For concrete structures: Existing structures - Assessment, through-life management & interventions


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An advanced guideline for the design of concrete structures

Summarises considered up-to-date knowledge, not only mature consensus material as legal codes mostly do

A premier design guideline worldwide

Is fib’s flagship publication
What was achieved?

- 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 conventional 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
MC2010 - Achievements include

- Introduction of a life cycle approach / sustainability principles
- Conceptual design included to recognise importance of ‘creativity’
- Service life design of structures
- Diverse range of loading types (static, fatigue, impact, explosion, seismic, fire, cryogenic)
- Improved safety formats applicable to new and existing structures
- Improved constitutive relations for concrete, inc. durability aspects
- Steel fibres & non-metallic reinforcement as alternatives to RC
- Scientifically based models, with levels of approximation
- Introduction of reliability concepts in numerical analysis
- **Introduction of maintenance strategies for through-life care for new and existing concrete structures**
fib Model Code 2010

New & existing structures

Matters concerned with existing structures mainly addressed in *Chapter 9: Conservation*
**fib Model Code 2010 - Overview**

Conservation of existing structures
- Response to design provisions for a new structure
- Gives Principles, but not all necessary technical details

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<td>10. Dismantlement</td>
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9.1 General
9.2 Conservation strategies and tactics
9.3 Conservation management
9.4 Condition survey
9.5 Condition assessment
9.6 Condition evaluation and decision-making
9.7 Interventions
9.8 Recording

Principles defined, but further technical details necessary for assessment and through-life care / interventions for the range of situations encountered with existing structures
Development of the *fib* Model Code and its influence on other standards

*fib* Model Codes are reference documents used worldwide for research and structural design.
The fib Model Code will become ..... 

- An advanced guideline for the design and assessment of new & existing concrete structures
- Summarises up-to-date knowledge, not only mature consensus material as legal codes mostly do
- The premier structural design and assessment guideline worldwide
- Is fib’s flagship publication

An ambitious aspiration
MC2020 - Conceptual Scope:
New, existing and altered / adapted structures

new structures
(future structures)
new structural members
as parts of existing structures
existing structures

New structures and existing structures are not always easy to distinguish (overlap region is very important for engineer's activity)
Conversion of grain silo into student housing - Oslo, Norway

Adaptation of existing assets

Courtesy: Petr Hajek, Czech Technical University, Prague
Strong driver is enhanced energy performance of upgraded and adapted buildings: Improved durability, functionality, etc

- Functional units needed

- Older buildings: 1900 - 1960

- Potentially improved performance due to works / adaptation
Challenges for MC2020: Materials / forms of construction

Increasing diversity of concrete materials & systems

Increasing rate of change

Inst. Structural Engineers: Appraisal of existing structures: 3rd edition
Concrete – An extended family of materials

Very different properties, characteristics & performances

- Compressive strength - 2 MPa to over 200 MPa
- High strength concretes
- High performance concretes
- Lightweight concretes
- Gas concretes
- High density concretes
- Flowable and self-compacting concretes
- Coloured concretes
- Concretes made with recycled and / or waste materials
- Fibre reinforced concretes: metallic & non-metallic fibres
- Concretes using corrosion resistant metallic reinforcement
- Concretes using non-metallic reinforcement ............ etc

Concretes used in previous generations of structures

Concretes using new binders

New repair & protection materials
Development of compressive strength of concrete since 1950

In terms of $f_{cm}$ = Mean value of concrete cylinder compressive strength

Compressive strength [MPa]  
Water-binder ratio [-]

HPC: c.1990s  
RPC, UHPC: c.2000s  
NSC: 1970-1980s  
NSC: c.1950s

Change in concrete compressive strength since ≈1950

[Expressed in terms of $f_{cm}$, the mean value of concrete cylinder compressive strength]:

Courtesy: Harald Mueller
Structures built using ultra high performance fibre reinforced concrete (UHPFRC)

Toll plaza Millau Viaduct, France

Sakata Mirai pedestrian bridge, Japan
UHPFRC structure has significant lower environmental impact in spite of higher material impact.

