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Chloride Ingress in Concrete

A Sensitivity Analysis of the Input Parameters in the fib Model for Chloride Ingress and a Validation of the Model for Short Exposure Times

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Sammendrag

Transport av klorider i betong er en kompleks prosess. Det finnes mange forskjellige modeller som beskriver transporten av klorider i betong, en av disse er fib modellen. fib modellen er basert på en feilfunksjons løsning av Ficks andre lov for diffusjon. Modellen er relativt lett å bruke i forhold til mange andre modeller og tar utgangspunkt i at transporten av klorider skjer ved diffusjon. Det er antatt at betongen er homogen, uten riss og at kloridtransporten er endimensjonal i ett makro perspektiv.

Målet med denne oppgaven er å undersøke sensitiviteten til parameterne som inngår i fib modellen, samt å se på hvordan modellen fungerer som ett verktøy for å beskrive transporten av klorider i betong. For å gjøre dette blir en sensitivitetsanalyse, en differensial analyse og en sammenligning mellom eksponeringsdata og projeksjoner produsert av fib modellen gjennomført.

Fra sensitivitets analysen ser vi at overflatekonsentrasjonen, aldringsfaktoren og dybden har en stor innvirkning på kloridinnholdet beregnet med fib modellen. En stor variasjon i kloridinnholdet er observert mellom den største og den minste verdien for hver av de enkelte variablene. En liten endring i hver enkelt av disse tre variablene vil også ha en betydelig innvirkning på resultatene fra fib modellen. Fra differensial analysen er det observert at aldringsfaktoren og dybden har de største førsteordens sensitivitetskoeffisientene, nesten to ganger større enn for kloriddiffusjonskoeffisienten og overflatekonsentrasjonen.

En liten endring i transformasjonsfaktoren og parameteren som beskriver temperaturen til konstruksjonselementet eller den omsluttende luften resulterer i en liten endring i kloridinnholdet i betongen. Parameteren med minst innvirkning på resultatet er regresjon variabelen.

De mest sensitive parameterne, som derfor trenger å bli bestemt så nøyaktig som mulige er aldringsfaktoren α, klorid migrasjons koeffisienten $D_{RCM,0}$, overflatekonsentrasjonen C_s og dybden a. Parameterne som er mindre viktig og kan brukes med en større spredning uten å påvirke resultatet nevneverdig er transformasjonsfaktoren k_t, regresjon variabelen b_e og temperaturen til konstruksjonelementet eller den omsluttende luften T_{real}.

Projeksjoner produsert av fib modellen for betongblanding som inneholder flyve aske er ikke så nøyaktige som ønsket. For betongblandinger som inneholder ordinær Portland sement er projeksjonene ganske gode. For en eksponeringstid på 5 år, underestimerer fib modellen kloridinnholdet når dybden er større enn 25 mm. Med en eksponeringstid på 2 år, blir det observert ett lite overestimat. Finheten til sementen har en innvirkning på resultatet, grovere sement gir et mere nøyaktig resultat en fin sement.

Abstract

Chloride transport in concrete is a rather complex process. There are numerous different models one can use to estimate chloride ingress in concrete. The fib model code presents a model based on an error function solution to Fick’s 2nd law, called the fib model. The fib model is relatively simple to use compared to other approaches. In this model, a difference in concentration is the driving potential for the chloride transport. It is assumed that the concrete is crack free, homogeneous and that the chloride ingress is one dimensional at macro-scale.

The aim of this thesis is to investigate which of the fib model input parameters that have the highest level of sensitivity and how the model performs as a tool for predicting the transport of chlorides into concrete for an exposure time of 2 and 5 years. To accomplish this, a sensitivity analysis, a differential analysis and a comparison between exposure data and predictions made by the fib model will be performed.

From the sensitivity analysis, we see that the chloride surface concentration, the ageing exponent, the chloride migration coefficient and the depth at which we want to know the chloride content has a large impact on the predicted chloride content. A large change in the chloride content is observed when these parameters are varied from the highest to the lowest value within their range. A small variation in these parameters will also have a significant impact on the chloride content. From the differential analysis we see that the ageing exponent and the depth at which we want to determine the chloride content are the parameters with the largest absolute value of the first order sensitivity coefficients, almost two times larger than the apparent diffusion coefficient and the surface chloride content.

A change in the transfer variable and the parameter that describes the temperature of the structural element or the ambient air results in a small change in the chloride content. The parameter with the least influence on the chloride content is by a large margin the regression variable.

The input parameters that have the largest sensitivity and therefore needs to be determined with a high level of accuracy is the ageing exponent, chloride migration coefficient, chloride surface concentration and the depth at which we want to determine the chloride content. Parameters that are less important and can be used with a bigger scatter without influencing the model to a critical degree is the transfer variable, the regression variable and the temperature of the structural element or the ambient air.

Predictions made by the fib model for concretes containing fly ash is not adequately accurate. For concretes composed of OPC the predictions made by the fib model is quite accurate. For an exposure time of 5 years, the fib model slightly underestimates the chloride content at depths greater than 25 mm. After 2 years we see a slight overestimation. The fineness of the cement has an impact on the predictions, a coarse cement blend gives a more accurate prediction than a fine cement blend.

Preface

This thesis has been written as the last step of a master's degree in structural engineering with a specialisation in concrete technology at the Norwegian University of Science and Technology in Trondheim. The work has been done over a period of 20 weeks. Prior to this thesis the author had a very limited knowledge on the subject. Chloride ingress and especially models that describe chloride ingress has only been mentioned in a few lectures.

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C_{crit}	Critical chloride content [%mass of cement]
$C(x,t)$	Chloride content at a time t and depth x [%weight of cement]
C	Chloride content [%weight of cement]
C_0	Initial chloride content [%weight of cement]
c_0	Chloride content with the variable parameter set to its base value [%weight of cement]
$C_{s,\Delta x}$	Chloride content at depth of Δx and a certain point of time t [%weight of cement]
$C_{S,0}$	Chloride saturation concentration [%weight of cement]
C_S	Chloride surface concentration [%weight of cement]
C_{eqv}	Potential chloride impact [g/l]
$C_{0,M}$	Natural chloride content of sea water [g/l]
$C_{0,R}$	Average chloride content of the chloride contaminated water [g/l]
$C_{R,i}$	Average amount of chloride spread within one spreading event [g/m^2]
ΔC	Change in chloride content [%wt. of cement]
x	Depth [mm]
a	Concrete cover [mm]
t	Concrete age [years]
Δx	Depth of the convection zone [mm]
$D_{app,C}$	Apparent chloride diffusion coefficient in concrete [mm^2/years]
$D_{RCM,0}$	Chloride migration coefficient [mm^2/years]
erf	Error function [-]
k_e	Environmental transfer variable [-]
k_t	Test method variable (transfer variable) [-]
$A(t)$	Ageing function [-]
t	Concrete age [years]
t_0	Reference concrete age (reference point of time) [years]
α	Age exponent [-]
b_e	Regression variable [K]
T_{ref}	Test temperature in [K]
T_{real}	Temperature of the structural element or the ambient air [K]
n	Average number of salting events per year [-]
$h_{S,i}$	Amount of water from rain and melted snow per spreading period [l/m^2].
X	Vector representing the governing parameters
X_0	Base value vector
S_j	Normalized first order sensitivity coefficient [-]

1 Introduction

1.1 Motivation

Reinforced concrete is one of the most important structural materials used in the construction industry worldwide due to its low coast, availability, formability and excellent structural and durability properties (Morris et al. 2002). However, certain physical and chemical factors in the service environment can contribute to a premature deterioration and failure, one of the most significant factors is rebar corrosion. There are several factors that influence the rebar corrosion process and one of these are chloride ions in concrete. It is therefore of great importance for the designer to understand how chloride ions are transported into concrete and be able to predict the chloride content in the concrete. To make a prediction on chloride ingress over time it is important to have a model which is easy to use and also describes the processes of chloride ingress in concrete with a high level of certainty. It is important to be aware of the uncertainties of the predictions made by the model and understand its strength and weaknesses.

This thesis will present a model for predicting the chloride ingress as well as describing which of the parameters that are most important to determine with a high level of accuracy and make the designer aware of the models strengths and weaknesses. This will help increase the confidence in the results produced by the model and also highlight the limitations and benefits in using this model.

1.2 Research question

The aim of this thesis is to investigate which input parameters that have the highest level of sensitivity and therefore needs to be determined as accurately as possible, and which of the parameters that have little or none impact on the results. This is done by performing a sensitivity analysis.

The full probabilistic chloride ingress model described in fib model code 2006, the fib model, will be investigated to see how the model performs as a tool for predicting the transport of chlorides into concrete structures. This will be done by comparing exposure data and projections made by the fib model. Together with the sensitivity analysis this will increase the confidence in the results and help the users to be aware of the models strengths and weaknesses.

1.3 Limitations

In this thesis it is assumed that the concrete is homogeneous, crack free and that the chloride ingress is one dimensional at macro scale. Validity of the fib model is only investigated for an exposure time of 2 and 5 years.

2 Background

2.1 Chloride transport in concrete

Chloride transport in concrete is a rather complex process. It involves diffusion, physical and chemical binding, capillary suction and migration. The two main mechanisms of chloride transportation in concrete are diffusion and migration. (Luping et al. 2012)

“Diffusion is the movement of a substance under a gradient of concentration, more strictly speaking, chemical potential, from an area of high concentration to an area with of low concentration.”(Luping et al. 2012) Where only the free chloride ions in a solution can contribute to a concentration or chemical potential. “Migration is the movement of a charged substance under the action of an electrical field. As in diffusion, only free chloride ions in a solution can contribute to the flow of migration.”(Luping et al. 2012)

Diffusion and migration assume that there are no water movement or exchange within the concrete. In reality concrete structures may be exposed to an environment where a gradient of water pressure exists. In these cases, other transportation mechanisms may occur such as:

- Hydraulic flow
- Capillary suction in an unsaturated pore system, caused by the surface tension of pore walls
  (Luping et al. 2012)

2.2 Chloride ingress

Chloride-ingress models generally make the assumption that the concrete is crack-free, homogeneous and that the chloride ingress is one dimensional at macro-scale. This might be too simplistic, even if the concrete is well mixed and compacted. The wall effect will create a binder content profile that is closer to a cast surface, if the penetration depth is small enough this will have a significant effect on the chloride profile. Vertical separation will result in differences in the water-to-binder ratio across the height of the structural element. (Luping et al. 2012)

Over time a number of different effects will change the concrete, these changes can be different at different depths depending on the initial curing conditions and the exposure conditions during the structures service life, these include:

- Continues binder reaction, resulting in a densification of the concrete and as a consequence a change in the pore system.
- Wetting and drying of the concrete causing shrinkage and swelling
- Carbonation

(Luping et al. 2012)

When working with chloride transport in concrete it is important to be aware of the effect of chloride binding. Bound chloride is usually assumed to be harmless to the reinforcement, but mechanisms such as sulphate ingress and carbonation can cause the bound chlorides to be released inside the concrete, effectively increasing the content of free chlorides inside the concrete. (Luping et al. 2012)

2.3 Service life analysis

Service life analysis can be used as a valuable tool in assessing, how much a certain change in the design can increase the service life of a reinforced concrete structure. It also provides a good basis for developing a maintenance plan.

Chloride itself does not directly result in any damage to the concrete under normal circumstances, but can induce corrosion of the reinforcement. The two most common sources of chlorides regarding concrete structures are seawater and de-icing salts. Chloride induced corrosion can lead to delamination and spalling of the concrete as well as sever pitting corrosion. In order to predict the service life of reinforced concrete structures exposed to chloride environments it is important to understand the mechanisms of chloride ingress and the concretes resistance to these mechanisms. Challenges involved in predicting the service life of a reinforced structure include:

- The environmental load is not constant
- Concrete is composed of different types of cement and binder, causing the properties of hydrated cement to evolve over time
- Transportation of chloride is not confined to one mechanism and may be a combination of several

(Luping et al. 2012)

2.4 Previous work on the subject

To the authors knowledge no previous work has been done on this subject with the same approach as the work presented in this thesis. There are however two studies done on the same subject with a different approach.

Luping et al. has written a book called “Resistance of Concrete to Chloride Ingress: Testing and modelling”, published in 2012. The book contains a description of basic mechanisms for chloride transport in chloride, analytical and probabilistic approaches for sensitivity analysis of various models including the The DuraCrete model. A model very similar to the chloride ingress model described in the fib model code. It also presents the results of benchmarking evaluation of different models describing chloride ingress in concrete. (Luping et al. 2012)

Zhang and Lounis have written and article in Cement and Concrete Research called “Sensitivity analysis of simplified diffusion-based corrosion initiation model of concrete structures exposed to chlorides”. Where analytical differentiation techniques are used to determine the sensitivity of the governing parameters of the diffusion-based corrosion initiation model.
(Zhang et al. 2006)

3 Methods and Investigations

3.1 The fib model

In this paper the fib model is presented as in the fib model code for service life bulletin 34. Most observations indicate that the transport of chlorides in concrete is diffusion controlled, and as a consequence, the fib model are based on Fick's 2nd law of diffusion (fib 2006). The convection zone is referred to as being the surface of a concrete that is exposed to a frequent wetting and drying. In the convection zone, diffusion is no longer the main method of transportation for chloride, resulting in Fick's 2nd law no longer being a satisfactory approximation to model the chloride ingress. For Fick's 2nd law to still give a good approximation of the chloride ingress, the data of the convection zone is neglected and Fick's 2nd law of diffusion is applied starting at a depth Δx, with a substitute surface concentration $C_{s,\Delta x}$. With this simplification, Fick's 2nd law of diffusion gives a good approximation of the chloride ingress at a depth $x \geq \Delta x$. (fib 2006)

The fib model is described by the following equation:

$$C_{crit} = C(x = a, t) = \left(C_0 + \left(C_{s,\Delta x} - C_0\right) \cdot \left[1 - erf\left(\frac{a - \Delta x}{2\sqrt{D_{app,C} \cdot t}}\right)\right]\right) \qquad (Eq. 1a)$$

Where:

C_{crit}	is the critical chloride content in % by mass of cement;
$C(x,t)$	is the chloride content of concrete in % by mass of cement at a time t and depth x (structure surface x=0m);
x	is the depth in mm;
a	is the concrete cover in mm;
t	is the concrete age in years;
C_0	is the initial chloride content in % by mass of cement;
$C_{s,\Delta x}$	is the chloride content at depth of Δx and a certain point of time t in % by mass of cement;
Δx	is the depth of the convection zone in mm (concrete layer, up to which the process of chloride penetration differs from Fick's 2nd law);
$D_{app,C}$	is the apparent chloride diffusion coefficient in concrete in mm^2/years;
erf	is the error function;

With

$$D_{app,C}(t) = k_e \cdot D_{RCM,0} \cdot k_t \cdot A(t) \qquad (Eq. 1b)$$

Where:

$D_{RCM,0}$	is the chloride migration coefficient in mm^2/years;
k_e	is the environmental transfer variable [-];
k_t	is the test method variable (transfer variable) [-];
$A(t)$	is the ageing function [-];

With

$$A(t) = \left(\frac{t_0}{t}\right)^{a} \qquad (Eq. 1c)$$

Where

t is the concrete age in years;

t_0 is the is the reference concrete age in years (reference point of time);

α is the age exponent [-];

With

$$k_e = exp\left(b_e\left(\frac{1}{T_{ref}} - \frac{1}{T_{real}}\right)\right) \qquad (Eq. 1d)$$

Where:

b_e is the regression variable in Kelvin;

T_{ref} is the test temperature in Kelvin;

T_{real} is the temperature of the structural element or the ambient air in Kelvin.

3.2 Description of the input parameters in the fib model

3.2.1 Critical chloride content $\boldsymbol{C_{crit}}$

In this context, the critical chloride content is defined as: “The total chloride content which leads to the depassivation of the reinforcement surface and initiation of iron dissolution, irrespective of whether it leads to visible corrosion damage on the concrete surface” (fib 2006).

3.2.2 Initial chloride content of the concrete $\boldsymbol{C_0}$

Chloride contamination of aggregates, cements or water used in the production and mixing of concrete needs to be taken into account. Especially when building in a marine environment, the chloride content of fine and coarse aggregates and water can be considerable. The distribution of the initial chloride content can be assumed to be uniform over the whole cross-section. (fib 2006)

3.2.3 Content of chlorides at the depth of the convection zone ($\Delta\boldsymbol{x}$) at a certain time t $\boldsymbol{C_{s,\Delta x}}$ or at the concrete surface $\boldsymbol{C_s}$

$C_{s,\Delta x}$ and C_s depend on the material properties of the concrete as well as geometrical and environmental conditions. The material properties that need to be taken into account are the type of binder and the concrete composition itself. The most important variable describing the environmental impact is the equivalent chloride concentration of the ambient solution C_{eqv}. The geometry of the structural element and the distance to the chloride source can also be of significance in some cases. (fib 2006)

When assessing existing structures exposed to a chloride rich environment, the chloride concentration on the surface or in the convection zone might be derived directly from chloride profiles from the structure (fib 2006).

The content of chlorides at the depth of the convection zone or at the surface are time dependent. However, there are indications that these built-up periods are often relatively short. For long time predictions this time dependency is for practical reasons not included. (fib 2006)

The information needed to determine $C_{s,\Delta x}$ and $C_s$is illustrated in the flow chart given in figure 1.

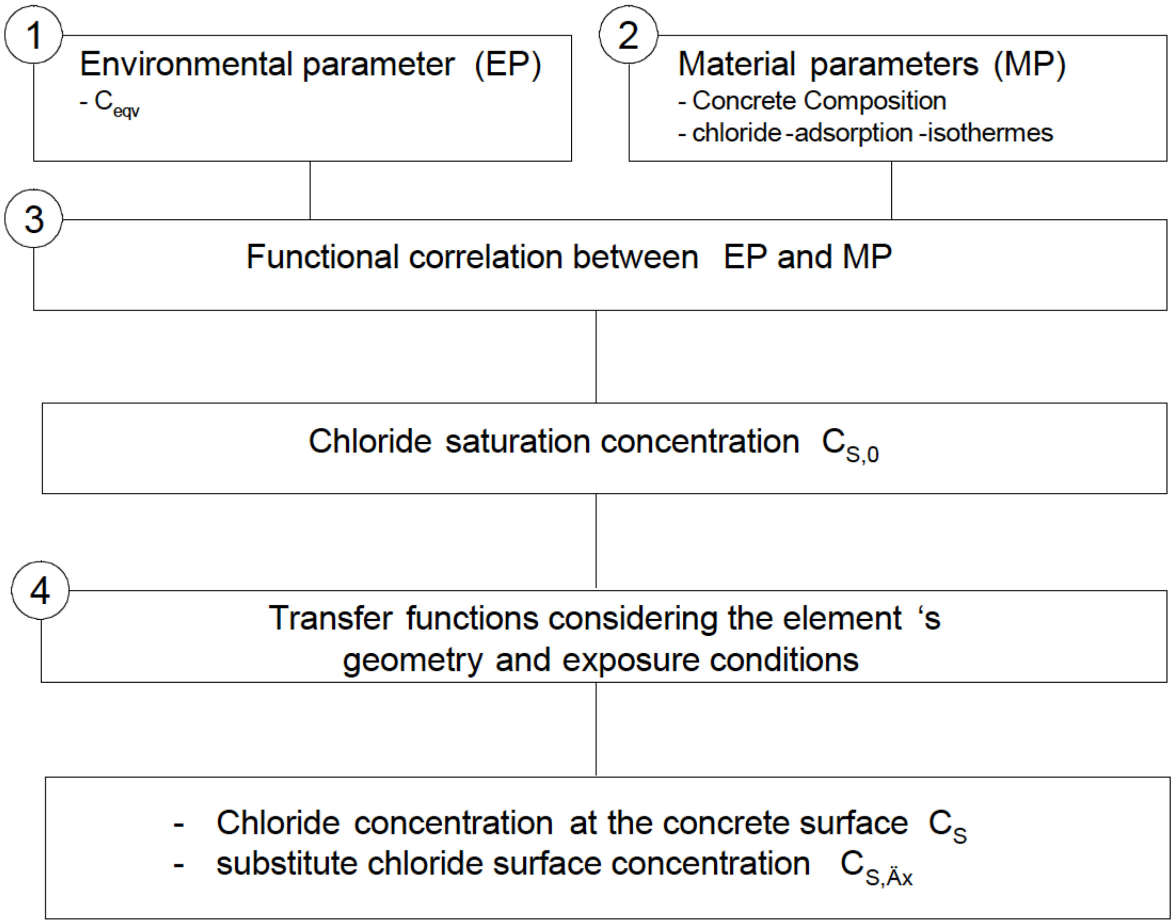

Figure 1, Information needed to determine the variables C(s,Δx) and Cs (fib 2006)

3.2.4 Potential chloride impact C_{eqv}

The potential chloride impact depends on the chloride content of the chloride source. For marine or coastal structures, the potential chloride impact is identical with the natural chloride content of the seawater

$$C_{eqv} = C_{0.M} \qquad (Eq.2a)$$

C_{eqv}: is the potential chloride impact [g/l];
$C_{0,M}$: is the natural chloride content of sea water [g/l].

The chloride content of chloride contaminated water due to de-icing salt presents a significantly larger variation than sea water. An adequate quantification of the potential chloride impact turns out to be very complex for structures that are subjected to chloride impact due to de-icing salt. For such structures the potential chloride impact can be assumed to be (fib 2006):

$$C_{eqv} = C_{0,R} = \frac{n \cdot C_{R,i}}{h_{S,i}} \qquad (Eq.2b)$$

$C_{0,R}$: is the average chloride content of the chloride contaminated water [g/l];
n: is the average number of salting events per year [-];
$C_{R,i}$: is the average amount of chloride spread within one spreading event [g/m^2];
$h_{S,i}$: is the amount of water from rain and melted snow per spreading period [l/m^2].

3.2.5 Chloride saturation concentration $\boldsymbol{C_{S,0}}$

To calculate the chloride saturation concentration, the following material characteristics have to be determined: chloride adsorption isotherms for the type of cement used and the concrete composition. The potential chloride impact also needs to be known. For structures continuously exposed to seawater the chloride saturation concentration on the surface is often reached in a relative short time compared to the service life. This allows a conservative simplification to be made, $C_{S,0} = C_S$. (fib 2006)

3.2.6 Depth of the convection zone (transfer function) $\boldsymbol{\Delta x}$

The convection zone is an area from the concrete surface to a distance Δx, where diffusion is no longer the governing transport mechanism of the chloride. In this zone a frequent wetting and drying of the concrete surface will result in a capillary suction which leads to a rapid transport of chlorides into the concrete up to a depth of Δx. At this depth chlorides can accumulate with time until they create a saturated concentration $C_{S,\Delta x} = C_{S,0}$. (fib 2006)

The depth of the convection zone can be described by a beta-distribution. On average the depth of the convection zone Δx can be limited to to $6.0 \leq \Delta x \leq 11.0\ mm$. For parts of a structure which are constantly submerged the chloride surface concentration is equal to the chloride saturation concentration. (fib 2006)

3.2.7 The concrete cover $\boldsymbol{a}$

Due to construction practices the actual concrete cover does vary and therefor has to be considered as a stochastic variable rather than a constant. The following distribution types are appropriate:

- Normal distribution
- Beta-distribution
- Weibull(min)-distribution
- Lognormal distribution
- Neville distribution

The characteristics of Beta-, Weibull(min)-, Lognormal, and Neville distribution will exclude negative values for the concrete cover. The same is not true for normal distribution and one has to be aware that negative values for the concrete cover is a possibility, especially for concrete covers with a small mean value. Negative values can lead to unrealistic results, since a high probability of negative values for the concrete cover may exist from a statistical point of view. When the mean value becomes larger this effect is negligible. For a statistic description of low concrete covers ($a_{nominal} = 20\ mm$) the right-skewd lognormal, Neville and Beta-distribution are considered appropriate. (fib 2006)

3.2.8 The regression variable b_e

The regression variable is normal distributed and describes the relationship between the temperature of the structure or ambient air T_{real} and the standard test temperature T_{ref}.

