Calcium-Sulfo-Aluminatzement (CSA) für spezielle Anwendungen

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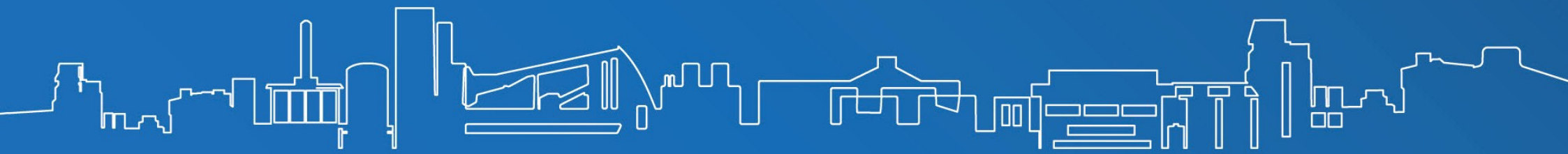
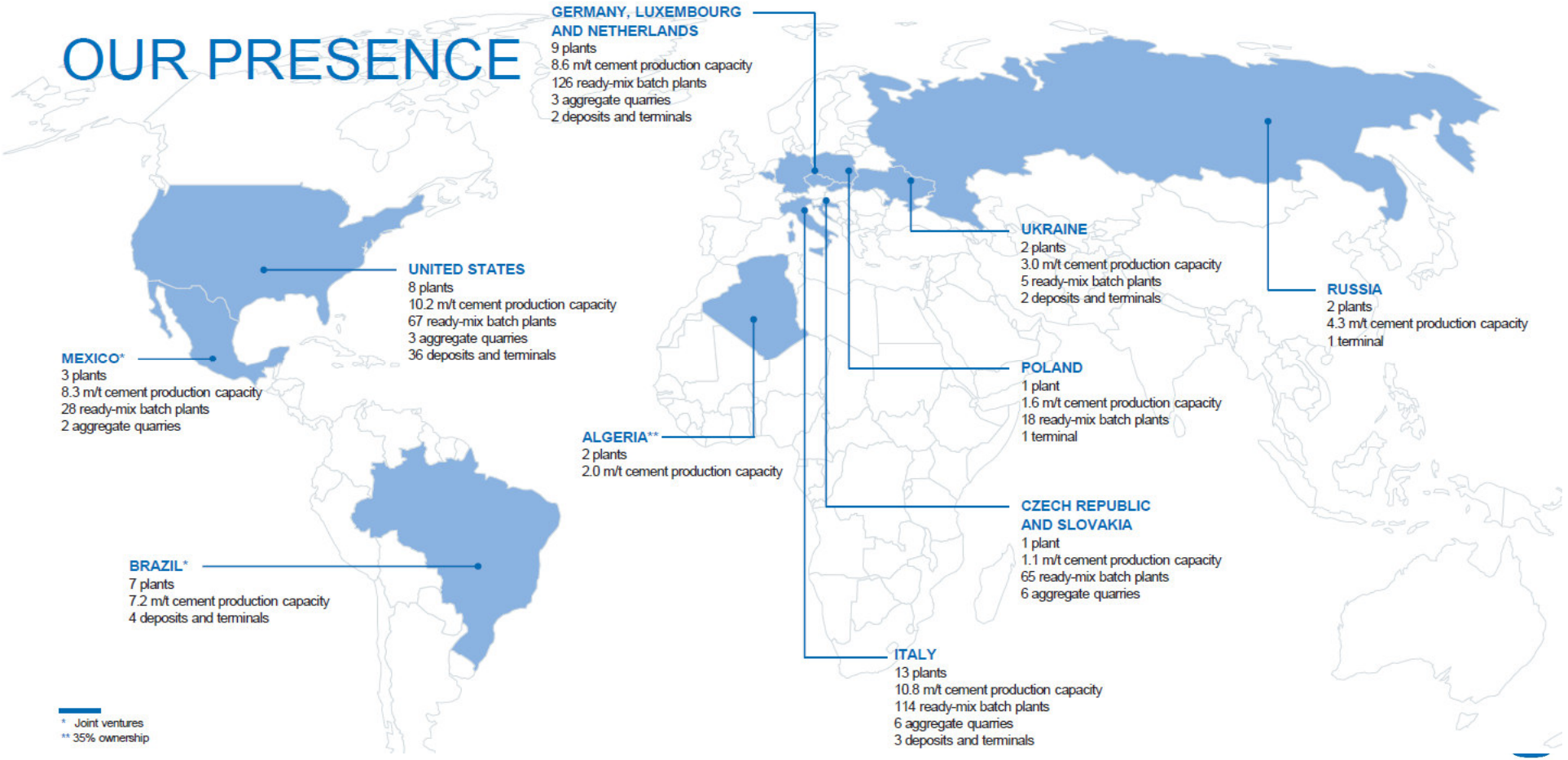
Wilhelm Dyckerhoff Institute

