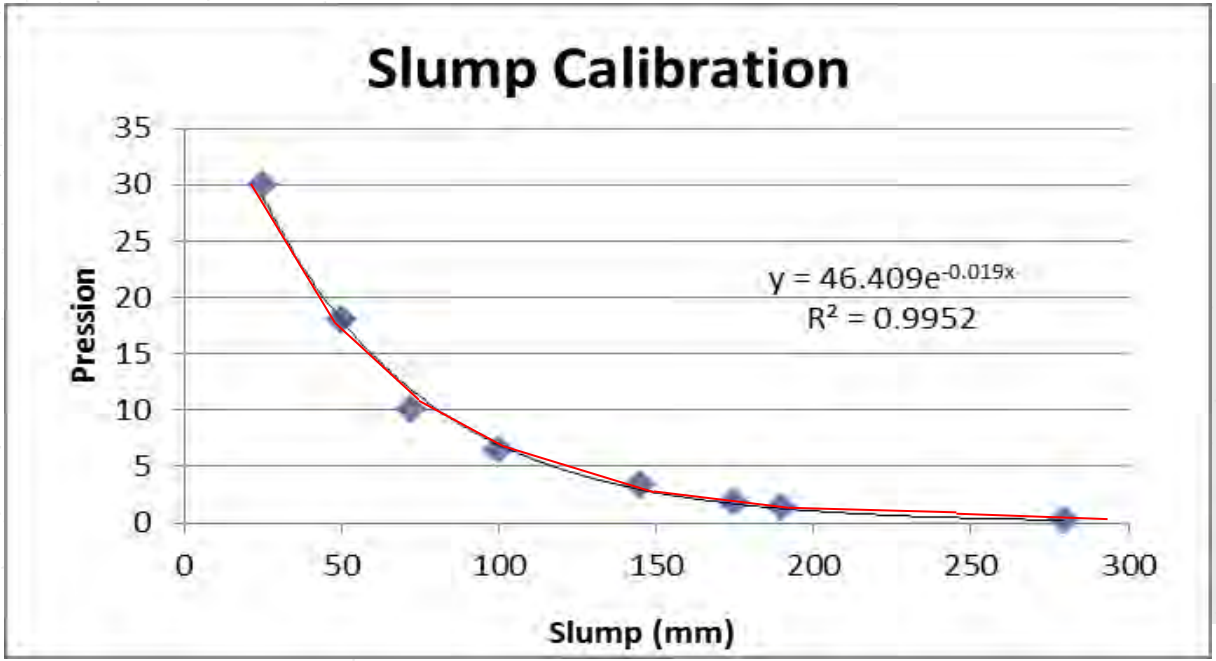


Calibration - Slump

- An other way to established a slump calibration is to measure simultaneously pressure and slump from many different loads of concrete at same time.



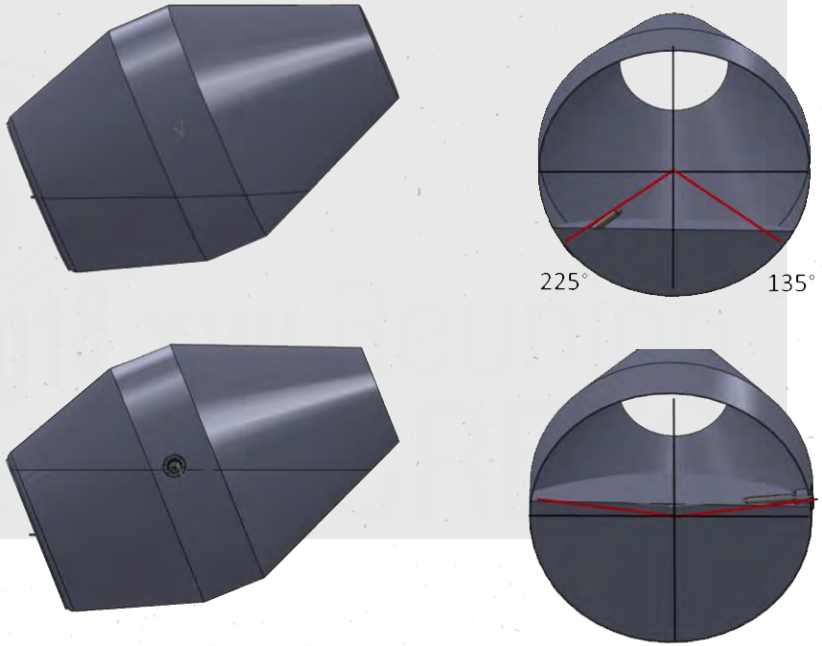
Calibration - Slump



Pressure	Slump
30	30
18	50
10	80
4	14
…	…
…	…
…	…
0.01	290

Measurement - Volume

- The Measured Volume is based on parameter called ‘’Ratio’’ which represents the level of concrete (needs Calibration)



Volume 1 m³

Arc = 90 °

Ratio = 0.25

Volume 3 m³

Arc = 190 °

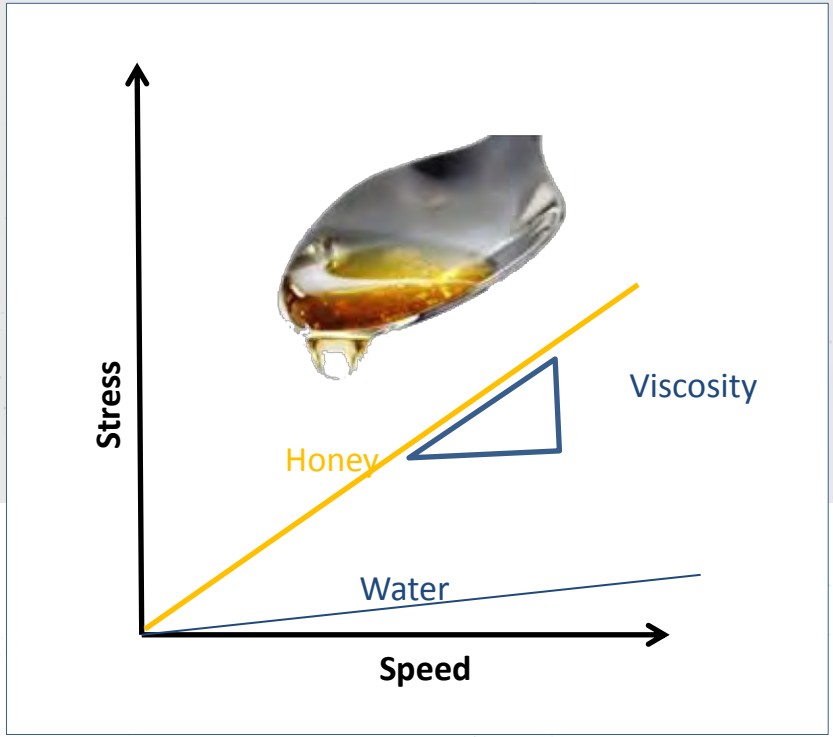
Ratio = 0.53

Measurement - Others

- Temperature (can detect rogue water addition)
- Status
  - Loading
  - Mixing
  - Mixing end (homogeneity)
  - Agitating
  - Unloading (calculates volume of remaining load)
  - Washing Drum empty
- Rheological Properties (Viscosity and Yield stress)
- The Probe sends all information to the Receiver or Display