3.2.9 Standard test temperature T_{ref}

The standard test temperature T_{ref} has been defined as 293 k (20°C) and can be considered as a constant (fib 2006).

3.2.10 Temperature of the structural element or the ambient air T_{real}

The temperature of the structural element or the ambient air is described by the variable T_{real}. T_{real} is normal distributed and can be determined by using available data from a weather station nearby. (fib 2006)

3.2.11 The apparent coefficient of chloride diffusion $D_{app,C}$

The apparent coefficient of chloride diffusion is a constant average value representing the period from start of exposure to the time of interest. $D_{app,C}$ is usually determined by using “chloride profiling method”. Chloride profiles can either be taken from existing structures or from test samples stored under conditions which are as expected in practise. The length of exposure should be at least several months when $D_{app,C}$ is derived from “chloride profiling method” making the determination of $D_{app,C}$ on test samples very time consuming, therefor an empirically derived approach have been given Eq. 1b. (fib 2006)

3.2.12 Chloride migration coefficient $D_{RCM,0}$

The chloride migration coefficient is normal distributed and one of the governing parameters describing the material properties. Sustainable data for $D_{RCM,0}$ may be obtained from literature for commonly used binders and concrete compositions. Quantitative results from literature are not widely available for special concrete mixes and mixes with a very low water/binder ratio and high contents of plasticiser, in these cases $D_{RCM,0}$ can be determined through testing. The rapid chloride migration method (RCM) is an approach that can be used to determine the chloride migration coefficient. (fib 2006)

If no test data is available, fib model code bulletin 34 have quantified the chloride migration coefficient for a selection of concrete mixes that can be used for orientation purposes. Values are shown table 1.

Table 1, Quantification of the chloride migration coefficient for different concrete mixtures (fib 2006)

$D_{RCM,0}$ [m^2/s] w/$c_{eqv.}$(1)	CEM I 42.5 R	CEM I 42.5 R + FA (k = 0.5)	CEM I 42.5 R + SF (k = 2.0)	CEM III/B 42.5
0.35	n.d(2)	n.d(2)	$4.4 \cdot 10^{-12}$	n.d(2)
0.40	$8.9 \cdot 10^{-12}$	$5.6 \cdot 10^{-12}$	$4.8 \cdot 10^{-12}$	$1.4 \cdot 10^{-12}$
0.45	$10.0 \cdot 10^{-12}$	$6.9 \cdot 10^{-12}$	n.d(2)	$1.9 \cdot 10^{-12}$

0.5	$15.8 \cdot 10^{-12}$	$9.0 \cdot 10^{-12}$	n.d(2)	$2.8 \cdot 10^{-12}$
0.55	$19.7 \cdot 10^{-12}$	$10.9 \cdot 10^{-12}$	$5.3 \cdot 10^{-12}$	$3.0 \cdot 10^{-12}$
0.6	$25.0 \cdot 10^{-12}$	$14.9 \cdot 10^{-12}$	n.d(2)	$3.4 \cdot 10^{-12}$

(1) *Equivalent water cement ratio, considering fly ash or silica fume with the respective k-value. The considered contents were: 22 % of cement weight for fly ash and 5 % of cement weight for silica fume.*

(2) *n.d. – chloride migration coefficient $D_{RCM,0}$ has not been determined for these mixtures*

3.2.13 The transfer parameter k_t, reference concrete age t_0 and ageing exponent α

The apparent diffusion coefficient $D_{app,C}$ is subjected to a considerable scatter and tends to reduce with increasing exposure time. Taking this into account when modelling the initiation process, a transfer parameter k_t in combination with an ageing exponent α has been introduced. α is a factor describing the time dependency of the apparent diffusion coefficient and cannot be measured by RCM. RCM results from concretes tested at different ages will give an ageing exponent which only represents a certain portion of the total effect, the increased resistance against chloride penetration due to ongoing hydration of the concrete. $t_0$is the concrete age at which $D_{RCM,0}$ is measured. (fib 2006)

fib model code bulletin 34 have quantified values of the ageing exponent α for three different cement types illustrated in table 2. The values have been quantified for $k_t = 1$ and $t_0 = 28\ days$. These values are valid for concretes in the splash zone, tidal zone and submerged zone, but can also be applied to concretes in the spray zone and atmospheric zone as an assumption on the safe side. (fib 2006)

Table 2, Results of the statistical quantification of the variable α (fib 2006)

Concrete	Aging exponent α			Distribution
	Range	Mean	St. div.	
Portland cement concrete, CEM I 0.40 ≤ w/c ≤ 0.6	0.0 – 1.0	0.30	0.12	Beta
Portland fly ash cement concrete, f ≥ 0.20 · z; k = 0.5; 0.40 ≤ w/c ≤ 0.62	0.0 – 1.0	0.6	0.15	Beta
Blast furnace slag cement, CEM III/B 0.40 ≤ w/c ≤ 0.60	0.0 – 1.0	0.45	0.20	Beta

3.2.14 The environmental transfer variable k_e

The environmental transfer variable k_e is introduced to take into account the influence of the temperature of the structural element or the ambient air T_{real} on the chloride diffusion coefficient. In order to determine the transfer variable k_e, the regression variable b_e, the standard test temperature T_{ref} and the temperature of the structural element or the ambient air T_{real} have to be determined. (fib 2006)

Table 3 illustrates the range, mean value, standard deviation and statistical distribution of the parameters in the fib model.

Table 3, Range and distribution of the given parameters

Parameter	Range, low	Range, high	Mean	Standard deviation	Distribution
$C_0[\%\,wt.cem]$	0.0	0.78(10)	n.a(9)	n.a(9)	n.a(9)
$C_{s,\Delta x}[\%\,wt.cem]$	-	-	-	-	-
$C_s[\%\,wt.cem]$	1.8(5)(6)	5.5(5)(6)	2.5 – 4.6(5)(6)	0.1-0.7(5)(6)	-
$\Delta x\ [mm]$	6.0(1) (0) (1)(2)	11.0(1) (0) (1)(2)	8.9(1)	5.6(1)	Beta distribution
$a\ [mm]$	20.0	150.0	70.0	8.0-10.0(1)(3) (6.0) (1)(4)	Normal-, Beta-, Weibull(min)-, Lognormal- and Neville distribution
$D_{app,C}\ [m^2/s]$	n.a(7)	n.a(7)	n.a(7)	n.a(7)	n.a(7)
$D_{RCM,0}\ [m^2/s]$	$1.4 \cdot 10^{-12}$ (1)	$25 \cdot 10^{-12}$ (1)	n.a(9)	n.a(9)	Normal distribution
$k_e\ [-]$	n.a(7)	n.a(7)	n.a(7)	n.a(7)	n.a(7)
$k_t\ [-]$	0.1	1.0	0.85(6)	0.024(6)	Constant
$A(t)$	n.a(7)	n.a(7)	n.a(7)	n.a(7)	n.a(7)
$t\ [years]$	0	100	50	0	Constant
$t_0\ [years]$	0	100	0.0767(6)	0	Constant
$\alpha\ [-]$	0.0(1)	1.0(1)	0.30 - 0.60(1)	0.12 - 0.20(1)	Beta distribution
$b_e\ [K]$	3500.0(1)	5500.0(1)	4800.0(1)	700.0(1)	Normal distribution
$T_{ref}\ [K]$	293.0(1)	293.0(1)	293.0(1)	0.0(1)	Constant
$T_{real}\ [K]$	n.a(8)	n.a(8)	n.a(8)	n.a(8)	Normal distribution

(1) Value from fib model code bulletin 34 (fib 2006)
(2) For submerged marine structures
(3) Without particular execution requirements
(4) With additional execution requirements targeted
(5) (Bamforth 1999)
(6) (Årskog 2004)
(7) Data is calculated from the other parameters
(8) Determined by using available data from a weather station nearby
(9) Due to a large range in the parameter value no sensible mean or standard deviation is available
(10) (Morris et al. 2002)

3.3 Sensitivity analysis

The fib model was implemented into an Excel spreadsheet. Each parameter was set to the mean value given in table 4. One at a time, each parameter was varied from the low to the high end of their range, while the others remained constant. The chloride content was then plotted at depths from 0 – 100 mm after an exposure time of 100 years.

The values used are typical values for a concrete with CEM I 42.5 R cement and a water-to-binder ratio of 0.45. The depth of the convection zone Δx and the initial chloride content C_0 is assumed to be equal to zero.

Table 4, Mean values and range for the input parameters

Input parameter	Range	Mean
$C_0[\%\, wt.cem]$	0.0	0.0
Δx	0.0	0.0
$C_s[\%\, wt.cem]$	1.8 - 5.5(1)(2)	2.527(1)(2)
$a\ [mm]$	0.0 – 100.0	n.a(4)
$D_{RCM,0}\ [mm^2/year]$	44.15 – 788.40 (3)	315.36 (3)
$t\ [years]$	n.a(5)	100(4)
$t_0\ [years]$	n.a(5)	0.0767(2)
$\alpha\ [-]$	0.0 - 1.0	0.3(3)
$k_t\ [-]$	0.1 – 1.0	0.85(2)
$b_e\ [K]$	3500.0 - 5500.0(3)	4800.0(3)
$T_{ref}\ [K]$	293.0(3)(5)	293.0(3)
$T_{real}\ [K]$	273.0 - 303.0	293.0

(1) (Bamforth 1999)
(2) (Årskog 2004)
(3) Value from fib model code bulletin 34 (fib 2006)
(4) Ranges from 0-100 in each calculation
(5) Constant value

3.4 Differential analysis

In the fib model there are various sources of uncertainty associated with the parameters which include, model uncertainty, statistical uncertainty and physical uncertainty. Model uncertainty arises from the use of a simplified mathematical relationship between the variables and the “true” values of the actual physical mechanism of chloride ingress. The statistical uncertainty emerges from estimating the mean and standard value of the parameters from a limited set of data and the physical uncertainty is associated with the uncertainties in the concrete cover depth, the diffusion coefficient and surface chloride concentration. Looking at the uncertainties mentioned above it is clear that a significant error can be associated with the fib model. (Zhang et al. 2006)

In this thesis a differential analysis method is used to investigate the sensitivity of the chloride surface concentration, the chloride migration coefficient, the ageing exponent and the depth at which we want to know the chloride content. The analyses will help the researcher in answering these important questions:

- Which parameters have the greatest impact on the output of the fib model?
- Which parameters will benefit most from being determined with a high level of accuracy?

- Which parameters are less important and can be used with a bigger scatter without influencing the model to a critical degree?

These three question can be answered with a ranking of the parameters, which the result of the analysis will provide upon completion.

Differentiation analysis is a relatively easy method to apply and provides the user with information on the impact of the different parameters on the output of the model, as well as a ranking of their relative importance. The analysis requires a limited amount of data, namely the mean/base value of the parameters and their standard deviations, which is not the case for many other types of analysis. (Zhang et al. 2006)

The concept of this analysis is to look at the ratio of the change in output to the change in input while all other parameters are kept constant (equal to their mean/base value). First a "base case" is defined, which is a scenario where all the parameters are set to their mean values (Hamby 1994). Then a Taylor series is used to approximate the fib model and replaces the model itself during the analysis(Zhang et al. 2006). The "base case" in this analysis is presented in table 5 below.

Table 5, Values for the "base case"

Input parameter	Mean
$C_0[\% \, wt. cem]$	0.0
$\Delta x \; [mm]$	0.0
$C_s[\% \, wt. cem]$	2.527
$a \; [mm]$	70.0
$D_{RCM,0} \; [mm^2/year]$	498.2688
$k_t \; [-]$	0.83
$k_e \; [-]$	0.7525
$A(t) \; [-]$	0.1163
$t \; [years]$	100.0
$t_0 \; [years]$	0.0767
$\alpha \; [-]$	0.3
$b_e \; [K]$	4800
$T_{ref} \; [K]$	293.0
$T_{real} \; [K]$	288.0
$C_0[\% \, wt. cem]$	1.642

The fib model can be presented as the following function:

$$C = f\left(C_s, D_{RCM,0}, a, \alpha\right) = \left(C_0 + \left(C_{s,\Delta x} - C_0\right) \cdot \left[1 - erf\left(\frac{a-\Delta x}{2\sqrt{D_{app,C} \cdot t}}\right)\right]\right) \qquad (Eq. 3a)$$

$$C = f\left(C_s, D_{RCM,0}, a, \alpha\right) = f(X_1, X_2, X_3, X_4) \qquad (Eq. 3b)$$

Where the governing parameters are the input variables represented by a vector:

$$\boldsymbol{X} = [X_1, X_2, X_3, X_4] \qquad (Eq. 4)$$

A first-order Taylor series approximation of C has the following form, with X_0representing a base value vector.

$$C(X) \cong C(X_0) + \sum_{j=1}^{4} \frac{\partial f(X_0)}{\partial X_j}\left(X_j - X_{j0}\right) \qquad (Eq.5)$$

The values of the partial derivatives are a measure of the local sensitivity. Eq. 5 can be rewritten in the following from:

$$\frac{C(X) - C(X_0)}{C(X_0)} = \sum_{j=1}^{4} \frac{\partial f(X_0)}{\partial X_j}\frac{X_{j0}}{C(X_0)}\frac{\left(X_j - X_{j0}\right)}{X_{j0}} \qquad (Eq.6)$$

Let

$$\Delta C = C(X) - C(X_0) \qquad (Eq.7a)$$

$$\Delta X_j = X_j - X_{j0} \qquad (Eq.7b)$$

and

$$C(X_0) = c_0 \qquad (Eq.7c)$$

In this approach, an estimate of the variability of C or $f(\boldsymbol{X})$ is made by changing one parameter at a time and keeping the others constant (equal to their mean value) and investigating the change in C, therefore:

$$\frac{\partial f}{\partial x_k} = 0 \qquad k = 1,2,\dots,n \; with \; k \neq j \qquad (Eq.8a)$$

and

$$\frac{\partial f}{\partial x_k} = f'\left(x_j\right) \qquad (Eq.8b)$$

Therefore, Eq. 6 becomes:

$$\frac{\Delta C}{\Delta X}\frac{X_{j0}}{C_0} = \frac{\partial f(X_0)}{\partial X_j}\frac{X_{j0}}{c_0} = S\left(X_j\right) = S_j \qquad (Eq.9a)$$

Where S_j is the normalized first order sensitivity coefficient of C to X_j, which provides a measure of the relative change in C that results from a relative change in X_j, when the other variables are kept constant. It should be mentioned that the change in X_j should be small, i.e. a small fraction of its mean value. (Zhang et al. 2006)

$$S_j = \frac{\partial f(X_0)}{\partial X_j}\frac{(X_{j0})}{c_0} \qquad j = 1,\dots,4 \qquad (Eq.9b)$$

S_j is a dimensionless quantity, which makes it possible to compare the sensitivity coefficients for the different parameters. The absolute value of S_j can be used to rank the individual parameters according to its relative importance. C is more sensitive to the variable X_1 than X_2 if the absolute value of $S(X_1)$ is greater than $S(X_2)$, $|S(X_1)| > |S(X_2)|$. The sign of the coefficient S_j indicates whether X_j and C move up or down together or in opposite directions. A negative value of S_j means that a change in X_j will result in a change in C in the opposite direction, a positive means that they move in the same direction. (Zhang et al. 2006)

3.5 Comparison between exposure data and predictions made by the fib model

Data from concrete cylinders exposed to seawater in the tidal zone at Østmarkneset in the Trondheim Fjord in Norway were made available by K. De Weerdt and M. Geiker. The data were collected within an R&D project at Norcem AS, which was later continued by the Norwegian Public Road Administration. The Norwegian Research council have financed both projects. Mrs. G Lundevall and Dr. T.F. Rønning at Norcem are credited with the design of the experimental set-up. (De Weerdt et al. 2016)

Three concretes with a water-to-binder ratio 0.45 and the composition given in table 6 were cast and cured for approximately 1 month before being exposed to the sea water. Chloride profiles were determined after 2 and 5 years. (De Weerdt et al. 2016)

Table 6, Concrete composition of the three test concretes (De Weerdt et al. 2016)

Concrete [kg/m^3]		PC-FA (B2)	C-PC (B9)	F-PC (B10)
Cement	CEM I 42.5 R(1)		369	369
	CEM II A-V 42.5 R(1)	369		
Aggregate	0-8 mm	1083	1078	1082
	2-8 mm	720	717	720
Water		166	165	167
Admixtures		4.8	5	6.3
Density		2340	2330	2340
Blaine specific fineness of cement [m^2/kg]		430	520	520
Water to binder ratio [-]		0.45	0.45	0.45
Slump [mm]		150	125	125
Air content [%]		3.7	4.8	4.8

(1) According to EN197

The fib model was used to predict the chloride ingress for the three different concretes. In the process of determining the different parameters for the fib model some simplifications and estimations were made. The chloride migration coefficient $D_{RCM,0}$, ageing exponent α, depth of the convection zone Δx, standard test temperature T_{ref}, regression variable b_e, transfer variable k_t and reference point of time t_0 where set to values given in the fib model code bulletin 34. Time of exposure

t, initial chloride content C_0 and the depth with a corresponding content of chlorides a where set to the same values as in the field exposure test. The average temperature of the structural element was assumed to be 283 K. The sub-function considering ageing $A(t)$, where determined from t_0, t and α. The environmental transfer variable k_e where determined by b_e, T_{real} and T_{ref}.

To determine the chloride content at the depth of the convection zone $C_{S,\Delta x}$, the potential chloride impact C_{eqv}, concrete composition and binder specific chloride adsorption need to be determined (fib 2006). The potential chloride impact, can in this case be set equal to the natural chloride content of the water $C_{0,M}$. The binder specific chloride adsorption isotherm for the different cements where not known. $C_{S,\Delta x}$ where therefore estimated on the basis of data from the field exposure test. Values mention above are shown for the three different concretes in table 7.

Table 7, fib model input parameters for the three test concretes

Concrete / Parameter	PC-FA (B2)	C-PC (B9)	F-PC (B10)
C_0 $[\%wt.dry\ concrete]$	0.0001	0.0001	0.0001
$C_{S,\Delta x}$ $[\%wt.dry\ concrete]$	0.95	0.55	0.55
Δx $[mm]$	8.9	8.9	8.9
$D_{RCM,0}$ $[mm^2/year]$	217.59	315.36	378.43
k_e $[-]$	0.5605	0.5605	0.5605
k_t $[-]$	1	1	1
$A(t)[-]$	0.0135	0.1162	0.1162
t_0 $[years]$	0.0767	0.0767	0.767
α $[-]$	0.6	0.3	0.3
b_e $[K]$	4800	4800	4800
T_{ref} $[K]$	293	293	293
T_{real} $[K]$	283	283	283

Chloride profiles from estimations done by the fib model and values determined through laboratory testing where plotted after an exposure time of 2 and 5 years.

4 Results

4.1 Sensitivity analysis results

The fib model as described in the fib model code bulletin 34, was modelled in Excel and used to produce the data and graphs presented below. A “base case” was defined and are presented in table 8. All the values were kept to their mean value while one parameter at a time was varied over its range. For each change in the varying parameter a chloride profile where plotted.

Table 8, Mean values for the input parameters

Parameters	Mean values
$C_s\ [\%wt.cem]$	2.5270
Δx	0.0
$D_{RCM,0}\ [mm^2/year]$	315.36
$k_e\ [-]$	0.7525
$k_t\ [-]$	0.85
$A(t)\ [-]$	0.1163
$t[years]$	100
$t_0\ [years]$	0.0767
α	0.3
$b_e\ [K]$	4800
$T_{ref}\ [K]$	293
$T_{real}\ [K]$	288

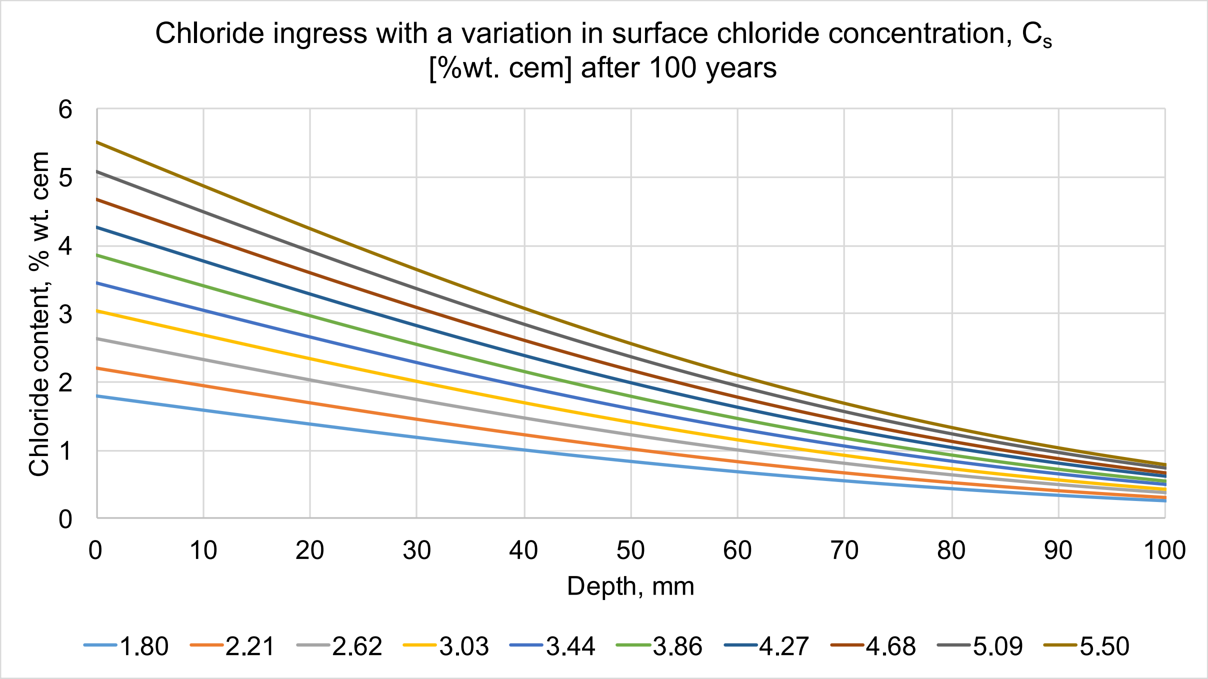

Figure 2, Chloride ingress with a variation in surface chloride concentration, C_s [%wt. cem] after 100 years

Figure 2 shows the chloride ingress after 100 years of exposure, with a variation in the surface chloride concentration C_s. The largest variation in the chloride content is at the surface of the concrete and is equal to the variation between the highest and lowest value of surface chloride content. As the depth of penetration increases, the total variation decreases from 3,7 to 0.53 %wt. of cement.

Figure 3 shows the chloride ingress after 100 years of exposure, with a variation in the chloride migration coefficient $D_{RCM,0}$. At the surface, a change in the migration coefficient results in a very small change in the chloride content. Moving deeper into the concrete a change in the migration coefficient leads to an increasingly higher change in the chloride content until a maximum is reached at 44 mm. For a chloride migration coefficient in the low end of the range, the change in chloride content is much higher than for a chloride coefficient in the high end.

