Geosil® – ready to use alkali silicates for Geopolymers

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- Basics of alkali silicates
  - Basic facts about alkali silicates
  - Production methods
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  - CLP - Classification
- Alkaline solution for geopolymeric systems
  - Commonly used alkaline solutions
  - Geosil® - Silicate binders for geopolymeric systems
  - Geopolymeric systems with Geosil®
- In-house testing methods
- R&D work in the Woellner Laboratory

COMPANY INTRODUCTION

Owned by Dr. Eduard Wöllner family foundation

Founded in 1896 – 125 years of experience

Head office in Ludwigshafen / Germany

Main product groups:

- industrial silicates
- raw materials and additives for paints, plasters and construction materials
- process chemicals for industrial water circuits

Approx. 150 employees

Annual turnover approx. 50M€

Sites in Germany & Austria

woellner

CCC	Betol®	Inorganic binders based on soluble silicates
	Betolin®/Sapetin®/ Sikalon®	Special binders and additives for paints/plasters/construction chemistry
	Collosil®	Water-based special adhesives for construction and insulating materials, paper tubes and cores, special technical applications
	Geosil®/Stabisil®	Binders and hardeners for alkali-activated systems
	Ligasil®/Stabisil®	Binders and hardener systems for specialist civil engineering and tunnelling

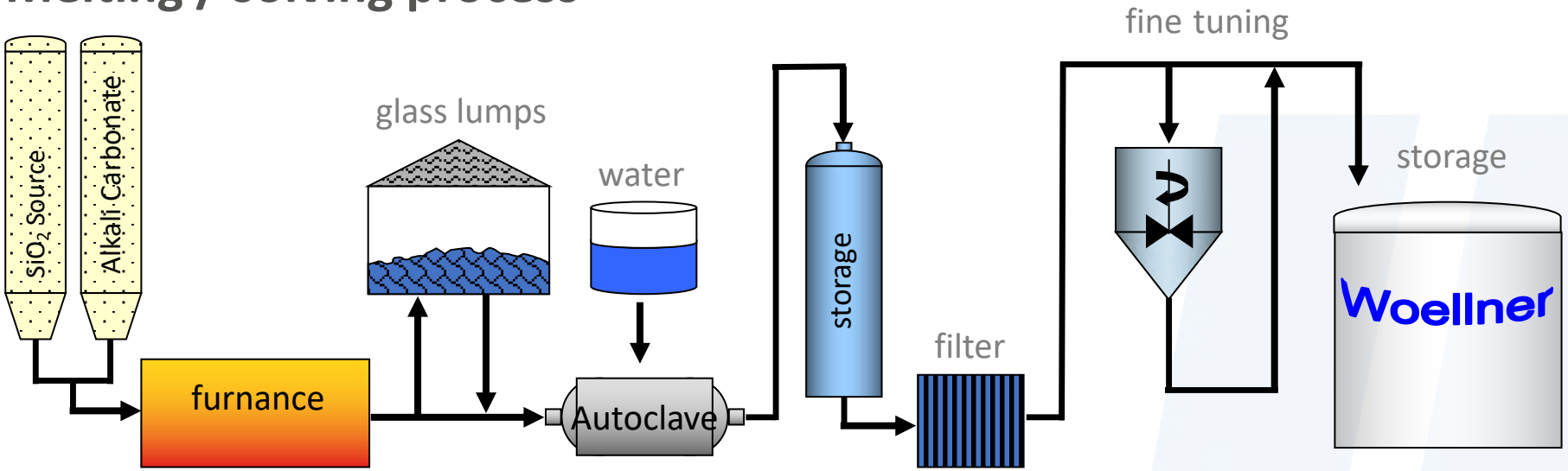
Basic facts about alkali silicates

Basic facts about alkali silicates

- Glasses soluble in water, resulting from combinations of alkali metal oxide (Na, K, Li) & silica (SiO_2) in varying ratios
- Alkali silicates are generally not distinct stoichiometric chemical substances
- No specific chemical formula for each product
- Trivial name = Waterglass
- Products available as solution and powder

