

# Implementing Geological Disposal Technology Platform IGD-TP EF4

## Working Group 2 (Monitoring)

### Recent experience with the use of DIC and AE to monitor surface cracking in a cylindrical concrete buffer

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# Outline

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- ❑ Objectives
- ❑ Overview of the Belgian Supercontainer concept
- ❑ Setup of DIC/AE used in half-scale test to monitor initiation and evolution of cracks in the concrete buffer
- ❑ Results
- ❑ Conclusions and recommendations for further research

# Acknowledgements

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# Objectives

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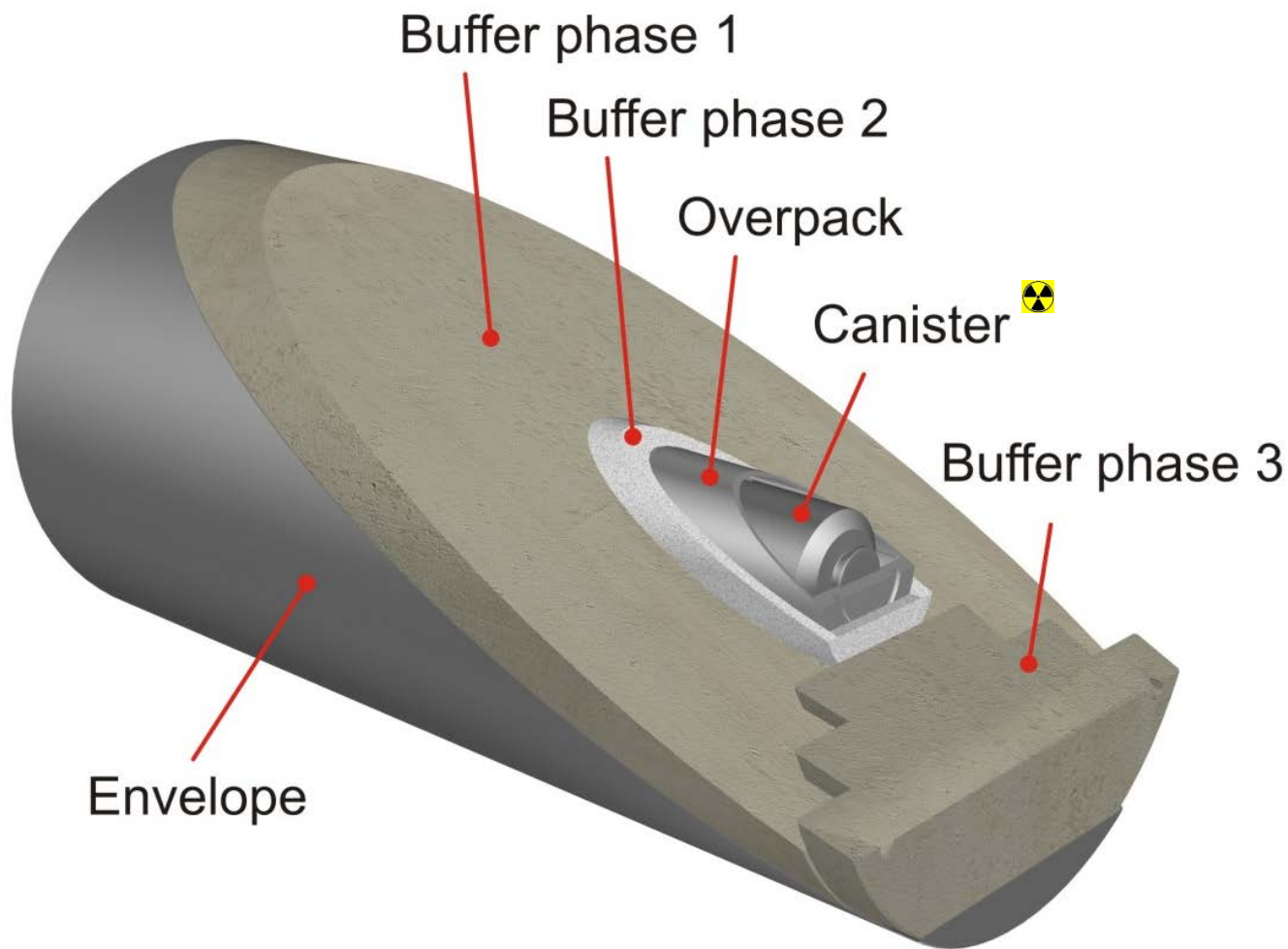
## □ Objectives of ½-scale test

- To demonstrate the construction feasibility of the Belgian Supercontainer concept
- (secondary) assess some innovative monitoring techniques to check the SC integrity
  - fiber optic strain/temp monitoring, corrosion sensing techniques, crack initiation and evolution

