THE PROJECT FOR CAPACITY DEVELOPMENT ON BRIDGE MAINTENANCE AND MANAGEMENT IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

BRIDGE INSPECTION AND DIAGNOSIS MANUAL (DRAFT VERSION JANUARY 2024)

VERSION 1.0

JAPAN INTERNATIONAL COOPERATION AGENCY

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FOREWORD

This manual was prepared under the JICA sponsored Project for Capacity Development on Bridge Maintenance and Management in Lao PDR for the purpose of mainstreaming preventive bridge maintenance and management in Laos. The manual was designed and adopted fully referring to Bridge Inspection Manual developed by Nagasaki Prefecture and the other Japanese Bridge Inspection Manuals.

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Chapter 1 General Provisions

1. Application of Manual

This manual (ver. 1.0) is applied to inspection works of road bridges along the National Roads managed by Department of Roads, MPWT and DPWTs.

【Notes】

This manual is applied for an inspection works to road bridges along the National Roads managed by Department of Roads, MPWT and DPWT of each province. Bridge maintenance work generally consists of a combination of inspection including routine inspection (regular road patrols for bridges), periodic inspection, inspection at extraordinary conditions, and measures after inspection such as follow-up surveys, detailed investigations, maintenance work. Among these, this manual covers the routine inspection, the periodic inspection (Inspection A and Inspection B) and the inspection at extraordinary conditions.

The periodic inspection is composed of two inspection methods: Inspection A aims to grasp the conditions of main members of the bridge against typical damages and is conducted annually for entire bridges along National Roads and the result of inspection is consolidated into the Bridge Management System in order to prioritize the bridges for repair and maintenance works and develop the short and long term investment plans. On the other hand, Inspection B aims at grasping more detailed conditions of all bridge members, comparing to those acquired by Inspection A, and is conducted for the severely deteriorated bridges along National Roads when it is necessary as the pre-inspection prior to the repair and maintenance works.

2. Overall Structure of Inspection

Inspection is conducted in bridge maintenance first. The inspection is the most important process to retain the life of the bridge for a long time.

【Notes】

Bridge maintenance work generally consists of a combination of inspection including routine inspection (regular road patrols for bridges), periodic inspection, inspection at extraordinary conditions, and measures after inspection such as follow-up surveys, detailed investigations, maintenance work, etc. Among these, this manual covers regular inspection, periodic inspection (Inspection A and Inspection B) and inspection at extraordinary conditions. In addition, the bridge structure and its member etc. are presented in “Appendix-1 Basic Content of Bridge”.

Periodic inspection is composed of two inspection methods: Inspection A aims to grasp the conditions of main bridge members and is conducted annually for entire bridges along National Roads and the result of inspection is consolidated into the Bridge Management System (BMS) in order to prioritize the bridges for repair and maintenance works and develop the short and long terms investment plan. On the other hand, Inspection B aims at grasping more detailed conditions of the bridge members, comparing to those acquired by Inspection A, and is conducted for the severely deteriorated bridges along National Roads when it is necessary as the pre-inspection prior to the repair and maintenance works.

