65º CONGRESSO BRASILEIRO DO CONCRETO
22 a 25 - outubro - 2024 - Alagoas - Maceió

O Estado da Arte em Normalização de Concreto
O que você precisa saber

O Código Modelo fib: sua evolução e importância no contexto global

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Abcic/*fib*

23.10.2024

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Evolution of fib Model Codes for structural concrete

Objective:	release model codes that can serve as the basis for future codes for concrete structures worldwide, reference for the research and development work, and a resource for professional education
Innovative Integration:	go beyond conventional approaches by incorporating the latest advancements in concrete technology, reinforcing materials, and construction techniques
Development approach:	respond to contemporary requirements and broad range of engineering needs
Global Recognition:	acknowledge diverse engineering communities worldwide and cater to regional requirements while maintaining global applicability
Joint Effort:	reflect collective efforts and expertise of more than 1’400 contributors from 67 countries

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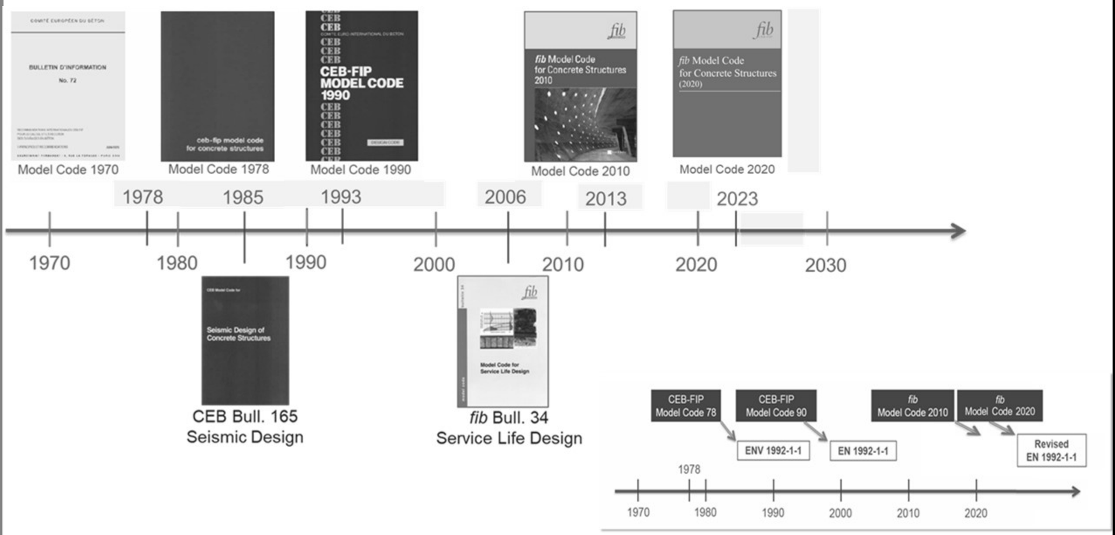
Evolution of fib Model Codes for structural concrete



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A brief history of the relationship Brazil *fib* (CEB - fip at the beginning)

- **First Luso-Brazilian Civil Engineering Journey Lisbon 1965, Fernando L. Lobo Carneiro and Yves Saillard agreed to have ABNT(Brazilian Association for Technical Standardization) as the Brazilian representative in CEB.**
- **Although Brazilian practice has always been influenced by Europe, with CEB, that influence has become more robust.**
- **Telemaco van Langendonk and Fernando L. Lobo B. Carneiro were Brazil's first representatives in CEB. Both collaborated on the first Brazilian Standard, which, in 1940, already allowed the ultimate limit state for flexure.**
- **Profs attended the course about the 1970 CEB Model Code in Lisbon in 1973. Pericles B. Fusco and Antonio R. Laranjeiras were essential for the review of our Standard**
- **NB1, now called NBR 6118, introduced Brazil's ultimate limit state method.**
- **Between the late 80' and early 90' Augusto Carlos de Vasconcelos and Lidia Shehata also participated in the Model Code. This participation led to the COLLOQUIUM ON THE CEB-FIP MC90 in Rio de Janeiro in 1991.**
- In 2006 Prof. Paulo Helene participated as deputy chair of bulletin 34 – Model Code for Service Life Design
- In 2008, after a difficult period, Brazil recovered its participation with the support of ABECE and ABCIC. Prof.Fernando Stucchi was the Brazilian representative at MC 2010 and Brazilian and Latin American 2020.
- The organization of the Workshop on fib MC2020 in São Paulo—2018 was a significant milestone, as it allowed IBRACON to regain its participation in our fib Brazilian Group.
- Brazil's culture of structural engineering is strongly focused on concrete, which enables it to contribute to and benefit community development through international technical community development. Joining an organization such as ***fib*** effectively means being in a globalized context.
- C6 – Commission on Prefabrication: Íria Doniak, Profs. Mounir Khalil El Debs, Prof. Marcelo de Araújo Ferreira, Francisco Paulo Graziano, Paulo Helene, Marcelo Waimberg (chair TG 6.5) Precast Bridges.
- 2022 – Íria Doniak – Deputy President (GA OSLO); Marcelo Melo (Chair of YMG and TG 10.3 Model Code Examples)

Highlight parts written by Prof. Fernando Stucchi and Prof. Augusto Carlos Vasconcelos to present at fib Congress – Mumbai 2014

fib events in Brazil

Brazilian Codes are less Conservative in some aspects/requirements:

- γc 1,4 x 1,5
- Different limits of slabs without stirrups
- Design criteria for slender pillars
- Train type (traffic loads) of Brazilian road bridges with probability 0,7% x 0,1% European

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MC 2020 Continuity...