Use of UHPFRC for 1.5m high retaining wall to monsoon drainage channel.

<table>
<thead>
<tr>
<th></th>
<th>Conventional PC design</th>
<th>UHPFRC design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of UHPFRC</td>
<td></td>
<td>27% of PC design</td>
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<tr>
<td>Embodied energy of UHPFRC</td>
<td></td>
<td>51% of PC design</td>
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<tr>
<td>CO(_2) emissions of UHPFRC</td>
<td></td>
<td>51% of PC design</td>
</tr>
<tr>
<td>100 year global warming potential of UHPFRC</td>
<td></td>
<td>57% of PC design</td>
</tr>
</tbody>
</table>
Concrete – Known for its longevity

- Pantheon, Rome built circa 126 BC and still remains in service
- Originally a Roman temple
- Now a working church
The Pont du Gard
Roman aqueduct, south France
Most concrete structures perform well and are adequately durable for their service environment and have satisfactorily long service lives

Some in extremely harsh or demanding service environments…
North Sea Oil Platforms: Oseberg A
Great Belt East Bridge, Denmark
Main span of 1624 m
100 year service life design

An extended family of concrete structures …

Service life for some infrastructure can be very long – Netherlands Delta Scheme 200 years !!
An extended family of concrete structures constructed from a diverse range of concrete materials…

Some structures deteriorate or are damaged in-service and need to be assessed for current safety and future performance / durability
<table>
<thead>
<tr>
<th>Type of structure</th>
<th>Corrosion of steel</th>
<th>Deterioration of concrete</th>
<th>Physical damage</th>
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<tbody>
<tr>
<td></td>
<td>CO₂-induced</td>
<td>Freeze/thaw</td>
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<td>Chloride induced</td>
<td>External chemicals</td>
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<td>Internal reactions</td>
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<td>Impact/Abrasion</td>
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<td>Fire</td>
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<td>Seismic</td>
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<td>Above ground buildings</td>
<td>C</td>
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<tr>
<td>Industrial floors</td>
<td>C</td>
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<td>Tunnels</td>
<td>C</td>
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<td></td>
<td>S</td>
<td>In Artic latitudes</td>
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<tr>
<td>Concrete chimneys</td>
<td>C</td>
<td>S</td>
<td>S</td>
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<tr>
<td>Sewage plants</td>
<td>C</td>
<td>C</td>
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<td>Bridges</td>
<td>S</td>
<td>C</td>
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<td>Car parks</td>
<td>S</td>
<td>S</td>
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<tr>
<td>Swimming pools</td>
<td>S</td>
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<td>S</td>
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<tr>
<td>Coast marine structures</td>
<td>S</td>
<td>C</td>
<td>S</td>
</tr>
<tr>
<td>Dams (unreinforced)</td>
<td>C</td>
<td>C</td>
<td>Erosion</td>
</tr>
<tr>
<td>Foundations</td>
<td>C</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Tanks and pipes</td>
<td>S</td>
<td>C</td>
<td>S</td>
</tr>
</tbody>
</table>

**Key:**
- **C** = Common
- **S** = Sometimes
- Infrequently
Deterioration processes affecting concrete: Jones et al [1997]

- Corrosion of reinforcements - ext chlorides
- Corrosion of reinforcements - int chlorides
- Corrosion of reinforcements - carbonation
- Freezing/thawing
- Chemical attack
- ASR
- Plastic shrinkage
- Plastic settlement
- Drying shrinkage
- thermal cracking
- Creep/thermal movements
- Abrasion/erosion
- Cavitation damage

Reinforcement corrosion
Carbonation induced reinforcement corrosion

Some structures deteriorate or are damaged in-service & need to be assessed for current safety and future performance / durability
Carbonation induced reinforcement corrosion
Potential combined attack:
ASR damage & cracking, then reinforcement corrosion

Reinforcing bars broken by severe ASR expansion of concrete
Accidental damage: Impact

Immediate implications for structural safety

Potential durability implications!!
Intervention options providing different levels of functionality / life

Service life

Time

Structural performance

Original performance

Minimum performance requirement

Intervention option 3

Intervention option 2

Intervention option 1

Note:
Option 1: Reduce the deterioration rate only
Option 2: Restore the performance and reduce the deterioration rate
Option 3: Upgrade the performance and reduce the deterioration rate
Maintenance and Repair Works in Japan

Percentage of maintenance and repair works is steadily increasing. Increase will continue in future.

