

## Water Content Monitor WCM411

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## Importance of moisture content

- w/c-ratio is needed to be known
  - If moisture content of aggregate is not known, also w/c-ratio will be incorrect
  - Correct w/c-ratio has significant effects on mix design, workability, strength properties, durability properties etc.
- Rapid changes in moisture content are problematic
  - If measured manually (e.g. once daily), the rapid changes cannot be observed
  - Rapid changes cause quality variation and increase the required safety margin in compressive strength etc.

## Measuring Water Content

- methods in use currently
  - capacitive sensors
  - microwave sensors
  - neutron scattering sensors
  - ...
- calibration challenges
  - unavoidable and often difficult to calibrate
  - most sensors are in contact with the sample
    - sensors wear, calibration changes, pieces of foreign material affect the result, sensitivity to pressure, ...

## Optical Measurement

- advantage: easy installation and calibration
  - no contact with the sample
- can be installed to measure over a conveyor belt
  - rapid response
- can be applied to measure water/cement ratio in the mixer
- measures on the surface of the sample
- measures continuously

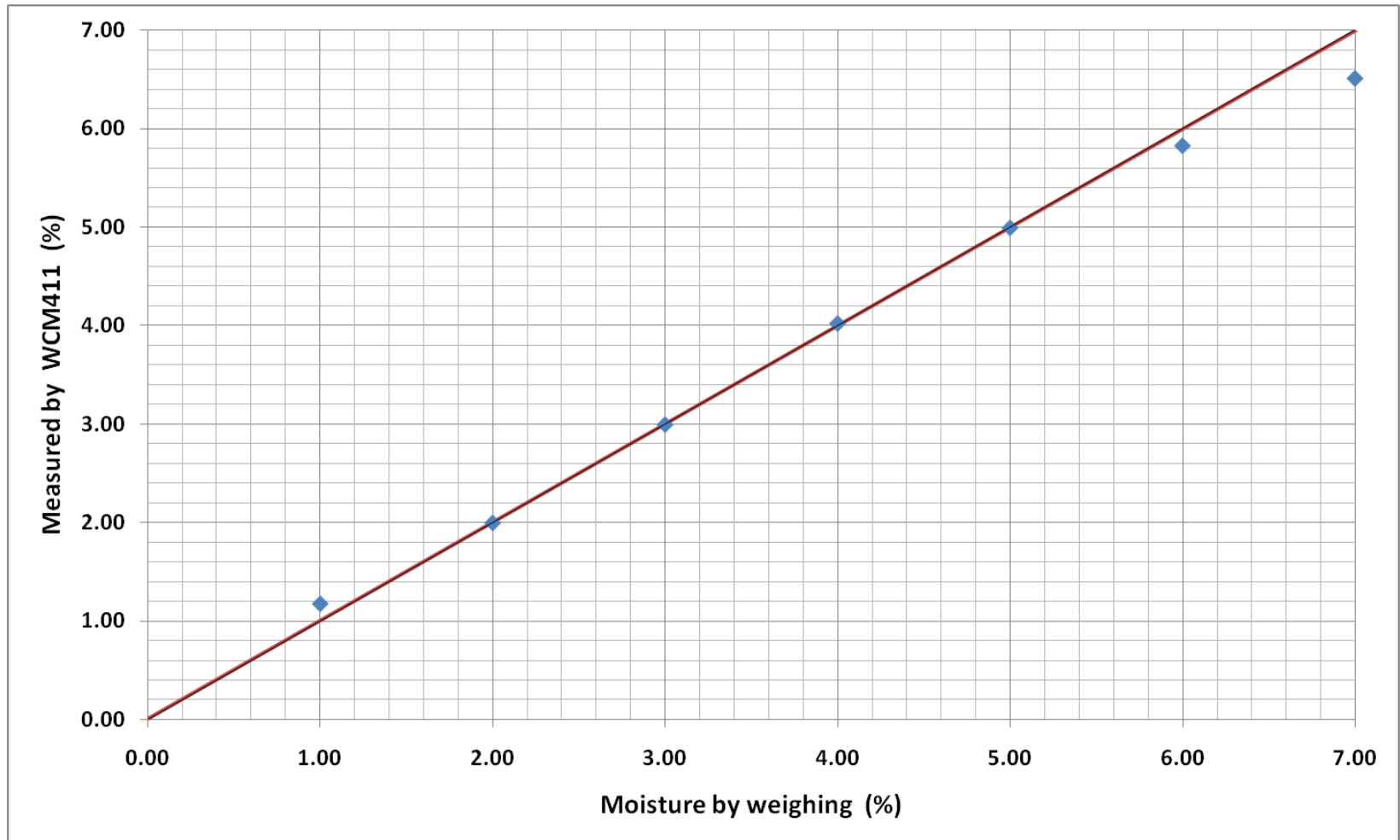
## Optical Measurement

- is based on absorption of water molecule
  - transmitter / receiver principle
  - employs near infrared wavelengths
  - measurement distance 1 – 2 m
  - noncontacting, no wearing parts
- requirements for optimal usage:
  1. sensor window should be dust protected
  2. measures over a moving sample, good representation

