Specifying sustainability in codes for concrete structures

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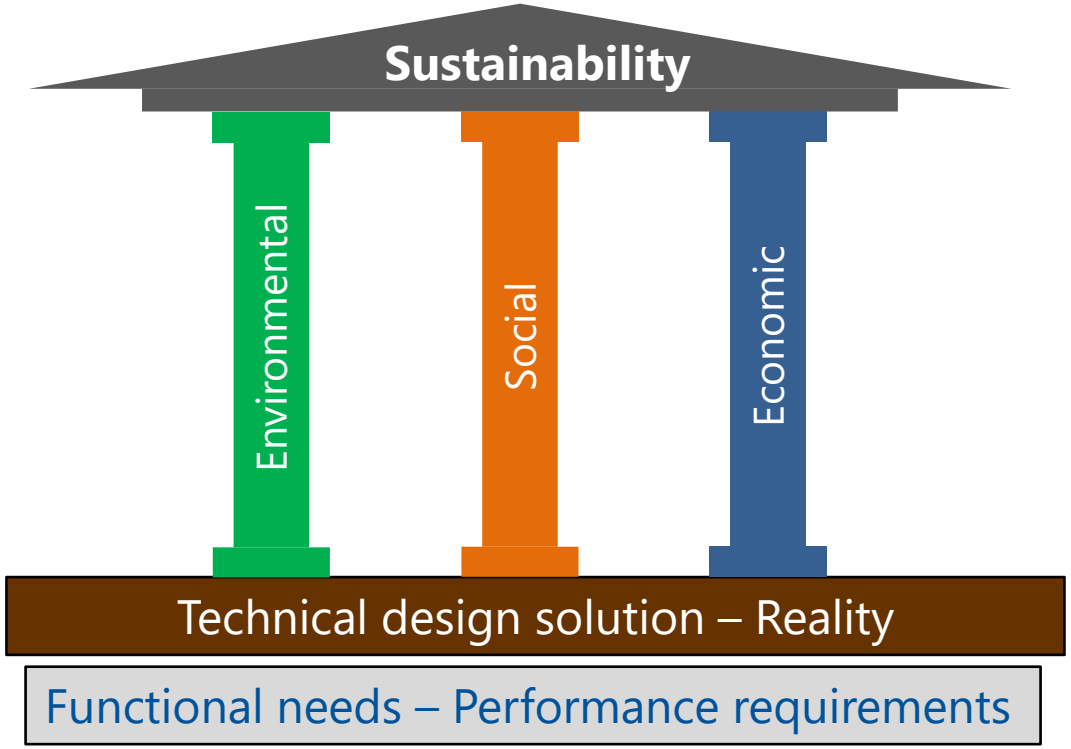
ISO/TC 71 Committee Manager

Outline

- Sustainability to be covered by structural design codes and standards
- ISO 22040: 2021
- ISO 19338: 2014 → ISO/WD 19338 (under revision)
- JSCE Common code of structural design (under development)