Ref: Kenstsu-gyo Handbook (2018)
Maintenance and Repair Works in S. Korea

30% for maintenance/repair in South Korea (Roads only)

Ref: Yearbook of Road Statistics (2016), Statistical Year Book of MOLIT (2016)
Maintenance and Repair Works in UK

- 40% for maintenance/repair in UK (in billion pounds)

- In Japan less than 30% and in Korea around 30% for maintenance/repair → expected to increase up to 40%
Conservation of concrete structures – Why should we be concerned about this?

- To ensure satisfactory through-life performance (functionality) of structure:
  - Safety of structure and users
  - Serviceability of structure
  - Maintenance / replacement works envisaged during design
  - Preserve satisfactory aesthetic appearance of structure

- Minimise through-life cost and environmental impacts
- Achieve the intended design service-life of structure
- Facilitate an extension of life / change of use of structure
- Significant sustainability benefits from extension of life
The starting point is *fib* Model Code 2010

- *fib* Model Code 2010 contained many advances and addressed a range of new technical topics

- The opportunity will be taken to update to reflect recent developments
Model Code 2020: General aspirations

- Single structural code for both new & existing concrete structures
- Integrated life cycle perspective
- Holistic sustainability framework: Social, environment & economic factors
  - Sustainability driven treatment of structural safety, service life, serviceability, durability, robustness, resilience etc
- Fundamental principles & safety philosophy based on reliability concepts
- Implementation of performance based concept
- Consistent approach to robustness and redundancy
- Utilises generalised models and level of approximation approach
- Removes constraints for novel types of concrete and reinforcing materials
- Particular attention to through-life management
- Takes advantage of information acquired by testing and monitoring
- Deterioration models for both initiation & propagation phases
- To have a strong international (world) perspective
Sustainable decision-making

Linkage between MC2020 and the UN Sustainable Development Goals
Sustainability - Process steps

- Social aspects
- Environmental aspects
- Economic aspects

Selection of structural design / assessment parameters

Iterative process

Conceptual design & execution / assessment
- The ‘three pillars’
- Through-life management

Chosen candidate scheme / scenario

Verification structural performance

Sustainable decision making: Evaluation of most suitable scenario / candidate scheme

Evaluation environmental performance

Evaluation economic performance
Improved material & mechanical models for assessment of ‘actual’ capacity

- Performance-based design
  - Ability of a structure to fulfil the performance requirements for the design service life at required probability level

- Limit state concepts
  - Transition between the desired state and the adverse state

- Incorporation of deterioration effects reducing structural resistance $R(t)$

- Increase in load effect $S(t)$ with time

- Recognition of resistance effects not accounted for in design (e.g., compressive membrane action) - Larger structural resistance

Decrease in structural resistance $R(t)$ with time & increase in the load effect $S(t)$ with time

Benefit of unaccounted behaviours upon structural resistance and on actual service life
Some technical objectives: LoA

Levels of approximation / sophistication of analytical treatment – say 4

IV System / global assessment of critical structures / design of special cases
III In depth elemental evaluation existing structures / design of special cases
II Typical elemental design / assessment
I Preliminary design, non governing limit state (design and assessment)
Load-carrying behaviours not normally considered in design

Justifying a higher load capacity in an existing concrete structure - Compressive membrane action (CMA)

CMA in laterally supported bridge deck

Effect of prestressing & CMA on the punching shear capacity & the use of LoA

Role of the rotation angle $\psi$ in the determination of the punching shear capacity according to fib MC2010