Production methods

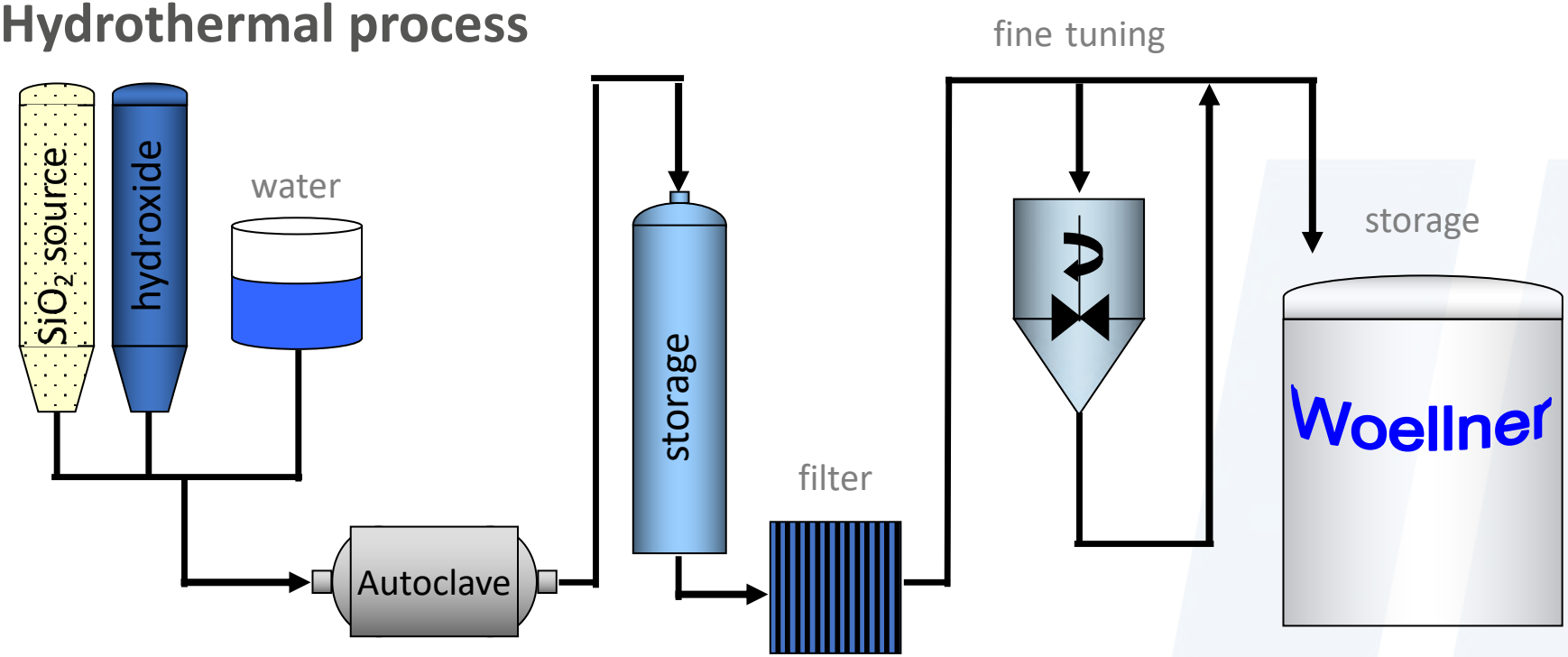
Melting / solving process



$$Me_2CO_3 + nSiO_2 \rightarrow Me_2O \cdot nSiO_2 + CO_2$$

$$Me = Na, K$$

Hydrothermal process



$$2\ \mathrm{MeOH} + nSiO_2 \rightarrow Me_2O \cdot nSiO_2 + \mathrm{H_2O}$$

$$Me = Na, K$$

Molar and weight ratio

Molar and weight ratio

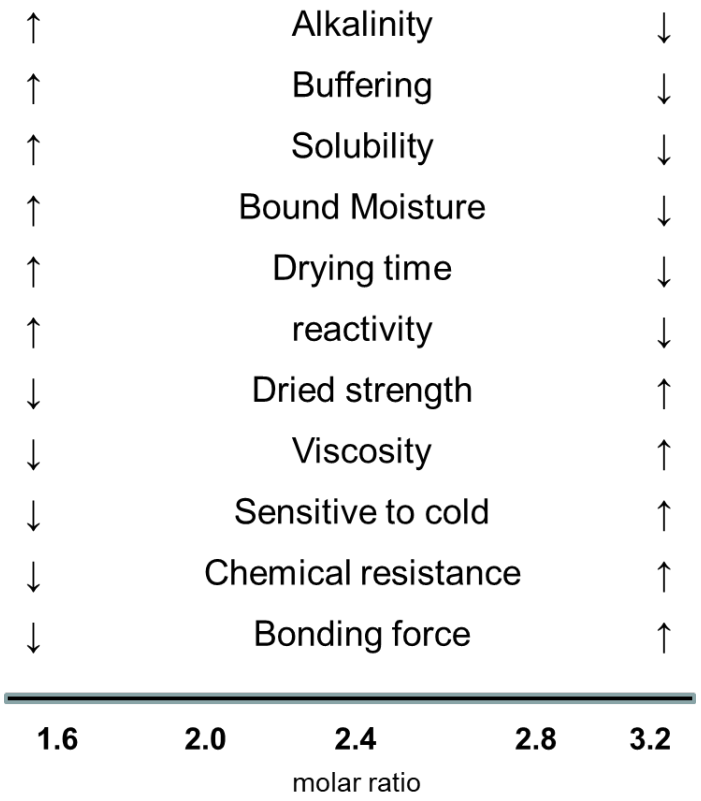
$$Molar\ ratio: \frac{n\ SiO_2\ [mol]}{n\ Me_2O\ [mol]} = MR$$

$$Weight\ ratio: \frac{w\ SIO_2\ [\%]}{w\ Me_2O\ [\%]} = WR$$

Technical significant liquid Na, K & Li-silicates and mixtures thereof:

- Sodium silicate $MR = 1{,}7 - 4{,}0$
- Potassium silicate $MR = 1{,}0 - 4{,}0$
- Lithium silicate $MR = 2{,}5\ and\ 5{,}0$

Influence of molar ratio on properties



CLP - Classification

Molar ratio $SiO_2 : M_2O$	Classification Dangerous Substances (Handling)	Classification Dangerous Goods (Transport)	Classification according CLP
> 3,2 (Conc. < 40 %)	none	none	none
> 3,2 (Conc. > 40 %)	Xi Irritant R 36/38	none	Warning Skin Irrit. 2 H315 Eye Irrit. 2 H319
> 2,6 ≤ 3,2	Xi Irritant R36/38	none	Warning Skin Irrit. 2 H315 Eye Irrit. 2 H319
> 1,6 ≤ 2,6	Xi Irritant R38, 41	none	Danger Skin Irrit. 2 H315 Eye Dam. 1 H318
≤ 1,6	C Corrosive R34	Cl. 8 / Packaging group II	Danger Skin Corr. 1B Eye Dam. 1 H314 Met.Corr. 1 H290

For more information please read the corresponding MSDS

Alkaline solutions for Geopolymeric systems

Usually used alkaline solutions

Sodium and potasium hydroxide

\+ For basic trials and scientific research work

– Soluble silica powder has to be added

– High corrosive solution, strong requirements for storage and handling

Waterglass (Betol types) & hydroxide

\+ Flexible adjustment of molar ratio

– Double handling and double storage (difficult to use on jobsite)

– Limitation of solids content

Geosil® - Silicate binders for geopolymeric systems

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- Geosils are not blends of standard alkali silicates with hydroxide
- New production technology
- Highest possible solid content & optimal Q-structure distribution

Pros

+ Ready-to-use solutions
+ Many variations are possible
+ Userfriendly - no hydroxide handling
+ High purity of raw materials
+ Reproducable & controlled production process
+ Stable solution

