3ª JORNADA DE AVANCES EN DISEÑO Y TECNOLOGÍA DEL HORMIGÓN
Viernes 27 de octubre - 8 a 12 hs - Facultad de Ingeniería
Anfiteatro del Edificio Polifuncional José L. Massera, anexo a la Facultad de Ingeniería (UdelaR) Senda Nelson Landoni esq. Julio Herrera y Reissig, Montevideo

ORGANIZA: PATROCINA: APOYA:

27 Oct 2017 Montevideo, Uruguay

Perspectivas del Código Modelo fib 2020. Verificaciones de Servicio, Vida Útil y Control de Fisuración.	G. Balazs

fib Model Code 2020 perspectives and

Verification of serviceability - CRACK CONTROL

György L. Balázs, Honorary President of ***fib***
Prof. Budapest Univ of Techn. and Economics

BME (1782)
Budapest University of Technology and Economics

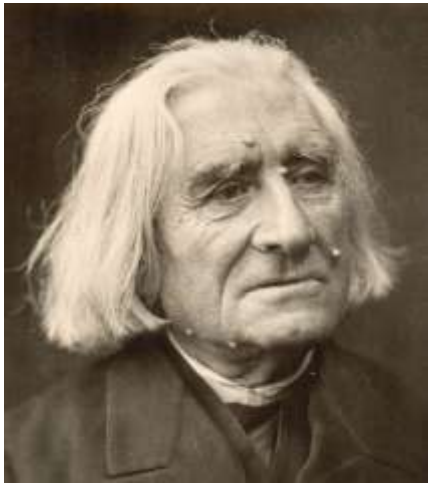
Where I come from?

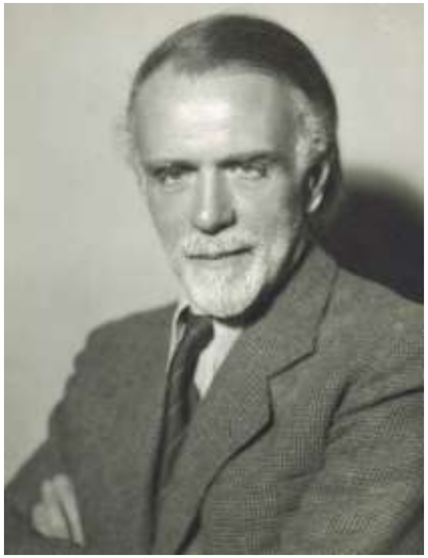
BME (1782)

Budapest University of Technology and Economics

Hungarian composers

- Liszt Ferenc (1811 - 1886)
- Kodály Zoltán (1882 - 1967)
- Bartók Béla (1881 - 1945)





Nobel prize winners of Hungarian origin

- 1905 Lénárd Fülöp
- 1914 Bárány Róbert
- 1925 Zsigmondy Richárd
- **1937 Szent-Györgyi Albert**
- 1943 Hevesy György
- 1961 Békésy György
- 1963 Wigner Jenő
- 1971 Gábor Dénes
- 1976 Daniel Carleton Gajdusek
- 1976 Milton Friedman
- 1986 Elie Wiesel
- 1986 Polányi János
- 1994 Harsányi János
- 1994 Oláh György
- 2002 Kertész Imre
- 2004 Herskó Ferenc

Hungarian inventions

- Matches
- Ball pen (Bíró)
- Camera
- Dynamo
- Basic language
- Floppy disk
- Rubik cube
- Telephone system
- Particle accelerator

Congratulations for the football Uruguay!

Hungarian football

Puskás Ferenc

fib = CEB + FIP: 60+ years of history; Presidents

fib = Internatonal Federation for Structural Concrete

CEB

1953-57 André Balency-Béarn (F)
1967-68 Franco Levi (I)
1968-71 Hubert Rüsch (D)
1971-78 Andrew Short (UK)
1979-83 Julio Ferry-Borges (P)
1983-87 Theodossios Tassios (GR)
1987-98 Roy Rowe (UK)

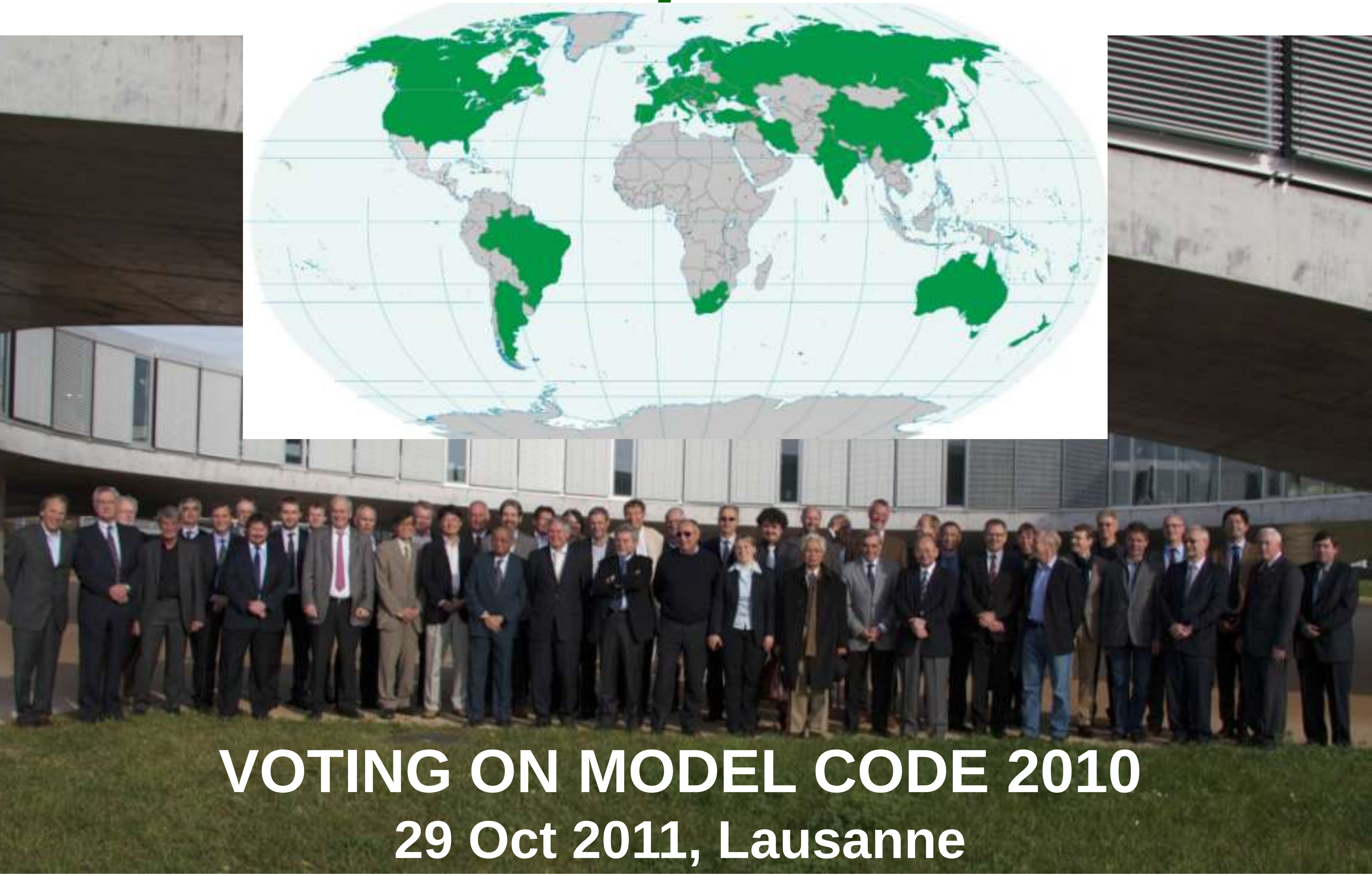
fib CEB-FIP

1998-2000 Michel Virlogeux (F)
2000-2002 Joost Walraven (NL)
2002-2004 Jim Forbes (AUS)
2005-2007 Giuseppe Mancini (I)
2007-2008 Hans-Rudolf Ganz (CH)
2009-2010 Michael Fardis (GR)
2011-2012 György L. Balázs (H)
2013-2014 Gordon Clark (UK)
2015-2016 Harald S. Müller (D)
2017-2018 Hugo Corres (E)

FIP

1953-58 Eugéne Freyssinet (F)
1958-61 Eduardo Torroja (E)
1961-66 Yves Guyon (F)
1966-70 Franco Levi (I)
1970-74 Gerrit F. Janssonius (NL)
1974-78 Ben C. Gerwick Jr. (USA)
1978-82 Roger Lacroix (F)
1982-84 John Derrington (UK)
1984-88 Hans Wittfoht (D)
1988-92 René Walther (CH)
1992-96 Jan Moksnes (N)
1996-98 Michel Virlogeux (F)

Historic fib Photo:



WE ALL PARTICIPATE IN THE CREATION OF CONCETE STRUCTURES

Developments should be included in codes

REQUIREMENTS TO CONCRETE STRUCTURES

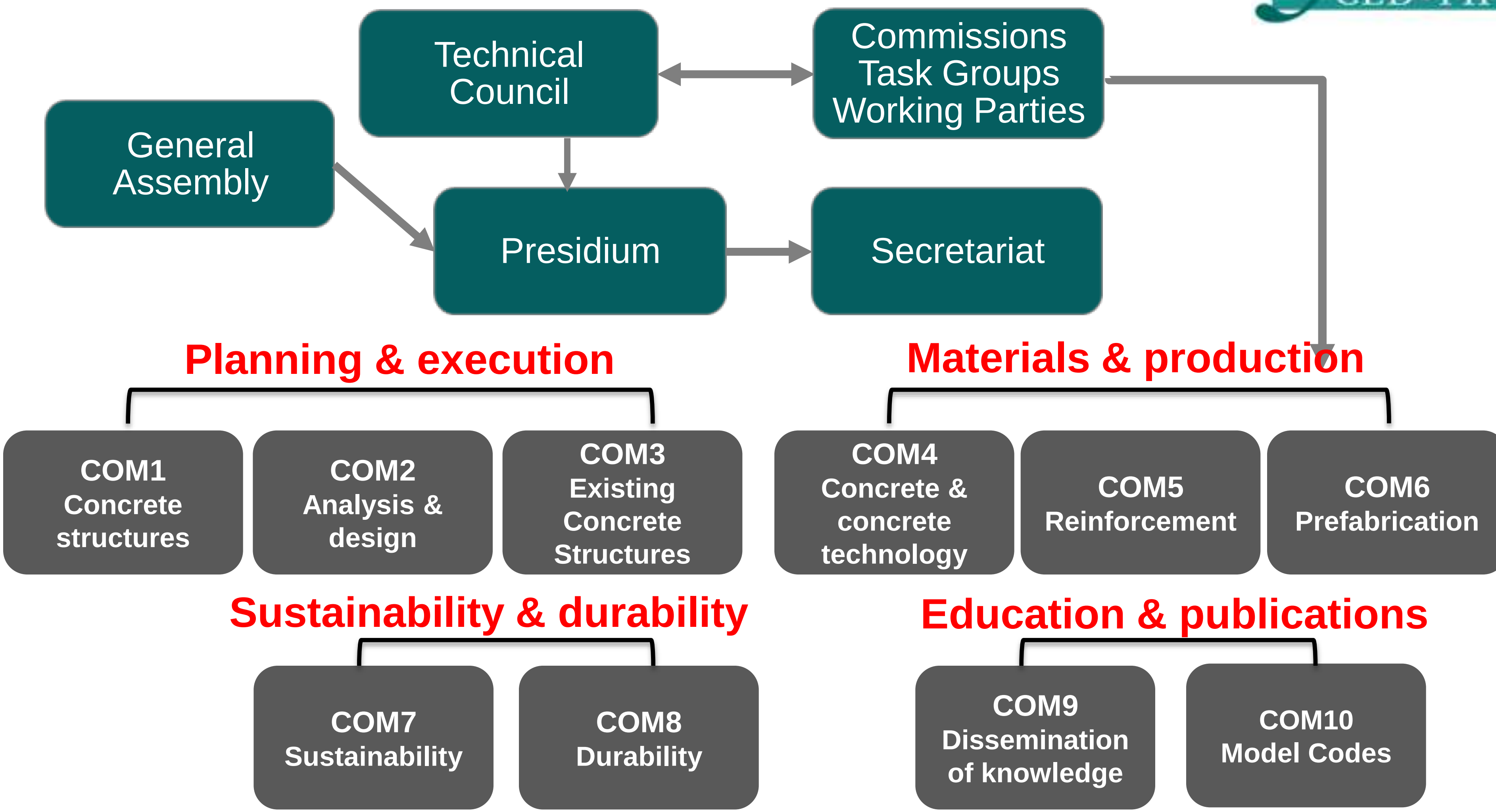
Concrete must be:

1. **Resistant**
2. **Serviceable**
3. **Durable**
4. **Constructable**
5. **Aesthetic**
6. **Economic**

and also:

7. Robust enough to avoid progressive collaps
8. Require minimal maintenance
9. Able to embed waste materials
10. Provide barriers against hazards
11. Provide protection against accidents
12. Reusable
13. Recycable
14. Fire and earthquake resistant
15. Environmentally compatible and support sustainability

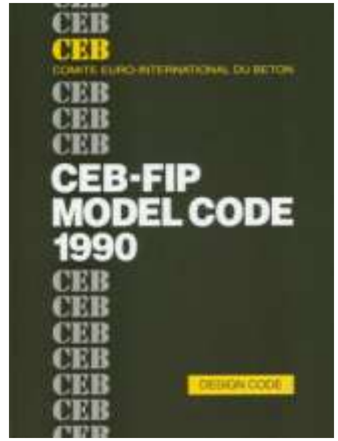
THE *fib's* STRUCTURE



Main activity of ***fib*** is: Pre-codification

Evolution of Model Codes

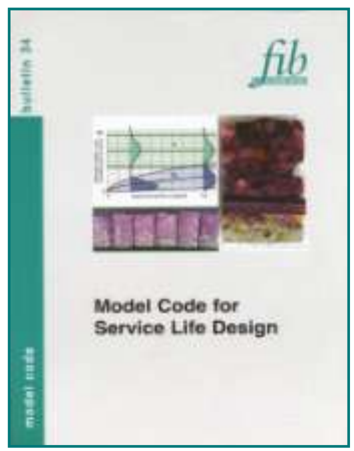
Model Code 1978



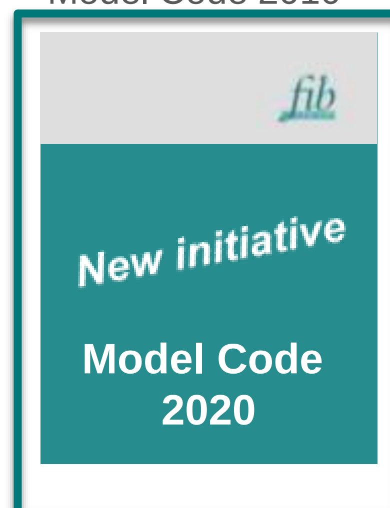
Model Code 1990

Model Code 2010

CEB Bull. 165 Seismic Design



fib Bull. 34 Service Life Design



fib is a pre-normative organization

STRONG INFLUENCE OF *fib* (CEB-FIP) MODEL CODES ON CODE DEVELOPEMENTS

CEB-FIP Model Code 78 → ENV 1992-1-1

CEB-FIP Model Code 90 → EN 1992-1-1

fib Model Code 2010 → Revised EN 1992-1-1

1978

1970 | 1980 | 1990 | 2000 | 2010 | 2020

MC78 and MC90 were used in Brazil partly as national codes

Collaboration with Asian Model code

Collaboration with African Model code

Model Codes are used as reference documents both in research and in design

www.ernst-und-sohn.de.mc2010

MODEL CODE 2010

Safety Servicability Durability Sustainability

Performance based requirements

Includes whole life of structures

DESIGN 〉 CON-STRUC-TION 〉 CON-SERVA-TION 〉 DIS-MANTL-ING

New types of concretes

New types of rf-s

Composite structures

Most comprehensive code for concrete structures

TYPES OF STRUCTURES

BUILD-
INGS

BRIDGES

CAST
IN SITU

PRECAST

NEW
STRUC-
TURES

EXSIT-
ING
STRUC-
TURES

CONTENT – *fib* MODEL CODE 2010

1-2. NOTATIONS, SCOPE, TERMINOLOGY

3. BASIC PRINCIPLES

4. PRINCIPLES OF STRUCTURAL DESIGN

5. MATERIALS

6. INTERFACE CHARACTERISTICS

7. DESIGN

8. CONSTRUCTION

9. CONSERVATION

10. DISMANTLEMENT

Main activity of ***fib*** is: **Pre-codification**
Evolution of Model Codes

Model Code

2020

We are happy to have you interest to develop it together!

MC2020 Initiative – Global involvement

THE *fib's* WAY OF WORKING

COM10 – First Meeting. Lausanne, 15 October 2016 at the EPFL

MC2010 for Concrete Structures

- A code, basically, for new and old structures
- Introduction of "conceptual design" to stimulate creativity
- Design with due regard to service life of structures
- First introduction of sustainability
- Improved safety formats for new and existing structures
- Improved constitutive relations for old and new types of concrete, with due attention to durability aspects
- Steel fibres and non-metallic reinforcement as new alternatives for reinforcing concrete structures
- Wide scope of loading types (static, fatigue, impact, explosion, seismic, fire, cryogenic)
- Scientifically based models, with simplified versions for lower level approximations (daily practice)
- Introduction of reliability concepts in numerical analysis
- Introduction of maintenance strategies for through-life care

- MC 2020 will be a single, merged structural code for new *and* existing structures
- It will be an operational model code and oriented towards practical needs
- It has to present more general and more rational models, removing all heritage from previous empirical design rules (MC2010 was an important step forward, but further steps are possible, and needed)
- It will recognize the needs of engineering communities around the world. MC 2020 has to be a real International Code.

2017 Statutory member countries

(National delegations)

We would be pleased to count <u>Uruguay</u> among our statutory members

The *fib's* Structural Concrete Journal

Impact factor 2016: 1.424
6 issues from 2016

Upcoming *fib* Symposia and Congresses

2017: **Symposium.**
Maastricht. The Netherlands

2018: **PhD Symposium**
Prague. Czech Republic

2018: **Congress.**
Melbourne. Australia

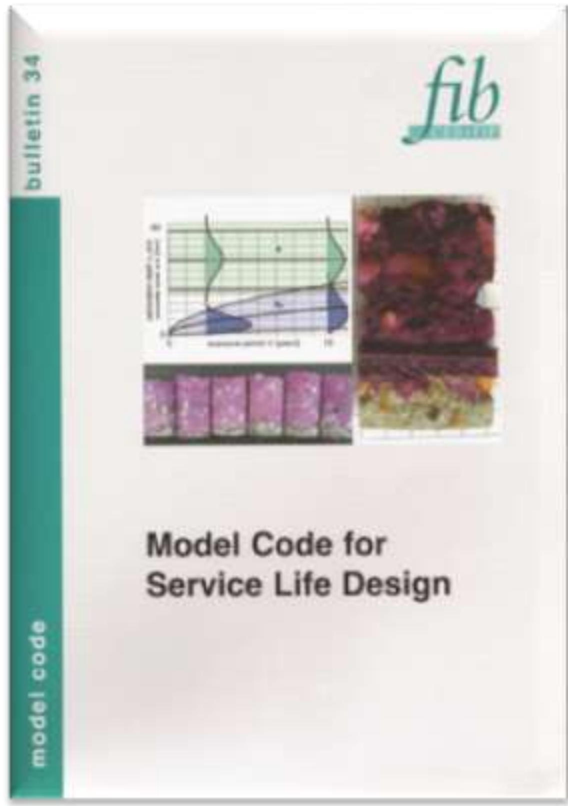
2019: **Symposium**
Krakow. Poland

2020: **Symposium**
Shanghai. China

RESULTS OF COMMISSIONS AND TASK GROUPS ARE PUBLISHED AS

fib BULLETINS

- **Technical reports**
- **State-of-the-art reports**
- **Textbooks**
- **Manuals or guides**
- **Recommendations**
- **Model Codes**



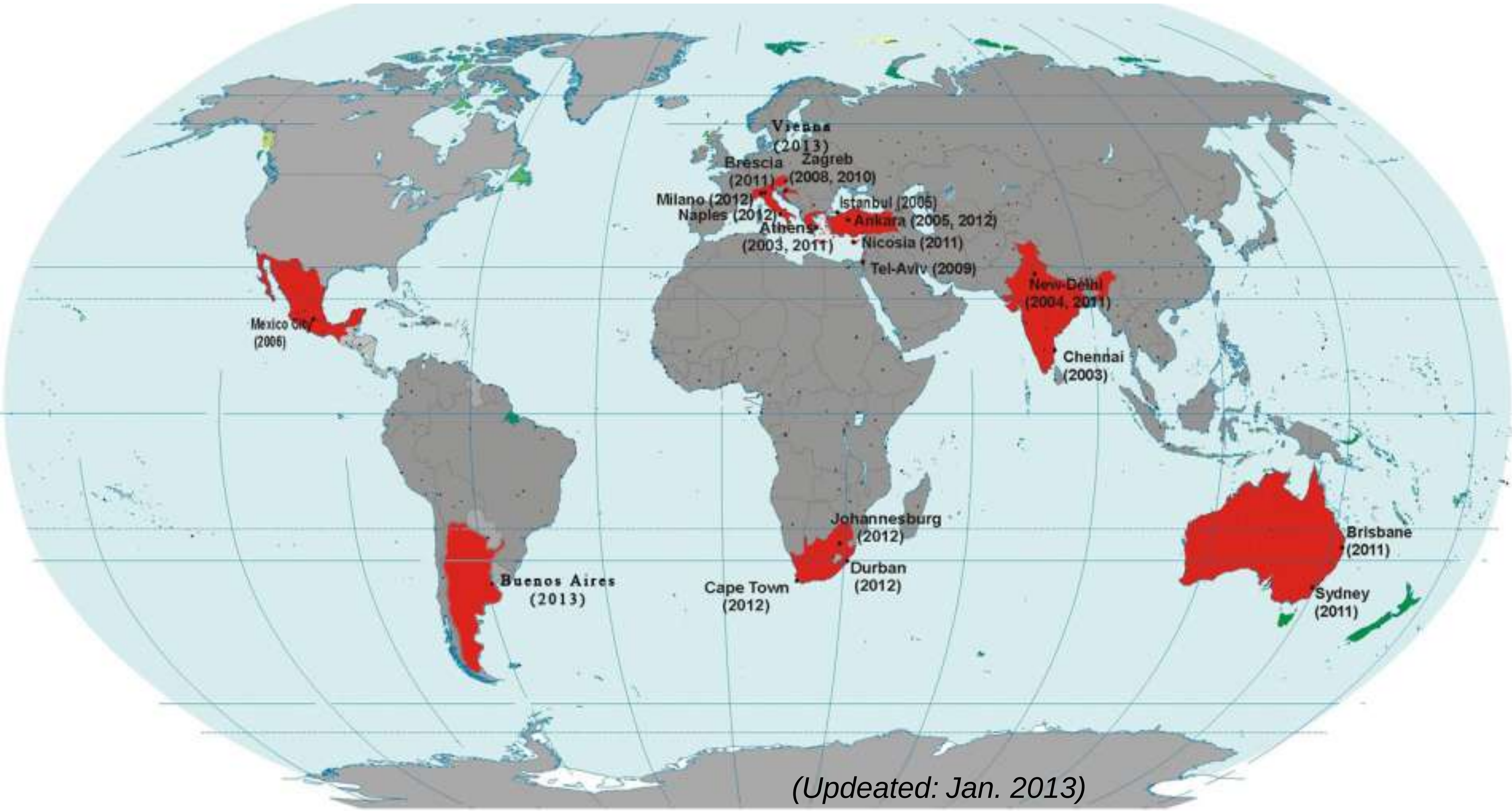
fib Textbook: STRUCTURAL CONCRETE
Behaviour, design and performance

fib - courses 2003 - 2017

2011-12: **Nicosia, Athens, New-Delhi, Brescia, Johannesburg, Durban, Cape Town, Milano, Napoli, Ankara**

2013: **Buenos Aires, Vienna** ***2014 Mumbai, Guimares***

2015: **Sao Paolo** ***2016 Sao Paolo, Cape Town***



PhD Symposia

ACI-***fib*** Collaboration:

1st Int. Conf. on Concrete Sustainability (ICCS13), Tokyo May 2013

27 Oct 2017 Montevideo, Uruguay

Verification of serviceability - CRACK CONTROL

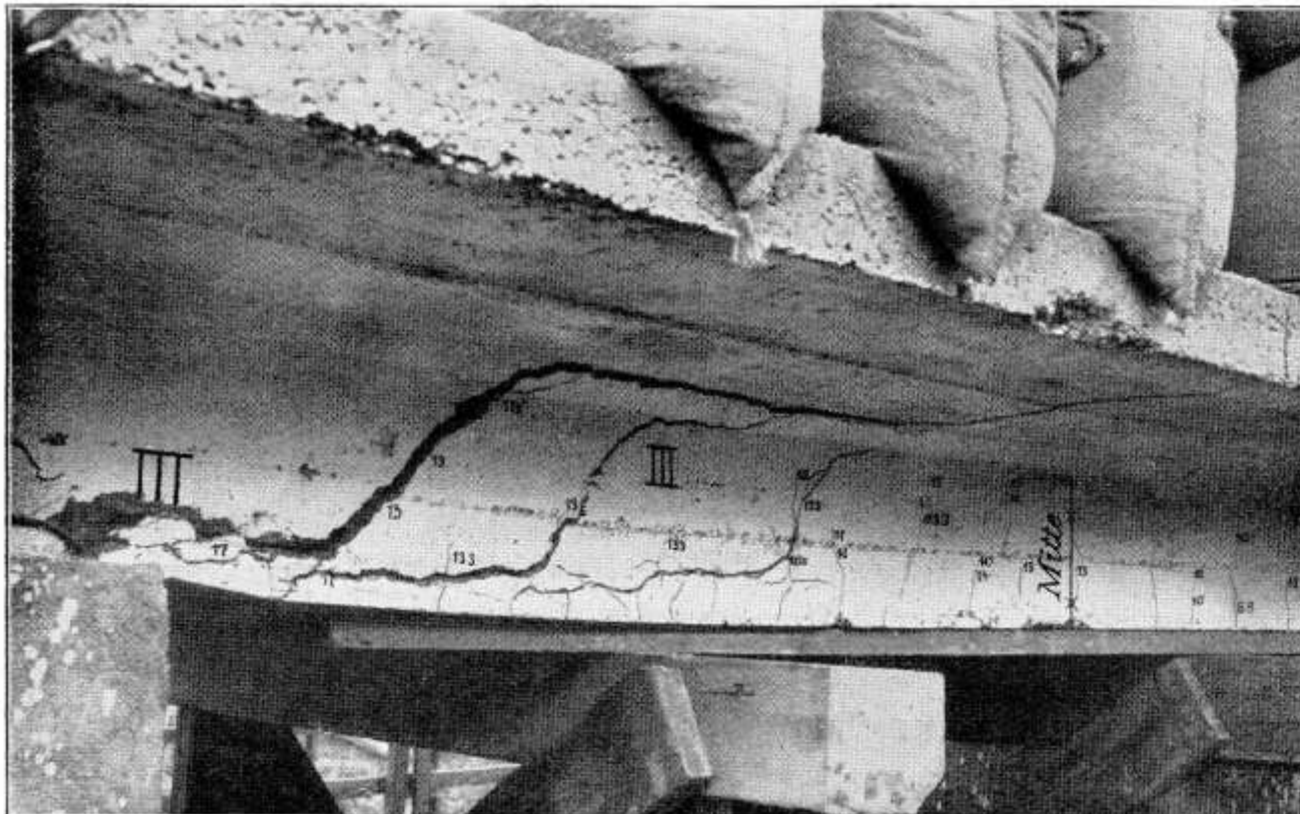
Every engineer in the world knows about **GOTO CRACKS**

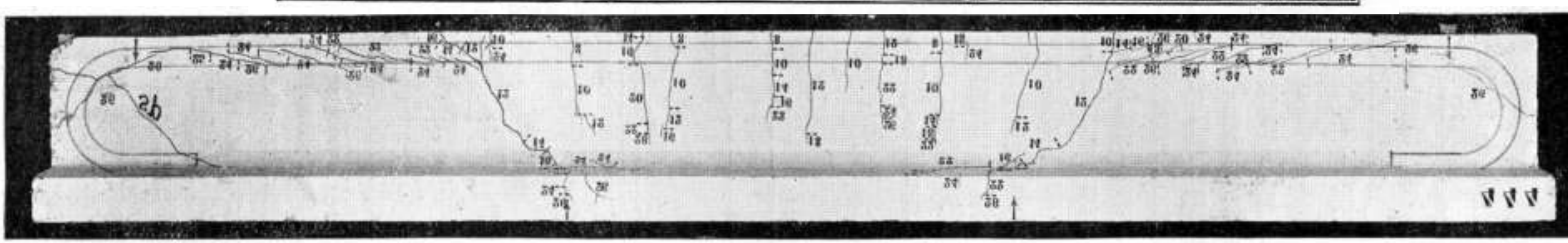
(Goto,1971)

Indication of difference between micro cracks and macro cracks

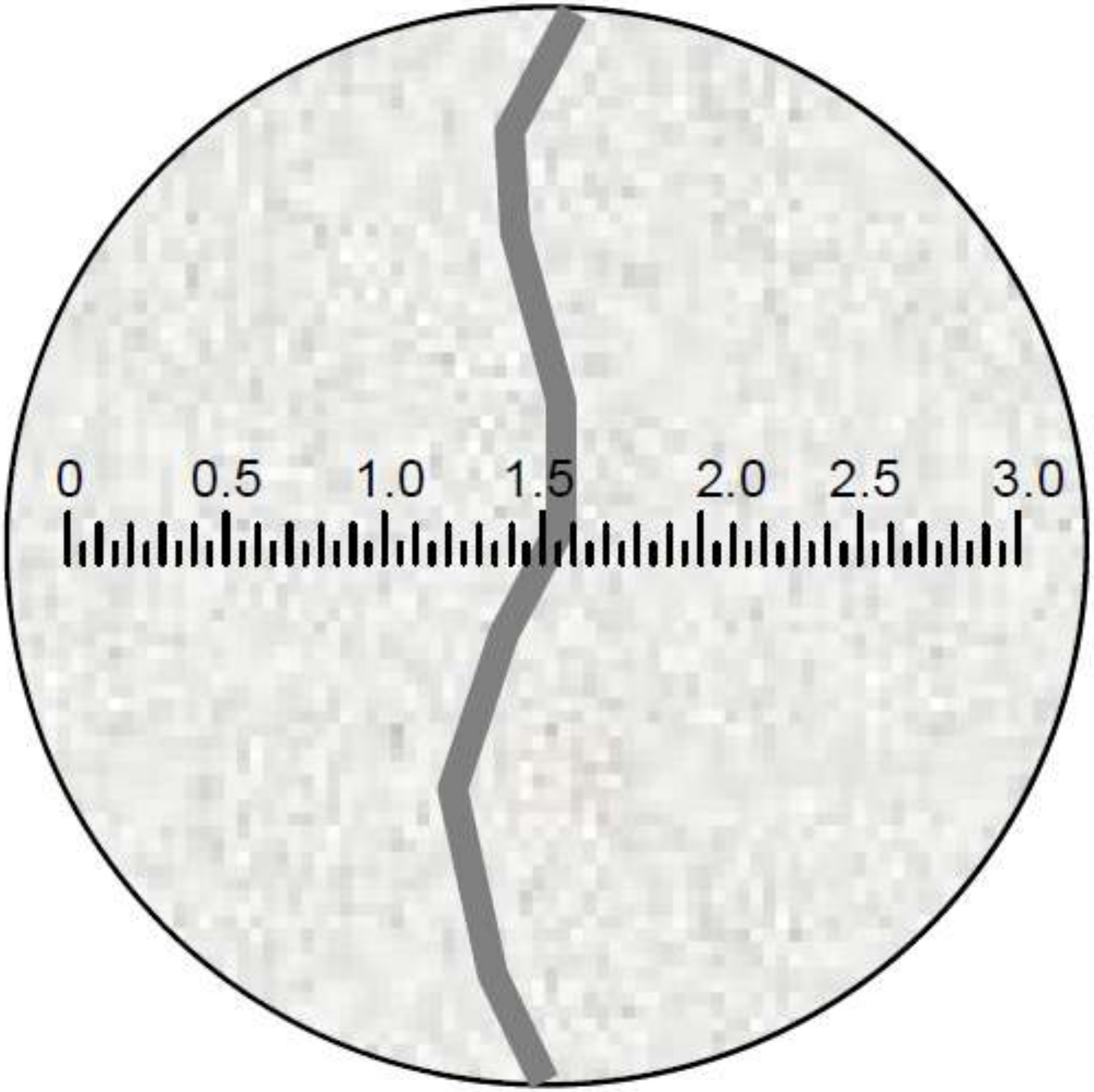
Cracking in structures: **MÖRSCH (1908)**

(Der Eisenbetonbau, seine Theorie und Anwendung)

