



# Formulating mortars for use in restoration practice

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Natural cements in European cultural heritage  
Les ciments naturels dans le patrimoine européen  
PARIS – 26/27-04-2012

Details may be found on Posters

Presentation is an Overview

# Materials

## Cements

Vicat Prompt

MBM Gartenau - ROCARE

W&P Wietersdorf – ROCARE

## Sand

Carbonate 0 – 4 mm

## Mortars

Cast elements & renders

# Mortar specifications

Cast mortars –

Proportions: 0.5 and 1:1 by volume

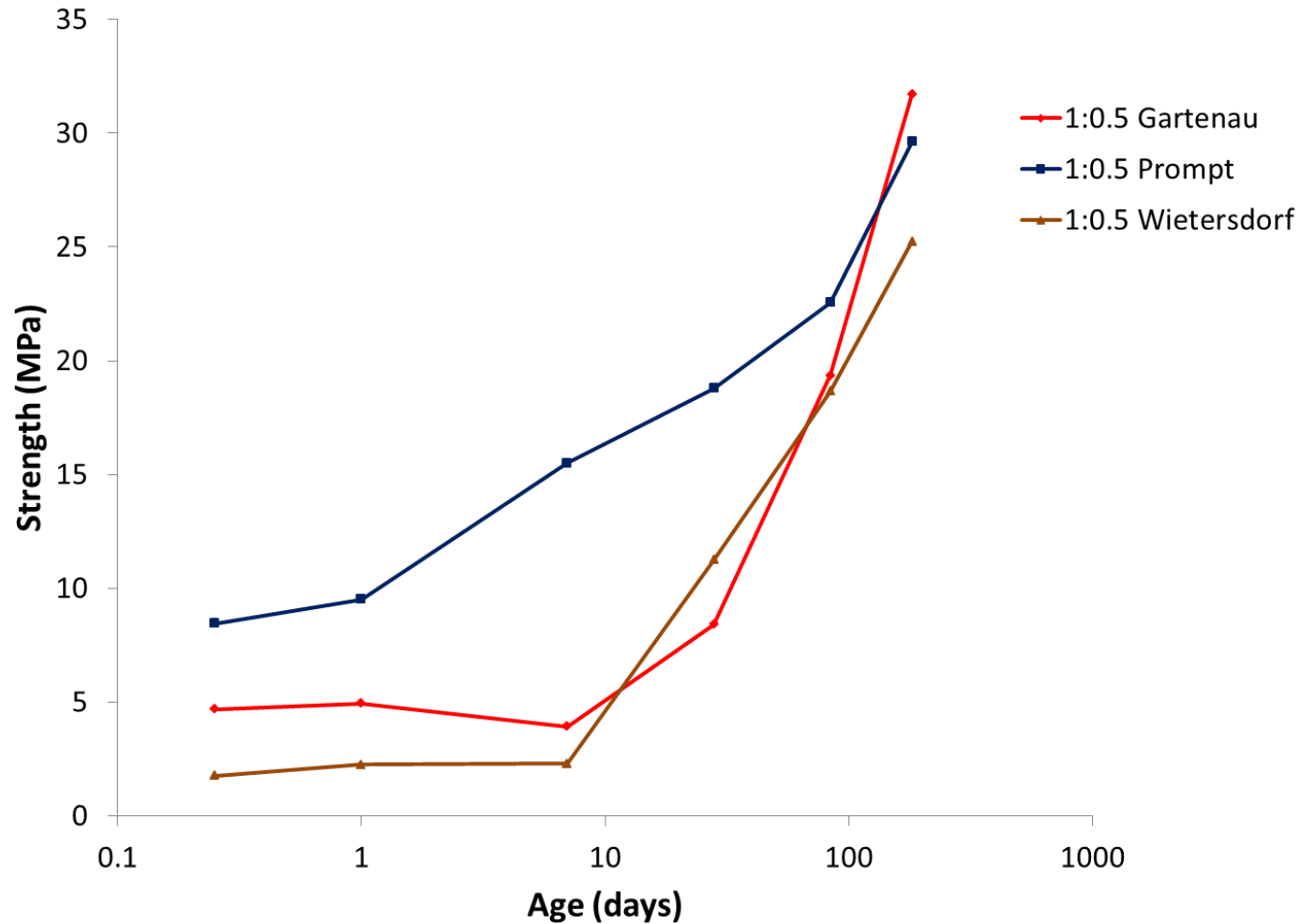
Flow: 19.5 cm

Workable life: 15 – 30 minutes

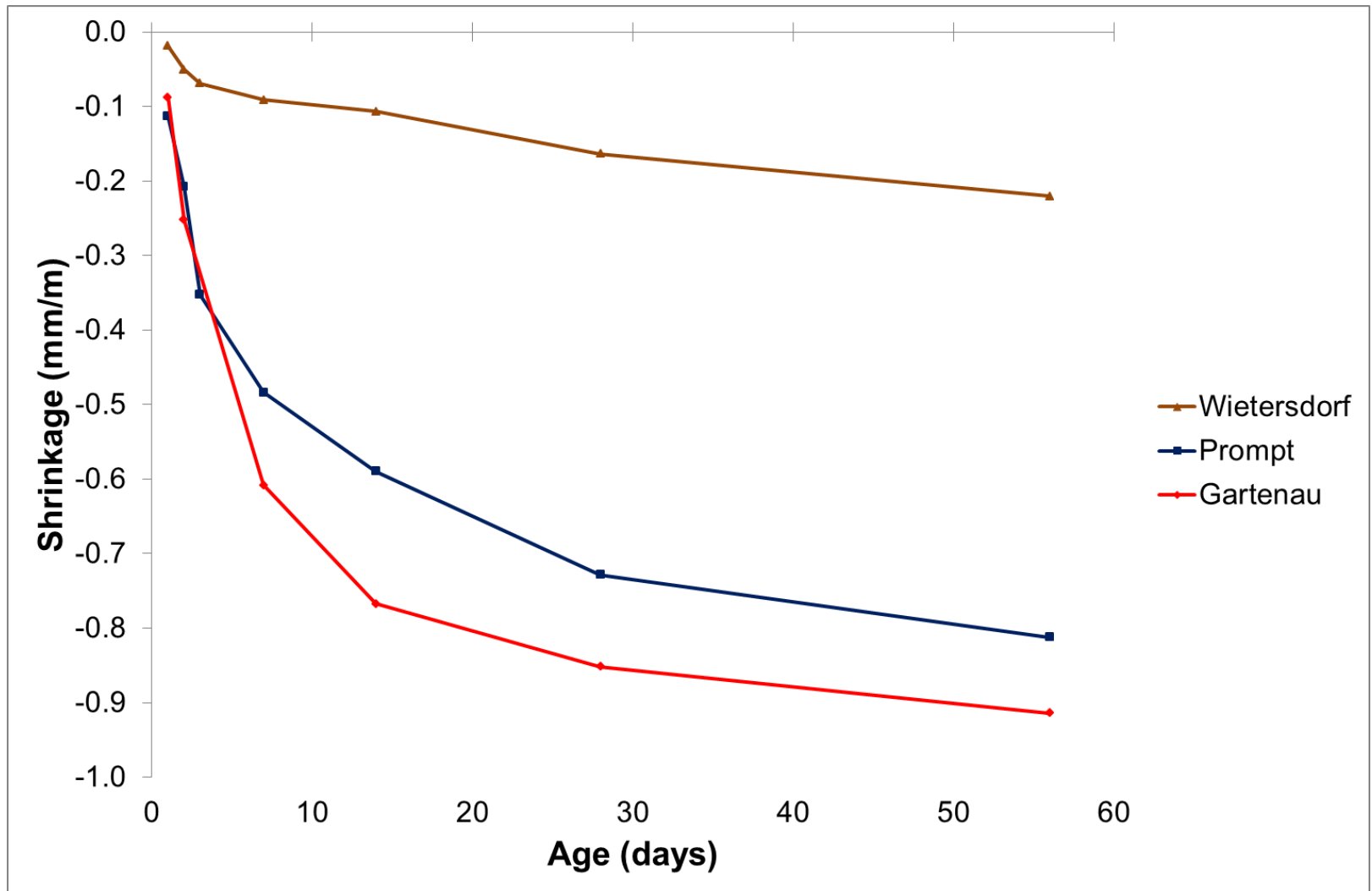
Retarder: Citric acid

	Citric acid	w/c	
		(1:0.5)	(1:1)
Prompt	0.5%	0.46	0.55
Gartenau	1.0%	0.5	0.57
Wietersdorf	0.4%	0.47	0.54