Cons

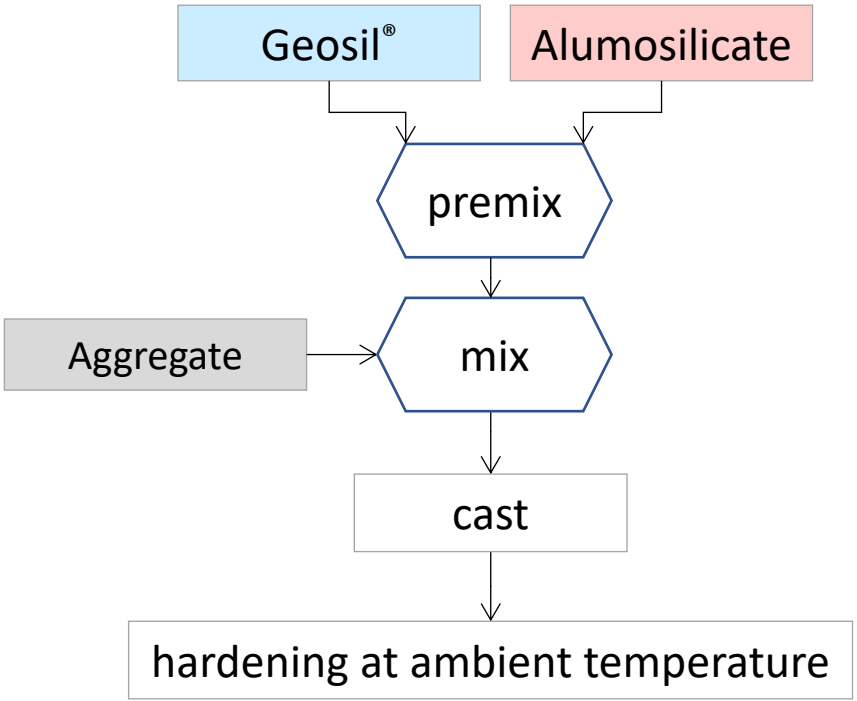
– Limitation: dangerous goods (ADR) for some molar ratios
– Molar ratio < 1,7 for sodium based products are not possible due to limited shelf life

Geosil® - Types

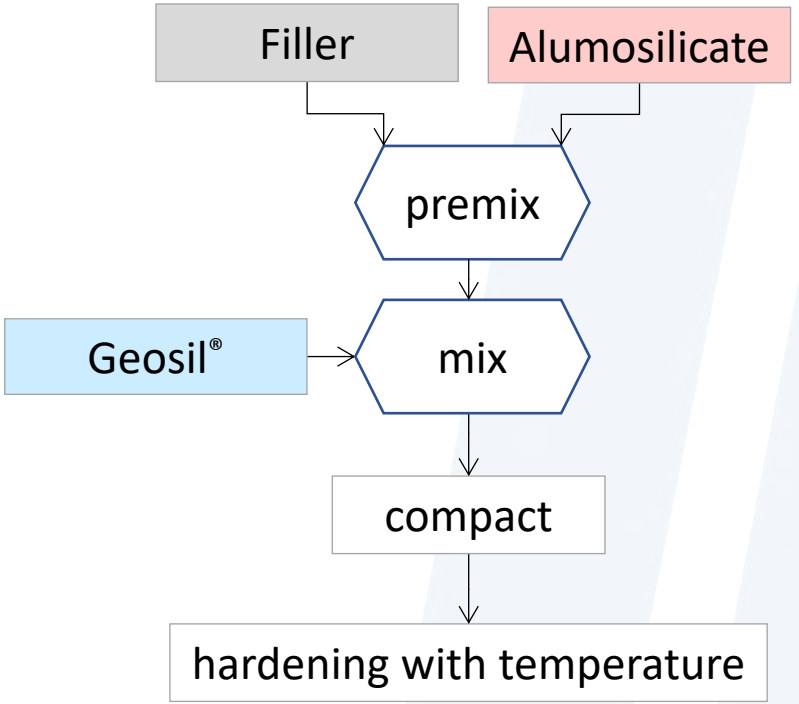
Product	Geosil® 14515	Geosil® 14517	Geosil® 34417
Alkali metal	potassium	potassium	sodium
Viscosity	20 [mPa·s]	20 [mPa·s]	430 [mPa·s]
CLP - classification	H290 / H314 (1B) / H318	H315 / H318	H315 / H318
CLP - label			
ADR - classification	Class 8 / packaging group II	non	non