Three pillars of sustainability

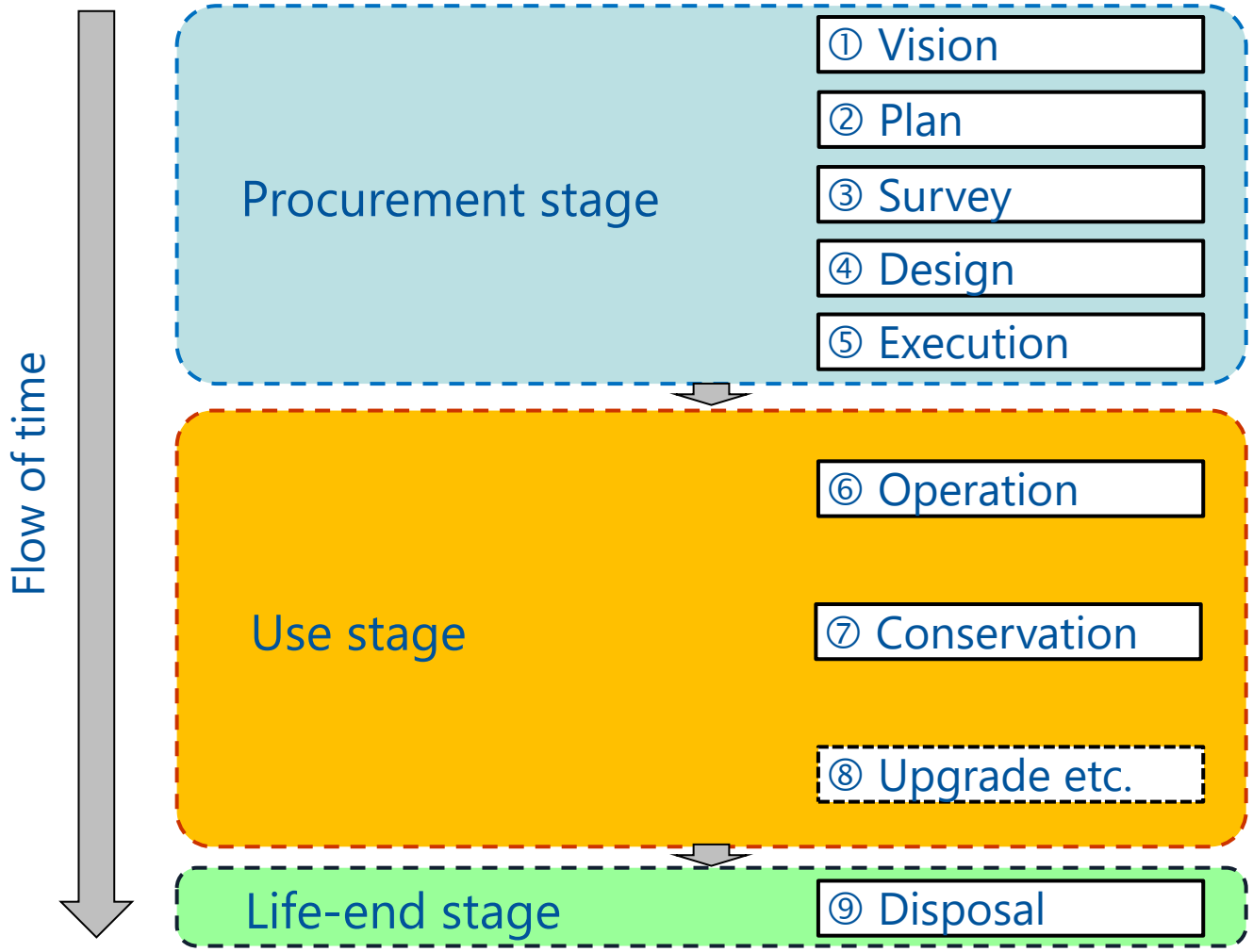


Definition of Sustainability

Ability of a structure or structural element to contribute positively to the fulfilment of the present needs of humankind with respect to nature, society, economy and well-being, without compromising the ability of future generations to meet their needs in a similar manner. [ISO, *fib*]

