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Structural Service Life Aspects

WORKSHOP REPORT (Summary)

HILTON HOTEL, São Paulo

November, 10 and 11, 1999

BRAZIL

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Structural Service Life Aspects

Task Groups

TG 5.1 Service Life Fundamentals and Design

TG 5.2 Construction for Service Life

TG 5.3 Assessment and Maintenance of Concrete Structures

***TG 5.4 Repair, Strengthening and Upgrading of** Concrete Structures*

TG 5.5

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Structural Service Life Aspects

Attendants

01 - Argentina (ICPA)

01 - Canada (IRC)

02 - Cuba (ISJAE)

01 - Denmark (COWI)

01 - Hungry (EMI)

01 - Norway (NDCS)

01 - Portugal (LNEC)

25 - Brazil { *designers, professors, researchers, contractors*

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Structural Service Life Aspects

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Structural Service Life Aspects

Objectives

Stimulate the gathering of Brazilian experts to discuss topics related to Service Life of Concrete Structures

Promote the exchange of technical experiences between the experts from different countries

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Task 1 - Service Life Fundamentals and Design

INVITED PAPERS:

Service life criteria in the new Brazilian design code for concrete structures

Prof. Paulo Helene / BRAZIL

Chloride ingress: Laboratory and field aspects

Prof. André Guimarães / BRAZIL
Prof. Paulo Helene / BRAZIL

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Task 1 - Service Life Fundamentals and Design

DISCUSSION:

Service life in codes

Prof. Antonio Carmona Filho / BRAZIL

The Portuguese approach to durability design of concrete structures

Dr. Arlindo Gonçalves / PORTUGAL

Provisions and controls for durable concrete structures

Dr. Roberto J. Torrent / ARGENTINA

Chloride ingress. A case study – The Casqueiro bridge

Prof. Fernando Stucchi / BRAZIL

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Task 1 - Service Life Fundamentals and Design

DISCUSSION:

Crack pattern as diagnostic tool in damage study

Prof. Antonio C. R. Laranjeiras / BRAZIL

***In situ* control of the elasticity modulus of concrete**

Prof. João Gaspar Djanikian / BRAZIL

Use of welded wire mesh as partition walls anchorage

Prof. Jonas S. Medeiros / BRAZIL

Prof. Luiz S. Franco / BRAZIL

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Task 2 - Construction for Service Life

INVITED PAPERS:

Mix design to reduce carbonation
Prof. Geraldo Cechella Isaia / BRAZIL

Coatings to protect concrete against carbonation
Prof. Claudio S. Kazmierczak / BRAZIL

Service life prediction of structures reinforced with stainless steel rebars.
Eng. Leonel Tula / CUBA
Prof. Paulo Helene / BRAZIL

Autogenous shrinkage – A threat to high performance concrete?
Dr. Wellington L. Repette / CANADA

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Task 2 - Construction for Service Life

DISCUSSION:

Mix Design to Reduce Carbonation
Prof. Claudio S. Kazmierczak / BRAZIL

Thinking about Mix Design to Reduce Carbonation
Dr. Carlos E. S. Tango / BRAZIL

Carbonation on Concrete
Prof. Jefferson B. L. Liborio / BRAZIL

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Task 2 - Construction for Service Life

DISCUSSION:

Investigations on Inhibitors to Increase the Service Life of Concrete

Prof. Vladimir A. Paulon / BRAZIL

Coatings to Protect against Carbonation

Prof. Giovanni Palermo / BRAZIL

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Task 3 - Assessment and Maintenance of Concrete Structures

INVITED PAPERS:

Prediction of Residual Service Life

Prof. Nelson Díaz Brito / CUBA
Prof. Paulo Helene / BRAZIL

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Task 3 - Assessment and Maintenance of Concrete Structures

DISCUSSION:

Recommendation for Maintenance of Marine Constructions

Prof. André Guimarães / BRAZIL

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Task 4 - Repair, Strengthening and Upgrading of Concrete Structures

INVITED PAPERS:

Recommendations for design of prestressed concrete structures

Eng. José Zamarion Ferreira Diniz / BRAZIL

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Task 4 - Repair, Strengthening and Upgrading of Concrete Structures

DISCUSSION:

The importance of good protection measures for prestressed elements

Prof. Antonio C. R. Laranjeiras / BRAZIL

Learning from some cases of bound and unbounded prestressing

Prof. Fernando Stucchi / BRAZIL

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São Paulo Workshop - Final Recommendations

TASK 1:

Stimulate the incorporation of durability criteria on codes

Divulge the use of existing models for performance prognosis and service life estimation;

Research new probabilistic methods for improved service life prediction;

Work with design specialists to increase awareness of durability aspects

Define adequate parameters to measure service life;

Divulge case-stories;

Encourage the development of standards applicable in the area.

