

CHAPTER 3 BASIC PRINCIPLES FOR MAINTENANCE

3.1 Principles

(1) Structures shall be maintained according to the designated maintenance category by formulating a maintenance program to ensure that the structures retain the performance within the specified tolerances throughout their service period. The maintenance program shall include appropriate “initial inspection”, “prediction of deterioration”, “inspection”, “evaluation/judgment”, “remedial measures”, and “record”.

(2) In the maintenance of structures, in addition to carrying out appropriate evaluation and judgment at the time of inspection, evaluation and judgment shall also be carried out on the basis of prediction of deterioration throughout the planned service period.

(3) In the evaluation and judgment, required performance for the structure or its related members shall be defined, and the design service life shall be made clear.

(4) Appropriate prediction of deterioration and evaluation/judgment shall be carried out taking into consideration the maintenance category and the state of deterioration.

(5) In order to carry out the maintenance of structures appropriately, results from the design and construction, initial inspection, prediction of deterioration, periodic inspection, evaluation and judgment, and remedial measures shall be recorded and preserved.

[Commentary] (1): In general, not all structures are assured to maintain the performance within the specified ranges throughout the planned service period. The maintainer should therefore designate the maintenance category of the structure based on 3.3 “Maintenance categories and descriptions.” Maintenance should then be carried out by formulating a maintenance program and establishing a maintenance system that enables the maintainer to carry out appropriate initial inspection, prediction of deterioration, post-initial inspection, evaluation/judgment, remedial measures, and recording.

“Maintenance program” refers to comprehensive programming including the assumption of the maintenance categorization, initial inspection, determination of the maintenance category, and the time, frequency, and methods for prediction of deterioration, inspection, evaluation/judgment, remedial measures, and recording.

In the case of newly constructed structures designed and constructed appropriately, in general, deterioration and performance degradation do not become serious during the design service life. In this case, the structures can be maintained by only routine inspection and periodic inspection based on mainly visual observation, not by detailed inspection. However, in the case that the planned service period is set longer than the design service life, maintenance plan after the design service life should be made appropriately considering the possibility of deterioration.

For the maintenance plan, structural details, construction, and, material of the structure should be clarified. In the case of newly constructed structures, not only structural plan and construction

plan (including material) but also maintenance plan is introduced from the planning stage of structures, then, rational maintenance plan can be made utilizing the information for structural details, construction, and, material. Also, in the case of existing structures, obtaining such information at the initial inspection is vital for accurate prediction of deterioration and rational maintenance.

This specification treats the criterion easy to judge for maintenance, and then, planned service period and performance requirement should be clarified.

(2): In the maintenance of the structures, the required performance at the inspection and throughout service period should be evaluated by prediction of deterioration based on the inspections (initial, routine, periodic, extraordinary and detailed inspections). As described in this descriptions, this Specification is performance-based methodology, and should be systematized as a specification, having interrelation with Standard Specifications for Concrete Structures [Design], [Construction],

In order to carry out appropriate and deliberate maintenance, it is necessary to recognize the practical in-situ deterioration of the structure or the segments/members under the environmental conditions of the structure. It is also necessary to identify the deterioration level of the structure or segments/members in terms of the required deterioration. Moreover, judgment should be made as to how fast and by what deteriorating mechanism the structure or its segments/members reach the critical state in the planned service period .

In this Specification, “initial defects” are defined as cracking, honeycombs, cold joints, sand streaking, and other placement-induced defects; “damage” is defined as events that occur in a short time and do not progress over time, such as cracking and delamination by earthquakes and collision; and “deterioration” is defined as degradation process over time and treated differently from normal damage. Here the generic term for initial defects, damage, and deterioration is “defective events.” This Specification primarily covers deterioration, which causes performance degradation in segments/members of a structure over time. The estimation of the state of deterioration made at each stage such as construction, inspection, and repair/strengthening is referred to as prediction of deterioration, which is essential for evaluation and judgment of the performance of a structure. Deterioration in actual structures is induced by multiple deterioration parameters, with composite deterioration by multiple deteriorating mechanisms in some cases. It is therefore necessary to include an appropriate safety factor.