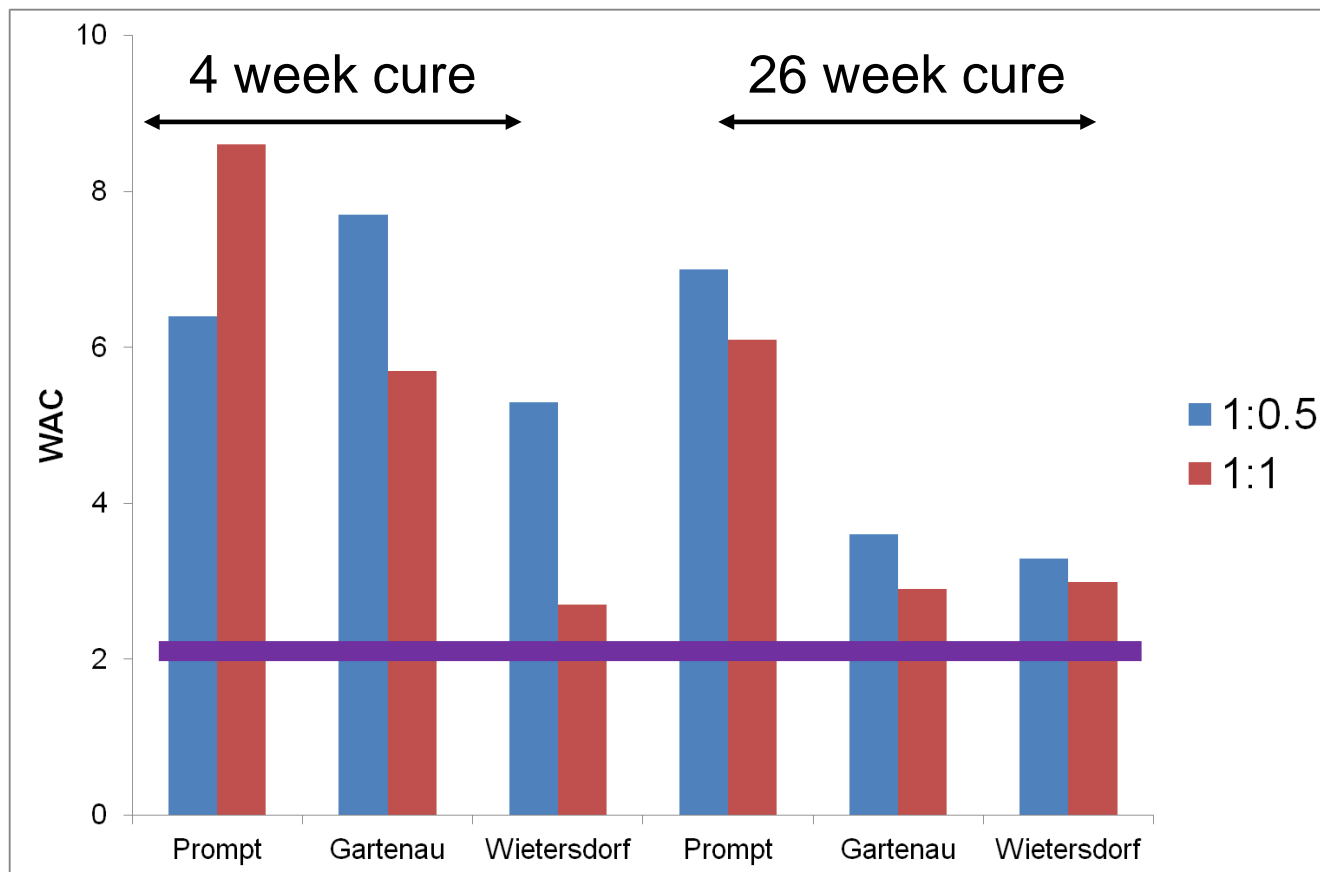
# Cast Mortar (1:0.5) - strength



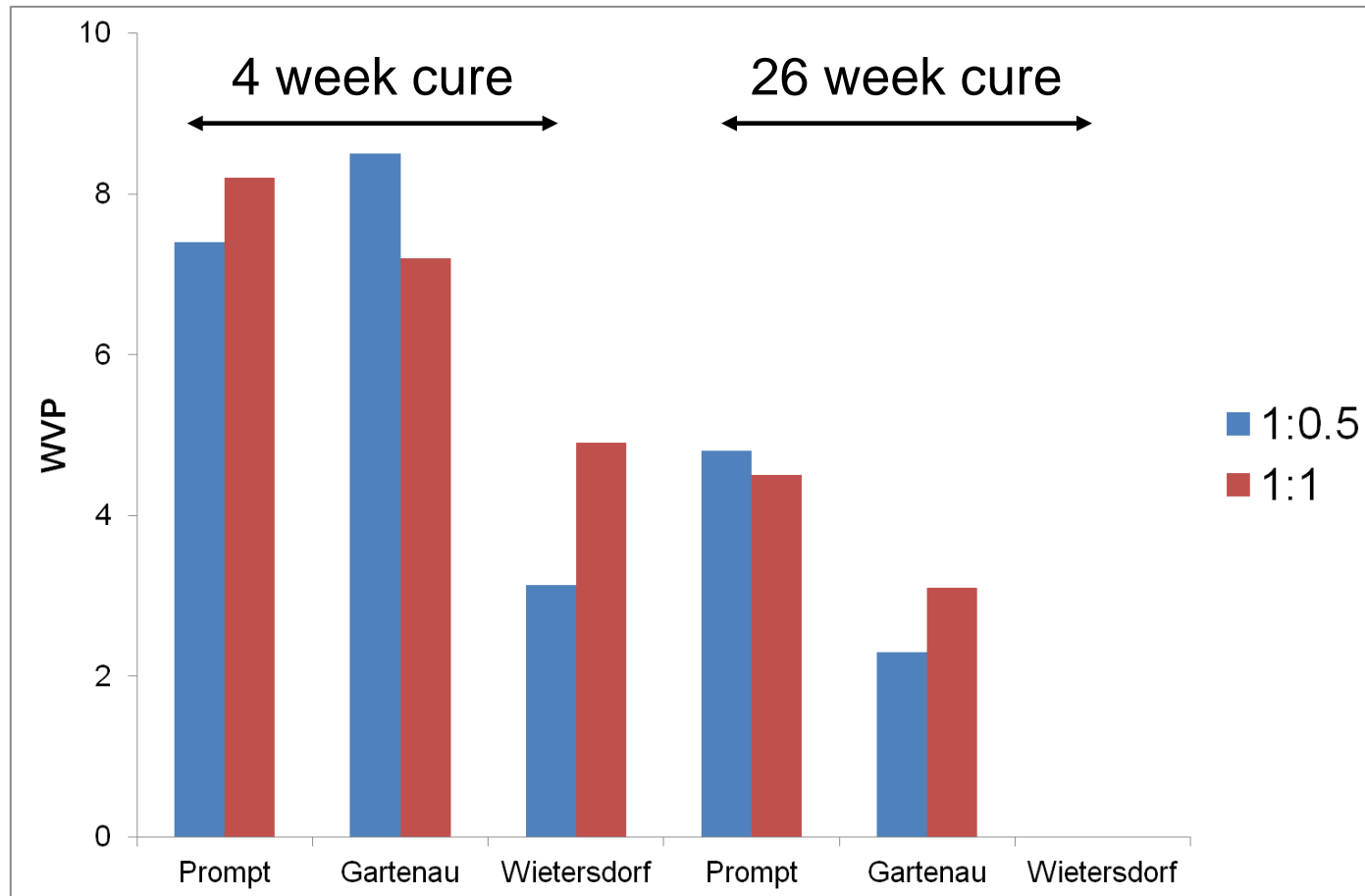
# Cast Mortar (1:0.5) – Shrinkage



# Cast Mortar – Water Absorption (kg/m<sup>2</sup>/hr<sup>0.5</sup>)



# Cast Mortar – Vapour Permeability ( $\text{kg/m}^2/\text{Pa/s} * 10^{-9}$ )





# Mortar specifications

## Render mortars –

Proportions: 1:1.5 and 1:2.5 by vol

Flow: 15.5 cm

Workable life: 1 – 2 hours

Retarder: Citric acid (**Prompt**)  