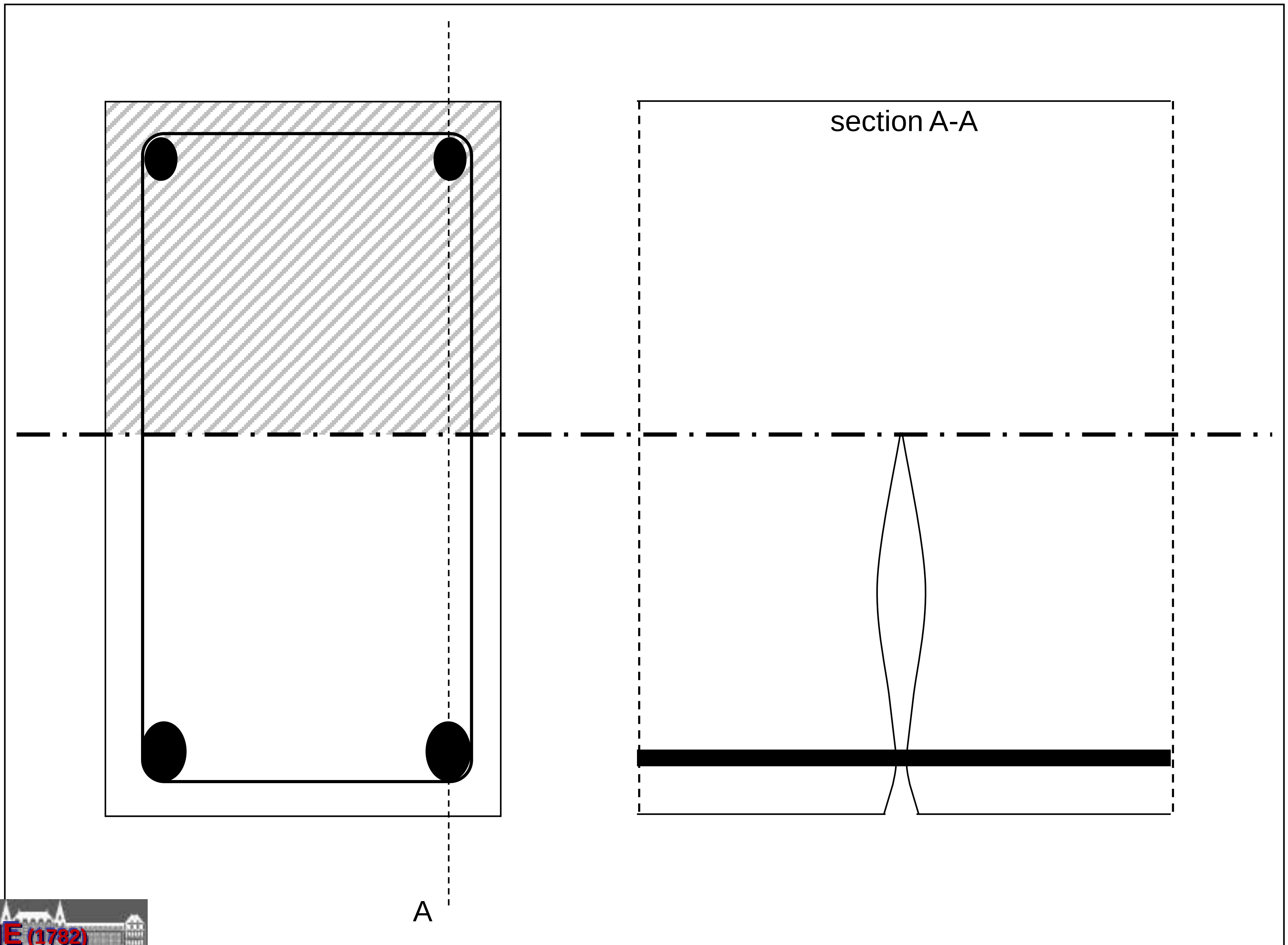




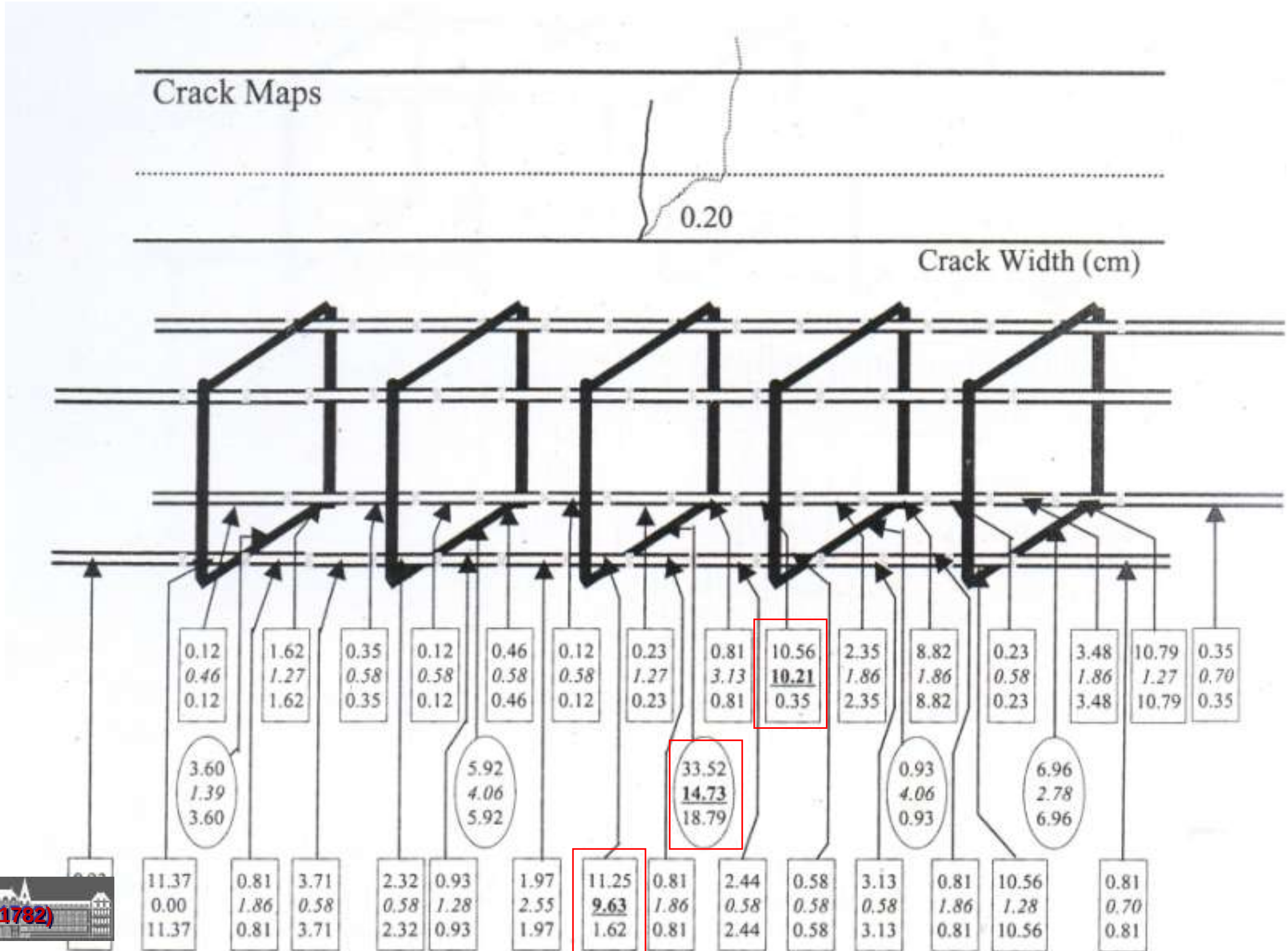
Cracks are visable



SHAPE OF FLEXURAL CRACK AND COVER THICKNESS



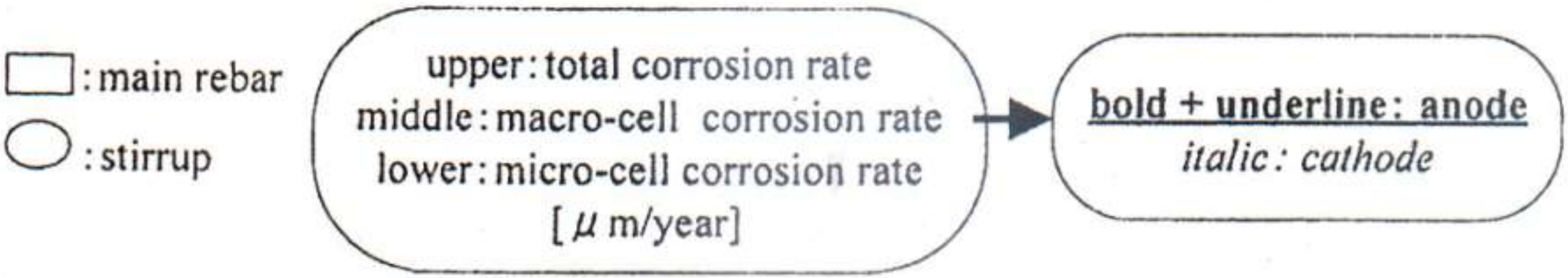
MEASURED CORROSION RATES
(Otsuki, Miyazoto, Diola, Suzuki, 2000)

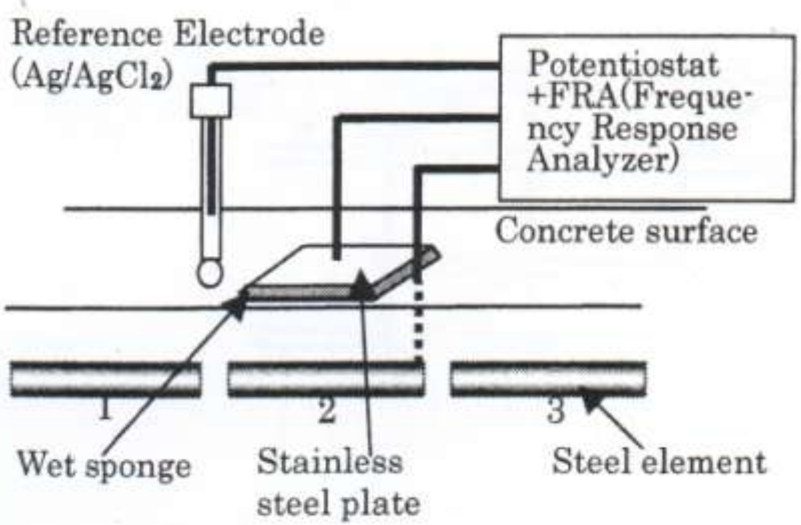


MEASURED CORROSION RATES

(Otsuki, Miyazoto, Diola, Suzuki, 2000)

The corrosion rates of main reinforcing bars and stirrups near a bending crack were clarified.





<u>Micro-cell:</u> current refers to the current flowing in the cell when only one steel component is involved.

<u>Macro-cell:</u> the total electric current flowing through all the adjacent steel components.

MEASURED CORROSION RATES

(Otsuki, Miyazoto, Diola, Suzuki, 2000)

-The influences of bending cracks and w/c on the corrosion rates of reinforcing bars were very large.

- In the vicinity of a bending crack a macrocell was formed and the corrosion rate increased remarkably.

-Since alkali content increases with the decrease in w/c, the corrosion rate slows down with low w/c.

Our everyday life is full of worries about cracks

Pine Island-Glacier (PIG)

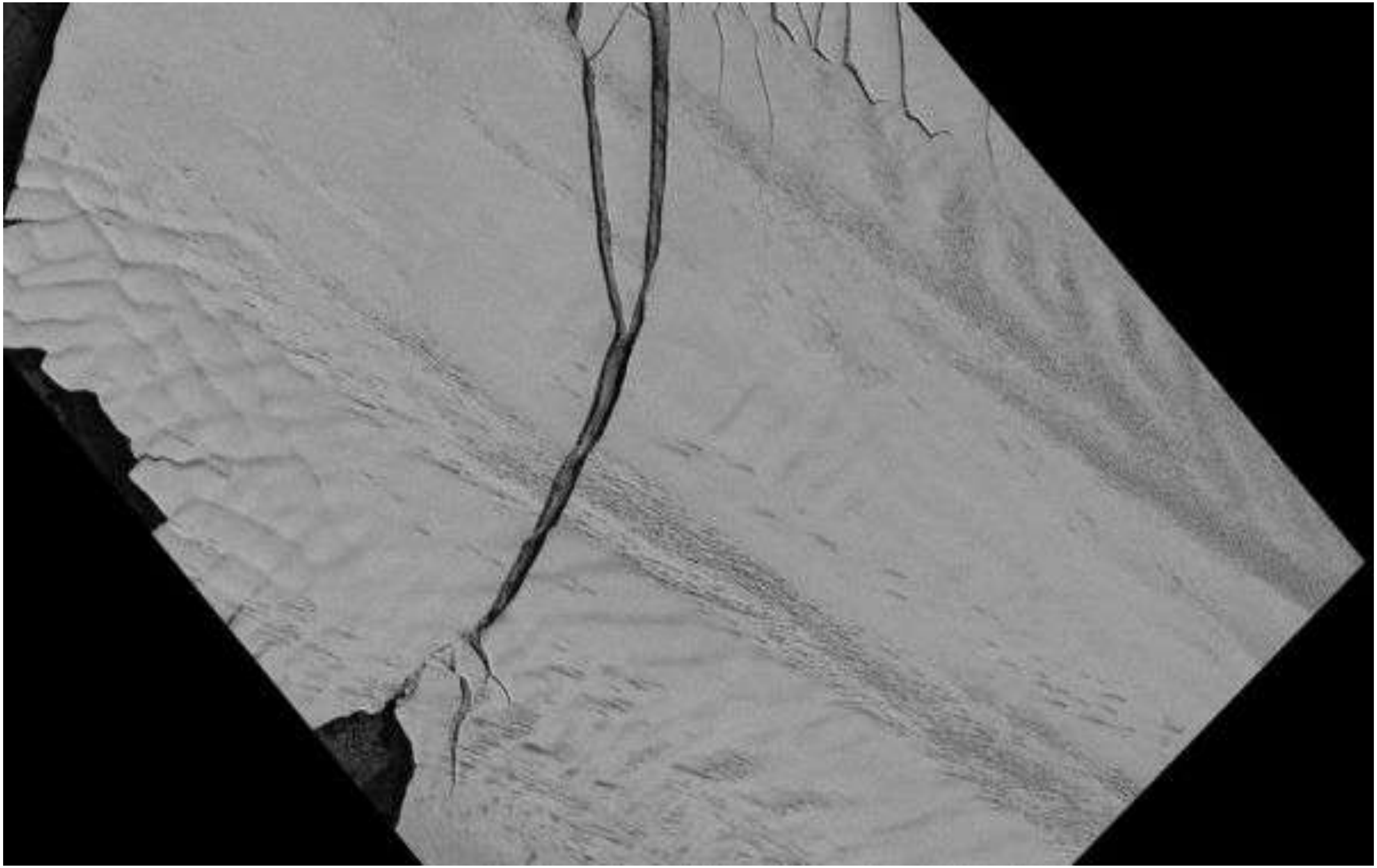
In the Antarktis

a crack produced separation of ice

10 July 2013, Wednesday - 13:54

http://richpoi.com/cikkek/tudomany/uj-jeghegy-szuletett-a-deli-sarkvideken.html

720 km2 ice cracked away in the Antarktis



Pine Island-Glacier (PIG)

1/ shear wall under *monotonic* shear loading
2/ shear wall under *cyclic* shear loading

CEOS Project

CEOS.fr

STUDIES:
- Cracking under mon load
- Free shrinkage
- Restrained shrinkage
- Thermo-hydro effects
- Alternating cyclic load

MEASUEREMENTS:
- LVDTs,
- VibrAting gauges,
- Optical sensors,
- Acoustic sensors

A/ Shear walls:

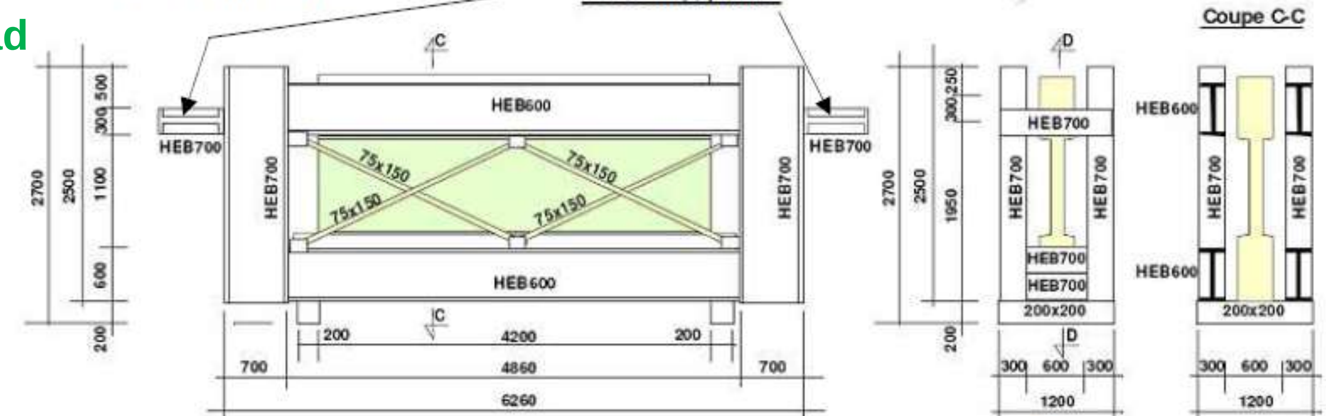


Figure 1: Shear wall specimens – left: wall on its testing bench- right: sectional elevation of the wall

3/ large beam specimens *loaded in flexion after free shrinkage* (figure 2 & 3)
4/ large beam specimens with *restrained shrinkage* (figure 4)