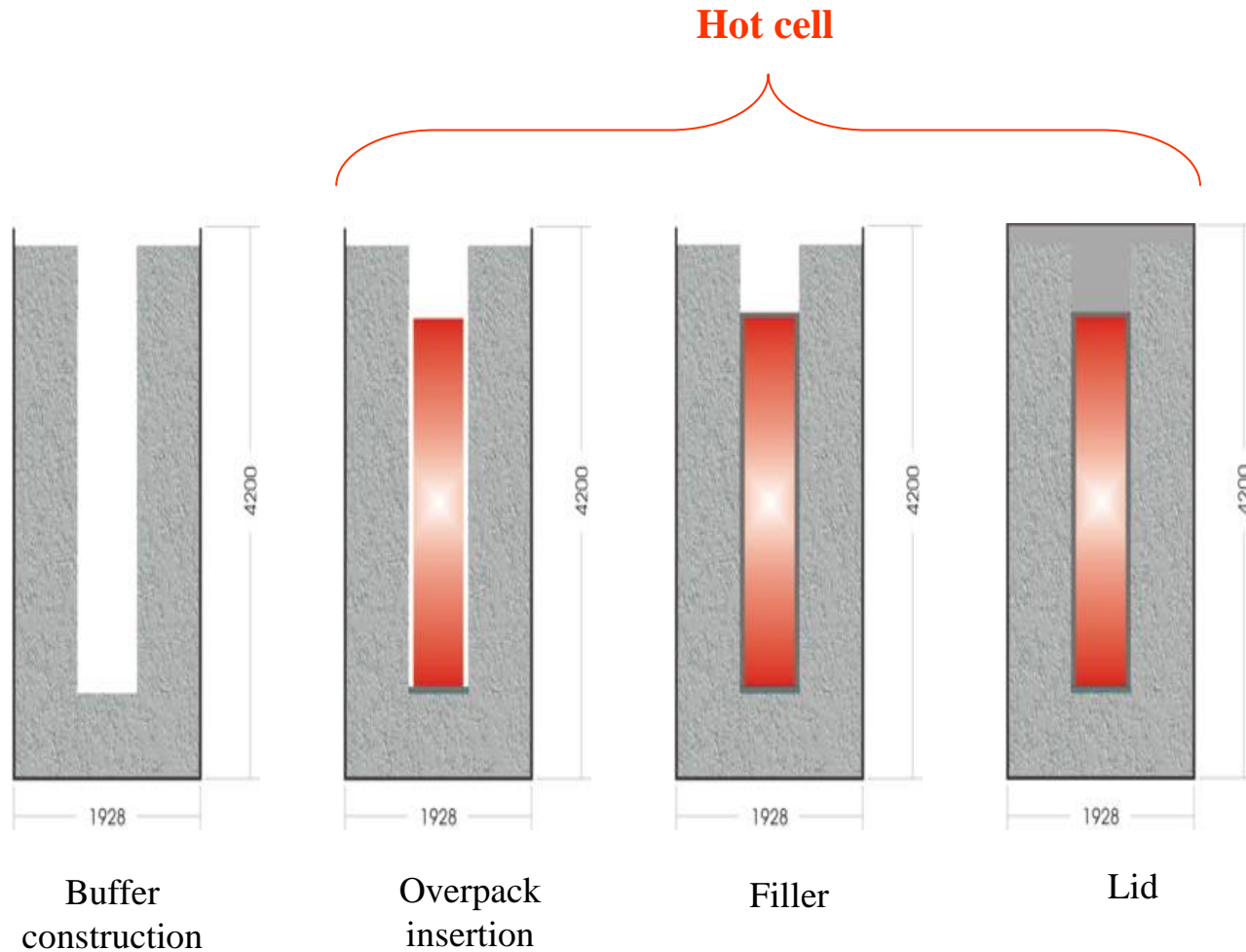
## □ Objectives of DIC/AE

- Test whether the combination of Digital Image Correlation (DIC) and Acoustic Emission (AE) could detect the initiation of cracks during curing of concrete buffer and heat phase

