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Harmonisation of test methods for the execution of the EC Construction Products Directive

Validation of a European leaching test for construction products

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Harmonisation of test methods for the execution of the EC Construction Products Directive

Validation of a European leaching test for construction products

by

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CEN/TC 351 „Construction products: Assessment of release of dangerous substances“ worked out three drafts for harmonized test methods, which are necessary for the implementation of the Essential Requirement No 3 „Hygiene, Health and the Environment“ of the Construction Products Directive. One of these standards describes the tank test, which is intended for the determination of the leaching of inorganic and organic substances from monolithic construction products. Before the test methods worked out by CEN/TC 351 can achieve the status of European standards (EN), robustness testing and, as a second validation step, round robin tests are necessary.

In the research project the robustness of the tank test – in agreement with CEN/TC 351 – was investigated for three concretes and one mortar. During these investigations the curing of the test specimen, the test temperature, the contact time, the ratio of the eluent volume to specimen surface as well as the pH-value of the starting test water was varied. For the mortars the TOC-release was determined besides the inorganic parameters. The leaching results for the cationes sodium and potassium can be interpreted in such a way that the test method by itself is robust. For the trace elements the range of the results is wider, this is probably due to the very low leached amounts for many parameters, which are often near or below the quantification limit.</td></tr>
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16. Zusammenfassung

Vom CEN/TC 351 „Bauprodukte: Bewertung der Freisetzung gefährlicher Substanzen“ wurden drei Entwürfe für harmonisierte Prüfnormen ausgearbeitet, die zur Umsetzung der Wesentliche Anforderung Nr. 3 „Hygiene, Gesundheit und Umweltschutz“ der europäischen Bauproduktenrichtlinie notwendig sind. Eine dieser Normen beschreibt den Tanktest, der für die Bestimmung der Auslaugung anorganischer und organischer Substanzen aus monolithischen Bauprodukten vorgesehen ist. Bevor die vom CEN/TC 351 erarbeiteten Prüfmethoden den Status von Europäischen Normen (EN) erlangen können, sind noch Robustheitsprüfungen und als zweiter Validierungsschritt Ringversuche erforderlich.

Im Forschungsvorhaben wurde die Robustheit des Tanktests – in Absprache mit CEN/TC 351 – an drei Betonen und einem Mörtel untersucht. Bei diesen Untersuchungen wurde die Vorlagerungszeit der Prüfkörper, die Prüftemperatur, die Kontaktzeiten, das Verhältnis vom Volumen des Eluenten zur Oberfläche des Prüfkörpers sowie für die Betone der pH-Wert des Ausgangsprüfwassers variiert. Bei den Mörteln wurde neben den anorganischen Parametern auch die TOC-Abgabe ermittelt. Die Auslaugergebnisse für die Kationen Natrium und Kalium können so interpretiert werden, dass das Prüfverfahren an sich robust ist. Bei den Spurenelementen ergeben sich jedoch größere Streubreiten der Ergebnisse, dies ist vermutlich auf die für viele Parameter sehr geringen ausgelaugten Mengen, die häufig in der Nähe oder unterhalb der Bestimmungsgrenze liegen, zurückzuführen.

17. Schlagwörter
Bauproduktenrichtlinie, wesentliche Anforderung Nr. 3, Mandat M/366, regulierte gefährliche Substanzen, CEN/TC 351, Auslaugung, Prüfmethoden, Validierung, Tanktest, Robustheitsprüfung, Beton, Technische Spezifikation

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1 Introduction

Construction products in terms of the European Construction Products Directive (CPD) are building materials, components and constructions, which are produced for incorporation in a permanent manner in buildings and civil engineering works, as well as prefabricated constructions which are produced with building materials and components to be connected with the ground, for example prefabs, prefabricated garages and silos. In addition products for the building equipment are counted as construction products. The CPD has the speciality that the essential public legal requirements are not worded relating to the construction product itself but are related to the construction work [1].

A construction product may be placed on the market and traded free only if the conformity with the essential requirements is proved. Essential requirements to construction works in terms of the CPD are:

- No 1: Mechanical resistance and stability
- No 2: Safety in case of fire
- No 3: Hygiene, health and the environment
- No 4: Safety in use
- No 5: Protection against noise
- No 6: Energy economy and heat retention

The European Union Member States act on the assumption that construction products are fit for use if the construction works at their application, at proper design and execution of the construction work, fulfil the above mentioned essential requirements during their service life, and if these products bear the CE-marking from which is evident that they meet all provisions of the Construction Products Directive including the system of conformity assessment.

Apart from the requirements traditionally defined in the building legislation the CPD explicitly demands construction works to be built with construction products that meet the requirements on hygiene, health and environment in force in their place of use and not to endanger the health of the occupants and neighbours, in particular as a result of any of the following impacts:

- The giving-off of toxic gas
- The presence of dangerous particles or gases in the air
- The emission of dangerous radiation
- Pollution or poisoning of the water or soil
- Faulty elimination of waste water, smoke, solid or liquid wastes
- The presence of damp in parts of the works or on surfaces within works

Technical specifications (standards or technical approvals) which are harmonised according to the European Construction Products Directive have therefore to comprise the provisions necessary to ensure the protection of the immediate vicinity of a construction work. The elaboration of such provisions presupposes, however, that the corresponding building regulations of the Member States stipulate qualitative and, if necessary, also quantitative requirements which are notified on the European level. An analysis of the existing requirements in the Member States of the EU revealed that at present only few Member States have quantitative requirements on the release of regulated dangerous substances from construction products/construction works. The most important provisions for the subject of environmental protection are the Dutch „Soil Quality Decree“ [2] and the German „Principles for assessing the effects of construction products on soil and groundwater“ [3,4]. These pursue the goal of limiting the release of dangerous substances from construction products to the environmental media water, soil and air during the use of construction works.

For protection of human health and indoor air quality the most conspicuous provisions are the French regulation (draft) on the „Labelling of construction and decoration products with their volatile pollutant emissions“ [5] as well as the German „Principles for the health assessment of construction products used in the interiors” [6]. Further information on the legal provisions of the Member States is available in a database of the European Commission [7].

As only few national regulations for construction products focus on the release of dangerous substances so far, no convenient European test methods are available. As a result of this, the harmonised European product standards adopted to date exclusively comprise general references to existing national requirements. For the future compilation and revision of harmonised technical specifications the European Commission now demands to work out the corresponding verification concepts and associated verification instruments, such as methods of testing and analysis. To that end, the Commission issued at the beginning of the year 2005 the mandate M/366 „Development of horizontal standardised assessment methods for harmonised approaches relating to dangerous substances under the Construction Products Directive (CPD) – Emission to indoor air, soil, surface water and ground water” [8]. The mandate intends that the European Committee for Standardisation (CEN) is going to elaborate horizontal test and assessment methods. However, the concrete requirements regarding the environmental compatibility of construction products will continue to be defined nationally by the individual Member States.

To allocate the necessary generic, horizontal test and assessment methods for the implementation of the mandate M/366 the European Committee for Standardisation CEN set up the technical committee CEN/TC 351 „Construction products: Assessment of release of dangerous substances“ in the year 2006.

Thereby it is intended not to work out new test and assessment methods. CEN/TC 351 shall only bring together existing, diverging national test methods or European methods from other, linked fields of law, to harmonised horizontal test methods for construction products. In CEN/TC 351 the European Organisation for Technical Approvals EOTA, the European Environmental Association ECOS and diverse industrial associations are represented besides the national standardisation bodies. Furthermore intensive cooperation exists with numerous CEN technical committees for construction products [9].

Three drafts for harmonised test methods are the main result of the work of CEN/TC 351 of the past few years. Two of these test methods are designed for the determination of the leaching of inorganic and organic substances from construction products with regard to soil and water. The methods of these test standards are a tank test „Generic horizontal dynamic surface leaching test (DSLT) for determination of surface dependent release of substances from monolithic or plate-like or sheet-like construction products“ and a column test „Generic horizontal up-flow percolation test for determination of the release of substances from granular construction products“. Starting point for these two test methods have been Dutch [10] and German [11] test methods as well as European standards which have been worked out by CEN/TC 292 „Characterisation of waste“ and for which positive experience exists. The third test method is dealing with the determination of the release of volatile organic compounds into indoor air by means of test chamber measurements „Determination of emissions into indoor air“.

Before the test methods, worked out by CEN/TC 351, can get the status of a European standard, robustness tests and as a second validation step round robin tests are necessary. The aim of the robustness tests is to determine through variation of selected test parameters, for example the temperature of the water in the tank and column test or the air exchange rate in the test chamber, how sensitive the test method reacts to changes of the test conditions. After robustness testing the working groups can decide which ranges of the test conditions are permitted in the standard. The draft standards will thereupon be adapted according to the result of the robustness tests and submitted for publication as Technical Specification (TS).

As the funding of the European validation tests was not clear in the year 2009 the German Federal Environmental Agency announced a tender for the research project „Harmonisation of test methods for the execution of the EU Construction Products Directive: Validation of a European leaching test for construction products (subproject in the context of a European Community project)“ to support this process (remark: In September 2010 the European Commission released the money intended for the robustness tests, so that the European validation tests can start in the year 2011). The research project was given to the “Verein Deutscher Zementwerke e. V.” in collaboration with the Institute for Building Materials Research of the RWTH Aachen University under the promotion reference (UFOPLAN) 3709 95 303. The aim of the research project was to execute the validation test for the tank test on concretes. For this purpose it was originally intended to test the robustness of the tank test in a first phase and then, on this basis, where appropriate respective after amendment of the draft standard, to execute a round robin test in a second phase, to establish the repeatability and reproducibility as well within one laboratory and different laboratories.

However the working group 1 (WG 1) „Release into soil and groundwater“ of CEN/TC 351 it to be too early for such a European round robin test. For this reason the round robin test was not carried out. Instead the robustness testing was extended to a further construction product, with a slightly reduced scale of tests. A mineral mortar with a high amount of organic constituents was scheduled to assess the suitability of the tank test for the investigation of the release of organic substances (TOC-release). At its meeting on 13th November

2009 in Berlin CEN/TC 351/WG 1 confirmed that these investigations are regarded as a substantial contribution to the overall validation process.

Decision 7, CEN/TC 351/WG 1, Berlin 2009-11-13:
CEN/TC 351/WG 1 agrees to take the results of the German VDZ/ibac-research programme on ruggedness validation for concrete (variables: temperature, L/S, curing time, pH-value, renewal scheme) as a substantial contribution in the CEN/TC 351 work. Approved with one abstention.

2 Execution of the research project and scientific-technical results

2.1 Concrete

2.1.1 Concrete production

For the investigation concerning the robustness of the tank test for concretes two different concretes were produced at three different concretings. The concrete production and storage have been carried out according to part II of the principles for “Assessment of the effects of construction products on soil and groundwater” of the German Institute of Structural Engineering (DIBt)“ [4]. For the concrete production a Portland cement CEM I 42.5 R and a slag cement CEM III/A 42.5 N, which was produced with the same clinker as the Portland cement, were used. The cements conformed to DIN EN 197-1 „Cement“ [12]. As aggregate a Rhine gravel/sand conforming to DIN EN 12620 „Aggregate for concrete“ [13] with a grading curve in the middle of the range A16/B16 according to DIN 1045-2 „Tragwerke aus Beton, Stahlbeton und Spannbeton“ [14] was used. The mixing water conformed to DIN EN 1008 „Mixing water for concrete“ [15]. The properties specified in the standard, the chemical composition and the trace element content of the cements were determined as well as the consistency, the air content and the 28 d-, 56 d- and 91 d-compressive strength of the concretes. In **Table 1** the results of the test according to the standard are summarised for the two cements. **Table 2** shows the results of the tests on fresh and hardened concrete for the three concretes produced.

Table 1: Results for the tests according to the standard for the two cements

Parameter	Portland cement CEM I 42,5 R	Slag cement CEM III/A 42,5 N
Loss on ignition [%]	1,95	0,89
Water demand [%]	29,0	31,0
Initial setting time [min]	155	220
Final setting time [min]	195	270
Specific surface (Blaine) [cm^2/g]	4190	4790
2d-compressive strength [MPa]	34,6	19,8
7d-compressive strength [MPa]	49,2	31,8
28d-compressive strength [MPa]	57,7	55,5
Slag content [%]	-	42,1

Table 2: Results of the test on fresh and hardened concrete for the three concretes

Concreting	Cement	Fresh concrete density [kg/dm^3]	Flow-table spread [cm]	Air content [Vol.-%]	Compressive strength [MPa]		
					28 d	56 d	91 d
No. 1	CEM I	2,38	40/42	0,8	49,3	53,1	55,7
No. 2	CEM I	2,36	38/40	1,4	48,3	54,5	56,7
No. 3	CEM III	2,37	41/41	1,0	48,6	54,1	53,6

Table 3 shows the chemical composition and **Table 4** the content of soluble anions and the trace elements of the two cements. The content of the soluble anions was measured in a leachate which was generated according to DIN 38414-4 „Deutsches Einheitsverfahren zur Wasser-, Abwasser- und Schlamm-untersuchungen“ [16].

Table 3: Chemical composition of the two cements (X-ray fluorescence analysis, including loss on ignition)

Parameter [%]	Portland cement CEM I 42,5 R	Slag cement CEM III/A 42,5 N
Silicon(IV)-oxide	18,9	25,2
Aluminium oxide	5,74	7,98
Titanium dioxide	0,29	0,61
Phosphor(V)-oxide	0,15	0,10
Iron(III)-oxide	4,30	2,80
Manganese(III)-oxide	0,70	0,60
Magnesium oxide	1,75	4,24
Calcium oxide	62,9	53,6
Sulphate as SO_3	3,25	2,97
Potassium oxide	0,78	0,61
Sodium oxide	0,15	0,19
Sodium-equivalent	0,66	0,59

Table 4: Content of soluble anions and of the trace elements in the two cements

Parameter	Portland cement CEM I 42,5 R	Slag cement CEM III/A 42,5 N
	Element content in µg/g	
Arsenic (As)	15,8	11,0
Barium (Ba)	47,1	72,5
Beryllium (Be)	1,29	2,44
Cadmium (Cd)	1,46	0,85
Cobalt (Co)	12,2	8,59
Chromium (Cr)	85,0	62,4
Copper (Cu)	88,5	56,7
Mercury (Hg)	0,05	0,04
Manganese (Mn)	4134	3735
Molybdenum (Mo)	2,71	2,02
Nickel (Ni)	41,4	25,6
Lead (Pb)	28,7	22,0
Antimony (Sb)	8,57	5,06
Selenium (Se)	<1,00	<1,00
Tin (Sn)	9,56	9,58
Tellurium (Te)	<2,00	<2,00
Thallium (Tl)	<0,20	<0,20
Vanadium (V)	66,6	51,0
Zinc (Zn)	528	341
	Content of soluble anions[1)] in mg/g	
Chloride (Cl^-)	0,50	0,30
Nitrate (NO_3^-)	<0,10	<0,10
Sulphate (SO_4^{2-})	15,5	17,1

[1)] Leachate according to DIN 38414-4

2.1.2 Leaching results for the concrete of the first concreting

At the first concreting 28 concrete cubes with an edge length of 100 mm were produced according to DIN EN 12390 “Testing hardened concrete” with the Portland cement (Cement content 280 kg/m^3, water/cement ratio w/c = 0,60) for the leaching tests. With eight test specimen the tank test was carried out according to the draft standard „Generic horizontal dynamic surface leaching test (DSLT) for determination of surface dependant release of substances from construction products“. The draft standard provides a test temperature of 20 ± 5 °C, a ratio of the volume of the test water to the surface of the test specimen of 80 ± 1 L/m^2 and contact times in relation to the beginning of the test of 0,083 d ± 5 %, 1 d ± 5 %, 2,25 d ± 5 %, 8 d ± 5 %, 14 d ± 5 %, 15 d ±5 %, 28 d ± 5 % und 36 ± 0,25 d. As test water pH-neutral grade 1 water according to EN ISO 3696 was used. The age of the test specimen at the beginning of the test was 56 days. The obtained leachates were investigated according to the DIBt-principles for inorganic parameters for which an insignificance threshold has been defined. Additionally the sodium and potassium concentration in the leachates was determined. At the leaching tests with the further 20 cubes of this concreting the test conditions were varied according to **Table 5**.

Figures 1 till **11** show the accumulated leached amounts of the eightfold tests in mg/m^2 for the parameter barium, lead, chloride, chromium, potassium, copper, sodium, selenium, sulphate, vanadium and zinc. **Figures 12** till **22** show the accumulated leached amounts in mg/m^2 for the aforementioned parameters for the different variations of the test conditions according to Table 5. In addition the average values of the eightfold DSLT-test are included in these figures.

The individual analytical data for the aforementioned leaching tests are listed in **Tables A1** till **A26** in the annex.

Table 5: Variation of the test conditions[1)] for the concrete tests

Variation No.	Specification
1	Decrease of the curing time to 28 days (56 days)[2)]
2	Increase of the curing time to 91 days (56 days)[2)]
3	Decrease of the testing temperature to 15 °C (20 ± 5 °C)[3)]
4	Increase of the testing temperature 25 °C (20 ± 5 °C)[3)]
5	Duration of the specific leaching step according to the DAfStb-long term leaching test (1 d, 3 d, 7d, 16 d, 32 d, 56 d, in each case ± 0,5 h)
6	Duration of the specific leaching step according to the Dutch standard NEN 7375 (0,25 d ± 10 %, 1 d ± 10 %, 2,25 d ± 10 %, 4 d ± 10 %, 9 d ± 10%, 16 ± 1 d, 36 ± 1 d, 64 ± 1 d)
7	Decrease of the surface to volume ratio to 40 L/m² (80 ± 1 L/m²)[3)]
8	Increase of the surface to volume ratio to 120 L/m² (80 ± 1 L/m²)[3)]
9	Decrease of the pH value of the starting test water to 4 (pH-neutral, grade 1 according to EN ISO 3696)[3)]
10	Increase of the pH value of the starting test water to 10 (pH-neutral, grade 1 according to EN ISO 3696)[3)]

[1)] All variations were done as double test
[2)] Common curing time according to the DIBt-principles
[3)] Test conditions according to the draft of the Tank test (DSLT)

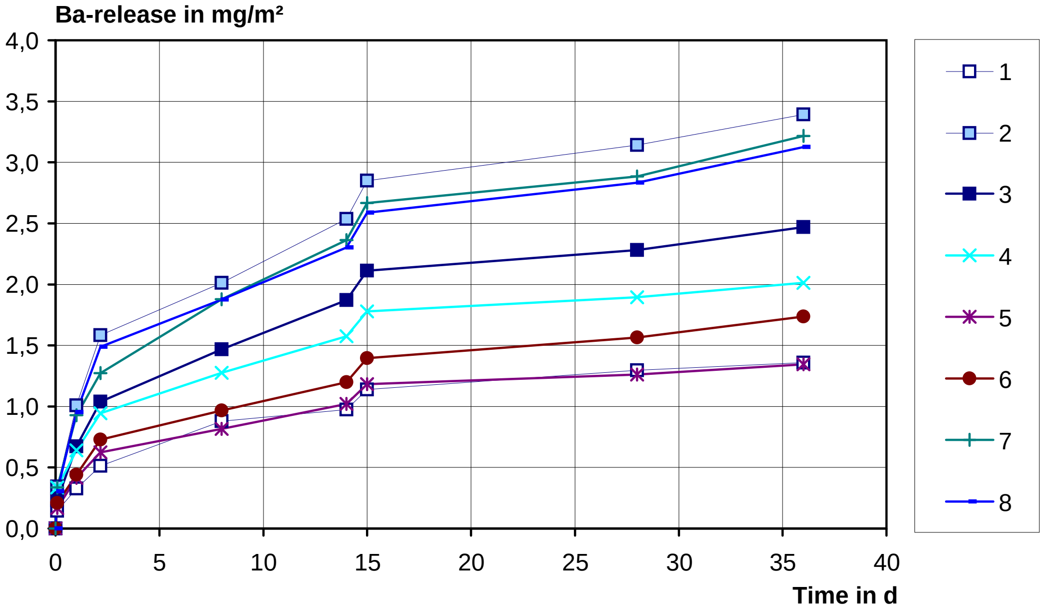

Figure 1: Release of barium in the eightfold test (first concreting)

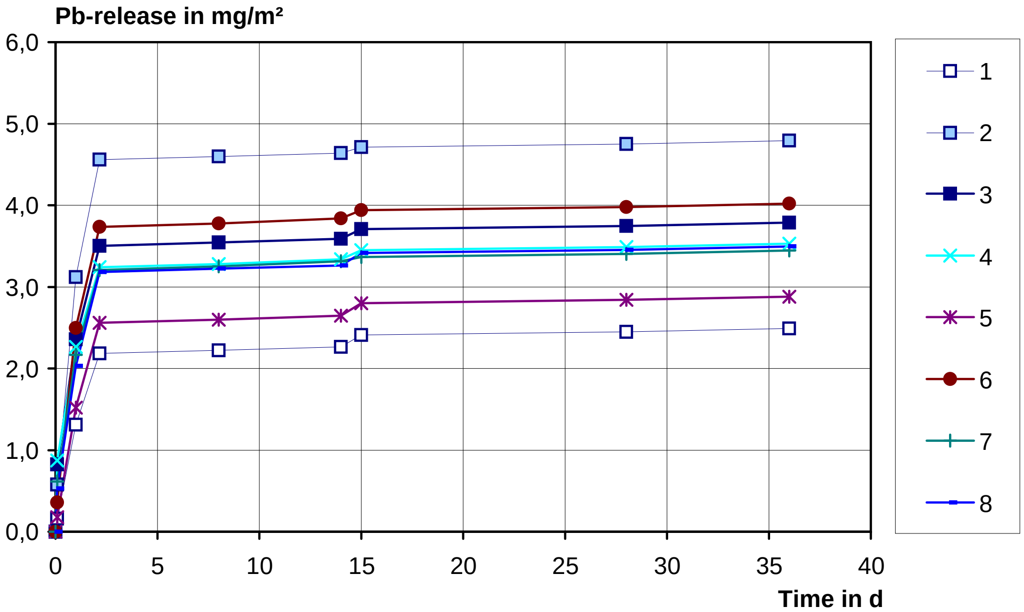

Figure 2: Release of lead in the eightfold test (first concreting)

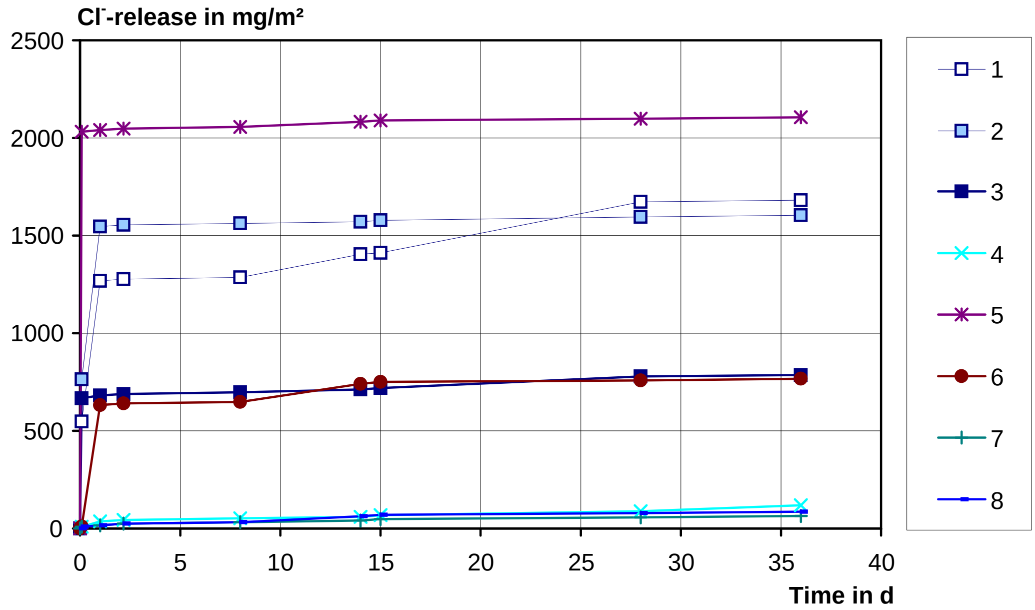

Figure 3: Release of chloride in the eightfold test (first concreting)

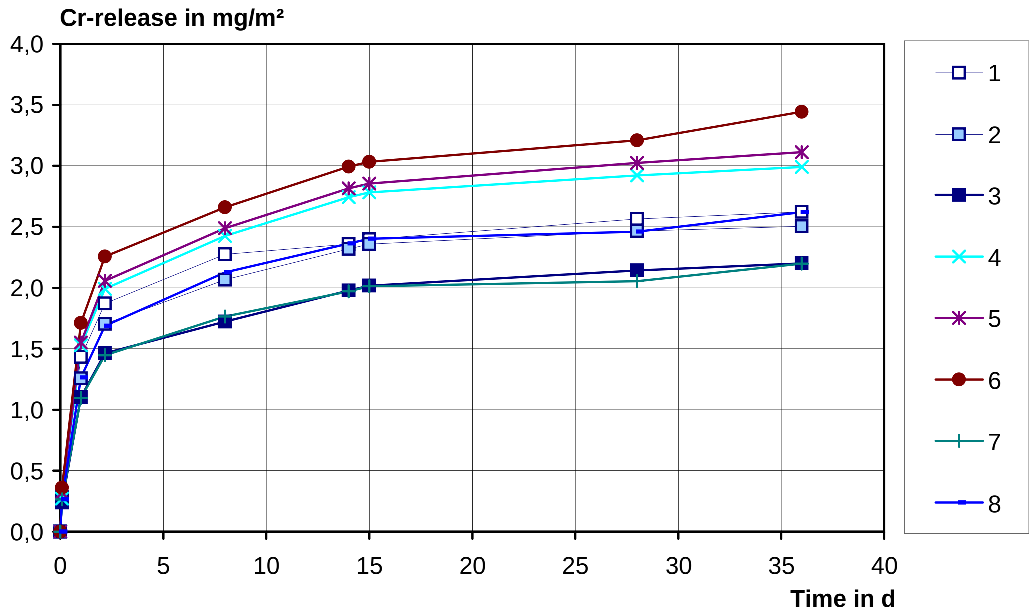

Figure 4: Release of chromium in the eightfold test (first concreting)

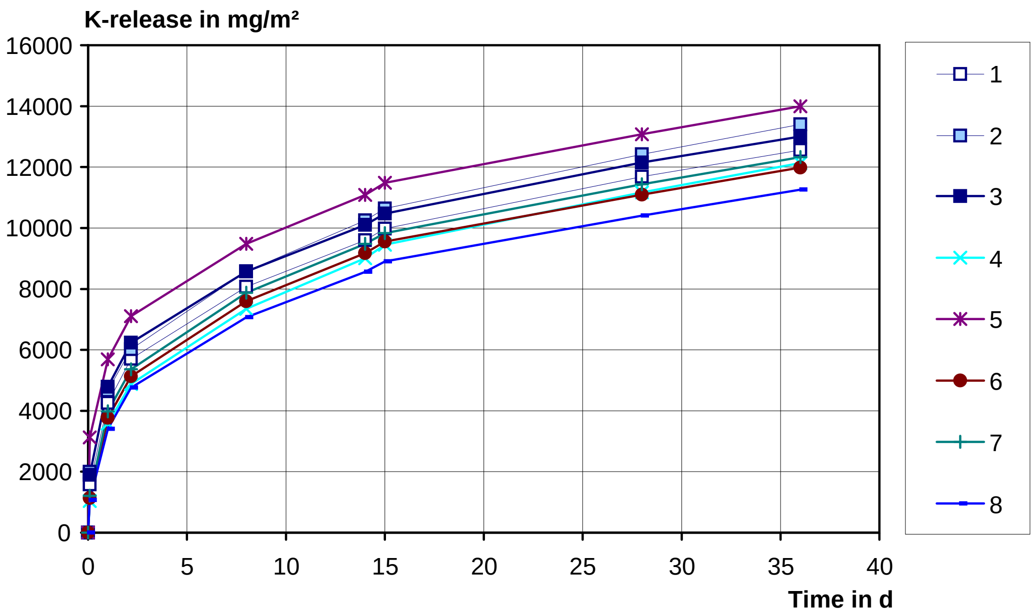

Figure 5: Release of potassium in the eightfold test (first concreting)

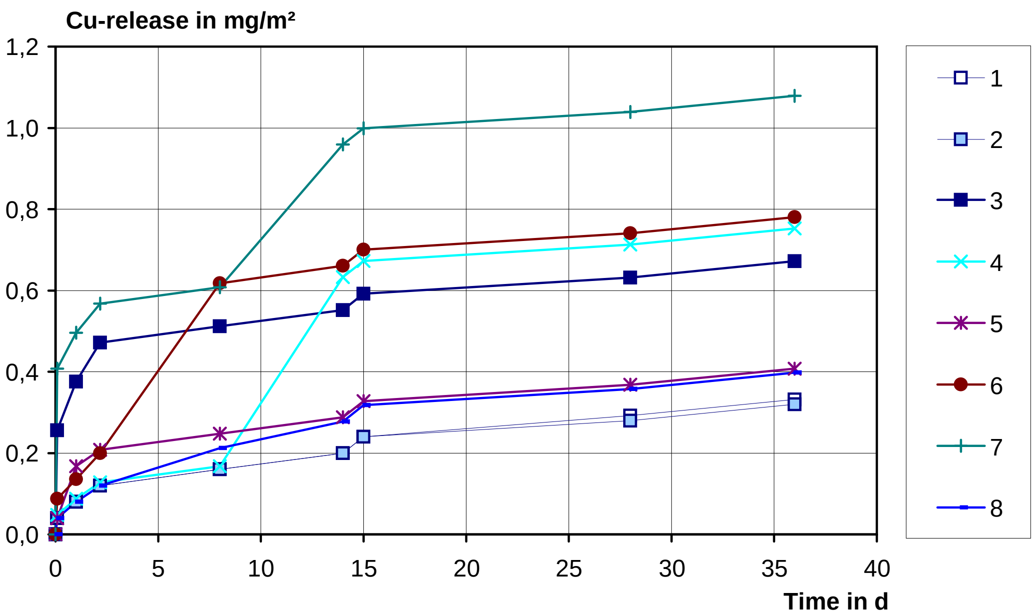

Figure 6: Release of copper in the eightfold test (first concreting)