Courtesy Joost Walraven
Revised MC2020 TOC

PART I  SCOPE AND TERMINOLOGY
PART II BASIC PRINCIPLES
PART III ACTIONS ON STRUCTURES
PART IV INPUT DATA FOR MATERIALS
PART V  INPUT DATA FOR INTERFACES
PART VI DESIGN AND ASSESSMENT PROCEDURES
PART VII EXECUTION
PART VIII THROUGH-LIFE MANAGEMENT
PART IX  DISMANTLEMENT AND REUSE
PART I - SCOPE AND TERMINOLOGY

1. Scope
2. Terminology

PART II - BASIC PRINCIPLES

3. Sustainability perspective
4. Through-life management and care
5. Performance-based approach
6. Principles of structural design and assessment
7. Principles of execution
8. Principles of conservation
9. Principles of dismantlement and reuse
10. Principles of quality and information management

PART III - ACTIONS ON STRUCTURES

11. Actions on structures
PART IV - INPUT DATA FOR MATERIALS

12. Concretes
13. Reinforcing steel
14. Prestressing steel & prestressing systems
15. Non-metallic reinforcement
16. Fibre reinforced concrete & UHPC
17. Protective materials & systems

PART V - INPUT DATA FOR INTERFACES

18. Bond of embedded steel reinforcement
19. Bond of embedded non-metallic reinforcement
20. Bond of externally applied reinforcement
21. Concrete to concrete
22. Concrete to steel
23. Anchorages in concrete
PART VI - DESIGN AND ASSESSMENT PROCEDURES
24. Conceptual approach to design and assessment
25. Approach to assessment
26. Structural analysis and dimensioning
27. Evaluations of social (structural) performance
28. Evaluation of environmental quality
29. Evaluation of economic efficiency

PART VII - EXECUTION
30. Execution management
31. Construction works
32. Execution of interventions
PART VIII - THROUGH-LIFE MANAGEMENT

33. Conservation

PART IX - DISMANTLEMENT AND REUSE

34. Dismantlement and reuse
**fib Model Code 2010**

- **MC2010**
  - 5Nr Parts
  - 10Nr Chapters

**fib Model Code 2020**

- **MC2020**
  - 9Nr Parts
  - 34Nr Chapters

Greatly extended technical scope and coverage
Need improved material & mechanical models for assessing existing structures

Structural models need to apply not only to the design of new structures, but also to the determination of the capacity / reliability, serviceability, remaining service life etc:

• Load carrying behaviours not accounted for in design
  – Compressive membrane action

• Structures with inappropriate details:
  – Shear reinforcement is less than the prescribed minimum %
  – Smooth reinforcing bars (without surface ribs)
  – Non-compliant anchorage details / lap lengths, etc

• Structures experiencing deterioration:
  – Reinforcement corrosion
  – Degradation of the concrete (ASR, Sulfate attack, freeze-thaw ..) etc
Modelling deterioration processes and propagation stages - 1

Initiation and propagation models for concrete:

• Physical deterioration and damage processes
  – Frost / Freeze-thaw-salt induced deterioration of concrete
  – Abrasion and erosion
  – Physical salt crystallisation and scaling
  – Water penetration and water vapour transport

• Chemical deterioration processes
  – Alkali-silica reaction
  – Acid attack
  – Sulfate attack (various forms including the thaumasite form of attack)
  – Delayed ettringite formation (DEF)

• Biological deterioration processes
Initiation & propagation models for reinforcement corrosion:

- Corrosion of reinforcement and prestressing components:
  - Carbonation induced and chloride induced corrosion
  - Possibly other corrosion processes
- The influence of cracking upon deterioration in different service environments
- Additional exposure environments - Hollow leg conditions (saline water on one face of element and air on the other)
- Corrosion of steel fibre reinforced concrete

The implications of cracking upon durability (other deterioration mechanisms)

Durability assessment / residual service life after interventions
TIME Through Life
Post Construction

“Birth Certificate” for Structure

Build Phase

通过生命期的失败阈值（ Structural or Service Failure Threshold ）

设计与建设（Stage 1）

- 设计细节、规格、建设记录。
- 定义性能标准。

 cumulative knowledge of through-life performance (Stage 2)

- 通过生命期监控/评估性能记录。

TIME Through Life
Post Intervention

“Re-Birth Certificate” for Structure

Condition assessment & evaluation

- 修复或改善措施。
- 定义成功标准。

Condition assessment & evaluation

Repair Undertaken

Cumulative knowledge of through-life performance (Stage 4)

- 通过生命期监控/评估性能记录。

通过生命期监控和评估

- 维护或干预实施。
- 通过生命期的性能记录。

“Birth Certificate” for Structure
Requires evaluation of safety and serviceability.