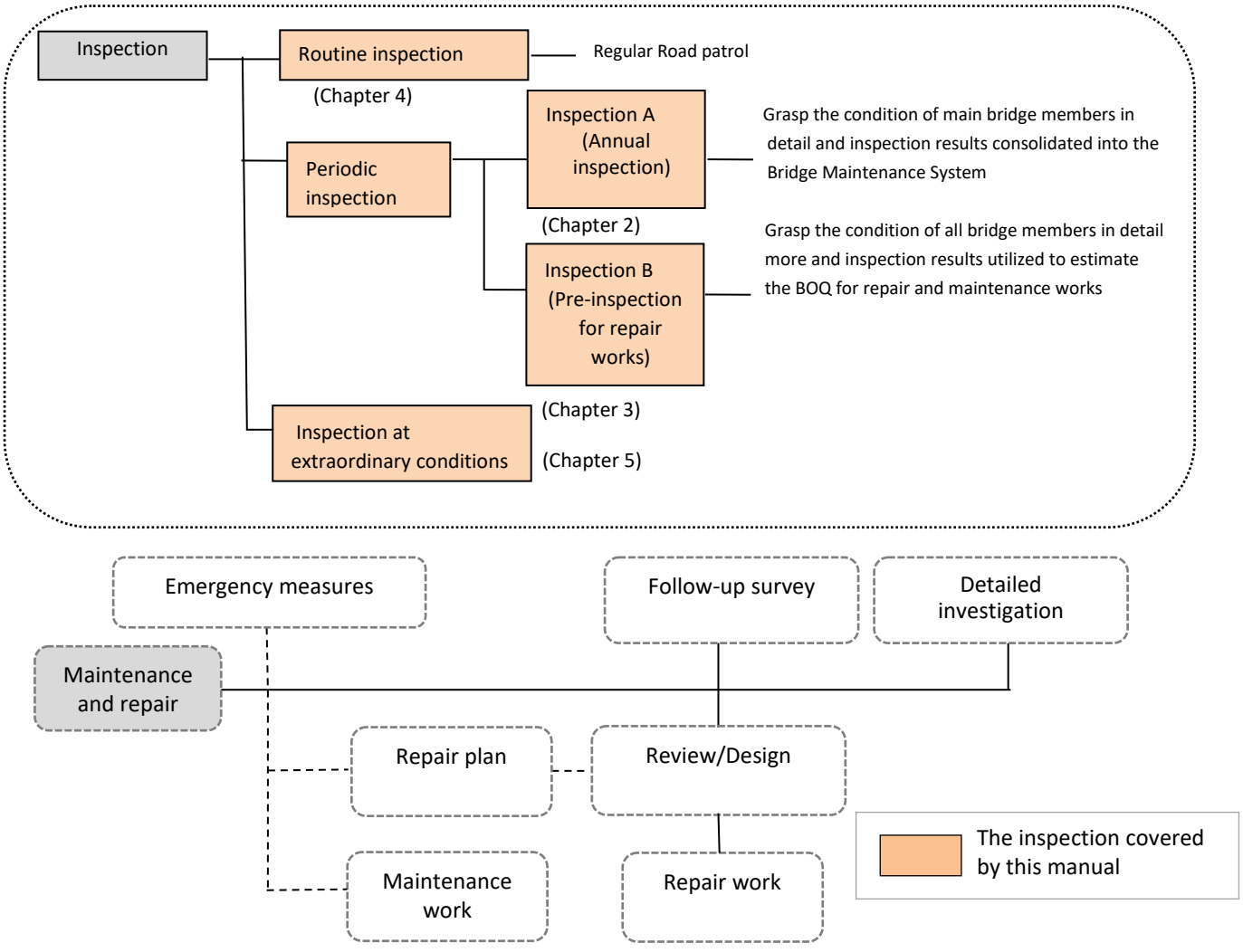


Figure 1.2.1 Structure of inspection, maintenance, and repair works in bridge management

3. Objective and Purpose of Inspection

The fundamental objective of the bridge inspection is to realize the preventive bridge maintenance to minimize the life cycle cost of the bridges. To do so, part of purpose of bridge inspection includes to continuously maintain bridges in good condition and ensure safe and smooth traffic by grasping the current status of the bridges as part of the road maintenance work and finding damage that could affect safety, load-bearing capacity, and durability of the bridge as early as possible. It also aims to conduct efficient maintenance works by accumulating information obtained from the inspection results.

【Notes】

This section shows the general purpose of bridge inspection. The primary purpose of bridge inspection is to grasp the current condition of the bridge to be managed, to detect damage that is adversely affecting the safety and usability of the bridge at an early stage, and to take appropriate measures to ensure safe and smooth traffic.
The second purpose is to accumulate basic information for efficient maintenance, and to conduct effective inspection and planned repairs and reinforcements continuously.
In addition, by analyzing the accumulated inspection results, structural problems and improvements from the viewpoint of maintenance and management will be clarified; these are expected to be reflected in the construction of more durable bridges.

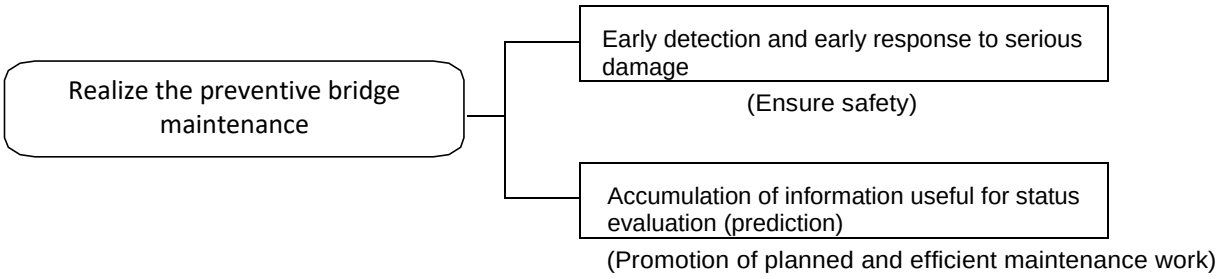


Figure 1.3.1 Objective and purpose of bridge inspection

4. Type of Inspection

The types of inspection are as follows.

(1) Routine inspection

Regular inspection is the inspection of bridges that are carried out as daily or regular road patrols with the primary purpose of ensuring traffic safety.

(2) Periodic inspection

Periodic inspection is performed periodically to maintain the bridge; the purpose is to grasp the condition of all the members of the bridge in detail. Basically, close visual inspection shall be carried out, and inspection machines and equipment. The periodic inspection standards are composed of "Inspection A" focusing on seven (7) types of damage of main members of the bridge and "Inspection B" more detailing the type of all twenty-six (26) types of damage of all members of the bridge.

