

CHAPTER 5 INSPECTION OF EXISTING STRUCTURES

5.1 General

- (1) An inspection shall be performed of existing structures for which retrofitting is being studied, in order to gather data needed to evaluate the various performance values of the structure at the time of retrofit design.
- (2) Inspections shall consist of two types: document checks and site inspections.
- (3) When inspecting structures, the study shall be conducted in accordance with the retrofitting method whose employment is being considered.

[Commentary]

(1) The need for retrofitting of an existing structure should be judged based on whether or not that structure fulfills performance requirements. Accordingly, the data needed to evaluate the performance of the existing structure should be gathered through inspections of that structure. When performing inspections, it should be kept in mind that quantitative data for calculating the dynamic performance of the structure is required to evaluate the various performance values. Particularly when deterioration or damage to the existing structure caused by salt damage, neutralization, freezing damage, alkali aggregate reaction, chemical concrete corrosion and fatigue has been confirmed through a primarily visual inspection, detailed reference materials regarding the deterioration of the structure can be obtained by performing a detailed inspection; see Chapter 4 "Inspections" in the Maintenance Guidelines (draft). However, deterioration from steel corrosion caused by salt damage and neutralization may have progressed even if no signs are apparent on the surface of the structure. Therefore, a detailed inspection must be performed if, considering the surrounding environment, the steel may be corroded.

For inspections in which retrofit is being considered to correct deterioration or damage caused by load action or environmental action, the inspection should consist of daily and periodic inspections up to the time at which the retrofitting study is conducted, and more detailed inspections based on the results of these daily and periodic inspections, in accordance with Chapter 4 "Inspections" in the Maintenance Guidelines (draft). When urgent situations must also be considered in the retrofitting of the structure, for example earthquakes, weathering or other natural damage or fire and collisions with motor vehicles, ships and so on, spot inspections should be conducted to gather as much data as quickly as possible. If retrofitting is being studied due to changes in the design load and as an earthquake proofing measure, the current status of the structure should be determined through prior inspections and more detailed site inspections performed later as needed.

(2) When studying retrofitting of structures, a document check should be performed first to obtain a general overview of the structure by organizing the design documents at the time the structure was built and, when necessary, the results of visual inspection and so on. Ambiguities or questions encountered in the document check should be cleared up through a detailed inspection at the site. This is done to enable as accurate an evaluation as possible of the performance of the structure at the time of the retrofitting study.

(3) Studies specific to the retrofitting method to be employed must be performed after the method has been selected. However, normally at the design documentation check and site survey stage, data needed to study the possibility of using the candidate retrofitting methods is gathered. Through these studies it is important to gather the data needed to determine whether or not each retrofitting method can be used and draft a construction plan.

5.2 Inspection Method

- (1) The document check shall be performed based on the design documents at the time of construction, the design documentation for repair and retrofitting work performed up until the time of the retrofitting study, and the results of visual inspection.
- (2) Site inspections shall be based on the results of the document check and shall cover the external appearance, surface, interior and surrounding environment of the structure.

[Commentary]

(1) In the document check, the date of design and construction, applicable standard, structural form, design conditions (material conditions, load conditions, etc.) foundation conditions and other matters should be identified. The document check also serves as a preliminary survey for a detailed inspection at the site. If the structure is one for whose performance would be difficult to evaluate from the results of daily inspections, periodic inspections and other primarily visual inspections, a plan for a detailed site inspection must be prepared. If no problems with the structure were discovered in the inspections conducted up to the time of the retrofitting study, the items in the detailed site inspection may be limited. From predictions of deterioration and damage in accordance with Chapter 3 "Predicting Deterioration" in the Maintenance Guidelines (draft), the possibility and degree of deterioration and damage caused by load action or environmental action on the structure in question can be predicted to some extent. If daily and periodic inspection records cannot be obtained, a visual inspection may be performed and the results added to a determination of the present status of the structure before conducting the detailed inspection at the site. If various types of monitoring are currently being performed for the structure, this data may also be used as reference. If repair and retrofitting work has already been performed for the structure, the relevant reference materials should be studied as well to determine the reason that retrofitting must again be considered. These procedures are necessary because they will aid in the selection of retrofitting materials and maintenance of the structure after retrofitting. **Table C5.2.1** shows the items for the document check in the case of retrofitting a bridge.