Consideration of issues such as:

• Structural sensitivity;
• The type of structure, and its function;
• The potential consequences of failure;
• Actual level of variable (imposed) loading - as distinct to that assumed in design, and;
• The ‘real’ effects of deterioration in respect of each individual action / loading effect.
MC2010 conservation process for a concrete structure - simplified overview

This may need to be adapted / evolved to suit other situations
Recording

START : NEW

Specification of conservation strategy (at time of design of new structure)

Determination of tactic and regime for condition control (at time of design of new structure)

Condition survey (after construction)

Condition assessment (after construction)

Review conservation strategy and conservation tactic

Finalise inspection regime for condition monitoring

Start / Continue through life condition monitoring

START : EXISTING

Provisional specification of conservation strategy (for existing structure or revised performance requirements)

Provisional determination of tactic and regime for condition control (for existing structure or revised requirements)

Condition survey (for re-design)

Condition assessment (for re-design)
Recording

Determination of tactic and regime for condition control (at time of design of new structure)

Provisional specification of conservation strategy (for existing structure or revised performance requirements)

Review conservation strategy and conservation tactic

Finalise inspection regime for condition monitoring

Start / Continue through life condition monitoring

Condition survey

Condition assessment

Condition evaluation and decision-making incl. specification of intervention

Execution of chosen intervention

Specification of conservation strategy (at time of design of new structure)
Activities involved in condition assessment and evaluation, structure / portfolio management and intervention activities, along with prognoses made about durability / future deterioration and the implications for structural performance / strength.
Simplified corrosion model (after Tuutti)

- Corrosion of Steel Reinforcement
- Time

Initiation phase
- No visible damage
- Reactive

Propagation phase
- Maximum Permissible Corrosion
- Visible damage
- Proactive

NDT & Monitoring
- Visual inspection
Life cycle management
Role of monitoring and the value of information in the management of concrete structures & decision making
Proactive & reactive approaches to through-life care of structures

Condition

Proactive

Reactive

Service failure

Time

cost
Relative structural performance

Proactive:
- Structure in good condition

Reactive:
- Structure in poor condition

Service 'failure' criteria

Relative Costs

(Cumulative)

Reactive
Proactive
Conservation strategies in MC2020

• **Strategy A:** Structures which are to be managed by planned condition control activities.
  – Structures where deterioration would be technically unacceptable or must not be seen.
  – Monumental, important or sensitive buildings & structures.

• **Strategy B:** Structures or parts thereof which are managed by reactive activities.
  – Structures where remedial measures can be taken after deterioration becomes visible.
  – Buildings and other common structures.

• **Strategy C:** Structures or parts thereof for which condition control is not practical.
  – Structures where it would be difficult economically and / or technically for preventative or remedial measures to be taken, such as foundations.
### List of interventions - After ISO 16311: Parts 3 & 4

<table>
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<tr>
<th>Remedy</th>
<th>Examples of Repair Strategies &amp; Methods</th>
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<td>Protection against ingress</td>
<td>For details refer to Table 1 in paper</td>
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<td>Moisture control</td>
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<td>Concrete restoration</td>
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<td>Increased physical resistance</td>
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<tr>
<td>Increased resistance to chemical attack</td>
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<tr>
<td>Preserve or restore passivity</td>
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<tr>
<td>Increase resistivity</td>
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<tr>
<td>Increase resistivity</td>
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<tr>
<td>Cathodic control</td>
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<td>Cathodic protection / prevention</td>
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<tr>
<td>Control of anodic areas</td>
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<tr>
<td>Structural strengthening</td>
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<tr>
<td>Adding new systems / devices for controlling structural response</td>
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</tbody>
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Structural Interventions