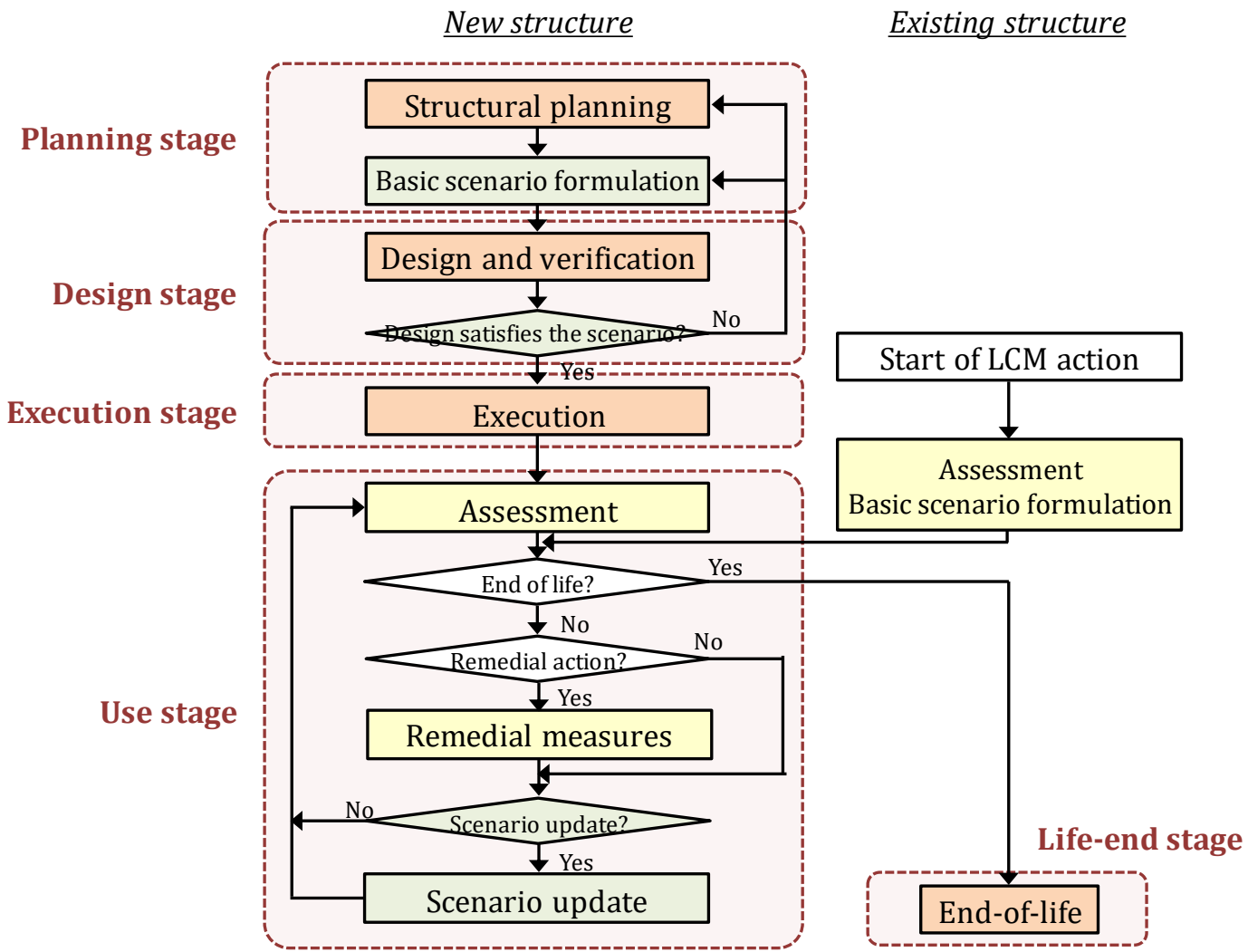
ENVIRONMENTAL: Climate change, Resources, Pollution, Biodiversity, Ecological system, etc.
SOCIAL: Quality of infrastructure, Safety and security, Accessibility, Users' satisfaction level, Cultural preservation, etc.
ECONOMIC: Direct and Indirect costs, Benefit, Efficiency, Values, etc.

Life cycle of structures



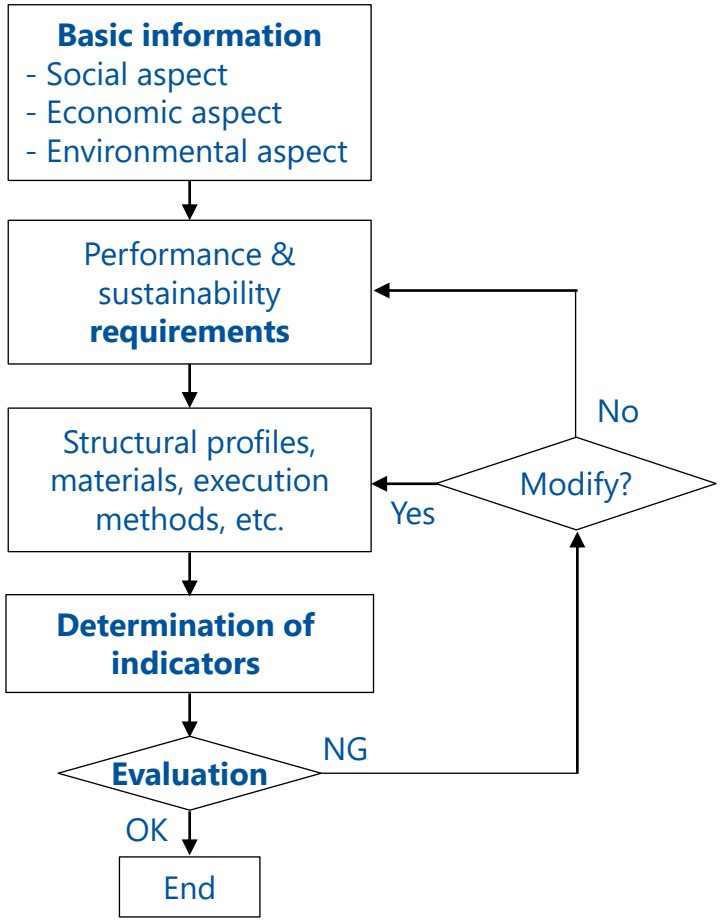
- Coordination of all stages based on the overall management concept
- Responding to the expectations of people and societies throughout the life cycle of structure
- Ensuring performance requirements of the structure
- Assurance of sustainability of the structure and the people & society around the structure