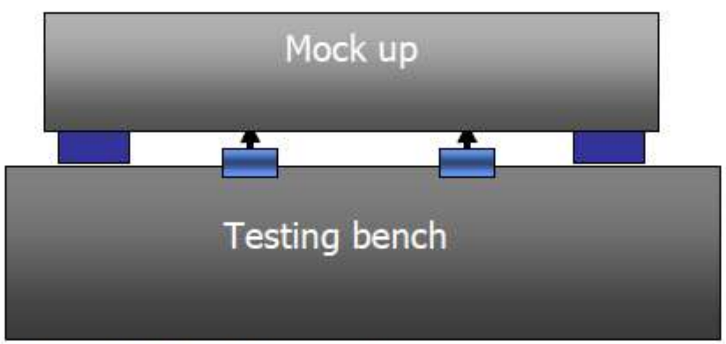


Figure 2: Large beam, scheme of the test

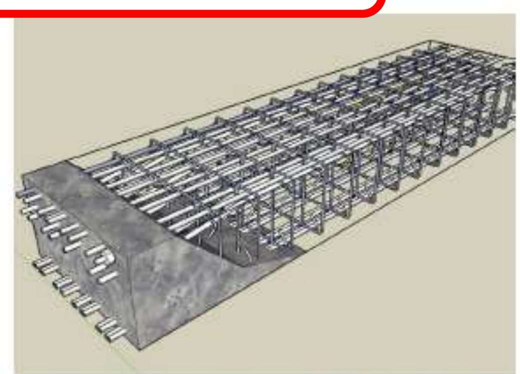


Figure 3: geometry and reinforcement scheme for the free shrinkage specimens

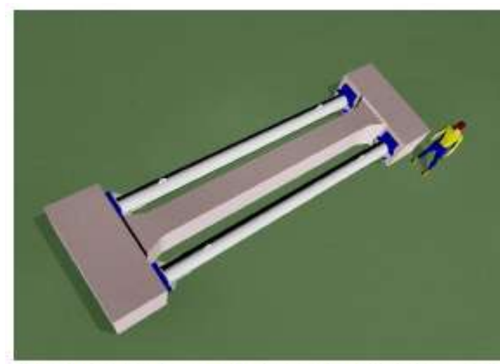


Figure 4: I geometry for the restrained shrinkage specimens and restrained system

ConCrack4: OBSERVATIONS

CEOS.fr

PROJET NATIONAL CEOS.fr

ConCrack 4
-
20-21 March

JRC Ispra

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Ministère de l'Écologie, du Développement durable et de l'Énergie

COMPORTEMENT ET ÉVALUATION DES OUVRAGES SPÉCIAUX
–
FISSURATION ET RETRAIT

Part 2. Main conclusions

- Crack spacing
  - **Both EC2 and MC2010 overestimate crack spacing**
  - Results are better with MC2010
- Strain difference
  - Both EC2 and MC2010 **underestimate the strain**, above all MC2010
  - **Tension stiffening** seems to be **overestimated** in both codes
- Crack width
  - EC2 **overestimates** crack width
  - MC2010 **slightly underestimates** crack width

18

Generic considerations on cracking based on tie experiments   Silvano Erlicher

CAUSES OF CRACKING

1. Technological (early age)

plastic shrinkage
plastic settlement…

2. Loads and imposed deformations (hardened concrete)

3. Volumetric changes in concrete

temperature differences
AAR, ASR…

NEEDS FOR CRACK CONTROL

- **tightness** (water and gas)
- **durability**

  propagation of corrosion

  permeability, chloride ingress…

  Where is the limit?

- **appearance**

Water and gas tightness

WATER TIGHT-NESS?

SELF HEAL-ING?

Pontoons need to swim

There are many other reasons of cracks In concrete structures in early ages and in service

Cracking between concretes of different ages

Cracking from stress concentrations

Railway sleeper

Airport

runway

BME (1782)

Budapest University of Technology and Economics

Precast form joints

MC2010 Ch. 3 Basic Principles

SERVICEABILITY LIMIT STATES (SLS)

The states beyond which specified demands for a structure or a structural component related to its

normal use or function are no longer met.

SLS criteria are related to

- **Unaceptable deformations or deflections**
  → impair functionality
  → damage to non-structural elements
  → discomfort to people
  → effect appearance

- **Excessive cracking and slip in connections**
  → affect efficiency
  → affect tightness
  → affect appearance, but
  → does not effect structural safety

- **Exessive vibrations**
  → impair user's comfort and structural effectivess

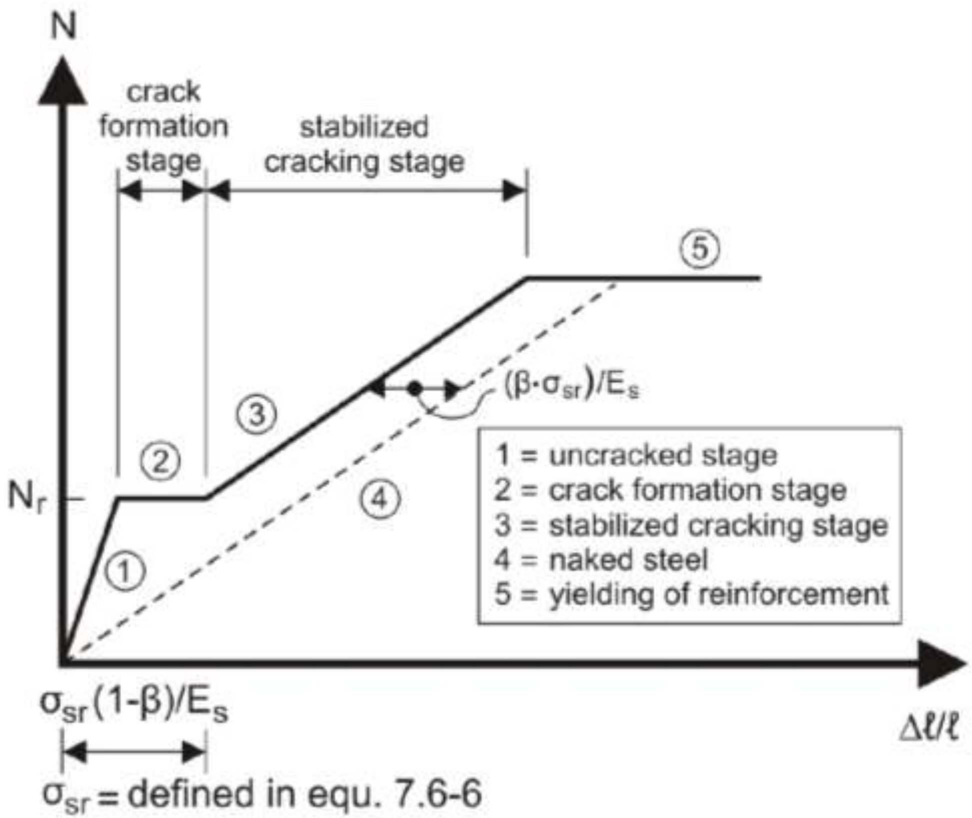
DEFINITION OF CRACK WIDTH

$$w = \int_0^{s_r} \left[\varepsilon_s(x) - \varepsilon_c(x) \right] dx$$

fib MODEL CODE 2010

7.6 DESIGN: SLS - Cracking and deflecions

Tensile force-strain diagram



Crack control

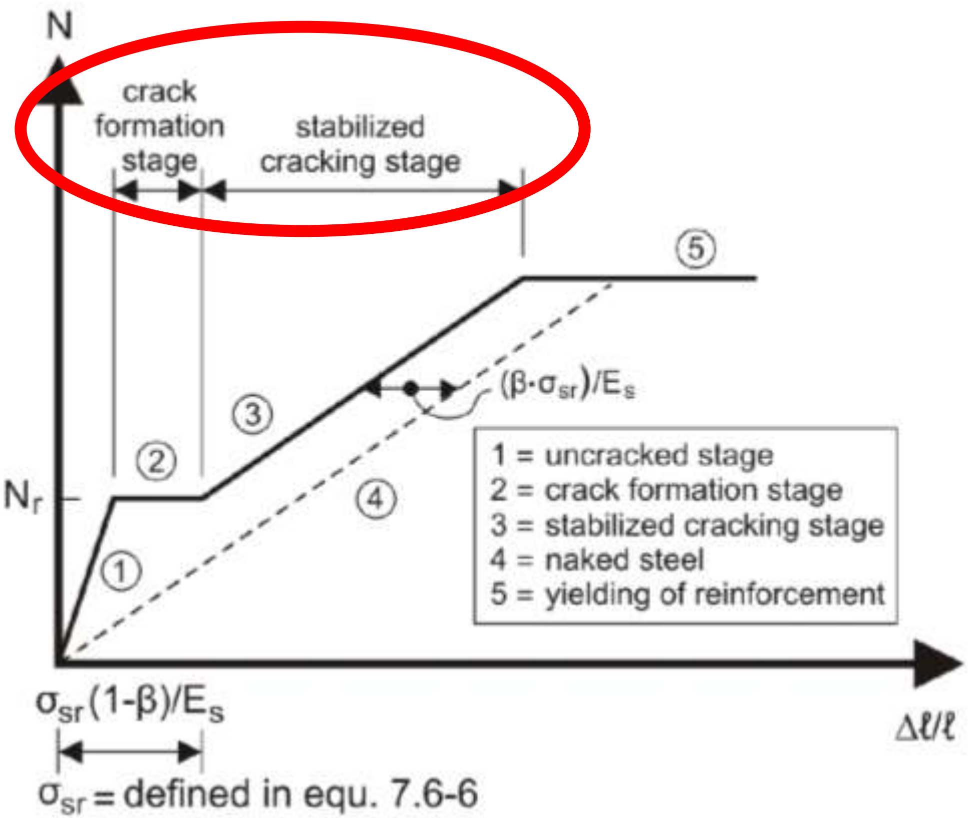
$$w_d = 2 l_{s,\max} (\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

$$l_{s,\max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} + \eta_r \cdot \varepsilon_{sh}$$

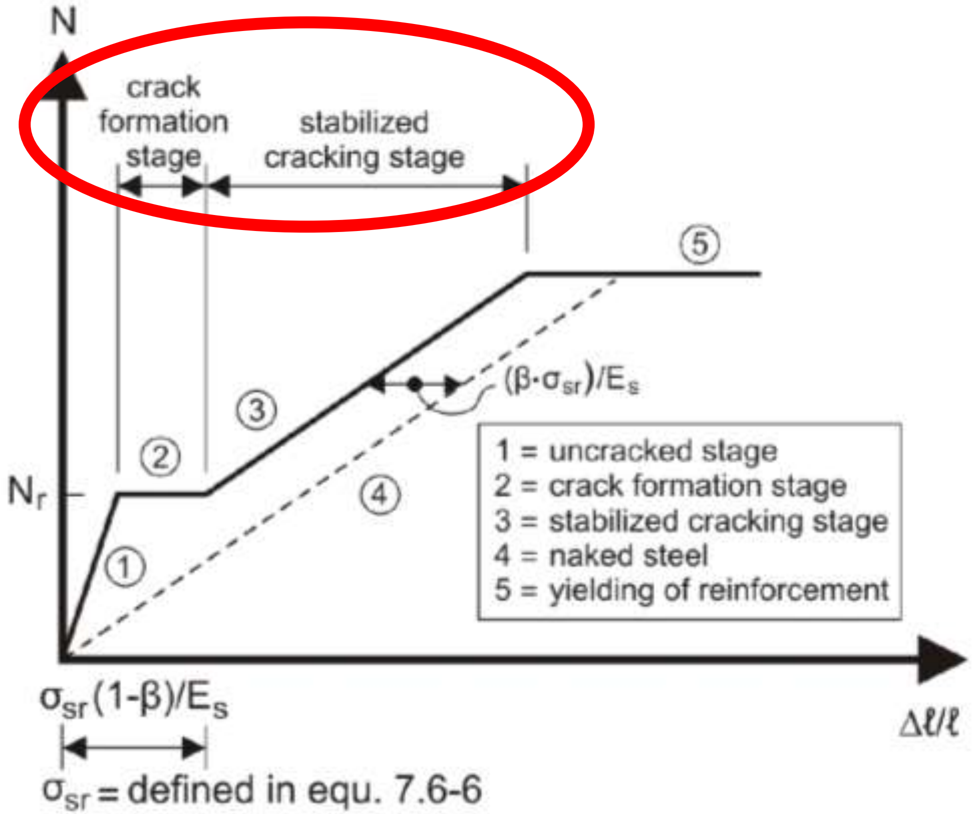
7.6 DESIGN: SLS - Cracking and deflections

