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ConcreCem

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The Benefits of ConcreCem Modified Concrete for floor slabs and bases.

Cost-effective and time-saving

ConcreCem modified concrete is a totally different material,cost-effective, long lasting and time saving.

Enabling simpler build technique and faster curing times, allowing contractors to complete on sites much more quickly. It is easy to lay, a saving on man hours and the equipment needed on site.

Further construction time is gained and savings will be made by the reduction and possible elimination of the need for cutting and filling of expansion joints, which will only be needed on larger expanses of concrete slab.

ConcreCem modified concrete is *different* in so many ways

- Shorter setting time
- Higher modulus of elasticity
- Higher breaking strain
- Usable with poor or secondary/recycled aggregates
- Usable with any type of water, including sea water
- Higher impact resistance
- Salt and Acid resistant
- Frost resistant
- Fewer smaller cracks
- Less shrinkage
- Higher Density
- Impermeable
- Faster strength gain up to 80 mpa within 24 hours
- Higher resistance to frost and heat

Applications

ConcreCem modified concrete can be laid in temperatures down to zero to replace any traditional concrete slab for use in all applications:

- Industrial floors; where its speed of construction, high impact and resistance to heat and acids will be beneficial.

- Commercial floors; where its longevity, cost and time saving will add value, together with increased density and absence of voids to enhances the properties for a polished finish.

- Retail floors; by allowing the contractor to complete the floor quicker without using traditional steel fabric and further reducing weight by building thinner slabs savings can be made in the design and construction of mezzanine floors. Also the thinner design requirement allowed due to the stiffer and faster curing ConcreCem product will allow final floor covering to be applied much sooner.

- Sea Defence applications; the speed of application and setting enables works to go ahead where concrete needs to be installed quickly with fast strength gain.
  Ideal for marine applications. As it can be applied under water.
  ConcreCem modified concrete offers high salt and water resistance and unlike traditional concrete can be produced using sea water and even non aggregate beach sand can be used if required.
  The greater flexibility of ConcreCem modified concrete allows for far thinner structures when used for under water applications, resistance to salts and greater impermeability also increases longevity and durability in marine applications.

- Rural applications; Silo's built with ConcreCem modified concrete will safely hold animal wastes with reduced leakage and damage from acids or heat.
  ConcreCem concrete composting slabs will also show greater durability with resistance to acidity and heat and show far greater impact resistance when heavy is used for turning and mixing the composts.

- Tunnel Lining and other heat sensitive applications; the University of Ulster has been able to confirm that mortars and concretes modified with PowerCem products; ConcreCem and RoadCem demonstrate remarkable resistance to fire and intense heats to the point that samples were actually still gaining in strength up to 2,000 Celcius.

University of ULSTER

Table 3 Strength gaining of FireCemX and FireCemY during Hydrocarbon fire exposure[3]

Sample	Max. surface temperature reached (°C)	Average compressive strength before fire N/mm^2	Average compressive strength after fire N/mm^2	Average strength gain due to fire exposure
FireCemX1	974	5.26	5.42	+%2.65
FireCemX2	1008			
FireCemY1	998	19.25	21.70	+%12.72
FireCemY2	1027			

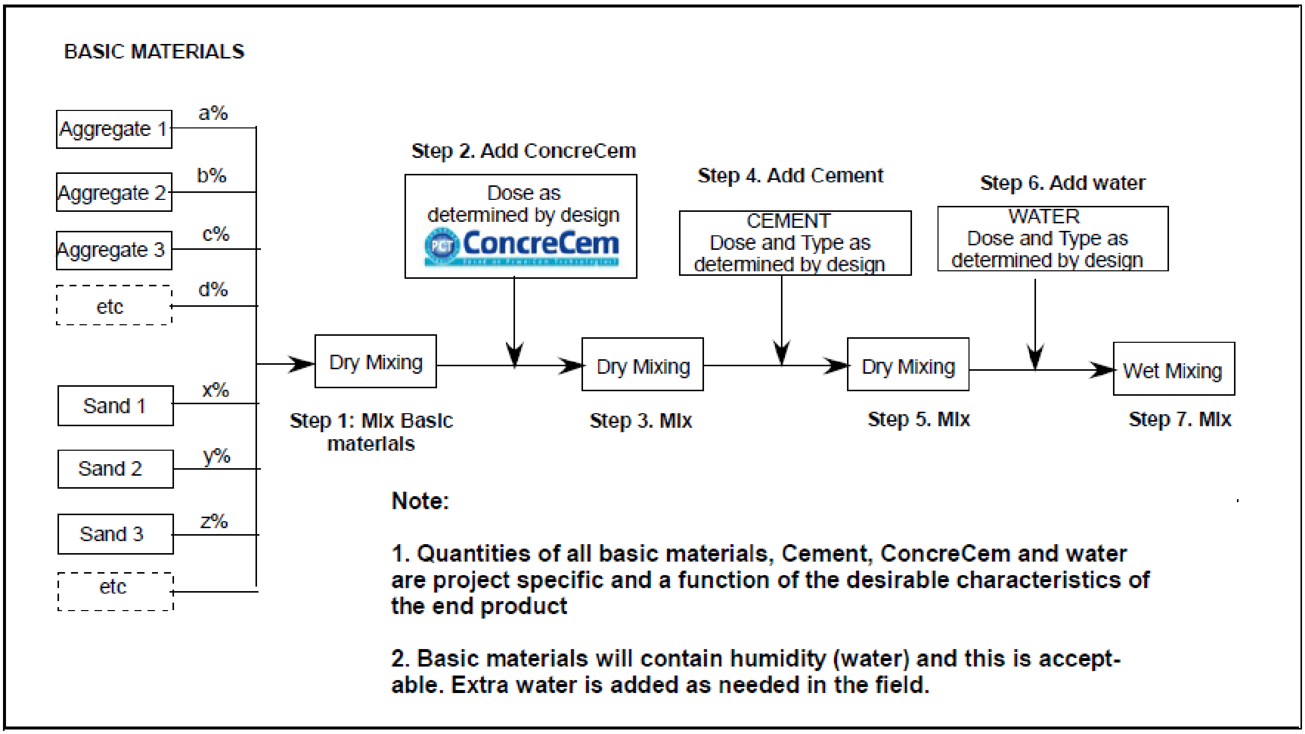
The increase in the strength of FireCem when subjected to fire, the complete resistance to explosive spalling with extremely high moisture content exceeding 16% (in weight) without the need to add polypropylene fibres (or any additives), and the excellent thermal insulation, provide strong justification to classify FireCem as a new type of fire protection material.

ConcreCem instructions for use

Use in wet mix and dry premix

The required dosage is determined as a function of the specified requirements and other materials to be used. Once the required dosage is specified the mixing can be initiated. The mix should be prepared in accordance with steps:

Use in wet mix



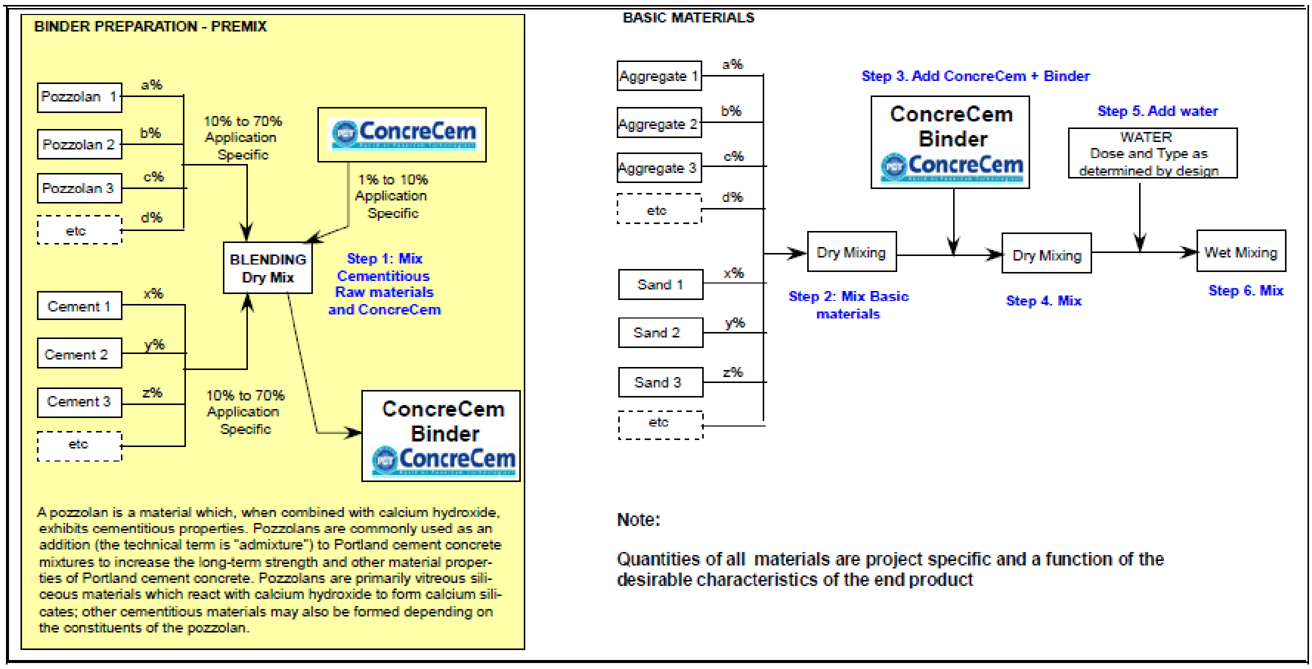
Note:

1. Quantities of all basic materials, Cement, ConcreCem and water are project specific and a function of the desirable characteristics of the end product

2. Basic materials will contain humidity (water) and this is acceptable. Extra water is added as needed in the field.

Use in dry-premix preparation

ConcreCem can be premixed with Cement and or other pozzolanic materials (e.g. fly ash) and used as a cementitious binder



A pozzolan is a material which, when combined with calcium hydroxide, exhibits cementitious properties. Pozzolans are commonly used as an addition (the technical term is "admixture") to Portland cement concrete mixtures to increase the long-term strength and other material properties of Portland cement concrete. Pozzolans are primarily vitreous siliceous materials which react with calcium hydroxide to form calcium silicates; other cementitious materials may also be formed depending on the constituents of the pozzolan.

Note:

Quantities of all materials are project specific and a function of the desirable characteristics of the end product

What is ConcreCem?

Table 1.1: Aspects of ConcreCem

Parameter	Value	Method
Color	Grey	visual
Composition	Alkalimetal(s): 60-80% Zeolites: 5-10% Alkali metal silicates: 5-10% Calcium Carbonite: 10-20%	-
Effective component	Infra red spectra (figure 4.1)	EN 480-6
Bulk density	900 – 1500 kg/m^3	-
Absolute density	2150 – 2210 kg/m^3	ISO 758
Conventional dry material content	84 – 93%	ISO 480-8
pH value	9,55	ISO 4316
Total chlorine	< 31,0 %	ISO 1158
Water soluble chloride (Cl^-, m/m)	< 34,0 %	EN 480-10, method 1
Alkali content (Na_2O-equivalent)	18,1%	EN 480-12
Particle size distribution (mean value)	Sieve size Passing 63µm: 100% 45µm: 99% 31 µm: 97% 16 µm: 87% 8 µm: 64% 4 µm: 37% 2 µm: 18% 1 µm: 7% 0 µm: 0%	CILAS 920-L (figure 4.2)

Cost Analysis of ConcreCem

This document describes the benefits of using ConcreCem, before we say something about the cost benefits, we first highlight the main benefits to concrete construction qualities contributed by the addition of ConcreCem:

- **A greater flexural strength.**
- **A significant increase of compressive strength in the early stage.**
- **A significantly lower shrinkage.**
- **A very low water impermeability and absorption.**
- **High resistance to thermal shock and thermal linear rising temperatures.**
- **High resistance to freezing and thawing.**
- **High resistance to acids and base chemicals.**
- **High resistance to heat, tested to 2000 Celsius**
- **More durable construction.**

The above mentioned benefits can normally only be achieved by the addition of a whole range of different additives. ConcreCem delivers all these benefits in one additive !

Compared to the chloride-free accelerators the using ConcreCem will achieve a saving of more than £ 3,00 per 1 m^3 of concrete (based on amount of 360 kg cement per 1 m^3 of concrete).

The addition of ConcreCem provides enhanced durability. This cannot easily be calculated and expressed in hard currency. It remains very difficult to calculate the costs of repairing concrete in which no ConcreCem was used. For instance the damage caused by freeze-thawing. The use of only 0,3% ConcreCem will reduce freezing-thawing damages by 500% !
For us the question remains how can we calculate these benefits, however the customer or local authority faced with the annual repair bill can quickly make this calculation!

In the next table two concrete mixes are compared in costs. Mix 1 with ConcreCem and Mix 2 with a traditional additive.

Both mixes are fully freeze-thaw resistant.

Materials	Costs per 1000 kg	Costs per kg	Mix 1		Mix 2	
			Amount per 1m^3 concrete	Costs	Amount per 1m^3 concrete	Costs
CEM I 42,5N	£ 100,00	£ 0,10	352	£ 35,20	-	-
CEM I 52,5N	£ 100,00	£ 0,10	-	-	466	£ 46,60
Silicafume	£ 800,00	£ 0,80	-	-	69	£ 55,20
GGBS	£ 50,00	£ 0,05	-	-	188	£ 9,40
Water	£ 2,00	£ 0,00	185	£ 0,37	144	£ 0,29
Superplasticizer	-	£ 2,00	-	-	13	£ 26,00
Sand 0/4	£ 20,00	£ 0,02	786	£ 15,72	625	£ 12,50
Gravel 4/16	£ 45,00	£ 0,00	-	-	951	-
Gravel 4/32	£ 40,00	£ 0,04	1026	£ 41,04	1026	£ 41,04
ConcreCem	-	£17.00	1,06	£ 18.02	-	-
Total costs of mix			**£ 110.35**		**£ 191,03**	

The difference between the two mixes is £ 80.68 per cubic metre of concrete.

ConcreCem and strength-improvement

Concrete mixtures have been tested in the laboratory. The composition of the reference concrete mixture is in accordance with EN 480-1 (Reference Concrete I).

Three different sizes of aggregate (figure 3.1) have been used to establish a particle size distribution which is within the requirements mentioned in the EN 480-1.
Table 3.1 shows the particle size distribution of the aggregate used in concrete mixtures.

Figure 3.1: Three different sizes of aggregate to establish the particle size distribution

Table 3.2 show the mix specifications. Also the results of testing the wet concrete and the strength improvement after 24 hours when different amounts of ConcreCem is used.

Table 3.1: Particle size distribution of aggregate used (sand and gravel)

Aperture size	Passing
31,5	100%
16	90%
8	56%
4	43%
2	40%
1	33%
0,500	18%
0,250	5%
0,125	2%
0,063	0%

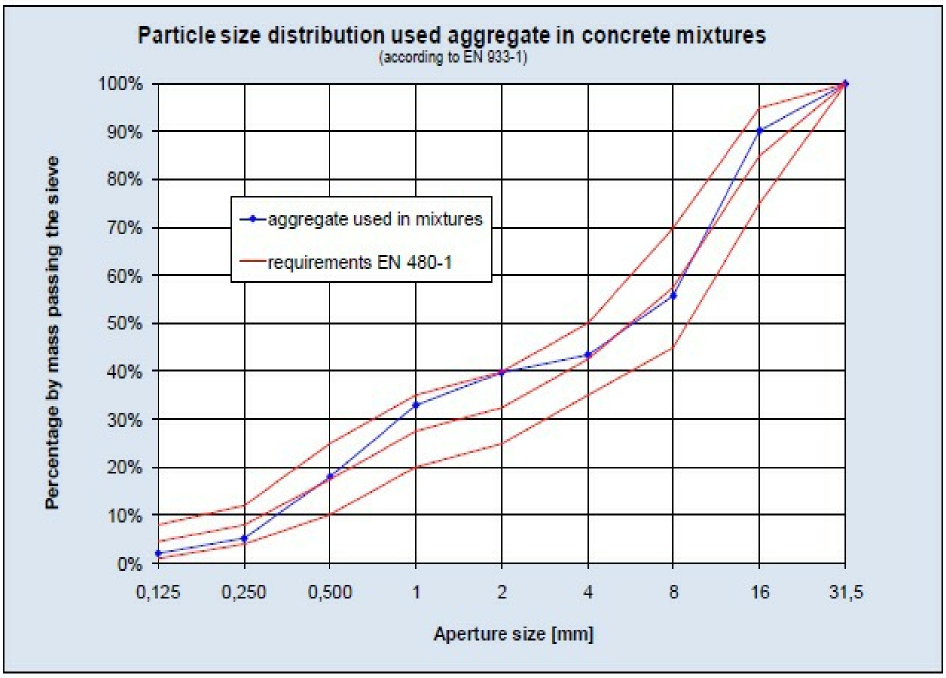


Table 3.2: Mix Specifications

Material	Amount (kgs) of material in 1m³ of concrete			
	Reference Mix: 0,0% ConcreCem	Mix I: 0,3% ConcreCem	Mix II: 0,6% ConcreCem	Mix III: 0,9% ConcreCem
CEM I 42.5 N	350	350	350	350
Water	180	180	180	180
Sand 0/4	793	793	793	793
Gravel 4/16	517	517	517	517
Gravel 4/32	517	517	517	517
ConcreCem	**0,00**	**1,05**	**2,10**	**3,15**
Water / cement ratio	0,51	0,51	0,51	0,51
Density wet concrete (EN 12350-6)	2380 kg/m³	2360 kg/m³	2370 kg/m³	2350 kg/m³
Air content wet concrete (EN 12350-7)	1,8%	1,5%	1,9%	2,1%
Slump (EN 12350-2)	70 mm	80 mm	60 mm	60 mm
Compressive Strength improvement after 24 hours as to reference mix	-	36%	34%	28%

Figure 3.2 shows compressive strength improvement after 24 hours when ConcreCem is used. Although there is still a large improvement, it is slightly lower at early stage when more ConcreCem is used. However, the strength improvement after 28 days will end higher in case of using a larger amount of ConcreCem. It is important to know what kind of properties the concrete should have (for example: a higher early strength or a higher 28-days strength) to develop a concrete mixture with the right amount of ConcreCem.
The three tested mixtures with ConcreCem comply with the requirements mentioned in the European standard EN 934-2, table 7 ("Specific requirements for hardening accelerating admixtures.")