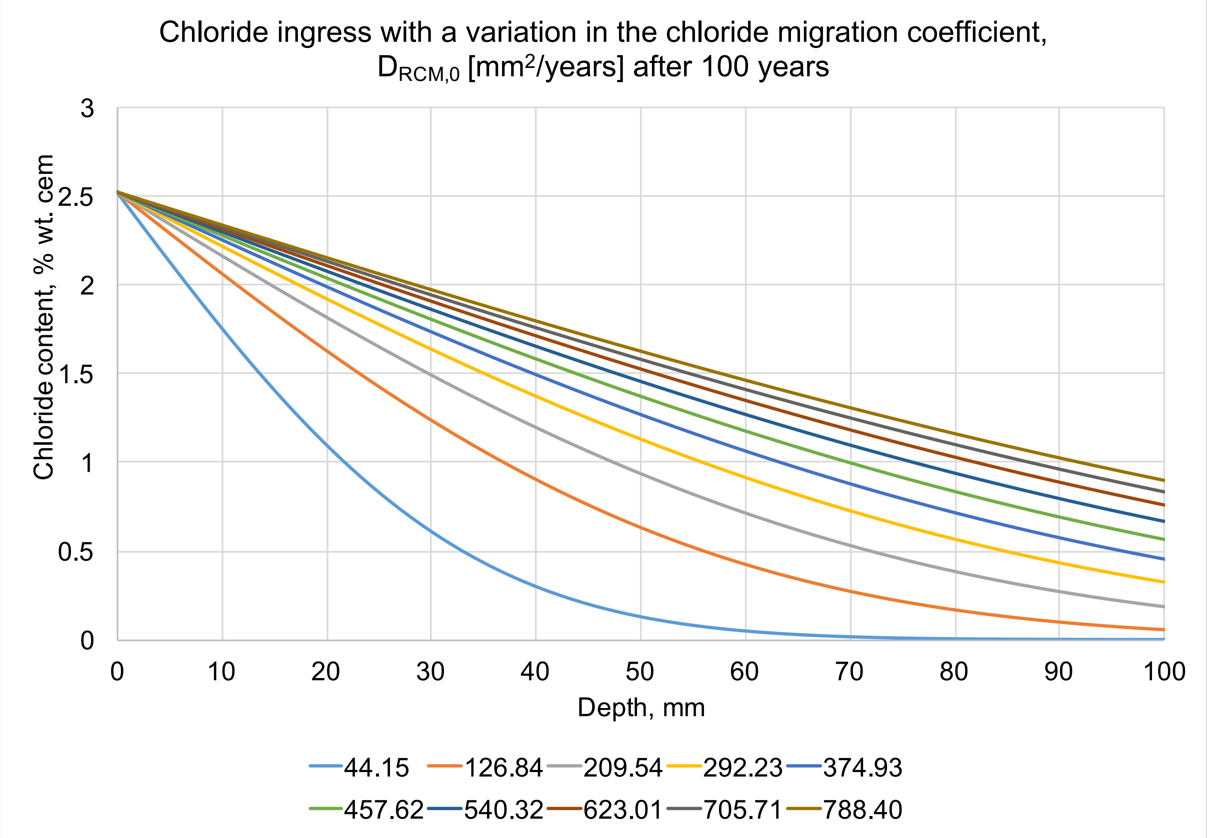

Figure 3, Chloride ingress with a variation in the chloride migration coefficient, $D_{RCM,0}$ [mm^2/years] after 100 years

The largest difference between the plotted values of the chloride content is between $D_{RCM,0} = 44.15\ mm^2/years$ and $D_{RCM,0} = 126.84\ mm^2/years$, with a difference of 0.63 %wt. of cement found at 32 mm. The smallest difference is located at the same depth is between $D_{RCM,0} = 705.71\ mm^2/years$ and $D_{RCM,0} = 788.40\ mm^2/years$ and are 0.03 %wt. of cement.

The largest total difference, i.e. the difference in chloride content at a given depth between the highest and lowest value of the chloride migration coefficient is 1.51 %wt. of cement located at 44 mm.

Figure 4 shows the chloride ingress after 100 years of exposure, with a variation in the ageing exponent α. The total difference in chloride content starts at zero and increases exponentially as the depth increases. At a depth of 15 mm the total difference in chloride content reaches its maximum at 2.36%wt. of cement. After this point the higher values of α subsequently reaches a chloride content of zero. Resulting in a decrease in the total difference at depths greater than 15 mm. The largest difference in chloride content between two values of α are found to be between 0.2 and 0.3, where the difference is observed to be 0.43 %wt. of cement at a depth of 81 mm.

When α is in the low end of its range, the chloride profile is linear or close to linear, but as α increases the chloride profile gets more and more an exponential shape.

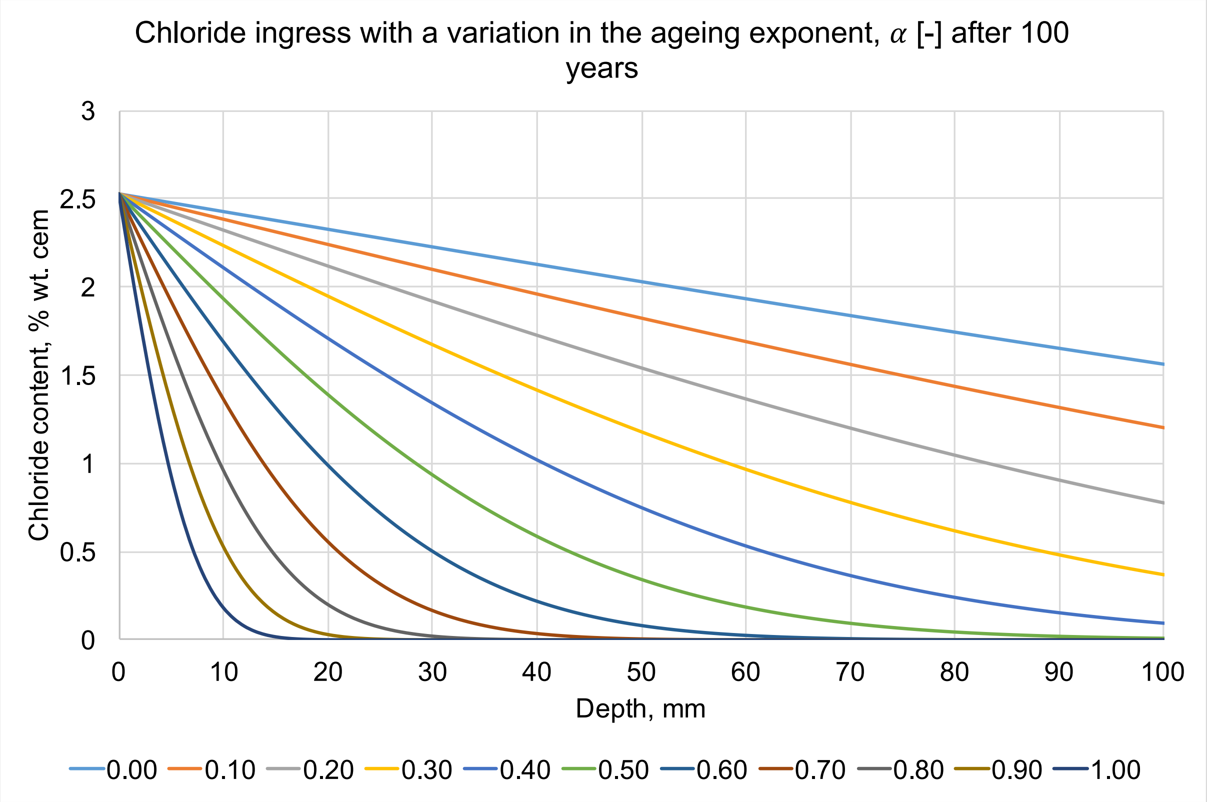

Figure 4, Chloride ingress with a variation in the ageing exponent, α [-] after 100 years

Figure 5 shows the chloride ingress after 100 years of exposure, with a variation in temperature of the structural element T_{real}. The total variation in chloride content is small close to the concrete surface and grows as the depth increases. At a depth of 62 mm the largest difference in chloride content between the lowest and highest value of the temperature of the structural element is reached at 1.0 %wt. of cement.

Between temperatures of 273 K and 276.33 K the largest difference in chloride content is observed, located at a depth of 45 mm with a difference of 0.13 %wt. of cement.

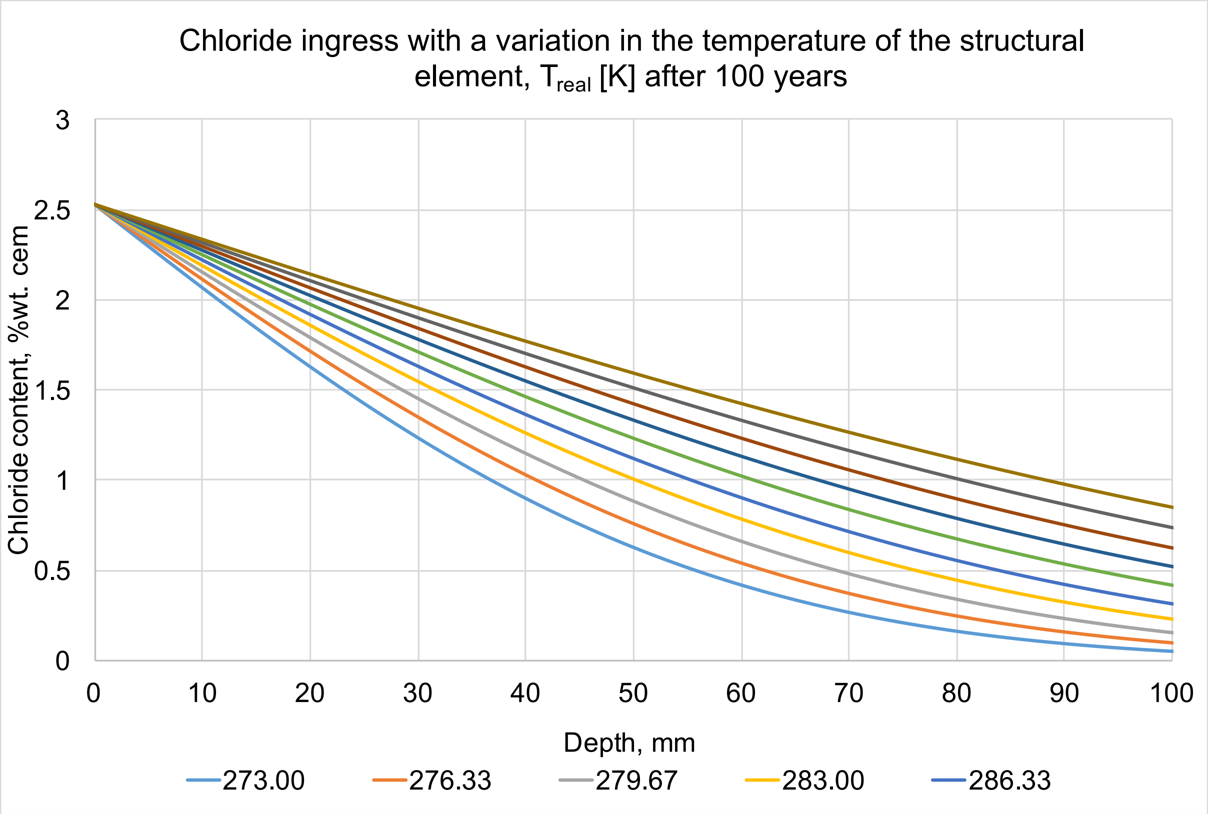

Figure 5, Chloride ingress with a variation in the temperature of the structural element, T_{real} [K] after 100 years

Figure 6 shows the chloride ingress after 100 years of exposure, with a variation in the transfer variable k_t. When the transfer variable is in the low end of its range, a change in k_t will have a greater influence on the chloride content than if it is in the high end. At 37 mm we find the largest difference between the lowest and highest value of k_t, which is 1.27 %wt. of cement. At a depth of 27 mm the biggest difference between two neighbouring values are observed between $k_t = 0.10$ and $k_t = 0.20$ and is 0.42 %wt. of cement.

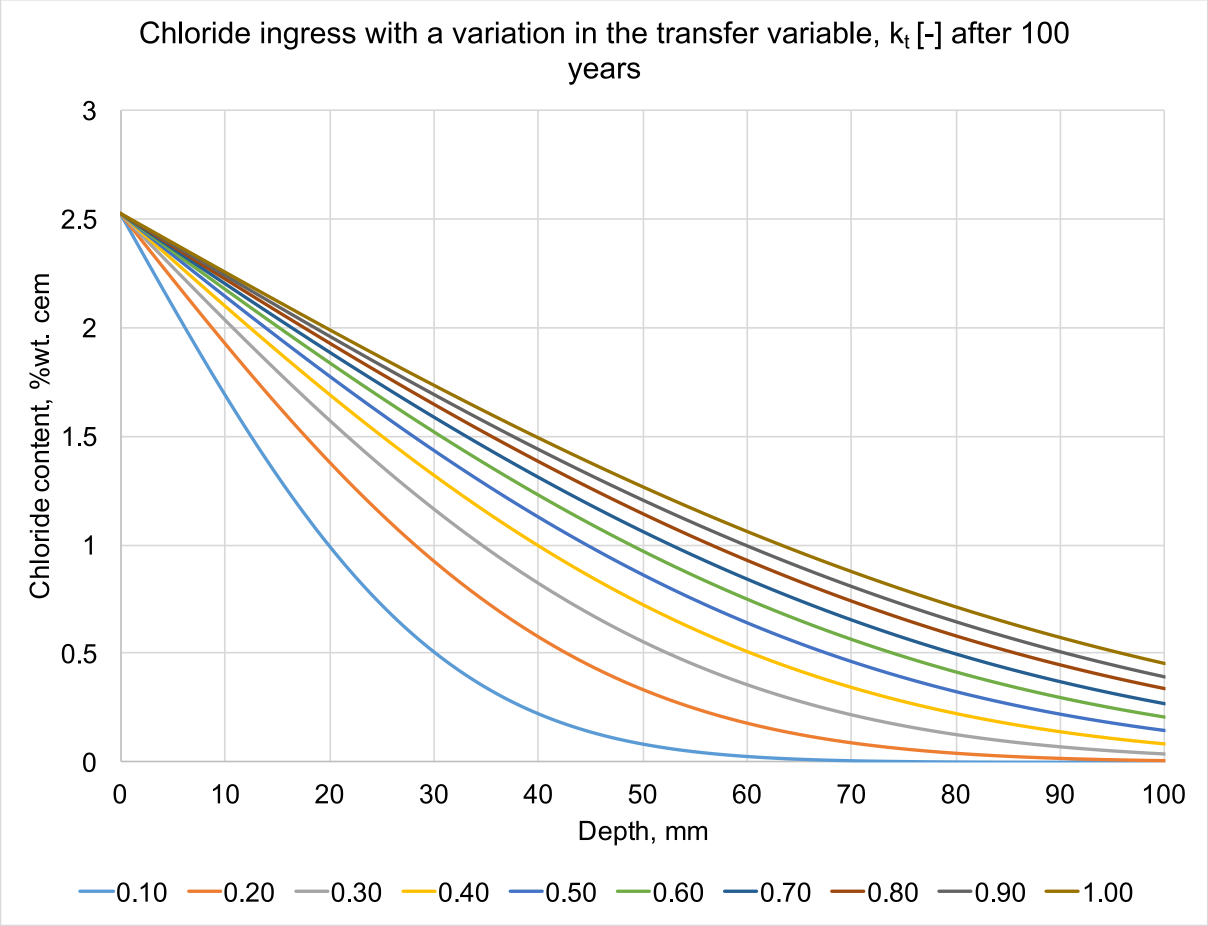

Figure 6, Chloride ingress with a variation in the transfer variable, k_t [-] after 100 years

Figure 7 shows the chloride ingress after 100 years of exposure, with a variation in the regression variable b_e. A variation in the regression variable, even from the highest to the lowest value plotted, have a small impact on the chloride content.

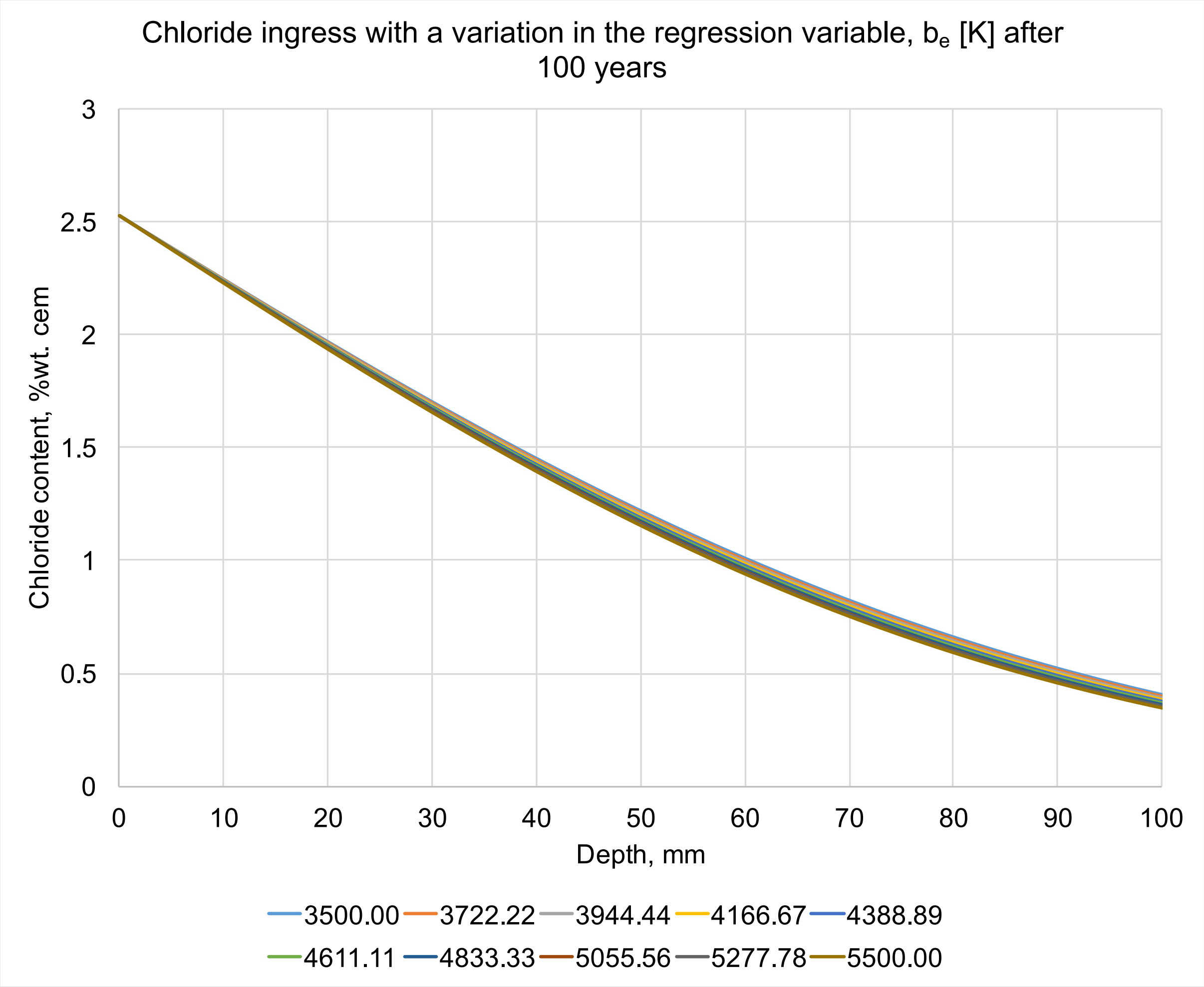

Figure 7, Chloride ingress with a variation in the regression variable, b_e [K] after 100 years

A variation in chloride content between the highest and lowest value of the chloride migration coefficient $D_{RCM,0}$, age exponent α, transfer variable k_t and temperature of the structural element T_{real} all start close to zero. As the depth increases the variation increase to a certain point before decreasing. At the low end of the range, a change in these parameters results in larger change in the chloride content compared to values in the high end.

The surface chloride concentration C_s, displaces the plot upwards when increased and downwards when decreased. A change in the surface chloride concentration does not change the curvature of the the plot. The biggest difference in chloride content is found near the surface.

A change in b_e is observed to have little impact on the chloride concentration.

Table 9 gives an overview of the largest variation in chloride content from the lowest to the highest value of each parameter (total variation) and the largest variation found between two neighbouring values.

Table 9, Overview of the largest and total variation for the parameters

	Largest variation between neighbouring values			Total variation	
Parameter	ΔC [%wt. cem]	Depth [mm]	Between value	ΔC [%wt. cem]	Depth [mm]
C_s	0.41	0.0	All	3.70	0.0
$D_{RCM,0}$	0.63	32.0	44.15 – 126.84	1.51	44.0
α	0.43	81.0	0.20 – 0.30	2.36	15.0
T_{real}	0.13	45.0	273.00 – 276.33	1.00	62.0
k_t	0.42	27.0	0.10 – 0.20	1.27	37.0
b_e	0.01	69.0	3944.44 – 4166.67	0.07	68.0

4.2 Differential analysis results

Using Eq. 9b the first order sensitivity coefficient of C to $D_{app,C}$, C_s, α and a is:

$$S(D_{app,C}) = 0.908$$
$$S(C_s) = 1.000$$
$$S(\alpha) = -1.946$$
$$S(a) = -1.804$$

By using the absolute values of the first order sensitivity coefficients, the parameters can be ranked by the relative importance illustrated in table 10. These absolute values tells us that the chloride content is most sensitive to a change in the age exponent α, followed by the depth a, followed by the surface chloride concentration C_s and the least sensitivie parameter out of the four is the apparent diffusion coefficient $D_{app,C}$. The least sensitive parameters can be used with a bigger scatter than the most sensitive without influencing the model to a critical degree.

Table 10, Ranking of the parameters by the first order sensitivity coefficient

Parameter	Absolute values of the first order sensitivity
$\lvert S(\alpha)\rvert$	1.946
$\lvert S(a)\rvert$	1.804
$\lvert S(C_s)\rvert$	1.000
$\lvert S(D_{app,C})\rvert$	0.908

Looking at the signs of the sensitivity coefficients, it is seen the ageing exponent α and the depth a has a negative sign. Meaning that and increase in these two values will lead to a decrease in the chloride content. For the surface chloride concentration C_s and the apparent diffusion coefficient $D_{app,C}$ the sign is positive. Meaning that an increase in these values will lead to an increase in the chloride content.

4.3 Comparison between exposure data and predictions made by the fib model results

The results and figure 8, 9 and 10 are based on predictions made by using the fib model and data from concrete cylinders exposed to seawater, describe in the background section of this thesis under “Comparison between exposure data and predictions made by the fib model”. The calculations were performed in Excel. The parameters used for the predictions are given in table 7.

Figure 8 shows a comparison between a prediction made by the fib model and a chloride profile for concrete C-PC. From the data it is observed that the fib model makes a precise estimation, after 2 years of exposure, for the last three data points (27.5, 32.5 and 37.5 mm). Here the average difference between the measured and the predicted chloride content is only 0.0045. The difference between predicted and observed chloride content, after 2 years of exposure, increases the closer we get to the concrete surface, but the predictions are on the safe side.

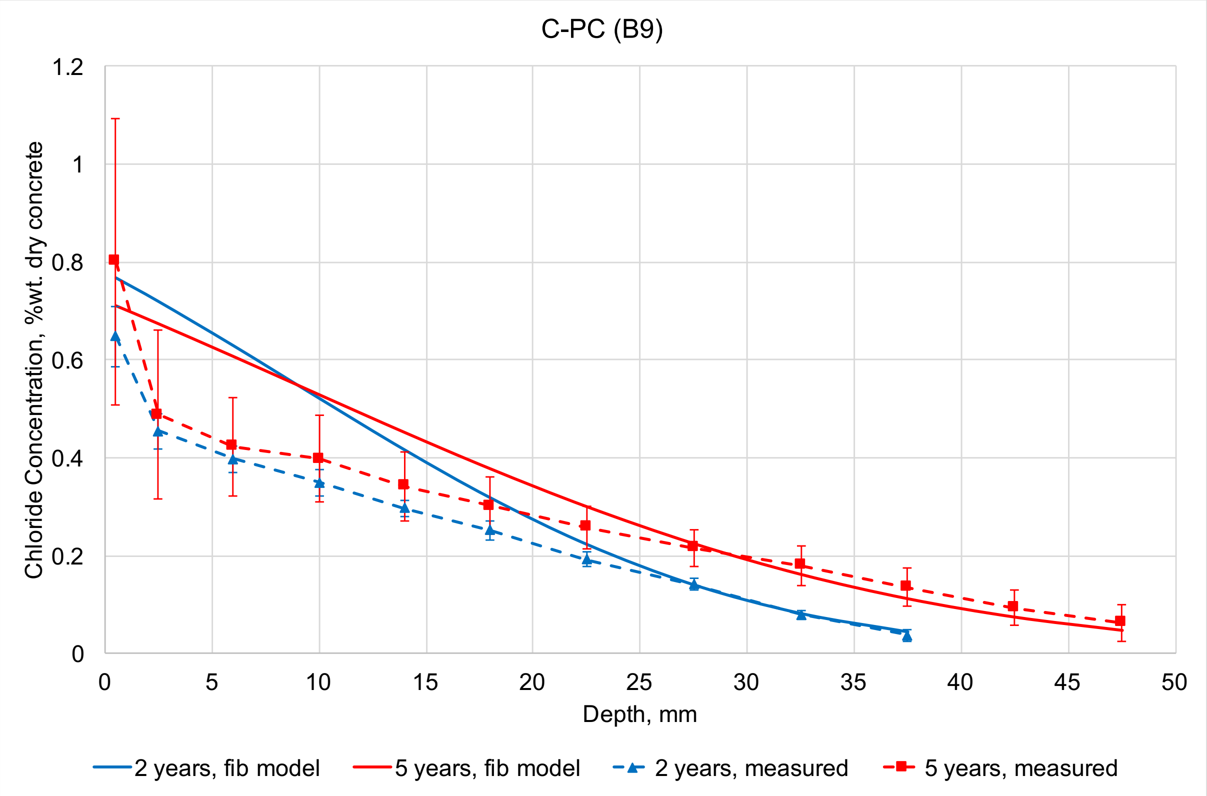

Figure 8, Comparison between exposure data from C-PC (B9) and predictions made by The fib model

For an exposure time of 5 years, the prediction for the last five data point (27.5, 32.5, 37.5, 42.5 and 47.5 mm) is also quite precise with an average difference of 0.0222. Only in this case the prediction made are not on the safe side. It is observed that the prediction gets more and more accurate as the depth increases.