Task Group 10.3 – Examples of the Model Code 2020

Convener: Melo Filho (Casagrande)

Co-conveners: Ohno (University of Tokyo)

Aim and scope :

- Translate Principles into **Tangible Examples**.
- **Provide Guidance** for Professionals: Develop examples that provide comprehensive guidance for professionals and practitioners in concrete structural design globally.
- **Enhance Understanding and Application**: Develop practical examples to enhance engineers', architects', contractors', and other stakeholders' understanding and application of the fib Model Code.
- Illustrate **Best Practices**: Use real-life examples to illustrate best practices in concrete engineering and construction and demonstrate adherence to the principles of the fib Model Code.
- Address **Real-World Challenges**: Develop examples comprehensively addressing the diverse challenges and scenarios encountered in real-world concrete construction design.
- Offer **Practical Insights**: Provide practical insights and solutions through examples to assist professionals in optimizing structural design.
- Promote Innovation: Promote the best practices proposed by the Model Code with practical examples.
- Ensure Relevance and **Applicability**: Ensure the developed examples are relevant, applicable, and adaptable to various concrete design projects worldwide.

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Task Group 10.3 – Examples of the Model Code 2020

Convener: Melo Filho (Casagrande)

Co-conveners: Ohno (University of Tokyo)

Description of workflow and timeline:

- TG10.3 workflow will include regular assessments, feedback of the material by the experts that were responsible for each section of the Model Code within the example and calculation review by another member.
- **Kickoff meeting happened 17nd June:** Nineteen members joined the meeting. The Terms of Reference (ToR) were discussed, and it was decided to organize separate working groups focused on specialized topics. The examples will emphasize the key innovations of the Model Code. Based on the main topics, five working groups were formed, and the conveners appointed leaders for each group..
- **Working group leaders meeting 03rd September:** The following WG were created:
  - WG 1 - General Design (Daniel Miranda)
  - WG 2 - Assessment of Existing Structures (Patrick Valeri)
  - WG 3 - Design of FRC (Andrea Monserrat/Albert de La Fuente)
  - WG 4- Embebbed FRP (Szinvai Szabolcs)
  - WG 5 - Recycle aggregates (Nikola Tosic)

The TG will start on Example B of fib bulletin 144, but each group will have the freedom and flexibility to modify/adapt some specific aspects of the examples.

Adriana Patricia	Abrahao	Brazil	TQS
Agnieszka	Bigaj-van Vliet	Netherlands	TNO - Buildings, Infrastructures and Maritime
Albert	De la Fuente	Spain	Universitat Politècnica de Catalunya
Alejandro	Nogales	Spain	-
Alio	Kimura	Brazil	TQS
Andrea	Monserrat López	Spain	Universitat Politècnica de Catalunya
Andri	Setiawan	United Kingdom	Imperial College London
Caterina	Rovati	Switzerland	Meyer Bauingenieure AG
Daniel	Miranda	Brazil	University of São Paulo
David	Fernández-Ordóñez	Switzerland	fib
Fangjie	Chen	Australia	-
Fernando	Stucchi	Brazil	ABECE/EGT
Hugo	Corres	Spain	FHECOR Ingenieros Consultores
Irene	Josa	United Kingdom	University College London (UCL)
Juan Mauricio	Lozano Valcarcel	Germany	Technical University of Munich
Ligia	Oliva Doniak	Brazil	-
Lisbel	Rueda García	Spain	ICITECH, Universitat Politecnica de Valencia
Marcelo	Melo	Brazil	Casagrande Engenharia
Morten	Engen	Norway	Multiconsult AS
Motohiro	Ohno	Japan	The University of Tokyo
Nikola	Tošić	Spain	Universitat Politècnica de Catalunya
Odinir	Klein Júnior	Brazil	França e Associados
Patrick	Valeri Lorenzo	Switzerland	Dr. Lüchinger+Meyer Bauingenieure AG
Petar	Bajic	Spain	-
Rob	Vergoossen	Netherlands	Royal HaskoningDHV
Sachinthani	Karunarathna	Australia	Arup
Stanislav	Aidarov	Spain	-
Szabolcs	Szinvai	Hungary	BME
Sérgio	Rodriguez	Spain	Tecnicas Reunidas

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What has been achieved in fib Model Code 2010

- A code, basically, for new structures
- Improved **safety formats for new structures**
- **Design with due regard to service life of structures**
- Improved **constitutive relations for conventional types of concrete, with due attention to durability aspects**
- Wide scope of loading types (**static, fatigue, impact, explosion, seismic, fire, cryogenic**)
- **Steel fibers and non-metallic reinforcement** as new alternatives for reinforcing concrete structures
- First introduction of **sustainability**
- First introduction of "**conceptual design**" to stimulate creativity
- First introduction of **numerical analysis**
- First introduction of **maintenance strategies for through-life care**