Flow of life cycle management

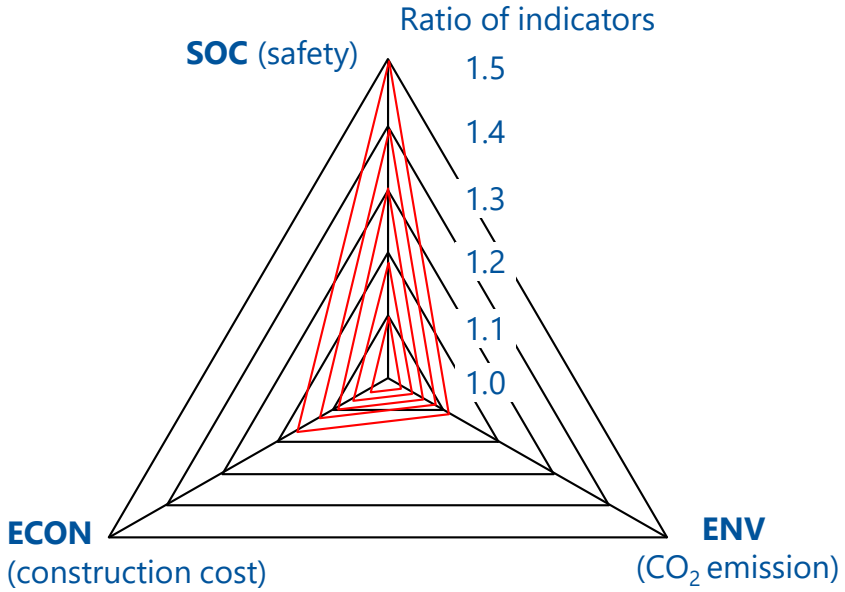


- Sustainability indicators for decision-making
- Scenario = Strategy
- Basic LCM scenario formulation
- Basic LCM scenario updates
- Detailed scenario for each stage