Figure 9 shows a comparison between a prediction made by the the fib model model and a chloride profile for concrete F-PC. Predictions made by the fib model after 5 years of exposure closely match the measured chloride profile for the last five data points (27.5, 32.5, 37.5, 42.5 and 47.5 mm), with an average difference of 0.0148 %wt. dry concrete. The predictions after 5 years are on the safe side at most depths, the exceptions are right below the surface and at a depth of 32.5 mm and deeper. Here the estimations are not on the safe side but the difference in measured and estimated chloride content are small.

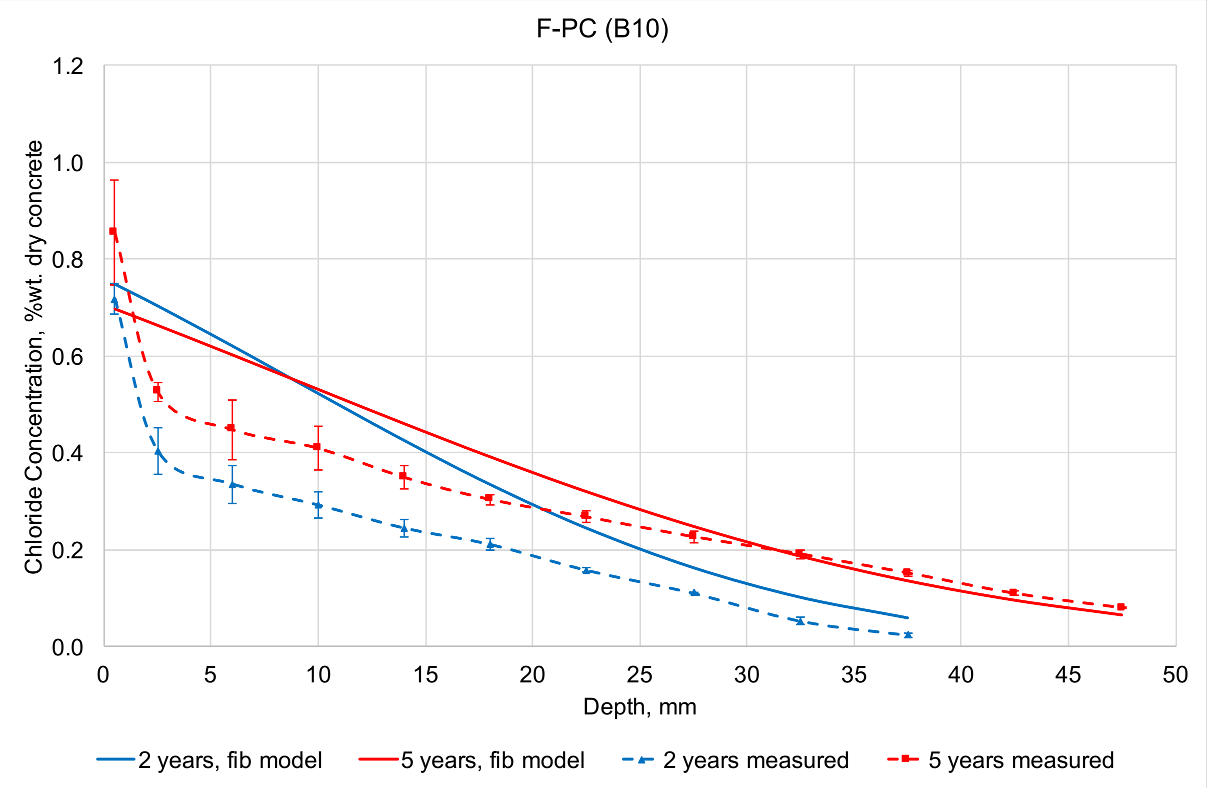

Figure 9, Comparison between exposure data from F-PC (B10) and predictions made by the fib model

Predictions after 2 years are on the safe side, but not as accurate as for 5 years. The prediction becomes more accurate as the depth increases and the average total difference is 0.138 %wt. dry concrete.

Figure 10 shows a comparison between a prediction made by the fib model and a measured chloride profile for concrete PC-FA. Here we see that the predictions are significantly more inaccurate than for C-PC and F-PC. One of the main contributing factors is that unlike the C-PC and F-PC, this concrete has 20% of the cement replaced by fly ash.

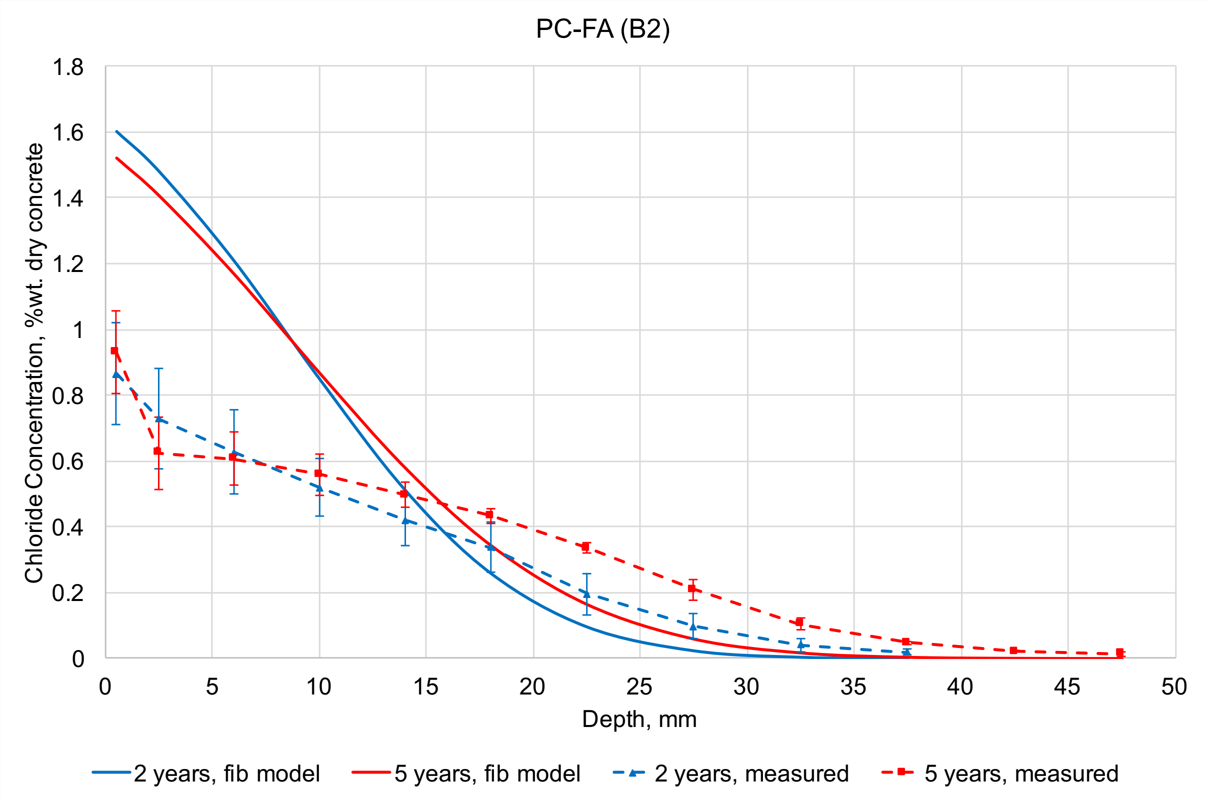

Figure 10, Comparison between exposure data from PC-FA (B2) and predictions made by the fib model

The fib model significantly overestimates the chloride content from the surface to a depth of approximately 16 mm for both 2 and 5 years of exposure. At this point the plot for predicted chloride content intersects the plot for the actual chloride content. As we go deeper into the concrete, the fib model underestimates the chloride content until both the predicted and the measured chloride content reaches zero. By summing up the absolute values for the difference between predicted chloride content and measured chloride content, up two a depth of 37,5 mm. It is seen that after 5 years of exposure, the predictions made by the fib model are slightly less accurate than after 2 years of exposure.

The concrete containing fly ash (PC-FA) has a higher chloride content, in approximately the first 10-15 mm, than the ones only containing Portland cement. This is in line with the higher binding capacity of fly ash blended cement. Deeper into the concrete it is observed that the chloride content is less than for the two others. The reason for this is that the pozzolanic reactions produce a finer pore structure through producing more C-S-H with its gel porosity. This improves permeability, which is a positive consequence for most durability properties, including chloride penetration. (Jacobsen et al. 2011)

All concretes show a distinctively higher chloride concentration right below the cast surface compared to deeper into the concrete. This is a result of the paste volume being relatively higher here than in the rest of the concrete. (De Weerdt et al. 2016)

5 Discussion

5.1 Sensitivity of the parameters in the fib model

From the results produced in the Excel analysis, we see that the parameter with the largest total variation, is the chloride surface concentration. Since the chloride content right under the concrete surface will be close to or the same as the surface chloride concentration, a relative large spread in the surface chloride concentration, will result in an equally large total difference. Here the concrete is modelled with a total difference in surface chloride concentration equal to 3.7 %wt. of cement, which is the same difference we find in the chloride content right below the surface of the concrete. This does not necessary mean that the surface chloride concentration is the parameter that has the greatest impact on the output of the fib model. In figure 2 we see that the total variation decreases as the penetration depth increases, and that the difference between neighbouring values are not as large as for some of the other parameters ($D_{RCM,0}$, α and k_t).

A small change in the ageing exponent will lead to a significant change in the chloride content, making the ageing exponent an important parameter to determine with a high amount of accuracy. It is the parameter with the second largest total difference and difference between neighbouring values. From figure 4 we see that if the ageing exponent has a value below 0.3 the chloride profile is linear or close to linear. As the ageing exponent increases, the function describing the chloride profile become more and more exponential. Even though there is a significant change in the curvature of the chloride profile as the value of the ageing exponent increases the biggest change in chloride content between two neighbouring values is found between $\alpha = 0.2$ and $\alpha = 0.3$.

From the differential analysis we see that the ageing exponent is the parameters with the largest absolute value of the first order sensitivity coefficients, almost two times larger than the apparent diffusion coefficient and the surface chloride content. Making it the parameter with the greatest impact on the output of the fib model. The ageing exponent describes the time dependency of the apparent diffusion coefficient, resulting in it having a large effect at long exposure periods. In the differential analysis and the modelling done in excel the exposure time is set to 100 years, explaining why the ageing exponent has been rank as such an important parameter in the investigations performed. This does not exclude the possibility that the ageing exponent is important at a shorter exposure time, but tells us that for short periods of exposure, the parameters importance may decrease. The first order sensitivity coefficient for the ageing exponent has a negative sign. Meaning that as the ageing exponent increases the chloride content decreases.

It has been conducted a fair amount of investigations by other researches to determine the size of the ageing exponent. Most of these investigations have considerable uncertainties connected to the sampling, the exposure conditions and the analytical methods used. This indicates that it is difficult and time consuming to determine the ageing exponent with a high amount of accuracy which is very unfortunate for the fib model since the ageing exponent is one of the most sensitive parameters.

The chloride migration coefficient is also one of the most important parameters to determine with a high amount of accuracy. The total variation is the third largest after the ageing exponent and the surface chloride concentration and it has the largest variation between two neighbouring values.

Figure 3 shows that a change in the chloride migration coefficient results in a significant change in the chloride content in the low end of the plotted values, especially between $D_{RCM,0} = 44.15\, mm^2/years$ and $D_{RCM,0} = 126.84\, mm^2/years$. The function describing the chloride profile becomes significantly more curved between these two values. The reason for this might be that the percentage change in the chloride migration coefficient between these two values is much higher than for the rest.

The surface chloride concentration and apparent diffusion coefficient are subsequently ranked third and fourth in the differential analysis. Both have a positive sign, meaning an increase in these two values will result in an increase in the chloride content. If the apparent diffusion coefficient is not determined directly by field exposure tests, it is composed of numerous other parameters (k_e, k_t, $D_{RCM,0}$ and $A(t)$), which will result in an increase in the uncertainty associated with the parameter.

A small change in the parameter that describes the temperature of the structural element or the ambient air results in a small change in the chloride content. Data for determining this parameter should be retrieved from a weather station nearby. Weather stations usually have large sets of accurately measured data which provides the user with a good basis when estimating the average temperature, resulting in a small scatter in the temperature of the structural element or ambient air. On the other hand, the temperature of the structural element or the ambient air are far from constant in most environments. The assumption that it is, may be a bigger source of error then the uncertainty in the value of the parameter itself.

The sensitivity of the transfer variable is increasing as it approaches the low end of its range. Since the transfer variable is usually found to be closer to 1.0 than 0.1, usually above 0.5, its impact on the chloride content is little.

The parameter with the least influence on the chloride content, is by a large margin, the regression variable. The regression variable describes the relationship between the temperature of the structural element and the standard test temperature, which is more or less the same at all times. A change in the regression variable therefore have little impact on the chloride content.

The depth at which we want to know the chloride content is rank as the second most important parameter in the ranking of the absolute values of the first order sensitivity coefficients. Almost two times larger than for the surface chloride concentration and the apparent diffusion coefficient. $S(a)$ has a negative sign, which means that as the depth increases, assuming one dimensional chloride ingress, the chloride content will decrease. In a practical sense this means that an increase in the cover depth will lead to an increase in service life.

To illustrate the chloride ingress in concrete a chloride profile is plotted with the depth on one axis and the chloride content on the other, as shown in figure 2 to figure 7. In this case, the depth at witch we want to know the chloride content do not have an impact on the chloride content since the chloride content is calculated throughout the depth of the concrete. However, when a life cycle analysis is performed where this depth is the cover depth, an uncertainty in a will have an impact on the chloride content.

5.2 Validity of the fib model

When we look at the comparison made between predictions made by the fib model and exposure data, we see that predictions made by the fib model do not fit as well as desired. Especially when the concrete contains fly ash i.e. PC-FA. Looking at figure 10, we see that the fib model overestimates the chloride content in approximately the first 16 mm. Then underestimating the chloride content for the remaining depth. We also see that this underestimation is larger after 5 years than 2 years, indicating the the predictions may get worse as the exposure time increases. It appears that the ageing exponent α, does not describe the time dependency of the apparent diffusion coefficient in a correct manner when a considerable amount of fly ash is used in the concrete.

For concrete with a coarse Portland cement, predictions made by the fib model at depths greater than 22.5 mm are very good. After 5 years the fib model makes a small underestimation and for 2 years the predictions a slightly on the safe side.

For a concrete with a fine Portland cement (F-PC), the fib model makes and overestimation of the chloride content at all depths after 2 years of exposure, and after five years a slight underestimation at approximately 30 mm and deeper.

6 Conclusion

The input parameters that have the largest sensitivity and therefore needs to be determined with a high level of accuracy is the ageing exponent, chloride migration coefficient, chloride surface concentration and the depth at which we want to determine the chloride content. From the sensitivity analysis, it is observed that the ageing exponent is most sensitive when it is between 0.2 and 0.3. It has the second largest total variation and is ranked by the differential analysis as the most sensitive parameter. Approximately two times as sensitive as the apparent diffusion coefficient and the surface chloride concentration. The depth at which we want to know the chloride concentration is ranked as the second most sensitive parameter by the differential analysis right below the ageing exponent and also is almost two times as sensitive as the apparent diffusion coefficient and the surface chloride concentration.

From the sensitivity analysis it is seen that the surface chloride concentration has the largest impact on the chloride concrete right below the concrete surface. As the depth increases the surface chloride concentration becomes less sensitive. It is the parameter with the largest total variation and the differential analysis ranks it as the third most sensitive parameter. The chloride migration coefficient has the largest variation between neighbouring values and the third largest total variation. The sensitivity of this parameter increases as the value of the parameter decreases.

Parameters that are less important and can be used with a bigger scatter without influencing the model to a critical degree is the transfer variable, the regression variable and the temperature of the structural element or the ambient air. The regression variable is the least sensitive parameter and has little to no impact on the predictions made by the fib model. A change in the temperature of the structural element or ambient air results in a small change in the chloride concentration. Data used to determine this parameter is usually accurate, which makes it relatively easy to determine this parameter accurately. The assumption that the temperature of the structural element or ambient air is not time dependent, may be a bigger source of error than the scatter in the parameter itself. The transfer variable has a small total variation. It can have a significant impact on the results if it’s in the low end of its range but are usually found to be in the high end.

From the comparison between data from concretes exposed to a chloride contaminated environment and predictions made by the fib model, we see that predictions for concretes containing fly ash are not adequately accurate. At depths greater than 15 mm, the fib model underestimates the chloride content.

For concrete containing OPC the predictions made by the fib model is quite accurate when the depth is greater than 25 mm. For an exposure time of 5 years, the fib model slightly under estimates the chloride content at depths greater than 25 mm. For an exposure of 2 years, we see a slight overestimation. The fineness of the cement also has a slight impact on the predictions, a coarse cement gives a more accurate prediction than a fine cement.

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Appendix A: Complete results from the sensitivity analysis

Below are the complete results from the Excel analysis. The number are rounded up to two decimals, for more exact numbers see "Calculation.xlsx". The second column from the left is the depth in mm, the top row is the value of the variable in question. The rest of the numbers are the chloride content at a certain depth for a certain value of the parameter in question.

Surface Chloride concentration

C_s [%wt. cem]		1.80	2.21	2.62	3.03	3.44	3.86	4.27	4.68	5.09	5.50
mm	0	1.80	2.21	2.62	3.03	3.44	3.86	4.27	4.68	5.09	5.50
mm	1	1.78	2.19	2.59	3.00	3.40	3.81	4.22	4.62	5.03	5.44
mm	2	1.76	2.16	2.56	2.96	3.36	3.77	4.17	4.57	4.97	5.37
mm	3	1.74	2.13	2.53	2.93	3.32	3.72	4.12	4.51	4.91	5.31
mm	4	1.72	2.11	2.50	2.89	3.28	3.68	4.07	4.46	4.85	5.24
mm	5	1.70	2.08	2.47	2.86	3.24	3.63	4.02	4.41	4.79	5.18
mm	6	1.67	2.06	2.44	2.82	3.20	3.59	3.97	4.35	4.73	5.12
mm	7	1.65	2.03	2.41	2.79	3.16	3.54	3.92	4.30	4.67	5.05
mm	8	1.63	2.01	2.38	2.75	3.12	3.50	3.87	4.24	4.62	4.99
mm	9	1.61	1.98	2.35	2.72	3.08	3.45	3.82	4.19	4.56	4.92
mm	10	1.59	1.95	2.32	2.68	3.04	3.41	3.77	4.13	4.50	4.86
mm	11	1.57	1.93	2.29	2.65	3.00	3.36	3.72	4.08	4.44	4.80
mm	12	1.55	1.90	2.26	2.61	2.97	3.32	3.67	4.03	4.38	4.73
mm	13	1.53	1.88	2.23	2.58	2.93	3.28	3.62	3.97	4.32	4.67
mm	14	1.51	1.85	2.20	2.54	2.89	3.23	3.58	3.92	4.26	4.61
mm	15	1.49	1.83	2.17	2.51	2.85	3.19	3.53	3.87	4.21	4.55
mm	16	1.47	1.80	2.14	2.47	2.81	3.14	3.48	3.81	4.15	4.48
mm	17	1.45	1.78	2.11	2.44	2.77	3.10	3.43	3.76	4.09	4.42
mm	18	1.43	1.75	2.08	2.40	2.73	3.06	3.38	3.71	4.03	4.36
mm	19	1.41	1.73	2.05	2.37	2.69	3.01	3.33	3.66	3.98	4.30
mm	20	1.39	1.70	2.02	2.34	2.65	2.97	3.29	3.60	3.92	4.24
mm	21	1.37	1.68	1.99	2.30	2.61	2.93	3.24	3.55	3.86	4.18
mm	22	1.35	1.65	1.96	2.27	2.58	2.88	3.19	3.50	3.81	4.11
mm	23	1.33	1.63	1.93	2.24	2.54	2.84	3.14	3.45	3.75	4.05
mm	24	1.31	1.61	1.90	2.20	2.50	2.80	3.10	3.40	3.69	3.99
mm	25	1.29	1.58	1.88	2.17	2.46	2.76	3.05	3.34	3.64	3.93
mm	26	1.27	1.56	1.85	2.14	2.43	2.72	3.00	3.29	3.58	3.87
mm	27	1.25	1.53	1.82	2.10	2.39	2.67	2.96	3.24	3.53	3.81
mm	28	1.23	1.51	1.79	2.07	2.35	2.63	2.91	3.19	3.47	3.75
mm	29	1.21	1.49	1.76	2.04	2.31	2.59	2.87	3.14	3.42	3.70
mm	30	1.19	1.46	1.73	2.01	2.28	2.55	2.82	3.09	3.37	3.64
mm	31	1.17	1.44	1.71	1.97	2.24	2.51	2.78	3.04	3.31	3.58