Kruft, 9.11.2023



The Buzzi company



CSA Cement at Buzzi SpA

- Industrial production of CSA cements (still niche compared to OPC!) since more than 25 years
- Two plants used for burning campaign of CSA clinker in US (OK) and Italy
- CSA clinker caracterized by high Yeelimite content ($C_4A_3\$$ > 50%) in both plants
- Binary CSA cement (CSA clinker + Anhydrite) and Ternary CSA cement (Clinker + Anhydrite + [OPC - EN 197-1] are produced
- In 2013 obtained ETA (European Technical Approval) also for structural application in Europe (Binary and Ternary blends): Next Base and Next Binder
- In 2015 obtained approval also in Germany for structural application (AbZ)

From R&D to industrial productions and sales Worldwide

Pilot kiln (~30 Kg/h @1350°C)

Buzzi Unicem Next

Technological evolution of sulfoaluminate hydraulic binders

Next is an innovative line of high-performance hydraulic binders produced in Italy by Buzzi Unicem, and opening up new frontiers in the construction industry. **Next** binders are suitable for all pre-mixed, precast and structural concrete product applications that require rapid setting, fast development of mechanical strength and very low hygrometric shrinkage. Next is "forward-looking" even during the production cycle, distinguished for its lower CO_2 emissions into the environment.

First in Europe to obtain CE marking

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Buzzi Unicem

CSA cements

EN standard do not classify univocally the CSA cements

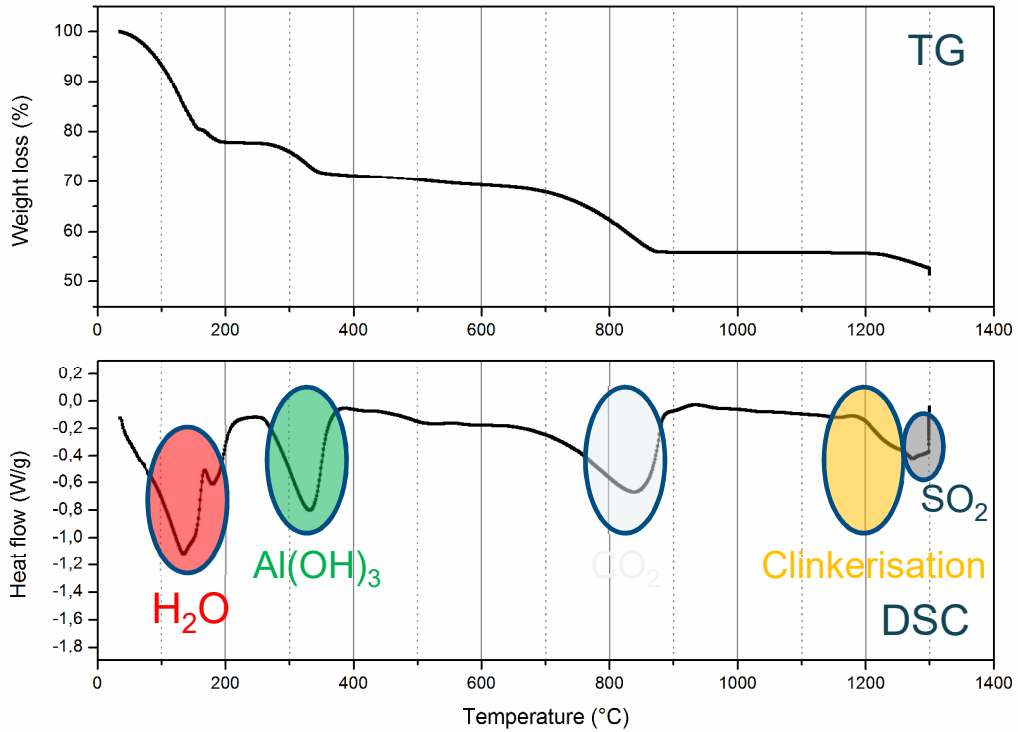
CSA cement	EN 197-1
$CaO + SiO_2 < 50\%$	requires > 50%
$C_3S + C_2S < 67\%$ (CSA does not contain C_3S)	EN 197-1 requires > 67%
$SO_3 > 4\%$	EN 197-1 requires < 4%

A binder that contains a **Calcium sulfoaluminate phases ($C_4A_3\$$)** can be in principle considered as CSA cement.