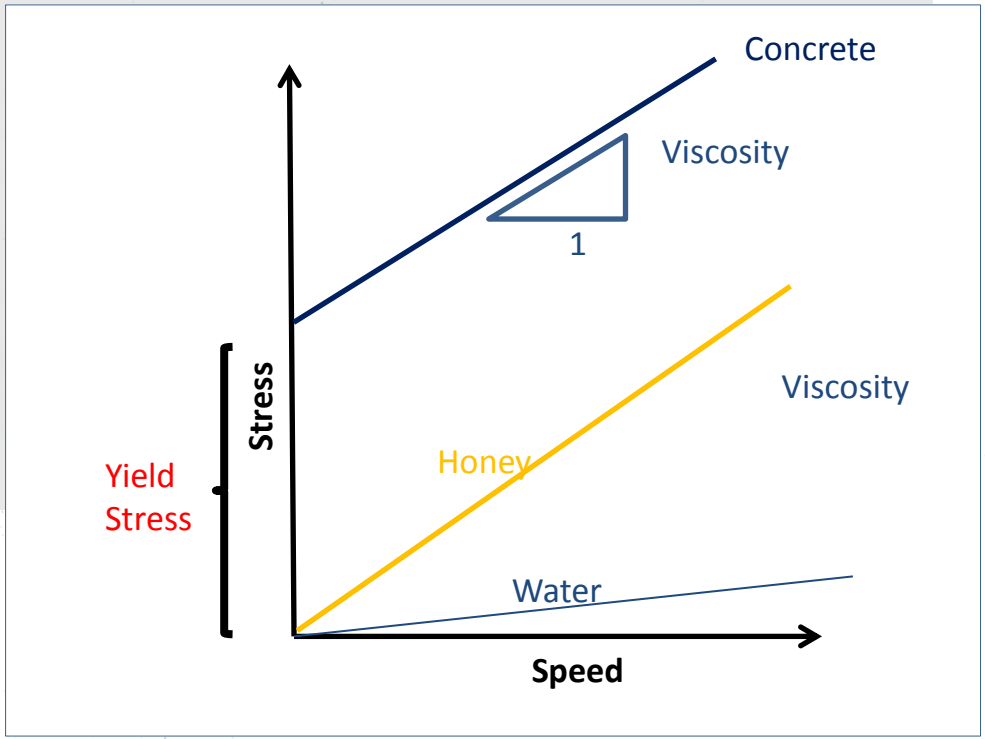
Viscosity

- Viscosity is the slope of the Stress vs Speed relationship

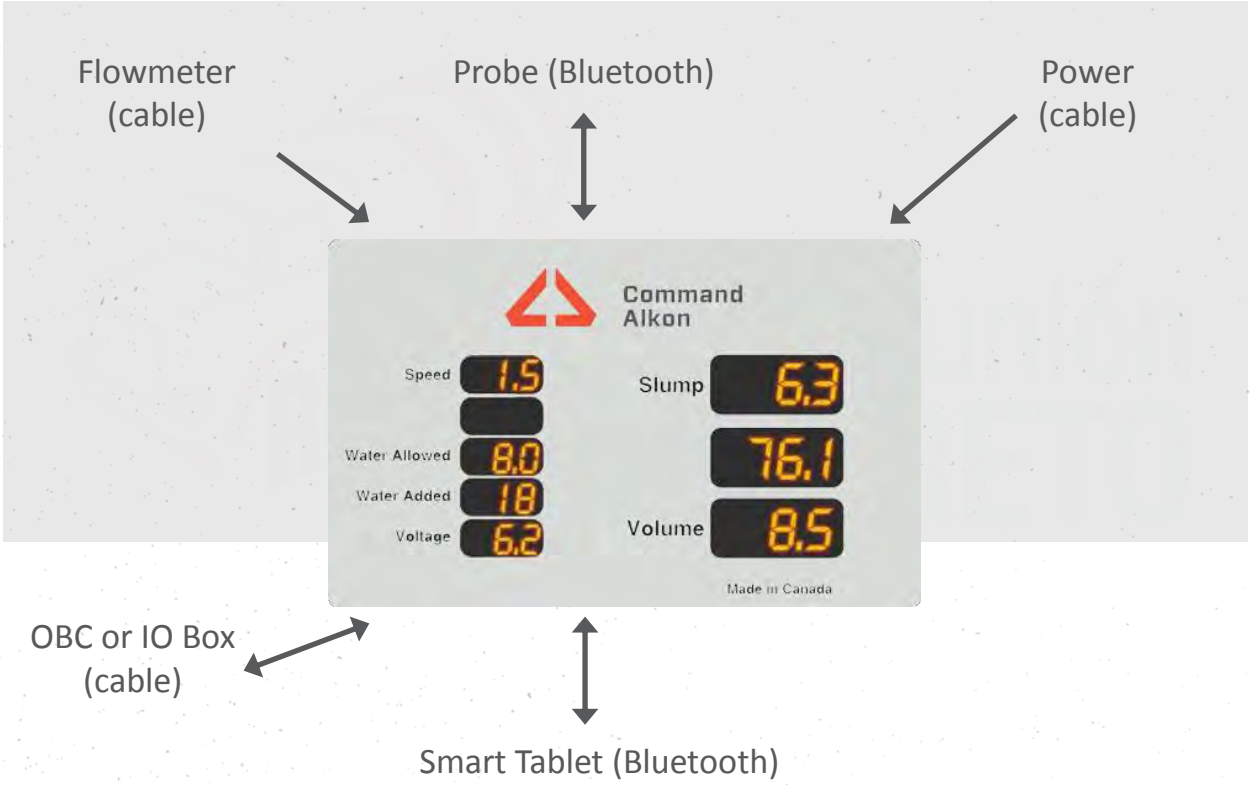


Rheological Properties

- Concrete, in addition to Viscosity, also has a Yield Stress (which is somewhat related to the slump)



Display - Optional

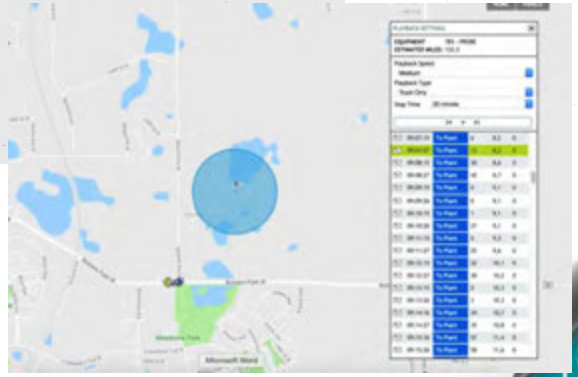


Advantages – Probe only

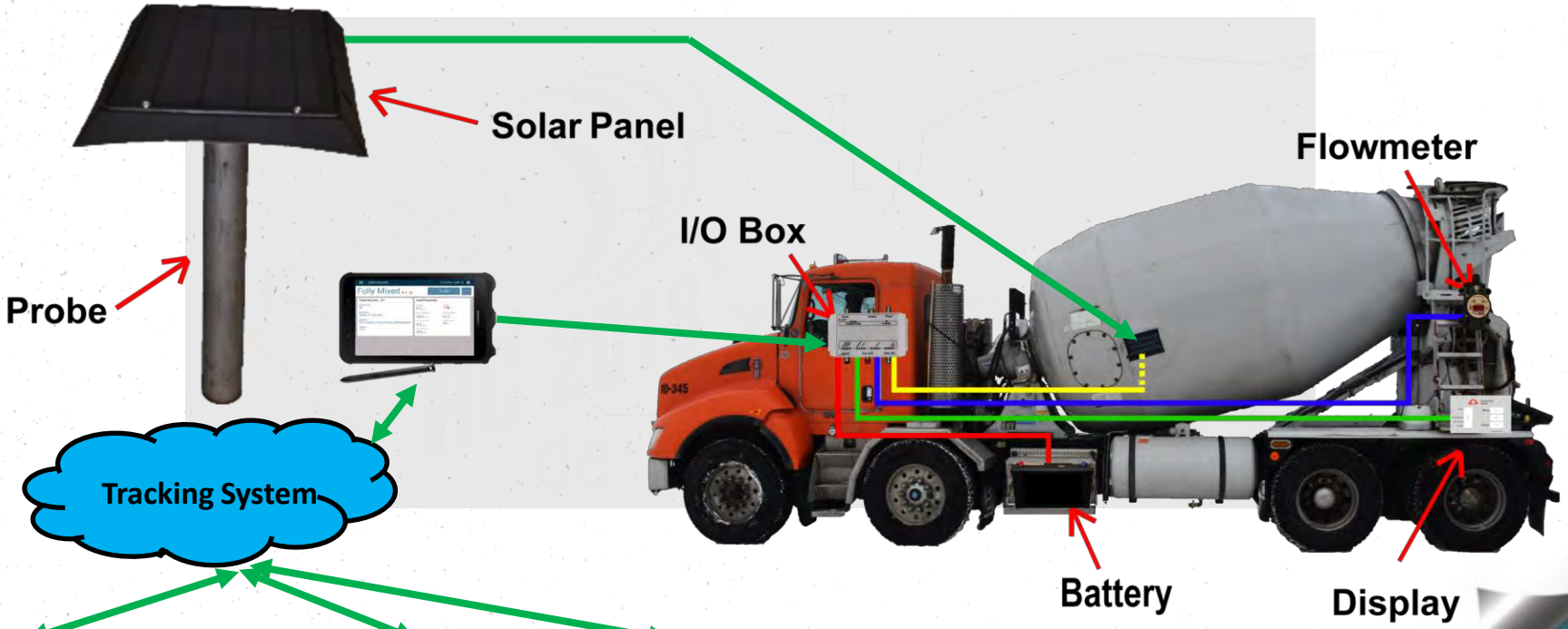
- Improves speed for site testing
- Reduces manpower needed at site
- Removes human influence from test results
- Reduces waste (no sampling)
- Each truck is a complete laboratory
- Improves operation control
- Reduces mixing time at plant and site (Cemstone 8-12$ per load)
- Allows smart reuse of returned concrete where allowed
- Reduces driver training time and improves safety