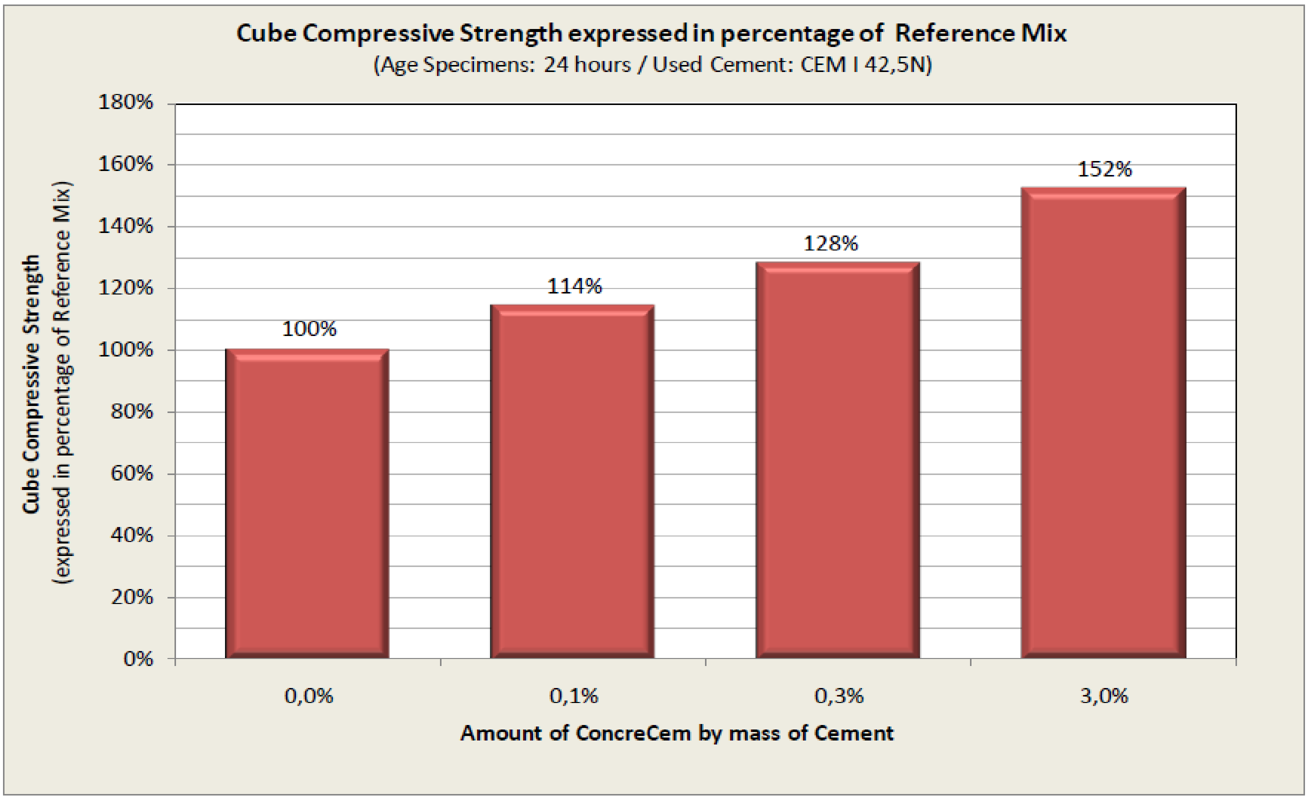


*Figure 3.2: Improvement of Compressive strength after **24 hours** when using ConcreCem*

Figure 3.3 to 3.5 shows the mixing and testing of wet concrete; the casting and monitoring of different kinds of samples and destructive testing on different kinds of samples after 28 days.

Figure 3.3: Mixing and testing (slump, air content and temperature) wet concrete

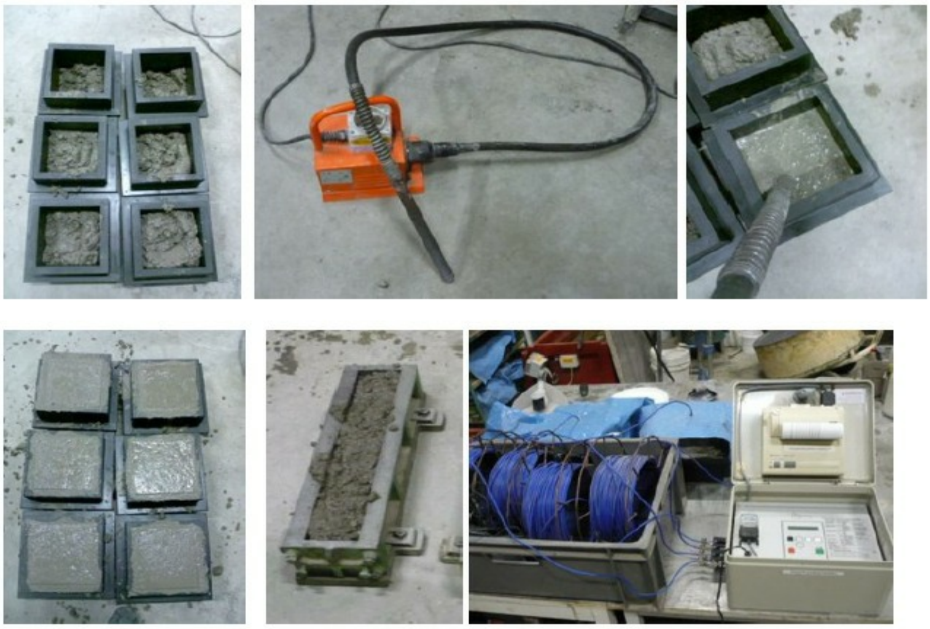


Figure 3.4: Casting and monitoring samples

Figure 3.5: Testing compressive strength, tensile strength and tensile splitting strength.

A very interesting property of ConcreCem is the ability to improve the early strength of concrete when mixing the concrete at a low temperature. All the materials were kept at 5°C prior to mixing in a climate chamber (figure 5.6).

The temperature of the wet reference concrete mix was 11,5 °C and the temperature of the wet concrete mix with 0,3% ConcreCem was 11,2 °C.

These tests show that concrete with 0,3% ConcreCem improves compressive strength after 48 hours with 35% compared to the reference mix.

This complies with the requirement mentioned in the European Standard EN 934-2, table 7 ("Specific requirements for hardening accelerating admixtures").