## Water Content Monitor WCM411

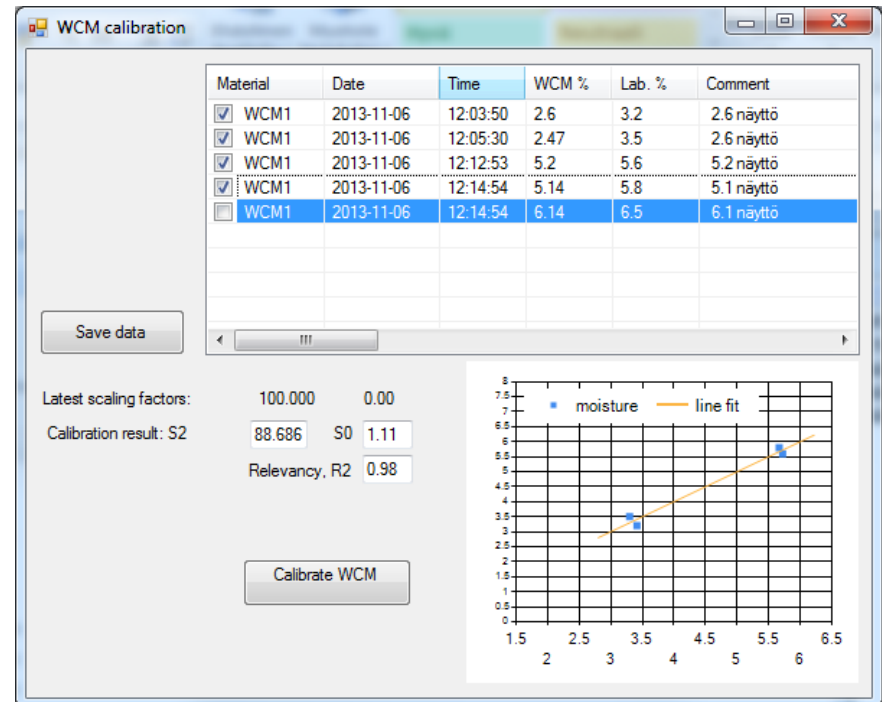
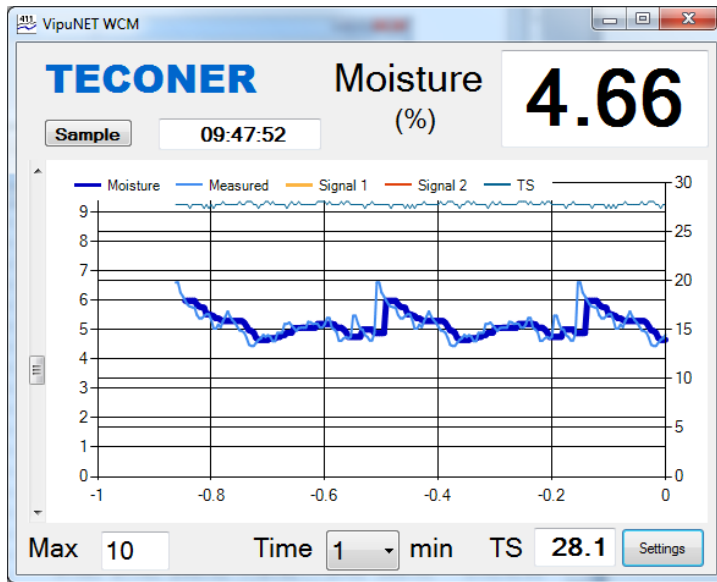