Deactivation process  
(**ROCARE cements**)

# Deactivation Process (DARC)

## Stage 1

- Mix sand with a **small amount of water** for 2 minutes (deactivation water)
- Add cement and mix for 2 minutes
- Store for **short period of time**

## Stage 2

- Mix mortar for longer than cast mortars

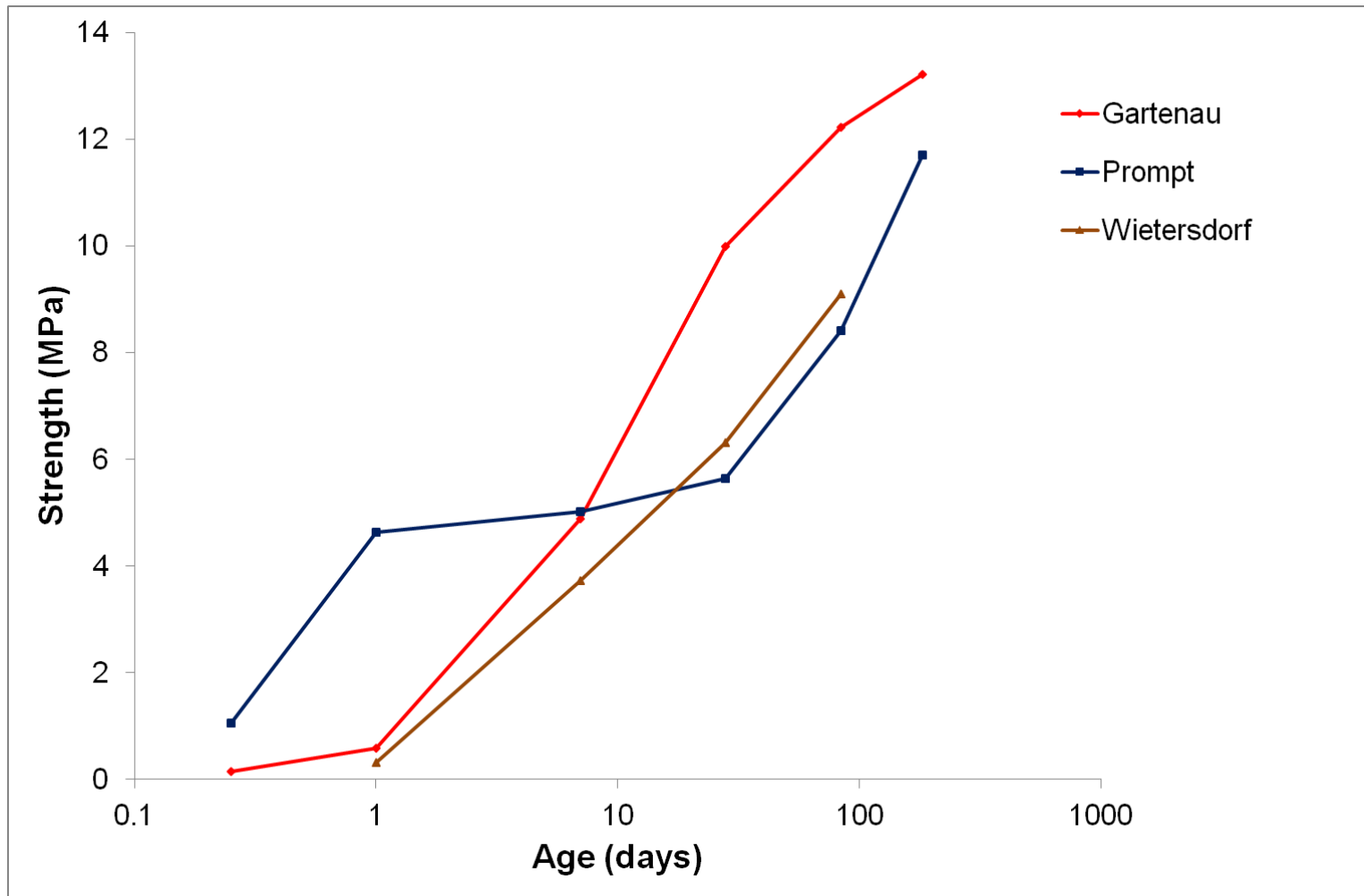
# Mortar specifications

	Retarder	w/c	
		(1:1.5)	(1:2.5)
Prompt	1.5% CA*	0.42	0.59
Gartenau	DARC**	0.5	0.57
Wietersdorf	DARC	0.56	0.76

