Secretariat of ISO/TC 71/SC 7
Maintenance and repair of concrete structures

Dear P-members,

ISO NEW WORK ITEM/CD BALLOT FOR ISO/TC 71/SC 7 – PART 1

Enclosed is the ballot for ISO/TC 71/SC 7 New Work Item/CD – Part 1.

This draft is being balloted simultaneously as a New Work Item and Committee Draft. Only when the ballot has met all the requirements for passing the New Work Item with the Committee Draft, votes can be taken into account.

BALLOTS ARE DUE TO THE SC7 SECRETARIAT NO LATER THAN 2010-05-25

Sincerely yours,

Dr. S. Shin
Secretary to ISO/TC 71/SC 7
KATS-Korea
A proposal for a new work item within the scope of an existing committee shall be submitted to the secretariat of that committee with a copy to the Central Secretariat and, in the case of a subcommittee, a copy to the secretariat of the parent technical committee. Proposals not within the scope of an existing committee shall be submitted to the secretariat of the ISO Technical Management Board.

The proposer of a new work item may be a member body of ISO, the secretariat itself, another technical committee or subcommittee, or organization in liaison, the Technical Management Board or one of the advisory groups, or the Secretary-General.

The proposal will be circulated to the P-members of the technical committee or subcommittee for voting, and to the O-members for information.

See overleaf for guidance on when to use this form.

**IMPORTANT NOTE:** Proposals without adequate justification risk rejection or referral to originator.

Guidelines for proposing and justifying a new work item are given overleaf.

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<td>(in the case of an amendment, revision or a new part of an existing document, show the reference number and current title)</td>
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Purpose and justification

Maintenance and repair are two closely related activities aimed at securing that a concrete structure (here-in-after referred to as "structure") is retained in a state in which it can perform its required functions, while in an acceptable and safe condition. Maintenance will be used as a general term that also covers repair as a distinct activity to restore worn, damaged or deteriorated parts. For a well designed and well executed concrete structure with proper maintenance, repair should not be necessary within the design service life of the structure.

This part covers the activities necessary to retain the performance of the structure above the required levels during its service life, such as:

- Assessment of structure including inspection/investigation and evaluation of the performance of structure
- Planning and designing repair in case it is required due to damage, deterioration or wear
- Execution of repair, preparation, execution and documentation

This part deals with maintenance and repair mainly related to existing structures, which can be planned systematic routines or within in practice often be initiated by observations that cause concern. The planned maintenance activities can minimize the deterioration followed by the degradation of performance of the structure during its remaining service life, and consequently may be accomplished a prolongation of the structure's service life inexpensively.

It is recommended not only in case of existing structures but also in particular for new built structures of which maintenance plan should be established at the design state. For new built structures also a so called "birth certificate" will be useful in later planning of maintenance and repair. However, this part does not cover for them.

This part of "Part 1: General principles" provides the framework of maintenance activities for maintenance of all structures of their components and gives general principles of each activity. This part is followed by three parts, which are considered the operational parts of the standard giving detailed requirements and guidelines;

- Part 2: Assessment of existing concrete structures
- Part 3: Design of repairs and prevention
- Part 4: Execution of repairs and prevention

Target date for availability

(date by which publication is considered to be necessary)

Proposed development track

☐ 1 (24 months)  ☒ 2 (36 months - default)  ☐ 3 (48 months)

Relevant documents to be considered

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

Relationship of project to activities of other international bodies

Liaison organizations
JCI/ICCMC

Need for coordination with:
☐ IEC  ☑ CEN  ☐ Other (please specify)

Preparatory work

(at a minimum an outline should be included with the proposal)

☒ A draft is attached  ☐ An outline is attached. It is possible to supply a draft by

The proposer or the proposer's organization is prepared to undertake the preparatory work required  ☒ Yes  ☐ No

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Comments of the TC or SC Secretariat

Supplementary information relating to the proposal

☐ This proposal relates to a new ISO document;
☐ This proposal relates to the amendment/revision of an existing ISO document;
☐ This proposal relates to the adoption as an active project of an item currently registered as a Preliminary Work Item;
☐ This proposal relates to the re-establishment of a cancelled project as an active project.

Other:

Voting information

The ballot associated with this proposal comprises a vote on:

☐ Adoption of the proposal as a new project
☐ Adoption of the associated draft as a committee draft (CD)
☐ Adoption of the associated draft for submission for the enquiry vote (DIS or equivalent)

Other:

Annex(es) are included with this proposal (give details)

☐

Date of circulation | Closing date for voting | Signature of the TC or SC Secretary
2010-02-25 | 2010-05-25 | Soobong Shin

Use this form to propose:

a) a new ISO document (including a new part to an existing document), or the amendment/revision of an existing ISO document;
b) the establishment as an active project of a preliminary work item, or the re-establishment of a cancelled project;
c) the change in the type of an existing document, e.g. conversion of a Technical Specification into an International Standard.

This form is not intended for use to propose an action following a systematic review - use ISO Form 21 for that purpose.

Proposals for correction (i.e. proposals for a Technical Corrigendum) should be submitted in writing directly to the secretariat concerned.