CSA cement combine three innovative properties compared to OPC:

Expansion	Early strengths	Low Energy
Ettringite formation during hydration	**Ettringite formation during hydration**	**Low enthalpy required for $C_4A_3\hat{S}$ formation**
$C_4A_3\bar{S} + 6C + 8C\bar{S} + 96H \Rightarrow 3C_6A\bar{S}_3H_{32}$	$C_4A_3\bar{S} + 2C\bar{S} + 38H \Rightarrow C_6A\bar{S}_3H_{32} + 2AH_3$	**≈ 800 kJ/Kg (≈ 1800 kJ/Kg for C_3S)**

CSA clinker burning process and hydration

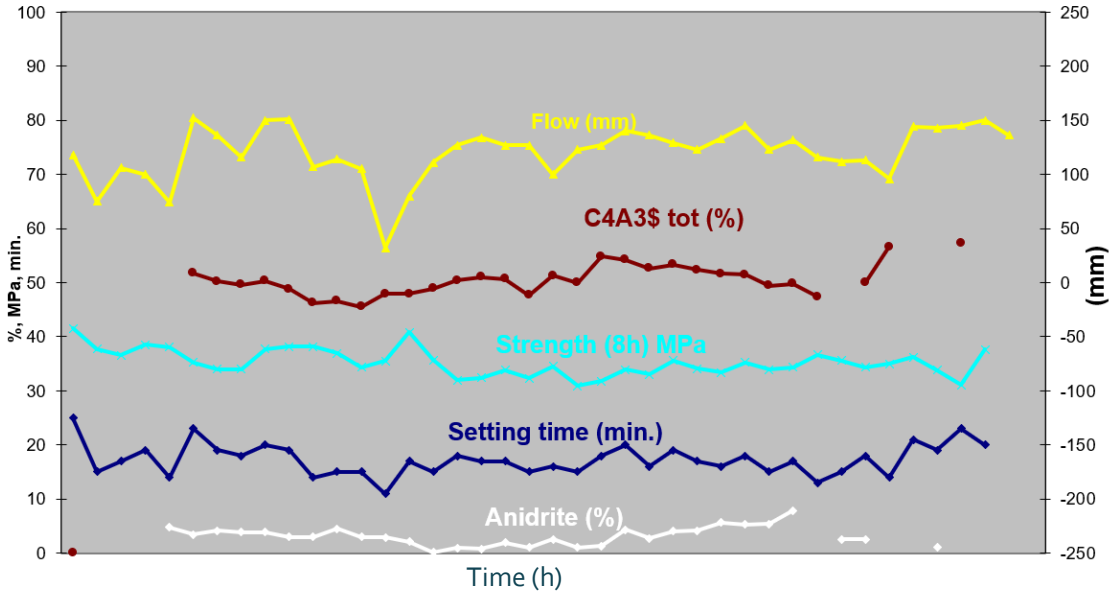


Low enthalpy required for $C_4A_3\$$ formation
≈ 800 kJ/Kg (≈ 1800 kJ/Kg for C_3S)

Main CSA clinker phases analysis	
$C_4A_3\$$	> 50%
C_2S	> 25%
$C\$$	≈ 5%

$C_4A_3\$ + 2C\$ + 38\ H \rightarrow C_6A\$_3H_{32} + 2\ AH_3$ (hydration reaction of CSA cement)

CSA clinker production



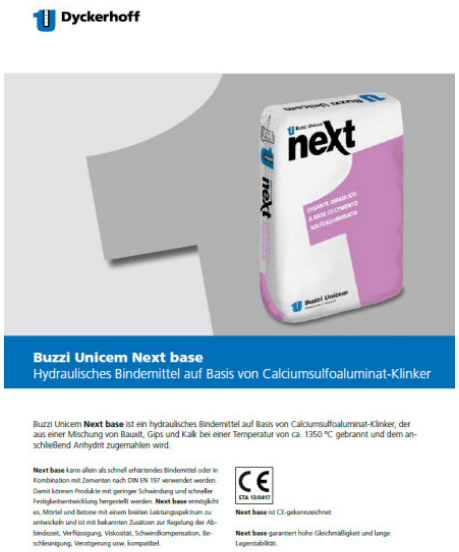
XRD - Bruker

Industrial production of CSA clinker is much more complicated and challenging than OPC clinker:

- Bild-up formation (kiln crust due to high SO_3 content)
- Risk of melting due to Fe_2O_3 content
- Controls of emission (SO_2, heavy metals, dust etc…)
- Quality and homogeneity of the final products

It requires accurate quality control of the clinker: XRF, XRD analysis, strengths, setting time

Sulfoaluminatklinker, eine Alternative zum Portland-Klinker?



Die CE-Kennzeichnung eröffnet die Möglichkeit der Verwendung von CSA-Zementen auch im konstruktiven Betonbau.