Table C5.2.1 Sample of document check items (bridge)

Type of Study	Study Item
Time of design / construction	Time of design / construction and age of structure
Applicable standard	Type of applicable standard
	Date enacted
Type of structure	Class
	Type of bridge
	Span length
	Bridge length
Type of structure	Lane width
Design conditions	Load conditions
	Material conditions (material strength, etc.)
	Section dimensions
	Steel reinforcements (diameter, quantity, placement, stress level, etc.)
Foundation conditions	Support conditions
	Geology and topography
Visual inspection records	Existence of, and location of, deterioration and damage
Other	Repair/retrofitting history
	Location of annexed structures and construction status

When detailed design documentation such as design documents and design calculations are available, it is possible to confirm the detailed specifications on the placement of reinforcing bars and the like, load action assumed during design and models of member characteristics. When detailed design documentation is not available, the ratio of reinforcement, load action during design and models of member characteristics can be deduced in many cases by determining standards of conformance to the shape and size of the structure.

(2) Even from the document check alone, it is possible to gather the data needed to evaluate the performance of the structure. However, since the design documentation may not match the current status of

the structure, performing an inspection at the site is recommended. In the site survey of the structure, the conformance to the design documentation, the actual environmental conditions at the structure, the degree of structural deterioration and damage (peeling, cracking, displacement etc.), the properties of the materials in the structure, and problems in implementing retrofitting work should be identified. Compared to visual inspections, detailed inspections at the site will require much more work, so the objectives of the inspection should be clarified and the inspection performed using an appropriate method for achieving these objectives. If no problems with the structure were discovered in evaluations during the daily and periodic inspections up to the point at the retrofitting study, the items required for the detailed inspection may be limited. For the items in detailed inspections of structures for which deterioration and damage has been discovered, and for spot inspections that are urgently required, refer to Chapter 4 "Inspections" in the Maintenance Guidelines (draft).

Table C5.2.2 shows sample survey items for site inspections covered by these (draft) guidelines, relating to surveys of structure safety, serviceability and restorability. Practical examples of survey items that are particularly necessary when evaluating load-carrying capacity are contained in Chapter 5 "Evaluation and Judgement" in the Maintenance Guidelines (draft).

The survey items generally included in site inspections are as follows:

1. Visual survey

From the external appearance of the structure, peeling, cracking status, rust fluid and free lime and the like can be surveyed. This corresponds to the daily and periodic inspections performed for ordinary structures. It is also conducted as needed before performing a detailed inspection. Primarily qualitative data is obtained through this type of survey; it would be most effective if this data could be reflected in performance evaluations of the structure.

Table C5.2.2 Sample survey items for site inspection

Type of Survey	Survey Item	
Conformance to design documents	Survey items in Table C5.1.1	
Survey of load and environmental conditions	Geographical conditions	Installation site / climatic conditions
	Traffic conditions	Amount of traffic, percentage of heavy vehicles, vehicle weight, road network
	Vibration / noise	
Survey of external appearance	Cracking status	Cracking location / width / density
	Defects	Concrete peeling, etc.
	Displacement / deformation	
	Rust fluid, free lime, discoloration, leakage of water	
Survey of interior	Performance of materials in structure	Concrete strength and modulus of elasticity / reinforcement strength and modulus of elasticity
	Reinforcing bar arrangement	Diameter / number / pitch / location
	Covering	
	Concrete deterioration	Interior cavities / depth of freezing damage
	Steel corrosion	Occurrence, percentage of steel section loss, natural displacement / polarization resistance / grout status
	Factors causing steel corrosion	Concrete neutralization depth / distribution of chlorides
Other	Foundation conditions	Support conditions / geology / ground water level
	Annexed structures	Location / construction status

2. Survey performed by means of chipping

This enables the concrete covering, neutralization depth, reinforcement corrosion etc. in particular to be surveyed.