mm	32	1.15	1.42	1.68	1.94	2.21	2.47	2.73	3.00	3.26	3.52
mm	33	1.13	1.39	1.65	1.91	2.17	2.43	2.69	2.95	3.21	3.46
mm	34	1.12	1.37	1.62	1.88	2.13	2.39	2.64	2.90	3.15	3.41
mm	35	1.10	1.35	1.60	1.85	2.10	2.35	2.60	2.85	3.10	3.35
mm	36	1.08	1.32	1.57	1.82	2.06	2.31	2.56	2.80	3.05	3.30
mm	37	1.06	1.30	1.54	1.79	2.03	2.27	2.51	2.76	3.00	3.24
mm	38	1.04	1.28	1.52	1.76	1.99	2.23	2.47	2.71	2.95	3.18
mm	39	1.02	1.26	1.49	1.73	1.96	2.19	2.43	2.66	2.90	3.13
mm	40	1.01	1.24	1.47	1.70	1.93	2.16	2.39	2.62	2.85	3.08
mm	41	0.99	1.21	1.44	1.67	1.89	2.12	2.34	2.57	2.80	3.02
mm	42	0.97	1.19	1.42	1.64	1.86	2.08	2.30	2.52	2.75	2.97
mm	43	0.95	1.17	1.39	1.61	1.83	2.04	2.26	2.48	2.70	2.92
mm	44	0.94	1.15	1.37	1.58	1.79	2.01	2.22	2.44	2.65	2.86
mm	45	0.92	1.13	1.34	1.55	1.76	1.97	2.18	2.39	2.60	2.81
mm	46	0.90	1.11	1.32	1.52	1.73	1.93	2.14	2.35	2.55	2.76
mm	47	0.89	1.09	1.29	1.49	1.70	1.90	2.10	2.30	2.51	2.71
mm	48	0.87	1.07	1.27	1.47	1.66	1.86	2.06	2.26	2.46	2.66
mm	49	0.85	1.05	1.24	1.44	1.63	1.83	2.02	2.22	2.41	2.61
mm	50	0.84	1.03	1.22	1.41	1.60	1.79	1.99	2.18	2.37	2.56
mm	51	0.82	1.01	1.20	1.38	1.57	1.76	1.95	2.14	2.32	2.51
mm	52	0.81	0.99	1.17	1.36	1.54	1.73	1.91	2.09	2.28	2.46
mm	53	0.79	0.97	1.15	1.33	1.51	1.69	1.87	2.05	2.23	2.41
mm	54	0.77	0.95	1.13	1.31	1.48	1.66	1.84	2.01	2.19	2.37
mm	55	0.76	0.93	1.11	1.28	1.45	1.63	1.80	1.97	2.15	2.32
mm	56	0.74	0.91	1.08	1.25	1.42	1.59	1.76	1.93	2.10	2.27
mm	57	0.73	0.90	1.06	1.23	1.40	1.56	1.73	1.90	2.06	2.23
mm	58	0.71	0.88	1.04	1.20	1.37	1.53	1.69	1.86	2.02	2.18
mm	59	0.70	0.86	1.02	1.18	1.34	1.50	1.66	1.82	1.98	2.14
mm	60	0.69	0.84	1.00	1.16	1.31	1.47	1.63	1.78	1.94	2.10
mm	61	0.67	0.82	0.98	1.13	1.29	1.44	1.59	1.75	1.90	2.05
mm	62	0.66	0.81	0.96	1.11	1.26	1.41	1.56	1.71	1.86	2.01
mm	63	0.64	0.79	0.94	1.08	1.23	1.38	1.53	1.67	1.82	1.97
mm	64	0.63	0.77	0.92	1.06	1.21	1.35	1.49	1.64	1.78	1.93
mm	65	0.62	0.76	0.90	1.04	1.18	1.32	1.46	1.60	1.74	1.88
mm	66	0.60	0.74	0.88	1.02	1.15	1.29	1.43	1.57	1.71	1.84
mm	67	0.59	0.73	0.86	0.99	1.13	1.26	1.40	1.53	1.67	1.80
mm	68	0.58	0.71	0.84	0.97	1.10	1.24	1.37	1.50	1.63	1.76
mm	69	0.56	0.69	0.82	0.95	1.08	1.21	1.34	1.47	1.60	1.73
mm	70	0.55	0.68	0.80	0.93	1.06	1.18	1.31	1.43	1.56	1.69
mm	71	0.54	0.66	0.79	0.91	1.03	1.16	1.28	1.40	1.53	1.65
mm	72	0.53	0.65	0.77	0.89	1.01	1.13	1.25	1.37	1.49	1.61
mm	73	0.52	0.63	0.75	0.87	0.99	1.10	1.22	1.34	1.46	1.58

mm	74	0.50	0.62	0.73	0.85	0.96	1.08	1.19	1.31	1.42	1.54
mm	75	0.49	0.60	0.72	0.83	0.94	1.05	1.17	1.28	1.39	1.50
mm	76	0.48	0.59	0.70	0.81	0.92	1.03	1.14	1.25	1.36	1.47
mm	77	0.47	0.58	0.68	0.79	0.90	1.01	1.11	1.22	1.33	1.43
mm	78	0.46	0.56	0.67	0.77	0.88	0.98	1.09	1.19	1.30	1.40
mm	79	0.45	0.55	0.65	0.75	0.86	0.96	1.06	1.16	1.27	1.37
mm	80	0.44	0.54	0.64	0.74	0.84	0.94	1.04	1.14	1.24	1.34
mm	81	0.43	0.52	0.62	0.72	0.82	0.91	1.01	1.11	1.21	1.30
mm	82	0.42	0.51	0.61	0.70	0.80	0.89	0.99	1.08	1.18	1.27
mm	83	0.41	0.50	0.59	0.68	0.78	0.87	0.96	1.05	1.15	1.24
mm	84	0.40	0.49	0.58	0.67	0.76	0.85	0.94	1.03	1.12	1.21
mm	85	0.39	0.47	0.56	0.65	0.74	0.83	0.92	1.00	1.09	1.18
mm	86	0.38	0.46	0.55	0.63	0.72	0.81	0.89	0.98	1.06	1.15
mm	87	0.37	0.45	0.53	0.62	0.70	0.79	0.87	0.95	1.04	1.12
mm	88	0.36	0.44	0.52	0.60	0.68	0.77	0.85	0.93	1.01	1.09
mm	89	0.35	0.43	0.51	0.59	0.67	0.75	0.83	0.91	0.99	1.07
mm	90	0.34	0.42	0.50	0.57	0.65	0.73	0.81	0.88	0.96	1.04
mm	91	0.33	0.41	0.48	0.56	0.63	0.71	0.78	0.86	0.94	1.01
mm	92	0.32	0.40	0.47	0.54	0.62	0.69	0.76	0.84	0.91	0.99
mm	93	0.31	0.39	0.46	0.53	0.60	0.67	0.74	0.82	0.89	0.96
mm	94	0.31	0.38	0.45	0.52	0.59	0.65	0.72	0.79	0.86	0.93
mm	95	0.30	0.37	0.43	0.50	0.57	0.64	0.71	0.77	0.84	0.91
mm	96	0.29	0.36	0.42	0.49	0.55	0.62	0.69	0.75	0.82	0.89
mm	97	0.28	0.35	0.41	0.48	0.54	0.60	0.67	0.73	0.80	0.86
mm	98	0.27	0.34	0.40	0.46	0.53	0.59	0.65	0.71	0.78	0.84
mm	99	0.27	0.33	0.39	0.45	0.51	0.57	0.63	0.69	0.75	0.82
mm	100	0.26	0.32	0.38	0.44	0.50	0.56	0.62	0.67	0.73	0.79

Chloride migration coefficient

$D_{RCM,0}$ $[mm^2/year]$		44.15	126.84	209.54	292.23	374.93	457.62	540.32	623.01	705.71	788.40
mm	0	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
mm	1	2.45	2.48	2.49	2.50	2.50	2.50	2.50	2.51	2.51	2.51
mm	2	2.37	2.43	2.45	2.47	2.47	2.48	2.48	2.49	2.49	2.49
mm	3	2.29	2.39	2.42	2.44	2.45	2.45	2.46	2.46	2.47	2.47
mm	4	2.21	2.34	2.38	2.40	2.42	2.43	2.44	2.44	2.45	2.45
mm	5	2.14	2.30	2.35	2.37	2.39	2.40	2.41	2.42	2.43	2.43
mm	6	2.06	2.25	2.31	2.34	2.37	2.38	2.39	2.40	2.41	2.42
mm	7	1.98	2.20	2.27	2.31	2.34	2.36	2.37	2.38	2.39	2.40
mm	8	1.91	2.16	2.24	2.28	2.31	2.33	2.35	2.36	2.37	2.38

mm	9	1.83	2.11	2.20	2.25	2.28	2.31	2.32	2.34	2.35	2.36
mm	10	1.76	2.07	2.17	2.22	2.26	2.28	2.30	2.32	2.33	2.34
mm	11	1.69	2.02	2.13	2.19	2.23	2.26	2.28	2.30	2.31	2.32
mm	12	1.62	1.98	2.10	2.16	2.20	2.23	2.26	2.28	2.29	2.30
mm	13	1.55	1.93	2.06	2.13	2.18	2.21	2.24	2.26	2.27	2.29
mm	14	1.48	1.89	2.03	2.10	2.15	2.19	2.21	2.23	2.25	2.27
mm	15	1.41	1.84	1.99	2.07	2.12	2.16	2.19	2.21	2.23	2.25
mm	16	1.35	1.80	1.96	2.04	2.10	2.14	2.17	2.19	2.21	2.23
mm	17	1.28	1.76	1.92	2.01	2.07	2.11	2.15	2.17	2.19	2.21
mm	18	1.22	1.71	1.89	1.98	2.05	2.09	2.12	2.15	2.17	2.19
mm	19	1.16	1.67	1.85	1.95	2.02	2.07	2.10	2.13	2.16	2.18
mm	20	1.10	1.63	1.82	1.92	1.99	2.04	2.08	2.11	2.14	2.16
mm	21	1.04	1.59	1.79	1.90	1.97	2.02	2.06	2.09	2.12	2.14
mm	22	0.99	1.55	1.75	1.87	1.94	2.00	2.04	2.07	2.10	2.12
mm	23	0.93	1.51	1.72	1.84	1.92	1.97	2.02	2.05	2.08	2.10
mm	24	0.88	1.47	1.69	1.81	1.89	1.95	1.99	2.03	2.06	2.08
mm	25	0.83	1.43	1.65	1.78	1.86	1.93	1.97	2.01	2.04	2.07
mm	26	0.78	1.39	1.62	1.75	1.84	1.90	1.95	1.99	2.02	2.05
mm	27	0.74	1.35	1.59	1.72	1.81	1.88	1.93	1.97	2.00	2.03
mm	28	0.69	1.31	1.56	1.70	1.79	1.86	1.91	1.95	1.98	2.01
mm	29	0.65	1.27	1.52	1.67	1.76	1.83	1.89	1.93	1.96	1.99
mm	30	0.61	1.24	1.49	1.64	1.74	1.81	1.86	1.91	1.94	1.98
mm	31	0.57	1.20	1.46	1.61	1.71	1.79	1.84	1.89	1.93	1.96
mm	32	0.54	1.17	1.43	1.59	1.69	1.76	1.82	1.87	1.91	1.94
mm	33	0.50	1.13	1.40	1.56	1.66	1.74	1.80	1.85	1.89	1.92
mm	34	0.47	1.10	1.37	1.53	1.64	1.72	1.78	1.83	1.87	1.90
mm	35	0.43	1.06	1.34	1.50	1.62	1.70	1.76	1.81	1.85	1.89
mm	36	0.40	1.03	1.31	1.48	1.59	1.67	1.74	1.79	1.83	1.87
mm	37	0.38	1.00	1.28	1.45	1.57	1.65	1.72	1.77	1.81	1.85
mm	38	0.35	0.96	1.25	1.43	1.54	1.63	1.70	1.75	1.80	1.83
mm	39	0.32	0.93	1.23	1.40	1.52	1.61	1.68	1.73	1.78	1.82
mm	40	0.30	0.90	1.20	1.37	1.50	1.59	1.66	1.71	1.76	1.80
mm	41	0.28	0.87	1.17	1.35	1.47	1.56	1.64	1.69	1.74	1.78
mm	42	0.26	0.84	1.14	1.32	1.45	1.54	1.62	1.67	1.72	1.76
mm	43	0.24	0.81	1.11	1.30	1.43	1.52	1.60	1.66	1.70	1.75
mm	44	0.22	0.79	1.09	1.27	1.40	1.50	1.58	1.64	1.69	1.73
mm	45	0.20	0.76	1.06	1.25	1.38	1.48	1.56	1.62	1.67	1.71
mm	46	0.18	0.73	1.04	1.23	1.36	1.46	1.54	1.60	1.65	1.70
mm	47	0.17	0.71	1.01	1.20	1.34	1.44	1.52	1.58	1.63	1.68
mm	48	0.15	0.68	0.99	1.18	1.31	1.42	1.50	1.56	1.62	1.66
mm	49	0.14	0.66	0.96	1.16	1.29	1.40	1.48	1.54	1.60	1.64
mm	50	0.13	0.63	0.94	1.13	1.27	1.38	1.46	1.52	1.58	1.63

mm	51	0.12	0.61	0.91	1.11	1.25	1.36	1.44	1.51	1.56	1.61
mm	52	0.11	0.58	0.89	1.09	1.23	1.34	1.42	1.49	1.55	1.59
mm	53	0.10	0.56	0.87	1.06	1.21	1.32	1.40	1.47	1.53	1.58
mm	54	0.09	0.54	0.84	1.04	1.19	1.30	1.38	1.45	1.51	1.56
mm	55	0.08	0.52	0.82	1.02	1.17	1.28	1.36	1.43	1.49	1.55
mm	56	0.07	0.50	0.80	1.00	1.15	1.26	1.34	1.42	1.48	1.53
mm	57	0.07	0.48	0.78	0.98	1.13	1.24	1.33	1.40	1.46	1.51
mm	58	0.06	0.46	0.76	0.96	1.11	1.22	1.31	1.38	1.44	1.50
mm	59	0.05	0.44	0.73	0.94	1.09	1.20	1.29	1.36	1.43	1.48
mm	60	0.05	0.42	0.71	0.92	1.07	1.18	1.27	1.35	1.41	1.46
mm	61	0.04	0.40	0.69	0.90	1.05	1.16	1.25	1.33	1.39	1.45
mm	62	0.04	0.39	0.67	0.88	1.03	1.14	1.24	1.31	1.38	1.43
mm	63	0.04	0.37	0.65	0.86	1.01	1.12	1.22	1.30	1.36	1.42
mm	64	0.03	0.36	0.64	0.84	0.99	1.11	1.20	1.28	1.34	1.40
mm	65	0.03	0.34	0.62	0.82	0.97	1.09	1.18	1.26	1.33	1.39
mm	66	0.03	0.33	0.60	0.80	0.95	1.07	1.17	1.25	1.31	1.37
mm	67	0.02	0.31	0.58	0.78	0.93	1.05	1.15	1.23	1.30	1.35
mm	68	0.02	0.30	0.56	0.76	0.92	1.04	1.13	1.21	1.28	1.34
mm	69	0.02	0.28	0.55	0.75	0.90	1.02	1.12	1.20	1.27	1.32
mm	70	0.02	0.27	0.53	0.73	0.88	1.00	1.10	1.18	1.25	1.31
mm	71	0.01	0.26	0.51	0.71	0.86	0.98	1.08	1.16	1.23	1.29
mm	72	0.01	0.25	0.50	0.69	0.85	0.97	1.07	1.15	1.22	1.28
mm	73	0.01	0.23	0.48	0.68	0.83	0.95	1.05	1.13	1.20	1.26
mm	74	0.01	0.22	0.47	0.66	0.81	0.93	1.03	1.12	1.19	1.25
mm	75	0.01	0.21	0.45	0.65	0.80	0.92	1.02	1.10	1.17	1.23
mm	76	0.01	0.20	0.44	0.63	0.78	0.90	1.00	1.09	1.16	1.22
mm	77	0.01	0.19	0.42	0.61	0.76	0.89	0.99	1.07	1.14	1.21
mm	78	0.01	0.18	0.41	0.60	0.75	0.87	0.97	1.06	1.13	1.19
mm	79	0.01	0.17	0.40	0.58	0.73	0.85	0.96	1.04	1.11	1.18
mm	80	0.00	0.17	0.38	0.57	0.72	0.84	0.94	1.03	1.10	1.16
mm	81	0.00	0.16	0.37	0.55	0.70	0.82	0.93	1.01	1.08	1.15
mm	82	0.00	0.15	0.36	0.54	0.69	0.81	0.91	1.00	1.07	1.13
mm	83	0.00	0.14	0.35	0.53	0.67	0.79	0.90	0.98	1.06	1.12
mm	84	0.00	0.13	0.33	0.51	0.66	0.78	0.88	0.97	1.04	1.11
mm	85	0.00	0.13	0.32	0.50	0.64	0.77	0.87	0.95	1.03	1.09
mm	86	0.00	0.12	0.31	0.49	0.63	0.75	0.85	0.94	1.01	1.08
mm	87	0.00	0.11	0.30	0.47	0.62	0.74	0.84	0.93	1.00	1.07
mm	88	0.00	0.11	0.29	0.46	0.60	0.72	0.82	0.91	0.99	1.05
mm	89	0.00	0.10	0.28	0.45	0.59	0.71	0.81	0.90	0.97	1.04
mm	90	0.00	0.10	0.27	0.44	0.58	0.70	0.80	0.88	0.96	1.03
mm	91	0.00	0.09	0.26	0.42	0.56	0.68	0.78	0.87	0.95	1.01
mm	92	0.00	0.09	0.25	0.41	0.55	0.67	0.77	0.86	0.93	1.00

mm	93	0.00	0.08	0.24	0.40	0.54	0.66	0.76	0.84	0.92	0.99
mm	94	0.00	0.08	0.23	0.39	0.53	0.64	0.74	0.83	0.91	0.97
mm	95	0.00	0.07	0.22	0.38	0.51	0.63	0.73	0.82	0.89	0.96
mm	96	0.00	0.07	0.22	0.37	0.50	0.62	0.72	0.81	0.88	0.95
mm	97	0.00	0.06	0.21	0.36	0.49	0.61	0.71	0.79	0.87	0.94
mm	98	0.00	0.06	0.20	0.35	0.48	0.59	0.69	0.78	0.86	0.92
mm	99	0.00	0.06	0.19	0.34	0.47	0.58	0.68	0.77	0.84	0.91
mm	100	0.00	0.05	0.19	0.33	0.46	0.57	0.67	0.76	0.83	0.90

The ageing exponent

α [-]		0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
mm	0	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
mm	1	2.52	2.51	2.51	2.50	2.48	2.47	2.44	2.40	2.35	2.27	2.17
mm	2	2.51	2.50	2.49	2.47	2.44	2.41	2.35	2.28	2.17	2.03	1.82
mm	3	2.50	2.48	2.47	2.44	2.40	2.35	2.27	2.16	2.00	1.78	1.49
mm	4	2.49	2.47	2.44	2.41	2.36	2.29	2.18	2.04	1.83	1.56	1.19
mm	5	2.48	2.46	2.42	2.38	2.32	2.23	2.10	1.92	1.67	1.34	0.93
mm	6	2.47	2.44	2.40	2.35	2.27	2.17	2.01	1.80	1.51	1.14	0.71
mm	7	2.46	2.43	2.38	2.32	2.23	2.11	1.93	1.69	1.36	0.96	0.53
mm	8	2.45	2.41	2.36	2.29	2.19	2.05	1.85	1.58	1.22	0.80	0.38
mm	9	2.44	2.40	2.34	2.26	2.15	1.99	1.77	1.47	1.09	0.65	0.27
mm	10	2.43	2.38	2.32	2.23	2.11	1.93	1.69	1.36	0.96	0.53	0.18
mm	11	2.42	2.37	2.30	2.20	2.07	1.88	1.61	1.26	0.85	0.42	0.12
mm	12	2.41	2.35	2.28	2.18	2.03	1.82	1.53	1.17	0.74	0.33	0.08
mm	13	2.40	2.34	2.26	2.15	1.99	1.76	1.46	1.08	0.64	0.26	0.05
mm	14	2.39	2.33	2.24	2.12	1.95	1.71	1.39	0.99	0.55	0.20	0.03
mm	15	2.38	2.31	2.22	2.09	1.91	1.65	1.32	0.90	0.48	0.15	0.02
mm	16	2.37	2.30	2.20	2.06	1.87	1.60	1.25	0.83	0.41	0.11	0.01
mm	17	2.36	2.28	2.18	2.03	1.83	1.54	1.18	0.75	0.34	0.08	0.01
mm	18	2.35	2.27	2.16	2.00	1.79	1.49	1.11	0.68	0.29	0.06	0.00
mm	19	2.34	2.25	2.14	1.97	1.75	1.44	1.05	0.62	0.24	0.04	0.00
mm	20	2.33	2.24	2.12	1.95	1.71	1.39	0.99	0.56	0.20	0.03	0.00
mm	21	2.32	2.23	2.10	1.92	1.67	1.34	0.93	0.50	0.17	0.02	0.00
mm	22	2.31	2.21	2.08	1.89	1.63	1.29	0.87	0.45	0.14	0.01	0.00
mm	23	2.30	2.20	2.06	1.86	1.59	1.24	0.82	0.40	0.11	0.01	0.00
mm	24	2.29	2.18	2.04	1.83	1.56	1.19	0.77	0.36	0.09	0.01	0.00
mm	25	2.28	2.17	2.02	1.81	1.52	1.15	0.72	0.32	0.07	0.00	0.00
mm	26	2.27	2.16	2.00	1.78	1.48	1.10	0.67	0.28	0.06	0.00	0.00
mm	27	2.26	2.14	1.98	1.75	1.45	1.06	0.63	0.25	0.05	0.00	0.00
mm	28	2.25	2.13	1.96	1.73	1.41	1.02	0.58	0.22	0.04	0.00	0.00
mm	29	2.24	2.11	1.94	1.70	1.38	0.97	0.54	0.19	0.03	0.00	0.00

mm	30	2.23	2.10	1.92	1.67	1.34	0.93	0.50	0.17	0.02	0.00	0.00
mm	31	2.22	2.09	1.90	1.64	1.31	0.89	0.47	0.15	0.02	0.00	0.00
mm	32	2.21	2.07	1.88	1.62	1.27	0.86	0.43	0.13	0.01	0.00	0.00
mm	33	2.20	2.06	1.86	1.59	1.24	0.82	0.40	0.11	0.01	0.00	0.00
mm	34	2.19	2.04	1.84	1.57	1.21	0.78	0.37	0.09	0.01	0.00	0.00
mm	35	2.18	2.03	1.82	1.54	1.17	0.75	0.34	0.08	0.01	0.00	0.00
mm	36	2.17	2.02	1.80	1.51	1.14	0.71	0.31	0.07	0.00	0.00	0.00
mm	37	2.16	2.00	1.78	1.49	1.11	0.68	0.29	0.06	0.00	0.00	0.00
mm	38	2.15	1.99	1.76	1.46	1.08	0.65	0.26	0.05	0.00	0.00	0.00
mm	39	2.14	1.97	1.75	1.44	1.05	0.61	0.24	0.04	0.00	0.00	0.00
mm	40	2.13	1.96	1.73	1.41	1.02	0.58	0.22	0.04	0.00	0.00	0.00
mm	41	2.12	1.95	1.71	1.39	0.99	0.56	0.20	0.03	0.00	0.00	0.00
mm	42	2.11	1.93	1.69	1.36	0.96	0.53	0.18	0.03	0.00	0.00	0.00
mm	43	2.10	1.92	1.67	1.34	0.93	0.50	0.17	0.02	0.00	0.00	0.00
mm	44	2.09	1.90	1.65	1.32	0.90	0.48	0.15	0.02	0.00	0.00	0.00
mm	45	2.08	1.89	1.63	1.29	0.88	0.45	0.14	0.01	0.00	0.00	0.00
mm	46	2.07	1.88	1.61	1.27	0.85	0.43	0.12	0.01	0.00	0.00	0.00
mm	47	2.06	1.86	1.60	1.24	0.82	0.40	0.11	0.01	0.00	0.00	0.00
mm	48	2.05	1.85	1.58	1.22	0.80	0.38	0.10	0.01	0.00	0.00	0.00
mm	49	2.04	1.84	1.56	1.20	0.77	0.36	0.09	0.01	0.00	0.00	0.00
mm	50	2.03	1.82	1.54	1.18	0.75	0.34	0.08	0.01	0.00	0.00	0.00
mm	51	2.02	1.81	1.52	1.15	0.72	0.32	0.07	0.00	0.00	0.00	0.00
mm	52	2.01	1.80	1.51	1.13	0.70	0.30	0.07	0.00	0.00	0.00	0.00
mm	53	2.00	1.78	1.49	1.11	0.68	0.29	0.06	0.00	0.00	0.00	0.00
mm	54	1.99	1.77	1.47	1.09	0.65	0.27	0.05	0.00	0.00	0.00	0.00
mm	55	1.98	1.76	1.45	1.07	0.63	0.25	0.05	0.00	0.00	0.00	0.00
mm	56	1.97	1.74	1.43	1.04	0.61	0.24	0.04	0.00	0.00	0.00	0.00
mm	57	1.96	1.73	1.42	1.02	0.59	0.22	0.04	0.00	0.00	0.00	0.00
mm	58	1.95	1.72	1.40	1.00	0.57	0.21	0.03	0.00	0.00	0.00	0.00
mm	59	1.94	1.70	1.38	0.98	0.55	0.20	0.03	0.00	0.00	0.00	0.00
mm	60	1.93	1.69	1.37	0.96	0.53	0.18	0.03	0.00	0.00	0.00	0.00
mm	61	1.92	1.68	1.35	0.94	0.51	0.17	0.02	0.00	0.00	0.00	0.00
mm	62	1.91	1.66	1.33	0.92	0.49	0.16	0.02	0.00	0.00	0.00	0.00
mm	63	1.90	1.65	1.32	0.90	0.47	0.15	0.02	0.00	0.00	0.00	0.00
mm	64	1.90	1.64	1.30	0.88	0.46	0.14	0.02	0.00	0.00	0.00	0.00
mm	65	1.89	1.63	1.28	0.87	0.44	0.13	0.01	0.00	0.00	0.00	0.00
mm	66	1.88	1.61	1.27	0.85	0.42	0.12	0.01	0.00	0.00	0.00	0.00
mm	67	1.87	1.60	1.25	0.83	0.41	0.11	0.01	0.00	0.00	0.00	0.00
mm	68	1.86	1.59	1.23	0.81	0.39	0.11	0.01	0.00	0.00	0.00	0.00
mm	69	1.85	1.57	1.22	0.79	0.38	0.10	0.01	0.00	0.00	0.00	0.00
mm	70	1.84	1.56	1.20	0.78	0.36	0.09	0.01	0.00	0.00	0.00	0.00
mm	71	1.83	1.55	1.18	0.76	0.35	0.09	0.01	0.00	0.00	0.00	0.00