Prediction of deterioration comprises evaluation and judgment of performances for the following purposes:

- Estimate whether or not the performance of the structure fulfills the required level during the planned service period.
- Estimate the remaining service life of the structure.
- Judge whether or not detailed inspection/remedial measures are required.

(3): The performances required of a structure vary depending on the purpose of the structure, and the performances required of each segment/member of a structure differ from one another. It is necessary to appropriately classify and define such performance requirements as a premise for evaluation and judgment of the performance of a structure.

(4): Items (1) to (3) describe the basic idea of the sequence of maintenance by the

performance-based methodology. However, individual technologies are not mature enough for carrying out ideal maintenance in accordance with this methodology for the wide variety of environmental conditions in which actual structures are placed and the complex deterioration actually occurring in such structures. For this reason, prediction of deterioration, evaluation, and judgment are performed by the currently practiced methods.

In short, prediction of deterioration, evaluation of performance and its judgment, which are the core of maintenance, is to clarify the evidence for the evaluation and judgment, and are vital requirements even in any levels of methodology. For recent research levels, there are large differences between the evaluation of deterioration of concrete or reinforcement itself and the performance of concrete structures, and its relations have not been clarified. Therefore, it is desirable to collect the data from detailed investigations of the structures, in which service period of the structure has been finished, for future maintenance. Especially, evaluating the safety performance such as load bearing capacity of the structures, which is difficult to assess in service period, is quite important to improve the maintenance technology

(5): Records of the design, construction methods, and results of initial inspection, prediction of deterioration, post-initial inspection, evaluation/judgment, and remedial measures should be stored in an easily accessible form for later reference for maintenance. This is necessary for reasonable maintenance.

3.2 Maintenance procedure

Maintenance of structures shall be carried out using an appropriate combination of initial inspection, prediction of deterioration, inspection, evaluation and judgment, remedial measures and record-keeping.

[Commentary] Fig.C3.2.1 shows a standard procedure of maintenance on a structure.

Since the durability and the service life of a structure are generally unknown, it is necessary to assume maintenance categories for a newly constructed structure at the design stage and carry out initial inspection prior to its use as the first step of maintenance to collect information on the structure. It is also necessary to determine the maintenance categories and carry out maintenance by reasonably combining prediction of deterioration, evaluation/judgment, remedial measures, and recording.

For an existing structure, maintenance should be carried out similar to the case of a newly constructed structure by assuming the first inspection to be the initial inspection and designating the maintenance categories based on the collected information on the structure. When large-scale remedial measures are taken for a newly constructed or existing structure, the maintenance categories should be reviewed, and initial inspection should be carried out. For the subsequent inspection, the state before remedial measures and the methods of remedial measures should be investigated as well.

Besides above mentioned the initial inspection and prediction of deterioration, a standard procedure of maintenance consists of inspection, performance evaluation and judgment, remedial measures, and, record. And the standard maintenance is determined corresponding to the maintenance category, considering importance of structure, hazards for third party, environmental condition, and so on. In the cases that deteriorating mechanism is difficult to be identified, remedial

measures is usually determined by engineering judgment. Prior to the judgment, frequent inspections are helpful for the rational measures.