## Calibration, 0-4 mm Aggregate



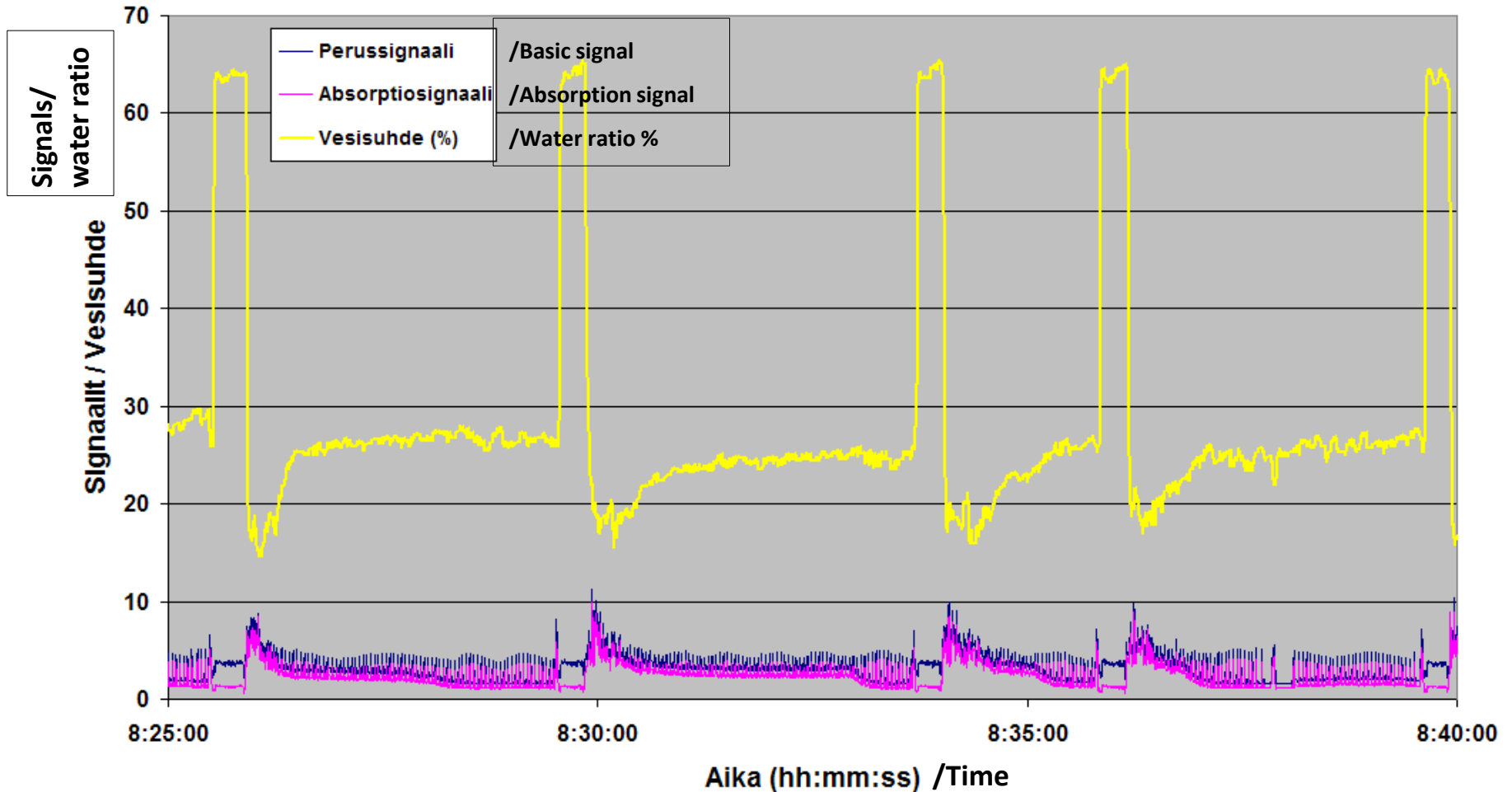
## Calibration with VipuNet

### Calibration window in VipuNet software



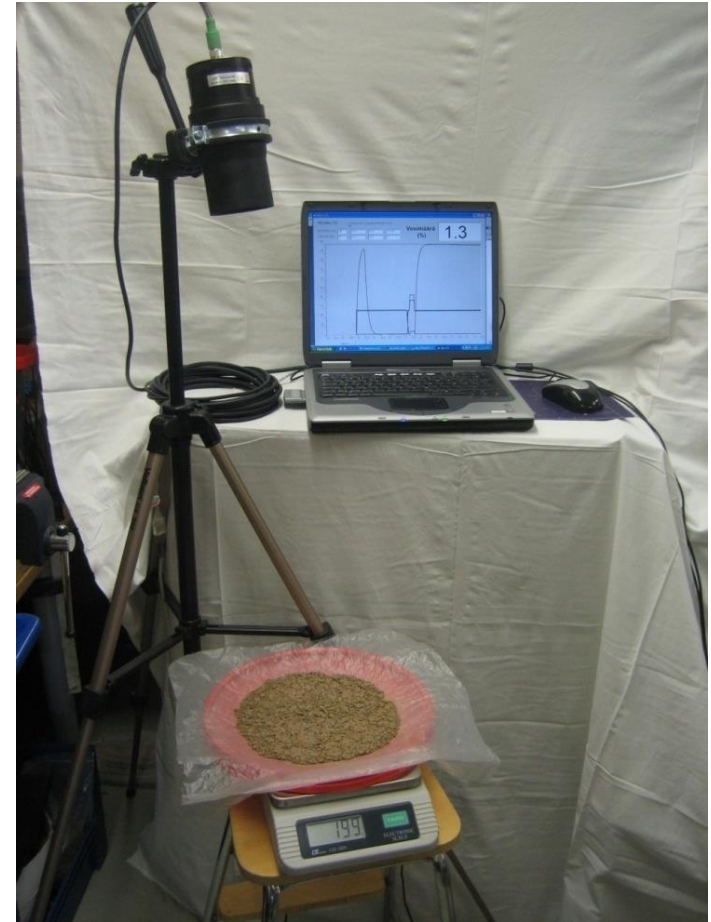