fib General Assembly voting on Model Code 2010, Lausanne, October 2011

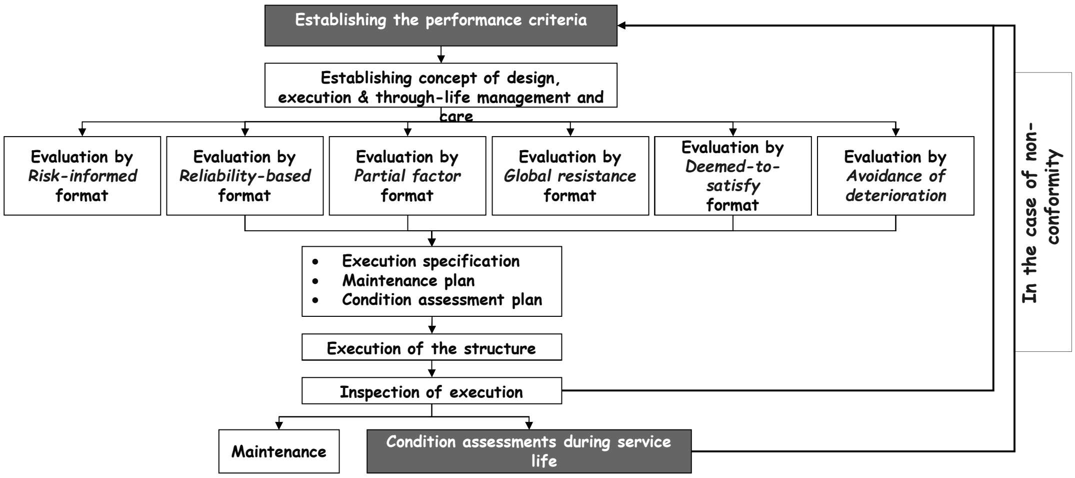
Aspiration and challenge of fib Model Code 2020

- All 'Engineering works' are **undertaken to meet established societal needs and SDG**
- The vision for MC2020 is for it to be future-oriented and capable of accommodating and not hindering technological progress, facilitating the ongoing evolution of concrete and reinforcement materials, associated technologies, and structural forms that might be created using them.
- MC2020 consistently deals with **new and existing concrete structures**, incl. structures after interventions, applying fundamental principles of a **performance-based approach to design and assessment**, **safety philosophy based on risk and reliability concepts**, and **consistent treatment of safety, serviceability, and durability verification**

The MC2020 Core Group, Madrid, December 2016

fib General Assembly voting on Model Code 2020,Istanbul, June 2023

Principles of structural performance verifications in the MC2020



Source: Agnieszka Bigaj-van Vliet (TNO, NL) Co-convenor fib Task Group 10.1: MC2020 - **Workshop MC2020 Rome - September 2nd 2022 Rome, Italy**

Sustainability framework in fib MC2020

- MC2020 adopts a **sustainability-driven performance-based approach to design, execution and life-cycle management of concrete structures**.
- The sustainability-driven performance-based approach to design and assessment seeks to ensure that the **structure fulfills the performance requirements** it is expected to meet **throughout its full / extended service life cycle**.
- The essence of the concept of the performance-based approach is that the **requirements which have to be met should be defined**, but **not the manner in which this should be done**

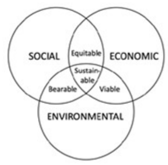


Figure 3.1-1: *Three pillars of sustainability and their interconnections*

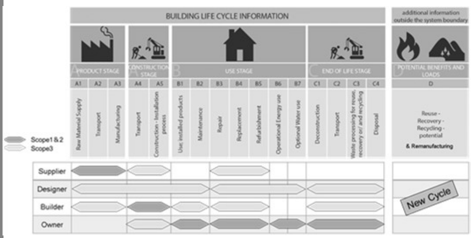
SPOILER

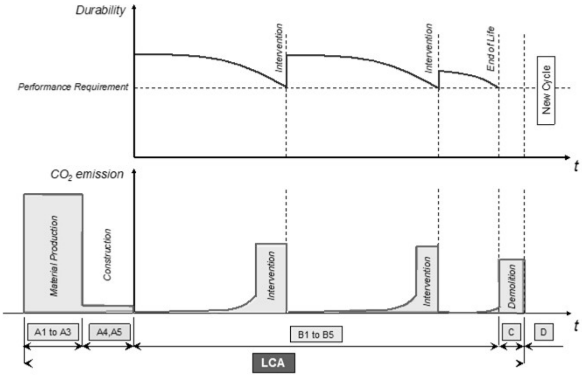
- Sustainability is described utilizing **3 interdependent pillars on which sustainable development depends:**

- **social pillar**
- **environmental pillar**
- **economic pillar**

Sustainability-driven performance-based

approach to design, execution and life-cycle management of concrete structures





Great importance during use and end-of-life stages *(figure prepared by fib)*

fib MC2020 ToC (Parts & Chapters)

fib MC2020 ToC (Parts & Chapters)

fib MC2020 ToC (Parts & Chapters)

fib MC2020 ToC (Parts & Chapters)

Concrete Considerations MC 2020 Chapter 14

14.1 Scope

- MC 2020 applies to concretes where the primary binder is Portland Cement, eventually containing secondary cement materials (SCM), such as blast furnace slag, sílica fume, natural pozzolans, and or rock powders. Here, whether the SCMs mentioned earlier are added as a part of the cement (composite cement) or as cement replacement material in the concrete product process is irrelevant.

- Durability behaviour is important in green concrete. In case of doubt, such as in deformation-sensitive structures or structures with pronounced durability loadings, a performance-based approach (chapter 4) is recommended.