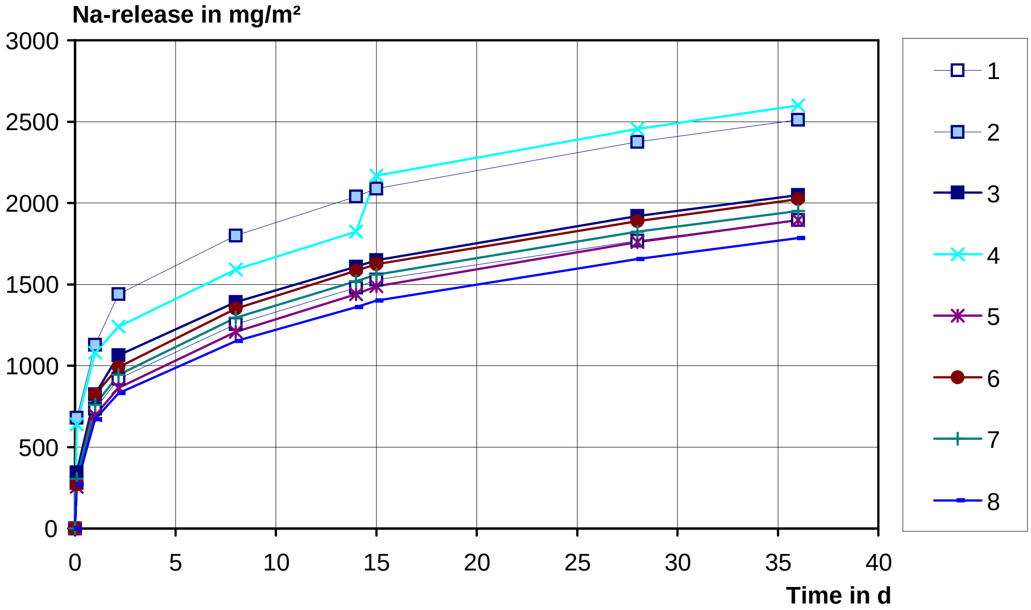

Figure 7: Release of sodium in the eightfold test (first concreting)

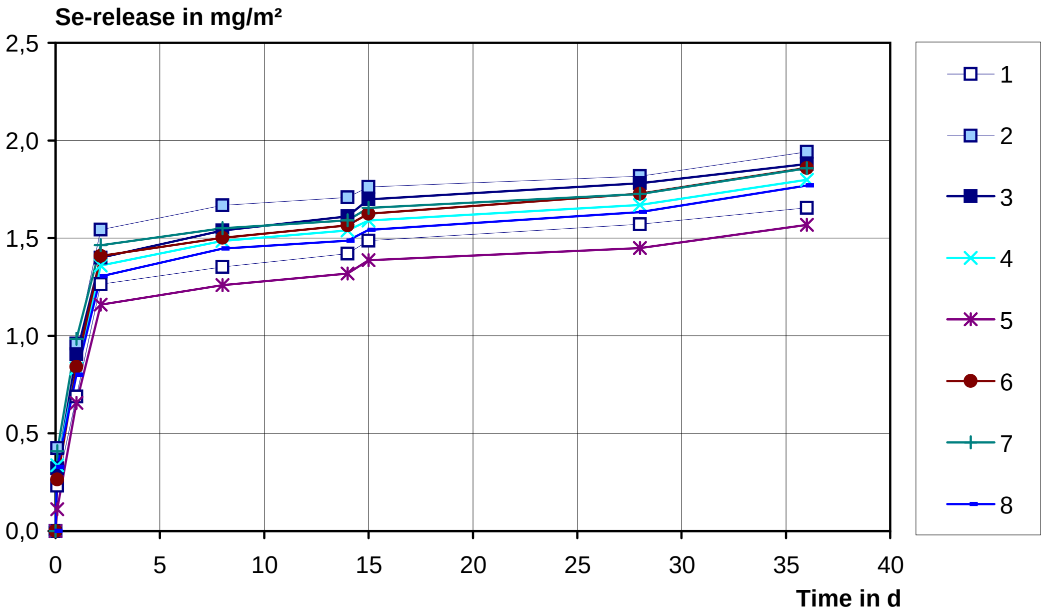

Figure 8: Release of selenium in the eightfold test (first concreting)

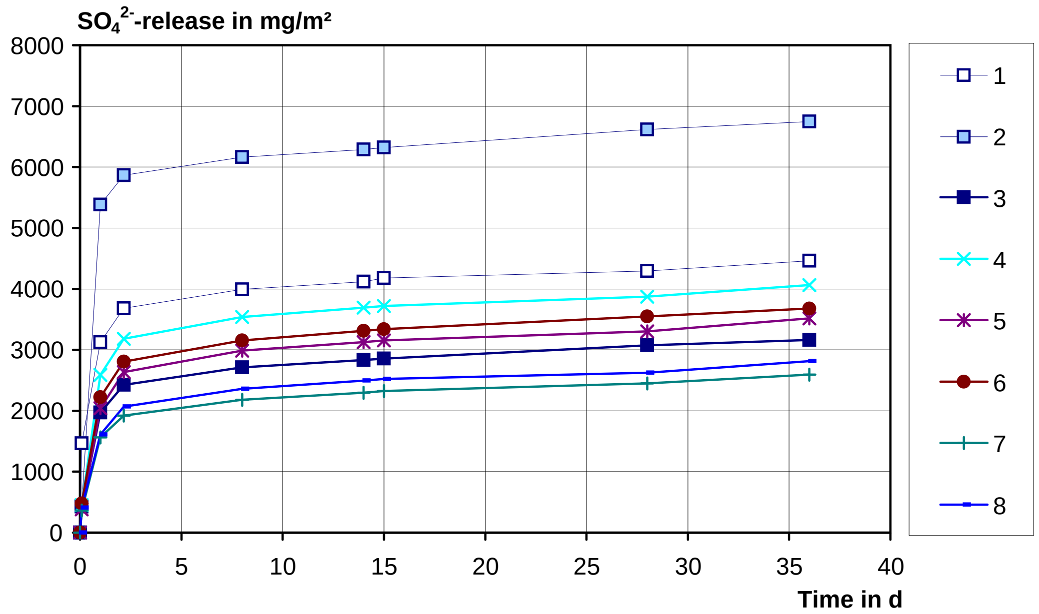

Figure 9: Release of sulphate in the eightfold test (first concreting)

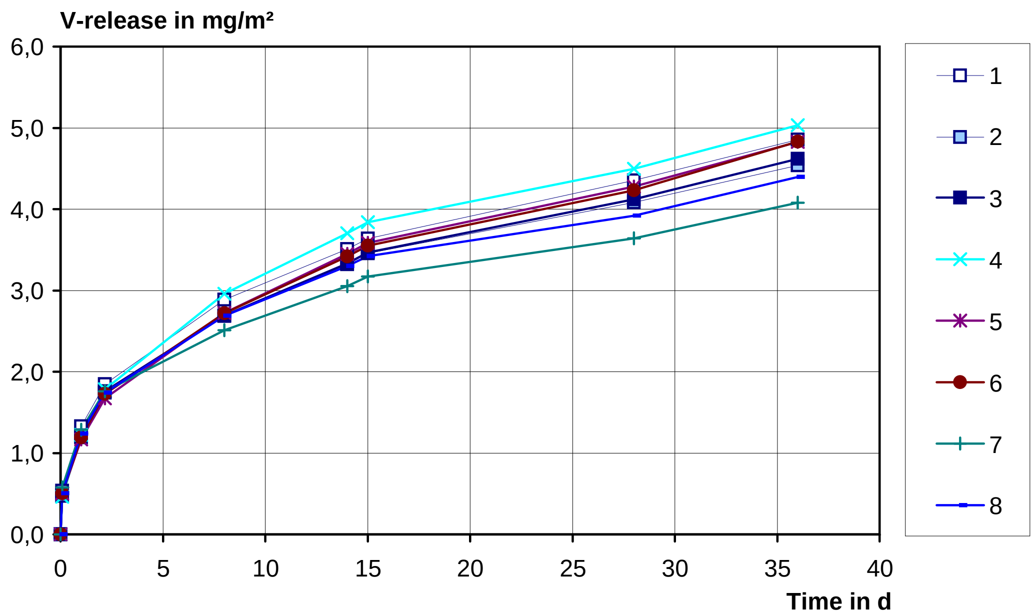

Figure 10: Release of vanadium in the eightfold test (first concreting)

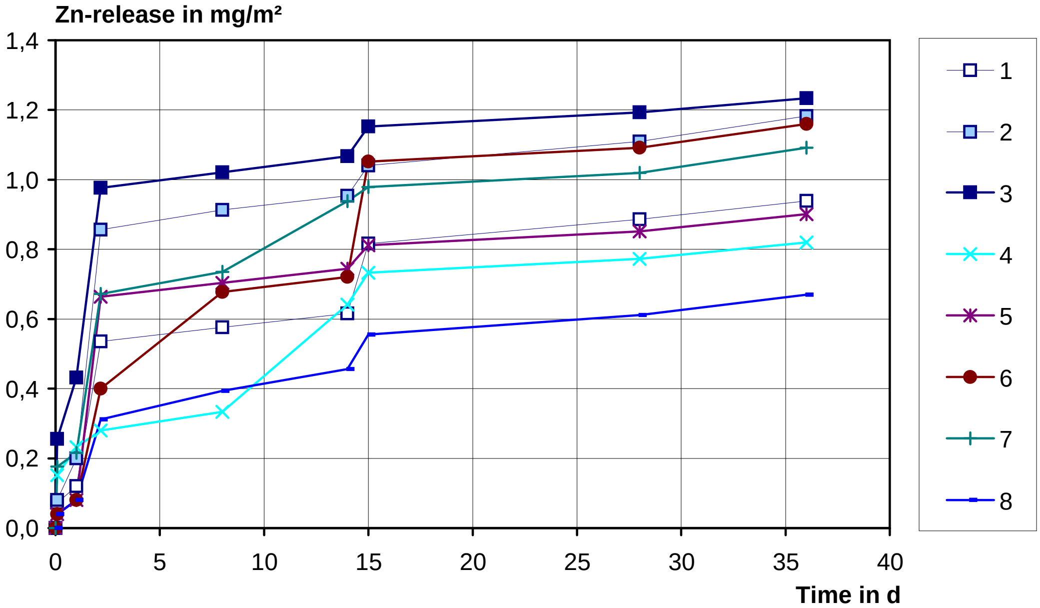

Figure 11: Release of zinc in the eightfold test (first concreting)

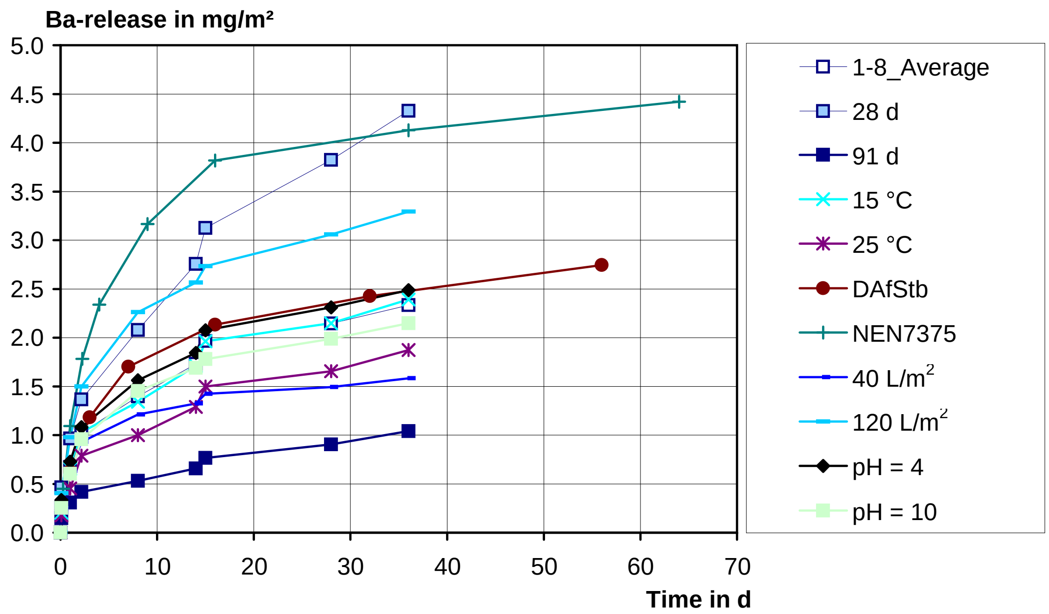

Figure 12: Release of barium for the variation of the test conditions according to Table 5 (first concreting)

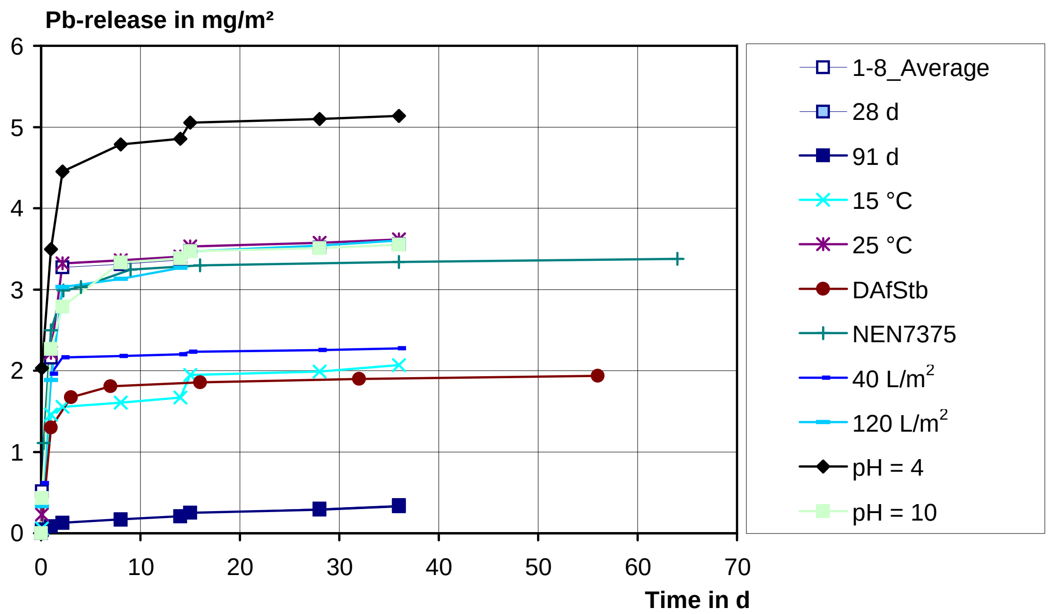

Figure 13: Release of lead for the variation of the test conditions according to Table 5 (first concreting)

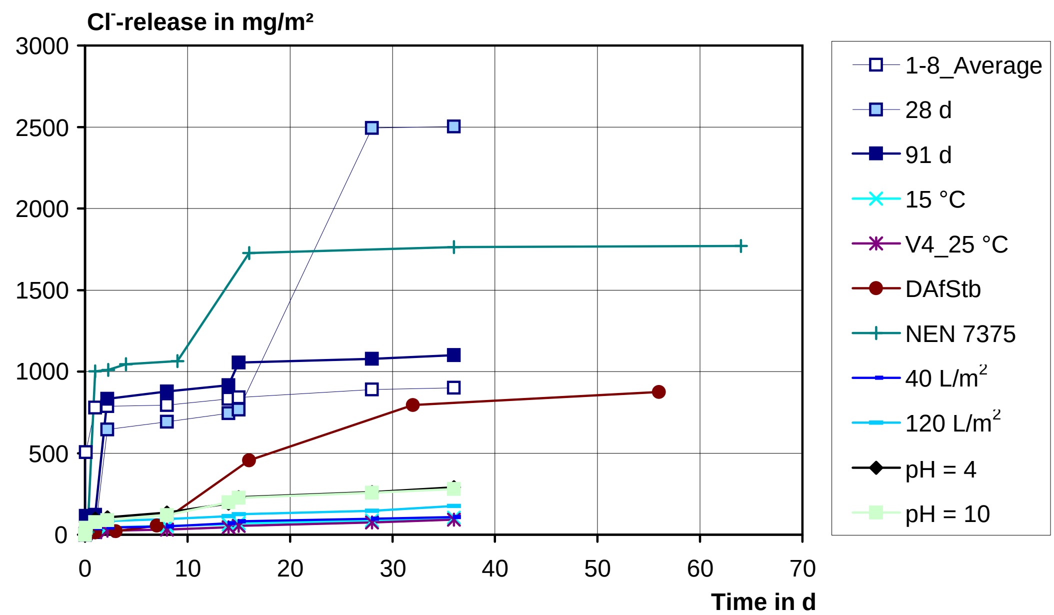

Figure 14: Release of chloride for the variation of the test conditions according to Table 5 (first concreting)

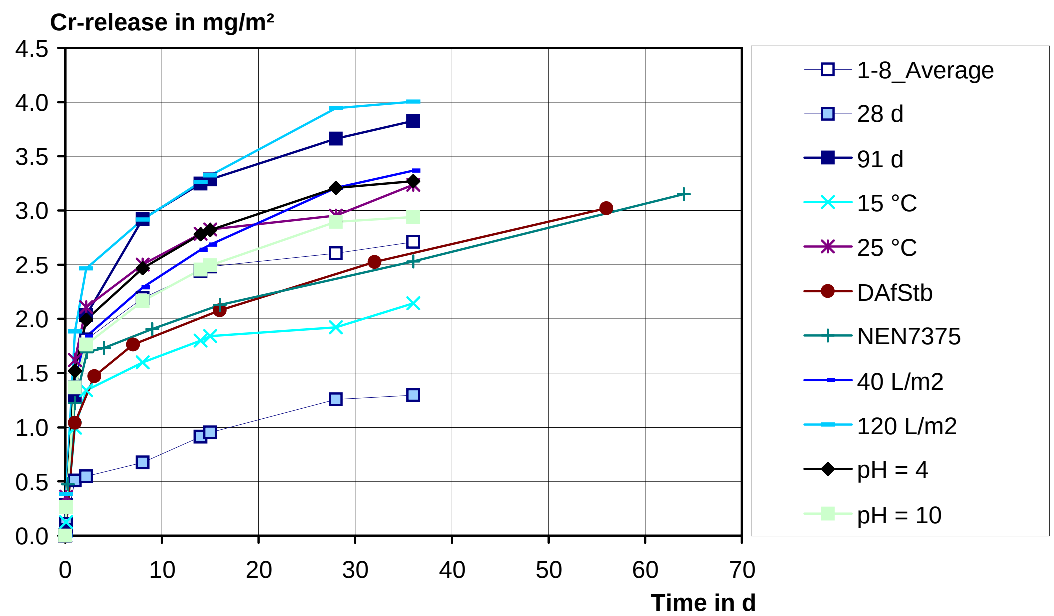

Figure 15: Release of chromium for the variation of the test conditions according to Table 5 (first concreting)

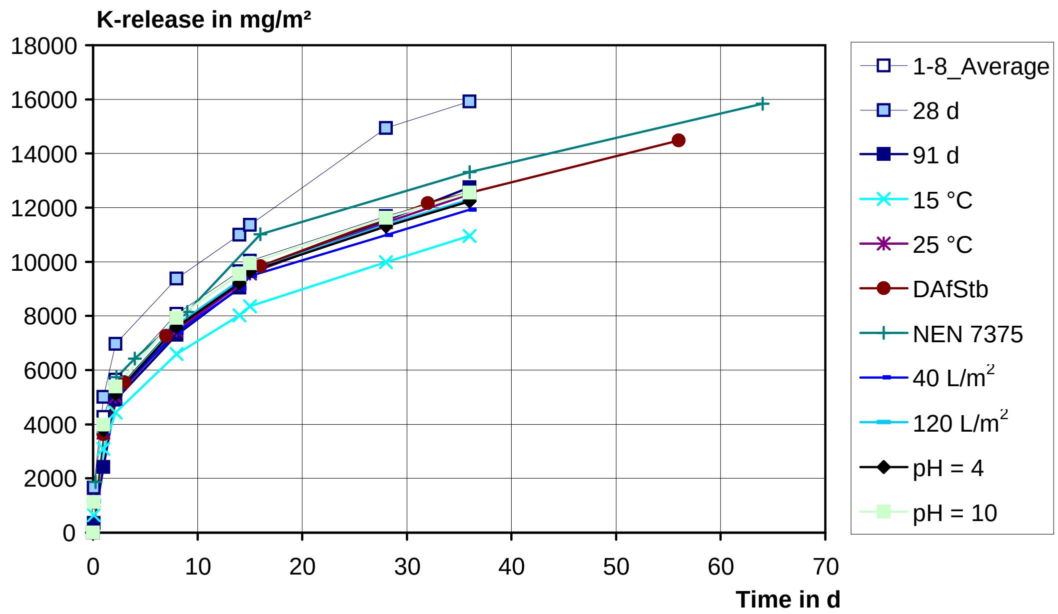

Figure 16: Release of potassium for the variation of the test conditions according to Table 5 (first concreting)

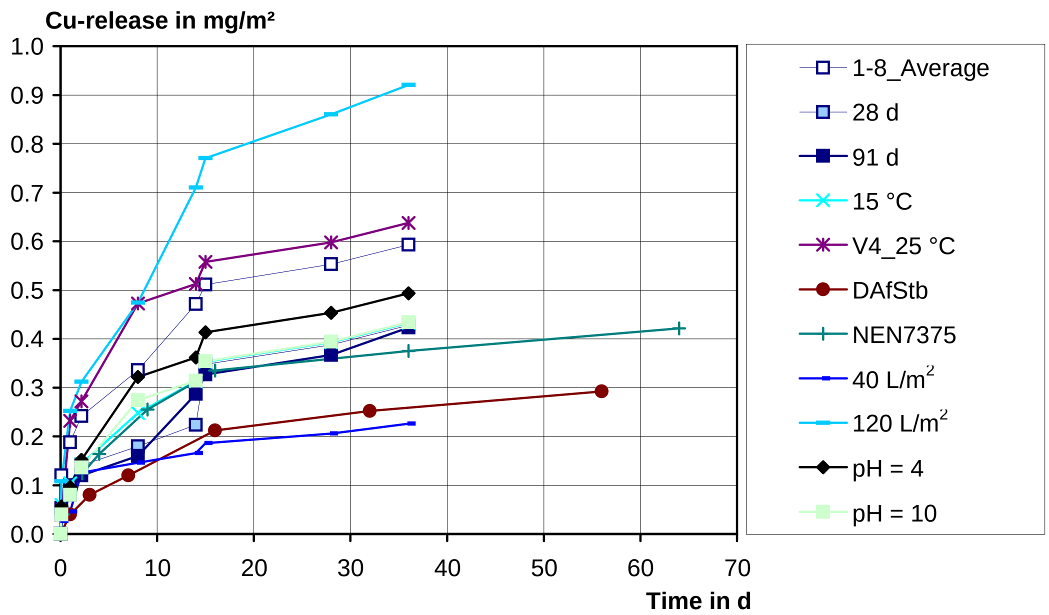

Figure 17: Release of copper for the variation of the test conditions according to Table 5 (first concreting)

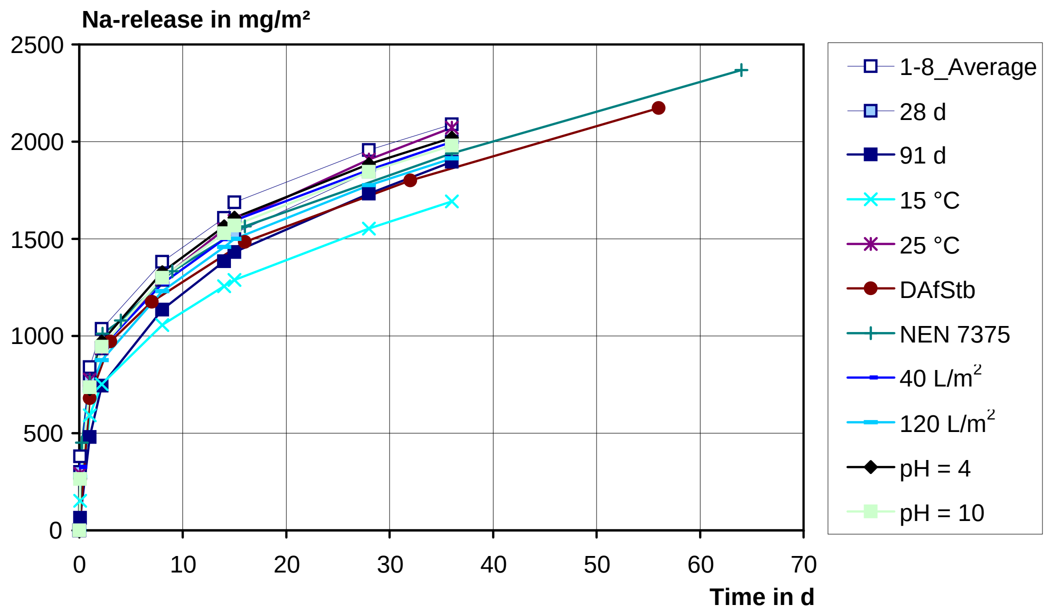

Figure 18: Release of sodium for the variation of the test conditions according to Table 5 (first concreting)

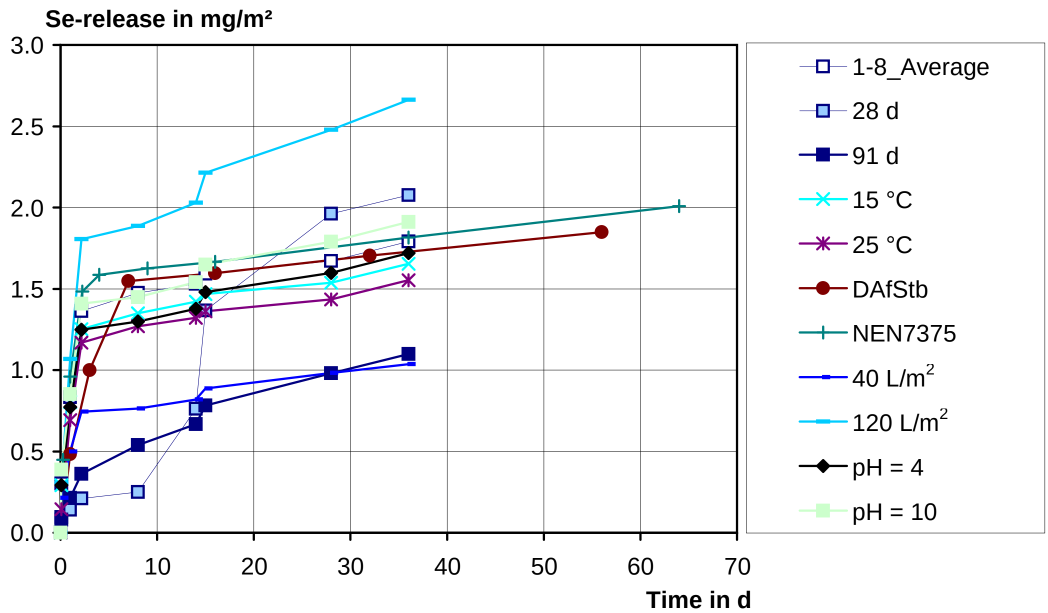

Figure 19: Release of selenium for the variation of the test conditions according to Table 5 (first concreting)

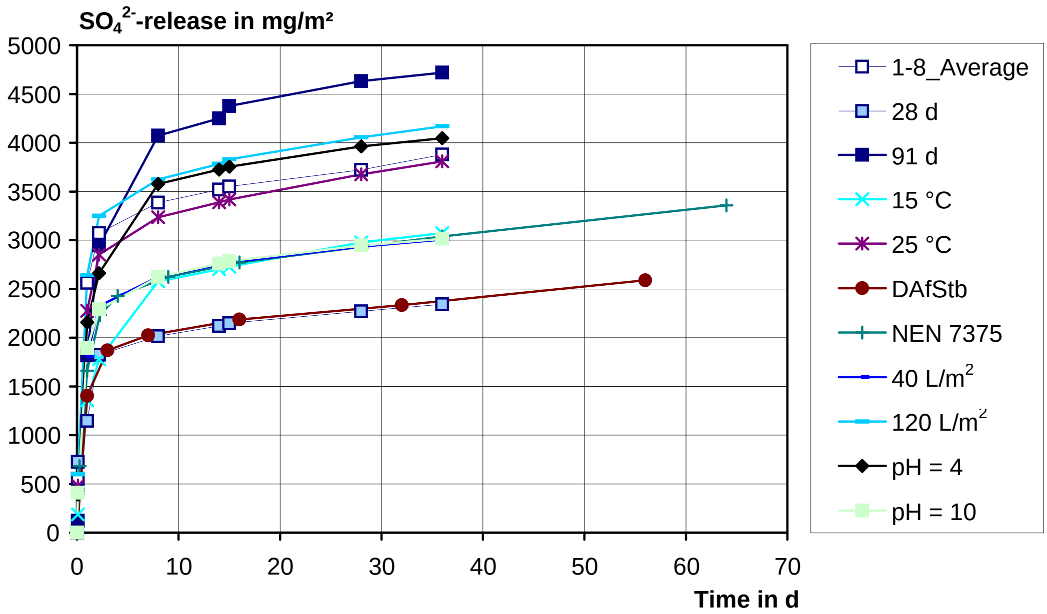

Figure 20: Release of sulphate for the variation of the test conditions according to Table 5 (first concreting)