System – 'Upgrades'

- A flow meter is installed to monitor:
  - Amount of water added in the mixture
  - Amount of water used for washing
- A tracking system can be connected to get additional information:
  - Position
  - Truck speed
- By combining these with the probe data (more status):
  - Detection of theft
  - Washing and emptying in unauthorized location
  - Insure truck is empty before loading
  - Alarms can be set for all bad practices

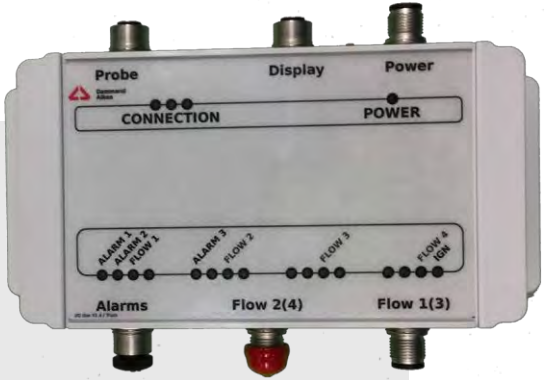


Integrated System



In-Cab Display

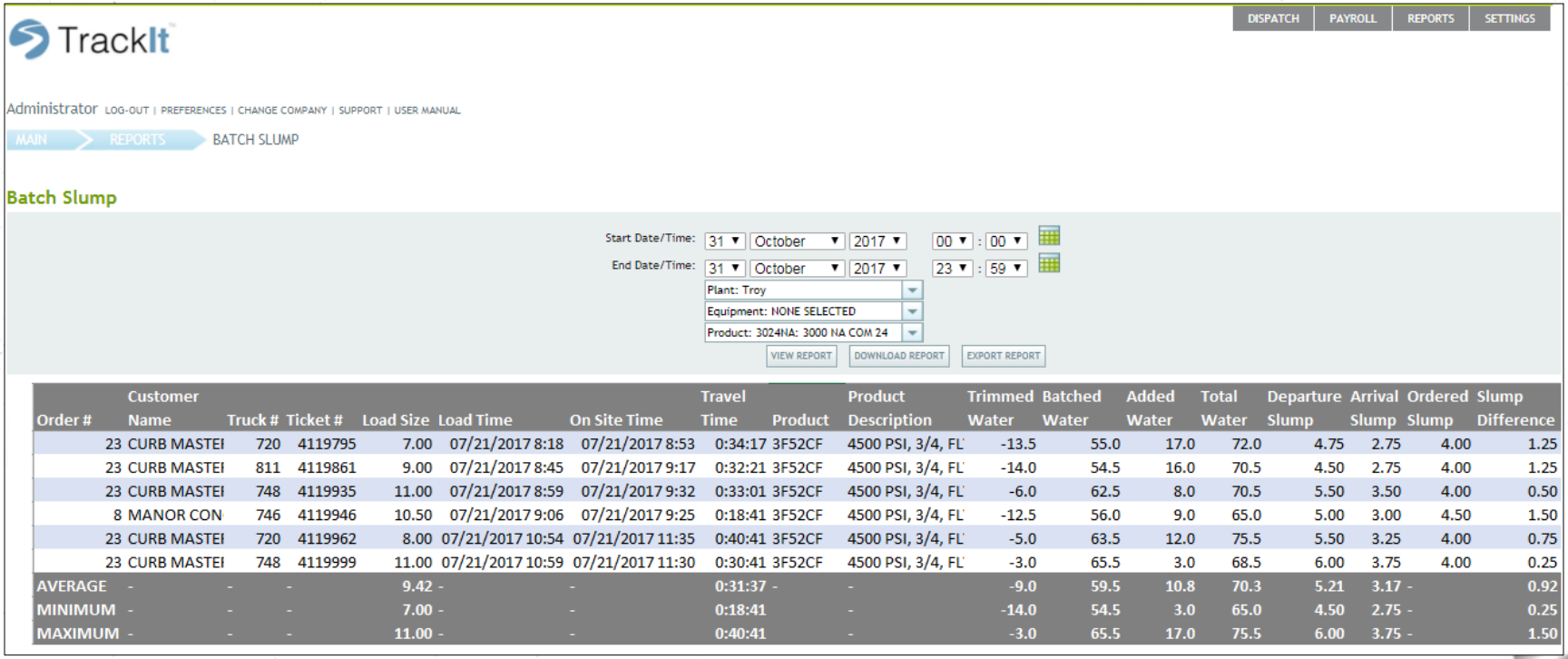
Probe, IO Box and Display



Production Features

- Batching:
  - Batch Report displays a historical view of load properties to batchman
  - Reuse water and concrete
- Transport & At Site:
  - The driver, batcher, dispatchers, and anyone with access can get quick feedback on fresh concrete properties
  - Automation of begin pour & end pour status
- Post Delivery:
  - Complete evolution of concrete properties can be reviewed after loads
  - Production timing & driver habit reviews
  - Tuning of water trim possible

Recording System



TrackIt

DISPATCH | PAYROLL | REPORTS | SETTINGS

Administrator LOG-OUT | PREFERENCES | CHANGE COMPANY | SUPPORT | USER MANUAL

MAIN > REPORTS > BATCH SLUMP

Batch Slump

Start Date/Time: 31 October 2017 00 : 00

End Date/Time: 31 October 2017 23 : 59

Plant: Troy

Equipment: NONE SELECTED

Product: 3024NA: 3000 NA COM 24

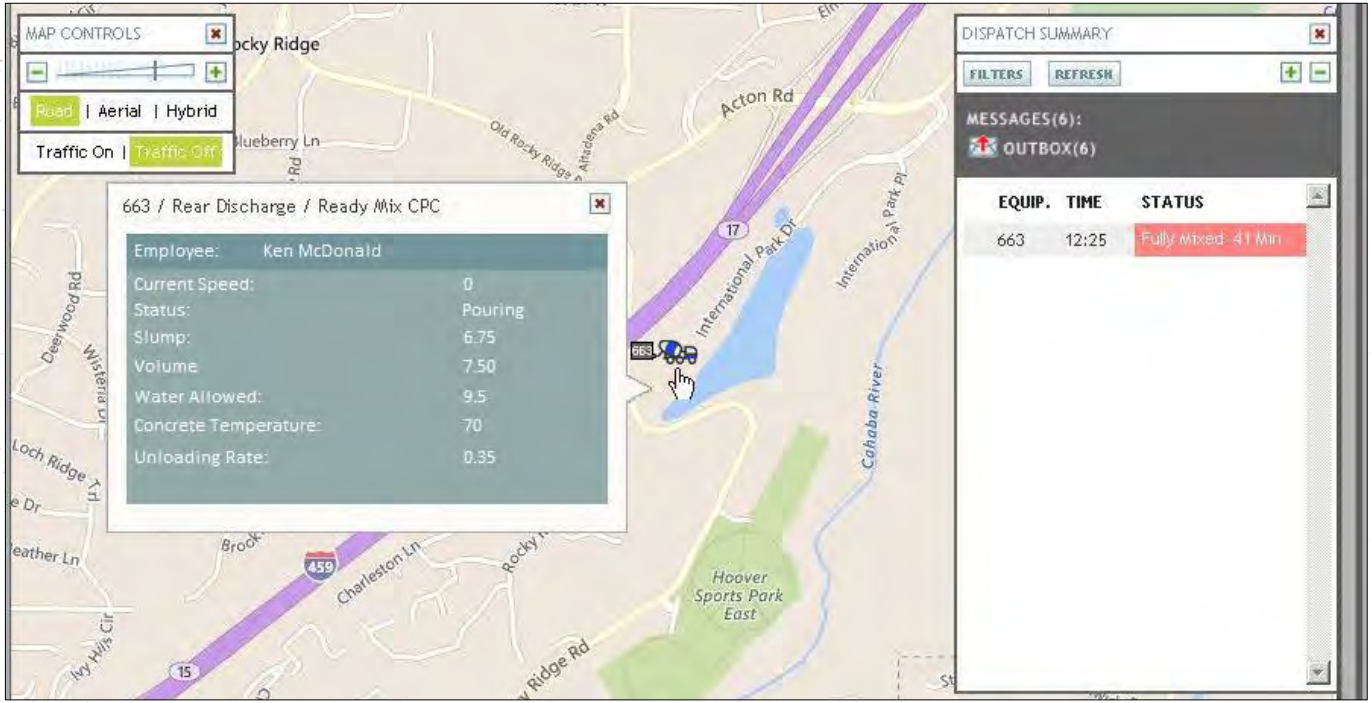
VIEW REPORT | DOWNLOAD REPORT | EXPORT REPORT