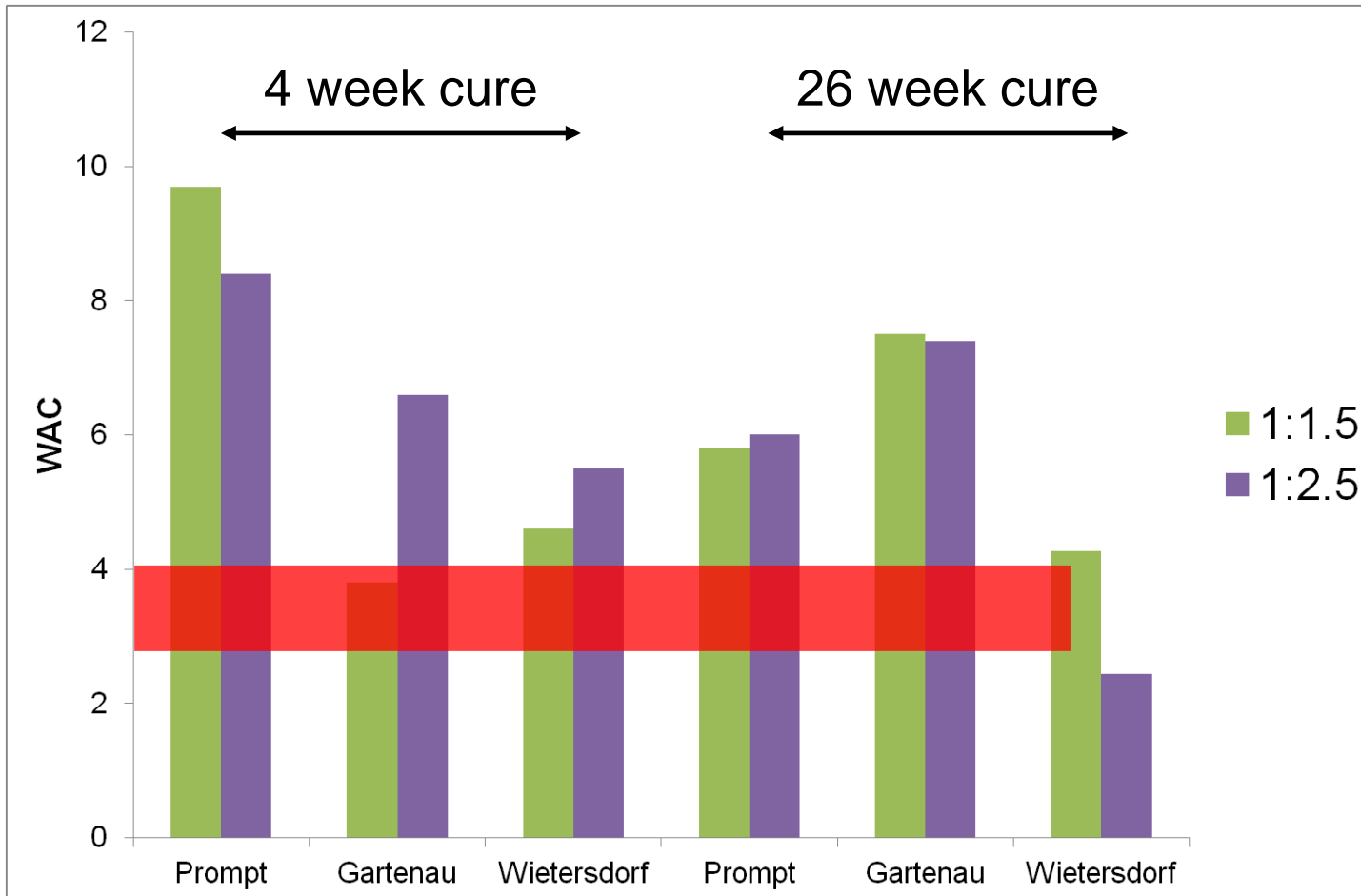
\* May be considered excessive

\*\* Requires twice the deactivation water as Wietersdorf cement

# Render Mortar (1:2.5) - strength



# Render Mortar – Water Absorption (kg/m<sup>2</sup>/hr<sup>0.5</sup>)



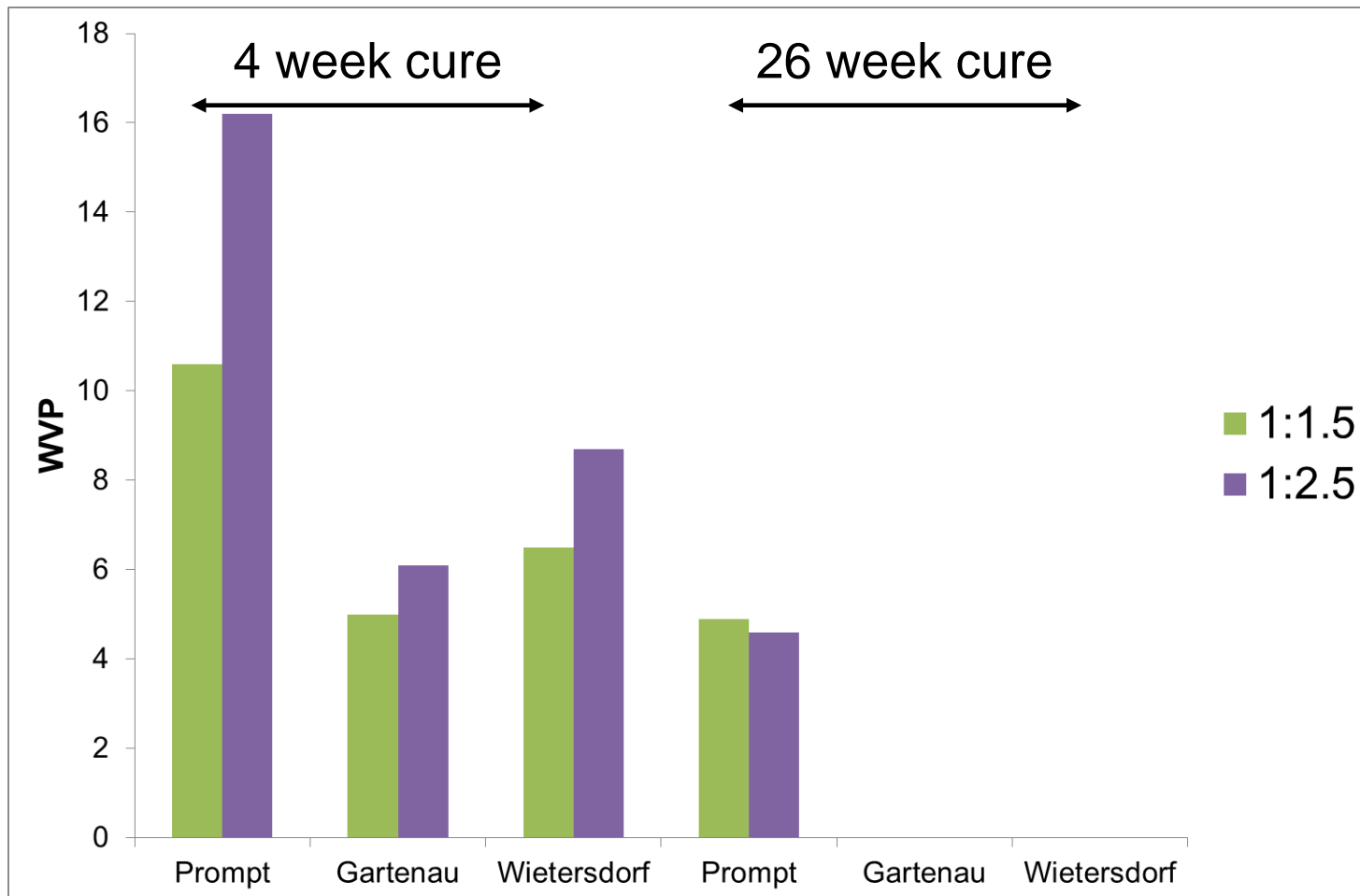
NHL 5  
@ 4 w

22 – 25

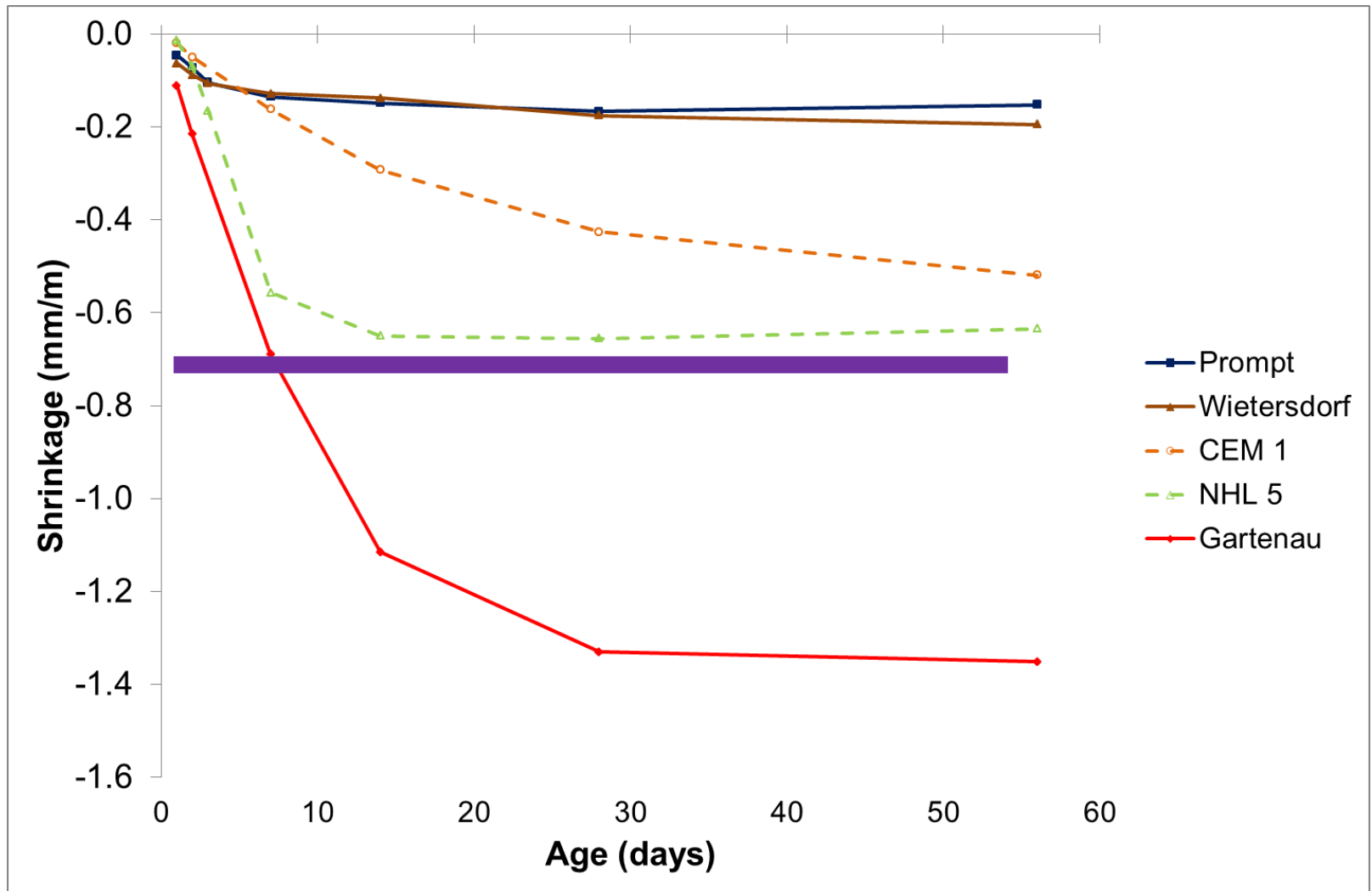
NHL 5  