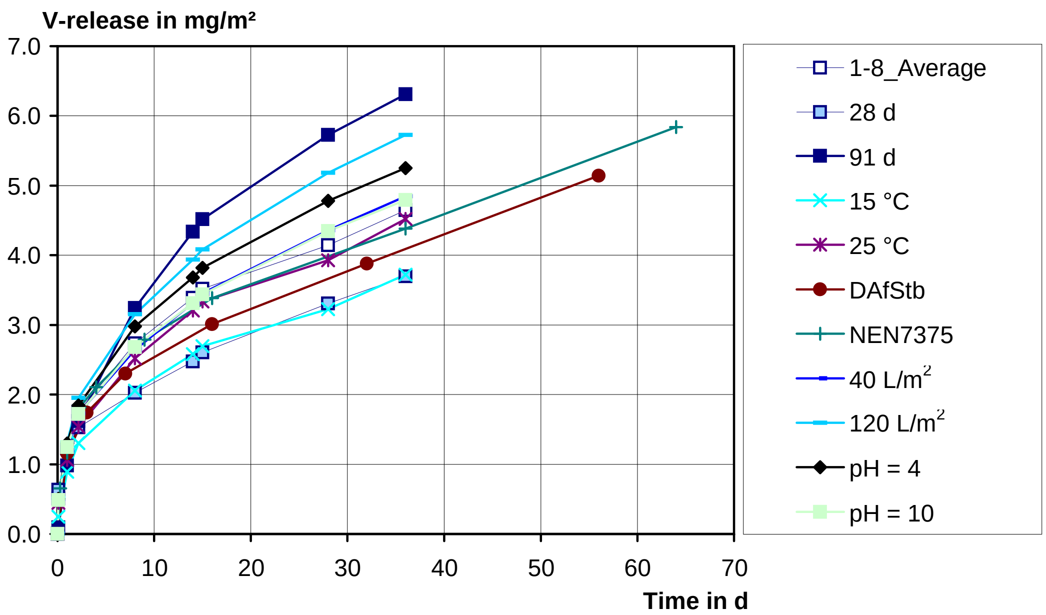

Figure 21: Release of vanadium for the variation of the test conditions according to Table 5 (first concreting)

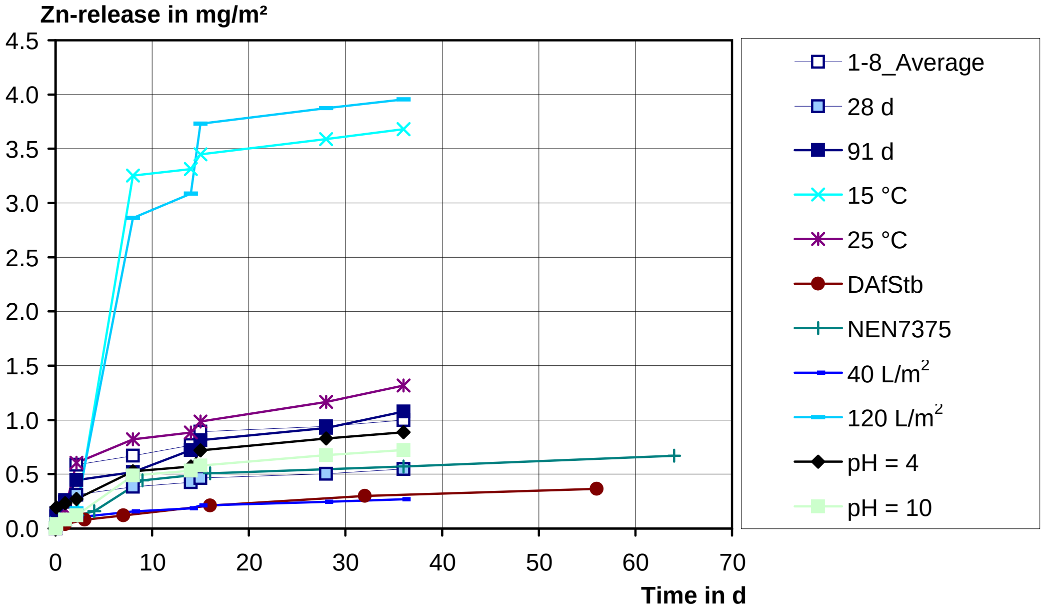

Figure 22: Release of zinc for the variation of the test conditions according to Table 5 (first concreting)

2.1.3 Leaching results for the concrete of the second concreting

With the second concreting the influence of a repeated concrete production on the test results should be checked. Therefore three test specimen were produced with the Portland cement in exact the same manner as for the first concreting (same amount of mixture etc.). The leaching tests were done according to the draft standard „Generic horizontal dynamic surface leaching test (DSLT) for determination of surface dependent release of substances from construction products“. The leaching tests were done as triplicate tests.

Figures 23 till **33** show the accumulated leached amounts of the triplicate tests in mg/m^2 for the parameter barium, lead, chloride, chromium, potassium, copper, sodium, selenium, sulphate, vanadium and zinc. **Figures 34** till **44** show the accumulated leached amounts in mg/m^2 for the aforementioned parameters for all concretes of the first concreting as well as the average values for the triplicate tests of the second concreting.

The individual analytical data for the aforementioned leaching tests are listed in **Tables A27** till **A39** in the annex.

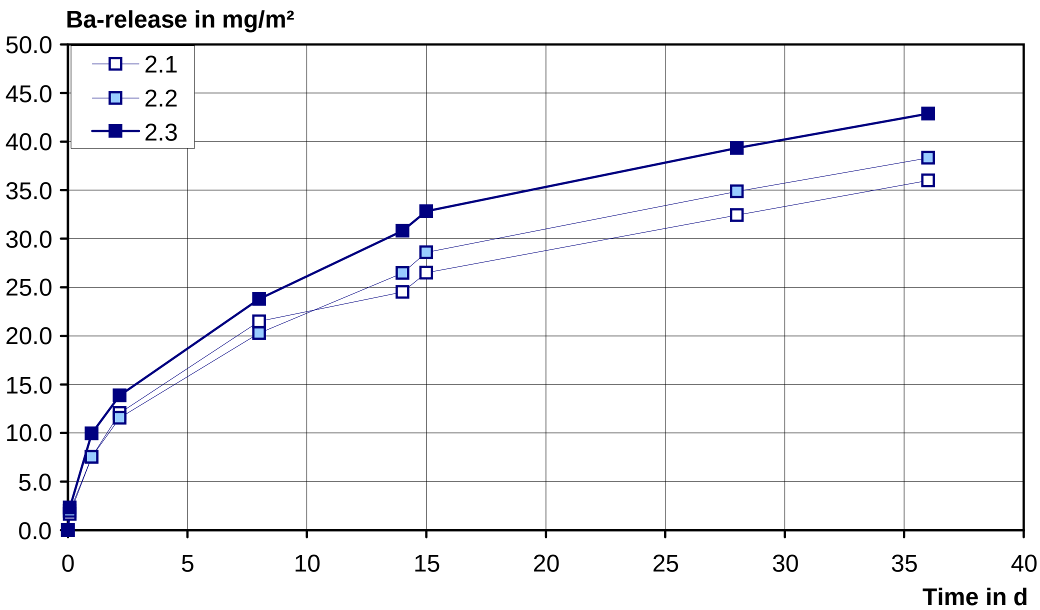

Figure 23: Release of barium in the triplicate test (second concreting)

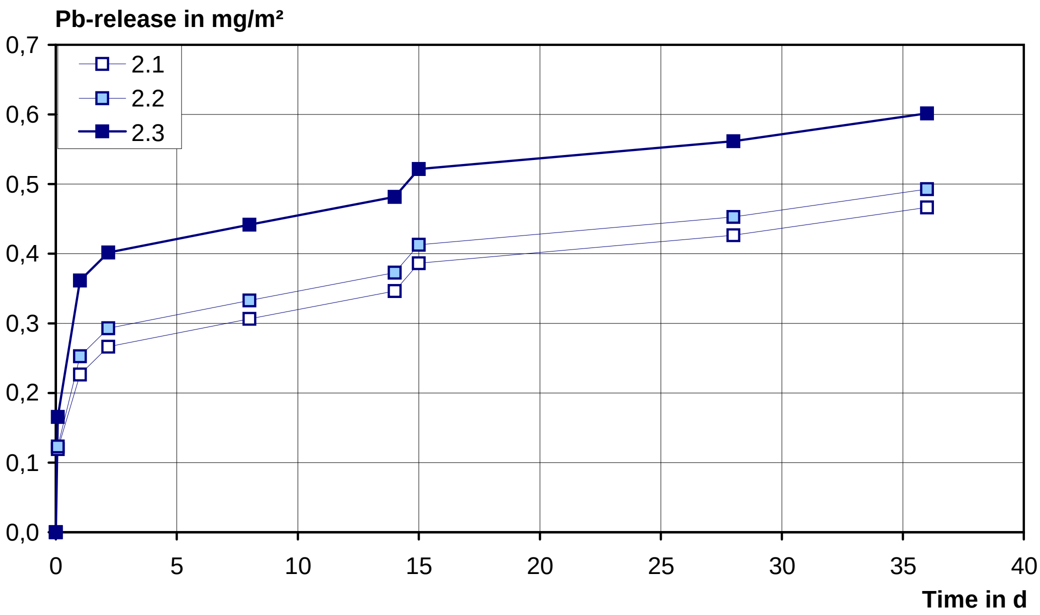

Figure 24: Release of lead in the triplicate test (second concreting)

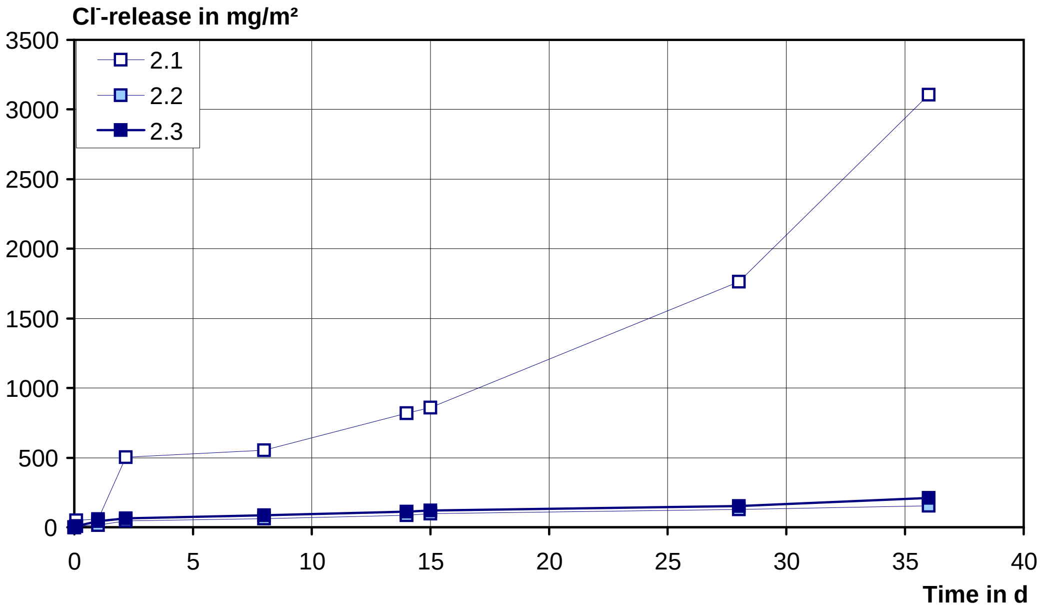

Figure 25: Release of chloride in the triplicate test (second concreting)

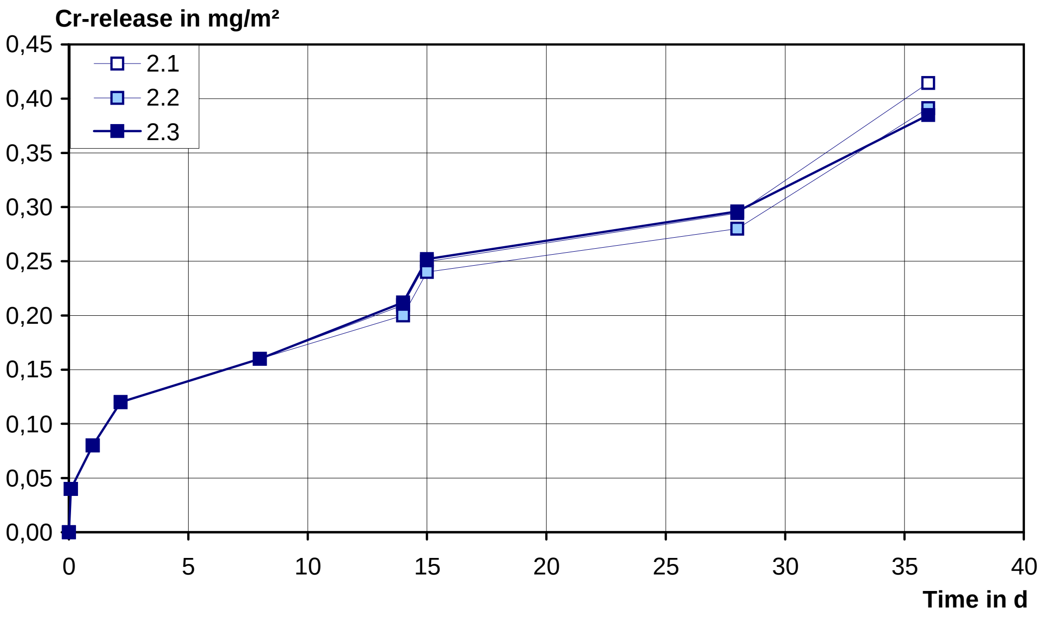

Figure 26: Release of chromium in the triplicate test (second concreting)

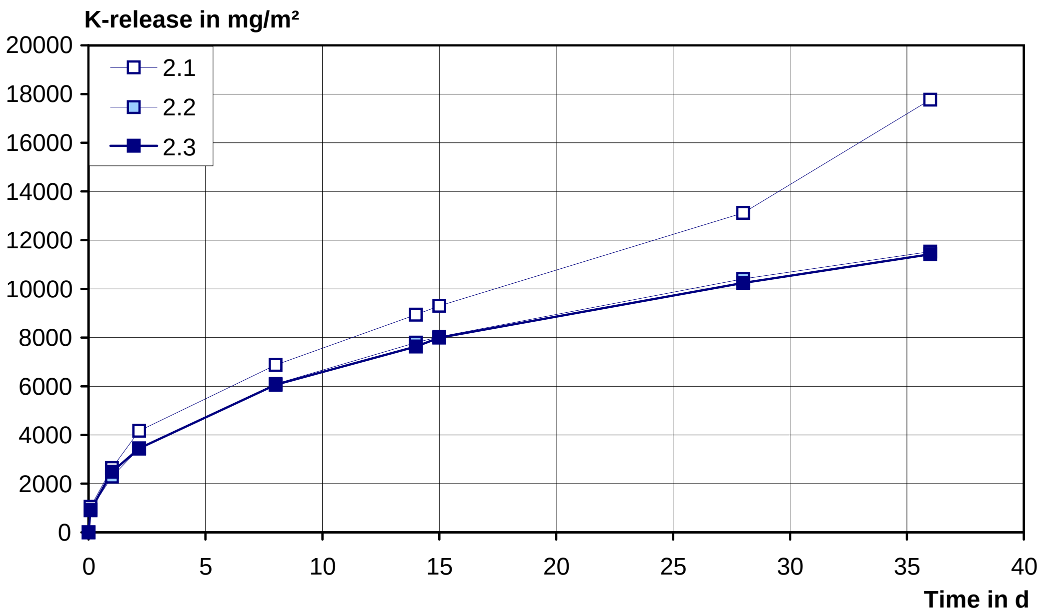

Figure 27: Release of potassium in the triplicate test (second concreting)

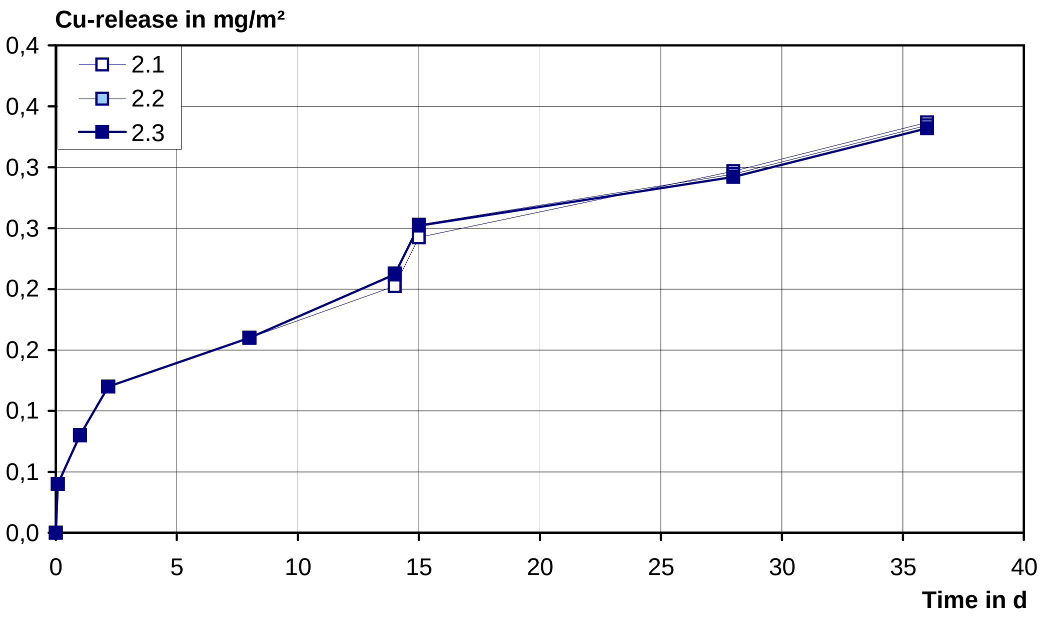

Figure 28: Release of copper in the triplicate test (second concreting)

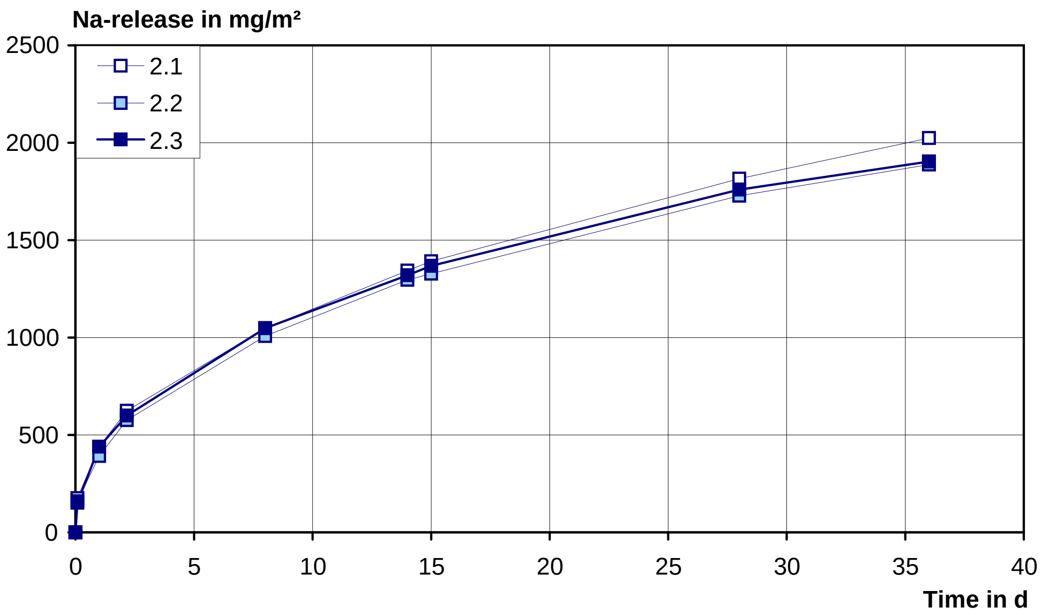

Figure 29: Release of sodium in the triplicate test (second concreting)

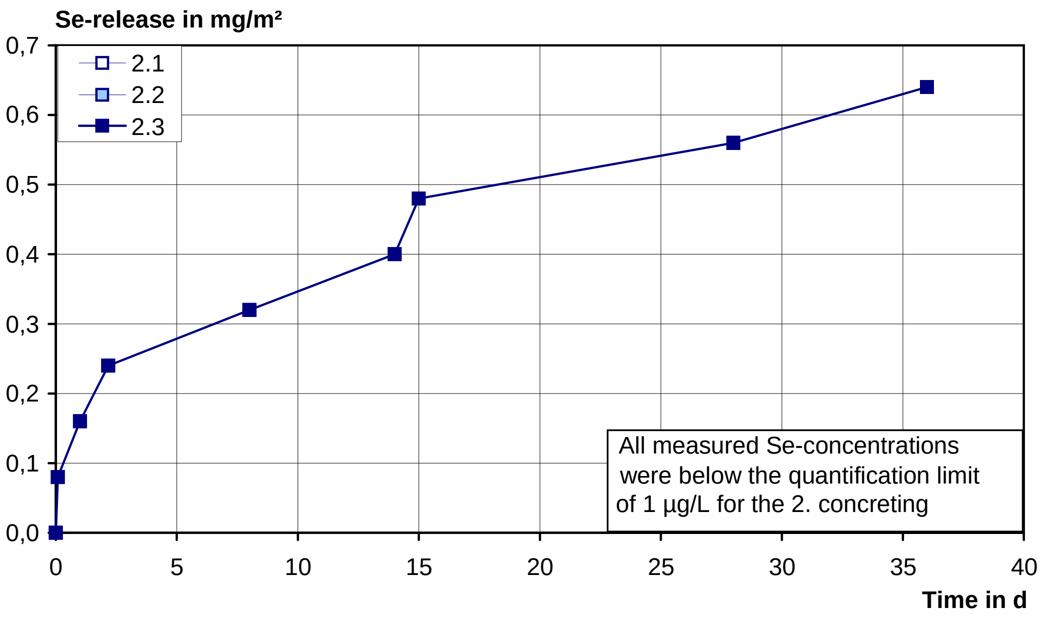

Figure 30: Release of selenium in the triplicate test (second concreting)

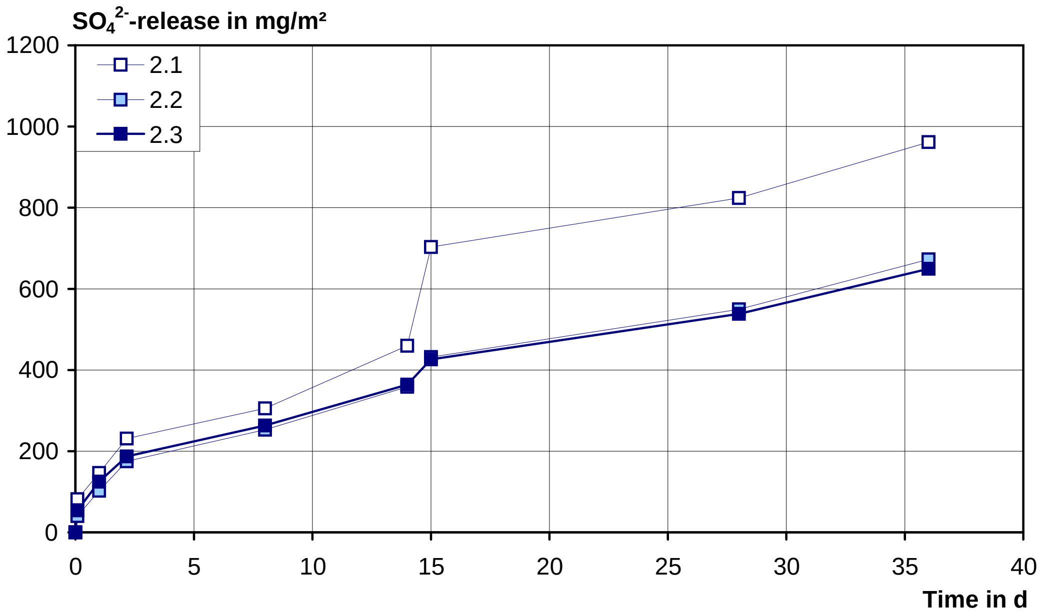

Figure 31: Release of sulphate in the triplicate test (second concreting)

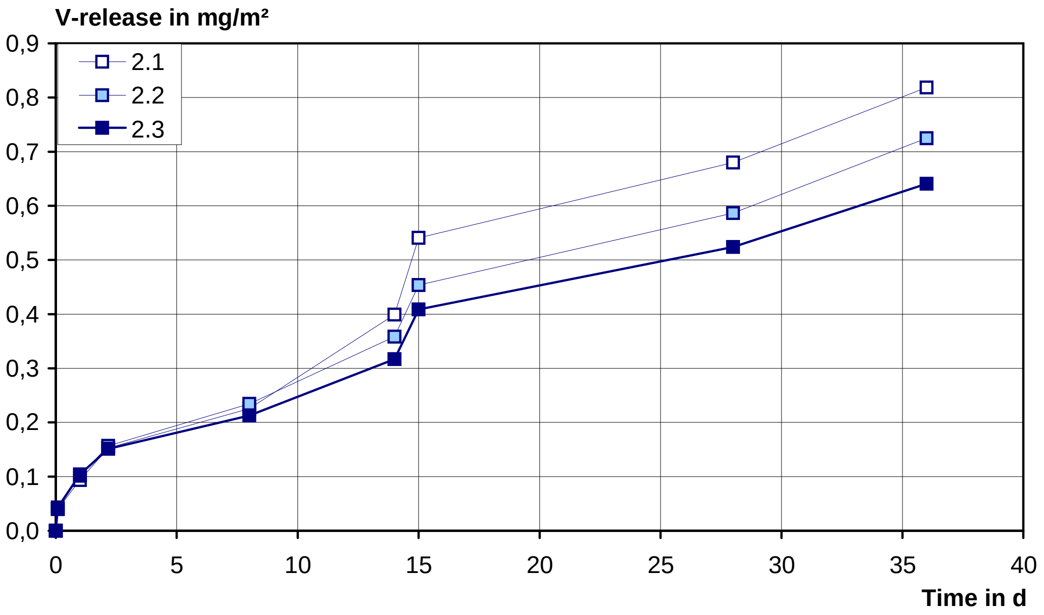

Figure 32: Release of vanadium in the triplicate test (second concreting)

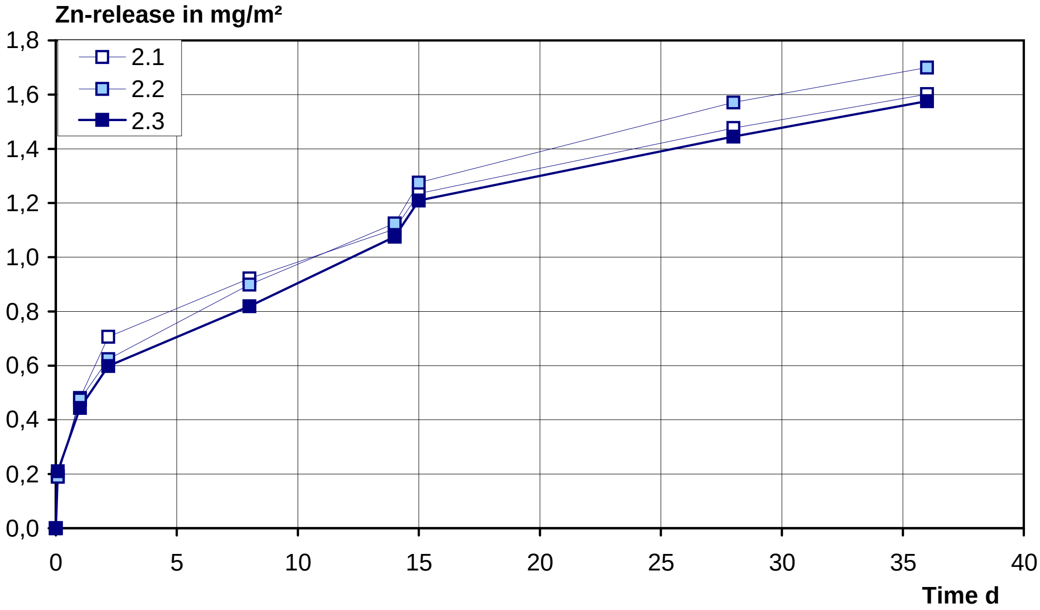

Figure 33: Release of zinc in the triplicate test (second concreting)

