KU LEUVEN

Ghent Technology Campus

TC 281 – CCC

Interlaboratory test on carbonation testing methods

Organizing committee:

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Presentation prepared by Hanne Vanoutrive and Elke Gruyaert

Introduction

Correlation between atmospheric carbonation and carbonation induced by accelerated testing at high CO_2 concentrations — **WG 1**

WG 2 — Effect of SCMs on natural and accelerated carbonation of blended Portland cements

- The higher susceptibility of SCM binders to carbonation is usually concluded from **accelerated tests**
  - **High CO_2 levels**: 1% to 100% ↔ in situ
  - **Fixed relative humidity** (RH) ↔ varying meteorological conditions in reality
  - **Fixed temperature** ↔ varying meteorological conditions in reality

- Different standards **differ with regard to the conditions and time of curing and pre-conditioning** → SCMs: reaction processes are delayed and curing/pre-conditioning times and circumstances can thus have a significant impact on the test results.

- Given the fact that the external parameters do change the carbonation process and carbonation products, there is a **need for representative accelerated tests**.

Objectives

Compare different national and European standards for carbonation testing of mortar / concrete with different types of cement **CEM I, CEM II/B-V and CEM III/B.**

Learn more about the following effects on carbonation resistance:

- the **effect of curing and pre-conditioning** (temperature, relative humidity and duration)
- the **effect of accelerated testing** (natural vs. increased CO_2 concentration)
- the **effects of coarse aggregates** in the mix (mortar vs. concrete)

The interlaboratory test will furthermore:

- **compare ranking of concrete types** following different carbonation standards
- learn more about the **uncertainty of results**, via the determination of the standard deviations of repeatability and reproducibility.

Test program

Test specimen

- Mortar (mandatory)
- Concrete

Binder types

- CEM I 42.5 N (mandatory)
- CEM II/B-V 42.5 N
- CEM III/B 42.5 N

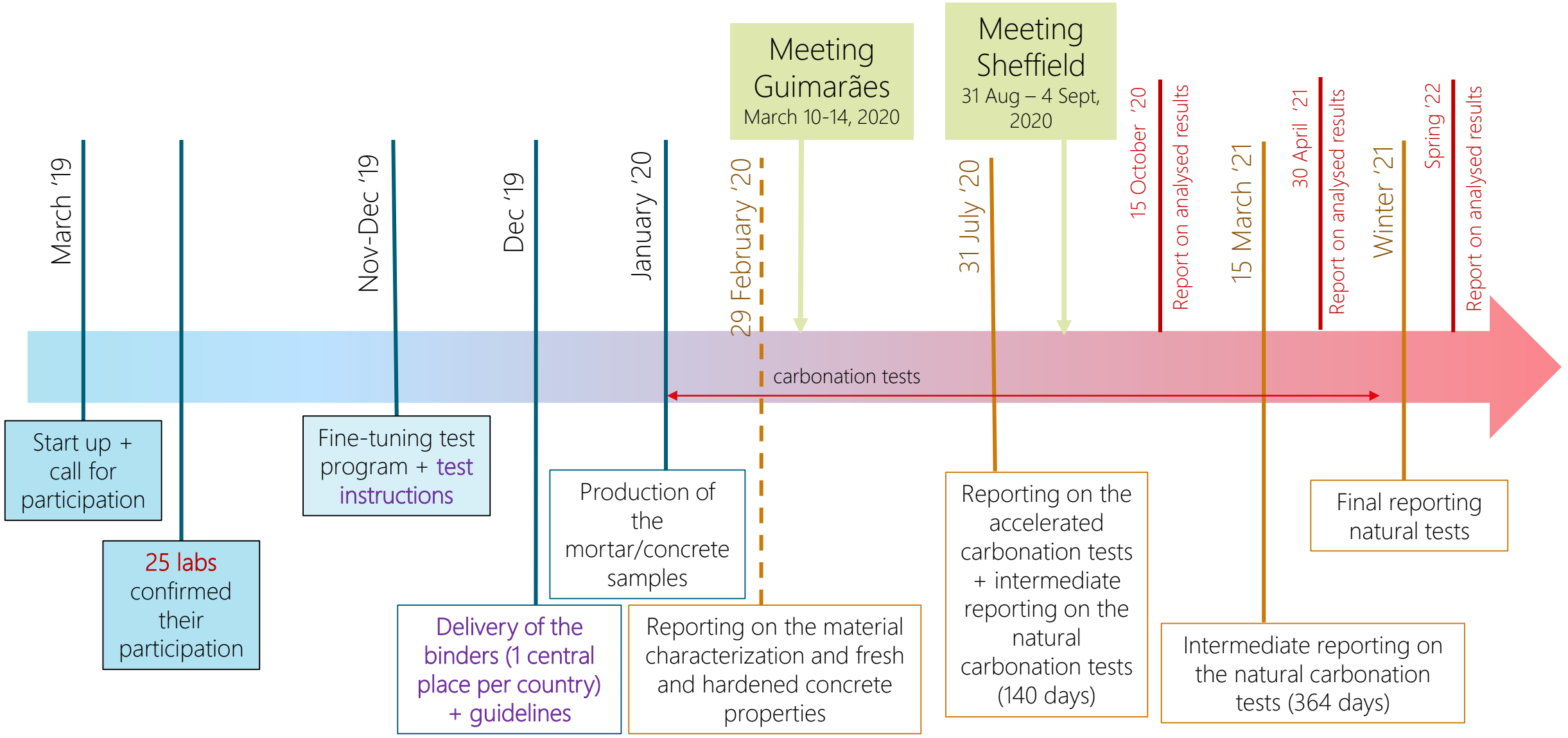
Curing and preconditionning

- Reference specimens (mandatory): only for accelerated carbonation tests on mortar and/or concrete
  - Pre-defined curing = 28 days sealed curing at 20°C
  - Preconditioning according to the standard your lab is following
- Test specimens
  - Curing and preconditioning according to the standard your lab is following

Carbonation

- Accelerated carbonation (according to the standard your lab is following) (mandatory)
- Natural carbonation (Indoor in climate chamber or (un)sheltered outdoor)

Timeline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Start up + call for participation
25 labs confirmed their participation
Nov-Dec '19
Fine-tuning test program + test instructions
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Delivery of the binders (1 central place per country) + guidelines
January '20
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March 10-14, 2020
Reporting on the material characterization and fresh and hardened concrete properties
carbonation tests
31 July '20
Meeting Sheffield
31 Aug – 4 Sept, 2020
Reporting on the accelerated carbonation tests + intermediate reporting on the natural carbonation tests (140 days)
15 October '20
Report on analysed results
15 March '21
Intermediate reporting on the natural carbonation tests (364 days)
30 April '21
Report on analysed results
Winter '21
Final reporting natural tests
Spring '22
Report on analysed results

Participants

	Institution	Contact person
PT	1 - University of Minho	Aires Camoes
ES	2 - University of Extremadura in collaboration with Instituto Eduardo Torroja (CSIC)	César Medina Martinez; Javier Sanchez Montero; Nuria Rebolledo
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ES	4 - Universitat Politecnica de Catalunya (UPC)	Miren Etxeberria
ES	5 - Universidad Politecnica de Madrid	Amparo Moragues; Carmen Andrade
BE	6 - KU Leuven – Technology Campus Ghent	Hanne Vanoutrive; Elke Gruyaert
BE	7 - Belgian Nuclear Research Center – SCK-CEN	Quoc Tri Phung
BE	8 - Magnel Laboratory for Concrete Research, Ghent University	Philip Van den Heede; Natalia Alderete; Nele De Belie; Zhiyuan Liu
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RS	18 - University of Belgrade	Ivan Ignjatovic
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IN	21 - Bennett University	Talakokula Visalakshi
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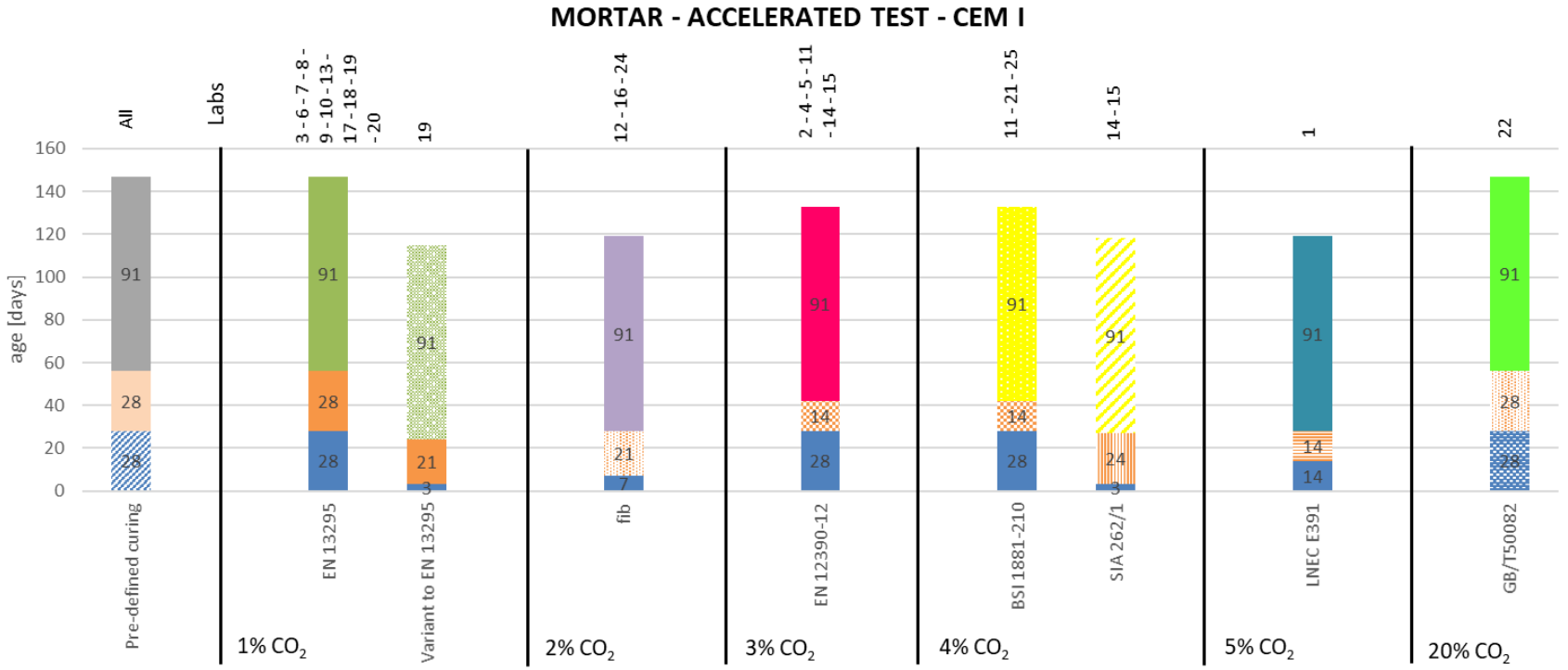
NG	23 - University of Lagos	Kolawole Olonade
US	24 - CTL group Illinois	José Pacheco
UK	25 - University of Leeds	Susan Bernal; Alastair Marsh