Tensile force-strain diagram

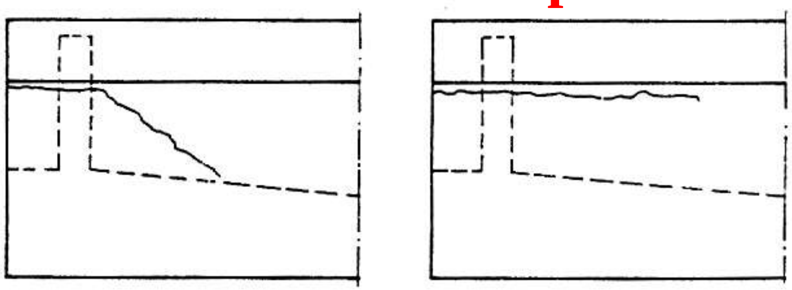


7.6 DESIGN: SLS - Cracking and deflections

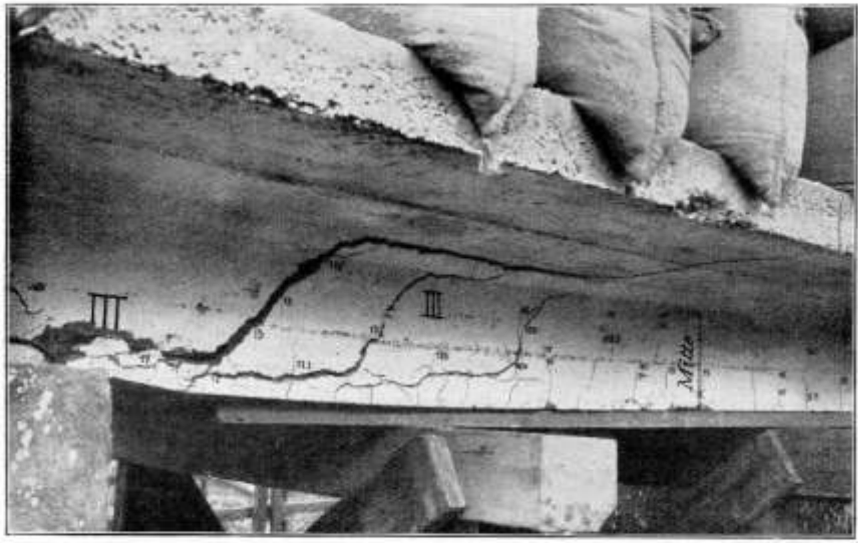
Tensile force-strain diagram



Crack formation phase

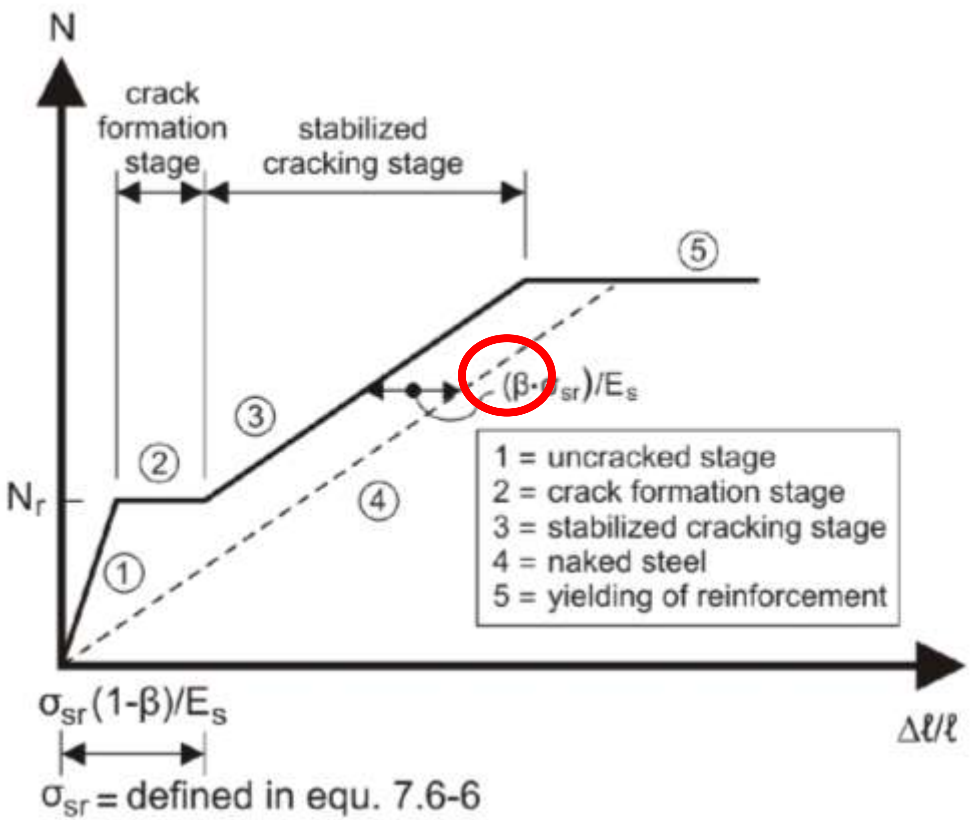


Stabilized cracking



7.6 DESIGN: SLS - Cracking and deflections

Tensile force-strain diagram



7.6 DESIGN: SLS - Cracking and deflections

Crack control

$$w_d = 2l_{s,\max}(\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

$$l_{s,\max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} + \eta_r \cdot \varepsilon_{sh}$$

7.6 DESIGN: SLS - Cracking and deflections

Crack control

$$w_d = 2l_{s,max}(\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

$$l_{s,max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

7.6 DESIGN: SLS - Cracking and deflections

Crack control

$$w_d = 2l_{s,\max}(\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

$$l_{s,\max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

7.6 DESIGN: SLS - Cracking and deflections

Crack control

$$w_d = 2l_{s,\max}(\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

$$l_{s,\max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

7.6 DESIGN: SLS - Cracking and deflections

Crack control

$$w_d = 2l_{s,\max}(\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

$$l_{s,\max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

7.6 DESIGN: SLS - Cracking and deflections

Crack control

$$w_d = 2 l_{s,\max} (\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

$$l_{s,\max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

7.6 DESIGN: SLS - Cracking and deflections

Crack control

$$w_d = 2l_{s,\max}(\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

$$l_{s,\max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

7.6 DESIGN: SLS - Cracking and deflections

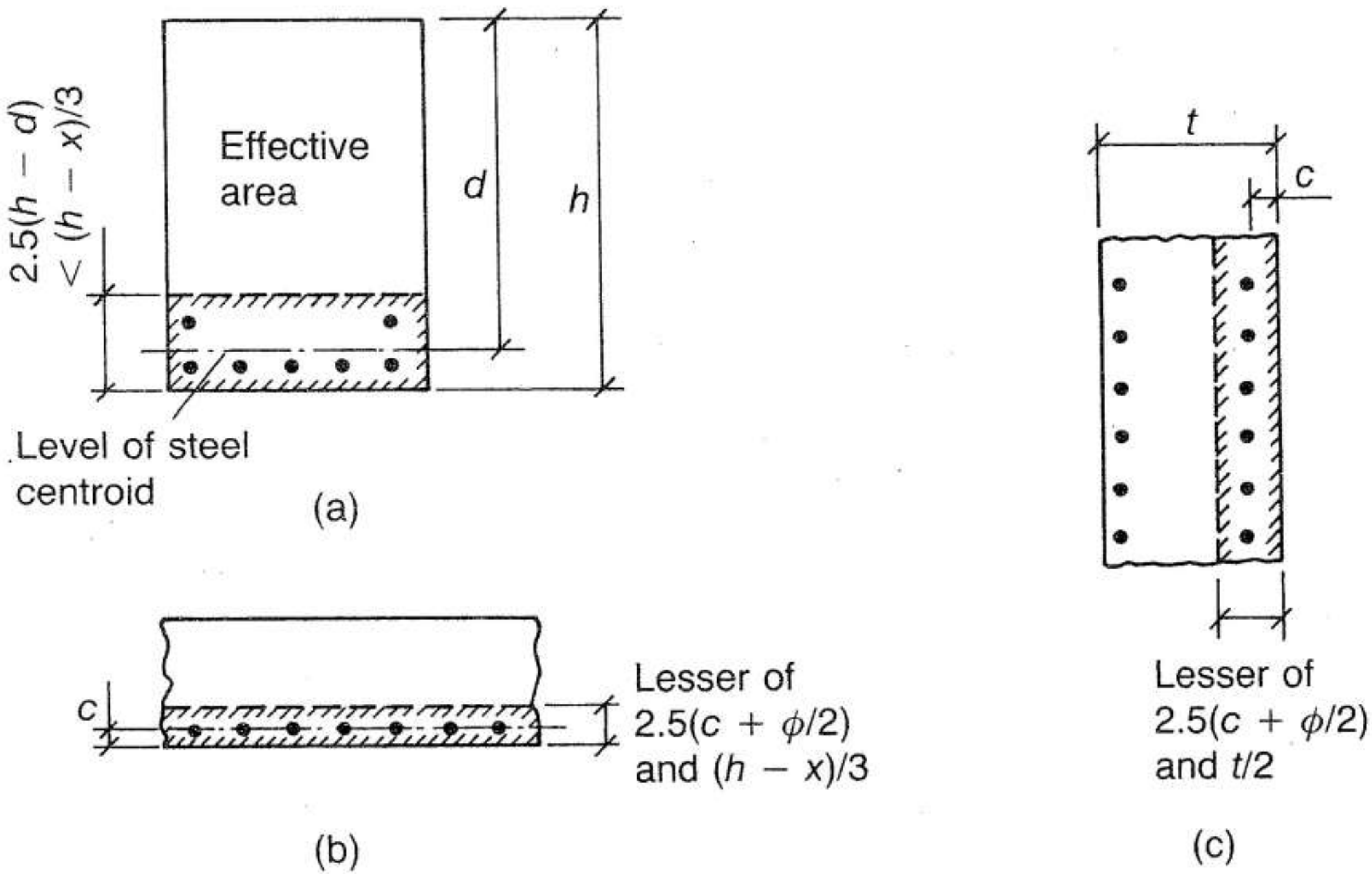
Crack control

$$w_d = 2l_{s,\max}(\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs})$$

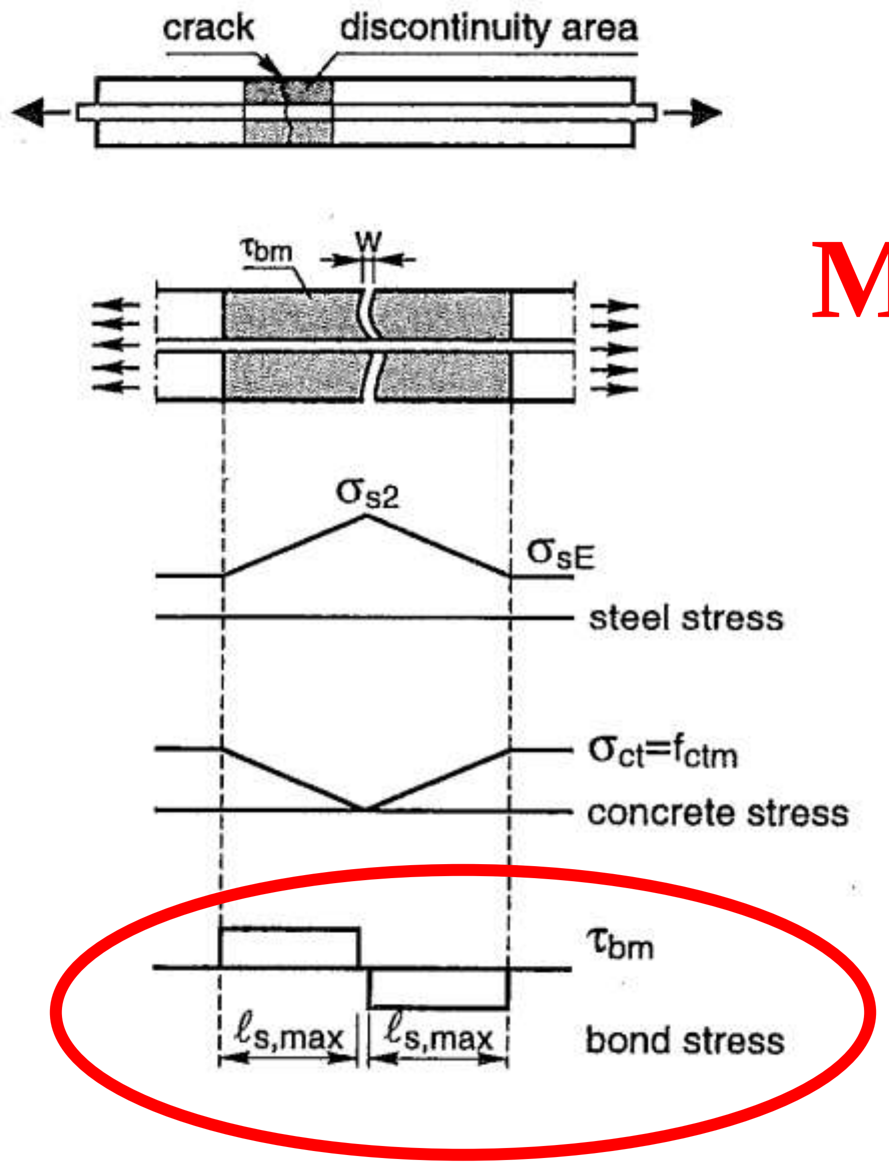
$$l_{s,\max} = k \cdot c + \frac{1}{4} \cdot \frac{f_{ctm}}{\tau_{bm}} \cdot \frac{\phi_s}{\rho_{s,ef}}$$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

