Latvijas Betona Savienība

LBS 31. Zinātniski Tehniskā konference

“Betona ilgmūžība un ilgizturība”

Asoc.prof., Dr. Rolands Cepurītis

LBS valdes priekšsēdētājs

2023.g. 23. novembrī

Rīga

Latvijas Betona Savienība

PRIMX

1862
RĪGAS TEHNISKĀ UNIVERSITĀTE

Heidelberg Materials

SCHWENK

PERI

stachema

RCK 1872
RĪGAS CELTNIECĪBAS KOLEDŽA

KORO BŪVE

A7 BETONS

SAKRET

VELVE MATERIĀLU SISTĒMAS

MAPEI

PRE fabrica

semtu

Latvijas Biozinātņu un tehnoloģiju universitāte

CHRYSO SAINT-GOBAIN

RDB INDUSTRIAL

DVL

ARILANS BETONA RAŽOTNE

BETONAM

CONCRETO

KILEN BALTIC X

SALENIEKU BLOKS

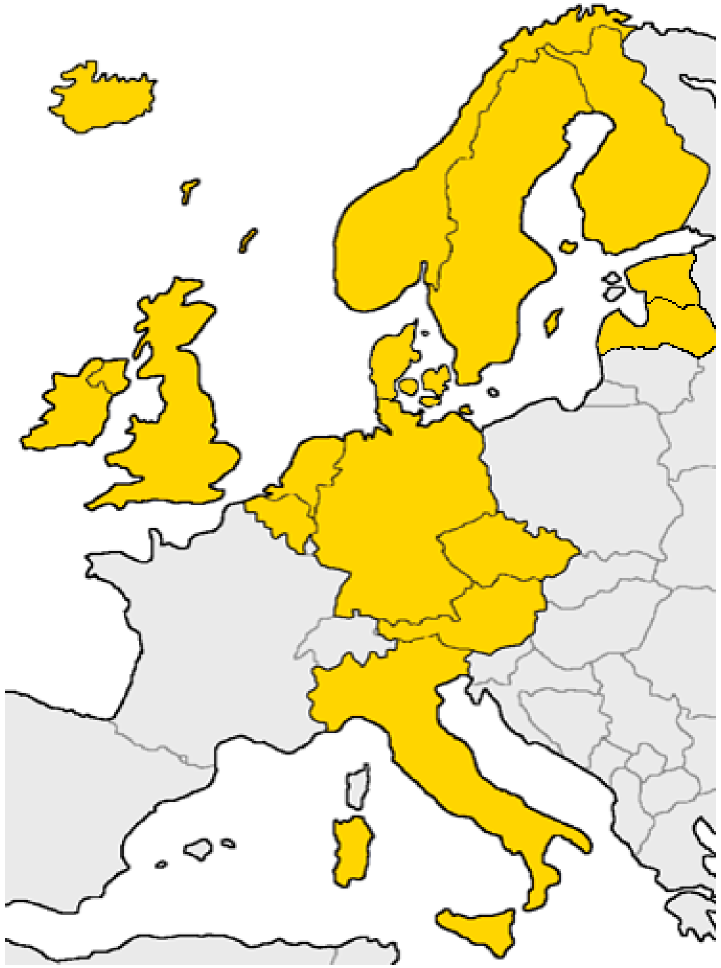
LBS konferences lieldraugs:

MB GRUPA

Latvijas
Betona
Savienība

European Concrete Societies Network

www.ecsn.net



ECSN Webinar – 29 March, 12:30 – 16.30 p.m. (CET)

Binders and concrete for the next decade

12:30	Introduction: European Concrete Societies Network & Short update Richard McCarthy, Chair of ECSN & Managing Director of the Swedish Concrete Association (Sweden)
12:40	Circular concrete: CO2 mineralization combined with concrete recycling Jan Skocek, R&D Program Manager, Carbonation Technologies, Heidelberg Materials (Germany)
13:00	New binders – what happens now and in the future? Ingemar Löfgren, R&D Manager, Thomas Concrete Group (Sweden)
13:20	Review of life cycle analysis principles as they apply to building materials or why we should let trees grow Hervé Camerlynck, Director of FEBELCEM (Belgium)
13:40	Carbon capture and utilisation in the cement industry – Case power-to-methanol Ulla Leveelahti, Environmental Manager, Finnsementti (Finland)
14:00	Break
14:10	Volcanic pozzolan from Iceland – VPI Björn Davíð Þorsteinsson, Production Manager, BM Vallá mortar factory – Part of Heidelberg Materials (Iceland)
14:30	Carbon capture, utilisation and storage in the Irish cement industry Paul Monaghan, Group Head of Sustainability, Mannok (Ireland)
14:50	Low carbon concrete in the UK MPA Cement (UK)
15:10	Low carbon calcined clay-limestone cement – FUTURECEM Jesper Damtoft & Stefano Zampaletta, Cementir Holding (Denmark)
15:30	Break
15:40	The composite cements and their direct certification for use in concretes according to exposure resistance classes Jan Gemrich, Executive director, Czech Cement Association (Czech Republic)
16:00	Carbon capture and storage at the Brevik cement plant in Norway Vetle Houg, Sustainability Manager, Heidelberg Materials Norway (Norway)

Latvijas Betona Savienība

23/11/2023

LBS 31. zinātniski tehniskās konferences **programma**

BETONA ILGMŪŽĪBA UN ILGIZTURĪBA

09:00 Konferences atklāšana
R. Cepurītis (LBS valdes priekšsēdētājs, SIA Primekss, NTNU)

Betona ilgizturība | Concrete Durability

Moderators: R. Cepurītis

09:20 Kas nosaka betona ilgizturību? [LV] G. Šahmenko (RTU)
09:45 Carbonization resistance of concrete / Betona karbonizācijas izturība [EN]
U. Müller (SCHWENK Sverige AB)
10:10 Alkali-aggregate reactions in concrete / Sārmu silikātu reakcijas betonā [EN]
B. Wigum (Heidelberg Materials)
10:35 Prevention of concrete alkali-silica reaction in Lithuania / Sārmu silikātu reakcijas novēršana betonā, Lietuvas pieredze [EN] A. Augonis (KTU)

11:00 Kafijas pauze

11:20 Resistance of concrete towards chloride ingress / Betona izturība pret hlorīdu difūziju [EN]
U. Müller (SCHWENK Sverige AB)
11:45 Betona salizturības testa metožu salīdzinājums [LV] J. Zāle (SCHWENK Latvija)
12:05 Betona olimpiādes rezultāti [LV] G. Šahmenko (RTU), T. Nowacki (Stachema)

12:20 Pusdienu pārtraukums

Betona ilgizturība | Concrete Durability

Moderators: G. Šahmenko

13:20 Betona ilgizturības testēšana lidlauka betonam [LV] J. Kudiņš, (BPC) A. Krūmiņš (A7 Betons)
13:40 TK01 Salizturība un LVS 156-1:2022 [LV] J. Zāle (SCHWENK Latvija)
14:00 Unlocking the construction industry's environmental challenges / Atrisināt vides izaicinājumus būvniecības nozarē [EN] T.Plauska (Consolis)
14:20 Betona stiprības noteikšana konstrukcijās ņemot vērā betona temperatūru cietēšanas laikā un tā ietekme uz betona ilgmūžību [LV] J. Kudiņš (BPC)
14:40 3D drukāta betona ilgizturība - aktuālie pētījumi šodien [LV]
M. Šinka (RTU), E. Dzene (SAKRET)
15:00 Sārmu silikātu reakcijas pārbaude LV materiāliem [LV] V. Baranovs (BPC)

15:15 Kafijas pauze

Nozares aktualitātes | Industry novelties

Moderators: J. Zāle

15:35 Šķiedru betona plānsienu trīsslāņu sienu paneļu slodzes nestspēja [LV] U.Skadiņš (LBTU)
15:55 Jauna veida piedevas betona stiprības paaugstināšanai ražošanā izmantojot zema CO2 satura cementus [LV] G. Bianchin, K. Kravalis (Mapei)
16:15 Par UHPC plāksnēm Ola Foundation projektā [LV] E. Ozoliņš (MB Betons)
16:35 Rail Baltica prasības būvju ilgmūžībai [LV] E. Ogliņš (RB Rail AS)
16:55 Jautājumi, diskusijas un konferences noslēgums
R. Cepurītis (LBS valdes priekšsēdētājs, SIA Primekss, NTNU)

CARBONATION RESISTANCE OF CONCRETE

SCHWENK Sverige AB

Scientific and Technical Conference ***Concrete durability and sustainability***

2023-11-23, Riga, Latvia

Urs Müller, Technical Manager

SCHWENK

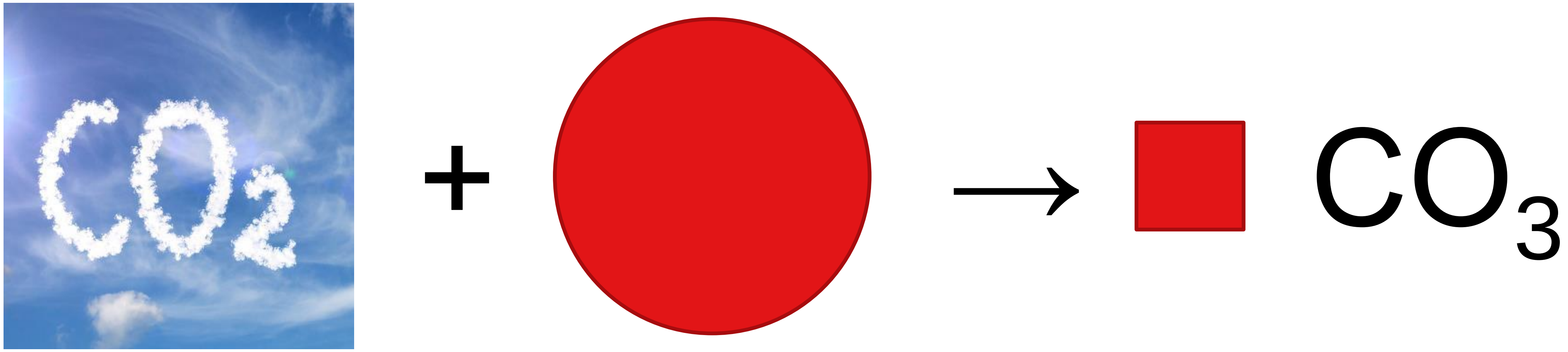
CONTENTS

- What is carbonation of concrete?
- Factors influencing carbonation
- Effects of carbonation
- Sustainability aspects
- Testing carbonation resistance

WHAT IS CARBONATION OF CONCRETE?

Carbonation is a chemical process

material

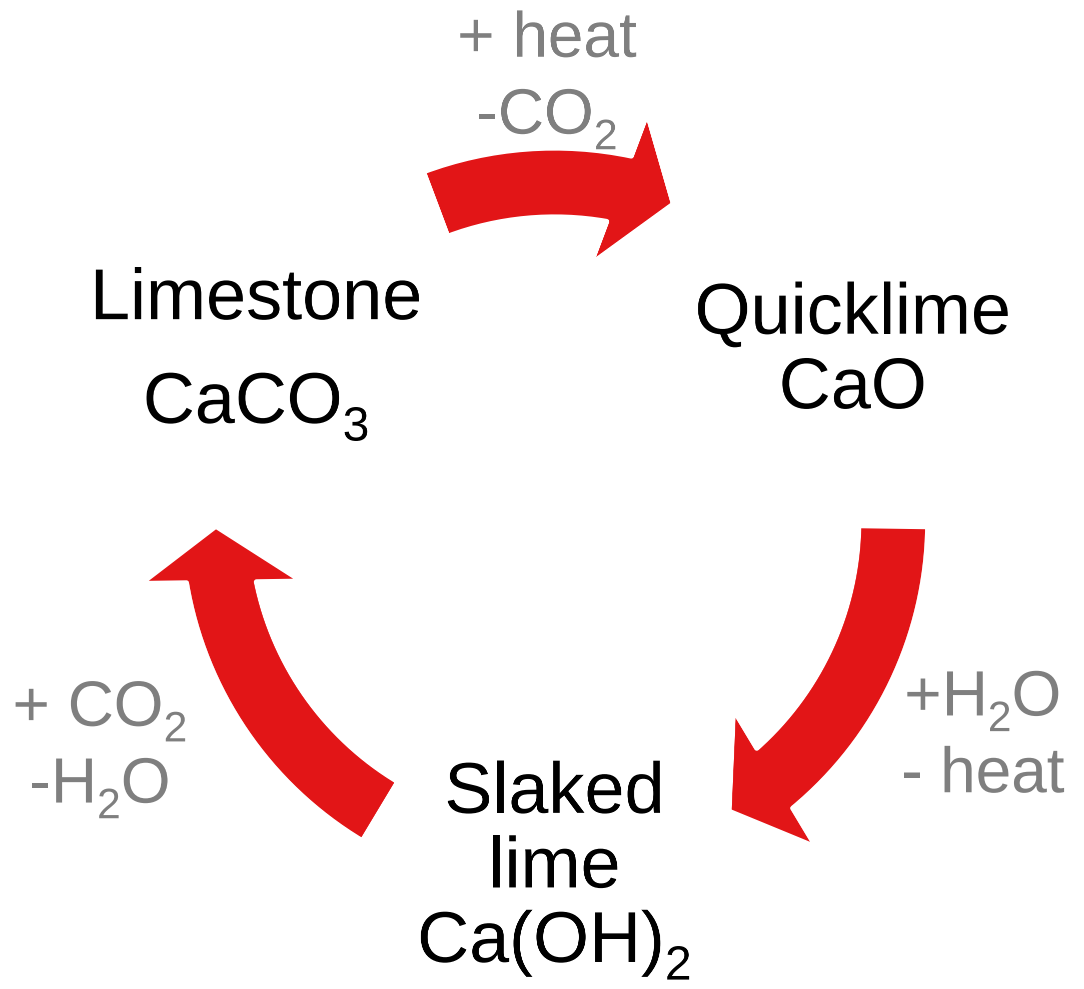


from atmosphere

carbonate

WHAT IS CARBONATION OF CONCRETE?

Carbonation is a chemical process and used for a long time for lime mortars: Lime cycle



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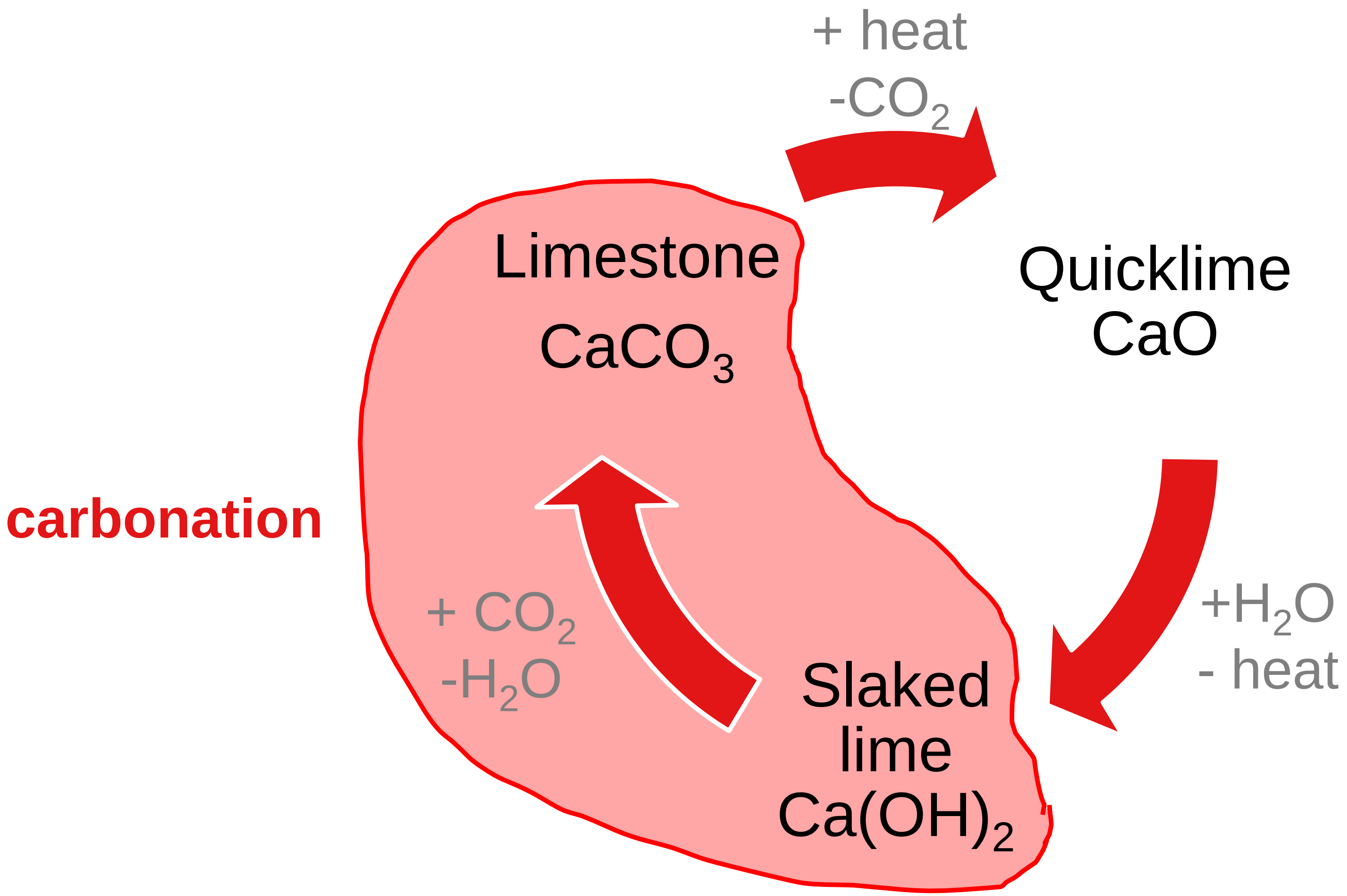


WHAT IS CARBONATION OF CONCRETE?

Carbonation of concrete: Essentially the same process

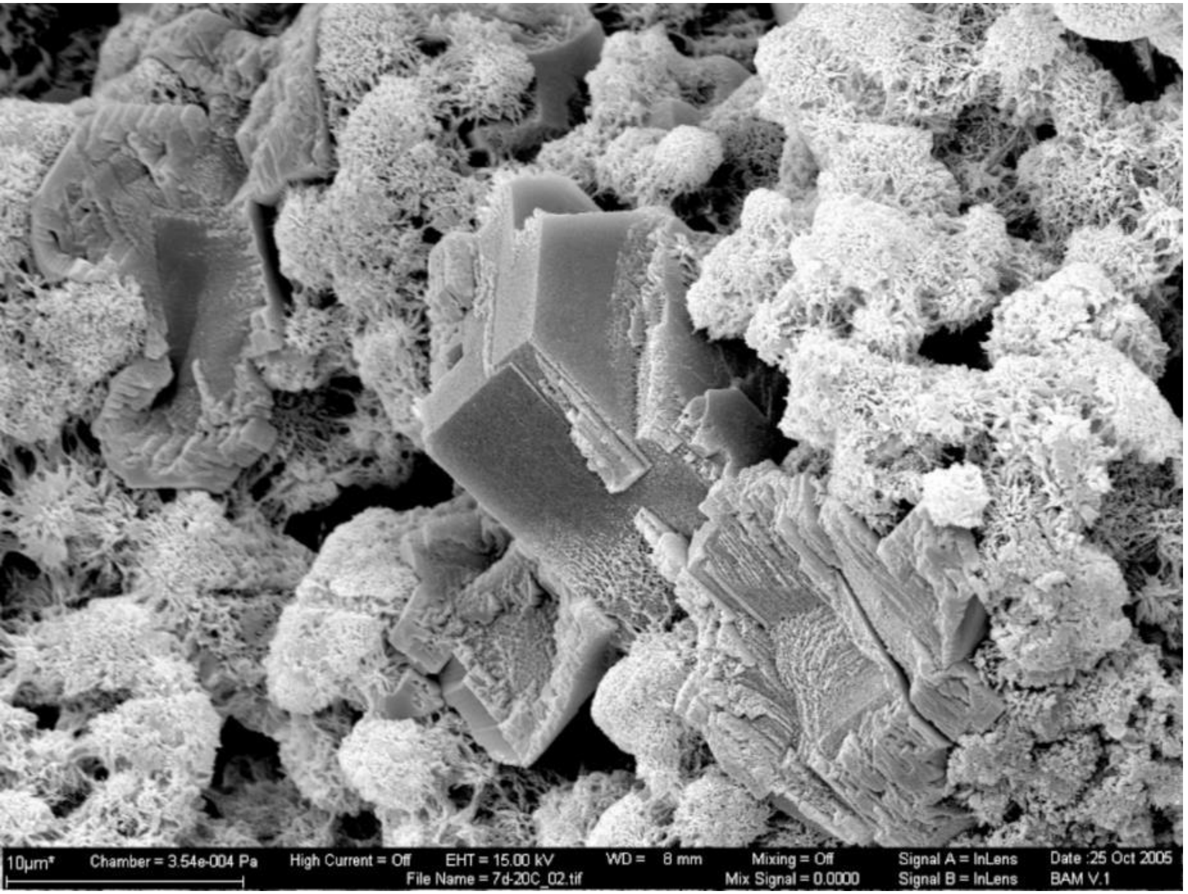
Hydrated cement phases + CO_2 → $CaCO_3$ + XYZ

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

Portlandite (lime hydrate) — Carbon dioxide — Calcite, aragonite, vaterite — water

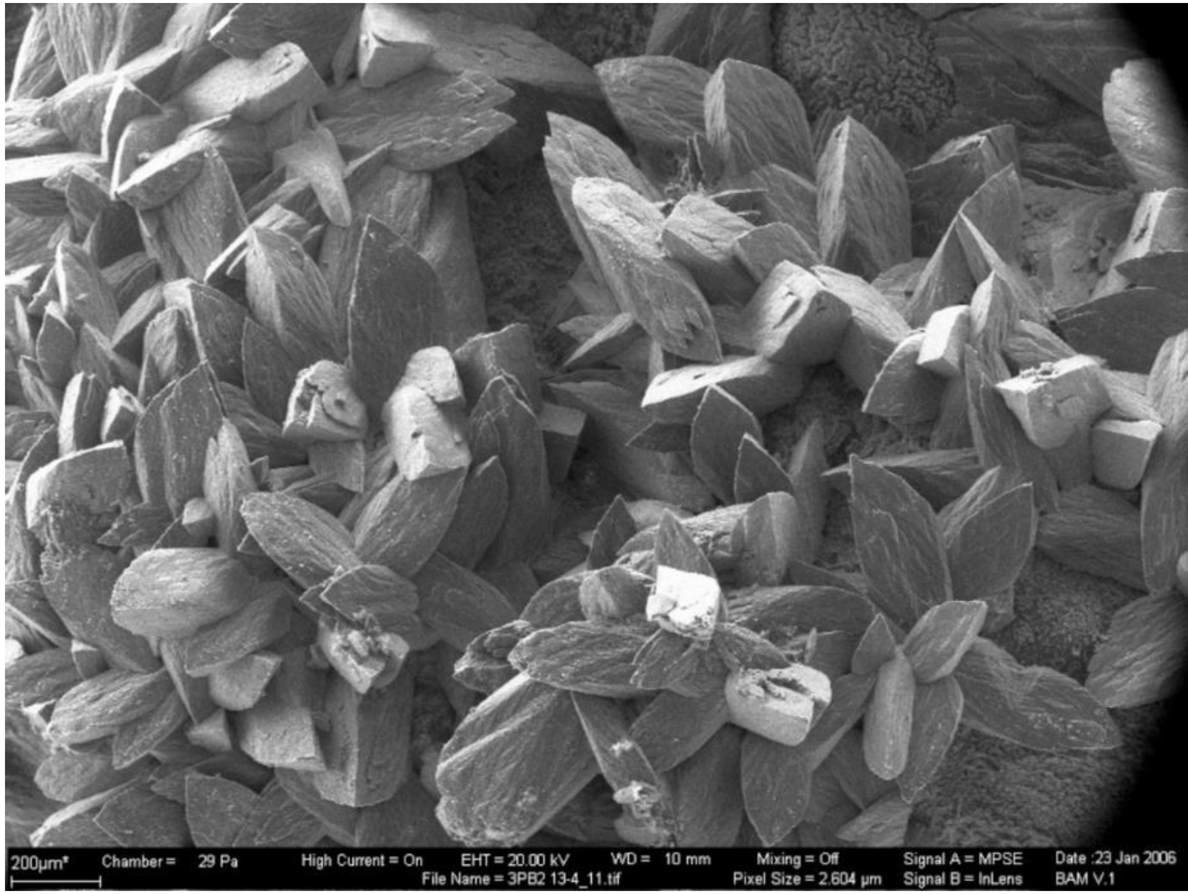
WHAT IS CARBONATION OF CONCRETE?

Portlandite



→

Calcite



WHAT IS CARBONATION OF CONCRETE?

Carbonation of concrete: Essentially the same process

$$\textbf{Hydrated cement phases} + CO_2 \rightarrow CaCO_3 + XYZ$$

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

$$2KOH + CO_2 \rightarrow K_2CO_3 + H_2O$$

$$K_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2KOH$$

$$\text{C-S-H: } 9CaO \cdot 6SiO_2 \cdot 11H_2O + 9CO_2 \rightarrow 9CaCO_3 + 6SiO_2 \cdot xH_2O + (11-x)H_2O$$

…

pH 13 – 13.5 → 8 – 10

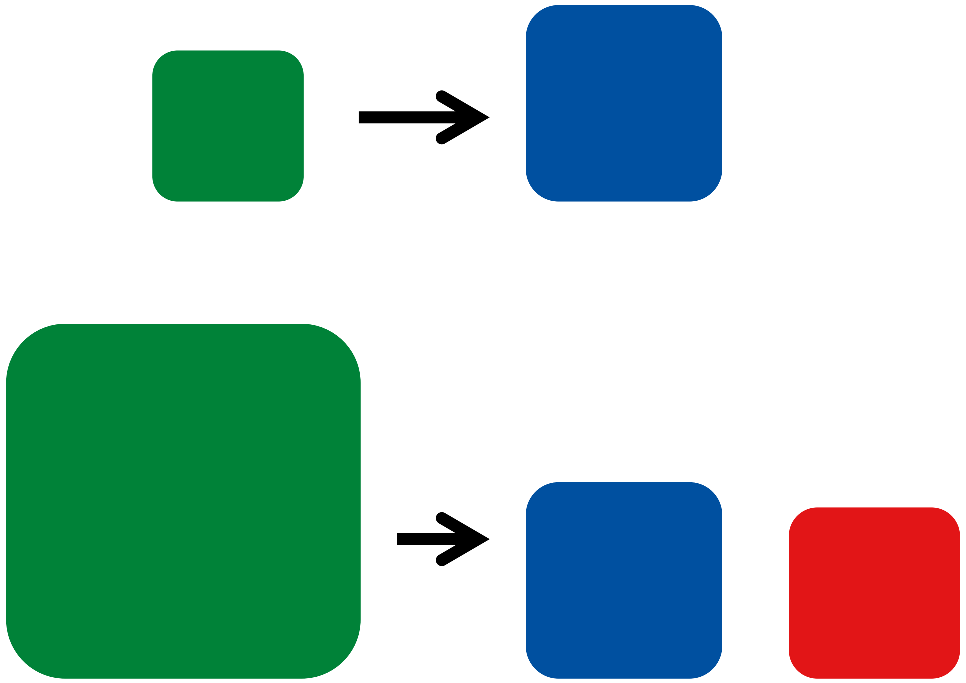
WHAT IS CARBONATION OF CONCRETE?

Carbonation of concrete: Essentially the same process

Volume relations (schematic)

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

C-S-H: $9CaO \cdot 6SiO_2 \cdot 11H_2O + 9CO_2$
$\rightarrow 9CaCO_3 + 6SiO_2 \cdot xH_2O + (11-x)H_2O$

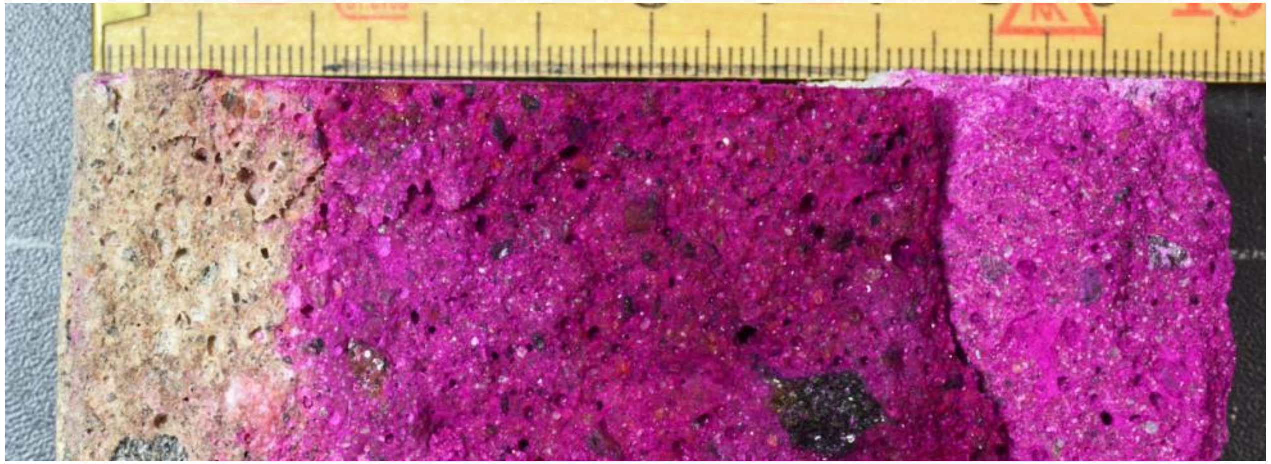


WHAT IS CARBONATION OF CONCRETE?

SUMMARY

Carbonation of concrete

- Caused by CO_2 from atmosphere
- Is a process which starts at the surface and progresses to the inside of the concrete



- The pH of the concrete is lowered in the carbonated areas from 13 to 13.5 to 8 to 10
- The main carbonated phases are portlandite and C-S-H
- Volume increase with carbonation of portlandite; volume decrease with carbonation of C-S-H

FACTORS INFLUENCING CARBONATION

The carbonation of concrete is influenced by several factors

- Parameters for the transport of CO_2 into the concrete
  - Porosity/permeability → w/c, w/b ratio
  - Water content of concrete (saturation)
- Composition of the binder/cement
- Curing conditions
- Environment towards exposure conditions (including temperature, moisture, CO_2 concentration)

FACTORS INFLUENCING CARBONATION

TRANSPORT PARAMETERS

- Porosity – w/c ratio (w/c_{eq})
- Water saturation of concrete
  - Solubility CO_2 in water low under ambient pressure
  - Therefore: Water saturated concrete no or very slow carbonation
  - Exception: Concrete in contact with water of high bicarbonate or carbonate content

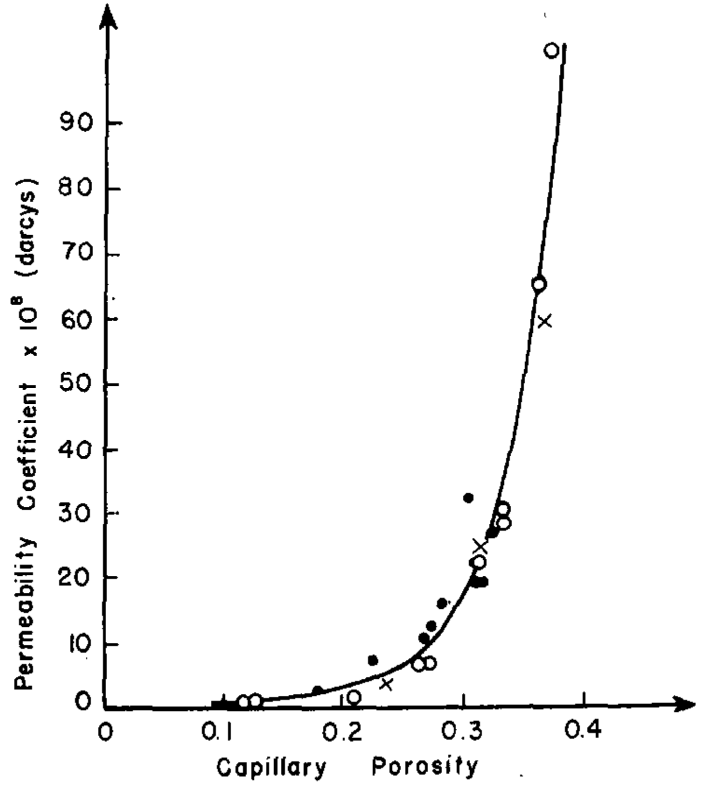
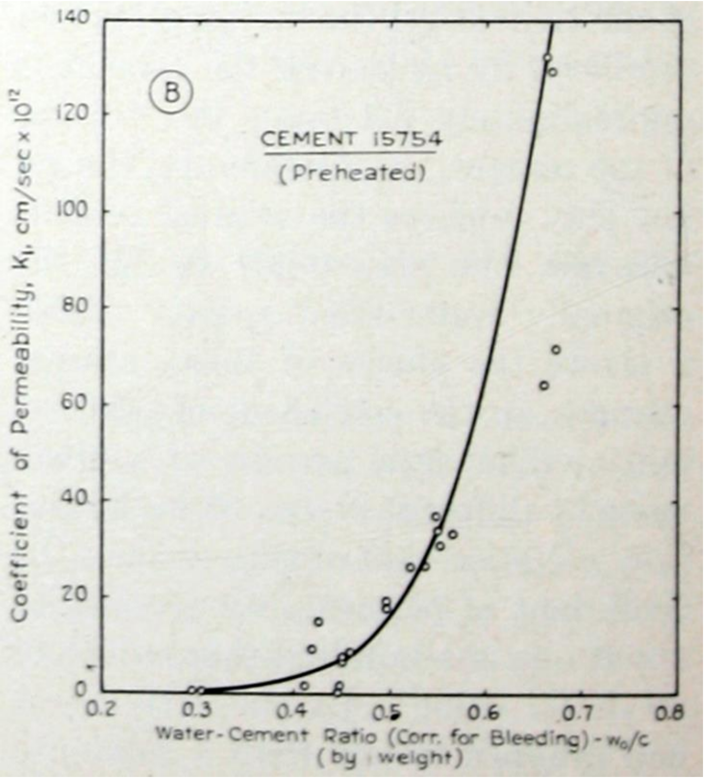


Fig. 4. Permeability vs. capillary porosity for cement paste. Different symbols designate different cements.

Powers (1958)



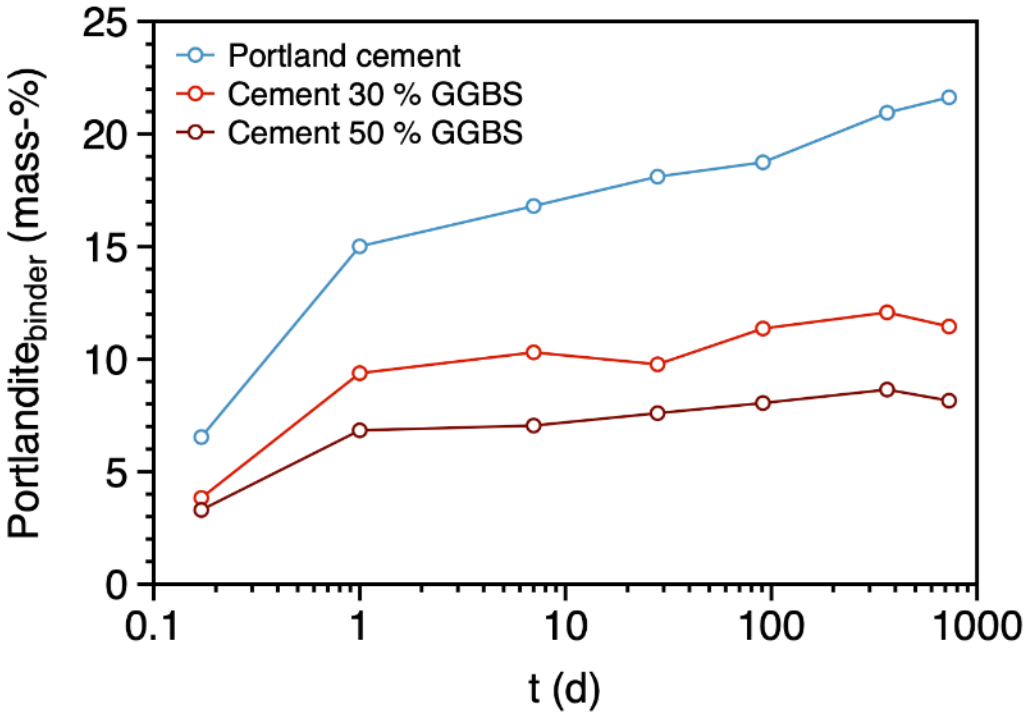
Powers (1954)

FACTORS INFLUENCING CARBONATION

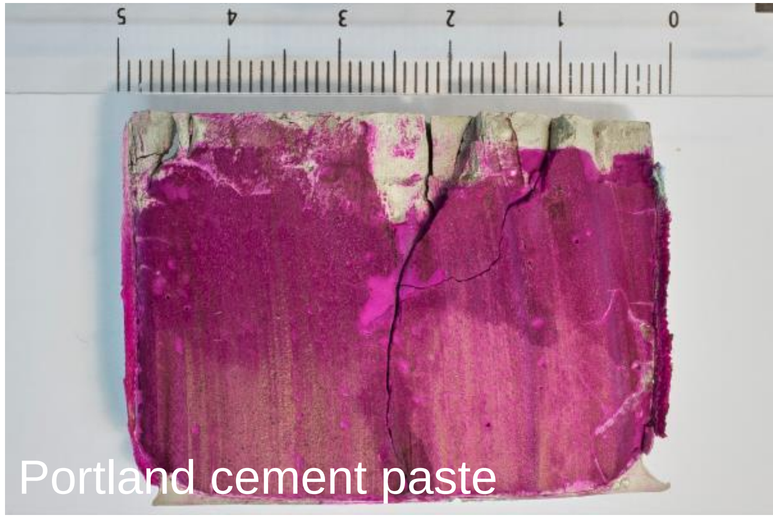
COMPOSITION OF CEMENT/BINDER

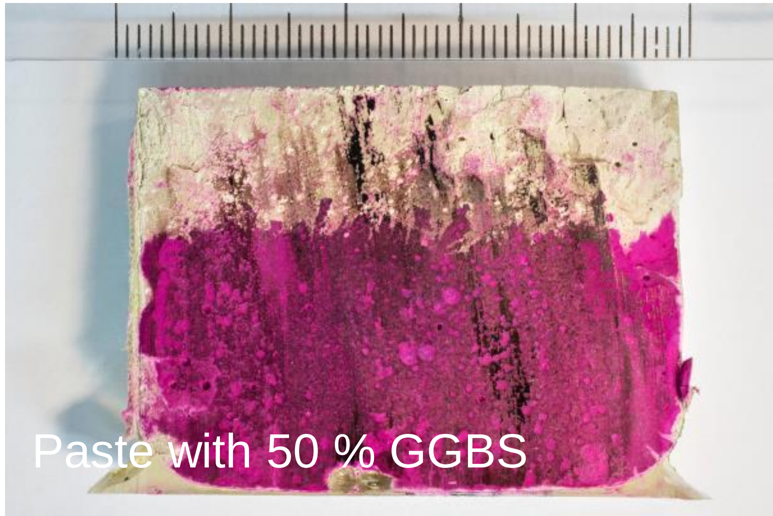
Binders with pozzolana or GGBS

- Carbonate faster
- Binders with pozzolana or GGBS have less $Ca(OH)_2$
  → Ca(OH)2 is used up quicker
  → C-S-H is carbonated much quicker compared to OPC



Accelerated carbonation (1 % CO_2) for 91 days, w/c = 0.45

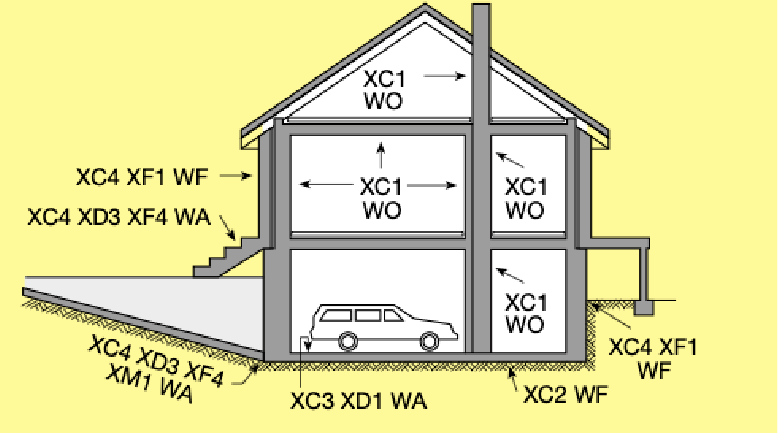


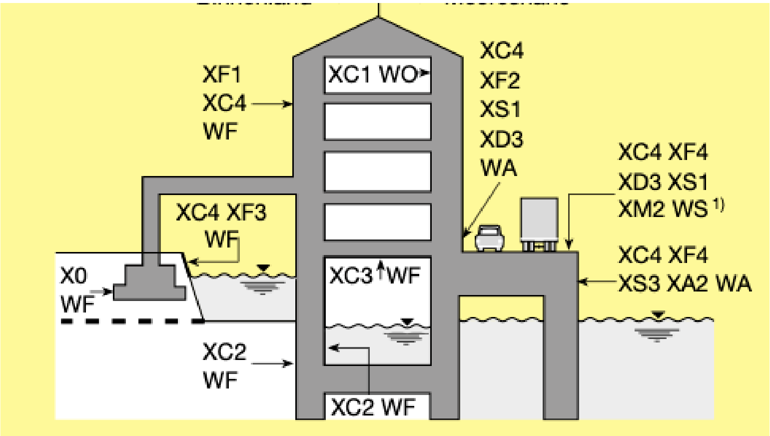


FACTORS INFLUENCING CARBONATION

CURING CONDITIONS AND EXPOSURE CONDITIONS

- Curing influences the surface porosity of concrete → resistance towards ingress of CO_2
- Availability of water in environment – State of concrete saturation
  - Concrete dry in equilibrium with relative humidity (low humidity)
  - Concrete permanently fully saturated
  - Concrete mostly highly saturated, rarely dry
  - Concrete partially saturated (moderate to high air humidity)
  - Concrete variably highly saturated and dry (e.g. exposed to rain)
- Situations with increased CO_2 concentrations
  - Road tunnels, parking garages, agriculture buildings





2 Corrosion induced by carbonation		
Where concrete containing reinforcement or other embedded metal is exposed to air and moisture, the exposure shall be classified as follows:		
XC1	Dry or permanently wet	Concrete inside buildings with low air humidity; Concrete permanently submerged in water
XC2	Wet, rarely dry	Concrete surfaces subject to long-term water contact; Many foundations
XC3	Moderate humidity	Concrete inside buildings with moderate or high air humidity; External concrete sheltered from rain
XC4	Cyclic wet and dry	Concrete surfaces subject to water contact, not within exposure class XC2

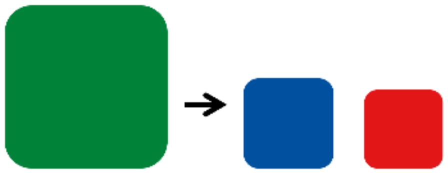
EFFECTS OF CARBONATION

CHANGES IN POROSITY OF CONCRETE

Carbonation changes porosity in the binder

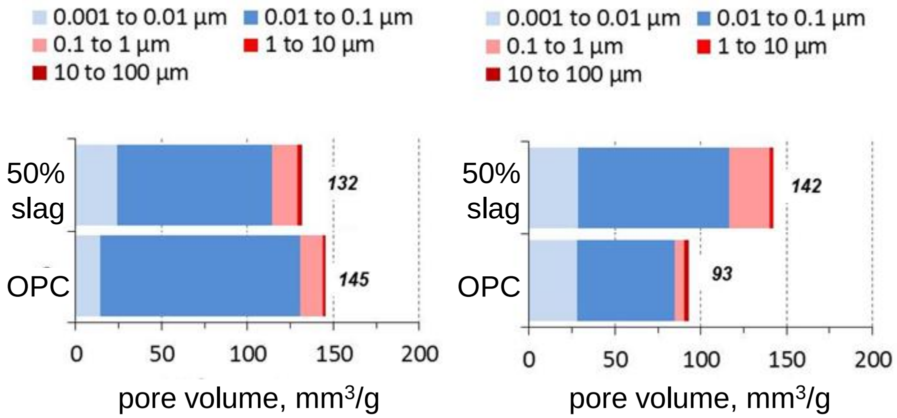
- Portland cement-based binders in concrete
  - Mostly reduction of porosity due to predominately carbonation of Ca(OH)2
  - Slight increase in strength in carbonated areas
  - Reduction of permeability
  - Reduction in moisture content (less pores = less overall moisture)

- Binders with pozzolana and blast furnace slag (GGBS)
  - Slight increase or slight decrease in porosity due to combined carbonation of $Ca(OH)_2$ and C-S-H → depending on amount of SCM (depending on amount of SCM in binder)
  - Slight reduction of strength in carbonated areas
  - Increase of permeability



Data from mercury intrusion porosimetry (MIP)

- Cement paste (w/c = 0.45)
- OPC vs. 50 % slag
- Non-carbonated vs. carbonated



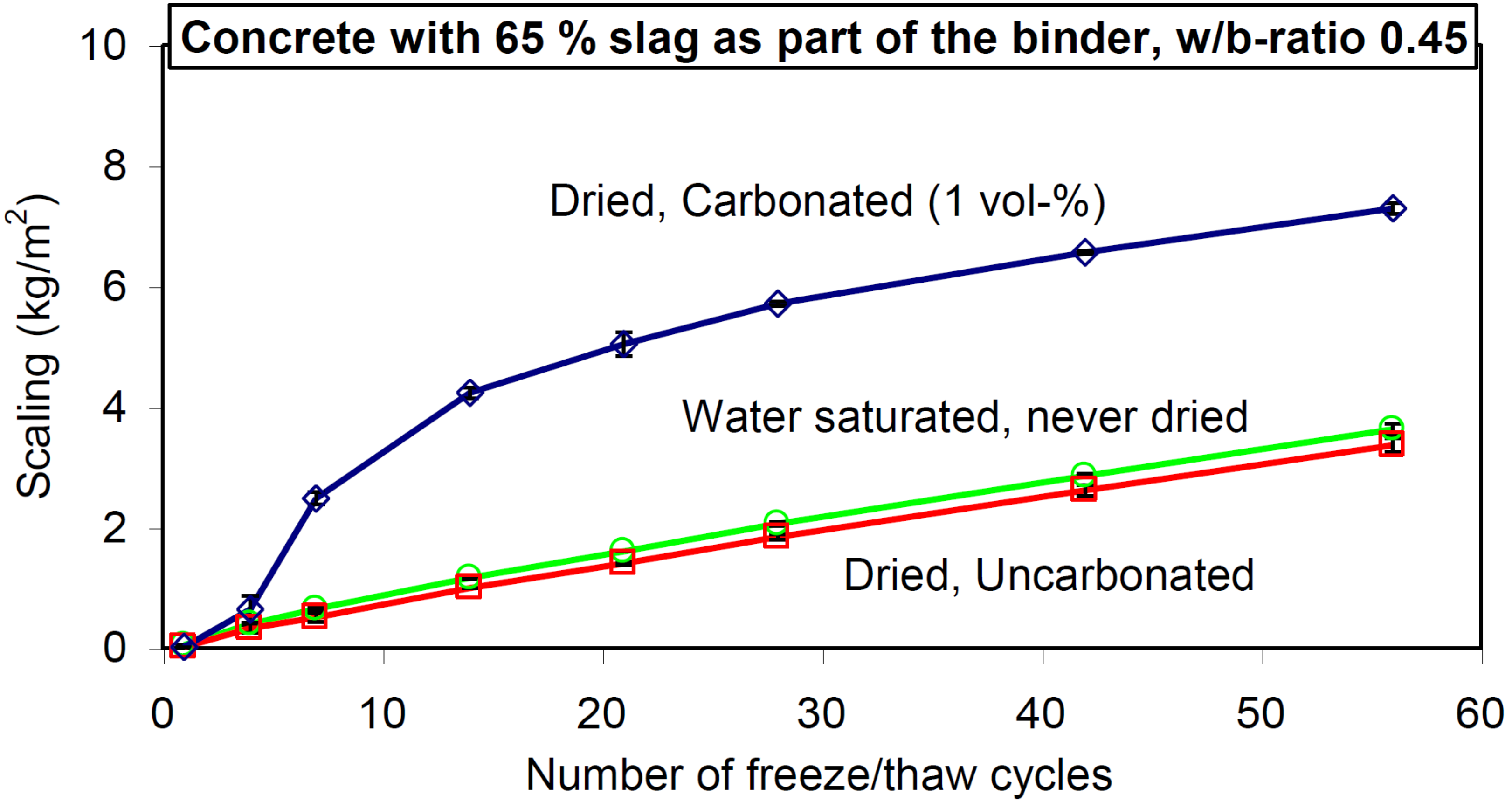
non-carbonated carbonated

EFFECTS OF CARBONATION

CHANGES IN POROSITY OF CONCRETE

Carbonation changes porosity in the binder

- Possible effects on frost resistance
- But: Only in extreme cases, when severely carbonated under ideal conditions and no air entrainment



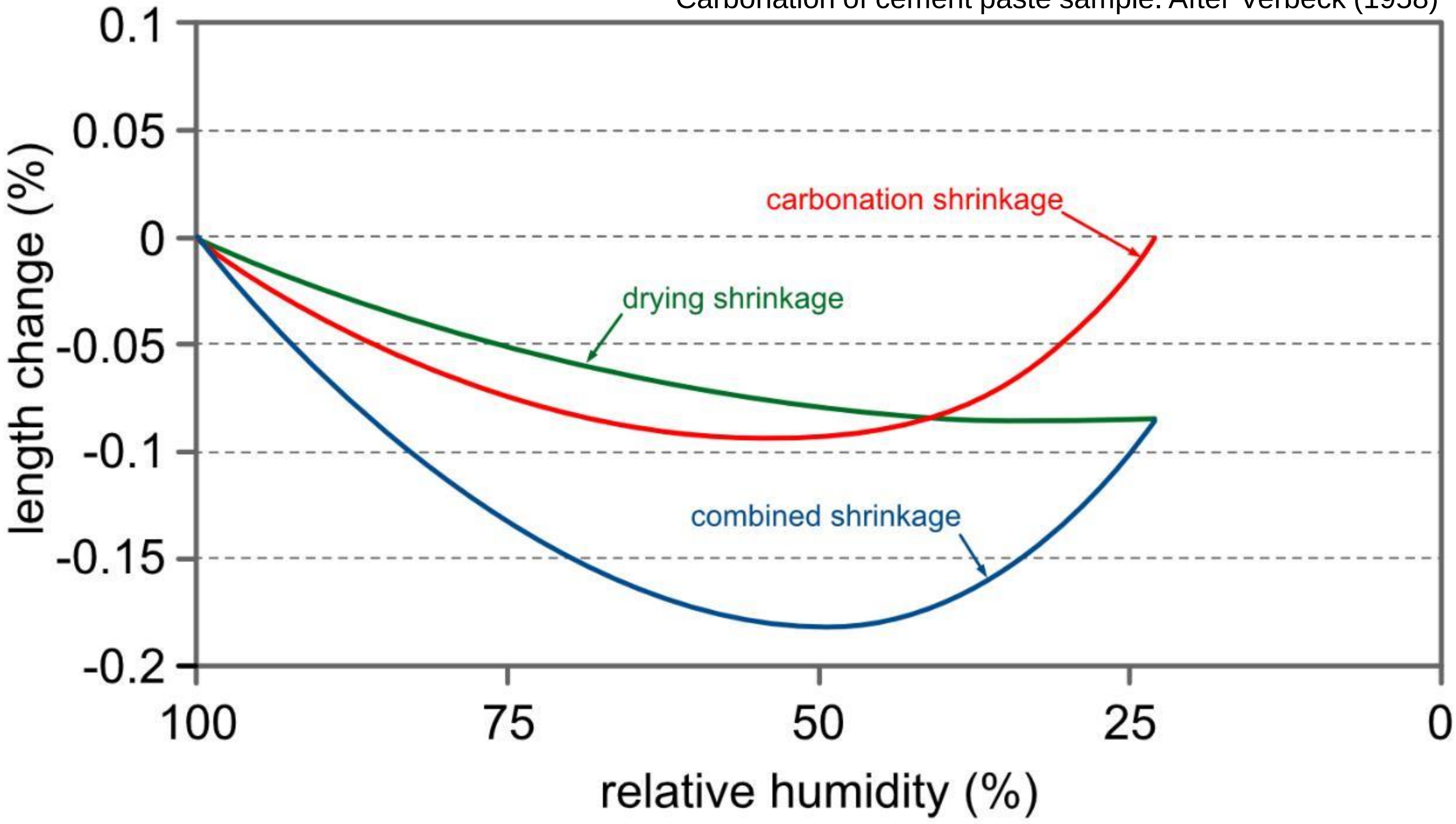
EFFECTS OF CARBONATION

CARBONATION SHRINKAGE

Caused by

- Change in porosity and pore structure
- Release of water during carbonation ($Ca(OH)_2$, C-S-H) → additional drying shrinkage
- Different at different moisture content → carbonation lowest at very dry and wet conditions

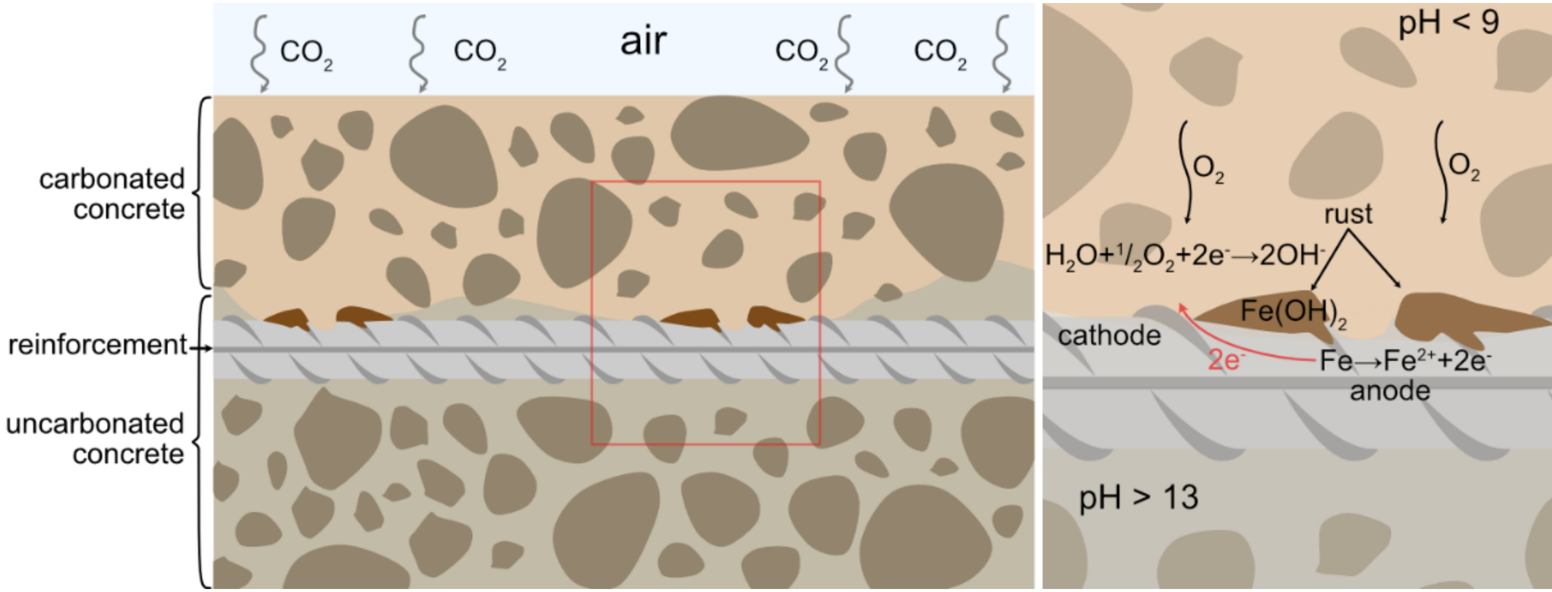
Carbonation of cement paste sample. After Verbeck (1958)



EFFECTS OF CARBONATION

REINFORCEMENT CORROSION

- Ingress of CO_2 and successive carbonation of concrete cover → lowering of pH < 9
- Loss of passivation layer of reinforcement
- Access of O_2 to reinforcement starts oxidation process



EFFECTS OF CARBONATION

REINFORCEMENT CORROSION

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- Loss of passivation layer of reinforcement
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SUSTAINABILITY ASPECTS

CONCRETE AS A CARBON SINK

- Carbonated concrete surfaces store CO_2
- With age the cover layer takes up more CO_2
- A rough estimation gives values of 15 to 20 % of CO_2, which is stored during the lifetime of a concrete building
- CO_2 uptake by concrete is now recognized by EN 16757 and can be counted e.g. in a building climate/environmental declaration

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 16757

October 2022

ICS 91.100.30

Supersedes EN 16757:2017

English Version

Sustainability of construction works - Environmental product declarations - Product Category Rules for concrete and concrete elements

Contribution des ouvrages de construction au développement durable - Déclarations environnementales sur les produits - Règles régissant la catégorie de produits pour le béton et les éléments en béton

Nachhaltigkeit von Bauwerken - Umweltproduktdeklarationen - Produktkategorieregeln für Beton und Betonelemente

This European Standard was approved by CEN on 19 September 2022.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

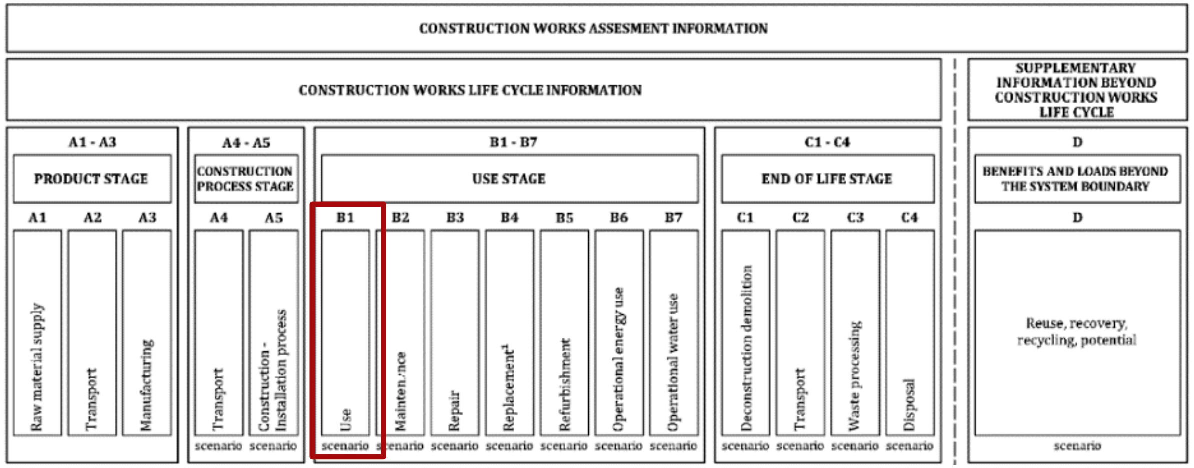
CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.

SUSTAINABILITY ASPECTS

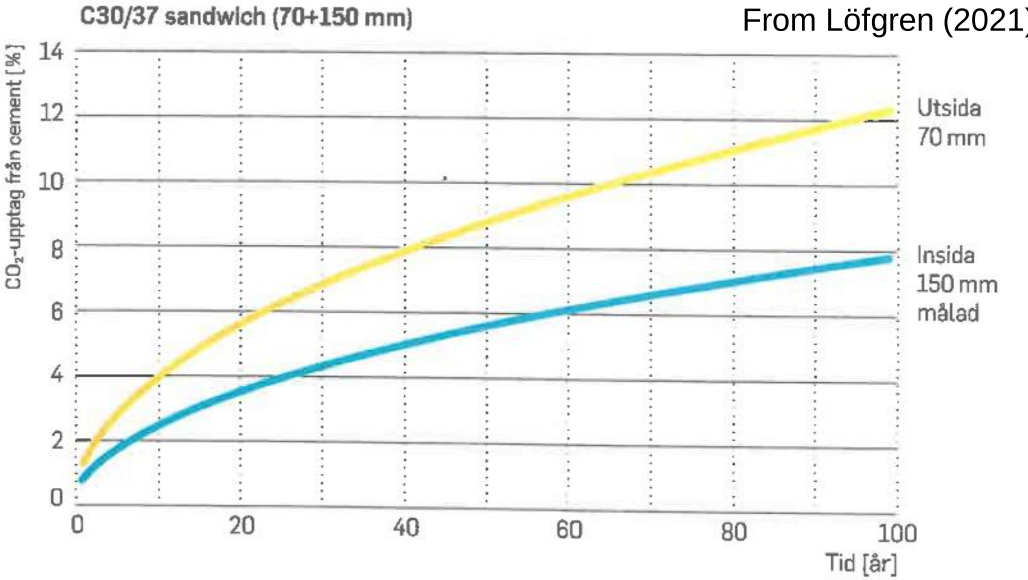
CONCRETE AS A CARBON SINK

- CO_2 uptake can be calculated by m^2 concrete surface with realistic carbonation depth over time
- Uptake is different for different surfaces (painted vs. non-painted surfaces, inner vs. outer exposure, etc.)
- CO_2 uptake should be used for improving the concrete building's climate footprint

From EN 16757 (2022)



From Löfgren (2021)

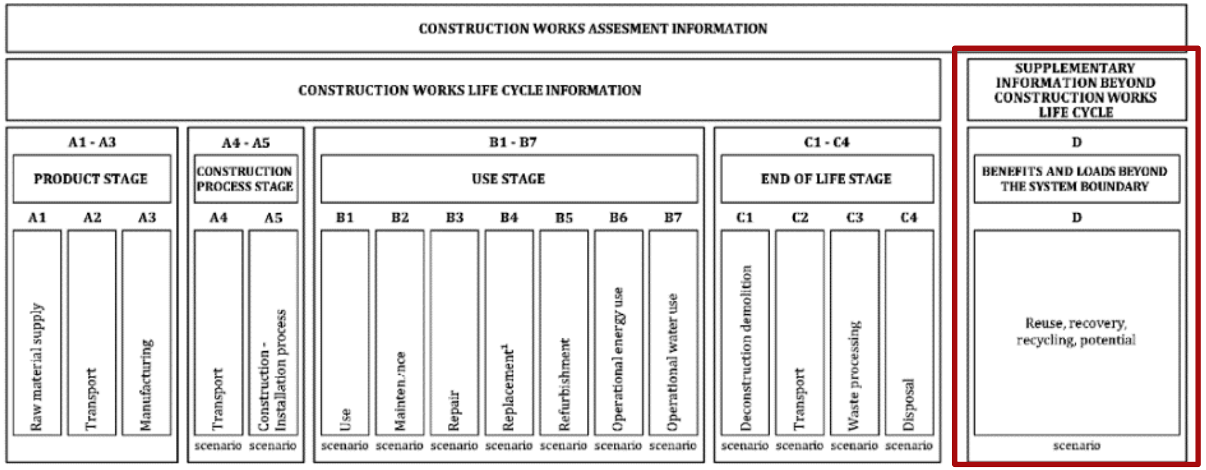


Figur 6. Koldioxidupptag i procent av utsläppen från cementet för ett fasadelement (sandwichelement, 75 mm betong på utsidan och 150 mm insida med målad/tapetserad yta), i modul B1.

SUSTAINABILITY ASPECTS

CONCRETE AS A CARBON SINK

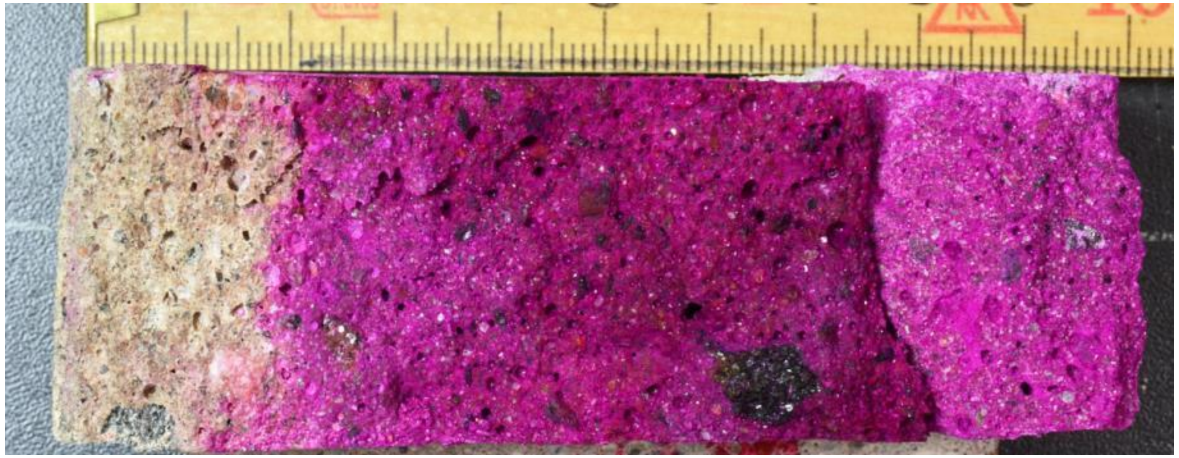
From EN 16757 (2022)

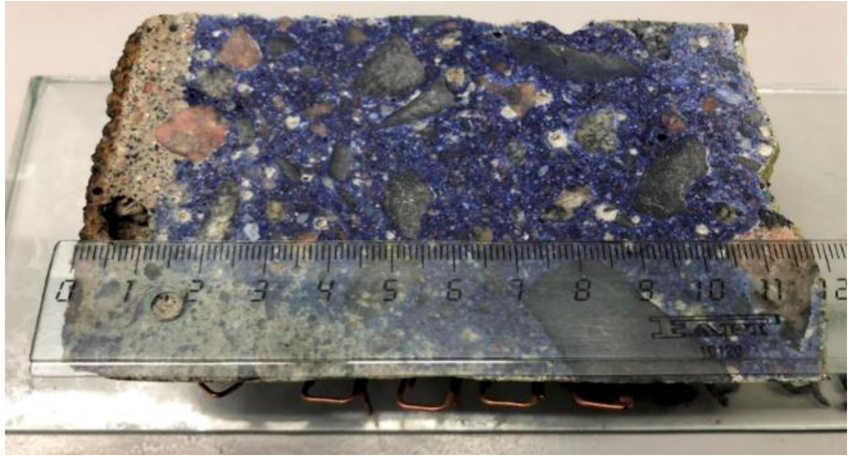


- But also, CO_2 uptake after end-of-life
  → Construction and demolition waste (CDW): if consisting mainly of concrete
- Reuse of recycled carbonated concrete as aggregate
- Reuse of fines from recycled, carbonated concrete for producing cement
  → EN 197-6

TESTING CARBONATION RESISTANCE

CARBONATION DEPTH

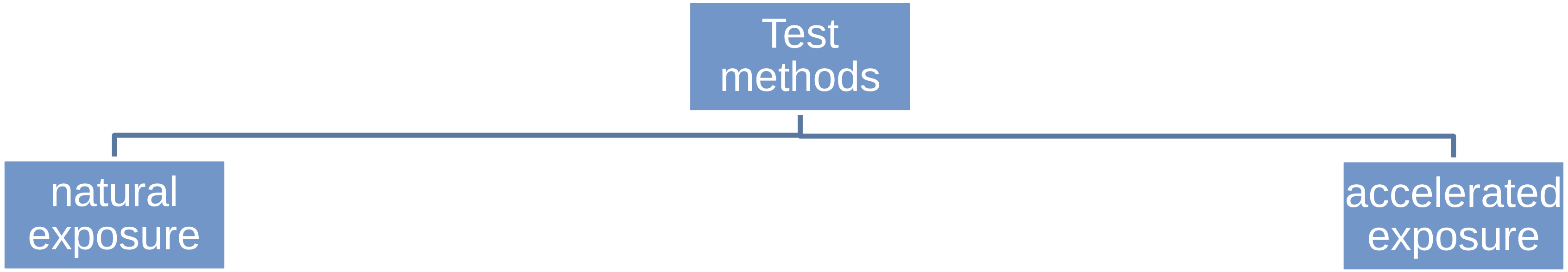




- Determination of carbonation depth on existing concrete structures is done with pH indicators
  - Solution of phenolphthalein (pH 9)
  - Solution of thymol blue (pH 9.6)
  - Other indicators
- Phenolphthalein solution is less used due to health and safety concerns
- Preferred is a fractured over cut surfaces → more accurate
- Important: The indicators should turn their color around pH 9-10
- EN 14630:2006 → but uses still phenolphthalein solution

TESTING CARBONATION RESISTANCE

CARBONATION TEST METHODS



EN 12390-10:2019

- Samples: Concrete prisms or cubes
- Preconditioning: Wet curing until 28 d (chamber), sealed until 50 % of reference strength (natural)
- Storage: Either in climate-controlled chamber (CO_{2conc} = 0.040 % or natural exposure in air (protected from rain)
- Measured: Carbonation depth at least after 3, 6 and 12 month; if carb. depth < 5 mm extension of test to 2 years
- Evaluation: Carbonation depth d_k vs. square root of time $\sqrt{t}$ and carbonation rate k_c
  $d_k = k_c \cdot \sqrt{t}$

EN 12390-12:2019

- Samples: Concrete prisms, cubes or cylinders
- Preconditioning: Wet curing until 28 d, thereafter 14 d under laboratory conditions
- Storage: In a climate-controlled chamber or cabinet at a CO_{2conc} = 3 %
- Measurement: Carbonation depth after 7, 28 and 70 days
- Evaluation: Carbonation depth d_k vs. square root of time $\sqrt{t}$ and carbonation rate K_{AC}
  $d_k = a + K_{AC} \cdot \sqrt{t}$

Questions

SCHWENK

Baustoff leben

23/11
/2023
Latvian Concrete Society's 31st scientific and technical conference

CONCRETE
DURABILITY AND
SUSTAINABILITY

Heidelberg Materials

Alkali-Aggregate Reactions in Concrete

What we know, what we do not yet know, and where we are going.

Prof. Børge Johannes Wigum
BorgeJohannes.Wigum@heidelbergmaterials.com

Presentation

- **What we know**
  - Alkali Aggregate Reactions – History – RILEM
  - RILEM TC 258-AAA
- **What we do not yet know**
  - Alkali-Release from Aggregates (ARA)
- **Where we are going**
  - New RILEM TC ASR

Alkali Aggregate Reactions (AAR)

- Alkalis producing a silica-gel by dissolving soluble SiO_2 (e.g. Quartz) in the aggregate.
- Gel has hygroscopic properties, leading to expansion under moist conditions.
- ~ 1-20 years, depending on the type of aggregate and environmental conditions

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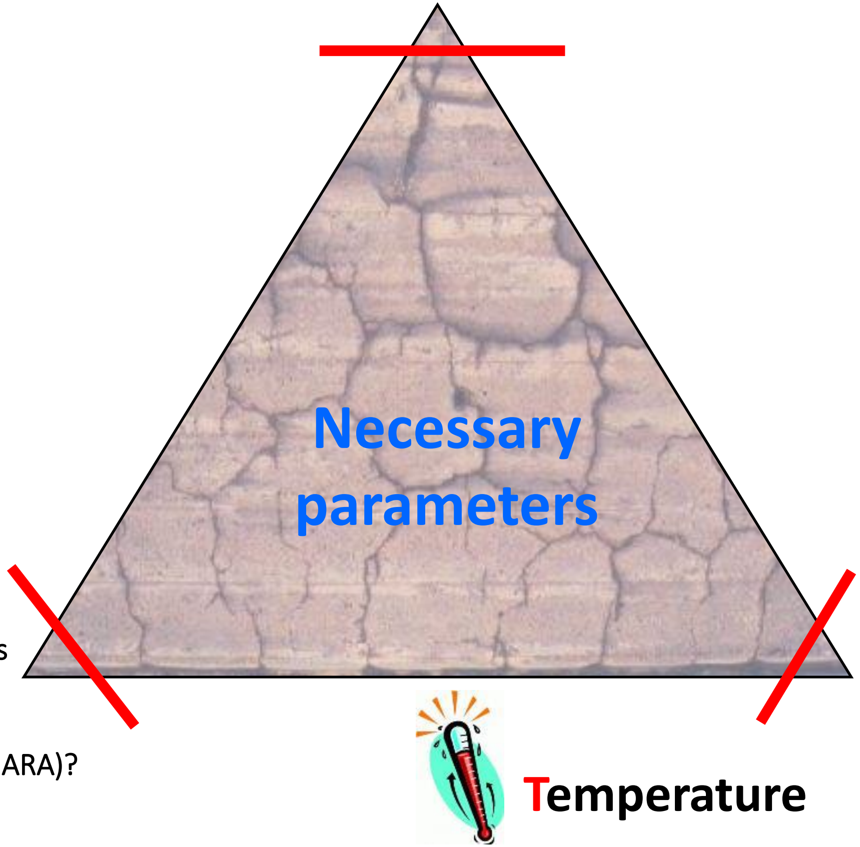
Mechanisms of AAR

Reactive aggregates



Alkalies

Low alkali-cements
Pozzolanas
External alkalis?
Releasable alkalis (ARA)?