Order #	Customer Name	Truck #	Ticket #	Load Size	Load Time	On Site Time	Travel Time	Product	Product Description	Trimmed Water	Batched Water	Added Water	Total Water	Departure Slump	Arrival Slump	Ordered Slump	Slump Difference
23	CURB MASTEI	720	4119795	7.00	07/21/2017 8:18	07/21/2017 8:53	0:34:17	3F52CF	4500 PSI, 3/4, FL	-13.5	55.0	17.0	72.0	4.75	2.75	4.00	1.25
23	CURB MASTEI	811	4119861	9.00	07/21/2017 8:45	07/21/2017 9:17	0:32:21	3F52CF	4500 PSI, 3/4, FL	-14.0	54.5	16.0	70.5	4.50	2.75	4.00	1.25
23	CURB MASTEI	748	4119935	11.00	07/21/2017 8:59	07/21/2017 9:32	0:33:01	3F52CF	4500 PSI, 3/4, FL	-6.0	62.5	8.0	70.5	5.50	3.50	4.00	0.50
8	MANOR CON	746	4119946	10.50	07/21/2017 9:06	07/21/2017 9:25	0:18:41	3F52CF	4500 PSI, 3/4, FL	-12.5	56.0	9.0	65.0	5.00	3.00	4.50	1.50
23	CURB MASTEI	720	4119962	8.00	07/21/2017 10:54	07/21/2017 11:35	0:40:41	3F52CF	4500 PSI, 3/4, FL	-5.0	63.5	12.0	75.5	5.50	3.25	4.00	0.75
23	CURB MASTEI	748	4119999	11.00	07/21/2017 10:59	07/21/2017 11:30	0:30:41	3F52CF	4500 PSI, 3/4, FL	-3.0	65.5	3.0	68.5	6.00	3.75	4.00	0.25
AVERAGE	-	-	-	9.42	-	-	0:31:37	-	-	-9.0	59.5	10.8	70.3	5.21	3.17	-	0.92
MINIMUM	-	-	-	7.00	-	-	0:18:41		-	-14.0	54.5	3.0	65.0	4.50	2.75	-	0.25
MAXIMUM	-	-	-	11.00	-	-	0:40:41		-	-3.0	65.5	17.0	75.5	6.00	3.75	-	1.50

Fleet Utilization Features

- Ability to identify when a load has reached a homogeneous state in the truck mixer (mixing end)
- Unloading rate at the jobsite is displayed in Yards per Minute
- Detects end of pour
- Record leftover concrete and washout water if it comes through the truck meter.

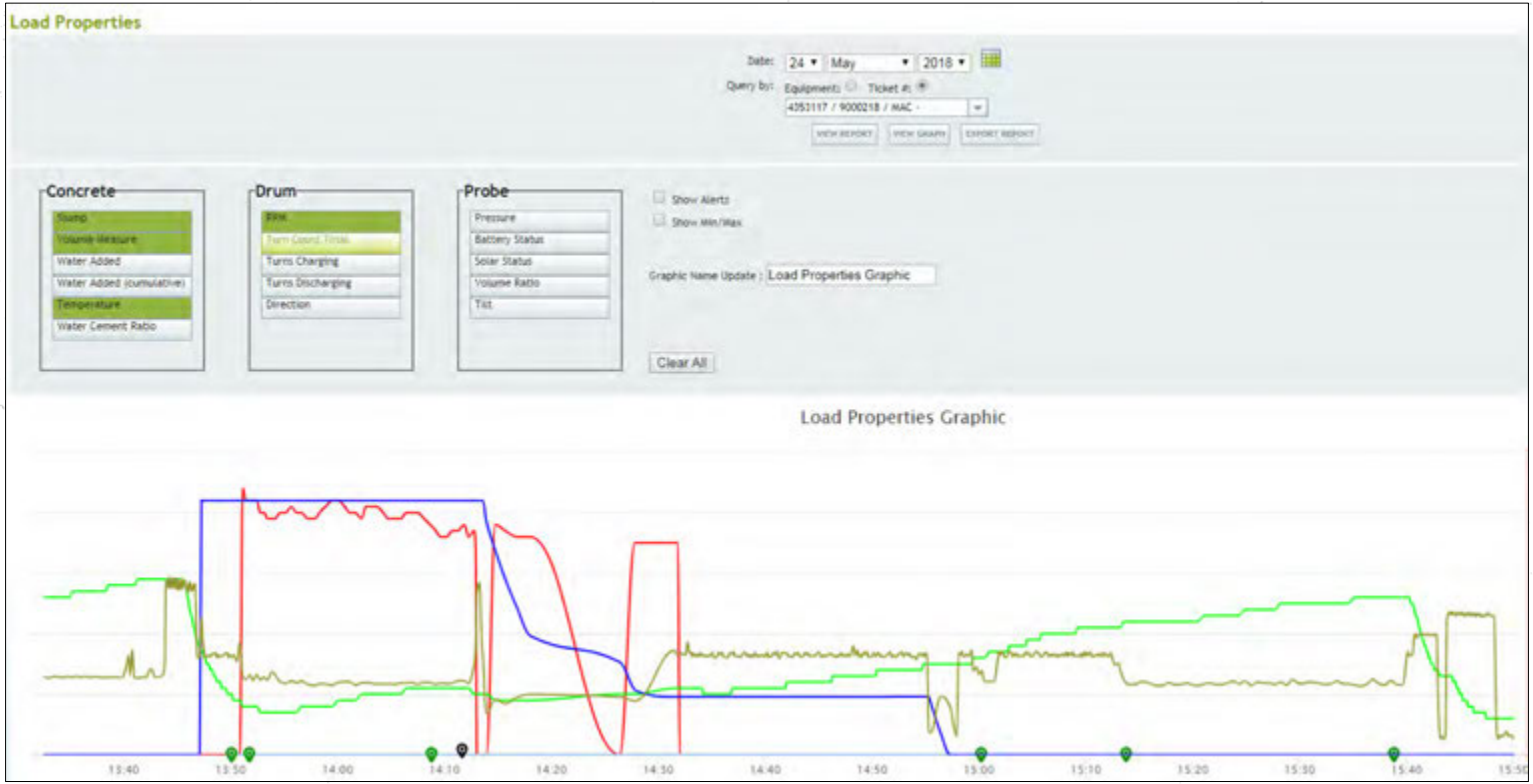
Tracking Map



QC Features

- Fresh concrete properties are monitored throughout the delivery cycle and available to Driver, Batchman, Dispatcher and QC personnel
- Tolerances for slump, temperature and W/C ratio are passed from QC-Dispatch–Batch and then to TrackIt
- Water allowed is based on mix design W/C ratio. Water held back during the batching process is passed to the system and is a part of the properties of the load that are measured. Water allowed decreases proportionally as the volume in the truck decreases.
- Any out of tolerance for W/C ratio, Slump or Temp generates an alert that will appear on the Driver Display and the COMMANDtrack/Integra Tracking screen. Notifications can be emailed out as well.