Effective concrete area in tension



The tie model



MC2010

Values for τ_{bm}, β and η_r for deformed reinforcing bars

	Crack formation stage	Stabilized cracking stage
Short term, instantaneous loading	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$
Long term, repeated loading	$\tau_{bm} = 1{,}35 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.4$ $\eta_r = 1$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} + \eta_r \cdot \varepsilon_{sh}$$

Values for τ_{bm}, β and η_r for deformed reinforcing bars

	Crack formation stage	Stabilized cracking stage
Short term, instantaneous loading	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$
Long term, repeated loading	$\tau_{bm} = 1{,}35 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.4$ $\eta_r = 1$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

Values for τ_{bm}, β and η_r for deformed reinforcing bars

	Crack formation stage	Stabilized cracking stage
Short term, instantaneous loading	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$
Long term, repeated loading	$\tau_{bm} = 1{,}35 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.4$ $\eta_r = 1$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

Values for τ_{bm}, β and η_r for deformed reinforcing bars

	Crack formation stage	Stabilized cracking stage
Short term, instantaneous loading	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$
Long term, repeated loading	$\tau_{bm} = 1{,}35 \cdot f_{ctm}(t)$ $\beta = 0.6$ $\eta_r = 0$	$\tau_{bm} = 1{,}8 \cdot f_{ctm}(t)$ $\beta = 0.4$ $\eta_r = 1$

$$\varepsilon_{sm} - \varepsilon_{cm} - \varepsilon_{cs} = \frac{\sigma_s - \beta \cdot \sigma_{sr}}{E_s} - \eta_r \cdot \varepsilon_{sh}$$

Crack width limits (wlim) (in mm) for RC and PC members with bonded prestressing steel

(Table 7.6-1 of MC2010). Exposure classes are given according to Table 4.7-2 of MC2010 and ISO 22965-1.

	RC	PL1	PL2	PL3
X0	0.3	0.2	0.3	0.3
XC	0.3	0.2	0.3	0.3
XD	0.2	$\sigma < 0$ *	0.2	0.2
XS	0.2	$\sigma < 0$ *	0.2	0.2
XF	0.2	$\sigma < 0$ *	0.2	0.2

* *Stress in concrete at the level of prestressed reinforcement*

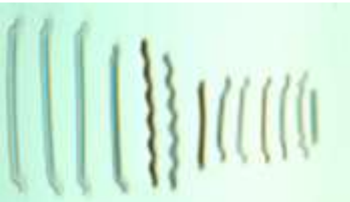
RC: For non-prestressed reinforcement

PL1: For all prestressing reinforcement used in environments which have relatively low aggressiveness and which are well protected by the structures

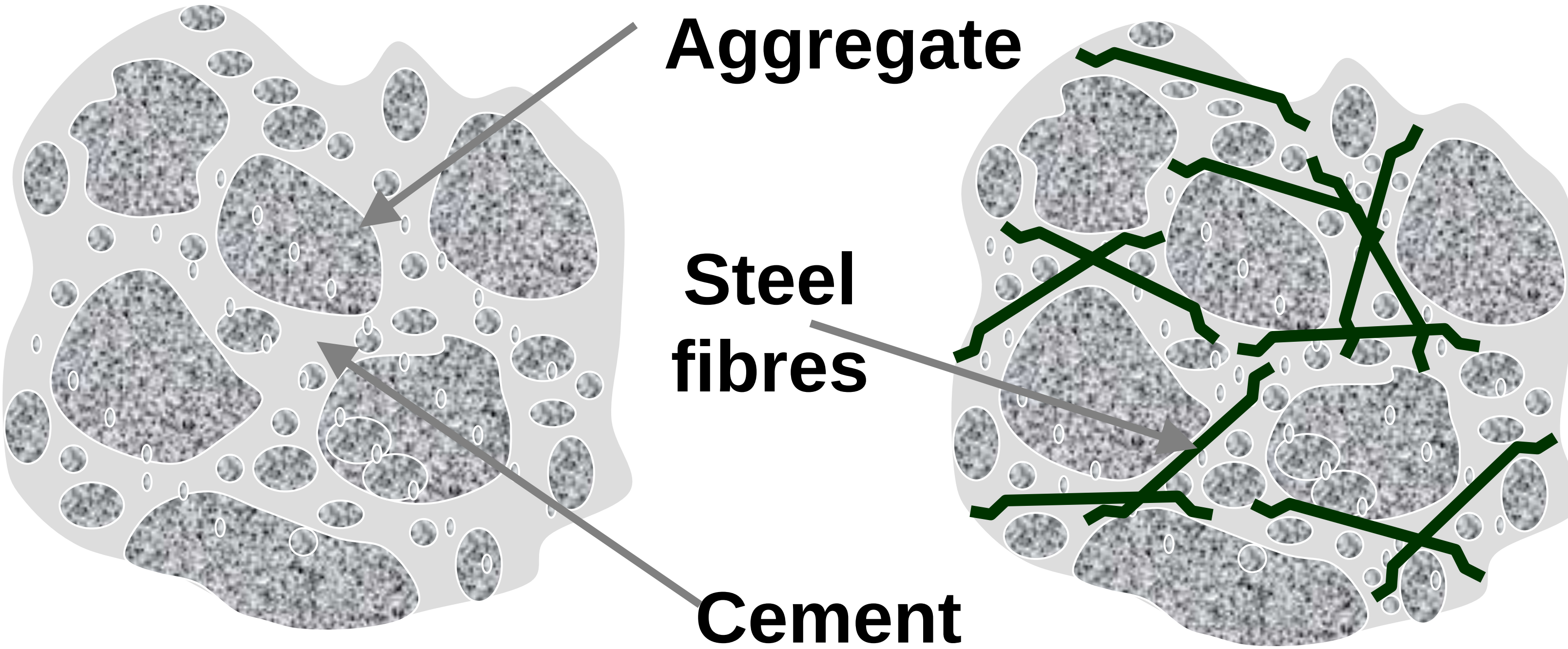
PL2: For all other prestressing reinforcement in all other combinations of environments and/or exposure and protection not included in protection levels PL1 and PL3 provided by the structures

PL3: For all prestressing reinforcement used in aggressive environment and/or severe exposure and with low protection provided by the structures

BOND

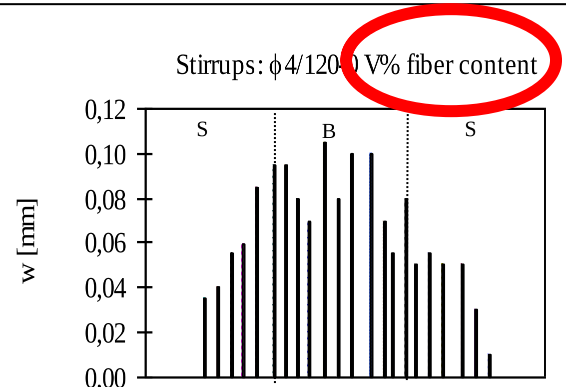


CRACKING
IN
STEEL FIBRE REINFORCED CONCRETE

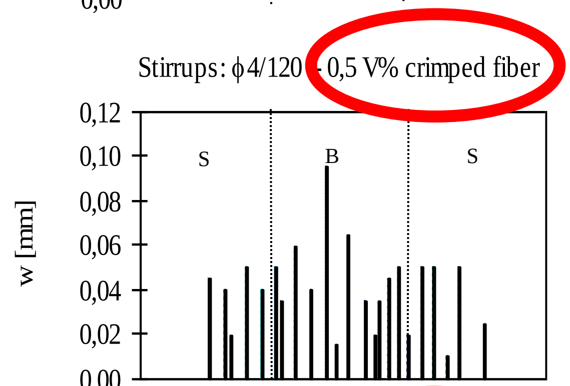


Plain concrete **Steel fibre reinforced concrete**

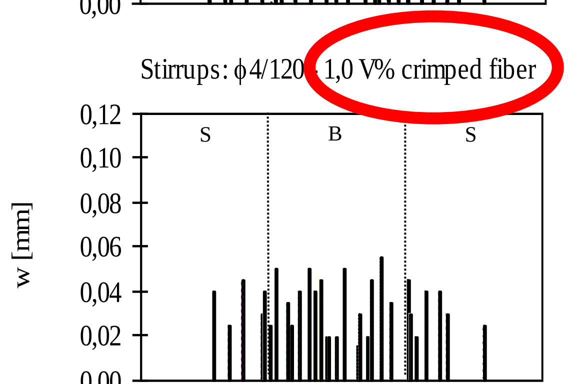
CRACK DISTRIBUTION (Kovács, Balázs, 2004)



	CRACKS		
	S+B	B	S
No.	22	9	13
Σw[mm]	1.45	0.74	0.71
w_m [mm]	0.066	0.082	0.055
s_w [mm]	82	67	92

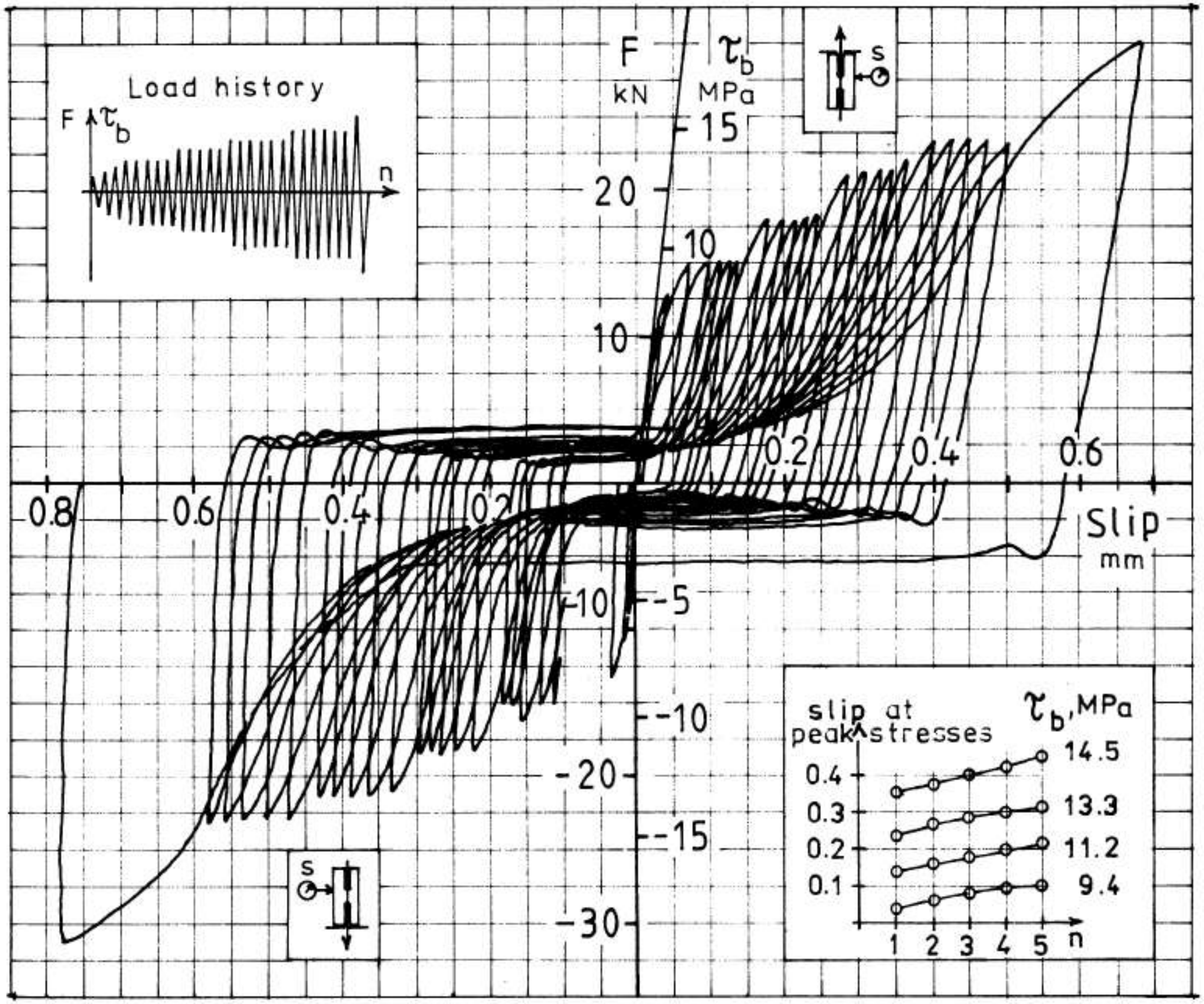


	CRACKS		
	S+B	B	S
No.	23	9	14
Σw[mm]	0.945	0.445	0.500
w_m [mm]	0.041	0.049	0.036
s_w [mm]	78	67	86