Temperature

Water

(or high moisture content)

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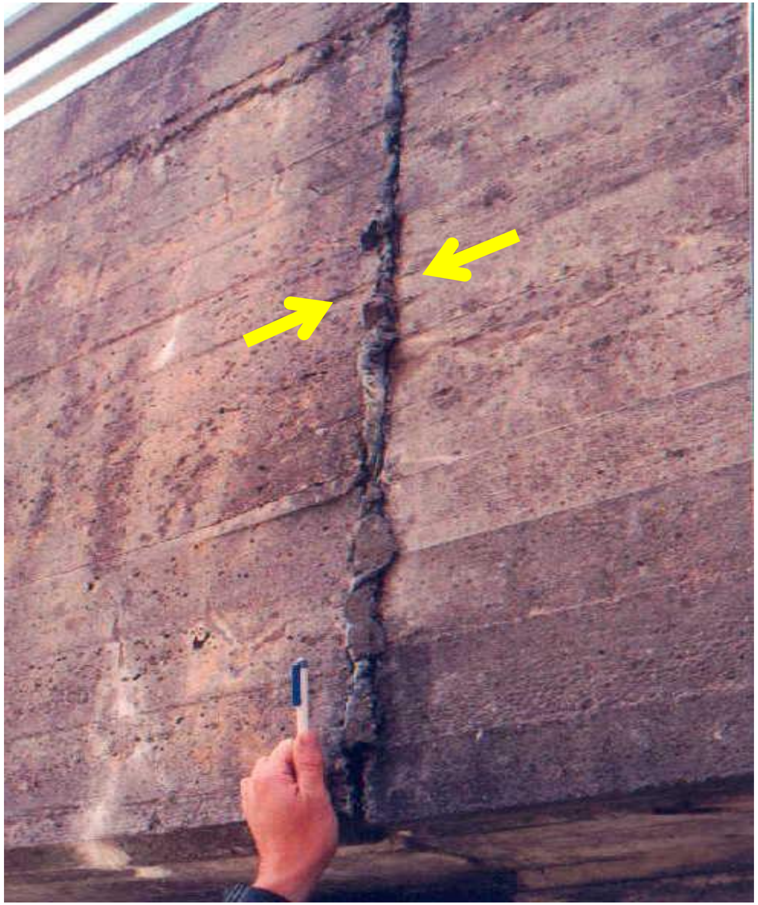
Cracking - Expansion



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Elgeseter Bridge Trondheim, Norway

- Built 1949-51
- Length 220 m
- Width 23 m
- Height 17 m

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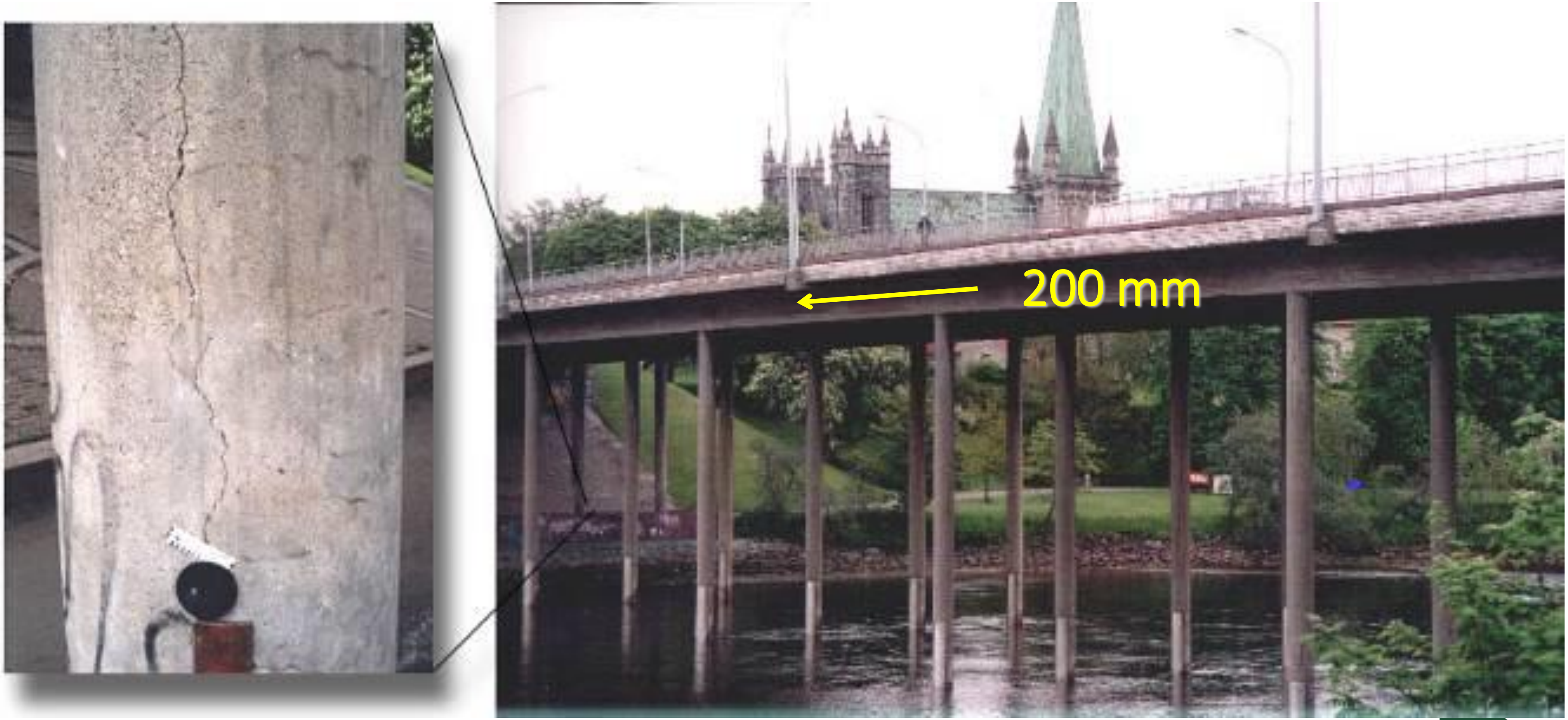
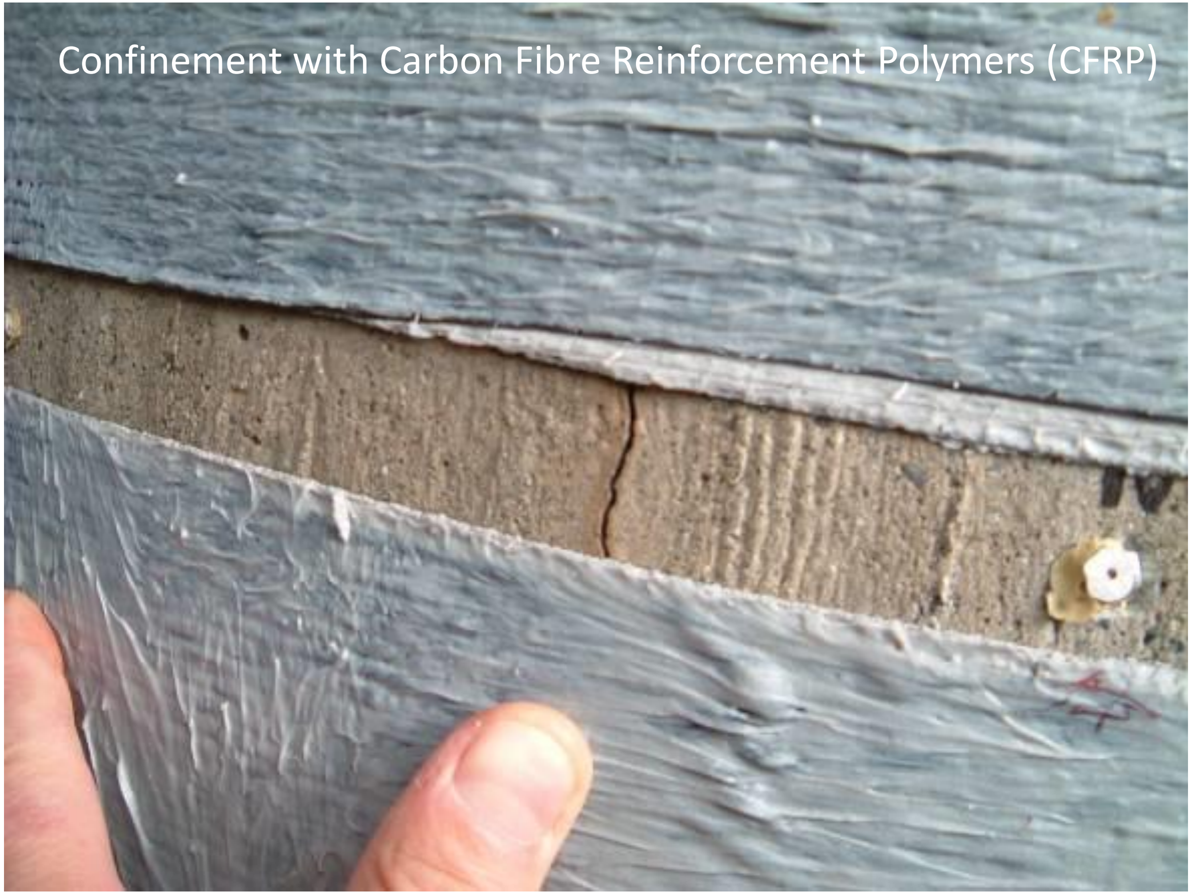
Elgeseter Bridge Trondheim, Norway



Elgeseter Bridge Trondheim, Norway

Elgeseter Bridge Trondheim, Norway



Swimming pool

Survey initiated due to severe damages in the pool, after only 1.5 years in service

- Tiles falling off
- Cracking of concrete

Swimming pool

Heidelberg Materials

Oslo

2000

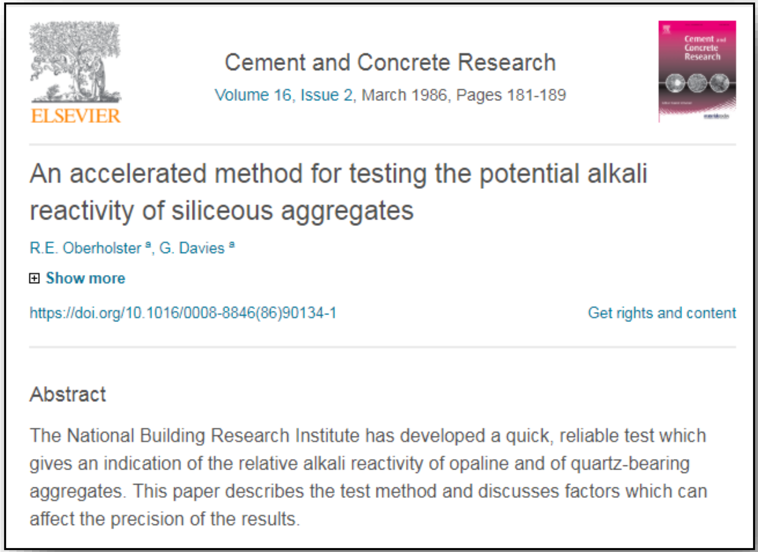
Oslo
2016

Concrete road - Canada

Test Methods

Testing for decades
Many test methods – difficult to compare

Thomas Stanton (1940)
ASTM 227 – Mortar Bar Test


ELSEVIER
Cement and Concrete Research
Volume 16, Issue 2, March 1986, Pages 181-189

An accelerated method for testing the potential alkali reactivity of siliceous aggregates

R.E. Oberholster [a], G. Davies [a]

Show more

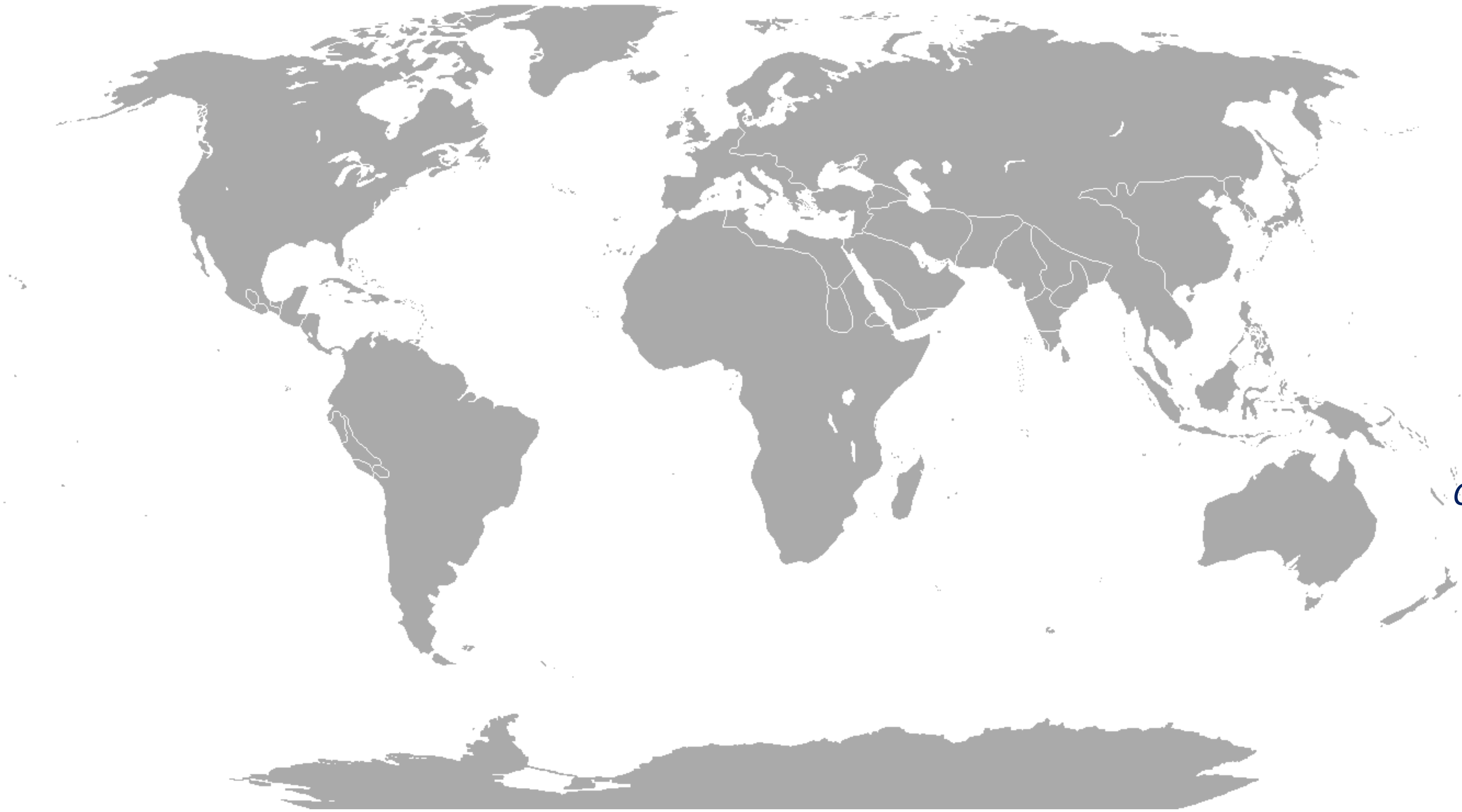
https://doi.org/10.1016/0008-8846(86)90134-1   Get rights and content

Abstract

The National Building Research Institute has developed a quick, reliable test which gives an indication of the relative alkali reactivity of opaline and of quartz-bearing aggregates. This paper describes the test method and discusses factors which can affect the precision of the results.

Oberholster & Davies (1986)
The South-African Accelerated Mortar Bar Test

AAR – Holistic Approach



International Union of Laboratories and Experts in Construction Materials, System and Structures

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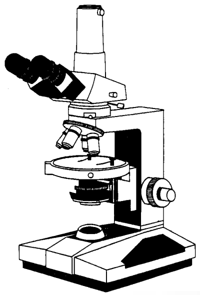
RILEM Technical Committees (TCs) – since 1988

- TC 106 (1988 – 2001) - Accelerated Aggregate Tests
- TC 191-ARP (2001 – 2006) - Diagnosis/Appraisal & Specification
- TC 219-ACS (2006 – 2014) - Performance Testing & Modelling

Dr Philip Nixon – Chairman

Dr Ian Sims – Secretary

Test methods for aggregates – (RILEM)



1 Petrographic Method

(RILEM AAR-1)

2 Accelerated Mortar Bar Test (AMBT)

(RILEM AAR-2)

80°C + 1N NaOH

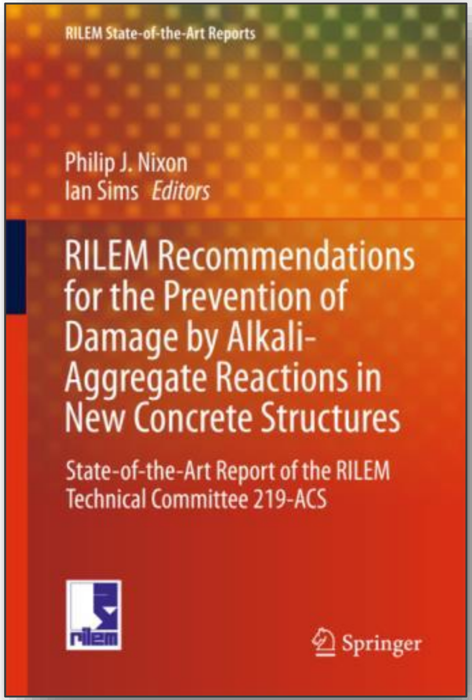
3 Concrete Prism Tests (CPT)

(RILEM AAR-3 & AAR-4.1)

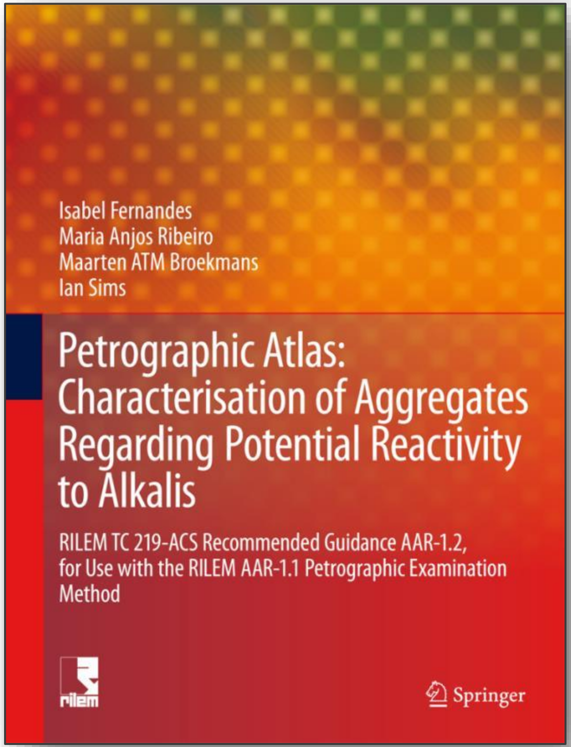
38°C or 60°C+ 100% RH

RILEM deliverables 2016 - TC 219-ACS

2013



2016



2016

RILEM TC 258-AAA (2014 – 2020)

(Avoiding Alkali Aggregate Reactions in Concrete – Performance Based Concept)

The purpose of this Technical Committee (TC) is to **develop** and **promote** a performance based testing concept for the prevention of deleterious Alkali Aggregate Reactions (AAR) in concrete.

Strong emphasis will be put on the **implementation** of the RILEM methods and recommendations as national- and international standards.

RILEM TC 258 AAA (2014 – 2020)

Professor **Børge Johannes Wigum**
Chairman – RILEM TC, AAA
HeidelbergCement Northern Europe
Norway/Iceland

Dr **Jan Lindgård**
Secretary – RILEM TC, AAA
SINTEF Building and Infrastructure, Trondheim - NORWAY

WP1 - Performance testing and accelerated testing in laboratory.

WP2 - Performance testing and laboratory vs. field; Exposure site.

WP3 - Assessment of detailed alkali inventory in concrete

WP4 – Verification of Performance Testing.

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WP1 - Performance testing and accelerated testing in laboratory.

Dr **Terje F. Rønning**

HeidelbergCement Northern Europe, Norway

Methods:

"RILEM **AAR-0**" (Outline Guide to the Use of RILEM Methods)

"RILEM **AAR-10**" (38°C concrete performance test)

"RILEM **AAR-11** & **12**" (60°C concrete performance test)

"RILEM **AAR-13**" (Japanese test procedure – alkali wrapping)

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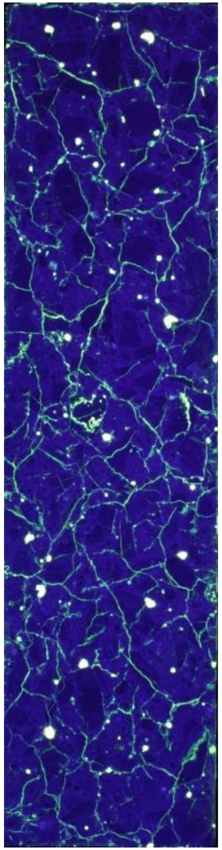
RILEM AAR-10: Increase prism size



Jan Lindgård, 2013

AAR-3: Prisms 75 mm

AAR-10: Prisms 100 mm

…. to reduce leaching and obtain a realistic expansion

WP2 - Performance testing and laboratory vs. field; Exposure site.

Professor **Benoît Fournier**

Université Laval, Québec, Canada

New cube study (2015) – *Environmental effects*

Old blocks study (2005) – *Post-documentation*

STAR-report on the lab./field correlation.

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WP2 - Laboratory testing vs. field behavior – Testing the performance?

Comparing apples and pears?

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WP2 - Laboratory testing vs. field behavior – Testing the performance?

Effect of temperature

Accelerated conditions,
6-8 minutes – 100°C

Real life,
21 days – 38°C

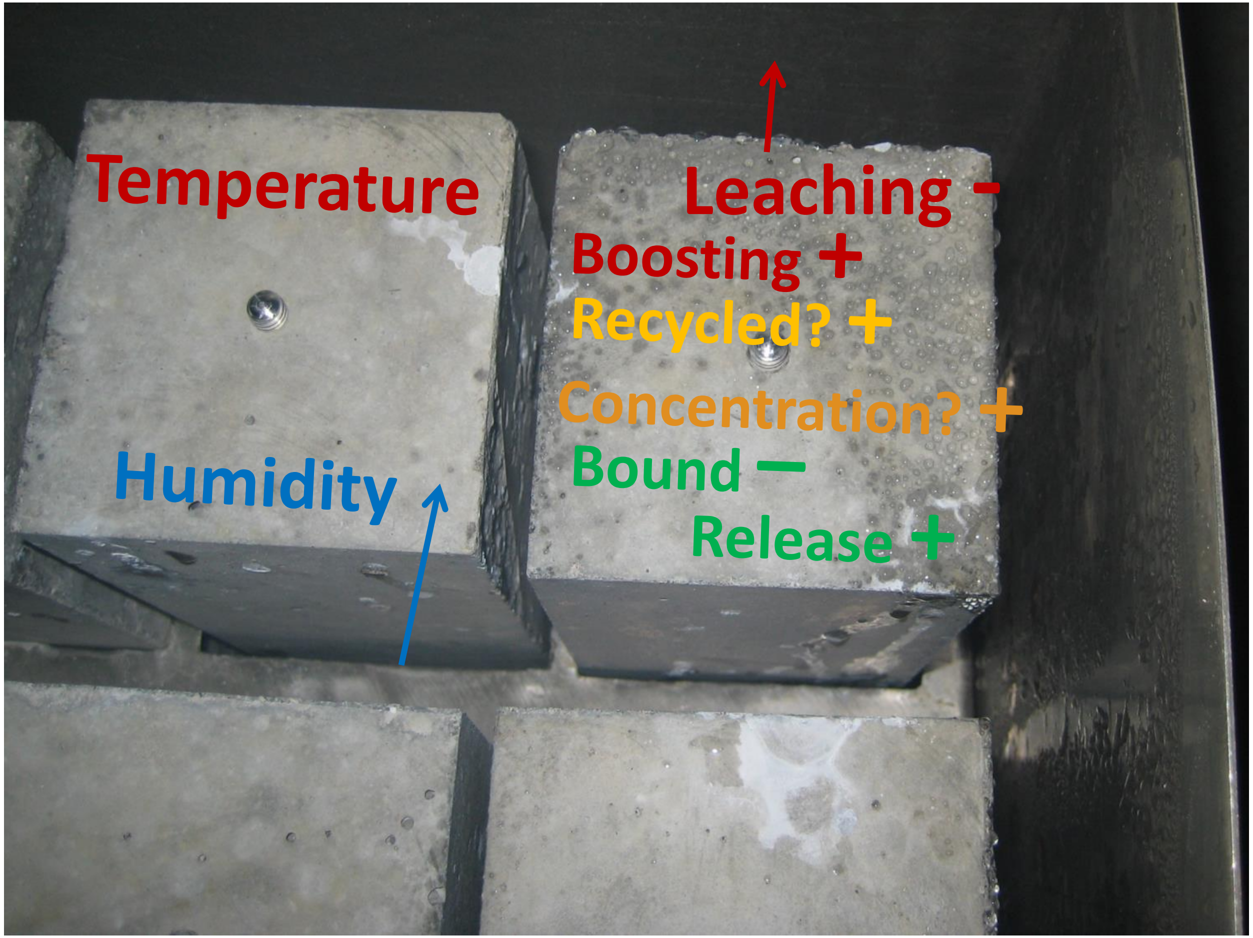
WP3 - Assessment of detailed alkali inventory in concrete, including internal aggregate release, recycling and external supply.

Dr **Esperanza Menéndez Méndez**
CSIC, Madrid, Spain

RILEM **AAR-8** (Releasable alkalis from aggregates)

STAR-report on "alkali inventory"

WP3 - The available resources of alkalis - inventory



Efficient alkali-load?

(critical 2.5kg/m³)

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WP4 - Verification of Alkalis Released from Aggregates (ARA).

Professor **Klaartje De Weerdt**

Norwegian University of Science and Technology, Norway

Verification of potential alkali-release in performance testing in lab.

Validate a test method for alkalis released by aggregates.

Official Deliverables:

Springer

Recommendations -submitted to Materials & Structure – Summer 2021

- RILEM AAR-0 (2021) **Outline Guide** to the Use of RILEM Methods in the Assessment of the Alkali-Reactivity Potential of Concrete.
- RILEM AAR-8 (2021) Determination of **Potential Releasable Alkalis by Aggregates** in Concrete.
- RILEM AAR-10 (2021) Determination of **Binder Combinations for Non-Reactive Mix Design Using Concrete prisms** – 38°C test Method.
- RILEM AAR-11 (2021) **Determination of Binder Combinations for Non-Reactive Mix Design** or the Resistance to Alkali-Silica Reaction of Concrete Mixes Using Concrete Prisms – 60°C Test Method.
- RILEM AAR-12 (2021) **Determination of Binder Combinations for Non-Reactive Mix Design** or the Resistance to Alkali-Silica Reaction of Concrete Mixes Using Concrete Prisms – 60°C **Test Method with Alkali Supply**.
- RILEM AAR-13 (2021) **Application of Alkali-Wrapping for Concrete Prism Testing** to Assess the Expansion Potential of Alkali-Silica Reaction.

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New RILEM TC: 301-ASR (2021 – 2025)

Risk assessment of concrete mixture designs with alkali-silica reactive (ASR) aggregates

Chairman: Jason H. Ideker - *Professor*
Oregon State University, USA

Deputy Chairman: Klaartje De Weerdt – *Professor*
Norwegian University of Science and Technology, Norway

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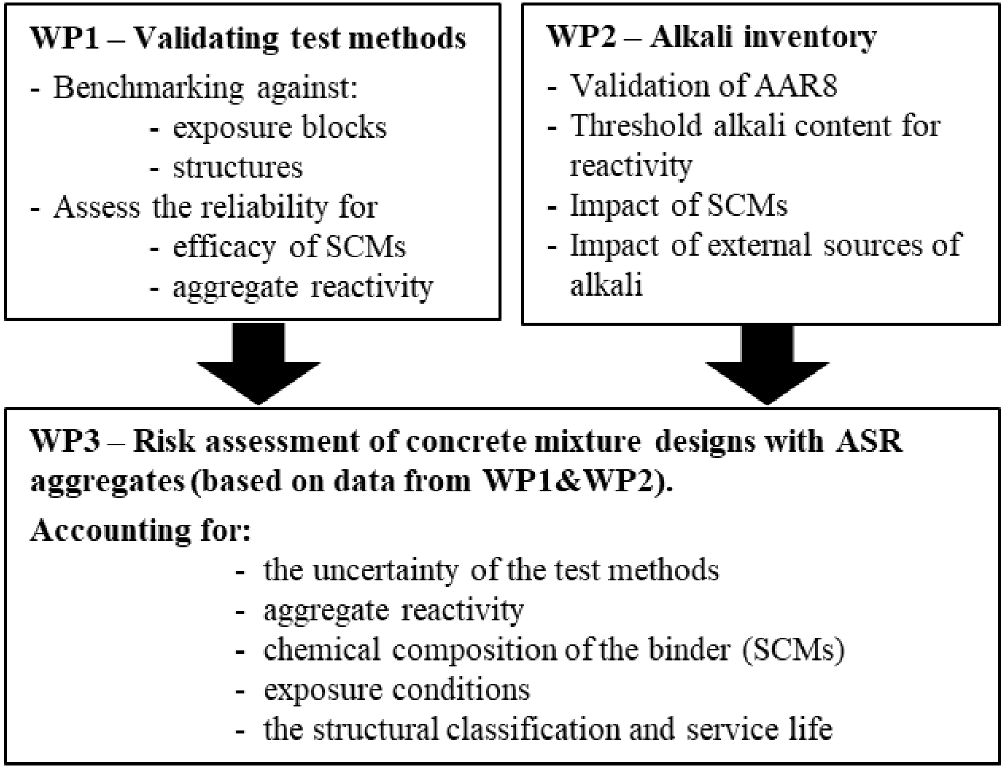
New RILEM TC: 301-ASR (2021 – 2025)

Risk assessment of concrete mixture designs with alkali-silica reactive (ASR) aggregates



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Summary

- **What we know**
  - RILEM – **Aggregate Test Methods**
  - RILEM TC 258-AAA – **Performance Testing**
- **What we do not yet know**
  - Alkali-Release from Aggregates **(ARA)**
- **Where we are going**
  - New RILEM TC ASR:
    - ✓ **Validation of Test Methods**
    - ✓ **Verification of Alkali Release**
    - ✓ **Risk Assessment**

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CEN European Standards

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 12620

September 2002

ICS 91.100.15; 91.100.30

English version

Aggregates for concrete

Granulats pour bétons | Gesteinskörnungen für Beton

This European Standard was approved by CEN on 1 August 2002.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 12620:2002 E

5.7.3 Alkali-silica reactivity

When required the alkali-silica reactivity of aggregates shall be assessed in accordance with the provisions valid in the place of use and the results declared.

NOTE Guidance on the effects of alkali-silica reactivity, is given in annex G.

Jonathan Simm	Chair CEN TC154 - Aggregates
Christophe Mueller	Chair CEN TC104 - Concrete
Xavier Guillot	CEN TC51 - Cement

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Thank you for your attention!

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“Prevention of concrete alkali-silica reaction in Lithuania”

assoc. prof. ALGIRDAS AUGONIS

Head of Kaunas University of Technology
BUILDING MATERIALS AND STRUCTURES RESEARCH CENTRE

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LITHUANIAN REACTIVE AGGREGATES

ASR problems in Lithuania

In Lithuania, two types of coarse aggregates are used in the construction sector: gravel (gravel crushed stone) and dolomite crushed stone.

In Lithuania, about 45 years ago, a serious problem of ASR was noticed, which caused defects and cracks. ASR was caused by the aggregates used in the construction, which contained impurities of opoka (opal) and flint particles. Decisions were made limiting the amount of Na2O eqv in portlandcement to 0.8%. Since then, there is no classic ASR (volumetric crack deformation) in Lithuania. However, we have a problem with ASR (pop outs) on the concrete surface.

ASR problems in Lithuania

Typical Lithuanian gravel and sand

Opoka (an opal-type mineral)

Opoka is considered to be a gray (various shades, may be spotted), hard, conch fracture porous rock, which is dominated by (up to 90%) opal silica, and may contain various, even carbonate, additives.

- density about 1000 – 1300 kg/m^3;
- hardness is average ;
- A significant part of SiO_2 in the opoka is amorphous, i.e. reacts with alkalis.

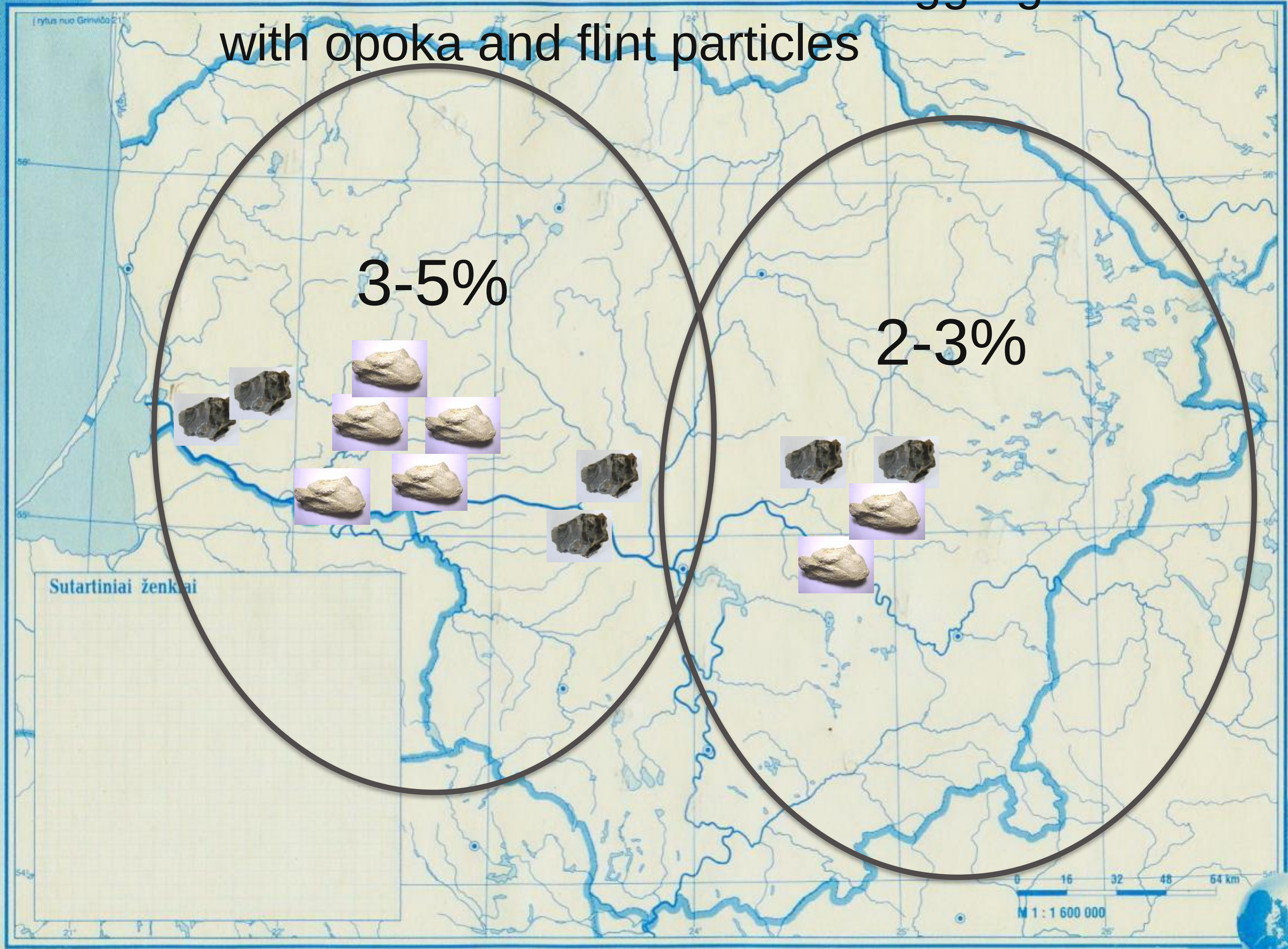
Opal, $SiO_2 \cdot nH_2O$, is amorphousan aggregate composed of gel, and therefore is mineraloid.

Flint

Flint comes in various dark or light colors, consisting of crystalline and amorphous SiO_2 and other impurities.

-hard (scratches glass);
- brittle;
- breaks into sharp-edged piece
- density about 2600 kg/m^3;
- the flint has a glassy luster;
- a significant part of SiO_2 in flint is amorphous, i.e. reacts with alkalis.

Level of contamination of the aggregates with opoka and flint particles



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ALKALINES IN CONCRETE

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ALKALINES IN CONCRETE

11
Na
22.990

19
K
39.098

Basic alkalis:

- Sodium (Na^+)
- Potassium (K^+)

Calculated in $Na_2O_{ekv.}$

$$(Na_2O)ekv = Na_2O + 0,658K_2O$$

According to the technical requirements currently legalized in Lithuania, the equivalent amount of alkali in cement, with the exception of slag portland cement and slag cement, must not exceed **0.8%**, because Lithuanian gravels are contaminated with reactive rocks that react with the alkalis of cement and its additives.

ASR environment classes of concrete according to LST 1974:2012

- Table 4 of the standard LST 1974:2012 shows the ASR effect classes of aggregates for normal concrete.

Class markers	Description of the environment	The environmental impact class includes examples
XR0	Non-aggressive environment with relative humidity in the room ϕ ≤ 60%	Internal structures of buildings, protected from moisture
XR1	Aggressive environment with relative humidity ϕ ≥ 80%, when there is free moisture in the concrete	Internal constructions of wet rooms, e.g. in swimming pools, saunas, etc., and external structures of buildings not protected from the effects of the atmosphere.
XR2	Very aggressive environment with free moisture in the concrete and additional Na and K compounds, e.g. with salts due to icing	Floors of road and bridge structures, garages, car washes, poorly insulated floors from soil moisture, etc.

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ASR Prevention in Lithuania

Table 4 of the standard LST 1974:2012 shows the ASR effect classes of aggregates for normal concrete – requirements:

- XR0. There are no restrictions on the composition of the concrete mix used for the aggressiveness of XR0 in terms of alkaline corrosion in the environment (see LST 1974:2012 Appendix L).
- XR1. The aggressiveness of XR1 in terms of alkaline corrosion in the environment (see LST 1974:2012 Appendix L), using a concrete mixture with aggregates from Lithuanian gravel quarries or with non-reactive coarse aggregates from other quarries but with fine aggregates (sand) from Lithuanian quarries, Na and K oxides, converted to equivalent $(Na_2O)ekv = Na_2O + 0{,}658K_2O$, the amount in CEM I cement must be ≤ 0.8% (mass), and the equivalent amount of Na and K oxides in the concrete mix must not exceed **4,0 kg/m^3**.
- XR2. The aggressiveness of XR2 in terms of alkaline corrosion in the environment (see LST 1974:2012 Appendix L), using a concrete mixture with aggregates from Lithuanian gravel quarries or with non-reactive coarse aggregates from other quarries but with fine aggregates (sand) from Lithuanian quarries, Na and K oxides, converted to equivalent $(Na_2O)ekv = Na_2O + 0{,}658K_2O$, the amount in CEM I cement must be ≤ 0.8% (mass), and the equivalent amount of Na and K oxides in the concrete mix must not exceed **3,0 kg/m^3**.

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Prevention of ASR

Limitation of alkali content in concrete according to Canadian standards

Prevention level	Alkali Na_2O_{ekv} content in concrete, kg/m^3
Weak	3,0
Average	2,4
Strong	1,8
Exclusive	1,8+Pozzolans

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THE MOST COMMON DAMAGES OF CONCRETE DUE TO ASR IN LITHUANIA

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DAMAGE TO CONCRETE DUE TO ASR

Weak reaction. Visual features

■*surface Pop-Outs. The expansion near the concrete surface due to the reaction of alkali and aggregates causes the cone-shaped mortar portion above the aggregate to break off, leaving the reactive aggregate unprotected at the bottom of the resulting conical depression.*;

■- Surface discoloration and gel plaque (cracks caused by ASR are often bordered by a wide zone - leaks, giving the appearance of a permanently wet zone).

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TEST METHODS

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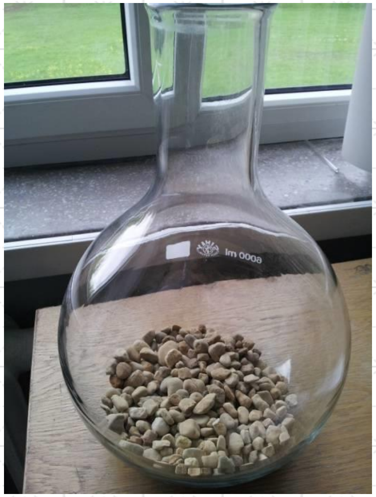
Test methods for aggregates

1) THE METHODOLOGY FOR DETERMINING THE CONTAMINATION OF AGGREGATES IS PRESENTED IN APPENDIX M1 OF THE LST 1974:2012 STANDARD



2) THE ASR OF CONCRETE IS DETERMINED ACCORDING TO RILEM OR ASTM METHODOLOGIES, OR THE METHODOLOGY ACCREDITED BY KTU SMKTC

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TYRIMŲ METODIKOS

LST 1974:2012 M1 STANDARD

METHODOLOGY FOR DETERMINING THE CONTAMINATION (REACTIVE ROCKS) OF THE AGGREGATES

SPECIMENS:

COARSE AGGREGATE (GRAVEL OR CRUSHED STONE) AND FINE AGGREGATE (SAND) ARE TESTED SEPARATELY.

STAGE 1: HYDROCHLORIC ACID (HCL) 10% SOLUTION; CARBONATES ARE DISSOLVED - GRANITIC AGGREGATES REMAIN WITH REACTIVE ONES. OPOKA AND FLINT ALSO DO NOT DISSOLVE IN ACID AND REMAIN.

STAGE 2: SODIUM ALKALI (NAOH) 10% SOLUTION;

IN THIS STEP, REACTIVE AGGREGATES ARE DISSOLVED.

The total amount of reactive rocks (opoka and flint) (%) in coarse and fine aggregate is calculated by summing the determined amounts of opoka and flint in the respective aggregates.

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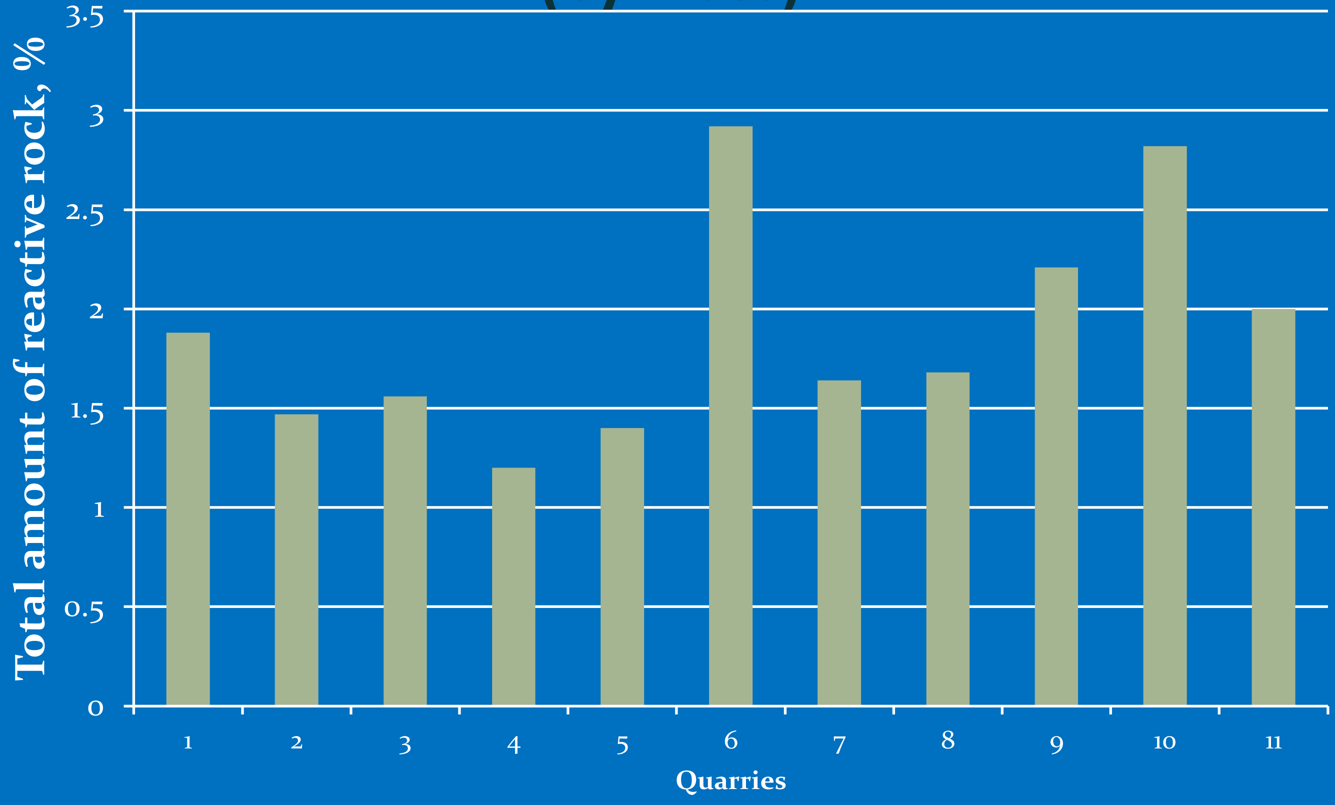
Test method LST 1974

Distribution of opoka and flint in coarse aggregates (by mass)



Average content of reactive rocks in coarse aggregate – 1,9 %.

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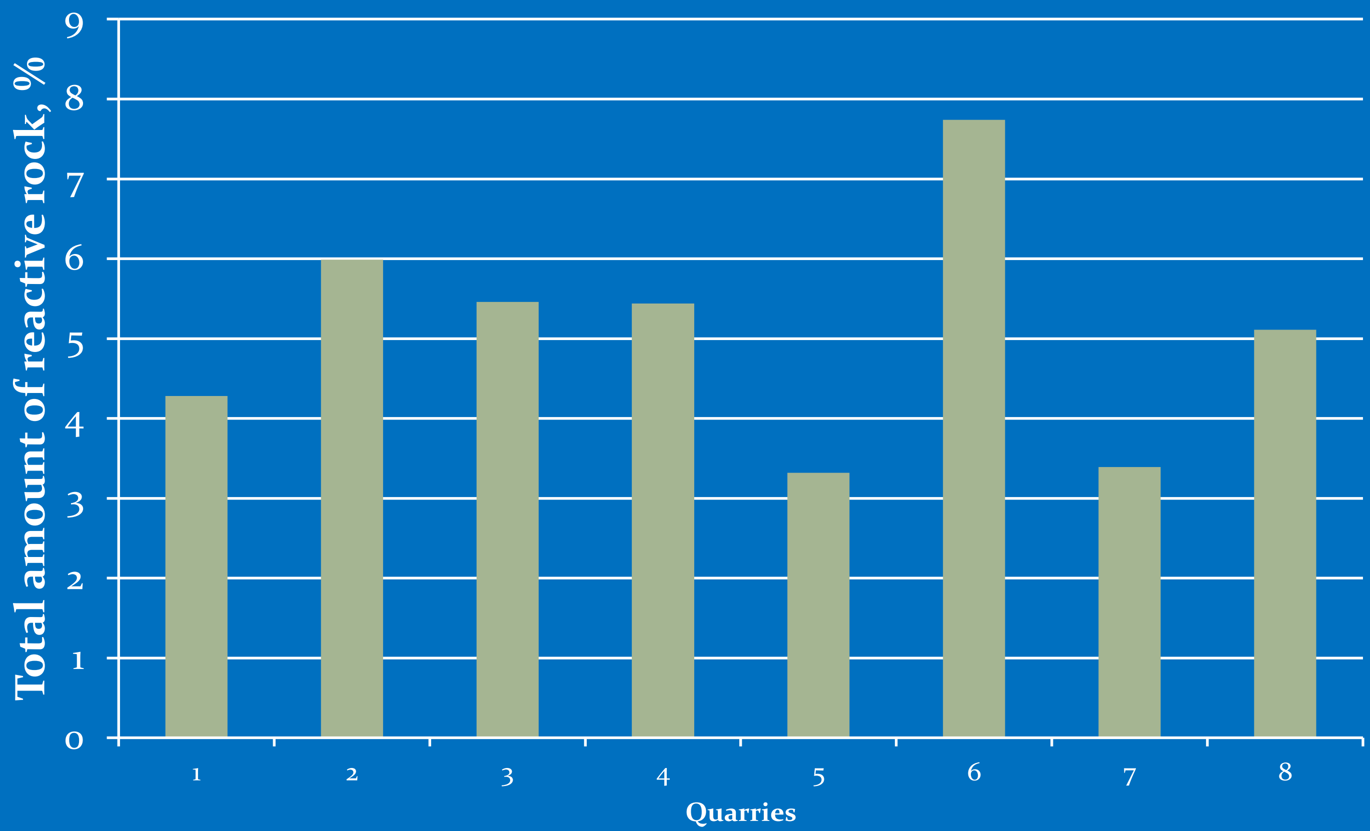
Test method LST 1974

Distribution of opoka and flint in fine aggregates by mass



Average content of reactive rocks in fine aggregate– 5,1 %.

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Test method LST 1974

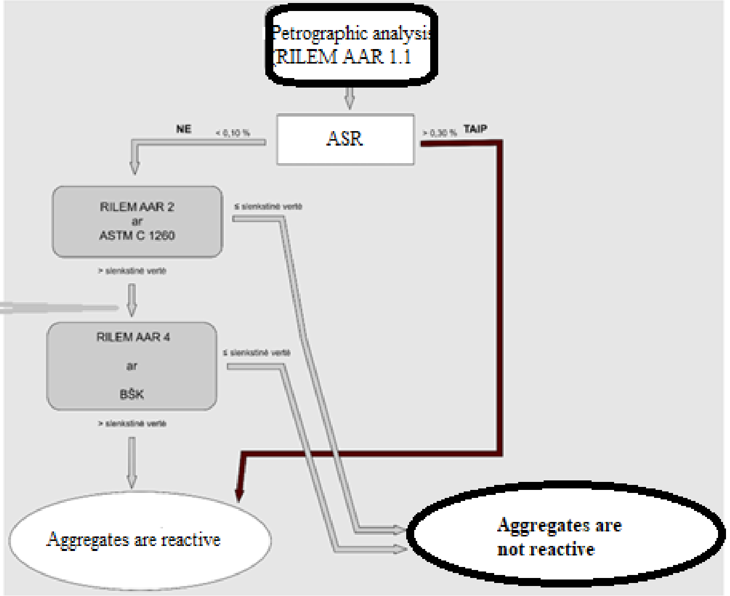
Discussions in Lithuania

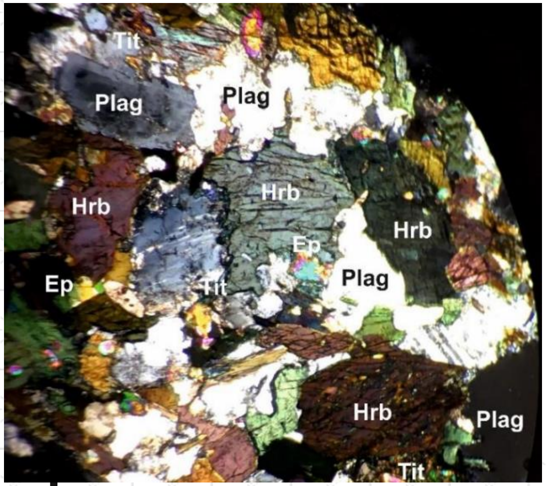
Local gravel and cruched gravel

a) Test light aggregates according ASTM C123 in gravel

b) Test amorfous SiO2 part according LST 1974:2012 M1

Other aggregates (granite or artificial)





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Concrete test method

KTU SMKTC ACCREDITED METHOD

(RILEM AAR-4.1 based)

„BŠK-1/2016“

- (75±5)×(75±5)×(250±50)mm Concrete prisms made from the tested recipe are kept for 20 weeks 60 °C (r.h. >95%) in a chamber above water.

This test methodology is applied to determine the resistance of samples of various concrete compositions to ASR of concrete, which are intended for operation in natural outdoor conditions or indoors with increased structural humidity. Not only changes in mass and expansion deformations are evaluated, but also the visual condition of the concrete surface.

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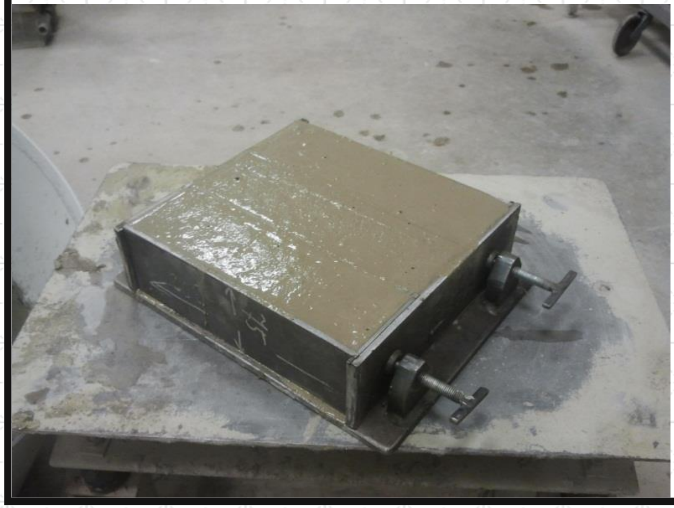
Concrete test method

PRINCIPLE

- An independent laboratory forms 6 concrete samples according to the concrete production mix provided by the concrete manufacturer, using the same materials and components that the concrete manufacturer actually plans to use.

Concrete samples (prisms) are placed in a shot blasting chamber, in which the water height is 35 ±5 mm and the temperature 60°C±2°C.

After 5, 10, 15, 20 weeks after mixing, the prisms are removed from the shaking chamber and placed in water as soon as possible for 24 ±1h, 20C±2C, and then visually checked for cracks and the change in mass is determined W_5, W_{10}, W_{15}, W_{20}, and change in length C_5 , C_{10} , C_{15} , C_{20}



Concrete test method

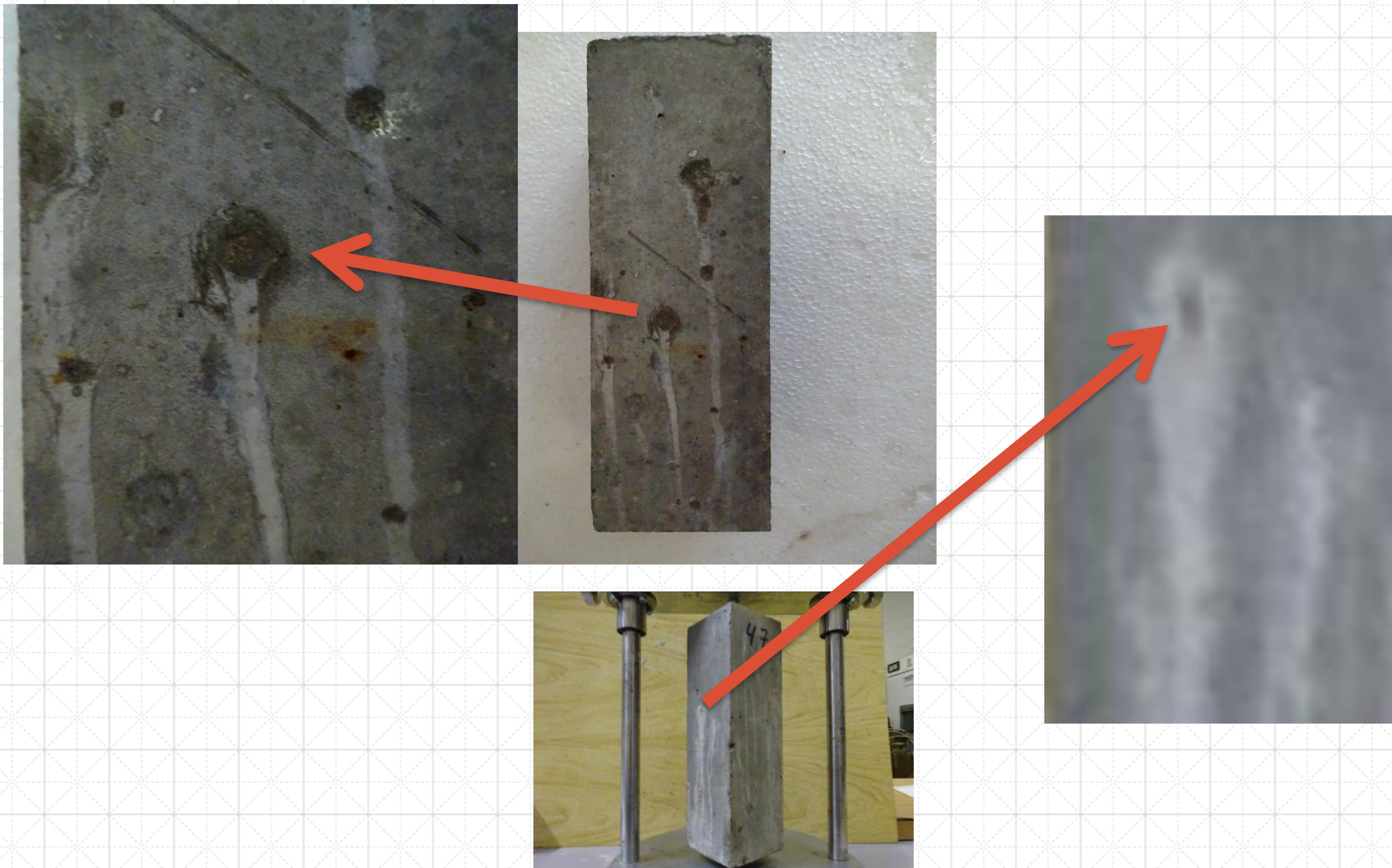
Proposed methodology and assessment of ASR in Lithuania

- After 20 weeks of retention, all planes of the six concrete specimens are visually inspected (it consist of approx 0,50 m^2 area). The amount of dark and white spots detected on the concrete surface, the amount of local ASR hearths - the amount of local surface pop-outs and cases of a network of cracks are recorded separately.

Threshold criteria for the assessment of ASR after 20 weeks of maintenance in an isothermal chamber:

- Average relative expansion deformation of concrete specimens ≤ 0,050% (for an individual sample ≤ 0,060%);
- *Local Pop-outs of the concrete surface* – must not exist (0).

Concrete test methods



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Concrete test methods

- Test protocol
- Commercial normal concrete LST EN 206 C30/37-XC4-XD2-XS1-XF4(LT)-F300(LT)-W12(LT)-XA2-XM2(LT)-**XR2**(LT)-Cl0,2-D16-S1, conforms the requirements of the resistance of concrete to ASR, according to the KTU ŠBK-1/2016 research methodology.
- In Lithuania, alkali-silica reaction of concrete with Lithuanian quarry aggregates is not typical due to volumetric developmental deformations, but it can occur in local locations due to pop outs of the concrete surface at individual reactive particles of aggregates. This can happen if aggregates for concrete contain individual particles of amorphous SiO2- rocks (opal and flint) and these particles can cause localized surface pop outs on the concrete surface as characteristic of alkali-silica reaction. It is for this reason that KTU SMKTC has accredited the ASR evaluation method (BŠK-1:2016*) suitable for Lithuanian conditions with Lithuanian quarry aggregates, according to which more attention is directed to the evaluation of the surface condition of concrete samples after 20 weeks of test according to Rilem AAR-4.1.

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PREVENTION OF ASR

PREVENTION OF ASR

1) Execute LST 1974:2002 requirements, i.e. not exceed Na_2O_{ekv} 3 ir 4 kg/m^3 calculating 1m^3 of concrete from the amount of cement, according to the relevant environmental classes (XR1 and XR2):

2) The use of low-alkalinity cement or the use of less cement.

3) Use uncontaminated aggregates, e.g. granite.

Other options:

Use of slag cement (CEM III).

Insulation of concrete from moisture.

Use of pocolan additives? (Rilem 4 method).

Experience of concrete producers and aggregate quarries!

The importance of the primer film

ASR causes bubbles on the coating.

The concrete is not permeable to water as a liquid, but it is permeable to water vapour, which can be confirmed by lifting the polymer coating at the factory to reveal condensed moisture.

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Thank you for your attention

RESISTANCE TOWARDS CHLORIDE INGRESS

SCHWENK Sverige AB

Scientific and Technical Conference ***Concrete durability and sustainability***

2023-11-23, Riga, Latvia

Urs Müller, Technical Manager

SCHWENK

CONTENTS

- Chloride induced steel reinforcement corrosion
- Chloride in hardened cement paste
- Factors influencing ingress of chlorides
- Mitigating chloride ingress
- Testing resistance of concrete towards chloride ingress

CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

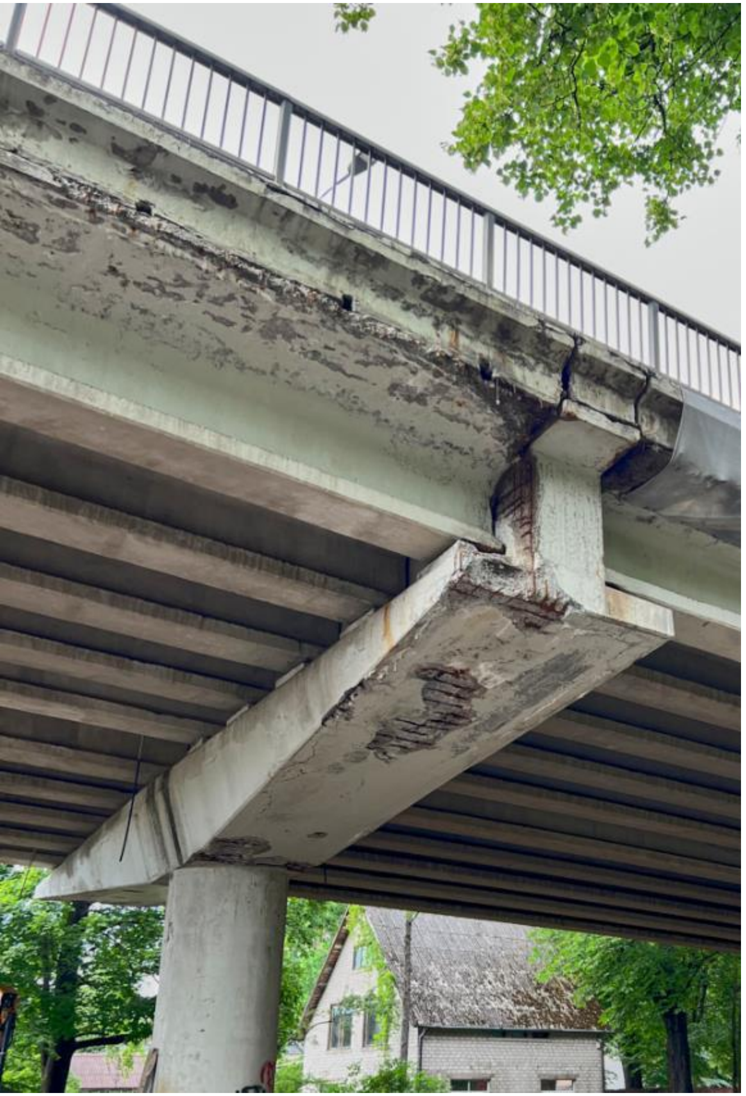
ONE OF THE MOST PROMINENT DAMAGES IN CONCRETE

Marine environment

Parking garages/structures

CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

ONE OF THE MOST PROMINENT DAMAGES IN CONCRETE

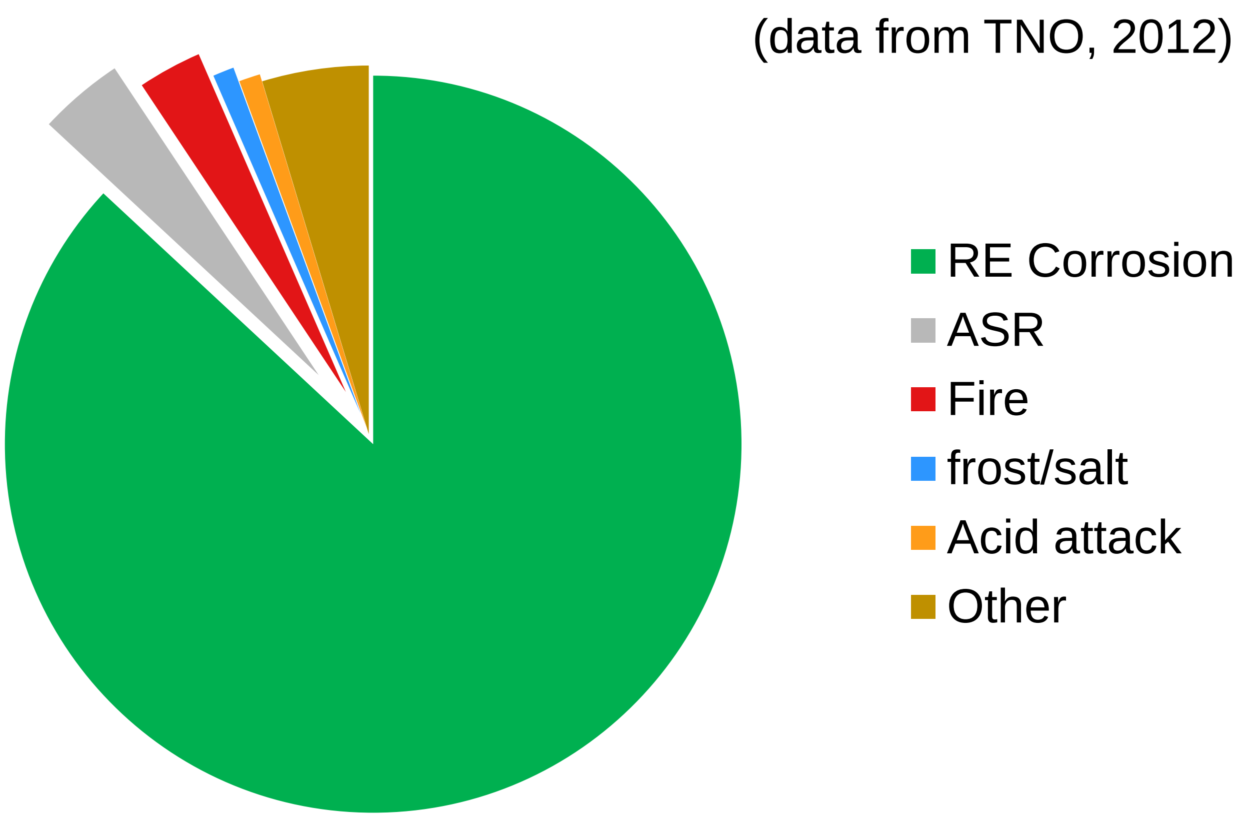


Traffic infrastructures

CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

ONE OF THE MOST PROMINENT DAMAGES IN CONCRETE

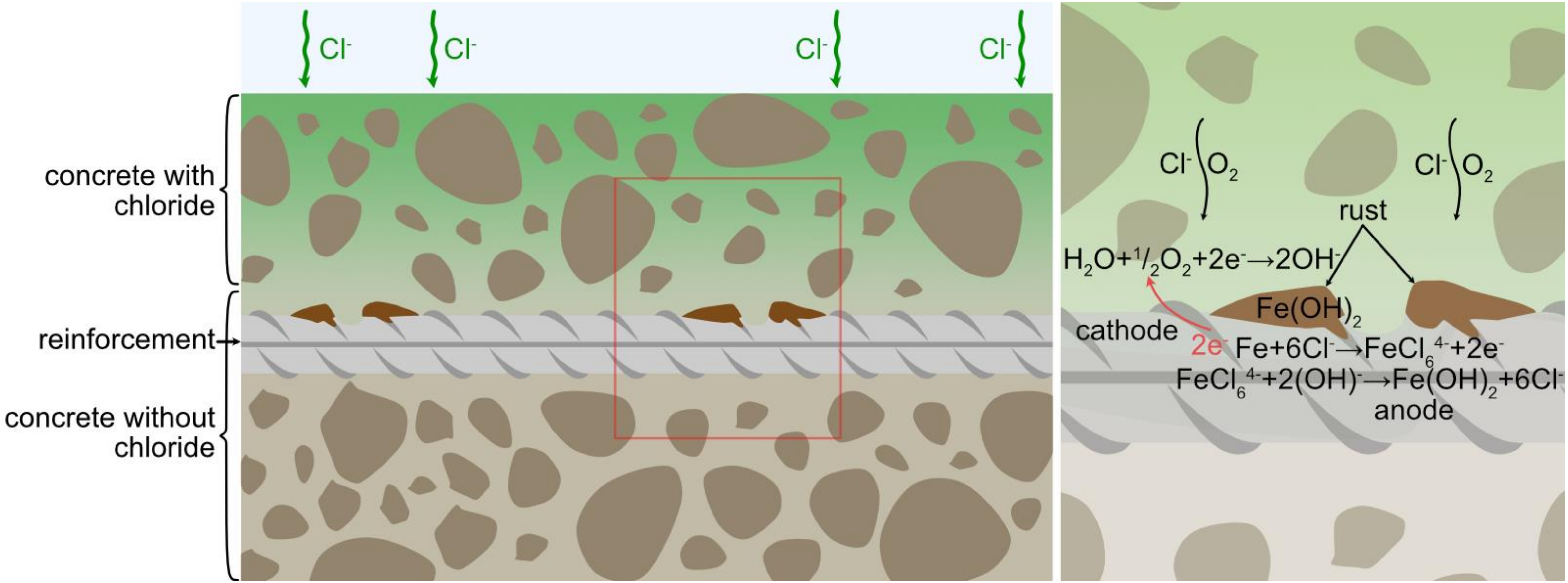
Common concrete damages on Dutch infrastructure buildings



CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

PROCESSES

Ingress of chloride to the reinforcement can start the corrosion process



CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

PROCESSES

Ingress of chloride to the reinforcement can start the corrosion process by depassivasion of steel

Cathode

$H_2O + \frac{1}{2}O_2 + 2e^- \rightarrow 2(OH)^-$

Anode

$Fe + 6Cl^- \rightarrow FeCl_6^{4-} + 2e^-$

$FeCl_6^{4-} + 2(OH)^- \rightarrow Fe(OH)_2 + 6Cl^-$

$Fe + 2(OH)^- \rightarrow Fe^{II}(OH)_2 + 2e^-$

$Fe^{II}(OH)_2 + O_2 + H_2O \rightarrow Fe^{III}(OOH) + OH^-$

rust

CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

EXPOSURE CLASSES

Exposure situations

- Deicing salts (traffic infrastructure)
- Sea water (traffic infrastructure, harbor structures, energy structures, etc.)