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Task 1 - Service Life Fundamentals and Design

Service life criteria in the new Brazilian design code for concrete structures

Prof. Paulo Helene / BRAZIL

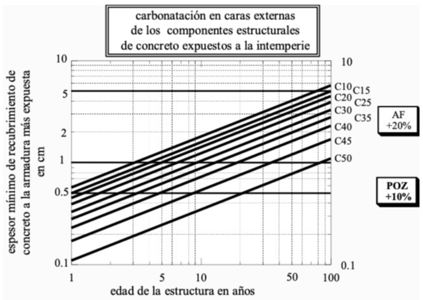
Durability concept

Aging

Service life definition

Exposure classification

Service Life Prediction



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Service Life Criteria in the New Brazilian Design Code for Concrete Structures

Durability concept

To achieve durability it is necessary:

→ to understand the *aging* mechanisms

→ to define service life clearly

→ to classify the environmental aggressiveness

→ to classify concrete resistance

→ to manage prediction models.

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Service Life Criteria in the New Brazilian Design Code for Concrete Structures

Aging

The main degradation mechanisms are:

→ for concrete: dissolution, sulfate attack, biological attack and alkali-aggregate

→ for reinforcement steel: carbonation and chloride induced corrosion

It is important to observe how useful can be to consider independently the two mechanisms or to try to determine the synergetic effects of their interaction

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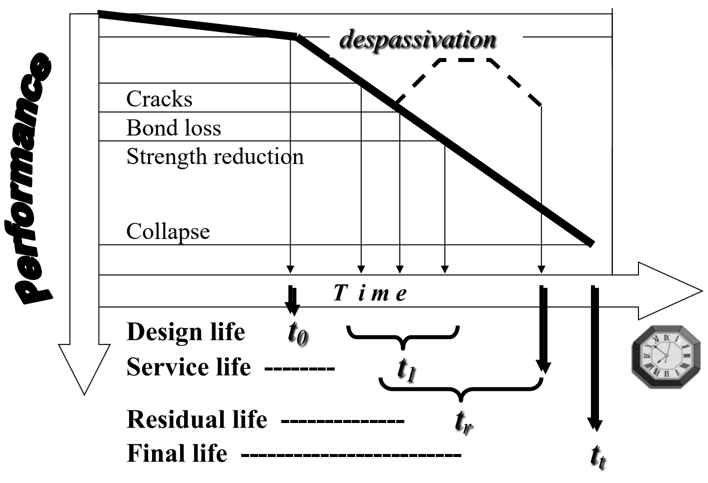
Service Life Criteria in the New Brazilian Design Code for Concrete Structures

Service life definition



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Service Life Criteria in the New Brazilian Design Code for Concrete Structures

Environment aggressiveness classes

Class	Aggressiveness	Deterioration Risk
I	slight	slight
II	moderate	small
III	high	high
IV	severe	very high

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Exposure classification

Macro-clime	Micro-clime			
	Inside Buildings		Outside Buildings	
	Dry HR ≤ 65%	Wet or cycles wet and dry	Dry HR ≤ 65%	Wet or cycles wet and dry
Rural	I	I	I	II
Urban	I	II	I	II
Sea coast	II	III	---	III
Industry	II	III	II	III
Particular	II	III or IV	III	III or IV
Splash zone	---	---	---	IV
Under water > 3m	---	---	---	I
Soil	---	---	I	Wet and cont. II, III or IV

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Service Life Criteria in the New Brazilian Design Code for Concrete Structures

Concrete classification

Concrete class	f_{ck}	W/C	Resistance to:	
			Carbonation	Chloride
			additions	
Durable	≥ C50	≤ 0.38	≤ 10% fly ash	≥ 20% fly ash ≥ 60% slag
Resistant	C45 C40 C35	≤ 0.50	≤ 15% fly ash ≤ 15% slag	≥ 10% fly ash ≥ 35% slag
Normal	C30 C25	≤ 0.62	free	free
No durable	≤ C20	free	free	free