mm	72	1.82	1.54	1.17	0.74	0.33	0.08	0.01	0.00	0.00	0.00	0.00
mm	73	1.81	1.52	1.15	0.72	0.32	0.07	0.00	0.00	0.00	0.00	0.00
mm	74	1.80	1.51	1.14	0.71	0.31	0.07	0.00	0.00	0.00	0.00	0.00
mm	75	1.79	1.50	1.12	0.69	0.30	0.06	0.00	0.00	0.00	0.00	0.00
mm	76	1.78	1.49	1.11	0.67	0.28	0.06	0.00	0.00	0.00	0.00	0.00
mm	77	1.77	1.47	1.09	0.66	0.27	0.05	0.00	0.00	0.00	0.00	0.00
mm	78	1.76	1.46	1.08	0.64	0.26	0.05	0.00	0.00	0.00	0.00	0.00
mm	79	1.75	1.45	1.06	0.63	0.25	0.05	0.00	0.00	0.00	0.00	0.00
mm	80	1.74	1.44	1.05	0.61	0.24	0.04	0.00	0.00	0.00	0.00	0.00
mm	81	1.74	1.42	1.03	0.60	0.23	0.04	0.00	0.00	0.00	0.00	0.00
mm	82	1.73	1.41	1.02	0.58	0.22	0.04	0.00	0.00	0.00	0.00	0.00
mm	83	1.72	1.40	1.00	0.57	0.21	0.03	0.00	0.00	0.00	0.00	0.00
mm	84	1.71	1.39	0.99	0.56	0.20	0.03	0.00	0.00	0.00	0.00	0.00
mm	85	1.70	1.38	0.98	0.54	0.19	0.03	0.00	0.00	0.00	0.00	0.00
mm	86	1.69	1.36	0.96	0.53	0.18	0.03	0.00	0.00	0.00	0.00	0.00
mm	87	1.68	1.35	0.95	0.52	0.17	0.02	0.00	0.00	0.00	0.00	0.00
mm	88	1.67	1.34	0.93	0.50	0.17	0.02	0.00	0.00	0.00	0.00	0.00
mm	89	1.66	1.33	0.92	0.49	0.16	0.02	0.00	0.00	0.00	0.00	0.00
mm	90	1.65	1.32	0.91	0.48	0.15	0.02	0.00	0.00	0.00	0.00	0.00
mm	91	1.64	1.31	0.89	0.46	0.14	0.02	0.00	0.00	0.00	0.00	0.00
mm	92	1.63	1.29	0.88	0.45	0.14	0.01	0.00	0.00	0.00	0.00	0.00
mm	93	1.63	1.28	0.87	0.44	0.13	0.01	0.00	0.00	0.00	0.00	0.00
mm	94	1.62	1.27	0.85	0.43	0.12	0.01	0.00	0.00	0.00	0.00	0.00
mm	95	1.61	1.26	0.84	0.42	0.12	0.01	0.00	0.00	0.00	0.00	0.00
mm	96	1.60	1.25	0.83	0.41	0.11	0.01	0.00	0.00	0.00	0.00	0.00
mm	97	1.59	1.24	0.81	0.40	0.11	0.01	0.00	0.00	0.00	0.00	0.00
mm	98	1.58	1.23	0.80	0.39	0.10	0.01	0.00	0.00	0.00	0.00	0.00
mm	99	1.57	1.21	0.79	0.37	0.10	0.01	0.00	0.00	0.00	0.00	0.00
mm	100	1.56	1.20	0.78	0.36	0.09	0.01	0.00	0.00	0.00	0.00	0.00

Temperature of the structural element or the ambient air

T_{real} [K]		273.00	276.33	279.67	283.00	286.33	289.67	293.00	296.33	299.67	303.00
mm	0	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
mm	1	2.48	2.49	2.49	2.49	2.50	2.50	2.50	2.50	2.51	2.51
mm	2	2.43	2.44	2.45	2.46	2.47	2.47	2.48	2.48	2.48	2.49
mm	3	2.39	2.40	2.41	2.42	2.43	2.44	2.45	2.46	2.46	2.47
mm	4	2.34	2.36	2.38	2.39	2.40	2.41	2.42	2.43	2.44	2.45
mm	5	2.29	2.32	2.34	2.36	2.37	2.39	2.40	2.41	2.42	2.43
mm	6	2.25	2.28	2.30	2.32	2.34	2.36	2.37	2.39	2.40	2.41
mm	7	2.20	2.24	2.26	2.29	2.31	2.33	2.35	2.36	2.38	2.39
mm	8	2.16	2.19	2.23	2.25	2.28	2.30	2.32	2.34	2.36	2.37

mm	9	2.11	2.15	2.19	2.22	2.25	2.28	2.30	2.32	2.34	2.35
mm	10	2.07	2.11	2.15	2.19	2.22	2.25	2.27	2.29	2.31	2.33
mm	11	2.02	2.07	2.11	2.15	2.19	2.22	2.25	2.27	2.29	2.31
mm	12	1.98	2.03	2.08	2.12	2.16	2.19	2.22	2.25	2.27	2.29
mm	13	1.93	1.99	2.04	2.09	2.13	2.16	2.20	2.23	2.25	2.27
mm	14	1.89	1.95	2.00	2.05	2.10	2.14	2.17	2.20	2.23	2.25
mm	15	1.84	1.91	1.97	2.02	2.07	2.11	2.15	2.18	2.21	2.24
mm	16	1.80	1.87	1.93	1.99	2.04	2.08	2.12	2.16	2.19	2.22
mm	17	1.76	1.83	1.90	1.96	2.01	2.05	2.10	2.13	2.17	2.20
mm	18	1.71	1.79	1.86	1.92	1.98	2.03	2.07	2.11	2.15	2.18
mm	19	1.67	1.75	1.82	1.89	1.95	2.00	2.05	2.09	2.13	2.16
mm	20	1.63	1.71	1.79	1.86	1.92	1.97	2.02	2.07	2.10	2.14
mm	21	1.59	1.68	1.75	1.83	1.89	1.95	2.00	2.04	2.08	2.12
mm	22	1.55	1.64	1.72	1.79	1.86	1.92	1.97	2.02	2.06	2.10
mm	23	1.50	1.60	1.69	1.76	1.83	1.89	1.95	2.00	2.04	2.08
mm	24	1.46	1.56	1.65	1.73	1.80	1.87	1.92	1.98	2.02	2.06
mm	25	1.43	1.53	1.62	1.70	1.77	1.84	1.90	1.95	2.00	2.04
mm	26	1.39	1.49	1.58	1.67	1.74	1.81	1.87	1.93	1.98	2.03
mm	27	1.35	1.45	1.55	1.64	1.72	1.79	1.85	1.91	1.96	2.01
mm	28	1.31	1.42	1.52	1.61	1.69	1.76	1.83	1.89	1.94	1.99
mm	29	1.27	1.38	1.48	1.58	1.66	1.73	1.80	1.86	1.92	1.97
mm	30	1.23	1.35	1.45	1.55	1.63	1.71	1.78	1.84	1.90	1.95
mm	31	1.20	1.31	1.42	1.52	1.60	1.68	1.76	1.82	1.88	1.93
mm	32	1.16	1.28	1.39	1.49	1.58	1.66	1.73	1.80	1.86	1.91
mm	33	1.13	1.25	1.36	1.46	1.55	1.63	1.71	1.78	1.84	1.89
mm	34	1.09	1.21	1.33	1.43	1.52	1.61	1.68	1.76	1.82	1.88
mm	35	1.06	1.18	1.29	1.40	1.50	1.58	1.66	1.73	1.80	1.86
mm	36	1.03	1.15	1.26	1.37	1.47	1.56	1.64	1.71	1.78	1.84
mm	37	0.99	1.12	1.23	1.34	1.44	1.53	1.62	1.69	1.76	1.82
mm	38	0.96	1.09	1.21	1.31	1.42	1.51	1.59	1.67	1.74	1.80
mm	39	0.93	1.06	1.18	1.29	1.39	1.48	1.57	1.65	1.72	1.78
mm	40	0.90	1.03	1.15	1.26	1.36	1.46	1.55	1.63	1.70	1.77
mm	41	0.87	1.00	1.12	1.23	1.34	1.44	1.53	1.61	1.68	1.75
mm	42	0.84	0.97	1.09	1.21	1.31	1.41	1.50	1.59	1.66	1.73
mm	43	0.81	0.94	1.06	1.18	1.29	1.39	1.48	1.57	1.64	1.71
mm	44	0.78	0.91	1.04	1.15	1.26	1.37	1.46	1.54	1.62	1.69
mm	45	0.76	0.89	1.01	1.13	1.24	1.34	1.44	1.52	1.60	1.68
mm	46	0.73	0.86	0.98	1.10	1.21	1.32	1.42	1.50	1.59	1.66
mm	47	0.70	0.83	0.96	1.08	1.19	1.30	1.39	1.48	1.57	1.64
mm	48	0.68	0.81	0.93	1.05	1.17	1.27	1.37	1.46	1.55	1.62
mm	49	0.65	0.78	0.91	1.03	1.14	1.25	1.35	1.44	1.53	1.61
mm	50	0.63	0.76	0.88	1.00	1.12	1.23	1.33	1.42	1.51	1.59

mm	51	0.60	0.73	0.86	0.98	1.10	1.21	1.31	1.40	1.49	1.57
mm	52	0.58	0.71	0.83	0.96	1.08	1.19	1.29	1.38	1.47	1.55
mm	53	0.56	0.69	0.81	0.93	1.05	1.16	1.27	1.37	1.46	1.54
mm	54	0.54	0.66	0.79	0.91	1.03	1.14	1.25	1.35	1.44	1.52
mm	55	0.52	0.64	0.77	0.89	1.01	1.12	1.23	1.33	1.42	1.50
mm	56	0.50	0.62	0.74	0.87	0.99	1.10	1.21	1.31	1.40	1.49
mm	57	0.48	0.60	0.72	0.85	0.97	1.08	1.19	1.29	1.38	1.47
mm	58	0.46	0.58	0.70	0.82	0.95	1.06	1.17	1.27	1.37	1.45
mm	59	0.44	0.56	0.68	0.80	0.92	1.04	1.15	1.25	1.35	1.44
mm	60	0.42	0.54	0.66	0.78	0.90	1.02	1.13	1.23	1.33	1.42
mm	61	0.40	0.52	0.64	0.76	0.88	1.00	1.11	1.22	1.31	1.40
mm	62	0.39	0.50	0.62	0.74	0.86	0.98	1.09	1.20	1.30	1.39
mm	63	0.37	0.48	0.60	0.72	0.84	0.96	1.07	1.18	1.28	1.37
mm	64	0.35	0.46	0.58	0.70	0.83	0.94	1.06	1.16	1.26	1.35
mm	65	0.34	0.45	0.57	0.69	0.81	0.92	1.04	1.14	1.24	1.34
mm	66	0.32	0.43	0.55	0.67	0.79	0.91	1.02	1.13	1.23	1.32
mm	67	0.31	0.42	0.53	0.65	0.77	0.89	1.00	1.11	1.21	1.31
mm	68	0.29	0.40	0.51	0.63	0.75	0.87	0.98	1.09	1.19	1.29
mm	69	0.28	0.38	0.50	0.61	0.73	0.85	0.97	1.08	1.18	1.28
mm	70	0.27	0.37	0.48	0.60	0.72	0.83	0.95	1.06	1.16	1.26
mm	71	0.26	0.36	0.46	0.58	0.70	0.82	0.93	1.04	1.15	1.24
mm	72	0.24	0.34	0.45	0.56	0.68	0.80	0.91	1.02	1.13	1.23
mm	73	0.23	0.33	0.43	0.55	0.67	0.78	0.90	1.01	1.11	1.21
mm	74	0.22	0.31	0.42	0.53	0.65	0.77	0.88	0.99	1.10	1.20
mm	75	0.21	0.30	0.41	0.52	0.63	0.75	0.86	0.98	1.08	1.18
mm	76	0.20	0.29	0.39	0.50	0.62	0.73	0.85	0.96	1.07	1.17
mm	77	0.19	0.28	0.38	0.49	0.60	0.72	0.83	0.94	1.05	1.15
mm	78	0.18	0.27	0.36	0.47	0.59	0.70	0.82	0.93	1.04	1.14
mm	79	0.17	0.26	0.35	0.46	0.57	0.69	0.80	0.91	1.02	1.12
mm	80	0.16	0.24	0.34	0.44	0.56	0.67	0.79	0.90	1.01	1.11
mm	81	0.16	0.23	0.33	0.43	0.54	0.66	0.77	0.88	0.99	1.10
mm	82	0.15	0.22	0.32	0.42	0.53	0.64	0.76	0.87	0.98	1.08
mm	83	0.14	0.21	0.30	0.40	0.51	0.63	0.74	0.85	0.96	1.07
mm	84	0.13	0.21	0.29	0.39	0.50	0.61	0.73	0.84	0.95	1.05
mm	85	0.13	0.20	0.28	0.38	0.49	0.60	0.71	0.82	0.93	1.04
mm	86	0.12	0.19	0.27	0.37	0.47	0.58	0.70	0.81	0.92	1.03
mm	87	0.11	0.18	0.26	0.36	0.46	0.57	0.68	0.80	0.91	1.01
mm	88	0.11	0.17	0.25	0.35	0.45	0.56	0.67	0.78	0.89	1.00
mm	89	0.10	0.16	0.24	0.33	0.44	0.54	0.66	0.77	0.88	0.98
mm	90	0.10	0.16	0.23	0.32	0.42	0.53	0.64	0.75	0.86	0.97
mm	91	0.09	0.15	0.22	0.31	0.41	0.52	0.63	0.74	0.85	0.96
mm	92	0.09	0.14	0.21	0.30	0.40	0.51	0.62	0.73	0.84	0.94

mm	93	0.08	0.14	0.21	0.29	0.39	0.49	0.60	0.71	0.82	0.93
mm	94	0.08	0.13	0.20	0.28	0.38	0.48	0.59	0.70	0.81	0.92
mm	95	0.07	0.12	0.19	0.27	0.37	0.47	0.58	0.69	0.80	0.91
mm	96	0.07	0.12	0.18	0.26	0.36	0.46	0.57	0.68	0.79	0.89
mm	97	0.06	0.11	0.18	0.25	0.35	0.45	0.55	0.66	0.77	0.88
mm	98	0.06	0.11	0.17	0.25	0.34	0.44	0.54	0.65	0.76	0.87
mm	99	0.06	0.10	0.16	0.24	0.33	0.43	0.53	0.64	0.75	0.86
mm	100	0.05	0.10	0.15	0.23	0.32	0.41	0.52	0.63	0.74	0.84

Transfer variable

k_t [-]		0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
mm	0	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
mm	1		2.47	2.48	2.48	2.49	2.49	2.49	2.50	2.50	2.50
mm	2	2.36	2.41	2.43	2.44	2.45	2.46	2.46	2.47	2.47	2.47
mm	3	2.27	2.35	2.38	2.40	2.41	2.42	2.43	2.44	2.44	2.45
mm	4	2.19	2.28	2.33	2.36	2.37	2.39	2.40	2.41	2.41	2.42
mm	5	2.10	2.22	2.28	2.31	2.34	2.35	2.36	2.38	2.38	2.39
mm	6	2.02	2.16	2.23	2.27	2.30	2.32	2.33	2.35	2.36	2.36
mm	7	1.93	2.11	2.18	2.23	2.26	2.28	2.30	2.31	2.33	2.34
mm	8	1.85	2.05	2.13	2.19	2.22	2.25	2.27	2.28	2.30	2.31
mm	9	1.77	1.99	2.08	2.14	2.18	2.21	2.24	2.25	2.27	2.28
mm	10	1.69	1.93	2.04	2.10	2.15	2.18	2.20	2.22	2.24	2.26
mm	11	1.62	1.87	1.99	2.06	2.11	2.14	2.17	2.19	2.21	2.23
mm	12	1.54	1.81	1.94	2.02	2.07	2.11	2.14	2.16	2.19	2.20
mm	13	1.47	1.76	1.89	1.98	2.03	2.08	2.11	2.13	2.16	2.18
mm	14	1.39	1.70	1.85	1.93	2.00	2.04	2.08	2.11	2.13	2.15
mm	15	1.32	1.65	1.80	1.89	1.96	2.01	2.05	2.08	2.10	2.12
mm	16	1.25	1.59	1.75	1.85	1.92	1.97	2.01	2.05	2.07	2.10
mm	17	1.19	1.54	1.71	1.81	1.89	1.94	1.98	2.02	2.05	2.07
mm	18	1.12	1.49	1.66	1.77	1.85	1.91	1.95	1.99	2.02	2.04
mm	19	1.06	1.43	1.62	1.73	1.81	1.87	1.92	1.96	1.99	2.02
mm	20	1.00	1.38	1.57	1.69	1.78	1.84	1.89	1.93	1.96	1.99
mm	21	0.94	1.33	1.53	1.65	1.74	1.81	1.86	1.90	1.93	1.96
mm	22	0.88	1.28	1.49	1.62	1.71	1.77	1.83	1.87	1.91	1.94
mm	23	0.83	1.23	1.45	1.58	1.67	1.74	1.80	1.84	1.88	1.91
mm	24	0.78	1.19	1.40	1.54	1.64	1.71	1.77	1.81	1.85	1.89
mm	25	0.73	1.14	1.36	1.50	1.60	1.68	1.74	1.79	1.83	1.86
mm	26	0.68	1.10	1.32	1.47	1.57	1.65	1.71	1.76	1.80	1.84
mm	27	0.63	1.05	1.28	1.43	1.53	1.61	1.68	1.73	1.77	1.81
mm	28	0.59	1.01	1.24	1.39	1.50	1.58	1.65	1.70	1.75	1.78
mm	29	0.55	0.97	1.20	1.36	1.47	1.55	1.62	1.67	1.72	1.76

mm	30	0.51	0.93	1.16	1.32	1.44	1.52	1.59	1.65	1.69	1.73
mm	31	0.47	0.89	1.13	1.29	1.40	1.49	1.56	1.62	1.67	1.71
mm	32	0.44	0.85	1.09	1.25	1.37	1.46	1.53	1.59	1.64	1.68
mm	33	0.40	0.81	1.05	1.22	1.34	1.43	1.50	1.57	1.62	1.66
mm	34	0.37	0.77	1.02	1.19	1.31	1.40	1.48	1.54	1.59	1.64
mm	35	0.34	0.74	0.98	1.15	1.28	1.37	1.45	1.51	1.57	1.61
mm	36	0.32	0.70	0.95	1.12	1.25	1.34	1.42	1.49	1.54	1.59
mm	37	0.29	0.67	0.92	1.09	1.22	1.31	1.39	1.46	1.52	1.56
mm	38	0.27	0.64	0.89	1.06	1.19	1.29	1.37	1.43	1.49	1.54
mm	39	0.24	0.61	0.85	1.03	1.16	1.26	1.34	1.41	1.47	1.52
mm	40	0.22	0.58	0.82	1.00	1.13	1.23	1.31	1.38	1.44	1.49
mm	41	0.20	0.55	0.79	0.97	1.10	1.20	1.29	1.36	1.42	1.47
mm	42	0.19	0.52	0.76	0.94	1.07	1.18	1.26	1.33	1.39	1.44
mm	43	0.17	0.49	0.73	0.91	1.04	1.15	1.24	1.31	1.37	1.42
mm	44	0.15	0.47	0.71	0.88	1.02	1.12	1.21	1.28	1.35	1.40
mm	45	0.14	0.44	0.68	0.85	0.99	1.10	1.19	1.26	1.32	1.38
mm	46	0.13	0.42	0.65	0.83	0.96	1.07	1.16	1.23	1.30	1.35
mm	47	0.11	0.40	0.63	0.80	0.94	1.05	1.14	1.21	1.28	1.33
mm	48	0.10	0.38	0.60	0.78	0.91	1.02	1.11	1.19	1.25	1.31
mm	49	0.09	0.35	0.58	0.75	0.89	1.00	1.09	1.16	1.23	1.29
mm	50	0.08	0.33	0.55	0.73	0.86	0.97	1.06	1.14	1.21	1.27
mm	51	0.08	0.32	0.53	0.70	0.84	0.95	1.04	1.12	1.19	1.24
mm	52	0.07	0.30	0.51	0.68	0.81	0.93	1.02	1.10	1.16	1.22
mm	53	0.06	0.28	0.49	0.66	0.79	0.90	1.00	1.07	1.14	1.20
mm	54	0.05	0.26	0.47	0.63	0.77	0.88	0.97	1.05	1.12	1.18
mm	55	0.05	0.25	0.45	0.61	0.75	0.86	0.95	1.03	1.10	1.16
mm	56	0.04	0.23	0.43	0.59	0.72	0.83	0.93	1.01	1.08	1.14
mm	57	0.04	0.22	0.41	0.57	0.70	0.81	0.91	0.99	1.06	1.12
mm	58	0.03	0.20	0.39	0.55	0.68	0.79	0.89	0.97	1.04	1.10
mm	59	0.03	0.19	0.37	0.53	0.66	0.77	0.87	0.95	1.02	1.08
mm	60	0.03	0.18	0.35	0.51	0.64	0.75	0.84	0.93	1.00	1.06
mm	61	0.02	0.17	0.34	0.49	0.62	0.73	0.82	0.91	0.98	1.04
mm	62	0.02	0.16	0.32	0.47	0.60	0.71	0.80	0.89	0.96	1.02
mm	63	0.02	0.15	0.31	0.45	0.58	0.69	0.79	0.87	0.94	1.00
mm	64	0.02	0.14	0.29	0.44	0.56	0.67	0.77	0.85	0.92	0.98
mm	65	0.01	0.13	0.28	0.42	0.55	0.65	0.75	0.83	0.90	0.96
mm	66	0.01	0.12	0.26	0.40	0.53	0.64	0.73	0.81	0.88	0.95
mm	67	0.01	0.11	0.25	0.39	0.51	0.62	0.71	0.79	0.86	0.93
mm	68	0.01	0.10	0.24	0.37	0.49	0.60	0.69	0.77	0.85	0.91
mm	69	0.01	0.10	0.23	0.36	0.48	0.58	0.67	0.76	0.83	0.89
mm	70	0.01	0.09	0.22	0.34	0.46	0.57	0.66	0.74	0.81	0.87
mm	71	0.01	0.08	0.20	0.33	0.45	0.55	0.64	0.72	0.79	0.86

mm	72	0.01	0.08	0.19	0.32	0.43	0.53	0.62	0.70	0.78	0.84
mm	73	0.00	0.07	0.18	0.30	0.42	0.52	0.61	0.69	0.76	0.82
mm	74	0.00	0.07	0.17	0.29	0.40	0.50	0.59	0.67	0.74	0.81
mm	75	0.00	0.06	0.16	0.28	0.39	0.49	0.57	0.65	0.73	0.79
mm	76	0.00	0.06	0.16	0.27	0.37	0.47	0.56	0.64	0.71	0.77
mm	77	0.00	0.05	0.15	0.26	0.36	0.46	0.54	0.62	0.69	0.76
mm	78	0.00	0.05	0.14	0.24	0.35	0.44	0.53	0.61	0.68	0.74
mm	79	0.00	0.04	0.13	0.23	0.33	0.43	0.51	0.59	0.66	0.73
mm	80	0.00	0.04	0.12	0.22	0.32	0.42	0.50	0.58	0.65	0.71
mm	81	0.00	0.04	0.12	0.21	0.31	0.40	0.49	0.56	0.63	0.70
mm	82	0.00	0.03	0.11	0.20	0.30	0.39	0.47	0.55	0.62	0.68
mm	83	0.00	0.03	0.10	0.20	0.29	0.38	0.46	0.53	0.60	0.67
mm	84	0.00	0.03	0.10	0.19	0.28	0.36	0.45	0.52	0.59	0.65
mm	85	0.00	0.03	0.09	0.18	0.27	0.35	0.43	0.51	0.58	0.64
mm	86	0.00	0.02	0.09	0.17	0.26	0.34	0.42	0.49	0.56	0.62
mm	87	0.00	0.02	0.08	0.16	0.25	0.33	0.41	0.48	0.55	0.61
mm	88	0.00	0.02	0.08	0.15	0.24	0.32	0.40	0.47	0.54	0.60
mm	89	0.00	0.02	0.07	0.15	0.23	0.31	0.38	0.46	0.52	0.58
mm	90	0.00	0.02	0.07	0.14	0.22	0.30	0.37	0.44	0.51	0.57
mm	91	0.00	0.02	0.06	0.13	0.21	0.29	0.36	0.43	0.50	0.56
mm	92	0.00	0.01	0.06	0.13	0.20	0.28	0.35	0.42	0.48	0.54
mm	93	0.00	0.01	0.06	0.12	0.19	0.27	0.34	0.41	0.47	0.53
mm	94	0.00	0.01	0.05	0.11	0.19	0.26	0.33	0.40	0.46	0.52
mm	95	0.00	0.01	0.05	0.11	0.18	0.25	0.32	0.39	0.45	0.51
mm	96	0.00	0.01	0.05	0.10	0.17	0.24	0.31	0.38	0.44	0.50
mm	97	0.00	0.01	0.04	0.10	0.16	0.23	0.30	0.36	0.43	0.48
mm	98	0.00	0.01	0.04	0.09	0.16	0.22	0.29	0.35	0.42	0.47
mm	99	0.00	0.01	0.04	0.09	0.15	0.22	0.28	0.34	0.40	0.46
mm	100	0.00	0.01	0.04	0.08	0.14	0.21	0.27	0.33	0.39	0.45