	CRACKS		
	S+B	B	S
No.	30	17	13
Σw[mm]	1.030	0.585	0.445
w_m [mm]	0.034	0.034	0.034
s_w [mm]	60	35	92

Reversed cyclic loading produces increase in slip and crack widths



. 9—Force-controlled load reversals: d_b = 6 mm (0.63 in.) deformed bar; f_y = MPa (58 ksi); f'_c = 25 MPa (3.6 ksi); l_b = $2d_b$

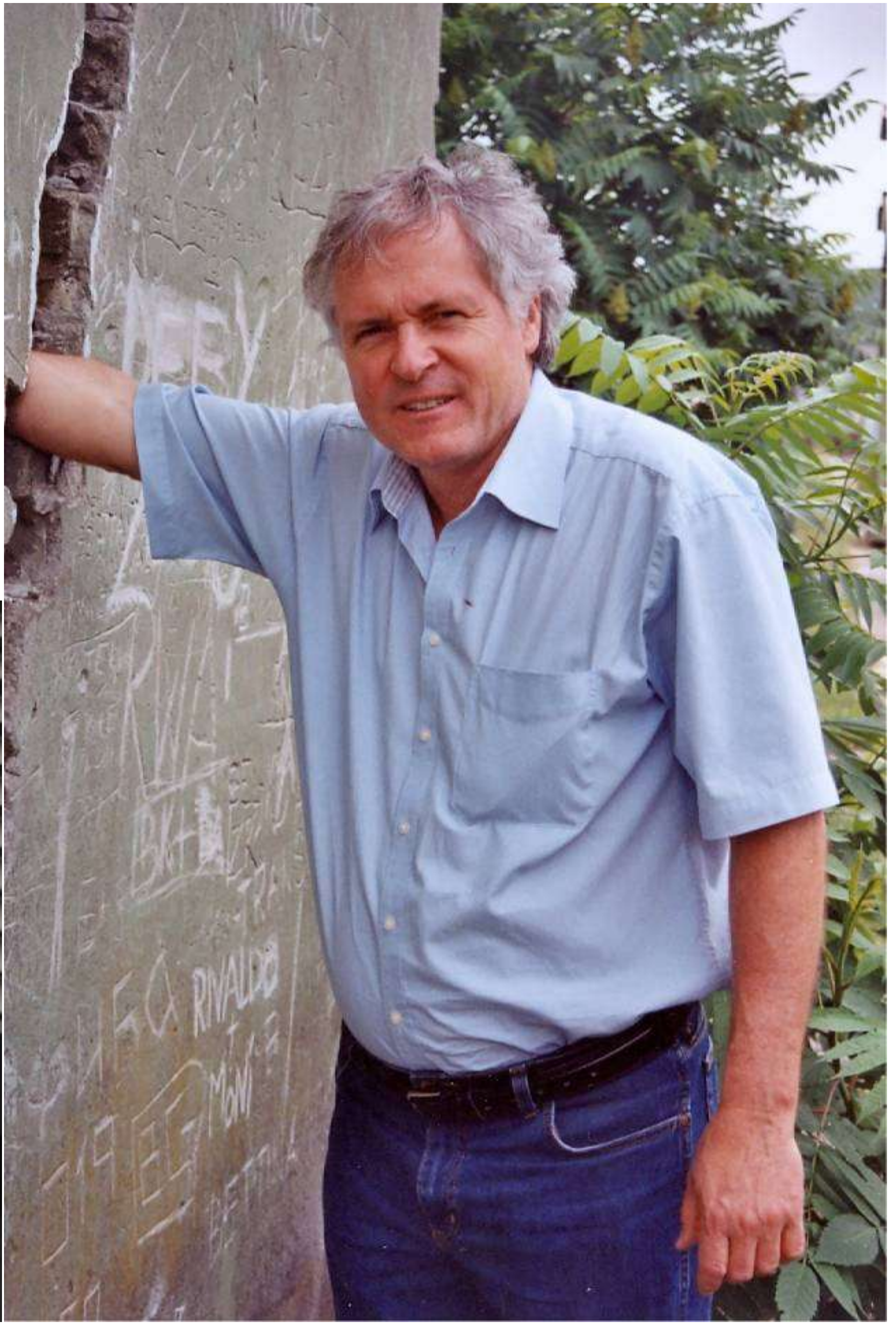
(Balázs, 1991)

Members of *fib* Task Group 2.1

„Serviceability Models”

CZ:	**Vítek, J., Cervenka, V.; Kohountková, A;**
F:	**Bisch, P.; Torrenti, J.-M.**
	Toutlemond, F.; Lorrain, M.
D:	**Eckfeldt, L.; Fehling, E.;**
	Ozbolt, J.; Windisch, A.;
H:	**Balázs, G.L.; Borosnyói,A.; Lenkei,P.**
I:	**Ceroni, F.; Debernardini, P. G.;**
	Pecce, M.; Taliano, M.,
	Chiorino, M.
J:	**Ueda, T.**
E:	**Caldentey, A. P., Mari-Bernat, A.; Torres, L.**
CH:	**Burdet, O.; Burns, C.**
Tun:	**Daoud, A.**
UK:	**Beeby†, A. W.; Lark, B.**

Thanks!
Be careful
with cracks



3ª JORNADA DE AVANCES EN DISEÑO Y TECNOLOGÍA DEL HORMIGÓN

Viernes 27 de octubre - 8 a 12 hs - Facultad de Ingeniería

Anfiteatro del Edificio Polifuncional José L. Massera, anexo a la Facultad de Ingeniería (UdelaR) Senda Nelson Landoni esq. Julio Herrera y Reissig, Montevideo

Horario	Tema	Ponente
8:00	Registro en la jornada	
8:15	Apertura de la jornada	L. Segura
8:30	Resultados preliminares del proyecto FMV – ANII "Aplicación de nuevos hormigones para premoldeados", realizado en Uruguay.	G. Rodríguez
9:00	Hormigón proyectado con fines estructurales: Aspectos básicos y nuevas tendencias.	S. Cavalaro
9:45	Pausa - Café	
10:00	Módulo de deformación del hormigón: Estudios experimentales y situación normativa en Uruguay.	M.N. Pereyra
10:30	Perspectivas del Código Modelo ***fib*** 2020. Verificaciones de Servicio, Vida Útil y Control de Fisuración.	G. Balazs
11:15	Discusión y cierre: Desarrollo del hormigón Estructural en Uruguay	L. Segura

Entrada gratuita con inscripción previa en: https://goo.gl/forms/kQzyXUokLSuOx1Vv1

Prof. Dr. György L. Balázs
Profesor de la Universidad de Tecnología y Economía de Budapest en Hungría (Jefe del Departamento de Materiales, Construcción y Tecnología). Ha trabajado en diversos campos de actividad relacionados con el hormigón, que incluyen: estudios experimentales y analíticos sobre hormigón, hormigón armado y estructuras de hormigón pretensado, FRC (hormigón reforzado con fibra), FRP (polímero reforzado con fibra) como refuerzos unidos internamente, refuerzos adheridos externamente o refuerzos casi montados en superficie (NSM), Durabilidad, Vida útil, Resistencia y diseño ante fuego, Adherencia y fisuración, HPC (hormigón de alto rendimiento), o Sostenibilidad. Es presidente de la Comisión fib para la difusión de conocimientos, que abarca cursos-fib, libros-fib sobre el diseño avanzado de estructuras de hormigón. Fundó la serie de "fib International PhD Symposia" en Ingeniería Civil en 1996. Ha sido elegido como Presidente de fib para el periodo de 2011 y 2012, sirviendo como presidente inmediato pasado (2013 y 2014), y actualmente como Presidente Honorario, participando como invitado en las reuniones del fib Presidium.

Prof. Dr. Ing. Sergio Cavalaro
Ingeniero Civil por la Universidade Estadual de Londrina (Brasil) en diciembre de 2006, Doctor en Ingeniería de la Construcción por la Universidad Politécnica de Cataluña (UPC), España, en 2009, además de la mención de Doctor Europeo en virtud del trabajo realizado en TU Delft (Delft, Holanda). Desde septiembre de 2010 es profesor del Departamento de Ingeniería de la Construcción de la Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos de Barcelona (UPC). Como parte de su actividad docente es profesor de las asignaturas Química de Materiales, Materiales de Construcción y Durabilidad y responsable de Técnicas experimentales, Materiales Avanzados y Hormigones especiales. Sus principales líneas de interés se encuentran en el ámbito de la tecnología de la construcción, hormigones especiales (p.ej. hormigón autocompactante, hormigón con fibras y hormigón proyectado entre otros), presas de hormigón, durabilidad y construcción subterránea. En dichos temas ha dirigido tesis doctorales y es autor de artículos científicos publicados en revistas indexadas y comunicaciones en congresos de ámbito técnico y científico.

Prof. Dr. Gemma Rodriguez
Profesora Titular del Instituto de la Construcción (IC) de Facultad de Arquitectura de UDELAR y Profesor Agregado del Instituto de Ensayo de Materiales (IEM), de Facultad de Ingeniería. Master y Doctor en Ingeniería Civil por la Universidad Federal de Rio Grande do Sul, Brasil, en 1994 y 2000, respectivamente. Arquitecto, egresada de UDELAR en 1983. Como parte de su actividad docente es Profesor de las asignaturas Materiales y Ensayos, y responsable de 3 cursos de Posgrado (Materiales: estructura, propiedades y Tecnología; Desarrollo de materiales para la industria de la construcción y Hormigones Especiales). Su área de investigación es el desarrollo y aplicación de materiales y componentes para la construcción abarcando en dicha área hormigones especiales (hormigones de alto desempeño, autocompactantes, hormigones verdes, y más recientemente hormigones con fibras y translúcidos), valorización de residuos y durabilidad, entre otros. En temas de dicha área ha sido y es responsable de más de una decena de proyectos concursados que obtuvieron financiación externa. Su trabajo se refleja en artículos en revistas indexadas y comunicaciones en congresos de ámbito técnico y científico, así como en la orientación de tesis de maestría y doctorado. Integra el Sistema Nacional de Investigadores (SNI) desde el año 2009, alcanzando el Nivel II en 2014.

Prof. Dr. María Noel Pereyra
Ingeniera Civil titulada en la Facultad de Ingeniería de la UdelaR (2002). Es Doctora en Ingeniería (Doktor Ingnieur) por la Universidad Técnica de Múnich (TUM), Alemania (2007), tesis doctoral: "Deformación Transversal de Hormigones Autocompactantes". Se desempeña como Profesora Adjunta (docente de Dedicación Total) del Departamento de Construcción del Instituto de Estructuras y Transporte (IET) de la Facultad de Ingeniería de la UdelaR. Es responsable de los cursos de "Introducción a la Construcción", "Tecnología del Hormigón" y "Laboratorio de Tecnología del Hormigón", de las carreras de Ingeniería Civil. Es responsable del Laboratorio de hormigones del Departamento de Construcción del IET, donde se realizan estudios, ensayos y trabajos de asesoramiento al medio e investigación en las áreas de control de calidad del hormigón, patologías y durabilidad de hormigones. En este marco actualmente desarrolla actividades de investigación en los siguientes proyectos: "Control de calidad de adoquines de hormigón para pavimentos articulados" (dirigiendo tesis doctoral en la temática), "Deformación en hormigones: Módulo de elasticidad y su correlación con la resistencia a la compresión para hormigones elaborados con materias primas nacionales" y "Estudio de la reactividad alcalina potencial de agregados nacionales, medidas de control".

Prof. Dr. Luis Segura
Ingeniero Civil por la Universidad de la República (UdelaR), Uruguay, en 2008. Doctor en Ingeniería de la Construcción por la Universidad Politécnica de Cataluña (UPC), España, en 2013, y mención de Doctor Europeo en virtud del trabajo realizado en Loughborough University (Inglaterra). En el ámbito académico es profesor a tiempo completo del Departamento de Estructuras de la Facultad de Ingeniería (FING) de la Universidad de la República (UdelaR). Responsable de las asignaturas Hormigón 1 y 2, y del curso de posgrado Hormigones Reforzados con Fibras, dentro de la Maestría en Ingeniería Estructural. Es miembro desde 2014 del Sistema Nacional de Investigadores (SNI), de la Agencia Nacional de Investigación e Innovación (ANII), de Uruguay. Su marco de investigación se centra en el desarrollo y aplicación de hormigones especiales, y en particular, de hormigones reforzados con fibras, tema sobre el que ha publicado varios artículos en revistas de alcance internacional, así como en congresos regionales e internacionales.

https://www.fing.edu.uy/node/24560

ORGANIZA: INSTITUTO DE ESTRUCTURAS Y TRANSPORTE — UNIVERSIDAD DE LA REPÚBLICA

PATROCINA: CONTROLS GROUP — CAIMA MACCAFERRI — CDP CEMENTOS DEL PLATA S.A.

APOYA: ANII — CSIC