## Water/Cement Ratio in Mixer

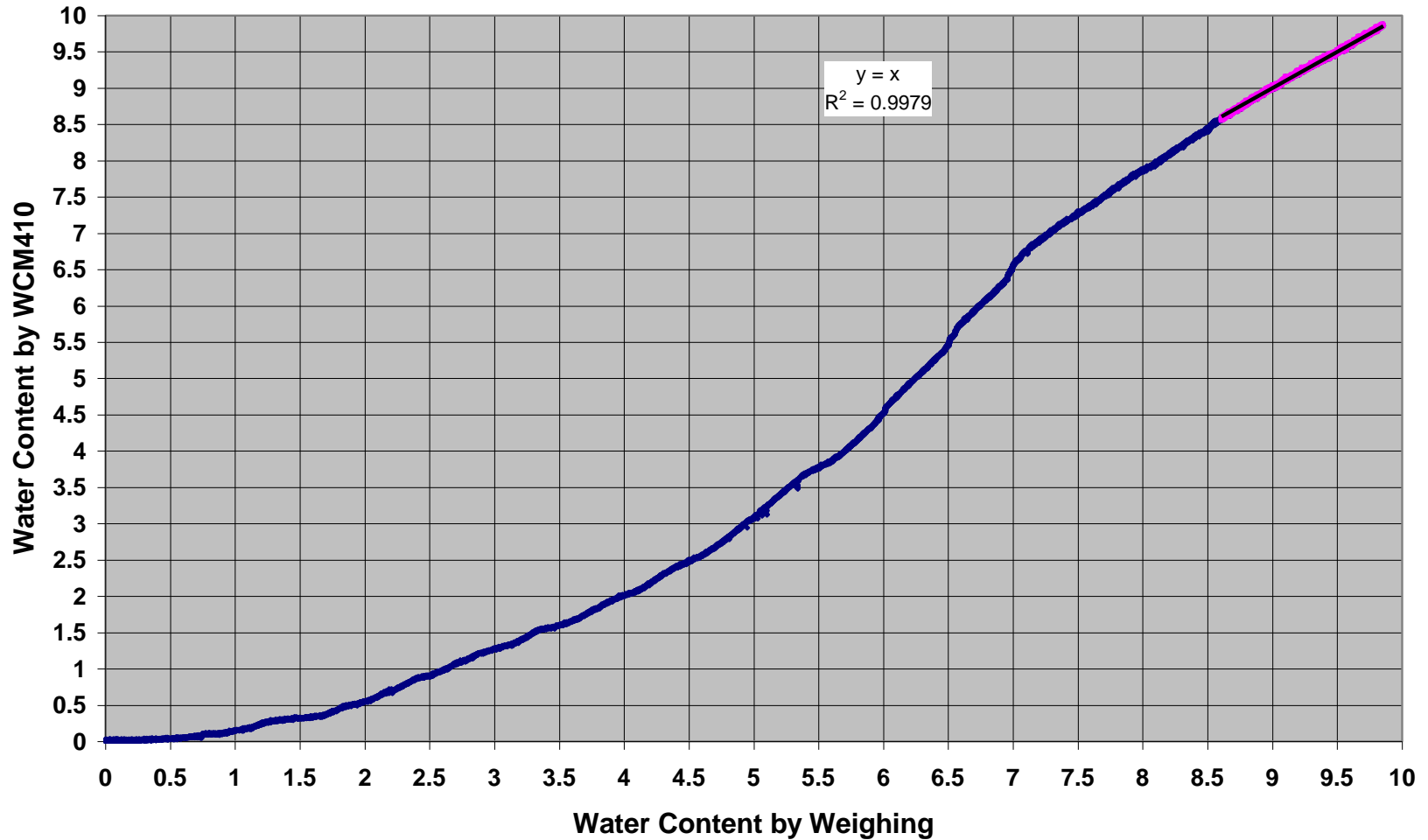


## Experiment of Free Drying

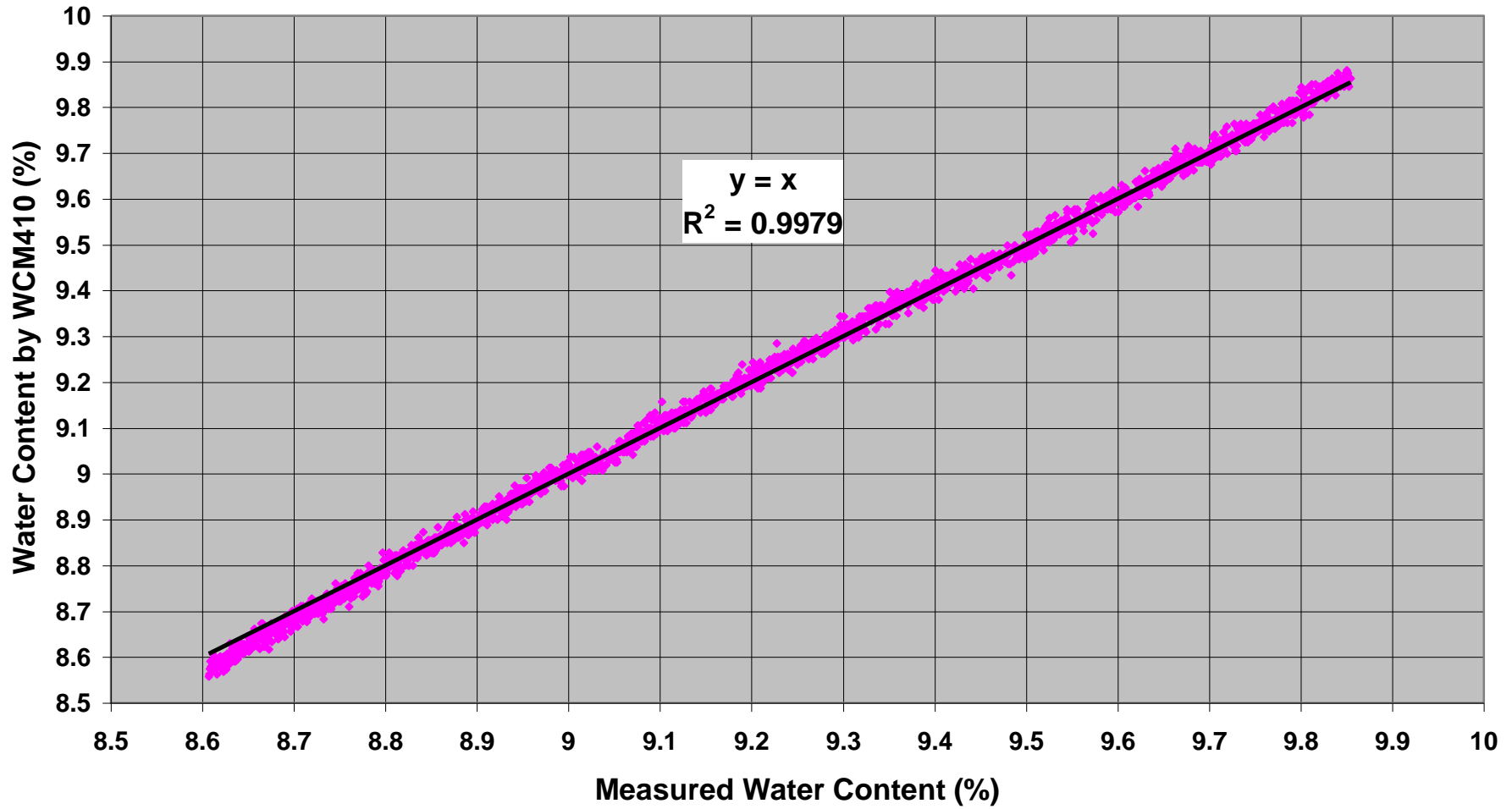
- A thin sample of sand spread on a weighing plate.
- Sample was moistened by spraying water on it.
- Sample was left to dry.
- Sample
  - 200 g, 0-8 mm stone aggregate
  - 20 g water
- Drying over night.