3 Corrosion induced by chlorides other than from sea water		
Where concrete containing reinforcement or other embedded metal is subject to contact with water containing chlorides, including de-icing salts, from sources other than from sea water, the exposure shall be classified as follows:		
XD1	Moderate humidity	Concrete surfaces exposed to airborne chlorides
XD2	Wet, rarely dry	Swimming pools; Concrete exposed to industrial waters containing chlorides
XD3	Cyclic wet and dry	Parts of bridges exposed to spray containing chlorides. Pavements, Car park slabs

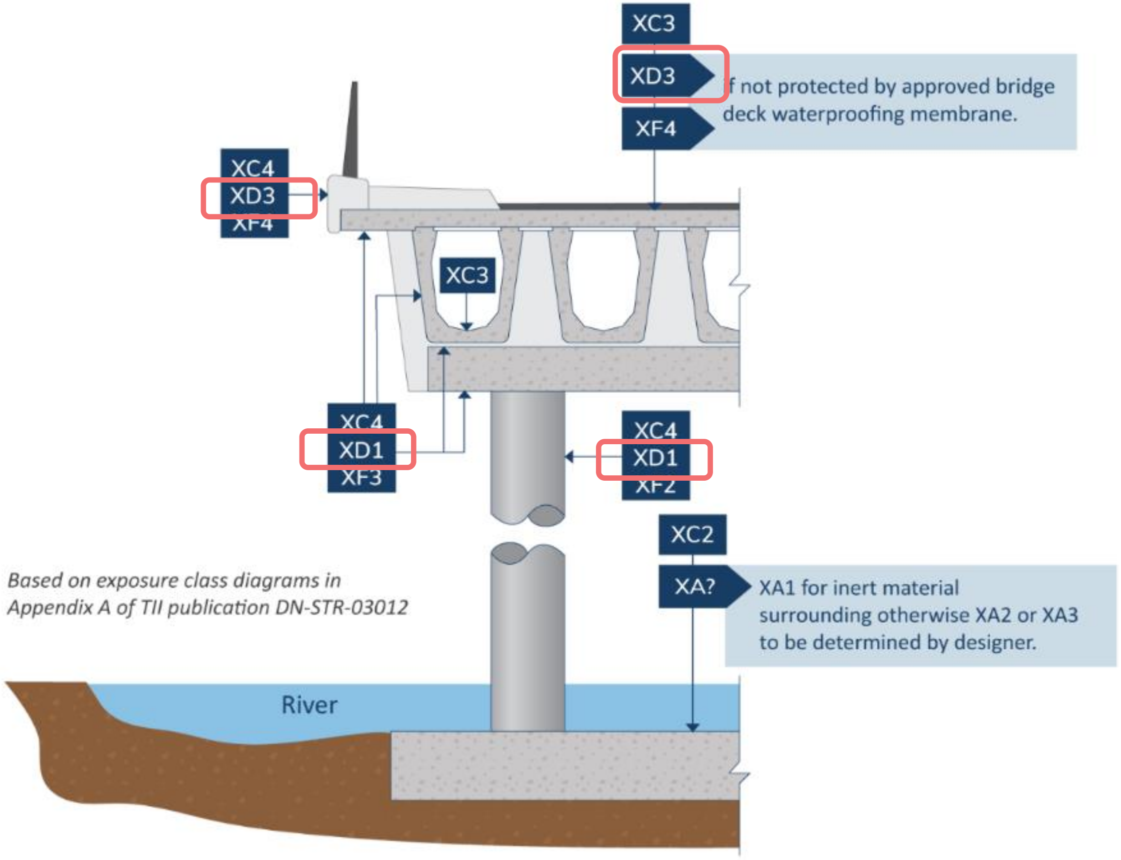
4 Corrosion induced by chlorides from sea water		
Where concrete containing reinforcement or other embedded metal is subject to contact with chlorides from sea water or air carrying salt originating from sea water, the exposure shall be classified as follows:		
XS1	Exposed to airborne salt but not in direct contact with sea water	Structures near to or on the coast
XS2	Permanently submerged	Parts of marine structures
XS3	Tidal, splash and spray zones	Parts of marine structures

CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

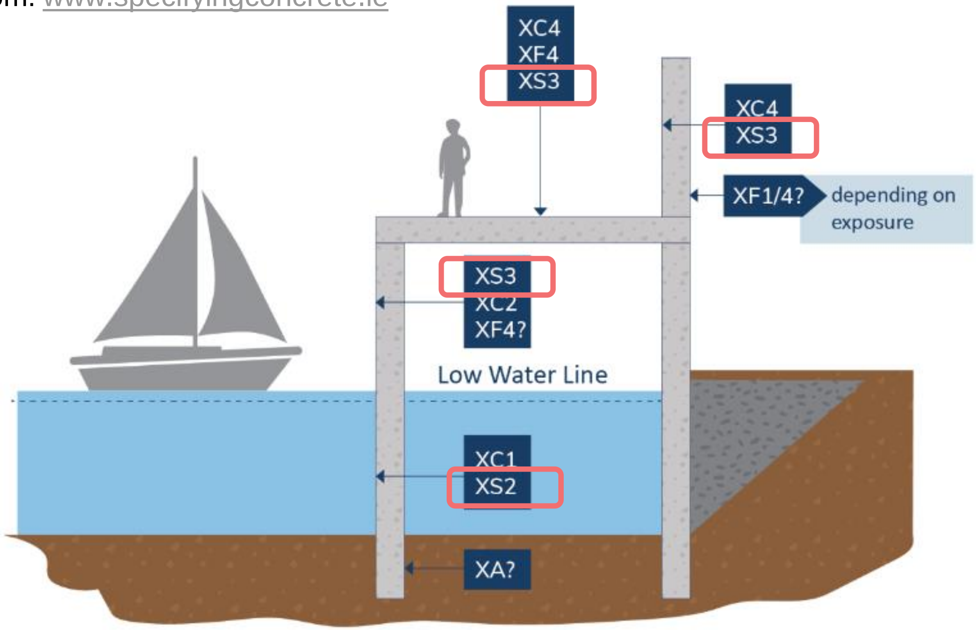
EXPOSURE CLASSES

Exposure situations

- Deicing salts (traffic infrastructure)
- Sea water (traffic infrastructures, harbor structures, energy structures, etc.)



Illustrations from: www.specifyingconcrete.ie



CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

TOLERATED CHLORIDE LEVELS IN CONCRETE

- According to EN 206:2013
- Single materials
  - Cement ≤ 0.10 % (except CEM III)
  - Fly ash, slag ≤ 0.10 %
  - Silica fume ≤ 0.30 %
  - Admixtures ≤ 0.10 %
  - Aggregate to be determined, national requirements
  - Water 500 mg/l (pre-stressed), 1000 mg/l (with reinforcement), 4500 mg/l (without reinforcement)
- National applications, e.g. Swedish standard

Table 15 — Maximum chloride content of concrete

Concrete use	Chloride content class [a]	Maximum Cl^- content by mass of cement[b] %
Not containing steel reinforcement or other embedded metal with the exception of corrosion-resisting lifting devices	Cl 1,00	1,00
Containing steel reinforcement or other embedded metal	Cl 0,20	0,20
	Cl 0,40[c]	0,40
Containing prestressing steel reinforcement in direct contact with concrete	Cl 0,10	0,10
	Cl 0,20	0,20

[a] For a specific concrete use, the class to be applied depends upon the provisions valid in the place of use of the concrete.

[b] Where additions are used and are taken into account for the cement content, the chloride content is expressed as the percentage chloride ion by mass of cement plus total mass of additions that are taken into account.

[c] Different chloride content classes may be permitted for concrete containing CEM III-cements according to provisions valid in the place of use.

Tabell 6 — Högsta kloridhalt i betong (svensk tillämpning av tabell 15 i SS-EN 206:2013+A2:2021)

Betongens användning	Kloridhaltsklass	Högstakloridjonhalt i förhållande till mängden cement som massfraktion[a]
Utan stålarmering eller annan ingjuten metall med undantag av korrosionsbeständiga lyftanordningar	Cl 1,0	1,0 %
Med stålarmering eller andra ingjutna metaller	Cl 0,20	0,20 %
Med spännarmering av stål i direkt kontakt med betongen	Cl 0,10	0,10 %

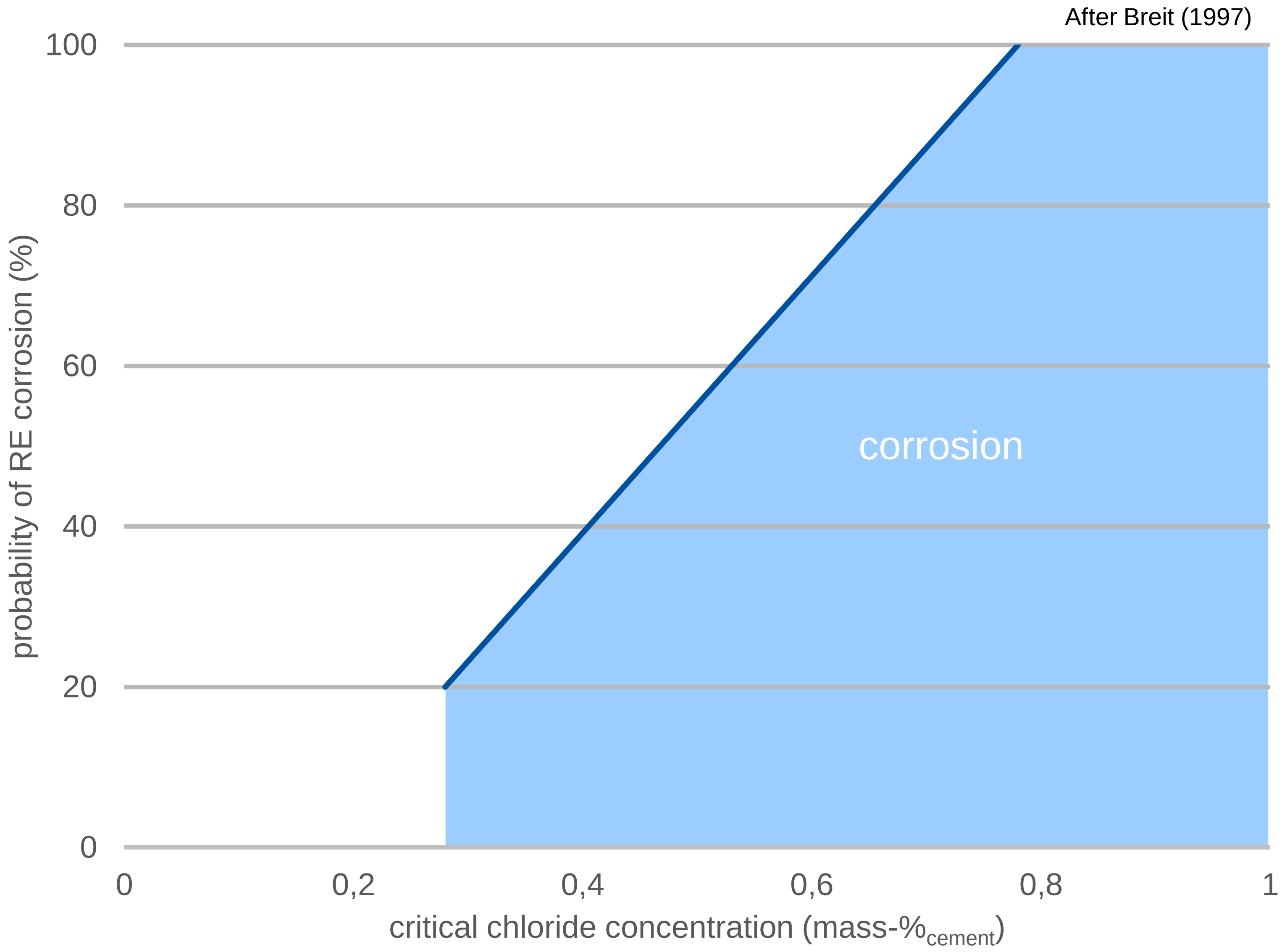
[a] Där tillsatsmaterial av typ II används och beaktas i cementhalten, anges kloridhalten som mängd kloridjoner uttryckt som massfraktion per mängd cement plus total mängd medräknat tillsatsmaterial.

CHLORIDE INDUCED STEEL REINFORCEMENT CORROSION

TOLERATED CHLORIDE LEVELS IN CONCRETE

Threshold levels for corrosion – two definitions (Schiesl & Raupach, 1988)

- Cl-concentration, causing depassivation of reinforcement surface, independently if concrete damages are detectable
- Cl-concentrations, causing detectable damages due to RE corrosion
- Higher Cl concentrations can be expected in the second case
- Evaluation of literature data and experiments indicate a minimum Cl concentration level of 0.20 mass-$\%_{cement}$



CHLORIDE IN HARDENED CEMENT PASTE

HYDRATION OF CEMENT

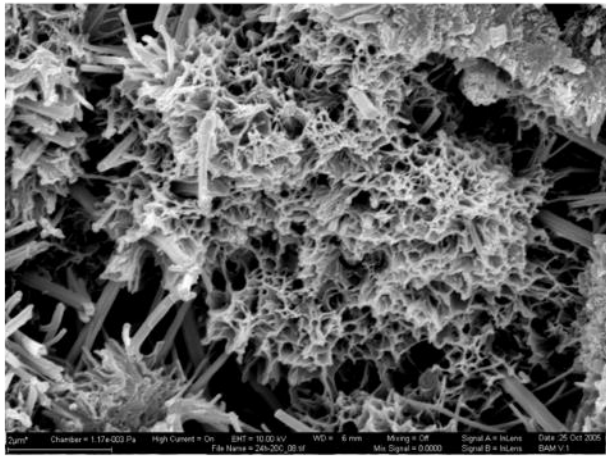
cement (anhydrates)

+

water

=

cement hydrates



Cement hydrates

- Calcium silicate hydrate (C-S-H)
- Calcium hydroxide (portlandite, $Ca(OH)_2$, CH)
- Calcium almuminate hydrates
  - Ettringite (AFt)
  - AFm phases (monosulfoaluminate, hemicarboaluminate, monocarboaluminate)

CHLORIDE IN HARDENED CEMENT PASTE

HYDRATION OF CEMENT

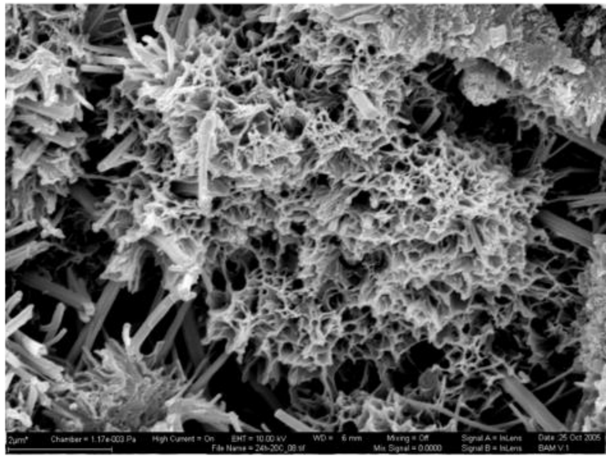
cement (anhydrates)

+

water

=

cement hydrates



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  - AFm phases (monosulfoaluminate, hemicarboaluminate, monocarboaluminate)

CHLORIDE IN HARDENED CEMENT PASTE

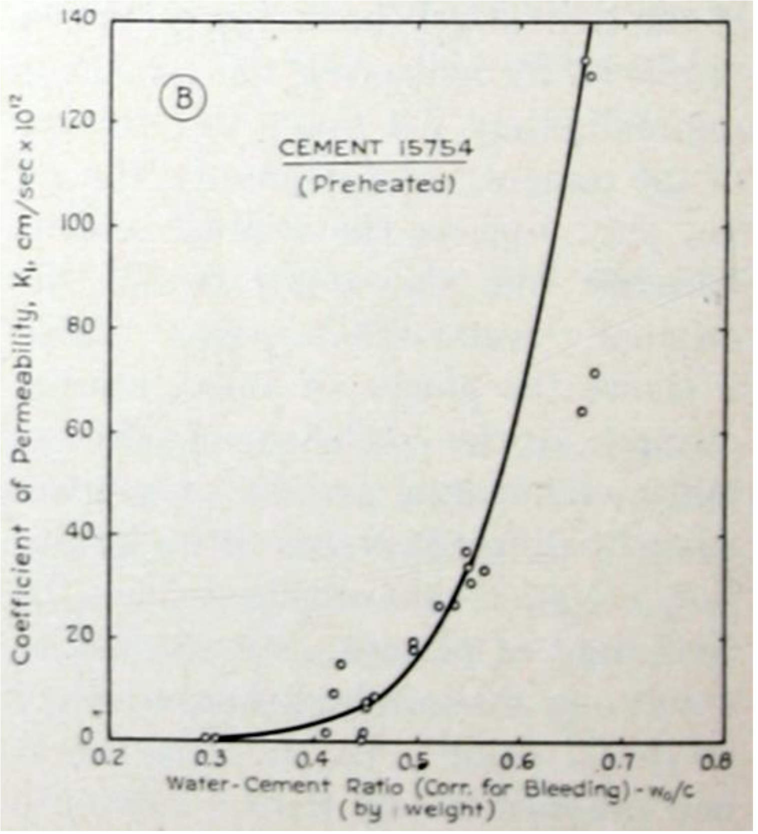
CHLORIDE BINDING BY HYDRATE PHASES

- Adsorptive binding by C-S-H phases
  → fairly low amounts of Cl^- and not stable bound
- Chemical binding by AFm phases in form of
  - Friedel and Kuzel salt $3CaO \cdot A_2O_3 \cdot CaCl_2 \cdot xH_2O$
  - Chemically stable bound in cement paste
- The higher amount of AFm, the higher binding capacity can be assumed
- Higher levels of AFm can be created by specific SCM, fly ash or slag

- Therefore: Bound and free chloride ions should be considered

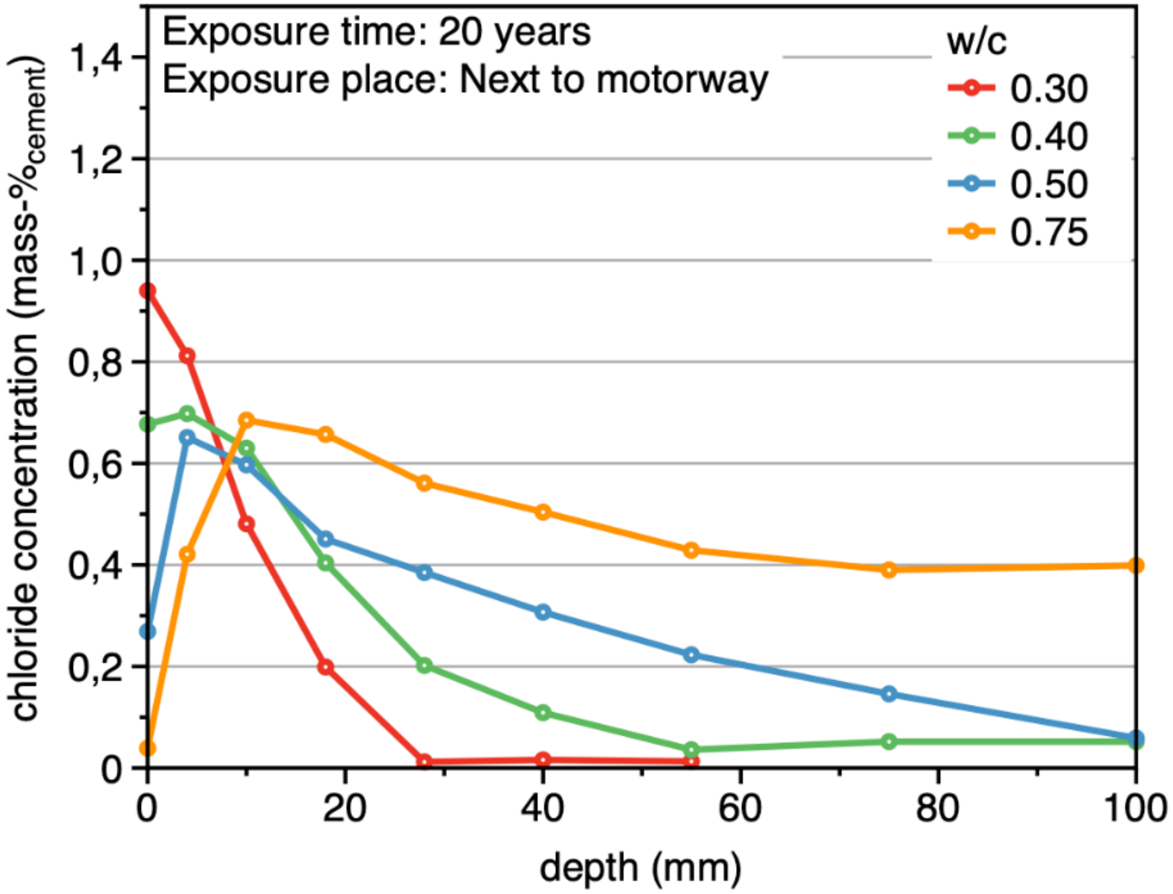
FACTORS INFLUENCING INGRESS OF CHLORIDES

- Water/binder ratio → influences transport parameters



From Powers (1954)

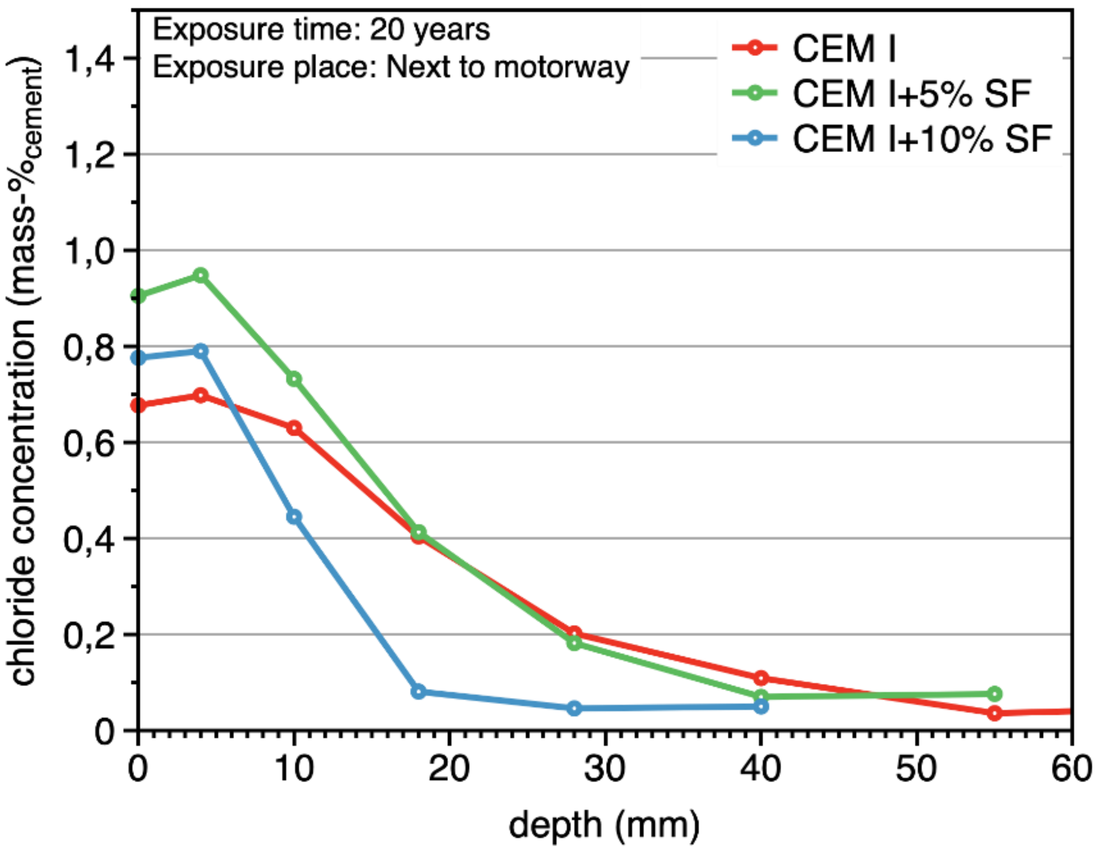
After Tang et al. (2018)



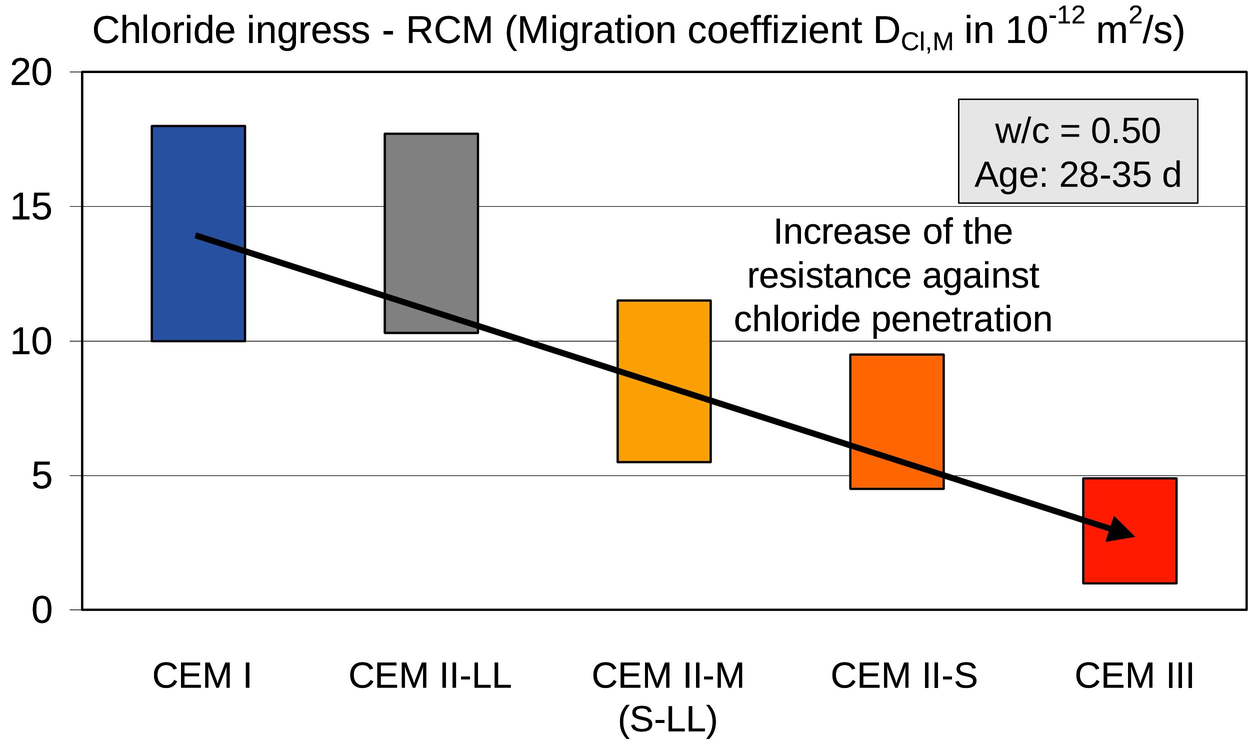
FACTORS INFLUENCING INGRESS OF CHLORIDES

- Type of binder

After Tang et al. (2018)



From Müller, C. (2006)



FACTORS INFLUENCING INGRESS OF CHLORIDES

- Marine environment – exposure zones

From Boubitsas et al. (2014)

Figure 2.2 Overview of the Träslövsläge field site.

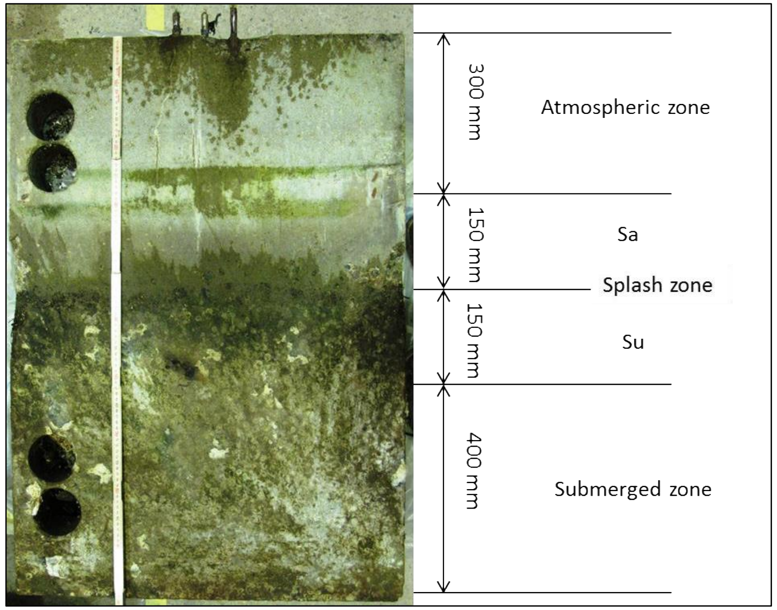
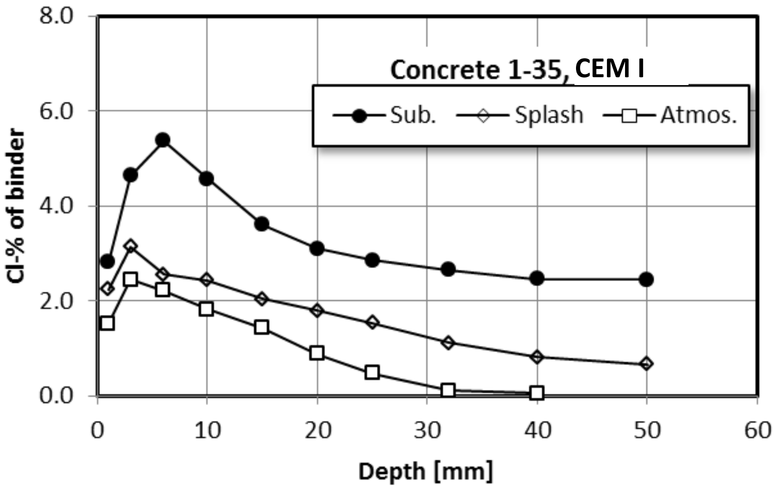


Figure 3.1 Sampling overview of a concrete slab after exposure.



FACTORS INFLUENCING INGRESS OF CHLORIDES

- Marine environment – exposure age

From Boubitsas et al. (2014)

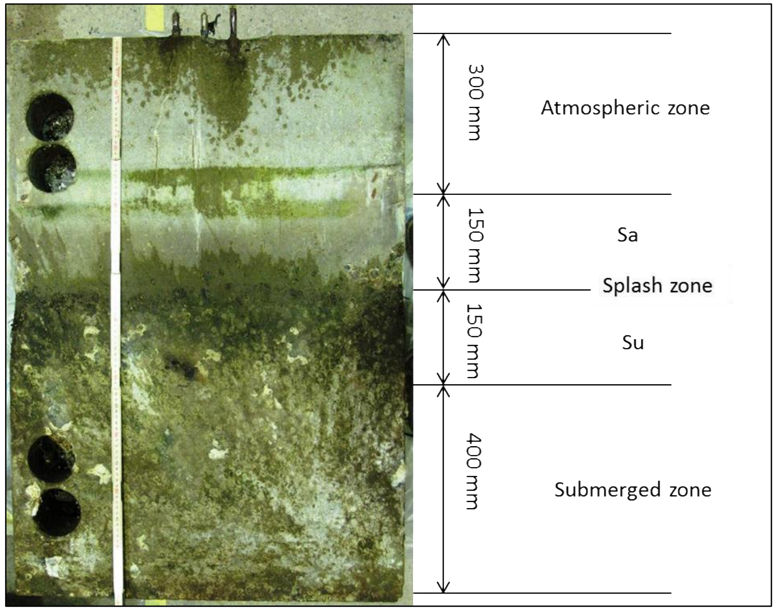
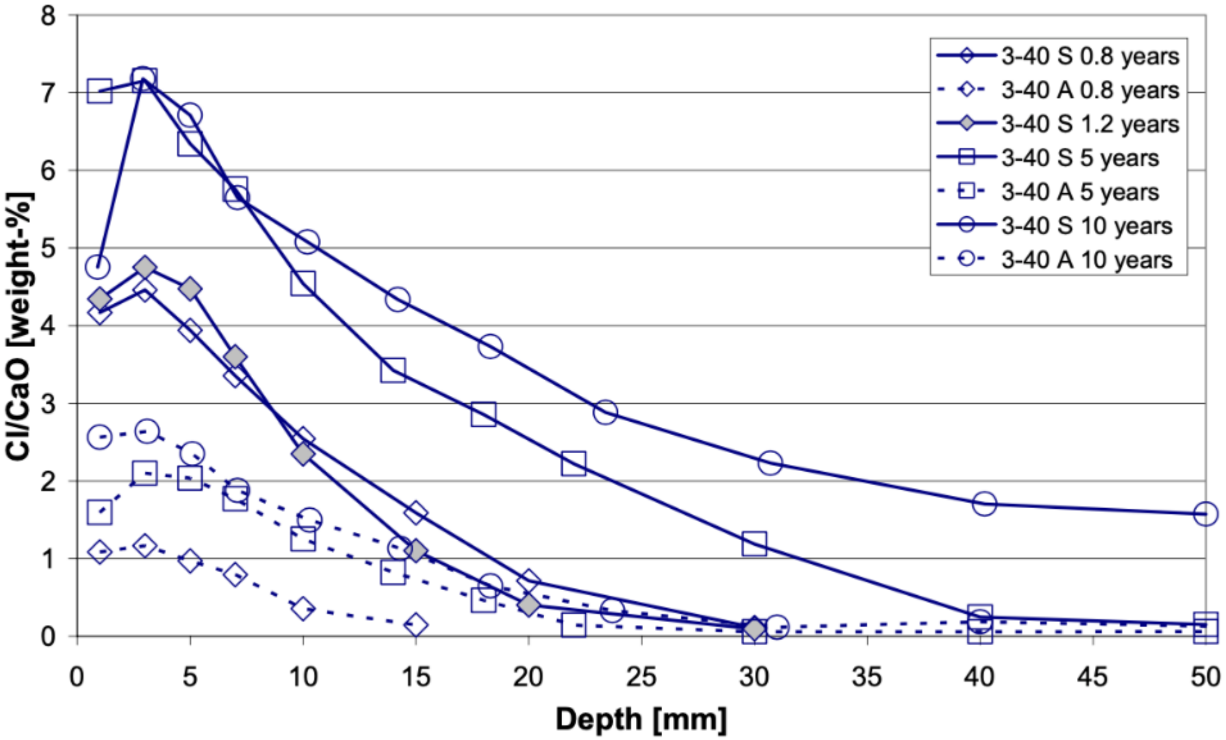


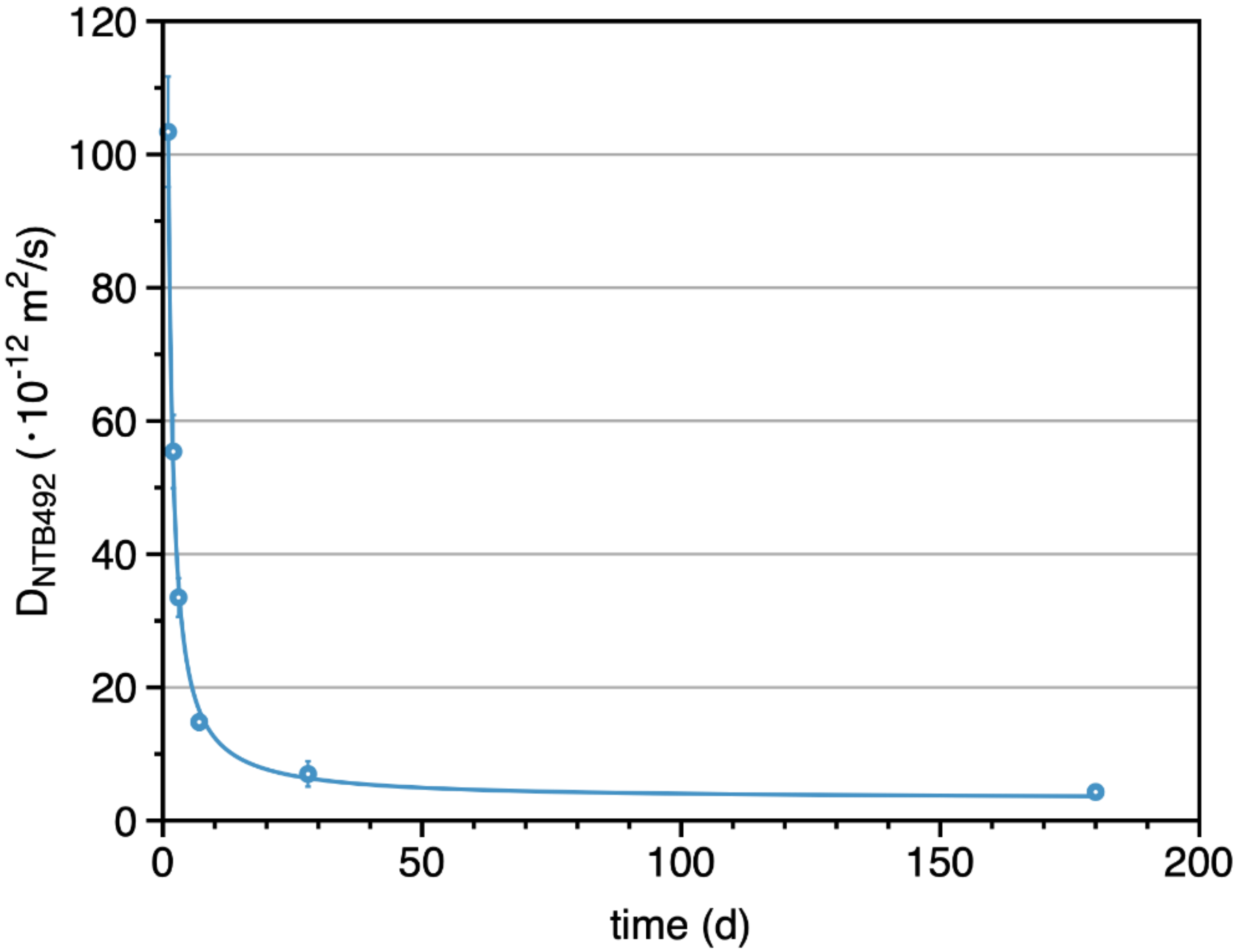
Figure 3.1 Sampling overview of a concrete slab after exposure.

From Tang (2003)



FACTORS INFLUENCING INGRESS OF CHLORIDES

- Concrete age
  - Chloride migration coefficient of the same concrete of different ages
  - CEM III/A, 350 kg/m^3 cement



MITIGATING CHLORIDE INGRESS

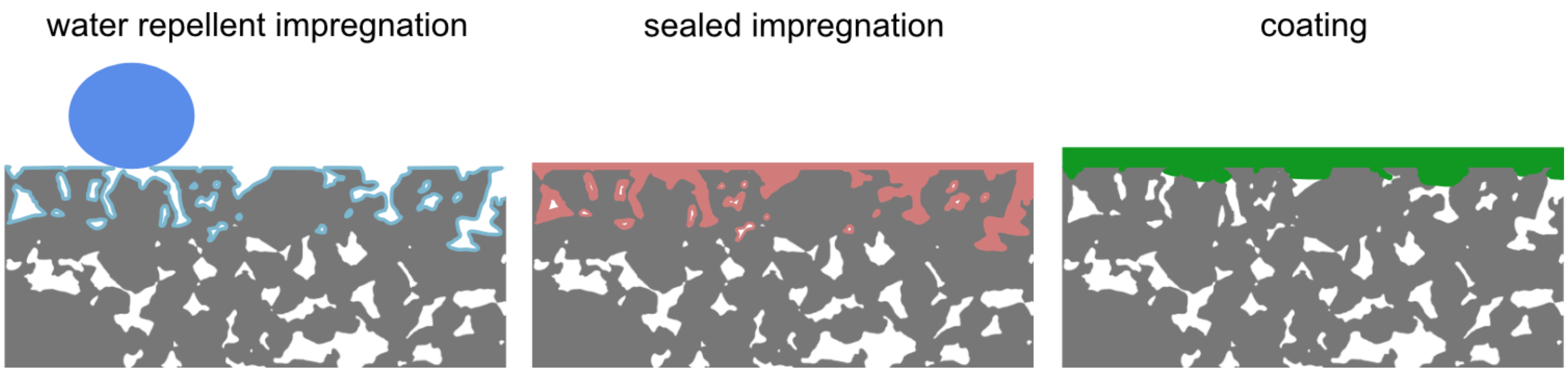
Some of the methods

- Protection systems conform with EN 1504-2
  - Hydrophobic impregnations
  - Polymer based coatings
- Admixtures in form of corrosion inhibitors
  - Anodic inhibitors
  - Cathodic inhibitors
- Cathodic protection (for mitigating reinforcement corrosion)
  - Passive system
  - Active system (impressed current cathodic protection)

MITIGATING CHLORIDE INGRESS

HYDROPHOBIC SYSTEMS AND COATINGS

- Hydrophobic agents and coatings



- Hydrophobic impregnations consists most of silanes and sometimes siloxanes
- Coatings consist of polymers such as epoxy, polyurethane or polyester and can be combinded with hydrophobic properties
- More information in the standard series EN 1504

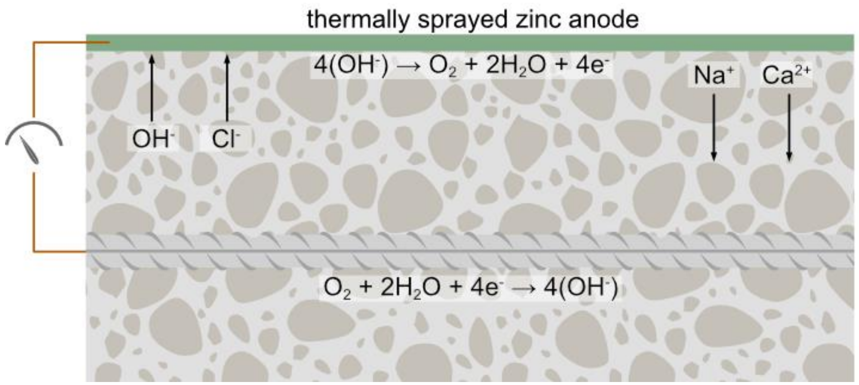
MITIGATING CHLORIDE INGRESS

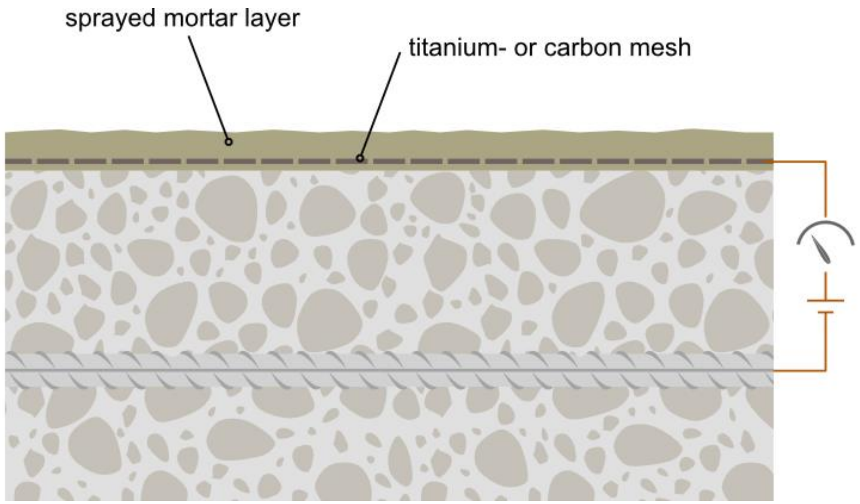
CORROSION INHIBITORS AND CATHODIC PROTECTION

Corrosion inhibitors → needs to be applied in fresh concrete

- Anodic inhibitors → form a passivation layer on anodic surfaces and shifts the potential to the passivation zone
  - Reduced corrosion rate
  - Anions such as nitrates, nitrites, chromate (oxidizing) as well as phosphate, molybdate (non-oxidizing)
- Cathodic inhibitors in form of zinc or magnesium salts

Cathodic protection → can be applied to existing concrete

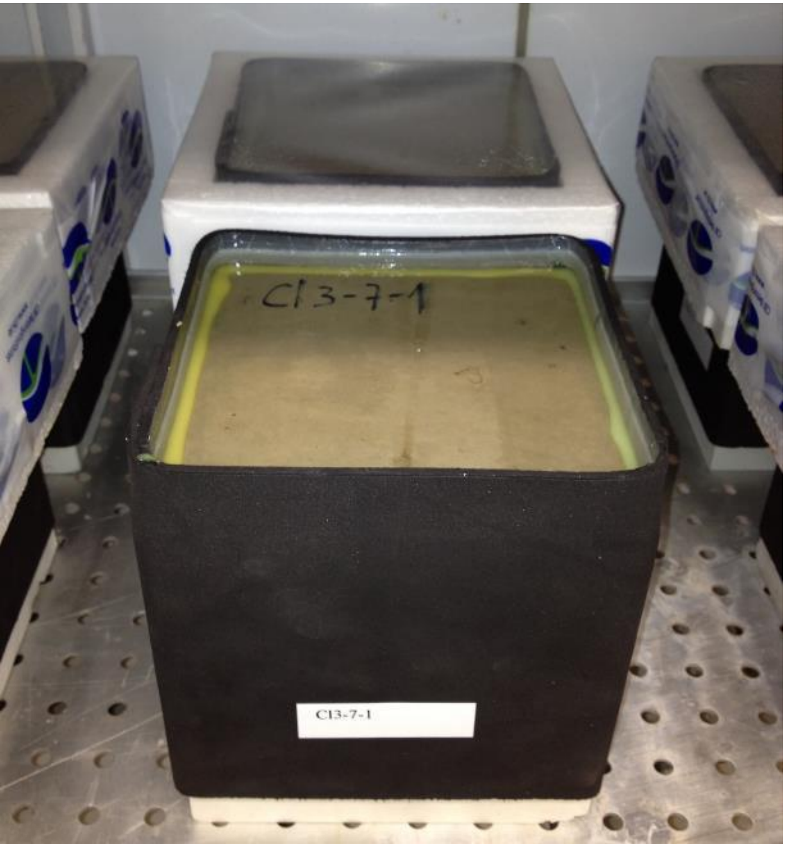


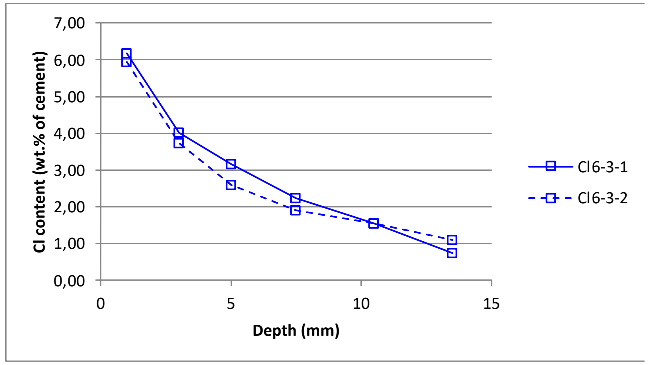


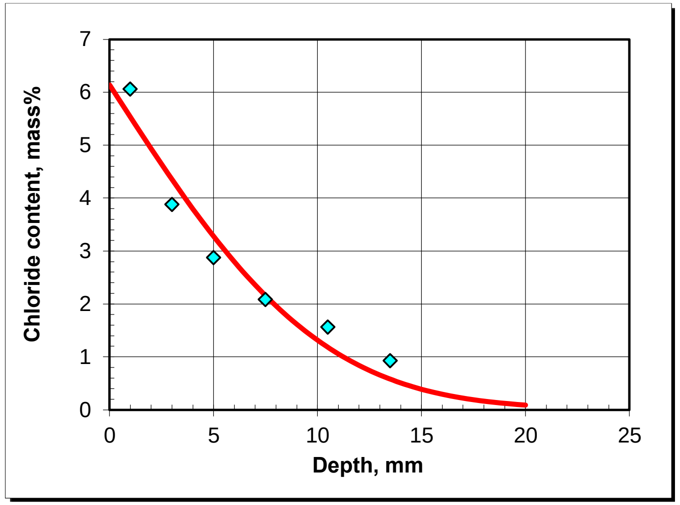
TESTING RESISTANCE OF CONCRETE TOWARDS CHLORIDE INGRESS

DIFFUSION BASED METHOD (UNIDIRECTIONAL)

- Test method according to EN 12390-11
  - 3 % NaCl solution until 90 d (or longer)





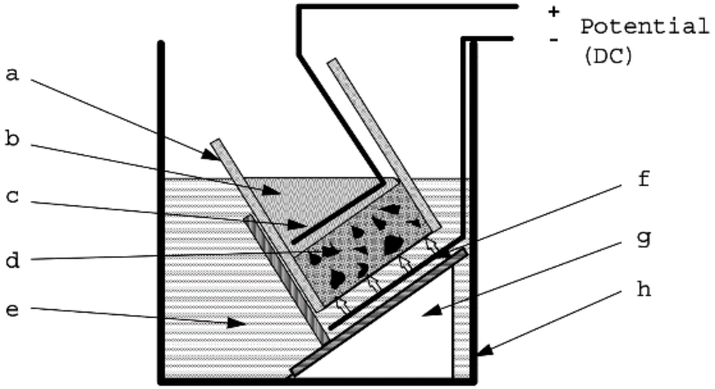


Curve-fitting results	
Surface Cl content C_s, mass%:	**6.137**
Transport coefficient D_a, m^2/s:	**2.07E-12**
R^2 (for selected data):	0.949

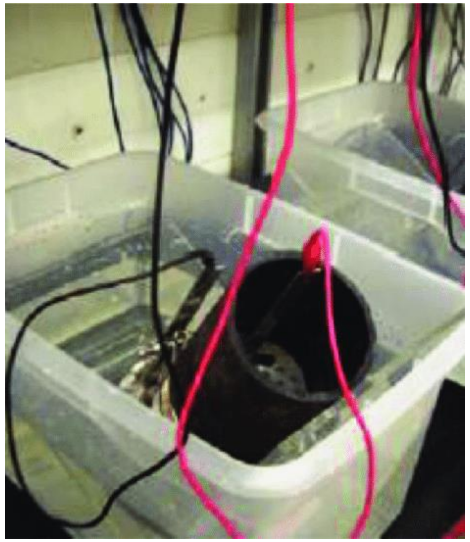
TESTING RESISTANCE OF CONCRETE TOWARDS CHLORIDE INGRESS

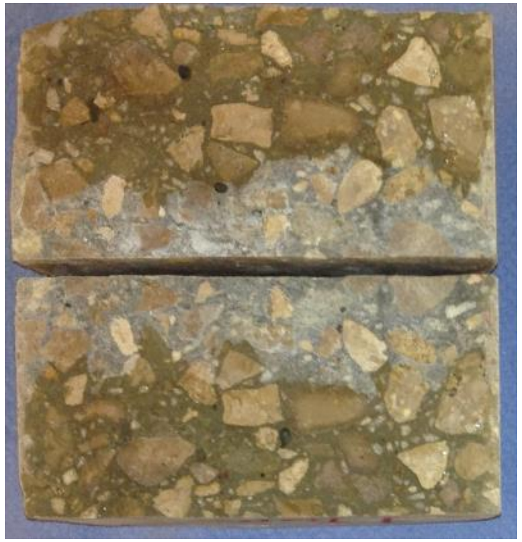
MIGRATION BASED METHOD (UNIDIRECTIONAL)

- Test method according to NT Build 492
  - Uses external electrical potential to force chloride ions into concrete
  - Catholyte 10 % NaCl solution, anolyte 0.3 % NaOH solution
  - Before test vacuum saturation of test specimen with $Ca(OH)_2$ solution for 18 h
  - Duration for test usually around 24 h



a. Rubber sleeve
b. Anolyte
c. Anode
d. Specimen
e. Catholyte
f. Cathode
g. Plastic support
h. Plastic box





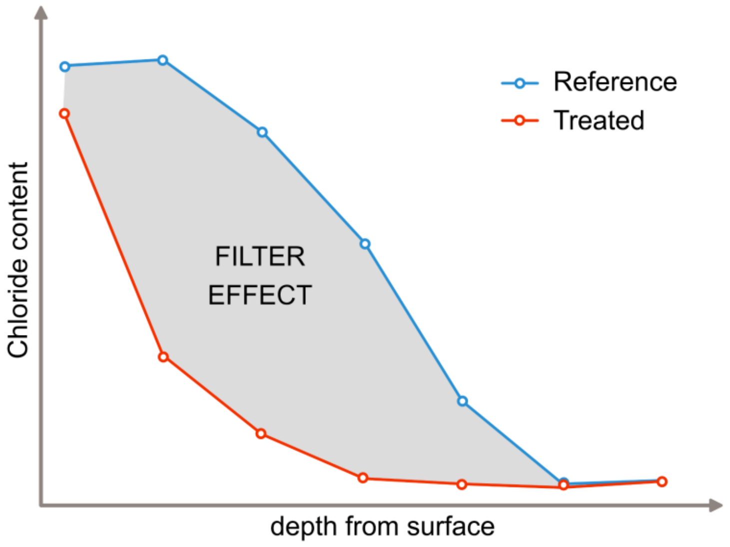
Test for Chloride Migration Coefficient
according to NT BUILD 492

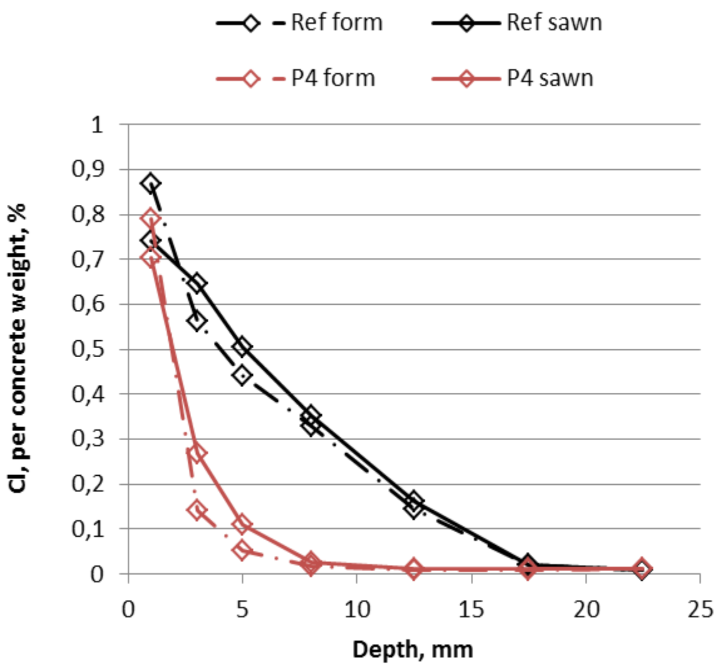
Client:	**Acciona**				
Project No.:	PX20736-02				
Specimen ID:	**RCM 28d**				
Age at the start of test, day:	28				
Date of test:	2013-05-21				
Tested by:	Nelson Silva				
Mean value of D_{NTB492}:	**7,0**	$x10^{-12}$ m^2/s			
Standard deviation:	1,9	$x10^{-12}$ m^2/s			
Coefficient of Variation:	26,9	%			
Specimen No.:	**1 Top**	**1 Bottom**	**2 Top**	**2 Bottom**	
Diameter d	100	100	100	100	mm
Thickness L	50,0	50,0	50,0	50,0	mm
Chloride concentration c_0	10	10	10	10	NaCl%
Applied potential U	35,0	35,0	35,0	35,0	V
Current at start I_i	35	35	35	35	mA
Temperature at start T_i	293	293	293	293	K
Test duration t	20,0	20,0	20,0	20,0	hr
Current at end I_1	30	30	30	30	mA
Temperature at end T_1	294	294	294	294	K
Average penetration depth x_d	20,1	15,7	12,0	12,3	mm
Migration coefficient D_{NTB492}	**9,5**	**7,3**	**5,5**	**5,6**	$x10^{-12}$ m^2/s
Expanded uncertainty (k=2)	0,00	0,00	0,00	0,00	$x10^{-12}$ m^2/s
Individual chloride penetration depths					
Penetration depth x_{d1}	16,0	16,5	9,0	14,5	mm
Penetration depth x_{d2}	24,0	18,0	12,0	11,5	mm
Penetration depth x_{d3}	22,0	15,0	14,0	11,0	mm
Penetration depth x_{d4}	19,5	14,5		12,0	mm
Penetration depth x_{d5}	21,0	13,0		14,0	mm
Penetration depth x_{d6}	17,0		15,0	11,0	mm
Penetration depth x_{d7}	21,0	17,0	10,0		mm
Remarks					

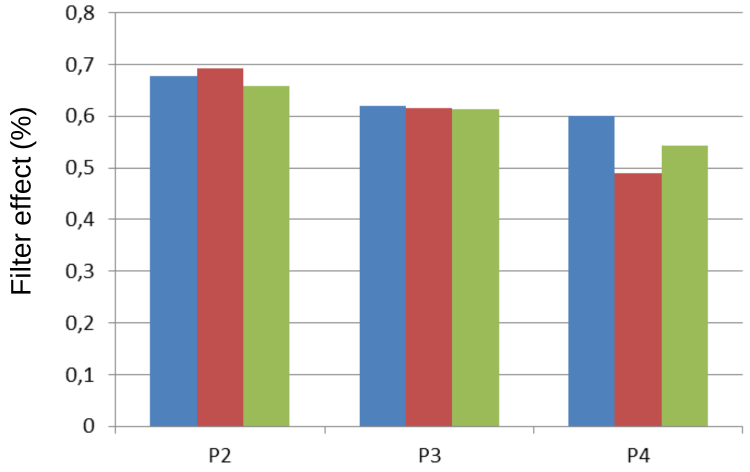
TESTING RESISTANCE OF CONCRETE TOWARDS CHLORIDE INGRESS

OTHER TEST METHODS

- Efficacy of hydrophobic agents towards chloride ingress
  → NT Build 515: Hydrophobic impregnations for concrete – prevention of chloride ingress – filter effect







Questions

SCHWENK

Baustoff leben

Latvijas
Betona
Savienība

BETONA SALIZTURĪBAS TESTĒŠANAS METOŽU SALĪDZINĀJUMS

Jānis Zāle, LBS 31. zinātniski tehniskā konference
23.11.2023., Rīga

SALA IZRAISĪTIE BOJĀJUMI BETONĀ

1. attēls Kalnciema tilta apmale Rīgā

2.attēls Gaisa tilta brauktuves apmale Rīgā

Latvijā – bieži problēmas ar sasalšanas/atkušanas rezultātā izraisītiem bojājumiem betonā

EN 206 STANDARTA PRASĪBAS

5. Sasalšanas – atkušanas iedarbība ar vai bez atledošanas reaģentiem		
Ja betons mitrā stāvoklī ir pakļauts būtiskam sasalšanas-atkušanas ciklu iedarbībai, jāklasificē šādi:		
XF1	Vidējs ūdens piesātinājums, bez atledošanas reaģenta	Vertikālas betona virsmas, kas pakļautas lietus un sala iedarbībai
XF2	Vidējs ūdens piesātinājums, ar atledošanas reaģentu	Vertikālās ceļa konstrukciju betona virsmas, kas pakļautas sasalšanai un gaisā esošiem atledošanas reaģentiem
XF3	Augsts ūdens piesātinājums, bez atledošanas reaģenta	Horizontālas betona virsmas, kas pakļautas lietus un sala iedarbībai
XF4	Augsts ūdens piesātinājums, ar atledošanas reaģentu vai jūras ūdeni	Ceļu un tiltu segumi, kas pakļauti atledošanas reaģentu iedarbībai; Betona virsmas, kas pakļautas tiešām šaltīm, kas satur atledošanas reaģentus, un sasalstošas jūras konstrukciju šļakatu zonas, kas pakļautas sasalšanai

LVS 156-1 STANDARTA PRASĪBAS TESTĒŠANAI

2 testēšanas metodes atbilstoši LVS 156-1 prasībām

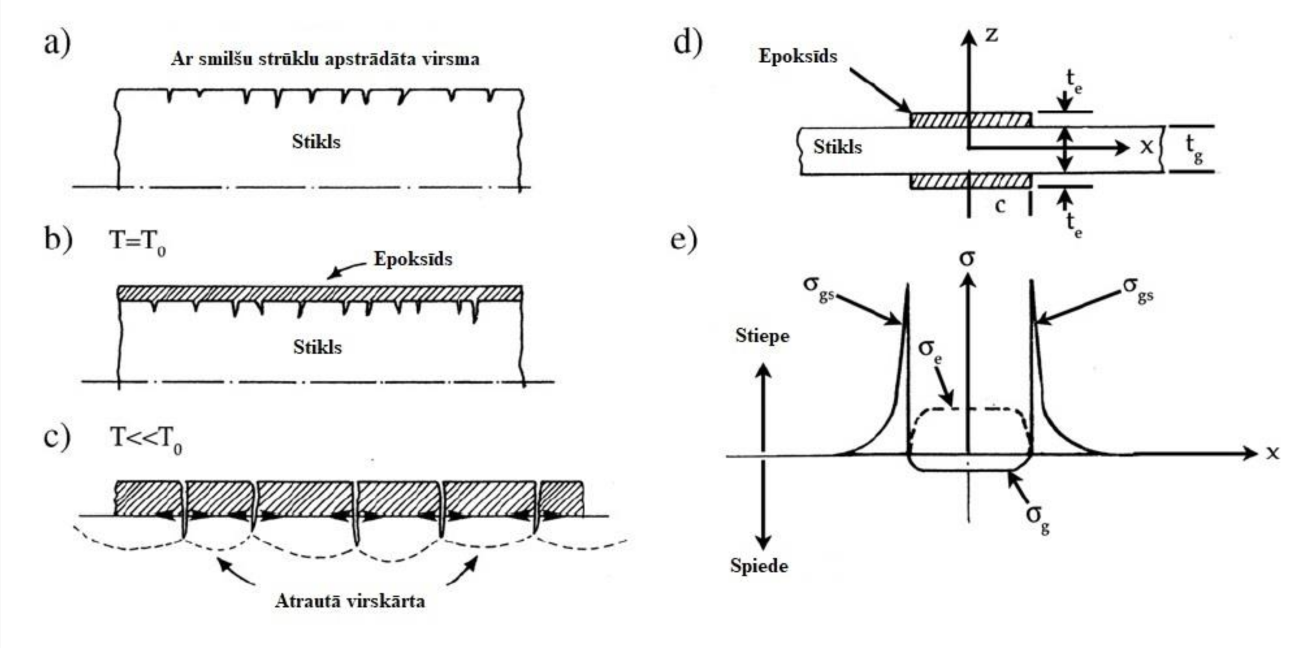
Ārējās vides iedarbības klase	CEN/TS 12390-9 5.p. (plātnes tests)
	Masas zudumi pēc 56 cikliem (g/m[2])
XF1	$m_{56} \leq 1000$
XF2	$m_{56} \leq 650$[2]
XF3	$m_{56} \leq 500$
XF4	$m_{56} \leq 350$[2]

PIEZĪME
[1]Metode attiecināma uz betoniem, kuriem primāra ir konstrukcijas funkcionālās virsmas noturība pret sala iedarbību – galvenokārt ceļu un laukumu nodilumvirsmām, kā arī nenesošajiem un pašnesošajiem dekoratīvajiem betona elementiem.
[2] Salizturības pārbaudi veic, betona paraugus izturot 3% nātrija hlorīda (NaCl) šķīdumā.

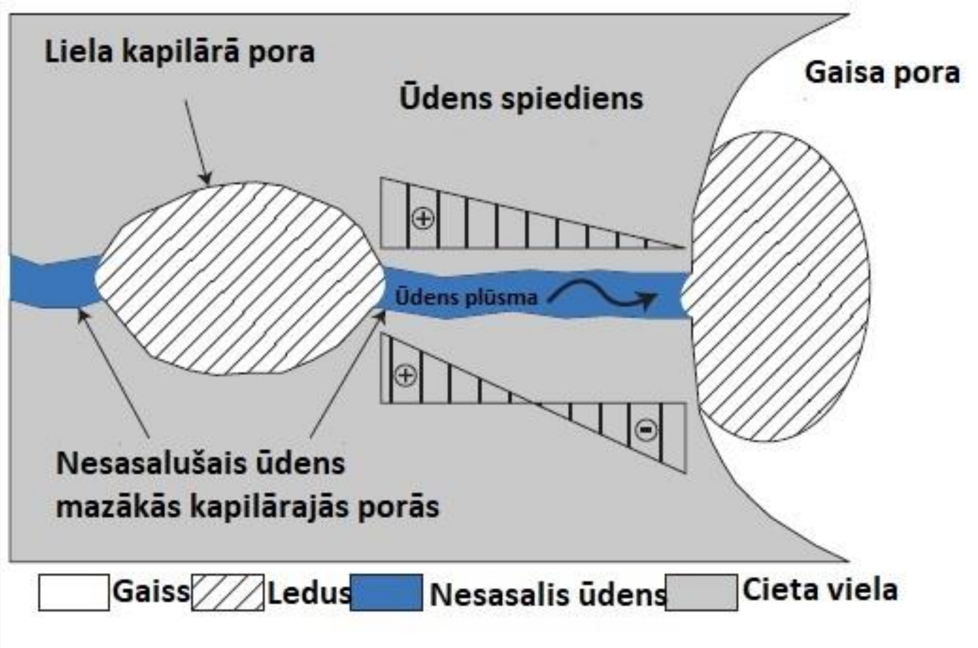
Ārējās vides iedarbības klase	LVS 156-1:2017 A pielikums	
	Salizturības klase	Stiprības zudumi %
XF1	F100	≤ 5
XF2	F200	
XF3	F200	
XF4	F300	

PIEZĪME
[1]Metode attiecināma uz betoniem, kuri paredzēti būvkonstrukciju nesošajām konstrukcijām, un primāra ir to stiprības nodrošināšana visā ekspluatācijas periodā pie atbilstošām iedarbības klasēm.