# Belgian Supercontainer concept – HLW



# Belgian Supercontainer – construction phases



# Belgian Supercontainer – half scale test 2



General test set up



Concrete casting



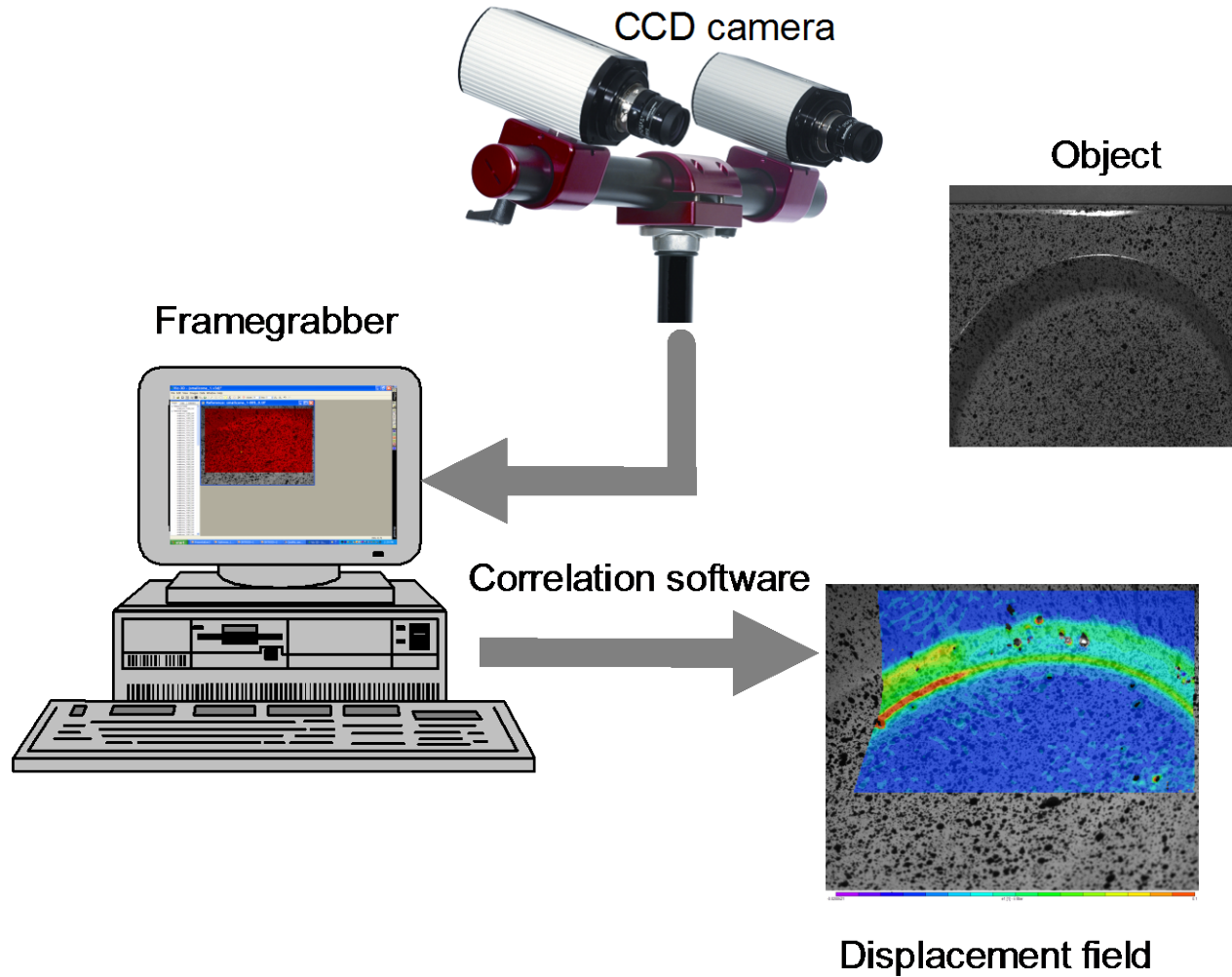
Corrosion sensors



Fiber optic sensing lines (FBG's)