(3) Inspection at extraordinary conditions

This refers to an emergency inspection mainly performed to confirm traffic safety during/after any extraordinary weather such as a typhoon, torrential rain, etc. occurs.

【Notes】

(1) Routine inspection is generally carried out by visual inspection from inside a vehicle as regular road patrols, and damage that cannot be observed from inside the vehicle shall be checked by periodic inspection. Daily or routine inspection, however, is indispensable for good maintenance and repairs; therefore, it is desirable to carry out visual inspection on foot during the patrol.

(2) It is ideal to grasp the current state of all members in detail through periodic inspection. However, it takes an enormous amount of time and money to inspect all members in detail, and it is not realistic considering the present management system and state of damage. Therefore, this manual specifies the inspection standards for two inspections: Inspection A and Inspection B.

i) Inspection A

Inspection A focuses on seven types of damage from the viewpoint of frequency of occurrence, etc., and checks the state and extent of those types of damage to major members and checks the presence of serious damage to other members. The purpose is to inspect numerous bridges economically and to maintain them in an efficient manner in combination with Inspection B.

ii) Inspection B

The aim of Inspection B is to grasp the details of the damage that has occurred on all members in detail; each part of the bridge shall be visually inspected at a very close distance so as to be able to observe the detailed damages and grade. In Inspection B, 26 types of damage shall be checked.

iii) Target members

The target members for each inspection are as follows.

Table 1.4.1 Target members for each inspection

Component	Member		Routine inspection	Periodic inspection		Inspection at extraordinary conditions
				Inspection A	Inspection B	
Superstructure	Deck		D	A	A	D
	Main structure		D	A	A	A
	Other than deck and main structure	Main member	D	D	A	A
		Non-main member	D	D	A	A
Substructure	Body		D	A	A	A
	Foundation		A	A	A	A
Bearings	Bearing body		D	B	A	A
	Shoe seat		D	B	A	A
	Bridge fall prevention device		NA	D	A	A
On the road	Railing, Guard fence		A	B	A	A
	Noise barrier		C	D	A	A
	Lights, Traffic signs		A	D	A	A
Road surface	Wheel guard		A	B	A	D
	Pavement		A	B	A	D
	Expansion joint		A	B	A	D
Others	Drainage facility		A	B	A	A
	Inspection facility		NA	D	A	A
	Accessories		NA	D	A	A

A: Mainly close visual inspection (Damage status)
B: Mainly close visual inspection (Presence/absence of serious damage)
C: Mainly visual inspection from a distance (Damage status, presence/absence of serious damage)
D: Take a photo if extraordinary condition may have developed
NA: Not applicable

- Periodic inspection shall cover all members of all spans and as a rule, visually inspect by approaching as close as possible to members using ladders, scaffoldings [if possible, inspection vehicles], etc. In the situation of obtaining the same visual accuracy, indirect inspection equipment [such as UAVs, pole cameras and self-running cameras] are possible to apply as close visual inspection.
- As for Inspection A, it should be noted that the soundness of the bridge shall be evaluated by each span and it is a precondition to complete all seven types of damages for each bridge member composed of each span to evaluate the span-wise bridge soundness. Since Inspection A allows a long distant inspection, the invisible damage, bridge member/component and span shall be recorded as NA (not available).
- Defects on railings, guard fences, wheel guards, median strips, pavements, noise barriers, lightings, and traffic signs have a direct effect on traffic safety; therefore, it is necessary to keep them in good condition not only by periodic inspection but also through routine patrols.

iv) Grasping of the condition against damages

Basically, the condition of damaged items is grasped by close visual inspection of all members. In addition, if necessary, non-destructive testing (NDT) such as palpation and tapping sound is also performed. Methods of application on tools/equipment of various NDTs are presented in Appendix-6.

The standard method of grasping the condition for damaged items is shown in Table 1.4.2.

Table 1.4.2 Standard method of grasping condition

Material	Type of damage		Standard method	Examples of methods that can be adopted according to needs and purposes
Steel	01	Corrosion	Visual, Caliper, Test hammer	Thickness measurement with the ultrasonic thickness meter
	02	Cracks	Visual	Magnetic particle testing, Ultrasonic flaw detecting testing, Eddy current testing, Penetrant testing
	03	Loose, Drop off	Visual, Test hammer	Checking the bolt head mark, hammering test, Ultrasonic flaw detecting testing, Axial force meter
	04	Fracture	Visual, Test hammer	Hammering test (bolt)
	05	Degradation of anti-corrosion performance	Visual	Photos (image analysis), Impedance measurement, Film thickness measurement, Adhesion test
Concrete	06	Cracks	Visual, Crack gauge	Photos (image analysis)
	07	Peeling, Exposure of rebar	Visual, Test hammer	Photos (image analysis), hammering test
	08	Leaching, Free lime	Visual	–
	09	Fall off	Visual	–
	11	Cracks on slab	Visual, Crack gauge	Photos (image analysis)
	12	Spalling	Visual, Test hammer	Hammering test, Infrared inspection
Other	13	Extraordinary gap	Visual, Measure	–
	14	Rough road surface	Visual, Measure, Pole for measurement	–
	15	Extraordinary pavement	Visual, Measure or crack gauge	–
	16	Lack of bearing function	Visual	Moving amount measurement
	17	Others	Visual	–
Common	10	Deterioration of repair/ reinforcement material	Visual, Test hammer	Hammering test, Infrared inspection
	18	Extraordinary anchorage	Visual, Test hammer, Crack gauge	Hammering test, Infrared inspection
	19	Discoloration, Degradation	Visual	–
	20	Water leakage, Surface ponding	Visual	Infrared inspection
	21	Extraordinary sound/vibration	Hearing, Visual	–
	22	Extraordinary deflection	Visual	Surveying
	23	Deformation, Loss	Visual, Leveling line, Measure	–
	24	Sediment clogging	Visual	–
	25	Subsidence, Displacement, Inclining	Visual, Leveling line, Measure	Surveying
	26	Scouring	Visual, pole for measurement	Colored imaging sonar, Underwater camera