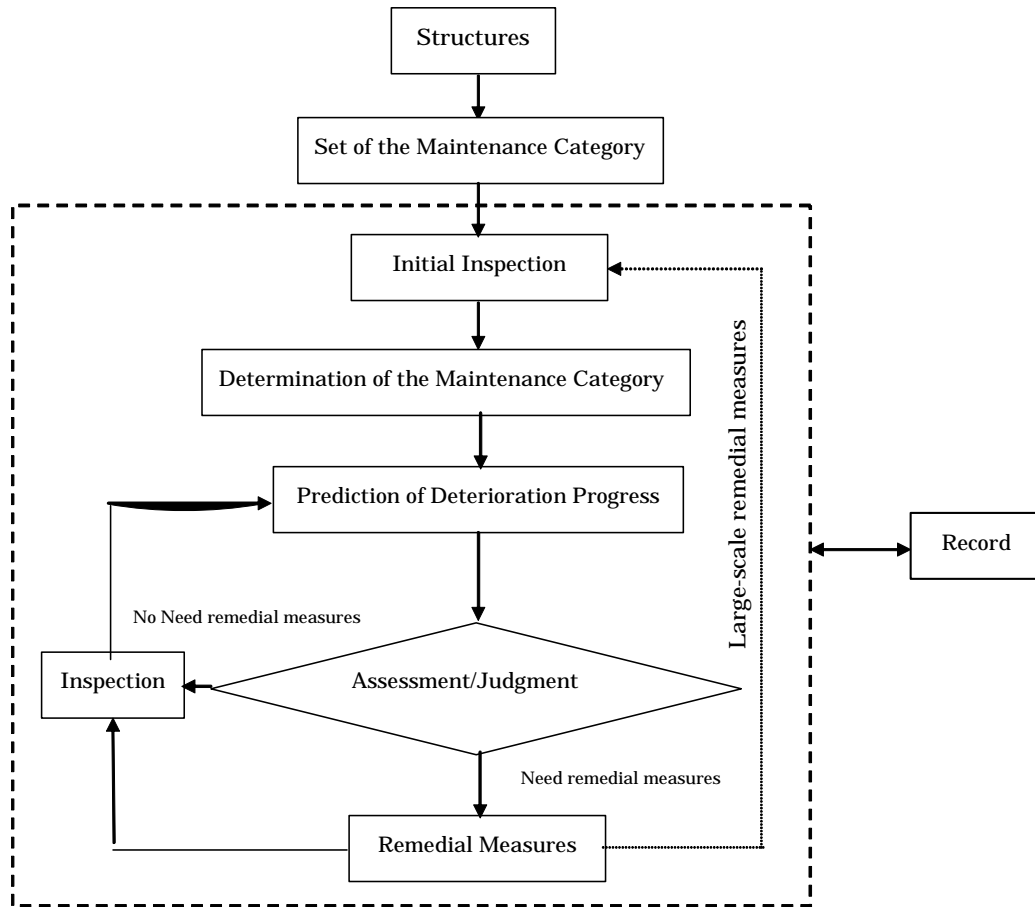


Figure C3.2.1 Standard procedure of maintenance on a structure

Composition of this Specification: This Specification consists of two parts. **Part 1** “Maintenance” provides the basic idea of maintenance; **Part 2** “Standards for Maintenance” provides the standard concept of maintenance for each deteriorating mechanism. Fig.C3.2.2 shows the composition of the Specification. As shown in the figure, this Specification is configured to enable the reader to refer to the maintenance standard for each specified deteriorating mechanism in **Part 2**. The cause of deterioration is identified by the estimation of the deteriorating mechanism provided in **Chapter 4** during the deterioration prediction stages of initial inspection, routine inspection, periodic inspection, and detailed inspection provided in **Chapters 5 to 8** in **Part 1**. **Part 2** provides the methods of deterioration prediction, inspection, and evaluation/judgment of the results of inspection, as well as remedial measures and recording, for each deteriorating mechanism. These can be referred to at each stage of maintenance given in **Part 1**. Since initial inspection, routine inspection, and periodic inspection are primarily based on visual observation, and also it is difficult to predict deterioration based on the Deteriorating mechanism, the relation between **Part 1** and **Part 2** is shown by broken lines. Where the deteriorating mechanism is unknown, detailed inspection should be carried out, if necessary, as shown in the figure to identify the deteriorating mechanism.