Guidelines on the completion of a proposal for a new work item

(see also the ISO/IEC Directives Part 1)

a) Title: Indicate the subject of the proposed new work item.
b) Scope: Give a clear indication of the coverage of the proposed new work item. Indicate, for example, if this is a proposal for a new document, or a proposed change (amendment/revision). It is often helpful to indicate what is not covered (exclusions).
c) Envisaged publication type: Details of the types of ISO deliverable available are given in the ISO/IEC Directives, Part 1 and/or the associated ISO Supplement.
d) Purpose and justification: Give details based on a critical study of the following elements wherever practicable. Wherever possible reference should be made to information contained in the related TC Business Plan.

1) The specific aims and reason for the standardization activity, with particular emphasis on the aspects of standardization to be covered, the problems it is expected to solve or the difficulties it is intended to overcome.
2) The main interests that might benefit from or be affected by the activity, such as industry, consumers, trade, governments, distributors.
3) Feasibility of the activity: Are there factors that could hinder the successful establishment or global application of the standard?
4) Timeliness of the standard to be produced: Is the technology reasonably stabilized? If not, how much time is likely to be available before advances in technology may render the proposed standard outdated? Is the proposed standard required as a basis for the future development of the technology in question?
5) Urgency of the activity, considering the needs of other fields or organizations. Indicate target date and, when a series of standards is proposed, suggest priorities.
6) The benefits to be gained by the implementation of the proposed standard; alternatively, the loss or disadvantage(s) if no standard is established within a reasonable time. Data such as product volume or value of trade should be included and quantified.
7) If the standardization activity is, or is likely to be, the subject of regulations or to require the harmonization of existing regulations, this should be indicated.

If a series of new work items is proposed having a common purpose and justification, a common proposal may be drafted including all elements to be clarified and enumerating the titles and scopes of each individual item.
e) Relevant documents and their effects on global relevancy: List any known relevant documents (such as standards and regulations), regardless of their source. When the proposer considers that an existing well-established document may be acceptable as a standard (with or without amendment), indicate this with appropriate justification and attach a copy to the proposal.
f) Cooperation and liaison: List relevant organizations or bodies with which cooperation and liaison should exist.
Maintenance and repair of concrete structures – Part 1: General principles

Élément introductif — Élément central — Élément complémentaire

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

This Draft International Standard has been prepared by Technical Committee ISO/TC 71 Subcommittee 7 “Maintenance and repair of concrete structures”, the secretariat of which is held by KATS. It consists of four parts:

- Part 1: General principles
- Part 2: Assessment of existing concrete structures
- Part 3: Design of repairs and prevention
- Part 4: Execution of repairs and prevention
**Introduction**

In the context of this standard maintenance and repair are two closely related activities aimed at securing that a concrete structure (here-in-after referred to as "structure") is retained in a state in which it can perform its required functions, while in an acceptable and safe condition. Maintenance will be used as a general term that also covers repair as a distinct activity to restore worn, damaged or deteriorated parts. For a well designed and well executed concrete structure with proper maintenance, repair should not be necessary within the design service life of the structure.

This International Standard covers the activities necessary to retain the performance of the structure above the required levels during its service life, such as;

- Assessment of structure including inspection/investigation and evaluation of the performance of structure
- Planning and designing repair in case it is required due to damage, deterioration or wear
- Execution of repair; preparation, execution and documentation

This International Standard deals with maintenance and repair mainly related to existing structures, which can be planned systematic routines or will in practice often be initiated by observations that cause concern. The planned maintenance activities can minimize the deterioration followed by the degradation of performance of the structure during its remaining service life, and consequently may be accomplished an extension of the structure’s service life inexpensively.

It is recommended not only in case of existing structures but also in particular for newly built structures of which maintenance plan should be established at the design stage. For newly built structures also a so called "birth certificate" will be useful in later planning of maintenance and repair. However, this standard does not cover for them.

This part of the standard “Part 1: General principles” provides the framework of maintenance activities for maintenance of all structures or their components and gives general principles of each activity. This part is followed by three parts, as shown in Figure 1, which are considered the operational parts of the standard giving detailed requirements and guidelines (an extended hierarchy of the parts and other related ISO code is shown in Annex A).

**Fig. 1 —Relationship between each part of this International Standard**
General Principles — Part 1:

1. Scope

This International Standard covers the framework and general principles for maintenance and repair of all kinds of existing concrete structures — un-reinforced and reinforced concrete, prestressed concrete and steel-concrete composite structures, or their structural members.

In this International Standard, deterioration is clearly distinguished from damage occurring in a short period and not developing over subsequent time, such as cracking and scaling due to earthquakes or impact loading, etc. Deterioration is mainly dealt with as a target for the maintenance activities.

This International Standard also provides the basic concept of remedial actions carried out to drawback structural performance of existing structure by repair.

This International Standard does not cover those aspects of maintenance and repair that are related to serviceability and esthetics without direct impact on durability and service life, e.g. cleaning of drains, removing vegetation, refreshing of paint etc.

2. Normative reference

The following normative documents contain provisions, which through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, the publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO maintain registers of currently valid International Standards.


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

3. Terms and definition

For the purpose of this International Standard, the following terms and definitions apply with those in ISO 19338.