3. Survey performed by means of test sampling

Test samples are taken from the structure and subjected to various types of analysis. This enables concrete strength, modulus of elasticity, neutralization depth, carbide ion content, reinforcement strength etc. to be surveyed.

4. Survey performed by means of nondestructive test

This is performed over a wide area in the structure and enables concrete internal defects (cavities, etc.), peeling, covering thickness, reinforcement positions, grout fill status etc. to be surveyed.

When highly reliable prediction methods can be used to predict the status of the materials in the structure, considering the history of load action and environmental action since the structure was built, these may be used in place of a portion of the inspections at the site.

If considerable damage or unexpected damage is discovered in site inspections, a detailed inspection including determination of the cause must be performed when necessary. Particularly with damaged structures, appropriate surveys for each objective must be implemented in sequence as needed: surveys with the objective of implementing emergency measures to prevent secondary disasters, surveys done to temporarily restore some of the functions, and surveys for permanent restoration.

(1)(2) In document checks and site inspections, surveys of items related to the retrofitting methods being considered are also performed. The inspection items relating to the external cable construction method, bonding and jacketing construction method and overlaying and jacketing construction method are described below.

External cable construction method

When studying the use of this method, it is necessary to check in the survey of geographical conditions to see whether or not there is enough space to place the external cables. In the external appearance survey, the placement of anchorage sections and deviators must be kept in mind and potential positions selected, and a survey of the status of cracking in the concrete surface at those locations and the presence of free lime and rust fluid, etc. must be conducted. In the interior survey, holes must be drilled in most cases to install the anchorage sections and deviators, so the arrangement of reinforcements must be surveyed without cutting the reinforcements and internal cables placed in the existing structure. The anchorage sections in particular are generally placed near the member edge where reinforcements and internal cables are grouped together, so the methods of taking x-rays and exploratory drilling must be used to check the difference between the placement status in drawings and the actual placement status. The strength of the concrete at the potential placement positions for the anchorage and deviators must also be surveyed.

Bonding and jacketing construction method

With this method, if the deterioration of the concrete surface is considerable, the bonding of the reinforcement and concrete cannot be confirmed and the retrofitted structure may not fulfill performance requirements. Depending on the status of damage of the bonding surface, measures performed may include removal of the embrittled portions of the concrete before bonding, filling of cracks, waterproofing measures, section repair or partial paving reconstruction. When anchors are used to fasten the reinforcing materials, the reinforcement positions must be checked to ensure that the anchors do not cut the reinforcement in the existing concrete structure. Accordingly, with the bonding and jacketing construction method, the strength of the surface layer of the concrete on the bonding surface, the status of dirt and cracking on the bonding surface, the presence of rust fluid, free lime or leakage of water, floating and peeling of the covering concrete and other factors relating to the status of the concrete surface and the actual placement locations of the reinforcements should also be surveyed.

Overlaying and jacketing construction method

For this method, fundamentally the same survey as for the bonding method must be performed. In addition, with the upper surface overlaying method, the following surveys are crucial:

1. In order to bond the existing and overlaying sections, the water-resistant layer must be removed completely, so a thorough check must be made to see whether or not there is any waterproofing.

2. Even if there is nothing wrong with the appearance of the paving, the levelness of the paving with the upper surface overlaying sections must be ensured, so the range of longitudinal correction before and after thickness addition must be examined.
3. The number of sections and additional vertical girders added to decks should be examined. If these differ from other bridges, the damage status of the deck at the time the vertical girders were added may have been different. Depending on the status of damage, it may be difficult to use the upper surface overlaying method.