v) Maintenance system and work descriptions

The concepts and contents of inspection in the bridge maintenance system are as follows.

Table 1.4.3. Bridge inspection and maintenance and work descriptions

Inspection			Purpose	Frequency and timing	Method	Target member
Bridge inspection	Routine inspection		Early detection of damage	Every four months	Visual inspection from inside of vehicle（on foot if necessary）	Members on the surface that can be observed from inside of vehicle
	Periodic inspection	Inspection A	Confirmation of the soundness of the bridge as a whole	Once a year (standard)	Close visual inspection	Main members of all spans
		Inspection B		As required for deteriorated bridges	Close visual inspection	All members of all spans
	Inspection at extraordinary conditions		Confirmation of the safety of the bridge after extraordinary weather, etc.	Every time an extraordinary event occurs	Visual inspection from a distance	Members with abnormality
Maintenance and repair	Emergency measures		Emergency measures for damage that may cause injury to third parties	Immediately after finding damage	－	All members
	Repair plan	Follow-up survey *1	Survey on damage whose progress needs to be monitored	Decided in repair plan	Close visual inspection	Members need to be surveyed
		Detailed investigation *2	Identify damage causes and grasp damage details	Decided in repair plan	Use equipment/tools and NDTs, etc.	Members need to be investigated
		Review and design of repair	Review the damage to be repaired and design repair work	Conduct based on the repair plan	－	All members
	Repair work		Recovery of the soundness of the damaged part	Conduct based on the repair plan	－	All members
	Maintenance work		Recovery of the soundness of the damaged part	Conduct in annual maintenance work plan	－	All members

*1: Follow-up surveys are conducted to monitor damage that may progress rapidly and need to be continued after routine inspection; therefore, it is classified in the "Maintenance and repair" category in this table. A follow-up survey shall be conducted once a year after selecting bridges and determining the content of the survey.

*2: Detailed investigations are conducted to identify the cause of damage and to grasp the degree of damage in detail. It is classified in the "Maintenance and repair" category because it is desirable to conduct the investigation together with "Review and design of repair" rather than conducting it alone in order to examine effective repair methods and repair areas based on using equipment/tools and NDTs, etc.

(3) Inspection at extraordinary conditions

This refers to an emergency inspection mainly performed to confirm traffic safety after extraordinary weather such as a typhoon, torrential rain, etc. occurs. The target members to be inspected depend on the type of extraordinary event; however, the damage to the bridge surface, foundation of substructures, bearings, expansion joints, bridge fall prevention devices, etc. shall be the focus for ensuring traffic safety.

5. Frequency and Standard of Inspection

The frequency of periodic inspection A is basically once a year. However, the severely deteriorated bridges required for urgent repair or replacement shall be inspected more often as necessary until the repair or replacement work is implemented.
Inspection must be conducted in the previous year of repair/strengthening or replacement in order to review the measures.

【Notes】

(1) The periodic inspection of the bridge in general shall be conducted every 5 years in other countries. This manual recommends periodic inspection A shall basically be conducted once a year in Laos, reflecting to the evidence that the bridge deterioration may be escalated due to external factors such as poor-quality control of the infrastructure during its construction works and uncontrolled overloading trucks. The poor-quality of inspection results also may become one of the reasons that the periodic inspection A should be conducted annually.

(2) However, if external factors to accelerate bridge deterioration is addressed and the quality of inspection results is ensured, the periodic inspection A will be desirable to conduct periodically say every 5 years as shown in table below based on the sample of Japan. It is important to review the frequency and system of the inspection depending on the damage condition and management standards.