BETONA BOJĀJUMUS RADOŠIE MEHĀNISMI



3.attēls Sala-sāls zvīņošanās mehānisms – izskaidrots ar «līmes atslāņošanās» mehānismu stikla/epoksīda kompozītā



4.attēls Ūdens sasalšanas rezultātā radītās mikroplaisas betona matricā

PĒTĪJUMA METODIKA

6 betona sastāvi:

Receptes kg/m3						
Paraugu identifikācija	L196	L197	L201	L202	L203	L204
CEM II A-P 42,5 N	355	450				
CEM I 42,5 N SR3			355	450		
CEM II A-LL 52,5 N					355	450
Plastifikators Sika Viscocrete D712, % no cementa svara	1,2	1,2	0,5	0,6	0,8	0,7
Gaisa piedeva Mapeair 50 (5%), % no cementa svara	0,8	0,15	0,12	0,15	0,2	0,15
Smilts 0/4mm	793	753	793	753	793	753
Granīta šķembas 4/16mm	997	947	997	947	997	947
Ūdens	160	172	160	165	160	165
Ū/C attiecība	**0,45**	**0,38**	**0,45**	**0,37**	**0,45**	**0,37**

- Gaisa saturs – 4,5-6% robežās
- Betona testēšana atbilstoši XF4 salizturības klasei

PĒTĪJUMA METODIKA

Testēšanas metodes:

- CEN/TS 12390-9, virsmas masas zudumi (LVS 156-1 5.1.tabula)
- Stiprības zudumi (LVS 156-1 5.2. tabula, A pielikums)
- Gaisa poru sadalījums sacietējušā betonā
- Ultraskaņas izplatīšanās ātruma izmaiņu noteikšana (CEN TR 15177 metode)
- Paraugu kvalitatīvā analīze ar skenējošās elektronu mikroskopijas (SEM) palīdzību

REZULTĀTI

Svaiga betona parametri

Paraugu identifikācija	L196	L197	L201	L202	L203	L204
Cementa veids	CEM II A-P 52,5 N		CEM I 42,5 N SR3		CEM II A-LL 52,5 N	
Ū/C attiecība	0,45	0,38	0,45	0,37	0,45	0,37
Gaisa saturs, %	**5,7**	**5,5**	**5,6**	**4,5**	**5,9**	**5,9**
Blīvums, kg/m^3	2353	2357	2330	2365	2342	2362
Konusa nosēdums, cm	10	6,5	13	19,5	16,5	11

Sacietējuša betona gaisa poru struktūra

Parauga apzīmējums	Kopējais gaisa saturs A, %, vidējā vērtība	A_{300} mikrogaisa saturs (poru izmērs līdz 0,3mm) vidējā vērtība, %	Īpatnējā virsma mm^{-1}, vidējā vērtība	Attāluma koeficients, mm, vidējā vērtība
L196	9,56	2,62	29,5	0,126
L197	7,02	1,87	26,7	0,183
L201	10,59	2,09	26,6	0,134
L202	6,29	1,71	25,4	0,193
L203	7,66	1,85	27,2	0,164
L204	7,78	1,91	24,3	0,187

>25mm^{-1} <0,2mm

Relatīvā dinamiskā elastības moduļa izmaiņas

Parauga apzīmējums	vidējais caurskaņosanas ātrums, m/s	RDM, %
L196 references	5036	91
L196 plātnes	4796	
L197 references	5091	98
L197 plātnes	5035	
L201 references	5142	100
L201 plātnes	5133	
L202 references	5148	98
L202 plātnes	5098	
L203 references	5177	89
L203 plātnes	4873	
L204 references	5224	96
L204 plātnes	5124	

$RDM_{56} \geq 85\%$

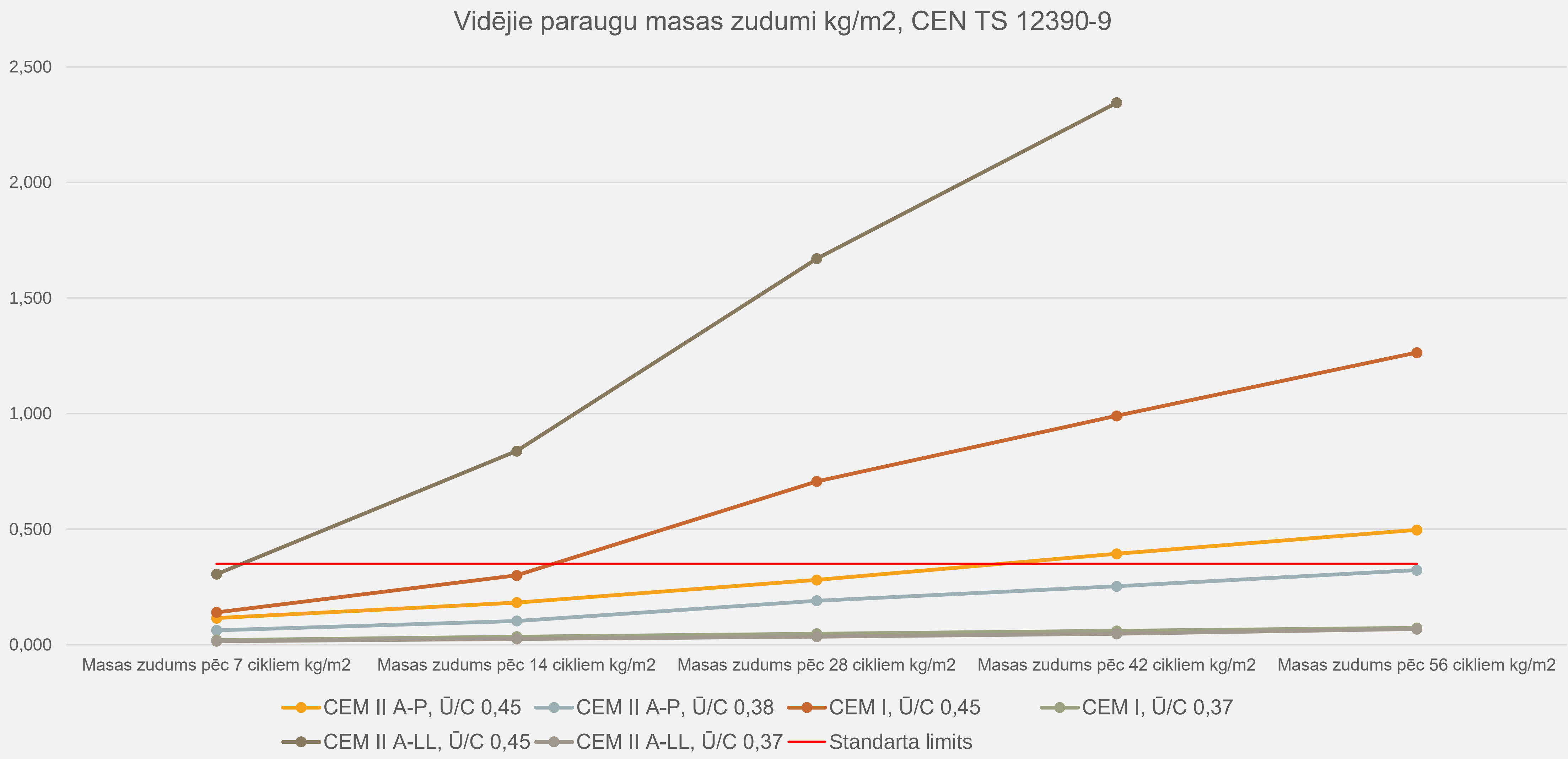
REZULTĀTI

Betona stiprības zudumi atbilstoši LVS 156-1 A pielikumam

Paraugu identifikācija	L196	L197	L201	L202	L203	L204
References paraugu vidējā stiprība, Mpa	65,5	77,9	63,3	77,3	63,7	74,5
Ciklošanai pakļauto paraugu vidējā stiprība, Mpa	65,3	79,6	62,9	79,7	60,6	75,0
Stiprības izmaiņas, %	-0,03%	2,20%	-0,60%	3,10%	-4,90%	0,70%

>-5%

REZULTĀTI



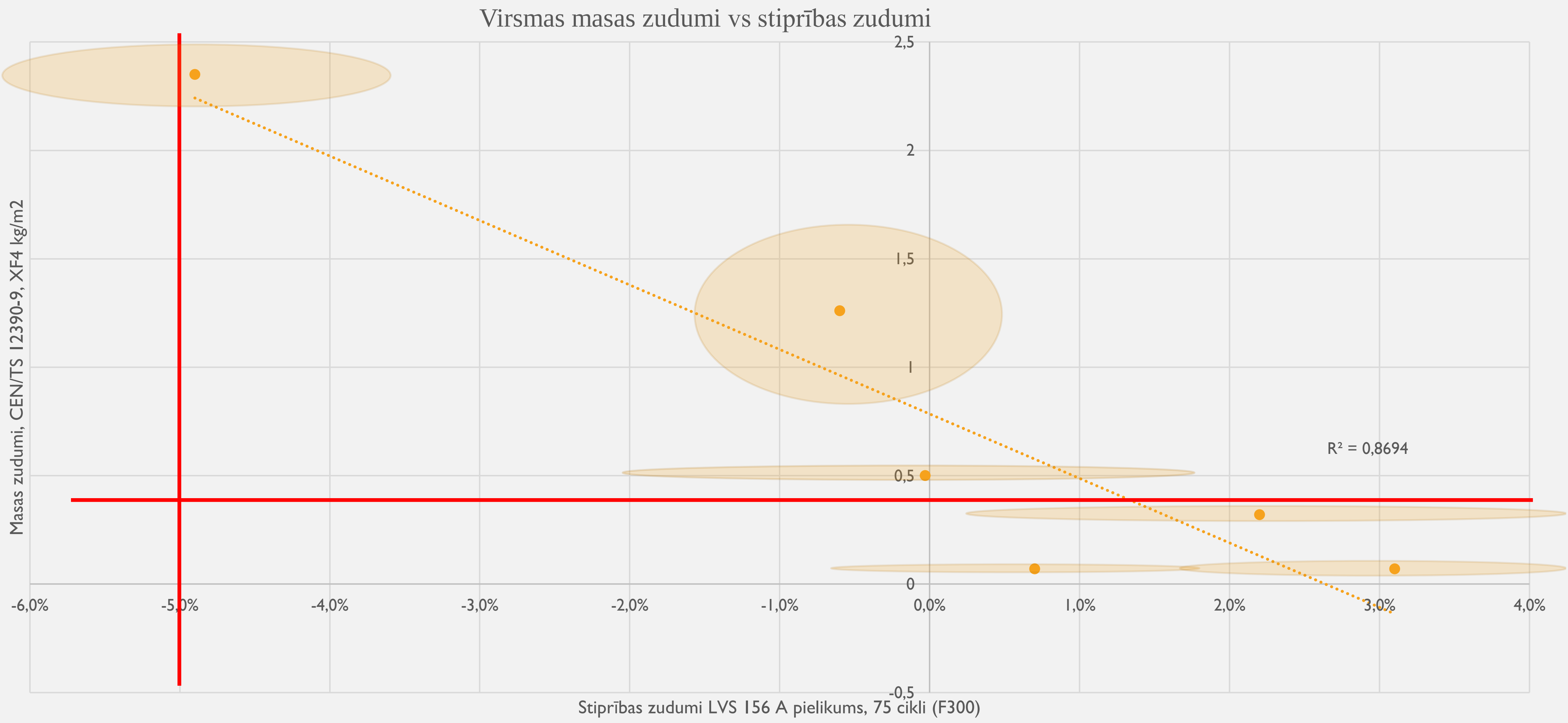
Vidējie paraugu masas zudumi kg/m2, CEN TS 12390-9
2,500
2,000
1,500
1,000
0,500
0,000
Masas zudums pēc 7 cikliem kg/m2
Masas zudums pēc 14 cikliem kg/m2
Masas zudums pēc 28 cikliem kg/m2
Masas zudums pēc 42 cikliem kg/m2
Masas zudums pēc 56 cikliem kg/m2
CEM II A-P, Ū/C 0,45
CEM II A-P, Ū/C 0,38
CEM I, Ū/C 0,45
CEM I, Ū/C 0,37
CEM II A-LL, Ū/C 0,45
CEM II A-LL, Ū/C 0,37
Standarta limits

REZULTĀTI

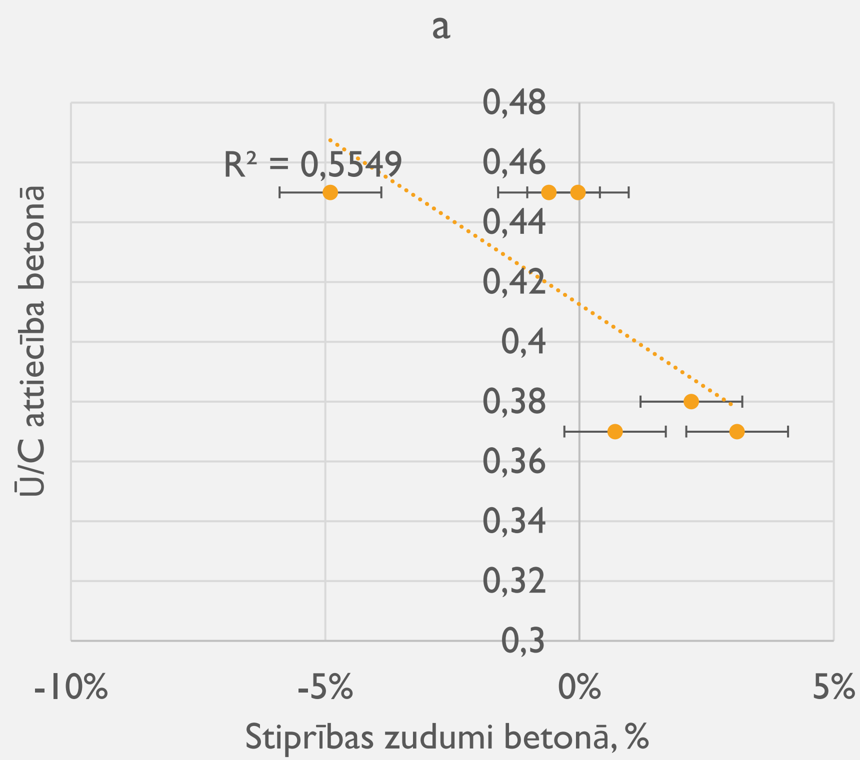
CEM II A-LL 52,5 N,
Ū/C 0,45

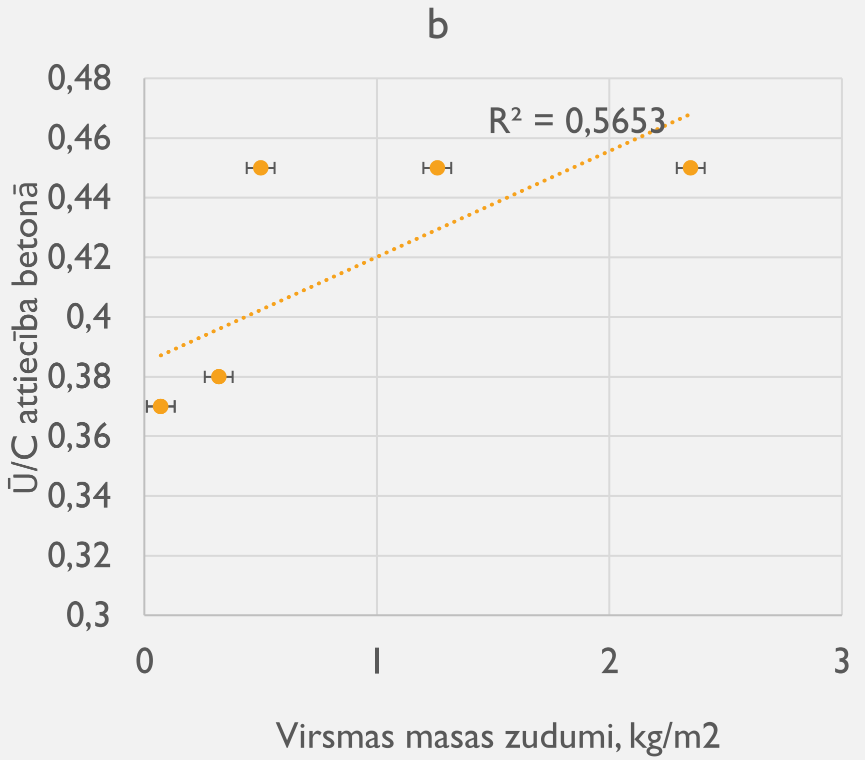
CEM II A-LL 52,5 N,
Ū/C 0,37

REZULTĀTI - KORELĀCIJAS



REZULTĀTI - KORELĀCIJAS





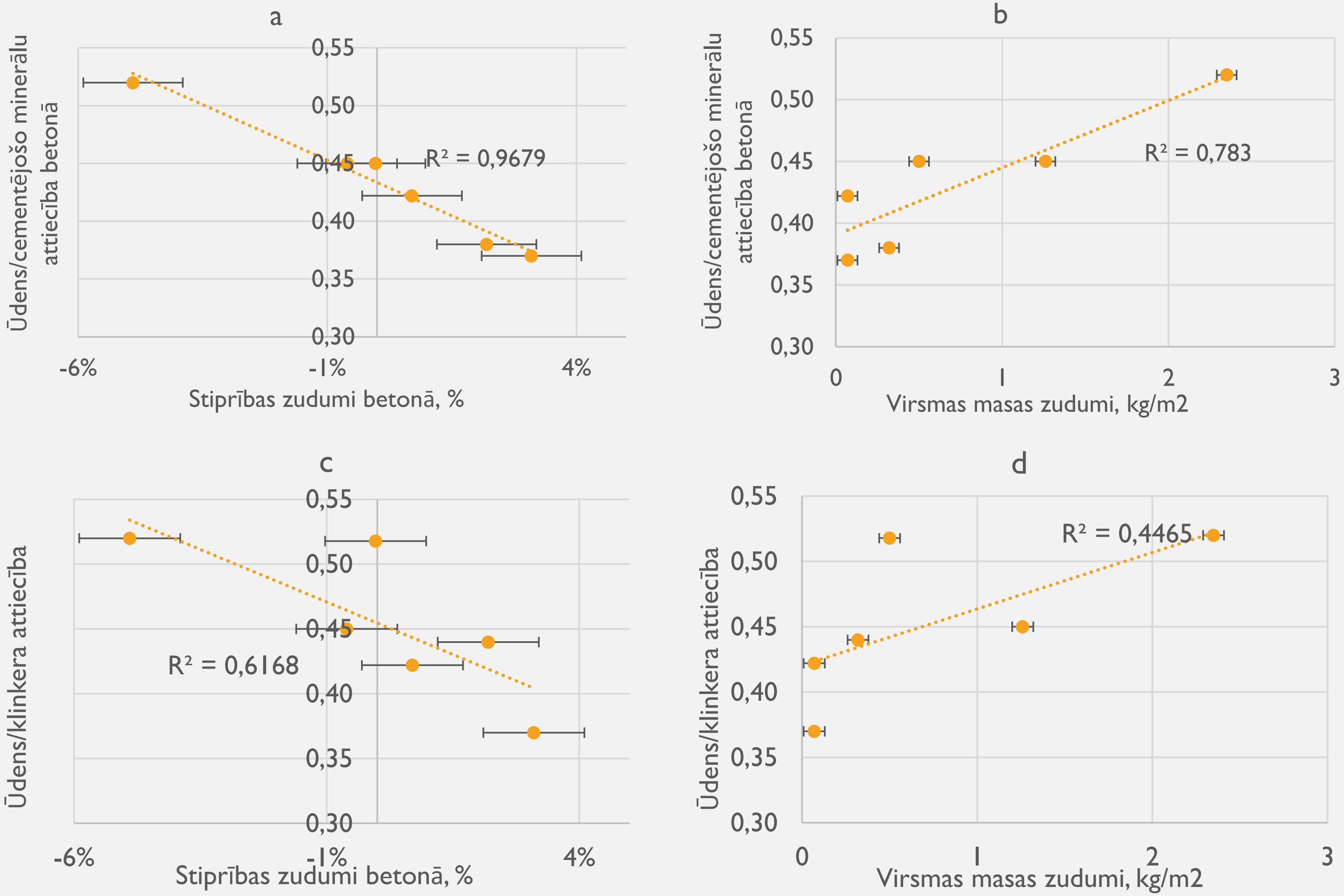
Ū/C attiecības ietekme uz betona stiprības zudumiem (a) un virsmas masas zudumiem (b).

REZULTĀTI - KORELĀCIJAS

Klinkera un cementa piedevu ietekme uz betona kapilāro porainību un salizturību:

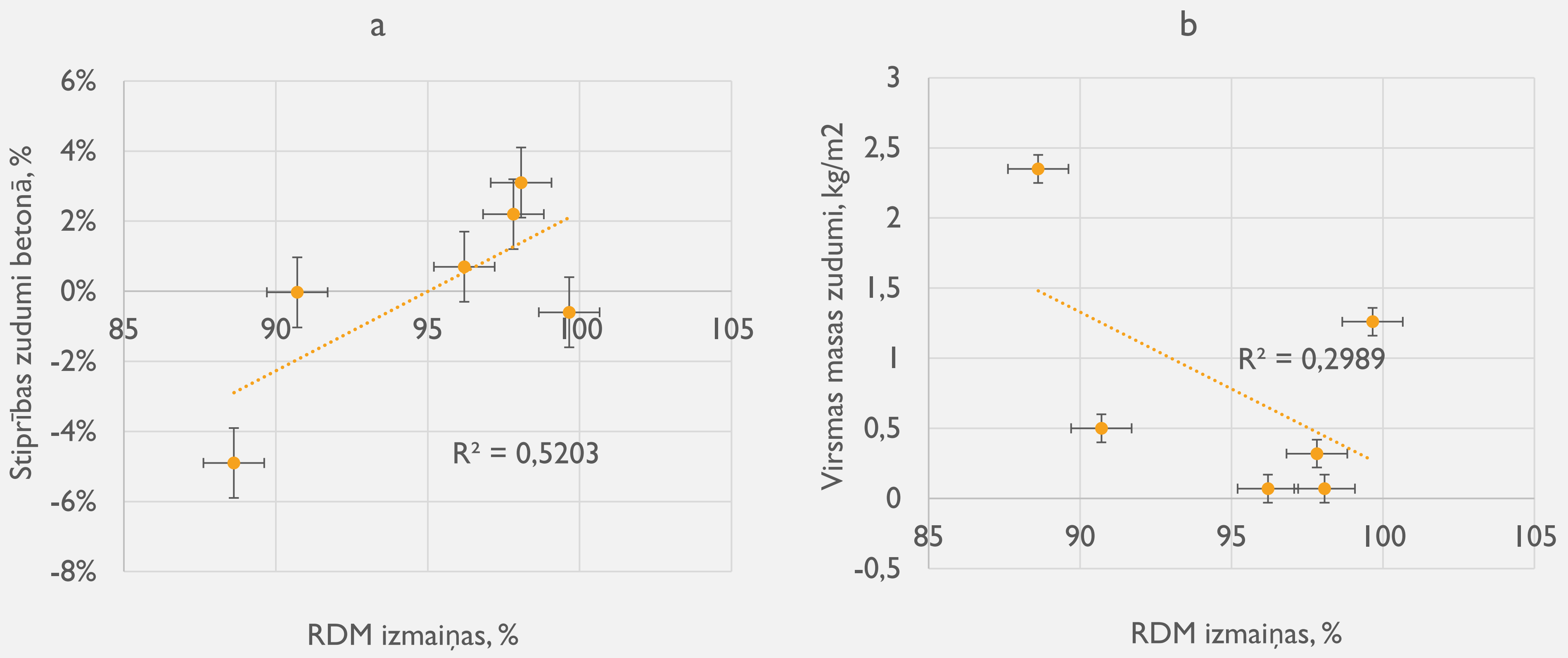
- CEM I 42,5 N SR3 – 95% klinkers
- CEM II A-P 52,5 N – 80% klinkers + 15% opoka (dabīgais pucolāns, piedalās CSH reakcijās) = 95% cementējošie minerāli
- CEM II A-LL 52,5 N – 80% klinkers + 15% kaļķakmens (vairāk kā latenta piedeva) = 80% cementējošie minerāli

REZULTĀTI - KORELĀCIJAS



Ūdens/cementējošo minerālu (a un b) attiecības ietekme un ūdens/klinkera attiecības (c un d) ietekme uz betona stiprības zudumiem un virsmas masas zudumiem.

REZULTĀTI - KORELĀCIJAS



Stiprības zudumu (a) un virsmas masas zudumu (b) sakarība ar RDM izmaiņām.

SECINĀJUMI

1. Pastāv laba korelācija starp betona virsmas masas zudumu un stiprības zudumu salizturības noteikšanas metodēm ar aprēķināto korelācijas koeficientu R2=0,8694.

2. Veicot paraugu mikrostruktūras pētījumus ar SEM, atšķirības betona mikrostruktūrā starp abām metodēm pakļautajiem paraugiem nav novērojamas.

3. Lai panāktu labu betona noturību pret sala-sāls zvīņošanos, nepietiek ar labu gaisa mikroporu sadalījumu betona matricā, bet nepieciešama arī zemāka Ū/C attiecība, nekā standarts to pieļauj. Laba noturība pret betona virsmas masas zudumiem tiek panākta, ja betona Ū/C attiecība <0,4.

4. Vissprecīzākā korelācija ar salizturības rezultātiem tika iegūta salīdzinot tos ar ūdens/cementējošo minerālu attiecību betonā. Korelācija ar stiprības zudumiem tika iegūta R2=0,9679. Ņemot šo vērā, būtu rekomendējams līdzīgu pieeju aprobēt arī attiecīgajā valsts standartā, nosakot maksimālo pieļaujamo ūdens/cementējošo minerālu attiecību betonā, vai arī noteikt zemāku pieļaujamu Ū/C attiecību kaļķakmeni saturošiem kompozītcementiem.

SECINĀJUMI

5. Pētījuma ietvaros neizdevās iegūt pietiekami labu korelāciju starp RDM samazinājumu virsmas masas zudumu testam pakļautajiem paraugiem ar stiprības zudumu testu rezultātiem. Galvenais iemesls tam visticamāk ir atšķirīgs references paraugu testēšanas vecums līdz ar to atšķirīga betona hidratācijas pakāpe.

6. Ņemot vērā, ka visi testētie paraugi izturēja standarta prasības attiecībā uz stiprības zudumiem, bet puse no paraugiem neizturēja standarta prasības attiecībā uz virsmas masas zudumiem, virsmas masas zudumu testēšanas metode ir uzskatāma par drastiskāku un būtu izvirzāma kā pamata metode LVS EN 156-1 standartā.

7. Turpmākajos pētījumus, lai iegūtu pilnīgāku informāciju par betona salizturību ietekmējošajiem faktoriem, nepieciešams apskatīt sekojošus jautājumus:

- betona salizturība pie Ū/C<0,4, bet nepietiekama gaisa mikroporu daudzuma vai sadalījuma;
- citu cementa veidu ietekme uz betona salizturību;
- betona II tipa piedevu (smalki dispersie pelni, mikrosilīcijs, malti granulētie domnas sārņi) izmantošanas ietekme uz betona salizturību un Ū/C attiecības aprēķina metodika tos izmantojot.

Latvijas
Betona
Savienība

Latvijas XX Betona olimpiāde – 2023

XX Latvian Concrete Olympic – 2023

Prezentāciju sagatavoja:

Genādijs Šahmenko (RTU),

Tomasz Nowacki (STACHEMA Polska)

22-23th November, 2023

Latvijas Betona olimpiāde – 2023

ŽURIJAS KOMANDA

Ģirts Būmanis

Egīls Zvejnieks

Pauls Ārgalis

Ģirts Kolendo

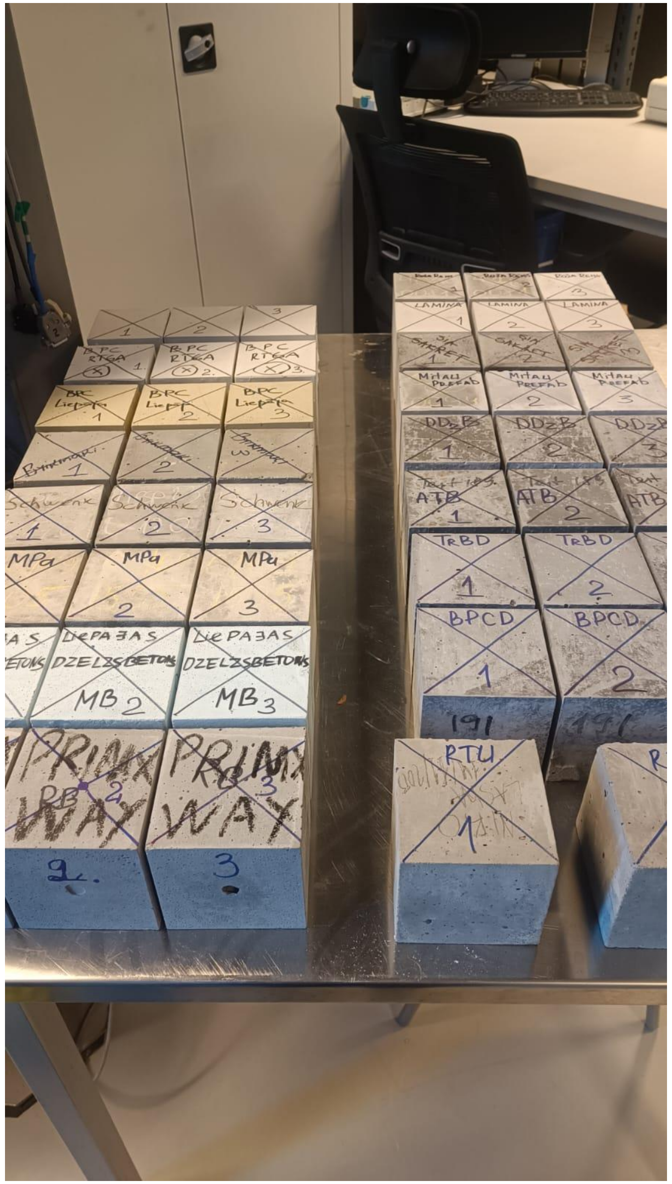
Eduards Protasevičs

Andrejs Krasņikovs

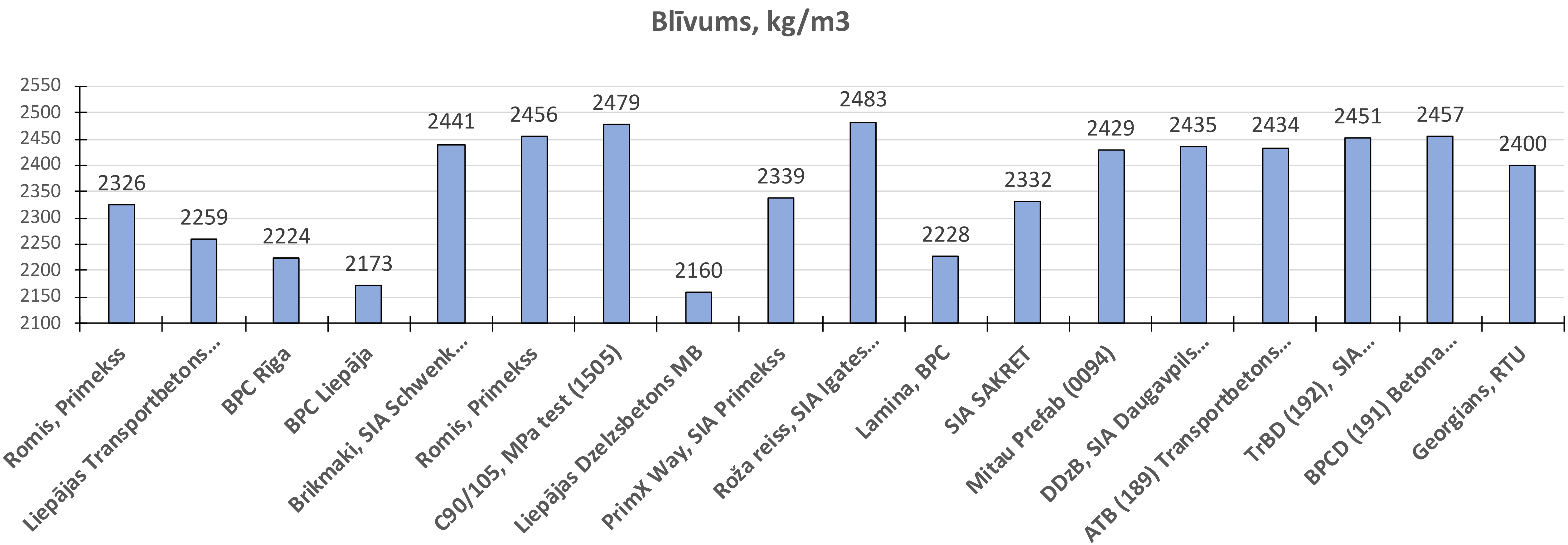
Genādijs Šahmenko

Latvijas Betona olimpiāde – 2023 DALĪBNIEKI UN PARAUGU APZĪMĒJUMI

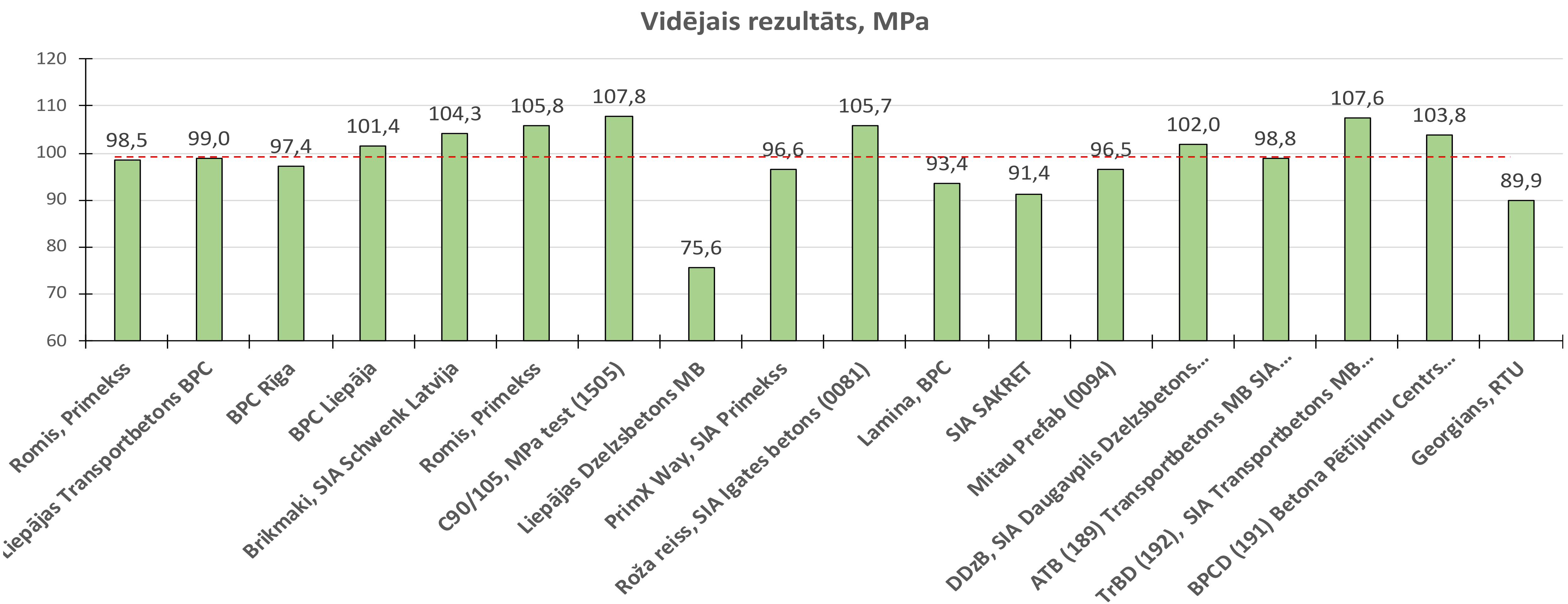
1	Romis, Primekss
2	Liepājas Transportbetons BPC
3	BPC Rīga
4	BPC Liepāja
5	Brikmaki, SIA Schwenk Latvija
6	SCHWENK
7	C90/105, MPa test (1505)
8	Liepājas Dzelzsbetons MB
9	PrimX Way, SIA Primekss
10	Roža reiss, SIA Igates betons (0081)
11	Lamina, BPC
12	SIA SAKRET
13	Mitau Prefab (0094)
14	DDzB, SIA Daugavpils Dzelzsbetons (190)
15	Mitau Prefab (0094)
16	TrBD (192), Transportbetons MB SIA Daugavpils
17	BPCD (191), Betona Pētījumu Centrs Daugavpils
18	Georgians, RTU



Latvijas Betona olimpiāde – 2023

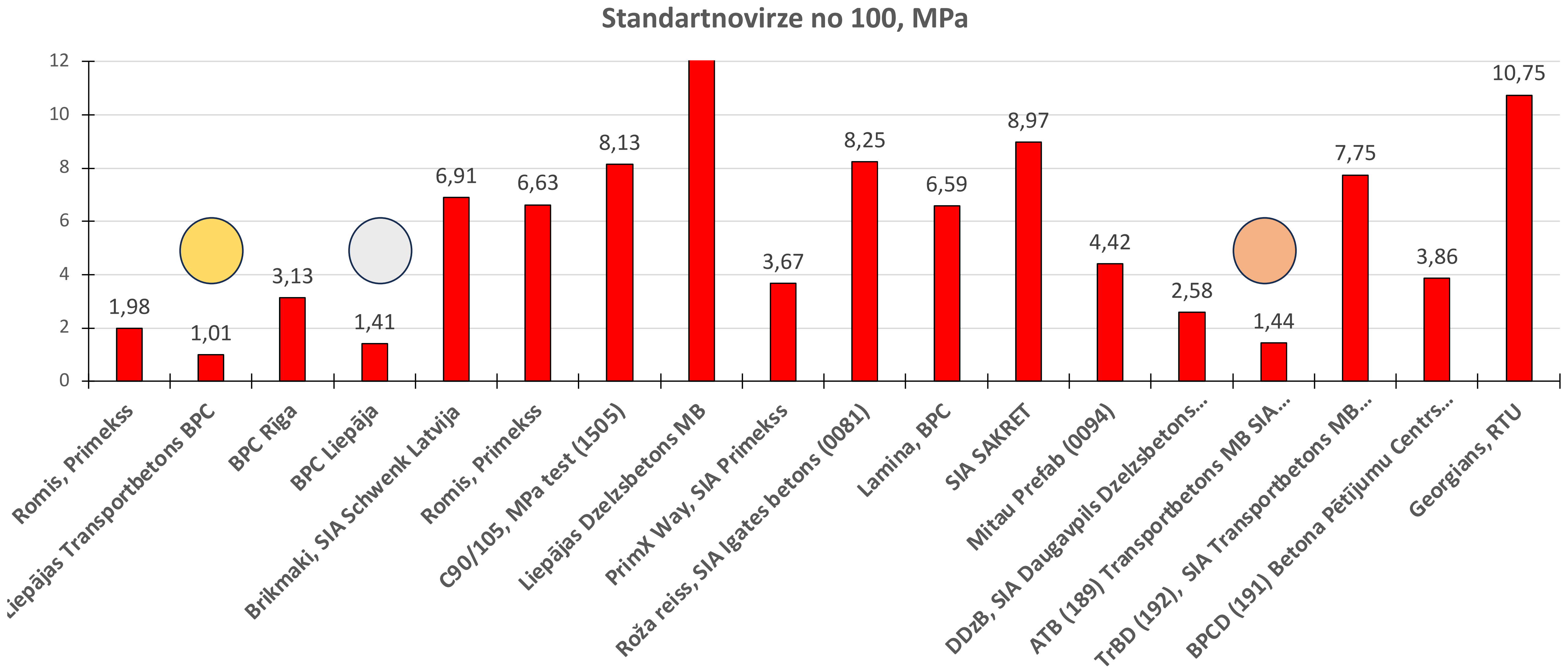


Latvijas Betona olimpiāde – 2023



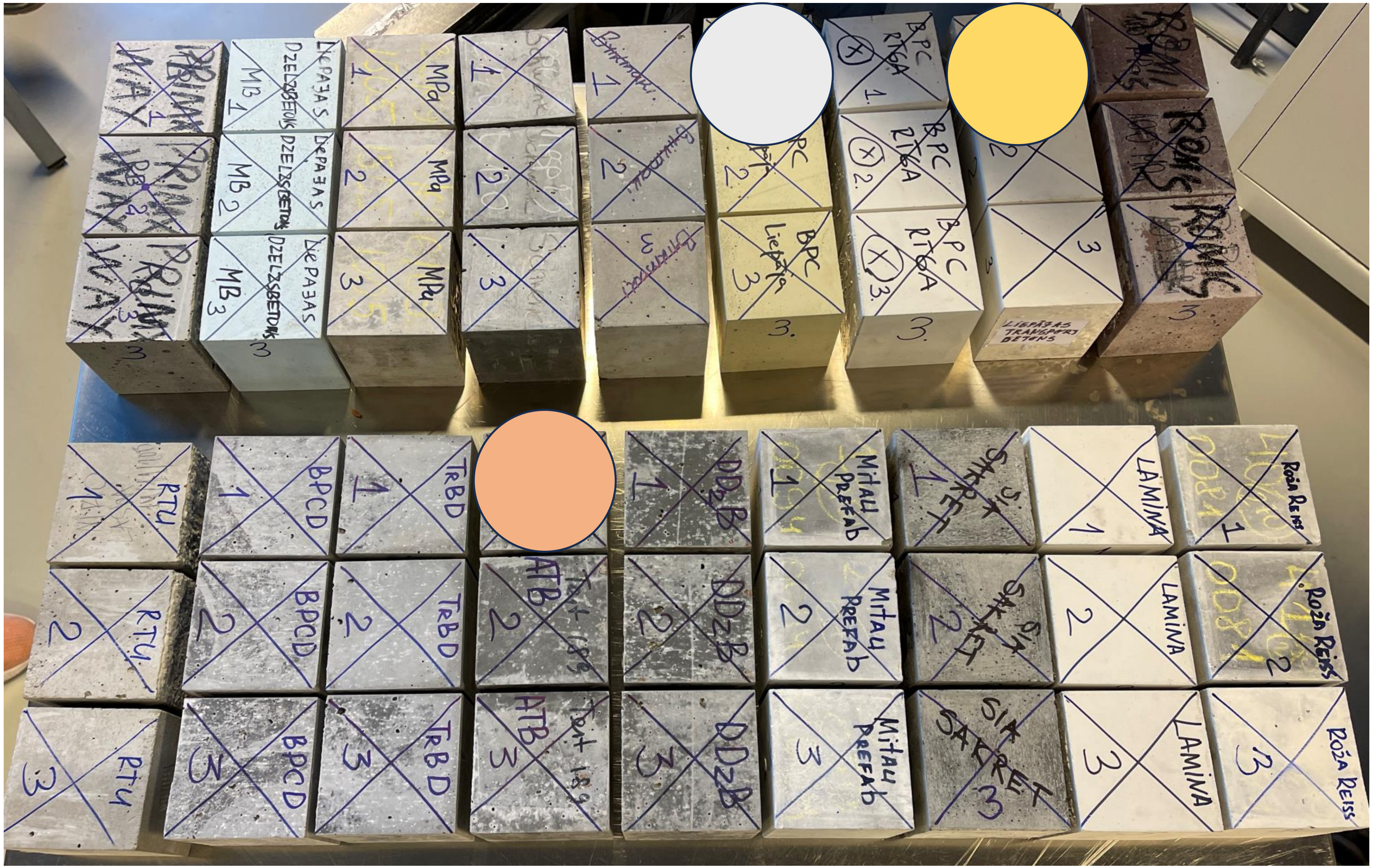
Latvijas Betona olimpiāde – 2023

DALĪBNIEKI UN PARAUGI



Latvijas Betona olimpiāde – 2023

DALĪBNIEKU PARAUGI



Latvijas
Betona
Savienība

Betona olimpiādes atbalstītājs – Stachema Polska

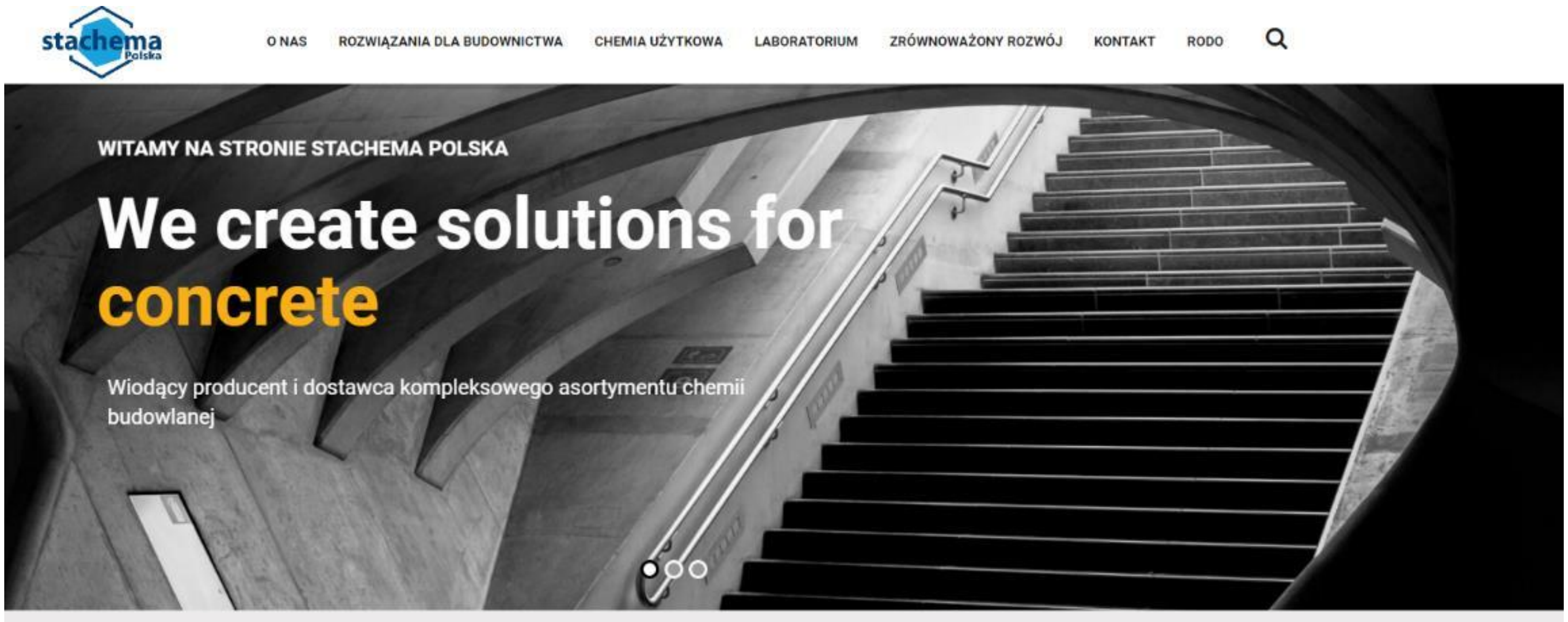
Supporter of the Concrete Olympiad - Stachema Polska

- Chemicals for building materials
- Concrete and mortar accelerators/hardeners
- Concrete and mortar retardants
- Concrete and mortar antifreeze agents
- Concrete and mortar bonding agents
- Concrete and mortar plasticisers
- Concrete and mortar guniting additives
- Concrete debonding agents
- Waterproofing agents for concrete and mortar
- Retardants for plaster
- Thickening agents for plaster

stachema Polska

STACHEMA POLSKA
tel. +48695732604

Tomasz Nowacki (STACHEMA Polska, Vice-President)



Concrete durability testing of air field concrete

Artūrs Krūmiņš

Jānis Kudiņš

A7 BETONS is concrete pavement construction company

We build concrete airports, roads and military projects

We established A7 BETONS in 2017

We have built ~ 500`000m^2 concrete pavements in over 40 projects in 4 countries

We work for clients like USA Army, NATO, MODs, Airports, Contractors

We are always learning to build better concrete


We have built the first public concrete road in Latvia since Latvia gained back independence.

Road in Ādaži, Kadaga, Mežaparka ceļš

Concrete road in Kadaga was built in November 2021
Length 1,5km
This will serve as a real life example to show benefits of concrete roads to everybody in our society

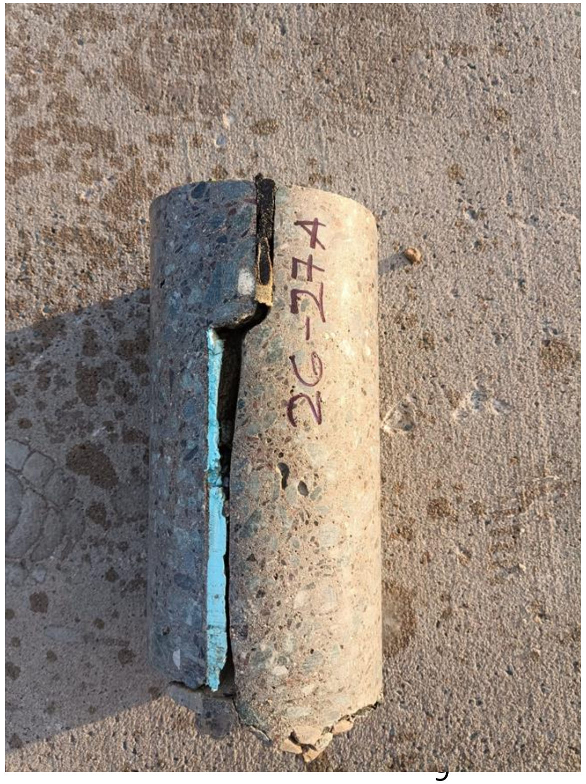
Today I want to tell You about interesting things that we found during design of reconstruction of concrete airport apron.

Project size is 10 ha.
Volume 30`000 m3.

- This project was built 10 years ago and it should have lasted for 50+ years, but after few years it was not usable anymore. Due to scaling.
- But this was only the visible part of the defects.

Original designers idea was to build a 8cm thin bonded overlay on top of existing and solve the scaling issue this way. All other things seemed to be good.

Until we started investigations...



We found that even though from surface only scaling issue could be seen, but inside the concrete had mayor mechanical and structural problems:
Cantilever joints, mislocated expansion joints, horizontal cracks, poorly compacted concrete, not enough/too large reinforcement cover, reinforcement corrosion.
Due to low traffic intensity and low loads these issues had not been coming out yet.

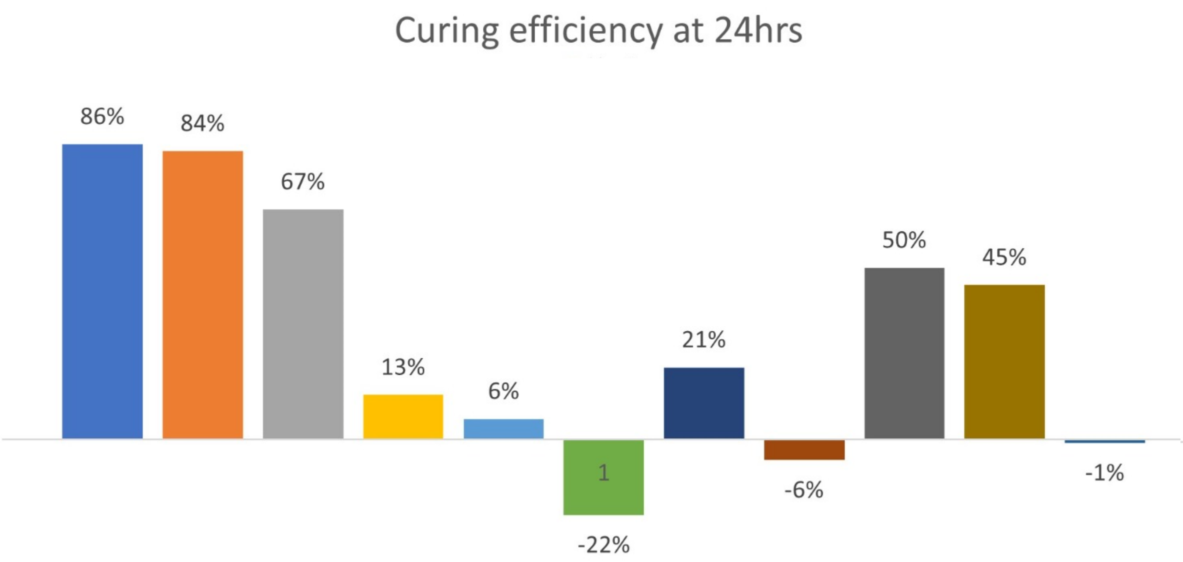
During our investigations we found also interesting things about airport de-icing chemicals....

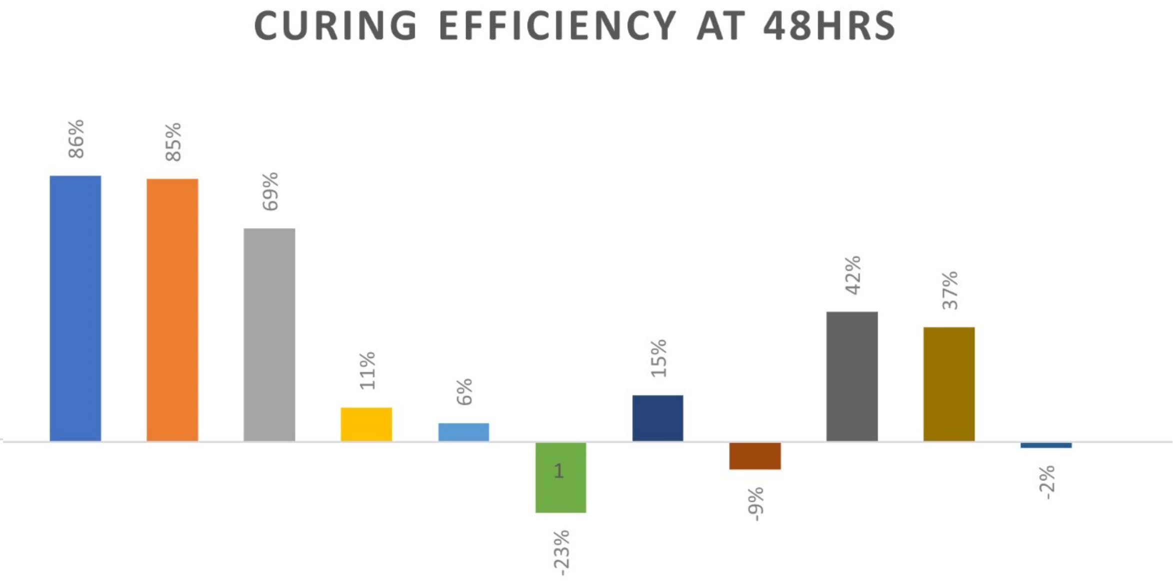
Usually salt (NaCl) is used for scaling tests.

It was found out that different chemicals have different impact on the scaling, some de-icers are even up to 20x more aggressive than regular salt.

During the experience we also better understood the importance of curing and many aspects of it....

1. Curing as material quality
2. Multiple layer curing
3. Rain impact on concrete scaling





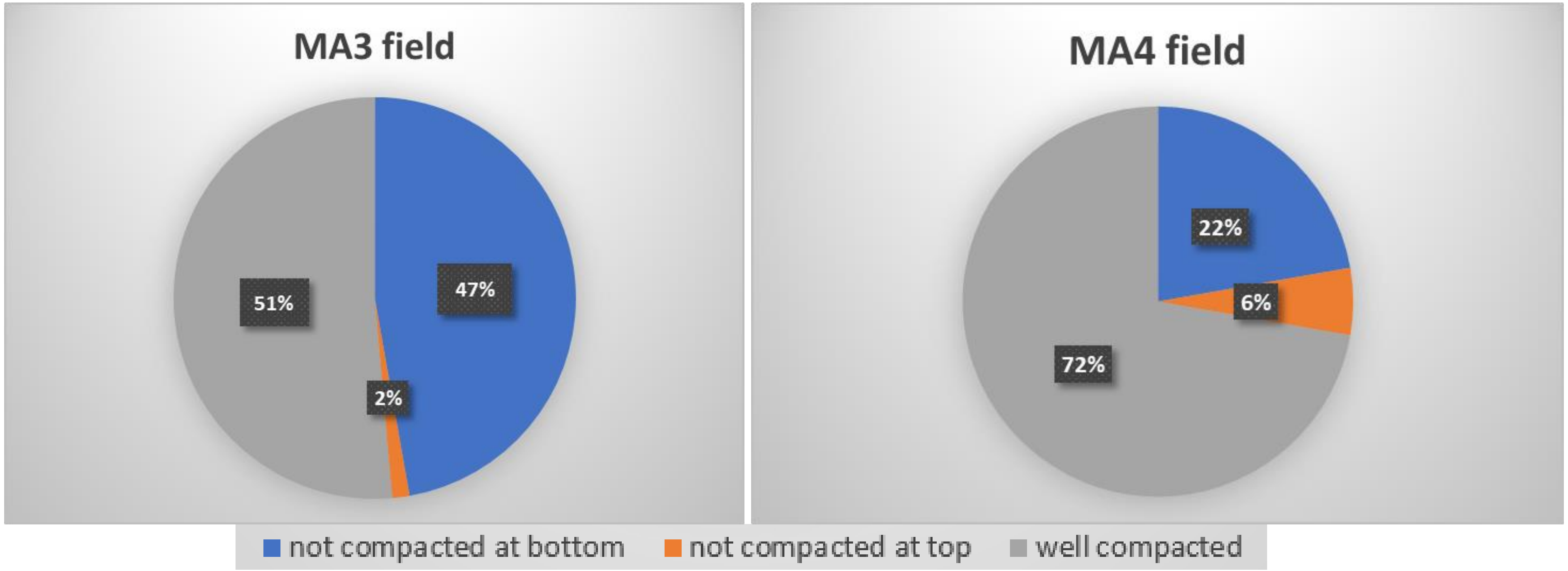
Samples and testing plan

MB GRUPA BETONA PĒTĪJUMU CENTRS

Cores D100 mm – 50 pcs
Cores D150 mm – 40 pcs

Test standard	Name of standard	Tested parameters
LVS 156-1 Annex A	«Testing method for determinating the frost resistance (F/T) of concrete»	F/T resistance is conformed F300. Sstrength reduction after F/T.
CEN TS 12390-9 slab test and CEN TS 15177 (RDM)	«Freeze-thaw resistance with deicing salt -scaling, Slab test» «Testing the freeze-thaw resistance of concrete-Internal structural damage»	Internal structural damages in the concrete due to the F/T. Is concrete samples meet the XF4 exposure durability class
SS 137244	«Frost resistance. Concrete testing-Hardened concrete-Scaling at freezing»	The amount of the scaled materials from the surface. Is concrete samples meet the XF4 exposure durability class
by 72	«Concrete quality assurance-Part 1- "Determination of air pore parameters of concrete from fine aggregates"»	Internal structure of concrete. Possible damages caused by F/T
LVS EN 480-11	«Determination of air void characteristics in hardened concrete»	Possible damage causes by F/T. Air pore analysis

Visual inspection of the samples



EN 12390-9 slab test

Sample ID	Cumulative mass of the dried scaled material, g/m^2				
	7 cycles	14 cycles	28 cycles	42 cycles	56 cycles
MA3 31A-4	48	90	1159	-	-
MA3 1E-2	41	793	6634	-	-
MA3 32B	55	738	4669	-	-
MA3 24B-4	14	172	3434	-	-
MA3 23B-2	172	1000	3524	-	-
Average	**66**	**559**	**3884**		

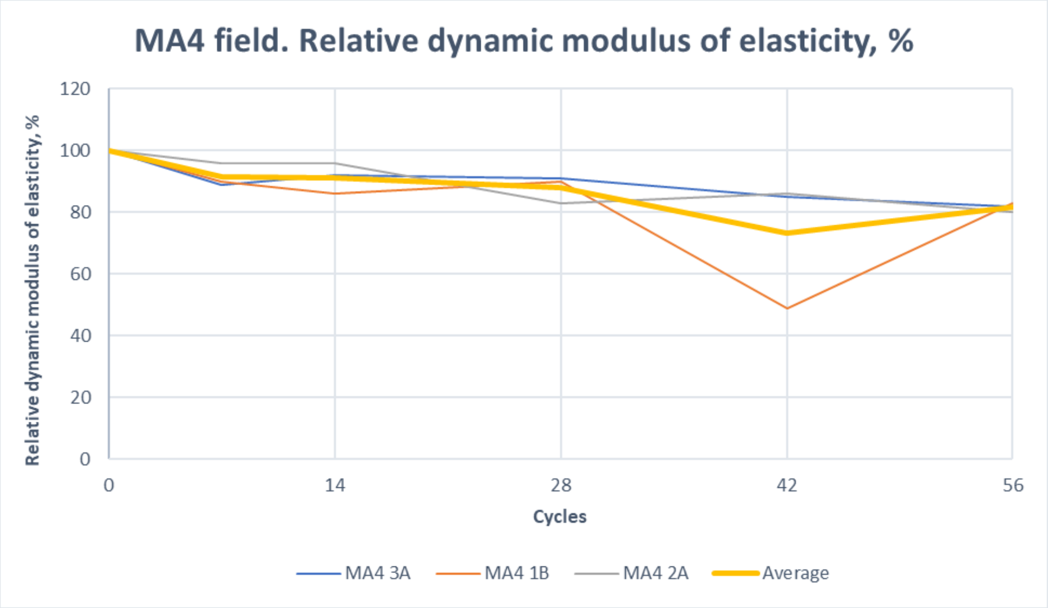
Sample ID	Cumulative mass of the dried scaled material, g/m^2				
	7 cycles	14 cycles	28 cycles	42 cycles	56 cycles
MA3 28B	49	82	115	131	131
MA3 36C	115	180	1016	1393	1459
MA3 4B	98	1869	11590	15262	16393
MA3 1C	967	1738	4098	6803	7885
MA3 37A	16	33	49	49	49
MA3 10A	885	951	1295	1869	2426
Average	**355**	**809**	**3027**	**4251**	**4724**

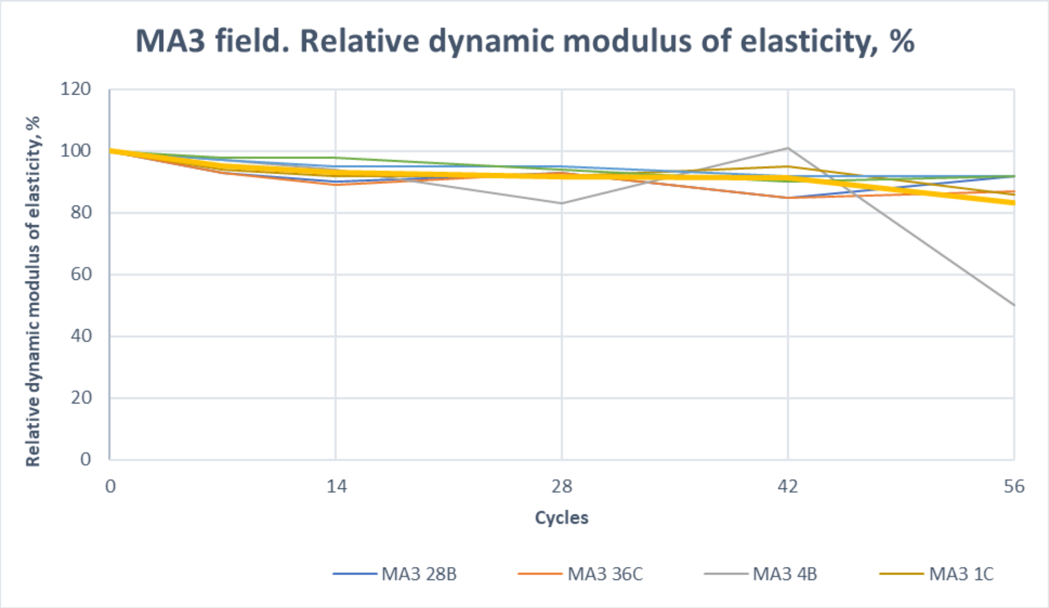
Sample ID	Cumulative mass of the dried scaled material, g/m^2				
	7 cycles	14 cycles	28 cycles	42 cycles	56 cycles
MA4 1B	49	66	66	82	82
MA4 2A	98	148	262	311	328
MA4 3A	131	180	230	246	246
Average	**93**	**131**	**186**	**213**	**219**

According to Finnish Betoninormit 2021 and SFS 7022 requirements for frost resistance of hardened concrete is:

Service life 50 years - XF4, scaling mass ≤ 350 g/m^2
Service life 100 years - XF4, scaling mass ≤ 250 g/m^2

CEN/TR 15177. Internal structural damages

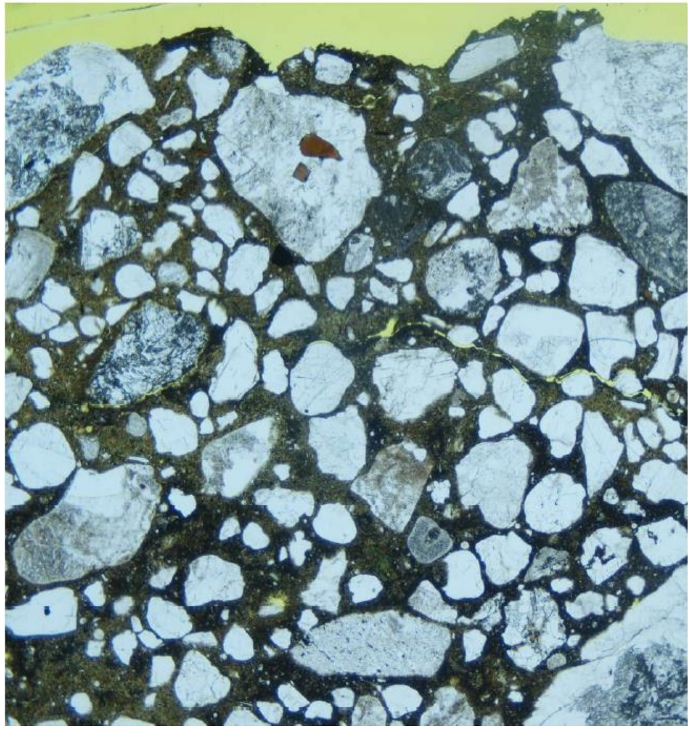




According to the RILEM TC 176-IDC: "Internal damage of concrete due to frost action", the concrete is defined as damaged when the relative modulus of elasticity after 56 cycles is less than 80%.

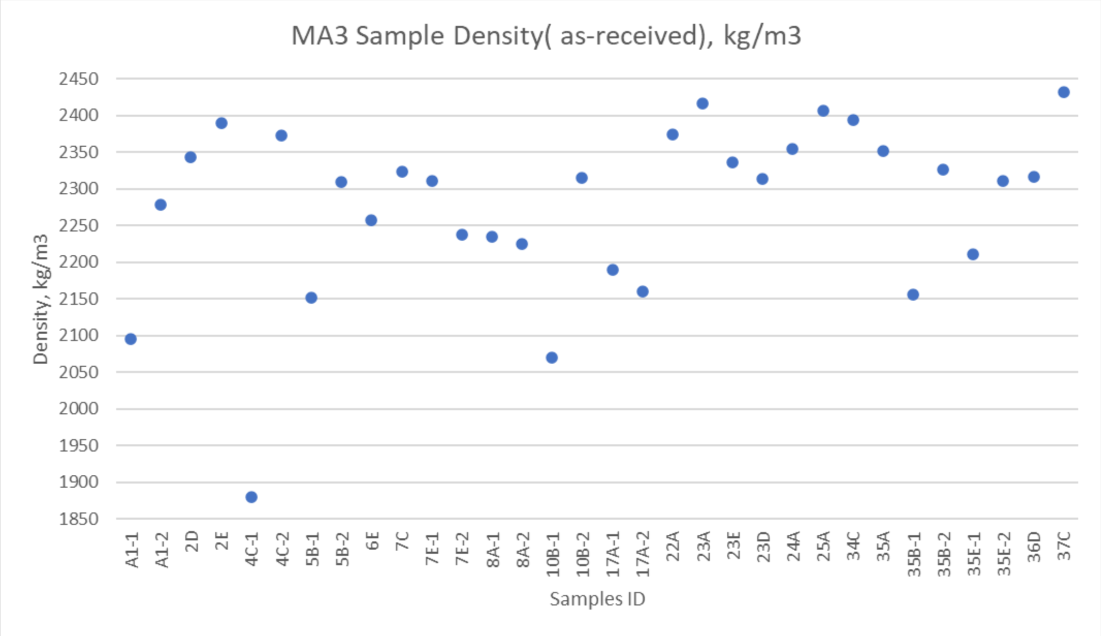
by72 Concrete quality assurance-Part 1- “Determination of air pore parameters of concrete from fine aggregates”

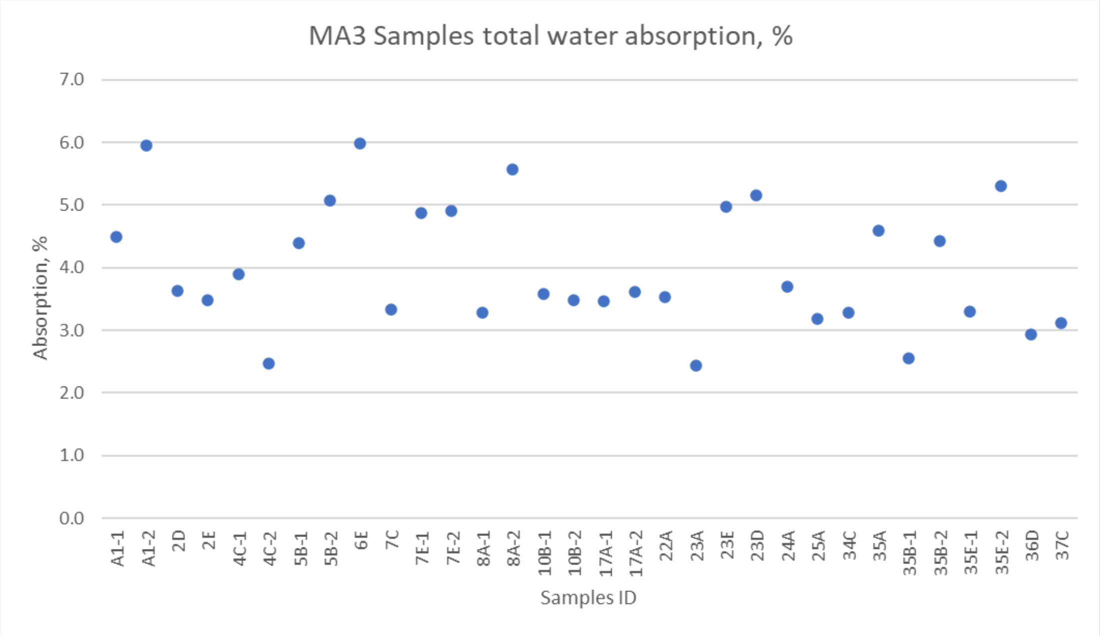
Sample ID	Total volume of air*, %	Number of protective pores (ø 0.020-0.800 mm), %	Number of compaction pores (ø>0.800 mm), %	Specific surface area of protective pores, mm^2/mm^3	Amount of binder paste on the sample, %	Spacing factor of protective pores (mm)
MA3 4B	2.7	1.2	1.5	22	32	>0.40
MA3 10A	4.1	2.5	1.6	25	28	0.26
MA3 26B-1	2.1	1.2	1.0	23	27	>0.40
MA4 1C	5.2	2.0	3.2	21	32	0.38
MA4 3/4A	3.1	1.2	1.9	19	29	>0.40
MA4 5/A	3.7	2.0	1.8	18	33	>0.40



Concrete code by65 2021 sets the required spacing factor of protective pores of freeze-thaw resistance concrete at ≤ 0.22 mm (the most demanding value) … ≤ 0.27 mm (the least demanding value) depending on the water-cement ratio, exposure class and design service life

Samples density and water absorption



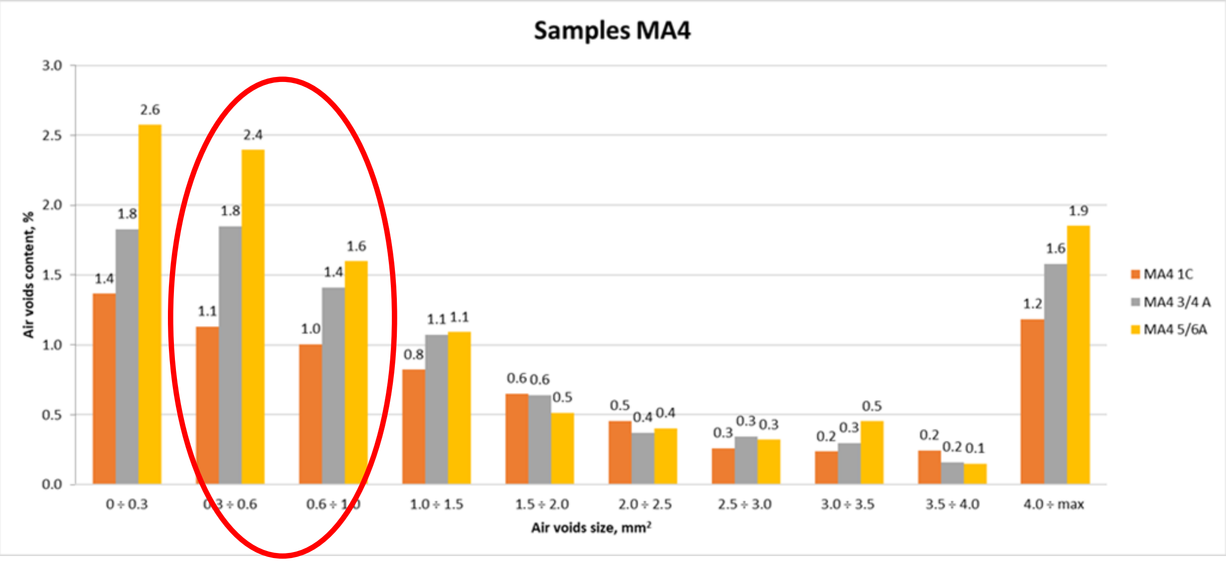


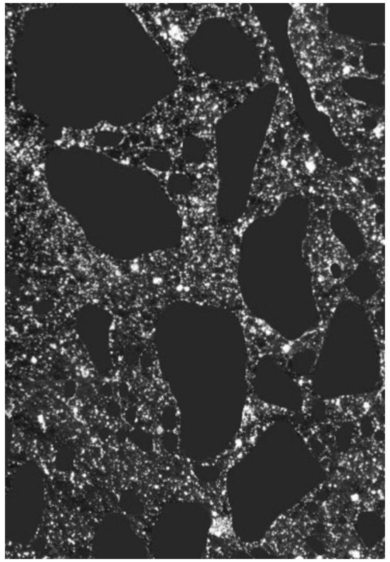
Air void analysis. Image analysis to quantify the air void system of hardened concrete

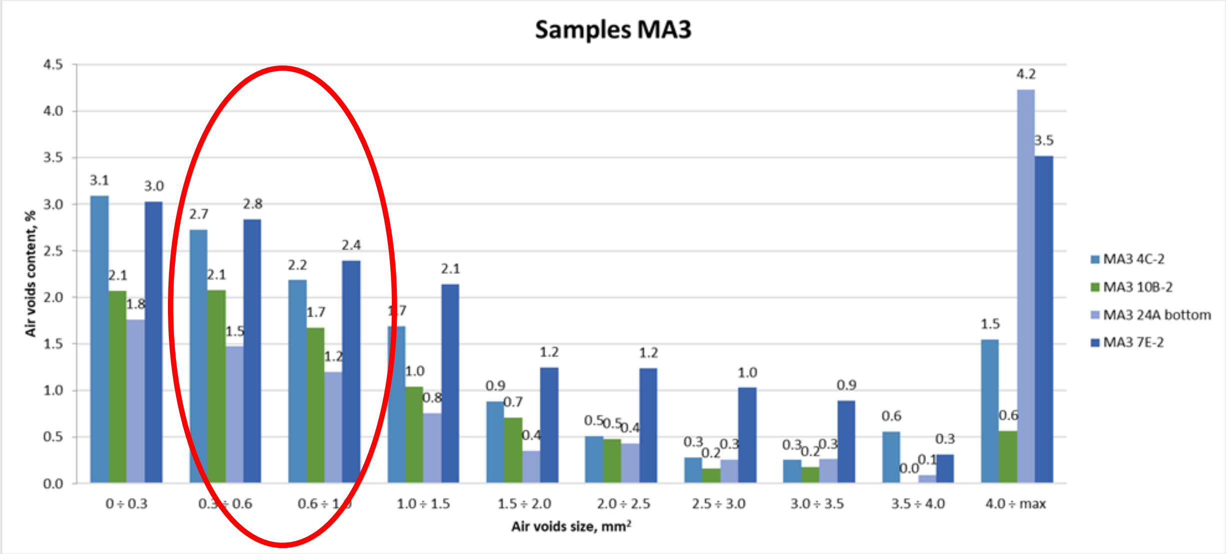
MA3

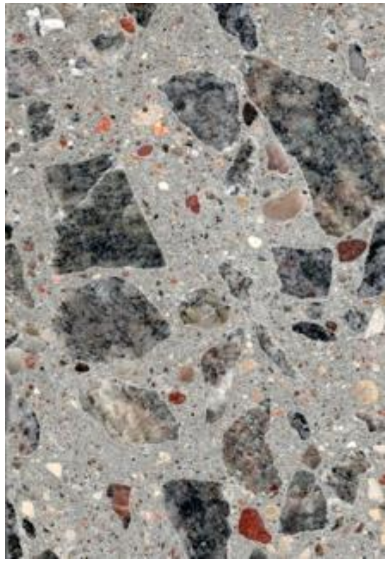
Nr	Sample ID	A_{300}, %	Total air content, %
1	4C-2	3.1	13.7
2	7E-2	3.0	18.6
3	10B-2	2.1	9.0
4	24A bottom	1.8	10.8
5	27A top	2.9	10.2
6	26A-2 bottom	1.3	15.5
7	37B bottom	1.4	7.6
8	26A-2 top	1.1	10.1
9	8A-2 bottom	2.5	9.8
10	8A-2 top	1.3	27.4
11	5B-2	1.3	11.6

According to the requirements of ZTV Concrete/Beton-StB 07, the micropore content A^{300} (air pores below 0.03mm) must be ≥1.5%.









Concrete compaction and curing have a huge impact on concrete durability

Latvijas Betona Savienība

http://fb.com/betonasavieniba

TK01 – Betona salizturība un LVS 156-1:2022

LBS **31.** zinātniski tehniskā konference, 23.11.2023

Jānis Zāle

TK01 – BETONA SALIZTURĪBA

LVS 156-1:2017 – jaunā versija LVS 156-1:2022.

Par mums | Jaunumi | Standartizācija | Standarti | Likumdošana | Noderīgi

solis 1 - meklē | solis 2 - izvēlies | solis 3 - iestatījumi | solis 4 - grozs | solis 5 - apmaksa

Ielikt grozā

Priekšskatīt

Saraksts

Formāti	Numurs / Nosaukums	Statuss	Cena EUR
	LVS 156-1:2022		30.69 €
	Betons. Latvijas nacionālais pielikums Eiropas standartam EN 206 "Betons. Tehniskie noteikumi, darbu izpildījums, ražošana un atbilstība"		

Angliski
Concrete - Latvian National Annex to European standard EN 206 "Concrete - Specification, performance, production and conformity"

Valodas: Latviešu valoda

Veids: standarts

ICS grupas: 91.100.30 Betons un betona izstrādājumi

Izstrādātājs: LVS/STK/04 Būvmateriāli

Reģistrācijas datums: 18.08.2022.
Spēkā no: 18.08.2022.

