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Life cycle management of concrete structures

Gestion du cycle de vie des structures en béton

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A concrete structure passes through different stages during its life: from the planning, design, execution and use to the end-of-life stages. Due to its long life, it involves different parties at each stage. This implies that it is essential to transfer important information from one stage to another in an appropriate form. However, in reality, no appropriate system has been developed regarding the basic concept and specific methods to achieve this and manage the life cycle of the structure in a consistent manner (life cycle management).

Such lack of an appropriate system creates limitations in durability management of concrete structures, which has been recognized as a serious problem in the field of concrete technologies. This means that the prerequisites at the design stage are not managed appropriately and that execution-induced problems are not ascertained and documented. Regarding the former, there has not been a system for clarifying a long-term maintenance program based on conditions elaborated at the design stage and ensuring its continuation in an appropriate form. Regarding the latter, since a number of uncertain elements exist in the construction of a concrete structure, the quality of construction does not always match the prerequisites of design. Therefore, construction involves factors impairing the durability of the structure in quite a few cases. This suggests that confirmation of completion of the structure and documentation of the procedure to completion are essential for ensuring its performance in its life cycle. It can also become necessary to alter the design conditions of a concrete structure in the use stage. In such a case, basic information regarding the original design becomes essential, but it is often not retained in an appropriate form. As a result, it takes much work to retrieve basic information of the existing structure. Moreover, the design and execution need to be based on uncertainty to a certain extent. For appropriate management of a structure, it is therefore extremely important to keep all basic information at each stage.

Some standards regarding the life cycle of infrastructure have already been developed. The pertinent standards are the ISO 15686 series. The ISO 15686 series is relevant to the service life planning of new and existing buildings and cover a part of the planning process. In the ISO 15686 series, service life estimation applies principally to the estimation of residual service lives of components of a building that are already in service, and to the selection of components for, and the detailing of, repairs and new work. While a part of basic philosophy of these standards can be applied, it is difficult or rather impossible to fully apply these documents to the life cycle management of concrete structures without misunderstanding because these standards only deal with buildings with replaceable components including ancillaries. This document covers any kind of concrete structures.

A standard is, therefore, necessary regarding the basic concept and specific procedures for methods of managing concrete structures in view of the current problems, in order to rationally control concrete structures throughout their life cycle and more reliably ensure functioning of future documents. With this as a background, it was decided to establish in this document the key principles, framework and procedures for appropriately implementing life cycle management (LCM) in which planning, design, execution, use and end-of-life of a structure are appropriately connected one after the other. It is worth noting that this document also serves as a guideline for other ISO standards. Table 1 lists the relationship between this document and other ISO standards.

A structure is constructed with its own purposes. It generally includes protecting people from disasters and ensuring a comfortable and safe life. A structure is required to maintain its functions and performance to achieve these purposes. The introduction of LCM for a structure contributes to all aspects of sustainability while maintaining the functions and performances to fulfil its purposes.

Sustainability is the goal of sustainable development. It refers to any state of the global system in which the needs of the present are met without compromising the ability of future generations to meet their own needs. The concept of sustainability is continually evolving. Understanding and achieving a balance between environmental, social and economic aspects, ideally in mutually supporting ways, is considered essential for making progress towards achieving sustainability. The achievement of sustainability is now recognized as one of the most important considerations in all human activities (ISO Guide 82).

A concrete structure inherently has a planned life when it is well designed, executed and maintained under proper life cycle management based on sustainability framework.

Table 1 — Relationship between this document and other ISO standards

<table>
<tr><th>Planning</th><th>Design</th><th>Execution</th><th>Use</th><th>End-of-life</th></tr>
<tr><td colspan="5">ISO 22040, Life cycle management of concrete structures</td></tr>
<tr><td>—</td><td colspan="3">[Test method]
ISO 1920 series
ISO 10406
ISO 17785
ISO 19044
ISO 20290 series</td><td>—</td></tr>
<tr><td>—</td><td>ISO 14484
ISO 15673
ISO 16204
ISO 19338
ISO 28841
ISO 28842</td><td>ISO 12439
ISO 14824
ISO 19595
ISO 22965
ISO 22966</td><td>ISO 16311
ISO 16711
ISO/TR 16475
ISO/TS 16774</td><td>—</td></tr>
<tr><td>—</td><td colspan="3">ISO 14484 (FRP)
ISO 18319 (FRP)</td><td>—</td></tr>
<tr><td colspan="5">ISO 13315 series (Environmental management)</td></tr>
</table>

Life cycle management of concrete structures

1 Scope

This document provides the principles for implementing life cycle management (LCM) of concrete structures throughout the stages of planning, design, execution, use and end-of-life, as well as the framework and procedures for LCM.