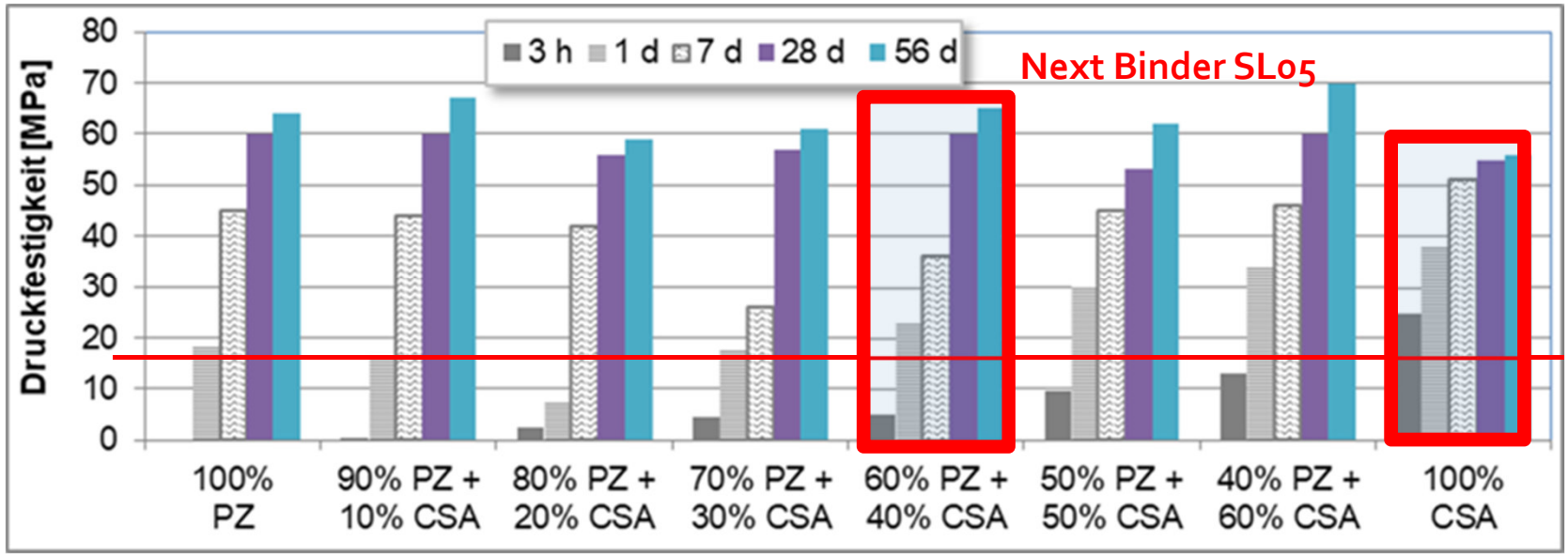
Zulassung CSA Next base SR03, Beton- und Stahlbeton DIN 1045-2 AbZ vom 22.07.2018

Expositionsklassen
- X0
- XC1, XC2
- XF1, XF3
- XA1 – XA3
- HS-Zement (SR)

CSA Cement produced at Buzzi in Europe

	Next Base SR03	**Next Binder SL05 (CEM II A LL + CSA)**	**Next Expansive SN18 (Addition)**
Standard	ETA	Zulassung	
Setting time	6 – 15 min	20 min	
Strenght development	20 MPa (3h)	8 MPa (5h)	
Shrinkage		< 250 µm/m (90 days)	
Expansion			Depending on the dosage
Application	Rapid hardening mortar	Rapid hardening concrete	Addition to mortar/concrete

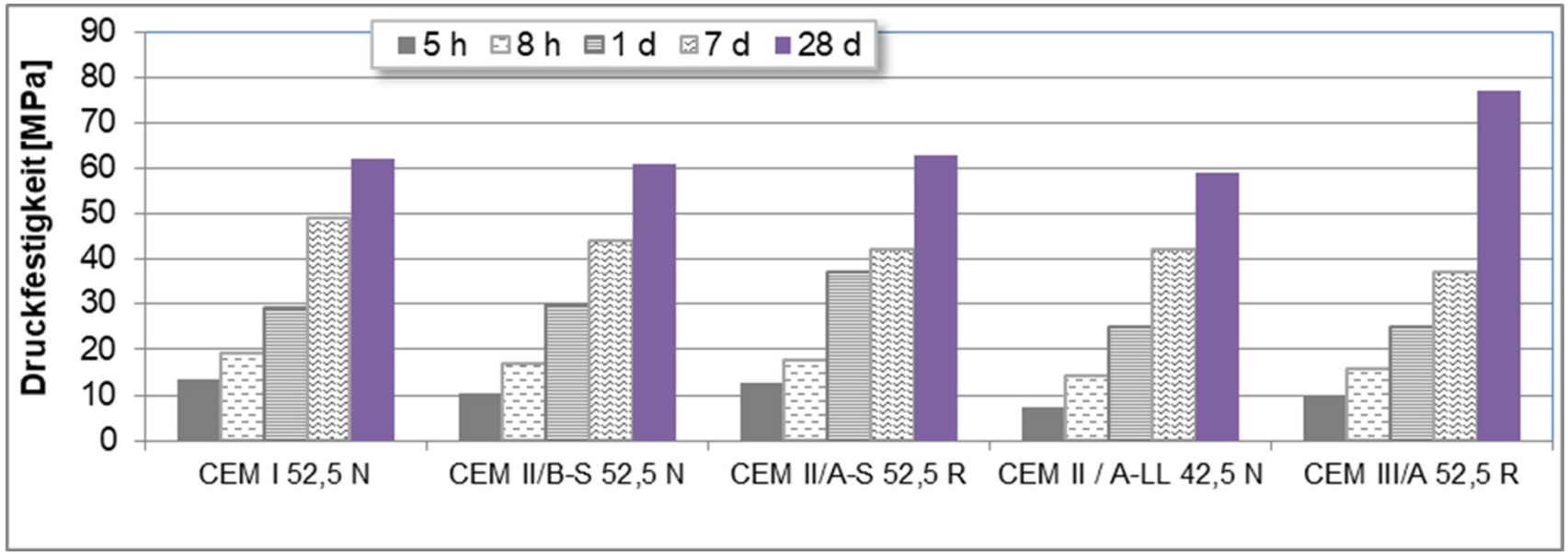
Druckfestigkeit Calcium-Sulfoaluminatzement *"SR03" mit Normzementen* Normmörtel nach EN 196