Test scheme MORTAR



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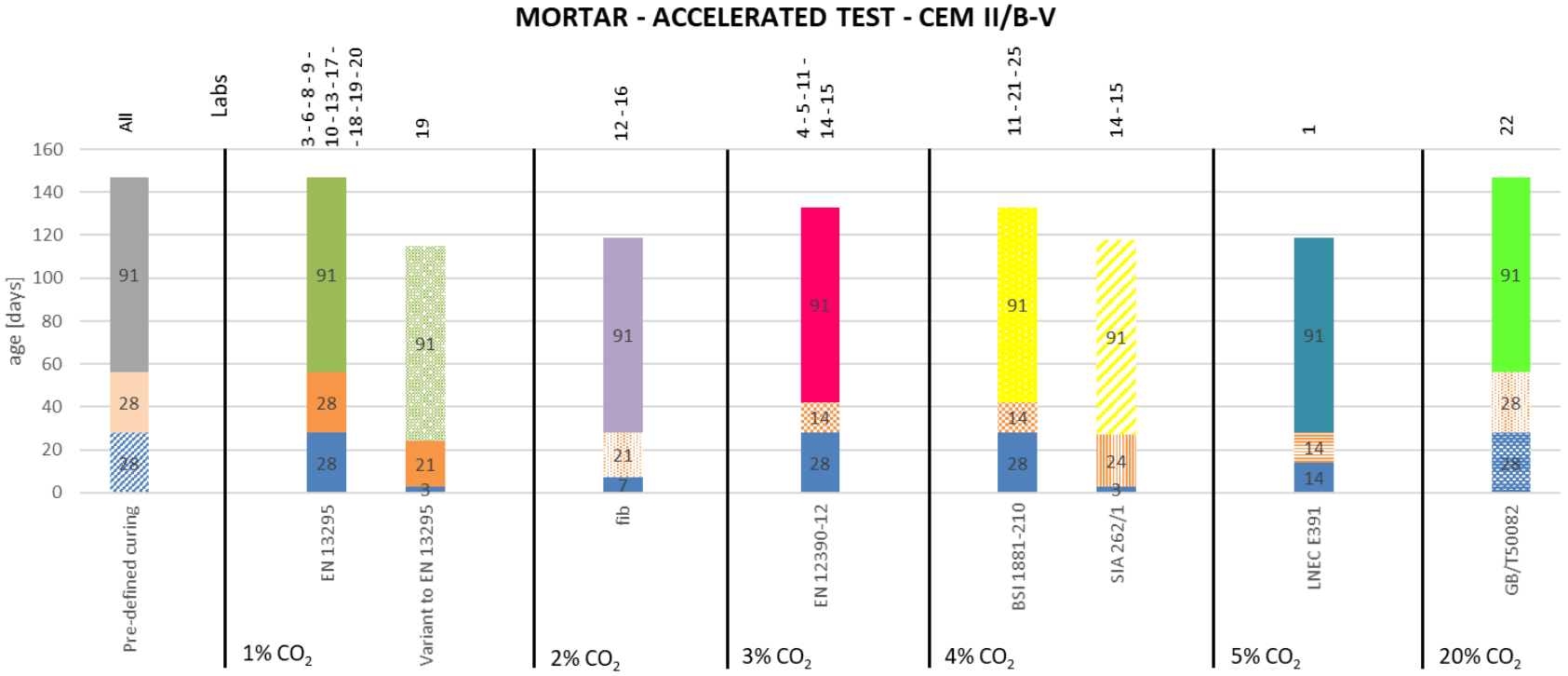

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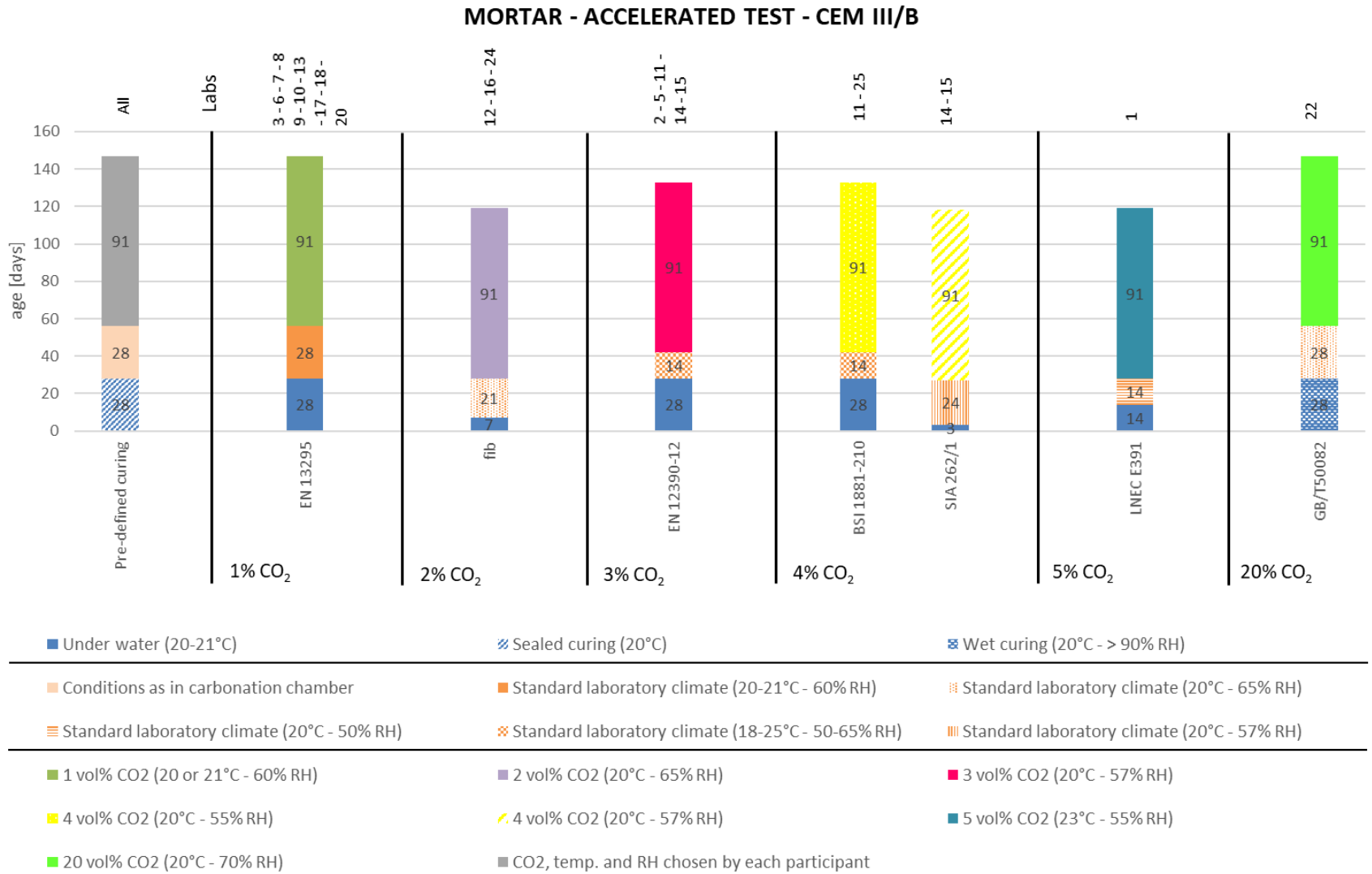