## Drying Sample



## Beginning of drying



## Specifications

Sensor type:	WCM411
Measures:	length 100 mm, diameter 75 mm, weight 750 g
Cable:	M12 connector, 5 leads and shield, 10 m length
Power supply:	9 ... 30 VDC
Power:	< 5 W
Temperature range:	0 ... 40 °C
Resolution:	0.1 %
Accuracy:	0.3 % by weight (short time, homogenous sample) 0.6 % by weight (long time, homogenous sample)
Measuring range:	1 ... 10 % (stone aggregates) 1 ... 20 % (very fine materials)
Response time:	0.2 ... 10 s, parameter adjustable
Noise level:	< 0.03 % with 1 s response time
Measuring distance:	0.6 ... 1.6 m
Output:	RS-232 serial interface, max. speed 115200 bit/s 4 ... 20 mA per 0 ... 16 % by weight
Installation:	installed optimally at a constant distance over a moving sample and the sensor window dust protected

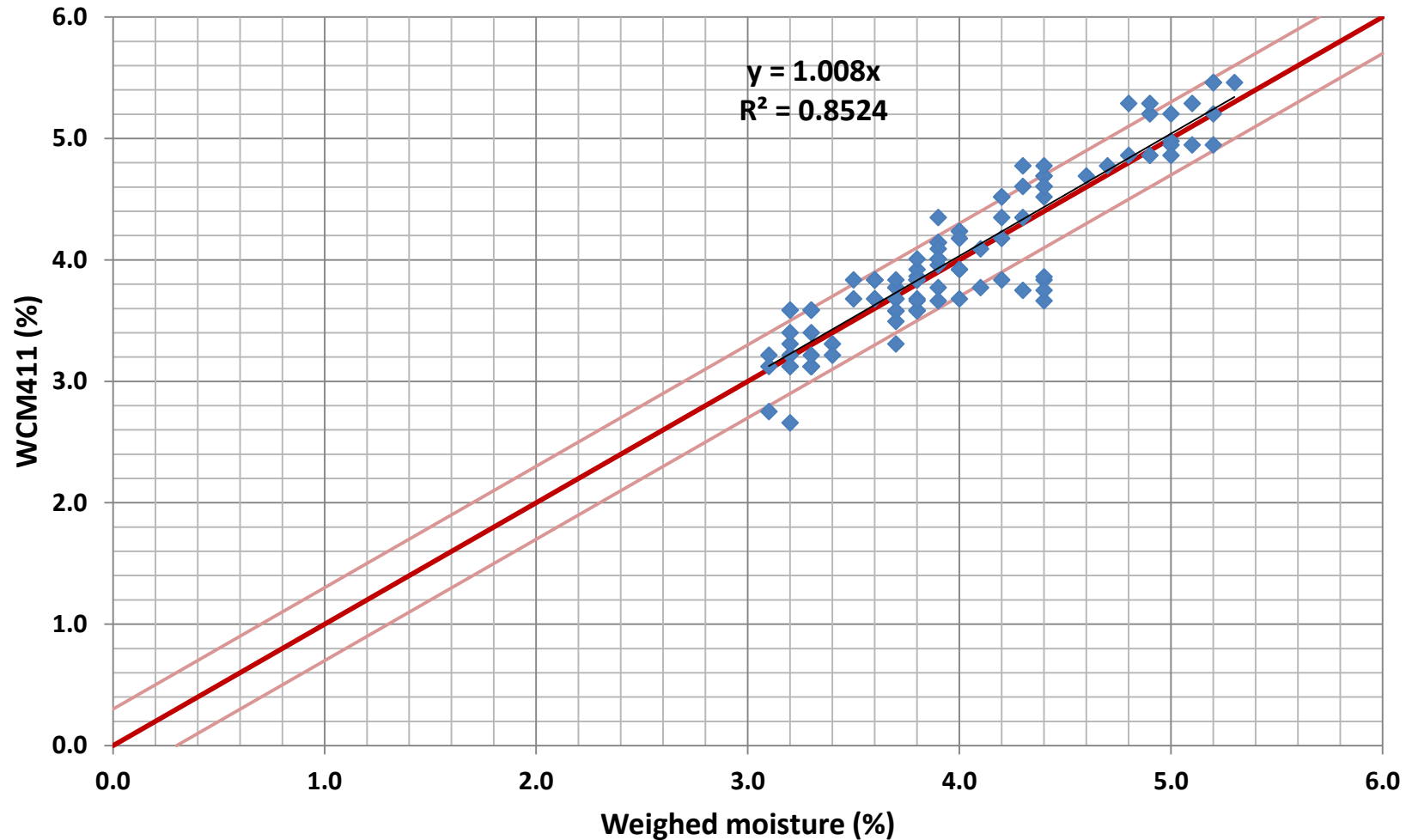
## Example of installation in aggregate silo