PZ: Portland Zement - CEM I 42,5 R

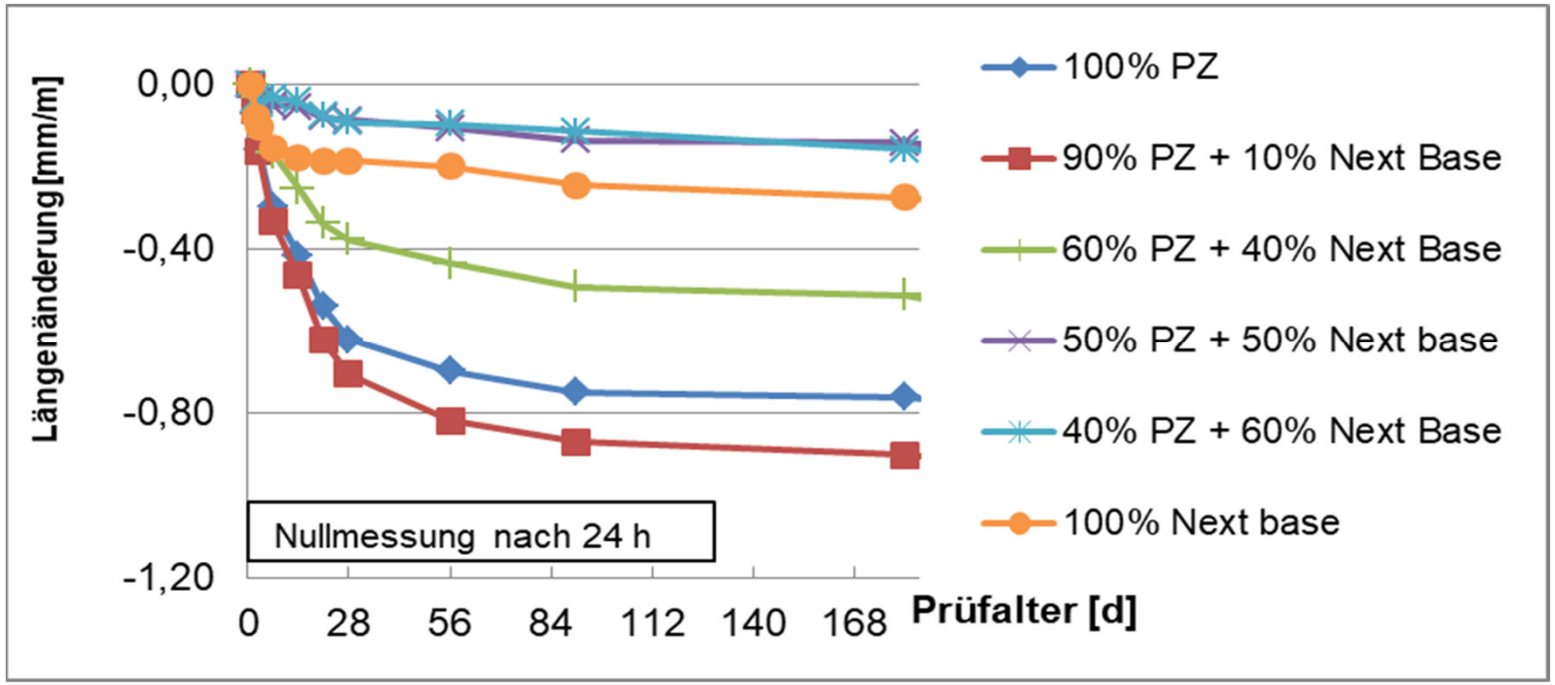
CSA: Buzzi Unicem Next Base SR03

Druckfestigkeit Calcium-Sulfoaluminatzement *"Next Base SR03" mit Normzementen* Normmörtel nach EN 196-2