- Overlaying (spraying cement-based material)
- External bonding (CFRP sheet)
- Jacketing (reinforced concrete)
- Bracing (steel frame & pipes)
- External cable (FRP cable)
Non-structural Interventions

- Crack injection (injecting resin)
- Prevention of concrete peel off (external bonding of FRP sheet)
- Surface protection (coating resin)

(Photos: SHO-BOND Corporation, Fuji PS Corporation)
### Example of interventions for reinforcement corrosion – Table 2 in paper

#### Stage 1: No change in appearance:
Chloride ion concentration at depth of reinforcing bar below corrosion threshold

<table>
<thead>
<tr>
<th>Deterioration / distress phenomena</th>
<th>Repair policy</th>
<th>Repair method</th>
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<tr>
<td>See Paper for details</td>
<td>See Paper for details</td>
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#### Stage 2: No change in appearance:
Chloride ion concentration at depth of reinforcing bar above corrosion threshold

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#### Stage 3: Concrete exhibiting cracking, spalling and rust staining

<table>
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</table>

#### Stage 4: Rebar corrosion having caused a reduction in load capacity (strength) of affected members

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</table>
Measures for existing structures

Many existing structures do not satisfy performance requirements due to

• Construction to outdated codes
• Damage by environmental actions, loadings, natural / manmade disasters

Assessment of performance of existing structures

Remedial action (Intervention) for improving performance of existing structures
MC2020 content on interventions

Related revisions of MC2010

- Greatly extended section on interventions
- Treatment of interventions harmonised with ISO 16311
- Addition of materials for interventions and protection systems (Part 4: Materials)
- Addition of bond of intervention materials to substrate concretes (Part 5: Interface characteristics)
- Addition of design of interventions, such as overlaying (Part 6: Design and assessment procedures)
- Addition of assessment of condition (damage / degradation) in existing structures, and effect after intervention undertaken (Part 6: Design and assessment procedures)
- Addition of execution of interventions (Part 7. Execution)
- Addition of conservation after intervention (Part 8: Through-life management / Conservation)
1. Protection Methods
   1.1. Surface protection methods
   1.2. Electrochemical methods

2. Repair Methods
   2.1. Material reinstatement
   2.2. Concrete crack repair

3. Strengthening Methods
   3.1. Strengthening existing members
   3.2. Adding new structural members
   3.3. Adding new systems/devices
1. Protection Methods

1.1. Surface protection methods
   1.1.1. Impregnation of concrete surface
   1.1.2. Hydrophobic impregnation of concrete surfaces
   1.1.3 Coating of concrete surfaces
   1.1.4. Over-cladding of concrete members
   1.1.5. Application of membranes
   1.1.6. Corrosion inhibitors for steel rebars

1.2. Electrochemical methods
   1.2.1. Corrosion control
   1.2.2. Cathodic prevention
   1.2.3. Cathodic protection
   1.2.4. Realkalisation
   1.2.5. Chloride extraction / Desalination
   1.2.6. Dehumidification
   1.2.7 Impressed current cathodic protection – structural strengthening
1. Protection Methods

1.1. Surface protection methods
   1.1.1. Impregnation of concrete surface
   1.1.2. Hydrophobic impregnation of concrete surfaces
   1.1.3. Coating of concrete surfaces
   1.1.4. Over-cladding of concrete members
   1.1.5. Application of membranes
   1.1.6. Corrosion inhibitors for steel rebars

1.2. Electrochemical methods
   1.2.1. Corrosion control
   1.2.2. Cathodic prevention
   1.2.3. Cathodic protection
   1.2.4. Realkalisation
   1.2.5. Chloride extraction / Desalination
   1.2.6. Dehumidification
   1.2.7. Impressed current cathodic protection – structural strengthening