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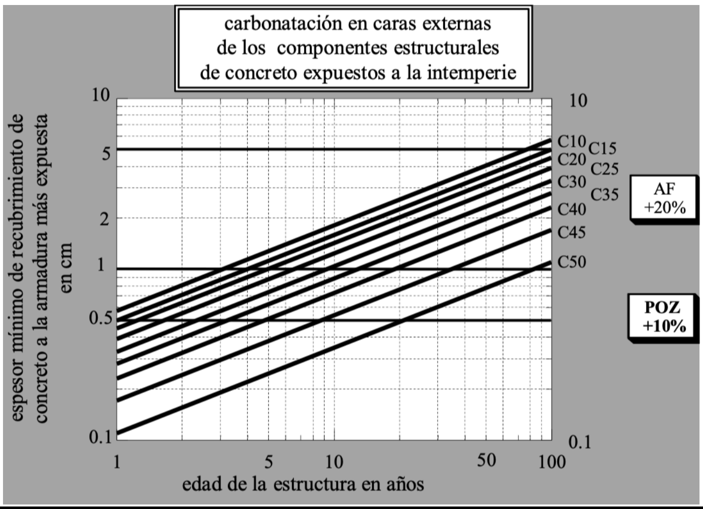
Service Life Criteria in the New Brazilian Design Code for Concrete Structures

Service Life Prediction



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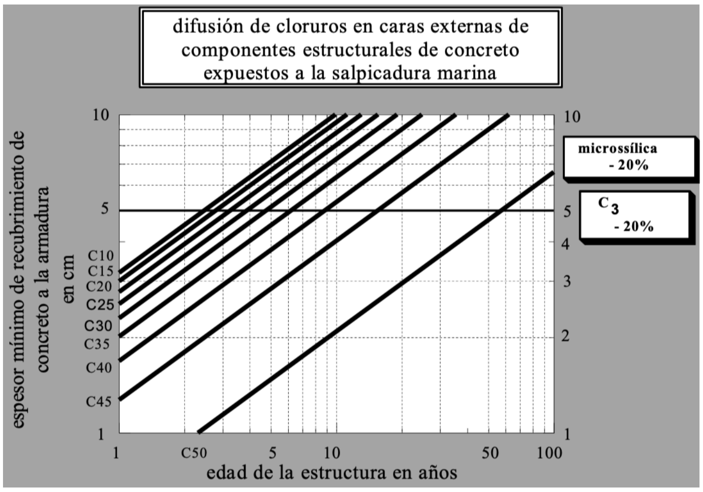
Service Life Prediction



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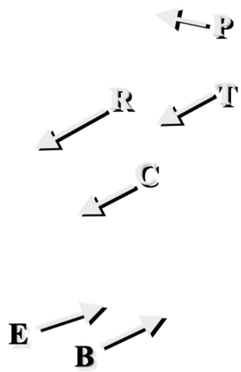
Task 2 - Construction for Service Life

Service life prediction of structures reinforced with stainless steel rebars

Eng. Leonel Tula / CUBA
Prof. Paulo Helene / BRAZIL



Study I. - Electrochemical behavior of relaxed, tensioned, bent and welded bars in different chloride content.

Study II. - Physic-mechanical behavior: loss of bond, of tensile strength and cracks.

Study III. - Systemic analysis by service life methodology

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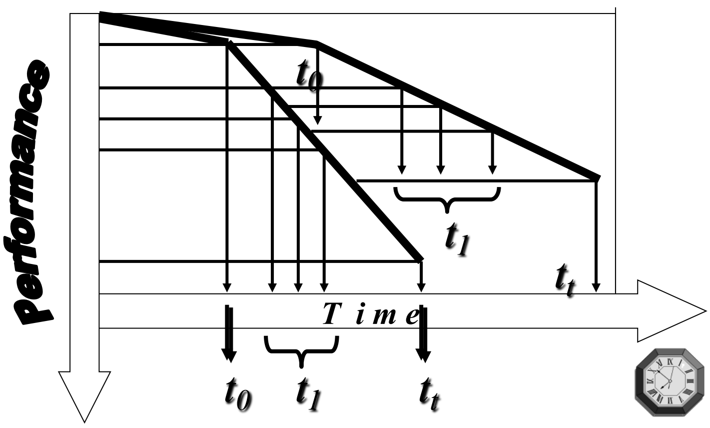
Service life prediction of structures reinforced with stainless steel rebars

Two types of steel



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Service life prediction of structures reinforced with stainless steel rebars

t_0 - *as function of type of steel (chloride threshold) and chloride contamination rate*

$t_{1\ crack}$; $t_{1\ bond}$; $t_{1\ strength}$ - *as function of type of steel (electrochemical behavior in different chloride level), chloride contamination rate and permissible physic-mechanical loses*

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Service life prediction of structures reinforced with stainless steel rebars

Example of Service Life Calculation.

Times bigger the service life of *Stainless Steel* variant

Structure	Elements	Service Life		
		Designing (t_0)	Serviceability (t_1)	Final (t_f)
Marine pier	Column and beam	47	36	5
Tank (14% Cl^-)	Wall	3	2.5	2
	Slab	8	11	8

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