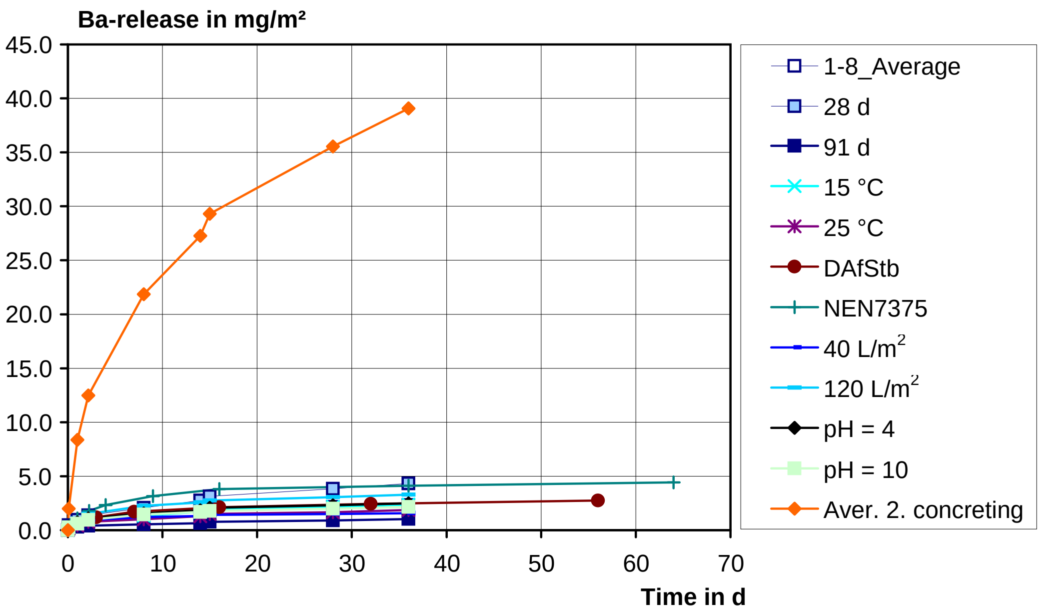

Figure 34: Release of barium for all concretes of the first and second concreting

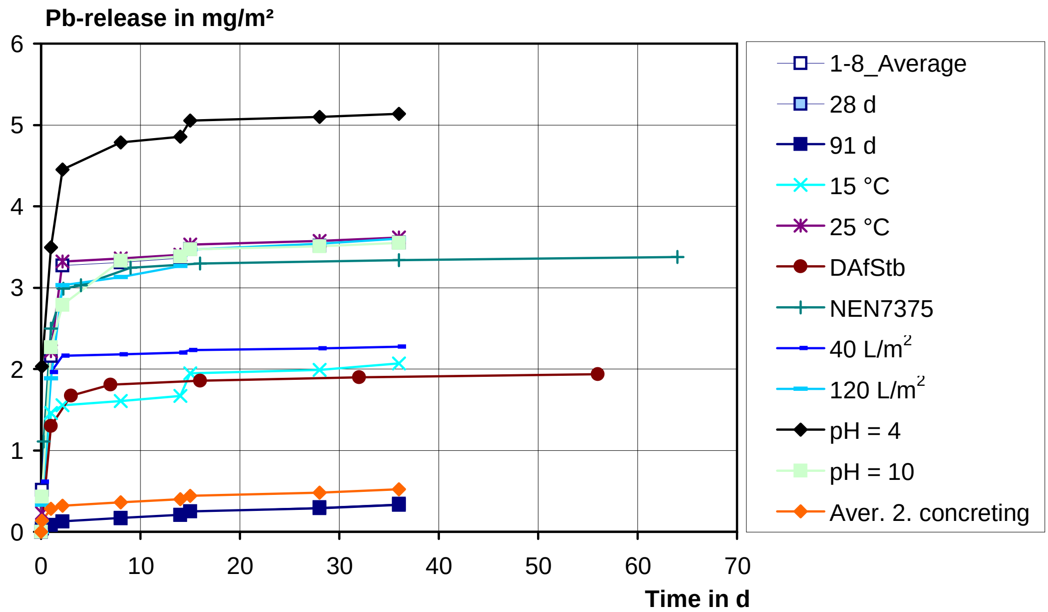

Figure 35: Release of lead for all concretes of the first and second concreting

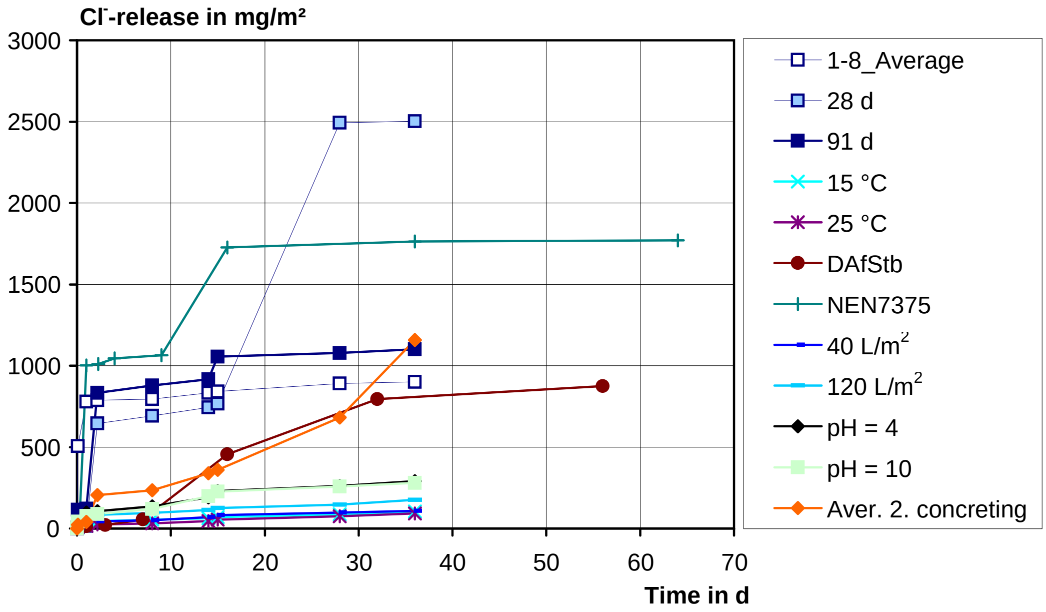

Figure 36: Release of chloride for all concretes of the first and second concreting

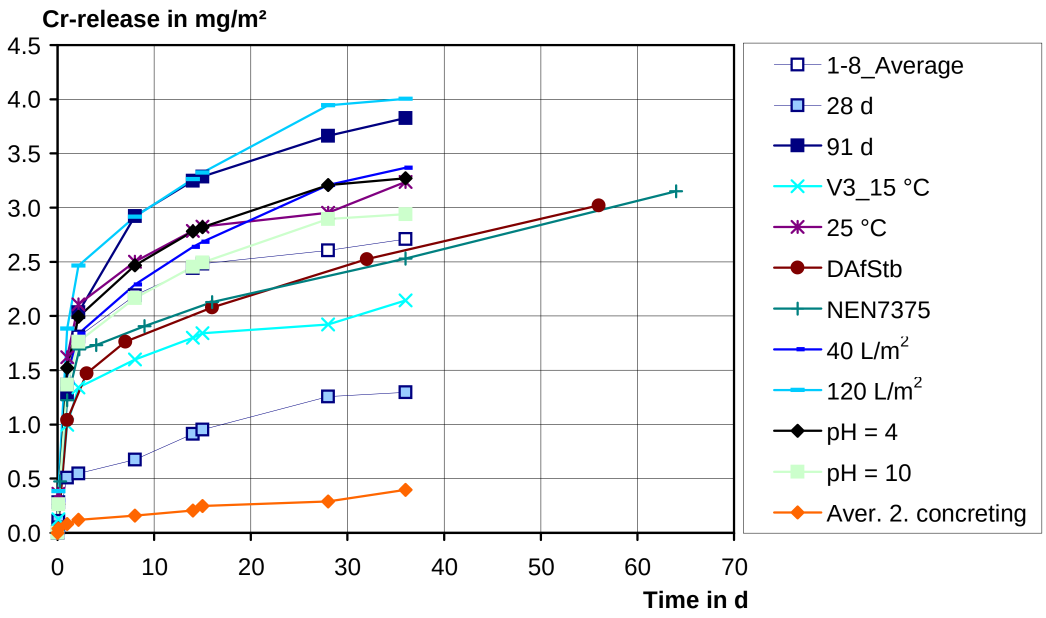

Figure 37: Release of chromium for all concretes of the first and second concreting

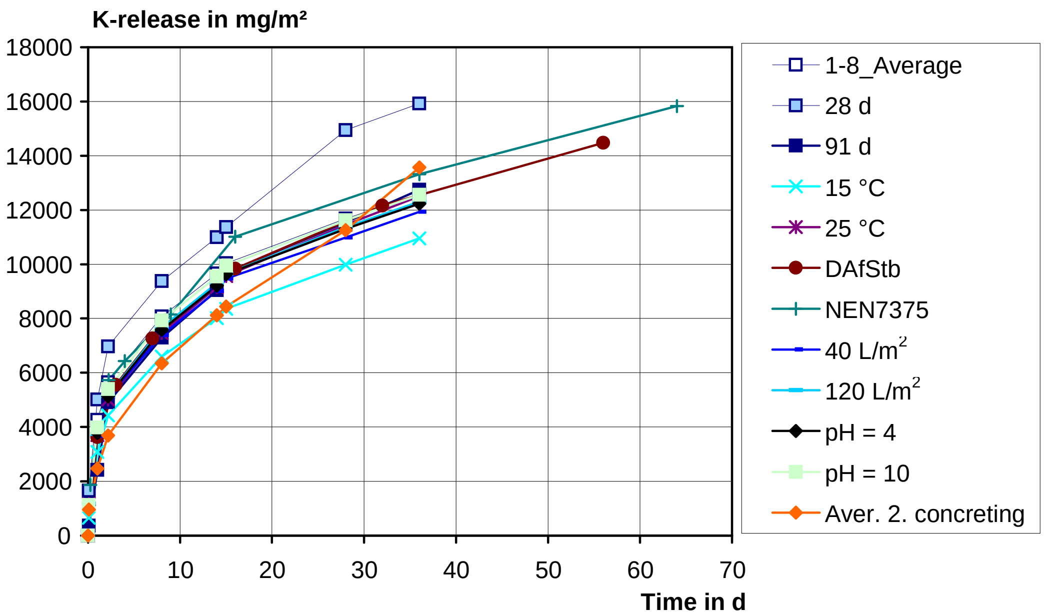

Figure 38: Release of potassium for all concretes of the first and second concreting

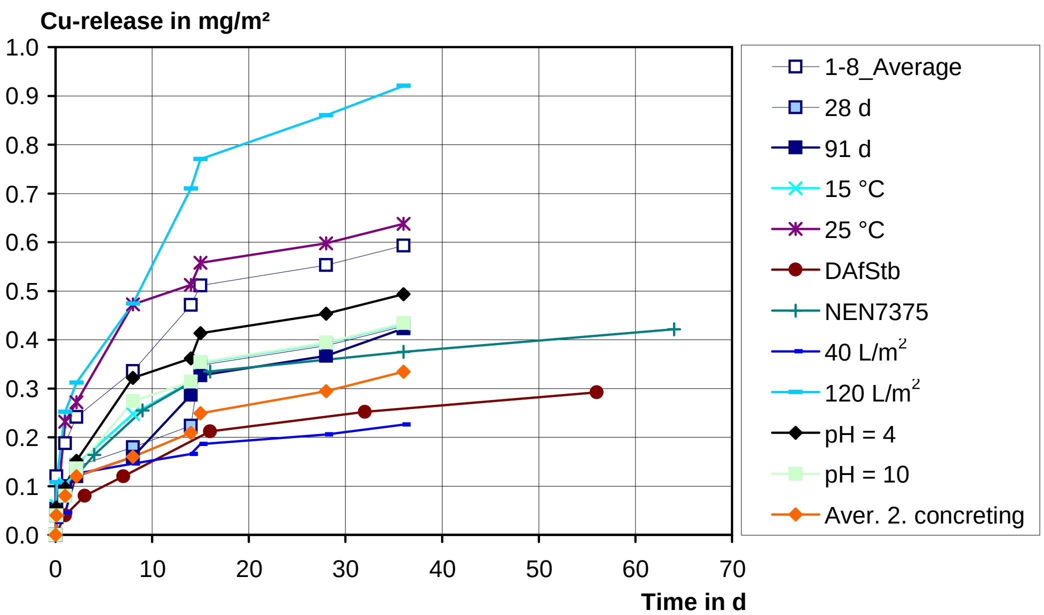

Figure 39: Release of copper for all concretes of the first and second concreting

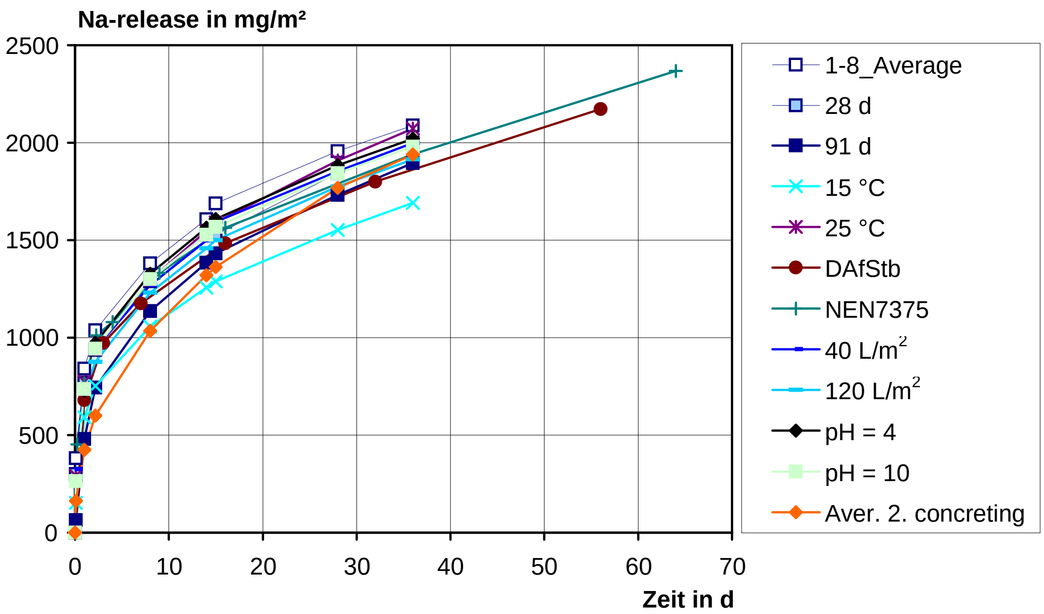

Figure 40: Release of sodium for all concretes of the first and second concreting

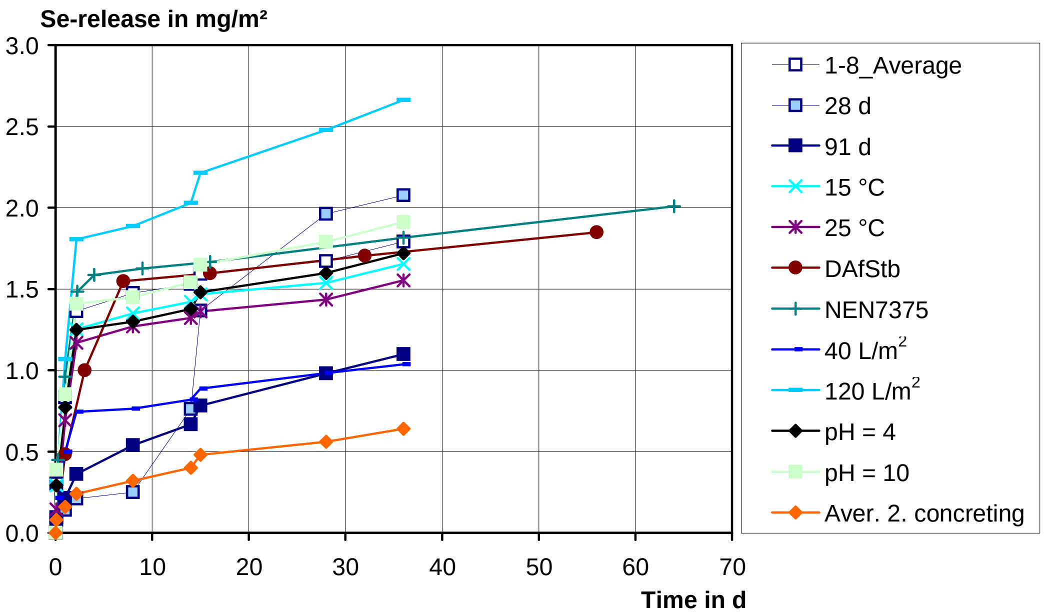

Figure 41: Release of selenium for all concretes of the first and second concreting

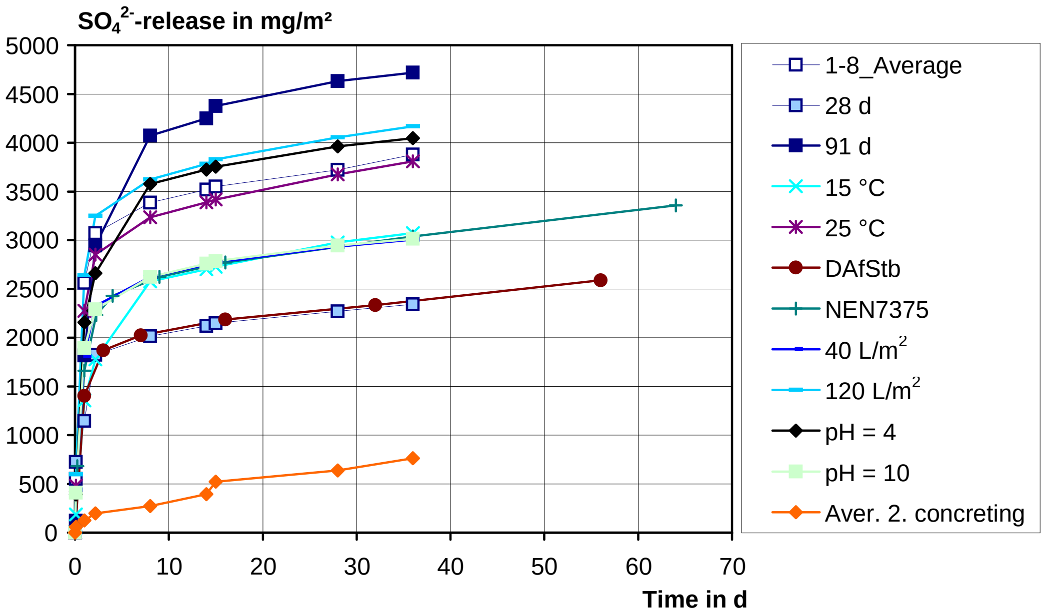

Figure 42: Release of sulphate for all concretes of the first and second concreting

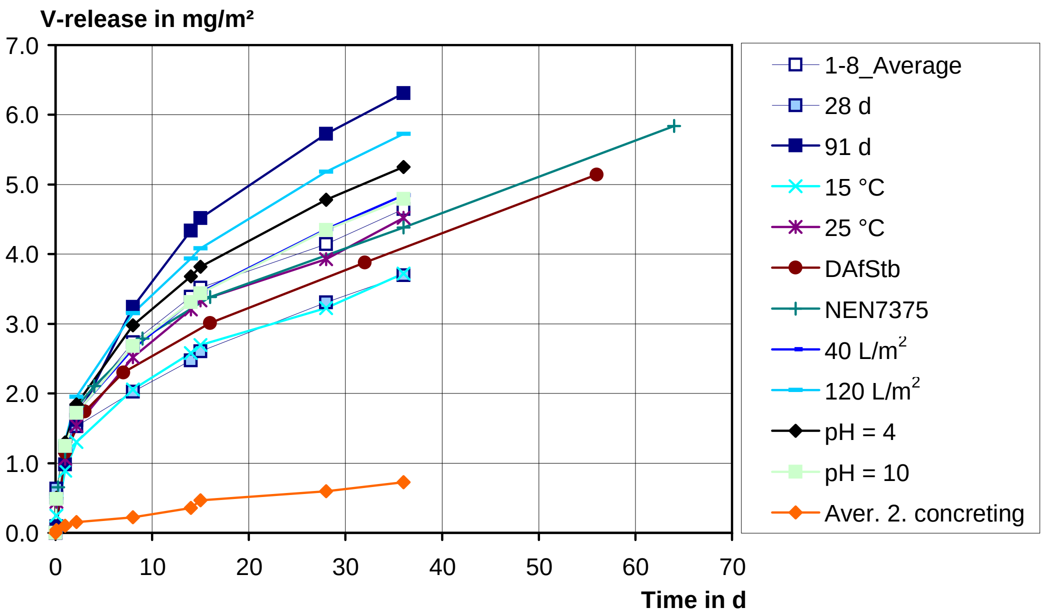

Figure 43: Release of vanadium for all concretes of the first and second concreting

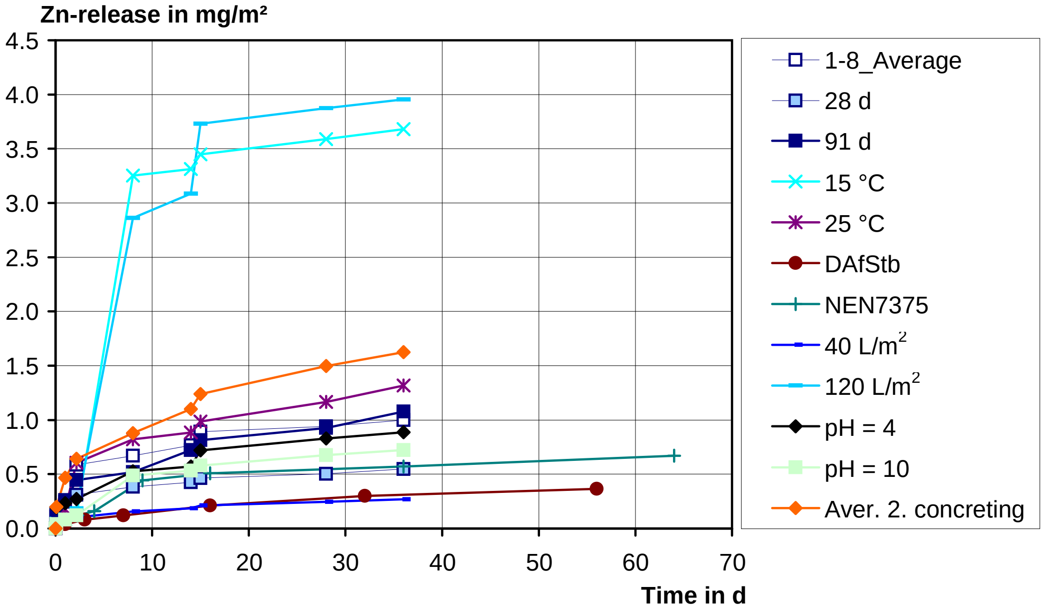

Figure 44: Release of zinc for all concretes of the first and second concreting

2.1.4 Leaching results for the concrete of the third concreting

With the concrete of the third concreting the influence of the cement type on the leaching behaviour should be investigated. Therefore six test specimen were produced with the slag cement in exact the same manner as for the first concreting (same amount of mixture etc.). The leaching tests were done according to the draft standard „Generic horizontal dynamic surface leaching test (DSLT) for determination of surface dependent release of substances from construction products“. In addition the tests were done at 15 °C and according to the Dutch standard NEN 7375, because these test variants have shown the greatest influence on the test results for the concretes of the first and second concreting. The leaching tests were done as double test.

Figures 45 till **55** show the accumulated leached amounts for the double tests mg/m^2 for the parameter barium, lead, chloride, chromium, potassium, copper, sodium, selenium, sulphate, vanadium and zinc. Plotted are in each case the average values of the double test for the tank test (DSLT) at 15 °C and 20 °C as well as for the test according to NEN 7375.

The individual analytical data for the aforementioned double tests are listed in **Tables A40** till **A52** in the annex.

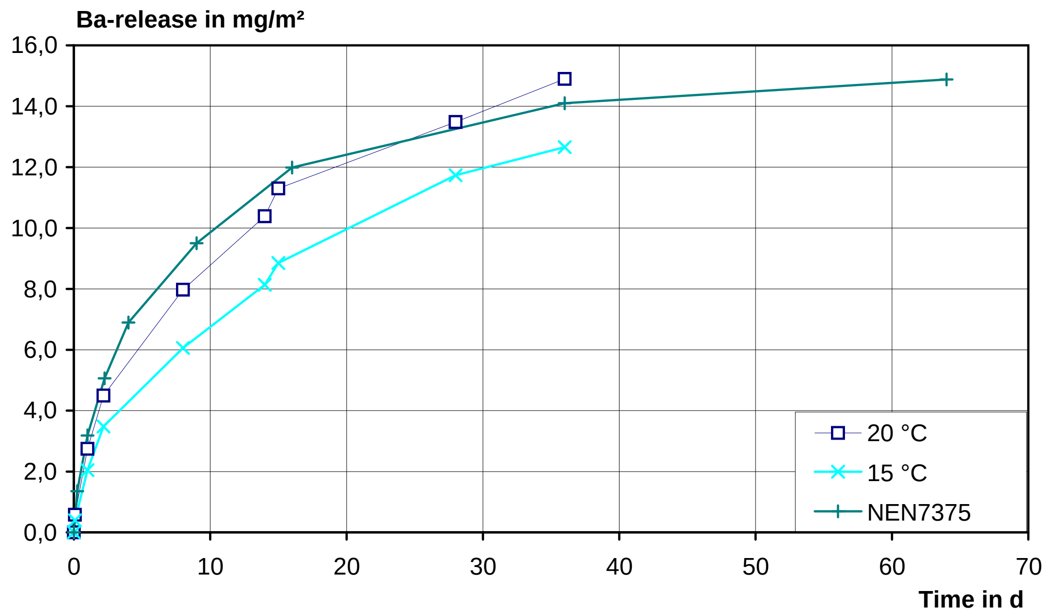

Figure 45: Release of barium for the three different test conditions (third concreting)

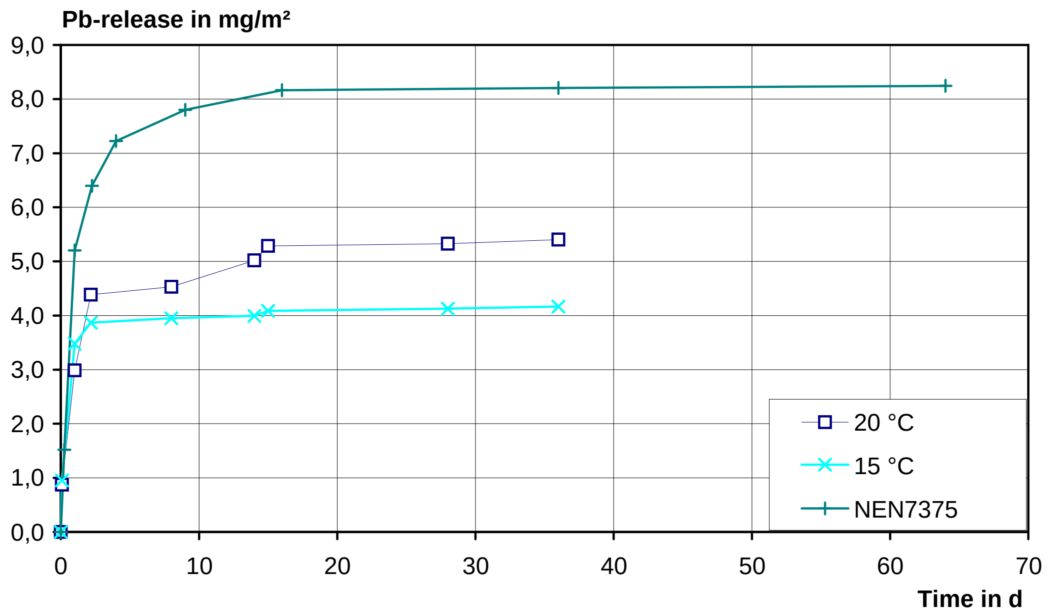

Figure 46: Release of lead for the three different test conditions (third concreting)

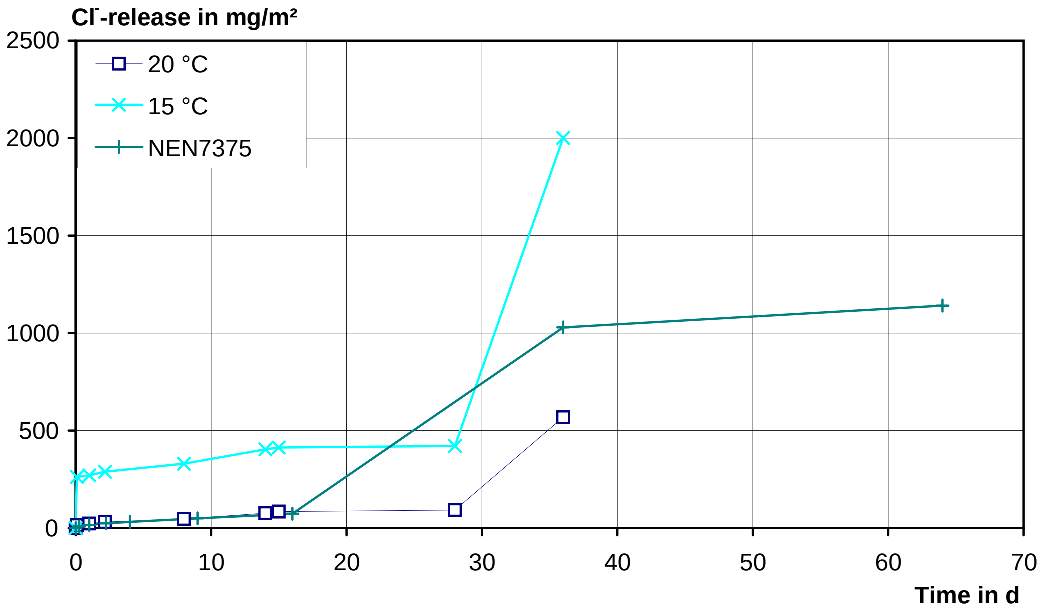

Figure 47: Release of chloride for the three different test conditions (third concreting)