- Concerning Compressive Strength MC 2020 covers concretes up to a characteristic strength of 120 MPa, NSC 50 ≤ MPa, or
- HSC ≥ 50MPa

14.2 Concrete Classification

The standard reference age at which concrete properties are defined is 28 days. For specific cases to be evaluated on a case-by-case basis, other ages may be used, subject to verification concerning structural design and durability, e.g., for concretes made with binders containing active supplementary cementitious materials. Bull 111- Modelling the structural performance of Existing Structures brings information on the reduction of strength measured at an age higher than 28 days, which is more critical for tension than compression.

Nevertheless, it should be remembered that some specifications- for example, the requirements defined for different exposure classes—are based on 28-day compressive strength.

Model Code pages 161-163

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Aging of structural concrete

MC2010:

$$\beta_{cc}(t) = exp\left\{s \cdot \left[1 - \left(\frac{28}{t}\right)^{0.5}\right]\right\}$$

β_{cc} = aging function for strengths and deformations

Introduced first in MC1990 and aplaied NBR6118

f_{cm} [MPa]	Strength class of cement	s
≤ 60	32.5 N	0.38
	32.5 R, 42.5 N	0.25
	42.5 R, 52.5 N, 52.5 R	0.20
> 60	all classes	0.20

MC2020:

$$\beta_{cc}(t) = exp\left\{s_{CON} \cdot \left[1 - \left(\frac{t_{ref}}{t}\right)^{0.5}\right]\right\} \cdot \left(\frac{28}{t_{ref}}\right)^{0.5}$$

with 28 d ≤ t_{ref} ≤ 90 d

f_{ck} [MPa]	S_{CON}		
	CR	CN	CS
$f_{ck} \leq 35$	0.3	0.5	0.6
$35 < f_{ck} < 60$	0.2	0.4	0.5
$f_{ck} \geq 60$	0.1	0.3	0.4

CR, CN, CS: Strength development classes of concrete (C)
R = rapid; N = normal; S = slow

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Concrete Chapter: (what's new?)

- Scope, definition and range of applicability
- Concrete classification (conventional and non-conventional concrete)
- Specification approach (durability specification and levels of approximation)
- Provisions for concrete material quality control
- Provisions for environmental performance

new compared to MC2010

- Compressive strength
- Tensile strength and fracture properties
- Strength under multiaxial states of stress
- Modulus of Elasticity and Poisson's ratio
- Stress-strain relations for short-term loading (uniaxial and multiaxial behaviors)
- Time effects (including aging of concrete, creep and shrinkage)
- Temperature effects
- Properties related to non-static loading (including fatigue and impact)
- Properties related to extreme thermal conditions
- Transport of liquids, gases and ions in hardened concrete
- Properties describing / defining durability
- Evaluation of equivalent performance for non-conventional concretes
- Concretes with recycled concrete aggregates
- Assumptions used for design

new compared to MC2010

Source: Harald S. Müeller – fib 2022 – Oslo Congress

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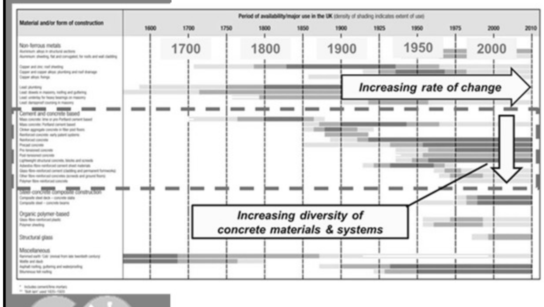
fib MC2020 Highlights : innovative materials



Criterion	MC 1990	MC 2010	MC 2020
concrete strength	20 … 60 (90) MPa	20 … 130 MPa	20 … 130 MPa
concrete type	normal strength	▪ normal strength ▪ high strength ▪ lightweight (10 … 90 MPa) ▪ self-compacting ▪ green (eco-concrete) → concretes comply largely with the provisions of EC2 and EN 206, resp.	▪ normal strength ▪ high strength ▪ lightweight (10 … 90 MPa) ▪ self-compacting ▪ green (eco-concrete) ▪ UHPC (…. 250 MPa) ▪ intervention materials ▪ old concrete
concrete loads	different ranges of applicability, depending on the related load (static, impact etc.); temperature range: mainly 0 ° C < T < 80 ° C		
tailor-made concrete	reference to test standards or recommendations		

Source : Dr. ir. A.J. Bigaj-van Vliet | TNO
Deputy-convener fib TG10.1 Model Code

The fib MC2020 covers **wide range of traditional and non-traditional solutions and includes provisions for various types of concrete and concrete structures (reinforced, prestressed, both pretensioned and post-tensioned, as well as steel-concrete composite structures)**. Provisions cover static and non-static conditions such as fatigue, seismic excitations, impact and explosions, and an extreme range of thermal exposure including fire and cryogenic conditions, in full range of environmental exposure conditions.

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fib MC2020 Highlights: innovative materials

Can concrete be used sustainably ?

Reductions in emissions > 80% (i.e. target for 2oC global warming prevention) can be achieved by combining various scenarios

Reduce CO_2 from clinker production → Reduce clinker in cement → Reduce cement in concrete → Reduce concrete in structures → More efficient (re)use of existing structures

Substitution involves replacing materials with a high environmental impact with alternatives of lower impact and equivalent or superior performance, with the aim of minimizing the use of materials that harm the environment.