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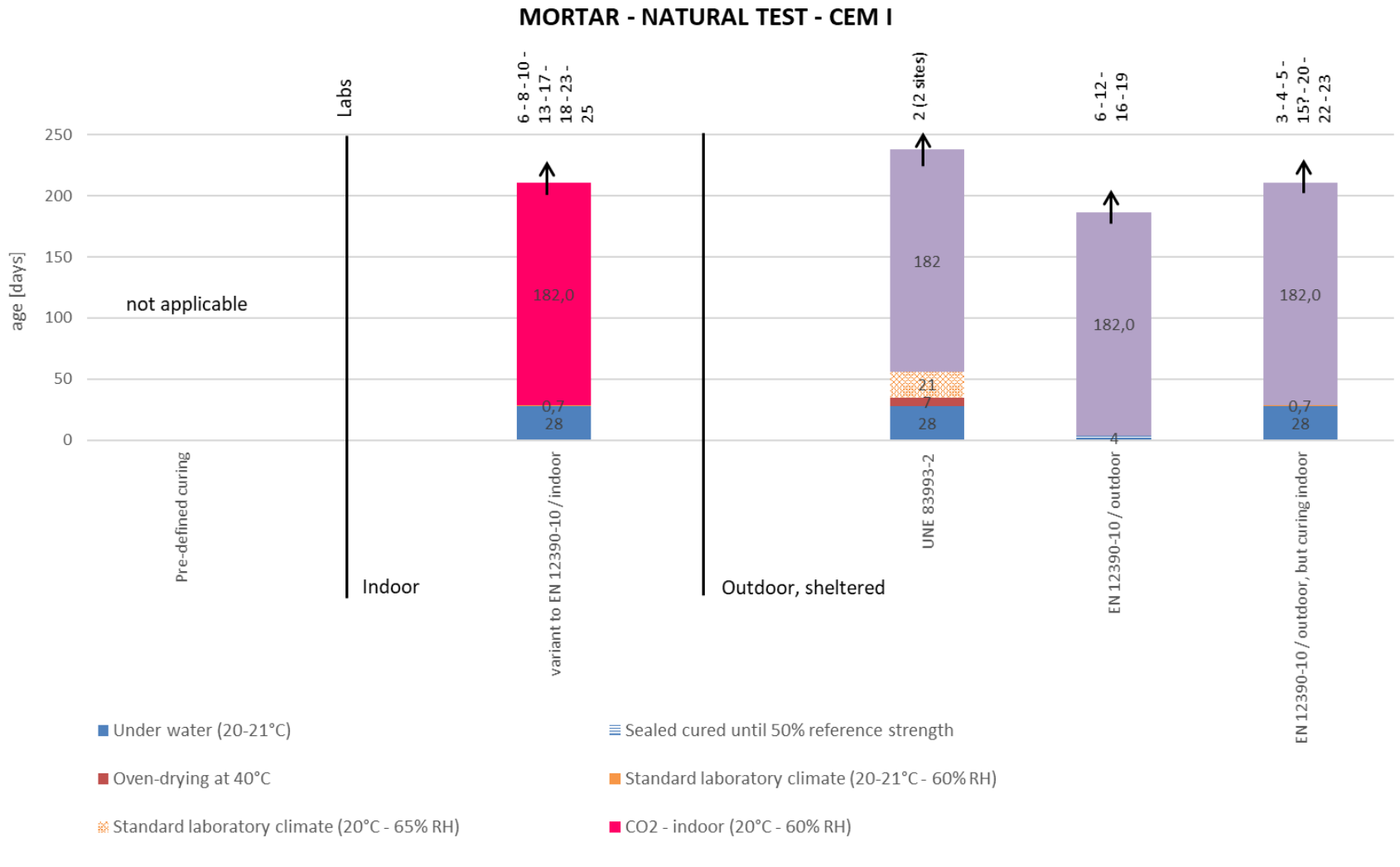

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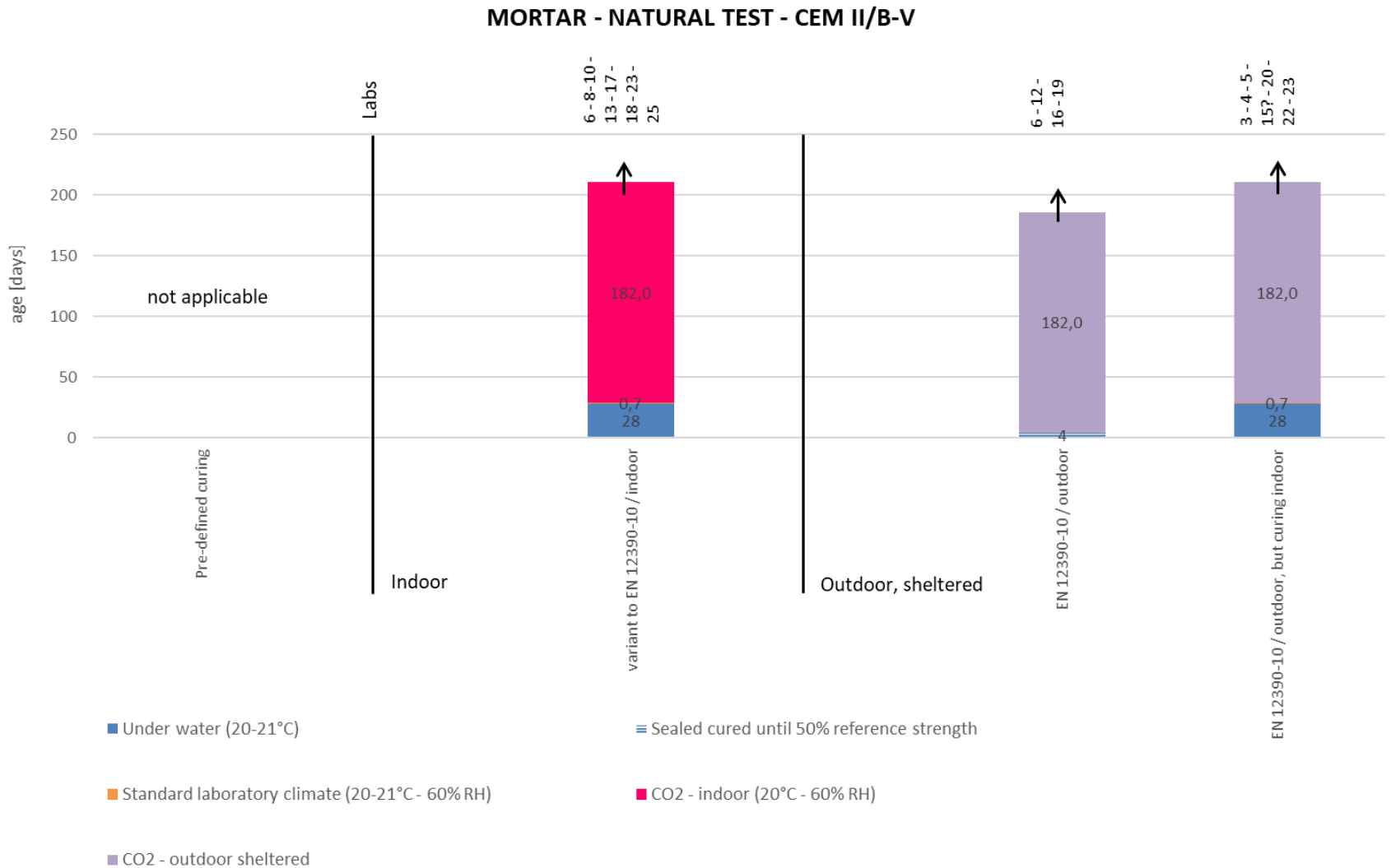

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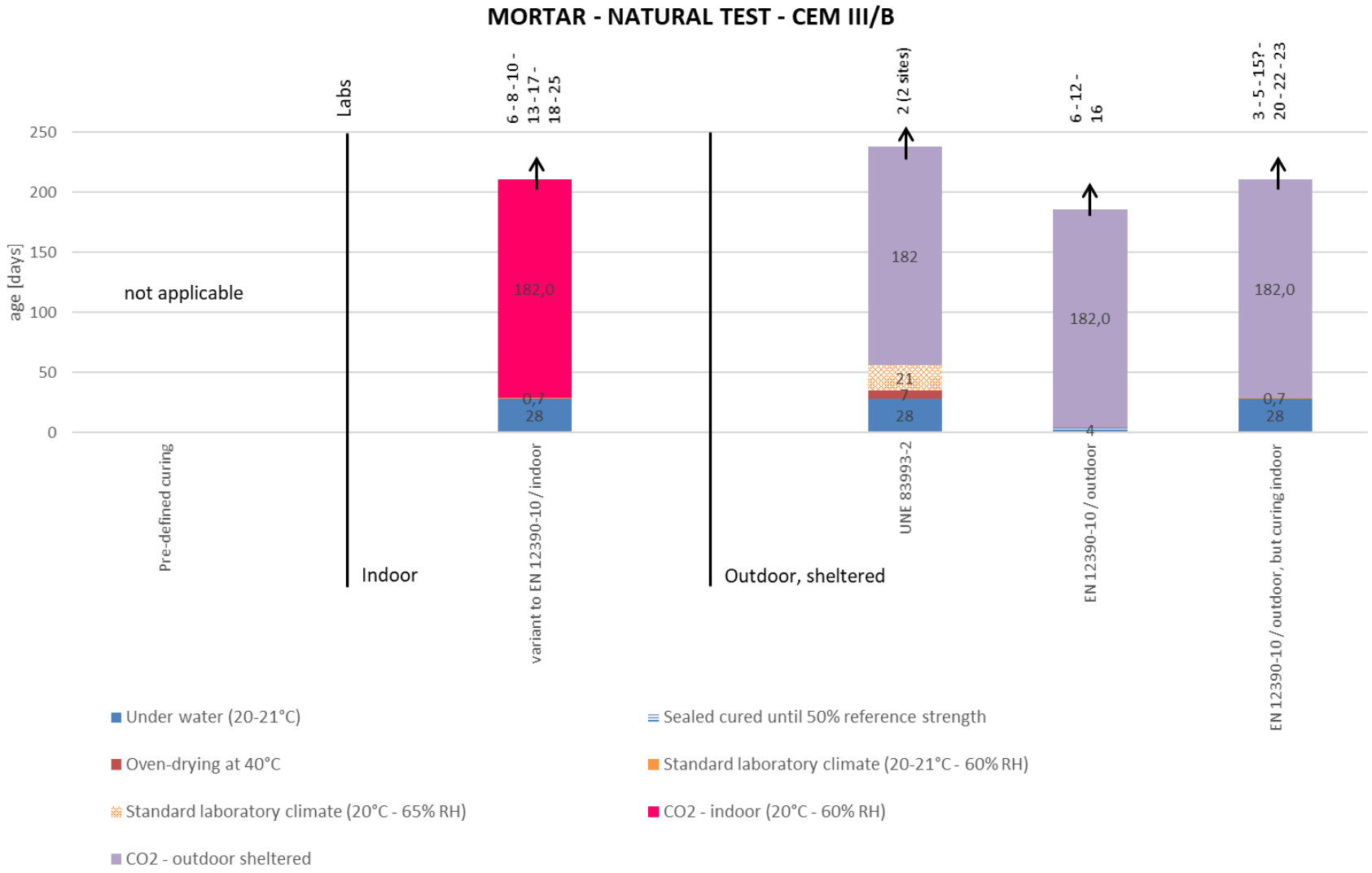
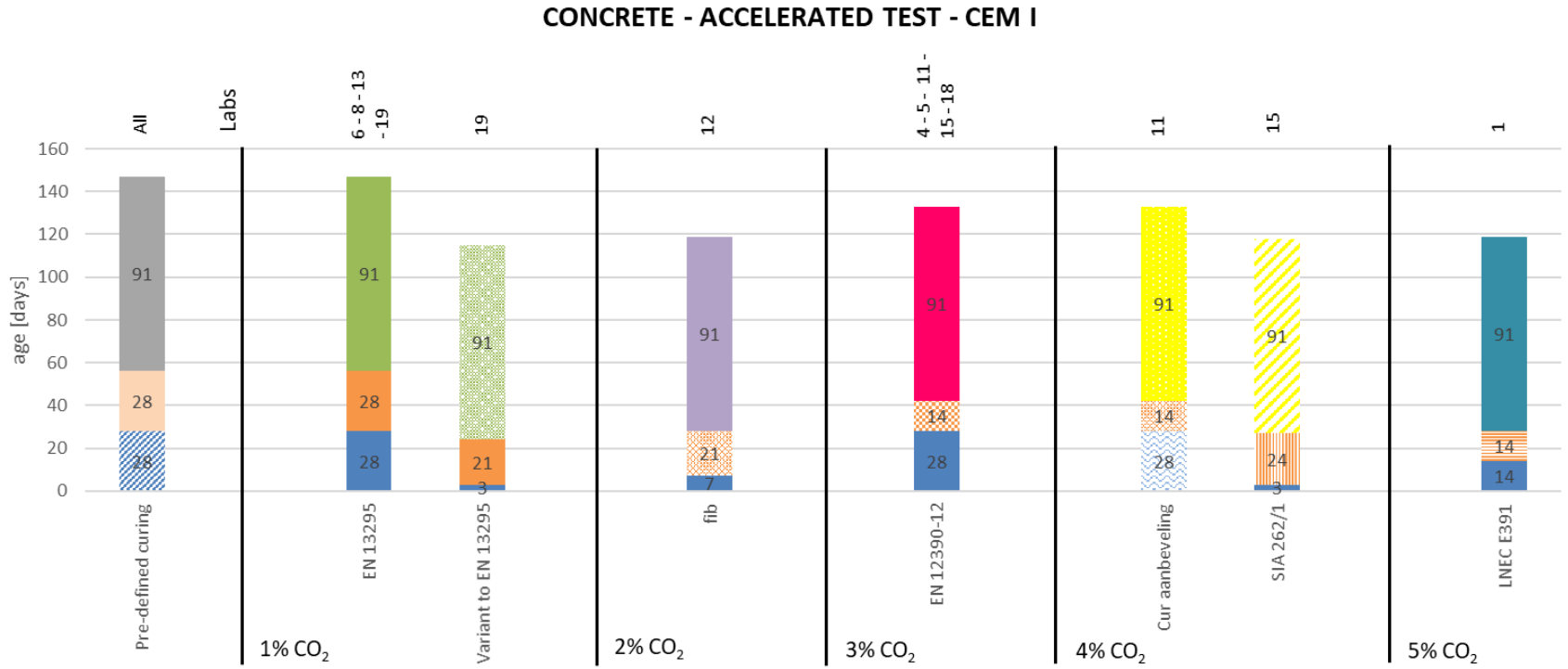