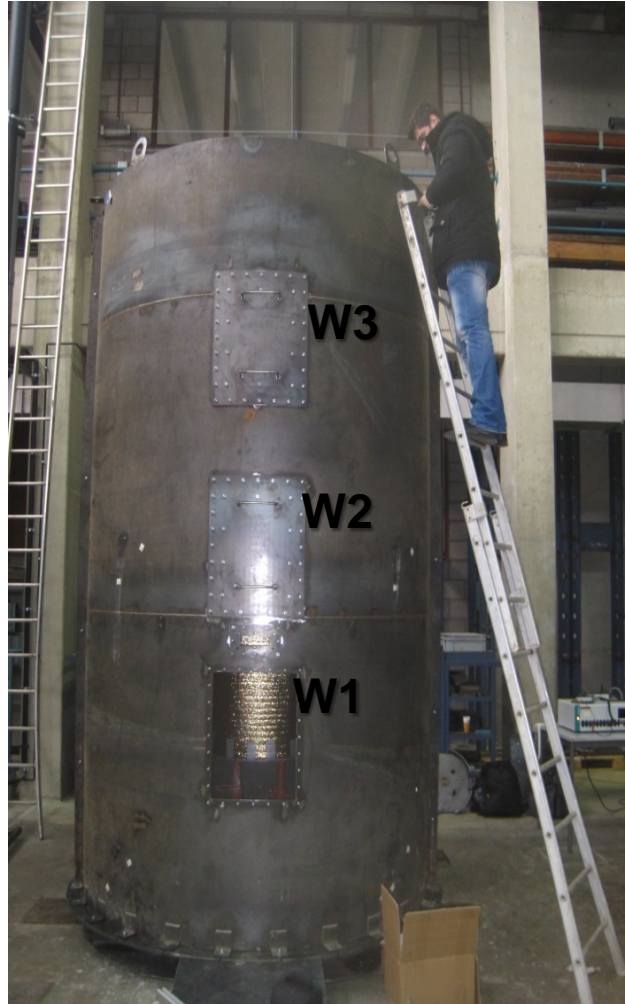


# DIC/AE – Working principle



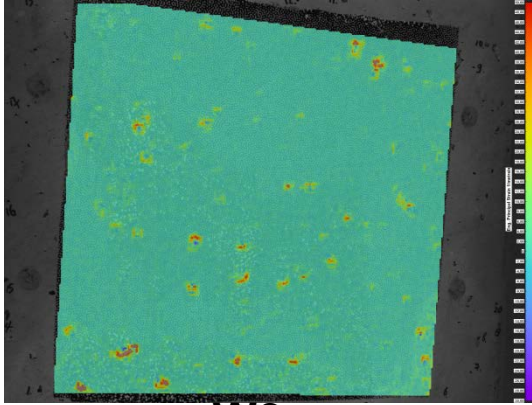


# DIC/AE – Setup in 1/2-scale test





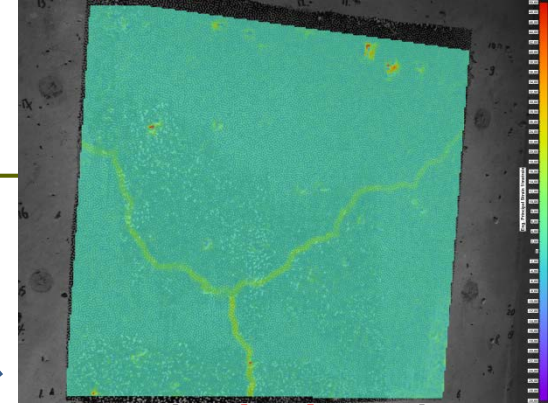
**Overview of cracking**  
**No cracking in Phase 1 [left]**



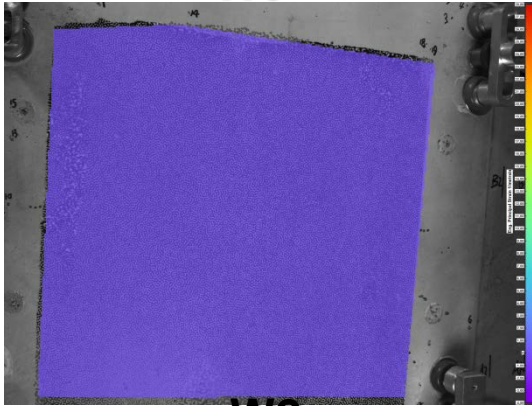
**W3**



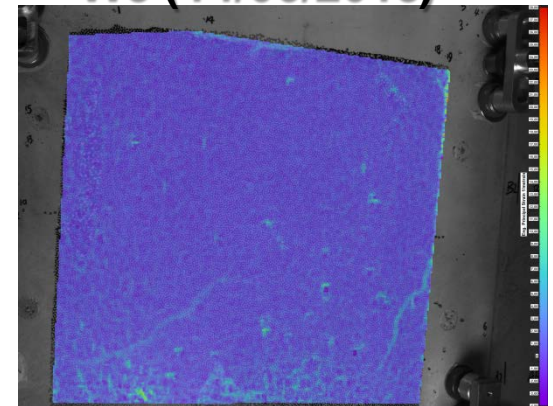
**Cracking initiation in Phase 2 [right]**