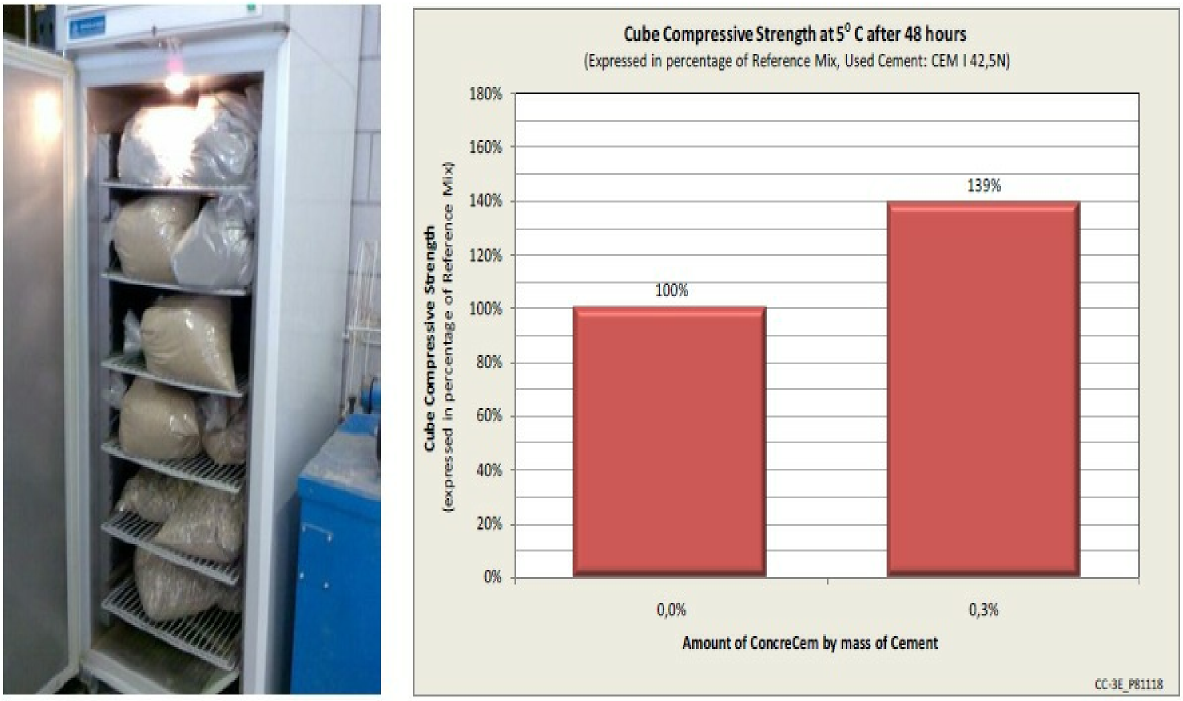


Figure 3.6: Keeping materials at 5°C prior to mixing and results compressive strength after 48 hours at 5°C

To understand how ConcreCem can enhance durability, it is important to know what "durability" means. Put in a simple way: durability is performance related to time. But two questions arise:

1. what is the period of time: where does it begin and where does it end;
2. when is something durable and when is it not.

To answer these questions we have to relate durability to a specific object. For concrete the following objects should be considered:

- a construction
- concrete
- a concrete construction

2.1 Durability of a construction

When talking about the durability of a construction or part of a construction in relation to time, we normally mean the design

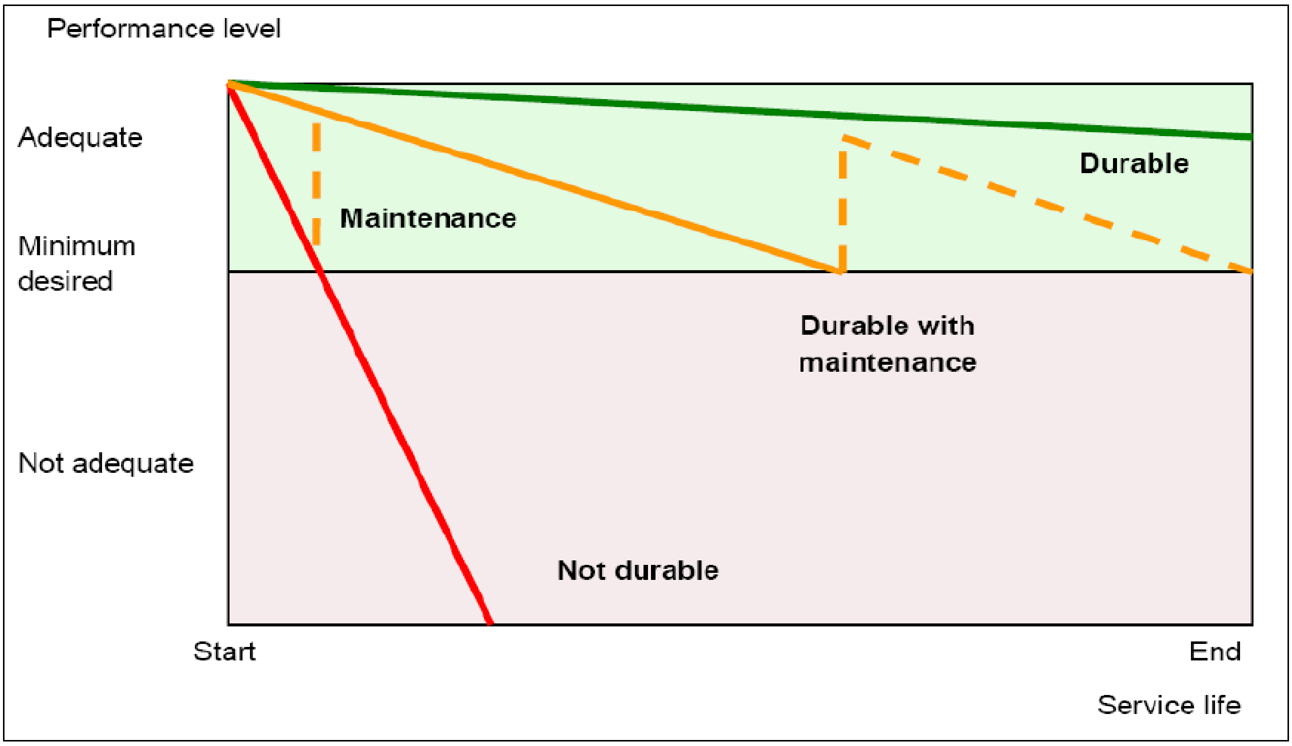


Figure 2.1: durability related to performance level in time

As shown in figure 2.1 in order to be durable, a construction has to meet its minimum desired performance level during its service life. When for some reason the performance level is not adequate anymore maintenance can restore it to an adequate level. This maintenance can be planned in advance or be unforeseen. In both cases it will involve costs, not only the actual costs but also additional costs when the construction can't be maintain in operative service.

Typically for modern economies infrastructure requires a long service life with no, or only as little as possible maintenance in order to keep the overall economic costs within control. A high performance level at the start and only a slow deterioration over time is a critical consideration.

2.2 Durability of concrete

When the durability of concrete is considered there is normally no reference to time. The only thing mentioned in literature is that concrete has to withstand chemical, physical or mechanical impact from the environment.

For design purposes a period of 50 years is considered as normal. But especially for infrastructure a design life of 100 or even 200 years is sometimes more appropriate.

2.3 Durability of a concrete construction

When we combine durability of a construction with durability of concrete the following definition of durability of a construction made of concrete can be formulated.

> A durable construction made of concrete, is able to perform during its service life at a minimum required service level with or without foreseen maintenance. To meet this requirement the concrete has to withstand chemical, physical or mechanical impact from the environment.

From this definition new questions arise which have to be answered:

1. Which performance is required from concrete?
2. What exactly are those impacts from the environment?
3. What influences the rate of deterioration?

2.3.1 Performance of concrete

Concrete has to fulfill the following requirements during its service life:

- take on all (compressive) tensions without exceptional deformation;
- to protect the reinforcement against high temperatures and corrosion;
- (when needed) a visually attractive surface

2.3.2 Service life influencing factors

All of the service life influencing factors on concrete and on reinforcement are mentioned in figure 2.2 and figure 2.3 respectively.

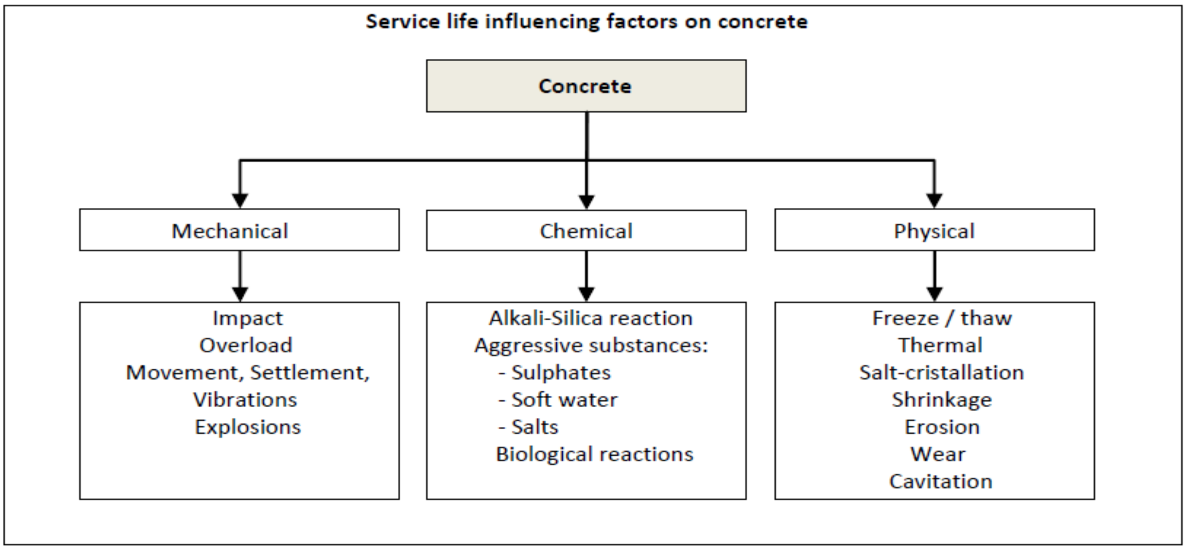


Figure 2.2: direct and indirect influencing factors on concrete according to EN 1504-9