Delivery Log



Quality Control

COMMANDqc - Concrete Properties In Transit

Files Concrete Producer Setup Tools Help

Optimal Fields | Elapsed TIme 2

Plant(s) 28,1 (Multiple)

Product(s)

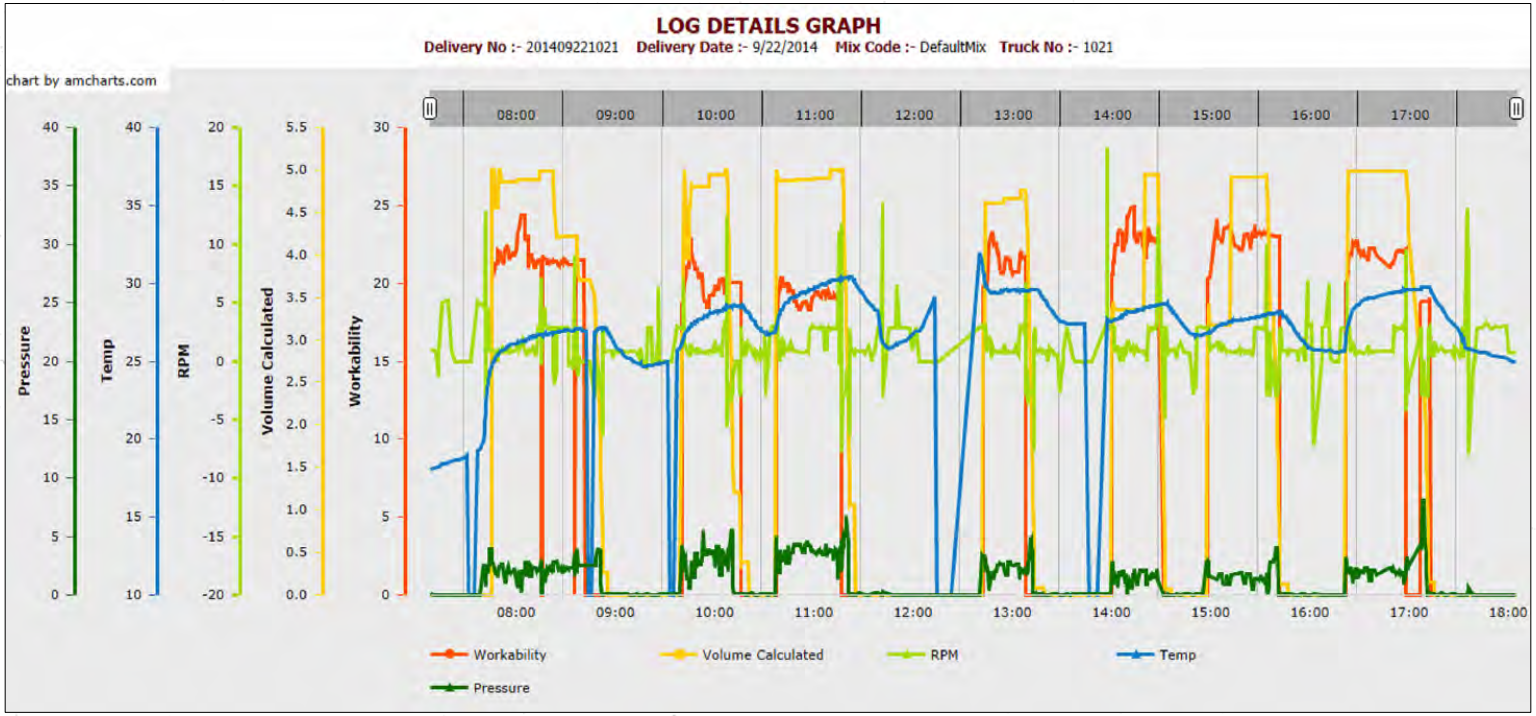
Ticket Number To

From 1/ 1/2016 To 1/31/2017 Ticket

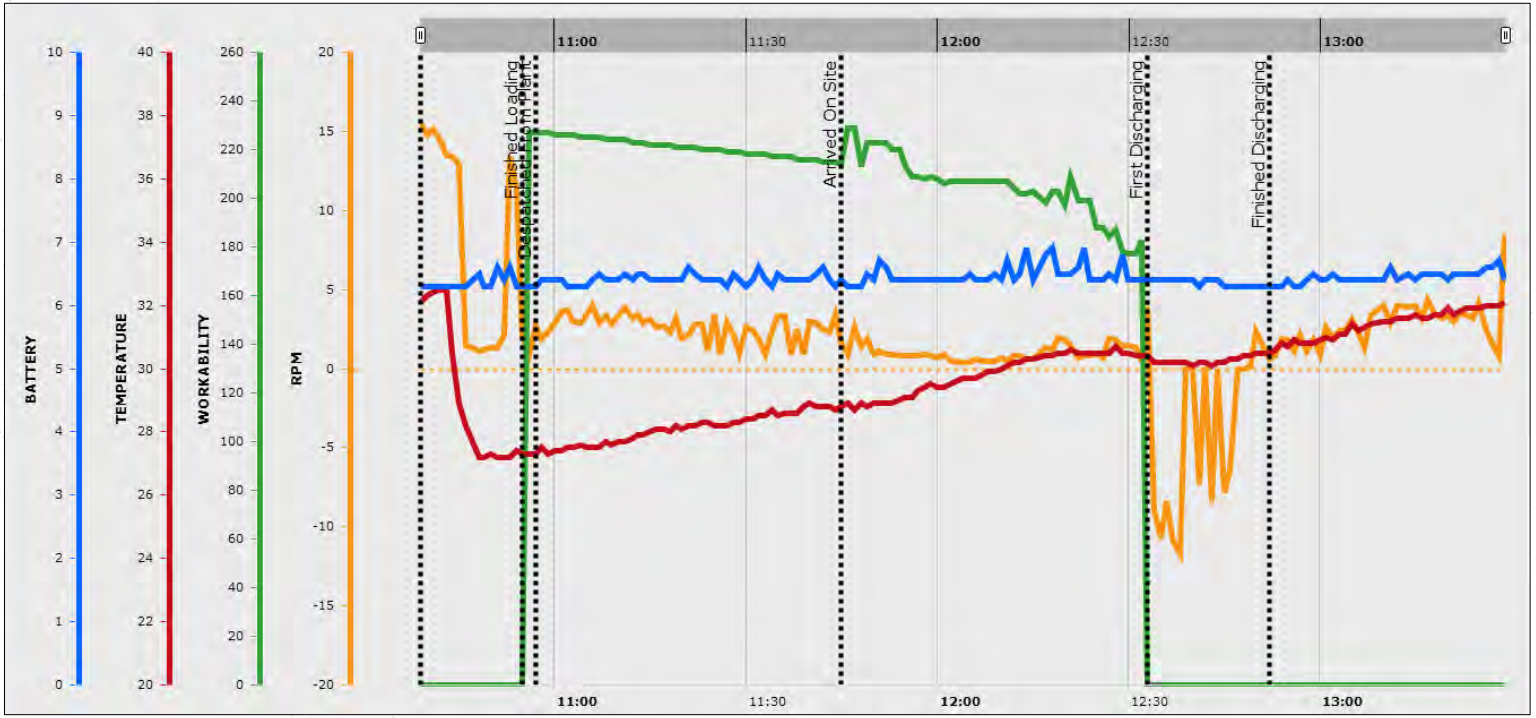
Drag a column header here to group by that column