Mischungen 40% Buzzi Next Base SR03 : 60% Normzement

Schwindverhalten Calcium-Sulfoaluminatzement *"SR03"*

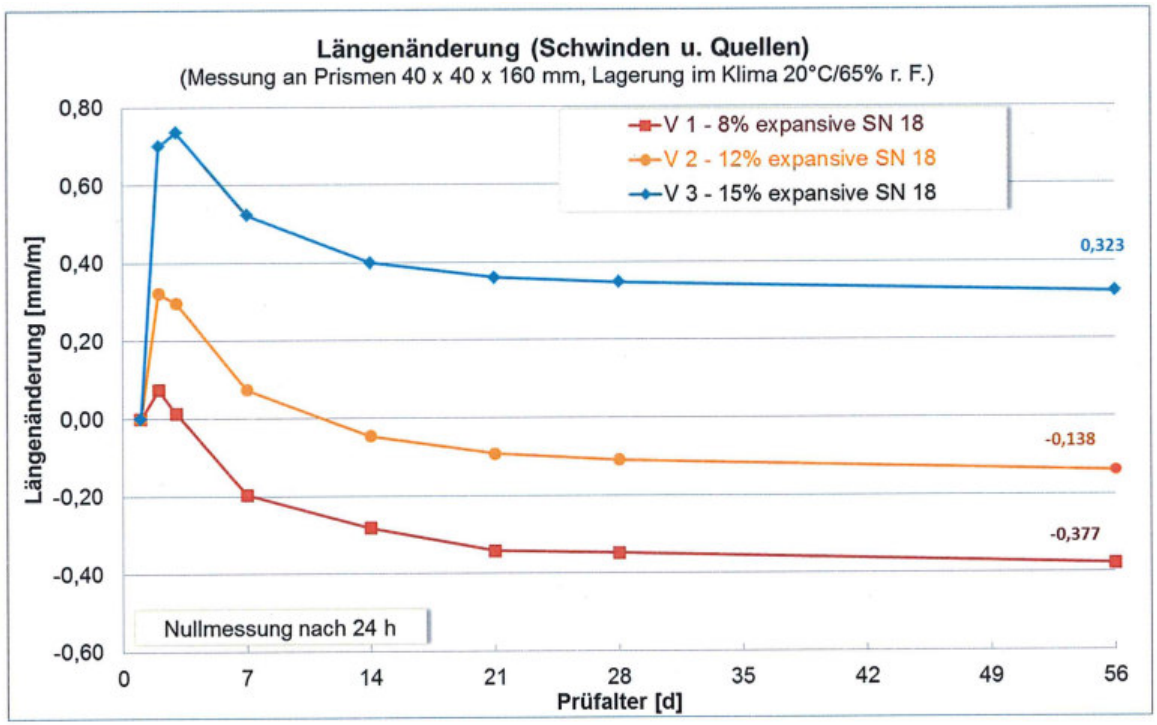


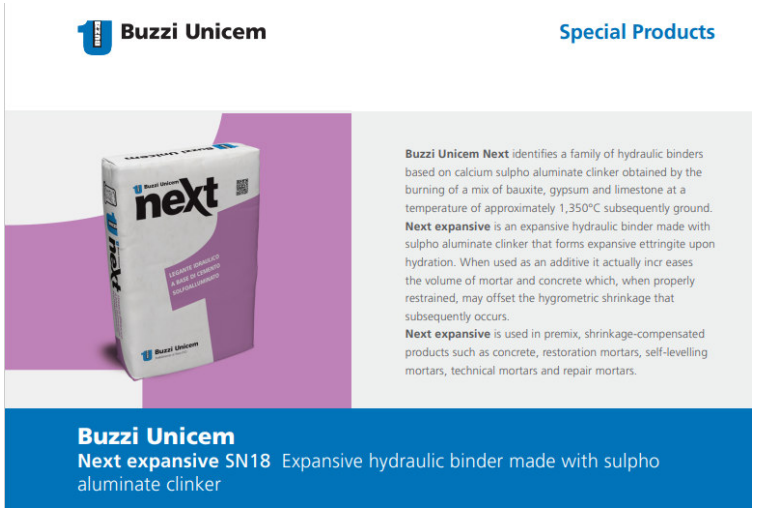
PZ: Portland Zement - CEM I 42,5 R

CSA: Buzzi Unicem Next Base SR03

Beste Schwindreduktion
bei 50 - 60%
Next Base SR03-Zugabe