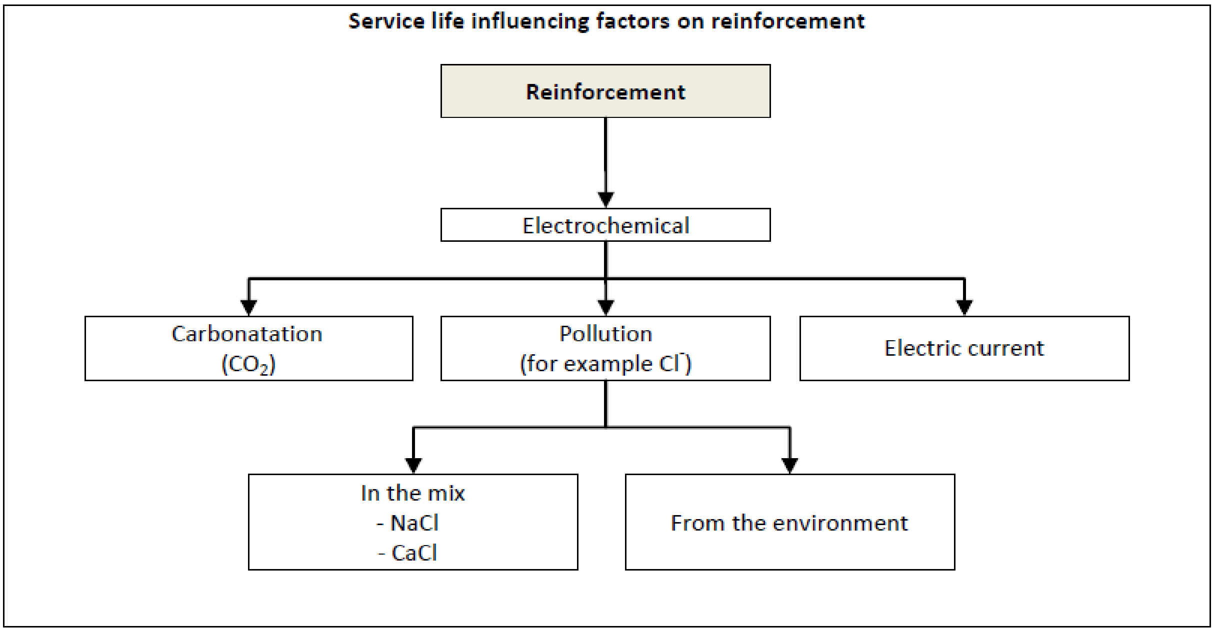


Figure 2.3: direct and indirect influencing factors on reinforcement according to EN 1504-9

2.3.3 Rate of deterioration

In order for concrete to deteriorate in most cases liquids or gases are needed, like for example carbon dioxide, oxygen, water, sulphates, alkalis, etcetera, which have to be transported from somewhere outside the concrete into the inner structure. Transportation processes and the available pores play a very important role.

The following pores and voids are present in the (micro-)structure of concrete:

Gel-pores
Gel-pores are formed within the CSH-gel during the hydration process. These pores are relatively small (< 2 nanometer) and are considered not to be available for transportation processes. No harm can be expected from this kind of pores.

Capillary pores
Capillary are also formed during the hydration process.(In these pores) The size of these pores are in the range of 10 to 1000 nanometer (1 micrometer). They can be interconnected and are filled with water which has not been used in the hydration process. All kinds of salts are dissolved in this water. The transport of gases and salts is possible and relatively easy in these pores.

Micro-cracks
Micro-cracks will occur locally when the tension exceeds tensile strength during hydration. The size of these cracks is in the range of 1 to 100 micrometer. Such micro-cracks could facilitate the transportation of dissolved contaminants.

Air-voids
Air voids could be entrained by using an air entrainer or could be formed during the mixing process. The average size is about 0,1 mm (100 micrometer). Entrained air voids will be in the range of 10 to 60 micrometer. Air voids normally will slow down transportation because these voids will interrupt the capillary pores.

Voids
Voids are the result of bad compaction or could be formed below coarse aggregate particles or reinforcement. The size is about 1 mm. Voids could facilitate the transportation when they are interconnected, but they could also function as a storage for harmful material.

Cracks
Cracks will form as a result of mechanical forces, physical processes or chemical reactions. The size will vary between 100 micrometer and several millimeters or even bigger. Also cracks can easily facilitate the transportation, but can also function as a storage for harmful material.

ConcreCem and Freeze-thawing Resistance

Concrete with the addition of ConcreCem is also tested on freeze-thaw behavior. A 50 mm thick samples was sawn from a cube 150 mm x 150 mm x 150 mm. A 3 mm thick rubber sheet was glued to all surfaces except the test surface. When the concrete was 28 days old, a layer of about 3 mm deep de-ionised water was poured on the top surface. This saturation was kept for 3 days. After 3 days (dated 18-5-2009) the de-ionised water was replaced by a solution of 97% by mass of de-ionised water and 3% by mass of NaCl and all surfaces of the samples (except the top surface) were thermally insulated with 20 mm thick polystyrene cellular plastic. The insulated samples was stored in a climate chamber which subjects the samples to repeated freezing and thawing during 56 cycles according to the time - temperature cycle mentioned in figure 8.1. After 56 cycles scaling of the samples was measured.

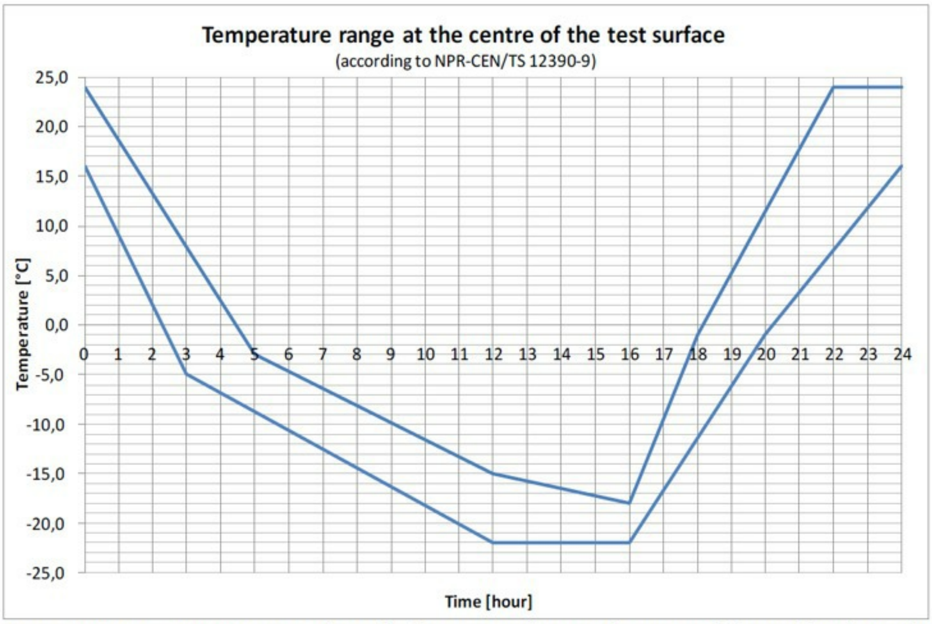


Figure 8.1: Time- Temperature cycle in the freezing medium at the centre of the surface (according to NPR CEN TS 12390-9)

Figure 8.2 shows several impressions of the testing procedure.

The tested samples is a steel-fibred concrete with 0,3% ConcreCem. After 7 cycles no scaling was determined. After 14 cycles only the fibres are corroded as can be seen in figure 5.4 but still no scaling appears.

Figure 8.3: Surface of steel-fibred concrete with 0,3% ConcreCem at 7 cycles of freeze-thaw testing and after 14 cycles.

Figure 8.2: Impressions of testing freeze-thaw behavior,(Nummering volgorde klopt niet)

Freeze-thawing tests are also performed to concrete of 205 days old, with and without the addition of ConcreCem. Except for the amount of ConcreCem both mixes have an identical mix design.
As can be seen in the following pictures, the concrete with 0,3% ConcreCem has clearly fewer scaling than the concrete without ConcreCem.

The concrete without ConcreCem had a weight loss of 3,6 kg/m^2 , whereas the concrete with 0,3% ConcreCem had a weight loss of a marginal 0,7 kg/m^2 only.

Figure 8.3: Surface of 205 days old concrete ***without ConcreCem*** *after 14 cycles of Freeze-thawing*

Figure 8.4: Surface of 205 days old concrete ***with*** *after 14* ***0,3% ConcreCem*** *after 14 cycles of Freeze-thawing*

After 28 cycles the mass of scaling is also measured and figure 8.5 shows the amount of scaling of the concrete with and without the addition of 0,3% ConcreCem. The difference in the amount of scaling is really huge!