Ticket Number	Ticket Date	Plant ID	Product Code	Vehicle Number	Date Time At Plant	Workability Type	Time At Plant (min)	Workability At Plant (in)	Concrete Temp At Plant (deg F)	Water Cement Ratio At Plant	Time Arrive Job (min)	Workability Arrive Job (in)	Concrete Temp Arrive Job (deg F)	Water Cement Ratio Arrive Job	Time Unload (min)	Workability Unload (in)	Concrete Temp Unload (deg F)	Water Cement Ratio Unload
3	2016-12-07	28	2561	663	12/7/2016 3:26:04 PM	SLUMP	0	9.69	69.22	0.49	2	9.82	69.24	0.49	13	10.62	69.39	0.00
4	2016-12-07	28	2561	663	12/7/2016 4:50:58 PM	SLUMP	0	9.69	69.22	0.57	4	9.45	69.28	0.57	15	10.60	69.38	0.00
10	2016-12-08	28	2561	663	12/8/2016 2:19:35 PM	SLUMP	0	9.31	69.93	0.50	2	9.40	69.95	0.54	6	9.83	69.89	0.59
11	2016-12-08	28	2561	663	12/8/2016 3:07:13 PM	SLUMP	0	9.12	69.96	0.63	1	9.32	69.95	0.63	11	9.89	69.88	0.68
12	2016-12-08	28	2561	663	12/8/2016 4:28:53 PM	SLUMP	0	9.68	69.76	0.67	2	9.41	69.70	0.67	4	9.43	69.70	0.67
13	2016-12-08	28	2561	663	12/8/2016 4:56:48 PM	SLUMP	0	9.30	69.76	0.50	3	9.62	69.72	0.50	3	9.59	69.71	0.50
5	2016-12-08	28	2561	663	12/8/2016 10:27:42 AM	SLUMP	0	9.28	69.20	0.48	2	9.69	69.22	0.48	2	9.91	69.28	0.49
7	2016-12-08	28	2561	663	12/8/2016 11:41:23 AM	SLUMP	0	9.54	69.21	0.50	4	9.46	69.29	0.50	7	10.05	69.36	0.52
15	2016-12-09	28	2561	663	12/9/2016 9:17:52 AM	SLUMP	0	9.68	69.76	0.54	8	9.56	69.72	0.54	17	9.59	69.70	0.58
16	2016-12-09	28	2561	663	12/9/2016 10:39:17 AM	SLUMP	0	9.00	69.69	0.62	1	9.71	69.70	0.63	3	9.62	69.70	0.63
17	2016-12-09	28	2561	663	12/9/2016 11:27:12 AM	SLUMP	0	9.05	69.79	0.41	1	9.38	69.74	0.41	4	9.72	69.70	0.58
18	2016-12-09	28	2561	663	12/9/2016 1:03:40 PM	SLUMP	0	9.05	69.79	0.41	1	9.57	69.74	0.45	3	9.73	69.71	0.55
107	2017-01-09	28	2561	663	1/9/2017 1:22:30 PM	SLUMP	0	8.51	69.72	0.56	1	8.50	69.75	0.56	6	8.34	69.74	0.56
111	2017-01-09	28	2561	663	1/9/2017 3:52:29 PM	SLUMP	0	9.39	68.59	0.63	0	9.41	68.55	0.63	2	9.23	68.61	0.63
118	2017-01-10	28	2561	663	1/10/2017 2:35:40 PM	SLUMP	0	7.54	69.64	0.48	-4	7.03	69.62	0.48	1	7.38	69.61	0.48
121	2017-01-10	28	2561	663	1/10/2017 4:09:51 PM	SLUMP	0	7.55	69.65	0.56	0	7.55	69.65	0.56	2	7.38	69.61	0.56
122	2017-01-11	28	2561	880	1/11/2017 9:13:07 AM	SLUMP	0	7.54	69.64	0.55	0	7.54	69.64	0.55	0	7.38	69.61	0.55
124	2017-01-11	28	2561	663	1/11/2017 9:39:35 AM	SLUMP	0	7.69	69.61	0.48	0	7.69	69.61	0.48	5	7.38	69.61	0.48

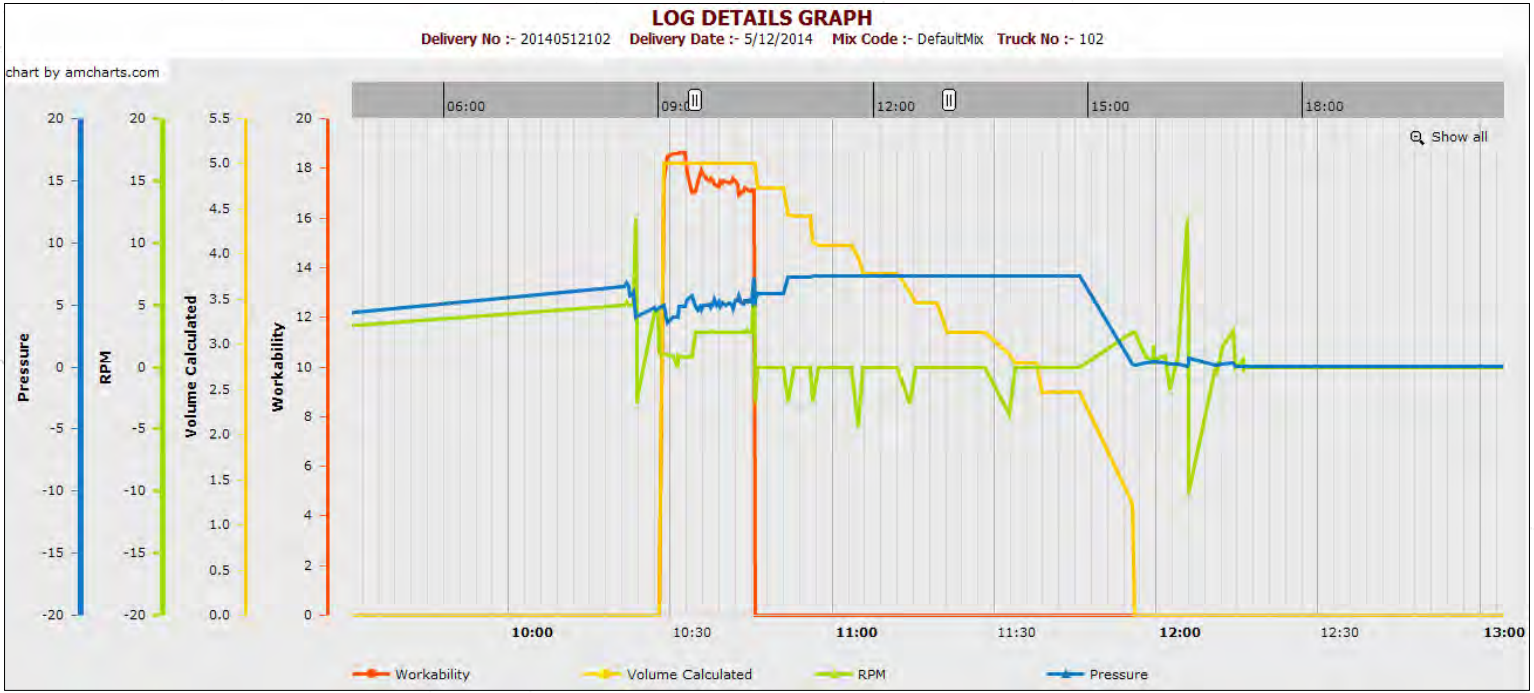
Traceability (full day)