Evaluation for performance/sustainability requirements

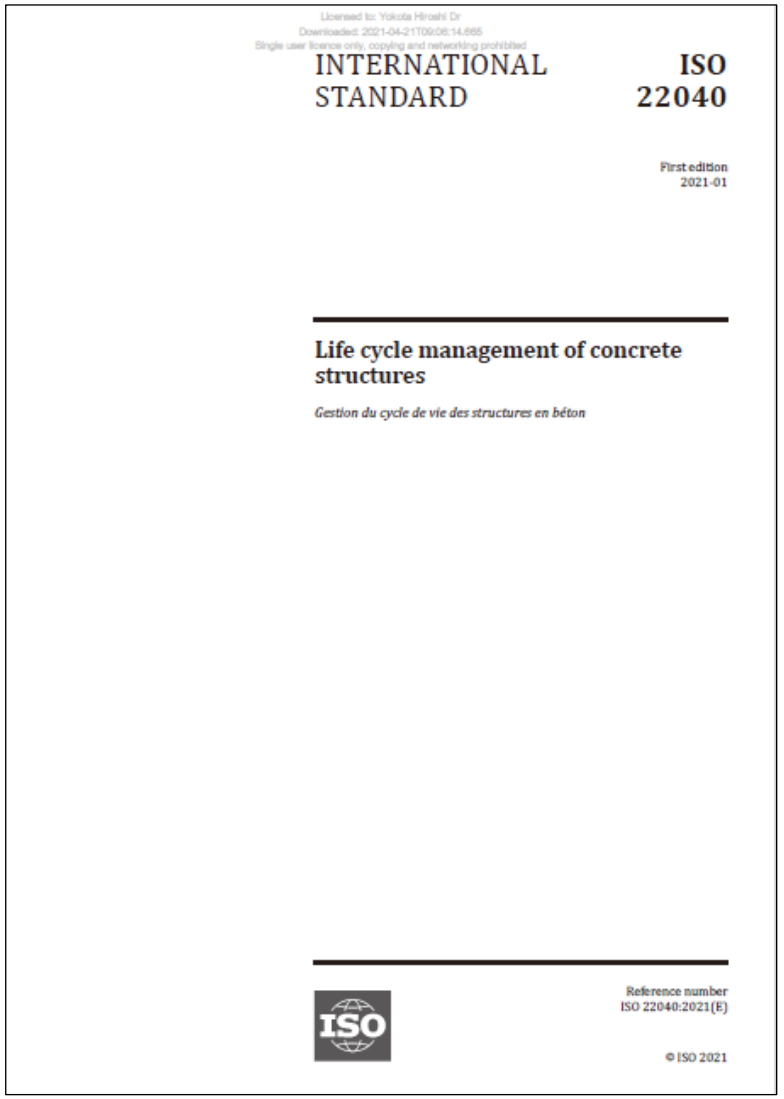


- **Sustainability indicators** can be used as **performance requirements** for structure and/or for **decision-making**.
- Indicators to evaluate structural performance and sustainability requirements should be determined.



Source: Yokota H, Goto S & Sakai K: Parametric analyses on sustainability indicators for design, execution and maintenance of concrete structures, Proc. of ICCS 16, Madrid, 2016

ISO 22040: 2021



INTERNATIONAL STANDARD

ISO 22040

First edition
2021-01

Life cycle management of concrete structures

Gestion du cycle de vie des structures en béton

Reference number
ISO 22040:2021(E)

ISO 22040: 2021

- ISO 22040, *Life cycle management of concrete structures* published in January 2021.
- ISO/TC 71/WG 1, Convenor: Hiroshi Yokota
- Project started in September 2016
- Framework and general principles of LCM
- Part 2: *Structural planning and design stage* & Part 3: *Execution stage* under development

ISO 22040: 2021

5. General framework of life cycle management

- When implementing LCM, an appropriate LCM scenario shall be created as measures to ensure the **performance requirements** are met during the life cycle of the structure and the **indicators are set appropriately**.
- The basic LCM scenario shall include the fundamental strategy on how the structure will be managed **in terms of sustainability aspects**.
- Appropriate indicators necessary for the assessment of the LCM scenario shall be set **for sustainability factors** regarding social, environmental and economic aspects. These indicators shall be calculated with respect to the period of LCM.

ISO 22040: 2021

5.3 Indicators for life cycle management
5.3.2 Social aspect

Social aspects shall be assessed with indicators objectively **expressing performance of the structure** in the use stage, safety of construction work and safety of users of the structure under conceivable conditions. Even when it is difficult to set and quantify indicators for such qualities as adaptability, comfort, cultural values and social contribution, these shall be considered in a social-scientific manner.