3.1 assessment

total set of activities performed in order to verify the reliability of an existing structure for future use

3.2 design service life

period of time specified in design of structure for which a structure or its members is to be used for its intended purpose without major repair being necessary

3.3 deterioration
process that adversely affects the performance of a structure, including reliability over time due to defects and damages caused by
-- naturally occurring chemical, physical, biological, or other environmental actions
-- repeated mechanical actions such as those causing fatigues
-- wear due to use, abuse, and others

3.4 deterioration factor
factor affecting the deterioration process

3.5 inspection
actions collecting information on the current state of a structure through observation and supplementary and simplified non-destructive testing

3.6 intended service life
a period during which a structure is in service decided by an owner

3.7 investigation
collection of information through inspection, document search, load testing and other testing

3.8 maintenance
a set of activities taken to check, evaluate the performance of a structure, and preserve/restore it so as to satisfy performance requirement during the design service life

3.9 maintenance category
category for classifying maintenance activities on each structure depending on importance, service life, environmental condition, ease of maintenance, and etc. of the structure

3.10 maintenance plan
plan for accomplishing strategy of maintenance to ensure that the structure retain the performance within the specified tolerances throughout its service life, which includes planning not only for assessment but also for repair or other remedial actions

3.11 monitoring
frequent or continuous, normally long-term, observation or measurement with recording of appropriate data for deterioration and/or performance of structure using appropriate equipment

3.12 prevention
remedial action to prevent or slow down the further deterioration of a structure or structural member and to reduce the possibility of damage to the user or any third party, inhibiting the progress of deterioration, and proactively preventing deterioration

3.13 rehabilitation
work required to repair, prevention, and possibly upgrade an existing structure

3.14 remaining design service life
period from the time of a given inspection of a structure till the end of its design service life
3.15 remedial action
action carried out with the objective of arresting or slowing down the deterioration process, restoring or improving the performance of structure, or reducing the danger of damage or injury to the user or any third party

3.16 repair
remedial action adopted for the measure to restore structural performance up to the initially required design level and to achieve the required service life

3.17 repair plan
plan for establishing the method and level of repair, determining the materials, sectional dimensions and execution methods, specifying the control items during execution in consideration of the policy and level of repair

3.18 service life
actual period during which a structure is in service

3.19 threat posed to third parties
hazards of damage and/or injury caused by concrete fragments and surface coating (finishing) materials, etc. falling from a deteriorated structure

3.20 upgrading
measure taken to improve the structural performance of an existing structure and/or its member

4. Basis of maintenance

4.1 General
A concrete structure shall retain the required performance for the intended service life by providing necessary maintenance activities, such that its performance is always above the required performance level with adequate reliability under an appropriate maintenance plan.

4.2 Procedure of maintenance
A general flow of maintenance procedure is shown in Fig. 4.1. The overall maintenance activities shall encompass the maintenance plan, assessment including investigation/inspection, prediction of progress of deterioration and evaluation of structural integrity/decision-making as well as repair or other remedial actions as may be required. Results of these activities are recorded with an easily accessible format.
4.3 Competence of personnel

All activities of maintenance and repair should be carried out by a team of qualified persons having the adequate knowledge of design, construction, maintenance and repair of concrete structures.

5. Maintenance plan

5.1 General

For accomplishing overall maintenance activities, an adequate maintenance plan shall be formulated taking into account a maintenance category selected provisionally in accordance with Clause 5.3, remaining service life, life-cycle cost and other considerations peculiar to the structure.

The following should be specified in the maintenance plan:

-- required performance and its level which a structure should retain for the remaining service life

-- methods and timing of assessment composed of investigation and prediction of deterioration of the structure or its structural members, performance evaluation for structure and decision of the need of remedial actions

-- basic consideration concerning repair and/or other remedial actions for the expected deterioration/performance degradation of structure

5.2 Timing of maintenance planning for structure

An appropriate maintenance plan should be formulated before starting maintenance actions.

Note: In the structure’s life, there are the following three stages where a maintenance plan should be formulated:

-- Maintenance plan for a new structure at the design stage, so that structural type and materials may be chosen to make the structure satisfy maintainability, which assures easy maintenance during its design service life.
5.3 Selection of maintenance category

The set of maintenance activities are classified into different maintenance categories corresponding to the situations of a structure.

In the maintenance plan, a suitable maintenance category shall be provisionally selected to carry out the maintenance work as effectively as possible in consideration of such factors as the importance of the structure, remaining service life, threat posed to third parties, environmental conditions, and ease of maintenance (see annex B).

When structural members have differences in their importance, environmental condition, effect on threat posed to third parties, ease of maintenance, etc., different maintenance categories should be selected on each member even in the same structure.

5.4 Final determination of maintenance plan

When the results of initial assessment prescribed in Clause 6.2.2 suggest that the maintenance category provisionally selected is not suitable, it shall be updated. Consequently, the maintenance plan shall be determined in accordance with the finally selected maintenance category.

6. Assessment

6.1 General

Assessment of a structure shall be carried out to verify its reliability taking into account structural performance.

The assessment procedure is generally composed of the following activities: investigation, prediction of deterioration progress, evaluation of actual structure condition, decision-making for necessity of remedial action, and record, so that an appropriate assessment plan should be established taking into account the actual conditions of the structure.

6.2 Assessment plan

6.2.1 Preparation of assessment plan

An expected condition of structure during its intended service life should be specified appropriately prior to the assessment planning in order to identify probable critical situations for the structure, which is required as the basis in the assessment to ensure performance of structure.

To carry out the assessment on a structure rationally and economically, the category and the level of assessment should be decided appropriately in the assessment plan prior to the composition of the assessment procedure, depending on the assessment objectives, the timing of assessments and other specific circumstances such as the availability of the design and construction document, the observation of damage, the use of the structure.