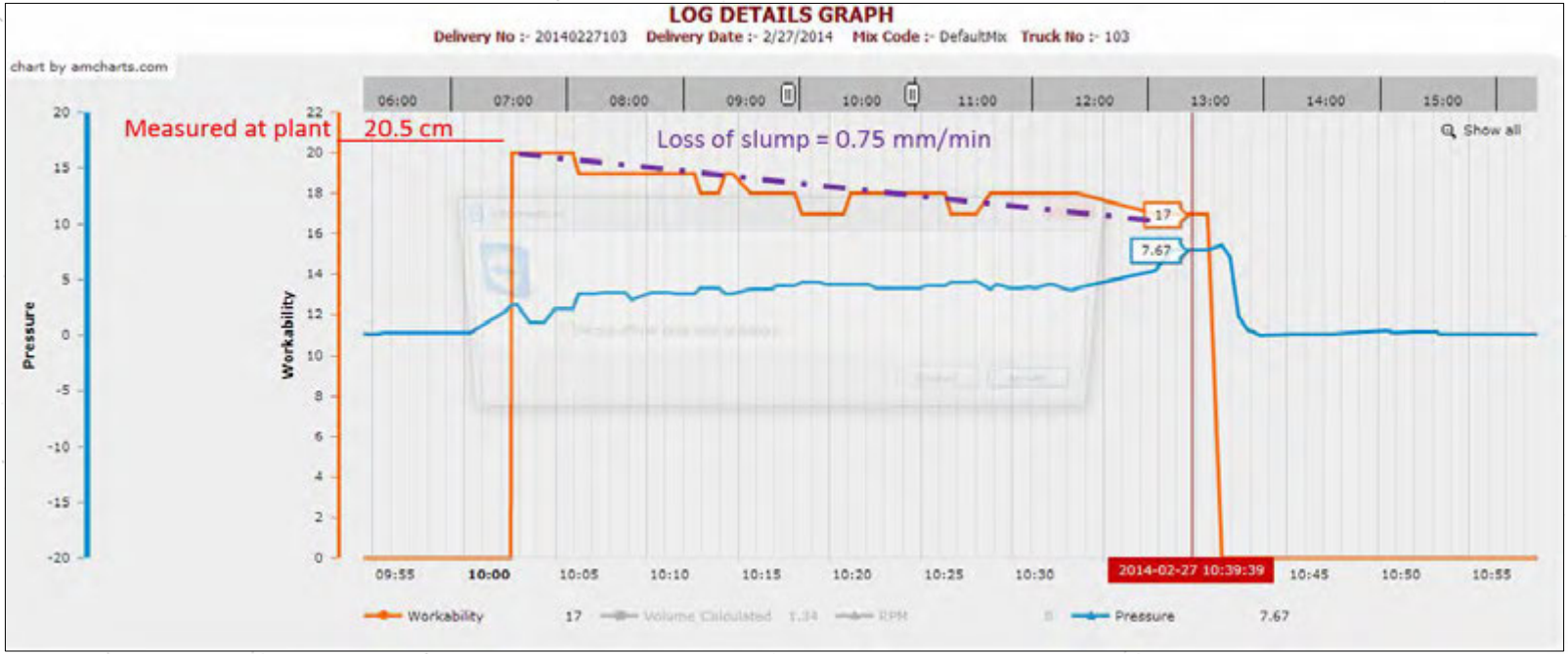
Traceability (full day)



(Unloading)

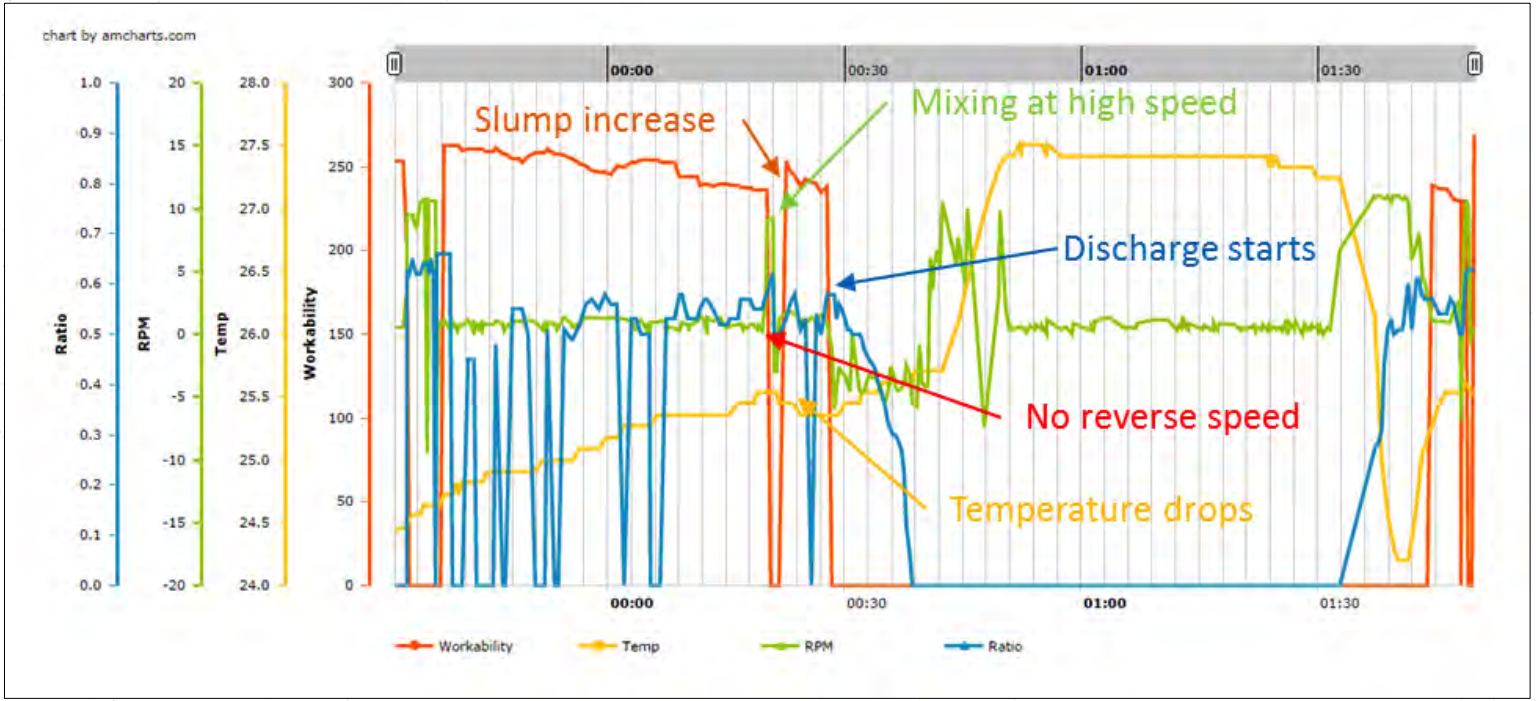

LOG DETAILS GRAPH
Delivery No :- 20140512102 Delivery Date :- 5/12/2014 Mix Code :- DefaultMix Truck No :- 102
chart by amcharts.com
Pressure
RPM
Volume Calculated
Workability
06:00
09:00
12:00
15:00
18:00
Show all
10:00
10:30
11:00
11:30
12:00
12:30
13:00
Workability
Volume Calculated
RPM
Pressure

Aging Rate (mm/min)



Admixture Addition

Water Addition



Slump vs Probe Variability

Type Index	Average Slump, mm (in.)	Standard Deviation [1s], mm (in.)	Acceptable Range of Two Results [d2s], Mm (in.)
Single-Operator Precision	30 (1.2)	6 (0.23)	17 (0.65)
	85 (3.4)	9 (0.38)	25 (1.07)
	160 (6.5)	10(0.40)	28 (1.13)
Multi-Laboratory Precision	30 (1.2)	7 (0.29)	20 (0.82)
	85 (3.4)	10 (0.39)	28 (1.10)
	160 (6.5)	13 (0.53) (CV 8.2%)	37 (1.50) (CV 23%)

Slump vs Probe Variability

Variability
On 12 ''mixes''