Table 1.5.1 Inspection frequency commonly applied in Japan

Soundness	Replacement	Early repair	Preventive repair	Repair is not required for the time being
Inspection frequency	Every year	Once every two years	Once every five years	Once every five years
After 1 year	Inspection			
After 2 years	Replacement	Inspection		
After 3 years		Repair/Strengthening		
After 4 years				
After 5 years			Inspection	Inspection
After 6 years			Preventive repair	
After 7 years	Inspection			
After 8 years		Inspection		
After 9 years				
After 10 years				Inspection
After 11 years			Inspection	
After 12 years	Inspection			
After 13 years		Inspection		
After 14 years				
After 15 years				Inspection
After 16 years			Inspection	
After 17 years	Inspection			
After 18 years		Inspection		
After 19 years				
After 20 years				Inspection
After 21 years			Inspection	
After 22 years	Inspection			
After 23 years		Inspection		
After 24 years				
After 25 years				Inspection
After 26 years			Inspection	
After 27 years	Inspection			
After 28 years		Inspection		
After 29 years				
After 30 years				Inspection

(3) The soundness shall be judged based on the latest inspection result.

(4) When deciding the priority, frequency, and standards of periodic inspection, it is necessary to consider the bridge scale, bridge age, the current degree of damage, the importance of the bridge, etc. in a comprehensive manner.

6. Inspection Team Composition and Safety Measures

Bridge inspection must be conducted with appropriate team composition considering the know-how of the persons engaged in the inspection and safety measures for controlling traffic vehicles.

【Notes】

Since bridge inspection are usually conducted while the bridge is in service, the first priority shall be given to the safety of traffic vehicles, third parties, and persons [Team organization] consisted of Table 1.6.1 engaged in the inspection. Appropriate safety measures shall be included in the inspection plan based on the condition of the inspection site while observing related laws and regulations.
The major precautions are:

(1) Personal protective equipment and belongings shown in Figure 1.6.1
- Always check your helmet before starting work and be sure to wear it while working.
- Always wear a safety vest whenever working on roads.
- Carefully keep personal belongings and materials; do not let them fall or throw them as there are usually vehicles and trains running on the surface of the bridge or under the girder of the bridge during inspection.

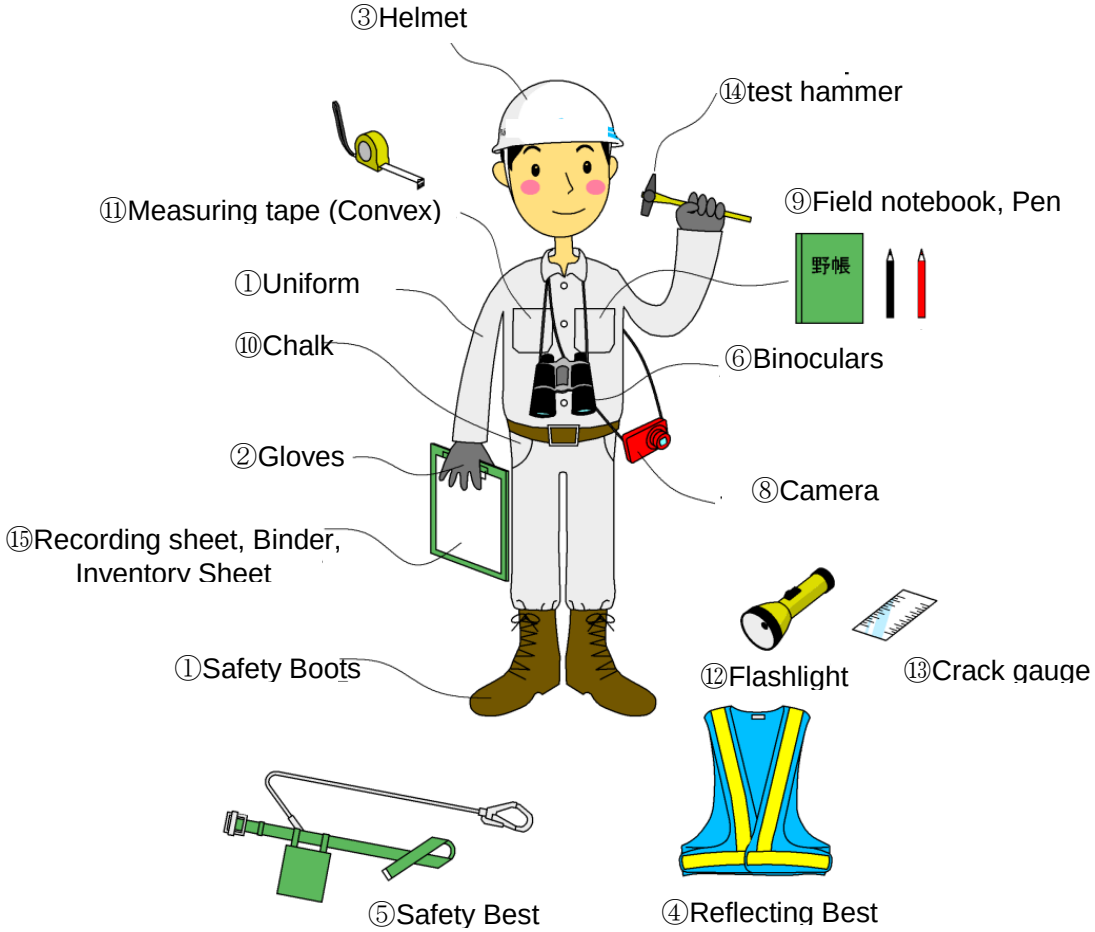
(2) Inspection site
- Pay enough attention to vehicles when walking on road shoulders.
- Do not enter dangerous places and ensure the safety of inspectors.
- In rivers and conduits, always confirm safe evacuation routes beforehand in case the water level rises.