6.2.2 Category of assessment

Assessment performed in maintenance activities for a structure throughout its service life are categorized suitably on the basis of the timing of assessment, the type of information desired, etc.

In general, the assessment are classified in the three categories (see Annex B):
-- Initial assessment: an assessment carried out for evaluating the initial condition of a structure before initiating into routine/regular maintenance activities.

Note: Usually, the first assessment of existing structures where no repair is necessary but a maintenance plan is recommended or of the ones which has been subjected to large-scale remedial actions and substantially renewed is classified in this category, while “birth certificate” of newly constructed structure is also in here.

-- Periodic assessment: assessment carried out routinely or regularly at certain intervals prescribed in the maintenance plan

-- Extraordinary assessment: assessment carried out after a structure has been subjected to an accidental load, such as that caused by an earthquake, storm, flood, fire, and impact by a vehicle or ship.

6.2.3 Level of assessment

An appropriate assessment level shall be selected depending upon the purpose and scope of the category of assessment.

In general, two levels of assessment are defined as follows;

-- Preliminary level of assessment: assessment to collect the basic information on structural condition by using simple inspection/investigation methods complied with a maintenance plan, such as a visual inspection and simple non-destructive test

-- Detailed level of assessment: assessment to obtain detailed and specific information regarding deterioration and performance degradation of the structure, when the assessment in the preliminary level is insufficient for identifying the deterioration and/or performance degradation or anytime when it is required

6.3 Investigation

6.3.1 Implementation plan

Investigation shall be carried out with the objectives of detecting deterioration and/or change in performance of the structure. Such investigation shall be carried out by inspection visually or with the help of appropriate methods and techniques, document search, load testing and other testing, etc. at appropriate intervals, depending on the importance of the structure, the category of maintenance, the category and level of assessment, and the expected mechanism and the rate of deterioration.

When commencing investigation, it is necessary to make an adequate implementation plan, which includes selection of items and method, identification of location, frequencies, etc. based on the expected deterioration prediction and past maintenance records.

6.3.2 Selection of items

The items for investigation shall be carefully selected so that desired information on the deterioration and/or structural performance can be obtained in consideration of the deterioration mechanism expected, the category and level of assessment, and the ease of maintenance.

6.3.3 Identification of locations

Critical locations should be identified in a structure for closer attention and more frequent investigation. The number of the locations selected shall depend upon the category and the level of assessment, and the state of structure such as the importance of the structure, the environment around the structure, and the type of loading.
Note: It is practically impossible to investigate an entire structure. Thus, appropriate sections and/or locations should be identified for investigation.

6.3.4 Selection of method

Appropriate methods are selected according to the item and the availability of measuring equipment, etc. The methods are classified into the following categories:

-- document search

-- inspection
   -- visual observation
   -- manipulation
   -- non-destructive method
   -- partially destructive method

-- testing
   -- material testing
   -- loading test for structure

The method shall be reviewed according to the changes in the category and the level of assessment.

6.3.5 Selection of tools and techniques

Tools and techniques used in each investigation method shall be appropriately chosen so that the desired information on the deterioration of materials and/or structural performance can be obtained. They shall be reviewed according to the result of investigation, the deterioration prediction, evaluation/judgment, and so on. Simultaneously, the inherent limitations of the tools and techniques in question shall be recognized.

6.3.6 Frequency of investigation

The frequency of investigation shall be appropriately determined, depending upon the category of maintenance, the importance of the structure, the environment around the structure, the type of loading, etc.

6.3.7 Emergency measures after investigation

When fatal defect or damage of urgency is found during investigation, it shall be subjected to emergency measures because leaving such a defect or damage untreated may subsequently lead to a serious accident or a serious economic disadvantage.

6.3.8 Monitoring

Monitoring can continually record appropriate data for condition of a structure, so that appropriate remedial action can be taken before the deterioration becomes detrimental to the appearance and performance of the structure.

The most appropriate monitoring method shall be selected in consideration of the kind of information required, the availability of tools and equipment, and so on.

6.4 Prediction of deterioration and performance degradation of structure

6.4.1 Identification of deterioration mechanisms
To carry out appropriate prediction of deterioration occurring on the structure and/or its structural member under consideration, the mechanism of deterioration shall be provisionally identified.

In general, deterioration mechanism should be identified in consideration of the deterioration factors specified and any signs of deterioration detected in the inspection and/or other tests in investigation.

Note: Deterioration factors may be classified into the following two areas:

-- deterioration factor related to the external situation, such as environmental conditions, weather conditions and external force conditions encompassing a concrete structure under consideration
-- deterioration factor related to the internal condition of structure relating design and construction

A structure and/or structural members are often subjected to more than one deterioration mechanism. In this case, the combined effects of those mechanisms shall be considered.

### 6.4.2 Determination of deterioration level and rate

According to the identified deterioration mechanism, current deterioration levels and rates on the structure and/or its members shall be determined using appropriate analysis models established on the basis of the environmental conditions and any other useful information obtained from investigation.

Appropriate deterioration indices representing the deterioration condition of the structure and/or its members under consideration can be selected to simplify modeling the deterioration and/or the performance degradation process.

### 6.4.3 Prediction of performance degradation of structure

The degradation in structural performance and its progress shall be properly predicted by appropriate models, which shall be formulated based on the relationship between the structure/member's performance and the predicted level and rate of deterioration.