Test scheme CONCRETE



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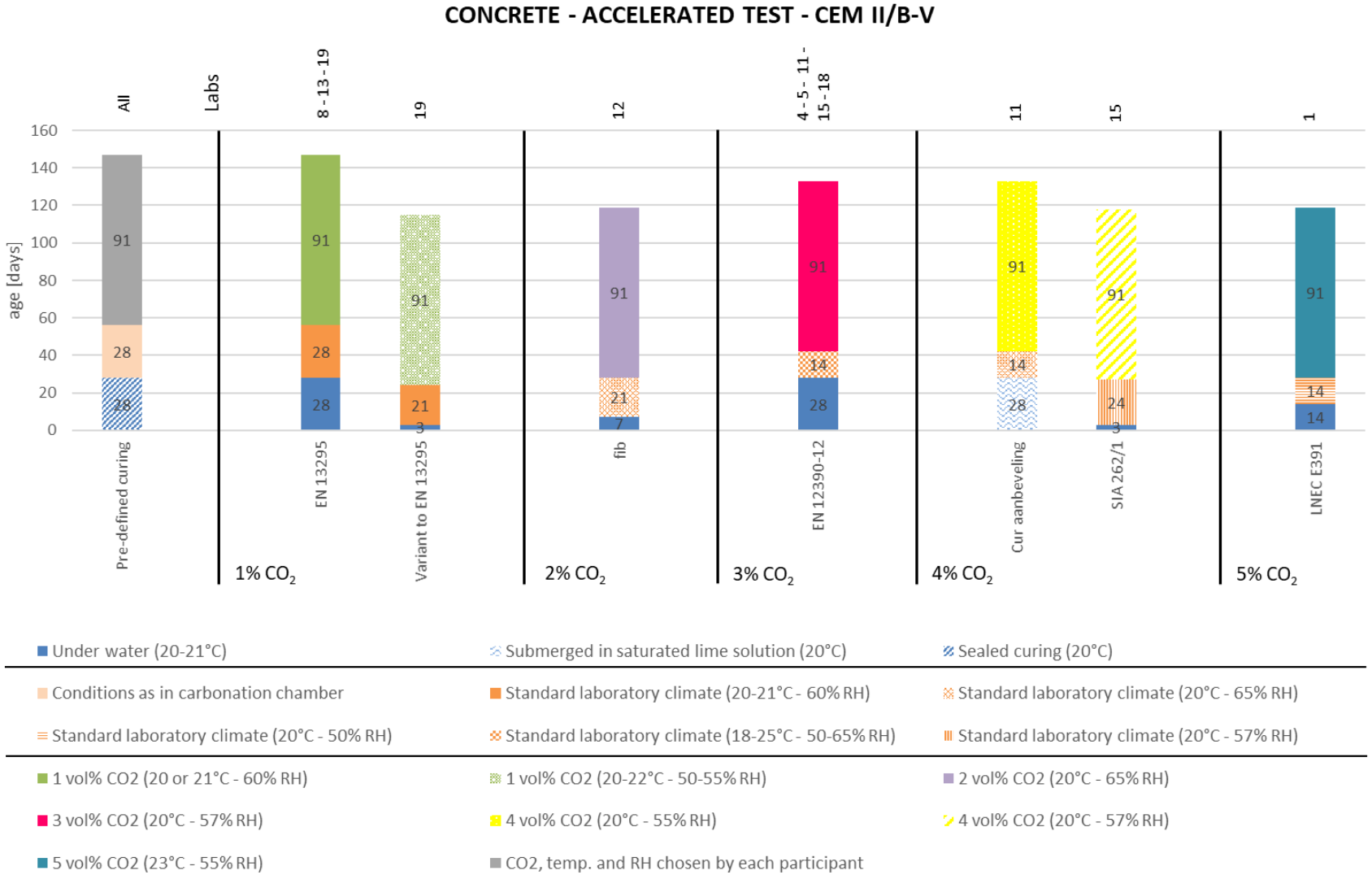

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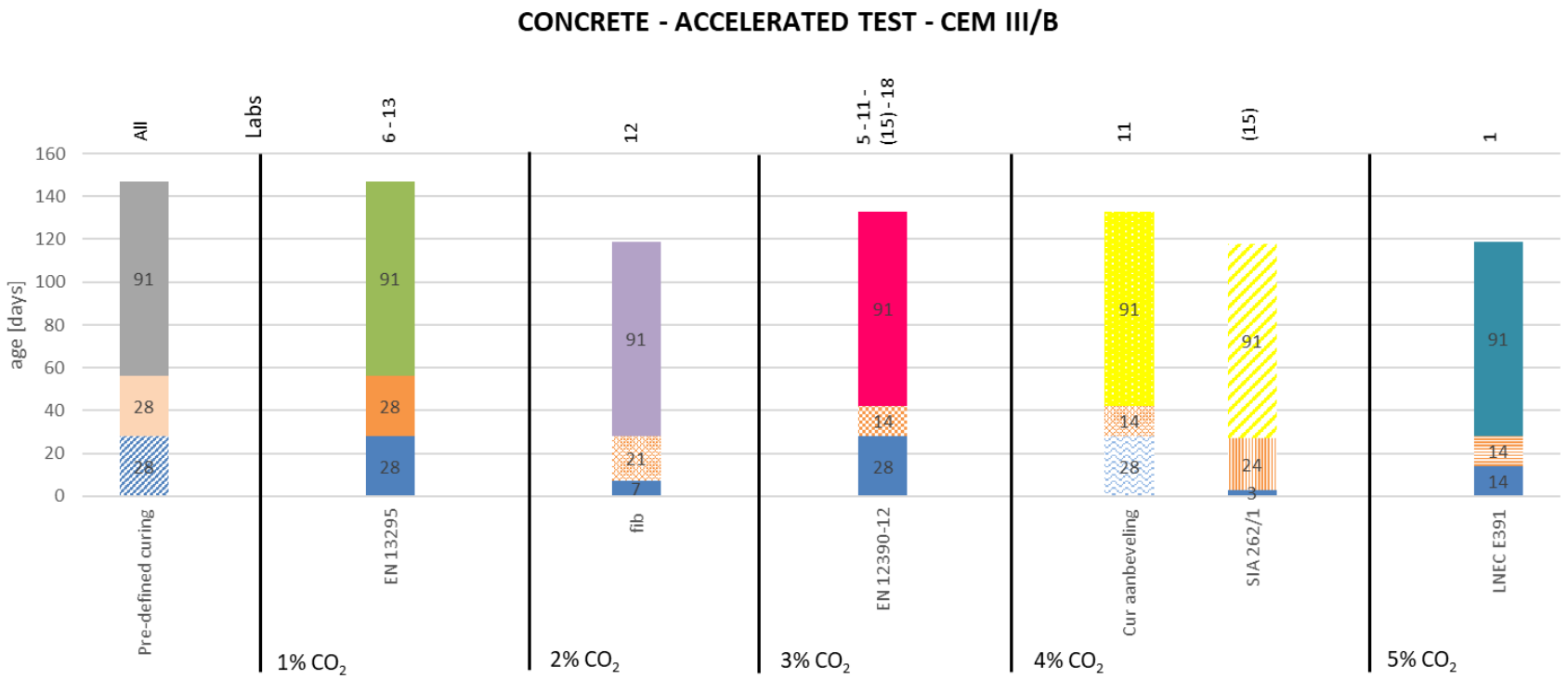

