

POTENTIALS OF NEW CEMENTS MADE FROM GBS, FLY ASH AND CLINKER

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Introduction

The production of cement is energy- and raw material-intensive. In particular, the use of granulated blast furnace slag as main cement constituents is of great importance due to its high performance and positive ecological footprint. The high performance of GBS also means that the proportion of additional main cement constituents can be increased significantly compared to the simultaneous use without GBS and beyond the compositions previously standardised in DIN EN 197-1. The inclusion of such cements in the revised European cement standard EN 197-1 is expected to take the form of CEM II/C and CEM VI cement.

Objectives

The main objective of the research project was to demonstrate the possibilities and limits of the performance of cements with combinations of granulated blast furnace slag (S), fly ash (V) and clinker (C). Quality requirements and customer expectations of market relevant cements (CEM I to CEM III/A) were used as benchmarks.

In addition to the technical cement requirements for the cements in accordance with DIN EN 197-1, the focus of the investigations was also on their application and thus their concrete-technical and durability-relevant properties.

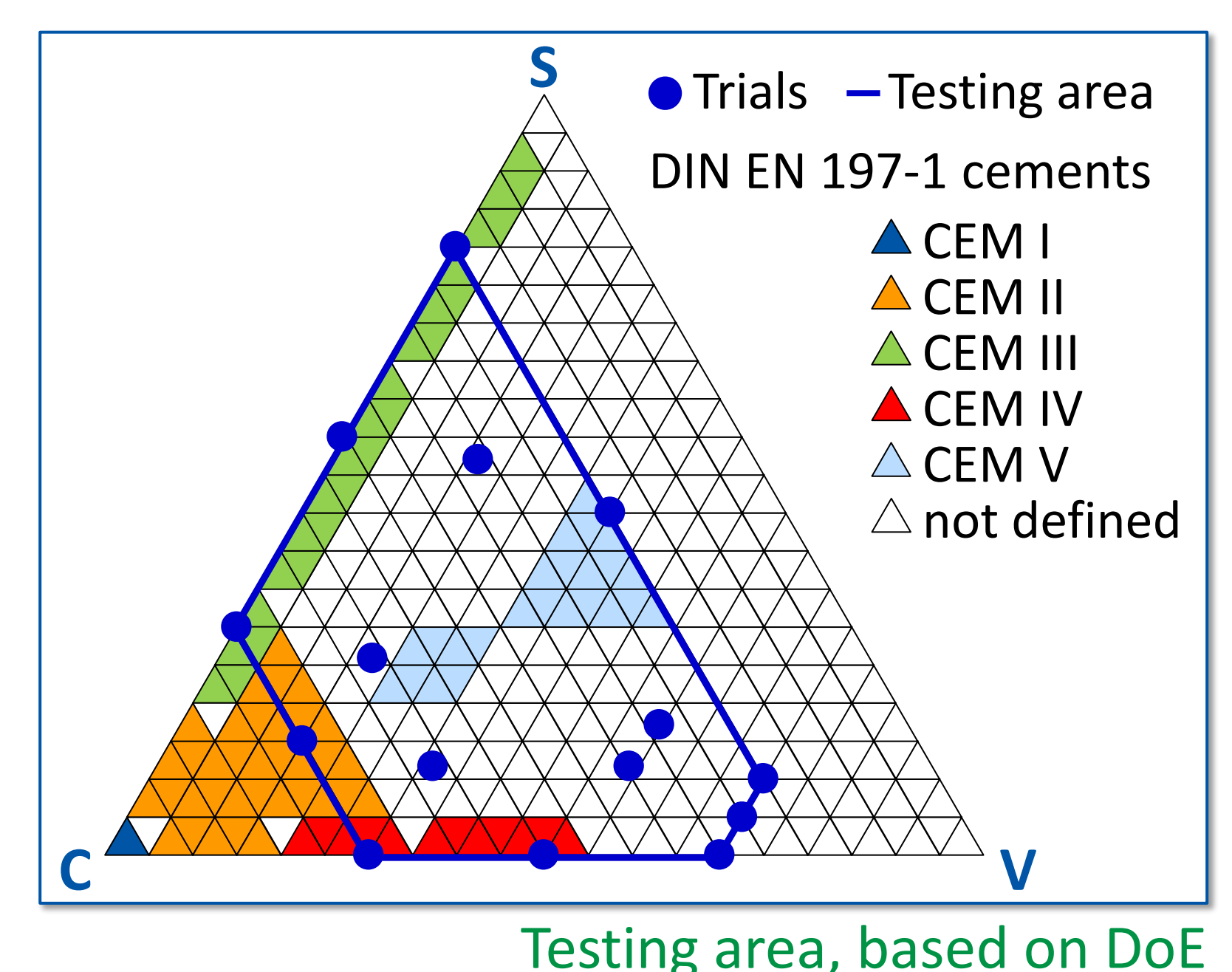
Testing program

Statistical Design of Experiments (DoE)

- Analysis of cement influencing factors important for performance (selection based on experience and scientific knowledge)
- Definition of boundary conditions
- Creation of a design with 108 trials in 15 compositions