- Aizstātie dokumenti
- LVS 156-1:2017

Attēlotā redakcija 08.09.2023.-... Spēkā esošā

Ministru kabineta noteikumi Nr.156

Rīgā 2014.gada 25.martā (prot. Nr.18 2.§)

Būvizstrādājumu tirgus uzraudzības kārtība

Piemērojamo standartu saraksts

Nr. p. k.	Nosaukums	Aizstātā standarta nosaukums	Standartu līdzāspastāvēšanas laikposma beigu datums
1.	LVS 203-2:2005 "Stikla materiāli būvniecībai. Stikla šķiedras sieti apmetuma javas stiegrošanai. Tehniskie noteikumi"		
2.	LVS 156-1:2022 "Betons. Latvijas nacionālais pielikums Eiropas standartam EN 206 "Betons. Tehniskie noteikumi, darbu izpildījums, ražošana un atbilstība""	LVS 156-1:2017 "Betons. Latvijas nacionālais pielikums Eiropas standartam EN 206:2013 "Betons. Tehniskie noteikumi, darbu izpildījums, ražošana un atbilstība""	01.03.2024.
3.	(Svītrots ar MK 21.11.2017. noteikumiem Nr. 680)		

TK01 – BETONA SALIZTURĪBA

LVS 156-1:2022 galvenās izmaiņas

5.1. tabula. Sacietējuša betona salizturībai noteiktās prasības saskaņā ar CEN/TS 12390-9[1]

Ārējās vides iedarbības klase	CEN/TS 12390-9 5.p. (plātnes tests)
	Masas zudumi pēc 56 cikliem (g/m²)
XF1	$m_{56} \le 1000$
XF2	$m_{56} \le 650$[2]
XF3	$m_{56} \le 500$
XF4	$m_{56} \le 350$[2]

PIEZĪME

[1]Metode attiecināma uz betoniem, kuriem primāra ir konstrukcijas funkcionālās virsmas noturība pret sala iedarbību – galvenokārt ceļu un laukumu nodilumvirsmām, kā arī nenesošajiem un pašnesošajiem dekoratīvajiem betona elementiem.

[2] Salizturības pārbaudi veic, betona paraugus izturot 3% nātrija hlorīda (NaCl) šķīdumā.

5.1. tabula. Sacietējuša betona salizturībai noteiktās prasības saskaņā ar CEN/TS 12390-9[1)]

Ārējās vides iedarbības klase	Projektētais betona kalpošanas laiks gados[2)]	LVS CEN/TS 12390-9 5.p. (plātnes tests), masas zudumi pēc 56 cikliem (g/m²)
XF1 (dejonizētā ūdenī)	50	$m_{56} \le 500$, vai $m_{56} \le 1000$, ja m_{56}/m_{28} attiecība ir mazāka kā 2
	100	$m_{56} \le 250$, vai $m_{56} \le 500$, ja m_{56}/m_{28} attiecība ir mazāka kā 2
XF2 (3% nātrija hlorīda (NaCl) šķīdumā)	50	$m_{56} \le 650$ vai $m_{56} \le 1300$, ja m_{56}/m_{28} attiecība ir mazāka kā 2
	100	$m_{56} \le 350$, vai $m_{56} \le 700$, ja m_{56}/m_{28} attiecība ir mazāka kā 2
XF3 (dejonizētā ūdenī)	50	$m_{56} \le 250$, vai $m_{56} \le 500$, ja m_{56}/m_{28} attiecība ir mazāka kā 2
	100	$m_{56} \le 100$, vai $m_{56} \le 250$, ja m_{56}/m_{28} attiecība ir mazāka kā 2
XF4 (3% nātrija hlorīda (NaCl) šķīdumā)	50	$m_{56} \le 350$ vai $m_{56} \le 700$, ja m_{56}/m_{28} attiecība ir mazāka kā 2
	100	$m_{56} \le 100$, vai $m_{56} \le 200$, ja m_{56}/m_{28} attiecība ir mazāka kā 2

PIEZĪMES

1) Metode attiecināma uz betoniem, kuriem primāra ir konstrukcijas funkcionālās virsmas noturība pret sala iedarbību.
2) Pēc noklusējuma tiek pieņemts betona projektētais kalpošanas laiks 50 gadi. Par nepieciešamību betona atbilstībai un kalpošanas kritērijiem 100 gadu periodam, prasībām jābūt skaidri definētām betona pasūtījumā un specifikācijā.

TK01 – BETONA SALIZTURĪBA

LVS 156-1:2022 galvenās izmaiņas

5.2. tabula. Sacietējuša betona salizturībai noteiktās prasības saskaņā ar LVS 156-1:2022 A pielikumu[1)]

Ārējās vides iedarbības klase	LVS 156-1:2022 A pielikums	
	Salizturības klase	Stiprības zudumi, %
XF1	F100	≤ 5
XF2	F200	
XF3	F200	
XF4	F300	

PIEZĪME

1) Metode attiecināma uz betoniem, kuri paredzēti būvkonstrukciju nesošajām konstrukcijām, un primāra ir to stiprības nodrošināšana visā ekspluatācijas periodā pie atbilstošām iedarbības klasēm.

TK01 – BETONA SALIZTURĪBA

Tālākais darbs standartu jomā – 2024.-2025.gadam???

~~PIEZĪME~~

~~[1] Metode attiecināma uz betoniem, kuri paredzēti būvkonstrukciju nesošajām konstrukcijām, un primāra ir to stiprības nodrošināšana visā ekspluatācijas periodā pie atbilstošām iedarbības klasēm.~~

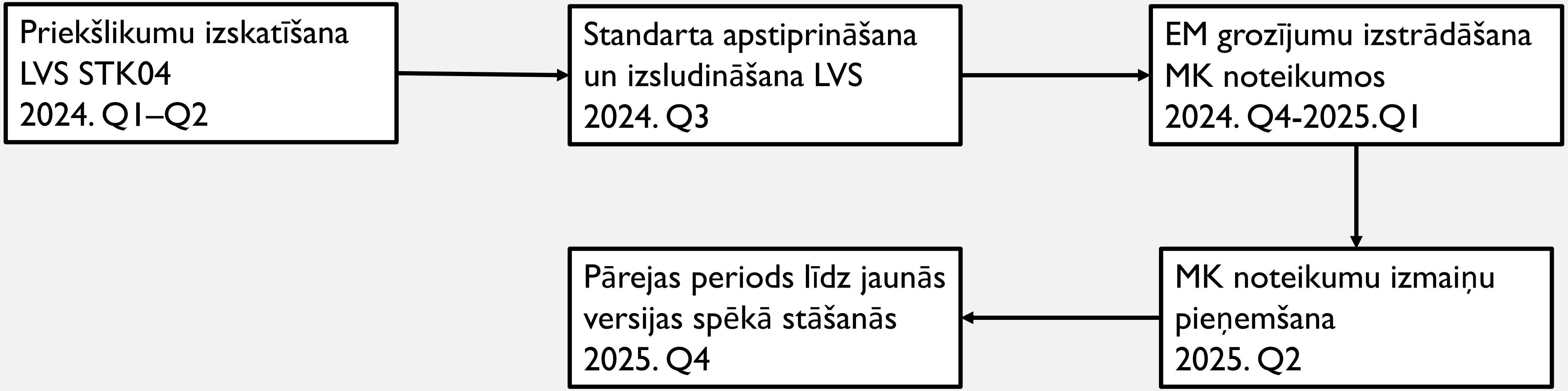
~~PIEZĪMES~~

~~[1] Metode attiecināma uz betoniem, kuriem primāra ir konstrukcijas funkcionālās virsmas noturība pret sala iedarbību.~~

Gadījumos, kad pasūtītājs izvirza prasības betona salizturībai atbilstoši "F" klasēm, testēšana un atbilstības apliecināšana jāveic atbilstoši šī standarta A pielikuma prasībām. Pretējā (vai citā) gadījumā salizturības testēšana un atbilstības apliecināšana jāveic atbilstoši CEN/TS 12390-9 5.p.

TK01 – BETONA SALIZTURĪBA

Tālākais darbs standartu jomā – 2024.-2025.gadam???



TK01 – BETONA SALIZTURĪBA

2023.gada salizturības metožu salīdzinošais pētījums

Mērķis – veikt starplaboratoriju salīdzinošo testēšanu

Uzdevums un pamatnostādnes:

- Testēšanā piedalās visas akreditētās un neakreditētās laboratorijas pēc brīvprātības principa.

- Tiek testēts viens betona sastāvs uz atbilstību XF4 salizturības klasei un F300.

- Tiek novērtēts arī gaisa poru izmēra sadalījums betonā, lai novērtētu betona salizturību no teorētiskā viedokļa.

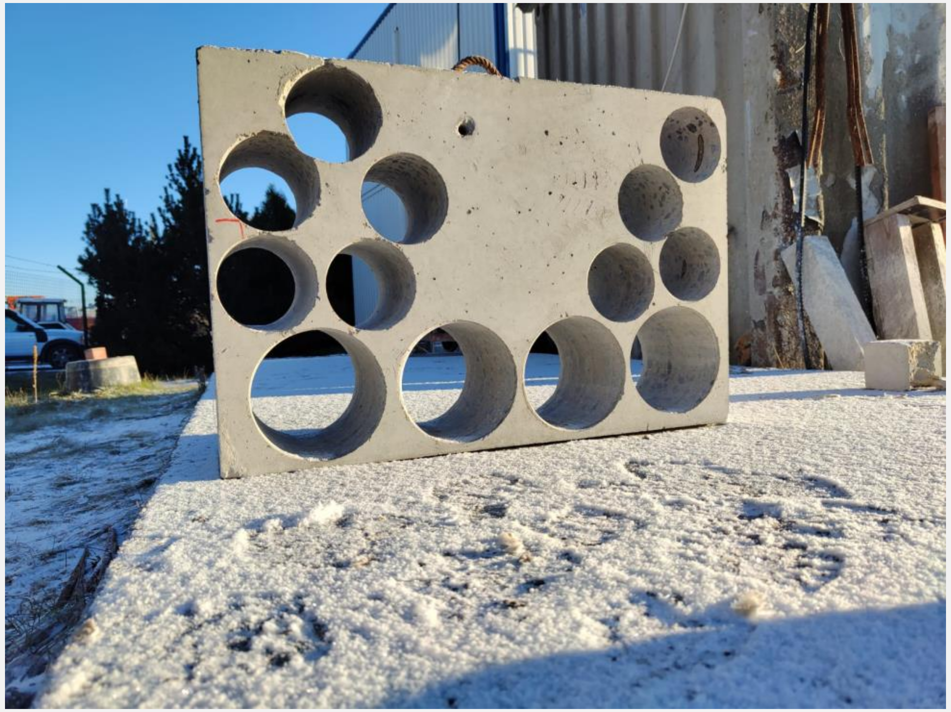
- Papildus tiek veikta salizturības novērtēšana tam pašam betonam – no konstrukcijas urbtiem paraugiem, rezultātu salīdzināšanai.

TK01 – BETONA SALIZTURĪBA

2023.gada salizturības metožu salīdzinošais pētījums

Betona sastāva uzstādījumi:

- C35/45 XF4 betons
- CEM II A-LL 42,5 N cements
- Cementa saturs tuvu minimālajai pieļaujamai robežai 400kg/m^3
- Ū/C tuvu maksimālajai pieļaujamajai robežai 0,4-0,45
- Rupjie minerālmateriāli – granīta šķembas
- Gaisa saturs 4,5-6%



Tālākās darbības

1. Izveidot ziņojumu par 2023.gada starplaboratoriju testēšanā iegūtajiem rezultātiem;

2. Skaidrojošais darbs projektētājiem par XF klašu izvēli un lietošanu būvprojektos;

3. Citi jautājumi?

Unlocking the construction industry’s environmental challenges

***Tomas Plauška**, Sustainability Manager at Consolis Group*

Latvian Concrete Association 31th Scientific and Technical Conference

23 November 2023, Riga, Latvia

CONSOLIS

Consolis in numbers

1894 - 2023	17	47
In business	Countries	Factories

8.000+	>1.000	1.3 bn EUR
Employees	Customers	Sales

Agenda

What are sustainability pros and cons of concrete as a construction material?

Why concrete industry needs to become more transparent and reduce climate impact in order to remain in business and stay competitive?

How can Concrete Industry Associations help its members and the whole concrete industry to improve sustainability performance and image of the sector?

Concrete sustainability.

Flexible

Versatile

Robust and resilient

Long durability

Material efficient

Affordable

Can be reused or at least recycled

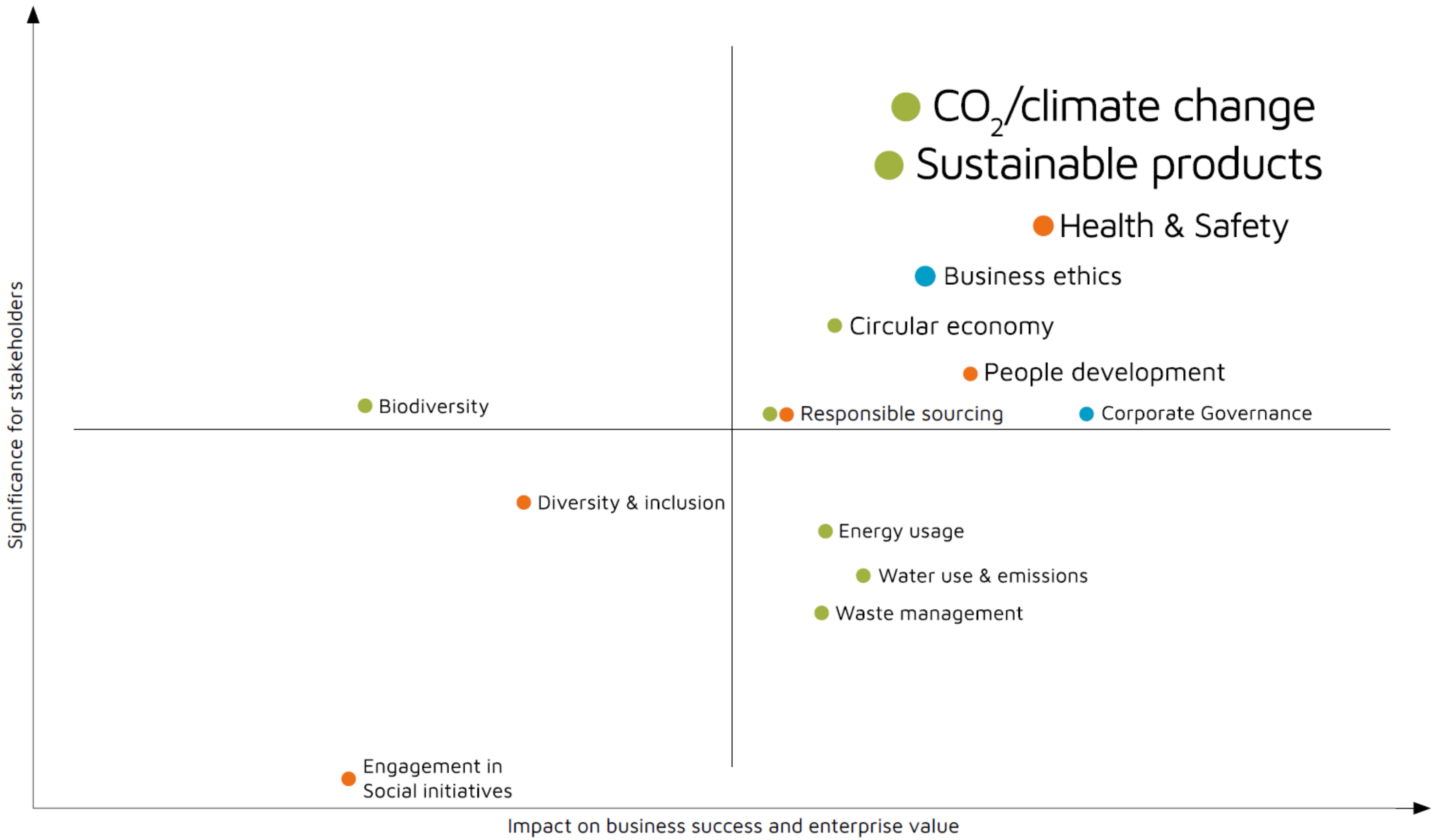
Locally available

No waste at construction site

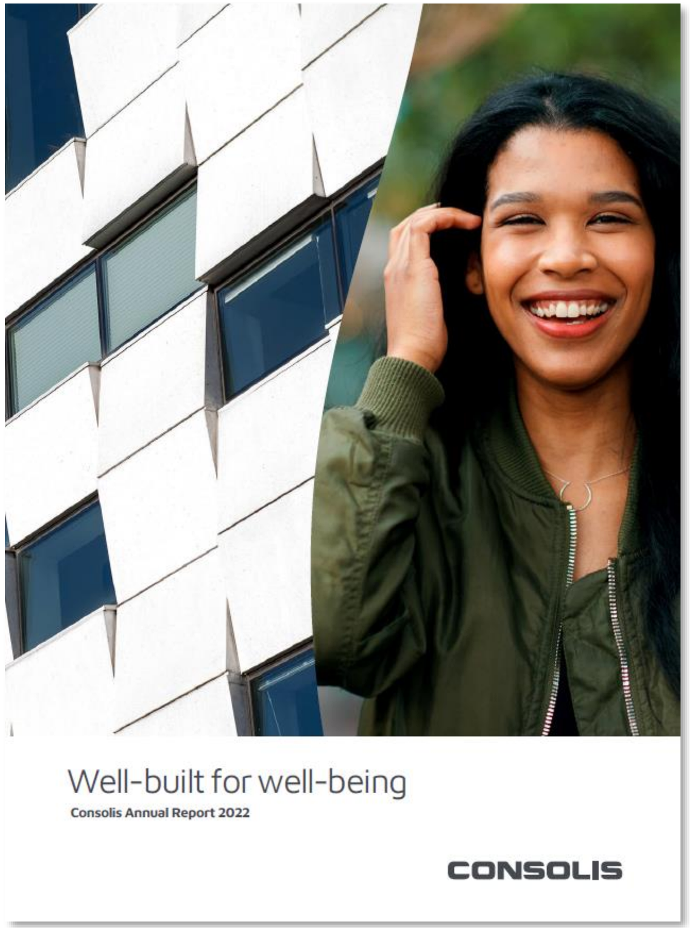
Inherent thermal mass

…

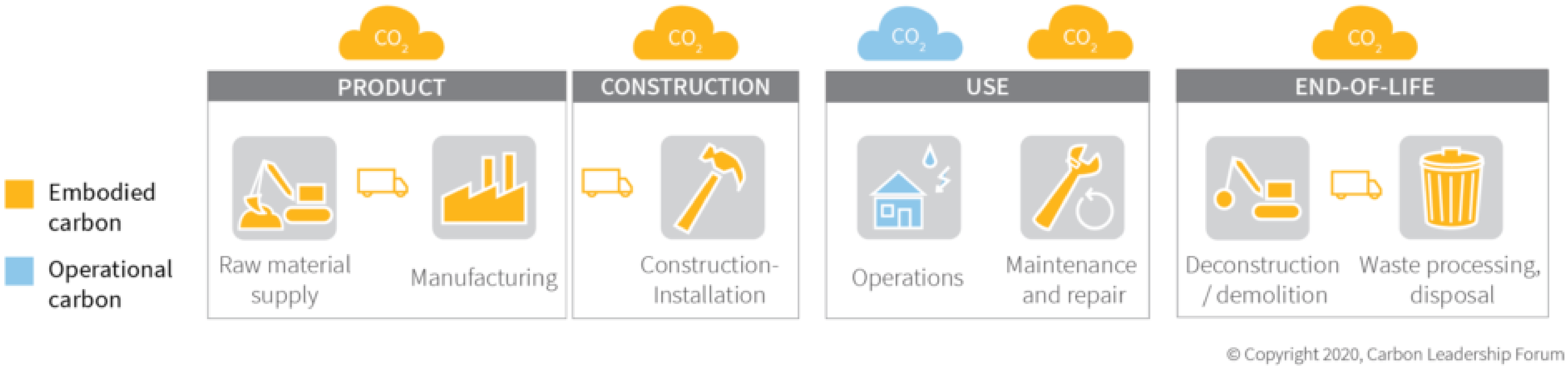
Reducing climate impact is one of the most important challenges we, and the whole building material industry, are facing



Green: Environment, blue: Business, orange: Social



Embodied and operational equivalent CO2 emissions over the building life cycle period



Source: carbonleadershipforum.org

CONSOLIS

Life cycle stages and modules

PRODUCT STAGE			ASSEMBLY STAGE		USE STAGE							END OF LIFE STAGE				BEYOND THE SYSTEM BOUNDARIES		
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D
Materials	Transport	Manufacturing	Transport	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demotion	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling

Mandatory modules according to EN 15804+A2

Non mandatory modules

Source: One Click LCA

Embodied equivalent CO2 emissions of a product are documented in Environmental Product Declaration (EPD)


epd-norge.no
The Norwegian EPD Foundation

ENVIRONMENTAL PRODUCT DECLARATION

in accordance with ISO 14025, ISO 21930 and EN 15804

Ägare av deklarationen:	Strängbetong AB
Program operatör:	Næringslivets Stiftelse for Miljødeklarasjoner
Utgivere:	Næringslivets Stiftelse for Miljødeklarasjoner
Deklarations nummer:	NEPD-1713-696-SE
Publiserings nummer:	NEPD-1713-696-SE
ECO Platform registreringsnummer:	
Godkänd datum:	21.02.2019
Giltig till:	21.02.2024

Håldäcksbjälklag (HD/F)

Strängbetong AB

www.epd-norge.no

CONSOLIS STRÄNGBETONG


epd-norge.no
The Norwegian EPD Foundation

ENVIRONMENTAL PRODUCT DECLARATION

in accordance with ISO 14025, ISO 21930 and EN 15804

Ägare av deklarationen:	Strängbetong AB
Program operatör:	Næringslivets Stiftelse for Miljødeklarasjoner
Utgivere:	Næringslivets Stiftelse for Miljødeklarasjoner
Deklarations nummer:	NEPD-1910-835-SE
Publiserings nummer:	NEPD-1910-835-SE
ECO Platform registreringsnummer:	-
Godkänd datum:	21.10.2019
Giltig till:	21.10.2024

Sandwichvägg (SW)

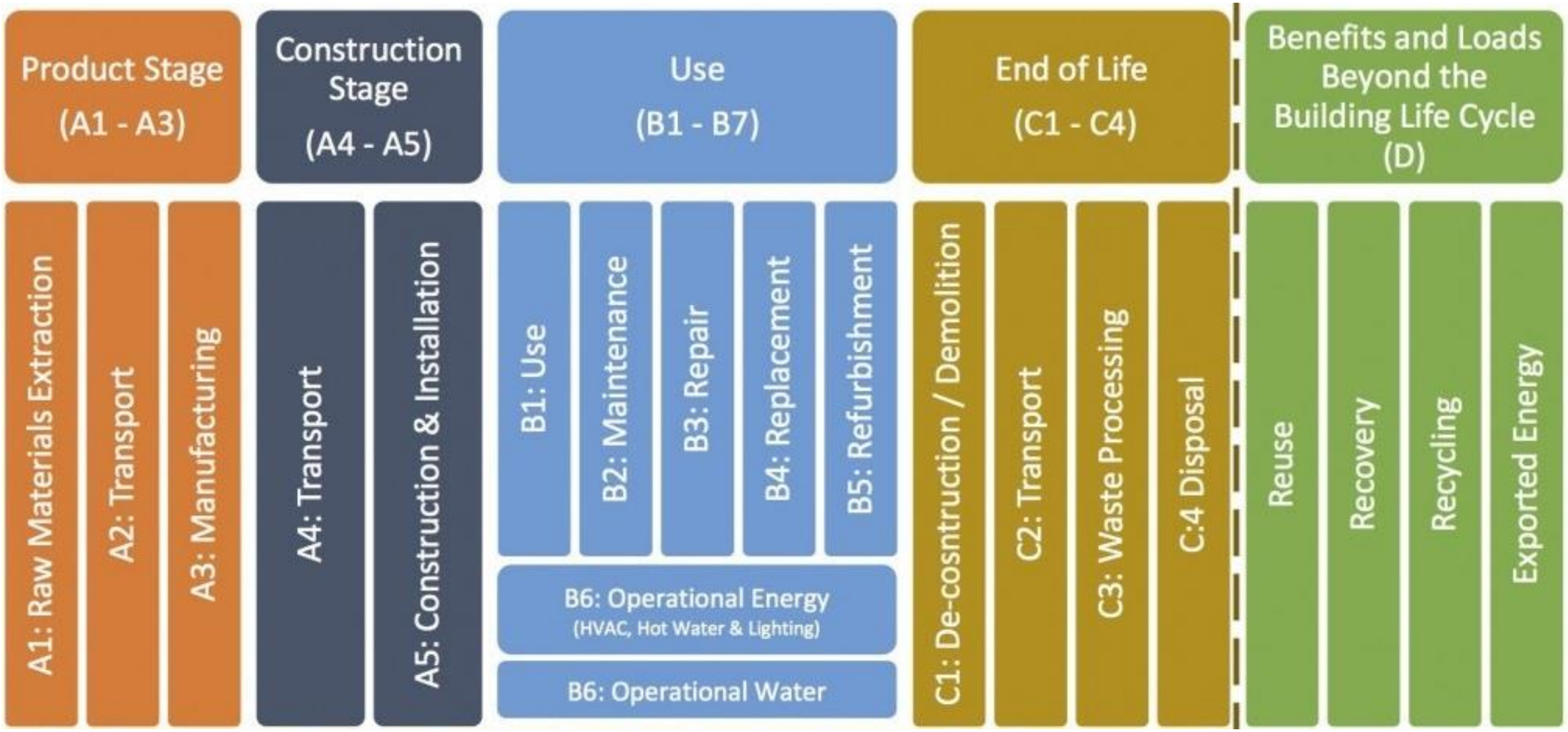
Strängbetong AB

www.epd-norge.no

CONSOLIS STRÄNGBETONG

CONSOLIS

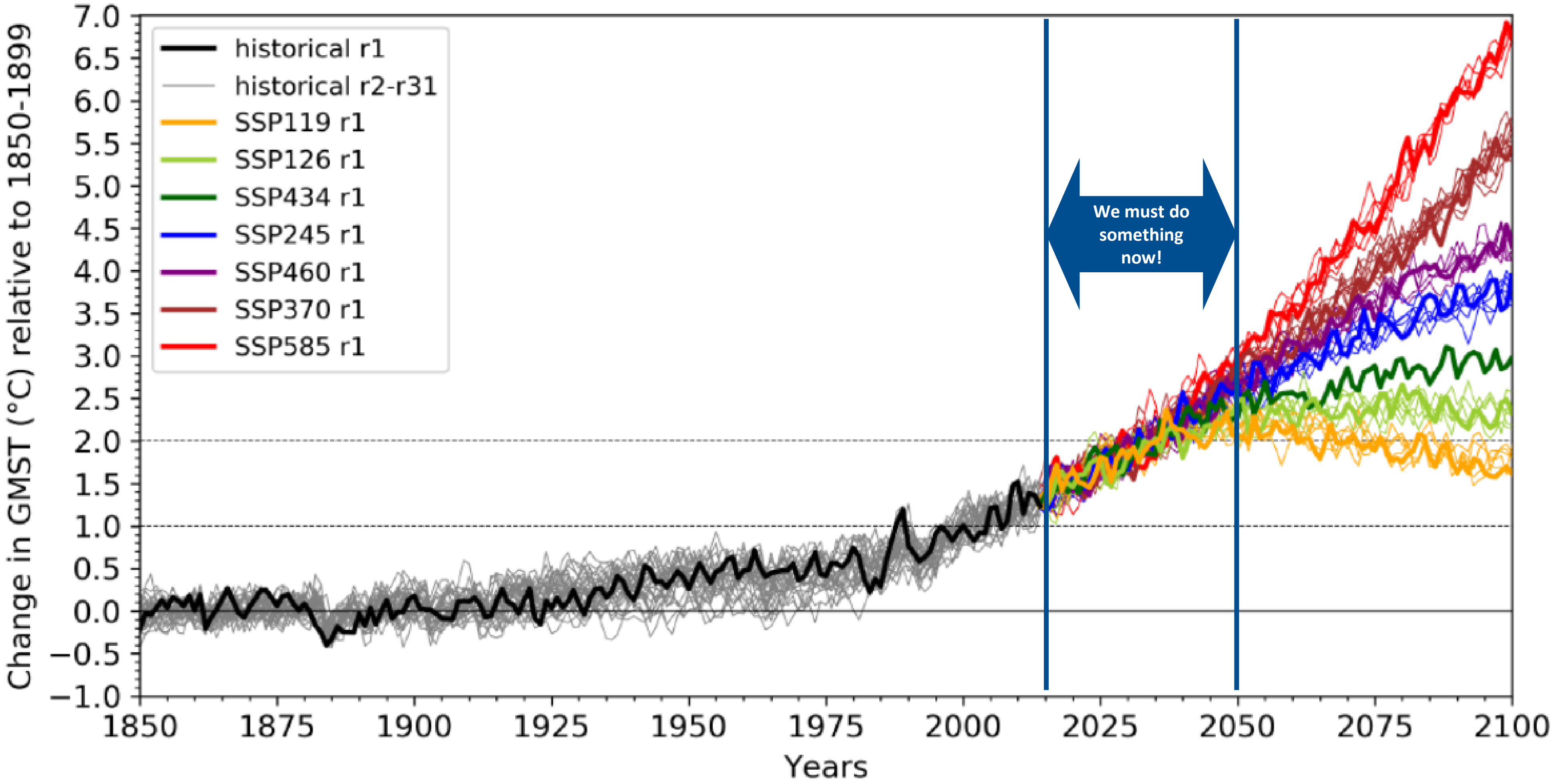
In precast concrete 80-90% of embodied carbon impact is linked to raw materials

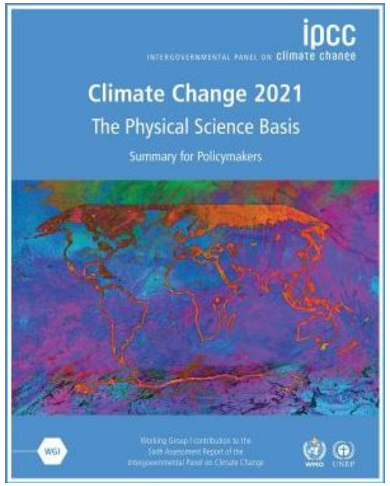


Hollowcore floor (kg-CO2-eq/tn)	89,2%	1,1%	0,8%	4,8%	0,2%	x	x	x	x	x	2,5%	1,3%	0%	0%	x	x	x	x
Insulated sandwich wall (kg-CO2-eq/tn)	82,8%	2,8%	5,4%	6,3%	0,0%	x	x	x	x	x	1,5%	0,9%	0,3%	0%	x	x	x	x

Source: EPD padaryta vadovaujantis EN 15804+A1 standarto versija

It is crucial to accelerate emissions reduction and achieve net zero by 2050 or even earlier!





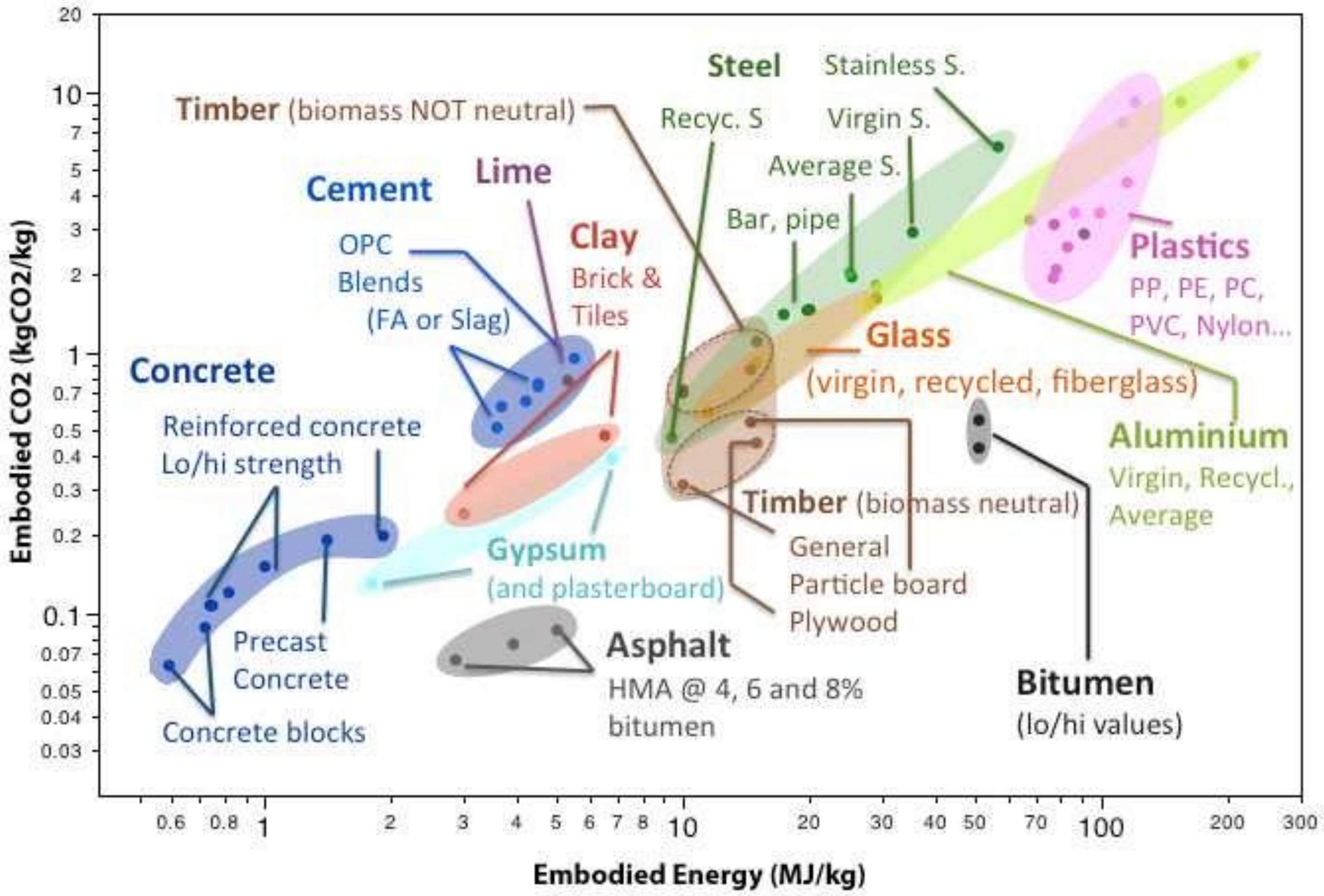
Source: Jean-Marc Jancovici, Climate model IPSL-CM6A-LR, Historical 1850-2014 / scenarios 2015-2100 https://www.bing.com/search?q=jancovici+scenarios+ppt&FORM=HDRSC1

Global carbon dioxide emissions of concrete

8%

Source: https://en.wikipedia.org/wiki/Environmental_impact_of_concrete#cite_note-wbcsd-1

Concrete is not a carbon intensive material



Source: Hammond(2011), “Embodied Carbon. The Inventory of Carbon and Energy (ICE)”

Concrete is one of the most used materials on Earth

14.0 billion m^3

2020 volume of concrete globally

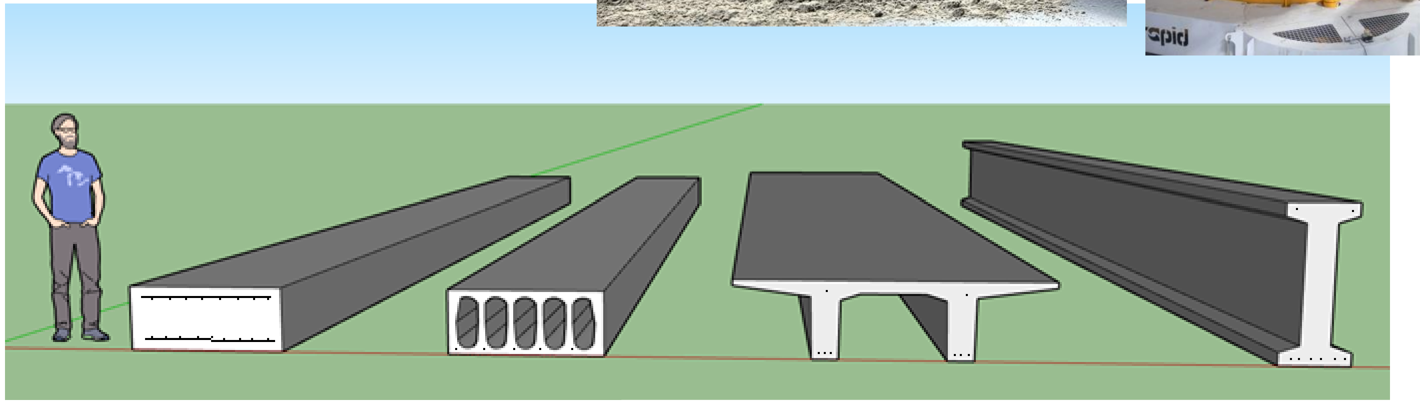
4.2 billion tonnes

2020 cement production globally

- 8% of the global concrete related emissions is relatively low considering that this material is so widely used.

Source: https://gccassociation.org/concretefuture/cement-concrete-around-the-world/

Carbon impact on a building level is what finally matters



CO2e/t of concrete

CO2e/t of element

CO2e/m2 of building floor area!

CONSOLIS

Countries are setting limits for carbon emissions on building level

- **Denmark** 12 kg-CO2-eq/m2/a (2023)
- **Finland** 10-14 kg-CO2-eq/m2/a (2025)
- **France** 12,8-14,8 kg-CO2-eq/m2/a
- **UK** 13,3 kg-CO2-eq/m2/a (2020) and 10,8 kg-CO2-eq/m2/a (2025)
- Other limit values including those in **Netherlands** (MPG), **Austria** (OI3) and **Switzerland** (SIA). These are however set using a different LCA indicator.

Paris Agreement 1.5 °C

SBTi – companies' own targets

EU Taxonomy CSRD

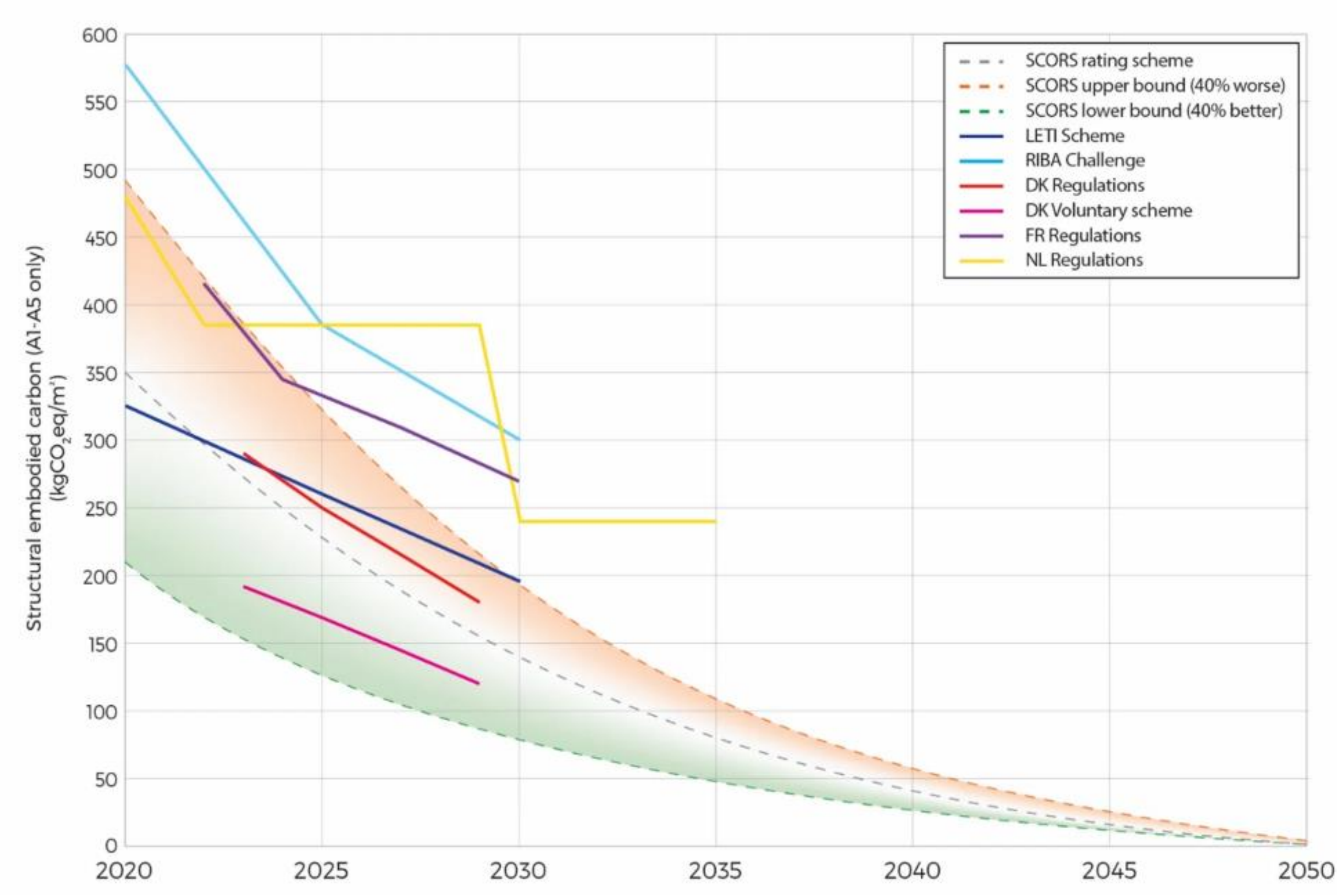
EU Fit for 55

National targets

Financial markets

Source: One Click LCA

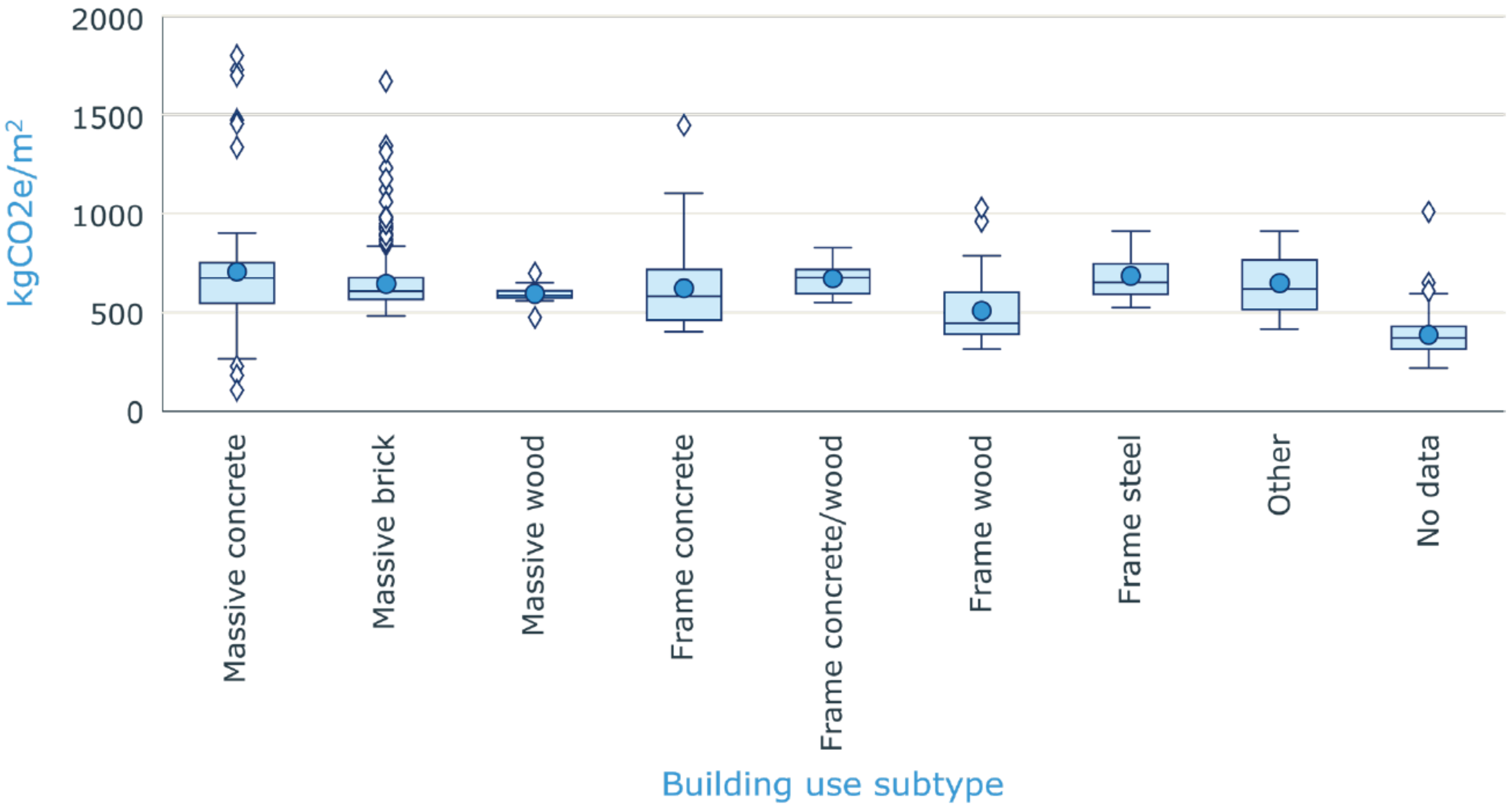
Approximate regulatory targets for structural embodied carbon LCA stages A1-A5



Source: The Institute of Structural Engineers

CONSOLIS

Concrete buildings have the widest spread which means also the biggest opportunities related to CO2 reduction



Source: Ramboll (2022), Towards embodied carbon benchmarks for buildings in Europe, #2 Setting the baseline: A bottom-up approach - Harmonized life cycle embodied carbon per m2 by type of building structure based on the EU-ECB dataset

Case from Lithuania..

Lithuania’s efforts moving towards climate neutrality

Source: https://klimatokaita.lt/

To achieve climate change mitigation goals, the Lithuanian Government obliges, starting from November 1, 2024, to construct public buildings using at least 50% organic and wood materials

Simonas Gentvilas
Liepa 19 d. ·

Ate betonui, labas medienai!

Lietuva pastatus statys iš medienos.

Šiandien Vyriausybė pritarė Aplinkos ministerija paruoštam proveržiui. Nuo 2024 m. lapkričio valstybiniai pastatai bus statomi iš medienos(organinių) statybinių medžiagų ir jos turės sudaryti bent 50% pastato. Tai reiškia, kad ne tik naujoji Valstybinių miškų urėdija būstinė Vievyje, bet ir naujasis Vyriausybės biurų miestelis, naujos mokyklos, koncertų salės ir visa kita bus statomi iš dominuojančių medinių konstrukcijų.

Kartu su komanda ėmėmės šio medinės statybos proveržio, nes turime gyventi sveikiau, kovoti su klimato kaita ir kurti gerai apmokamas darbo vietas Lietuvoje:
✅Mediniai namai yra sveikesni ir ergonomiški mums gyventojams ir jų lankytojams.
✅Jei betonas būtų atskira pasaulio valstybė, jis būtų 3-a didžiausia CO_2 teršėja po Kinijos ir JAV. Betoną keisdami mediena mes ne tik neišmetame anglies dvideginio, bet jį ir užrakiname ilgamečiuose organiniuose statybos produktuose. Fotosintezės metu medienoje sukaupta anglis ilgam tampa stabiliu nepūvančiu, nesudeginamu komponentu pastate.
✅Medis Lietuvoje - visų mūsų vertybė. Ką tik paviešinome naują miškų įstatymą, kuriame valstybinių miškų kirtimus apribojame vietoje 100% iki 70% metinio prieaugio. Tačiau, nukirsta mediena ligi šiol sukurdavo per mažą pridėtinę vertę. Skaičiuojama, kad 1 kubinis metras statybinės medienos sukuria daugiau nei 10 kartų didesnę vertę nei 1 kub. m. biokuro, kurio deginimą ateity tikrai privalėsime riboti. Tad medinių statybinių produktų gamyba sukurs tūkstančius naujų darbo vietų ir naują(seną) ekonomiką Lietuvoje naujojoje statyboje ir renovacijoje.

LIETUVOS RESPUBLIKOS VYRIAUSYBĖS KANCELIARIJA
2022-07-13 Nr. G-7161
DOKUMENTAS PASIRAŠYTAS ELEKTRONINIU PARAŠU
2022-07-13 Nr. D8(E)-3742

LIETUVOS RESPUBLIKOS APLINKOS MINISTERIJA

Valstybės biudžetinė įstaiga, A. Jakšto g. 4/9, LT-01105 Vilnius,
tel. (8~5) 266 3661, faks. (8~5) 266 3663, el. p. info@am.lt, http://www.am.lt.
Duomenys kaupiami ir saugomi Juridinių asmenų registre, kodas 188602370

Lietuvos Respublikos Vyriausybei 2022-07- Nr. (61)-D8(E)-

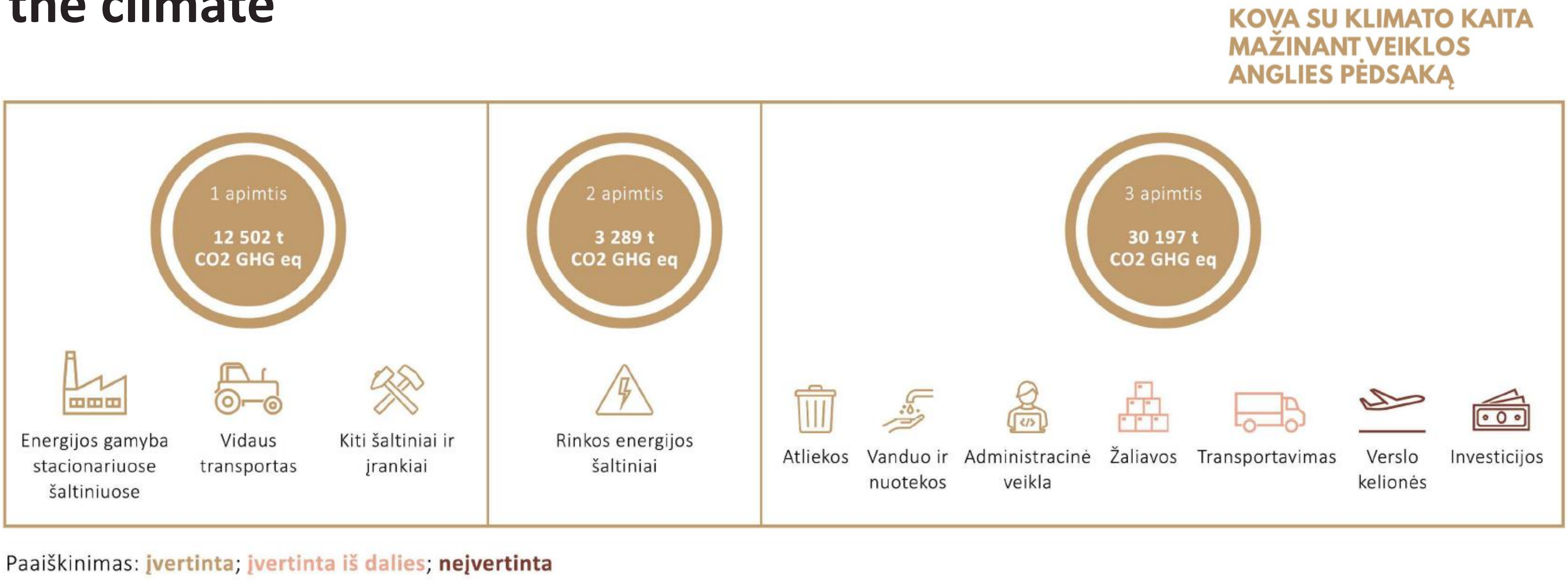
DĖL LIETUVOS RESPUBLIKOS VYRIAUSYBĖS NUTARIMO PROJEKTO TEIKIMO

Aštuonioliktosios Lietuvos Respublikos Vyriausybės programos, patvirtintos Lietuvos Respublikos Seimo 2020 m. gruodžio 11 d. nutarimu Nr. XIV-72 „Dėl Aštuonioliktosios Lietuvos Respublikos Vyriausybės programos“, 157.6 papunktyje nurodyta priemonė – 2024 m. visi visuomeniniai pastatai bus statomi bent iš 50 proc. organinių ir medienos statybos medžiagų, bus didinamas antrinių žaliavų naudojimas ir mažinamas statybinių atliekų susidarymas.

Nurodytas siekis atspindi investavimo kriterijaus kiekybinę išraišką. Investavimo kriterijaus kokybinę išraišką atspindi tai, kad statybos iš medienos skatinimas prisidėtų prie šiltnamio efektą sukeliančių dujų (toliau – ŠESD) emisijos mažinimo. Statybų sektorius pagal ŠESD emisiją yra vienas kenksmingiausių aplinkai. Medis iš atmosferos sugeria anglies dioksidą ir naudoja jį medienos prieaugiui. Medienoje sukaupta anglis nebepatenka į atmosferą, todėl reikšmingai prisideda prie ŠESD emisijos mažinimo.

Source: facebook.com, AM.LRV.lt,

..and currently, climate impact assessments are not required for these public buildings, although it is known that companies producing wooden construction products have a negative impact on the climate



Source: VMG grupės tvarumo ataskaita už 2022 metus

How can we assess if government's initiatives effectively contribute to achieving climate change mitigation goals when emissions calculations are not conducted?

Source: www.dreamstime.com

Companies collaborate and invest in developing tall buildings made of wood

Betonas ir kitos masyvios bei sunkios pastatų konstrukcijos po truputį užleidžia vietą tvaresniems statybų sprendimams. Dygstantys mediniai daugiaaukščiai pastatai pasaulyje jau nelabai ką stebina, tačiau Lietuvoje medienos naudojimas ne individualių namų statybai dar nėra išplėtotas. Situaciją keisti ketina NT vystytojas „Releven“ ir statybos konstrukcijų gamintoja VMG grupė – bendrovės sutarė ieškoti inovatyvių ir tvarių sprendimų aukštuminiams pastatams vystyti.

Source: delfi.lt, LRT.lt

VMG grupė Akmenės LEZ atveria trečią gamyklą – investicijos siekia 100 mln. eurų 12

BNS
2023.09.11 13:54

VMG grupė atidaro 82 mln. eurų vertės baldų gamyklą Akmenės LEZ / VMG nuotr.

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The first multi-story wooden office building in Lithuania will be built in 2024

Source: Citify and Newsec

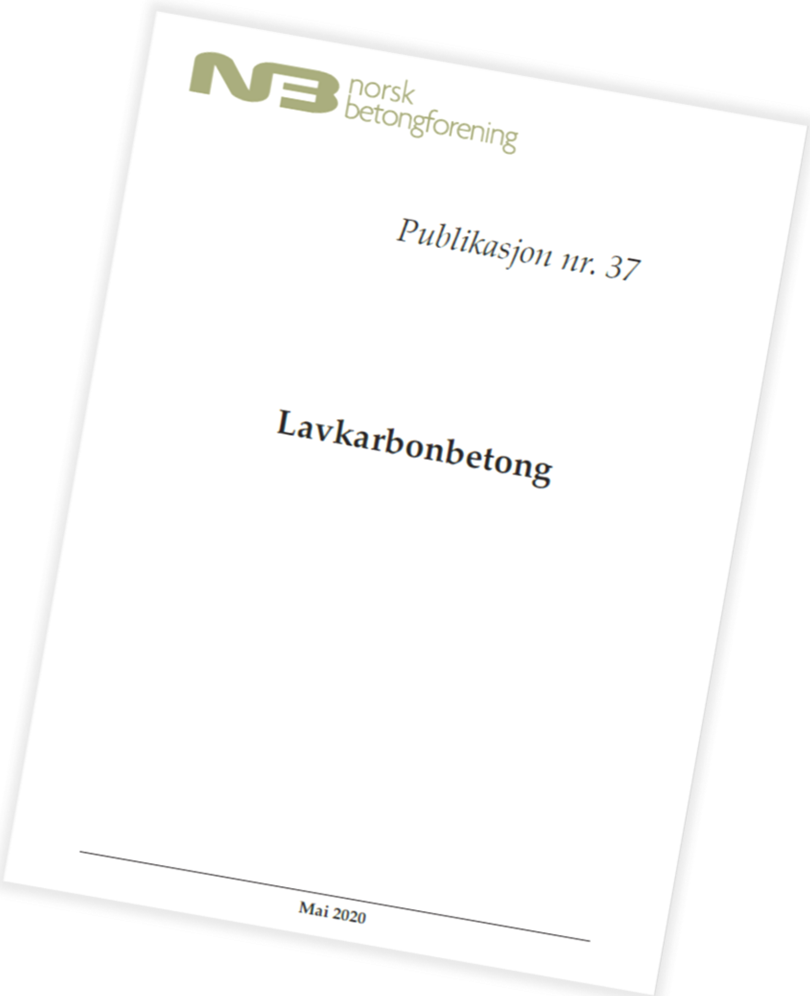
Concrete industry must become more transparent and reduce its impact on the climate to remain in business and improve its image

- Otherwise **political decisions may phase out concrete from the market** or potential introduction of environmental and **carbon-related emission taxes may make concrete less affordable** and less used
- **LCA methodology and Environmental Product Declarations (EPD)** are important tools to ensure transparency and reduce the environmental impact of construction products - they are increasingly demanded not only in Western Europe and Scandinavia but also in the Baltic countries
  - Most leading construction companies and real estate developers set emission reduction goals for developing and constructing projects
  - Some precast concrete manufacturers in the Baltic countries already have Environmental Product Declarations (EPD) for their products and are working on reducing climate impact going forward
  - Acquiring EPDs is not cheap, especially for small concrete and precast concrete manufacturers
  - In Western countries and Scandinavia, national construction industry associations/concrete associations help create EPDs at the industry level (establishing average emissions for concrete products and assisting manufacturers in becoming more transparent).

Concrete Industry Association can play a significant role in helping local concrete industry to become more transparent and reduce the negative impact on the climate

- Developing tools and using them to gather information from concrete manufacturers, thereby **calculating the average emissions of the concrete industry**
- **Sharing best practices** and **establishing a classification for low carbon concrete** (see example in the next slide)
- **Developing a roadmap** on how the concrete industry will achieve **net zero carbon emissions**
- Creating guidelines that **instruct concrete manufacturers** on the initial steps they need to take **to reduce the environmental impact of concrete**
- Organizing **training** for concrete and precast concrete manufacturers on how **to reduce carbon emissions**
- **Challenging current construction practices** and **improving standards and regulations** to allow for innovations, expanding the range of alternative cementitious materials (e.g., bio-ashes), promoting concrete recycling/reuse to reduce the environmental impact of concrete structures, and positively contributing to the circular economy.

Classification of low carbon concrete in Norway


norsk betongforening

Publikasjon nr. 37

Lavkarbonbetong

Mai 2020

Tabell 1 Lavkarbonbetongklasser med grenseverdier for klimagassutslipp (begrenset til modul A1-A3 i NS-EN 15804:2012+A2:2019 /7/). Valg av klasse skal skje under de forutsetningene som er gitt i kapittel A2.

Fasthetsklasse 1) og lavkarbonklasse	B20	B25	B30	B35	B45	B55	B65
Maksimalt tillatt klimagassutslipp [kg CO_2-ekv. pr m^3 betong]							
Bransjereferanse	240	260	280	330	360	370	380
Lavkarbon B	190	210	230	280	290	300	310
Lavkarbon A	170	180	200	210	220	230	240
Lavkarbon Pluss 2)			150	160	170	180	190
Lavkarbon Ekstrem 2)			110	120	130	140	150

1) Se kapittel A2 om sammenhengen mellom fasthetsklasser, bestandighetsklasser og karbonklasser
2) Mulig nivå for enkelte prosjekt, men med flere begrensinger i standardverket, og begrenset tilgjengelighet. Gjennomførbarhet må avklares i hvert enkelt prosjekt

Source: Norwegian Concrete Association

Classification of low carbon concrete in Finland

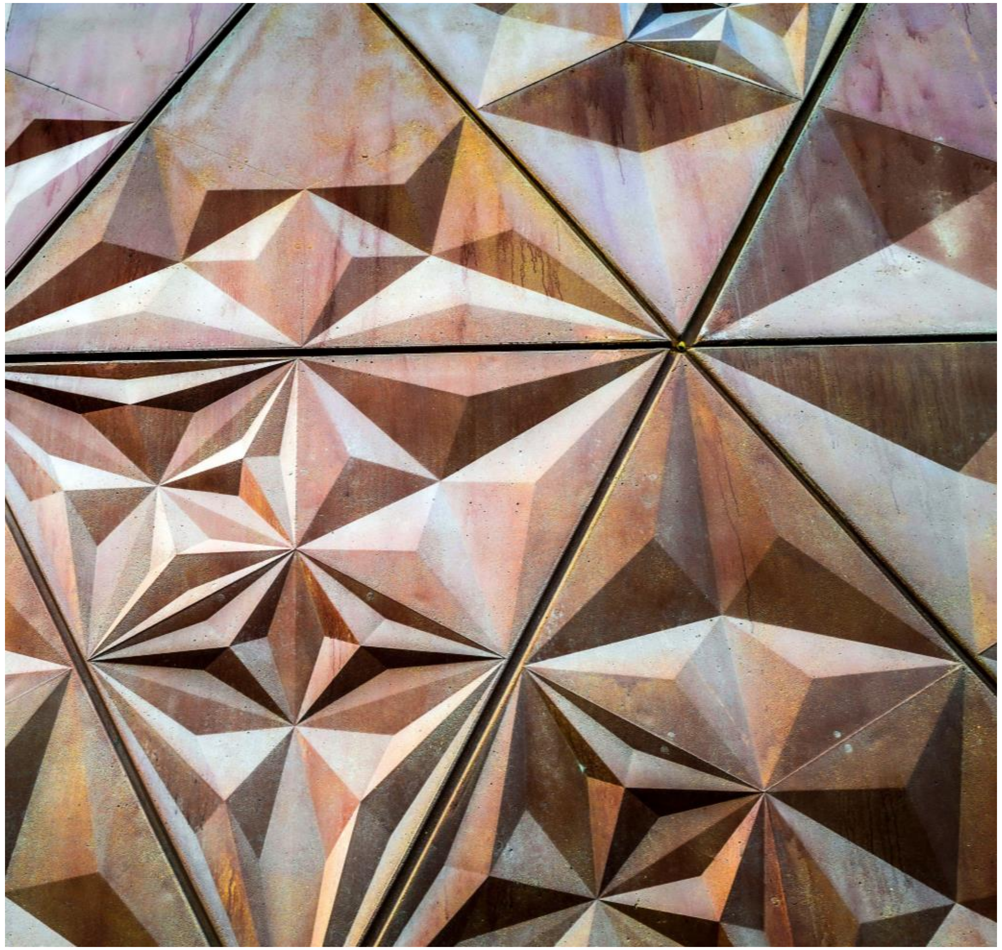


Table 1. Concrete types included in BY Low-carbon classification and limit values for low-carbon classes. The values are GWP_{total} values and include modules A1...A3. The values are given in kg (GWP_{total}) / m^3 of concrete.

CONCRETE QUALITY	GWP.REF (Ref.level)	GWP.85	GWP.70	GWP.55	GWP.40
C20/25	210	180	145	115	85
C25/30	230	195	160	125	90
C30/37	255	215	180	140	100
C35/45	285	240	200	155	115
C45/55	320	270	225	175	130
C50/60	340	290	240	185	135
C30/37 - Air-entrained	290	245	205	160	115
C35/45 - Air-entrained	330	280	230	180	130
C45/55 - Air-entrained	375	320	265	205	150
C50/60 - Air-entrained	395	335	275	215	160
C30/37 P0	270	230	190	150	110
C30/37 P30	300	255	210	165	120
C35/45 P0	300	255	210	165	120
C35/45 P30	330	280	230	180	130
C35/45 P50	340	290	240	185	135
C45/55 P50	375	320	265	205	150

Source: Finnish Concrete Association

Classification of low carbon concrete in Sweden

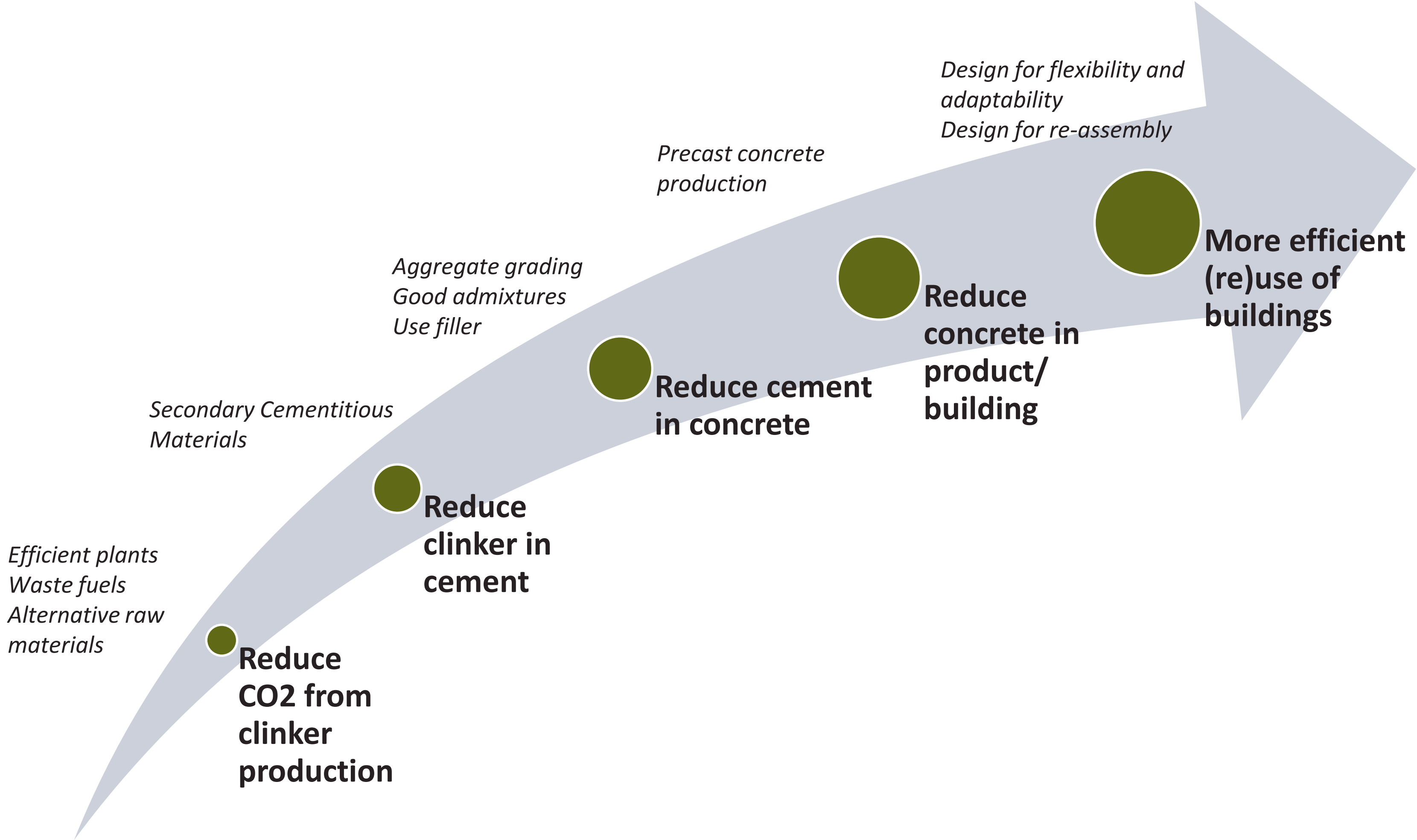
Prefabricerade betongprodukter

Kontor, Bostäder, Skolor, Hotell
Tabell 3

	Exponerings-klass	vct ekv*	Klimatpåverkan GWP-GHG, kg CO2-ekv/ton				
			Typiskt värde	Klimatförbättrad, max			
				Nivå 1	Nivå 2	Nivå 3	Nivå 4
Inomhus, torr miljö	XC1						
Håldäck (HD/F)		0,40	135	120	110	95	< 80
Håldäck (HD/F)		0,50	115	105	95	80	< 70
Massiva förspända plattor (RD/F)		0,50	185	165	145	130	< 110
TT plattor		0,50	185	165	145	130	< 110
Massiva slakarmerade plattor (D/F)		0,50	185	165	145	130	< 110
Plattbärlag		0,55	185	165	145	130	< 110
Sandwichvägg (RW)		0,55	235	210	185	165	< 140
Halvsandwich (VI)		0,55	205	185	165	145	< 125
Skalvägg (VS)		0,55	185	165	145	130	< 110
Balk slakarmerad (RB)		0,45	200	180	160	140	< 120
Balk förspänd (RB/F)		0,40	190	175	155	135	< 115
Pelare (RP)		0,50	240	215	190	170	< 145
Väggar (RV)		0,50	155	140	125	110	< 95
Trappor		0,45	210	190	170	145	< 125
Utomhus, fuktig miljö	XC3						
Balkonger		0,45	210	190	170	145	< 125
Loftgångar		0,40	220	190	175	155	< 130

**Typiska värden. Styrs främst av exponeringsklass och hållfasthetskrav. Kan variera, se texten i avnittet.*
Svensk Betong Vägledning Klimatförbättrad betong utgåva 2.0

Significant reduction in emissions (~80%) can be achieved by working through the whole value chain



Source: ETH Zürich, (2018), A SUSTAINABLE FUTURE FOR THE EUROPEAN CEMENT AND CONCRETE INDUSTRY

Thank you!


Coming together is the beginning.
Keeping together is progress.
Working together is success.
Henry Ford
quotefancy

CONSOLIS

Well-built for well-being

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Determination of concrete strength in constructions taking into account concrete temperature during hardening and its effect on concrete durability

Jānis Kudiņš

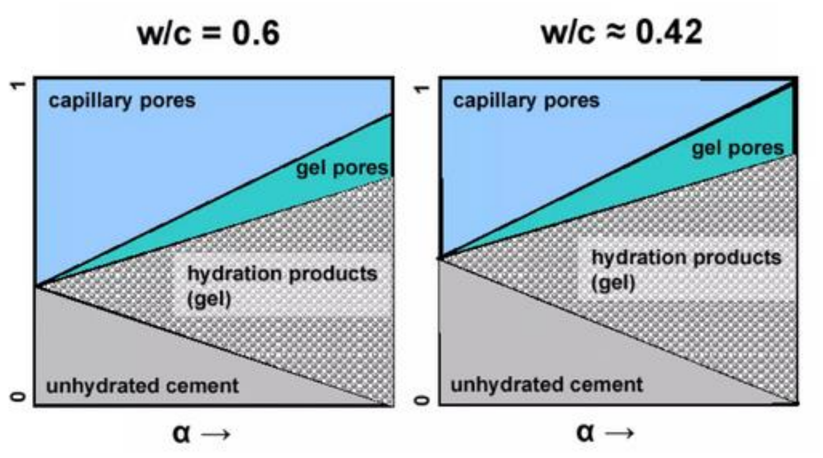
Curing of concrete have a huge impact on concrete durability

LVS EN 13670 8.5 Curing and protection

Concrete in its early life shall be cured and protected:
– to minimise plastic shrinkage;
– to ensure adequate surface strength;
– to ensure adequate surface zone durability;
– from freezing;
– from harmful vibration, impact or damage

The following methods are suitable for curing used separately or in sequence:
– keeping the formwork in place;
– covering the concrete surface with vapour-proof sheets which are secured at the edges and joints to prevent draughts;
– placing of wet coverings on the surface and protection of these coverings against drying out;
– keeping the concrete surface visibly wet with suitable water;
– application of a curing compound of established suitability.

NOTE Guidance to characterizing curing compound can be found in CEN/TS 14754-1.