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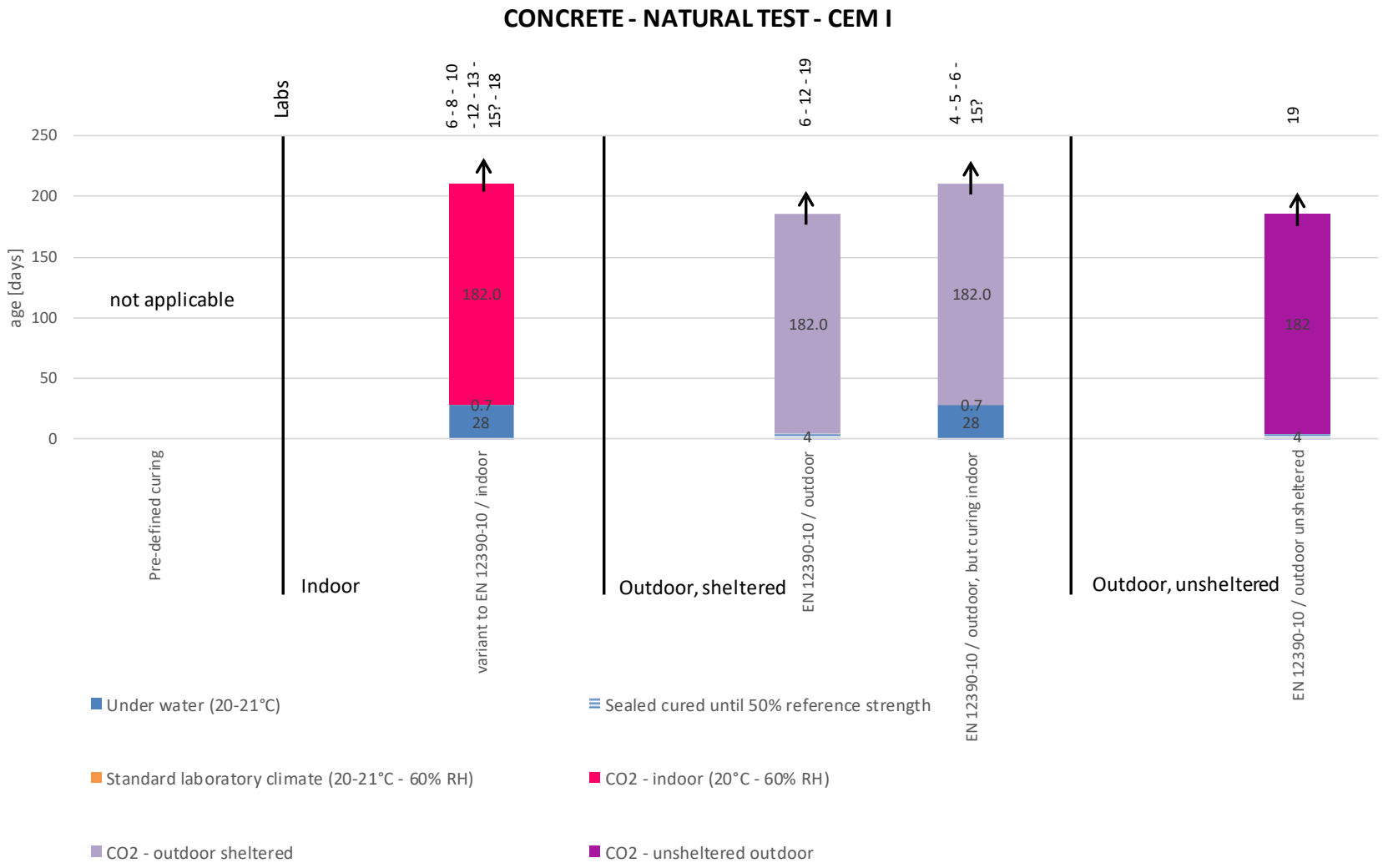

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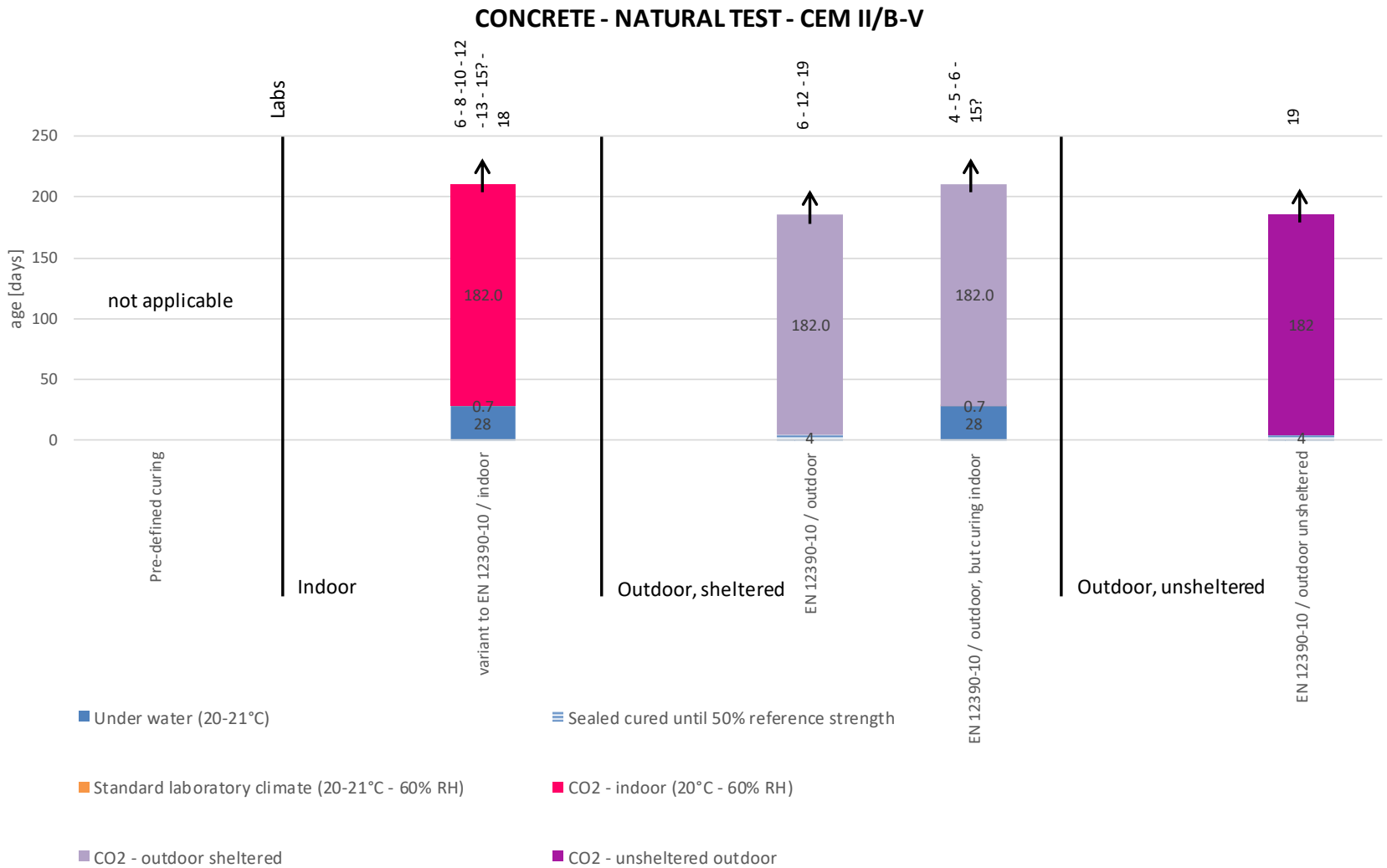

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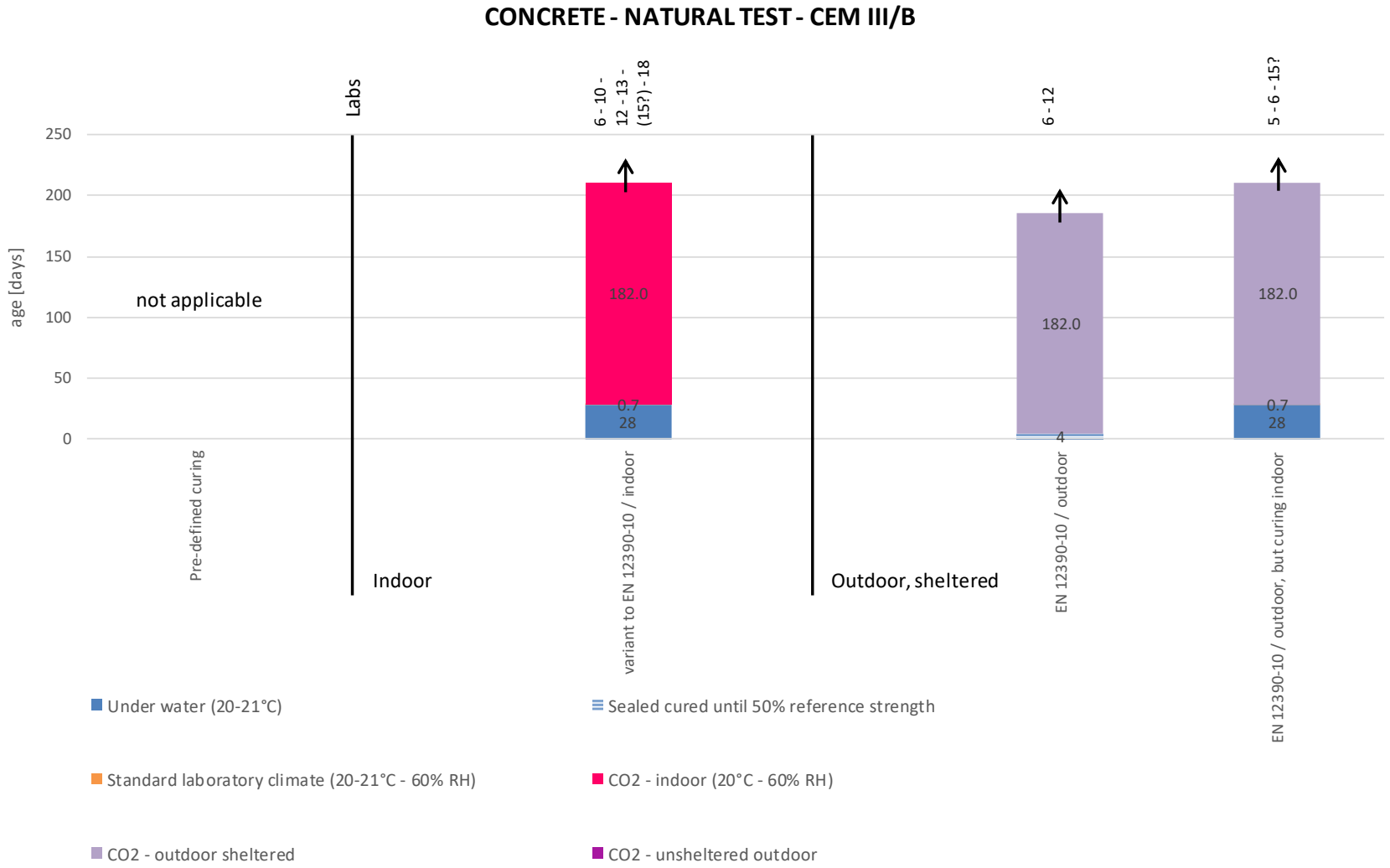