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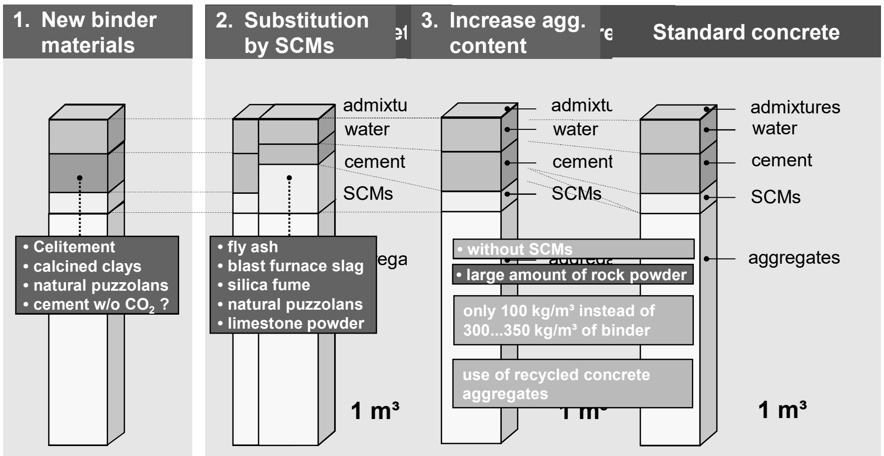
Structural Concrete: Paths towards Green Concrete

Aim: **Minimal use of materials with significant influence on environmental impact**

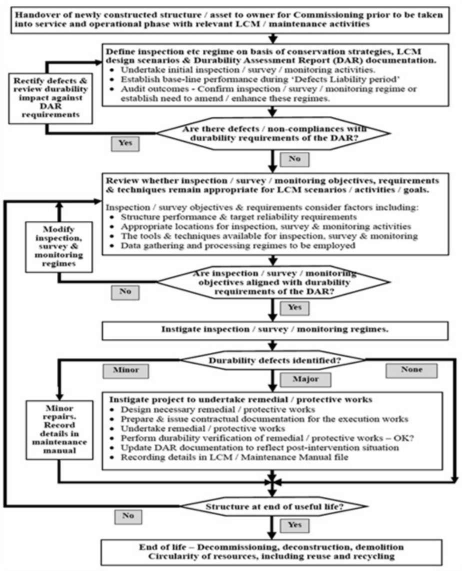


Source: H.S. Müller, *Green concretes – approaches, properties and challenges*, Workshop on fib Model Code 2020, Rome, 2022

fib MC2020 Highlights: durability planning

Developing guidance documents for effective and efficient life-cycle management (LCM), the durability design, and the associated conservation processes

- For life-cycle management, it is necessary to incorporate durability considerations into the design and execution processes and maintenance operations to avoid premature deterioration of concrete structures. This holistic process is referred to as **Durability planning**



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fib MC2020 Highlights: durability planning

Developing guidance documents for effective and efficient life-cycle management (LCM) the durability design and the associated conservation processes

- formal durability planning
    - structures requiring formal durability planning
    - structures not requiring formal durability planning
- conceptual & detailed durability design studies
- requirement for expertise
- execution aspect

27.6 Durability planning

27.6.1 Introduction

In performance-based design the objective is to create a concrete structure which has the ability to fulfil the performance requirements for the specified design service life or extended service life at the required level of reliability.

To allow effective and efficient life-cycle management (LCM) the durability design and the associated conservation processes shall be adequately planned, documented and managed through the life of the structure – refer chapter 5: *Life-cycle management*. The durability design and conservation planning shall be prepared taking account of the conservation categories which have been selected for the concrete structure and/or its component parts.

27.6.2 Formal durability planning

Durability planning is a formalised approach which applies durability knowledge during project design, execution / construction and operational maintenance activities to minimise the likelihood of premature deterioration.

Formalising the durability planning processes is intended to incorporate durability thinking into the wider aspects of design, execution / construction processes and, critically, in subsequent life-cycle management activities.

Durability planning work-flow employs a series of steps to achieve the design service life or extended service life. The following sequence would be for a project designed and with subsequent tendered construction, which was a common contract design and delivery process until recent times:

a) Concrete structure owner's brief (or of the responsible entity);
b) Life-cycle management / maintenance in operation and use phase;
c) Scope of works and technical criteria (SWTC) in tender documents;
d) Conceptual design;
e) Preliminary design;
f) Detailed design;
g) Project contractor tender;
h) Execution / construction;
i) Durability assessment report (DAR) deliverables for the above.

The durability planning requirements are to apply irrespective of the project contract delivery process.

The associated documentation and work activities will vary with the particular requirements of the chosen procurement process. The names given to the durability documentation may vary (i.e. durability assessment report, durability management plan) - refer to *Definitions* in chapter 2.

Achieving the specified service life design objectives requires the durability aspects to be taken into account in the design, construction / execution and LCM processes, in order to avoid the premature deterioration of concrete structures. These issues and considerations are commonly referred to as *Durability planning*, which involves all construction materials and components used to create a concrete structure.

Conservation strategies and tactics are classified into three categories as described in section 5.2; namely, 'A: *Proactive conservation*', 'B: *Reactive conservation*' and 'C: *No conservation*'.

An increase in the level of the performance requirements during the operational use stage may necessitate an intervention being made to enhance the performance or possibly the durability of the concrete structure.