Microstructure of hydrated cement paste

Different curing agent tests according to CEN/TS 14754-1

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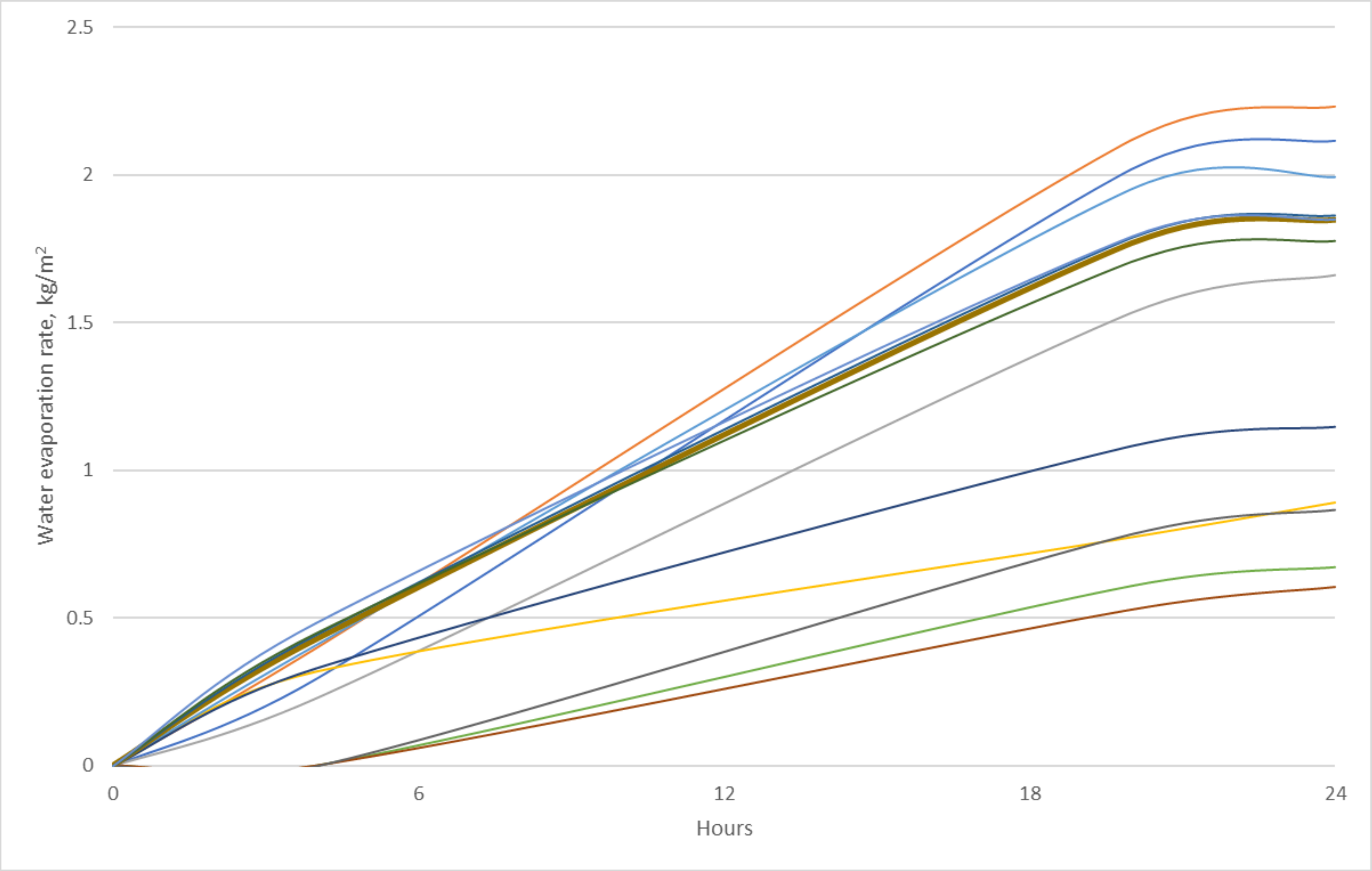

Concrete curing classes. LVS EN 13670 table 4

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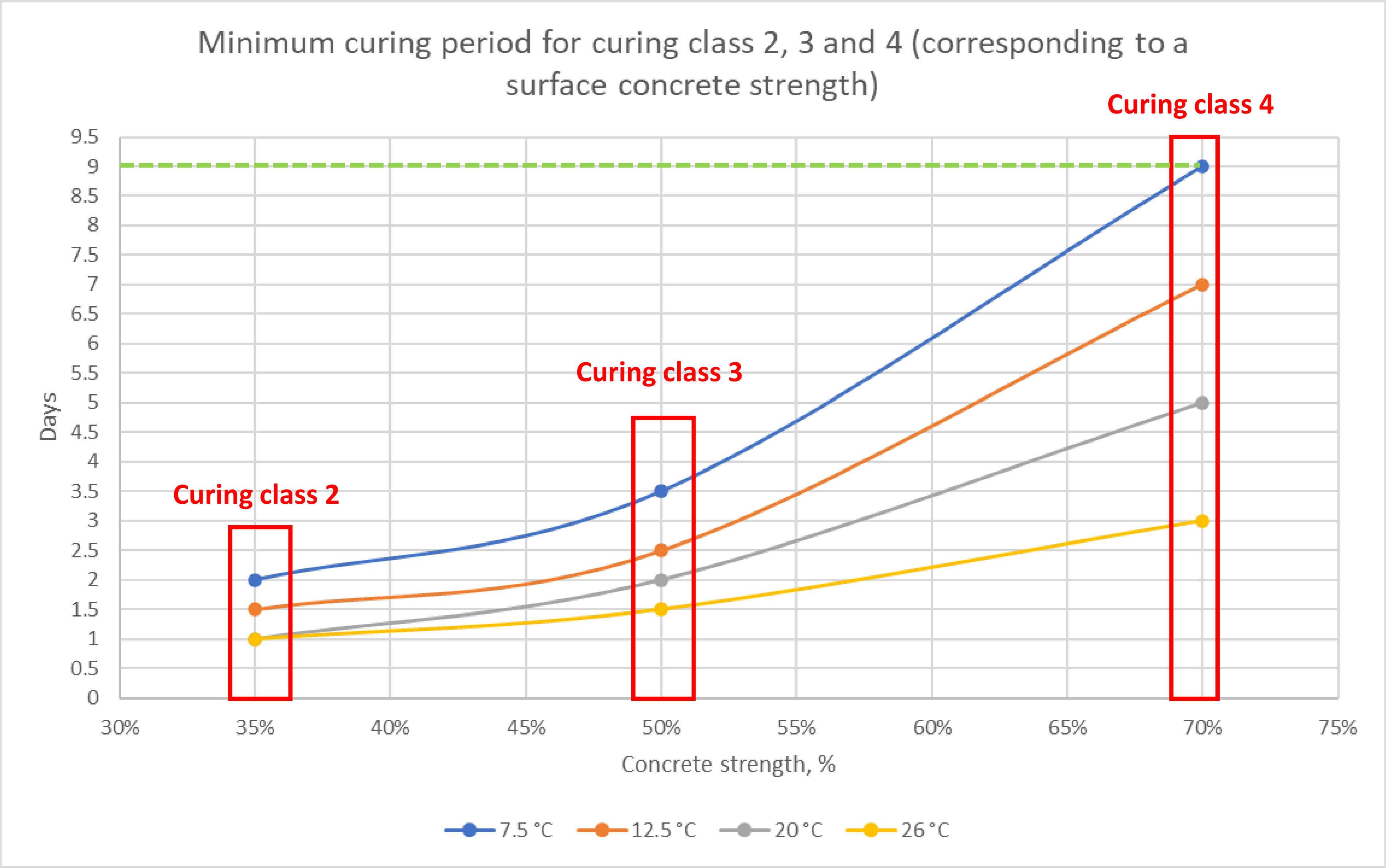
	Curing class 1	Curing class 2	Curing class 3	Curing class 4
Period (hours)	12[a]	N/A	N/A	N/A
Percentage of specified characreristic 28 days compressive strength	N/A – Note applicable	35%	50%	70%
Exposure classes	X0 XC1	XC2	XC3 XD1/XS1 XD2/XS2 XF1 XF2 XF3 XA2	XC4 XD3/XS3 XF4 XA3
a - provide the set does not exceed 5 hours, and the surface concrete temperature is equal to or above 5°C				

Suggestion

How long concrete must be cured? LVS EN 13670 Annex F with r≥0.5



Methods of estimation of concrete properties

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LVS EN 13670 F 8.5

– maturity calculation from temperature measurements taken at a maximum depth of 10 mm below the surface;
– maturity calculation based on the daily average air temperature;
– temperature-matched curing;
– rebound hammer testing(after calibration on relevant concrete test sample)
– other methods of established suitability.

ASTM C 1074 Standard Practice for Estimating Concrete Strength by the Maturity Method

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Maturity method - **a non-destructive method** to estimate the **real-time strength development** of in-place concrete, specifically **at early ages** less than 14 days.

It uses the **temperature history** of concrete during curing to estimate strength development. The maturity method requires **a calibration** prior to use in order to correlate the maturity to strength. Maturity **calibration is specific for a mix design**.

Nurse-Saul method
Time Temperature Factor (TTF)

Saul developed the following principle through his research that is now known as the maturity rule, stating that Concrete of the same mix at the same maturity (reckoned in temperature-time) has approximately the same strength whatever combination of temperature and time go to make up that maturity

$$M(t) = \sum (T_a - T_0)\Delta t$$

20^oC * 20h = 400 TTF = 15MPa

10^oC * 40h = 400 TTF = 15MPa

Nurse-Saul method. Time Temperature Factor (TTF)

- Prepare at least 17 specimens (15x15x15 cm)
  15 samples for strength control
  2 samples for temperature monitoring

- Provide the same curing condition for all samples

- Select a minimum 5 strength measurement points
  (1, 3, 7, 14 and 28 days or 12, 16, 24, 48, 72 hours)

- Calculate Time Temperature Factor

Day	Date	Hours	Average temperature, °C	TTF, °C-hrs	∑ TTF, °C-hrs
1	01.11.2023 16:00	0	-	-	-
2	02.11.2023 16:00	24	20	480	480
3	03.11.2023 16:00	24	15	360	840
7	08.11.2023 16:00	120	10	1200	2040

Nurse-Saul method. Maturity-Strength curve

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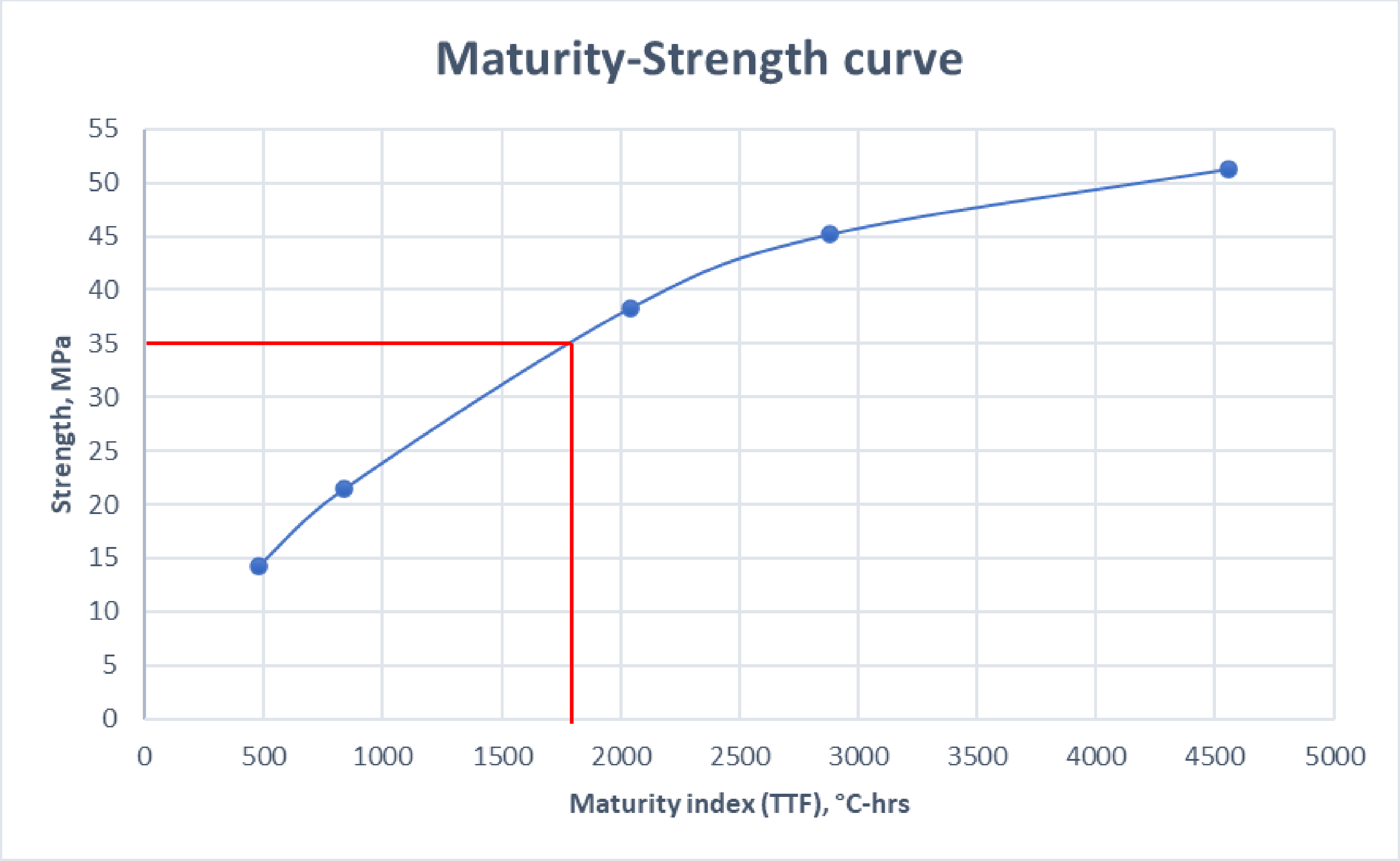
Day	∑ TTF, °C-hrs	Strength, MPa
1	480	14.3
2	840	21.5
7	2040	38.3
14	2880	45.2
28	4560	51.3

35 MPa – 70% of 50 Mpa
TTF – 1700 °C-hrs

1700 °C-hrs / 25 °C = 68 hours

35 MPa – 70% of 50 Mpa
TTF – 1700 °C-hrs

1700 °C-hrs / 7.5 °C = 9.4 days



Intelligent real-time concrete monitoring

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Maturix – Gaia 200

Giatec - SmartRock

Adventum - TempSense

Intelligent real-time concrete monitoring

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30.10.2023_PLAN06_STAGE1.2-31. no rīta apsegts ar putu polietilēna plēvi 10mm. Bez sildīšanas…

Sections

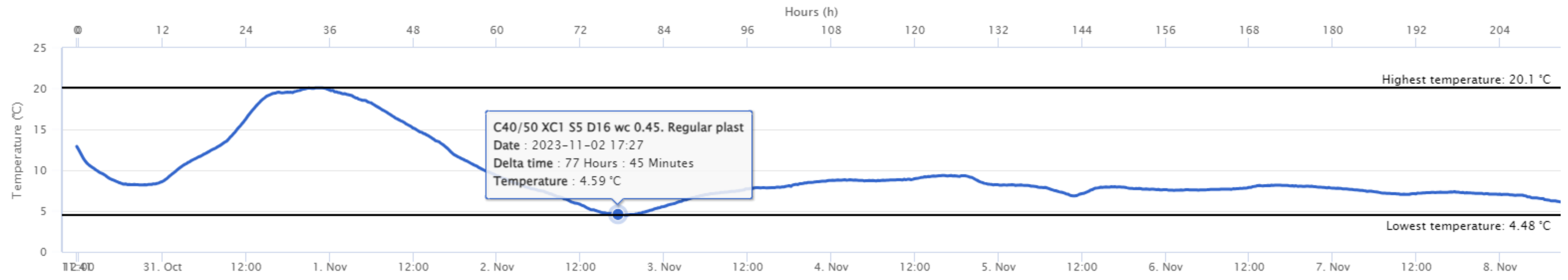
Finish Cast | Actions | Export

	Monitoring Description	Device Name	Device ID	Targets			
—	C40/50 XC1 S5 D16 wc 0.45. Regular plast		7FT7FD	Stiprība Stiprība	30 MPa 20 MPa	100 % ✓ 100 % ✓	… Resume

> Alarms

Temperature

Expand



	Monitoring Description	Min	Average	Max	Latest	☑
—	C40/50 XC1 S5 D16 wc 0.45. Regular plast	4.48 °C	9.31 °C	20.1 °C	6.13 °C ⓘ	☑

Intelligent real-time concrete monitoring

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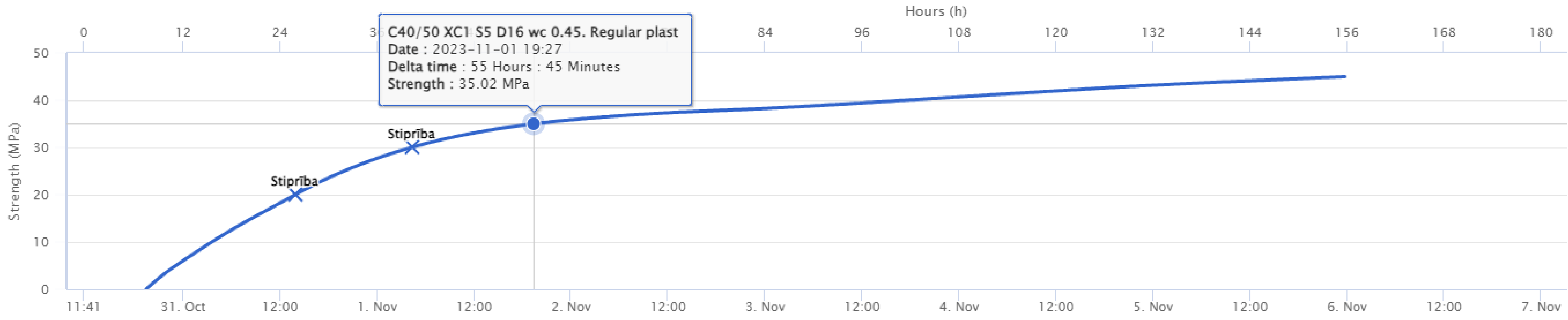
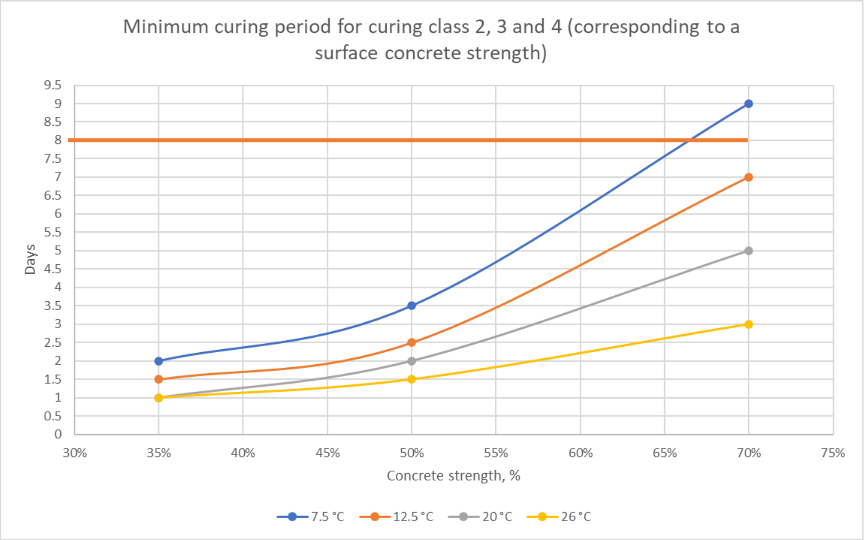
Strength





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LBS Site trial test 05.10.2023

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F/T testing for the drilled samples unmolded at the different curing time

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Lai izdodas ar betona kopšanu!

1862

RIGA TECHNICAL UNIVERSITY

3D drukāta betona ilgizturība - aktuālie pētījumi šodien

RTU

3D betona drukāšanas zinātniskās laboratorijas vadītājs

Dr. Sc. Ing.

Māris Šinka

SAKRET Baltic attīstības un kvalitātes vadītāja Eva Dzene

SAKRET®

23.11.2023.

3D drukāta betona ilgmūžības un mehānisko īpašību testi

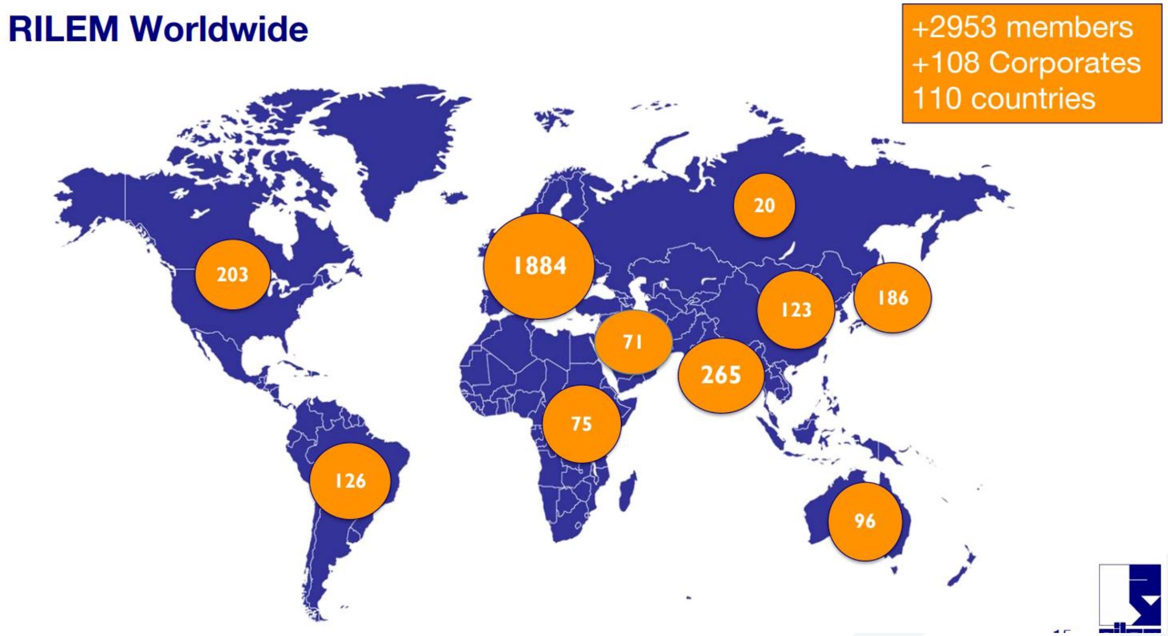
Pētījums RILEM tehniskās komitejas *304-ADC: Assessment of Additively Manufactured Concrete Materials and Structures* ietvaros

RILEM savienība (1947)

(The International Union of Laboratories and Experts in Construction Materials, Systems and Structures)

- **Mērķis** – padarīt informāciju, kas saistīta ar būvniecībā izmantojamiem materiāliem, sistēmām un konstrukcijām brīvi pieejamu un internacionālu

- Līdz šim izdotas >200 rekomendācijas, ko plaši pielieto:
  - ASR accelerated testing
  - RILEM Test tube
  - uc



Pētījuma process un mērķis

- RILEM TC *304-ADC*
- Vada zinātnieki no *TU Dresden, TU Munich un Ghent University*
- Kopā pāri pa 30 laboratorijām:
  - *Universitātes – ETH Zurich, Gustave Eiffel University, Swinburne University of Technology, utt*
  - *Industrija – COBOD (PERI printeri), Holcim, Heidelberg materials*

TECHNISCHE UNIVERSITÄT DRESDEN

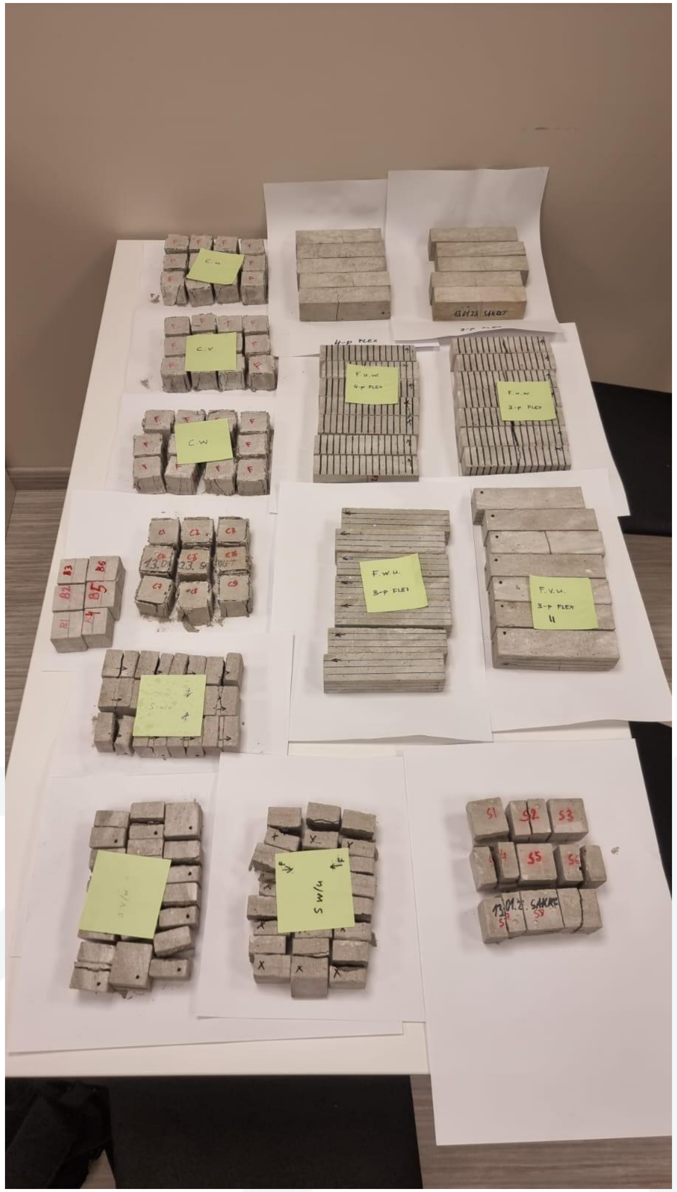
Technische Universität München

GHENT UNIVERSITY

- Veicām **mehānisko īpašību** un **ilgmūžības testus**, ievērojot sākotnēji izstrādātus RILEM komitejas norādījumus;
- **Mērķi:**
  - **Apkopot** un **analizēt** starplaboratoriju rezultātus, atrast likumsakarības;
  - Izstrādāt **rekomendācijas**, kas balstītas uz praksē pārbaudītajiem testiem;
  - Šīs rekomendācijas kalpos kā **pamats** un dos **ieguldījumu standartu izstrādāšanā**

Test scale	Test	Orientation[b]	Specimen extraction	Preferred geometry shape and size [mm]	Process parameters[d]	Min no of experimental results[c]	X[b]
Mortar	Compression	u	Sawn	Cube of 40x40x40	default	9	
		v	Sawn			9	
		w	Sawn			9	
		u	Core-drilled	Cylinder of dxh=50	default	9	
		v	Core-drilled			9	
		w	Core-drilled			9	
		-	Cast	Cube of 40x40x40	default	9	
		u	Sawn	Cube of 40x40x40	dev1	5	
		v	Sawn			5	
		w	Sawn			5	
		u	Sawn	Cube of 40x40x40	dev2	5	
		v	Sawn			5	
		w	Sawn			5	
	Flexural tension, 3-point bending[a]	u.w	Sawn	Prism of 40x40x160	default	5	
		v.u	Sawn			5	
		w.u	Sawn			5	
		-	Cast	Prism of 40x40x160	default	5	
		u.w	Sawn	Prism of 40x40x160	dev1	5	
		v.u	Sawn			5	
		w.u	Sawn			5	
		u.w	Sawn	Prism of 40x40x160	dev2	5	
		v.u	Sawn			5	
		w.u	Sawn			5	
	Flexural tension, 4-point bending[a]	u.w	Sawn	Prism of 40x40x160	default	5	
		-	Cast	Prism of 40x40x160	default	5	
		u.w	Sawn	Prism of 40x40x160	Dev1	5	
		u.w	Sawn	Prism of 40x40x160	Dev2	5	
	Splitting tension	u/v	Sawn	Cube of 40x40x40	Default	9	
		v/w	Sawn			9	
		w/u	Sawn			9	
		u.w/v	Core-drilled	Cylinder of dxh=50x100	Default	5	
		v.u/w	Core-drilled			5	
		w.u/v	Core-drilled			5	
		-	Cast	Cube of 40x40x40	default	9	
	Uniaxial tension	u	sawn	Prism of 40x40x160	Default	5	
		w	Sawn			5	
		u	Core-drilled	Cylinder of dxh=50x150	Default	5	
		w	Core-drilled			5	
		-	Cast	Prism of 40x40x160	default	5	
	Modulus of elasticity	u	Sawn	Prism of 40x40x80-160	Default	5	
		w	Sawn			5	
		u	Core-drilled	Cylinder of dxh=50x100-200	Default	5	
		w	Core-drilled			5	
		-	Cast	Prism of 40x40x80-160	default	5	

[a] for the flexural tests in the u.w direction it is compulsory to perform both the 3-point and the corresponding 4-point bending test.
[b] marking column to indicate which tests will be performed by a laboratory.
[c] yellow hatched tests are compulsory for all participating laboratories. Note that a minimum number of additional tests also need to be performed (see General Information). Other tests are optional. Laboratories are encouraged to perform as many tests as possible to maximize the impact of this interlaboratory study.



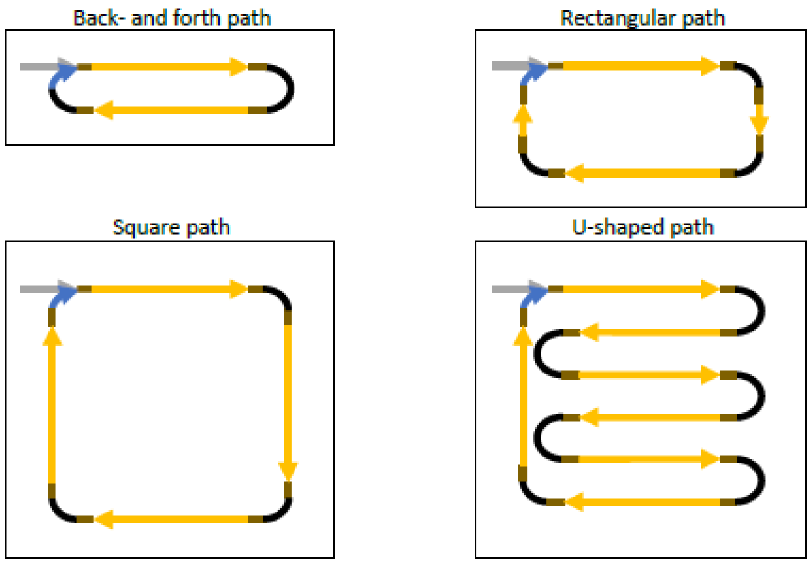


Fig. 3.1. Suggested print paths of single filament-width, for mortar-scale specimens.

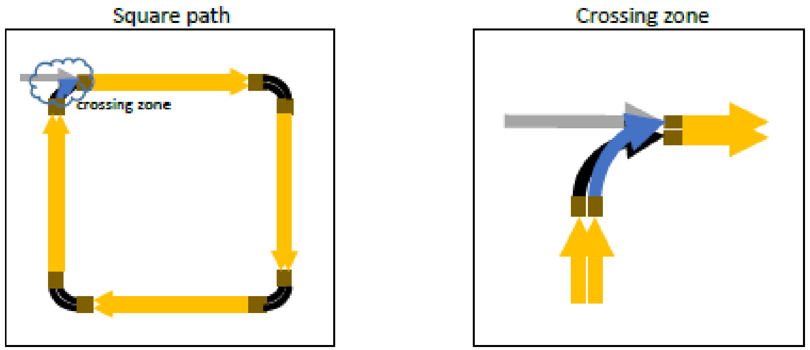


Fig. 3.2. Suggested print path of double filament-width, for mortar-scale specimens.

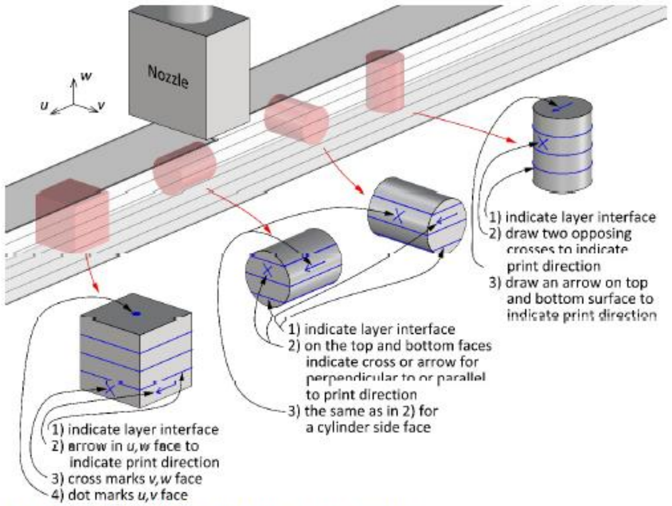
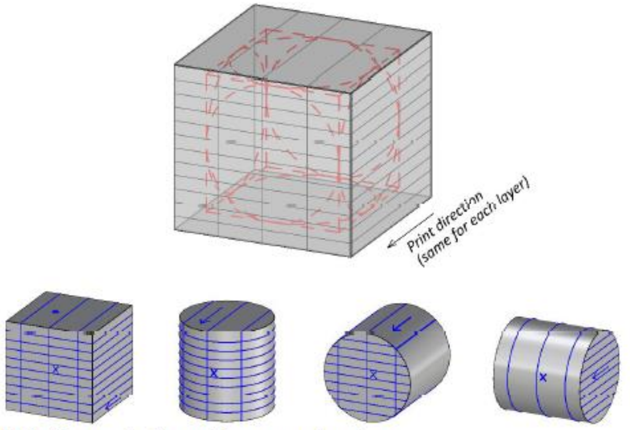
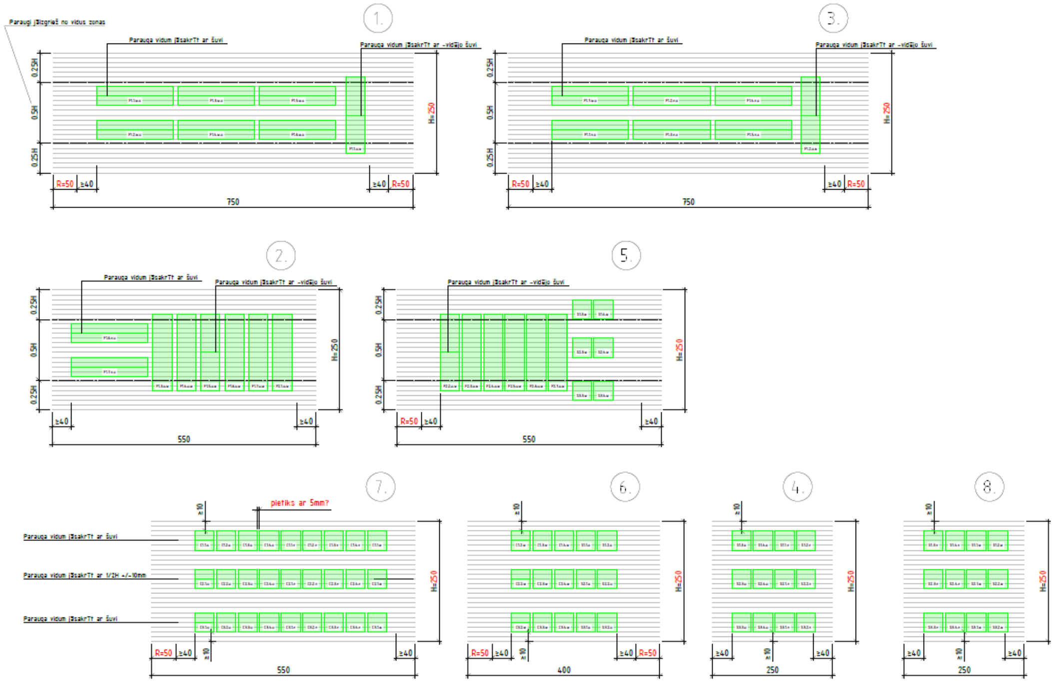


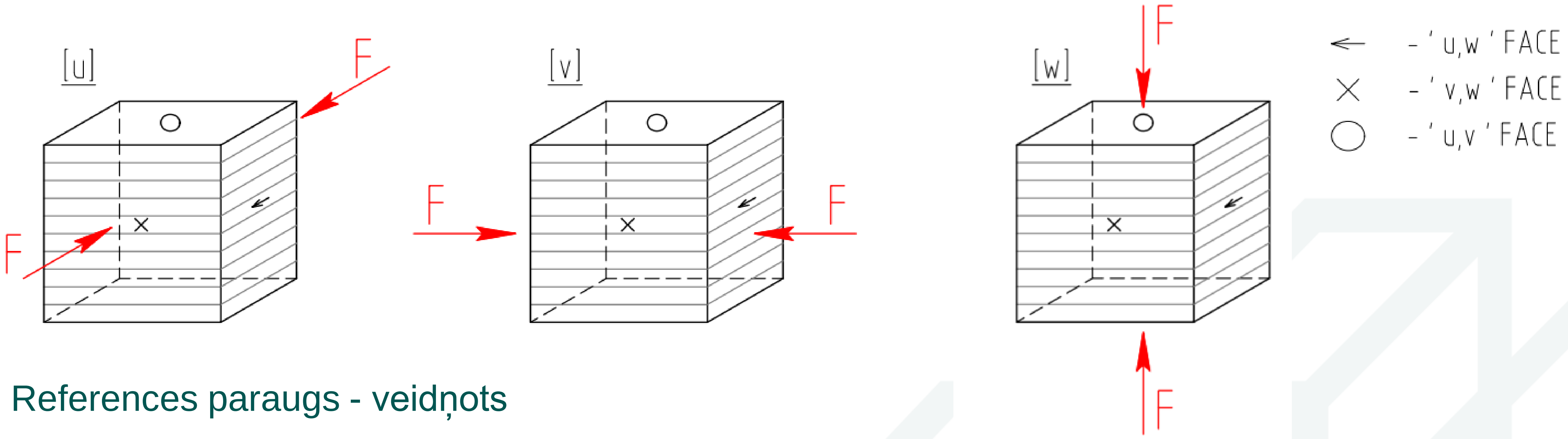
Fig. 3.4. Marking convention illustrated for mortar-scale specimens.





Spiedes stiprības testi – testēšanas virzieni

- Testējām 3 virzienos:
  - **[u] virziens** (slodze pielikta **pret v,w plakni**)
  - **[v] virziens** (slodze pielikta **pret u,w plakni**)
  - **[w] virziens** (slodze pielikta **pret u,v plakni**)



- References paraugs - veidņots

Lieces stiprības testi – testēšanas virzieni

- Testējām 3 virzienos:
  - **[u.w] virziens** – 3-punktu un 4-punktu liece
  - **[v.u] virziens** – 3-punktu liece
  - **[w.u] virziens** – 3-punktu liece
- **Pirmais burts** – apzīmē asi, ap kuru rodas **rotācija**, pieliekot **spēku**
- **Otrais burts** – apzīmē parauga **garenvirziena asi**
- References paraugs – veidņots – 3-punktu un 4-punktu liece

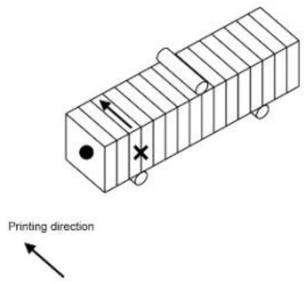


Fig. 5.4a. Illustration of specimen orientation **u.w**,

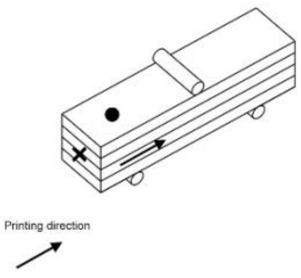


Fig. 5.4b. Illustration of specimen orientation **v.u**,

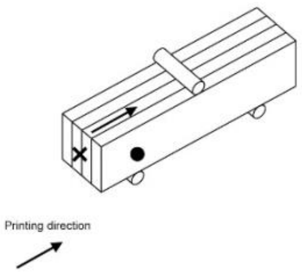
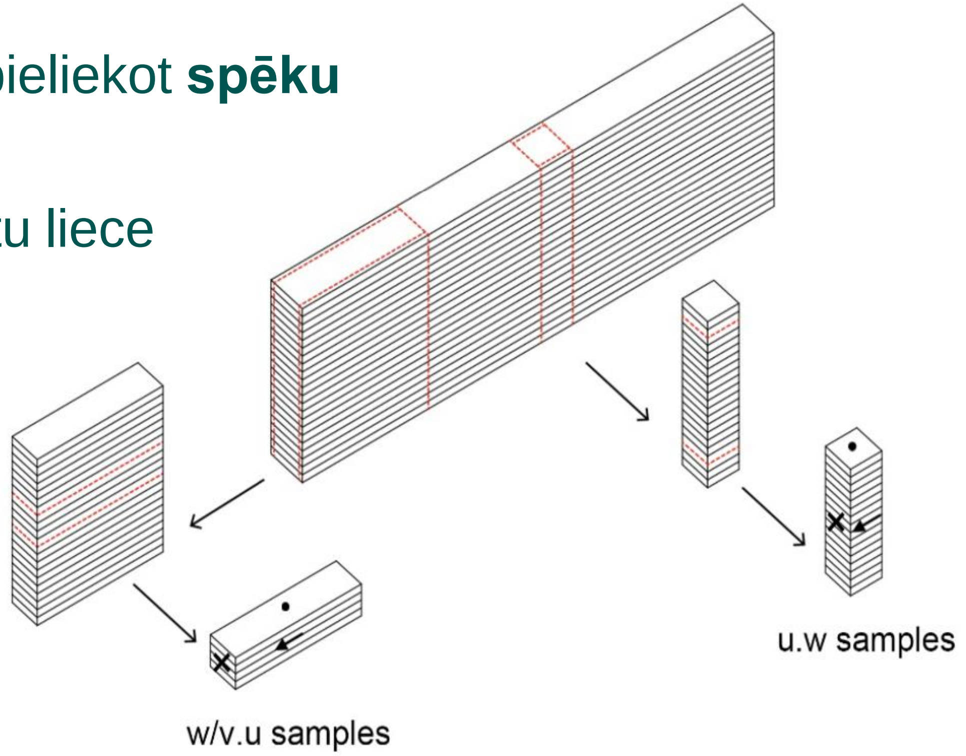
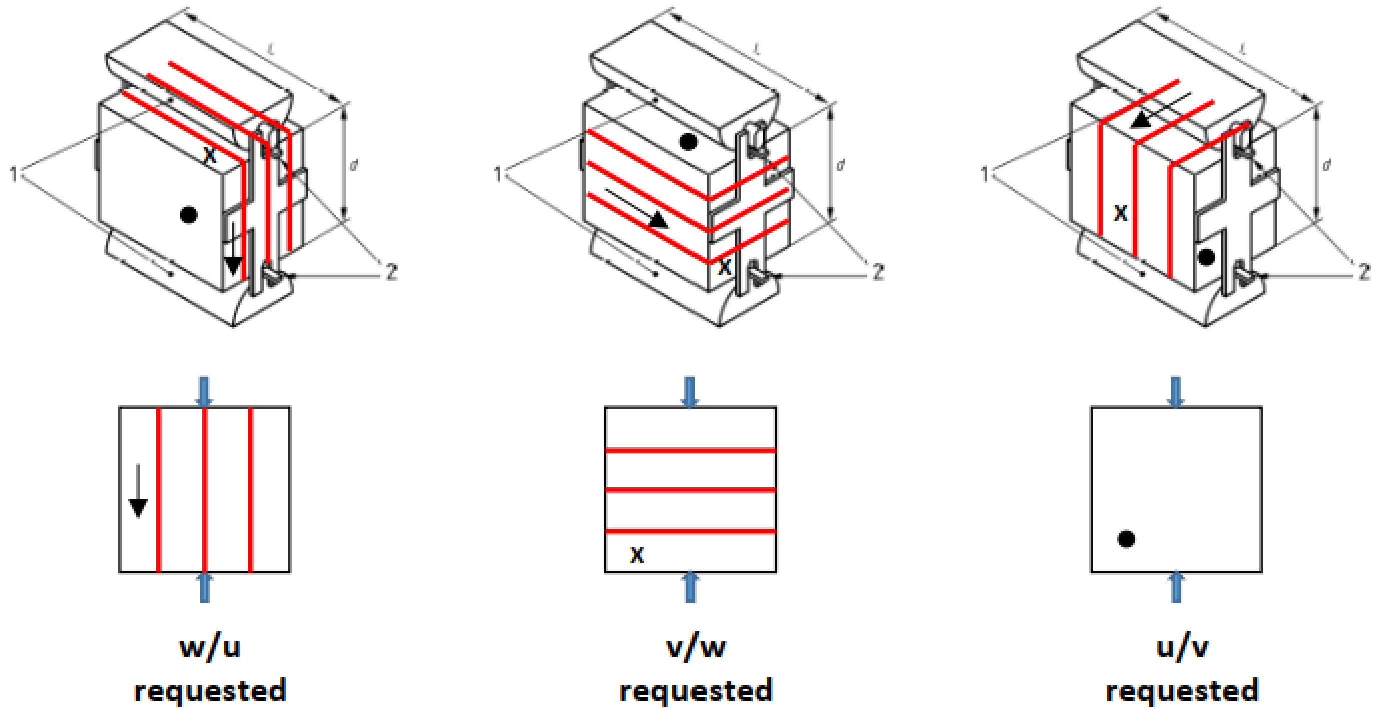


Fig. 5.4c. Illustration of specimen orientation **w.u**,



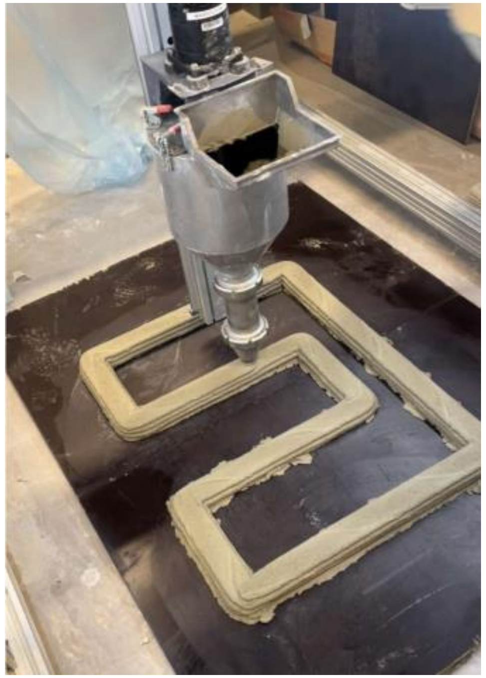
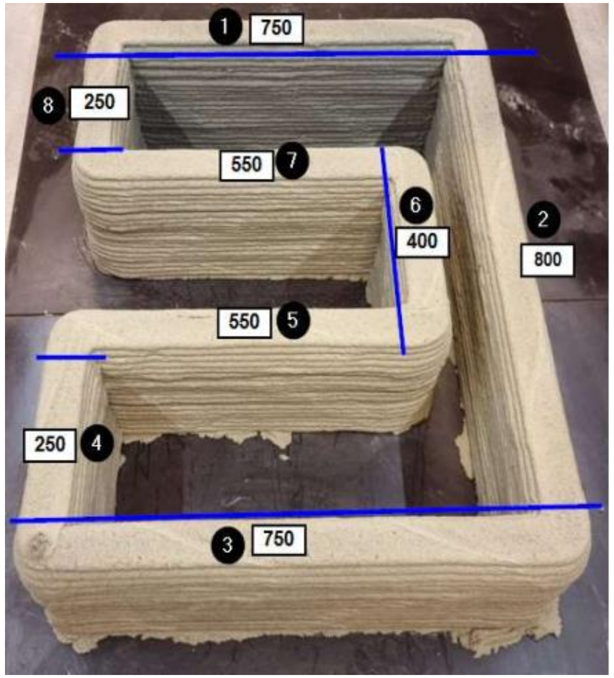
Stiepes stiprības testi – testēšanas virzieni

- Testējām 3 virzienos:
  - **w/u virziens**
  - **v/w virziens**
  - **u/v virziens**
- References paraugs – veidņots



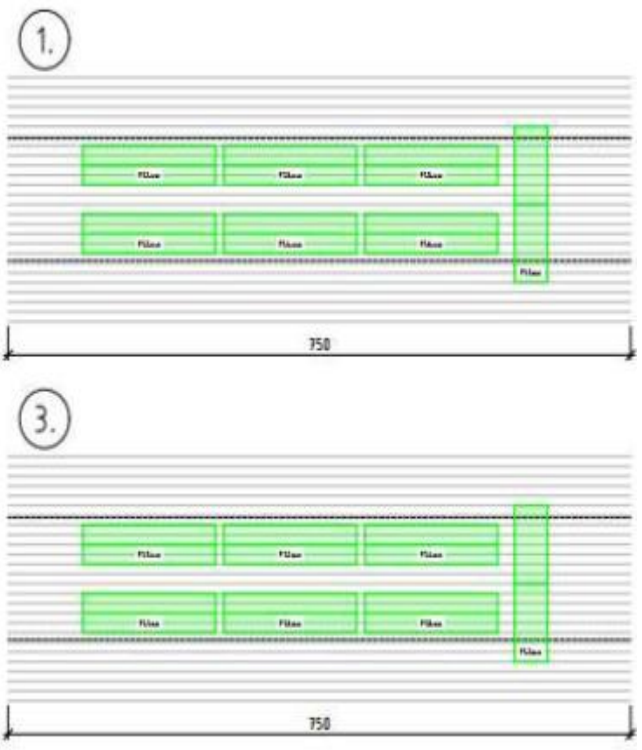
Mehāniskie testi – paraugu sagatavošana

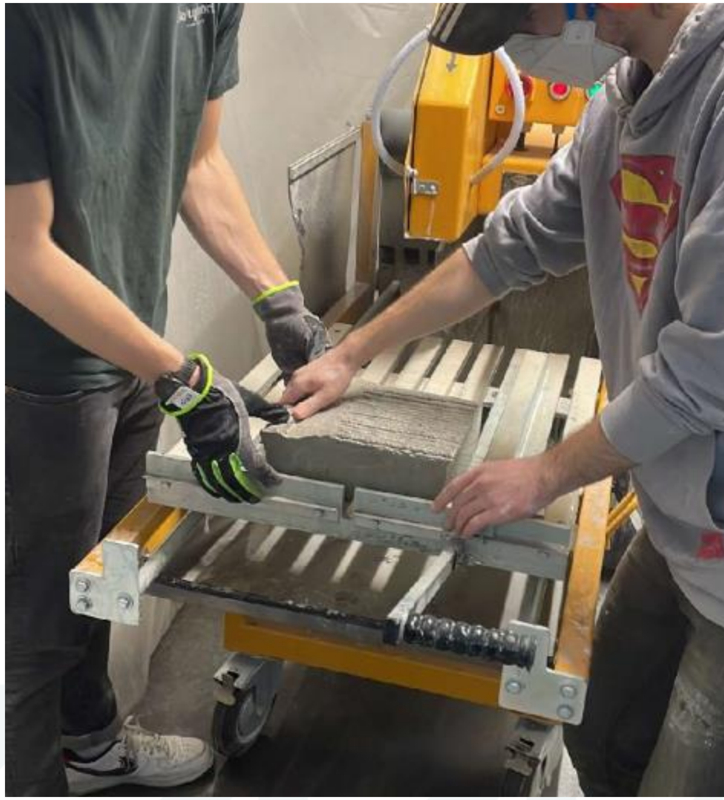
- Izmantojām **SIA *Sakret* gatavo 3D mix**
- Pēc printēšanas nesacietējis paraugs tika sadalīts **8 daļās**
- Sākotnējā uzglabāšana – **zem plēves**
- Pēc 72h paraugi tika pārvietoti **ūdenī**


Mehāniskie testi – paraugu sagatavošana

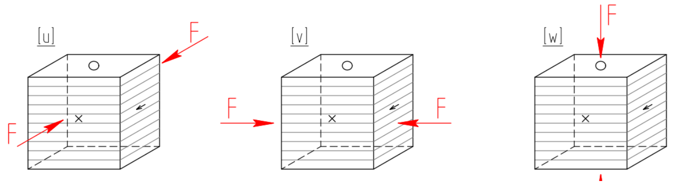
- Katra no 8 daļām **tika zāģēta un marķēta** atbilstoši **skicei**
- Vienāds paraugu skaits no printētā objekta **apakšdaļas, vidusdaļas un augšdaļas**

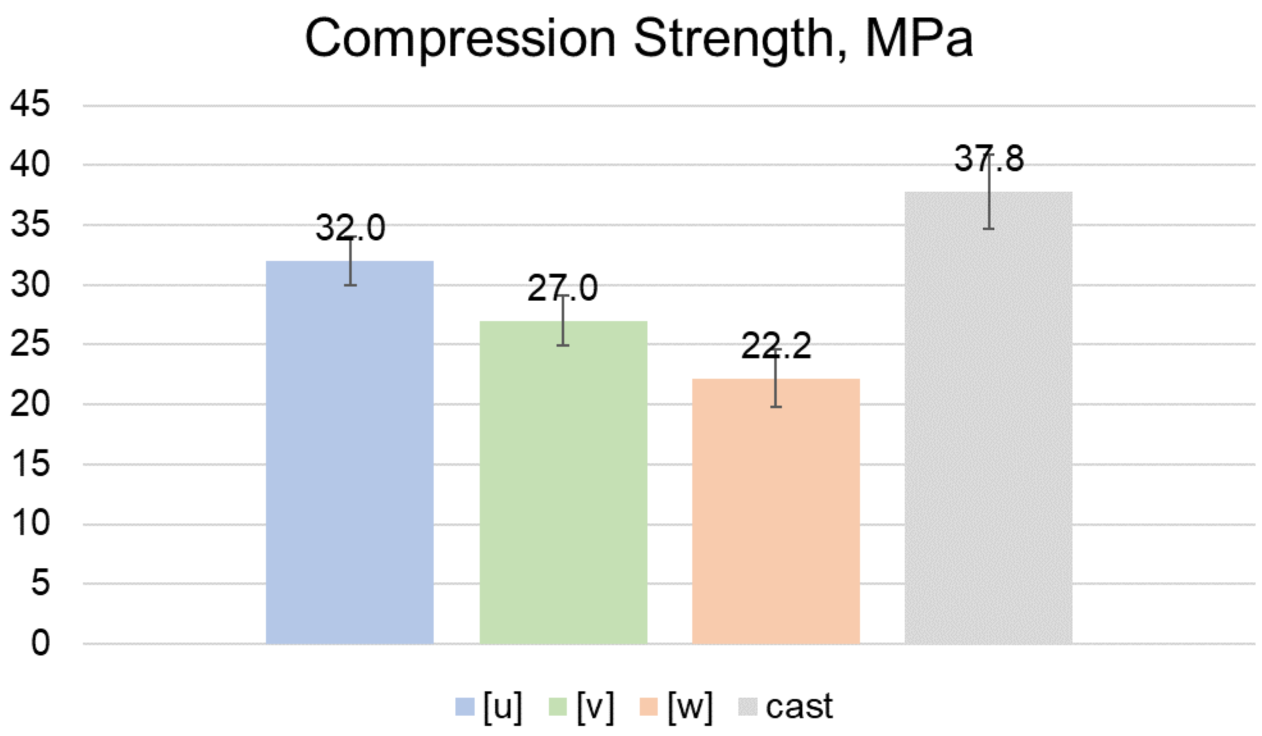




Spiedes stiprības testi – rezultāti

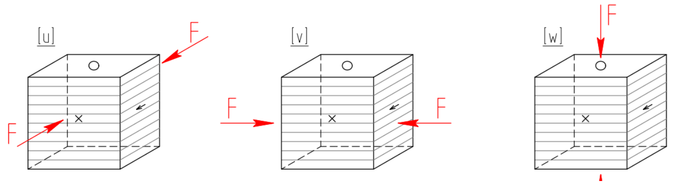
- **Augstākā spiedes stiprība – [u]** jeb printēšanas virzienā
- **Zemākā spiedes stiprība – [w]** jeb virzienā spiežot no augšas
- Sabrukuma aina – nebija novērojama sadalīšanās pa šuvēm

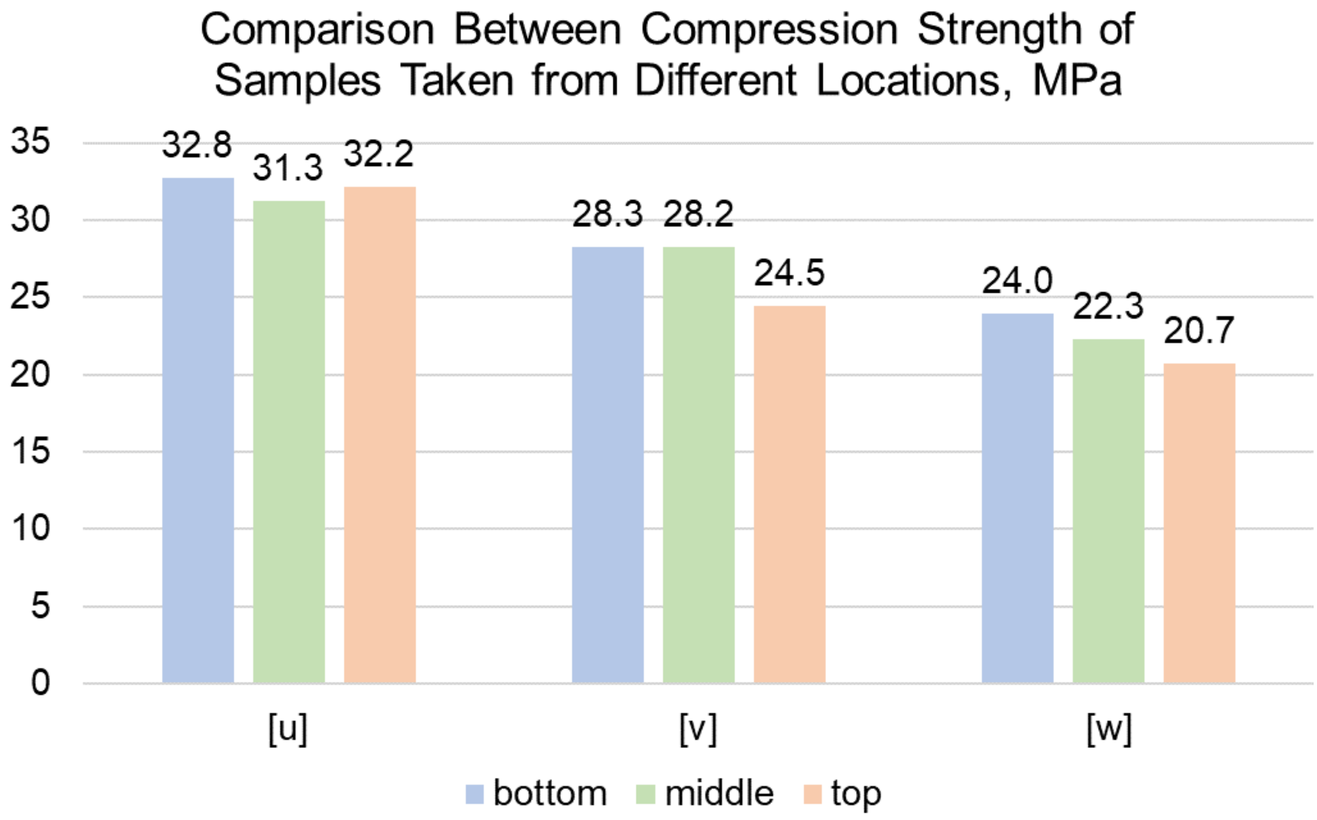




Spiedes stiprības testi – rezultāti

- **Augstākā spiedes stiprība –** apakšējiem slāņiem





Lieces stiprības testi – rezultāti

- **Augstākā lieces stiprība – [w.u]**
- **Zemākā lieces stiprība – [u.w]**

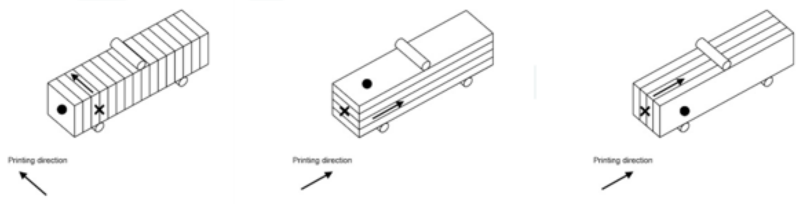
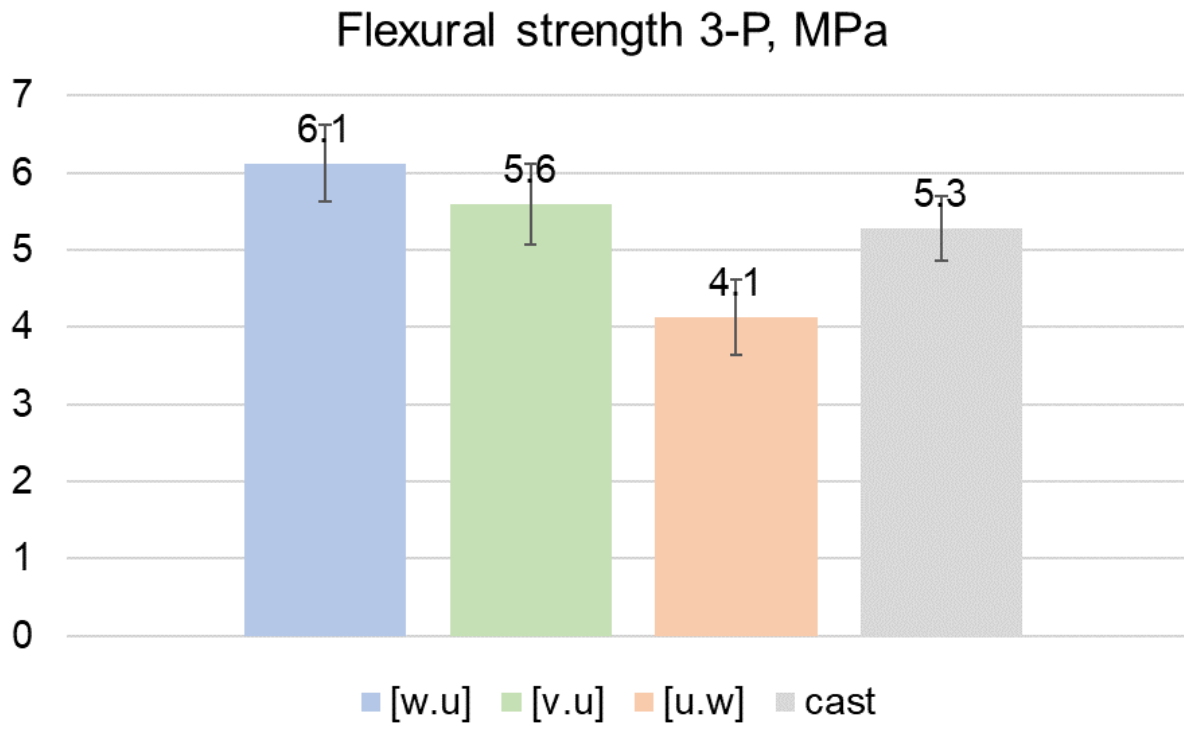
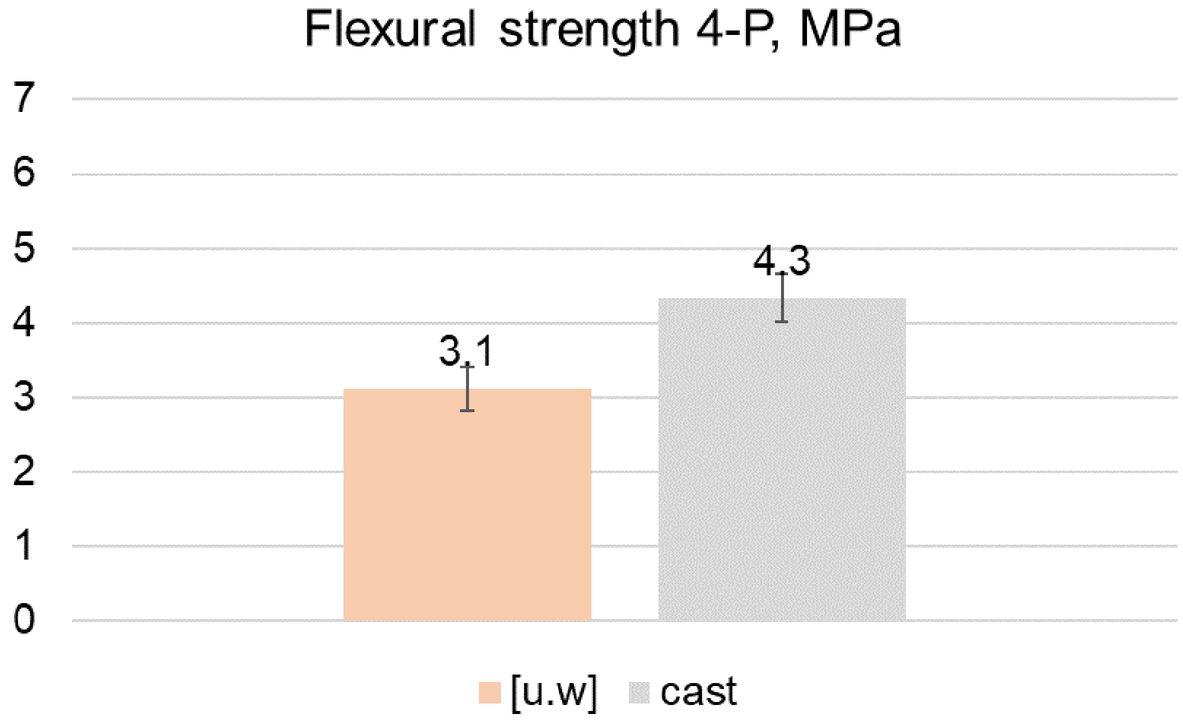


Fig. 5.4a. Illustration of specimen orientation **u.w,**

Fig. 5.4b. Illustration of specimen orientation **v.u,**

Fig. 5.4c. Illustration of specimen orientation **w.u,**





Lieces stiprības testi – rezultāti

- Sabrukuma aina – nebija novērojama sadalīšanās pa šuvēm

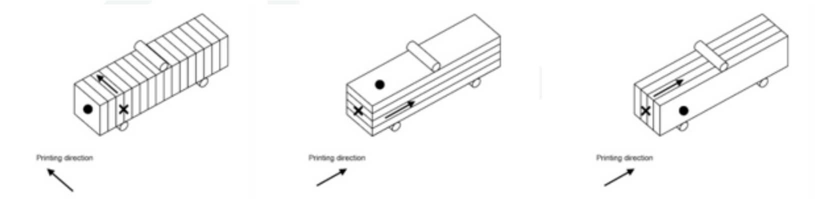
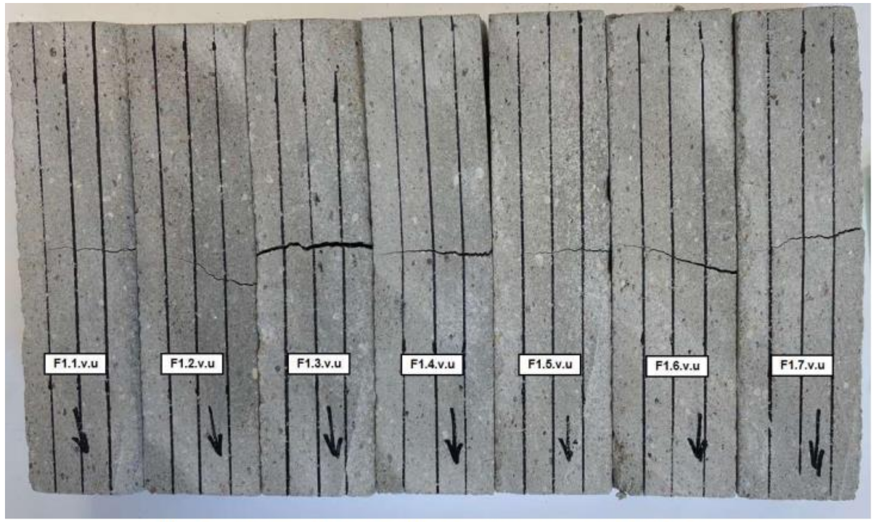


Fig. 5.4a. Illustration of specimen orientation **u.w**, **Fig. 5.4b.** Illustration of specimen orientation **v.u**, **Fig. 5.4c.** Illustration of specimen orientation **w.u**,



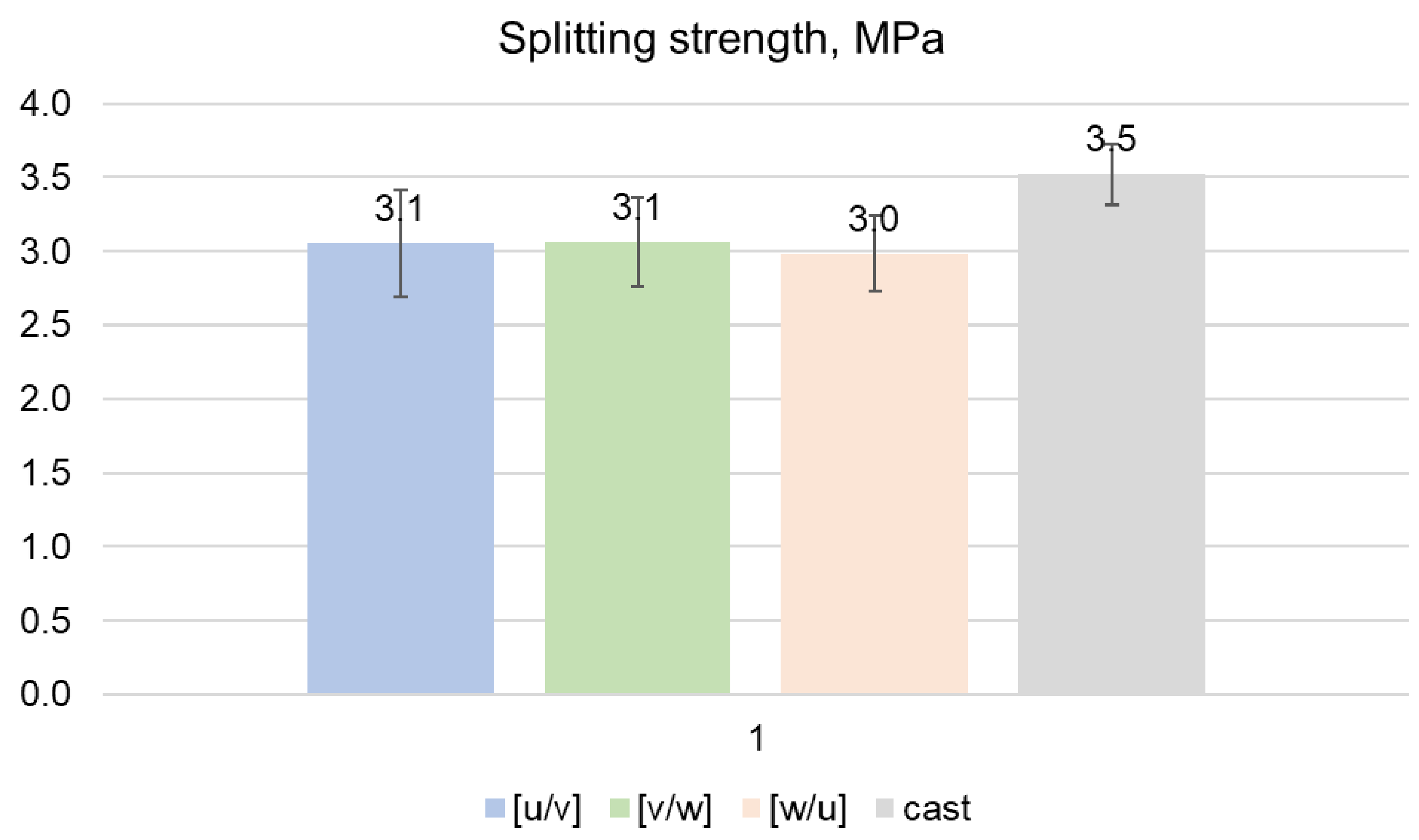
Fracture pattern after 3-point bending – test orientation 'v-u'

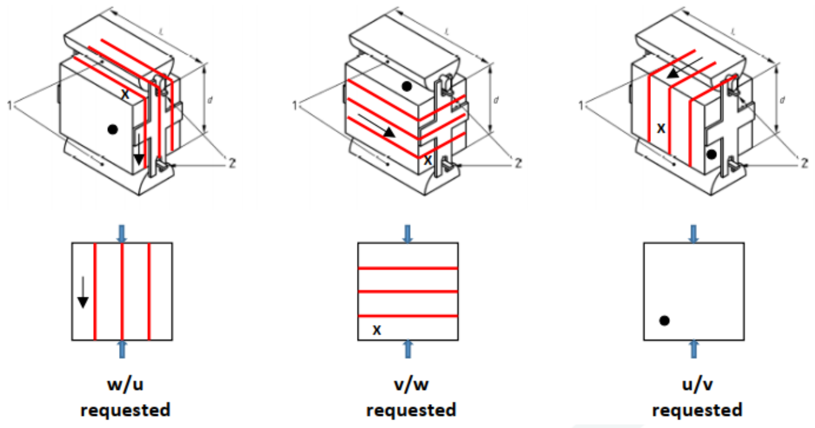
Fracture pattern after 3-point bending – test orientation 'u-w'

Fracture pattern after 3-point bending – test orientation 'w-u', side view.