Figure 8.5: Amount of scaling of the concrete with and without the addition of 0,3% ConcreCem

The addition of ConcreCem provides enhanced durability. This cannot easily be calculated and expressed in hard currency. It remains very difficult to calculate the costs of repairing concrete in which no ConcreCem was used. For instance the damage caused by freeze-thawing as shown in this chapter. **The use of only 0,3% ConcreCem will reduce freezing-thawing damages fivefold!**

For us the question remains how can we calculate these benefits, however the customer or authority faced with the annual repair bill can quickly make this calculation!

ConcreCem against chloride induced corrosion of reinforcement

exterra concrete technology

Most concrete structures show good performance over a long period of time, partly as a result of the passive environment provided by the concrete to the reinforcing steel. However, changes to the concrete environment itself (for example using salt water or salt aggregate) can make it possible to change the corrosiveness leading to the initiation of corrosion beneath apparently solid concrete.

Very often the first indication of the problem is the appearance of a crack following the line of the reinforcement, or the development of rust stains in porous concrete. The corrosion of steel produces products which have a 2 to 3 times the volume of the original metal. This causes tensile stress which results in cracking and spalling of the concrete cover. Figure 7.1 shows examples of chloride induced corrosion of reinforcement.

Figure 7.1: Examples of chloride induced corrosion

To see if an admixture causes corrosion of steel, the European standard EN 480-14 ("Admixtures for concrete, mortar and grout – Test methods – Part 14: Determination of the effect on corrosion susceptibility of reinforcing steel by potentiostatic electrochemical test") describes a test method. The test cell layout is shown in figure 7.2 and 7.3. The maximum current between 1 hour and 24 hours is measured and the maximum current density is calculated as $\mu A/cm^2$ using the calculated area of the rebar in contact with mortar.

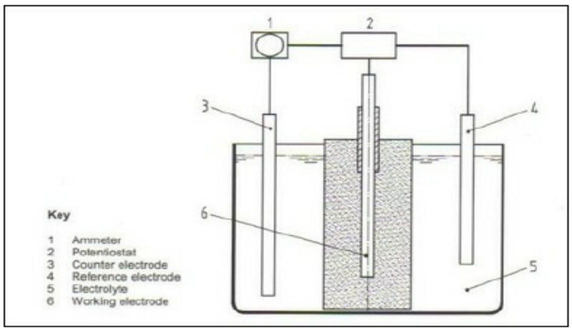


Figure 7.2: Test cell layout according to EN 480-14

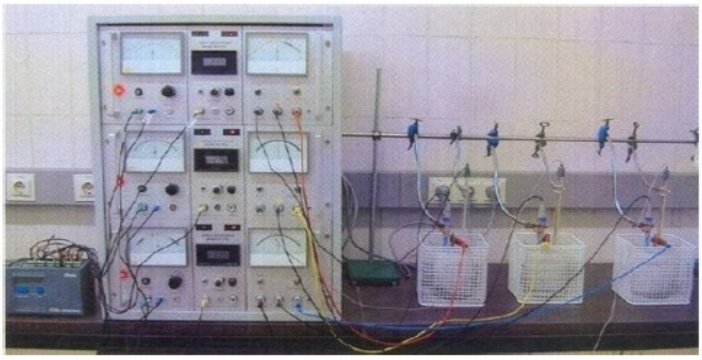


Figure 7.3: Test cell lay-out lined up in MPA Stuttgart

Tests have been performed in accordance with the mentioned method to see what happens if the maximum dosage of chlorides is added in the reference mortar mix according to EN 196-1. After testing the samples were split. The samples on the left of figure 5.21 was already split during testing. In this samples 10% Chlorides, by mass of cement were added. This is an extremely large amount of chlorides and the influence on the reinforcement steel can clearly be seen in figure 7.4.

Figure 7.4: Samples after testing according to EN 480-14

EN 934-1 prescribes requirements for the current density. The current density shall not exceed 10 µA/cm^2. At MPA in Stuttgart ConcreCem was tested according to EN 480-14. The reference mix (without ConcreCem) had a mean (n = 3) current density of 0,4 µA/cm^2. The mix with 0,8% ConcreCem by mass of cement had a current density of 0,4 µA/cm^2. This is in the same range as the reference mixture and considerably below the limit mentioned in the EN 934-1. Figure 7.5 shows the test results of MPA Stuttgart of the reference mortar and the mortar with 0,8% ConcreCem.

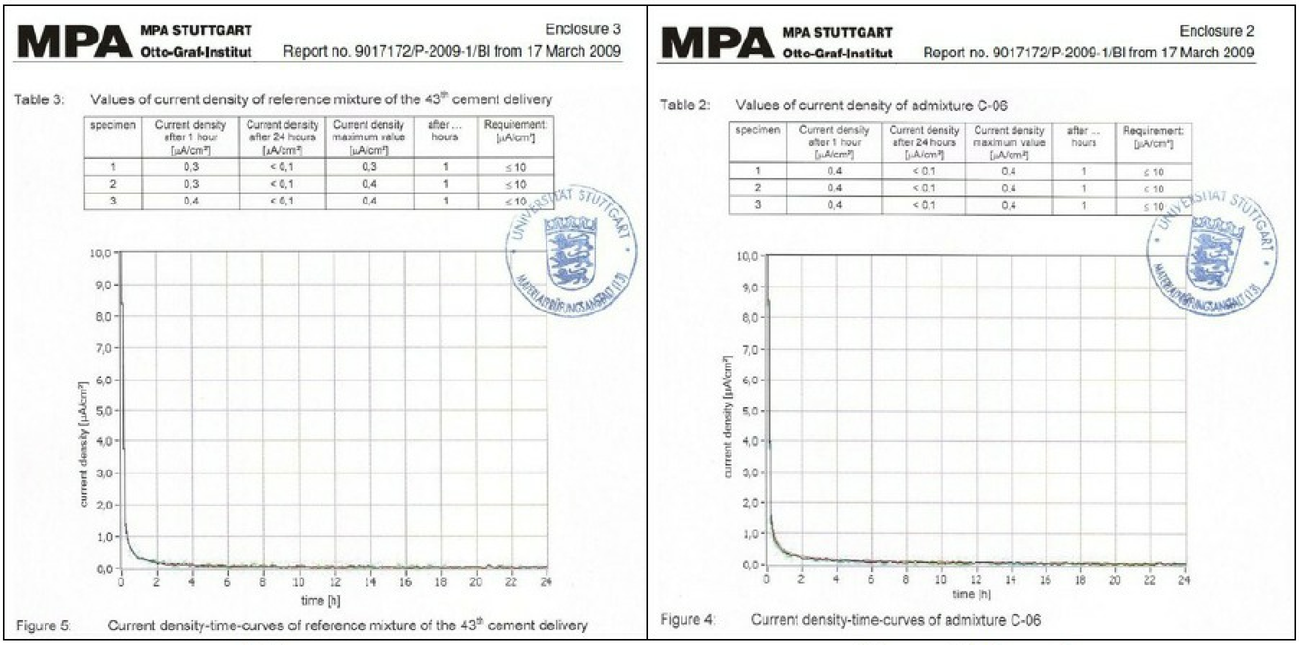

MPA STUTTGART Otto-Graf-Institut — Enclosure 3 — Report no. 9017172/P-2009-1/BI from 17 March 2009

Table 3: Values of current density of reference mixture of the 43th cement delivery

specimen	Current density after 1 hour [µA/cm²]	Current density after 24 hours [µA/cm²]	Current density maximum value [µA/cm²]	after ... hours	Requirement: [µA/cm²]
1	0,3	< 0,1	0,3	1	≤ 10
2	0,3	< 0,1	0,4	1	≤ 10
3	0,4	< 0,1	0,4	1	≤ 10

Figure 5: Current density-time-curves of reference mixture of the 43th cement delivery

MPA STUTTGART Otto-Graf-Institut — Enclosure 2 — Report no. 9017172/P-2009-1/BI from 17 March 2009

Table 2: Values of current density of admixture C-06

specimen	Current density after 1 hour [µA/cm²]	Current density after 24 hours [µA/cm²]	Current density maximum value [µA/cm²]	after ... hours	Requirement: [µA/cm²]
1	0.4	< 0.1	0.4	1	≤ 10
2	0.4	< 0.1	0.4	1	≤ 10
3	0,4	< 0.1	0.4	1	≤ 10

Figure 4: Current density-time-curves of admixture C-06

Reference mortar *Mortar with ConcreCem*

Figure 7.5: Test results of the reference mortar and mortar with 0,8% ConcreCem

Although ConcreCem is characterized for CE-label as a hardening accelerator, it is far from the same as an admixture based on Calcium-Chlorides. This type of admixture was used in a reference mortar in an amount of 1,2% and 2,4% by mass of cement. The admixture was a liquid with a solid content of 33%. The amount of liquid CaCl of 2,4% is similar to the amount of ConcreCem used in the tests performed by MPA Stuttgart.