@ 26 w

11 - 12

# Render Mortar – Vapour Permeability (kg/m<sup>2</sup>/Pa/s \* 10<sup>-9</sup>)



# Render Mortar (1:2.5) – Shrinkage



# Hybrid mortars – 1:1.5

50% Gartenau – 50% NHL5\* / CL90

33% Gartenau – 67% NHL5\* / CL90

\* Otterbein NHL5

Pure Gartenau

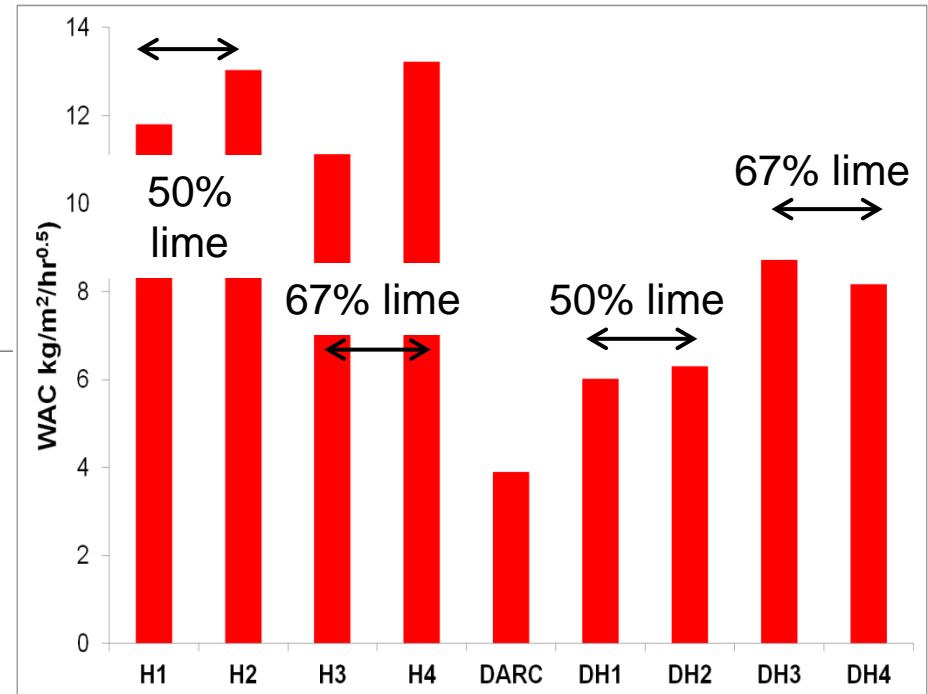
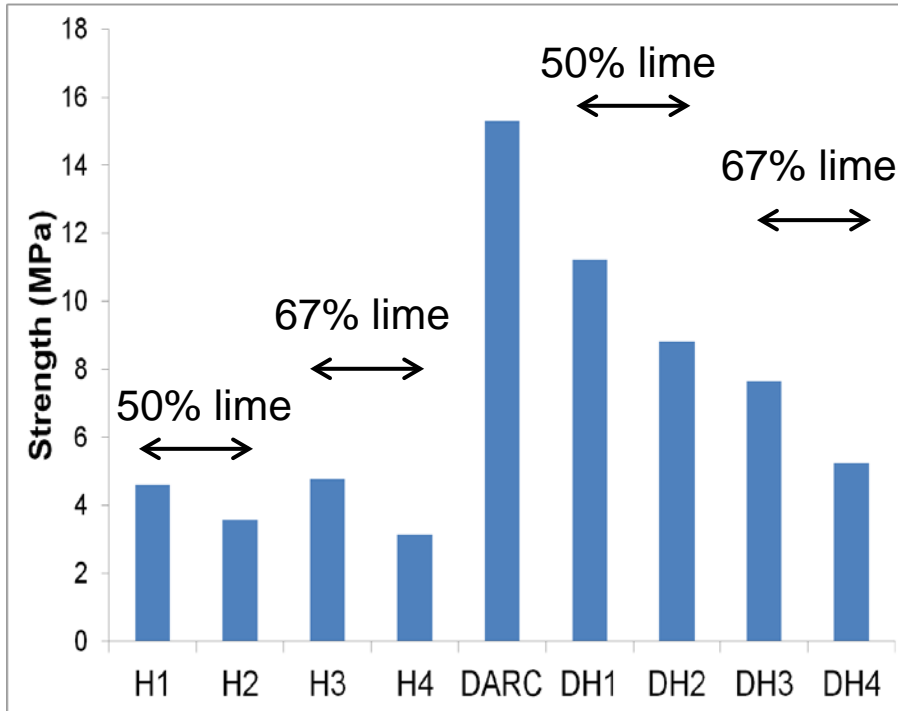
DARC Gartenau