Geopolymeric systems with Geosil®

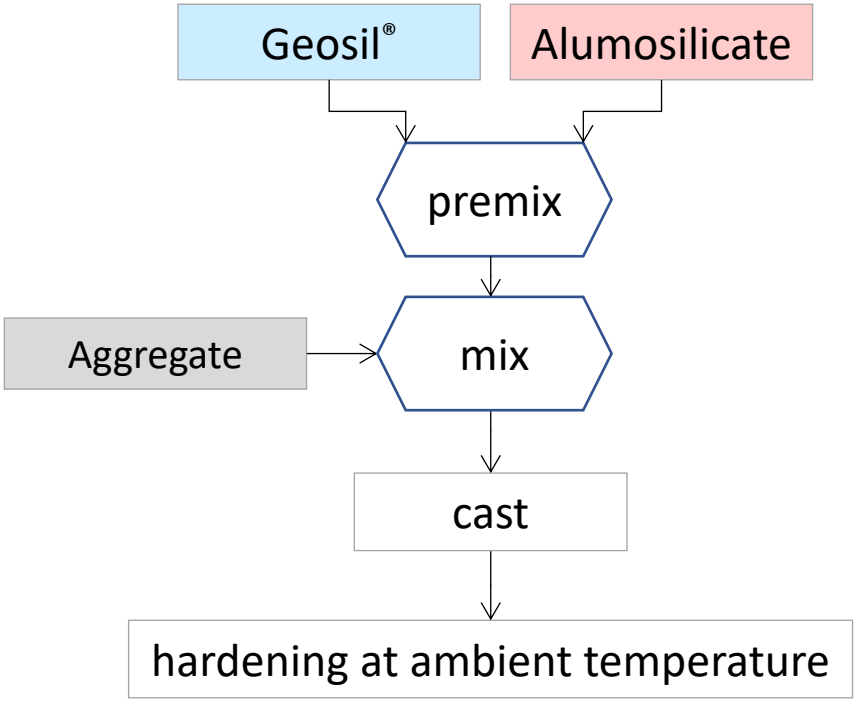
Binder rich system

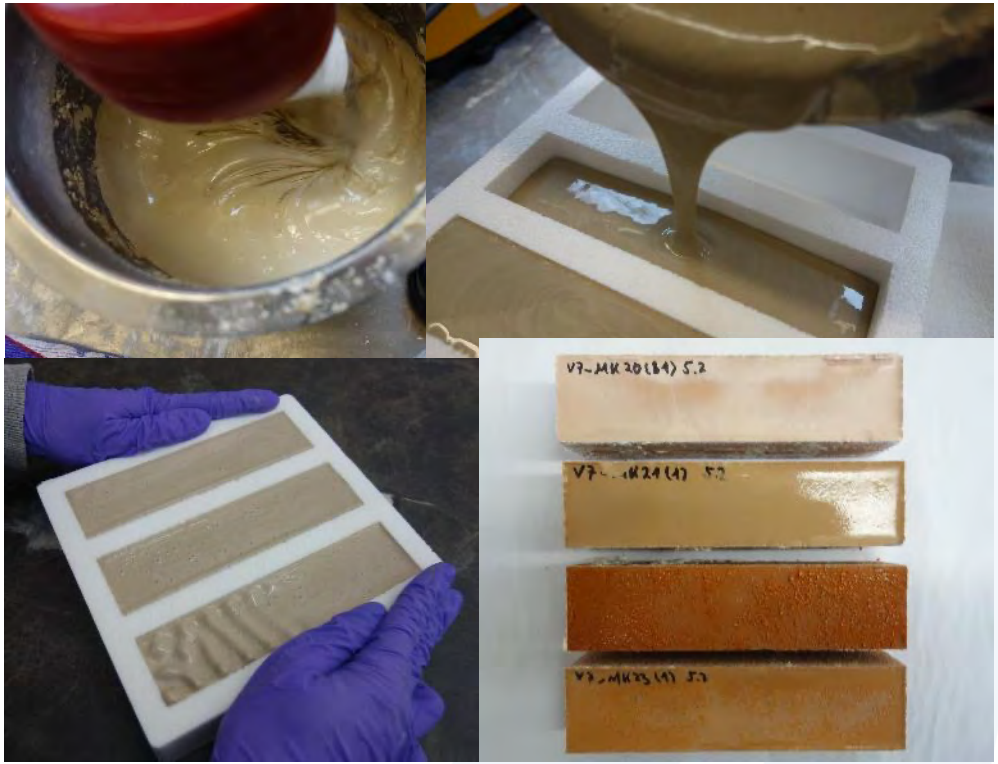


High solids system

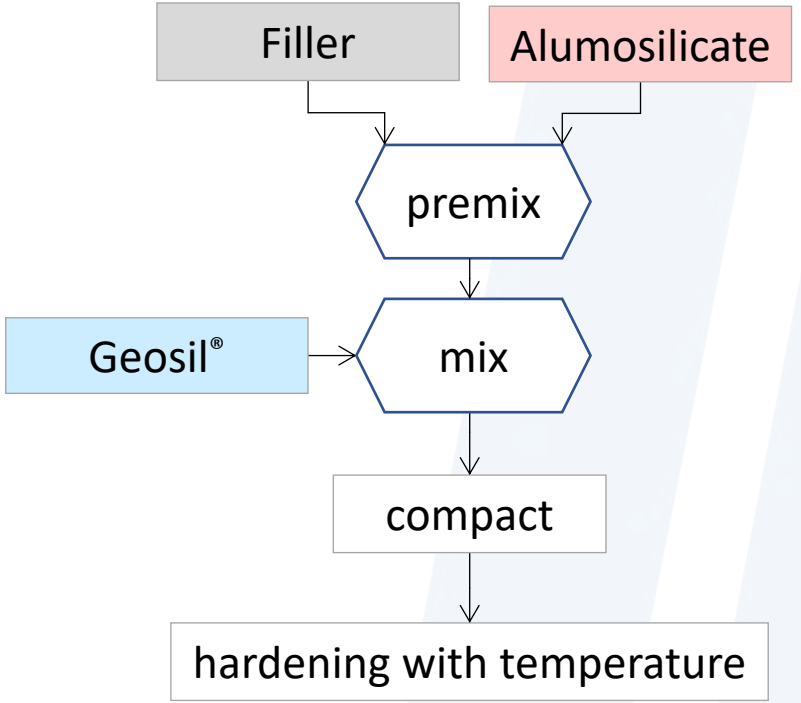


Binder rich system





High solids system



Binder rich system

- Geopolymer concrete
- Geopolymer adhesive
- Geopolymer mortar
- Inorganic foam A1 class
- Toxic waste immobilisation
- Composites
- Steel coating

High solids system

- Acoustic panels
- Thermal insulation boards
- Fire protection boards
- Refractory bricks
- Pavement stone
- Facade elements
- Core binder foundry
- Arts & decoration

In-house testing methods

Rheological and physical properties

Rheological properties

- Viscosity
  - Thixotropy
  - Flowability
- Concrete slump test
- Compacting

Physical properties

- Compressive / Cold crushing strength
- Tensile / Cold bending strength
- Adhesive strength
- Density
- Permeability
- Scratch resistance
- ……..