This document is applicable not only to new structures but also existing structures. It is also applicable to the entire life cycle and each one or more stages composing the life cycle of a structure.

NOTE Details in the procedures and specific methodologies for management in each stage of structure's life cycle based on this document is established separately.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2394, *General principles on reliability for structures*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
life cycle
set of consecutive, interlinked stages of a structure, which comprise planning, design, execution, use and end-of-life stages

3.2
life cycle management
LCM
set of systematic and coordinated activities and practices through which a structure is appropriately managed over its *life cycle* (3.1)

3.3
life cycle management scenario
LCM scenario
plan for ensuring *performance* (3.5) of a structure throughout its *life cycle* (3.1)

3.4
maintenance
set of activities taken to check, evaluate the *performance* (3.5) of a structure and preserve/restore it so as to satisfy *performance requirements* (3.6) in service

[SOURCE: ISO 16311-1:2014, 3.8]

3.5
performance
qualitative or quantitative representation of the behaviour of a structure

3.6
performance requirement
definition of the required *performance* (3.5) in designed concrete structures

3.7
sustainability
ability of a structure or structural element to contribute positively to the fulfilment of the present needs of humankind with respect to social, economic and environmental aspects, without compromising the ability of future generations to meet their needs in a similar manner

3.8
sustainability indicator
indicator related to economic, environmental or social impacts

[SOURCE: ISO 21929-1:2011, 3.33]

4 General principles of life cycle management

As a sophisticated system to support the activities of appropriately managing the life cycle of concrete structures with various shapes and forms, LCM shall cover their life cycle from the point at which its necessity is recognized to the end-of-life of the structures. A structure shall securely retain the required functions and performance throughout its life cycle. Decisions shall be made so that the work at each stage of the structure's life cycle can be connected and managed appropriately based on a consistent concept.

The period of LCM shall cover the planning, design, execution, use and end-of-life stages of the structure. In the LCM, during the period that the structure is used, natural environment, variable actions and the importance of the structure shall be appropriately considered.

The LCM shall be carried out with the LCM scenario that includes fundamental strategy for managing the structure.

The performance requirements of the structure shall be determined according to ISO 2394 and ISO 19338.

5 General framework of life cycle management

5.1 General

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.

5.2 Scenario formulation

For implementing an LCM, an appropriate basic LCM scenario shall be formulated to connect each stage. The basic LCM scenario shall include the fundamental strategy on how the structure will be managed in terms of sustainability aspects. A structure shall be designed to keep its function and performance without major remedial measures. However, planned remedial measures shall be included in the LCM scenario if they are required.

The basic LCM scenario shall be modified as required. Since this scenario is based on future predictions and various assumptions, LCM-related data acquired at each stage shall be utilized effectively to review

the assumptions. Predictions shall be updated based on newly acquired data, and the LCM scenario shall be re-formulated if necessary, to enable appropriate management at subsequent stages.

5.3 Indicators for life cycle management

5.3.1 General

In the LCM, 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.

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.

NOTE Social indicators include health and safety, satisfaction, population and community and cultural heritage.

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.

NOTE See the ISO 13315 series for details of the environmental management of concrete structures.

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.

NOTE 1 ISO 15686-5 serves as a reference for details of calculating life cycle cost.

NOTE 2 Direct costs are directly attributable to managing of a structure, for example, the costs of materials, labour, equipment, etc., and all efforts or expenses directly involved. Indirect costs are not directly attributable to managing a structure and can include social inconvenience.

NOTE 3 Maintenance, repair, upgrade and adaptation at the use stage are sometimes costly.

6 Procedures of life cycle management

The basic flow of life cycle management is presented in Figure 1.

A new structure shall be thoroughly managed based on the LCM concept during its life cycle. The basic LCM scenario shall be formulated at the planning stage of the structure. Design work shall be carried out to satisfy the plan and the scenario. When the design outputs do not satisfy the initially formulated LCM scenario, either:

— the LCM scenario shall be modified to be consistent with design outputs; or

— the plan and/or design shall be carried out again.

After the execution, initial assessment shall be carried out to check the state of the structure. When any defect is found from the assessment, remedial measures shall be taken as required. Then, it shall be assessed whether the basic LCM scenario is suitable for the subsequent life cycle of the structure. If modification is deemed necessary, the basic LCM scenario shall be updated. At the following

assessment, the conditions of the structure shall be re-assessed. Also, the LCM scenario shall be updated as necessary. If the sustainability evaluation shows that no remedial measures are necessary, the structure shall go to the end-of-life stage.