5.3.3 Environmental aspect

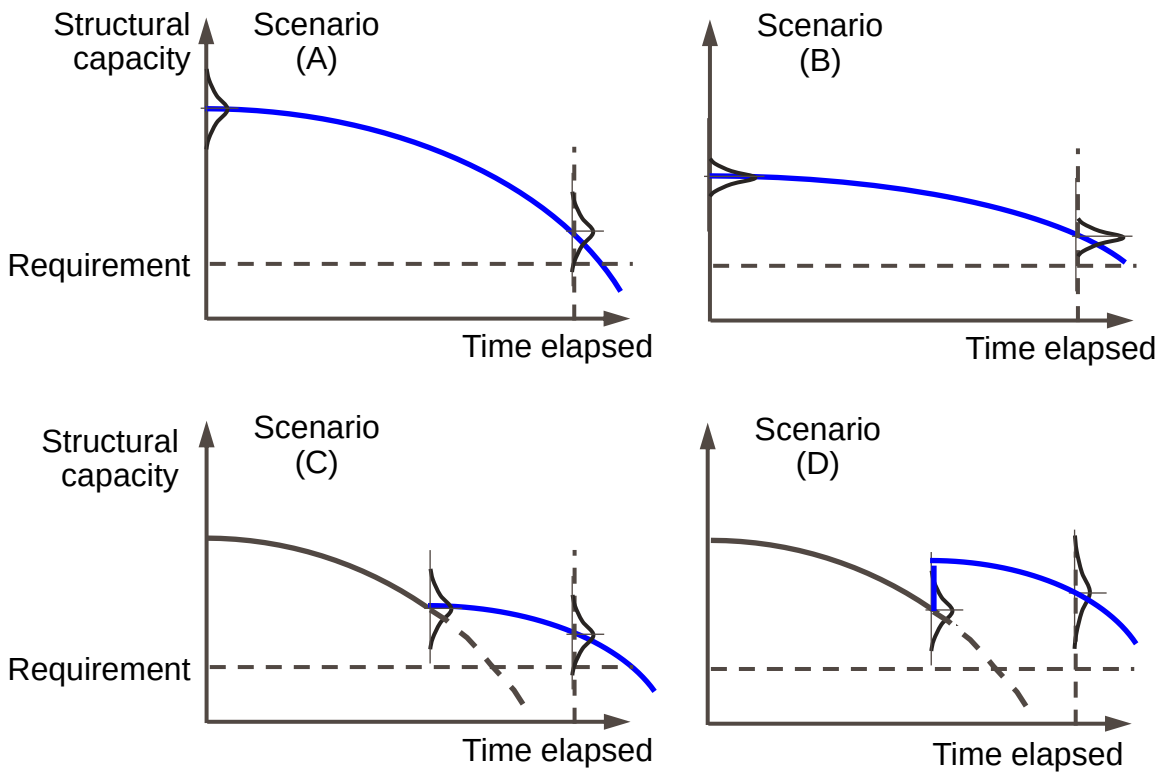
Appropriate indicators shall be set for **environmental impacts in the execution and use stages** of the structure, such as resources consumption, greenhouse gas emissions and impacts on the ambient environment.

5.3.4 Economic aspect

All the direct and indirect **costs** during the life cycle of the structure, as well as the **benefits** and **values** provided by the structure, shall be set as indicators.

Conclusions: Sustainability in the framework of LCM

- LCM is activated with the specific life cycle scenario (LCM scenario) how to ensure the requirements to the structure including sustainability.
- Creating an appropriate LCM scenario as measures to ensure attainment of the performance requirements and sustainability during the design service life.
- Setting the evaluation indicators (sustainability indicators) in consideration of their balance.
- The scenario is formulated at the planning or the initial design stage followed by updates through periodic maintenance activities.



ISO/WD 19338

ISO/WD 19338, *Performance requirements for standard on concrete structures*

- ISO/TC 71/SC 4/WG 1, Performance requirements for structural concrete; Convenor: Prof. Carrato Diniz Sofia Maria (Brazil)
- ISO 19338:2014, *Performance and assessment requirements for design standards on structural concrete* published in September 2014 and last reviewed and confirmed in 2019.

ISO/WD 19338

ISO 19338, Performance and assessment requirements for design standards on structural concrete

1 Scope
2 Normative references
3 Terms and definitions
4 General requirements
5 Performance requirements
6 Loadings and actions
7 Assessment
8 Construction and quality control

ISO/WD 19338, Performance requirements for standard on concrete structures

1 Scope
2 Normative references
3 Terms and definitions
4 General principles
5 General requirements
6 Performance requirements
7 Sustainability
8 Loadings and actions
9 Resistance
10 Performance evaluation
11 Sustainability evaluation
12 Construction and quality control

ISO/WD 19338

4 General principles

In the design of a concrete structure, the purpose, functions and performance requirements of the structure to be ensured during the design service life shall be determined. The performance requirements shall be appropriately selected as the ability of the structure **to maintain the function and sustainability of the structure.** The sustainability considerations are given in Clause 7. The performance evaluation method shall always be sufficiently clear about the relationship between the performance requirements and design actions to be considered.

5.3 Design and assessment approach

Design and assessment standards for concrete structures shall be based on quantitative performance evaluation at the limit states. Design and assessment shall consider safety, serviceability, restorability, structural integrity, robustness, **sustainability**, environmental adequacy, and durability. Where applicable, limit states caused by fatigue, fire, explosion, impact, and rare accidental actions or other extreme loadings or actions shall be considered.

ISO/WD 19338

7 Sustainability

Among the items required for sustainability, those that can be quantified are recommended to be **considered as performance requirements**. Sustainability of the structure should be evaluated from social, environmental, and economic aspects, and design should be carried out so that each of these aspects can be maintained **in a well-balanced manner**. While there are performance indicators that clearly handles the evaluation of sustainability, some indicators are still difficult to handle so as to provide a performance measurement. In any case, it is necessary to consider the sustainability that shall be achieved **throughout the design service life** of the structure.