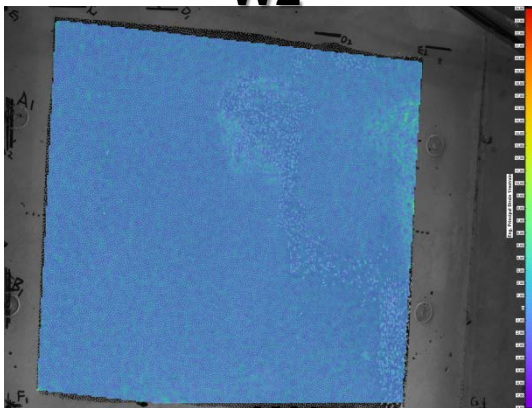
**W3 (14/06/2013)**



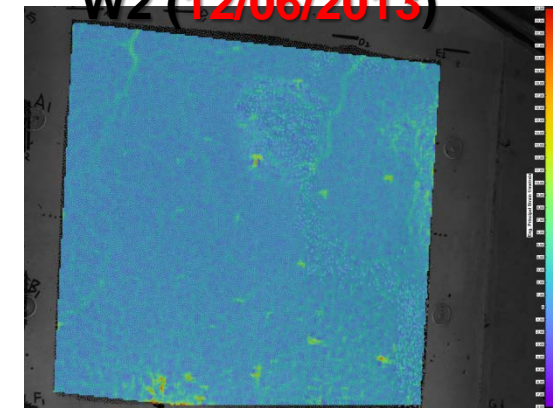
**W2**



**W2 (12/06/2013)**

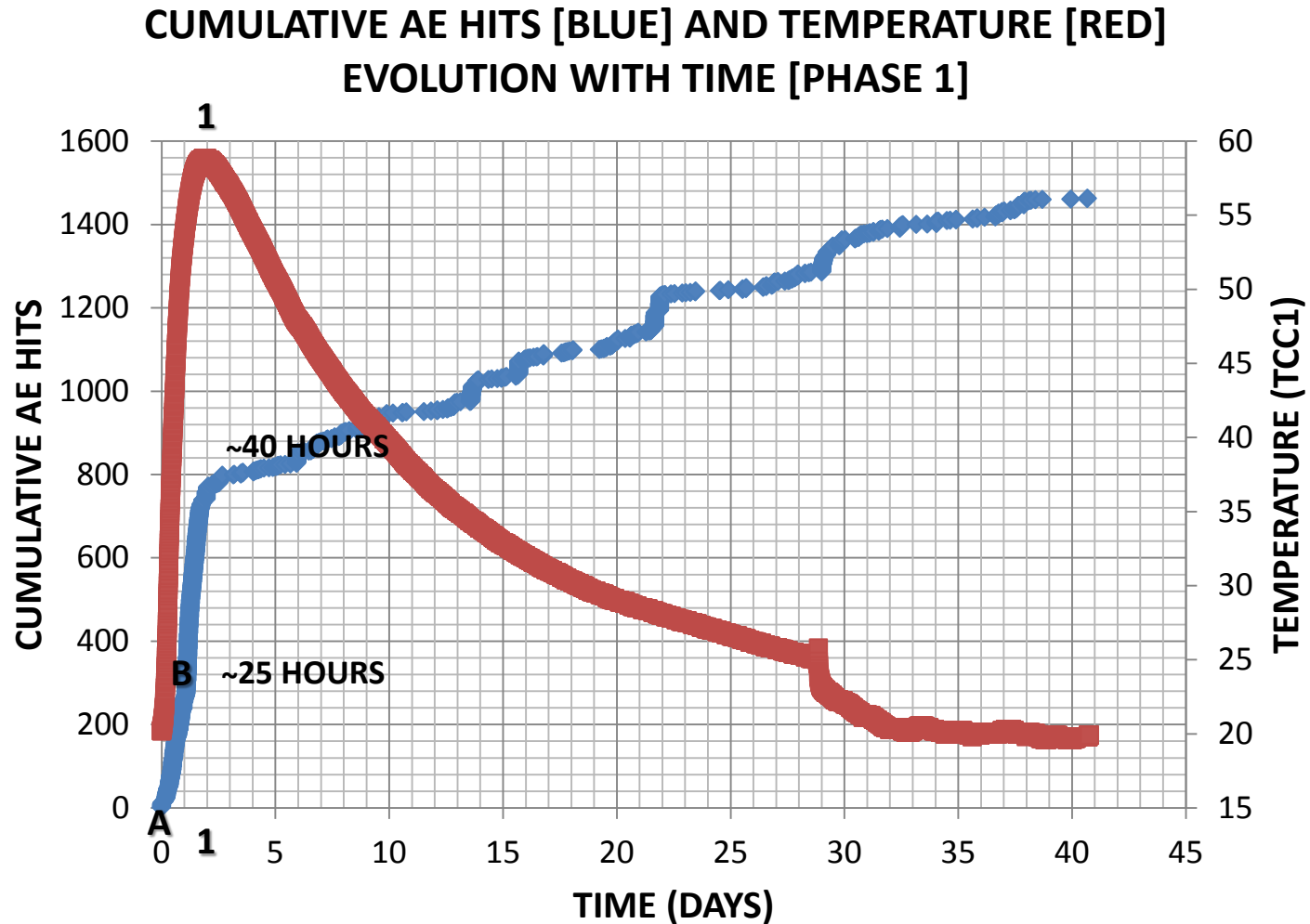


**W1**

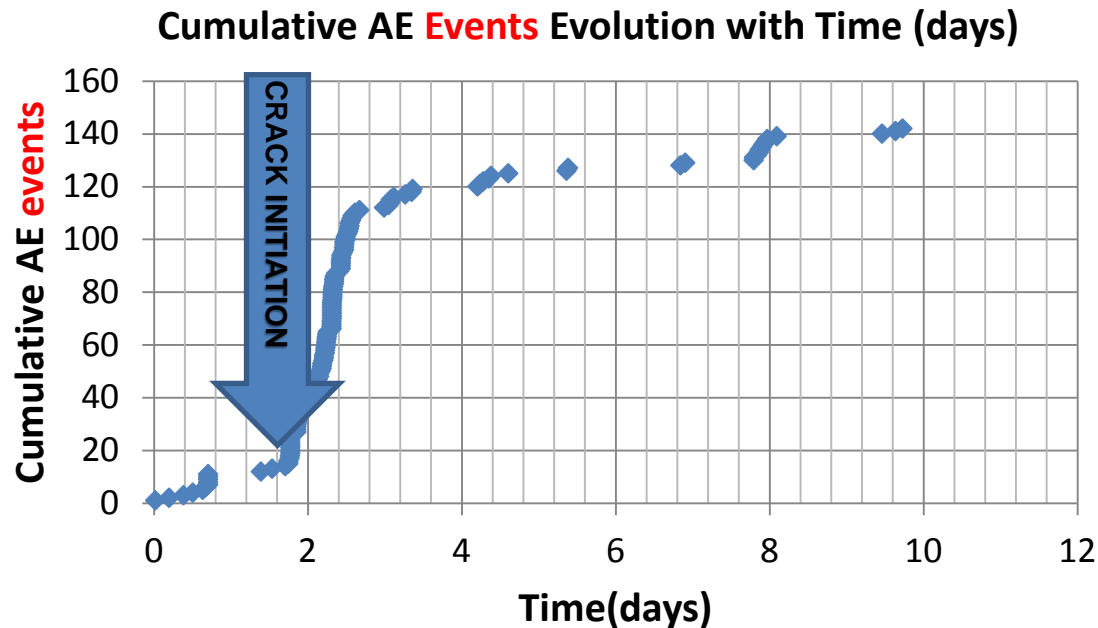


**W1 (17/06/2013)**

# Results DIC/AE – Phase 1 no cracking



# Results DIC/AE – Phase 2 cracking



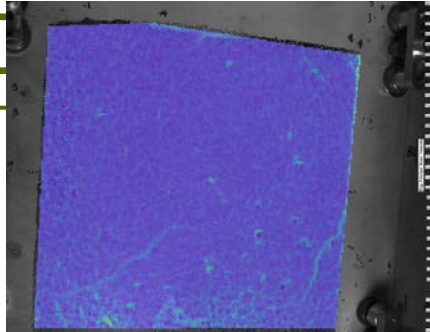
## INITIATION OF CRACKING

- **START OF AE MONITORING**  
11/06/2013 15:54 (Day 0)
- **FIRST CRACK INITIATION IN WINDOW 2**  
**12/06/2013 ~ 08:40 AM (Day 1)**  
**CONFIRMED BY DIC IMAGE CAPTURED ON 11:30 AM**
- **INDICATION OF CRACKING**  