Current situation

- Binders were sent to the different European institutions by December 2019

  India, China, US, Nigeria use a local equivalent cement

- Binders were analysed by the manufacturer
- Instructions were made and sent to the different institutions by January 2020
- Worksheet was made and sent to the different institutions by January 2020
- First results of fresh and hardened properties of mortar and concrete are available

Results received of
16 institutes
Results available very soon
of 8 institutes

Analysis binders

	CEM I 42.5 N	CEMII/B-V 42.5 N	CEM III/B 42.5 N
CaO	63.12	49.28	46.21
SiO_2	20.32	28.26	30.67
Al_2O_3	4.604	8.953	9.086
Fe_2O_3	3.299	4.32	1.165
MgO	1.923	1.896	5.545
K_2O	0.612	0.906	0.698
Na_2O	0.264	0.368	0.203
TiO_2	0.439	0.561	0.8
MnO	0.07	0.065	0.127
P_2O_5	0.348	0.427	0.048
SO_3	3.196	2.638	4.93
Loss on ignition [%]	1.69	1.86	(+0.74)
Blaine fineness [cm^2/g]	2640	4130	4840
Density [g/cm^3]	3.16	2.89	2.97
Strength 1d [MPa]	9.9	12.6	5.2
Strength 2d [MPa]	21.5	24.8	13.9
Strength 7d [MPa]	38.7	40.5	35.8
Strength 28d [MPa]	52.5	52.8	55.2

XRD analysis and PSD also available

Mortar composition

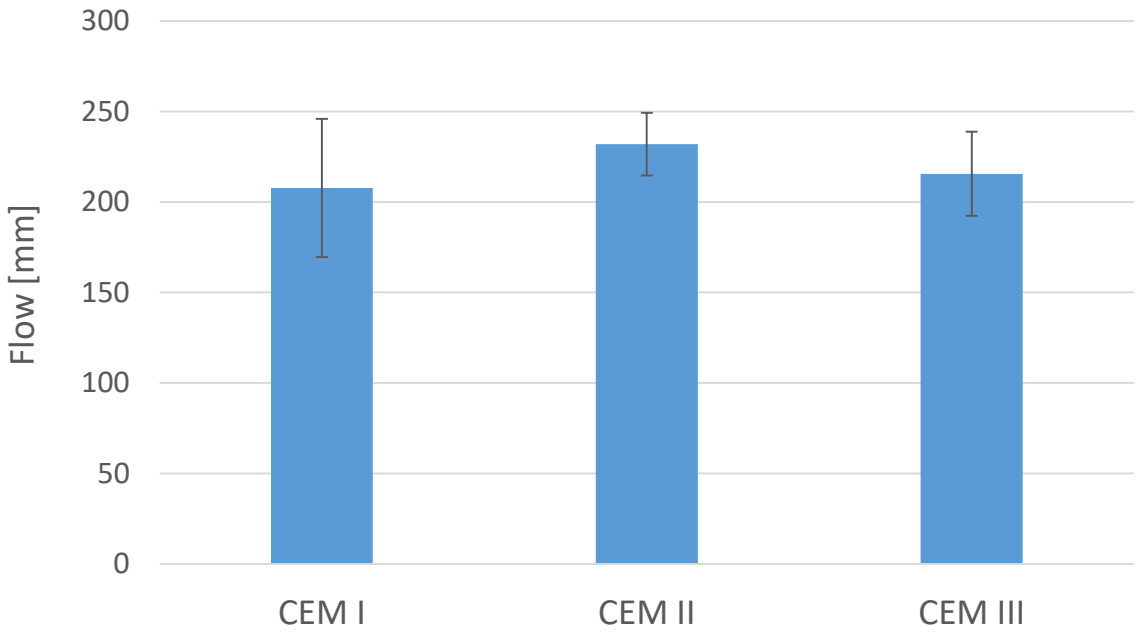
- Mortars made according to EN 196-1
- Exception: W/B ratio = 0.55

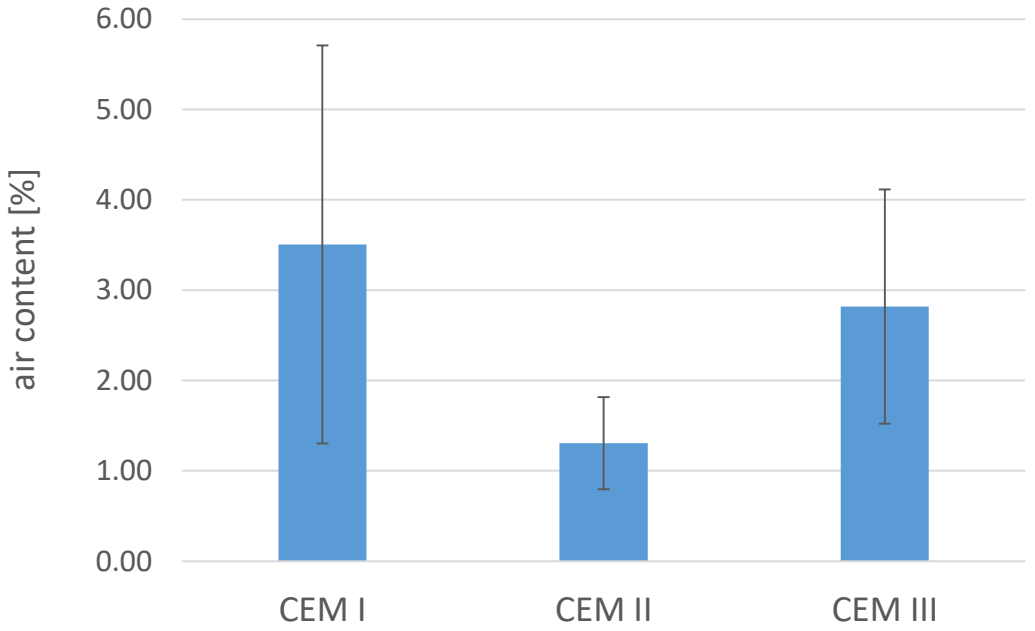
Component	Mass
cement	450 ± 2 g
water	247.5 ± 1 g
CEN standard sand	1350 ± 5 g

Results mortar

- To be reported
  - Consistence (flow table)
  - Air content
  - Flexural strength (4 days – only for outdoor carbonation – and 28 days)
  - Compressive strength (4 days – only for outdoor carbonation – and 28 days)