The regression variable

b_e[-]		3500.00	3722.22	3944.44	4166.67	4388.89	4611.11	4833.33	5055.56	5277.78	5500.00
mm	0	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
mm	1	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
mm	2	2.47	2.47	2.47	2.47	2.47	2.47	2.47	2.47	2.47	2.47
mm	3	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44
mm	4	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41
mm	5	2.39	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38
mm	6	2.36	2.36	2.35	2.35	2.35	2.35	2.35	2.35	2.35	2.35
mm	7	2.33	2.33	2.33	2.33	2.32	2.32	2.32	2.32	2.32	2.32
mm	8	2.30	2.30	2.30	2.30	2.29	2.29	2.29	2.29	2.29	2.29

mm	9	2.27	2.27	2.27	2.27	2.27	2.26	2.26	2.26	2.26	2.26
mm	10	2.24	2.24	2.24	2.24	2.24	2.24	2.23	2.23	2.23	2.23
mm	11	2.22	2.21	2.21	2.21	2.21	2.21	2.20	2.20	2.20	2.20
mm	12	2.19	2.19	2.18	2.18	2.18	2.18	2.18	2.17	2.17	2.17
mm	13	2.16	2.16	2.16	2.15	2.15	2.15	2.15	2.14	2.14	2.14
mm	14	2.13	2.13	2.13	2.13	2.12	2.12	2.12	2.11	2.11	2.11
mm	15	2.11	2.10	2.10	2.10	2.09	2.09	2.09	2.09	2.08	2.08
mm	16	2.08	2.07	2.07	2.07	2.07	2.06	2.06	2.06	2.05	2.05
mm	17	2.05	2.05	2.04	2.04	2.04	2.03	2.03	2.03	2.02	2.02
mm	18	2.02	2.02	2.02	2.01	2.01	2.01	2.00	2.00	2.00	1.99
mm	19	2.00	1.99	1.99	1.98	1.98	1.98	1.97	1.97	1.97	1.96
mm	20	1.97	1.96	1.96	1.96	1.95	1.95	1.95	1.94	1.94	1.93
mm	21	1.94	1.94	1.93	1.93	1.93	1.92	1.92	1.91	1.91	1.91
mm	22	1.91	1.91	1.91	1.90	1.90	1.89	1.89	1.89	1.88	1.88
mm	23	1.89	1.88	1.88	1.87	1.87	1.87	1.86	1.86	1.85	1.85
mm	24	1.86	1.86	1.85	1.85	1.84	1.84	1.83	1.83	1.83	1.82
mm	25	1.83	1.83	1.82	1.82	1.82	1.81	1.81	1.80	1.80	1.79
mm	26	1.81	1.80	1.80	1.79	1.79	1.78	1.78	1.77	1.77	1.76
mm	27	1.78	1.78	1.77	1.77	1.76	1.76	1.75	1.75	1.74	1.74
mm	28	1.75	1.75	1.74	1.74	1.73	1.73	1.72	1.72	1.71	1.71
mm	29	1.73	1.72	1.72	1.71	1.71	1.70	1.70	1.69	1.69	1.68
mm	30	1.70	1.70	1.69	1.69	1.68	1.68	1.67	1.67	1.66	1.65
mm	31	1.68	1.67	1.67	1.66	1.65	1.65	1.64	1.64	1.63	1.63
mm	32	1.65	1.64	1.64	1.63	1.63	1.62	1.62	1.61	1.61	1.60
mm	33	1.62	1.62	1.61	1.61	1.60	1.60	1.59	1.59	1.58	1.57
mm	34	1.60	1.59	1.59	1.58	1.58	1.57	1.56	1.56	1.55	1.55
mm	35	1.57	1.57	1.56	1.56	1.55	1.54	1.54	1.53	1.53	1.52
mm	36	1.55	1.54	1.54	1.53	1.53	1.52	1.51	1.51	1.50	1.49
mm	37	1.52	1.52	1.51	1.51	1.50	1.49	1.49	1.48	1.48	1.47
mm	38	1.50	1.49	1.49	1.48	1.47	1.47	1.46	1.46	1.45	1.44
mm	39	1.48	1.47	1.46	1.46	1.45	1.44	1.44	1.43	1.42	1.42
mm	40	1.45	1.44	1.44	1.43	1.43	1.42	1.41	1.41	1.40	1.39
mm	41	1.43	1.42	1.41	1.41	1.40	1.39	1.39	1.38	1.37	1.37
mm	42	1.40	1.40	1.39	1.38	1.38	1.37	1.36	1.36	1.35	1.34
mm	43	1.38	1.37	1.37	1.36	1.35	1.35	1.34	1.33	1.32	1.32
mm	44	1.36	1.35	1.34	1.34	1.33	1.32	1.31	1.31	1.30	1.29
mm	45	1.33	1.33	1.32	1.31	1.30	1.30	1.29	1.28	1.28	1.27
mm	46	1.31	1.30	1.30	1.29	1.28	1.27	1.27	1.26	1.25	1.25
mm	47	1.29	1.28	1.27	1.27	1.26	1.25	1.24	1.24	1.23	1.22
mm	48	1.26	1.26	1.25	1.24	1.23	1.23	1.22	1.21	1.21	1.20
mm	49	1.24	1.23	1.23	1.22	1.21	1.20	1.20	1.19	1.18	1.18
mm	50	1.22	1.21	1.20	1.20	1.19	1.18	1.17	1.17	1.16	1.15

mm	51	1.20	1.19	1.18	1.17	1.17	1.16	1.15	1.14	1.14	1.13
mm	52	1.18	1.17	1.16	1.15	1.15	1.14	1.13	1.12	1.11	1.11
mm	53	1.15	1.15	1.14	1.13	1.12	1.12	1.11	1.10	1.09	1.09
mm	54	1.13	1.12	1.12	1.11	1.10	1.09	1.09	1.08	1.07	1.06
mm	55	1.11	1.10	1.10	1.09	1.08	1.07	1.07	1.06	1.05	1.04
mm	56	1.09	1.08	1.07	1.07	1.06	1.05	1.04	1.04	1.03	1.02
mm	57	1.07	1.06	1.05	1.05	1.04	1.03	1.02	1.02	1.01	1.00
mm	58	1.05	1.04	1.03	1.03	1.02	1.01	1.00	0.99	0.99	0.98
mm	59	1.03	1.02	1.01	1.01	1.00	0.99	0.98	0.97	0.97	0.96
mm	60	1.01	1.00	0.99	0.99	0.98	0.97	0.96	0.95	0.95	0.94
mm	61	0.99	0.98	0.97	0.97	0.96	0.95	0.94	0.93	0.93	0.92
mm	62	0.97	0.96	0.95	0.95	0.94	0.93	0.92	0.91	0.91	0.90
mm	63	0.95	0.94	0.93	0.93	0.92	0.91	0.90	0.89	0.89	0.88
mm	64	0.93	0.92	0.92	0.91	0.90	0.89	0.88	0.88	0.87	0.86
mm	65	0.91	0.90	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.84
mm	66	0.89	0.89	0.88	0.87	0.86	0.85	0.85	0.84	0.83	0.82
mm	67	0.88	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.81	0.80
mm	68	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.80	0.79	0.79
mm	69	0.84	0.83	0.82	0.82	0.81	0.80	0.79	0.78	0.78	0.77
mm	70	0.82	0.81	0.81	0.80	0.79	0.78	0.77	0.77	0.76	0.75
mm	71	0.80	0.80	0.79	0.78	0.77	0.76	0.76	0.75	0.74	0.73
mm	72	0.79	0.78	0.77	0.76	0.76	0.75	0.74	0.73	0.72	0.72
mm	73	0.77	0.76	0.75	0.75	0.74	0.73	0.72	0.71	0.71	0.70
mm	74	0.75	0.75	0.74	0.73	0.72	0.71	0.71	0.70	0.69	0.68
mm	75	0.74	0.73	0.72	0.71	0.71	0.70	0.69	0.68	0.67	0.67
mm	76	0.72	0.71	0.71	0.70	0.69	0.68	0.67	0.67	0.66	0.65
mm	77	0.71	0.70	0.69	0.68	0.67	0.67	0.66	0.65	0.64	0.63
mm	78	0.69	0.68	0.67	0.67	0.66	0.65	0.64	0.63	0.63	0.62
mm	79	0.67	0.67	0.66	0.65	0.64	0.64	0.63	0.62	0.61	0.60
mm	80	0.66	0.65	0.64	0.64	0.63	0.62	0.61	0.60	0.60	0.59
mm	81	0.64	0.64	0.63	0.62	0.61	0.61	0.60	0.59	0.58	0.57
mm	82	0.63	0.62	0.61	0.61	0.60	0.59	0.58	0.58	0.57	0.56
mm	83	0.62	0.61	0.60	0.59	0.58	0.58	0.57	0.56	0.55	0.55
mm	84	0.60	0.59	0.59	0.58	0.57	0.56	0.55	0.55	0.54	0.53
mm	85	0.59	0.58	0.57	0.56	0.56	0.55	0.54	0.53	0.53	0.52
mm	86	0.57	0.57	0.56	0.55	0.54	0.54	0.53	0.52	0.51	0.50
mm	87	0.56	0.55	0.54	0.54	0.53	0.52	0.51	0.51	0.50	0.49
mm	88	0.55	0.54	0.53	0.52	0.52	0.51	0.50	0.49	0.49	0.48
mm	89	0.53	0.53	0.52	0.51	0.50	0.50	0.49	0.48	0.47	0.47
mm	90	0.52	0.51	0.51	0.50	0.49	0.48	0.48	0.47	0.46	0.45
mm	91	0.51	0.50	0.49	0.49	0.48	0.47	0.46	0.46	0.45	0.44
mm	92	0.50	0.49	0.48	0.47	0.47	0.46	0.45	0.44	0.44	0.43

mm	93	0.48	0.48	0.47	0.46	0.45	0.45	0.44	0.43	0.43	0.42
mm	94	0.47	0.46	0.46	0.45	0.44	0.44	0.43	0.42	0.41	0.41
mm	95	0.46	0.45	0.45	0.44	0.43	0.42	0.42	0.41	0.40	0.40
mm	96	0.45	0.44	0.43	0.43	0.42	0.41	0.41	0.40	0.39	0.39
mm	97	0.44	0.43	0.42	0.42	0.41	0.40	0.39	0.39	0.38	0.37
mm	98	0.43	0.42	0.41	0.40	0.40	0.39	0.38	0.38	0.37	0.36
mm	99	0.42	0.41	0.40	0.39	0.39	0.38	0.37	0.37	0.36	0.35
mm	100	0.40	0.40	0.39	0.38	0.38	0.37	0.36	0.36	0.35	0.34

Appendix B: Complete results for predictions made by the fib model

Below is the measured value, projections made by DuraCrete and the difference between the two values for the three concretes that was exposed to a chloride contaminated environment. A positive sign in the difference column indicates an overestimation, a negative sign indicates an underestimation.

B2

2 Years		DuraCrete	Measured	Difference
mm	0.5	1.604	0.865	0.738
mm	2.5	1.481	0.728	0.753
mm	6	1.209	0.626	0.583
mm	10	0.850	0.519	0.331
mm	14	0.512	0.421	0.091
mm	18	0.260	0.336	-0.077
mm	22.5	0.096	0.196	-0.099
mm	27.5	0.024	0.097	-0.073
mm	32.5	0.004	0.040	-0.036
mm	37.5	0.001	0.019	-0.019

5 Years		DuraCrete	Measured	Difference
mm	0.5	1.520	0.930503897	0.590
mm	2.5	1.405	0.624411246	0.781
mm	6	1.167	0.606980129	0.560
mm	10	0.867	0.558257045	0.308
mm	14	0.579	0.497579868	0.081
mm	18	0.344	0.433443104	-0.090
mm	22.5	0.164	0.334941675	-0.171
mm	27.5	0.059	0.209356554	-0.150
mm	32.5	0.017	0.104568044	-0.087
mm	37.5	0.004	0.048005982	-0.044
mm	42.5	0.001	0.020528206	-0.020
mm	47.5	0.000	0.012820147	-0.013

B9

2 Years		DuraCrete	Measured	Difference
mm	0.5	0.766	0.648	0.118
mm	2.5	0.718	0.455	0.263
mm	6	0.628	0.397	0.230
mm	10	0.520	0.349	0.171
mm	14	0.415	0.297	0.118

mm	18	0.317	0.252	0.066
mm	22.5	0.222	0.192	0.030
mm	27.5	0.140	0.141	-0.001
mm	32.5	0.081	0.079	0.002
mm	37.5	0.044	0.038	0.006

5 Years		DuraCrete	Measured	Difference
mm	0.5	0.710	0.801	-0.091
mm	2.5	0.673	0.488	0.185
mm	6	0.606	0.423	0.184
mm	10	0.529	0.398	0.130
mm	14	0.451	0.342	0.109
mm	18	0.377	0.302	0.075
mm	22.5	0.300	0.258	0.042
mm	27.5	0.224	0.217	0.008
mm	32.5	0.162	0.180	-0.018
mm	37.5	0.112	0.136	-0.024
mm	42.5	0.074	0.093	-0.019
mm	47.5	0.047	0.063	-0.016

B10

2 Years		DuraCrete	Measured	Difference
mm	0.5	0.749	0.718	0.031
mm	2.5	0.704	0.404	0.300
mm	6	0.621	0.336	0.285
mm	10	0.523	0.293	0.230
mm	14	0.426	0.245	0.181
mm	18	0.336	0.212	0.124
mm	22.5	0.246	0.158	0.087
mm	27.5	0.164	0.111	0.053
mm	32.5	0.103	0.053	0.050
mm	37.5	0.060	0.024	0.036

5 Years		DuraCrete	Measured	Difference
mm	0.5	0.697	0.855	-0.158
mm	2.5	0.663	0.526	0.137
mm	6	0.602	0.448	0.153
mm	10	0.530	0.410	0.120
mm	14	0.460	0.350	0.110
mm	18	0.391	0.304	0.087
mm	22.5	0.319	0.268	0.051
mm	27.5	0.247	0.227	0.020

mm	32.5	0.186	0.192	-0.006
mm	37.5	0.135	0.152	-0.017
mm	42.5	0.095	0.110	-0.015
mm	47.5	0.064	0.080	-0.016

Appendix C: Complete results from the differential analysis

$D_{app,C}, C_{i,0} = 1.037482375\ [\%wt.cem]$

x	df/dx	Si	gjennomsnitt
35	0.026881157	0.93740692	**0.908**
35.01	0.026872327	0.937098996	
35.02	0.026863502	0.936791234	
35.03	0.026854681	0.936483635	
35.04	0.026845865	0.936176197	
35.05	0.026837054	0.935868922	
35.06	0.026828247	0.935561808	
35.07	0.026819445	0.935254857	
35.08	0.026810647	0.934948066	
35.09	0.026801854	0.934641438	
35.1	0.026793066	0.934334971	
35.11	0.026784282	0.934028665	
35.12	0.026775503	0.93372252	
35.13	0.026766729	0.933416536	
35.14	0.026757959	0.933110713	
35.15	0.026749194	0.932805051	
35.16	0.026740433	0.93249955	
35.17	0.026731677	0.93219421	
35.18	0.026722926	0.93188903	
35.19	0.026714179	0.93158401	
35.2	0.026705437	0.931279151	
35.21	0.026696699	0.930974451	
35.22	0.026687966	0.930669912	
35.23	0.026679238	0.930365533	
35.24	0.026670514	0.930061314	
35.25	0.026661795	0.929757254	
35.26	0.02665308	0.929453354	
35.27	0.02664437	0.929149614	
35.28	0.026635665	0.928846033	
35.29	0.026626964	0.928542611	
35.3	0.026618267	0.928239348	
35.31	0.026609576	0.927936245	
35.32	0.026600888	0.9276333	
35.33	0.026592206	0.927330514	
35.34	0.026583527	0.927027887	
35.35	0.026574854	0.926725419	
35.36	0.026566185	0.926423109	
35.37	0.02655752	0.926120957	

35.38	0.02654886	0.925818964
35.39	0.026540205	0.925517129
35.4	0.026531554	0.925215452
35.41	0.026522908	0.924913933
35.42	0.026514266	0.924612572
35.43	0.026505628	0.924311368
35.44	0.026496996	0.924010323
35.45	0.026488367	0.923709434
35.46	0.026479743	0.923408704
35.47	0.026471124	0.92310813
35.48	0.026462509	0.922807714
35.49	0.026453899	0.922507454
35.5	0.026445293	0.922207352
35.51	0.026436692	0.921907407
35.52	0.026428095	0.921607618
35.53	0.026419503	0.921307986
35.54	0.026410915	0.921008511
35.55	0.026402332	0.920709192
35.56	0.026393753	0.920410029
35.57	0.026385179	0.920111023
35.58	0.026376609	0.919812172
35.59	0.026368044	0.919513478
35.6	0.026359483	0.919214939
35.61	0.026350926	0.918916557
35.62	0.026342374	0.91861833
35.63	0.026333827	0.918320258
35.64	0.026325284	0.918022342
35.65	0.026316745	0.917724582
35.66	0.026308211	0.917426977
35.67	0.026299681	0.917129526
35.68	0.026291156	0.916832231
35.69	0.026282635	0.916535091
35.7	0.026274119	0.916238105
35.71	0.026265607	0.915941275
35.72	0.026257099	0.915644599
35.73	0.026248596	0.915348077
35.74	0.026240098	0.91505171
35.75	0.026231603	0.914755497
35.76	0.026223114	0.914459438
35.77	0.026214628	0.914163533
35.78	0.026206147	0.913867783
35.79	0.026197671	0.913572186

35.8	0.026189198	0.913276743
35.81	0.026180731	0.912981453
35.82	0.026172267	0.912686317
35.83	0.026163808	0.912391335
35.84	0.026155354	0.912096506
35.85	0.026146904	0.91180183
35.86	0.026138458	0.911507307
35.87	0.026130017	0.911212937
35.88	0.02612158	0.91091872
35.89	0.026113147	0.910624656
35.9	0.026104719	0.910330745
35.91	0.026096295	0.910036986
35.92	0.026087875	0.90974338
35.93	0.02607946	0.909449926
35.94	0.02607105	0.909156624
35.95	0.026062643	0.908863475
35.96	0.026054241	0.908570477
35.97	0.026045844	0.908277632
35.98	0.02603745	0.907984938
35.99	0.026029061	0.907692396
36	0.026020677	0.907400006
36.01	0.026012296	0.907107767
36.02	0.026003921	0.90681568
36.03	0.025995549	0.906523744
36.04	0.025987182	0.90623196
36.05	0.025978819	0.905940326
36.06	0.02597046	0.905648844
36.07	0.025962106	0.905357512
36.08	0.025953756	0.905066331
36.09	0.02594541	0.904775301
36.1	0.025937069	0.904484422
36.11	0.025928732	0.904193693
36.12	0.0259204	0.903903114
36.13	0.025912071	0.903612686
36.14	0.025903747	0.903322408
36.15	0.025895427	0.90303228
36.16	0.025887112	0.902742301
36.17	0.025878801	0.902452473
36.18	0.025870494	0.902162795
36.19	0.025862191	0.901873266
36.2	0.025853893	0.901583887
36.21	0.025845599	0.901294657

36.22	0.02583731	0.901005577
36.23	0.025829024	0.900716646
36.24	0.025820743	0.900427864
36.25	0.025812466	0.900139231
36.26	0.025804194	0.899850748
36.27	0.025795925	0.899562413
36.28	0.025787661	0.899274226
36.29	0.025779401	0.898986189
36.3	0.025771146	0.8986983
36.31	0.025762895	0.898410559
36.32	0.025754648	0.898122967
36.33	0.025746405	0.897835523
36.34	0.025738166	0.897548227
36.35	0.025729932	0.897261079
36.36	0.025721702	0.896974079
36.37	0.025713476	0.896687227
36.38	0.025705255	0.896400523
36.39	0.025697037	0.896113966
36.4	0.025688824	0.895827557
36.41	0.025680615	0.895541295
36.42	0.025672411	0.895255181
36.43	0.02566421	0.894969214
36.44	0.025656014	0.894683394
36.45	0.025647822	0.894397721
36.46	0.025639634	0.894112195
36.47	0.025631451	0.893826816
36.48	0.025623271	0.893541583
36.49	0.025615096	0.893256497
36.5	0.025606925	0.892971558
36.51	0.025598759	0.892686765
36.52	0.025590596	0.892402118
36.53	0.025582438	0.892117618
36.54	0.025574284	0.891833264
36.55	0.025566134	0.891549055
36.56	0.025557988	0.891264993
36.57	0.025549846	0.890981077
36.58	0.025541709	0.890697306
36.59	0.025533575	0.890413681
36.6	0.025525446	0.890130201
36.61	0.025517321	0.889846867
36.62	0.025509201	0.889563678
36.63	0.025501084	0.889280634

36.64	0.025492972	0.888997736
36.65	0.025484863	0.888714982
36.66	0.025476759	0.888432374
36.67	0.025468659	0.88814991
36.68	0.025460564	0.887867591
36.69	0.025452472	0.887585417
36.7	0.025444384	0.887303387
36.71	0.025436301	0.887021502
36.72	0.025428222	0.88673976
36.73	0.025420147	0.886458164
36.74	0.025412076	0.886176711
36.75	0.025404009	0.885895402
36.76	0.025395946	0.885614238
36.77	0.025387888	0.885333217
36.78	0.025379833	0.88505234
36.79	0.025371783	0.884771606
36.8	0.025363737	0.884491016
36.81	0.025355695	0.88421057
36.82	0.025347657	0.883930267
36.83	0.025339623	0.883650107
36.84	0.025331593	0.88337009
36.85	0.025323567	0.883090217
36.86	0.025315546	0.882810486
36.87	0.025307528	0.882530898
36.88	0.025299515	0.882251453
36.89	0.025291505	0.881972151
36.9	0.0252835	0.881692991
36.91	0.025275499	0.881413974
36.92	0.025267502	0.881135099
36.93	0.025259509	0.880856367
36.94	0.02525152	0.880577776
36.95	0.025243535	0.880299328
36.96	0.025235555	0.880021022
36.97	0.025227578	0.879742857
36.98	0.025219605	0.879464835
36.99	0.025211637	0.879186954
37	0.025203672	0.878909214

