INCREASE OF AIR CONTENT OF CONCRETE AFTER MIXING

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Background

- Strength defects were observed in Finnish infra-structures in summer 2016
  - One small railway bridge was needed to demolished
- It was observed low densities (< 2000 kg/m^3) / elevated air contents (> 10%) in hardened concrete
  - High air content affects compressive strength (1% air -> 5% in strength)
  - Some similar cases have been reported, e.g. in U.S. and Germany
  - Also other factors behind the strength defects
- Reason for the elevated air contents in the PCE-type superplasticizers
  - Tend to increase air content
  - Foam killers are added into SP to reduce the effect
- Entrained air pore system is not stable enough

Robust Air-project at Aalto University

- A contract research project
- Target: Secure the stability of the protective pore system
  - Air content should not change significantly after mixing
- Financiers of the project:
  - Finnish Road Agency
  - Confederation of Finnish Construction Industries RT
  - 7 admixture suppliers
  - 3 RM-concrete producers

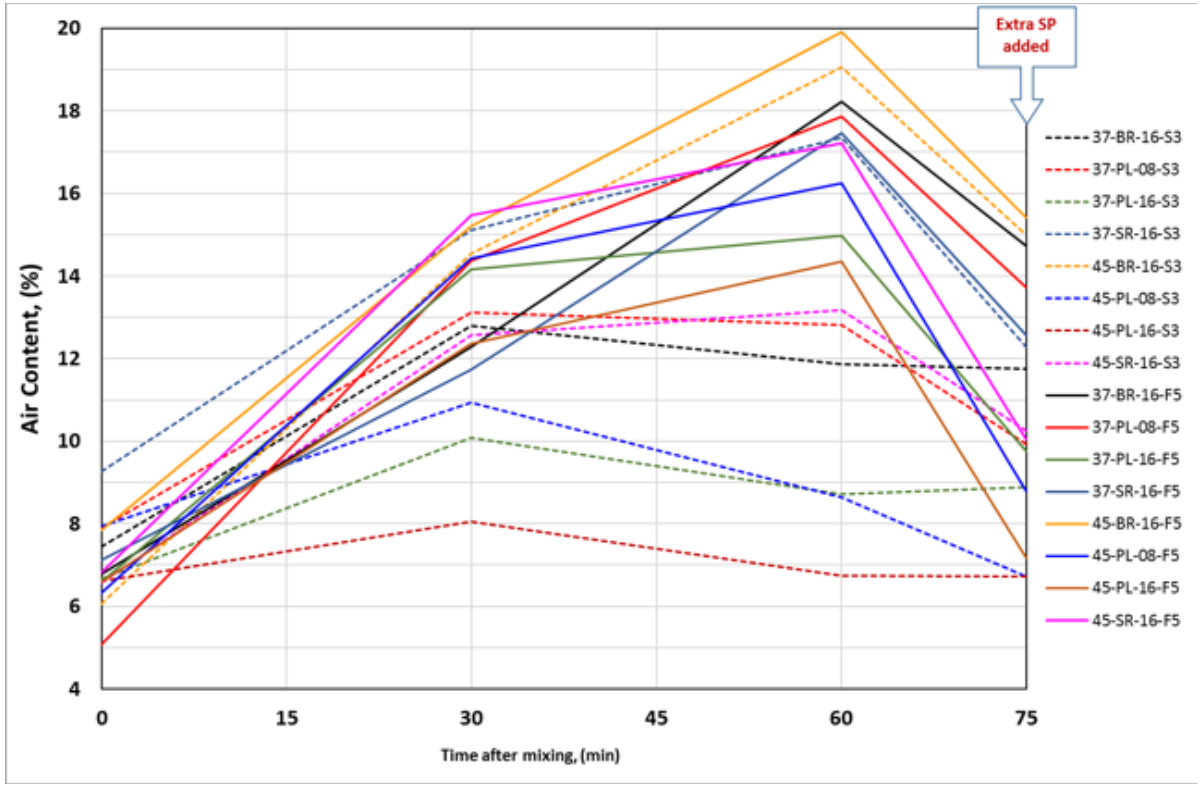
Robust Air- Contents of the project

1. Concrete tests
   - Concrete properties were altered
     - Strength class
     - Consistency class
     - Cement type
     - Max aggregate size
   - Same admixtures in all the tests
2. Admixture tests
   - 7 different admixture combinations (SP & AEA)
   - Concrete properties were kept constants
     - 3 different concretes