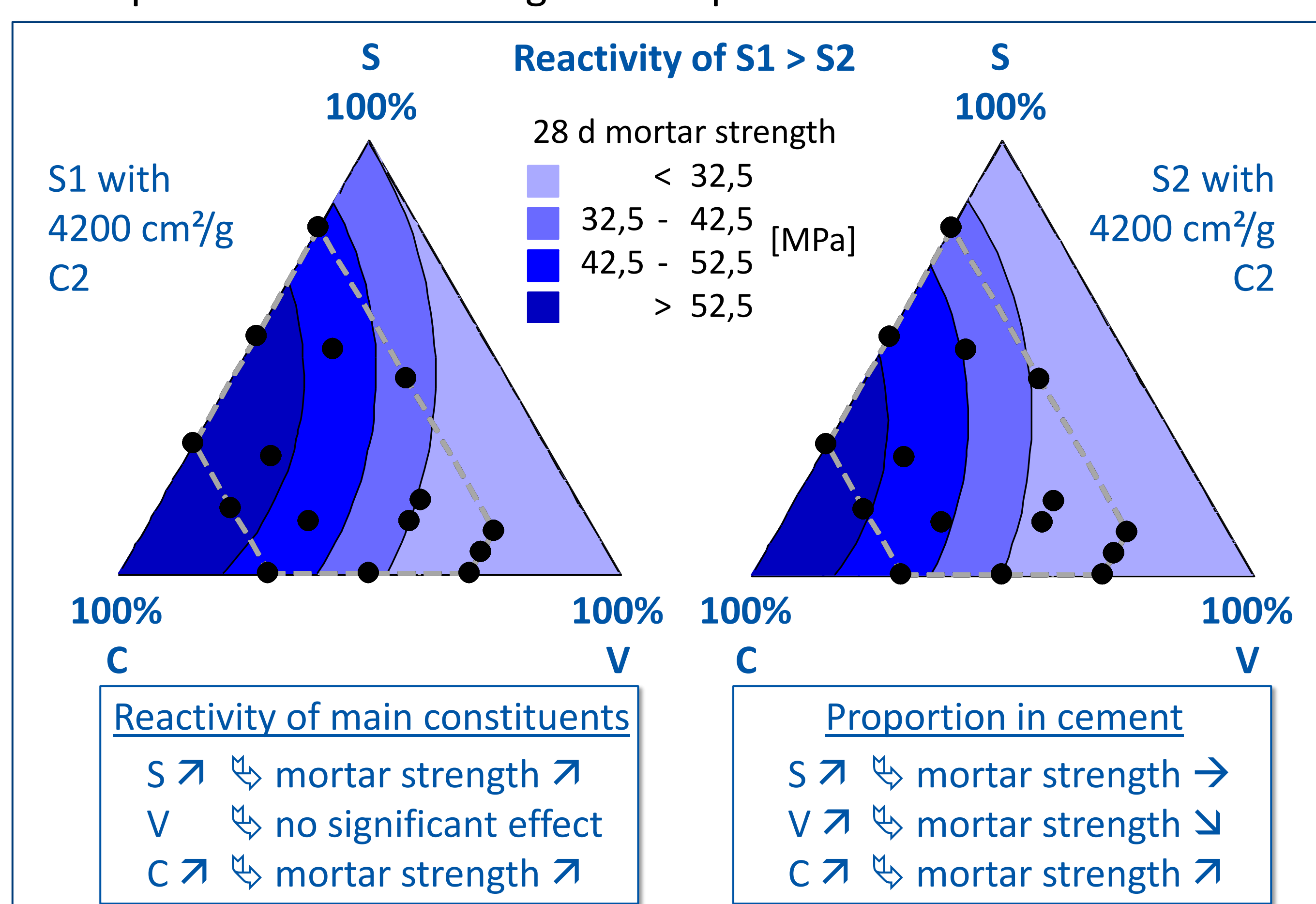
Parameter study with statistical evaluation of results; design and validation of models

- Definition of cement compositions for assessing concrete durability
- Durability tests
 - Carbonation, chloride, freeze-thaw, freeze-thaw and de-icing salt and sulphate resistance
 - Concrete compositions in line with minimum requirements of German concrete standard DIN 1045-2
 - Tests carried out in comparison to concretes with 2 CEM III/A 42.5 N
- Ecological assessment of optimised cements



Results

Statistically verified models between mortar strength of cements and parameter influencing cement performance