Compare to
ASTM, BS, BSEN
allowance

CV -BS

CV -ASTM

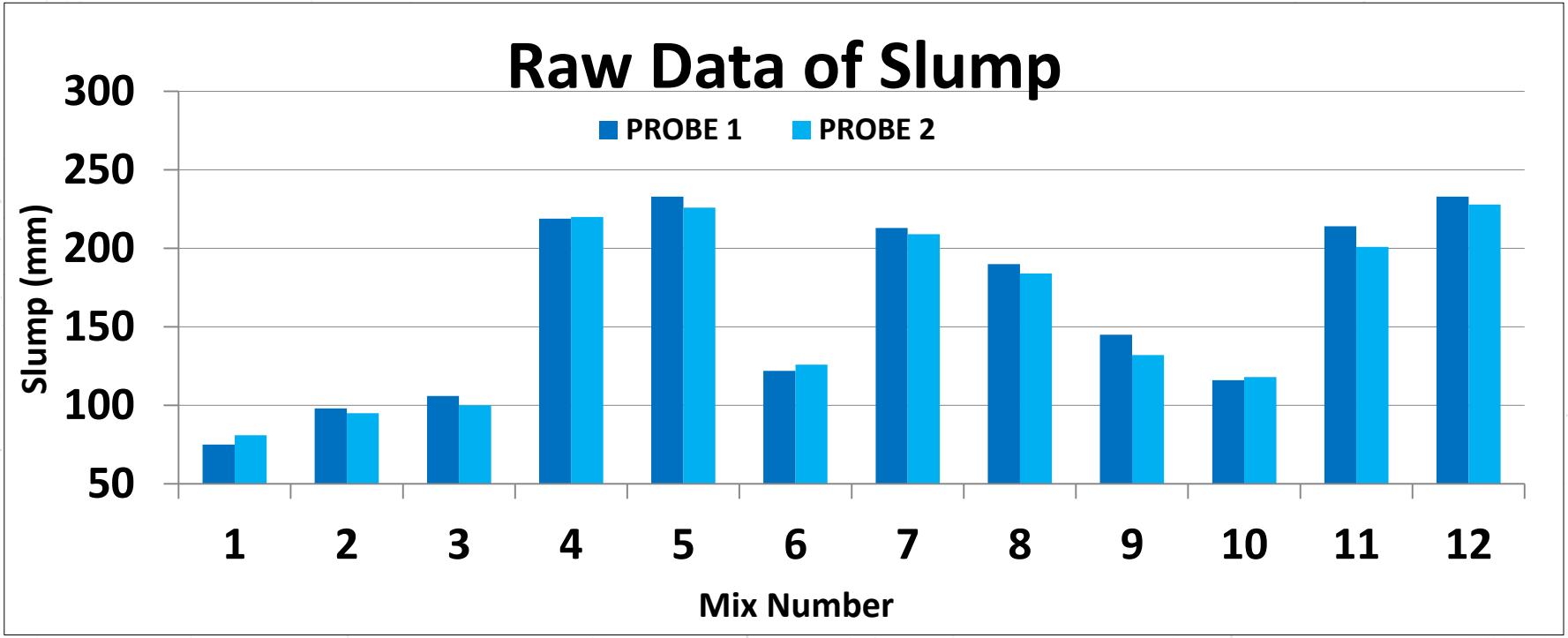
CV -Probe

Manual slump testing

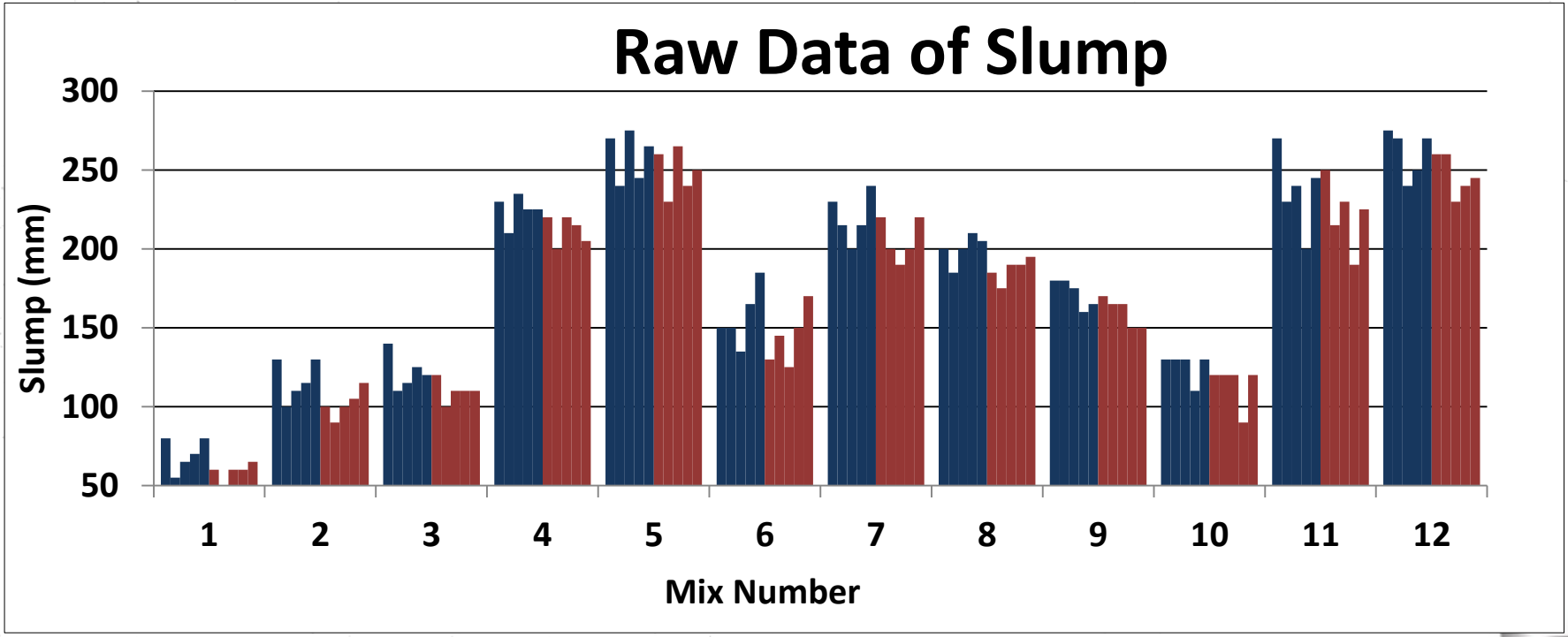
5 experienced technicians

2 Workability Probes

Slump vs Probe Variability



Slump vs Probe Variability



Slump vs Probe Variability

MIXTURE	1	2	3	4	5	6	7	8	9	10	11	12	
Average ASTM	70	117	122	225	259	157	220	200	172	126	237	261	
Standard Dev ASTM	10.6	13.0	11.5	9.4	15.6	18.9	15.4	9.4	9.1	8.9	25.4	15.2	CV ASTM
CV ASTM	15.2	11.1	9.4	4.2	6.0	12.0	7.0	4.7	5.3	7.1	10.7	5.8	8.2
Average BS	59	102	110	212	249	144	206	187	160	114	222	247	
Standard Dev BS	5.5	9.1	7.1	9.1	14.3	17.8	13.4	7.6	9.4	13.4	22.0	13.0	CV BS
CV BS	9.3	8.9	6.4	4.3	5.8	12.4	6.5	4.1	5.8	11.8	9.9	5.3	7.5
Average Probe	64.5	109.5	116	218.5	254	150.5	213	193.5	166	120	229.5	254	
Standard Dev Probe	4.2	2.1	4.2	0.7	4.9	2.8	2.8	4.2	9.2	1.4	9.2	3.5	CV Probe
CV Probe	5.4	2.2	4.1	0.3	2.2	2.3	1.3	2.3	6.6	1.2	4.4	1.5	2.8

Conclusion

This is just the beginning…

Conclusion

- It is now possible to:
  - Get full traceability from Loading to truck washing
  - To estimate workability (slump or other, including rheology) precisely continuously, automatically, without sampling or human influence
  - It is possible to follow the temperature evolution of a concrete load to detect water addition
  - It is possible to track the volume of concrete inside the drum of a ready-mix truck
  - All the above are also possible in real time situation when linked with a GPS + communication system.
  - A manager system is available to produce graph and useful reports

Conclusion

- Knowing the slump at all times and having automatic analysis of its initial value and evolution for all mixtures definitively will help to:
  - Optimise mixture due to better knowledge of this parameter.
  - Give feed pack to Plant Operator to adjust initial water content and admixture which allow optimising mixing time.
  - Detect unstable mixture from concrete aging rate
  - Help the drivers to make slight adjustment before arriving at site to reduce rejection

Conclusion

- Knowing (and showing) the current volume of concrete in the truck at all times allows:
  - The client to trust the delivered quantity: Gain trust, get repeat job.
  - To plan better the completion of the pour as the client does not need to wait for the last truck to be emptied before ordering additional concrete for the poor completion: client satisfaction
  - To bill the exact quantity left, without too much discussion or discounted quantity because there is no measurement: increases income
  - To optimise the use of the left over concrete without the need to add safety margin for quantity
  - To use the concrete without downgrading the concrete

Conclusion

- Knowing the concrete temperature at all times and real time analysis of sudden changes allows:
  - To give feed pack to Plant Operator to adjust hot water/ice quantity: avoid rejection
  - To detect water addition in to the mixture: control Driver's behavior
  - To monitor water addition for washing purpose: ability to detection when water is added without flow meter: monitor Driver's behavior, reduce cost of harden concrete removal.

Conclusion

- Knowing the concrete viscosity (when measured) allows:
  - To predict concrete strength for a given concrete mixture
  - To know when it is safe to add water: avoid low cube strength

(what else can you ask?)