# Hybrid mortars – w/b ratio workable life

	50% NHL 5	67% NHL5	50% CL90	67% CL90
<b>w/b</b>				
DARC Gartenau	0.75	0.79	0.81	0.85
Pure Gartenau	0.99	0.97	1.07	1.07
<b>Workable Life</b>				
DARC Gartenau	~95 min	~105 min	~100 min	~110 min
Pure Gartenau	~270 min	~200 min	~220 min	~170 min
Original DARC ~60 min				

# Hybrid mortars – strength & WAC



# Conclusions

- Different cements require different retardation techniques for render mortars
- Not all cements may facilitate rapid demoulding of cast elements
- DARC render mortars have low early age strength
- Hybrid mortars permit further control of strength and water transmission
- Carbonate sands may yield high shrinkage for some grading profiles



For additional information see

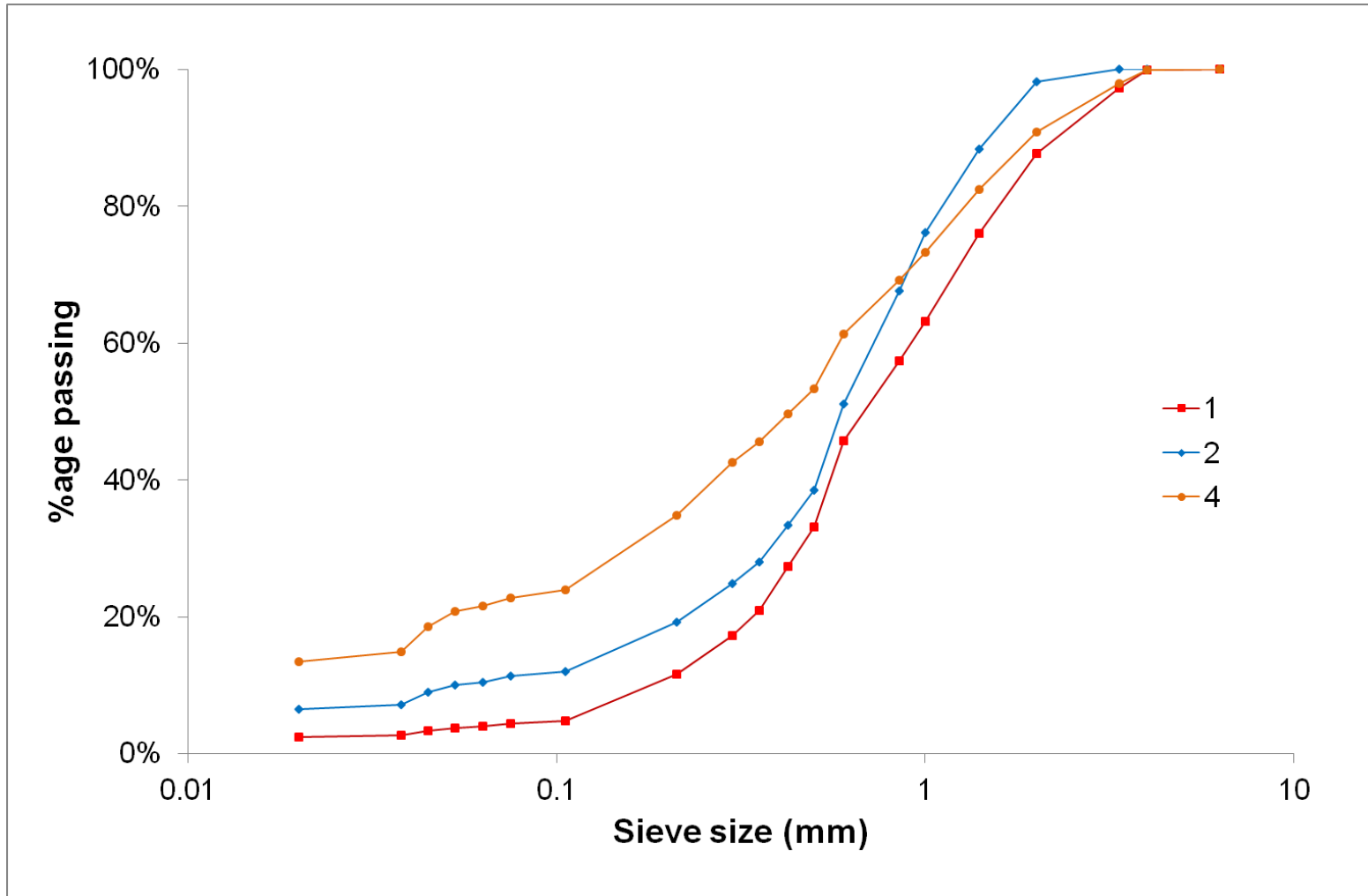
Poster Exhibition and

[www.rocare.eu](http://www.rocare.eu)

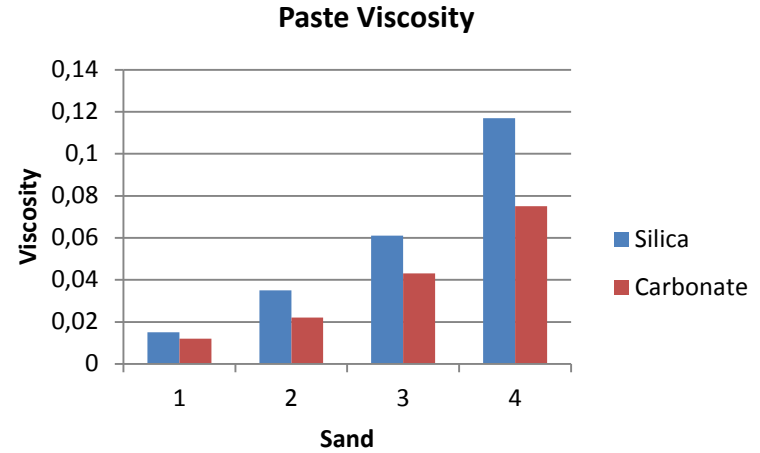
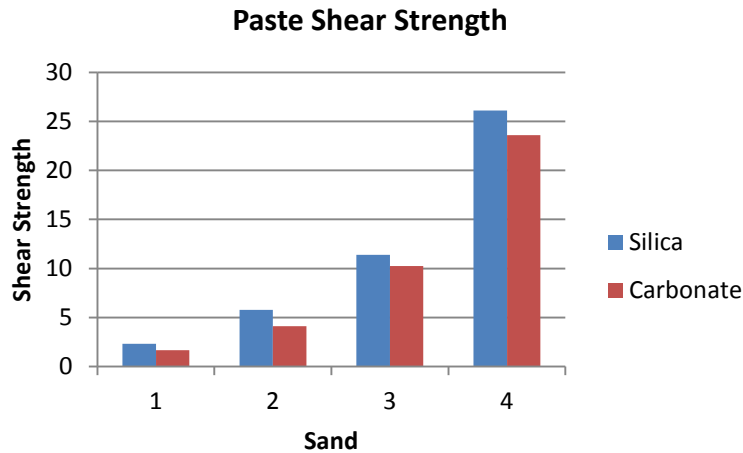
If you have any questions contact me at