## Current Position

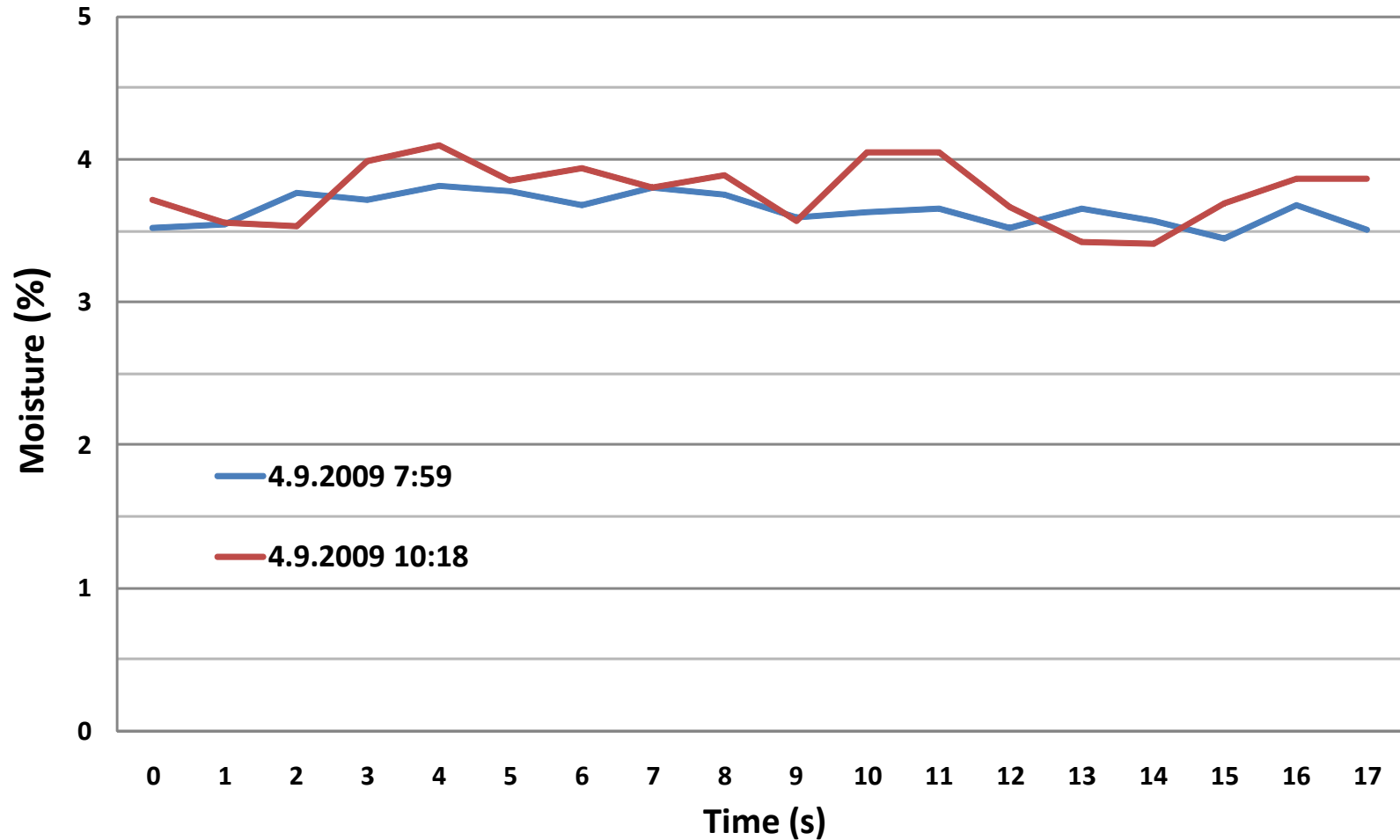
- Nearly 100 WCM411 sensors currently in use
- Typically 2 sensors/factory,  
quantity range 1-4 sensors/factory
- first production series of WCM411
  - November 2008
- testing
  - long term testing in 2009
  - RMS difference to weighed samples 0.25 %