- Tests as function of time
  - Immediately, 30 min, 60 min and 75 min after mixing
    - After 60 min SP added to compensate workability loss
- Main focus in air content, tested with:
  - Pressure method
  - Calculated from the fresh concrete density
  - CiDRA AIRtrac
    - Measures air content directly from the mixer (acoustic method)
  - Thin section analyses
  - Pressure saturation

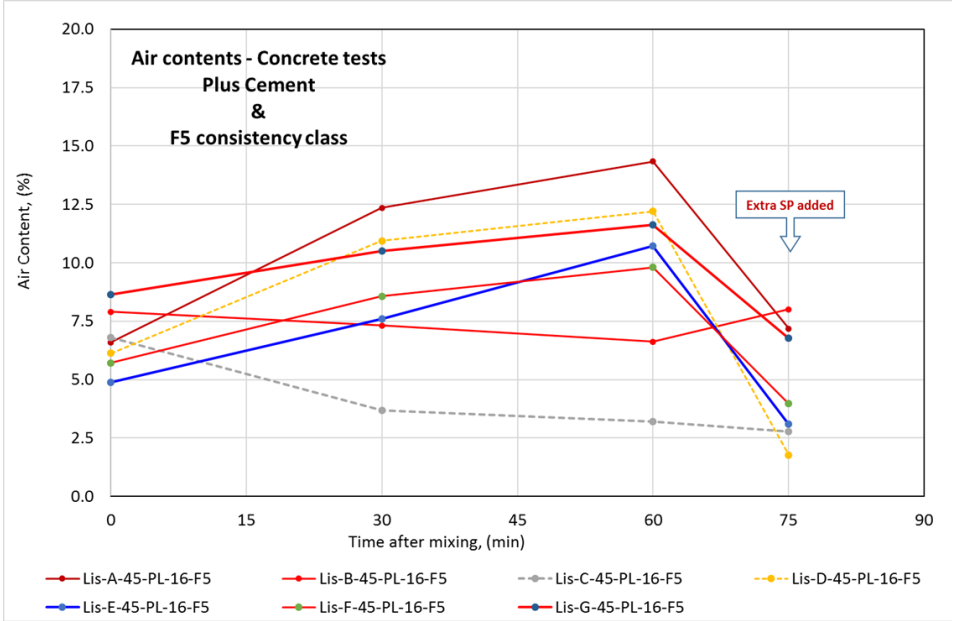
Concrete tests
Effects of concrete properties

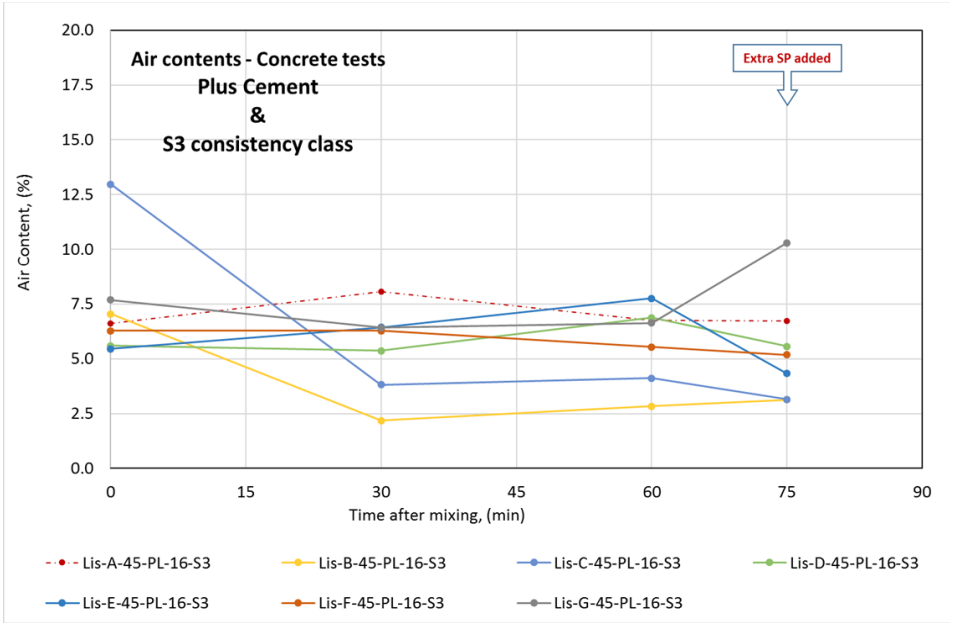
- Air content increased in most of the tests and surprisingly much
- Most significant factor was consistency of concrete
- Low efficiency of the mixer may have exaggerated the effect
  - However, relatively low w/c-ratios and high cement contents were used