(3) Weather
- Before starting work, check the meteorological conditions and collect information about weather, temperature, etc. At rivers and conduits, collect information not only around the bridge site but also upstream of the river.
- If any danger is foreseen due to sudden changes of weather (rainfall (water level), strong wind, etc.) during inspection, immediately stop working, ensure safety, and try to collect information by radio, etc.
- If a risk of falling or slipping due to rain, stop working.
- If water level is expected to rise due to rainfall, take early evacuation actions. It should be noted that flash floods may occur depending on the conditions of river basin and channel structure, especially on steep slopes and urban areas.
- In addition to the cases mentioned above, if danger is foreseen, immediately stop working and do not resume the work unless safety is ensured.

Table 1.6.1 Minimum team organization during inspections

Inspectors	Positions (Tentative)	Inspection Type			
		Routine	Periodic A	Periodic B	Extraordinary Condition
1. Team Leader	Project Manager or Deputy Project Manager	0	1	1-2*	1
2. Inspector	Project Roads staff	1	1	1	1
3. Supporting Staff	OPWT	1	1	1	1
4. Safety Control Staff	OPWT	0	0-1	1-2	0-1
	Total	2	3-4	5-6	3-4

* Note: A team for Periodic Inspection B should include at least one DOR engineer.



Source: Hanshin Expressway

Figure 1.6.1 Bridge Inspection tool and its uniform

7. Update of Manual

This manual shall be reviewed every fiscal year and revised as necessary.

【Notes】

The inspection manual reflects the latest observation outcomes and findings at the time of its publication; however, the contents may not match the current situation exactly at some point during its use.
For this reason, the manual shall be reviewed every fiscal year and revised as necessary. In the process of reviewing, the contents shall be verified based on the following information and updated as necessary.

(1) New findings obtained from inspection
The results of bridge inspection in each fiscal year shall be summarized. If there are structural details with significant damage, they will be reflected in the manual by modifying the inspection items.
(2) New research findings concerning damage
Research findings concerning damage, etc. shall be reflected in the manual by modifying the evaluation criteria of damage grades, etc.
(3) New technology development related to inspection/investigation and repair/reinforcement.
The contents of the manual shall be revised when more efficient and effective inspection methods are established through the development of inspection and investigation technologies, or when the significance of damage changes by the development of repair and reinforcement technologies.
(4) Issues on the operation of the manual
If any issues are reported regarding the operation of the manual, measures shall be considered and the contents revised appropriately.

Chapter 2 Inspection A

1. Flow of Inspection Work

The Inspection A shall generally be conducted according to the flow below.