Achieving durability is a world-wide concern and the need for improved durability has long been identified. One problem is that not all international and national technical standards incorporate appropriate provisions which account for the severity of all the macro / micro environmental exposure conditions or the deterioration mechanism(s) involved. The missing element in achieving satisfactory durability has been formal durability planning to coordinate and appropriately implement the available durability related technical knowledge.

An appropriate durability philosophy applied to the project design and delivery processes will contribute to achieving the sustainable design objectives, efficient capital investment, lowering the risk of unexpected or early deterioration / damage and, through appropriate design, execution and life-cycle management measures, help to achieve the concrete structure owner's required design life / extended design life and desired functionality.

The precise sequence of the durability planning processes and activities depends upon the form of contractual arrangement and documentation adopted for the works. Rather than the traditional sequence of project design followed by tendered construction, many present-day projects may have early contractor engagement via design and construct (i.e. contractor lead with designer engaged), adopt an alliance approach (e.g. owner with contractor and designer) or employ some other form of contractual arrangement.

The durability planning inputs to achieve the design service life or extended service life are described in *fib* Bulletin 112[27-7]. Other contemporary guidance on durability planning also includes CIA Z7-01: *Durability Planning*[27-8].

Projects with early contractor engagement often adopt the processes and activities below:

1) Concrete structure owner's brief;
2) Life-cycle management activities;
3) Scope of works and technical criteria (SWTC) for the tender documents;
4) Contractor tender, which may include a conceptual design for durability;
5) Conceptual design studies for the durability approach;
6) Preliminary and detailed design studies for the durability approach;
7) Execution / construction durability approach;
8) Durability assessment report (DAR) documentation / deliverables for the above.

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fib MC2020 Highlights : Conceptual Design

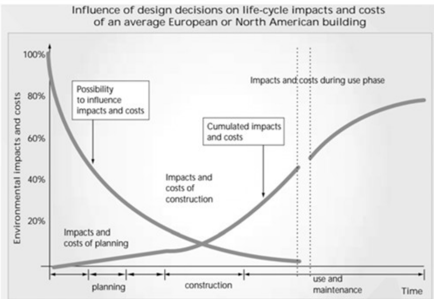

Figure 26.1-1: Impact of design decisions made at various stages of the life-cycle (Crawford 2011[26-12] Rice[26-2] and/or Kohler[26-13] and/or Schlaich[26-4])

Source : MC 2020 Chapter 26 –page 351

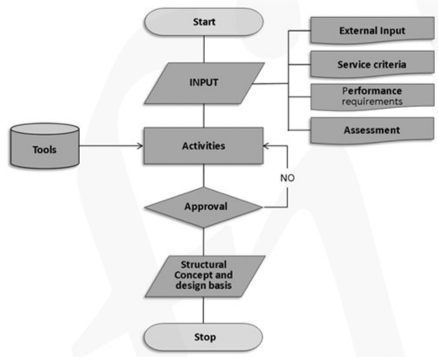

Figure 26.1-1: Methodological flowchart for conceptual design of new structures and adaptations/interventions/restorations upon existing structures

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fib MC2020 Highlights : Conceptual Design

- Deep consideration of sustainability during the conceptual design stage will allow optimization of the concrete structure's sustainable performance.

- The Institution of Structural Engineers of London’s publication “Design for Zero” empowers structural designers to play a crucial role in achieving net zero or carbon-neutral design. Among others, the actions proposed are :

• Making Carbon as important as safety in structural calculations
• Extending the life of existing constructed assets/resisting demolition
• The reuse of existing constructed assets as the start pointing of a new design
• Choosing appropriate low-carbon materials, Technologies and products
• Interrogating /challenging Project briefs to better align them towards net zero

- The Conceptual Design proposal to be a rational response to the client’s requirements (in addition to the technical and legal aspects) : Employ appropriate discretion, as well as display quality and elegance of the design; Satisfy the various functional uses of the work to achieve balance and compatible with the requirements and the integration of the structure into the landscape must be compatible with the general philosophy of the structure.

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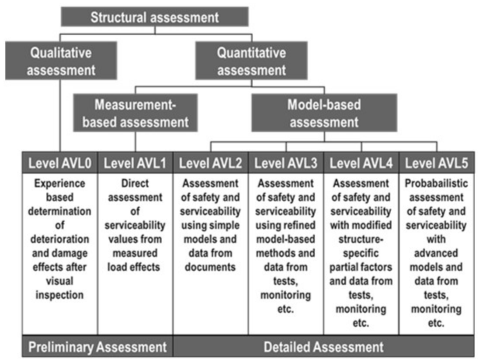
fib MC2020 Highlights: Structural assessment of existing structures

MC2020 provisions for assessment cover :

- **Existing structures without deterioration**
  Principally the same behavioral models apply as for new structures: if concrete strength and steel properties are known, the determination of the bearing references
- Capacity can be achieved by taking advantage of the LoA approach (?)
- **Existing structures with deterioration**
  Principally, the same basic behavioral models as for new structures are only adjusted to include the effect of deterioration on the mechanism. Therefore, additional parameters are included.
- **Existing structures with non-compliant detailing**
  Principally, the same basic behavioral models are used for new structures with additional/different parameter values to include the effect of non-compliant details.