**RAPID INCREASE OF AE EVENTS**

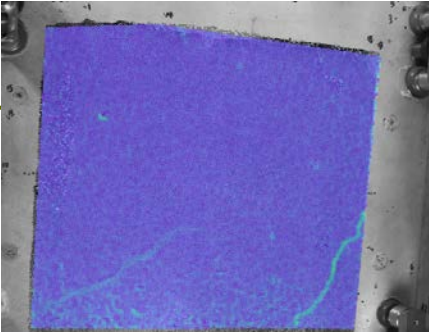




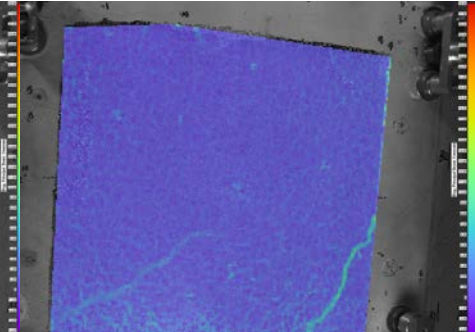
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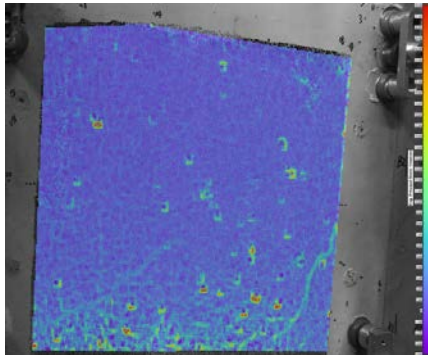
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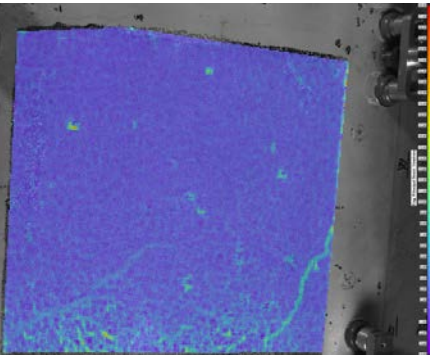
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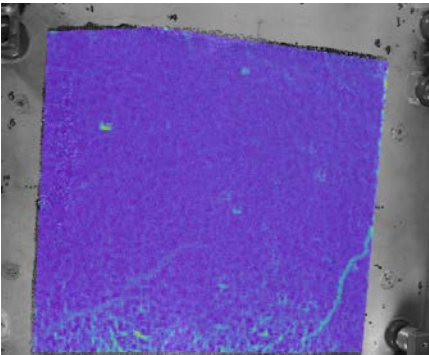
17/06/2013



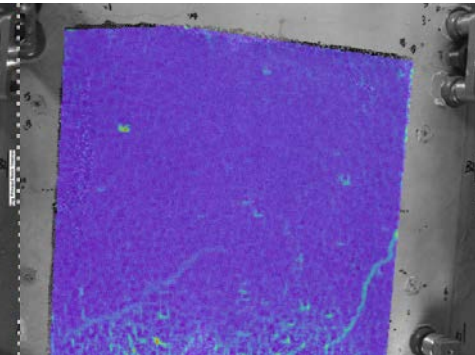
19/06/2013



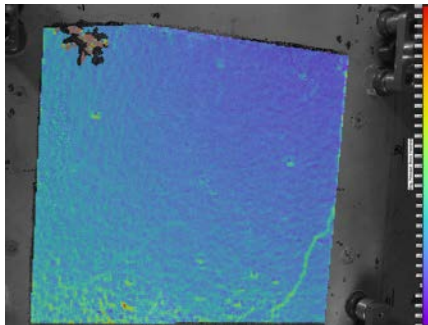
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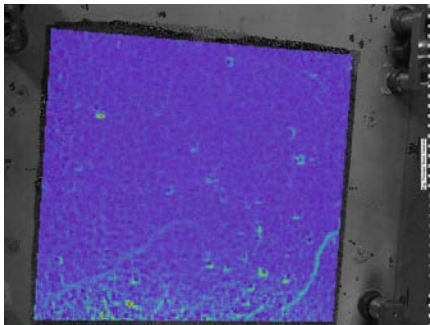
05/07/2013