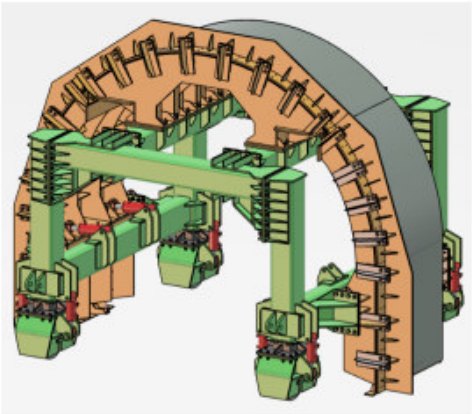
Next Espansive SN18





	V1 - 8% Next Expansive SN18	V2 - 10% Next Expansive SN18	V3 - 15% Next Expansive SN18
Strengths 1 day (MPa)	14	11	11
Strengths 28 days (MPa)	58	55	47

HINFRA - ETLR Project Roadmap



H2 21
R&D (materials)

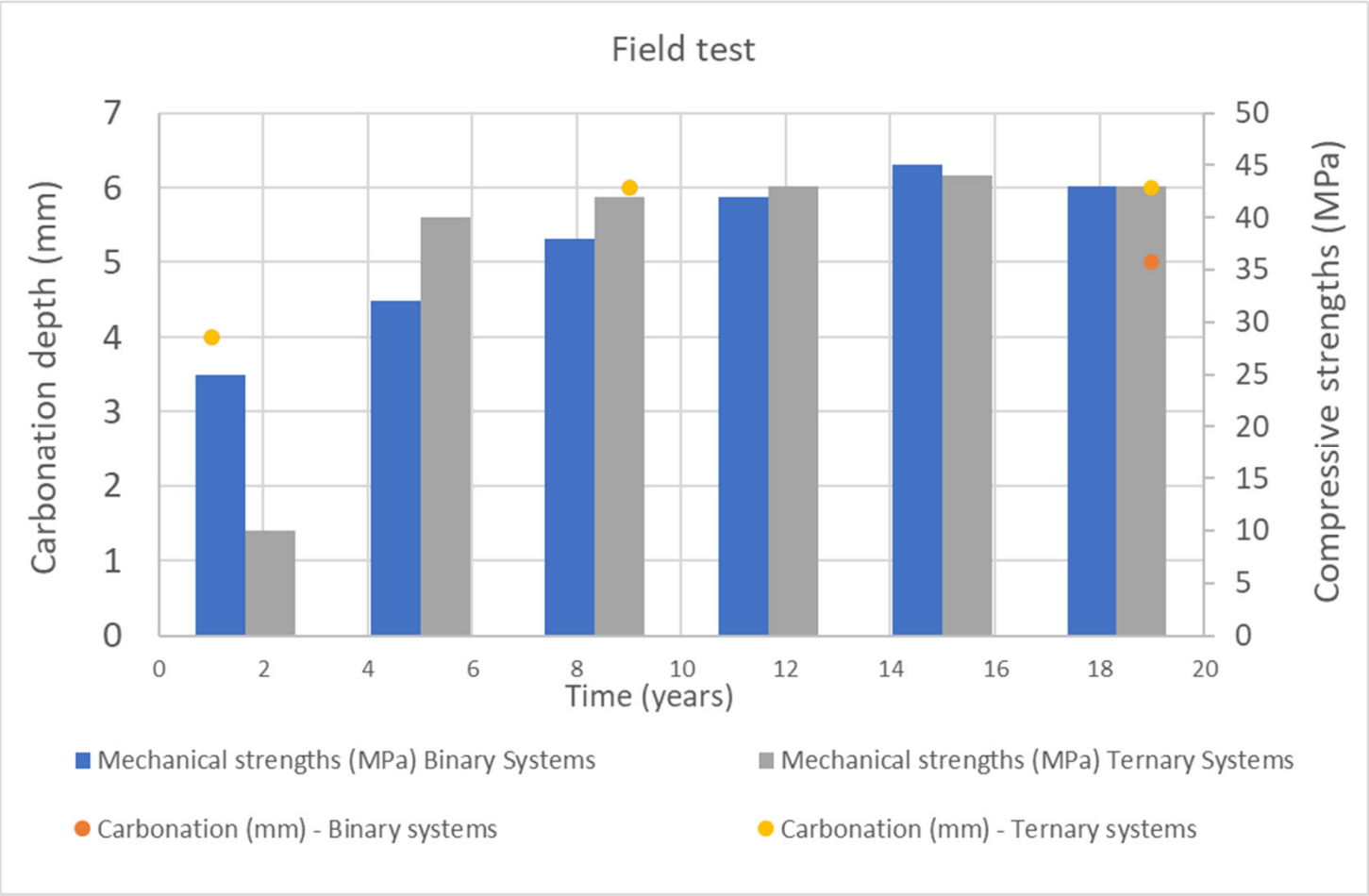
Otc. – Nov 21
Small-scale extrusion tests