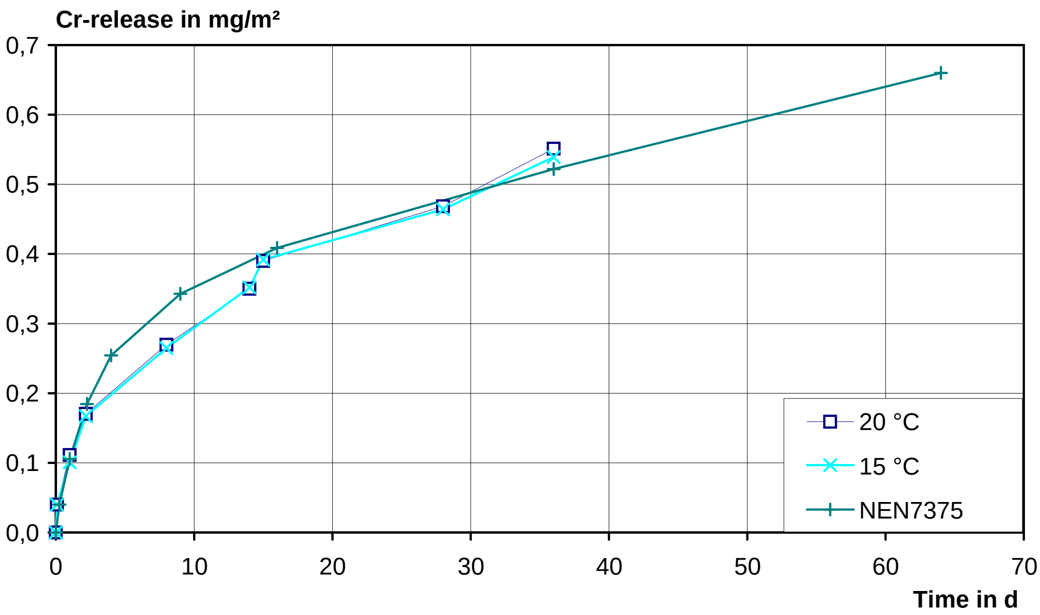

Figure 48: Release of chromium for the three different test conditions (third concreting)

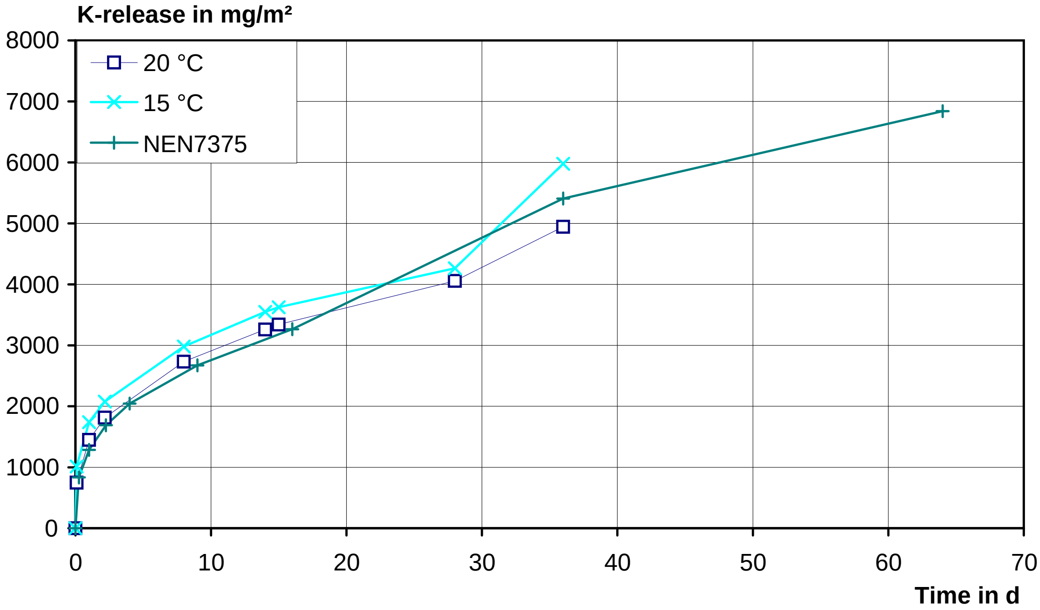

Figure 49: Release of potassium for the three different test conditions (third concreting)

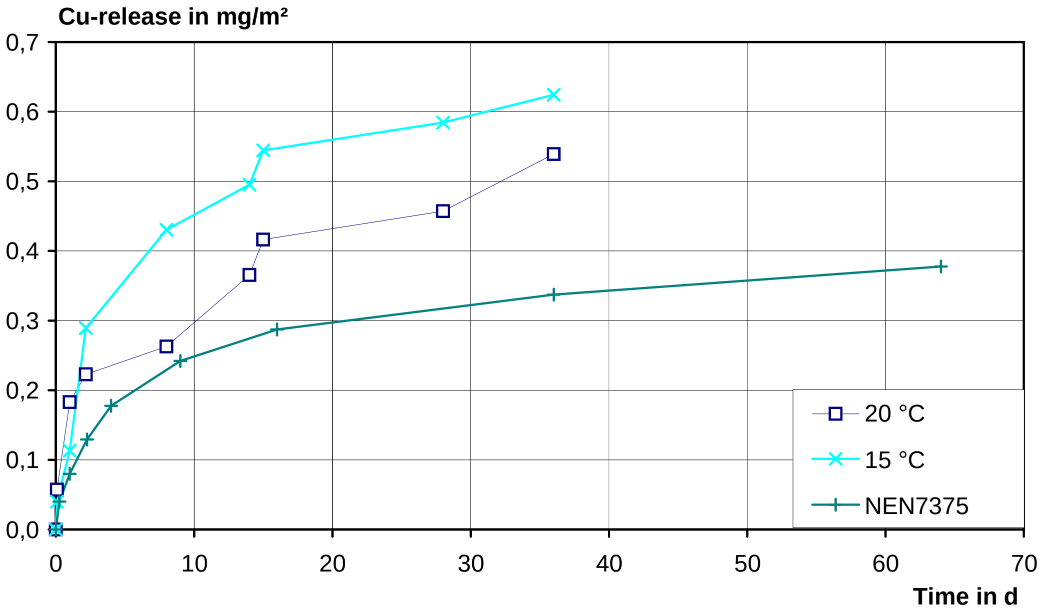

Figure 50: Release of copper for the three different test conditions (third concreting)

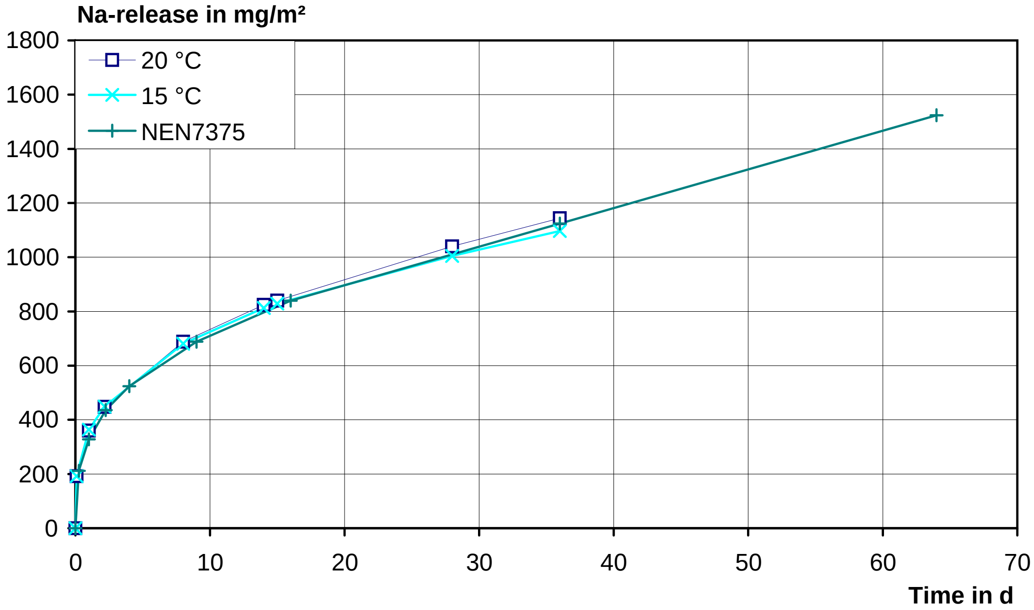

Figure 51: Release of sodium for the three different test conditions (third concreting)

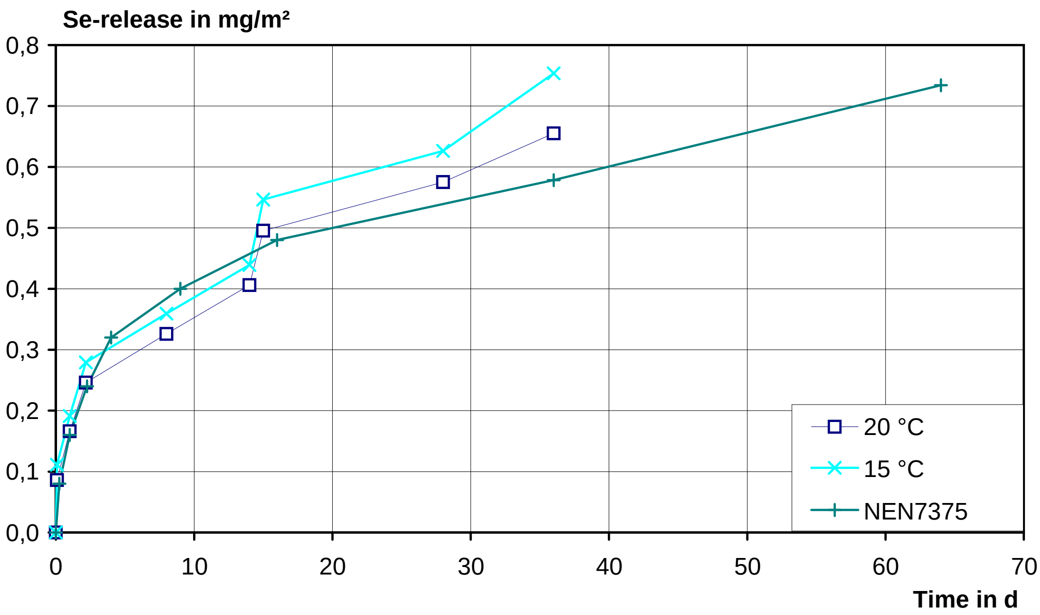

Figure 52: Release of selenium for the three different test conditions (third concreting)

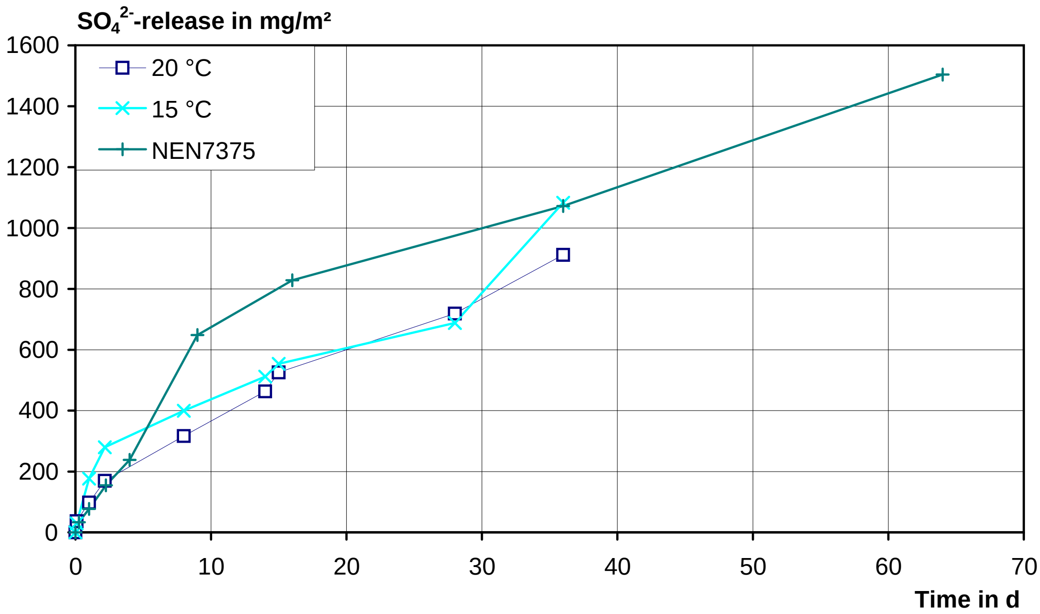

Figure 53: Release of sulphate for the three different test conditions (third concreting)

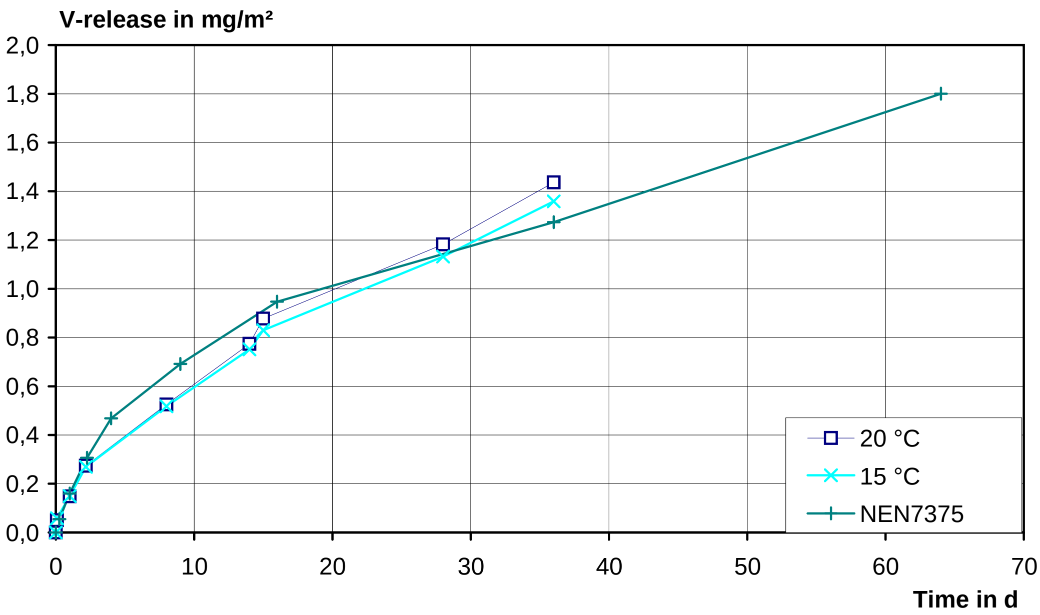

Figure 54: Release of vanadium for the three different test conditions (third concreting)

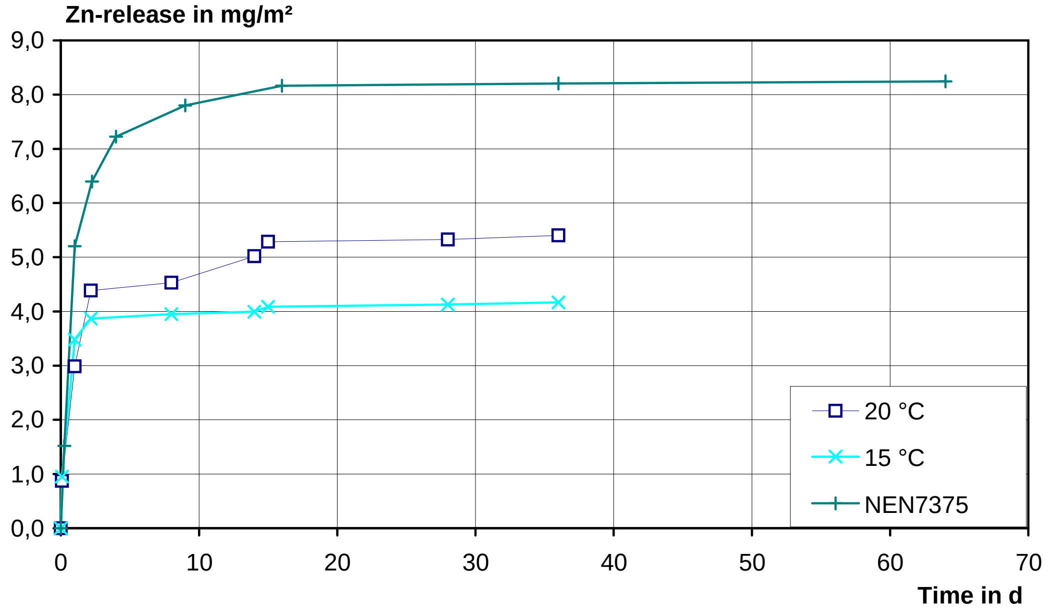

Figure 55: Release of zinc for the three different test conditions (third concreting)

2.1.5 Assessment of the leaching results for the concretes of the first till third concreting

Figures 1 till 11 show that the accumulated leached amounts at the eightfold test for the first concreting match well for the elements potassium, sodium, selenium and vanadium. For the other parameters a greater scattering is observed in contrast. This is particularly important if the individual test results are close to the quantification limit (see Tables A1 till A11). Figures 23 till 33 at the triplicate test of the second concreting generally show a better conformity as for the eightfold test of the first concreting. However, the leaching results show in many cases a greater difference between the first and second concreting as through the variation of the test conditions according to Table 5, which can be seen from Figures 34 till 44 which summarise the results of all leaching test done with the concretes of the first and second concreting. In **Table 6** the relative standard deviations (coefficient of variation V) for the eightfold test of the first concreting, the triplicate test of the second concreting as well as for the combination of the first and second concreting are summarised. Whether the greater scatterings are due to the leaching test, the chemical analysis or to inhomogeneities of the concrete test specimen, could not be resolved in this research project.

Table 6: Relative standard deviation (coefficient of variation V) for the eight-fold test of the first concreting, the triplicate test of the second concreting as well as for the combination of the first and second concreting

Parameter	First concreting	Second concreting	First and second concreting
	Relative standard deviation (coefficient of variation V) in %		
Barium (Ba)	36,3	8,98	139
Lead (Pb)	19,8	13,5	56,3
Chloride (Cl^-)	89,6	146	105
Chromium (Cr)	17,2	3,88	55,2
Potassium (K)	6,86	26,8	14,3
Copper (Cu)	56,6	1,73	61,9
Sodium (Na)	14,4	3,83	12,9
Selenium (Se)	7,16	-[1)]	37,2
Sulphate (SO_4^{2-})	33,8	22,8	60,3
Vanadium (V)	6,55	12,4	51,7
Zinc (Zn)	34,9	3,95	28,8

[1)] All values below the quantification limit

The results for the accumulated leached amounts for the elements potassium and sodium match very well for all tests of the concretes of the first and second concreting (Figures 38 and 40). Thereby, as expected a decrease of the testing temperature results in reduced leached amounts and a decrease of the curing time results in increased leached amounts. These results show on the one hand that the concretes of the first and second concreting were produced alike, and on the other hand that the leaching test as such is robust and that for the conducted variations of the test conditions only a minor scattering is observed.

The leaching results for the concrete of the third concreting with the slag cement CEM III/A 42.5 N show a similar behaviour as the results for the concretes of the first and second concreting. The accumulated leached amounts for the parameters investigated are in the same order of magnitude as for the concretes with the Portland cement CEM I 42.5 R.

A further essential result of the investigations of the concretes of the first and second concreting is that the leaching results for the elements potassium and sodium which were obtained by the Dutch standard NEN7375 and the DAfStb-long term leaching test, in both cases are located approximately in the middle of the scattering for the realised test variations. This shows that transmission of the results observed by the Dutch standard NEN 7375 and the DAfStb-long term leaching test on the 36-days tank test according to the draft standard „Generic horizontal dynamic surface leaching test (DSLT) for determination of surface dependent release of substances from construction products“ should be possible relative easily. This result is a substantial contribution to the validation process.

2.2 Mortar

2.2.1 Mortar production

For the investigations concerning the robustness of the tank test for mortars a reinforcing render, with a high amount of an organic additive was used. The prefabricated mortar complies with DIN EN 998 „Specification for mortar for masonry“ [18]. The mortar production has been carried out according to the manufacturer’s instructions. The water/solid ratio was 1 to 5.3.The mixing water conformed to DIN EN 1008 „Mixing water for concrete“ [15]. The storage of the test specimen has been carried out according to part II of the principles for „Assessment of the effects of construction products on soil and groundwater“ of the German Institute for Structural Engineering (DIBt) [4].

Table 7 shows the compressive strength and the bending tensile strength of the reinforcing render determined on standard prism according DIN EN 196-1 „Methods of testing cement“ [19]. **Table 8** shows the chemical composition and **Table 9** the trace element content of the reinforcing render.

Table 7: Compressive strength and bending tensile strength of the reinforcing render

Parameter [MPa]	Reinforcing render
28d-compressive strength	8,8
56d-compressive strength	8,9
91d-compressive strength	8,7
28d-bending tensile strength	2,6
56d-bending tensile strength	2,4
91d-bending tensile strength	2,4

Table 8: Chemical composition of the reinforcing render (X-ray fluorescence analysis, including loss on ignition)

Parameter [%]	Reinforcing render
Silicon(IV)-oxide	50,2
Aluminiumoxide	2,53
Iron(III)-oxide	0,48
Magnesium oxide	0,66
Calcium oxide	42,3
Sulphate als SO_3	1,13
Potassium oxide	0,57
Sodium oxide	0,89
Chloride	0,02

Table 9: Content of trace elements in the reinforcing render

Parameter	Reinforcing render
	Element content in µg/g
Arsenic (As)	2,66
Barium (Ba)	88,6
Cadmium (Cd)	0,14
Cobalt (Co)	28,8
Chromium (Cr)	13,6
Mercury (Hg)	0,04
Molybdenum (Mo)	0,15
Antimony (Sb)	0,26
Selenium (Se)	3,30
Vanadium (V)	30,3

2.2.2 Leaching results for the reinforcing render

From the prefabricated reinforcing render 16 mortar cubes with an edge length of 100 mm were produced for the leaching tests. With two test specimen the tank test was carried out according to the draft standard „Generic horizontal dynamic surface leaching test (DSLT) for determination of surface dependant release of substances from construction products“. The age of the test specimen at the beginning of the test was 56 days. The obtained leachates were investigated according to the DIBt-principles for inorganic parameters for which an insignificance threshold has been defined. Furthermore the TOC-release and the concentration of sodium and potassium in the leachates has been determined. At the leaching tests with the further 14 mortar cubes the test conditions were varied according to **Table 10**.

Table 10: Variation of the test conditions[1)] for the mortar tests

Variation No.	Specification
1	Decrease of the curing time to 28 days (56 days)[2)]
2	Decrease of the testing temperature to 15 °C (20 ± 5 °C)[3)]
3	Increase of the testing temperature 25 °C (20 ± 5 °C)[3)]
4	Duration of the specific leaching step according to the DAfStb-long term leaching test (1 d, 3 d, 7d, 16 d, 32 d, 56 d, in each case ± 0,5 h)
5	Duration of the specific leaching step according to the Dutch standard NEN 7375 (0,25 d ± 10 %, 1 d ± 10 %, 2,25 d ± 10 %, 4 d ± 10 %, 9 d ± 10%, 16 ± 1 d, 36 ± 1 d, 64 ± 1 d)
7	Decrease of the surface to volume ratio to 40 L/m² (80 ± 1 L/m²)[3)]
8	Increase of the surface to volume ratio to 120 L/m² (80 ± 1 L/m²)[3)]

1) All variations were done as double test
2) Common curing time according to the DIBt-principles
3) Test conditions according to the draft of the tank test (DSLT)

Figures 56 till **67** show the average values for the accumulated amounts in mg/m^2 for the parameter barium, lead, chloride, chromium, potassium, copper, sodium, selenium, sulphate, vanadium and zinc as well as the TOC-release for the tank test (DSLT) and for the different variations of the test conditions according to Table 10.

The individual analytical data for the aforementioned leaching tests are listed in **Tables A53** till **A66** in the annex.

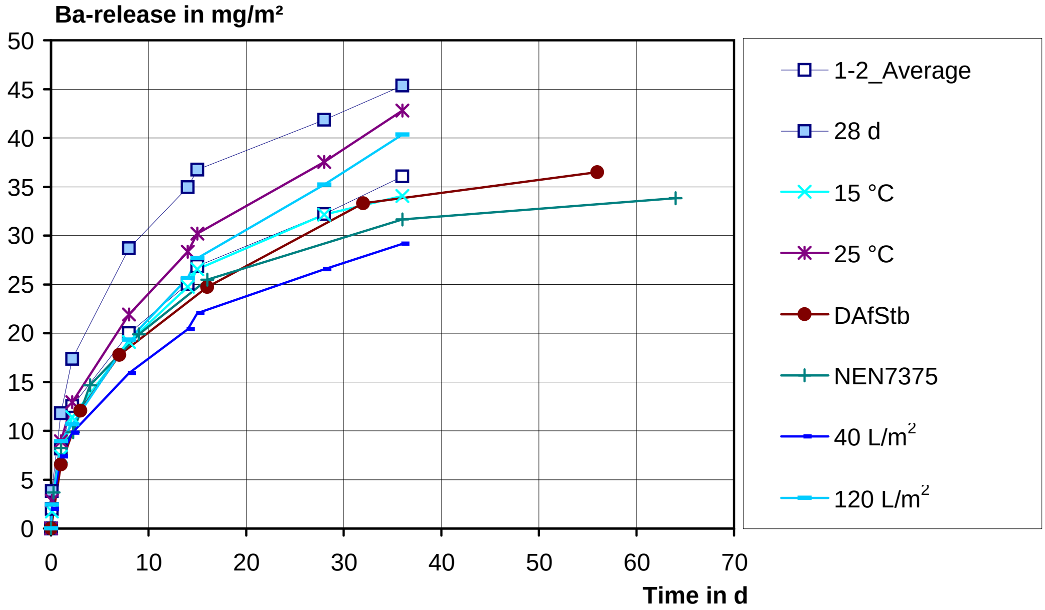

Figure 56: Release of barium for the variation of the test conditions according to Table 10

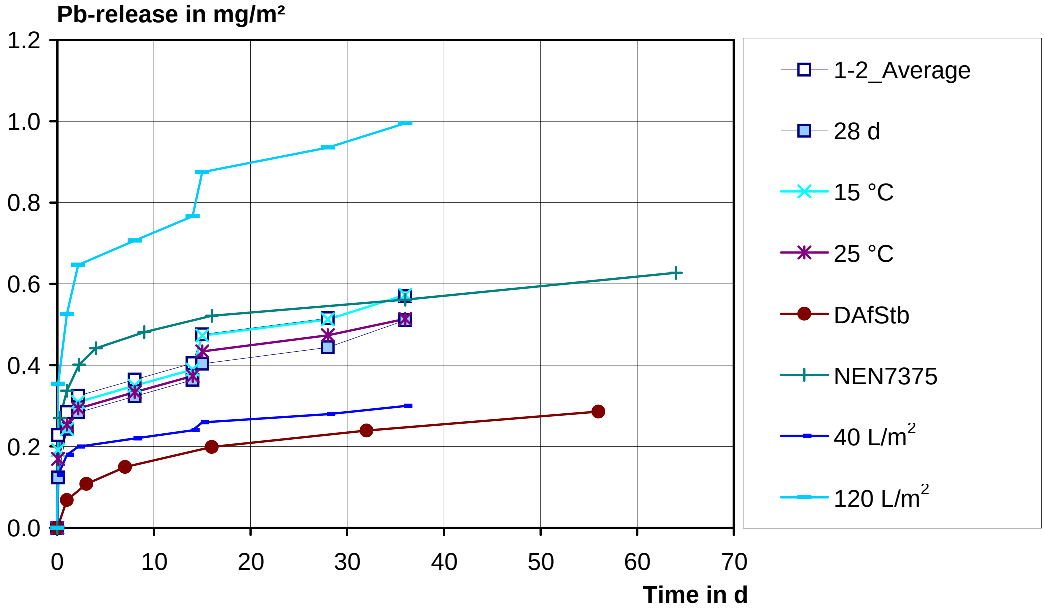

Figure 57: Release of lead for the variation of the test conditions according to Table 10