In principle, performance degradation predictions should be made quantitatively relating to all the performance requirements of the structure/members.

Note: For the structure's performance, quantitative prediction is desirable, but this may be difficult in many cases. In such a case, the performance shall be evaluated by a "grading method," that is, the structure's performance is semi-quantitatively classified into grades.

### 6.5 Evaluation and decision

#### 6.5.1 Evaluation of performance of structure

##### 6.5.1.1 Performance verification method

For evaluating structure/members condition, the performance possessed during intended service life, which is predicted in accordance with the specification in Clause 6.5.2, shall be verified with the threshold level. The verification, in principle, should be carried out respectively for one or more of performance requirements.

Note: In general, the performance degradation of a general structure over time is considered in a monotonic process. Therefore, it is sufficient to check the performance at two points such as the time of an inspection and the end of intended service life.

##### 6.5.1.2 Threshold levels for performance degradation of structure
The minimum level of degraded performance of the structure shall be determined in accordance with each performance requirement, depending on the category of maintenance, importance and the conservation level of the structure.

6.5.1.3 Overall evaluation of performance level possessed

Performance possessed should be synthetically evaluated by confirming that each performance is verified to satisfy the required level.

6.5.2 Decision

Depending on the importance of structure, the category of maintenance, the remaining service life, life-cycle cost and other such considerations, as well as the overall results on the performance of structure evaluated through the assessment, decision shall be made appropriately to give recommended actions in the preliminary and detailed levels of assessment, respectively.

In the preliminary assessment level, decision should be made on the evaluation of the structure/members condition as to whether a detailed investigation is called for.

In the detailed assessment level, decision should be made as to whether any remedial action is called for.

7. Remedial action

7.1 Selection of remedial action

The following shall be taken into account as the remedial action for a structure of which performance does not meet its requirement:

-- repair
-- strengthening
-- intensified inspection
-- restriction in service
-- dismantling and removal, etc.

A suitable remedial action on the intended structure shall be selected on the basis not only of the assessment results but also of the more comprehensive considerations on the following items:

-- importance of the structure
-- category of maintenance
-- remaining service life
-- easiness of maintenance
-- advantage of immediate action from the aspect of life-cycle cost

7.2 Repair

7.2.1 General
Repair including prevention measure (here-in-after referred to as “repair”) of a structure refers to the remedial action taken to prevent or reduce further deterioration, which include repair of defective events such as cracks, removal of deterioration portion or deterioration factors, surface coating, etc.

Note: This standard clearly distinguishes “prevention” from “repair” in the definitions. However, both of them are the almost same manner in their methods and using materials. Therefore, the prevention measure of structure also should be executed on the provisions specified in Clause 7.2.

The procedure of repair mainly consists of planning, design, execution, and completion inspection.

For execution of repair, appropriate steps shall be taken to ensure the use of proper materials and methods as well as being subjected to good quality control.

After the repair is taken, the performance of the structure shall be evaluated by the assessment. The performance of the structure shall be upheld by implementing a new plan of maintenance.

7.2.2 Planning and design

7.2.2.1 Formulation of repair plan

Formulating a repair plan refers to establishing the required repair level set in accordance with the specification in Clause 7.2.2.2, and selecting a repair method, repair materials, sectional dimensions after repair, and execution methods.

7.2.2.2 Repair level

An appropriate repair level shall be set considering the maintenance category, the importance of the structure, remaining service life, cost effectiveness, and the post-repair maintenance plan.

Note: For instance, the repair level may be simply classified into the following three categories:

-- repair level requiring a service life as long as the remaining service life of structure

-- repair level requiring a medium service life

-- repair level requiring only a short service life

7.2.2.3 Selection of methods and materials

The method and materials for repair shall be adequately chosen based on the deterioration mechanism, remaining service life, the importance and maintenance level of the structure.

Note: Care should be taken, as the method of restoring the performance may vary depending on the deterioration mechanism, even if the level of performance degradation is the same.

7.2.2.4 Design of repair

A repair design should be executed after selecting the repair method, the materials used and the level of repair. In the repair design, the types and combinations of repair materials, execution methods, and repair area or portion should be determined.

7.2.3 Execution

7.2.3.1 Execution plan

Before execution of repair, a detailed execution plan should be formulated in consideration of the execution environment, time of execution and execution period.
Repair shall be carried out with minimum disturbance to the surrounding environment and the service condition of the structure.

7.2.3.2 Quality control in execution

The effectiveness of repair is strongly affected by the quality of execution. Therefore, the execution of repair shall be carried out under the sufficient quality control based on the prescribed execution plan.

During the execution of repair, necessary tests shall be carried out on the materials and other related control items.

Detailed quality control records during the execution of repair shall be maintained for future reference.

7.2.3.3 Completion inspection

After repair, completion investigation shall be carried out to examine the condition of material and the execution method carried out, thereby confirming that repair in accordance with the repair plan was executed.

7.3 Other remedial actions

7.3.1 Strengthening

Strengthening of a structure refers to the remedial action taken to upgrade structural performance to a level which is higher than that possessed at the original design.

An appropriate strengthening plan shall be formulated based on the target level of performance, then methods and materials for strengthening shall be selected considering the degradation condition of structural performance, deterioration mechanism, and maintenance after strengthening.

Note: Strengthening includes (a) increase in the cross-sectional area of concrete, (b) addition of members, (c) increase in the supporting points, (d) addition of strengthening members, (e) application of prestress, etc.