The structural assessment process is commonly taken forward using an incremental approach



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fib MC2020 Highlights : Structural assessment of existing structures

Use of structure-specific information in verification of performance during the assessment of existing structures

TESTING of materials

- updating the **basic variables related to material characteristics** in the assessment model(s)
- updating the **material behavior model for the assessment** on the resistance side, taking into account the intrinsic variability of material properties and the material behavior model uncertainties
- updating the **assessment values of basic variables related to material characteristics** in the assessment model, which is the basis for **updating the partial safety factor γ_M for the basic variables related to material characteristics** used in the limit state verifications at the semi-probabilistic level

TESTING of elements & systems

- assessing directly the **compliance with reliability requirements** with regard to the limit state under consideration by proof-load testing
- assessing directly the **compliance with performance requirements under service load** and/or **structural identification** based on diagnostic testing
- updating the **action effect model** for the assessment

INSPECTION & MONITORING

-**SHM & data-informed diagnostics,** which may be considered as a trigger for decisions regarding conservation or LCM

-**updating of the assessment (FEM) model** of the existing structural elements or systems, accounting for the uncertainty of the (FEM) model

-verification of performance of structural element(s) and/or system(s) based on their **past performance**

fib MC2020 Highlights : Interventions

fib MC2020 : 1st international code addressing LCM of both new and existing structures

- **Concept of life-cycle management (LCM)** : clearly defined, especially those activities and processes involved in conservation.
- **Durability planning**: newly introduced as preparatory activities in conservation planning.
- **Monitoring**: described in detail in parallel with the activities for making a condition survey.
- **Interventions on existing structures upon existing concrete structures**, including.
  - **maintenance interventions** involving minor works to prevent/restore changes / deterioration
  - **preventive interventions**, comprising proactive works to prevent/lessen major changes/deterioration
  - **remedial interventions**, which are major reactive works to restore changes/deterioration
  - **strengthening and upgrading interventions** to enhance structural and/or other performances
  - **other life-cycle management measures** (eg. intensified survey/monitoring, usage restriction, emergency measures)

37 Execution of interventions

The term execution is used to refer to all the physical activities undertaken for the physical completion of the intervention works. These activities include procurement, scaffolding, falsework, formwork, reinforcement, concreting and curing, as well as the related inspection and documentation of those activities. The principles of execution of interventions are found in section 7.4.

The certainty that the desired outcomes will be achieved can be improved by "thinking intervention" long before the intervention process actually starts on site. In this way, those involved develop a process-focused approach which potentially leads not only to a reduction in problems on site and associated costs, but also to related improvements in health and safety for those involved, as well as potentially in reducing subsequent additional (and unnecessary) environmental impacts, etc. Typical problems on site are related to space and time constraints from the service conditions of existing structures, which usually do not have to be considered for execution of new structures.

37.1 General

Execution of interventions should be carried out with minimum disturbance to the surrounding environment and the service condition of the structure, and by considering climate- and environmental impact, cost, benefit and safety.

The common issues between execution of new structures and interventions are provided in chapter 35 and 36.

A detailed project specification for the execution of the intervention works should be developed clarifying and extending the general requirements of ISO 22966 for new structures and ISO 16311-4 for interventions as necessary, with project specific needs to meet the performance and durability requirements for the structure, together with the necessary supporting documents.

As part of the activities associated with selecting an appropriate intervention option, all execution processes of intervention should be effectively analysed with a view to identify significant potential problems and risks of non-conformance with the project requirements, including assessing the level of each risk involved.

When making an intervention, the constraints relating to the space and time available for the execution activities need to be considered, along with the condition of the existing structure, as these can be quite different (i.e. more restricted) to those encountered with new structures. In order to achieve the target structural performance required after the intervention is made, it is important to have an execution plan appropriate to the selected intervention method(s).

37.2 Execution plan

The execution plan shall be prepared in advance considering not only the condition of the structure subject to the intervention but also the surrounding environment and the service conditions.

The execution plan should include not only the execution process but also the quality management plan and preparation of the existing structure.

Quality assurance activities: ensure that effective preventive actions are incorporated in relevant process control procedures at all stages of the definition and execution of the intervention so as to minimise the identified problems and/or reduce the level of risk to an acceptable value.

The process control procedures, and the preventive actions incorporated in them, should be documented so that the responsible operators and supervisors understand not only what is to be done during the course of each process, but also how the process has to be undertaken.

Quality control activities: ensure that verification procedures are prepared and implemented which define how, when, where and by whom each intervention related process will be monitored. The observations need to be recorded by appropriately qualified, experienced and independent staff, dedicated to surveillance activities, with adequate time and resources to conduct the required surveillance activities.

Appendix G of *fib* Bulletin 44 sets out steps for the development of supplementary documents to support the preparation of a project specification for the execution works for concrete structures, linking with the requirements of ISO 22966.

Further information on quality management during execution is also given in the Model Code chapter on life cycle management – see chapter 10.

37.3 Execution management

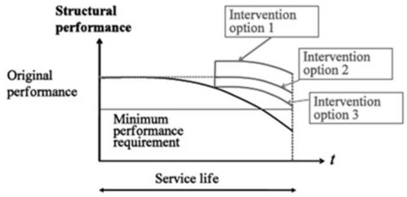
The performance of the structure after intervention is strongly affected by the quality of execution. Therefore, the execution of intervention should be properly planned and carried out under an approved quality management plan based on the selected intervention option(s) and the requirements set down in the project specification. These activities should be supported by appropriate quality assurance and quality control activities.