Apr. 22 – May 23
Large-scale extrusion tests

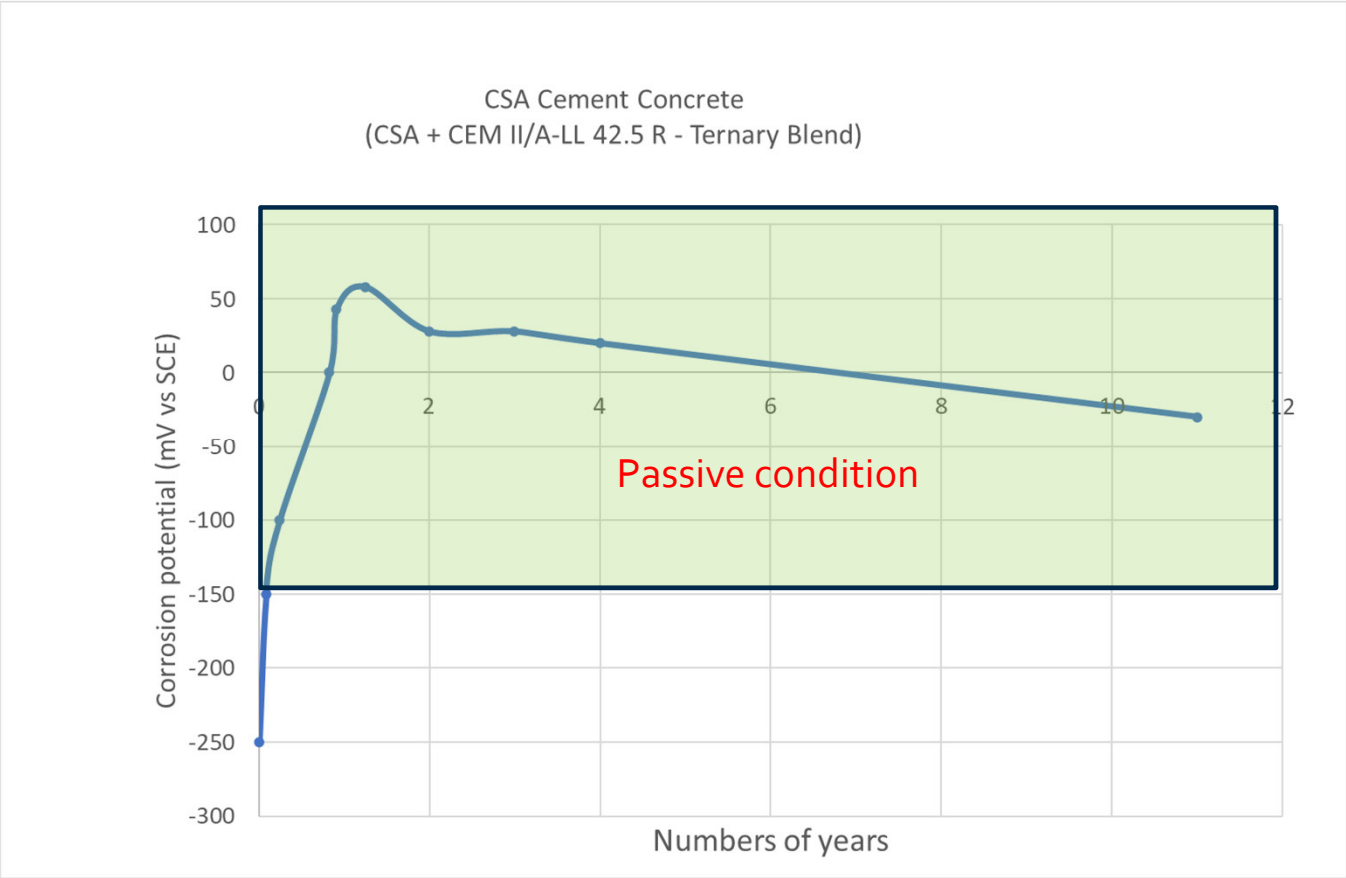
H2 23
Pilot in real tunnel

Samples removed from service (20 years old)

Samples removed from service (20 years old)



Field test on SCC CSA pre-cast concrete (11 years old)
Corrosion resistance



Carbonation depth: 0.4 mm

The steel is still embedded in a non-carbonated concrete matrix

CSA Cements - Conclusion

CSA Cement is a very interesting binder that allow formulation of high early strength and low shrinkage mortar and concrete

CSA cement Next Base SR03 is authorized in Germany also for structural use.

Interest on CSA cement is increasing also due to the reduction of clinker in Portland cement

Buzzi and Dyckerhoff have long experience on production, application and customer support

We are continuosly exploring new application

GRAZIE