7.3.2 Intensified inspection

Intensified inspection refers to the remedial action carried out by increasing the inspection frequency, number of inspection items and/or location for inspection without any improvement of the condition or performance of structure in cases where repair or retrofit cannot be implemented immediately or where it is only required to keep the structure in present state.

When intensifying inspection, the maintenance plan should be reviewed considering the results of performance evaluation, expected remaining service life, importance of structure, cost for maintenance, etc. and then, appropriate inspection frequencies and items should be determined.

7.3.3 Restriction in service

Restriction in service may be effective for reducing damage as a measure to impose some restriction on the usage, such as limiting the maximum live load that the structure may carry. The degree and method of the restriction imposed on the usage shall be determined depending on the level of deterioration observed, so that such a restriction shall be implemented after carrying out the detailed assessment.

7.3.4 Dismantling and removal

Dismantling and removal of a severely deteriorated structure/member shall be carried out based on an implementation plan for the selected method which is formulated in consideration of threat posed to the environment, public safety and disposal of debris.
7.4 Special care for emergency

Where a structure is considered to be unsafe on the environment, its users or any third parties, appropriate action shall be immediately implemented to make it safe before repair or other preservation work is undertaken, taking into account any additional risks that may arise from the repair work itself. Such action may include local protection or repair, the installation of support or other temporary work, or partial or even complete demolition.

In addition, plans for the following remedial action shall be formulated on the basis of the extent of deterioration, remaining design service life, remaining and desired structural performance for safety such as load bearing capacity, importance of the structure, the conservation level and previous remedial action taken.

8. Recording

8.1 General

Details concerning maintenance and repair shall be recorded. Such records as well as drawings and related documents shall be preserved for future references.

8.2 Period of preservation

The maintenance records of a structure shall be preserved while the structure is in service. It is also desirable that such the records should be preserved for a period as required for reference purposes in the design, construction, and maintenance of other similar structures.

Note: It is expected that analysis of records can contribute to progress in maintenance technologies by clarifying problems and needed improvements in design and construction.

8.3 Method of recording

8.3.1 Format of records and its accessibility

The records shall be preserved in an easily understandable format so that they can easily be referred to. Since the record is preserved for a long time, much attention should be paid to make it be accessible even when the data recording and storing system is changed.

8.3.2 Items included in records

The records shall include the following items:

-- basic data concerning immediate and nearby environment, details of structure, the methods and results of deterioration prediction and investigation carried out, the result of evaluation/judgment of the structure and photographs.

-- names of the persons responsible for maintenance

-- design drawings and specifications of construction

8.3.3 Records concerning remedial action

When remedial action is taken, records of the method used and details of execution shall be recorded together with the names of persons responsible for design, execution, and quality control of remedial actions.
Annex A

Appendix to Maintenance and Repair of Concrete Structures
– Part 1: General Principles –

A. Extended hierarchy of “Standards for maintenance and repair of concrete structures” with national legislation and other related ISOs

<table>
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<th>Product N</th>
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Part 1: General principles
ISO TC71 / SC7

Part 2: Assessment of existing concrete structures
ISO TC 71 / SC7
(Actions ISO TC98)

Technical Report: Assessment and repair of water leakage cracks
Technical Report: Seismic assessment and retrofit

Part 3: Design of repair and prevention
ISO TC71 / SC7
(Design of concrete structures ISO TC71)

Technical Report: Assessment and repair of water leakage cracks
Technical Report: Seismic assessment and retrofit

Part 4: Execution of repair and prevention
ISO TC71 / SC7
(Execution of concrete structures ISO TC71/SC3)

Technical Report: Assessment and repair of water leakage cracks
Technical Report: Seismic assessment and retrofit

LAW and Regulations
(National)

Basis of design
ISO TC 98

Technical Report: Seismic assessment and retrofit

Project Work
Specification for pricing
(National)
Annex B

Appendix to Maintenance and Repair of Concrete Structures
– Part 1: General Principles –

B. Hierarchy of terms

- Maintenance
  - Assessment
    - Prediction of performance
    - Evaluation of performance
    - Decision making
- Record
- Remedial action
- Repair
- Prevention
  - Strengthening
  - Intensified inspection
  - Restriction in service
  - Dismantling and removal

* ---- Not include in this standard
Annex C

Appendix to Maintenance and Repair of Concrete Structures
– Part 1: General Principles –

C. Category of maintenance

C1. General

For example, such important structures as dams and nuclear power plants have a long service life, and structures situated in very harsh environment (e.g. marine environment) may fall into a higher priority category than common structures such as multi-story buildings. Similarly, criteria for classifying structures into other priority levels need to be developed. Certain structures for which any maintenance action is very different to execute (e.g. underground structures) may be classified separately.

Consequently, maintenance actions should be classified into different categories depending on such factors as the importance of the structure, design service life, threat posed to third parties, environmental conditions, ease of maintenance and cost.

Maintenance actions are recommended to be classified into the following three categories: preventive maintenance, corrective maintenance and maintenance without any practical measure, as levels of maintenance work.