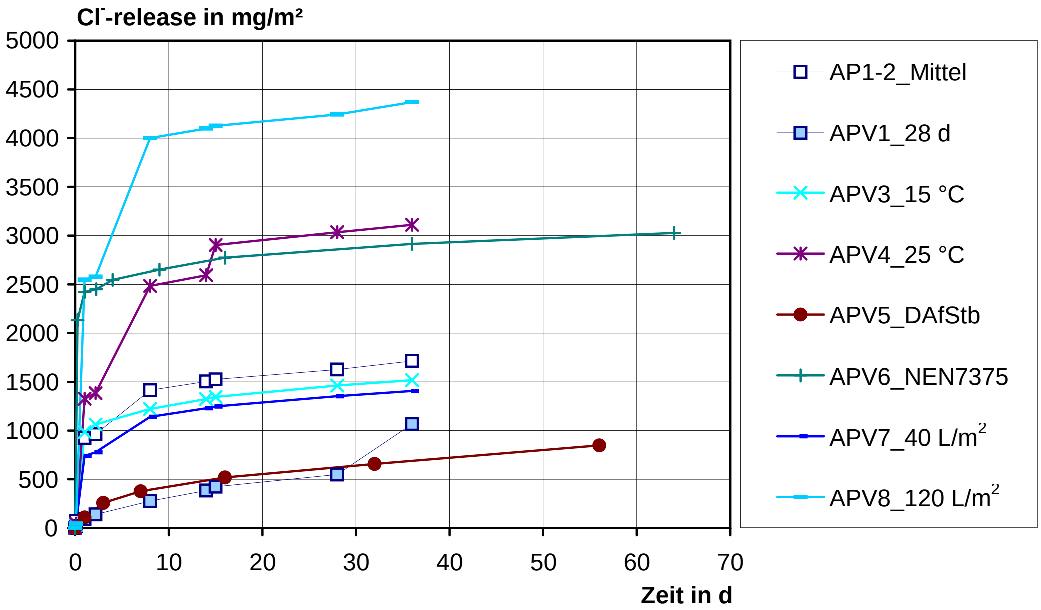

Figure 58: Release of chloride for the variation of the test conditions according to Table 10

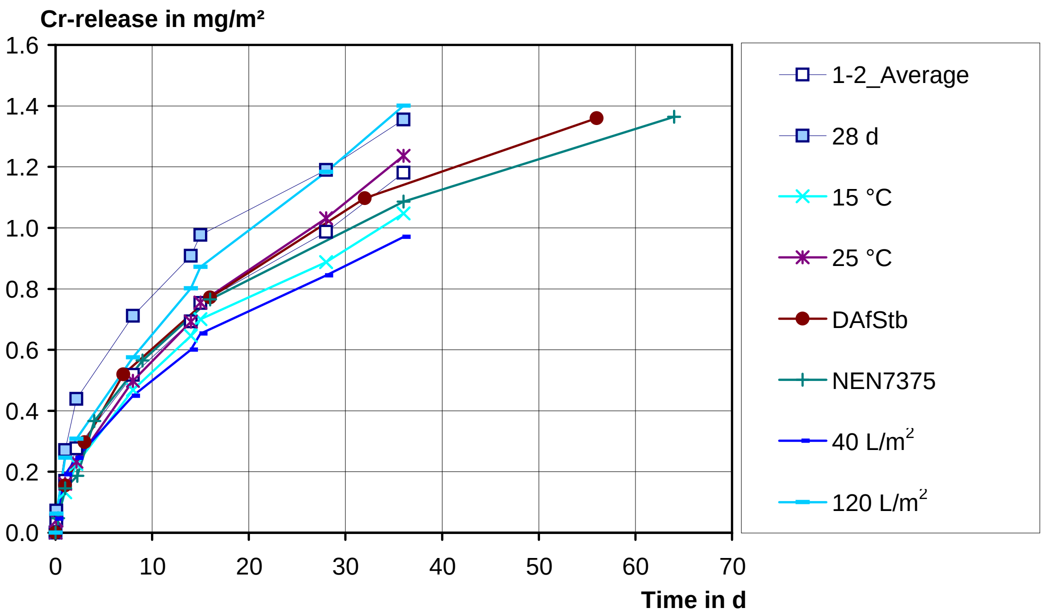

Figure 59: Release of chromium for the variation of the test conditions according to Table 10

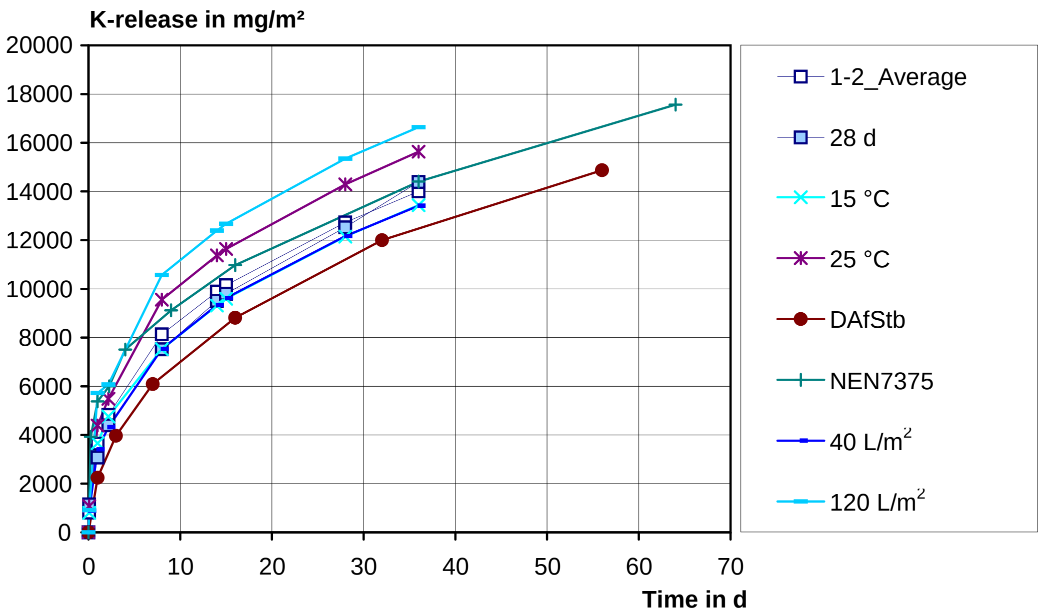

Figure 60: Release of potassium for the variation of the test conditions according to Table 10

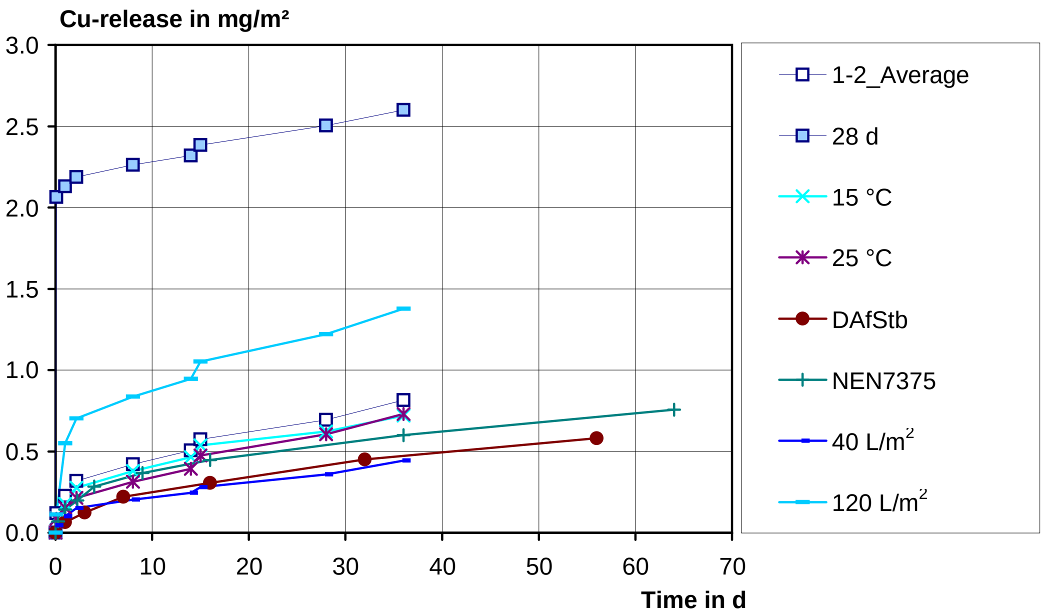

Figure 61: Release of copper for the variation of the test conditions according to Table 10

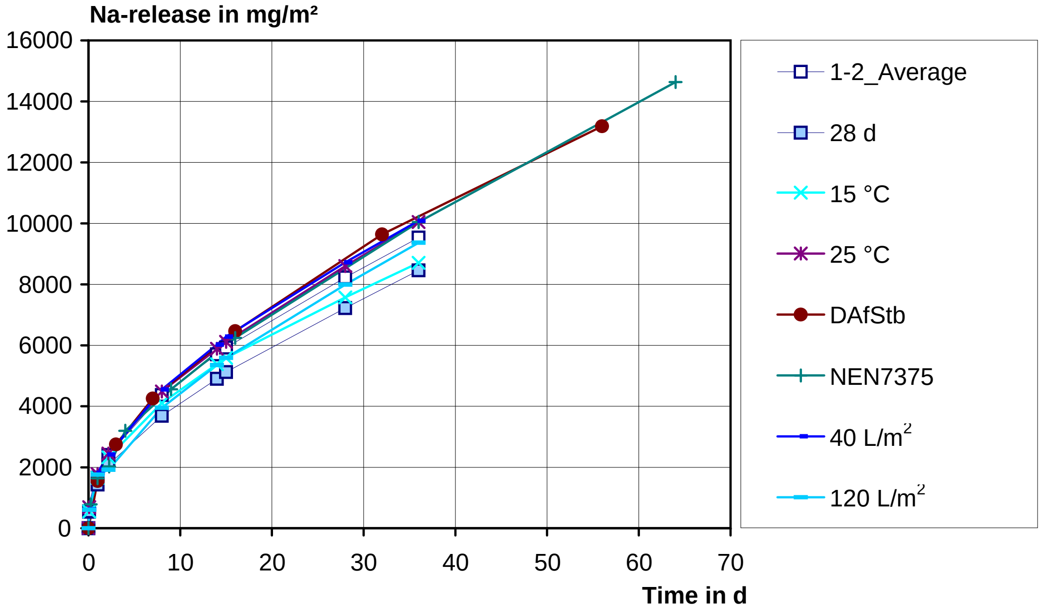

Figure 62: Release of sodium for the variation of the test conditions according to Table 10

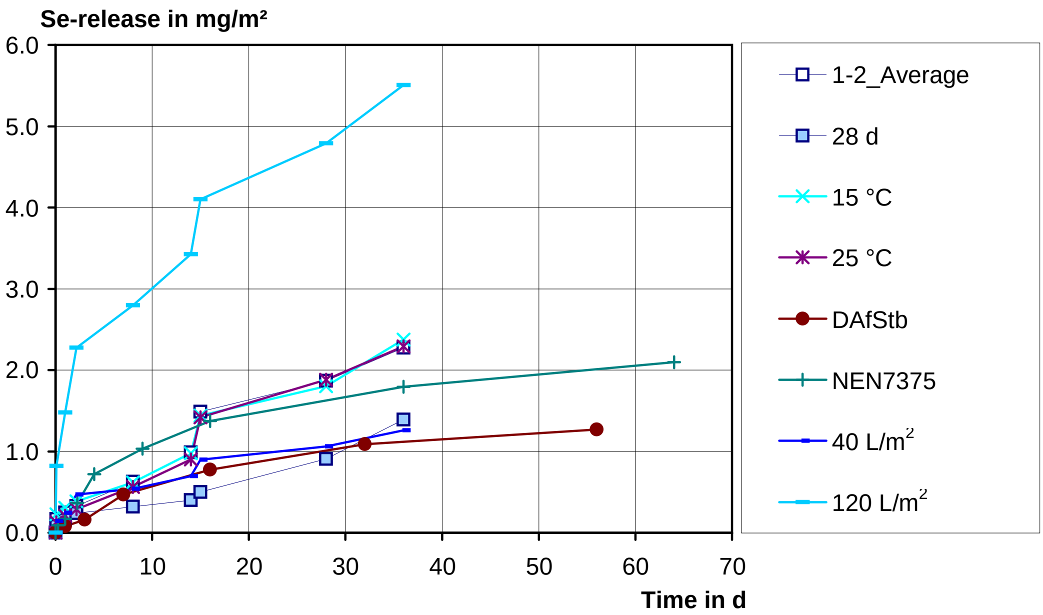

Figure 63: Release of selenium for the variation of the test conditions according to Table 10

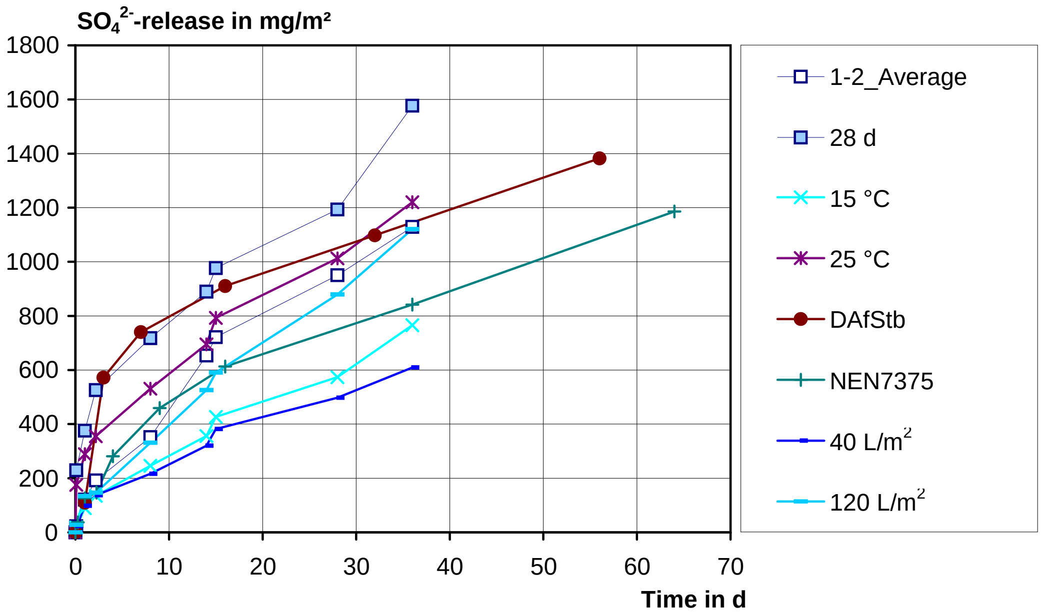

Figure 64: Release of sulphate for the variation of the test conditions according to Table 10

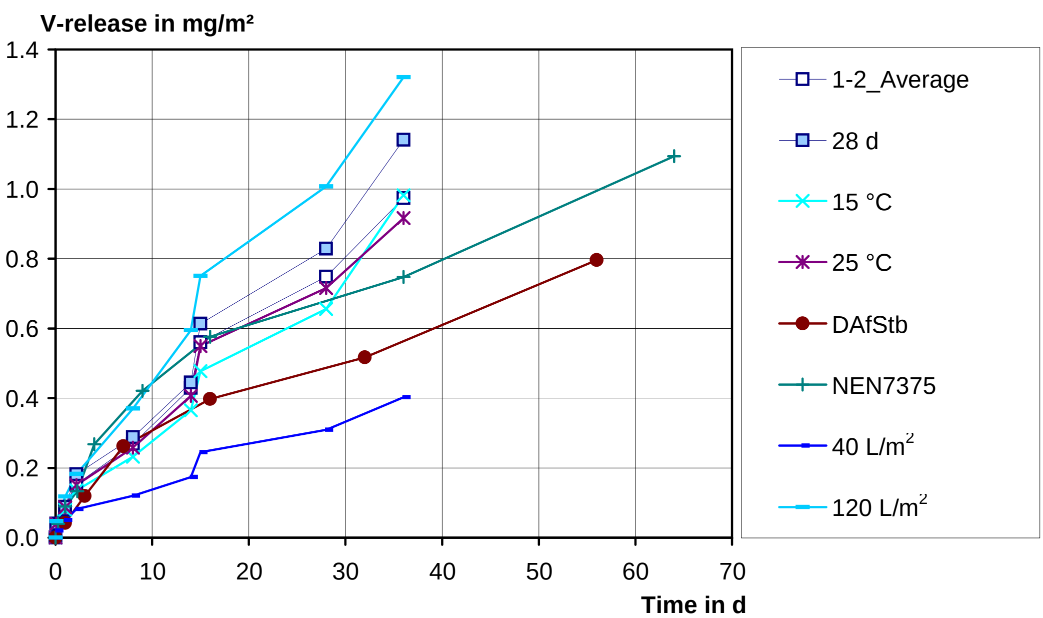

Figure 65: Release of vanadium for the variation of the test conditions according to Table 10

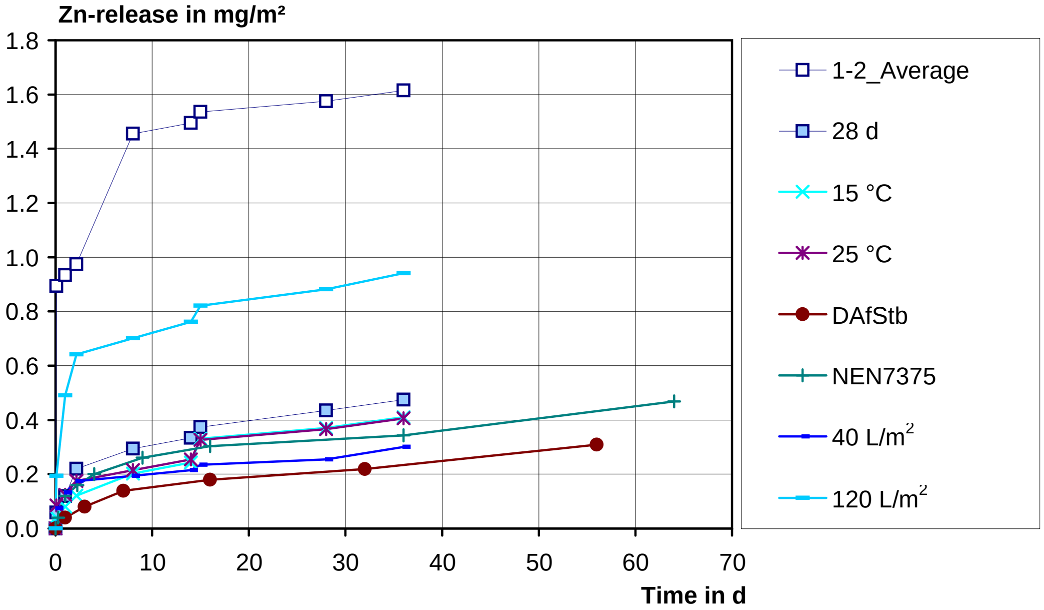

Figure 66: Release of zinc for the variation of the test conditions according to Table 10

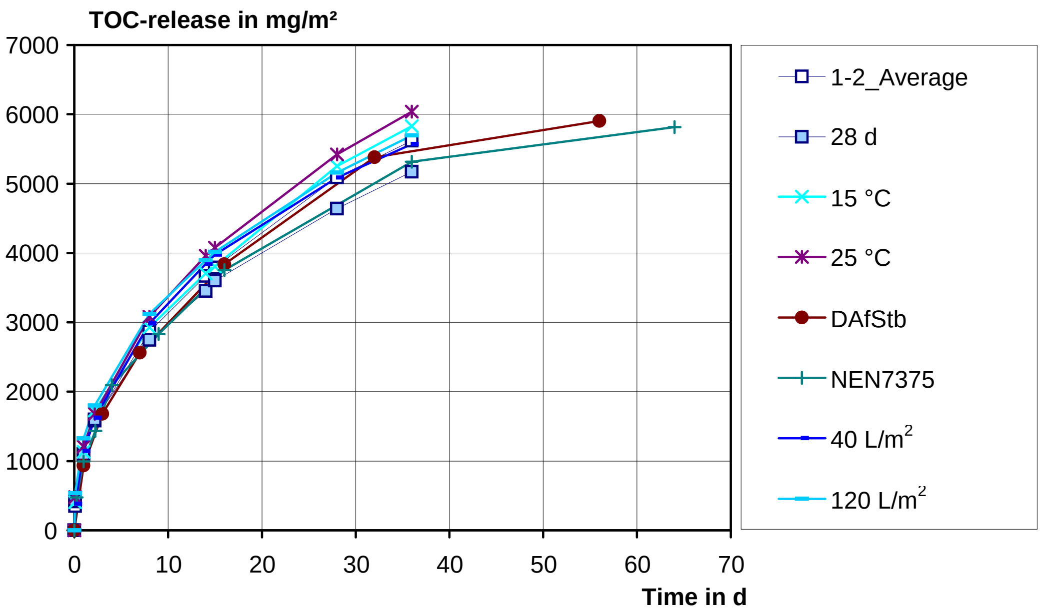

Figure 67: TOC-release for the variation of the test conditions according to Table 10

2.2.3 Assessment of the leaching results for the reinforcing render

The leaching results for the reinforcing render are similar to the results for the concretes. The accumulated amounts for the parameter investigated have the same order of magnitude as for the concretes. Also as for the concretes the accumulated amounts for potassium and sodium show a very good conformity (Figures 60 and 62). For the TOC-release a very good conformity of the test results for the variation of the test conditions was observed, too (Figure 67). The results for these parameter show, just as for the investigated concretes, that the tank leaching test as such is robust and that for the conducted variation of the test conditions only minor scattering is observed.

A further essential result of the investigations of the reinforcing render is that the TOC-release shows a very good conformity for the variation of the test conditions. From this result it can be concluded that the tank test (DSLT) is also suitable for the investigation of the release of organic substances from construction products. This result is a substantial contribution to the validation process.

3 Summary

Apart from the requirements traditionally defined in the building legislation the European Construction Products Directive (CPD) explicitly demands construction works to be built with construction products that meet the requirements on hygiene, health and environment in force in their place of use and not to endanger the health of the occupants and neighbours. However, at present only few Member States have quantitative requirements on the release of dangerous substances from construction products / construction works. Harmonised European products standards adopted so far include only general references to existing national requirements for dangerous substances.

For the future compilation and revision of harmonised technical specifications the European Commission now demands to work out the corresponding verification concepts and associated verification instruments, such as methods of testing and analysis. To that end, the Commission issued at the beginning of 2005 the mandate M/366. To allocate the necessary generic, horizontal test and assessment methods for the implementation of the mandate the European Committee for Standardisation CEN set up the technical committee CEN/TC 351 in the year 2006. Three drafts for harmonised test methods are the main result of the work of CEN/TC 351 of the past few years. Two of these test methods are designed for the determination of the leaching of inorganic and organic substances from construction products with regard to soil and water. The third test method is dealing with the determination of the release of volatile organic substances into indoor air.

Before the test methods worked out by CEN/TC 351 can get the status of a European standard (EN), robustness tests and as a second validation step round robin tests are necessary. As the funding of the European validation tests was not clear in the year 2009 the German Federal Environmental Agency announced a tender for the research project „Harmonisation of test methods for the execution of the EU Construction Products Directive: Validation of a European leaching test for construction products“ to support this process. The research project was assigned to the Verein Deutscher Zementwerke e. V. in collaboration with the Institute for Building Materials Research of the RWTH Aachen University under the promotion reference (UFOPLAN) 3709 95 303.

The aim of the research project was to execute the validation tests for the tank test on monolithic construction products for which harmonised European Standards are available under the CPD. The products chosen for the tests were concretes manufactured of concrete constituents according to hEN and mineral mortars according to hEN.

For the investigations concerning the robustness of the tank test for concretes two different concretes were produced at three concretings. At the first and second concreting concretes with the same composition were produced to check the influence of a repeated concrete production on the leaching test results. At the third concreting another cement type has been used. For the investigations on the mortar a reinforcing render, with a high amount of an organic additive, was used.

At the first multiple determinations according to the draft European standard were carried out for the concretes and the mortar. Then the curing time (28 d and 91 d), the testing temperature (15 °C and 25 °C), the duration of the specific leaching step (NEN 7375 and DAfStb-long term leaching test), the surface to volume ratio (40 L/m^2 and 120 L/m^2) as well as the pH value of the starting test water were varied. The obtained leachates were investigated according to the DIBt-principles for inorganic parameters for which an insignificance threshold has been defined. Aside this, the sodium and potassium concentrations in the leachates have been determined. For the mortar also the TOC content in the leachates has been investigated.

For the elements sodium and potassium, which are present in greater amounts and largely dissolved in the pore water and whose release is largely diffusion controlled, as well as for the TOC-release the results of the leaching tests on concrete and mortar show only a minor scattering. Also the variation of the test conditions has no larger influence on the test results. This shows that the leaching test as such is robust. The greater scattering for the trace elements and anions is probably caused by the fact that in most cases only minor amounts of these substances are leached, which are usually close or below the quantification limit of the analysis methods. Whether the greater scatterings of the leaching results for trace elements and anions are due to the chemical analysis or inhomogeneities of the concrete test specimen, in particular the test specimen surface could not be resolved in this research project. Perhaps a certain preconditioning, for example sharp blasting with oil-free compressed air – to remove loose particles from the concrete upper surface – may contribute to a lower scattering of the test results for the trace elements.

A further essential result of the investigations on the concretes and the mortar is, that the leaching results for the elements potassium and sodium as well as for the TOC, which were obtained by the Dutch standard NEN 7375 and the DAfStb-long term leaching test, in all cases are located approximately in the middle of the scattering for the realised variations of the test conditions. This shows that the transmission of the results observed by the Dutch standard NEN 7375 and the DAfStb-long term leaching test on the 36-days-tank according to the draft European standard (DSLT) should be possible relatively easily. Essential result of the investigations on the reinforced render is, that the TOC-release shows only a minor scattering for the variation of the test conditions. From this it can be deduced that the draft European standard is also appropriate for the investigation of the release of organic substances from construction products.

As a whole it can be concluded from the presented results of the investigations that an amendment of the draft European standard (DSLT) with regard to the test conditions is not necessary. This result is a substantial contribution to the validation process.

4 References

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[3] Grundsätze zur Bewertung der Auswirkungen von Bauprodukten auf Boden und Grundwasser - Teil 1, Mai 2009. DIBt Mitteilungen 40 (2009) 4, S. 116-134.

[4] Grundsätze zur Bewertung der Auswirkungen von Bauprodukten auf Boden und Grundwasser, Teil II - Juli 2009, Teil III - Mai 2009. DIBt Mitteilungen 40 (2009) 5, S. 169-179.

[5] Verordnungsentwurf über die Etikettierung von Bau- und Dekorationsprodukten im Hinblick auf die von diesen emittierten flüchtigen Schadstoffe. Französische Republik. Ministerium für Ökologie, Energie, nachhaltige Entwicklung und Meeresfragen, zuständig für grüne Technologien und Klimaverhandlungen. Notifizierung mit den Nummern 2009/701/F und 2009/702/F in der Datenbank TRIS unter: http://ec.europa.eu/enterprise/tris/pisa/app/search/index.cfm?lang=de.