The two mixes with CaCl were tested according to EN 934-1 and the current density measured in the samples with 0,8% CaCl was beyond the range of the test-equipment (more than 54 µA/cm^2). ***The mix with 0,4% CaCl didn't meet the requirements of 10 µA/cm^2***. The maximum measured current density was 52 µA/cm^2. More than 5 times higher than the allowed limit. Figure 7.5 shows test equipment and test results of this mix.

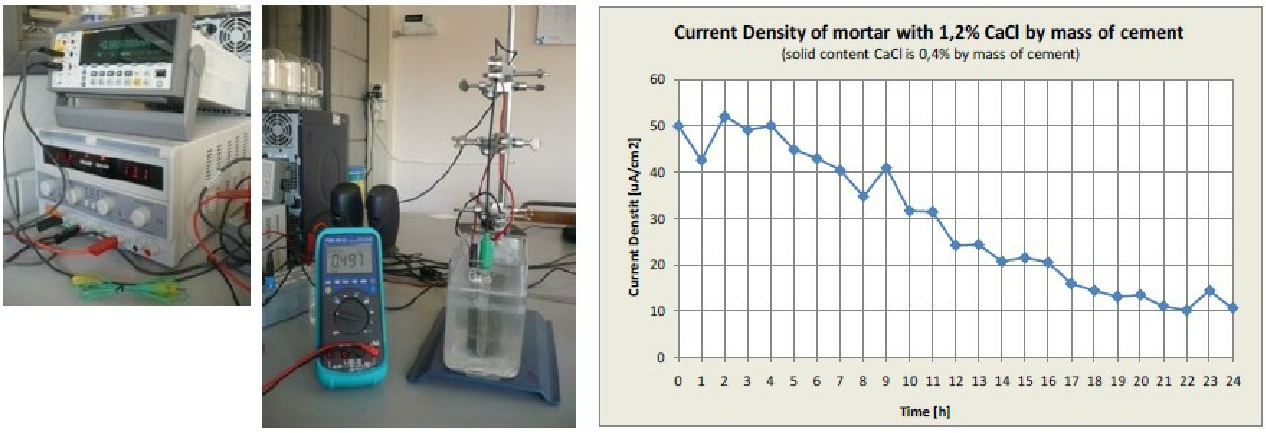


Figure 7.6: Pictures of testing equipment and test results of the mortar with 1,2% CaCl by mass of cement (solid content is 0,4% by mass of cement)

ConcreCem protects against deterioration by Hydrochloric and Sulphuric acid

ConcreCem increases the durability of concrete, because of the chemical reaction between water and cement particles inside the concrete. To validate this statement tests with immersion of specimen in **hydrochloric** and **sulphuric acid** were executed.

6.1 Hydrochloric acid (36% M - 1,19 g/ml)

Two regular mortar samples of a 28-days-days-old mixture (prepared with saltwater and salt Sahara sand) have been immersed in a solution of **hydrochloric acid**. One sample was a mixture with 0,3% ConcreCem and the other was the same mixture but then without any ConcreCem added. The **hydrochloric acid** had a pH-value of 0,45.
Immediately after being immersed the samples were getting damaged. Figure 6.16 shows several pictures of the immersion in **hydrochloric acid** and the deterioration of the samples.

Figure 6.1: Immersion in 36% M hydrochloric acid (pH = 0,45) and deterioration of the prisms

The loss of weight was measured after a couple of minutes. Table 6.1 shows the results and figure 6.2 shows these results in a graph.

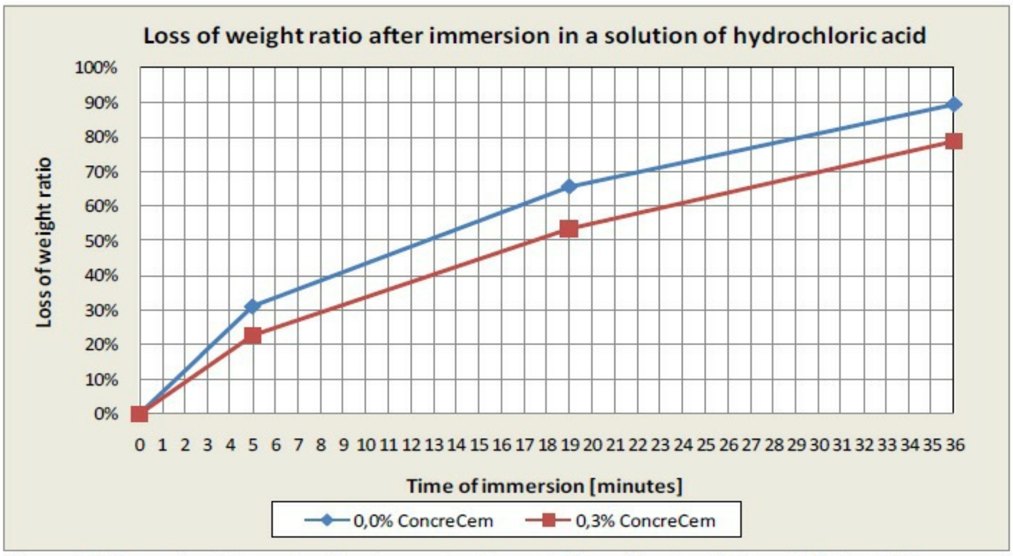
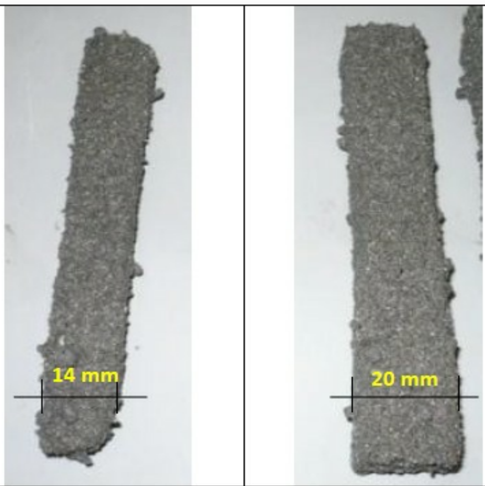


Figure 6.2: Loss of weight ratio after immersion in a solution of hydrochloric acid (pH = 0,45)

Table 6.1: Results loss of weight (ratio) after immersion in hydrochloric acid

Time of immersion [minutes]	Loss of weight of prisms [g]			
	Mix 1 **0,0% ConcreCem**		Mix 2 **0,3% ConcreCem**	
0	537,1	0%	550,9	0%
5	370,2	31%	425,8	23%
19	184,1	66%	256,4	53%
36	56,6	**89%**	117,4	**79%**

The mixture with 0,3% ConcreCem (mix 2) has a lower weight loss ratio than the mixture without ConcreCem. Figure 6.3 shows the difference in weight loss after 36 minutes. We can clearly see that there is more left of the samples with ConcreCem than the samples without ConcreCem. Normally a sample is 40 mm in width. After 36 minutes immersion in hydrochloric acid the width of the sample without ConcreCem decreases to 14 mm and the width of the sample with 0,3% ConcreCem decreases to 20 mm. There is a difference in width of 6 mm (as can be seen in figure 6.3). As calculated to the width of a sample this difference is 15%.
In this test the samples were exposed to the worst possible scenario of an acid-attack with a pH-value of 0,45. In reality this process will be much slower. However, the mortar mix with ConcreCem is more resistant to these attacks than the mixture without ConcreCem.



Mix 1: 0,0% ConcreCem sample in hydrochloric acid

Mix 2: 0,3% ConcreCem sample in hydrochloric acid

Figure 6.3: samples after 36 minutes of immersion in hydrochloric acid

6.2 Sulphuric acid (37% - 1,28 g/ml)

Tests with 273 days old normal weight concrete (water-cement-ratio = 0,51) without ConcreCem and with 0,3% ConcreCem in **sulphuric acid** (37% M) are executed. Figure 6.4 shows the dried specimen immersed in water and in **sulphuric acid** for 16 days.

273 days old concrete **without ConcreCem**

273 days old concrete with **0,3% ConcreCem**

Immersed in water | immersed in sulphuric acid

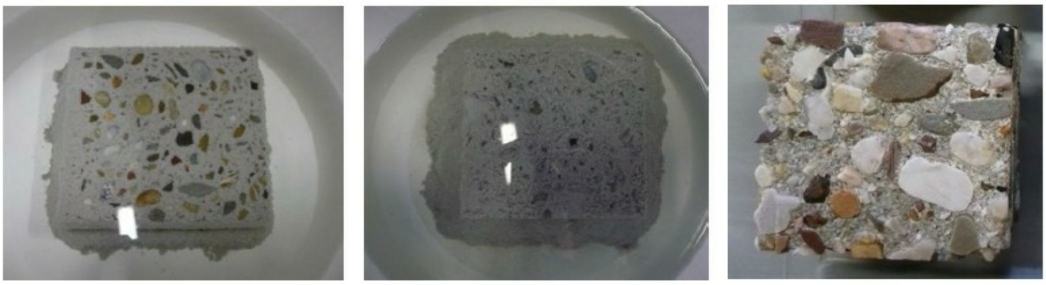
Immersed in water | Immersed in sulphuric acid

Figure 6.4: Specimen immersed in water and in Sulphuric acid

Figure 6.5 shows the steps of deterioration after immersion in sulphuric acid of concrete specimen without and with 0,3% ConcreCem.