## Testing July - October 2009, belt feeder

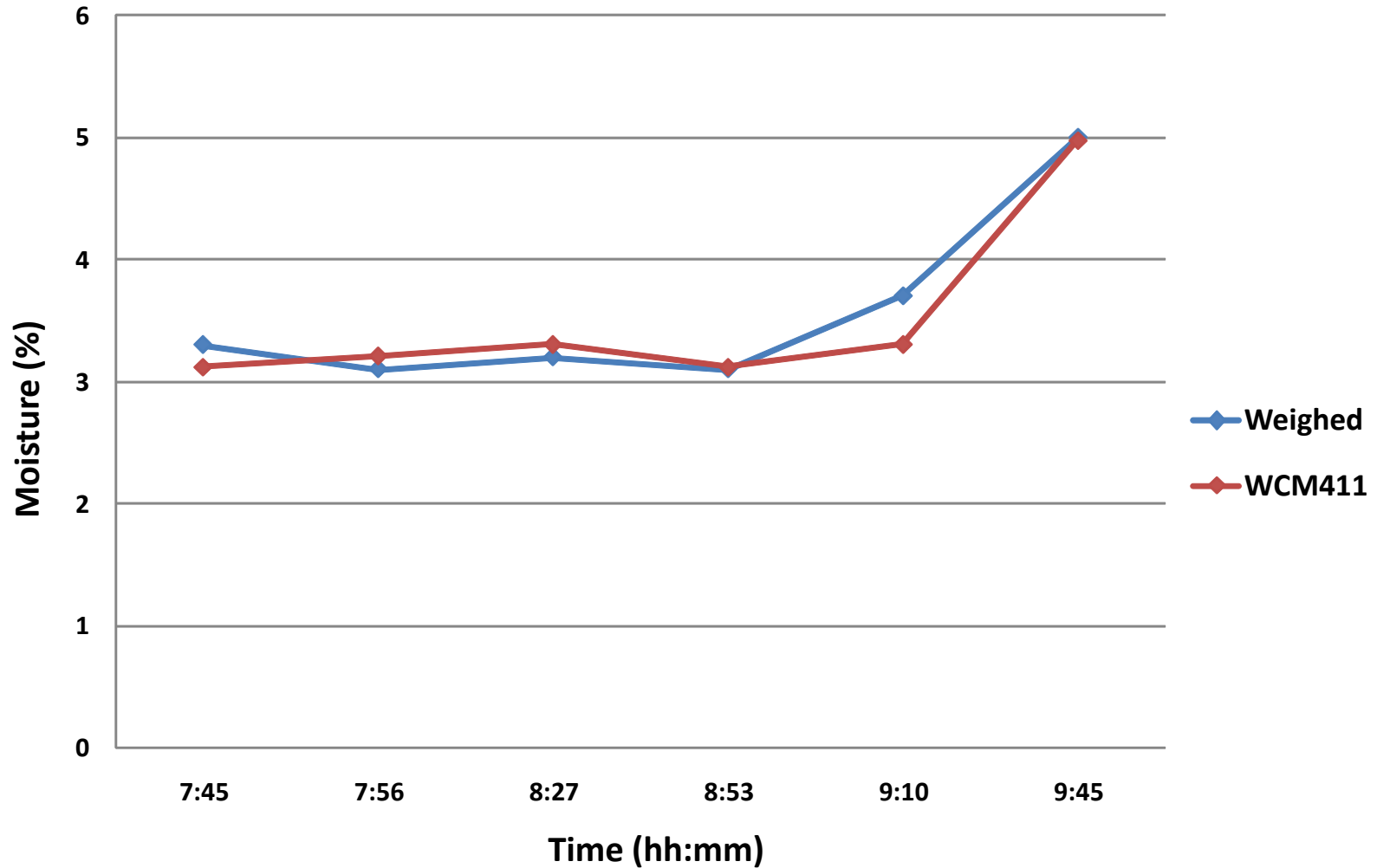




## Example of sudden changes in moisture, 1



## Example of sudden changes in moisture, 2



## Conclusion

- Water Content Monitor WCM411
  - moisture sensor for concrete aggregates
  - has proved to be reliable
    - first prototype has been working since 2006!
    - MTBF of light sources on the order of 10 years!
  - good accuracy
    - standard deviation 0.3 %
  - noncontacting, no wearing nor moving parts