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[15] DIN EN 1008:2002 „Zugabewasser für Beton – Festlegungen für die Probenahme, Prüfung und Beurteilung der Eignung von Wasser, einschließlich bei der Betonherstellung anfallendem Wasser, als Zugabewasser für Beton“

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[17] DIN EN 12390:2009 „Prüfung von Festbeton – Teil 2: Herstellung und Lagerung von Probekörpern für Festigkeitsprüfungen“

[18] DIN EN 998:2010 „Festlegungen für Mörtel im Mauerwerksbau – Teil 1: Putzmörtel“

[19] DIN EN 196:2005 „Prüfverfahren für Zement – Teil 1: Bestimmung der Festigkeit“

Annex (Tables)

Table A1: Measured barium concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	1,80	2,30	2,30	4,59	1,17	2,08	1,95	0,79
2		4,30	8,30	7,20	5,35	6,56	3,92	3,65	3,12
3		2,90	5,50	4,60	5,35	5,03	3,03	2,11	2,36
4		4,20	3,80	3,80	4,13	3,74	2,55	1,47	1,48
5		2,10	3,10	2,60	2,40	2,55	2,03	1,00	1,03
6		2,60	2,90	3,60	3,00	2,90	2,44	2,12	2,16
7		4,20	7,40	4,30	7,59	6,05	3,79	2,72	4,14
8		3,80	8,10	6,70	4,86	5,33	3,56	3,06	3,66

Table A2: Measured lead concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	2,00	14,4	10,9	<0,5	<0,5	1,81	<0,5	<0,5
2		7,20	31,8	18,0	<0,5	<0,5	0,90	<0,5	<0,5
3		10,30	19,2	14,3	<0,5	0,59	1,44	<0,5	<0,5
4		10,90	17,4	12,2	<0,5	0,72	1,40	<0,5	<0,5
5		2,20	16,8	13,0	<0,5	0,58	1,94	<0,5	<0,5
6		4,50	26,7	15,5	<0,5	0,78	1,27	<0,5	<0,5
7		7,70	19,4	13,0	0,55	0,78	0,64	<0,5	<0,5
8		6,60	18,8	14,4	<0,5	<0,5	1,89	<0,5	<0,5

Table A3: Measured chloride concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	6,85	9,01	<0,1	<0,1	1,49	<0,1	3,26	<0,1
2		9,55	9,78	<0,1	<0,1	<0,1	<0,1	0,22	<0,1
3		8,33	0,18	<0,1	<0,1	0,18	<0,1	0,73	<0,1
4		<0,1	0,40	<0,1	<0,1	<0,1	<0,1	0,25	0,38
5		25,4	<0,1	<0,1	<0,1	0,33	<0,1	<0,1	<0,1
6		0,13	7,77	<0,1	<0,1	1,16	0,12	<0,1	<0,1
7		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1
8		<0,1	<0,1	<0,1	<0,1	0,37	<0,1	<0,1	<0,1

Table A4: Measured chromium concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	3,50	14,4	5,50	5,04	1,03	<0,5	2,10	0,71
2		3,10	12,6	5,60	4,52	3,16	<0,5	1,32	<0,5
3		3,00	10,8	4,50	3,23	3,20	<0,5	1,56	0,71
4		3,40	15,7	5,80	5,42	3,97	<0,5	1,74	0,86
5		4,00	15,4	6,30	5,40	4,09	<0,5	2,11	1,10
6		4,50	16,9	6,80	5,06	4,15	<0,5	2,21	2,91
7		3,30	10,4	4,40	3,96	2,59	<0,5	0,54	1,80
8		3,30	12,5	5,30	5,49	2,95	<0,5	0,72	1,98

Table A5: Measured potassium concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	19,7	33,5	18,1	29,6	19,1	4,80	21,3	10,9
2		24,9	33,4	17,0	31,9	20,9	4,90	22,3	12,2
3		23,6	36,2	18,1	29,2	19,2	4,60	21,0	10,7
4		13,0	31,7	16,3	30,8	20,8	5,50	21,5	12,1
5		39,1	32,0	17,7	29,7	20,0	5,00	20,0	11,4
6		14,2	32,9	17,0	30,9	19,7	4,70	19,3	11,1
7		15,1	34,6	17,3	31,4	20,1	4,40	20,1	11,1
8		13,3	29,3	16,9	28,9	18,6	4,30	18,8	10,6

Table A6: Measured copper concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	<0,5	<0,5	0,50	<0,5	<0,5	<0,5	0,65	<0,5
2		0,50	0,50	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
3		3,20	1,50	1,20	<0,5	<0,5	<0,5	<0,5	<0,5
4		0,60	<0,5	<0,5	<0,5	5,81	<0,5	<0,5	<0,5
5		0,50	1,60	0,50	<0,5	<0,5	<0,5	<0,5	<0,5
6		1,10	0,60	0,80	5,22	0,54	<0,5	<0,5	<0,5
7		5,10	1,10	0,90	<0,5	4,39	<0,5	<0,5	<0,5
8		< 0,5	0,50	0,50	1,15	0,82	<0,5	<0,5	<0,5

Table A7: Measured sodium concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	3,50	5,70	2,30	4,20	2,80	0,60	3,00	1,60
2		8,50	5,60	3,90	4,50	3,00	0,60	3,60	1,70
3		4,30	6,00	3,00	4,10	2,70	0,50	3,40	1,60
4		8,00	5,50	2,00	4,40	2,90	4,30	3,60	1,80
5		3,20	5,50	2,10	4,30	2,90	0,60	3,40	1,70
6		3,40	6,90	2,10	4,50	2,90	0,50	3,30	1,70
7		3,80	5,70	2,30	4,40	2,80	0,50	3,30	1,60
8		3,40	5,00	2,00	4,00	2,60	0,50	3,20	1,60

Table A8: Measured selenium concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	2,90	5,70	7,20	1,11	0,84	0,83	1,06	1,05
2		5,30	6,70	7,30	1,55	<0,5	0,68	0,68	1,56
3		4,00	7,30	6,20	1,74	0,90	1,09	1,03	1,23
4		4,20	6,20	6,60	1,57	0,67	0,64	0,99	1,62
5		1,40	6,80	6,30	1,25	0,74	0,84	0,78	1,49
6		3,30	7,20	7,10	1,16	0,80	0,75	1,28	1,65
7		5,10	7,20	6,00	1,09	<0,5	0,80	0,89	1,64
8		4,10	5,90	6,30	1,78	<0,5	0,69	1,15	1,70

Table A9: Measured sulphate concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	18,30	20,8	6,94	3,85	1,60	0,74	1,44	2,07
2		5,48	61,8	6,07	3,71	1,54	0,39	3,72	1,61
3		5,33	19,3	5,66	3,63	1,50	0,30	2,69	1,13
4		5,65	26,7	7,40	4,50	1,90	0,36	1,88	2,38
5		4,78	20,7	7,47	4,37	1,75	0,33	1,86	2,68
6		5,95	21,8	7,30	4,39	1,94	0,34	2,65	1,63
7		4,52	15,0	4,50	3,24	1,44	0,32	1,59	1,82
8		5,12	15,0	5,71	3,70	1,69	0,32	1,30	2,34

Table A10: Measured vanadium concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	6,70	9,90	6,50	13,0	7,80	1,58	8,96	6,26
2		5,90	9,00	6,90	11,8	7,95	1,71	7,81	5,69
3		6,30	8,90	6,80	11,7	8,01	1,69	8,17	6,19
4		5,80	9,50	7,00	14,7	9,33	1,67	8,24	6,69
5		6,30	8,30	6,30	13,1	9,07	1,70	8,68	6,84
6		6,30	8,60	6,70	12,4	8,75	1,65	8,50	7,46
7		7,20	8,90	5,90	9,39	6,77	1,49	5,87	5,50
8		6,30	9,20	6,30	11,8	7,61	1,53	6,25	5,93

Table A11: Measured zinc concentration for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	0,90	0,60	5,20	<0,5	<0,5	2,51	0,87	0,66
2		1,00	1,50	8,20	0,71	0,51	1,09	0,86	0,91
3		3,20	2,20	6,80	0,56	0,58	1,07	<0,5	0,51
4		1,90	1,00	0,60	0,67	3,84	1,15	<0,5	0,59
5		<0,5	<0,5	7,30	<0,5	<0,5	0,84	<0,5	0,62
6		<0,5	<0,5	4,00	3,47	0,54	4,14	<0,5	0,85
7		2,20	<0,5	5,70	0,79	2,54	<0,5	0,51	0,91
8		<0,5	<0,5	2,90	1,02	0,78	1,24	0,70	0,73

Table A12: Measured pH-values for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	-	10,5	10,8	10,9	11,0	11,1	10,5	10,6	10,4
2		10,7	10,4	11,0	11,2	11,3	10,7	10,9	10,8
3		10,6	11,1	11,0	11,1	11,2	10,6	10,6	10,5
4		10,4	10,9	10,9	11,0	11,1	10,6	10,0	10,6
5		10,3	10,8	10,9	10,9	10,8	10,2	10,4	10,3
6		10,3	10,9	10,9	11,1	10,9	10,6	10,4	10,3
7		10,7	11,0	11,0	11,2	11,3	10,7	11,0	10,8
8		10,6	11,0	11,1	10,7	11,1	10,6	10,7	10,5

Table A13: Measured electric conductivities for the eightfold test (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µS/cm	103	246	198	300	215	87,5	108	89,0
2		152	254	233	422	288	115	205	141
3		133	304	238	345	252	109	142	98,0
4		78,7	248	181	332	241	95,7	173	115
5		167	232	202	262	172	83,4	123	83,5
6		84,3	281	206	335	180	92,0	118	82,9
7		114	297	249	437	310	124	236	151
8		104	262	243	219	225	103	156	105

Table A14: Measured barium concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	µg/L	3,24	5,18	4,39	4,66	4,17	2,93	2,26	2,34
28 d		8,70	3,11	3,05	6,02	5,90	3,40	6,9	4,47
		2,89	9,44	6,91	11,9	11,0	5,80	10,6	8,16
91 d		1,85	2,35	1,27	1,38	1,51	1,26	1,29	2,18
		1,85	1,63	1,48	1,48	1,66	1,44	2,19	1,21
15 °C		2,10	4,20	3,90	2,33	3,10	2,55	1,18	2,01
		3,00	7,10	5,40	5,54	6,07	3,77	3,44	4,11
25 °C		2,20	3,90	4,30	2,90	3,84	2,80	2,12	3,03
		2,20	3,00	4,10	2,42	3,37	2,45	1,75	2,40
40 L/m^2		5,40	8,20	6,30	6,68	2,22	2,03	0,84	1,94
		6,70	11,3	8,60	7,44	3,45	2,88	2,59	2,57
120 L/m^2		4,40	7,10	6,20	8,61	4,37	1,70	4,18	3,17
		2,30	2,50	2,50	4,08	0,71	1,09	1,25	0,74
pH = 4		3,50	4,10	3,10	5,10	2,19	3,88	2,14	1,50
		4,80	5,80	5,70	6,95	4,86	1,87	3,76	2,94
pH = 10		2,70	3,30	3,10	5,27	1,90	0,81	2,06	1,45
		3,60	5,50	5,70	7,10	4,06	1,44	3,18	2,50
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		10,5	9,30	8,30	7,14	4,94	4,78	-	-
		5,20	4,60	4,60	3,66	2,44	3,14	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		5,90	8,30	9,60	7,21	10,7	9,07	4,17	3,83
		5,30	7,80	7,70	6,70	9,89	7,30	3,55	3,48

Table A15: Measured lead concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	µg/L	6,43	20,6	13,9	0,51	0,62	1,41	0,50	0,50
28 d		<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	0,7	<0,5
		0,59	<0,5	<0,5	<0,5	<0,5	0,70	0,6	<0,5
91 d		<0,5	<0,5	0,61	<0,5	<0,5	<0,5	<0,5	0,53
		<0,5	0,60	0,52	<0,5	<0,5	<0,5	<0,5	<0,5
15 °C		<0,5	16,0	1,40	<0,5	<0,5	5,98	<0,5	1,46
		1,00	19,0	1,00	0,80	1,02	1,00	0,52	0,55
25 °C		3,00	28,5	12,7	<0,5	0,65	1,63	<0,5	<0,5
		2,70	21,3	14,8	<0,5	<0,5	1,51	0,60	0,58
40 L/m^2		12,7	25,2	4,60	<0,5	<0,5	0,86	<0,5	<0,5
		18,1	42,1	5,40	<0,5	<0,5	0,72	<0,5	<0,5
120 L/m^2		3,60	15,1	10,8	1,15	1,31	1,51	0,51	<0,5
		1,90	10,8	8,30	<0,5	0,99	1,83	0,73	0,53
pH = 4		24,7	17,9	11,7	1,94	0,66	3,01	0,63	<0,5
		26,1	18,7	12,2	6,39	1,07	1,94	<0,5	<0,5
pH = 10		3,10	15,4	5,20	12,3	0,78	1,28	<0,5	<0,5
		7,70	30,5	7,80	1,36	<0,5	0,89	<0,5	<0,5
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		18,8	6,00	1,70	0,58	<0,5	<0,5	-	-
		13,7	3,30	1,70	0,69	<0,5	<0,5	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		10,1	13,1	3,30	<0,5	2,98	0,51	<0,5	<0,5
		17,6	21,6	9,00	<0,5	2,46	0,80	<0,5	<0,5

Table A16: Measured chloride concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	mg/L	6,30	3,40	0,10	0,10	0,50	0,10	0,60	0,10
28 d		<0,1	<0,1	15,3	0,50	0,30	0,50	19,1	<0,1
		<0,1	<0,1	0,40	0,60	1,00	<0,1	24,1	<0,1
91 d		2,70	<0,1	12,4	0,50	0,30	0,20	0,20	0,50
		0,10	<0,1	5,40	0,70	0,60	3,30	0,30	<0,1
15 °C		<0,1	<0,1	0,60	<0,1	<0,1	<0,1	0,20	0,20
		<0,1	<0,1	<0,1	<0,1	0,10	<0,1	0,20	0,20
25 °C		<0,1	<0,1	<0,1	<0,1	0,20	<0,1	0,30	0,20
		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	0,20	0,20
40 L/m^2		0,90	0,50	<0,1	0,30	0,60	0,10	0,40	0,30
		0,30	0,40	<0,1	<0,1	0,40	0,50	0,40	0,30
120 L/m^2		<0,1	0,40	<0,1	<0,1	0,20	<0,1	0,20	0,30
		0,30	0,40	<0,1	<0,1	<0,1	<0,1	0,20	0,20
pH = 4		0,30	1,70	<0,1	0,40	0,50	0,40	0,50	0,50
		<0,1	0,30	<0,1	0,40	0,90	0,50	0,30	0,30
pH = 10		0,50	0,70	<0,1	0,40	0,50	0,40	0,30	0,20
		0,50	0,20	0,20	0,40	1,40	0,30	0,50	0,40
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		0,20	<0,1	<0,1	0,10	8,20	0,40	-	-
		0,10	<0,1	0,80	9,90	0,20	1,60	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<0,1	24,4	0,10	0,40	<0,1	9,30	0,70	<0,1
		0,30	0,30	<0,10	0,40	0,40	7,30	0,20	<0,1

Table A17: Measured chromium concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	µg/L	3,51	13,6	5,53	4,77	3,14	0,50	1,54	1,32
28 d		1,37	5,75	<0,5	1,94	3,10	<0,5	4,20	<0,5
		1,40	4,19	<0,5	1,26	2,80	<0,5	3,40	<0,5
91 d		<0,5	17,0	10,2	12,2	4,45	<0,5	4,92	1,46
		0,74	13,8	8,56	10,0	3,72	<0,5	4,45	2,63
15 °C		1,00	11,2	5,00	3,91	2,93	<0,5	1,46	2,95
		2,10	10,6	3,60	2,55	2,14	<0,5	0,58	2,57
25 °C		5,40	19,1	7,30	5,22	3,52	<0,5	1,48	3,44
		3,60	12,4	4,90	4,64	3,56	<0,5	1,70	3,65
40 L/m^2		7,50	30,0	12,6	13,1	10,5	1,32	15,5	4,95
		7,40	24,3	10,0	9,61	6,92	0,95	10,8	3,03
120 L/m^2		2,50	9,20	3,50	2,51	2,33	<0,5	4,40	<0,5
		3,90	15,8	6,20	4,98	3,47	<0,5	5,94	<0,5
pH = 4		3,60	20,0	6,70	6,92	4,23	<0,5	5,18	1,07
		3,00	11,4	5,10	4,96	3,60	<0,5	4,54	<0,5
pH = 10		3,00	13,2	4,80	5,24	3,70	<0,5	5,14	0,61
		3,60	14,4	5,10	4,78	3,55	<0,5	4,89	0,52
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		12,2	5,00	2,90	3,28	5,12	5,73	-	-
		13,8	5,80	4,40	4,58	6,08	6,62	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		5,60	7,90	5,50	<0,5	2,12	2,53	4,88	7,27
		6,30	10,8	6,20	<0,5	2,24	3,04	5,18	8,25

Table A18: Measured potassium concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	mg/L	20,4	33,0	17,3	30,3	19,8	4,80	20,5	11,3
28 d		22,6	45,6	30,8	29,2	19,2	4,90	41,7	12,2
		18,9	38,2	18,2	31,1	21,2	4,30	47,7	12,3
91 d		5,60	25,7	38,7	29,2	22,3	6,50	24,0	15,7
		3,40	25,7	23,6	30,6	21,5	9,50	22,3	14,4
15 °C		6,80	31,8	18,4	28,5	18,3	4,50	20,7	12,9
		9,50	29,1	15,2	25,6	17,3	3,90	20,1	11,2
25 °C		14,1	30,0	15,4	29,4	20,0	4,80	22,5	12,4
		15,1	33,2	17,6	31,8	22,4	5,30	24,8	13,8
40 L/m^2		28,5	60,3	35,2	55,0	40,0	11,2	37,3	23,7
		29,4	65,1	37,5	58,6	41,2	11,5	38,5	23,6
120 L/m^2		9,80	22,1	11,7	21,0	13,6	2,70	14,2	7,50
		9,90	20,6	11,8	20,9	13,8	3,00	14,5	8,00
pH = 4		13,7	35,0	17,1	32,0	21,8	5,90	22,4	12,7
		14,2	31,8	16,3	29,7	18,8	4,80	19,2	10,6
pH = 10		13,7	35,0	17,1	31,2	19,7	4,80	20,0	11,3
		14,5	36,4	18,3	32,1	20,7	5,00	22,0	12,1
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		45,0	24,0	19,5	27,9	33,5	28,4	-	-
		45,8	24,0	23,3	36,5	24,6	29,5	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		23,8	25,0	24,2	9,10	22,0	31,6	29,2	32,0
		22,9	24,3	23,2	8,20	21,1	40,1	28,2	31,0

Table A19: Measured copper concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	µg/L	1,50	0,85	0,68	1,17	1,70	0,50	0,52	0,50
28 d		0,63	<0,5	<0,5	<0,5	<0,5	2,60	0,50	<0,5
		0,71	0,66	<0,5	<0,5	0,60	<0,5	0,50	<0,5
91 d		<0,5	<0,5	<0,5	<0,5	2,68	<0,5	<0,5	0,77
		<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	0,63
15 °C		<0,5	0,60	0,50	0,69	1,12	<0,5	<0,5	<0,5
		1,00	0,50	<0,5	1,91	<0,5	<0,5	<0,5	<0,5
25 °C		0,50	4,30	0,50	4,02	<0,5	0,63	<0,5	<0,5
		<0,5	0,50	<0,5	0,99	<0,5	<0,5	<0,5	<0,5
40 L/m^2		0,80	<0,5	3,50	<0,5	<0,5	<0,5	<0,5	<0,5
		0,50	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
120 L/m^2		1,30	0,60	<0,5	2,14	<0,5	<0,5	1,00	<0,5
		<0,5	1,80	<0,5	0,56	3,44	<0,5	<0,5	<0,5
pH = 4		0,50	<0,5	<0,5	3,75	<0,5	0,79	<0,5	<0,5
		0,90	0,50	0,90	<0,5	<0,5	<0,5	<0,5	<0,5
pH = 10		<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
		<0,5	<0,5	0,90	2,96	<0,5	<0,5	<0,5	<0,5
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		0,50	<0,5	<0,5	<0,5	<0,5	<0,5	-	-
		0,50	<0,5	<0,5	1,81	<0,5	<0,5	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		0,50	<0,5	<0,5	<0,5	1,57	<0,5	<0,5	0,66
		<0,5	0,60	<0,5	<0,5	0,71	1,49	<0,5	<0,5

Table A20: Measured sodium concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	mg/L	4,80	5,70	2,50	4,30	2,80	1,00	3,40	1,70
28 d		3,80	5,90	2,00	4,30	2,90	<0,1	3,90	1,90
		3,70	5,80	2,20	4,50	3,10	<0,1	4,00	2,00
91 d		0,80	5,20	3,50	5,00	3,20	0,60	3,90	2,10
		0,80	5,20	3,10	4,80	3,00	0,60	3,60	2,00
15 °C		1,40	5,50	2,10	3,90	2,60	0,40	3,30	1,80
		2,40	5,50	1,90	3,70	2,40	0,40	3,30	1,70
25 °C		3,60	5,50	2,00	4,40	3,00	0,50	3,80	1,90
		3,70	6,60	2,10	4,50	3,30	0,60	4,10	2,20
40 L/m^2		9,40	9,90	4,60	8,00	5,60	1,20	6,40	3,60
		6,90	11,4	4,90	8,40	5,80	3,60	6,60	3,60
120 L/m^2		2,40	3,80	1,30	3,00	2,00	0,40	2,30	1,10
		2,20	3,60	1,30	2,90	1,80	0,30	2,30	1,20
pH = 4		3,10	5,70	4,20	4,60	3,00	0,60	3,60	1,80
		3,60	5,80	1,90	4,30	2,90	0,50	3,30	1,60
pH = 10		3,20	5,80	3,00	4,50	2,80	0,50	3,40	1,70
		3,40	6,00	2,20	4,40	2,90	0,50	3,50	1,70
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		8,50	3,20	2,40	4,00	4,00	4,70	-	-
		8,50	4,10	2,70	3,70	3,90	4,60	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		5,20	4,00	3,20	0,90	3,20	2,90	4,70	5,40
		6,10	3,80	3,00	0,80	3,10	2,90	4,70	5,30

Table A21: Measured selenium concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	µg/L	3,79	6,63	6,63	1,41	0,68	0,79	0,98	1,49
28 d		1,40	0,65	0,95	<0,5	6,30	7,30	7,50	1,61
		0,99	<0,5	0,77	<0,5	6,50	7,80	7,40	1,24
91 d		<0,5	1,69	2,15	2,41	1,82	1,88	2,42	1,66
		<0,5	1,65	1,54	2,06	1,37	<0,5	2,55	1,28
15 °C		2,40	6,20	6,20	1,20	1,28	0,64	0,91	1,45
		4,90	6,60	5,00	1,25	<0,5	0,51	0,83	1,49
25 °C		2,00	7,10	6,40	1,34	<0,5	<0,5	1,09	1,27
		1,60	6,60	5,50	1,20	0,82	<0,5	0,71	1,68
40 L/m^2		6,10	7,20	5,50	<0,5	1,67	1,72	2,50	1,53
		4,60	7,10	6,70	<0,5	1,10	1,68	2,25	1,18
120 L/m^2		3,40	7,50	6,40	<0,5	0,70	1,51	2,19	1,22
		1,70	5,20	5,90	0,84	1,68	1,58	2,19	1,87
pH = 4		3,30	6,40	6,30	0,80	1,07	1,32	1,48	2,04
		4,00	5,60	5,60	<0,5	0,86	1,27	1,45	1,01
pH = 10		4,60	5,80	6,90	<0,5	1,45	1,46	1,60	1,41
		5,10	5,80	7,00	<0,5	0,89	1,22	1,90	1,67
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		7,10	6,70	6,70	<0,5	1,38	1,73	-	-
		5,00	6,20	7,00	0,70	1,32	1,88	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		5,80	6,40	6,80	1,33	<0,5	<0,5	1,95	2,97
		5,40	6,40	6,30	1,22	<0,5	<0,5	1,79	1,87

Table A22: Measured sulphate concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	mg/L	6,90	25,1	6,40	3,90	1,70	0,40	2,10	2,00
28 d		15,6	6,30	14,5	2,40	1,20	0,30	1,30	0,80
		2,50	4,20	2,50	2,40	1,50	0,40	1,70	1,10
91 d		1,30	23,4	16,4	16,1	1,00	2,60	4,20	1,10
		1,70	19,0	11,8	12,1	3,40	0,60	2,30	1,00
15 °C		1,80	14,6	5,20	15,6	1,60	0,30	4,00	1,30
		2,80	14,7	5,30	4,40	1,60	0,30	2,20	1,00
25 °C		7,80	28,3	9,10	5,50	2,00	0,40	3,30	1,70
		4,20	16,6	5,30	4,00	1,90	0,40	3,10	1,70
40 L/m^2		11,4	37,7	14,1	8,50	3,60	0,70	4,30	2,10
		10,6	30,9	11,5	6,40	2,70	0,50	3,80	1,50
120 L/m^2		4,00	13,2	3,70	2,40	1,20	0,50	1,50	0,80
		6,00	20,9	6,40	3,80	1,50	0,30	2,30	1,10
pH = 4		5,70	29,0	7,90	18,6	2,00	0,40	2,30	1,10
		4,00	15,1	4,70	4,30	1,70	0,40	2,90	1,00
pH = 10		4,80	18,0	4,90	4,20	1,80	0,40	2,10	0,90
		5,50	19,1	5,00	4,10	1,70	0,30	1,90	0,90
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		18,7	5,80	1,40	1,90	1,80	2,60	-	-
		16,4	5,90	2,40	2,20	1,90	3,80	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		8,30	10,8	6,60	2,60	2,30	1,70	3,90	3,80
		8,70	13,7	7,70	2,30	2,60	2,00	2,80	4,10

Table A23: Measured vanadium concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	µg/L	6,35	9,04	6,55	12,2	8,16	1,63	7,81	6,32
28 d		7,25	6,96	3,60	6,67	5,80	1,40	9,70	4,85
		8,56	7,88	4,03	5,68	5,50	1,80	7,90	4,85
91 d		1,48	11,5	8,45	21,6	14,8	2,42	16,3	8,05
		0,86	10,7	7,48	19,0	12,6	2,08	13,9	6,49
15 °C		2,20	8,50	5,70	10,4	7,17	1,46	7,48	6,65
		4,00	7,60	4,60	8,36	6,00	1,35	5,76	5,77
25 °C		5,40	8,00	6,30	13,9	9,19	1,75	7,58	7,49
		5,80	7,40	5,60	10,6	7,98	1,50	7,18	7,31
40 L/m^2		12,9	17,7	14,1	24,7	19,2	3,74	26,2	13,9
		12,2	17,0	12,5	21,0	14,6	3,14	19,1	10,4
120 L/m^2		4,50	6,20	4,50	7,84	5,64	1,19	7,68	3,94
		4,10	7,10	6,10	12,2	7,42	1,24	10,7	5,14
pH = 4		6,10	10,9	7,30	16,0	9,46	1,66	12,7	6,32
		6,50	9,00	6,30	12,4	8,11	1,75	11,4	5,50
pH = 10		6,20	9,50	5,90	12,6	7,96	1,57	11,5	5,74
		6,00	9,40	6,00	11,5	7,78	1,60	11,2	5,41
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		13,7	7,20	5,90	7,81	9,80	14,4	-	-
		15,2	7,40	8,10	9,94	11,9	17,1	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		8,50	6,70	8,20	3,73	8,32	7,05	11,9	17,0
		7,80	6,10	8,00	3,66	8,64	7,88	13,1	19,4

Table A24: Measured zinc concentration for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	µg/L	1,34	0,91	5,09	1,03	1,22	1,57	0,62	0,72
28 d		1,40	1,82	0,71	0,86	<0,5	0,50	<0,5	<0,5
		1,45	1,83	0,55	0,98	<0,5	<0,5	<0,5	0,60
91 d		2,15	1,43	2,20	0,91	4,27	0,98	1,49	2,21
		1,34	1,23	2,78	0,97	0,78	1,32	1,33	1,54
15 °C		<0,5	<0,5	<0,5	66,6	0,71	1,29	<0,5	1,31
		0,60	<0,5	<0,5	11,6	0,79	2,09	3,02	1,00
25 °C		<0,5	2,50	9,40	3,31	1,05	1,61	3,02	1,83
		<0,5	0,90	1,30	2,12	<0,5	0,94	1,47	1,99
40 L/m^2		1,80	<0,5	<0,5	1,04	0,69	0,77	0,72	0,64
		1,30	<0,5	<0,5	1,65	0,76	0,62	0,85	0,57
120 L/m^2		<0,5	<0,5	0,6	39,7	1,49	1,60	1,54	0,77
		<0,5	<0,5	<0,5	4,92	2,23	9,16	0,83	0,59
pH = 4		1,50	<0,5	<0,5	4,18	<0,5	2,56	1,01	0,62
		3,30	0,50	<0,5	2,19	0,62	1,16	1,70	0,81
pH = 10		<0,5	<0,5	<0,5	4,49	<0,5	0,68	1,15	0,54
		<0,5	<0,5	<0,5	4,71	0,60	0,50	1,28	0,61
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		<0,5	<0,5	<0,5	1,00	1,30	0,75	-	-
		<0,5	<0,5	<0,5	1,31	0,92	0,84	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<0,5	<0,5	<0,5	<0,5	5,16	1,06	0,73	1,35
		<0,5	<0,5	<0,5	<0,5	1,95	0,52	0,84	1,14

Table A25: Measured pH-values fort he variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	-	10,5	10,9	11,0	11,0	11,1	10,6	10,6	10,5
28 d		10,5	11,1	11,0	11,4	11,2	10,8	11,2	10,9
		10,7	11,2	11,2	11,5	11,4	11,0	11,3	11,0
91 d		9,5	10,5	10,7	10,2	10,1	9,9	9,7	9,6
		9,0	10,4	10,6	10,5	10,2	10,1	9,7	9,5
15 °C		10,0	10,9	11,0	10,9	10,7	10,2	10,1	10,5
		10,4	11,1	11,1	11,2	11,4	10,6	10,7	10,6
25 °C		10,3	11,0	11,1	11,0	11,1	10,5	10,8	10,6
		10,3	11,0	11,0	10,9	11,0	10,5	10,4	10,3
40 L/m^2		10,7	11,2	11,3	11,2	11,0	10,8	10,4	10,5
		10,9	11,3	11,3	11,3	11,3	10,9	10,8	10,7
120 L/m^2		10,4	10,9	11,0	11,1	11,2	10,5	10,9	10,8
		9,9	10,6	10,7	10,8	10,8	10,2	10,3	10,1
pH = 4		8,0	10,8	10,7	11,0	11,0	10,2	10,6	10,5
		9,5	10,9	11,0	11,1	11,2	10,4	10,9	10,6
pH = 10		10,6	10,9	10,9	11,0	11,1	10,6	10,6	10,5
		10,7	11,1	11,0	11,1	11,2	10,7	10,9	10,8
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		11,2	11,2	10,9	11,3	11,2	10,6	-	-
		11,0	11,1	11,0	10,5	10,7	10,3	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		10,9	11,1	11,3	11,1	11,3	11,2	10,9	10,3
		10,8	11,1	11,3	11,0	11,3	11,2	11,0	10,2

Table A26: Measured electric conductivities for the variation of the test conditions according to Table 5 (first concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-8_Ave.	µS/cm	117	265	219	332	235	101	158	108
28 d		118	331	264	461	365	126	341	233
		158	379	297	621	483	156	466	295
91 d		24,2	145	214	168	123	60,6	102	81,2
		17,9	139	154	188	131	61,4	98,1	77,9
15 °C		46,6	240	170	270	137	64,7	105	111
		80,1	280	247	391	303	100	179	125
25 °C		86,4	260	224	309	242	93,5	182	119
		88,7	255	220	275	186	85,8	136	91,9
40 L/m^2		196	455	363	503	236	152	169	127
		239	495	405	513	344	175	226	155
120 L/m^2		86,8	220	192	342	246	78,3	197	130
		58,2	153	125	206	136	48,6	95,8	69,9
pH = 4		78,5	253	181	331	248	88,7	183	136
		88,4	256	225	368	300	101	218	142
pH = 10		128	248	205	320	244	109	143	100
		152	306	239	385	287	117	209	144
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		389	359	273	345	287	187	-	-
		311	283	266	182	153	146	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		209	349	378	188	387	339	236	148
		176	176	392	203	389	385	268	141