Stiepes stiprības testi – rezultāti

- Virziens stiepes stiprību ietekmē minimāli

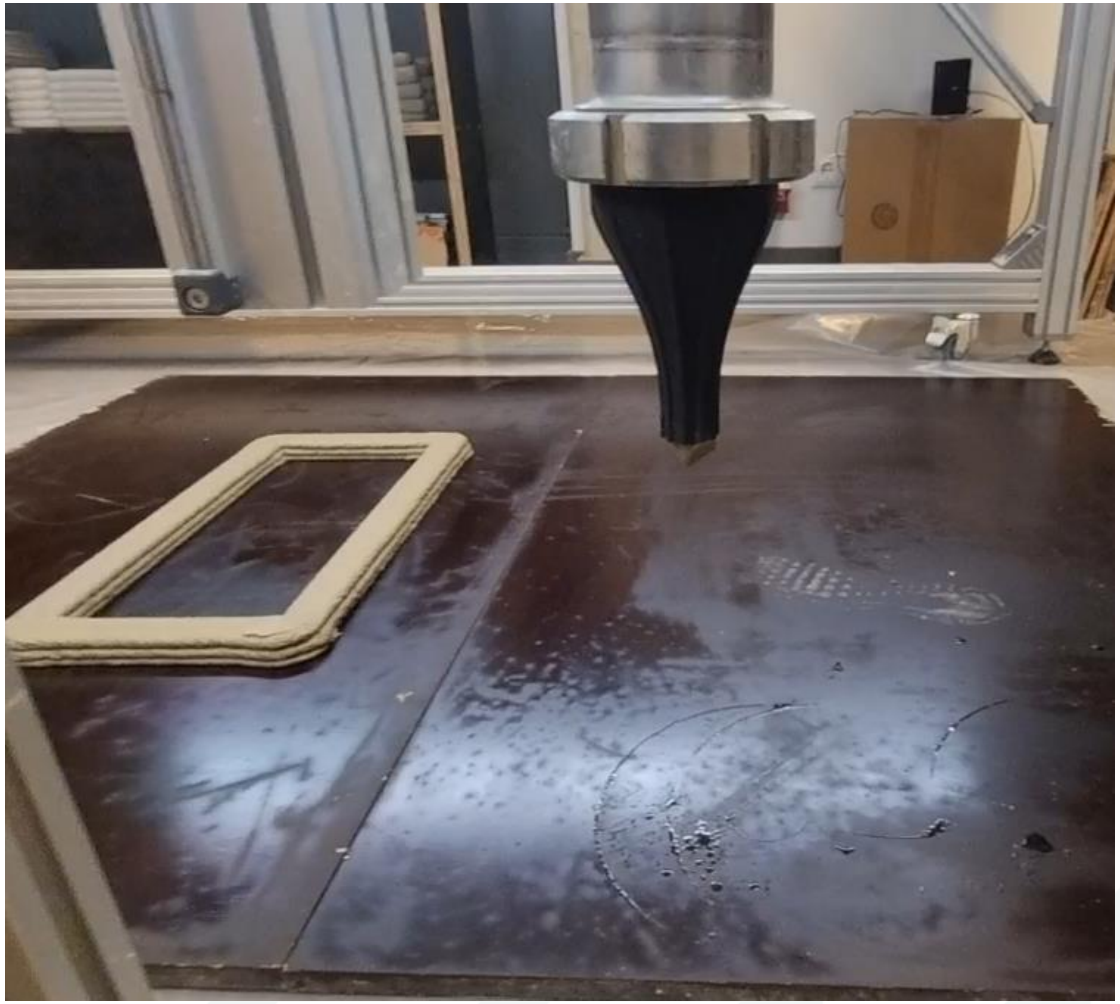




Ilgmūžības testi – paraugu sagatavošana

- Izmantojām **SIA *Sakret* gatavo 3D mix**

- Tika izprintēti **2 objekti**:
  - 6 slāņus augsts paraugs **bez šuves**
  - 6 slāņus augsts paraugs **ar horizontālu šuvi** vidusdaļā, ieturot **2h 58min** pauzi (**sākotnējais saistīšanās laiks**) pēc 3. šuves izprintēšanas



ILGMŪŽĪBAS TESTI

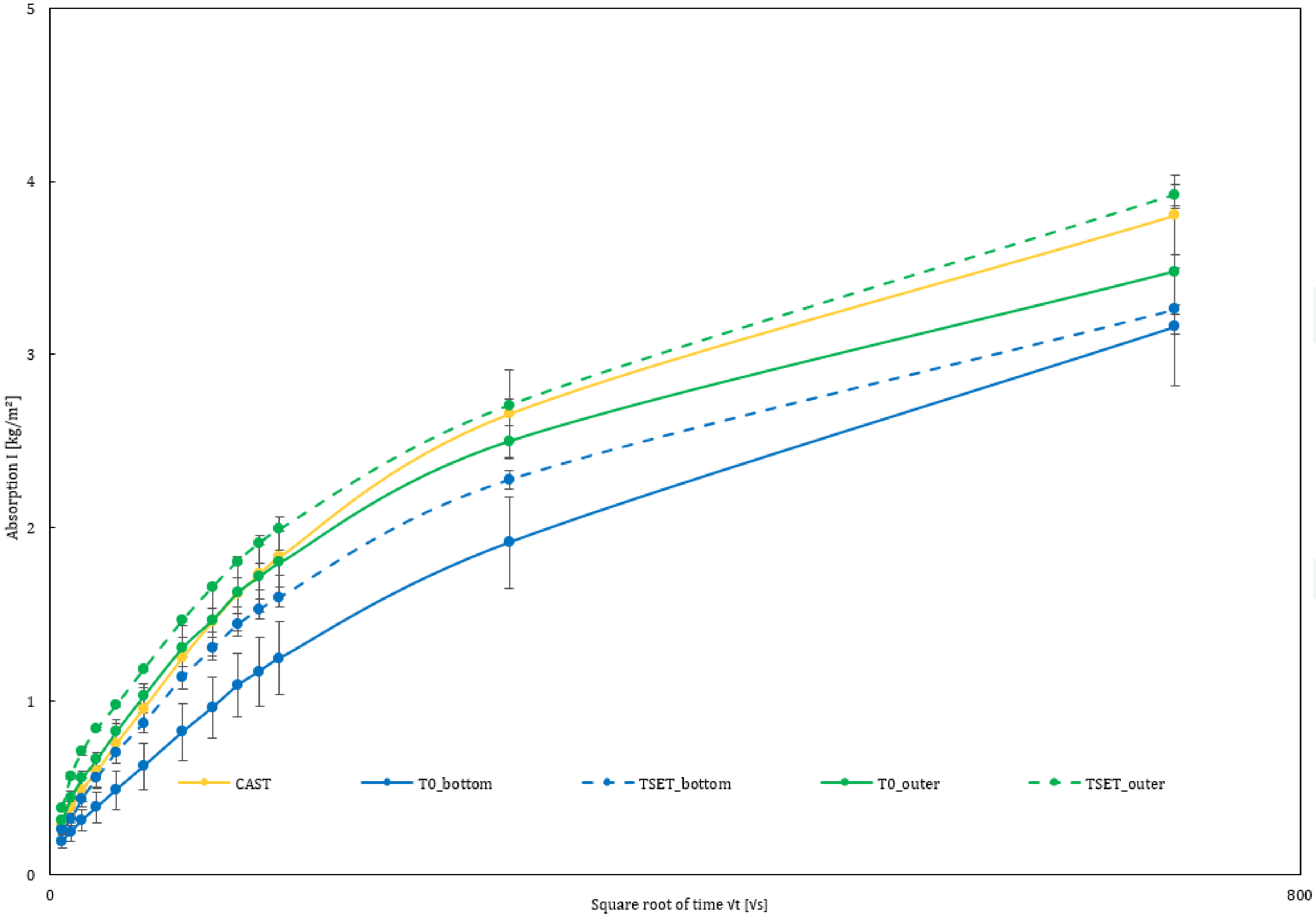
- Ūdensuzsūces tests
  Paraugi tika noklāti ar epoksīdu, eksponētas atstājot:

a) sānu jeb printētās virsmas
b) apakšējas jeb veidņa virsmas

- CO_2 tests
  Kamerā ar CO_2 koncentrāciju 1% tiek ievietoti paraugi uz 90 dienām

Ūdensuzsūces tests – rezultāti

- Abu veidu **paraugiem bez šuves zemāka ūdensuzsūce** nekā paraugiem ar šuvi;
- Paraugiem, kas ūdeni uzsūc **caur apakšējo plakni zemāka ūdensuzsūce** nekā paraugiem, kas ūdeni uzsūc caur sānu plakni.



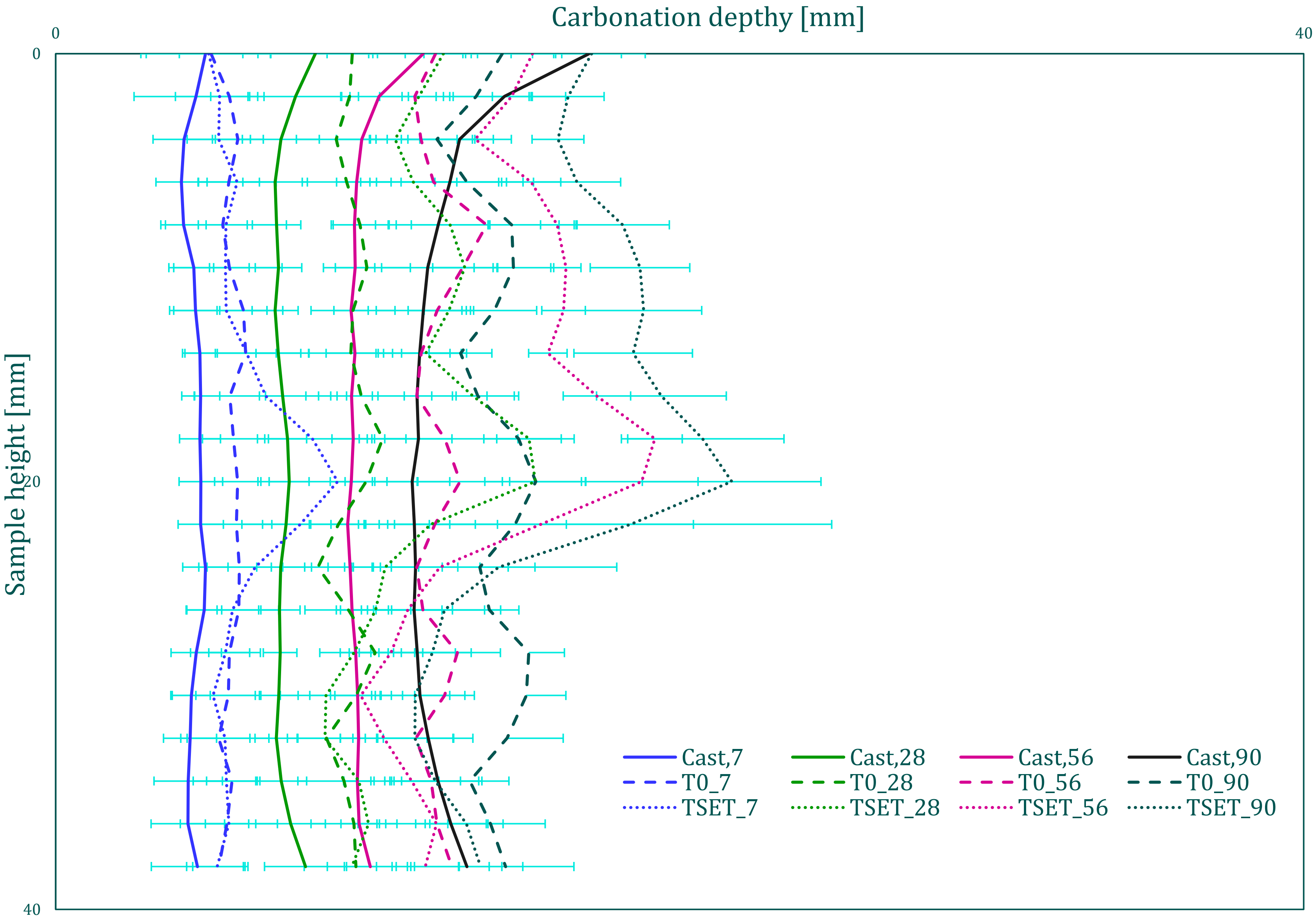
Karbonizācijas tests

- Tika testēti 2 sēriju paraugi:
  - karbonizācija caur **sānu plakni, ar šuvi**
  - karbonizācija caur **sānu plakni, bez šuves**
- References paraugs – veidņots
- 1% CO_2
- Tika noteikts **karbonizācijas dziļums pēc 7, 28, 56, 90 dienām** – paraugus pāršķeļot un uzpūšot 1% fenoftaleīna šķīdumu, uzņemot attēlus un analizējot ar ImageJ

Karbonizācijas tests – rezultāti

- **Paraugiem bez šuves mazāks karbonizācijas dziļums** nekā paraugiem ar šuvi;
- Ļoti **augstas standartnovirzes;**

- Staprlaboratoriju rezultāti būs pieejami pēc to apkopošanas un publicēšanas



Iepriekšējie testi – salturība 3D drukātam betonam

Salizturība

- Modificētas plātnes tests (CEN 12390-9)
- Testa virsmas, kas iegremdētas 3% NaCl, ievietotas klimata pārbaudes kamerā
- Masas mērīšana pēc 14, 28 un 56 sasaldēšanas-atkausēšanas cikliem
- Virsmas laukums mērīts, neņemot vērā rievas, ko veido drukāto paraugu slāņi

Iepriekšējie testi – salturība 3D drukātam betonam

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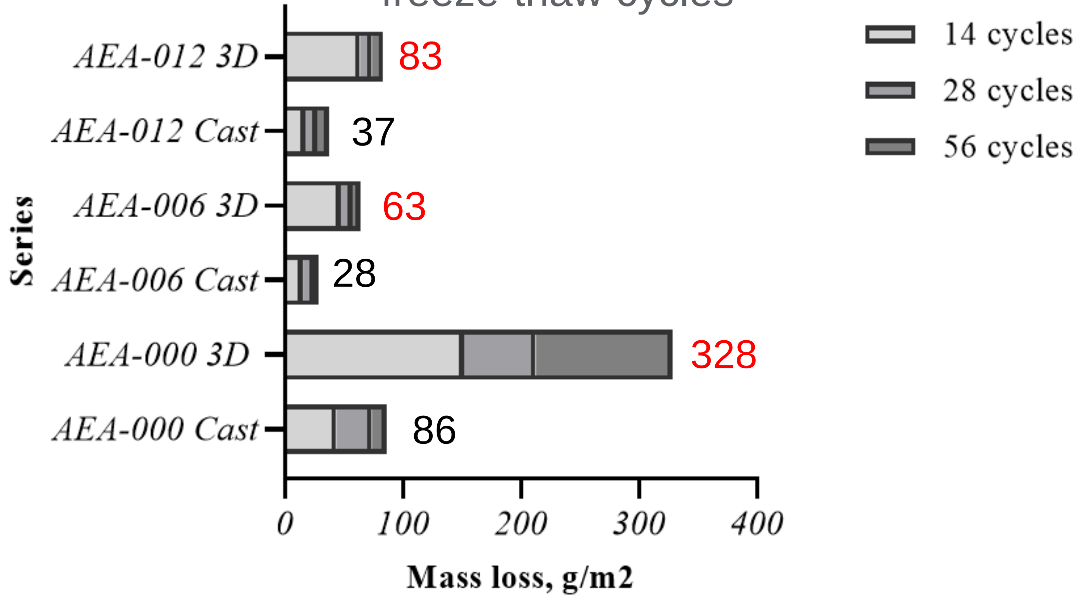
Mass loss of 3D printed and cast samples after freeze-thaw cycles

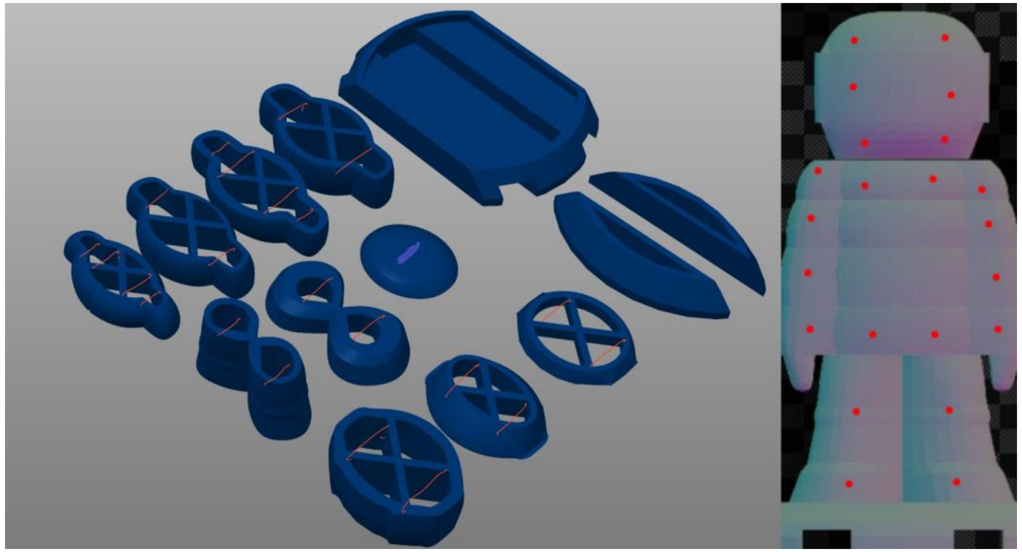


AEA significantly increased frost resistance of the printed and cast concrete (almost 5 times) – no significant difference between 0.06 and 0.12%.

Different amounts of AEA

RTU ZIC talismans

- Plānoti divi objekti – ZIC talismans, astronauts LabLabs
- Novietne RTU teritorijā
- Materiāla ilgmūžības testēšana laboratorijas un reālos apstākļos



RTU ZIC talismans

- Plānoti divi objekti – ZIC talismans, astronauts LabLabs
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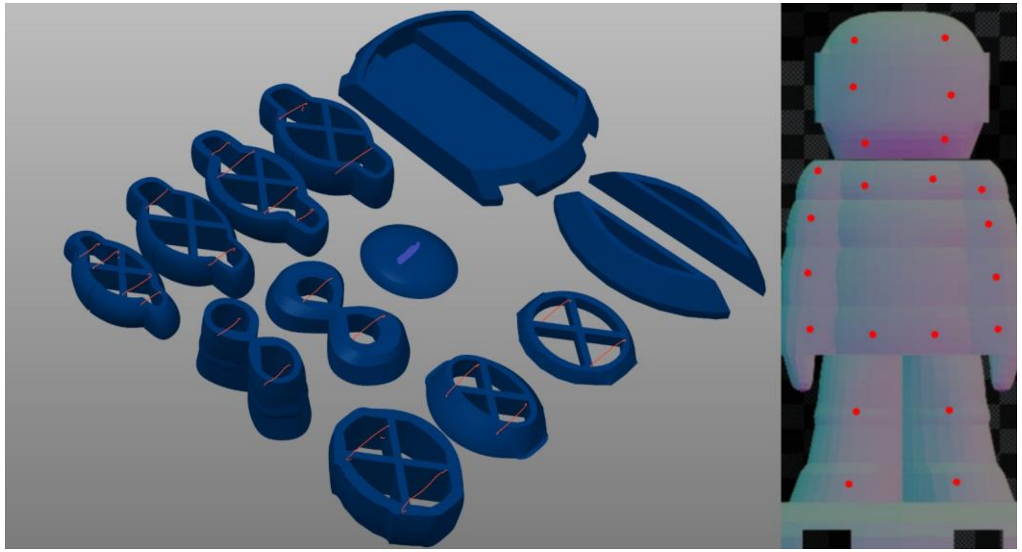
- Materiāla ilgmūžības testēšana laboratorijas un reālos apstākļos



TRANSITION
Waste to 3D printing

M-era.Net

- **«Transforming Waste Into High-Performance 3D Printable Cementitious Composite»**
- RTU (LV), SAKRET (LV), KTU (LT) un ZAG (SLO)
- Degakmens pelnu izmantošana 3D drukājama betona maisījumos
- Liels uzsvars uz ilgmūžības pētījumiem

https://transition.rtu.lv/

TRANSITION
Waste to 3D printing

About project | Main activities | Partners | Work packages | Contacts

Transforming Waste Into High-Performance 3D Printable Cementitious Composite

The project aims to develop a ready-to-use blend of components with a large proportion of oil shale ash suitable for various types of extrusion 3D printers whose mechanical resistance and durability are validated on a large-scale prototype.

www.facebook.com/3DconcreteRTU

Paldies par uzmanību!

maris.sinka@rtu.lv

MB GRUPA
BETONA PĒTĪJUMU CENTRS

Alkali-silica reactions for LV materials

Sārmu silikātu reakcija LV materiāliem

Vladislavs Baranovs

MB GRUPA DZELZSBETONS

MB GRUPA DAUGAVPILS DZELZSBETONS

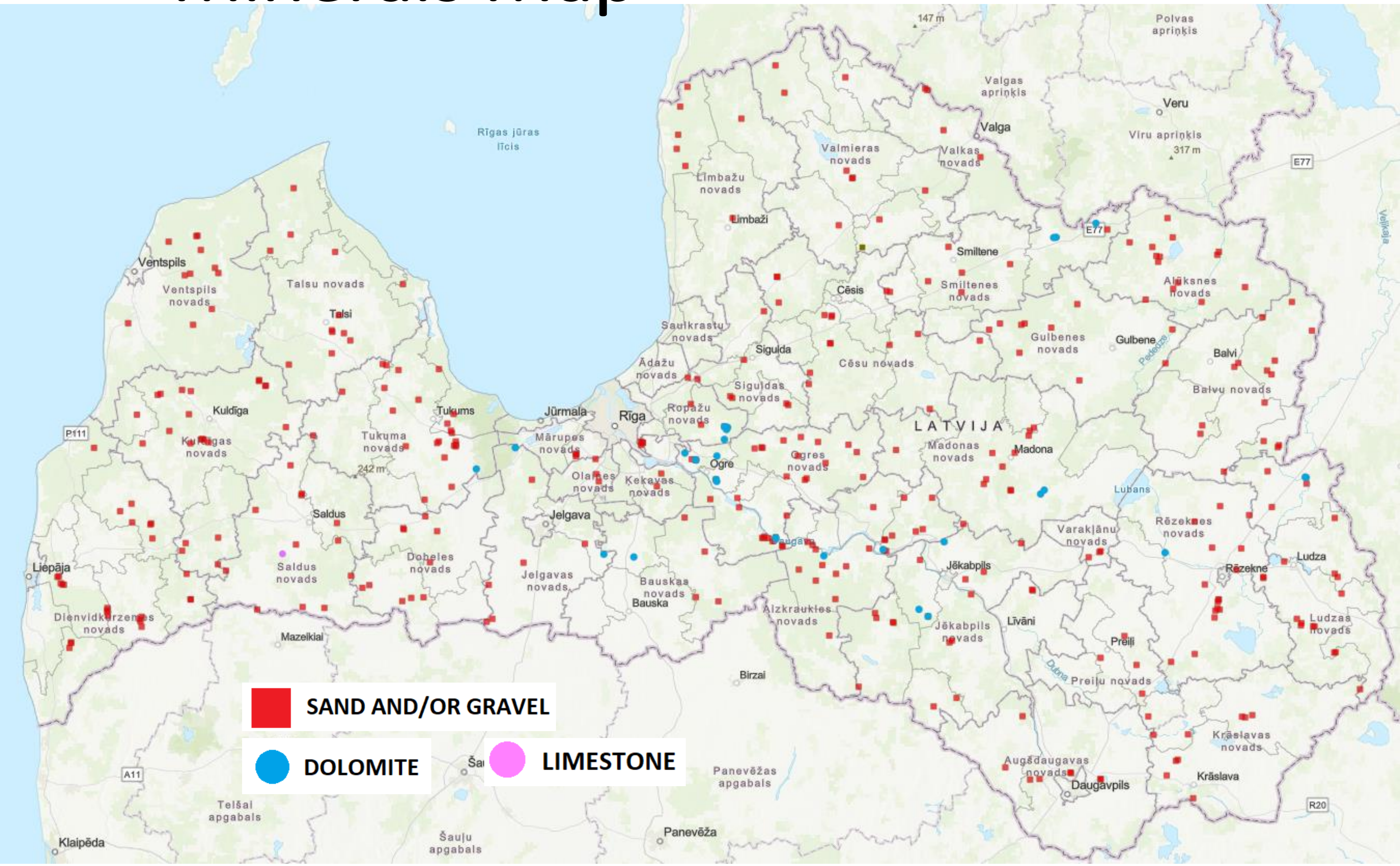
MB GRUPA TRANSPORTBETONS

MB GRUPA INERTIE MATERIĀLI

MB GRUPA BETONA PĒTĪJUMU CENTRS

Minerals Map

MB GRUPA
BETONA PĒTĪJUMU CENTRS



Concrete research centre are testing alkali-silica reaction in agregates since 2021.

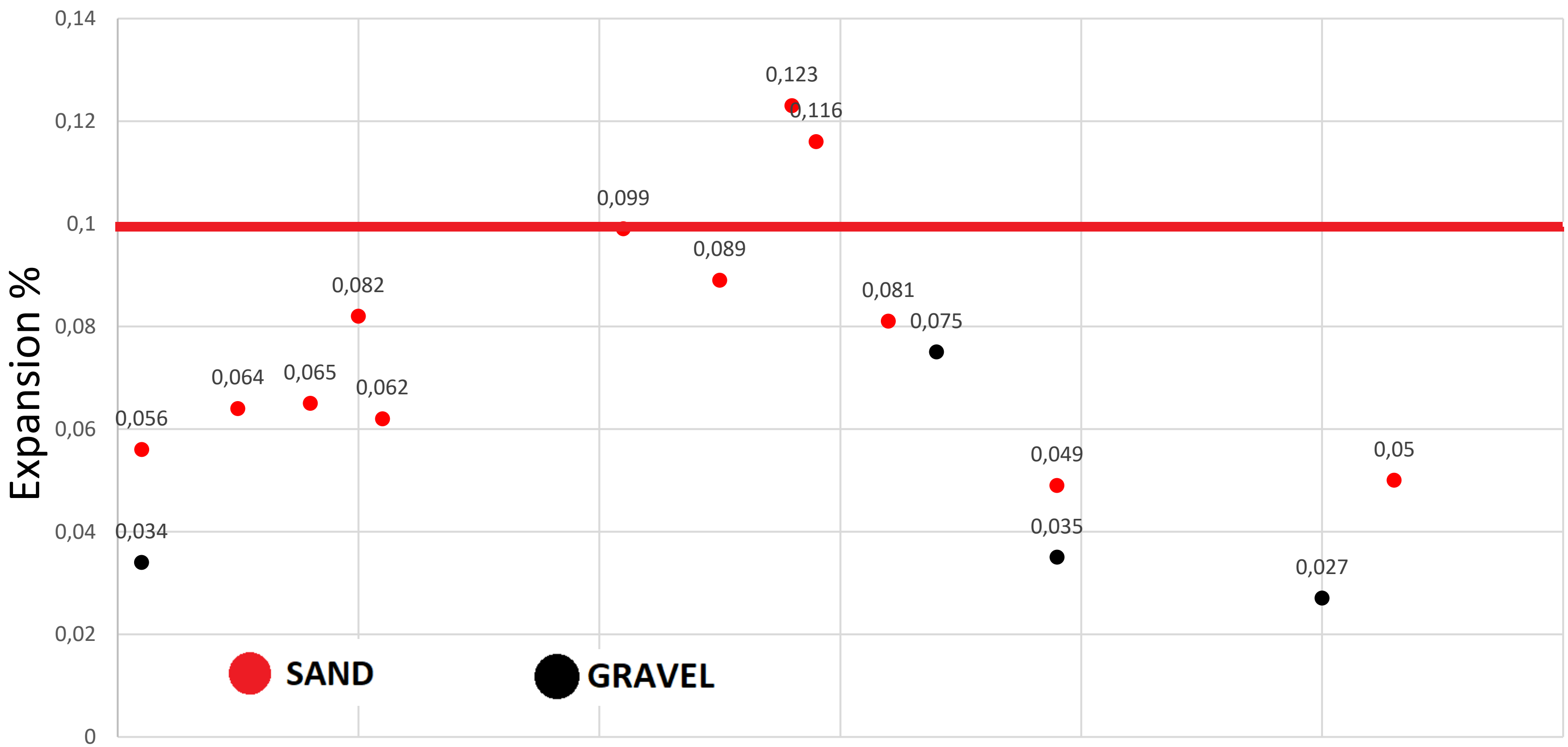
In this period we made tests for Latvian materials as:

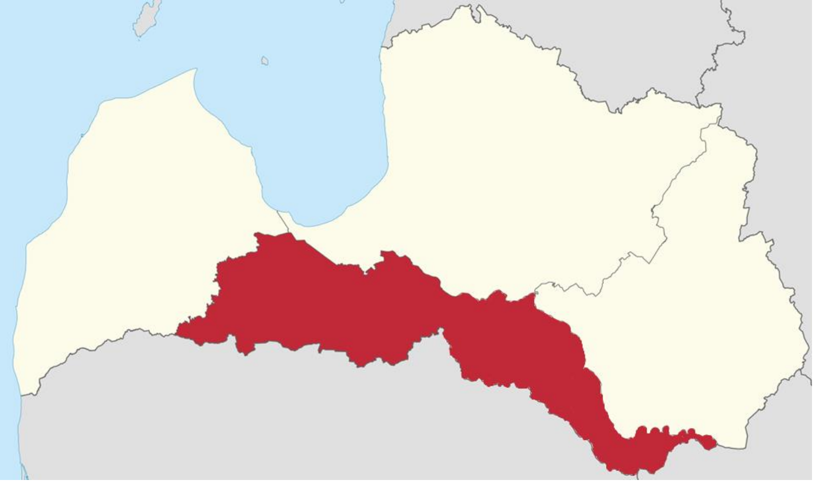
Sand - 37
Gravel – 17
Dolomite - 1

FROM:

Kurzeme - 22
Zemgale – 11
Vidzeme - 15
Latgale - 6

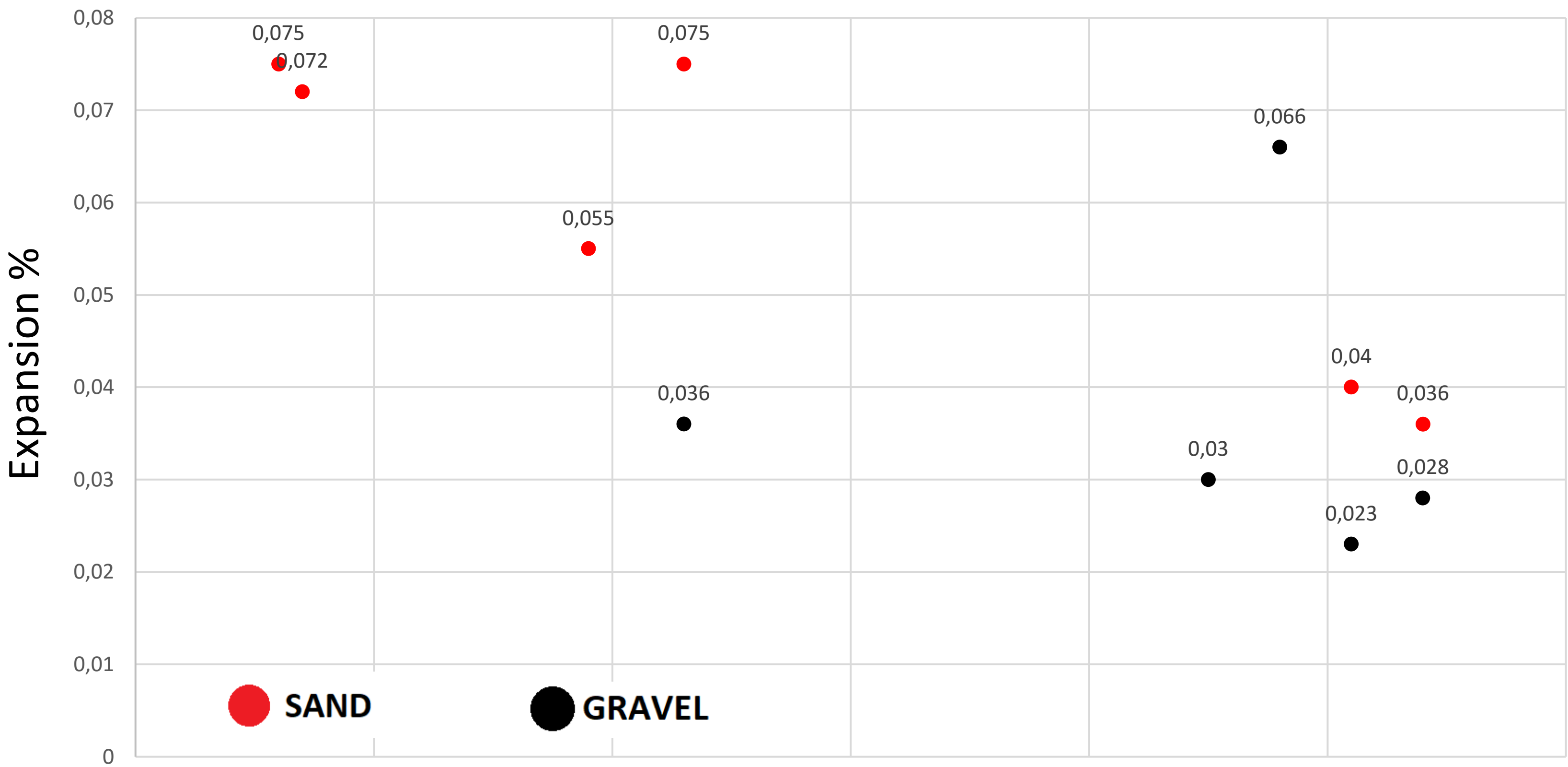
Results in Kurzeme (for 14d test):



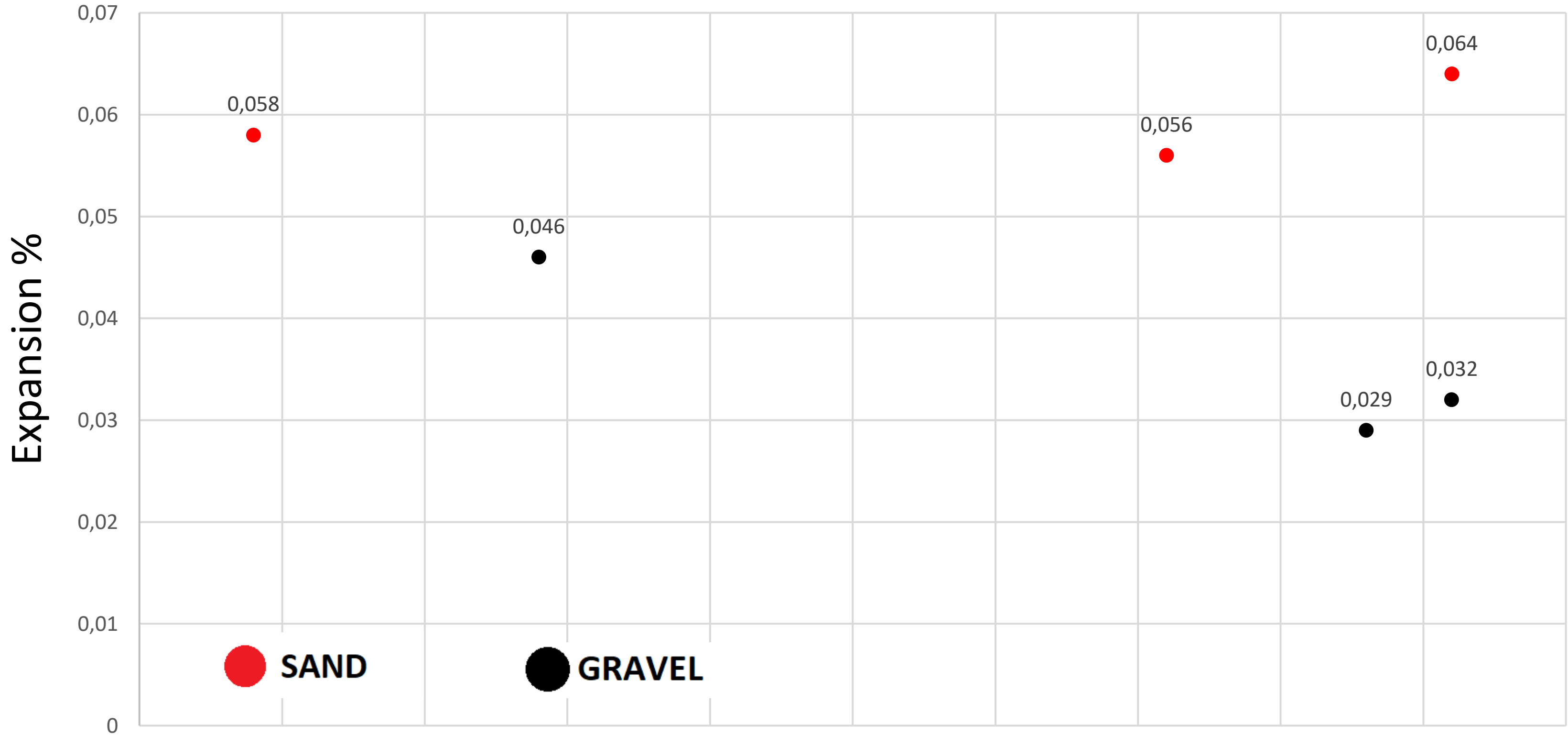


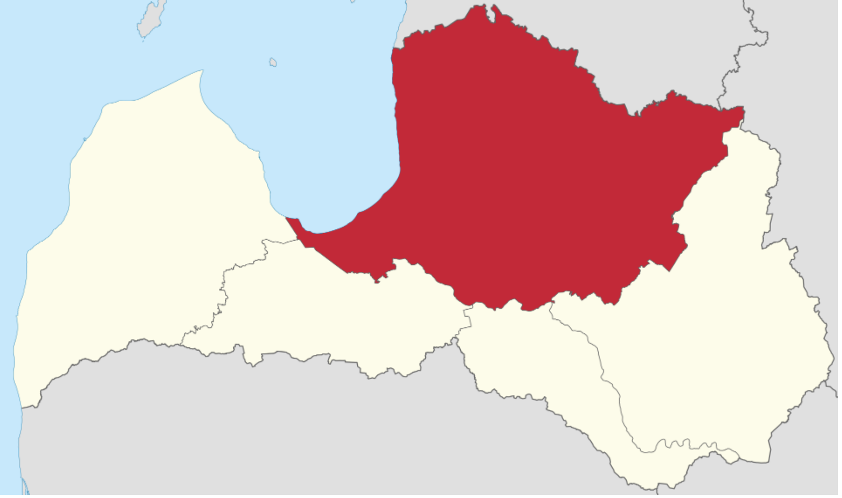
MB GRUPA BETONA PĒTĪJUMU CENTRS

Results in Zemgale (for 14d test):

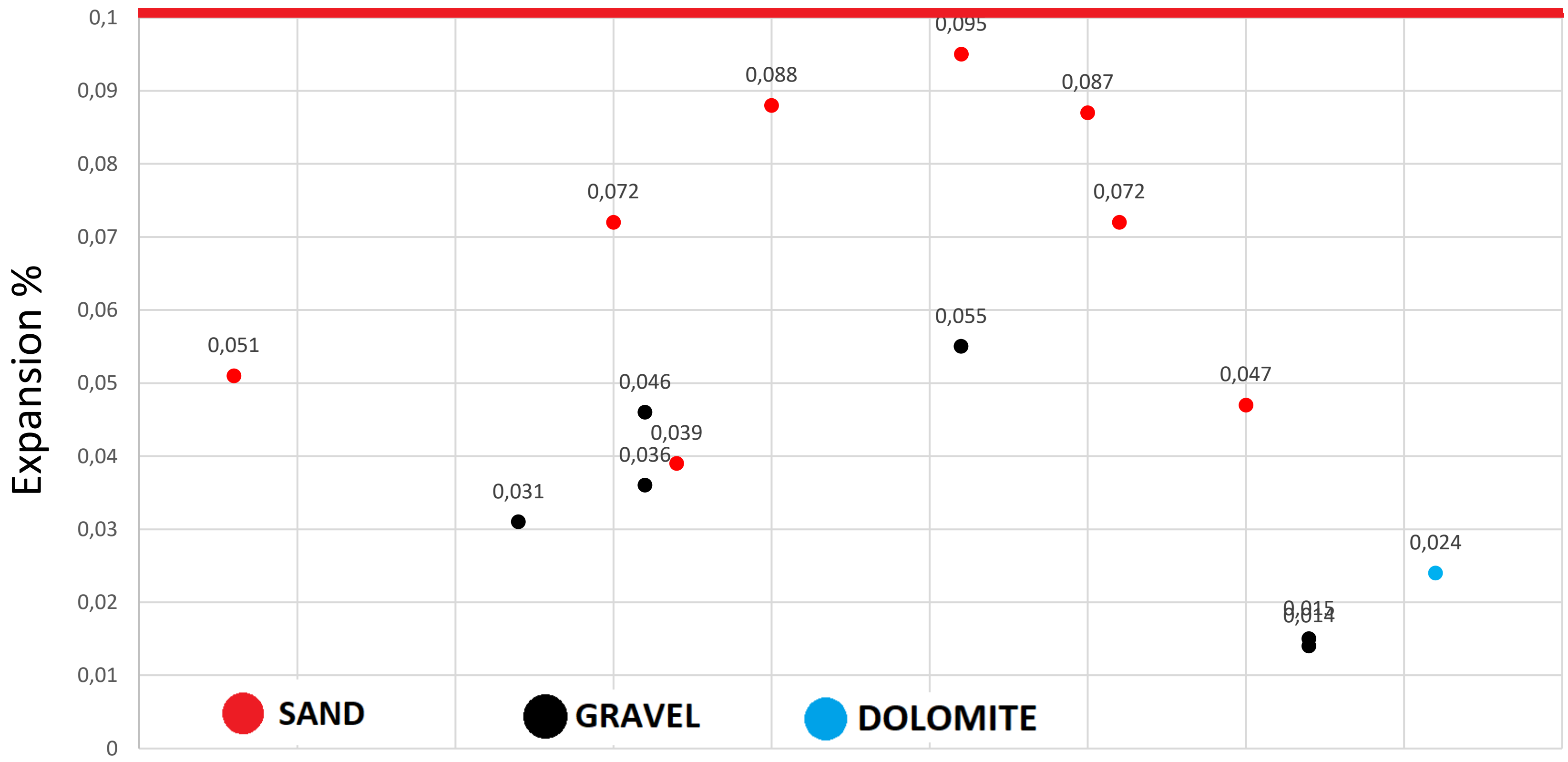


Results in Latgale (for 14d test):

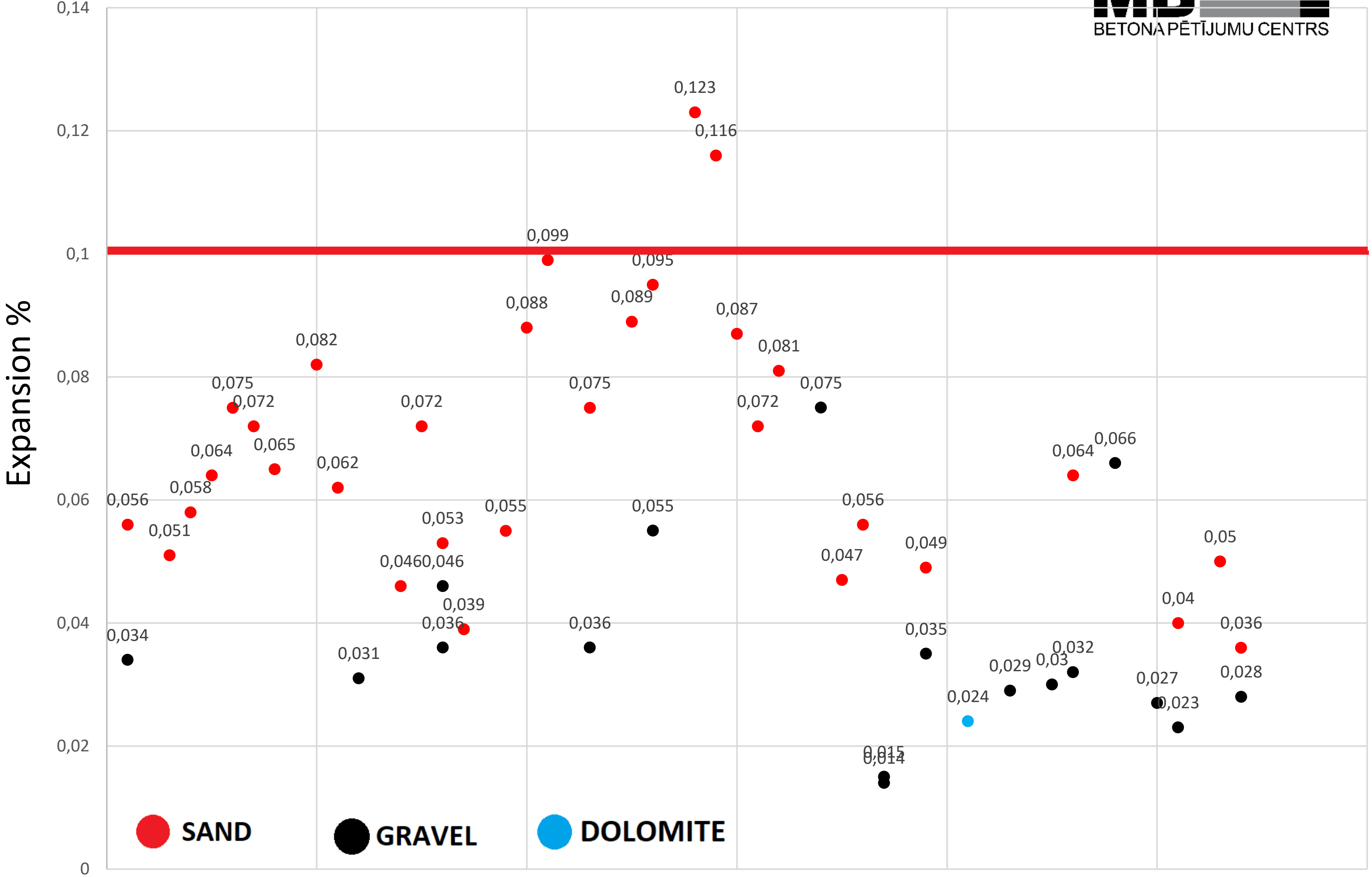




Results in Vidzeme (for 14d test):



Results in Latvia (for 14d tests):



IN summary of results we can say that if sand pass test, gravel will also pass.

According to SS_137003_2021

MB GRUPA
BETONA PĒTĪJUMU CENTRS

Table U.1 — Testing frequency based on the results of the previous expansion test

Test method	Expansion at previous test		
	Alt. C	Alt. B	Alt. A
RILEM AAR-2[a] after 28 days	≤ 0.10 % every 6 years	≤ 0.20 % every 3 years	> 0.20 % every year
RILEM AAR-2[a] after 14 days	≤ 0.03 % every 6 years	≤ 0.06 % every 3 years	> 0.06 % every year
RILEM AAR-3[a] after 1 year	≤ 0.020 % every 6 years	≤ 0.030 % every 3 years	> 0.030 % every year
RILEM AAR-4[a] after 20 weeks	≤ 0.015 % every 6 years	≤ 0.025 % every 3 years	> 0.025 % every year

According to SS_137003_2021

MB GRUPA
BETONA PĒTĪJUMU CENTRS

Table U.1 — Testing frequency based on the results of the previous expansion test

Test method	Expansion at previous test		
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RILEM AAR-2[a] after 14 days	≤ 0.03 % every 6 years	≤ 0.06 % every 3 years	> 0.06 % every year
RILEM AAR-3[a] after 1 year	≤ 0.020 % every 6 years	≤ 0.030 % every 3 years	> 0.030 % every year
RILEM AAR-4[a] after 20 weeks	≤ 0.015 % every 6 years	≤ 0.025 % every 3 years	> 0.025 % every year

THANK YOU FOR YOUR ATTENTION

MB GRUPA
BETONA PĒTĪJUMU CENTRS

Latvijas Biozinātņu un tehnoloģiju universitāte

Šķiedru betona plānsienu trīsslāņu sienu paneļu slodzes nestspēja

Mg.sc.ing. Atis Dandens

Dr.sc.ing. Ulvis Skadiņš

Ievads

Skadiņš, U.; Kuļevskis, K.; Vulāns, A.; Brencis, R. Thin-Layer Fibre-Reinforced Concrete Sandwich Walls: Numerical Evaluation. *Fibers* **2023**, 11, 19. https://doi.org/10.3390/fib11020019

- Analizētas vienstāva dzīvojamās ēkas šķiedru betona plānsienu trīsslāņu sienas;
- Betona slāņu biezums 60 mm, izolācijas slāņa biezums 150 mm. Sienu augstums 3.5 m;
- Pieņemts, ka jumta pārseguma laidums nepārsniedz 6 m. Pieņemts, ka slodzes no pārseguma uz ārsienu aprēķina vērtība varētu būt aptuveni 23 kN/m.

Ievads – teorētisko aprēķinu rezultāti

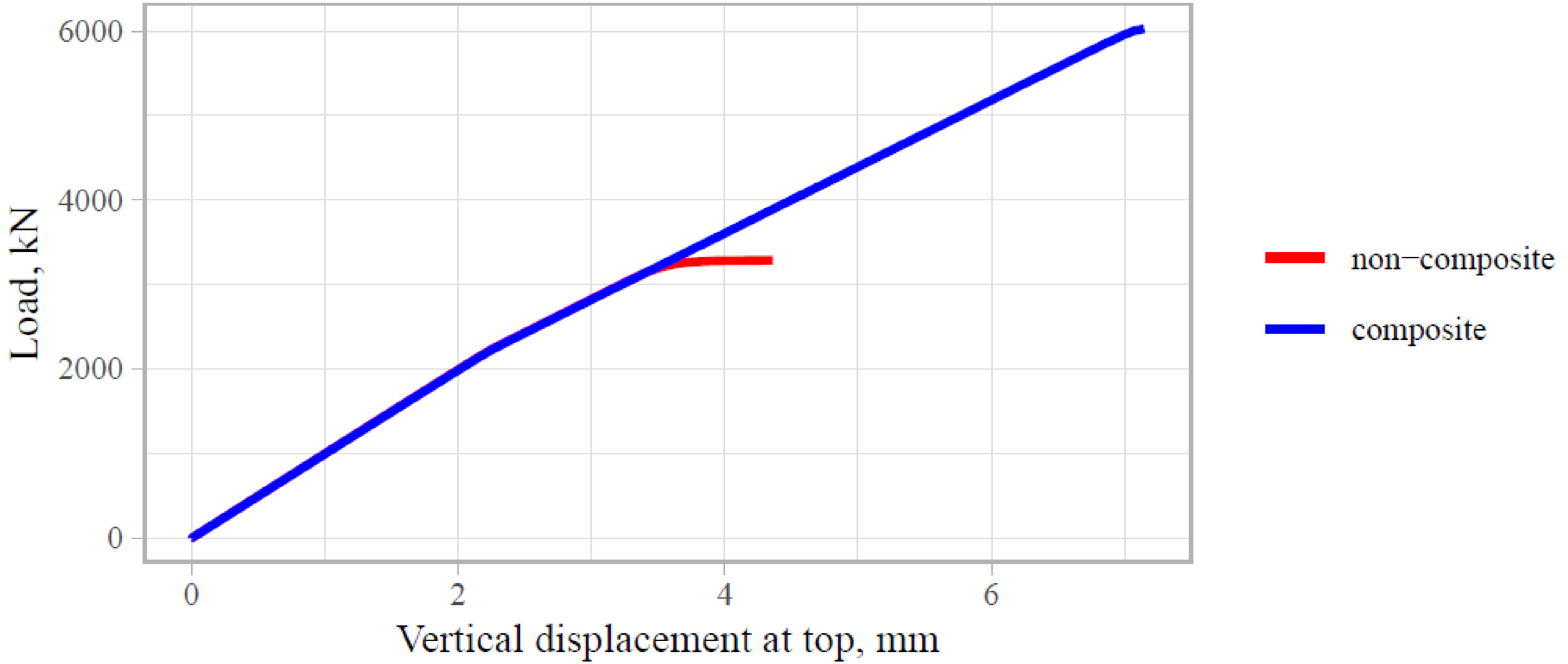


Figure 16. *Load–displacement* behaviour of the inner wall until failure.

Ievads

Mērķis

Eksperimentāli pārbaudīt šķiedru betona plānsienu trīsslāņu sienu paneļu nestspēju.

Uzdevumi

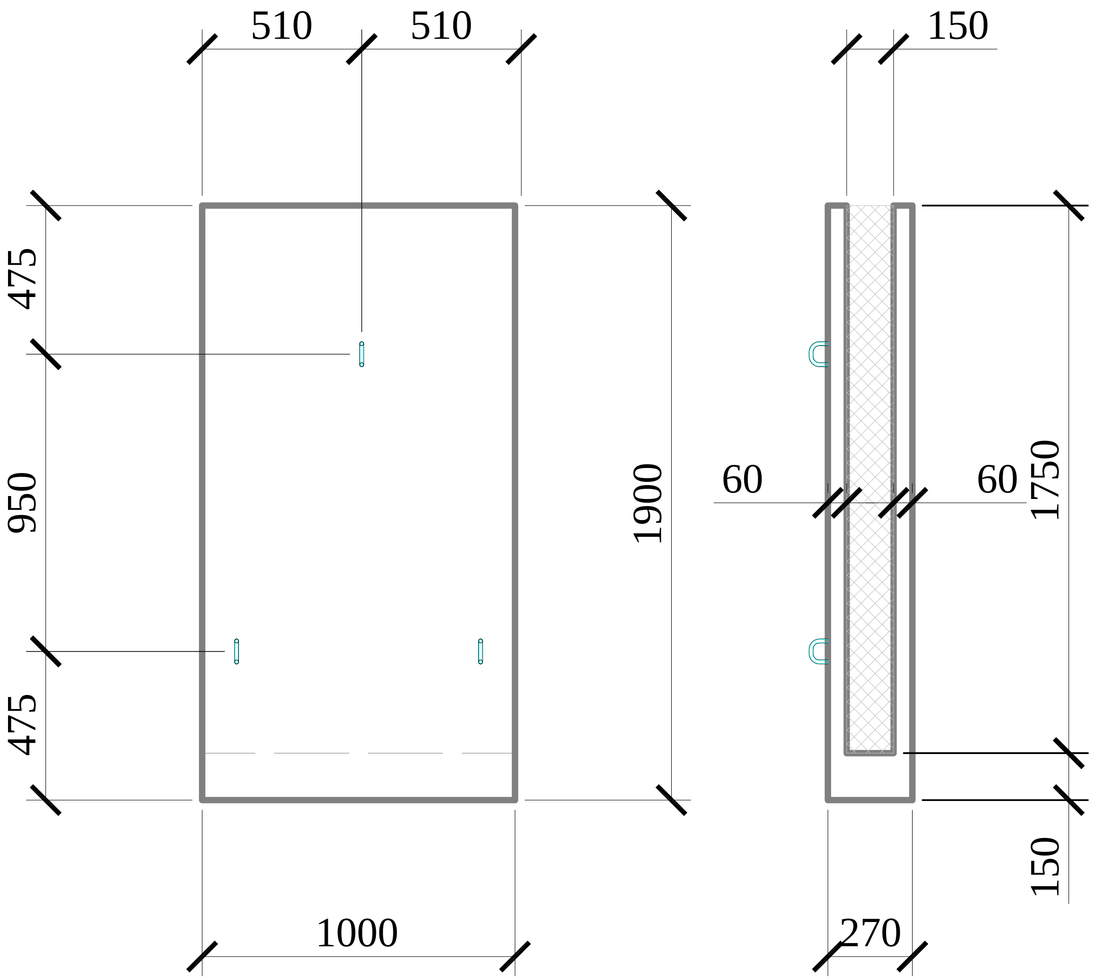
1. Veikt gandrīz pilna mēroga sienu paneļu paraugu slogošanu ekscentriskā spiedē;
2. Nestspējas vērtības salīdzināt ar teorētisko aprēķinu rezultātiem;
3. Novērtēt šķiedru daudzuma ietekmi uz sienu paneļu nestspēju.

Materiāli

Eksperimenta paraugi

<u>Ģeometriskie izmēri:</u>

- betona slāņu biezums 60 mm;
- izolācijas slāņa biezums 150 mm;
- parauga biezums 270 mm;
- parauga platums 1.0 m;
- parauga augstums 1.9 m.



Materiāli

Eksperimenta paraugi

<u>Stiegrojuma stieņu diametrs:</u>

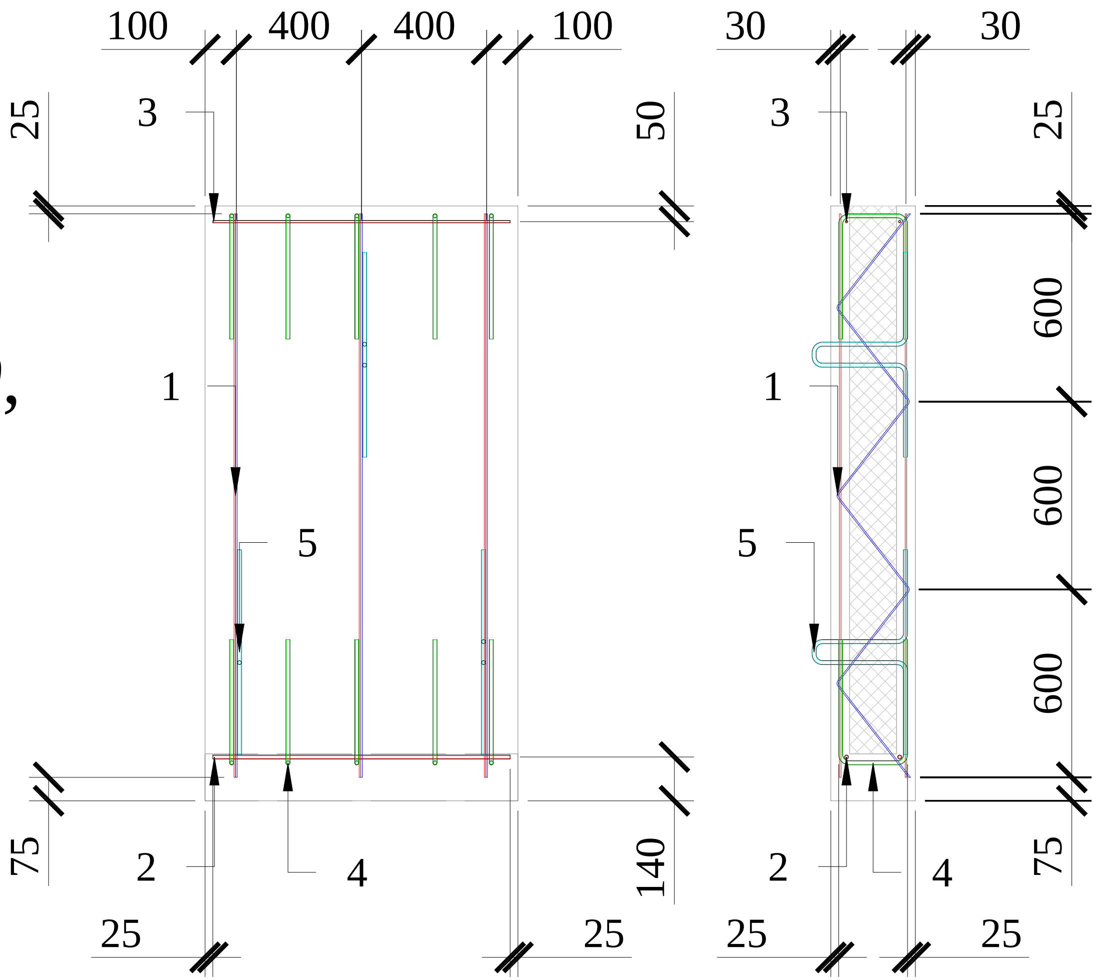
1 – ražotāja *peikko* produkts *PD 210*, ϕ = 5 mm;

2 – taisns stienis, ϕ = 10 mm;

3 – taisns stienis, ϕ = 6 mm;

4 – locīts stienis, ϕ = 10 mm;

5 – locīts stienis, ϕ = 10 mm.



Materiāli

Stiegrojums

Stiegrojuma stieņi:

- *PD 210* ārējā slānī – taisns stienis ar ribotu virsmu, klase B600XB, tecēšanas stiprība, f_{yk} = 600 N/mm^2;
- *PD 210* izolācijas slānī – locīts stienis ar gludu virsmu, klase 1.4301, tecēšanas stiprība, f_y = 190 N/mm^2;
- *PD 210* iekšējā slānī – taisns stienis ar ribotu virsmu, klase B500A, tecēšanas stiprība, f_{yk} = 500 N/mm^2;
- pārējie – taisni un locīti stieņi ar ribotu virsmu, klase B500B, tecēšanas stiprība, f_{yk} = 500 N/mm^2.

Materiāli

Stiegrojums

Šķiedras:

- Ražotāja *KrampeHarex* produkts *DE 35/0.50 – N*, šķiedra, kas izgatavota no tērauda stieples, gali – locīti, šķiedras garums 35 mm, diametrs 0.50 mm;

- Šķiedru daudzums 30 kg/m^3 (SFRSCC-1) un 50 kg/m^3 (SFRSCC-2).

Materiāli

Betons

Stiprības klase C40/50, kuba spiedes stiprība, $f_{ck,cube}$ = 50 N/mm^2, stiepes stiprības vidējā vērtība, f_{ctm} = 3.5 N/mm^2.

Izolācijas materiāls

Ražotāja *Tenax* produkts *TENAPORS 150*, spiedes spriegumi pie 10% deformācijas, σ_{10} = 150 kN/m^2.

Eksperimenta paraugu izgatavotājs un piegādātājs – MB Betons, AS.

Materiāli

Eksperimenta paraugi

Materiāli

Kubi, SFRSCC-1 (30 kg/m³)

$f_{c,cube,1}$ = 84.6 N/mm^2;

$f_{c,cube,2}$ = 82.1 N/mm^2;

$f_{c,cube,3}$ = 83.1 N/mm^2;

m_X = 83.3 N/mm^2;

s_X = 1.3 N/mm^2;

V_X = 0.02.

Kubi, SFRSCC-2 (50 kg/m³)

$f_{c,cube,1}$ = 71.1 N/mm^2;

$f_{c,cube,2}$ = 73.2 N/mm^2;

$f_{c,cube,3}$ = 77.3 N/mm^2;

m_X = 73.9 N/mm^2;

s_X = 3.2 N/mm^2;

V_X = 0.04.

Materiāli

Latvijas Biozinātņu un tehnoloģiju universitāte

Prizmas, SFRSCC-1 (30 kg/m³)

Stiprības vērtības atbilstoši LVS EN 14651:

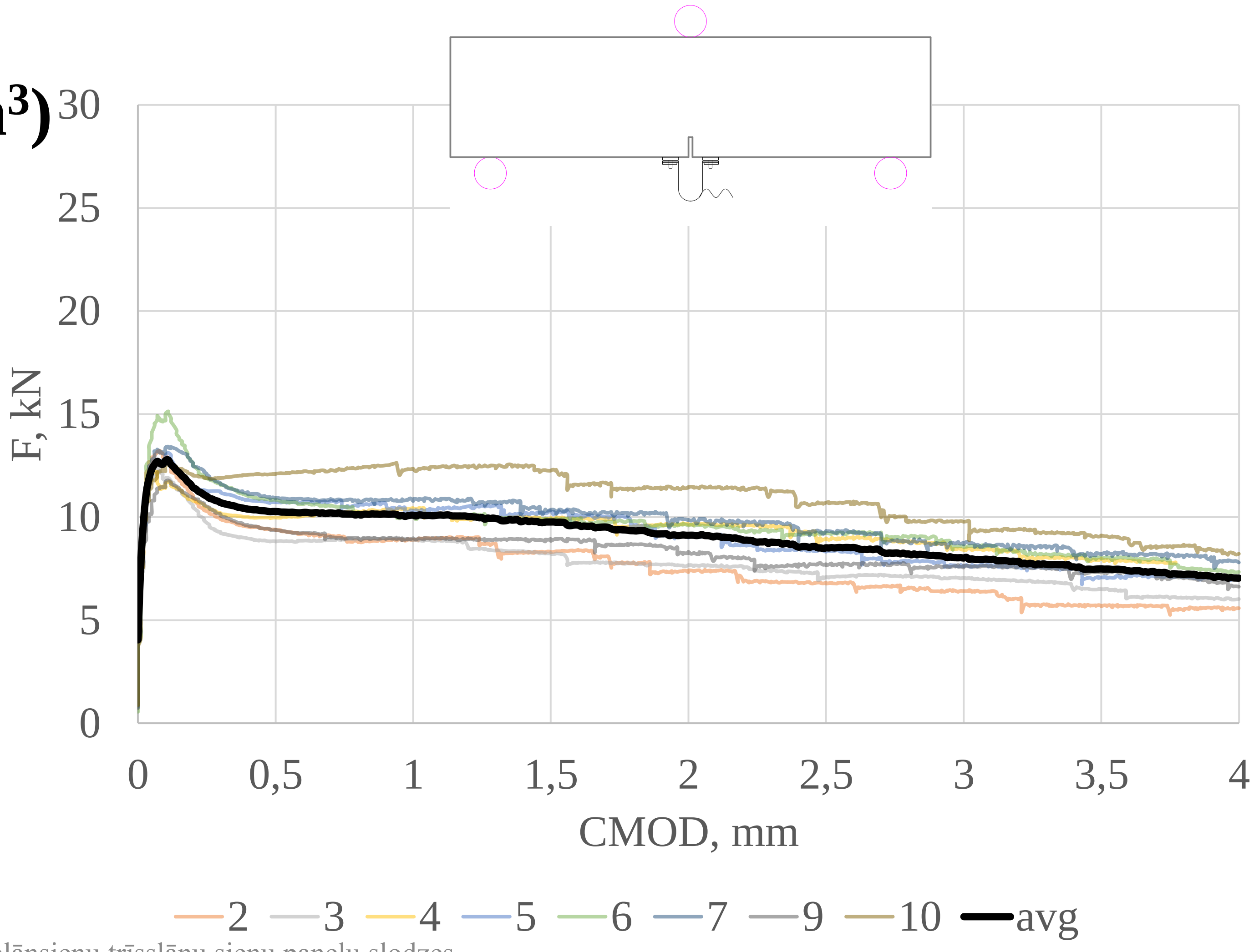
$f_{ct,L,avg}$ = 3.7 N/mm²;

$f_{R,1,avg}$ = 3.1 N/mm²;

$f_{R,2,avg}$ = 3.0 N/mm²;

$f_{R,3,avg}$ = 2.6 N/mm²;

$f_{R,4,avg}$ = 2.3 N/mm².



Materiāli

Prizmas, SFRSCC-2 (50 kg/m³)

<u>Stiprības vērtības atbilstoši</u>

<u>LVS EN 14651:</u>

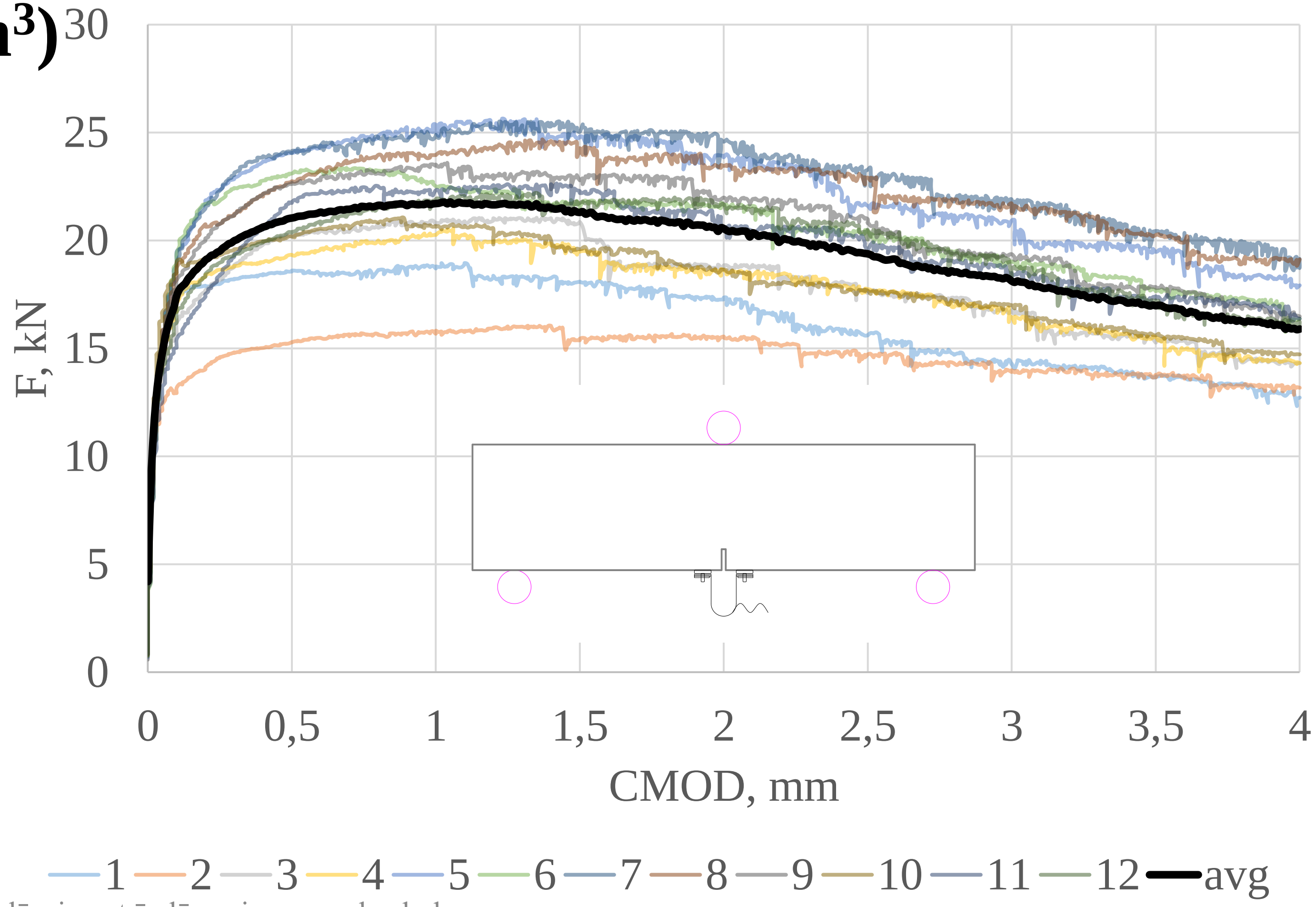
$f_{ct,L,avg}$ = 4.5 N/mm²;

$f_{R,1,avg}$ = 6.4 N/mm²;

$f_{R,2,avg}$ = 6.5 N/mm²;

$f_{R,3,avg}$ = 5.9 N/mm²;

$f_{R,4.avg}$ = 5.2 N/mm².