[d.c.hughes@bradford.ac.uk](mailto:d.c.hughes@bradford.ac.uk)

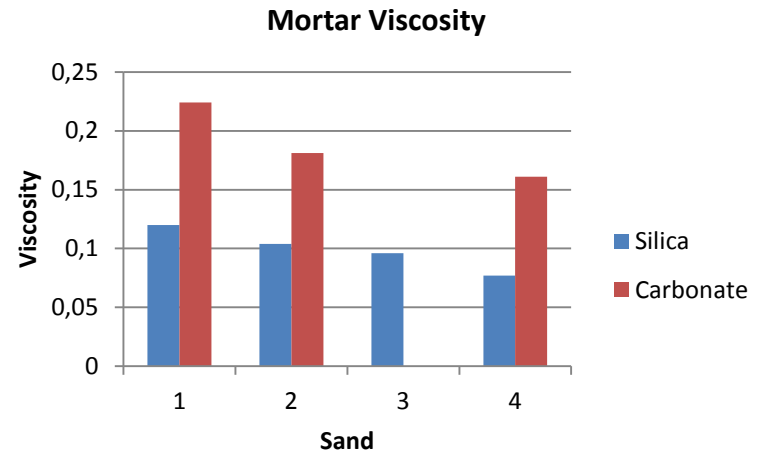
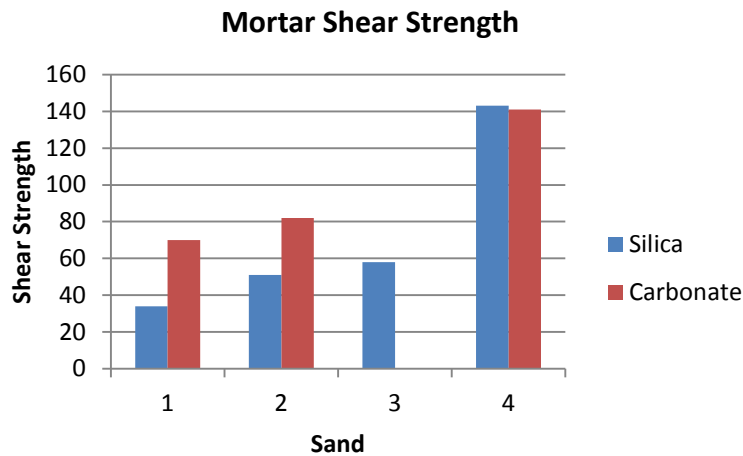
# Influence of sand - grading



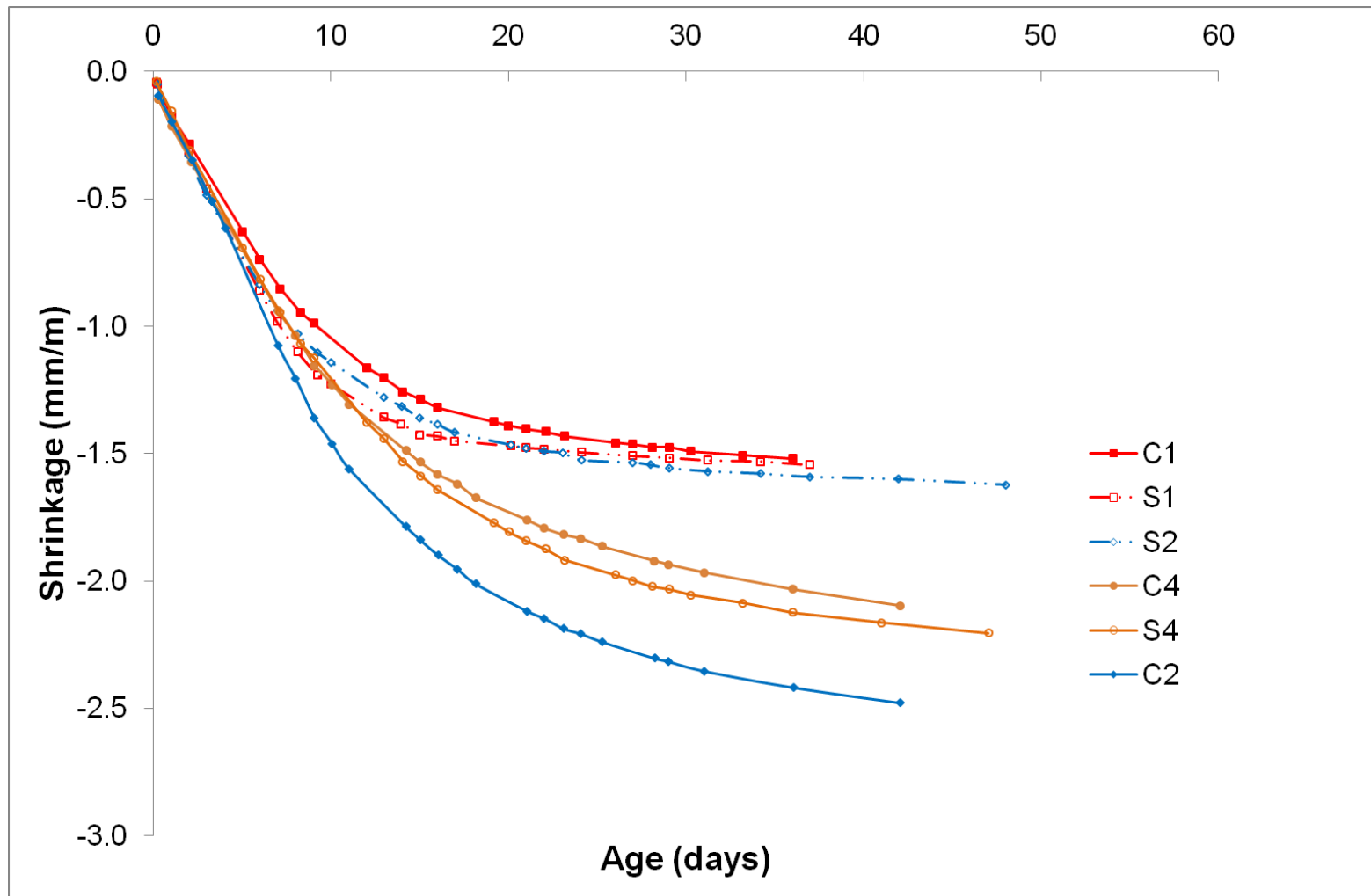
# Influence of sand – rheology (const w/c)