Part 1

Part 2

“Maintenance Fundamentals”

“Maintenance Standard”

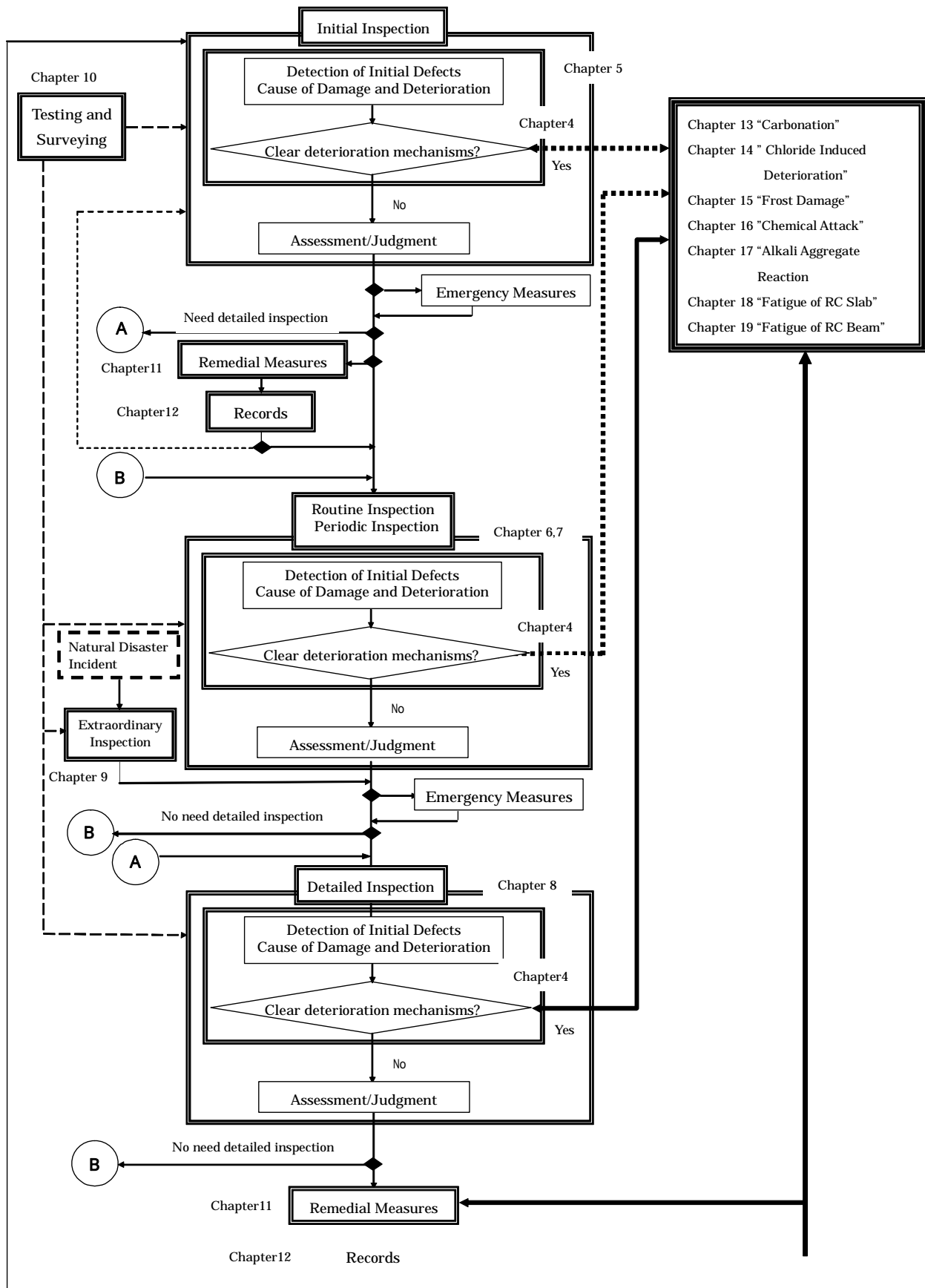


Fig.C3.2.2 Flow of maintenance and structure of this standard specofocation