Assistance needed
2. Repair Methods

2.1. Material reinstatement

2.1.1. Patch-repair (hand-applied mortar)
2.1.2. Concrete replacement (cast-in-place)
2.1.3. Concrete replacement (shotcrete)
2.1.4. Concrete autogenous healing
2.1.5. Rebar replacement
2.1.6 Repair of prestress tendons through reinjection of grout

2.2. Concrete crack repair

2.2.1. Injection for sealing concrete cracks
2.2.2. Concrete crack arrest
2.2.3. Surface bandaging of cracks
2.2.4. Turning cracks into joints
2. Repair Methods

2.1. Material reinstatement

2.1.1. Patch-repair (*hand-applied mortar*)
2.1.2. Concrete replacement (*cast-in-place*)
2.1.3. Concrete replacement (*shotcrete*)
2.1.4. Concrete autogenous healing
2.1.5. Rebar replacement
2.1.6. Repair of prestress tendons through reinjection of grout

2.2. Concrete crack repair

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2.2.2. Concrete crack arrest
2.2.3. Surface bandaging of cracks
2.2.4. Turning cracks into joints

Assistance needed
3. Strengthening Methods - 1

3.1. Strengthening existing members
   3.1.1. RC jacketing
   3.1.2. FRP jacketing
   3.1.3. Steel jacketing
   3.1.4. Addition of reinforcement
   3.1.5. Concrete overlay
   3.1.6. Textile-reinforced concrete (TRC) jacketing
   3.1.7. Externally applied steel plates
   3.1.8. Externally applied or near surface mounted FRP
   3.1.9. Strengthening foundations with steel micro-piles
3. Strengthening Methods - 1

3.1. Strengthening existing members

3.1.1. RC jacketing
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Assistance needed

3.1. Strengthening existing members

3.2. Adding new structural members
   3.2.1. Steel bracing
   3.2.2. Concrete shear walls

3.3. Adding new systems/devices
   3.3.1. External post-tensioning
   3.3.2. Base-isolation devices
   3.3.3. Energy-absorption devices

3.1. Strengthening existing members ………

3.2. Adding new structural members
   3.2.1. Steel bracing
   3.2.2. Concrete shear walls

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   3.3.1. External post-tensioning
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   3.3.3. Energy-absorption devices
Compendium for Interventions on Concrete Structures:
Description of Methods for making Interventions on Concrete Structures - 1

Main section headings of Template

1. Foreword
2. Basics
3. Stakeholders' Roles and Qualifications
4. Design
5. Execution  Plus case history examples
6. Quality Control
7. Monitoring and Maintenance
Description of Methods for making Interventions on Concrete Structures - 2

1. Foreword

2. Basics
   2.1. When to adopt this method
   2.2. Materials and systems
   2.3. Techniques
   2.4. Equipment

3. Stakeholders' Roles and Qualifications
   3.1. Owner
   3.2. Designer
   3.3. Contractor
   3.4. User
Description of Methods for making Interventions on Concrete Structures - 3

4. Design
   4.1. Assessment of existing conditions
   4.2. Service life
   4.3. Reliability requirements
   4.4. Codes and standards and other relevant references
   4.5. Design assumptions
   4.6. Design procedure
   4.7. Supporting documents

5. Execution
   5.1. Preparatory works
   5.2. Systems trials
   5.3. Execution procedure
   5.4. Finishing
6. **Quality Control**
   6.1. Quality control of materials
   6.2. Quality control before intervention
   6.3. Quality control during intervention
   6.4. Quality control after intervention

7. **Monitoring and Maintenance**
   7.1. Monitoring
   7.2. Maintenance
   7.3. Post-intervention documentation
Looking for global involvement and contributions to MC2020
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Evolution of *fib* Model Codes for structural concrete

MC2020 will, for the first time, include comprehensive provisions for existing structures
fib Model Code 2020 - for new and existing concrete structures

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Developing *fib* MC2020

**T10.1 Model Code 2020**: Co-ordinating & drafting body for MC2020 activated Oct 2016 (Lausanne)

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Convenors of the MC2020 Action Groups (12Nr)

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