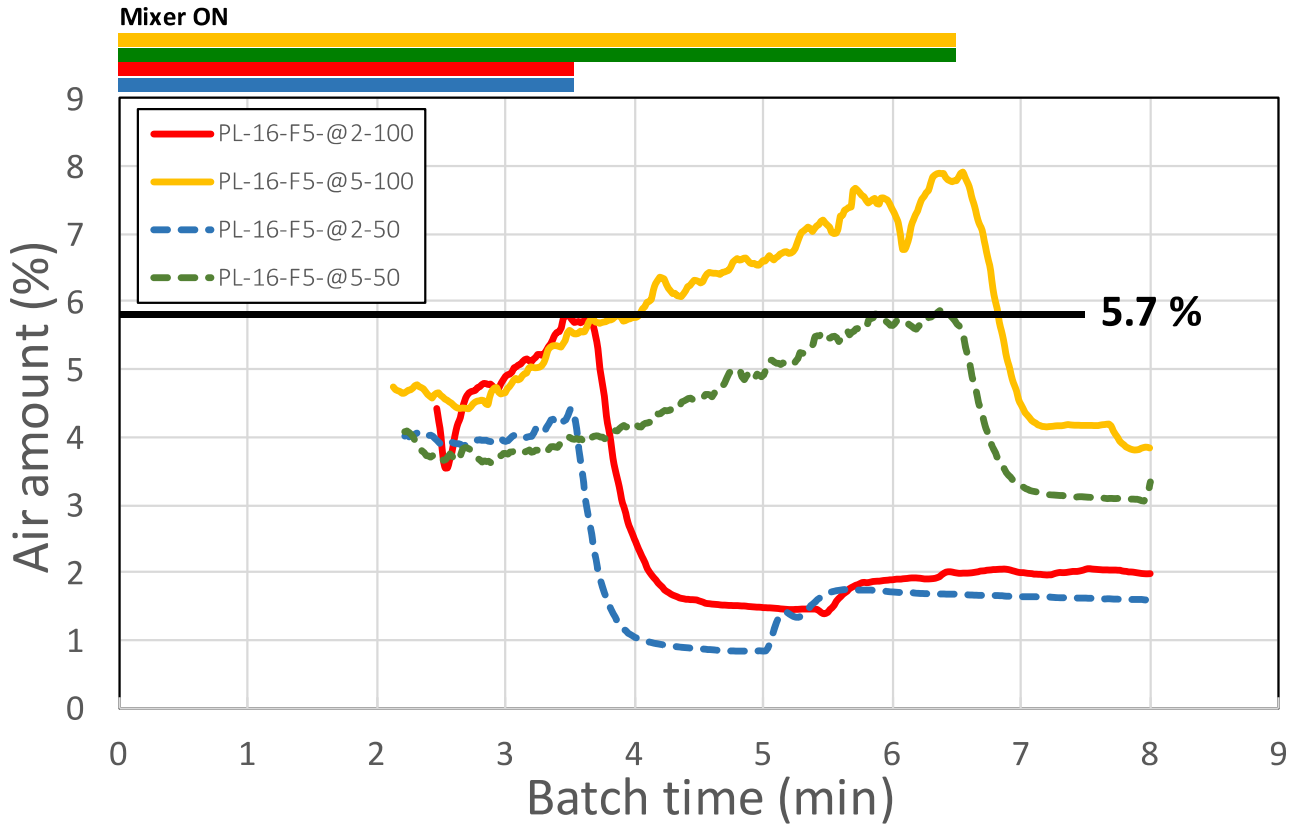
Admixture tests
7 admixture combinations

- Differences between admixtures were observed
  - Low / no increase with some admixtures
  - Not possible to rank the admixtures
- Effect of consistency was observed
- Low efficiency of the lab. mixer may have exaggerated the effect