C2. Preventive maintenance

Maintenance is conducted based on preventive preservation. Structures in this category generally have a high degree of importance, requiring monitoring in many cases. Examples of structures classified into this category are as follows:

-- structures for which remedial measures are difficult economically and/or technically to be taken after deterioration becomes apparent

-- structures whose deterioration must not be apparent, such as monument

-- structures having a long design service life

C3. Corrective maintenance

Maintenance is conducted based on corrective preservation. In this category, maintenance is conducted to restore deterioration level and/or reduce deterioration rate so as to make structural performance satisfactory in the remaining design service life. Examples of structures classified into this category are as follows:

-- structures for which remedial measures can be taken after deterioration becomes apparent

-- structures for which apparent deterioration causes no immediate failure of satisfying performance requirements

C4. Observational maintenance
A visual inspection is only conducted in this category without any remedial action regardless of the deterioration level because the maintenance activities are economically and/or technically difficult. Examples of structures classified into this category are as follows:

-- structures for use as long as usable without any remedial actions except for the action to ensure the safety from threat posed to third parties

-- structures such as foundations, for which direct inspection is economically and/or technically difficult. The assessment and judgment can be made based on indirect inspection, such as land surveying, ground settlement measurement, and leakage detection. Another option is that such structures can be constructed such a way that “maintenance free” condition is achieved.
Annex D

Appendix to Maintenance and Repair of Concrete Structures
– Part 1: Framework and General Principles –

D. Category of assessment

D1. General

The maintenance procedure consists of various components; investigation, deterioration prediction, evaluation, judgment, remedial measures, and recording. In the procedure, a set of activities to predict the structure’s condition, which includes “investigation,” “deterioration prediction,” “evaluation” and “judgment,” is called as “assessment” in this International Standard.

The investigation in assessment is for collecting information on the performance of a structure. Based on the information by the investigation, the prediction of deterioration can be made, followed by the evaluation of structural performance at present and in the future. The judgment on whether the remedial action would be necessary is finally made considering the evaluation results.

On the basis of the methods used, frequency and timing of assessment, and the type of information desired, the assessment is categorized into three types as “initial assessment,” “periodic assessment,” and “extraordinary assessment,” for fulfilling the assessment on a structure rationally and economically.

In each assessment, occurrence of deterioration and/or change in its performance of a structure should be detected through investigation. Obviously if undesirable signs of deterioration can be detected in the early stage of deterioration, suitable, timely remedial action can be taken. Actual locations in a structure for investigation, tools used, items recorded, etc. should be carefully selected depending on the category of assessment, so that the necessary information can be obtained reliably.

D2. Position of assessments in maintenance activity

Position of assessments in the framework of maintenance actions for concrete structures is shown in Fig.D1.

D3. Initial assessment

D3.1 General

Initial assessment is defined as an assessment carried out for evaluating the initial condition of a structure before initiating into routine/regular maintenance activities.

Based on the results obtained in the initial assessment, the maintenance plan can be finally determined.

Information from the initial assessment can be used for subsequent planned periodic assessment as the initial information of structure.

Note Investigation in initial assessment allows the collection of basic data for initiating a maintenance program. The major purpose is to understand the initial condition related to the performance of the structure. This is important from the aspect of detecting initial defects and/or damage and defining the initial data for deterioration prediction.
D3.2 Types of initial assessment

The following three types of assessment are regarded as the initial assessment:

-- assessment carried out before a newly constructed structure is put into operation upon completion of construction

-- the first assessment of an existing structure carried out for the purpose of a maintenance activity

-- the first assessment of an existing structure which has been subjected to large-scale remedial actions and substantially renewed

D3.3 Method of investigation
As a first step of maintenance procedure, it is necessary to collect information on the structure by initial assessment. For a new structure, a provisional maintenance plan set in the design procedure should be revised based on the results in the "birth certificate." On the other hand, for existing structures, the inspection should be carried out to collect information on the structure. Based on the information, the maintenance plan can be finally determined.

One of the major aims of the investigation in the initial assessment is to collect the information detecting and disposing initial defects such as honeycombs, cold joint, sand streaking and so on, and some deterioration damage arising on the existing structures before starting maintenance activities. Therefore, when doing inspection, it should, in principle, be applied to the entire structure to check whether there are any defects or damages in the entire structure. However, when members of the structure located on the back of underground structures or under the foundation, the investigation may be based on the design record or construction records.

The investigation should include not only obvious inspection of external appearance of structure but also the ones for fluctuation of concrete quality, existence of construction defects in concrete, construction error on rebar arrangement, and so on.

### D3.4 Records and storing of result

The results of initial assessment should be appropriately records, as they provide useful data for the entire practice of maintenance.

### D4 Periodic assessment

#### D4.1 General

After the maintenance activities start on the structure, assessment of the structure should be fulfilled periodically at certain intervals according to a maintenance plan to evaluate the condition of the structure.

The aim of the periodic assessment is to provide information regarding the condition of the structure and its member under consideration, the causes for and the seriousness of any the deterioration. If necessarily, the investigation should be carried out to determine the current deterioration levels and rates, then, a target reliability level that represents the required level of structural performance should be ensured.

The periodic assessment is further categorized into two ones, which are “routine assessment” and “regular assessment.”

#### D4.2 Routine assessment

##### D4.2.1 General

Routine assessment shall be carried out on a routine basis at certain intervals mainly to detect the location and state of deterioration by only simple investigation methods, such as visual observation and hummer tapping, etc.

Routine assessment shall be fulfilled according to the maintenance plan. Normally, people having no special knowledge about maintenance carry out it, so that a manual, which the maintenance manager should formulate adequately, is required for maintaining the quality of assessment.