14 labs included
2 labs with other cements are not included in the results





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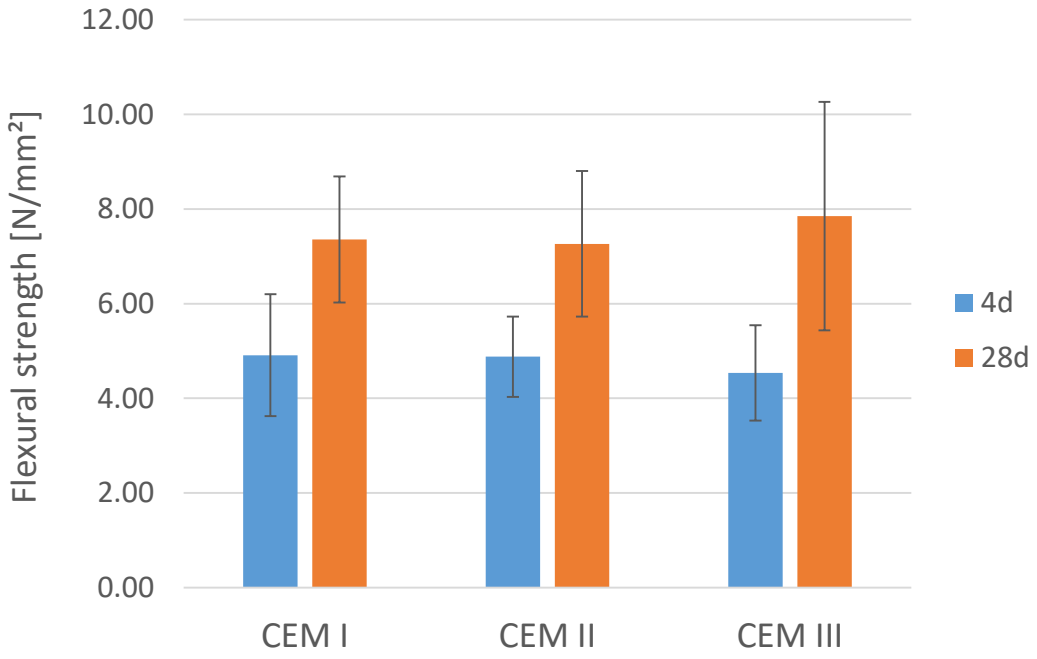
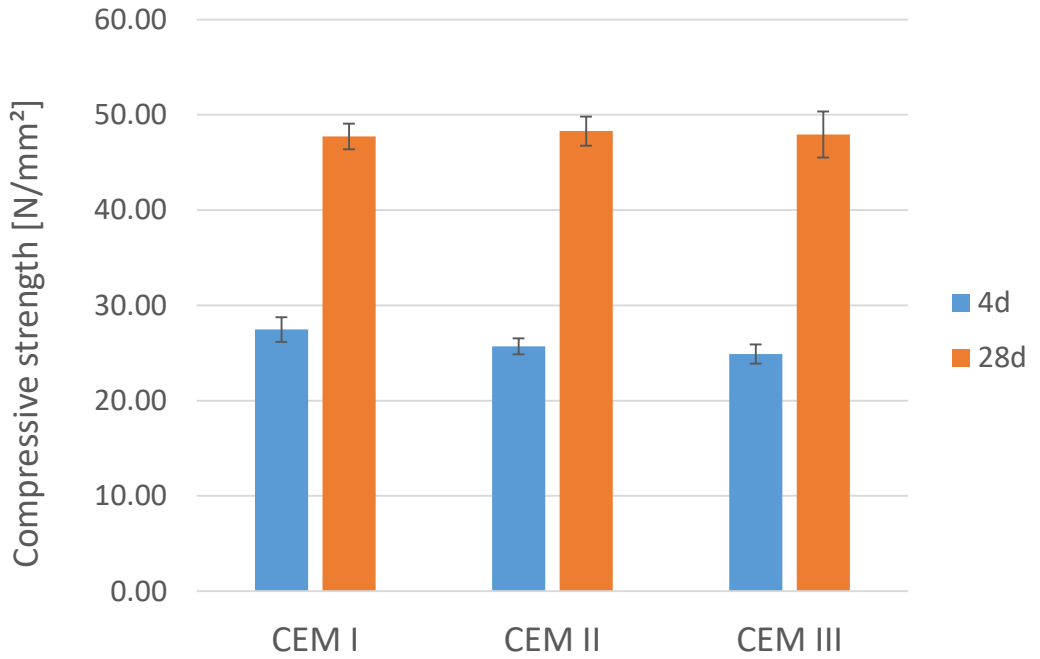
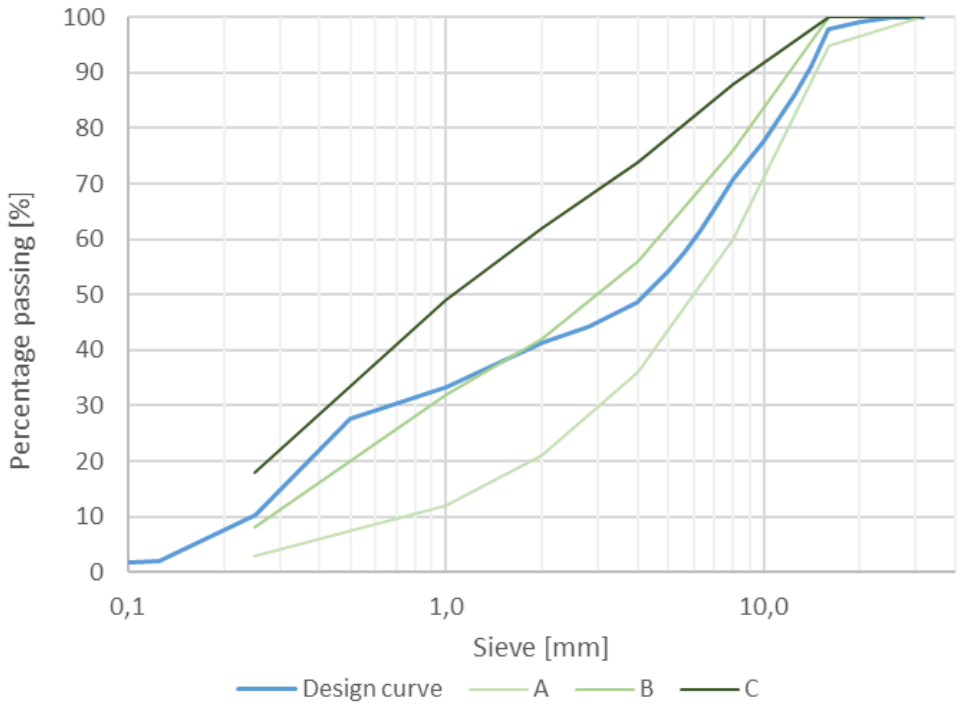




Concrete composition

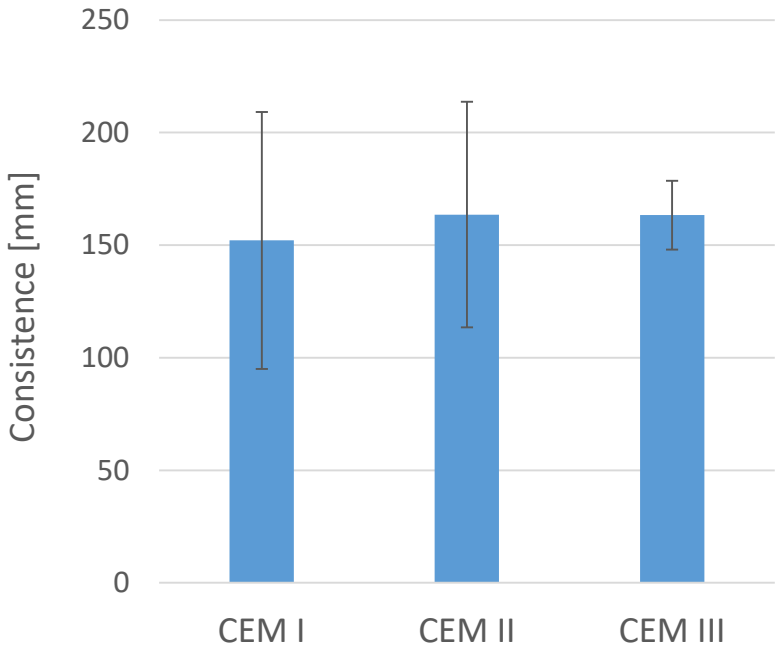
- The concrete mix design consists of:
  - Binder content: 340 kg/m³
  - W/B-ratio: 0.55
  - Target consistence: S3
  - Inert structure: round shaped siliceous aggregates with a maximum grain size of 16 mm
  - Target grading curve:

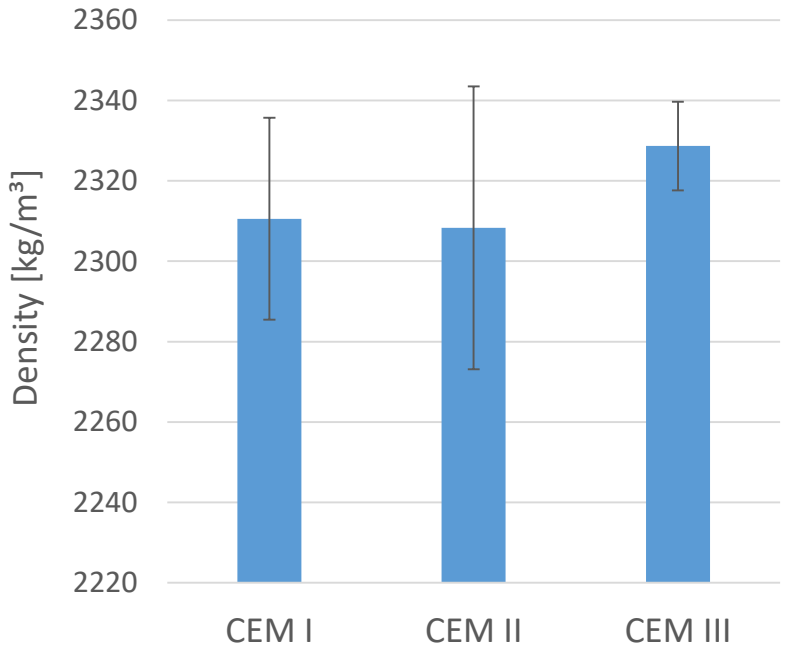


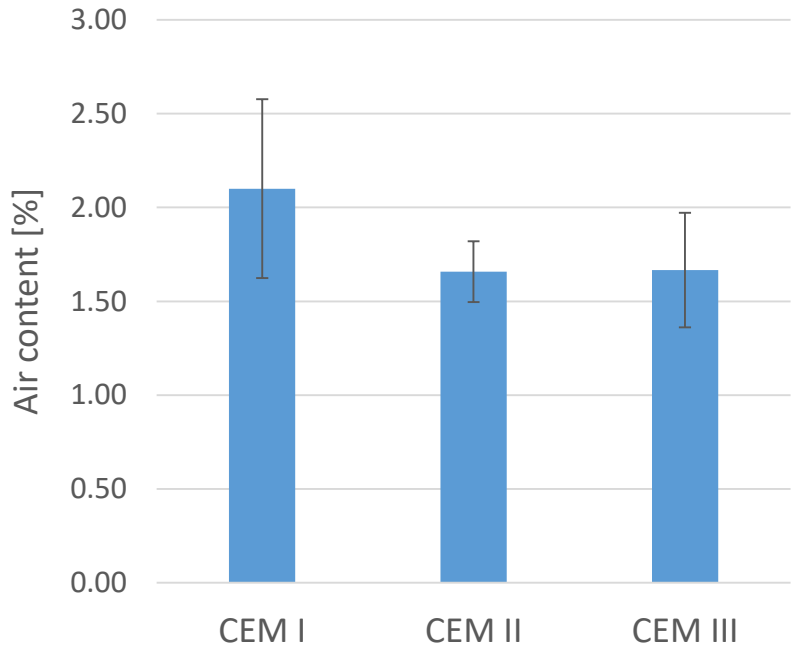
Results concrete

- To be reported
  - Consistence (slump test)
  - Density of fresh concrete
  - Air content of fresh concrete
  - Compressive strength (4 days – only for outdoor carbonation – and 28 days)