$C_s,\ C_{i,0} = 1.037482375\ [\%wt.cem]$

x	df/dx	Si	gjennomsnitt

3	0.410558914	1	**1.000**
3.01	0.410558914	1	
3.02	0.410558914	1	
3.03	0.410558914	1	
3.04	0.410558914	1	
3.05	0.410558914	1	
3.06	0.410558914	1	
3.07	0.410558914	1	
3.08	0.410558914	1	
3.09	0.410558914	1	
3.1	0.410558914	1	
3.11	0.410558914	1	
3.12	0.410558914	1	
3.13	0.410558914	1	
3.14	0.410558914	1	
3.15	0.410558914	1	
3.16	0.410558914	1	
3.17	0.410558914	1	
3.18	0.410558914	1	
3.19	0.410558914	1	
3.2	0.410558914	1	
3.21	0.410558914	1	
3.22	0.410558914	1	
3.23	0.410558914	1	
3.24	0.410558914	1	
3.25	0.410558914	1	
3.26	0.410558914	1	
3.27	0.410558914	1	
3.28	0.410558914	1	
3.29	0.410558914	1	
3.3	0.410558914	1	
3.31	0.410558914	1	
3.32	0.410558914	1	
3.33	0.410558914	1	
3.34	0.410558914	1	
3.35	0.410558914	1	
3.36	0.410558914	1	
3.37	0.410558914	1	
3.38	0.410558914	1	
3.39	0.410558914	1	
3.4	0.410558914	1	
3.41	0.410558914	1	

3.42	0.410558914	1
3.43	0.410558914	1
3.44	0.410558914	1
3.45	0.410558914	1
3.46	0.410558914	1
3.47	0.410558914	1
3.48	0.410558914	1
3.49	0.410558914	1
3.5	0.410558914	1
3.51	0.410558914	1
3.52	0.410558914	1
3.53	0.410558914	1
3.54	0.410558914	1
3.55	0.410558914	1
3.56	0.410558914	1
3.57	0.410558914	1
3.58	0.410558914	1
3.59	0.410558914	1
3.6	0.410558914	1
3.61	0.410558914	1
3.62	0.410558914	1
3.63	0.410558914	1
3.64	0.410558914	1
3.65	0.410558914	1
3.66	0.410558914	1
3.67	0.410558914	1
3.68	0.410558914	1
3.69	0.410558914	1
3.7	0.410558914	1
3.71	0.410558914	1
3.72	0.410558914	1
3.73	0.410558914	1
3.74	0.410558914	1
3.75	0.410558914	1
3.76	0.410558914	1
3.77	0.410558914	1
3.78	0.410558914	1
3.79	0.410558914	1
3.8	0.410558914	1
3.81	0.410558914	1
3.82	0.410558914	1
3.83	0.410558914	1

3.84	0.410558914	1
3.85	0.410558914	1
3.86	0.410558914	1
3.87	0.410558914	1
3.88	0.410558914	1
3.89	0.410558914	1
3.9	0.410558914	1
3.91	0.410558914	1
3.92	0.410558914	1
3.93	0.410558914	1
3.94	0.410558914	1
3.95	0.410558914	1
3.96	0.410558914	1
3.97	0.410558914	1
3.98	0.410558914	1
3.99	0.410558914	1
4.01	0.410558914	1
4.02	0.410558914	1
4.03	0.410558914	1
4.04	0.410558914	1
4.05	0.410558914	1
4.06	0.410558914	1
4.07	0.410558914	1
4.08	0.410558914	1
4.09	0.410558914	1
4.1	0.410558914	1
4.11	0.410558914	1
4.12	0.410558914	1
4.13	0.410558914	1
4.14	0.410558914	1
4.15	0.410558914	1
4.16	0.410558914	1
4.17	0.410558914	1
4.18	0.410558914	1
4.19	0.410558914	1
4.2	0.410558914	1
4.21	0.410558914	1
4.22	0.410558914	1
4.23	0.410558914	1
4.24	0.410558914	1
4.25	0.410558914	1
4.26	0.410558914	1

4.27	0.410558914	1
4.28	0.410558914	1
4.29	0.410558914	1
4.3	0.410558914	1
4.31	0.410558914	1
4.32	0.410558914	1
4.33	0.410558914	1
4.34	0.410558914	1
4.35	0.410558914	1
4.36	0.410558914	1
4.37	0.410558914	1
4.38	0.410558914	1
4.39	0.410558914	1
4.4	0.410558914	1
4.41	0.410558914	1
4.42	0.410558914	1
4.43	0.410558914	1
4.44	0.410558914	1
4.45	0.410558914	1
4.46	0.410558914	1
4.47	0.410558914	1
4.48	0.410558914	1
4.49	0.410558914	1
4.5	0.410558914	1
4.51	0.410558914	1
4.52	0.410558914	1
4.53	0.410558914	1
4.54	0.410558914	1
4.55	0.410558914	1
4.56	0.410558914	1
4.57	0.410558914	1
4.58	0.410558914	1
4.59	0.410558914	1
4.6	0.410558914	1
4.61	0.410558914	1
4.62	0.410558914	1
4.63	0.410558914	1
4.64	0.410558914	1
4.65	0.410558914	1
4.66	0.410558914	1
4.67	0.410558914	1
4.68	0.410558914	1

4.69	0.410558914	1
4.7	0.410558914	1
4.71	0.410558914	1
4.72	0.410558914	1
4.73	0.410558914	1
4.74	0.410558914	1
4.75	0.410558914	1
4.76	0.410558914	1
4.77	0.410558914	1
4.78	0.410558914	1
4.79	0.410558914	1
4.8	0.410558914	1
4.81	0.410558914	1
4.82	0.410558914	1
4.83	0.410558914	1
4.84	0.410558914	1
4.85	0.410558914	1
4.86	0.410558914	1
4.87	0.410558914	1
4.88	0.410558914	1
4.89	0.410558914	1
4.9	0.410558914	1
4.91	0.410558914	1
4.92	0.410558914	1
4.93	0.410558914	1
4.94	0.410558914	1
4.95	0.410558914	1
4.96	0.410558914	1
4.97	0.410558914	1
4.98	0.410558914	1
4.99	0.410558914	1
5	0.410558914	1

Depth, $C_{i,0} = 1.037482375\ [\%wt.cem]$

x	df/dx	Si	gjennomsnitt
69.91	-0.026766054	-1.805933139	**-1.804**
69.911	-0.026765796	-1.805915691	
69.912	-0.026765537	-1.805898242	
69.913	-0.026765278	-1.805880794	
69.914	-0.02676502	-1.805863346	
69.915	-0.026764761	-1.805845897	
69.916	-0.026764503	-1.805828448	

69.917	-0.026764244	-1.805811
69.918	-0.026763985	-1.805793551
69.919	-0.026763727	-1.805776102
69.92	-0.026763468	-1.805758653
69.921	-0.02676321	-1.805741204
69.922	-0.026762951	-1.805723755
69.923	-0.026762692	-1.805706306
69.924	-0.026762434	-1.805688857
69.925	-0.026762175	-1.805671407
69.926	-0.026761917	-1.805653958
69.927	-0.026761658	-1.805636508
69.928	-0.026761399	-1.805619059
69.929	-0.026761141	-1.805601609
69.93	-0.026760882	-1.805584159
69.931	-0.026760623	-1.805566709
69.932	-0.026760365	-1.805549259
69.933	-0.026760106	-1.805531809
69.934	-0.026759847	-1.805514359
69.935	-0.026759589	-1.805496909
69.936	-0.02675933	-1.805479459
69.937	-0.026759072	-1.805462009
69.938	-0.026758813	-1.805444558
69.939	-0.026758554	-1.805427108
69.94	-0.026758296	-1.805409657
69.941	-0.026758037	-1.805392207
69.942	-0.026757778	-1.805374756
69.943	-0.02675752	-1.805357305
69.944	-0.026757261	-1.805339854
69.945	-0.026757002	-1.805322403
69.946	-0.026756744	-1.805304952
69.947	-0.026756485	-1.805287501
69.948	-0.026756227	-1.80527005
69.949	-0.026755968	-1.805252599
69.95	-0.026755709	-1.805235147
69.951	-0.026755451	-1.805217696
69.952	-0.026755192	-1.805200244
69.953	-0.026754933	-1.805182793
69.954	-0.026754675	-1.805165341
69.955	-0.026754416	-1.805147889
69.956	-0.026754157	-1.805130437
69.957	-0.026753899	-1.805112985
69.958	-0.02675364	-1.805095533

69.959	-0.026753381	-1.805078081
69.96	-0.026753123	-1.805060629
69.961	-0.026752864	-1.805043177
69.962	-0.026752605	-1.805025724
69.963	-0.026752347	-1.805008272
69.964	-0.026752088	-1.804990819
69.965	-0.026751829	-1.804973367
69.966	-0.026751571	-1.804955914
69.967	-0.026751312	-1.804938461
69.968	-0.026751053	-1.804921009
69.969	-0.026750795	-1.804903556
69.97	-0.026750536	-1.804886103
69.971	-0.026750277	-1.80486865
69.972	-0.026750019	-1.804851197
69.973	-0.02674976	-1.804833743
69.974	-0.026749501	-1.80481629
69.975	-0.026749243	-1.804798837
69.976	-0.026748984	-1.804781383
69.977	-0.026748725	-1.80476393
69.978	-0.026748467	-1.804746476
69.979	-0.026748208	-1.804729022
69.98	-0.026747949	-1.804711568
69.981	-0.026747691	-1.804694115
69.982	-0.026747432	-1.804676661
69.983	-0.026747173	-1.804659207
69.984	-0.026746914	-1.804641752
69.985	-0.026746656	-1.804624298
69.986	-0.026746397	-1.804606844
69.987	-0.026746138	-1.80458939
69.988	-0.02674588	-1.804571935
69.989	-0.026745621	-1.804554481
69.99	-0.026745362	-1.804537026
69.991	-0.026745104	-1.804519571
69.992	-0.026744845	-1.804502117
69.993	-0.026744586	-1.804484662
69.994	-0.026744327	-1.804467207
69.995	-0.026744069	-1.804449752
69.996	-0.02674381	-1.804432297
69.997	-0.026743551	-1.804414842
69.998	-0.026743293	-1.804397386
69.999	-0.026743034	-1.804379931
70.001	-0.026742517	-1.80434502

70.002	-0.026742258	-1.804327565
70.003	-0.026741999	-1.804310109
70.004	-0.02674174	-1.804292653
70.005	-0.026741482	-1.804275197
70.006	-0.026741223	-1.804257742
70.007	-0.026740964	-1.804240286
70.008	-0.026740706	-1.80422283
70.009	-0.026740447	-1.804205373
70.01	-0.026740188	-1.804187917
70.011	-0.026739929	-1.804170461
70.012	-0.026739671	-1.804153005
70.013	-0.026739412	-1.804135548
70.014	-0.026739153	-1.804118092
70.015	-0.026738894	-1.804100635
70.016	-0.026738636	-1.804083178
70.017	-0.026738377	-1.804065721
70.018	-0.026738118	-1.804048265
70.019	-0.02673786	-1.804030808
70.02	-0.026737601	-1.804013351
70.021	-0.026737342	-1.803995894
70.022	-0.026737083	-1.803978436
70.023	-0.026736825	-1.803960979
70.024	-0.026736566	-1.803943522
70.025	-0.026736307	-1.803926064
70.026	-0.026736048	-1.803908607
70.027	-0.02673579	-1.803891149
70.028	-0.026735531	-1.803873692
70.029	-0.026735272	-1.803856234
70.03	-0.026735013	-1.803838776
70.031	-0.026734755	-1.803821318
70.032	-0.026734496	-1.80380386
70.033	-0.026734237	-1.803786402
70.034	-0.026733978	-1.803768944
70.035	-0.02673372	-1.803751486
70.036	-0.026733461	-1.803734028
70.037	-0.026733202	-1.803716569
70.038	-0.026732943	-1.803699111
70.039	-0.026732685	-1.803681652
70.04	-0.026732426	-1.803664194
70.041	-0.026732167	-1.803646735
70.042	-0.026731908	-1.803629276
70.043	-0.02673165	-1.803611817

70.044	-0.026731391	-1.803594358
70.045	-0.026731132	-1.803576899
70.046	-0.026730873	-1.80355944
70.047	-0.026730615	-1.803541981
70.048	-0.026730356	-1.803524522
70.049	-0.026730097	-1.803507062
70.05	-0.026729838	-1.803489603
70.051	-0.026729579	-1.803472143
70.052	-0.026729321	-1.803454684
70.053	-0.026729062	-1.803437224
70.054	-0.026728803	-1.803419764
70.055	-0.026728544	-1.803402305
70.056	-0.026728286	-1.803384845
70.057	-0.026728027	-1.803367385
70.058	-0.026727768	-1.803349925
70.059	-0.026727509	-1.803332465
70.06	-0.02672725	-1.803315004
70.061	-0.026726992	-1.803297544
70.062	-0.026726733	-1.803280084
70.063	-0.026726474	-1.803262623
70.064	-0.026726215	-1.803245163
70.065	-0.026725957	-1.803227702
70.066	-0.026725698	-1.803210241
70.067	-0.026725439	-1.80319278
70.068	-0.02672518	-1.80317532
70.069	-0.026724921	-1.803157859
70.07	-0.026724663	-1.803140398
70.071	-0.026724404	-1.803122937
70.072	-0.026724145	-1.803105475
70.073	-0.026723886	-1.803088014
70.074	-0.026723627	-1.803070553
70.075	-0.026723369	-1.803053091
70.076	-0.02672311	-1.80303563
70.077	-0.026722851	-1.803018168
70.078	-0.026722592	-1.803000707
70.079	-0.026722333	-1.802983245
70.08	-0.026722075	-1.802965783
70.081	-0.026721816	-1.802948321
70.082	-0.026721557	-1.802930859
70.083	-0.026721298	-1.802913397
70.084	-0.026721039	-1.802895935
70.085	-0.026720781	-1.802878473

70.086	-0.026720522	-1.80286101
70.087	-0.026720263	-1.802843548
70.088	-0.026720004	-1.802826085
70.089	-0.026719745	-1.802808623
70.09	-0.026719486	-1.80279116
70.091	-0.026719228	-1.802773698
70.092	-0.026718969	-1.802756235
70.093	-0.02671871	-1.802738772
70.094	-0.026718451	-1.802721309
70.095	-0.026718192	-1.802703846
70.096	-0.026717934	-1.802686383
70.097	-0.026717675	-1.80266892
70.098	-0.026717416	-1.802651456
70.099	-0.026717157	-1.802633993
70.1	-0.026716898	-1.80261653

$\alpha,\, C_{i,0} = 1.037482375\ [\%wt.cem]$

x	df/dx	Si	gjennomsnitt
0.2993	-6.720855133	-1.943412813	**-1.946**
0.29931	-6.720933759	-1.943435549	
0.29932	-6.721012374	-1.943458281	
0.29933	-6.721090979	-1.943481011	
0.29934	-6.721169573	-1.943503737	
0.29935	-6.721248156	-1.94352646	
0.29936	-6.721326728	-1.94354918	
0.29937	-6.72140529	-1.943571897	
0.29938	-6.721483841	-1.943594611	
0.29939	-6.721562381	-1.943617322	
0.2994	-6.72164091	-1.94364003	
0.29941	-6.721719429	-1.943662734	
0.29942	-6.721797937	-1.943685436	
0.29943	-6.721876434	-1.943708134	
0.29944	-6.721954921	-1.943730829	
0.29945	-6.722033396	-1.943753521	
0.29946	-6.722111861	-1.94377621	
0.29947	-6.722190316	-1.943798896	
0.29948	-6.722268759	-1.943821579	
0.29949	-6.722347192	-1.943844259	
0.2995	-6.722425614	-1.943866936	
0.29951	-6.722504025	-1.943889609	
0.29952	-6.722582425	-1.943912279	
0.29953	-6.722660815	-1.943934947	

0.29954	-6.722739194	-1.943957611
0.29955	-6.722817562	-1.943980272
0.29956	-6.722895919	-1.94400293
0.29957	-6.722974266	-1.944025585
0.29958	-6.723052602	-1.944048236
0.29959	-6.723130927	-1.944070885
0.2996	-6.723209241	-1.944093531
0.29961	-6.723287545	-1.944116173
0.29962	-6.723365838	-1.944138812
0.29963	-6.72344412	-1.944161448
0.29964	-6.723522391	-1.944184081
0.29965	-6.723600652	-1.944206711
0.29966	-6.723678901	-1.944229338
0.29967	-6.72375714	-1.944251962
0.29968	-6.723835368	-1.944274582
0.29969	-6.723913586	-1.9442972
0.2997	-6.723991792	-1.944319814
0.29971	-6.724069988	-1.944342425
0.29972	-6.724148173	-1.944365034
0.29973	-6.724226348	-1.944387639
0.29974	-6.724304511	-1.94441024
0.29975	-6.724382664	-1.944432839
0.29976	-6.724460806	-1.944455435
0.29977	-6.724538937	-1.944478027
0.29978	-6.724617057	-1.944500617
0.29979	-6.724695167	-1.944523203
0.2998	-6.724773265	-1.944545786
0.29981	-6.724851353	-1.944568366
0.29982	-6.724929431	-1.944590943
0.29983	-6.725007497	-1.944613517
0.29984	-6.725085553	-1.944636088
0.29985	-6.725163597	-1.944658655
0.29986	-6.725241631	-1.94468122
0.29987	-6.725319655	-1.944703781
0.29988	-6.725397667	-1.944726339
0.29989	-6.725475669	-1.944748894
0.2999	-6.725553659	-1.944771446
0.29991	-6.725631639	-1.944793995
0.29992	-6.725709609	-1.944816541
0.29993	-6.725787567	-1.944839083
0.29994	-6.725865515	-1.944861623
0.29995	-6.725943451	-1.944884159

0.29996	-6.726021377	-1.944906692
0.29997	-6.726099292	-1.944929222
0.29998	-6.726177197	-1.944951749
0.29999	-6.72625509	-1.944974273
0.30001	-6.726410845	-1.945019311
0.30002	-6.726488706	-1.945041826
0.30003	-6.726566556	-1.945064337
0.30004	-6.726644396	-1.945086845
0.30005	-6.726722224	-1.94510935
0.30006	-6.726800042	-1.945131852
0.30007	-6.726877849	-1.945154351
0.30008	-6.726955645	-1.945176846
0.30009	-6.72703343	-1.945199339
0.3001	-6.727111205	-1.945221828
0.30011	-6.727188968	-1.945244315
0.30012	-6.727266721	-1.945266798
0.30013	-6.727344463	-1.945289278
0.30014	-6.727422194	-1.945311755
0.30015	-6.727499915	-1.945334228
0.30016	-6.727577624	-1.945356699
0.30017	-6.727655323	-1.945379166
0.30018	-6.727733011	-1.945401631
0.30019	-6.727810688	-1.945424092
0.3002	-6.727888354	-1.94544655
0.30021	-6.727966009	-1.945469005
0.30022	-6.728043654	-1.945491457
0.30023	-6.728121287	-1.945513905
0.30024	-6.72819891	-1.945536351
0.30025	-6.728276522	-1.945558793
0.30026	-6.728354123	-1.945581232
0.30027	-6.728431713	-1.945603669
0.30028	-6.728509292	-1.945626102
0.30029	-6.728586861	-1.945648531
0.3003	-6.728664419	-1.945670958
0.30031	-6.728741965	-1.945693382
0.30032	-6.728819501	-1.945715802
0.30033	-6.728897027	-1.945738219
0.30034	-6.728974541	-1.945760633
0.30035	-6.729052044	-1.945783044
0.30036	-6.729129537	-1.945805452
0.30037	-6.729207018	-1.945827857
0.30038	-6.729284489	-1.945850259

0.30039	-6.729361949	-1.945872657
0.3004	-6.729439398	-1.945895052
0.30041	-6.729516836	-1.945917444
0.30042	-6.729594264	-1.945939833
0.30043	-6.72967168	-1.945962219
0.30044	-6.729749086	-1.945984602
0.30045	-6.729826481	-1.946006982
0.30046	-6.729903864	-1.946029358
0.30047	-6.729981237	-1.946051731
0.30048	-6.7300586	-1.946074102
0.30049	-6.730135951	-1.946096469
0.3005	-6.730213291	-1.946118832
0.30051	-6.730290621	-1.946141193
0.30052	-6.730367939	-1.946163551
0.30053	-6.730445247	-1.946185905
0.30054	-6.730522544	-1.946208256
0.30055	-6.73059983	-1.946230605
0.30056	-6.730677105	-1.946252949
0.30057	-6.730754369	-1.946275291
0.30058	-6.730831622	-1.94629763
0.30059	-6.730908865	-1.946319966
0.3006	-6.730986096	-1.946342298
0.30061	-6.731063317	-1.946364627
0.30062	-6.731140527	-1.946386953
0.30063	-6.731217725	-1.946409276
0.30064	-6.731294913	-1.946431596
0.30065	-6.73137209	-1.946453913
0.30066	-6.731449257	-1.946476226
0.30067	-6.731526412	-1.946498536
0.30068	-6.731603556	-1.946520844
0.30069	-6.73168069	-1.946543148
0.3007	-6.731757812	-1.946565449
0.30071	-6.731834924	-1.946587746
0.30072	-6.731912025	-1.946610041
0.30073	-6.731989114	-1.946632332
0.30074	-6.732066193	-1.94665462
0.30075	-6.732143261	-1.946676906
0.30076	-6.732220319	-1.946699188
0.30077	-6.732297365	-1.946721466
0.30078	-6.7323744	-1.946743742
0.30079	-6.732451424	-1.946766014
0.3008	-6.732528438	-1.946788284

0.30081	-6.73260544	-1.94681055
0.30082	-6.732682432	-1.946832813
0.30083	-6.732759413	-1.946855073
0.30084	-6.732836383	-1.94687733
0.30085	-6.732913342	-1.946899583
0.30086	-6.732990289	-1.946921834
0.30087	-6.733067227	-1.946944081
0.30088	-6.733144153	-1.946966325
0.30089	-6.733221068	-1.946988566
0.3009	-6.733297972	-1.947010804
0.30091	-6.733374865	-1.947033038
0.30092	-6.733451748	-1.94705527
0.30093	-6.733528619	-1.947077498
0.30094	-6.73360548	-1.947099723
0.30095	-6.733682329	-1.947121945
0.30096	-6.733759168	-1.947144164
0.30097	-6.733835996	-1.947166379
0.30098	-6.733912813	-1.947188592
0.30099	-6.733989619	-1.947210801
0.301	-6.734066413	-1.947233007
0.30101	-6.734143197	-1.94725521
0.30102	-6.73421997	-1.94727741
0.30103	-6.734296733	-1.947299607
0.30104	-6.734373484	-1.9473218
0.30105	-6.734450224	-1.94734399
0.30106	-6.734526953	-1.947366178
0.30107	-6.734603672	-1.947388362
0.30108	-6.734680379	-1.947410542
0.30109	-6.734757075	-1.94743272
0.3011	-6.734833761	-1.947454895
0.30111	-6.734910435	-1.947477066
0.30112	-6.734987099	-1.947499234
0.30113	-6.735063751	-1.947521399
0.30114	-6.735140393	-1.947543561
0.30115	-6.735217024	-1.947565719
0.30116	-6.735293643	-1.947587875
0.30117	-6.735370252	-1.947610027
0.30118	-6.73544685	-1.947632176
0.30119	-6.735523437	-1.947654322
0.3012	-6.735600013	-1.947676465