For an existing structure that has not been managed so far but is decided to be managed based on the LCM concept, the LCM shall start with the first assessment of its performance at the use stage. The basic LCM scenario shall be formulated by using all available assessment data and design and execution documents. If the assessment results indicate that no remedial measures are necessary, the structure shall go to the end-of-life stage. Otherwise, the same procedure as that for a new structure shall be followed.

When the basic LCM scenario is updated, subsequent management shall be carried out according to the updated scenario.

For the LCM, the appropriate scenario shall be selected from several basic LCM scenarios set at each stage of the structure's life cycle, considering the balance between the sustainability indicators in 5.3.

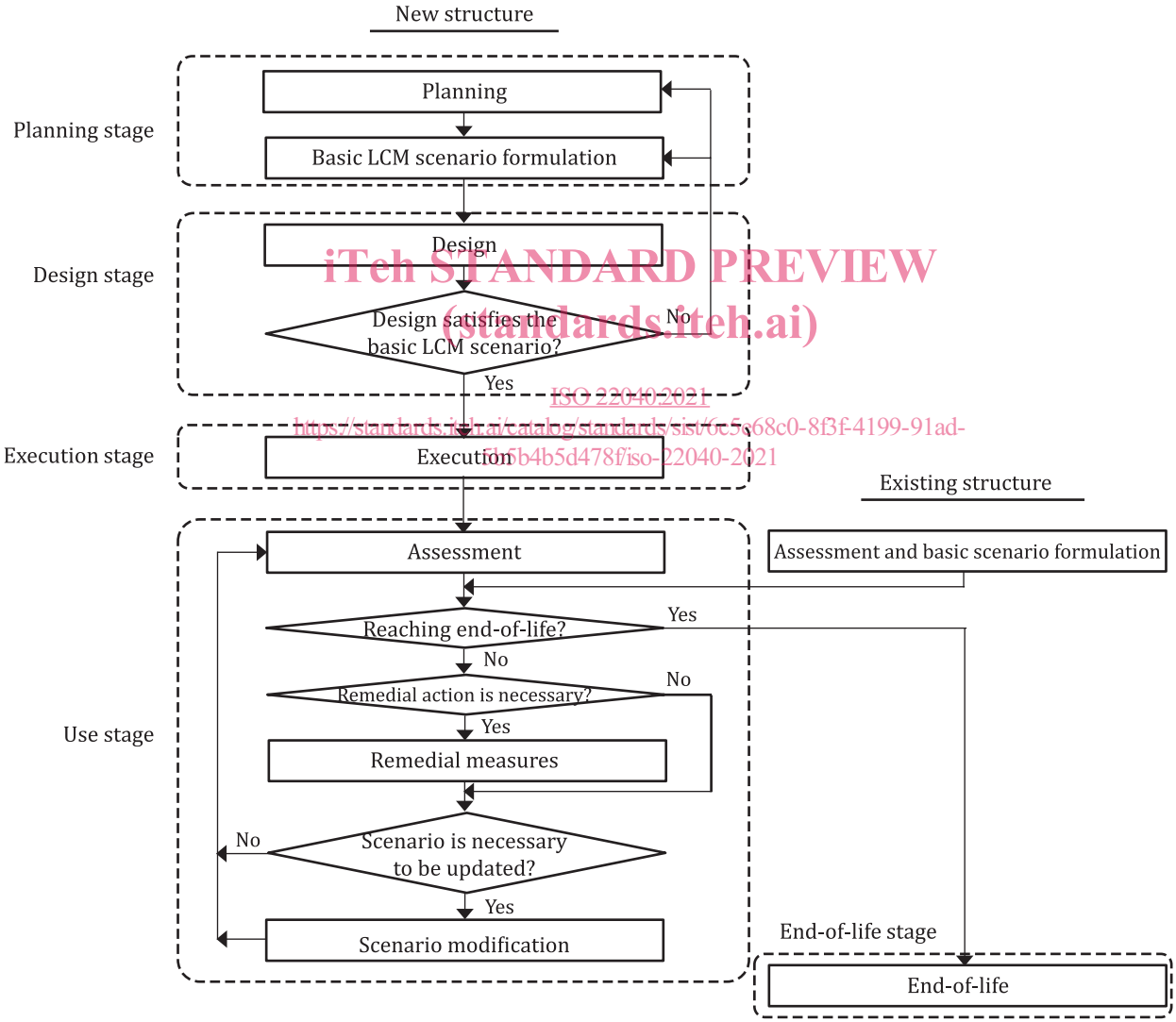

Figure 1 — Flow of LCM