4 labs included







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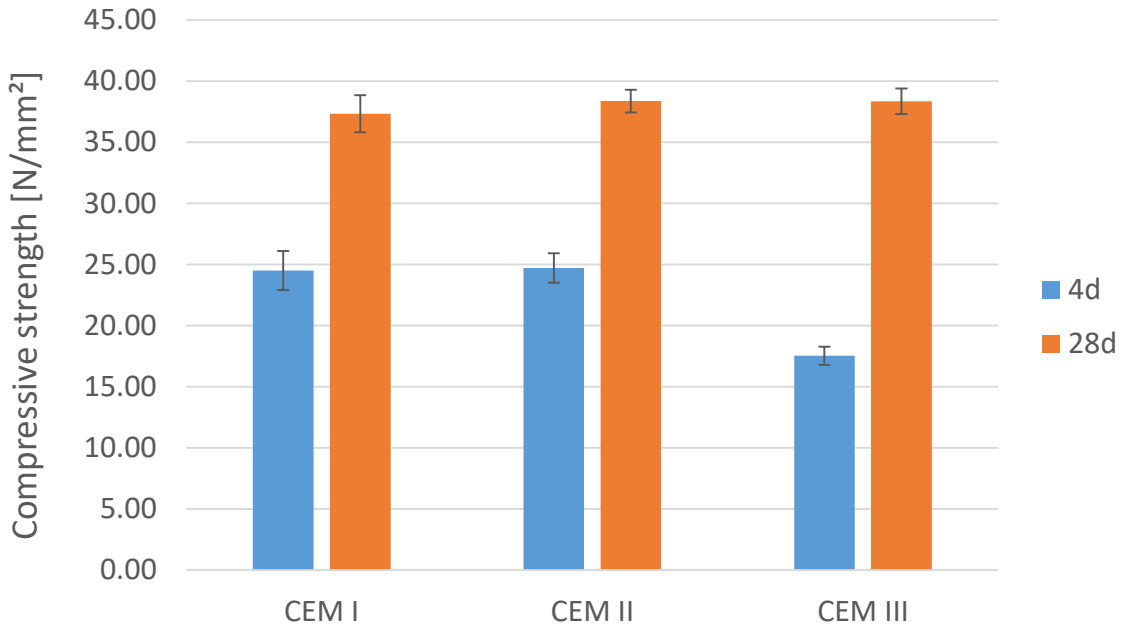
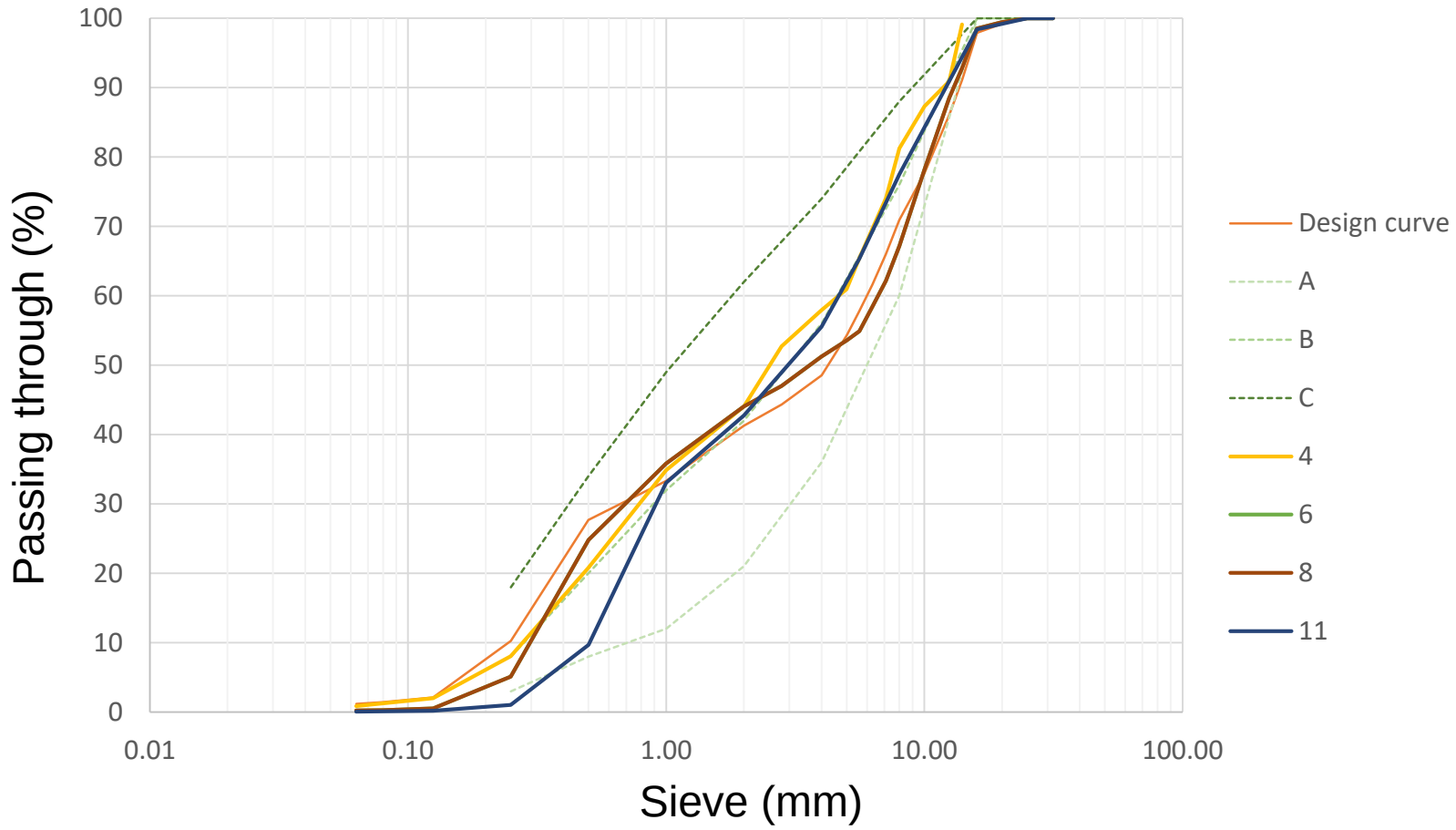


Results concrete

- To be reported
  - Inert structure

4 labs included



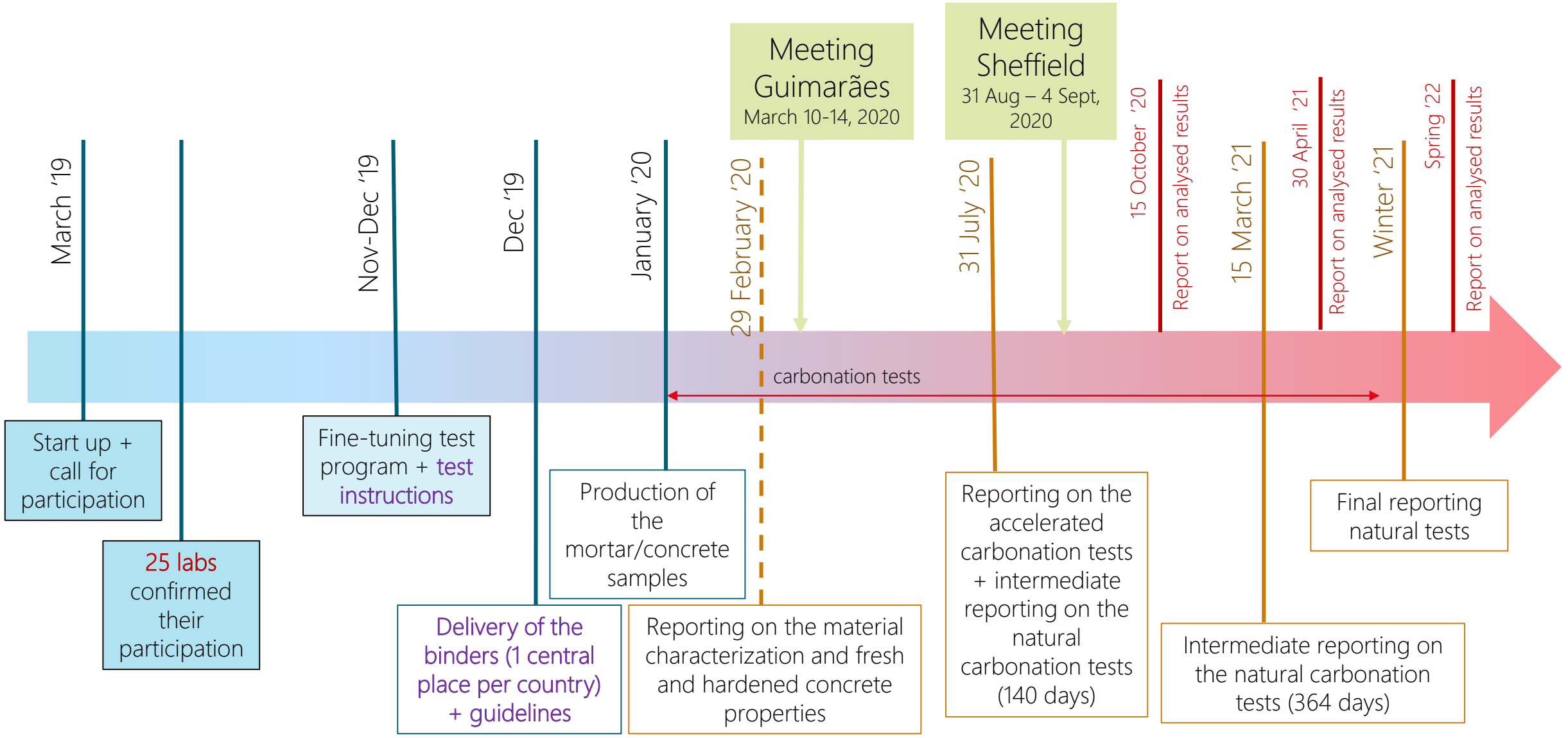
Attention

- Check test procedures and fill in the Excel *(Test proc._mortar and concrete)*: as stated in the standard – not the real conditions
- Check and fill in the Excel *temperature, relative humidity and CO_2* monitoring
- *Please report on*
  - Test procedures
  - Fresh and hardened properties
  - Temperature, relative humidity and CO_2 monitoring

  when all hardened properties are available and at the latest by the **end of May**
- *Please report on*
  - Accelerated carbonation tests
  - Natural carbonation tests (140 days)

  at the latest by the **end of July**

Timeline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THANK YOU

- *To **Maciej Zajac** of **Heidelberg Cement** for providing us with the cements and shipping them to the participants*
- *To all **ILT participants** for your commitment and providing us in time the first results*
- *To **Hanne** for analysing the first results*
- *To **all of you** for participating in this ILT discussion*