CiDRA AIRtrac tests
Air content from the mixer



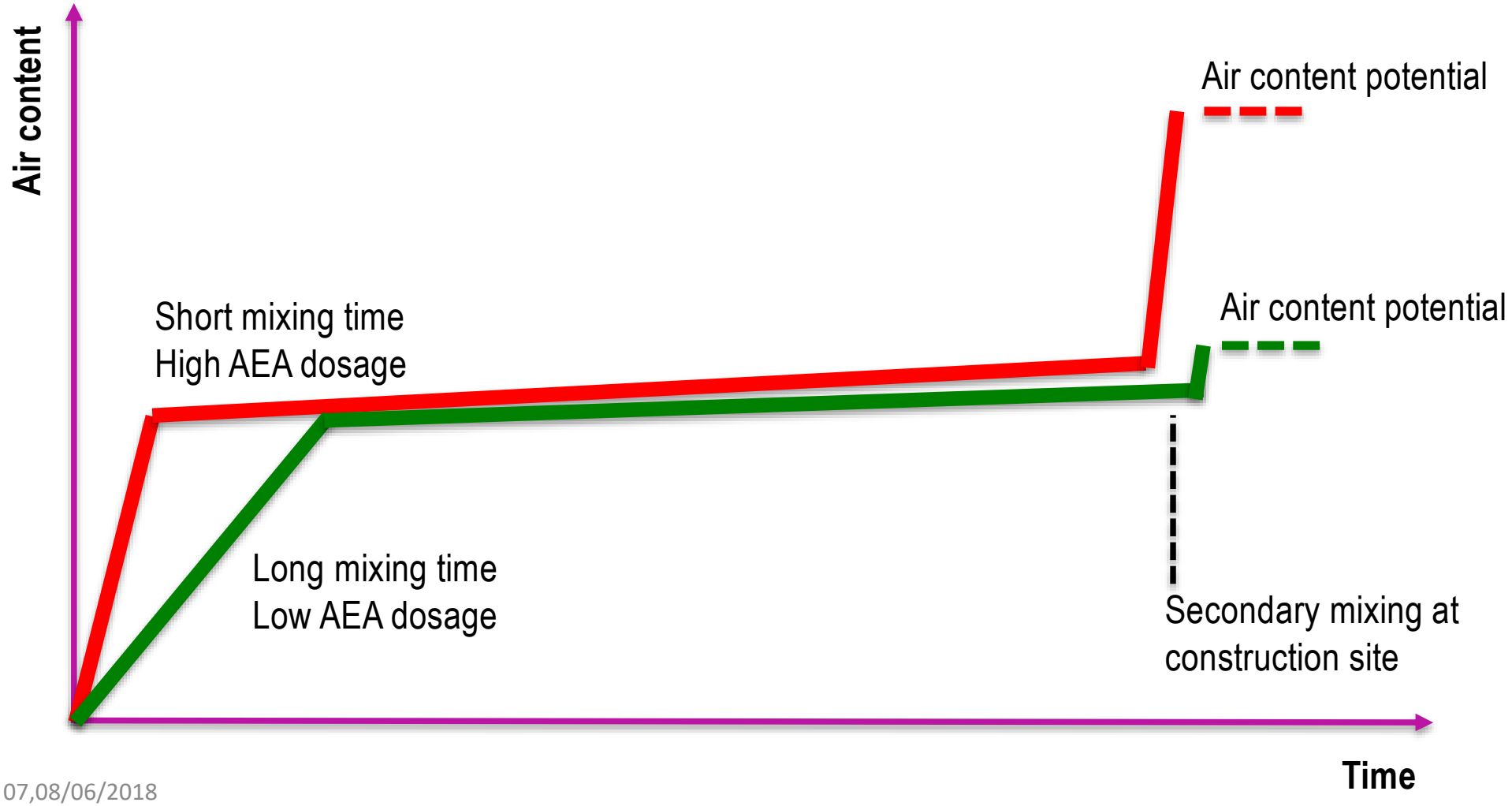
- CiDRA AIRtrac measures air content directly from the mixer
- Correlates well with the pressure methods
- Enables analyses of the mixing time etc.

Mixing time: 2 min / 5 min
AEA dosage: Normal (100%) / 50%

Conclusions
Air content potential

1. Each concrete has an "*air content potential*", which depends on
   - Admixture combination (admixtures and dosages)
   - Concrete composition, cement type
   - Consistency of concrete
2. Relatively long mixing time is needed to achieve the air content potential
   - Depends on the mixer
3. If the air potential is not achieved during the mixing, air content may increase after mixing
   - When mixed in the truck
   - During pumping and casting

Elevated air content illustrated



Conclusions

- New type of superplasticizer (PCE) and air-entrainers involve risks for elevated air content
- The risk increases:
  - When mixing efficiency is not good enough
  - With high concrete consistency
  - With high SP and AEA dosages
  - With low cement contents

How to avoid high air contents

- Know your concretes. Know the behaviour of concrete in different situations (long transportation time etc.)
- High consistencies should be avoided with AEA-concretes whenever possible. Special care is needed with fluid consistencies.
- Target air content should be on reasonable level.
- Effective quality control is needed. Focus on the properties at site. Development of continuous and automatic QC is needed.

THANK YOU
FOR YOUR ATTENTION!

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