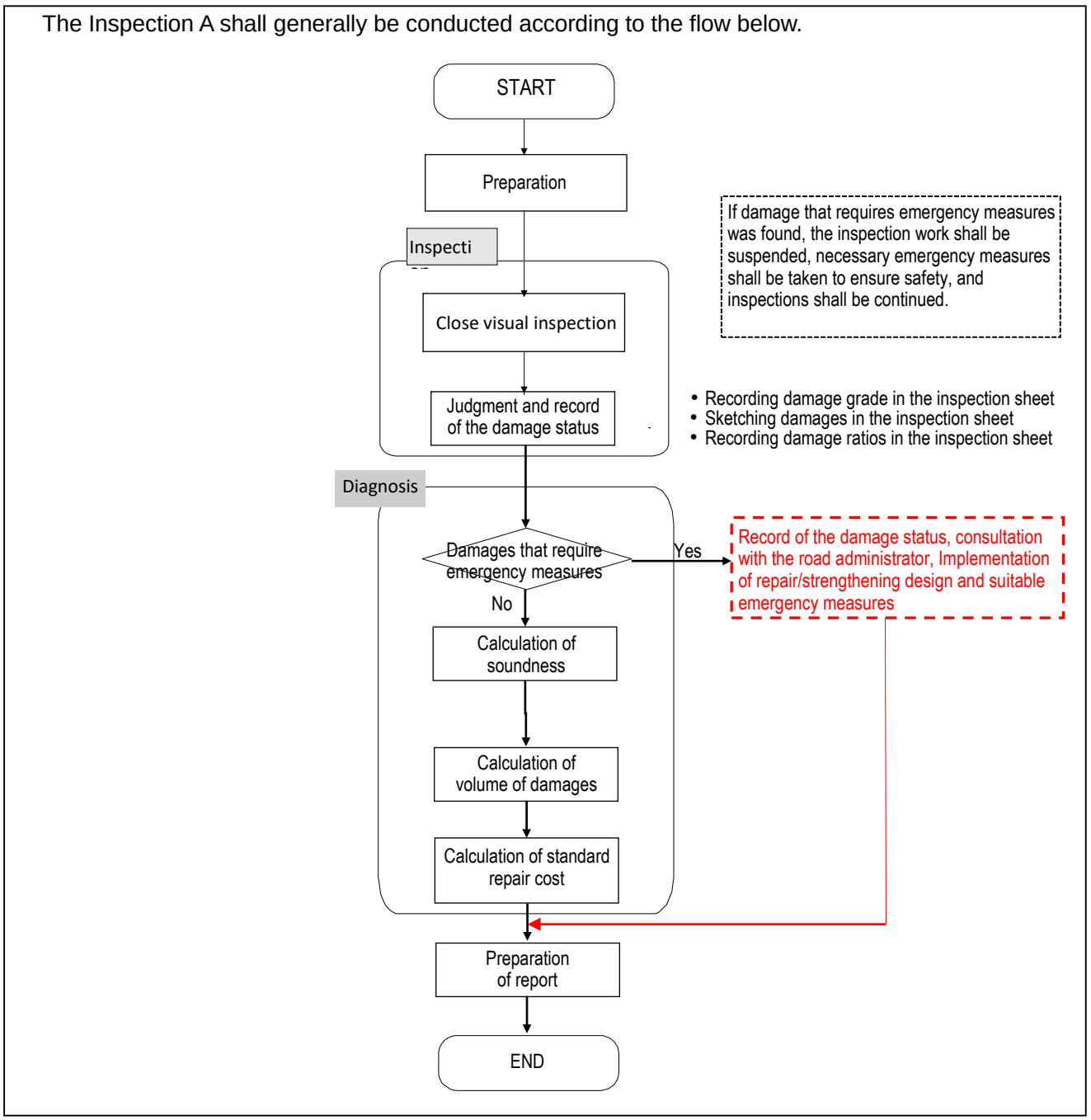


Figure 2.1.1 Flow of inspection work

【Notes】

The flow chart above shows the standard procedure of Inspection A. In the evaluation process of Inspection A, the soundness and the standard repair cost will be estimated. This estimation can be carried out using the "Bridge Management System".

2. Contents of Inspection

2.1 Basic Concept

In Inspection A, the damage of main members shall be evaluated and recorded.

【Notes】

Main members mean the following three (3) members.

- Slab: deck slab, overhanging slab, filling concrete between girders
- Main structure: main girder, main structure [Truss bridge (upper/lower chord members, diagonal member, hanger member), Arch bridge (arch rib, stiffening girder, strut)]
- Substructure

Inspection shall be performed by persons who have the necessary knowledge and skills regarding bridges to perform proper inspection.

i. For the purpose of collecting information that is used for status evaluation
   Evaluate and record the damage status of all spans regarding the three (3) main members (slab, main structures, and substructures) that greatly affect the soundness of the whole bridge.

ii. For the purpose of early detection of serious damage
   Detect and record the presence or absence of serious damage regarding bearings and members on the road and road surface of all spans.

2.2 Type of Damage

There are seven (7) types of damage to evaluate the status of as shown in the table below.

Table 2.2.1 Type of damage to evaluate its status

Material	Type of damage	
Steel	01	Corrosion
	02	Cracks
	04	Fracture
Concrete	06 (11)	Cracks (Cracks on deck slab)
	07	Peeling, Exposure of rebar
	08	Leaching, Free lime
Common	26	Scouring

【Explanation】

Inspection A focuses on the seven (7) types of damage to evaluate the status of them from the following viewpoints, while Inspection B specifies 26 types (See 2.1 in Chapter 3).

i. Damage that greatly affects the soundness of the whole bridge (damage that is included in the soundness evaluation)

ii. Damage that frequently occurs

2.3 Target Member and Inspection Item

Table 2.2.2 shows the standards of target members, damage type, and status to be checked in Inspection A.

Table 2.2.2 Damage type and status to be checked

《Items to be evaluated and recorded its damage status》			
Component	Member	Material	Type of damage
Superstructure	Deck slab	Steel	・Corrosion, Cracks*, Fracture*
		Concrete	・Peeling, Exposure of rebar ・Leaching, Free lime, ・Cracks on deck slab
	Main structure	Steel	・Corrosion, Cracks*, Fracture*
		Concrete	・Cracks ・Peeling, Exposure of rebar ・Leaching, Free lime
Substructure	Body	Steel	・Corrosion, Cracks*, Fracture*
		Concrete	・Cracks ・Peeling, Exposure of rebar ・Leaching, Free lime
	Foundation	－	・Scouring