##### D4.2.2 Investigation in routine assessment

#### D4.2.2.1 Method

The methods of investigation in routine assessment include visual inspections by visual observation, photographs, videos and binoculars, and inspection by hammer tapping which may sometimes be used. The
visual observation is carried out for the whole of accessible parts, but hammer tapping is only carried out for a part capable of tapping.

The items checked by the investigation are as follows:

(i) cracking
(ii) delamination, peeling, spalling and scaling on the concrete surface
(iii) steel reinforcement exposure and corrosion
(iv) exudation of rust and efflorescence
(v) water leakage
(vi) any other discoloration

Investigation by driving feeling is effective to inspect the driving performance on bridges and other road structures, and could estimate abnormal displacement/deformation, abnormal sound/vibration and other conditions on expansion joint, extraordinary deflection and bumping.

D4.2.2.2 Location
The actual locations in a structure to be investigated in routine assessment should be basically those that can be inspected during routine patrol, but it is advisable that investigation should cover the locations as much as possible.

D4.2.3 Frequency of routine assessment
Routine assessment should be carried out frequently to confirm the absence of abnormality on the structure. The frequency should be appropriately determined in consideration of the workforce and/or budget, as well as the importance of the structure, the threat posed to third parties, and results of deterioration prediction.

D4.2.4 Records and storing of results
Routine assessment is frequently carried out, normally to confirm the absence of abnormality. Therefore, the record may be sufficient if the execution of inspection is indicated by the date/time and the name of the inspector. In a case when some abnormality is detected, however, the detected abnormal conditions should be added to the record in accordance with the manual for routine assessment.

D4.3 Regular assessment
D4.3.1 General
Regular assessment shall be carried out by using appropriate methods at regular intervals to observe closely on a whole of structure and to obtain more accurate information about signs of deterioration, which are difficult to gather during the routine inspection.

The items and frequency of the regular assessment should be appropriately determined. These should be determined in consideration of the category of maintenance, the relative importance of the structure and its members, past maintenance records, and results of deterioration prediction.

D4.3.2 Investigation in regular assessment
D4.3.2.1 Method
The investigation method in regular assessment should mainly be visual inspection or hammer tapping. In general, scaffolding for investigation becomes necessary in regular assessment since scaffolding permits close-range inspection, etc. Therefore, the inspection should be carried out not only by the simple methods, but also by using some other techniques, such as non-destructive testing methods, core drilling, etc.
The appropriate investigation methods used for the regular assessment shall be decided on the basis of such factors as the likely mechanism of deterioration, environmental conditions, the importance of the structure, and the category of maintenance.

D4.3.2.2 Location

The regular assessment basically should be carried out entirely on the structure. Careful investigation should be carried out for the location of the structure where defects are difficult to be detected during routine assessment. Sometimes, it is not easy to investigate large structures such as tunnel or viaduct entirely at one time. In this circumstance, it is possible to divide the location of investigation on the structure and inspect them in due order. Occasionally, it is advisable to decide the order or section investigated in consideration of existing maintenance records, importance of parts/members, or cost efficiency.

D4.3.3 Frequency of regular assessment

The frequency of regular assessment, which is normally every two to ten years, should be determined, in consideration of the results of deterioration prediction, importance and types of the structure, design service life, remaining service life, environmental conditions, maintenance category, existing maintenance records and cost efficiency.

D4.3.4 Records and storing of result

The regular assessment, which provides time series information of the structure, is useful for identifying the progress of deterioration and confirming the validity of deterioration prediction. For this reason, it is important to maintain accurate records, such as the inspection data, the name of inspector, and detailed drawings of defects.

D5 Extraordinary assessment

D5.1 General

Natural disasters such as an earthquake, strong storm or flood, fire, impact by a vehicle or ship, and so on have strong impacts on structures, their members and parts. Therefore, extraordinary assessment shall be carried out after a structure has been subjected to such the accidental loads, to examine the extent of the damage and the need for a remedial action.

When an accident due to deterioration of a structure, such as falling concrete fragment, is found, extraordinary assessment also shall be carried out not only for the structure itself but also for the similar type structures to check if the similar accident may occur.

It is advisable to consider carrying out extraordinary assessment in view of maintenance category, the importance of the member/part of the structure, structural performance, remaining service life and cost efficiency.

D5.2 Investigation in extraordinary assessment

D5.2.1 Method

The purpose of investigation in extraordinary assessment is to grasp the state of the structure or its members after it is subjected to a disaster or accident. Detection of damages is particularly important.

Investigation shall be carried out closely to the structure to obtain more accurate information. The appropriate tools for the investigation shall be decided on the basis of such factors as the cause and condition of damage/deterioration, environmental conditions, the relative importance of the structure and category of maintenance level.
Simple methods such as visual observation and hammer tapping are specified as the normal methods. Where instrumental inspection is relatively easily feasible and effective in detecting damage or other events, it is advisable to carry out instrumental inspection, if necessary, in consideration of the cost efficiency and degree of emergency.

**D5.2.2 Location**

The range to be investigated is the member of the structure with the risk of damage due to the disaster or accident. The part under the ground or foundation is often subjected to the load of earthquake, and sometimes the damage might be difficult to investigate.

**D5.3 Records and storing of results**

Items to be recorded in extraordinary assessment should contain the description of the unexpected event, purpose of inspection, the location and the conditions of damage, and so on, in addition to those for regular assessment.