ISO/WD 19338

7.1 Principles of design and assessment with respect to sustainable development

In the design of new structures and in the assessment of existing structures, **evaluation of performance should be conducted for all three aspects of sustainability**. Hence, the relevant aspects of social, environmental and economic issues should be **dealt with as performances**, with the associated balanced requirements, to be considered in order to provide satisfactory function throughout the service life of the structure.

The relevant aspects of social, environmental and economic performance related to fulfilling sustainability development goals during the entire life of a structure shall be defined **based on society and client needs**. They should be specified during the briefing phase in the client brief and during the subsequent phases of the design and assessment process. The relevant aspects should be dealt with in a way that is compatible with the decision process employed by the owner.

ISO/WD 19338

11 Sustainability evaluation

Sustainability evaluation shall embrace the assessment of the three aspects of sustainability, social, environmental and economic, as a whole.

The **criteria and indicators that compose each of these aspects are generally not combinable**; it is not possible to combine them in a direct way. For the sustainability assessment of structures, stakeholders and decision-makers are the bodies that take the leading role in selecting the criteria and the relative importance of them that are used to organize the results derived from each aspect to estimate a global sustainability, i.e. **a combination of the three aspects**.

⋮

It is necessary to consider changes and development of performance within the entire life of a structure. Therefore, **a life cycle approach** based on ISO 22040 is important in the sustainability evaluation.

Structural design code (draft)

Common principles of structural design for buildings and civil infrastructure (tentative title)

- JSCE – AIJ Joint Task Force; Convenor: Hiroshi Yokota
- The code provides a comprehensive framework and principles for structural design including performance evaluation in buildings and civil structures. It indicates the direction for formulating and revising design standards for each structure. The principles should be applied regardless of the objectives, forms and types of structures and materials used. It can be applied not only to new structures but also to existing structures when designing measures related to conservation and upgrade.
- Currently under development

Structural design code (draft)

Bases of structural design

There are lots of solutions to satisfy the performance requirements. Accordingly, it is necessary to select the most effective, rational solution among them, considering the degree of satisfaction of the performance requirements. For that purpose, it is necessary to determine the **engineering value standard** that can explain the validity and rationality of the design solution.

As this value standard, it is recommended to use **a set of indexes based on sustainability** considerations. In addition, to perform performance evaluation efficiently, it is necessary to thoroughly examine the value-evaluation results **at the structural planning stage** so that the they can produce a rational solution.

Structural design code (draft)

Performance requirements

(1) A structure shall hold the performance required to achieve its purpose, to ensure its functions and **to make the society sustainable**.

(2) The performance requirements shall be appropriately determined as **the ability to maintain the function and sustainability of the structure**.

(3) The levels of performance requirements shall be clearly defined, taking into consideration the **social impact of the degree of achievement of the purpose and function of the structure**.

Structural design code (Draft) – Examples of indicators

- Indicators to evaluate social sustainability
  - Contribution to the safety of society
  - Contribution to the resilience of society
  - Others
- Indicators to evaluate environmental sustainability
  - Energy input
  - Natural resource consumption
  - Greenhouse gas emission
  - Degree of environmental pollution (chemicals, noise, vibration, etc.);
  - Amount of waste generated
  - Others
- Indicators to evaluate economic sustainability
  - Costs, life cycle costs
  - Benefits
  - Others

Structural design code (draft)

- Indicators to evaluate economic sustainability
  - Costs, life cycle costs;
  - Benefits
  - Others

Appropriate indexes shall be selected from them and be quantified.
However, since it is generally difficult to determine maximization or minimization of all the indices, the final solution should be found by considering the **balance** between indexes.

Structural design code (draft)

Performance requirements include:

- structure itself or the users' benefit, such as functional usability, safety, serviceability, and restorability