Metodes

Paraugu slogošanas shēma

1 – Tērauda platforma;

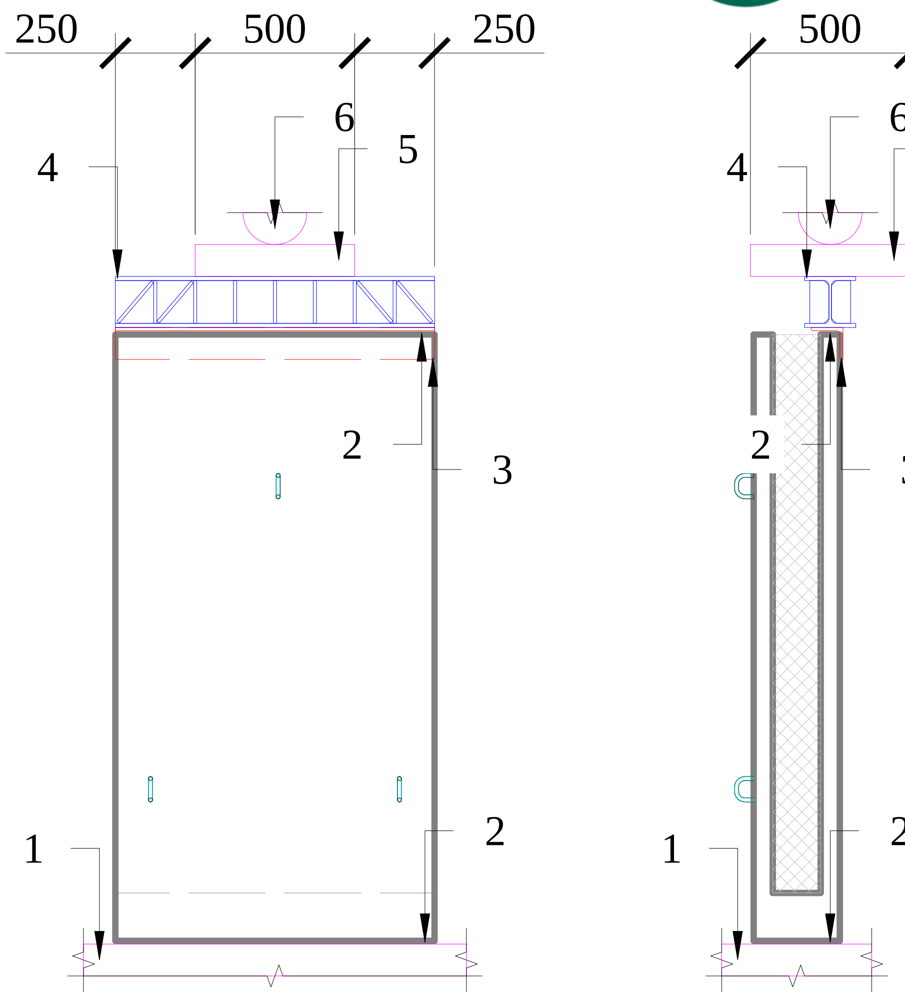
2 – Java, ražotāja *weber* produkts *S-30*;

3 – Tērauda profils, L EN E 100×10;

4 – Tērauda profils, HE 160 B;

5 – Tērauda plāksne, 500×500×100(h);

6 – Šarnīrs.



Metodes

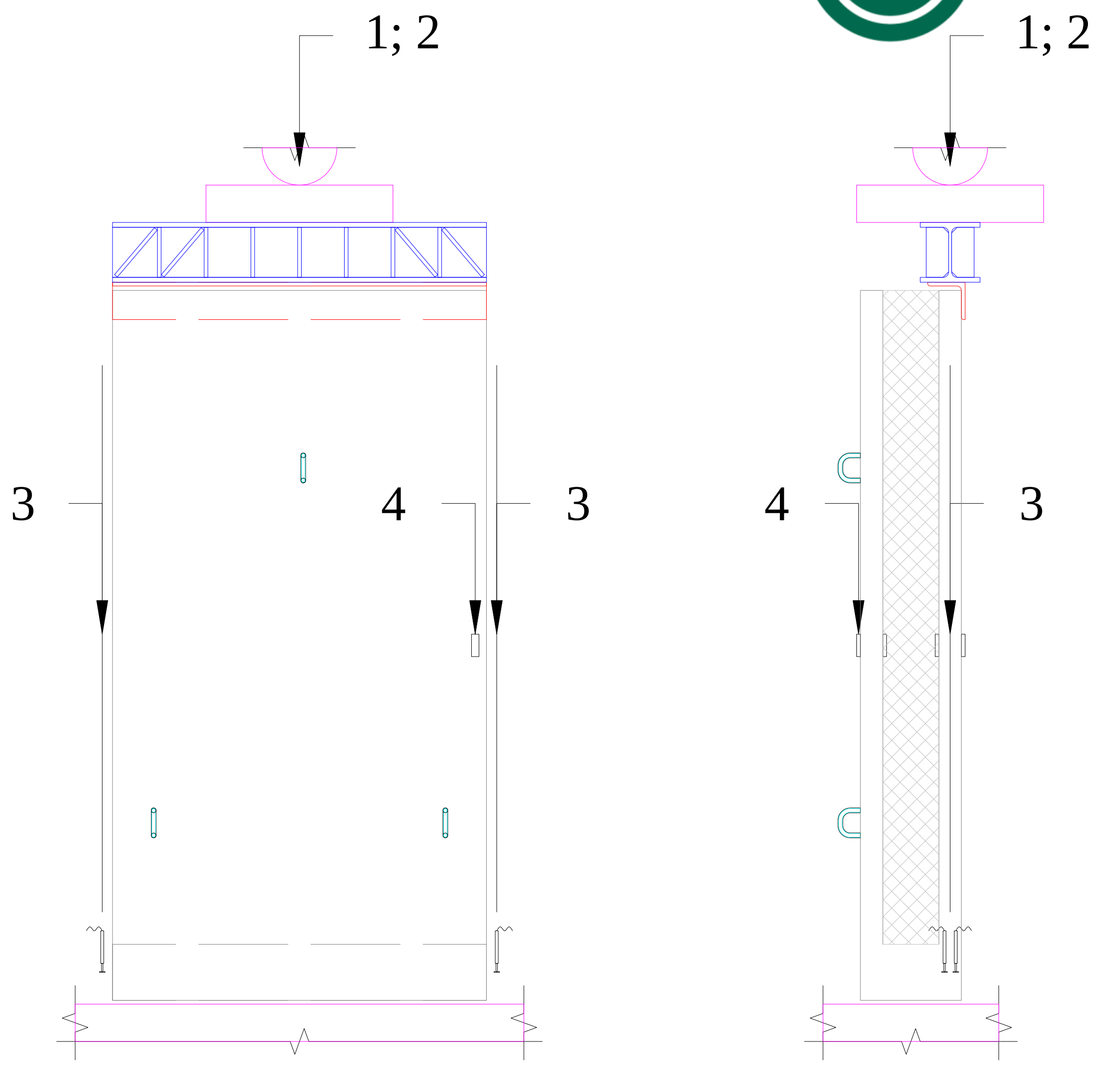
Mērījumi

1 – Cilindra pārvietojums;

2 – Spēks;

3 – Betona slāņa vertikālie pārvietojumi;

4 – Betona slāņu virsmu deformācijas.



Metodes

Parauga nr. 4 (SFRSCC-2) slogošana

Rezultāti

SFRSCC-1 (30 kg/m³)

$F_{R,1}$ = 2899.1 kN;

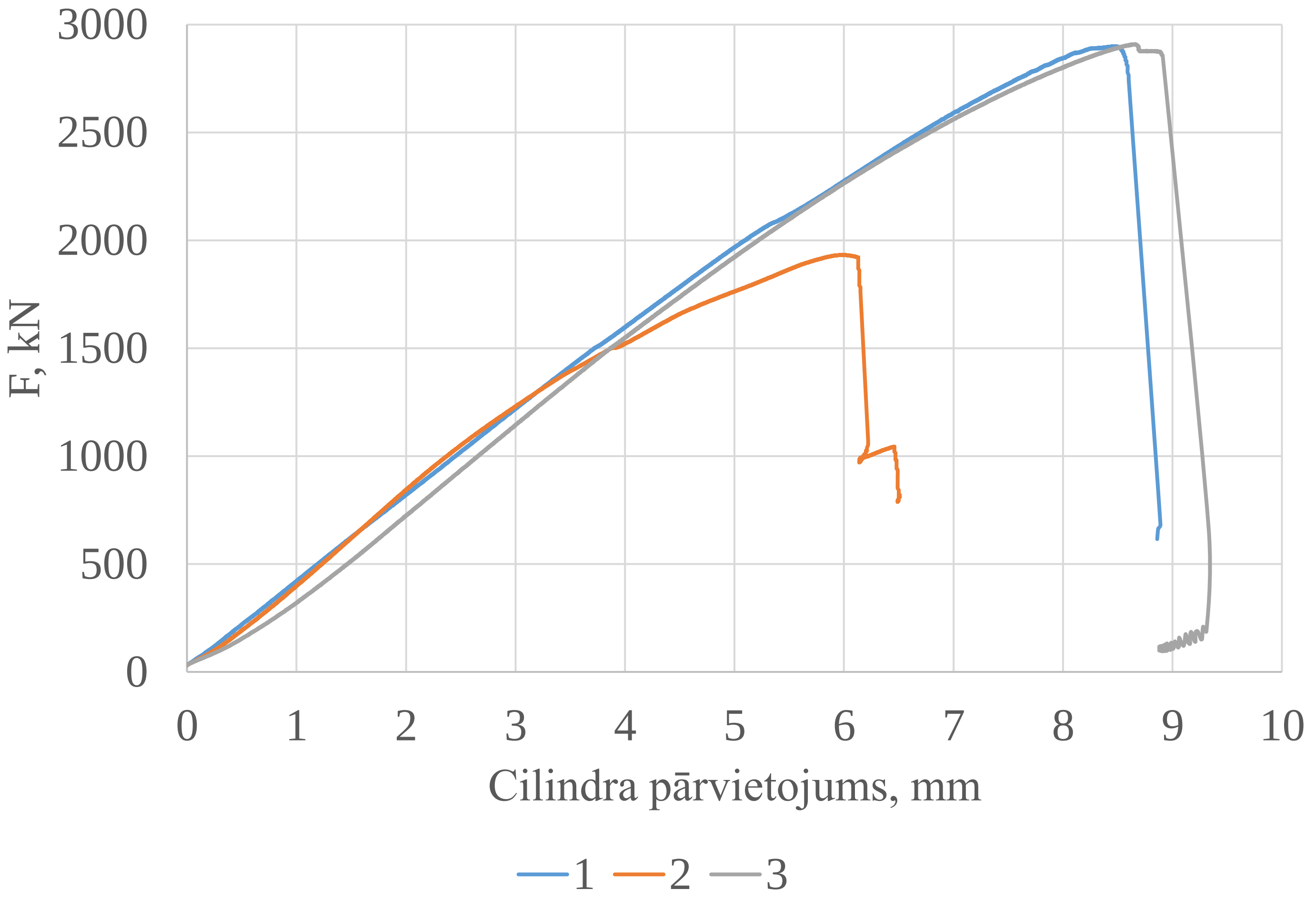
$F_{R,2}$ = 1932.3 kN;

$F_{R,3}$ = 2909.2 kN;

m_X = 2580.2 kN;

s_X = 561.12 kN;

V_X = 0.22.



Rezultāti

SFRSCC-2 (50 kg/m³)

$F_{R,4}$ = 2668.1 kN;

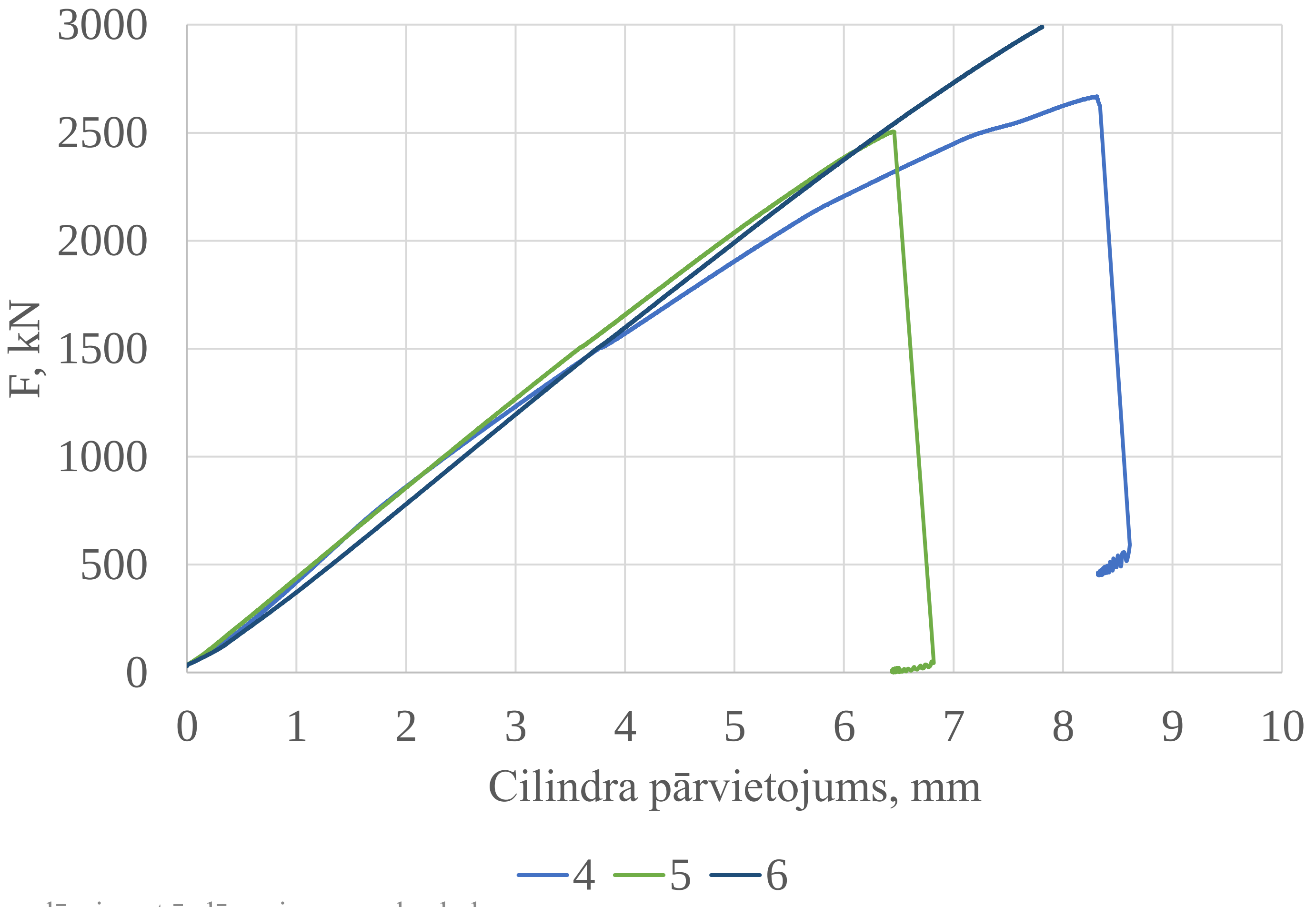
$F_{R,5}$ = 2505.6 kN;

$F_{R,6}$ > 2991.0 kN;

m_X = 2721.6 kN;

s_X = 247.08 kN;

V_X = 0.09.

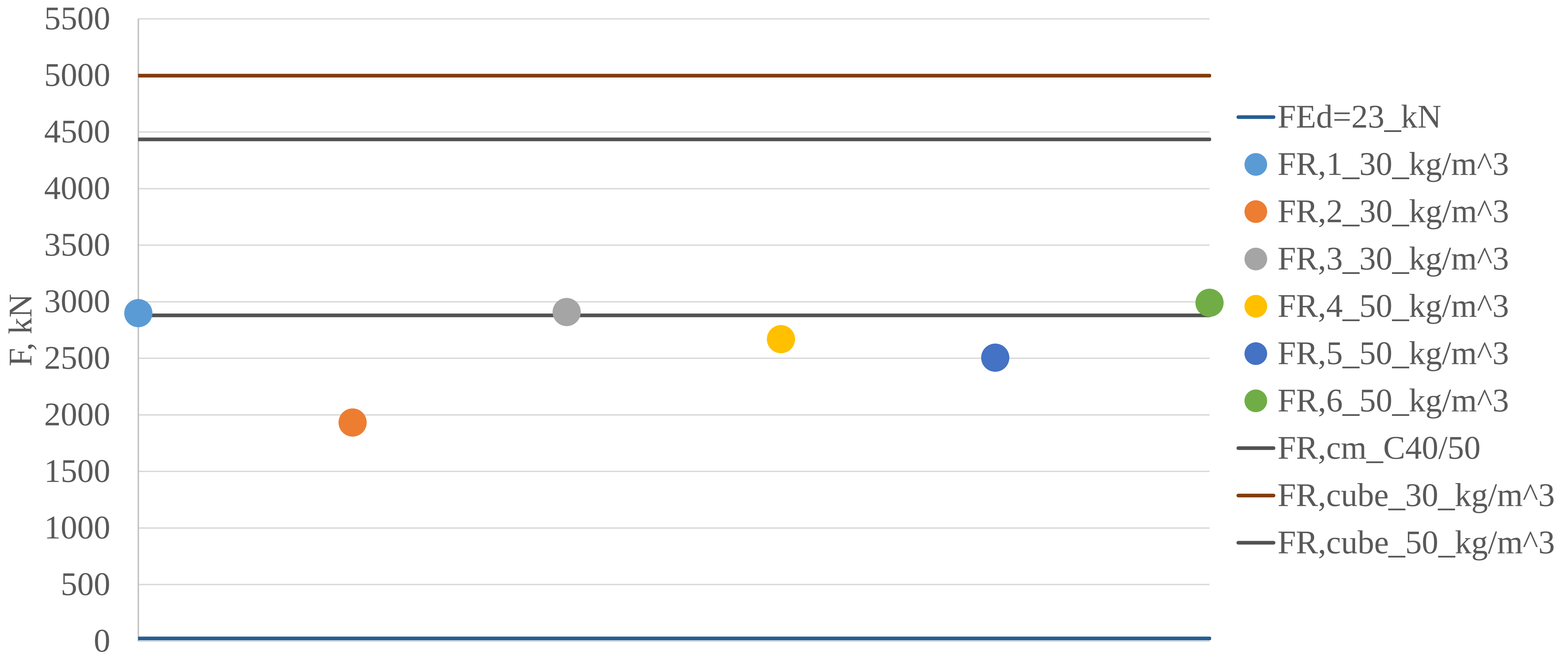


Rezultāti – sabrukuma veids

Latvijas Biozinātņu un tehnoloģiju universitāte

Rezultāti

Latvijas Biozinātņu un tehnoloģiju universitāte



Secinājumi

1. Plānsienu trīsslāņu sienu paneļi spēj uzņemt slodzi, kas ļoti būtiski pārsniedz mazstāvu apbūvei paredzēto.

2. Sienas nestspēju noteica lokālie sabrukumi nevis nesošā slāņa izkļaušanās. Betona slāņu savstarpēja savienošana ar stiepļveida detaļām nodrošina slogotā slāņa noturību.

3. Paraugiem ar biezāku un vājāku javas izlīdzinošo kārtu zem slogošanas traversas, nestspēja bija mazāka, jo slogotais slānis sabruka no šķērsvirziena deformācijām slogošanas zonā.

PIEDEVAS ZEMA CO_2 SATURA BETONIEM

Kaspars Kravalis
MAPEI AS Norway

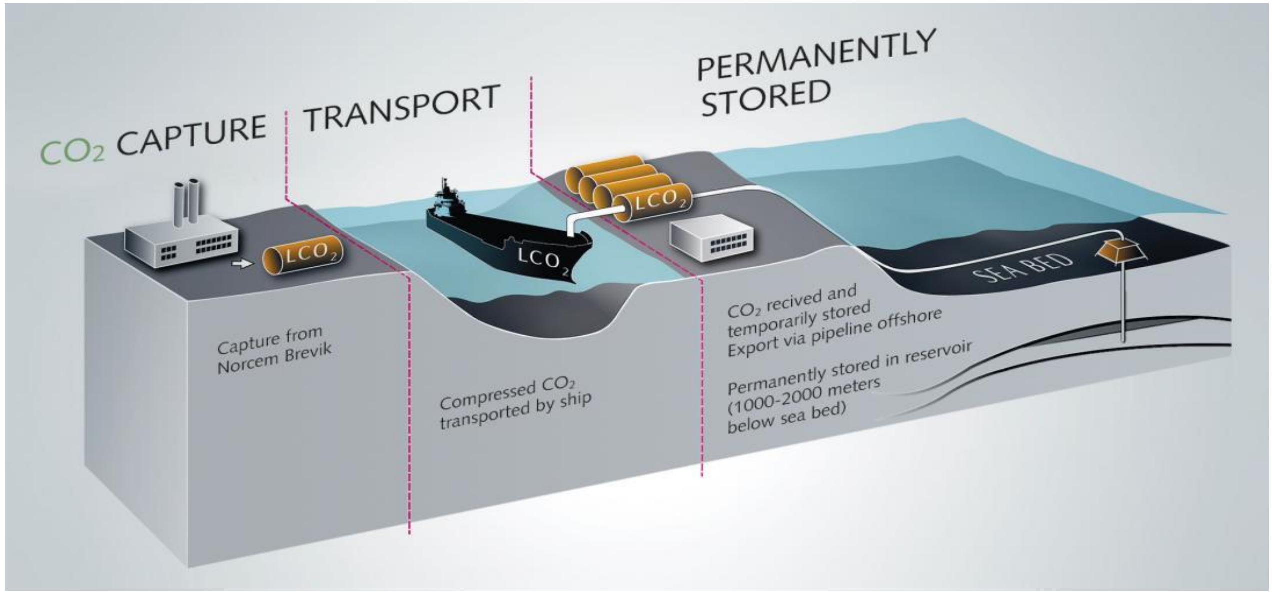

BETONS IR OTRS VISVAIRĀK LIETOTAIS
MATERIĀLS PĒC ŪDENS

ILGTSPĒJĪGĀKS BETONS

Cementa ražošana rada 7% no pasaules CO_2 emisijām.

Cementa industrija pašlaik dodas virzienā samazināt portlandcementa ražošanu lietojot vairāk kompozīt piedevas kombinācijā ar jauno oglekļa 'pārķeršanas' metodi

Heidelberg Materials projekts Breivikā (NOR), kur sākot ar 2024. gadu, savāks 400 000T CO_2 gadā no cementa ražošanas procesa un noglabās to okeāna gultnē. Projekta izmaksas: 2,1 miljards EUR



ILGTSPĒJĪGĀKS BETONS

Līdz ar dabīgo betona sastāvdaļu pieejamības samazinājumu, **aizvien vairāk tiks lietoti pārstrādāti inertie materiāli**

RISINĀJUMI TUVĀKĀ UN TĀLĀKĀ NĀKOTNĒ

NEAR-TERM

Replace raw materials with recycled materials

Produce low-carbon cement blends

Optimize designs for the lowest life cycle emissions

MID-TERM

Increase the use of alternative fuels

Use renewable energy

LONG-TERM

Carbon capture

Introduce new cement blends

PCA® Since 1916
America's Cement Manufacturers™

IZAICINĀJUMI ŠOBRĪD

Pieaugs ne tikai pieprasījums pēc betona, bet arī paaugstinātas prasības tā izturībai.

Ilgtspējīgāks betons tiks ražots izmantojot dažādas pucolānu piedevas un palielinātus reciklēto vai rūpnieciski ražoto inerto materiālu apjomus.

- **Ietekmējot agrīno un kopējo beigu stiprību**
- **Paaugstināts ūdens daudzums betonā**
- **Ietekmēta reoloģija un iestrādājamība**

KĀDS BIJA IZGUDROJUMA MĒRĶIS?

CUBE system

- **Palielinot klinkera aizstājpiedevu apjomu** saglabāt tādas pat agrīnās un beigu stiprības īpašības
- **Palielināt betona beigu stiprību** nemainot recepti
- **Samazināt cementa daudzumu** saglabājot beigu stiprību
- **Procentuāli palielināt pārstrādāto izejmateriālu pielietojamību**

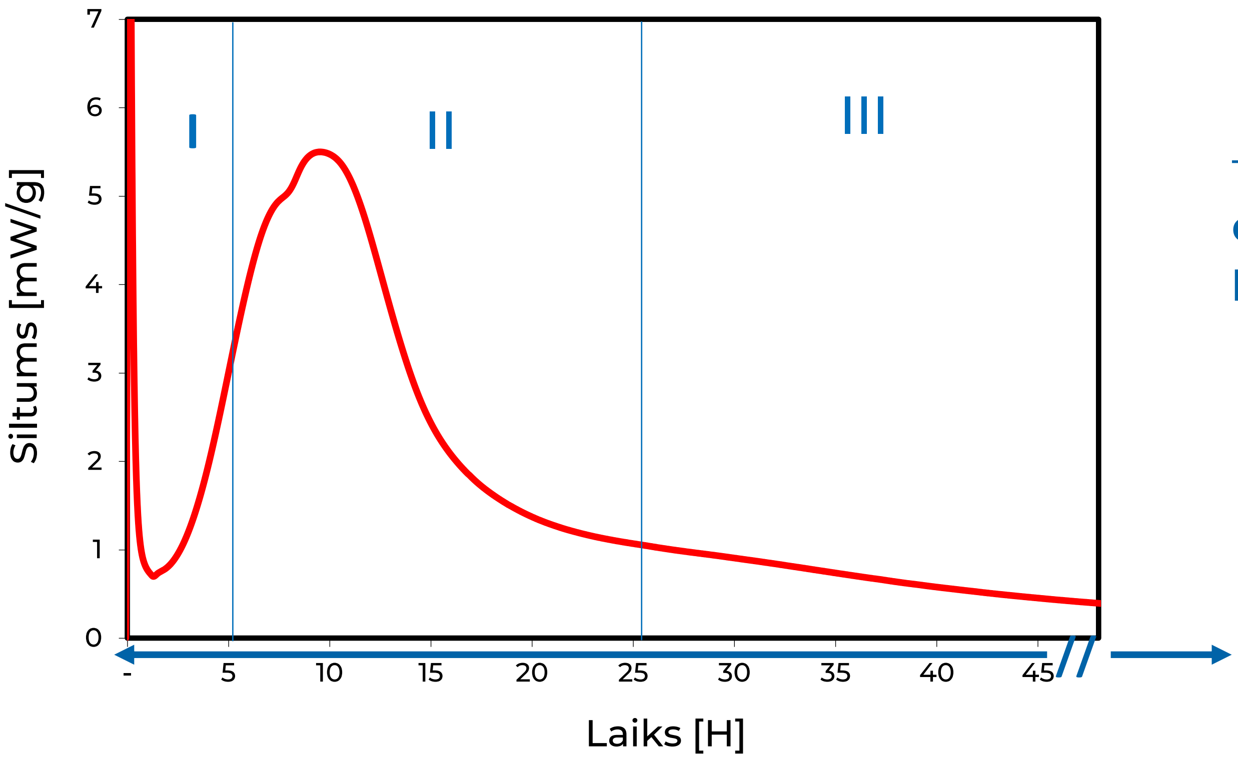
STIPRĪBAS UZLABOŠANA

Low Carbon Concrete Admixtures – LCCA

Zema oglekļa satura cementu speciālas betona piedevas: ir radīts unikāls, patentēts sintēzes process lai iegūtu šādas piedevas stiprības uzlabošanai

MAPEI radītie ***MAPECUBE*** sistēmas produkti

MAPECUBE princips

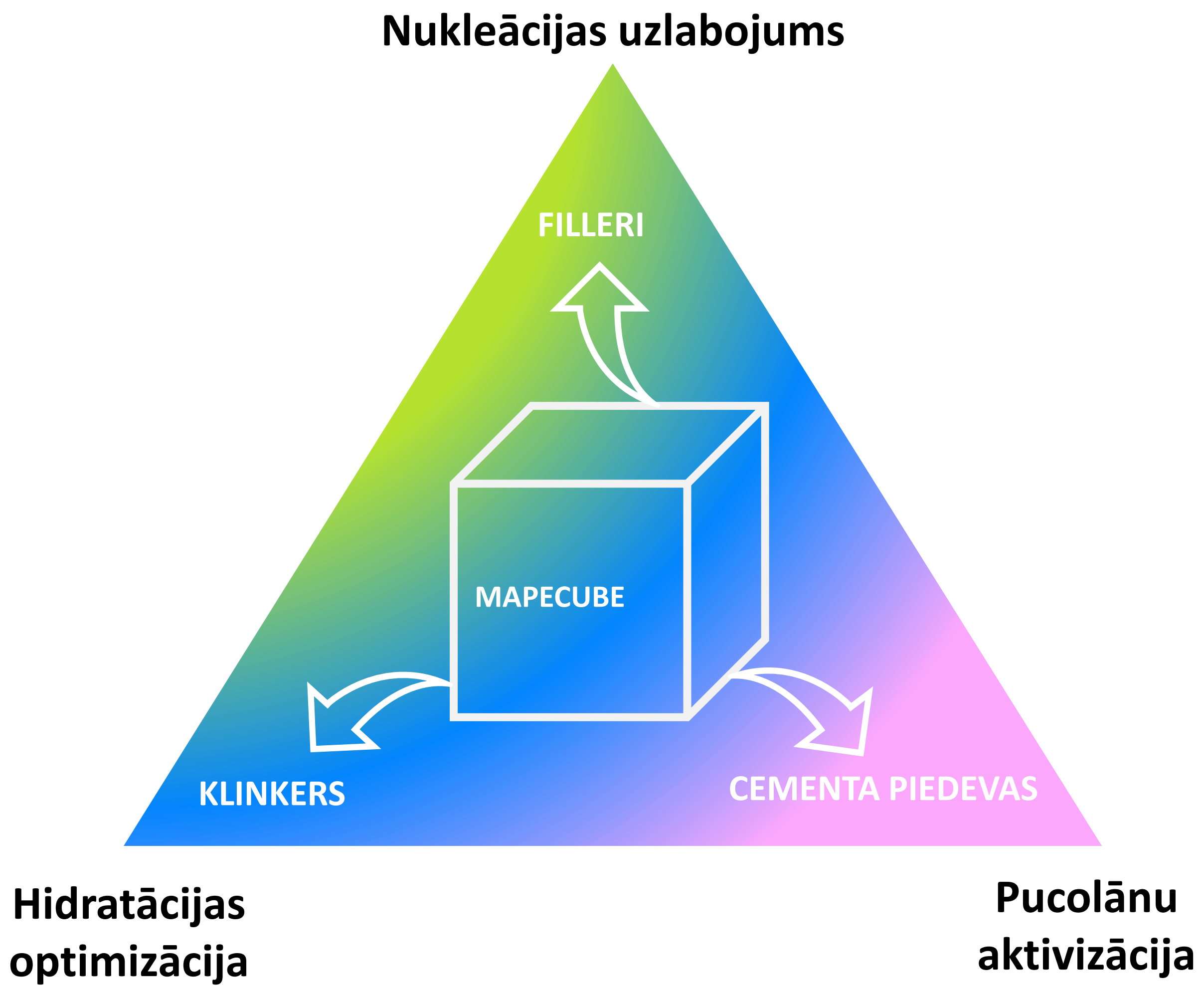


Tradicionālās betona piedevas **dod efektu hidratācijas pirmajos posmos (I–II)**.

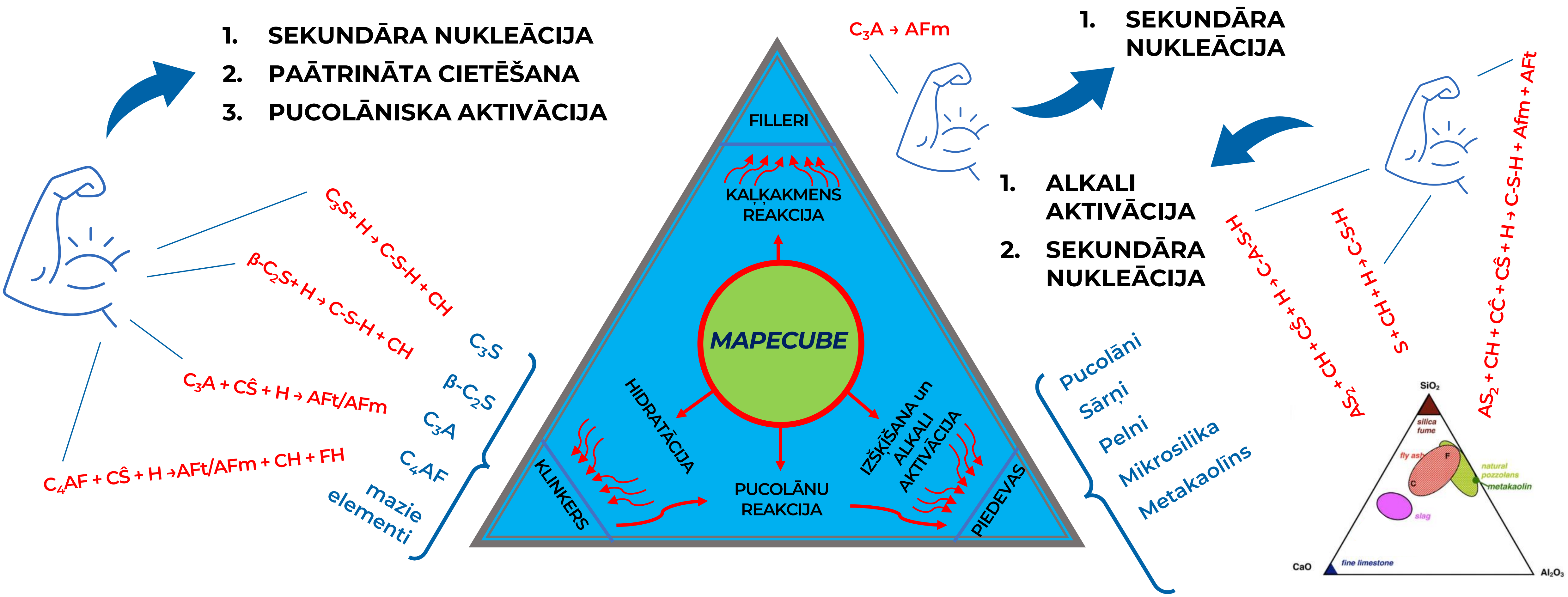
MAPECUBE paildzina funkciju **visu hidratācijas periodu (I–II–III)**, no **maisīšanas sākuma** līdz pat **nedēļām/mēnešiem**

MAPECUBE mehānisms

1. **PAAUGSTINĀTA STIPRĪBA** kompozīta vai piedevu cementiem, jo tiek **maksimizēts hidratācijas apjoms visām klinkera fāzēm**
2. **Maksimizēta klinkera aizstājējpiedevu REAKCIJAS spēja** kompozīta, piedevu cementiem un filleriem veidojot **STABILAS HIDRATĀCIJAS FĀZES**



MAPECUBE MEHĀNISMS



MAPECUBE EFEKTS

- **Increase the substitution of clinker** with SCMs, maintaining the same performances both at early and late ages
- **Paaugstināta betona beigu stiprība** nemainot cementa daudzumu

  + 15 - 25%

- **Iespēja samazināt cementa daudzumu** saglabājot betona stiprību

  20 – 50 kg/m3

- **Increase the use of recycled aggregates**

CUBE system

KĀ LIETOT MAPECUBE

STIPRĪBAS UZLABOTĀJS

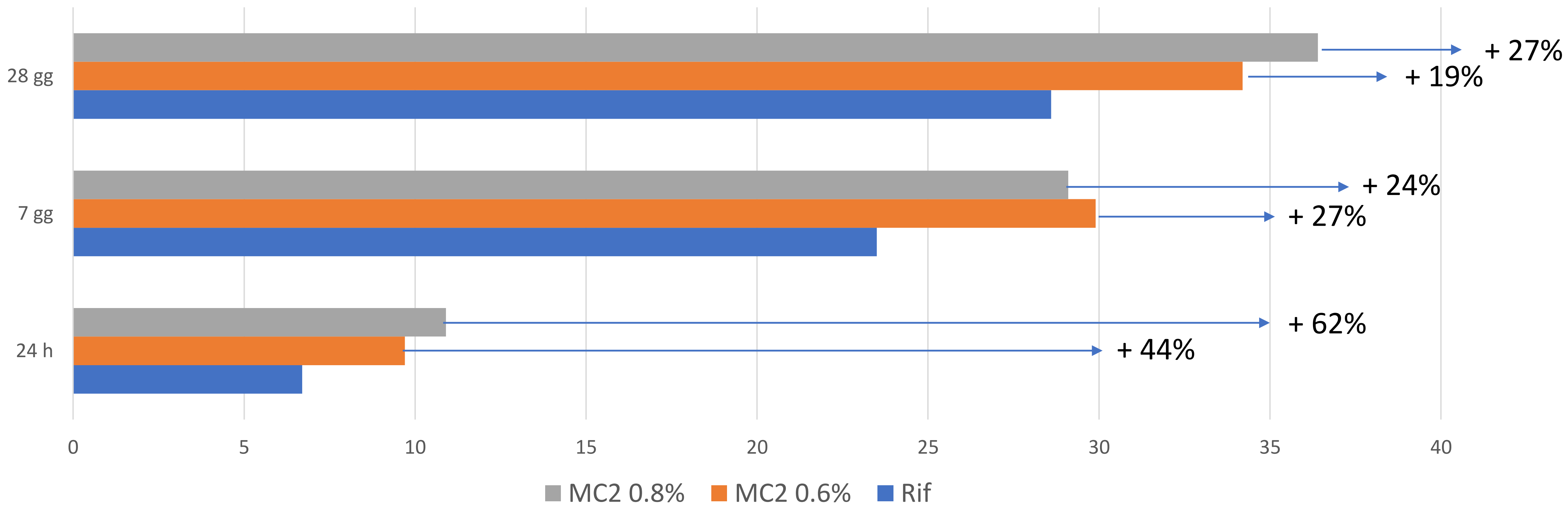
- AUGSTĀKA STIPRĪBA
- AUGSTĀKA IZTURĪBA
- UZLABOTA ILGTSPĒJA
- NEMAINOT RECEPTŪRU

CUBE
system

STIPRĪBAS UZLABOTĀJS

ID	CEMENTS	STIPRĪBAS UZLABOTĀJS	DOZĀCIJA (%)
REFERENCE	CEM II/A-L 42,5 R	-	-
MC2 0.6%		MAPECUBE	0,60%
MC2 0.8%			0,80%

Stiprības uzlabojums



KĀ LIETOT MAPECUBE

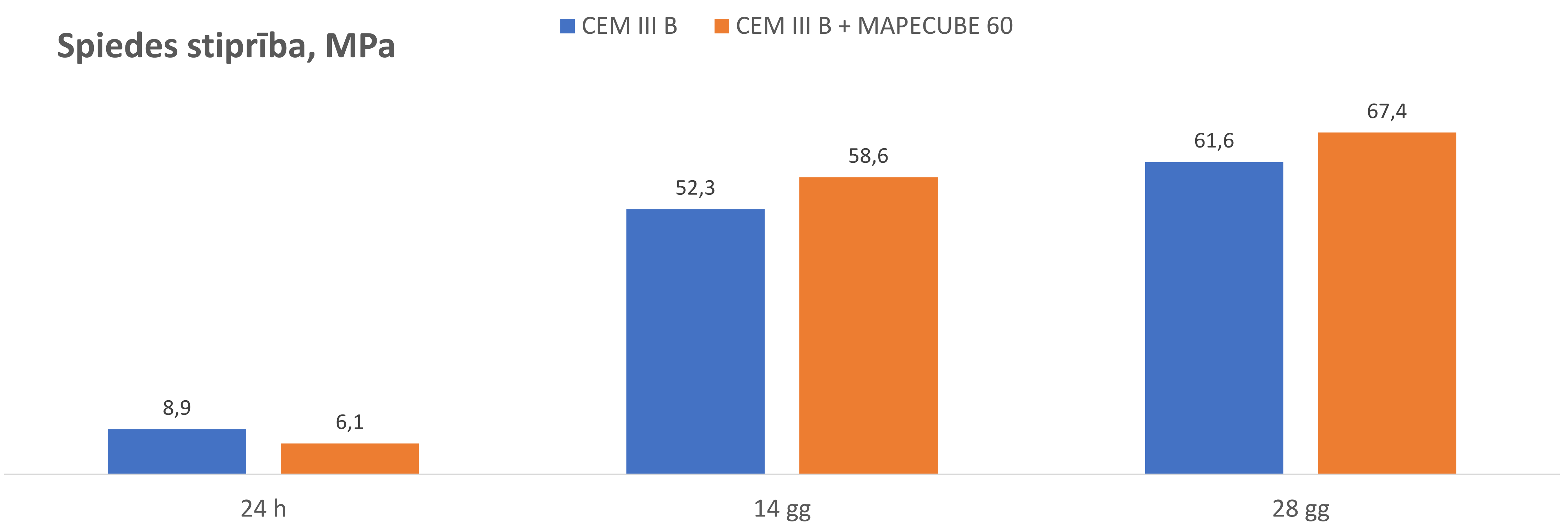
CUBE system

RECEPTŪRAS OPTIMIZĀCIJA

- MAZĀKA CEMENTA DOZĀCIJA
- ZEMĀKS HIDRATĀCIJAS SILTUMS
- MAZĀKS RUKUMS
- STIPRĪBA NEMAINĀS
- IZTURĪBA NEMAINĀS
- UZLABOTA ILGTSPĒJA
- ZEMĀKAS CO2 EMISIJAS
- ZEMĀKAS IZMAKSAS

RECEPTŪRAS OPTIMIZĀCIJA

CEMENTS	DOZĀCIJA, kg/m3	Ū/C	STIPRĪBAS UZLABOTĀJS	DOZĀCIJA (%)
CEM III B 42,5 N LH/SR	**380**	0,48	MAPECUBE 60	
	330	0,51		1,00%



KĀ LIETOT MAPECUBE

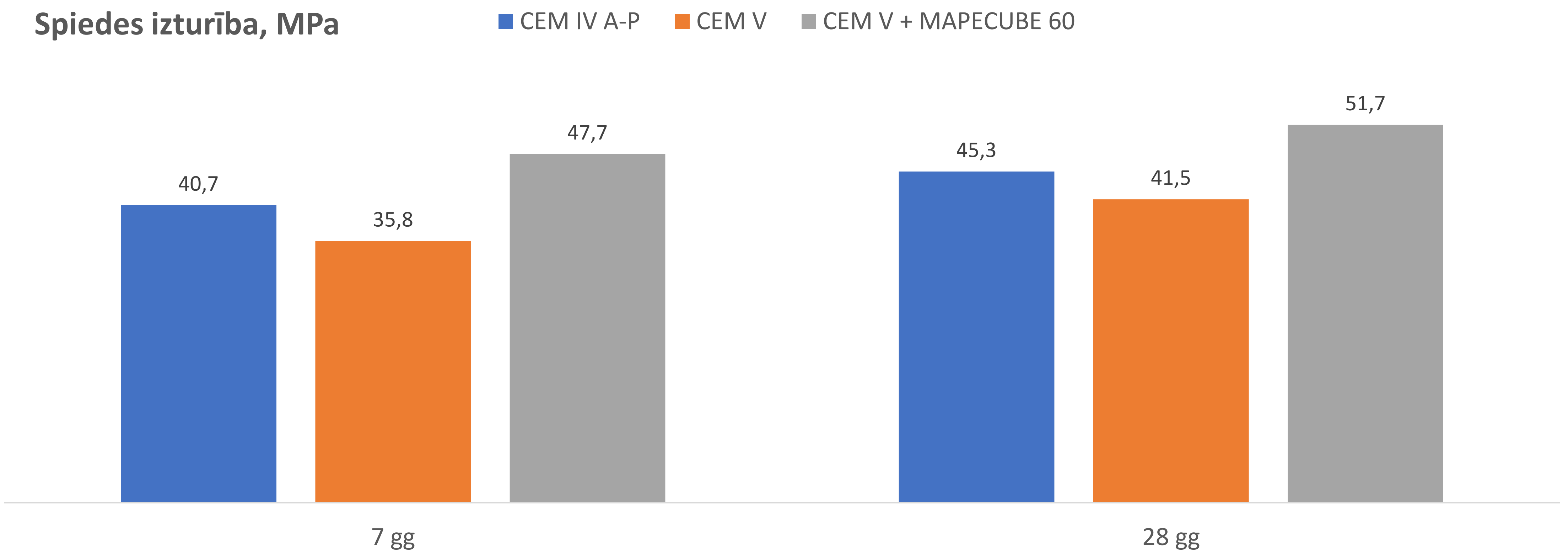
CUBE system

CEMENTA KLASES MAIŅA

- SAGLABĀTA CEMENTA DOZĀCIJA
- STIPRĪBA NEMAINĀS
- IZTURĪBA NEMAINĀS
- UZLABOTA ILGTSPĒJA
- ZEMĀKAS CO_2 EMISIJAS
- ZEMĀKAS IZMAKSAS

CEMENTA KLASES MAIŅA

CEMENTS	DOZĀCIJA	Ū/C	STIPRĪBAS UZLABOTĀJS	DOZĀCIJA (%)
CEM IV A-P 42,5 R	310 Kg/m³	0,57	-	-
CEM V 42,5 N		0,56	-	-
		0,54	MAPECUBE 60	1,00%

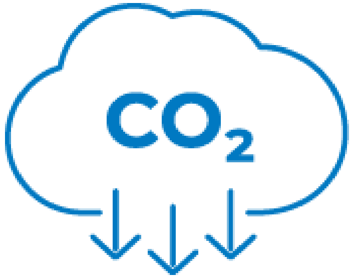


MAPECUBE-UZLABOTS BETONS

CUBE system

CUBE-uzlabots betons –Videi draudzīgs, ar optimizētu izejvielu daudzumu ražots betons, izmantojot alternatīvas cementiskas piedevas un fillerus

- Iespēja lietot reciklētus izejmateriālus
- Saderīgs ar citām betonā lietotajām ķīmiskajām piedevām
- Uzlabota iestrādājamība
- Palielināta konstrukcijas ilgturība
- Augstāka veiktspēja nemainot cementa daudzumu
- Nemainīga veiktspēja samazinot cementa daudzumu
- Samazinātas izmaksas ražotājam
- Ekoloģisks betons – EPD punktu ieguvums



Q&A

INOVATĪVAS UHPC PLĀKSNES OLA FOUNDATION PROJEKTAM RĪGĀ

Ernests Ozoliņš
23.11.2023

OLA FOUNDATION PROJEKTS

- Unikāla olas forma
- UHPC plātnes novietotas pa ēkas perimetru
  - 256 – unikālas formas elementi
- UHPC materiāla papildus prasība – pretslīdes tekstūra
  - Tipiski iegūst aizkavējot betona virsmas cietēšanu vai ar matricas palīdzību
- Objekts nominēts Eiropas savienības laikmetīgās arhitektūras balvai
- MB grupa piegādāja betonu un konsultēja betonēšanas procesu dekoratīvajām sienām objektā

UHPC JEB SEVIŠĶI AUGSTAS VEIKTSPĒJAS BETONS

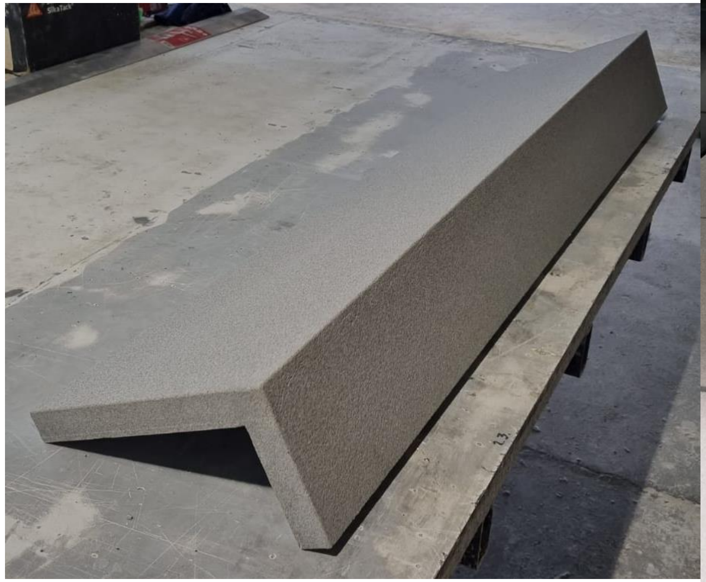
- Īpaši optimizēts betona sastāvs
- Zema ūdens/cementa attiecība, bieži zem 0.2
- Spiedes stiprība >130 MPa
- Stiepes stiprība > 6 MPa
- Lieces stiprība > 20 MPa

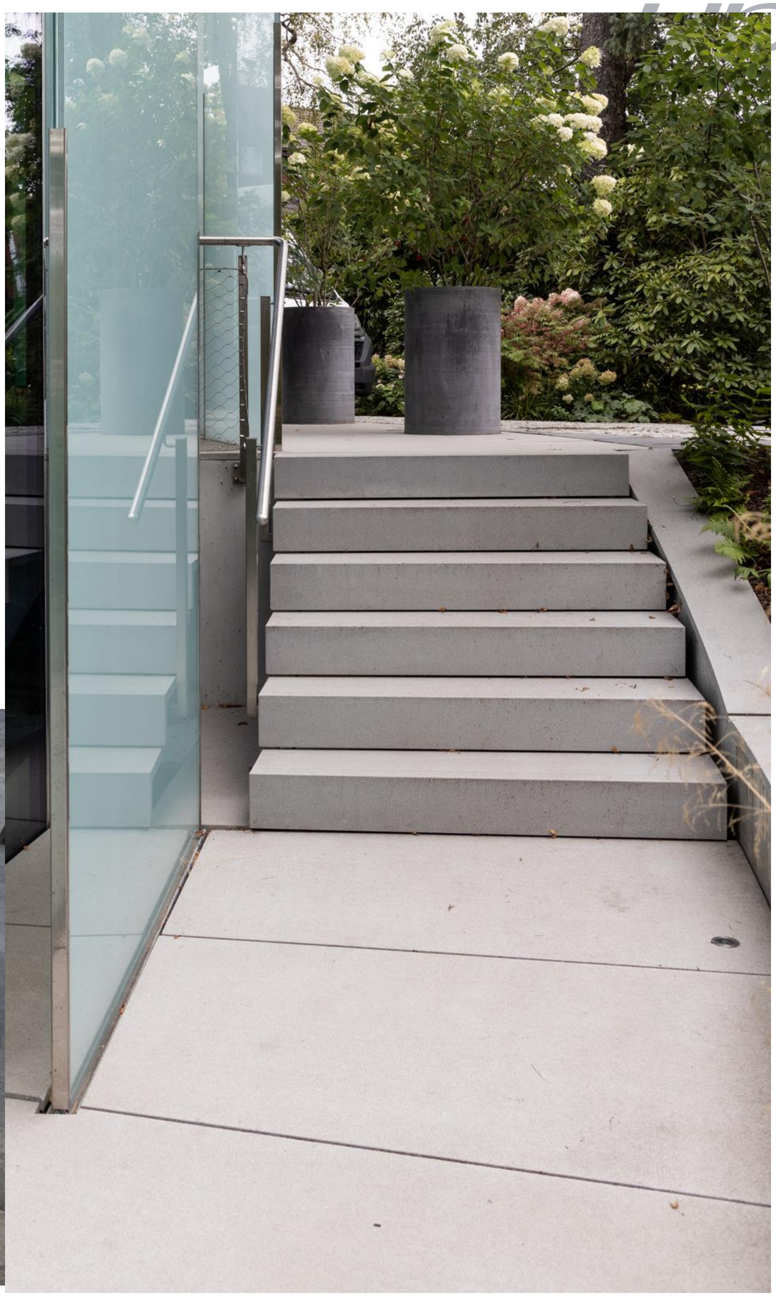
UHPC SASTĀVA IZSTRĀDE

- UHPC sastāvs izstrādāts no vietējiem izejmateriāliem
- Izstrādāti sastāvi divu veidu šķiedrām
  - Metāla šķiedrām
  - Stikla šķiedrām
- Veiktas vairāk kā 180 receptes iterācijas
- Spiedes stiprība > 135 Mpa
- Ola foundation projektam speciāli pielāgots sastāvs

SARAŽOTIE ELEMENTI

- 159 unikālas ģeometrijas UHPC plāksnes
- 15 unikālas ģeometrijas pakāpieni
- 82 unikālas ģeometrijas apmales elementi





IEGUVUMI PROJEKTĀ NO UHPC MATERIĀLA

- 30 mm biezas plātnes
- Iespēja ražot unikālas ģeometrijas elementus
- Iespējams realizēt vizuālās prasības
- Pielāgota virsmas apstrāde un sastāvs
- Iespēja elementā iestrādāt pretslīdes rievas
- Ilgmūžība un izturība

VEIDŅI PRIEKŠ UNIKĀLIEM ELEMENTIEM

- Veikti mērījumi uz vietas būvē
- Elementa perimetrs tiek ar CNC frēzi izfrēzēts
- Ar plastmasas līsti nofiksējam perimetru un elementa biezumu
- Laba veidņa virsmas kvalitāte
- Aizkavētāja uzklāšana - ļoti svarīgs process
  - Plāksnes
  - Telpiskie elementi
    - Jāpielāgo aizkavētāja iedarbība visās redzamajās plaknēs

VIRSMAS APSTRĀDES IZAICINĀJUMI

- Aizkavētājs laboratorijā (jeb teorijā) strādā
- Bet ražotnē?
- Šķiedra uz elementa virsmas

TELPISKIE ELEMENTI

- Vizuālas prasības vairākām elementa plaknēm
- Īpaši veidņi šādu elementu ražošanai
- Pielāgots sastāvs elementu ražošanai

VIRSMAS AIZSARDZĪBA PRET NETĪRUMIEM

- Pa elementiem ikdienā tiek staigāts
  - Liels risks, ka tiks nosmērēti
    - Eksploatacija būvniecības laikā
    - Koku lapas / putekšņi
    - Cilvēku radīti traipi
- Apstrāde ar hidrofobu, lai mazinātu risku
- Testēti 12 dažādi produkti
  - 4 produkti veidoja ūdens pilienus uz betona virsmas, pārējie neveidoja

IZAICINĀJUMI RAŽOŠANĀ

- Betona iestrādes tehnoloģija
- Betona iestrādājamības logs (25-50 min)
- Laikapstākļi
- Elementu kopšana (temperatūra, mitrums, laiks)
- Telpiskie elementi


PALDIES!

Rail Baltica prasības būvju ilgmūžībai

Rail Baltica

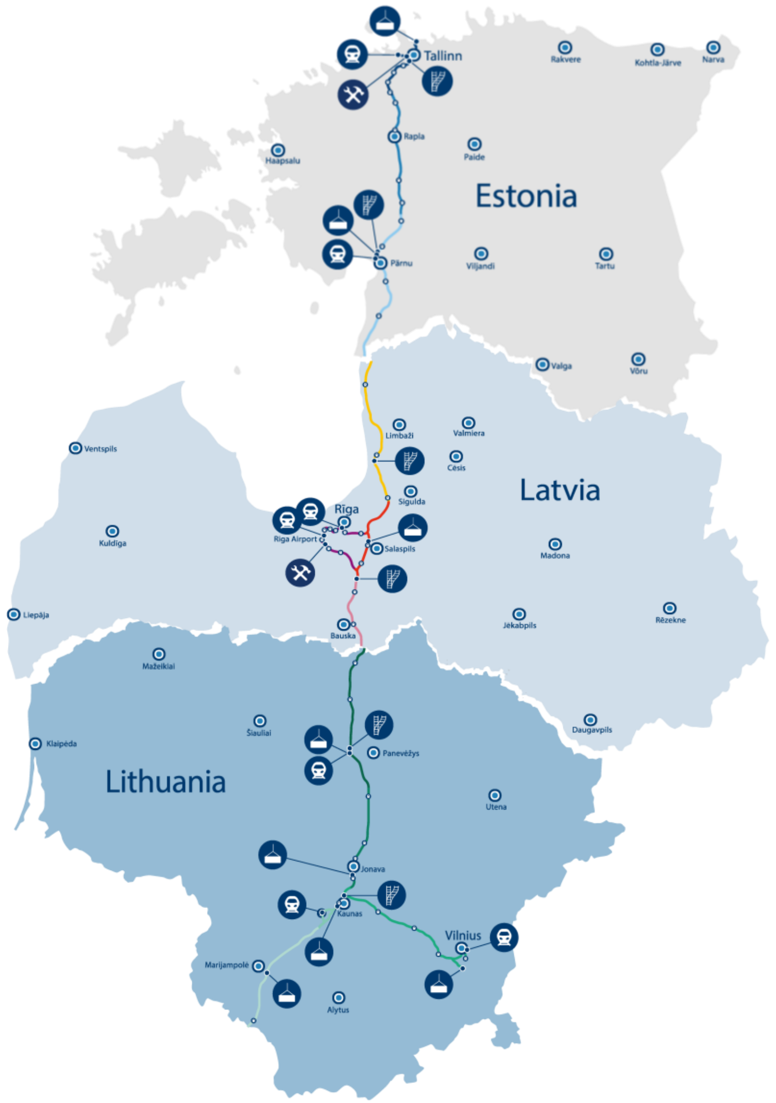
Co-funded by the European Union

Edgars Ogliņš, RB Rail Vecākais tiltu inženieris

23.11.2023.

#RailBaltica

Rail Baltica tehniskais progress



Plānošana un projektēšana

- Pamattrases projektēšanas darbi tuvojas noslēgumam vairāk nekā 640 km; precizēts trases novietojums Kauņas – Lietuvas / Polijas robežas pārrobežu posmam un Kauņas-Viļņas posmā
- Projekta ieviešanas laika grafiks tiek sinhronizēts ar Poliju
- Operacionālās darbības nodrošināšanai nepieciešamo jautājumu risināšana

Būvdarbi

- Norit pirmās kārtas būvdarbi visās Baltijas valstīs (stacijas, tilti, viadukti, dzīvnieku pārejas);
- Pamattrases būvdarbu iepirkumi turpinās Lietuvā, Latvijā un Igaunijā
- Turpinās konsolidēto būvmateriālu iepirkums

Dzelzceļa apakšsistēmu ieviešana

- Turpinās elektrifikācijas, kā arī vadības un signalizācijas iekārtu apakšsistēmas projektēšanas un būvdarbu iepirkumi visai dzelzceļa līnijai 870 km garumā

Īstenošanas programma 2030

- 2030. gadu kā mērķa datumu apstiprināja trīs Baltijas valstu transporta ministri (janvāris, 2023)
- Projektēšanas laika plāna stabilizēšana kā galvenais priekšnosacījums turpmākai darbu veikšanai
- Būvdarbu un citu saistīto darbību salāgošana Baltijas mērogā un ar Poliju
- Projektam nepieciešamo investīciju un izmaksu aplēšu atjaunošana tiks pabeigta kopā ar izmaksu un ieguvumu analīzi 2024. gadā
- Starpinstitūciju projekta ieviešanas struktūras uzlabojumi

Projekta kopsavilkums

	Igaunija	Latvija	Lietuva
Projektēšanas posmi	3	4	4
Kopējais garums	213 km	265 km	392 km
Dzelzceļa struktūras (tilti, pārvadi/ pārejas, viadukti, ekodukti, tuneļi)	84	103	43*
Ceļu pārvadi	55	83	21*
Ievērojamākās būves	Dzelzceļa tilts pār **Pērnavas upi:** kopējais garums 320m Dzelzceļa tilts pār **Keila upi:** kopējais garums 206 m	Dzelzceļa tilts pār **Gaujas upi:** kopējais garums 1440 m Apvienotais dzelzceļa / autoceļa tilts pār **Daugavas upi:** kopējais garums 1150 m Dzelzceļa tunelis **Torņakalnā:** garums 1350m	Dzelzceļa tilts pār **Neris upi:** kopējais garums 1510 m Dzelzceļa tilts pār **Šešuva/Vėsa upi:** kopējais garums 580 m Dzelzceļa tilts pār **Mūsas upi:** LV/LT, pārrobežu posms: kopējais garums 157m

**Dati par posmu Kaunas – LV robeža, posmā Viļņa – Kauņa, un Kauņas mezgls un Jiesia – PL robeža notiek teritorijas plāna izstrāde*

Rail Baltica projektēšanas vadlīniju prasības attiecībā uz betona konstrukciju ilgmūžību

- Projektētais būvju kalpošanas laiks – >100 gadi
- Betona konstrukcijas projektētas ievērojot ārējās vides iedarbības klases atbilstoši EN 206
- Ārējās vides iedarbības klasēm jābūt izvēlētām atbilstoši vides apstākļiem un būves tipam
    - Projektējot platformas jāparedz pretapledojuma sāļu klātbūtne
    - XC3 virmām, kas pasargātas ar hidroizolāciju
    - XD3, XF4 virsmām, kas pakļautas tiešai pretapledojuma sāļu ietekmei
- Betona stiprības klase dzelzceļa būvēm
    - Laiduma konstrukcijas – C45/55
    - Balsti – C35/45
    - Pamati – C30/37
- Betona aizsargslānis c_{nom} un plaisu platums w_{max} atbilstoši EN 1992-1-1 prasībām

Rail Baltica būvniecības specifikāciju prasības

CONCRETE SPECIFICATION ACCORDING TO EN-1992-1-1:2004, EN 206-1:2000 and EVS-EN 206						
	Element type	Exposure class *	fck (MPa)	Min. Cement (kg/m^3)	Max. w/c	max. aggregate size (mm)
Lean Concrete	N/A	N/A	C16/20	N/A	N/A	20
Foundations	Spread Footings	XC2(1)	C30/37(1)	280(1)	0.60(1)	20
	Piles Caps	XC2(1)	C30/37(1)	280(1)	0.60(1)	20
	Piles	XC2(1)	C30/37(1)	280(1)	0.60(1)	20
Superstructure	Abutments & Walls	XC4/XD1/XF2	C35/45	340	0.5	20
		XS1/XD1/XF2(2)		“	“	
		XC4/XD3/XF4(3)		380	0.4	
		XS1/XD3/XF4(2)&(3)		“	“	
	Piers	XC4/XD1/XF2	C40/50	360	0.45	20
		XS1/XD1/XF2(2)		“	“	
		XC4/XD3/XF4(3)		380	0.4	
		XS1/XD3/XF4(2)&(3)		“	“	
	Prefabricated vault	XC4/XD1/XF2	C45/55	380	0.4	20
		XS1/XD1/XF2(2)				
	Cast In situ vault	XC4/XD1/XF2	C45/55	360	0.45	20
		XS1/XD1/XF2(2)				
	Bridge Decks and Top Slab in Underpasses	XC4/XD3/XF4	C45/55	380	0.35	20
		XS1/XD3/XF4(2)				
Details	Pedestrian Path, Ballast Wall…	XC4/XD3/XF4	C35/45	380	0.4	20
		XS1/XD3/XF4(2)				
	Edge Beam Precast	XC4/XD3/XF4	C35/45	380	0.4	10
		XS1/XD3/XF4(2)				
(1) Non-Aggressive conditions for the soil and water to be confirmed.						
(2) Located at distances less than 5 km from the coast.						
(3) Piers, abutments and walls in close proximity of salted roads. (in the case of pathways shall be assesed by Rail Baltica when a change of usage is expected in the future)						

Exposure Class	Design Working Life of the structure / component	Testing medium and requirements based on design working life and exposure class	
		Water	3% NaCl
XF1	50 years	$S_{56} \leq 0{,}50$ kg/m^2 or $S_{56} \leq 1{,}00$ kg/m^2 if S_{56} / S_{28} is ≤ 2	-
	100 years	$S_{56} \leq 0{,}20$ kg/m^2 or $S_{56} \leq 0{,}50$ kg/m^2 if S_{56} / S_{28} is ≤ 2	-
XF2	50 years	-	$S_{56} \leq 0{,}65$ kg/m^2 or $S_{56} \leq 1{,}30$ kg/m^2 if S_{56} / S_{28} is ≤ 2
	100 years	-	$S_{56} \leq 0{,}50$ kg/m^2 or $S_{56} \leq 1{,}00$ kg/m^2 if S_{56} / S_{28} is ≤ 2
XF3	50 years	$S_{56} \leq 0{,}20$ kg/m^2 or $S_{56} \leq 0{,}50$ kg/m^2 if S_{56} / S_{28} is ≤ 2	-
	100 years	$S_{56} \leq 0{,}10$ kg/m^2 or $S_{56} \leq 0{,}20$ kg/m^2 if S_{56} / S_{28} is ≤ 2	-
XF4	50 years	-	$S_{56} \leq 0{,}35$ kg/m^2 or $S_{56} \leq 0{,}70$ kg/m^2 if S_{56} / S_{28} is ≤ 2
	100 years	-	$S_{56} \leq 0{,}20$ kg/m^2 or $S_{56} \leq 0{,}50$ kg/m^2 if S_{56} / S_{28} is ≤ 2
S_{56} – loss of mass after 56 freeze/thaw cycles (test method CEN/TS 12390-9)			
S_{28} – loss of mass after 28 freeze/thaw cycles (test method CEN/TS 12390-9)			

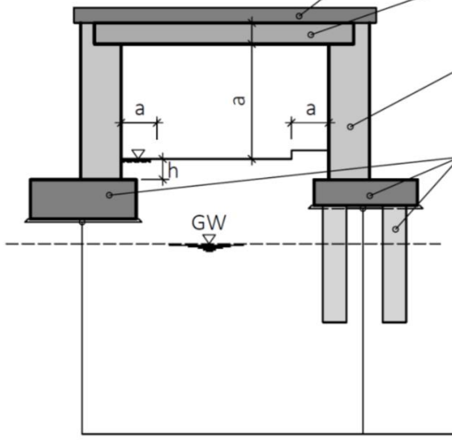
* Vispārīgas prasības gadījumiem, ja projektā objektam nav norādītas konkrētas prasības

XS ārējās vides iedarbības klašu pielietojums

Avots: https://www.dlubal.com/en/load-zones-for-snow-wind-earthquake/wind-lvs-en-1991-1-4.html

Rail Baltica Standard Bridge Solution Study 2019

railway bridges crossing streets, cycle - and pedestrian routes and railway lines



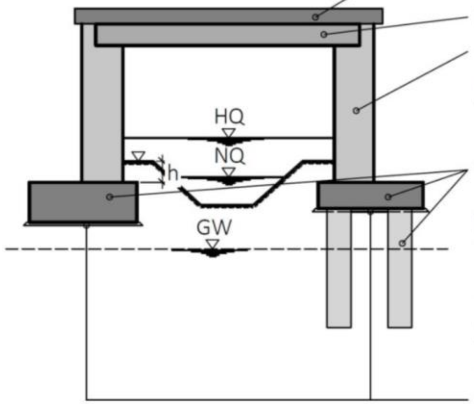
	a < 10m: de-icing salt risk	a ≥ 10m: no de-icing salt risk
edge beam	edge beam spray zone XC4, XD1, XF2, WA	edge beam XC4, XF1, WF
superstructure	superstructure spray zone XC4, XD1, XF2, WA	superstructure XC4, XF1, WF
abutments/ piers	abutments/ piers spray zone XC4, XD2, XF2[1], WA	abutments/ piers XC4, XF1, WF
founding	founding[2] h ≥ 80cm under top ground surface XC2, WA if necessary XA1/2/3	founding[2] h ≥ 80cm under top ground surface XC2, WF if necessary XA1/2/3
	h < 80cm under top ground surface XC2, XD2, XF2, WA if necessary XA1/2/3	h < 80cm under top ground surface XC2, XF1[3], WF if necessary XA1/2/3

granular subbase
X0, WA (no reinforcement)

For all components: Near the coast XS1 und WA (instead of WF) are required in addition.

1) Constructive measures for discharge of de-icing salt water in spray zone, otherwise XD3, XF4.
2) Note frost line, groundwater level and precolation ability of soil.
3) In case of groundwater: XF3 required.

railway bridges crossing waters



edge beam
XC4, XF1, WF

superstructure
XC4, XF1, WF

abutments/ piers
along watercourse[1]: XC4, XF1, WG
water exchange area: XC4, XF3, WF
underwater area: XC2, XM1, WF

founding[2]
h ≥ 80cm under top ground surface
XC2, WF
if necessary XA1/2/3

h < 80cm under top ground surface
XC2, XF1[3], WF
if necessary XA1/2/3

granular subbase
X0, WA (no reinforcement)

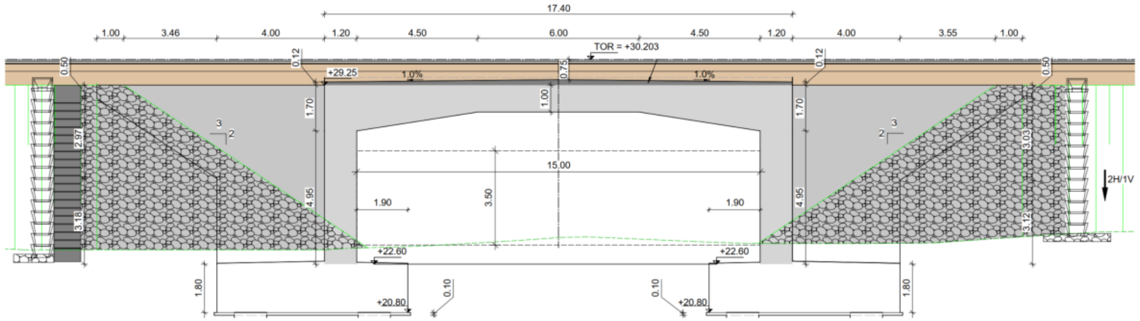
For all components: Near the coast XS1 und WA (instead of WF) are required in addition.

1) Note HQ
2) Note frost line, groundwater level and precolation ability of soil.
3) In case of groundwater: XF3 required.

Avots: VDEI- Verband Deutscher Eisenbahn-Ingenieure E.V. - information Konstruktiver IngenieurBau Nr.05

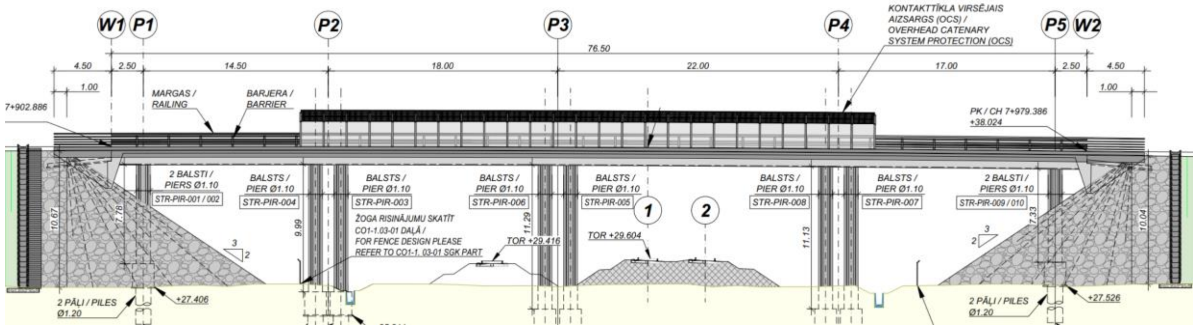
Piemēri

Dzelzceļa pārvads pār dzīvnieku šķērsojumu



MATERIĀLS / MATERIAL	ELEMENTS / ELEMENT	KLASE / GRADE	VIDES AGRESISVITĀTE / EXPOSURE	CNOM(mm) / CNOM(mm)	Min CEMENTA DAUDZUMS / Min CEMENT CONTENT (kg/m³)	MAX ŪDENS/CEMENTA ATTIECĪBA / MAX W/C	MAX PILDVIELAS DAĻIŅU IZMĒRS / MAX AGREGATE SIZE	BŪVES KLASE / STRUCTURAL CLASS
IZLĪDZINOŠAIS BETONS / LEAN CONCRETE	N/A	C16/20	N/A	N/A	N/A	N/A	20	N/A
PAMATI / FOUNDATIONS	PĀĻU UZKALA / PILE CAPS	C30/37	XC2/XA1	50	300	0.55	20	S6
	PĀĻI / PILES	C30/37	XC2/XA1	75	300	0.55	20	S6
VIRSBŪVE / SUPERSTRUCTURE	SIENAS / WALLS	C35/45	XC4/XD1/XF2	55	340	0.50	20	S5
	VIRSMAS PLĀKSNE / TOP SLAB	C45/55	XC4/XD1/XF3	45	360	0.45	20	S4

Ceļa pārvads pār dzelzceļu



METERIĀLS / MATERIAL	ELEMENTS / ELEMENT	KLASE / GRADE	IEDARBĪBA / EXPOSURE	CNOM(mm)	MIN BETONA SASTĀVS / Min CEMENT CONTENT (kg/m³)	MAX W/C	MAX AGREGĀTA IZMĒRS / MAX AGREGATE SIZE	STRUKTŪRAS KLASE / STRUCTURAL CLASS
LIESS BETONS / LEAN CONCRETE	N/A	C16/20	N/A	N/A	N/A	N/A	20	N/A
BETONS / CONCRETE	PĀREJAS PLĀTNE / TRANSITION SLAB	C30/37	XC2	50	280	0.60	20	S6
	PĀĻI / PILES	C30/37	XC2	75	280	0.60	20	S6
	PĀĻU CEPURES / PILE CAPS	C30/37	XC2	50	280	0.60	20	S6
	SPĀRNU SIENAS / WINGWALLS	C45/55	XC4/XD3/XF4	55	380	0.35	20	S4
	BALSTI / PIERS	C40/50	XC4/XD1/XF2	45	360	0.45	20	S4
	KLĀJS / DECK	C45/55	XC4/XD3/XF4	55	380	0.35	20	S4
	MALAS SIJA / EDGE BEAM	C35/45	XC4/XD3/XF4	60	380	0.40	10	S5

Rail Baltica

Co-funded by the European Union

Paldies!

Sazinieties ar mums!

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