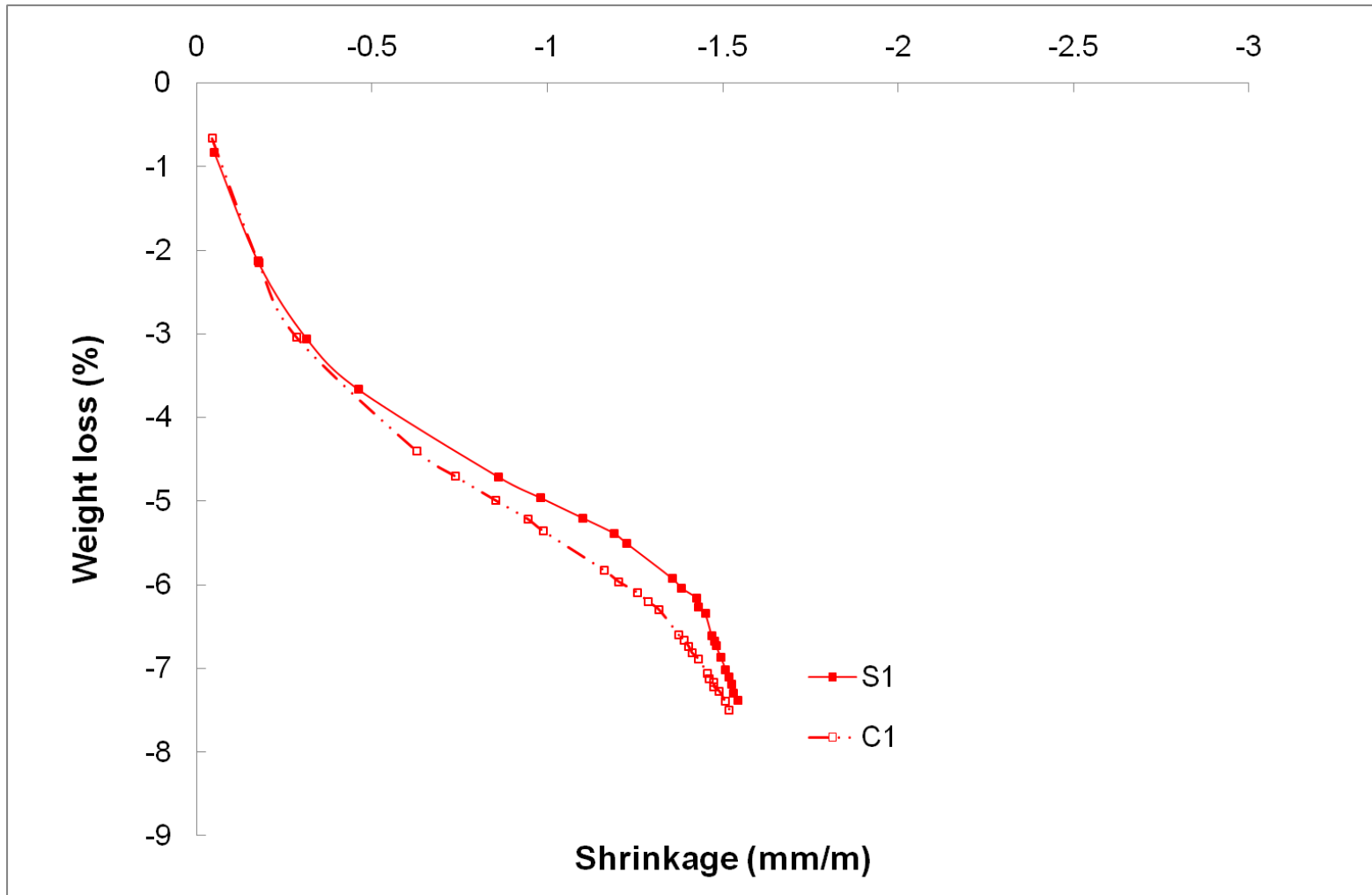
~14 μm ~23 μm ~24 μm ~47 μm



# Influence of sand – Shrinkage

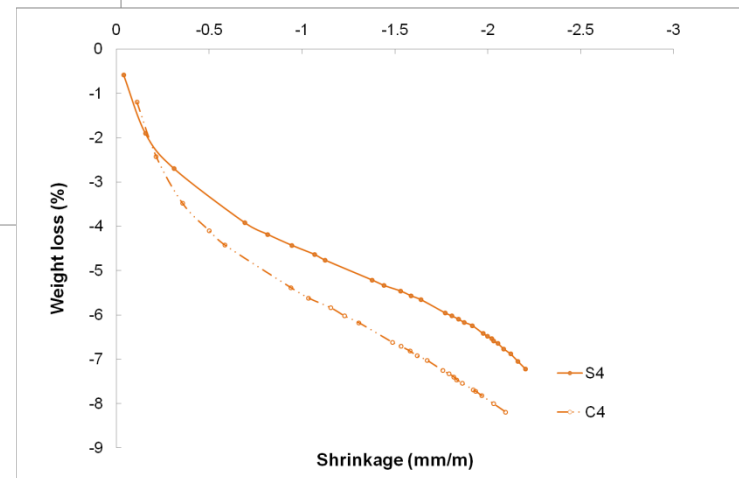
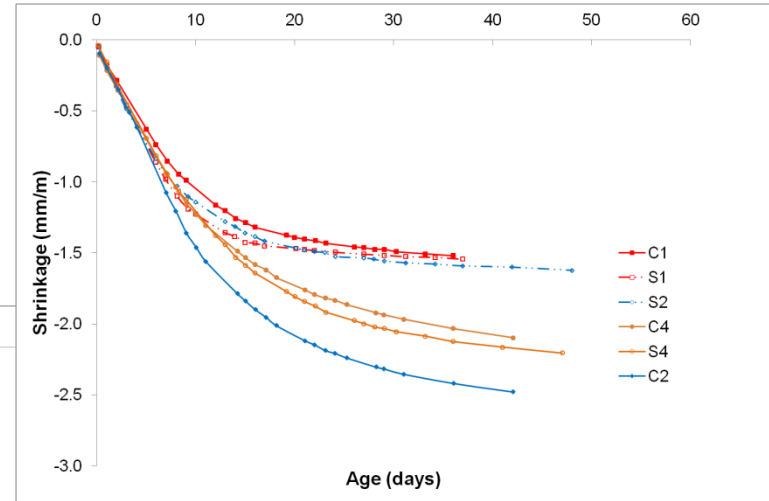
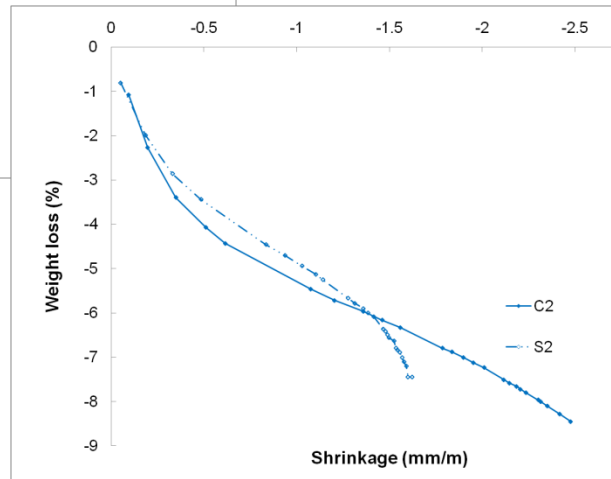
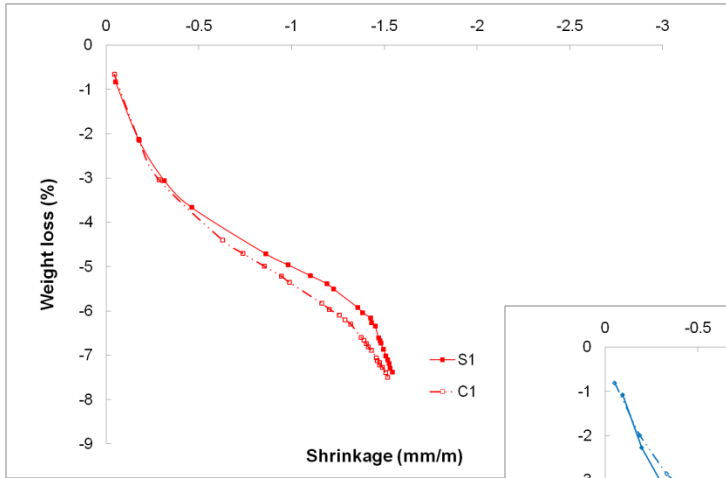


# Influence of sand – Shrinkage





# Influence of sand – Shrinkage



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