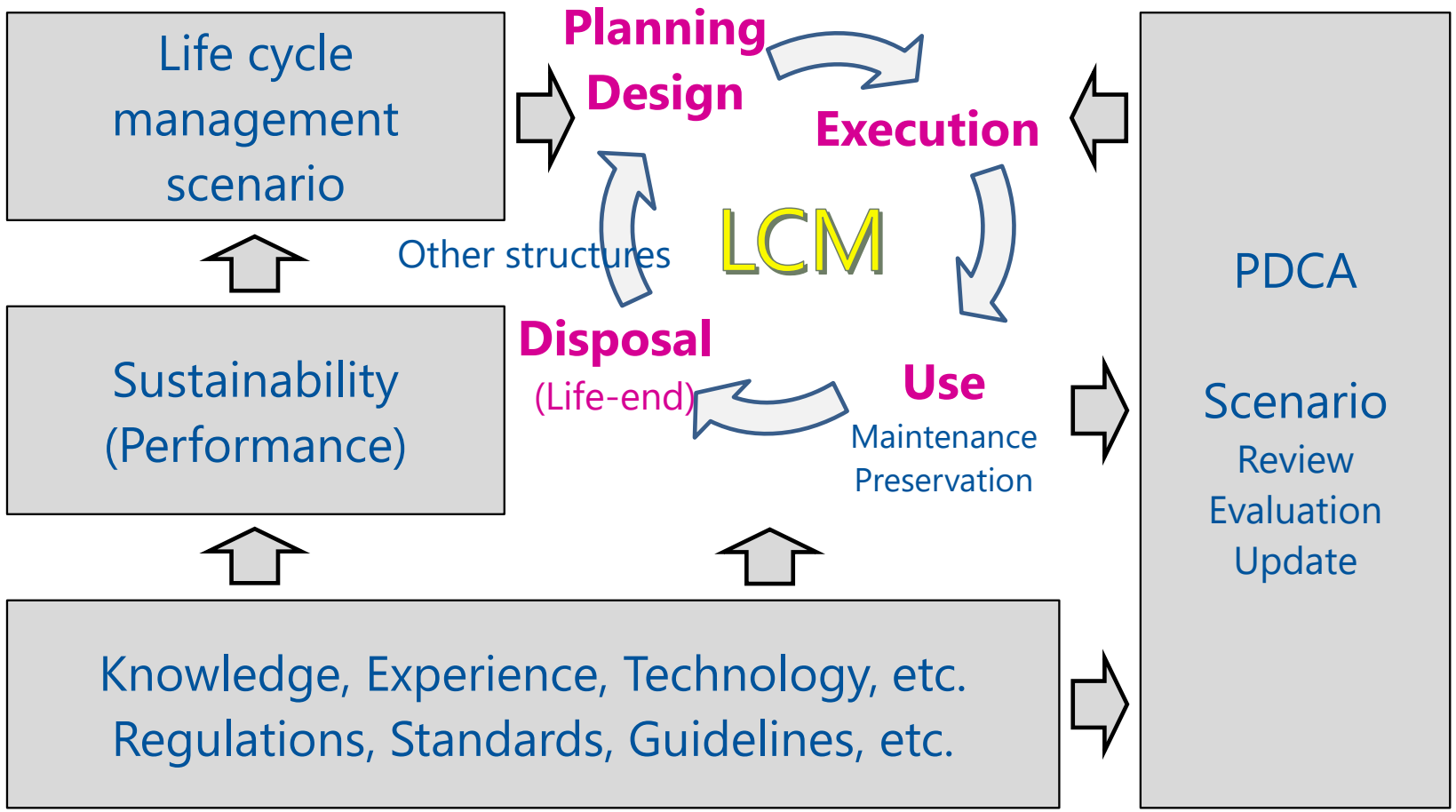
  functional usability – ability to ensure the functions of the structure
  safety – ability to ensure users' and surrounding people's lives and properties
  serviceability – ability to use the structure comfortably
  restorability – ability to recover performance of the structure subjected to accidental actions

- effect on society (benefits for other than users), such as social, environmental, and economic efficiency.

  ability to embody sustainability
  can be considered directly as performance requirements or indirectly for decision-making]

To ensure the performance requirements, it is necessary to consider the impact of the achievement status of the performance requirements on the sustainability of society.

Conclusions



Conclusions

- As performance requirements, it is recommended to explicitly determine the sustainability requirements of the structure.
- Sustainability is one of the most important considerations during the life cycle of the structure. Sustainability should be well considered from the environmental, economic and social aspects.
- It is necessary to consider the balance between sustainability indicators.
- It is recommended to specify the requirements in design standards and codes on how we can consider, quantify, verify and ensure sustainability of the structure throughout its life cycle.

Thank you for your attention!

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Acknowledgements:
Members of ISO/TC71, ISO/TC71/WG1 and JSCE/WG on Bases for design of structures