Table A27: Measured barium concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	20,7	73,6	56,2	118	37,7	24,9	74,1	44,5
2		24,8	69,6	50,1	109	77,4	26,6	78,4	43,1
3		29,1	95,5	48,7	124	88,0	25,2	81,3	44,2

Table A28: Measured lead concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	1,49	1,34	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
2		1,54	1,62	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
3		2,07	2,45	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5

Table A29: Measured chloride concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	0,62	<0,1	5,58	0,61	3,33	0,49	11,3	16,8
2		<0,1	<0,1	0,39	0,20	0,29	0,15	0,39	0,31
3		<0,1	0,46	0,25	0,28	0,32	<0,1	0,39	0,75

Table A30: Measured chromium concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	<0,5	<0,5	<0,5	<0,5	0,62	<0,5	0,56	1,50
2		<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	1,39
3		<0,5	<0,5	<0,5	<0,5	0,65	<0,5	0,55	1,11

Table A31: Measured potassium concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	13,1	19,9	19,1	33,8	25,8	4,60	47,7	58,1
2		11,7	16,9	14,4	33,2	21,2	3,00	29,7	14,0
3		11,3	19,8	12,0	32,7	19,6	4,50	28,1	14,7

Table A32: Measured copper concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	<0,5	<0,5	<0,5	<0,5	0,53	<0,5	0,68	<0,5
2		<0,5	<0,5	<0,5	<0,5	0,66	<0,5	0,52	<0,5
3		<0,5	<0,5	<0,5	<0,5	0,65	<0,5	<0,5	<0,5

Table A33: Measured sodium concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	2,20	3,30	2,30	5,30	3,70	0,60	5,30	2,60
2		2,00	2,90	2,30	5,40	3,60	0,40	5,00	2,00
3		1,90	3,60	2,00	5,60	3,40	0,60	4,90	1,80

Table A34: Measured selenium concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
2		<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
3		<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0

Table A35: Measured sulphate concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	1,02	0,81	1,06	0,93	1,93	3,04	1,51	1,72
2		0,50	0,78	0,91	0,97	1,32	0,92	1,47	1,54
3		0,68	0,88	0,78	0,95	1,26	0,78	1,40	1,39

Table A36: Measured vanadium concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	<0,5	0,67	0,74	0,91	2,17	1,77	1,74	1,73
2		<0,5	0,77	0,69	0,97	1,55	1,19	1,66	1,73
3		0,54	0,76	0,59	0,77	1,30	1,15	1,44	1,46

Table A37: Measured zinc concentration for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	2,40	3,61	2,82	2,69	2,28	1,64	3,02	1,56
2		2,37	3,56	1,87	3,44	2,82	1,88	3,70	1,61
3		2,63	2,92	1,93	2,76	3,20	1,68	2,94	1,64

Table A38: Measured pH-values for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	-	11,5	11,9	12,1	11,7	11,4	11,2	11,6	11,6
2		11,5	11,8	12,1	11,7	11,6	11,2	11,7	11,5
3		11,3	11,9	12,0	11,8	11,6	11,2	11,7	11,5

Table A39: Measured electric conductivities for the triplicate test (second concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µS/cm	525	1117	911	1511	701	407	1167	870
2		574	972	949	1576	1141	391	1158	680
3		370	1199	843	1831	1195	409	1211	728

Table A40: Measured barium concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	5,71	24,8	21,6	45,5	31,2	11,5	29,9	17,1
2		8,68	29,4	22,1	41,6	29,1	11,4	24,7	18,4
15 °C		5,14	20,5	19,3	34,6	28,6	9,04	43,8	12,7
		4,76	20,6	16,6	29,8	23,3	8,83	28,4	10,4
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		17,1	26,5	25,2	22,8	33,1	33,1	27,2	9,73
		16,7	19,3	21,8	23,0	32,1	29,0	25,6	9,83

Table A41: Measured lead concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	6,65	19,9	34,5	2,57	11,8	3,69	<0,5	<0,5
2		15,2	32,9	<0,5	1,02	<0,5	2,98	<0,5	1,44
15 °C		9,58	35,5	6,10	<0,5	0,60	1,12	<0,5	<0,5
		14,3	27,7	3,58	1,52	<0,5	1,19	<0,5	<0,5
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		1,43	56,8	13,5	12,1	3,82	3,96	<0,5	<0,5
		36,6	35,3	16,4	8,61	10,5	5,18	<0,5	<0,5

Table A42: Measured chloride concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	0,27	<0,1	<0,1	0,22	0,56	<0,1	<0,1	1,92
2		<0,1	<0,1	<0,1	0,18	0,18	<0,1	<0,1	9,98
15 °C		6,46	<0,1	<0,1	0,65	1,45	0,13	<0,1	15,8
		<0,1	<0,1	0,37	0,37	0,39	<0,1	<0,1	23,7
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<0,1	<0,1	<0,1	<0,1	0,27	0,48	23,8	0,42
		<0,1	<0,1	<0,1	<0,1	0,17	0,12	<0,1	2,37

Table A43: Measured chromium concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	<0,5	0,86	0,73	1,19	1,04	<0,5	0,98	0,94
2		<0,5	0,92	0,75	1,29	0,97	<0,5	0,98	1,13
15 °C		<0,5	0,79	0,87	1,26	1,10	<0,5	0,86	0,93
		<0,5	0,73	0,79	1,18	1,08	<0,5	0,94	0,95
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<0,5	0,91	1,20	0,83	1,39	0,90	1,40	1,66
		<0,5	0,73	0,77	0,92	0,82	0,75	1,43	1,79

Table A44: Measured potassium concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	10,7	8,70	4,80	11,6	6,60	1,00	8,80	6,40
2		8,00	8,80	4,30	11,4	6,60	1,00	9,10	15,8
15 °C		15,8	9,30	4,20	10,8	7,30	0,90	7,70	21,4
		9,50	8,90	4,20	11,8	6,90	1,00	8,30	21,4
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		10,7	6,30	5,50	4,50	8,10	7,80	41,1	16,9
		10,1	5,00	4,60	4,40	7,60	7,00	12,5	18,9

Table A45: Measured copper concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	<0,5	1,74	<0,5	<0,5	0,60	0,77	0,52	0,88
2		0,93	1,40	<0,5	<0,5	1,97	<0,5	<0,5	1,17
15 °C		<0,5	0,93	1,75	1,69	1,06	0,73	<0,5	<0,5
		<0,5	0,90	2,65	1,84	0,56	<0,5	<0,5	<0,5
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<0,5	<0,5	0,730	0,51	1,11	0,63	0,58	0,51
		<0,5	<0,5	<0,5	0,70	<0,5	<0,5	0,67	<0,5

Table A46: Measured sodium concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	2,70	2,10	1,20	3,00	1,70	0,20	2,50	1,20
2		2,10	2,10	1,00	3,00	1,70	0,20	2,50	1,40
15 °C		2,40	2,20	1,02	2,80	1,60	0,20	2,10	1,10
		2,40	2,10	1,10	3,00	1,70	0,20	2,30	1,20
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		2,70	1,60	1,40	1,10	2,10	1,90	3,60	5,10
		2,60	1,30	1,30	1,10	2,00	1,90	3,50	4,90

Table A47: Measured selenium concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	1,15	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
2		<1,0	<1,0	<1,0	<1,0	<1,0	1,23	<1,0	<1,0
15 °C		1,61	<1,0	1,20	<1,0	<1,0	1,10	<1,0	1,59
		1,17	<1,0	<1,0	<1,0	<1,0	1,58	<1,0	1,59
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	1,93
		<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	1,46	1,96

Table A48: Measured sulphate concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	mg/L	0,66	0,77	0,88	1,73	1,65	0,71	2,3	2,21
2		0,25	0,77	0,90	1,95	2,02	0,85	2,53	2,61
15 °C		0,39	3,01	0,88	1,31	1,57	0,42	1,69	8,25
		0,35	0,67	1,69	1,69	1,23	0,63	1,67	1,62
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		0,47	0,65	1,10	1,11	8,41	2,36	2,79	5,35
		0,36	0,45	0,83	0,98	1,85	2,13	3,32	5,44

Table A49: Measured vanadium concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	<0,5	1,27	1,55	3,13	3,05	1,24	3,73	3,11
2		0,75	1,19	1,59	3,15	3,17	1,35	3,88	3,26
15 °C		0,90	1,23	1,51	3,08	2,94	0,97	3,77	2,75
		0,55	1,06	1,49	3,13	2,90	0,98	3,79	2,92
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		0,81	1,46	1,96	2,01	2,82	3,30	3,96	6,55
		1,69	2,04	2,77	3,08	4,20	6,63	0,56	1,17

Table A50: Measured zinc concentration for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µg/L	0,65	11,0	8,50	6,35	2,28	0,53	<0,5	0,72
2		1,16	4,57	<0,5	<0,5	1,02	<0,5	<0,5	15,8
15 °C		1,39	4,00	7,19	18,0	3,90	2,54	0,95	<0,5
		1,28	1,70	2,07	5,46	3,28	2,17	1,13	6,27
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		1,21	0,68	0,82	0,96	4,73	<0,5	<0,5	<0,5
		0,82	1,11	0,73	1,51	<0,5	0,56	<0,5	<0,5

Table A51: Measured pH-values for the variation of the test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	-	11,1	11,2	11,2	11,3	11,4	10,9	11,3	10,9
2		11,0	11,2	11,2	11,3	11,3	10,8	11,0	10,9
15 °C		11,0	11,2	11,0	11,4	11,4	10,7	11,3	10,9
		11,0	11,2	11,1	11,3	11,2	10,6	11,1	10,9
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		11,2	11,2	11,3	11,3	11,4	11,2	11,2	10,5
		11,2	11,1	11,2	11,3	11,4	11,2	11,2	10,4

Table A52: Measured electric conductivities for the variation of test conditions (third concreting)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1	µS/cm	270	381	381	468	431	187	408	257
2		242	769	350	494	409	167	403	295
15 °C		191	355	256	472	362	135	333	311
		188	360	266	413	267	122	202	246
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		373	377	455	410	512	379	555	146
		363	293	380	319	459	361	438	140

Table A53: Measured barium concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	µg/L	24,7	80,2	54,3	88,5	59,7	22,3	57,0	41,7
		25,5	74,2	54,0	98,3	66,6	23,6	76,0	54,8
28 d		45,6	97,1	67,0	141	79,4	22,5	64,5	42,1
		50,0	102	72,0	142	76,8	22,3	63,3	45,9
15 °C		22,0	75,2	51,7	98,0	71,6	22,7	74,5	24,3
		21,7	65,1	49,4	94,9	69,2	22,7	65,4	23,6
25 °C		39,4	81,9	52,4	115	81,9	23,4	92,5	67,1
		31,5	70,1	47,8	110	78,6	22,9	91,0	64,8
40 L/m^2		50,9	143	78,9	164	120	43,4	135	66,9
		49,1	125	43,4	142	105	39,3	89,4	63,9
120 L/m^2		20,5	56,4	21,7	72,2	54,0	16,4	63,1	42,3
		20,1	52,0	7,20	72,0	51,3	17,5	62,7	43,2
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		74,7	73,5	74,2	88,2	122	74,0	-	-
		89,2	63,8	68,9	85,5	93,1	5,2	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		29,5	50,4	13,0	55,3	61,6	63,2	64,7	16,1
		62,7	63,4	27,4	64,7	69,0	76,7	90,0	37,9

Table A54: Measured lead concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	µg/L	2,47	<0,5	<0,5	<0,5	<0,5	0,85	<0,5	0,85
		3,23	0,92	<0,5	<0,5	<0,5	0,92	<0,5	<0,5
28 d		1,55	0,73	<0,5	<0,5	<0,5	<0,5	<0,5	0,79
		1,55	2,26	<0,5	<0,5	<0,5	<0,5	<0,5	0,88
15 °C		2,58	0,78	0,74	<0,5	<0,5	0,93	<0,5	0,75
		2,21	<0,5	0,93	<0,5	<0,5	1,15	<0,5	0,76
25 °C		1,15	<0,5	<0,5	<0,5	<0,5	0,67	<0,5	<0,5
		3,09	1,60	<0,5	<0,5	<0,5	0,84	<0,5	<0,5
40 L/m^2		6,00	1,99	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
		<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
120 L/m^2		1,49	0,54	0,95	<0,5	<0,5	0,85	<0,5	<0,5
		4,41	2,32	1,07	<0,5	<0,5	0,9	<0,5	0,50
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		1,18	<0,5	<0,5	0,74	<0,5	<0,5	-	-
		0,52	<0,5	0,54	<0,5	<0,5	0,67	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		2,42	0,64	1,06	<0,5	<0,5	<0,5	<0,5	0,58
		4,34	1,03	0,55	<0,5	<0,5	<0,5	<0,5	1,07

Table A55: Measured chloride concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	mg/L	0,64	10,9	0,49	8,30	1,30	0,28	1,10	0,90
		1,17	10,4	0,50	3,00	1,00	0,27	1,50	1,30
28 d		0,29	0,80	0,30	1,60	1,40	0,48	1,60	5,00
		0,17	1,10	0,80	1,80	1,40	0,48	1,60	8,00
15 °C		0,40	11,1	1,33	2,12	1,30	0,26	1,34	0,81
		0,42	12,7	0,62	1,84	1,26	0,28	1,58	0,56
25 °C		0,62	15,1	0,74	13,2	1,37	7,47	1,67	0,81
		0,55	16,9	0,70	14,3	1,35	0,30	1,62	1,10
40 L/m²		1,13	21,9	0,62	2,93	2,16	0,50	2,83	1,28
		1,02	12,9	1,30	15,2	2,25	0,42	2,49	1,33
120 L/m²		0,37	23,2	0,24	10,2	0,69	0,21	0,89	0,81
		0,39	18,5	0,27	13,5	0,96	0,24	1,07	1,29
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		1,21	2,26	1,56	1,73	1,85	3,52	-	-
		1,53	1,44	1,45	1,80	1,62	1,23	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		30,6	0,71	0,37	1,22	1,39	1,66	1,75	1,28
		22,7	6,56	0,31	1,17	1,24	1,42	1,79	1,53

Table A56: Measured chromium concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	µg/L	<0,5	1,69	1,33	3,05	2,13	0,75	2,84	2,41
		<0,5	1,56	1,32	2,98	2,27	0,75	3,00	2,43
28 d		1,05	2,54	2,08	3,42	2,49	0,88	2,70	2,19
		0,77	2,42	2,11	3,40	2,41	0,85	2,64	1,93
15 °C		<0,5	1,49	1,18	2,73	2,08	0,65	2,29	1,99
		<0,5	0,82	1,14	3,34	2,37	0,70	2,39	2,01
25 °C		<0,5	1,68	1,01	3,47	2,45	0,81	3,32	2,55
		<0,5	1,33	0,79	3,17	2,40	0,77	3,58	2,59
40 L/m^2		0,59	3,25	1,57	4,62	3,56	1,23	4,71	3,31
		1,66	4,05	1,14	5,56	4,02	1,41	4,83	3,02
120 L/m^2		<0,5	1,49	0,53	2,14	1,76	0,53	2,44	1,75
		0,54	1,57	<0,5	2,31	2,01	0,65	2,75	1,88
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		1,56	1,63	2,67	3,06	4,19	3,33	-	-
		2,31	1,92	2,90	3,25	3,94	3,23	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<0,5	1,32	<0,5	2,37	2,75	2,64	4,07	3,47
		0,68	1,15	<0,5	2,13	2,23	2,37	3,94	3,48

Table A57: Measured potassium concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	mg/L	10,2	36,1	14,8	45,1	21,9	3,30	32,3	15,7
		10,2	34,6	14,7	37,6	21,9	3,40	32,1	16,1
28 d		14,3	22,3	16,1	39,4	24,9	3,70	34,0	21,0
		14,4	25,7	17,1	38,5	24,9	3,60	34,3	25,5
15 °C		10,0	35,0	13,9	33,7	21,5	3,40	31,1	16,1
		10,1	36,5	13,4	35,4	23,4	3,60	32,7	16,2
25 °C		13,4	38,6	13,4	50,2	22,8	3,30	33,7	17,2
		13,6	44,1	14,0	51,6	22,6	3,30	32,6	16,4
40 L/m²		21,4	68,2	18,9	71,3	43,8	7,20	64,6	33,9
		22,7	58,2	26,5	89,4	46,4	7,40	62,3	28,5
120 L/m²		7,20	43,1	2,60	35,2	14,5	2,20	21,4	10,6
		8,00	37,0	3,30	39,8	15,9	2,40	23,2	10,9
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		23,6	22,0	26,8	34,1	41,1	39,0	-	-
		32,5	21,1	26,3	33,9	38,7	32,8	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		54,1	13,1	8,10	17,9	19,6	22,1	39,5	33,2
		44,0	23,3	7,30	19,9	20,7	24,2	46,3	45,9

Table A58: Measured copper concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	µg/L	1,48	1,30	1,13	1,37	1,10	0,89	1,56	1,58
		1,50	1,38	1,17	1,19	1,03	0,81	1,44	1,46
28 d		0,61	1,02	0,72	0,91	0,73	0,81	1,20	1,24
		51,0	0,63	0,71	0,98	0,71	0,77	1,82	1,14
15 °C		1,43	1,40	1,47	1,13	1,08	0,88	1,08	1,29
		0,80	0,81	1,02	1,42	1,05	0,93	1,08	1,14
25 °C		1,26	0,89	0,78	1,24	1,00	0,88	1,60	1,56
		0,89	0,79	0,75	1,24	0,97	1,18	1,66	1,55
40 L/m^2		0,86	1,17	1,19	1,29	1,01	0,83	2,14	1,92
		1,43	1,62	1,26	1,35	1,05	0,93	1,78	2,36
120 L/m^2		1,05	0,84	0,87	1,10	0,89	0,85	1,34	1,28
		0,80	6,47	1,69	1,13	0,93	0,91	1,47	1,34
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		0,75	0,73	1,14	1,13	1,90	1,85	-	-
		0,84	0,76	1,30	0,99	1,71	1,41	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		0,90	0,88	0,69	1,11	1,00	0,98	1,86	1,70
		0,86	0,91	0,70	1,02	1,10	1,01	2,00	2,21

Table A59: Measured sodium concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	mg/L	6,80	14,0	9,40	24,7	16,7	2,70	28,7	16,0
		6,70	13,9	9,30	24,4	16,7	2,80	28,8	16,7
28 d		6,90	10,1	8,10	20,3	15,2	2,80	26,3	15,4
		6,90	11,8	8,30	19,7	15,2	2,70	26,2	15,5
15 °C		6,60	13,5	8,10	21,1	15,0	2,50	23,4	13,6
		7,10	14,0	8,80	23,5	16,8	2,70	26,2	14,7
25 °C		8,80	13,2	8,50	25,9	17,9	2,80	31,9	18,1
		8,50	13,9	8,40	24,9	17,2	2,80	30,3	18,0
40 L/m^2		14,0	27,5	10,8	47,9	33,4	5,90	57,1	34,1
		17,0	32,4	19,1	58,8	40,2	7,10	64,8	34,2
120 L/m^2		4,70	9,30	1,30	16,2	11,0	1,80	18,8	10,9
		5,40	9,90	1,40	17,6	12,4	2,10	21,3	12,0
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		14,0	13,8	16,9	24,5	36,8	43,0	-	-
		24,7	16,2	20,8	30,7	42,6	45,6	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		8,80	11,2	5,80	16,0	19,0	23,6	51,9	58,3
		10,8	10,1	3,90	13,3	15,0	18,6	43,1	56,5

Table A60 Measured selenium concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	µg/L	1,80	<1,0	<1,0	3,69	4,67	6,73	5,18	5,60
		2,36	<1,0	<1,0	3,81	4,36	5,77	4,29	4,63
28 d		<1,0	<1,0	<1,0	<1,0	<1,0	1,51	5,16	6,08
		<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	5,01	6,05
15 °C		2,42	<1,0	<1,0	3,42	4,84	5,67	4,48	7,31
		3,21	<1,0	<1,0	2,45	4,09	5,91	4,58	7,02
25 °C		1,43	<1,0	<1,0	3,53	4,36	6,75	5,46	5,93
		1,80	<1,0	<1,0	3,35	4,03	6,22	6,08	4,37
40 L/m²		<1,0	2,67	4,78	1,87	3,51	4,96	3,21	5,34
		6,05	2,42	6,52	1,68	4,20	5,19	5,07	4,55
120 L/m²		6,83	5,29	6,67	4,33	4,93	5,66	5,74	6,19
		6,88	5,65	6,60	4,34	5,61	5,55	5,76	5,71
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		<1,0	<1,0	3,48	4,34	2,87	<1,0	-	-
		<1,0	<1,0	4,26	3,33	4,91	3,56	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		1,22	<1,0	3,33	4,32	3,24	4,70	6,33	6,13
		<1,0	<1,0	1,55	4,54	4,65	3,78	4,18	5,89

Table A61: Measured sulphate concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	mg/L	0,29	1,20	1,00	2,00	5,30	0,92	3,10	2,20
		0,27	1,30	0,80	2,00	2,20	0,77	2,60	2,20
28 d		4,88	1,70	1,90	1,70	2,20	1,15	2,80	6,30
		0,86	1,90	1,90	3,10	2,10	1,03	2,60	3,30
15 °C		0,23	0,84	0,55	1,31	1,42	0,86	1,79	2,41
		0,23	0,93	0,60	1,46	1,33	0,91	1,88	2,39
25 °C		3,46	1,49	0,90	2,29	2,02	1,19	2,87	2,67
		0,92	1,36	0,75	2,11	2,07	1,25	2,63	2,53
40 L/m^2		0,61	1,79	0,65	2,24	2,79	1,46	2,69	3,22
		0,55	1,96	1,30	1,72	2,41	1,62	3,10	2,37
120 L/m^2		0,20	0,86	<0,1	1,52	1,59	0,27	2,61	2,03
		0,26	0,92	<0,1	1,56	1,65	0,81	2,20	2,00
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		1,27	9,46	2,18	2,11	2,00	3,11	-	-
		1,47	2,1	2,02	2,15	2,68	4,00	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		0,34	1,09	0,26	1,71	2,56	1,95	2,78	4,54
		0,58	1,14	0,26	1,65	1,90	1,89	2,94	4,06

Table A62: Measured vanadium concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	µg/L	<0,5	0,51	0,91	1,46	2,01	1,70	2,68	2,95
		<0,5	<0,5	0,91	1,42	2,02	1,55	2,04	2,69
28 d		<0,5	0,65	1,23	1,33	2,03	2,13	2,78	4,01
		<0,5	0,57	1,09	1,34	1,88	2,08	2,61	3,80
15 °C		<0,5	<0,5	0,67	1,20	1,76	1,43	2,34	4,25
		<0,5	<0,5	0,71	1,22	1,58	1,36	2,13	3,90
25 °C		<0,5	0,54	0,79	1,32	1,84	1,86	2,09	2,57
		<0,5	0,63	0,81	1,36	1,88	1,71	2,07	2,43
40 L/m²		<0,5	0,77	0,90	0,90	1,33	1,73	1,43	3,06
		<0,5	0,75	0,66	1,02	1,34	1,87	1,75	1,63
120 L/m²		<0,5	0,57	0,59	1,54	1,91	1,34	2,20	2,67
		0,28	0,61	<0,5	1,58	1,83	1,26	2,07	2,56
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		0,55	0,99	1,77	1,71	1,38	1,85	-	-
		<0,5	0,95	1,80	1,67	1,60	5,14	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<0,5	0,64	<0,5	1,67	1,86	1,97	2,33	5,3
		<0,5	0,60	0,58	1,70	1,98	1,91	1,94	3,38

Table A63: Measured zinc concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	µg/L	0,99	<0,5	<0,5	11,5	<0,5	<0,5	<0,5	<0,5
		21,4	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
28 d		0,79	1,02	1,40	1,18	<0,5	<0,5	<0,5	<0,5
		0,67	<0,5	1,13	0,66	<0,5	<0,5	1,02	<0,5
15 °C		<0,5	<0,5	<0,5	<0,5	<0,5	0,53	<0,5	<0,5
		0,52	<0,5	<0,5	1,55	<0,5	1,66	<0,5	<0,5
25 °C		1,27	<0,5	0,76	<0,5	<0,5	<0,5	<0,5	<0,5
		0,84	<0,5	<0,5	<0,5	<0,5	1,29	<0,5	<0,5
40 L/m^2		<0,5	1,25	1,51	<0,5	<0,5	<0,5	<0,5	<0,5
		3,23	1,67	0,57	<0,5	<0,5	<0,5	<0,5	1,81
120 L/m^2		1,34	1,31	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5
		1,89	3,64	2,01	<0,5	<0,5	<0,5	<0,5	<0,5
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		<0,5	<0,5	<0,5	0,52	<0,5	1,74	-	-
		<0,5	<0,5	0,97	<0,5	<0,5	<0,5	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		<0,5	1,50	<0,5	<0,5	<0,5	0,56	<0,5	0,62
		<0,5	<0,5	<0,5	<0,5	1,03	<0,5	<0,5	2,49

Table A64: Measured TOC concentration for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	mg/L	4,40	9,40	6,10	16,0	10,1	1,40	15,1	6,30
		4,40	9,20	6,10	16,0	10,0	1,60	17,5	6,90
28 d		5,20	8,10	6,50	14,2	8,70	2,00	13,0	6,50
		5,20	9,00	6,00	14,5	8,90	1,70	13,0	6,80
15 °C		5,40	9,00	8,80	15,0	9,60	1,20	17,4	7,30
		4,80	9,10	6,10	15,0	9,80	1,40	18,7	7,10
25 °C		6,50	9,50	6,10	17,0	11,0	1,50	17,8	8,00
		5,50	8,70	5,70	18,0	11,0	1,40	15,8	7,40
40 L/m^2		9,30	19,0	13,0	34,0	22,0	3,30	29,6	13,8
		9,90	19,0	11,0	34,0	21,0	3,20	26,0	10,5
120 L/m^2		5,10	6,70	4,10	11,0	6,50	1,00	9,60	4,50
		3,80	6,50	3,80	11,0	6,40	<1,0	9,50	4,40
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		9,40	9,70	11,0	16,0	20,5	7,4	-	-
		14,0	8,90	11,0	16,0	18,0	5,7	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		4,70	5,50	4,40	7,80	8,90	11,0	17,8	5,1
		7,20	7,50	6,50	8,80	9,50	12,0	21,3	7,4

Table A65: Measured pH-values for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	-	11,7	12,2	11,9	12,1	11,9	11,4	11,9	11,6
		11,7	12,1	11,9	12,1	12,0	11,4	12,0	11,8
28 d		11,4	11,7	11,7	11,9	12,0	11,4	12,1	11,7
		11,4	11,7	11,7	11,9	12,0	11,4	12,1	11,8
15 °C		11,6	12,2	12,1	12,1	12,0	11,4	12,1	11,5
		11,6	12,2	12,1	12,1	12,0	11,5	12,0	11,5
25 °C		11,8	12,2	12,0	12,1	12,0	11,5	12,1	11,9
		11,7	12,1	11,9	12,1	12,0	11,5	12,1	11,9
40 L/m^2		11,9	12,4	11,8	12,3	12,2	11,7	12,2	11,9
		12,0	12,4	12,2	12,3	12,2	11,8	12,1	11,9
120 L/m^2		11,5	12,0	11,0	12,0	11,8	11,3	11,9	11,6
		11,5	12,0	10,9	12,0	11,8	11,3	11,9	11,7
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		12,2	11,9	12,0	12,1	12,4	12,2	-	-
		12,3	11,9	12,1	12,1	12,3	11,3	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		11,8	12,0	11,6	11,9	12,0	11,9	12,0	11,5
		12,0	12,1	11,5	11,9	12,0	11,9	12,0	11,7

Table A66: Measured electric conductivities for the variation of the test conditions (reinforcing render)

Variation	Unit	Time in days							
		0,083	1	2,25	8	14	15	28	36
1	2	3	4	5	6	7	8	9	10
1-2	µS/cm	488	1366	990	1556	1011	380	941	735
		473	1261	997	1768	1219	406	1294	933
28 d		675	1339	1067	1793	1385	379	1154	797
		708	1673	1178	1822	1345	377	1125	870
15 °C		471	1343	913	1726	1208	389	1341	487
		468	1404	945	1832	1221	421	1173	515
25 °C		728	1348	933	1884	1155	471	1499	1072
		617	1116	807	1826	1188	411	1335	1044
40 L/m^2		1044	2240	834	2746	2058	756	2190	1204
		1206	2211	1568	2785	1977	753	1803	1216
120 L/m^2		390	1045	131	1247	772	250	972	672
		407	995	114	1324	845	363	1082	659
DAfStb		Time in days							
		1	3	7	16	32	56	-	-
		1261	1308	1348	1527	1775	1496	-	-
		1683	1249	1373	1533	1703	427	-	-
NEN 7375		Time in days							
		0,25	1	2,25	4	9	16	36	64
		590	989	392	1162	1149	1207	1316	590
		875	1075	347	1183	1215	1162	1481	961