1 day | 4 days | 16 days

273 days old normal weight of concrete **without ConcreCem** after immersion in Sulphuric acid (37% M)



1 day | 4 days | 16 days

273 days old normal weight of concrete **with 0,3% ConcreCem** after immersion in Sulphuric acid (37% M)

Figure 6.5: Steps of deterioration after immersion in sulfuric acid of concrete samples without and with 0,3% ConcreCem

After a safe curing period of 273 days the first class concrete samples are placed for 16 days in a sulphuric acid bath. After such a long period of perfect conditioning the samples are exposed for a period in an aggressive environment with a 37% M Sulfuric concentration, visually no engraving differences so far. However checking the physically/mechanically behavior and reduction in compressive strength we see an impressive difference in advance of just this minor quantity of ConcreCem. Safety and security especially within the framework of sensitive applications is possible if the end product can be marked as durable or long lasting!!!

After immersion in sulphuric acid the specimen were dried in a ventilated oven and tested on compressive strength. Table 6.2 shows the results.

Table 6.2: Compressive strength before and after immersion in sulphuric acid

Compressive strength [N/mm^2]			
Mix (water-cement-ratio = 0,51)	28 days old specimen stored in water	289 days old specimen stored in water	273 days old specimen stored in water + 16 days stored in Sulphuric acid
0,0% ConcreCem	42,7	59,2	**34,7** (41% strength loss)
0,3% ConcreCem	47,3	59,8	**42,3** (29% strength loss)

First of all there is an increase in compressive strength after 289 days compared to the compressive strength after 28 days. But immersion in **sulphuric acid for 16 days** decreases compressive strength of concrete **without ConcreCem** with **41%**. **Adding a minor quantity of 0,3% ConcreCem will lower this deterioration in this mix design with just 12%!**

I t can be concluded that ConcreCem indeed increases durability! An higher percentage of CC gives a higher resistant against all types of chemicals like Sulphuric acids, Hydrochloric based acids, Ammoniac based substances etc.

ConcreCem Field applications

ConcreCem has successfully been applied in different kinds of field applications where details and durability are critical. Some project examples are given below.

Landing strip repair Air Force Pretoria South Africa

Landing strip repair (electronically devices)??? for **Air Force Pretoria South Africa**




Taxi trip repair Airport Weeze Germany

Repair Taxi strip Airport Weeze (former NATO base) at Germany

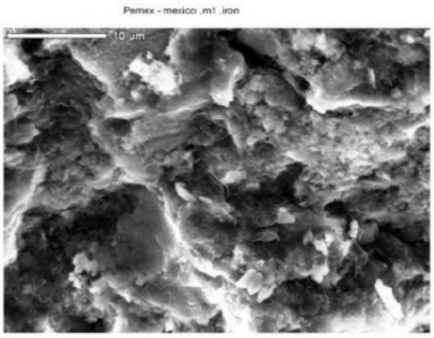


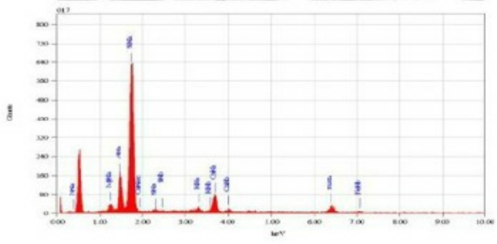


Concrete repair at Chemical Factory Mexico

Repair concrete columns and beams at **Chemical Factory in Mexico**

An investigation and repair of concrete corrosion caused by air pollution (SO_x and NO_x impact).
ConcreCem prevents future corrosion of the reinforcement.





Parts of concrete fallen from the damaged concrete columns and concrete beams

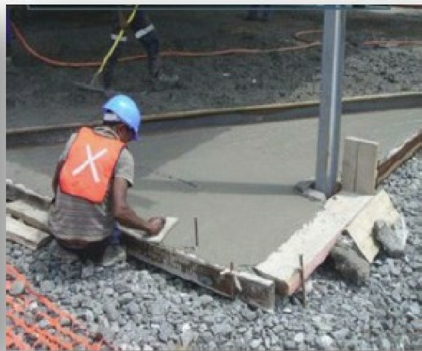
Air pollution and sulphur emissions are causes of acid rain and humidity which are working abrasively and could be responsible for concrete corrosion. ConcreCem is not only a superior solution for repairing older and damaged concrete structures it is also a superior product to protect new concrete structures under various types of chemically aggressive environments whilst withstanding heavy physical and mechanical challenges.

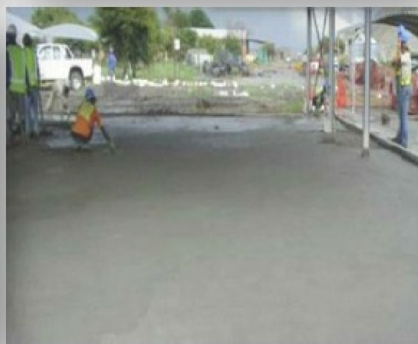
Concrete slab South Africa

A company in South Africa requested PowerCem Southern Africa a solution for a concrete floor, without joints, and applied on a average bearing layer. A concrete slab of 375 m^2 was applied with traditional concrete modified with ConcreCem. ConcreCem is used to significantly enhance the physical and mechanical properties of the monolith structure. ConcreCem also contributes to more flexibility and a faster binding process.

The Slab with a thickness of 200 mm was applied on a granular foundation that was directly applied on the black cotton clay soil. The slab has **no** reinforcement and **no** expansion joints. After 4 months of intensive mechanical use the flexible concrete layer is in great shape! In the mixture 300 kg Cement and 2,1 kg ConcreCem were used per 1 cubic meter of concrete with a water/cement ratio of 0,55.





ConcreCem actually benefits from the sustainable addition of PFA in the production of mortars and Concretes.

It has been shown that the effect of ConcreCem additive on mortar and concrete strength improves significantly when it is used in conjunction with PFA.

When 30 % PFA was used to replace CEM 1 with 0.6 % ConcreCem additive in concrete, there was 21.3 % increase in compressive strength at 180 days when compared to the control.

With 0.6 % ConcreCem additive and cement alone alone, a small increase of 7.5 % in compressive strength was observed at 180 days.

Accelerated compressive strength test on mortar samples also showed 25.6 % increase in compressive strength with 0.6 % ConcreCem + 30 % PFA sample at 28 days and 12.6 % increase in compressive strength with 0.6 % ConcreCem additive without PFA at 28 days.

Results show that ConcreCem additive is most effective when used in the presence of PFA. It also was found that when ConcreCem additive is used at low dosages of 0.4 % and 0.6 % it causes a reduction in expansion due to sulphate attack.

Though with higher dosages of ConcreCem additive, greater expansion occurs when compared to control samples.

This result indicates that the optimum proportion of ConcreCem additive to be used must lie in the range between 0.4 % and 0.6 % and going higher is detrimental to results.

ConcreCem used in concrete clearly reduces carbonation. Carbonation depth was reduced by up to 21 % in concrete of 28 days' age due to use of 0.6 % ConcreCem additive alone.

Confirming the optimum proportion for use of ConcreCem additive in mortars and concrete lies between 0.4 % and 0.6 %.

Within this range of proportions, ConcreCem additive increases late flexural strength, split tensile strength, and compressive strength of mortars and concretes. It also decreases permeability, sorptivity, porosity, and expansion due to sulphate attack.

The proven low optimum use of ConcreCem and the environmental benefit of added PFA makes ConcreCem environmentally and economically beneficial.

UNIVERSITY OF THE
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Certificate

Number 0620-CPD-49855/02 Replaces 0620-CPD-49855/01

Issued 2010-09-01 First edition 2009-05-15

EC-FPC CERTIFICATE
AoC-level 2+

Notified Body 0620, Kiwa N.V. has determined that

PowerCem Technologies

fulfils all provisions concerning the attestation of factory production control (FPC) described in Annex ZA of the standards EN 934-2.

Product:
Hardening accelerating admixture ConcreCem

Task PowerCem Technologies	Task Kiwa N.V.
Factory Production Contol	Initial inspection of FPC
Initial Type Testing	Certification of FPC
Further Type Testing	Surveillance of FPC

B. Meekma

Bouke Meekma
Director Kiwa Nederland B.V.

This certificate consists of 2 pages .
Publication of the certificate is allowed.

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