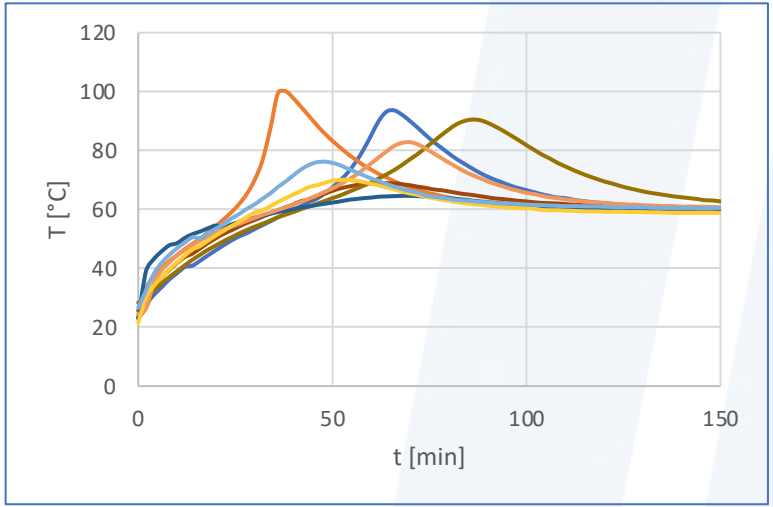
Rheological properties

Workability according to DIN EN 1015-3

Concrete slump test

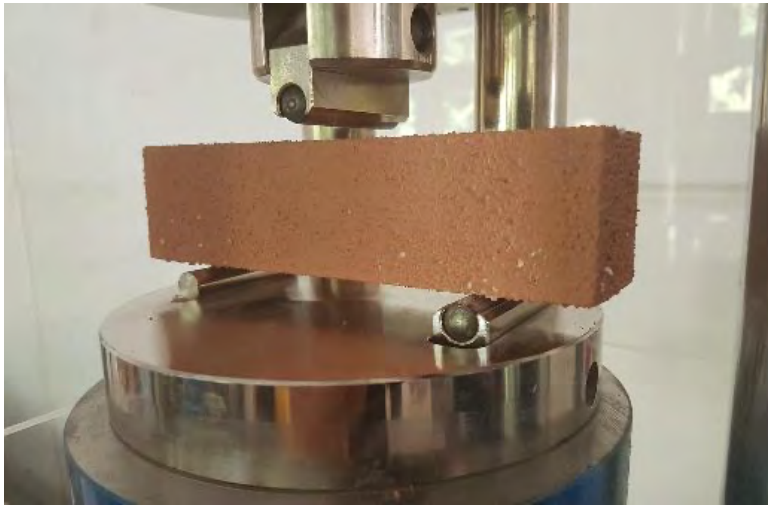
Reactivity

Kinetics measurement

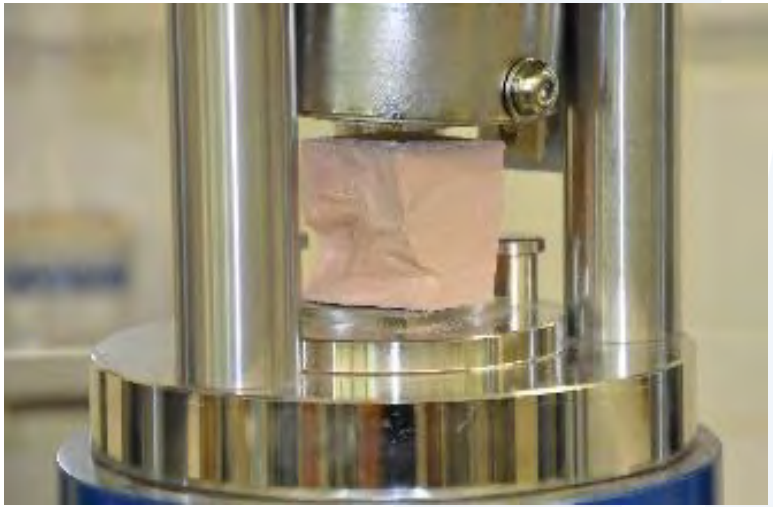


Physical properties

Strength according to DIN EN 196-1



Tensile / Cold bending strength



Compressive / Cold crushing strength

Resistance and refractory properties

Resitance against…..

- Water / Vapour
- Acids
- Alkaline lye
- Organic solvent
- Freeze-thaw cycles and deicing salt
- …….

Refractory properties

- Thermal shock resistance
- Pyrometric cone equivalent
- Softening under load
- Hot crushing and hot transverse strenght
- …….

Refractory properties

Thermal shock resistance according to DIN 51068

High performance after 30 cycles

Low performance after 5 cycles

Water resistance

High water resistance

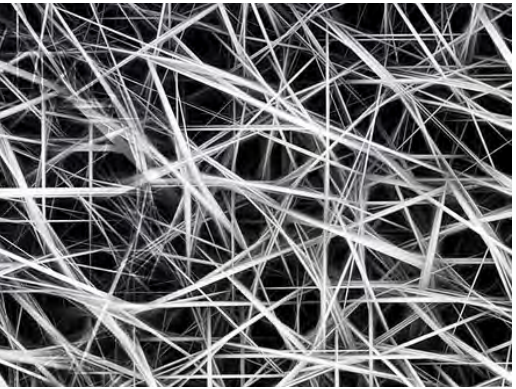
Low water resistance

Chemical resistance

High acid resistance Geopolymer

Low acid resistance OPC

R&D Work in the Wöllner laboratory



R&D work

- Raw material studies
  - Reactive raw materials
  - Functional and non-functional fillers
- How to reinforce?
  - Fiber materials
  - Laminated structured materials
- Additive study
  - Liquefying
  - Dispersing
  - Retarding
  - Shrinking
  - Cracking
- Development of testing methods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