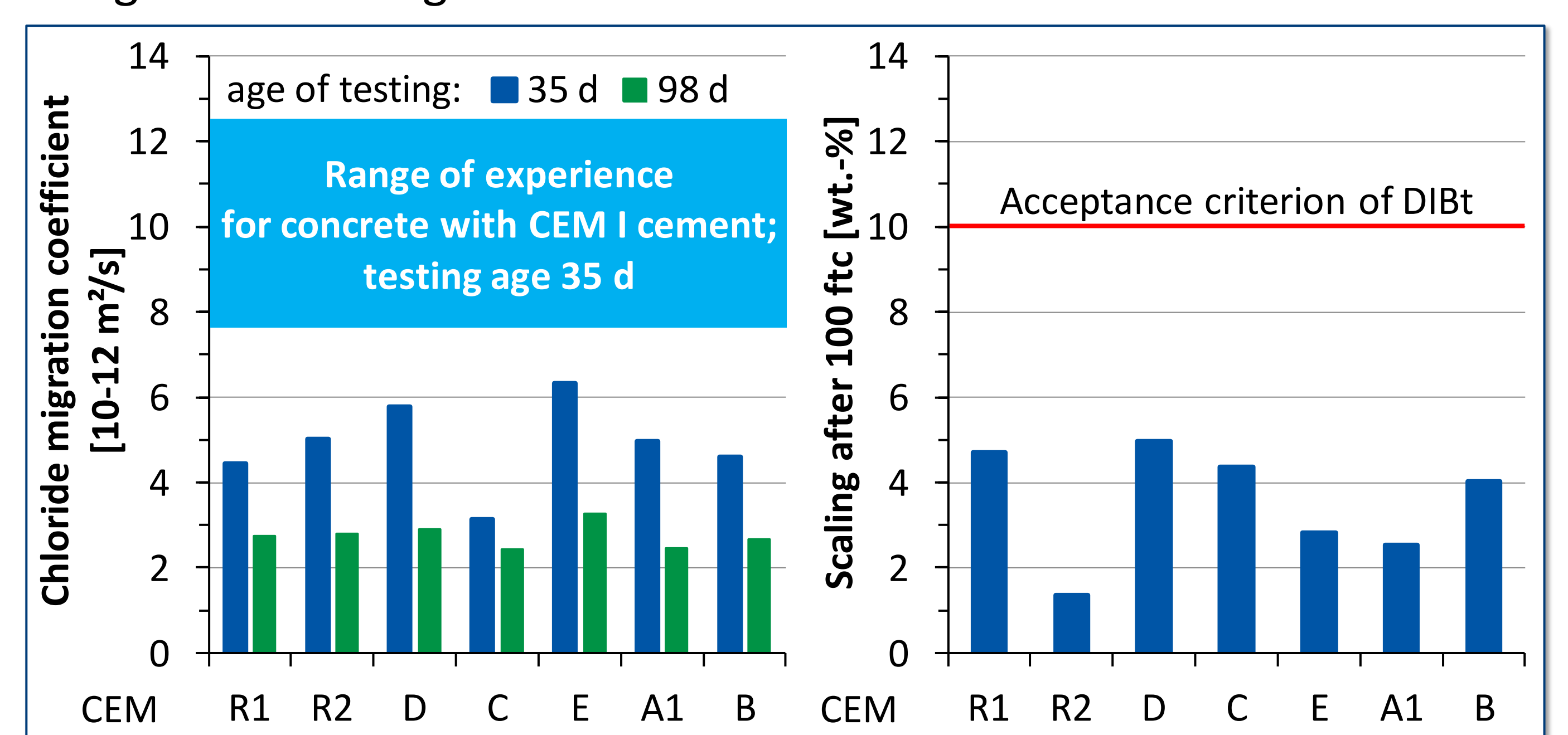


- Manufacturing of cements with strength class 42.5 N possible in a wide range of compositions
- Cement properties comparable to commercially available blastfurnace cements CEM III/A 42.5 N

Cement compositions defined according to results of DoE

CEM III/A 42,5 N	CEM II/C		CEM VI			CEM X	
	R1	R2	D	C	E	A1	B
Commercially available CEM III/A cements			OPC2 50 wt.-%	OPC2 35 wt.-%	OPC1 45 wt.-%	OPC1 30 wt.-%	OPC1 30 wt.-%
			GBS2 30 wt.-%	GBS2 45 wt.-%	GBS2 43 wt.-%	GBS3 40 wt.-%	GBS3 64 wt.-%
			Fly ash1 20 wt.-%	Fly ash1 20 wt.-%	Fly ash1 12 wt.-%	Fly ash1 30 wt.-%	Fly ash1 6 wt.-%

- Workability comparable to concrete with CEM III/A 42.5 N
- The general concrete-technological context between cement strength, w/c ratio and concrete strength applicable
- High chloride migration and freeze thaw resistance of all concretes



Chloride migration test: rapid method
acc. to BAW code of practice

Cube test acc. to CEN/TS 12390-9

Conclusions

- ✓ The huge potential of using DoE and statistically evaluation tools in the building materials sector could be demonstrated.
- ✓ Cements of strength class 42.5 can be produced within a wide range of composition and quality of cement main constituents.
- ✓ Taking into account sufficient cement strength and the minimum requirements for concrete composition, concretes produced with such cements have sufficient durability.
- ✓ These cements can have a significant ecological contribution due to their high CO2 saving potential.
- ✓ The results provided an important basis for including CEM II/C (S-V) and CEM VI (S-V) cements in the current draft EN 197-1.