Appropriate verification tests should be carried out as part of the execution process for quality control purposes. A detailed record of the execution shall be maintained for future reference.

After execution, an initial inspection/survey shall be carried out to examine the structural performance after intervention and to collect necessary data for future performance assessment.

fib MC2020 Highlights : Interventions

- Three possible conceptual options for intervention
- Factors considered:
  - the importance of the structure
  - its remaining service life
  - the deterioration mechanisms
  - the technical feasibility
  - time/space constraints for execution
  - the available budget
- Selection of intervention method considering the followings
  - deterioration mechanism
    - chloride-induced corrosion
    - carbonation-induced corrosion
    - frost damage
    - ASR damage
    - thermal/shrinkage cracking
    - fatigue damage
    - damage by seismic action
  - deterioration level (4 levels)



Note:
Option 1 is to upgrade the performance and to lessen the deterioration rate.
Option 2 is to restore the performance and to lessen the deterioration rate.
Option 3 is to lessen the deterioration rate only.

The future

Future aspiration :

- In the future, standards/codes of practice will still include prescriptive approaches that provide effective and easy-to-prove solutions in particular circumstances.
- to enable possibilities **to optimize design solutions to fit the needs of the stakeholders better and remove constraints for novel types of concrete, reinforcing materials, and design concepts,** enabling **performance-based approaches** is needed

Future work :

- to **develop methods to define & evaluate performance requirements** for innovative solutions (e.g. novel types of materials) **:**
  - enable methods to demonstrate compliance with longer-term performance requirements (e.g. by a combination of testing and performance modeling)
  - Enable efficient methods to evaluate environmental & economic impact and **optimize decisions during design, construction, and use from a suitability perspective**
- to **educate the engineering community** to master the processes and procedures involved in performance-based approaches, in which the standards / specifications will have to play a necessary supporting role

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Reflextions and Conclusions

- We are in a transition process where new materials are tested and introduced into the structural concrete.

For green/eco-concretes (composition beyond EN 206 provisions) and other new types of concrete no defined models are available

- Concrete models have to be constructed adaptive“, i.e., a model is specified employing included regression parameters to be obtained from specific tests

- All ‘Engineering works’ are undertaken to meet established societal needs and goals. MC2020 adopts a sustainability-driven approach to the design, execution, and life-cycle management of concrete structures.

- The vision for MC2020 is for it to be future-oriented and capable of accommodating and not hindering technological progress, thereby facilitating the ongoing evolution of concrete and reinforcement materials, associated technologies, and the structural forms that might potentially be created using them.

- MC2020 consistently deals with **new and existing concrete structures, incl. structures after interventions**, applying fundamental principles of a performance-based approach to design and assessment, safety philosophy based on risk and reliability concepts, and consistent treatment of safety, serviceability and durability verification

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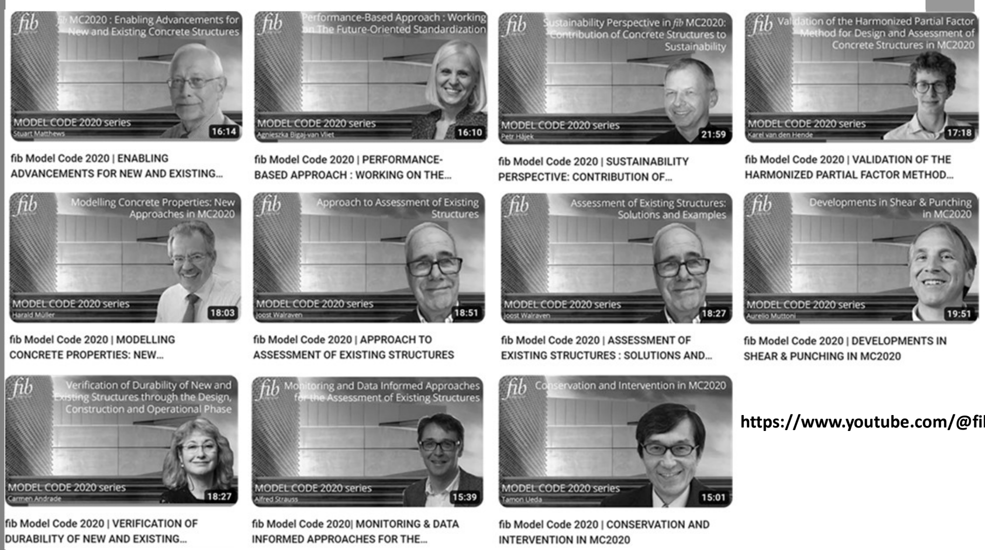

https://www.youtube.com/@fib-international

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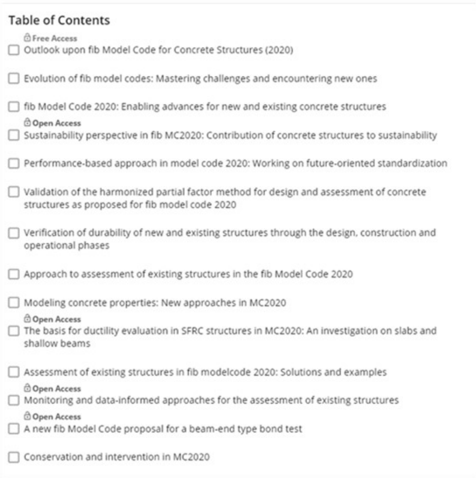
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