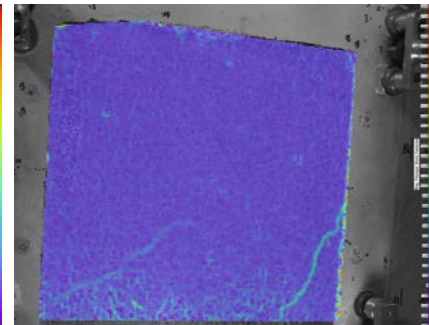
12/07/2013



19/07/2013



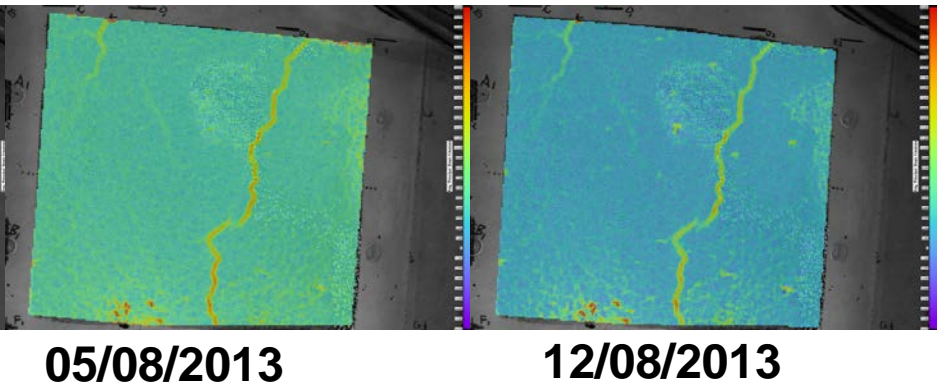
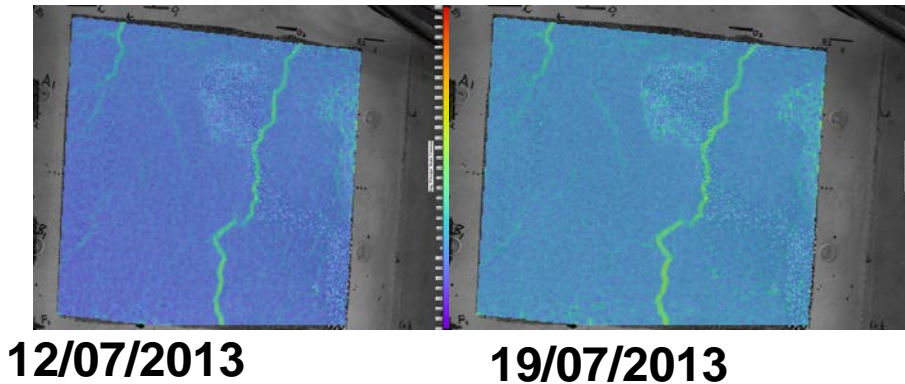
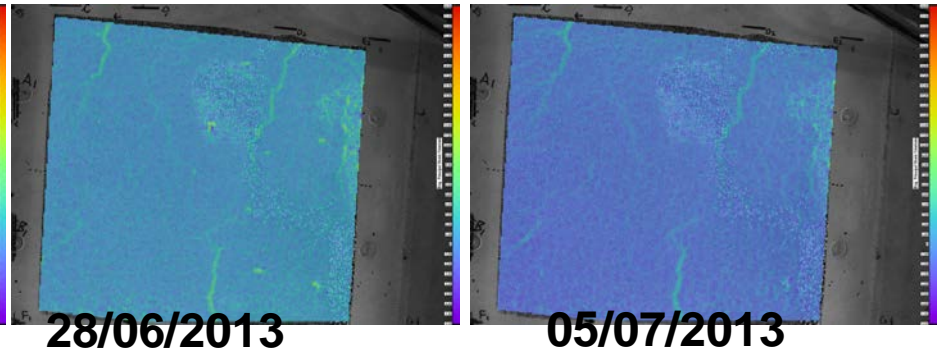
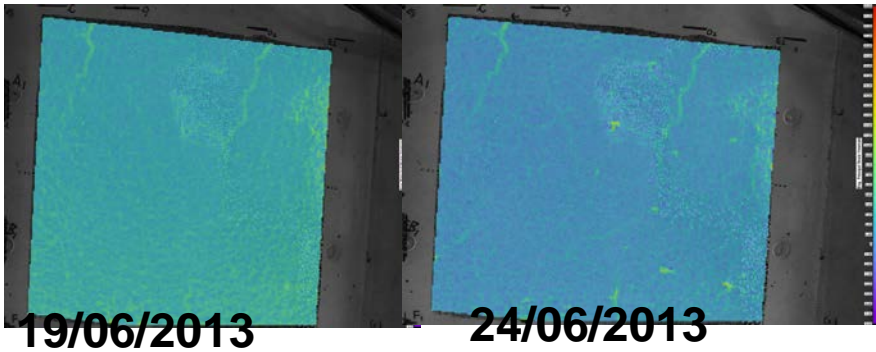
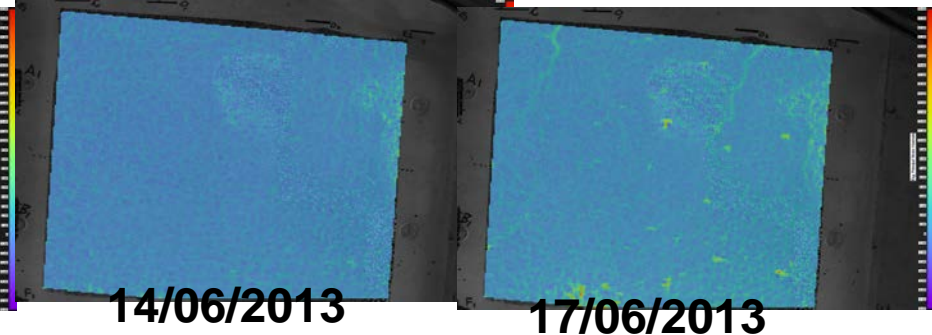
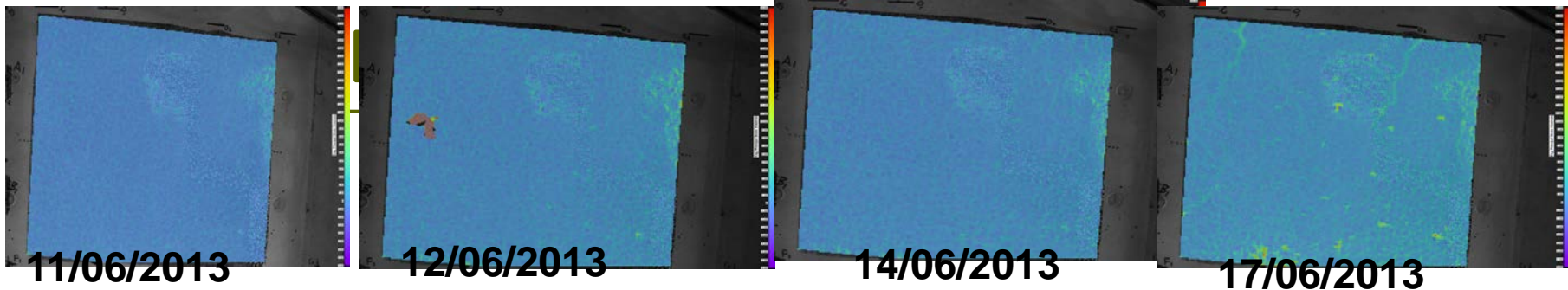
05/08/2013



12/08/2013

## W2 crack evolution

- 12/06 crack initiation



**Crack evolution in Window 1:  
First cracks on 17/06**



# Conclusions

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- ❑ The high number of AE hits (~800) recorded in the first 2 days of Phase 1 represent segregation of aggregates after casting, migration of gas and water and start of hydration process. No cracking was observed either visually with the naked eye or with DIC /AE for the whole of Phase 1
- ❑ The maximum rate of AE hits coincides with the peak temperature of hydration in Phase 1 (~ 40 hours after casting)
- ❑ Crack initiation was detected less than one day after the start of the heating phase in Window 2 AE at 08:40 AM on 12/06/2013. This was confirmed by DIC images in Window 2 the same day at 11:30 AM. The initiation of cracks in Window 2 is consistent with the location of the maximum stress and temperature distribution in the ½-scale test at this window
- ❑ The results of DIC/AE provided a valuable contribution to the interpretation and confirmation of temperature and strain data obtained using VW and optical fibre sensors



# Recommendations for further work

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- ❑ AE sensors could not be installed directly on the concrete surface due to the presence of the steel mould during the first 28 days of curing. A smart fixing system should be developed to allow direct access to the fresh concrete asap after casting
- ❑ The AE installation was limited to the surface of the concrete buffer, which provides a 2D field of view. Embedding AE sensors in the concrete would provide a third dimension. This would allow locating the precise points of crack initiation as well as a better follow-up of their evolution. Further research is needed to determine optimum spacing, optimization of data transmission in real time, and calibration of sensors in a three-dimension configuration
- ❑ Fixing the DIC cameras at the same position for each measurement was difficult with the current setup. An improved system of fixation should be developed to enhance the monitoring capabilities (repeatability) of the system
- ❑ As the number of AE sensors and the DIC windows that can be designed and utilized is limited, especially when the structure to be monitored is large, there is a need to complement the measurements of this technique with predictive modeling. The use of DIC and AE measurements in combination with conventional monitoring techniques, such as the ones used in the 1/2-scale test, offer the possibility to provide the material parameters needed to construct and verify these models

# Recommendations for further work

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THANK YOU