《Items to be checked and recorded for the presence of serious damage》			
Component	Member	Material	Serious damage
Bearings	Bearing body	－	・Makes extraordinary sound when a vehicle runs over it. ・Severely corroded; some parts are missing; rubber is damaged, hardened, or lost
	Shoe seat, Mortar	－	・Sediment accumulates; water is pooled ・Mortar is cracked and partially lost.
On the Road	Railing, Guard fence	－	・Damaged due to vehicle collision, etc. ・Some places are considered dangerous for road users.
Road surface	Pavement	－	・Potholes, large bumps, or cracks ・Some places are considered dangerous for road users.
	Expansion joint	－	・Gaps in height (about 2 cm or more) ・Damaged, makes extraordinary sound when a vehicle runs over it
	Drainage facility	－	・Clogged with sediment, pavement overlay, etc. ・Damaged and drained water is affecting girders

【Notes】

The tables specify target members, damage type, and status to be checked.

Regarding cracks and fractures, the damage status and the photo numbers shall be noted in the "Other urgent damage" column of the Inspection A report template.
The same shall be applied to the damage of members not listed in the tables above.

3. Judgment and Record of Damage

3.1 Judgement of Damages

The damage status of the target members shall be judged by the inspector's subjective assessment based on "3.2 Damage Grade Standards" in "Chapter 3 Inspection B" presented in "Appendix-2 Criteria for Damage Grade Evaluation" and recorded in sheet presented in "Appendix-3 Inventory and Inspection Sheet".

【Notes】

The basic concept of damage evaluation is the same as that of Inspection B (See 3. Evaluation of Damage in Chapter 3). The damage status is judged by inspector's subjective assessment in the following manner, while comparing the actual condition of the inspection site with "3.2. Damage Grade Standards" in "Chapter 3 Inspection B".

Record the damage grade that is closest to the average damage state of the entire members. If the damage state is advanced in some parts, record the grade closer to the damage status. As for partial damage, one span is divided into nine segments, and record the location of the damage schematically as shown in the figure below.

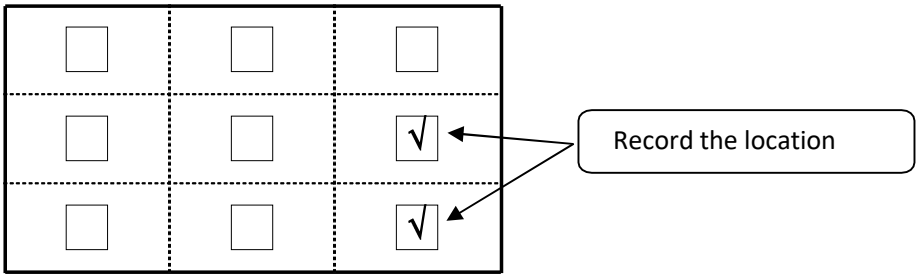


Figure 2.3.1 Example of the record of damage location

【If any damage requiring emergency countermeasures is found】

For damage requiring urgent measures, the inspector's comments, recommendations, emergency measures, etc. shall be recorded in the "Notes" column. (See 5.2 Damage Requiring Emergency Countermeasures).

3.2 Record of Damage Drawings

Record of the damage drawings shall be recorded pursuant to Clause Chapter 3 Inspection B, Sub-Clause 3.4 Record of Damage Drawings.

3.3 Precaution in Photography

Record of the damage photos shall be recorded pursuant to Clause Chapter 3 Inspection B, Sub-Clause 3.5 Precaution in the photography.

4. Calculation of Soundness

The soundness shall be calculated for each member and each span based on the damage status records and the standard repair cost shall be calculated according to the soundness.

【Notes】

Inspection survey evaluates a Damage Level for a list of damages types for each element of the bridge, span by span. Damage is evaluated as a percent for each of 5 levels (A, B, C, D, E), with a total of 100% per damage type. Each damage grade criteria are detailed in “Appendix-2 Criteria for Damage Grade Evaluation”.

[Conversion of damage status]

No damage, No repair work required	→	Damage Grade A
Minor damage, repair when convenient	→	Damage Grade B
Moderate damage, repair soon	→	Damage Grade C
Severe damage, repair immediately	→	Damage Grade D
Ultimate damage, element has failed	→	Damage Grade E

For example:

				A	B	C	D	E
Superstructure	Deck	Concrete	11. Cracks (Slab)	0		30		70
		Concrete	07. Peeling-Exposure of Rebar	100		0		0
		Concrete	08. Leaching-Free Lime	100		0		0
	Main Girder	Steel	01. Corrosion	70	20	10	0	0
		Steel	02. Cracks (Steel)	100		0		0
		Steel	04. Fracture	100				0
	Other than Deck and Main Girder	Steel	01. Corrosion	80	10	10	0	0
		Steel	02. Cracks (Steel)	100		0		0
		Steel	04. Fracture	100				0

A Damage Grade (DG) is calculated for each damage type as following:

DG = 0 * Damage level A
+ 0.25 * Damage level B
+ 0.5 * Damage level C
+ 0.75 * Damage level D
+ 1 * Damage level D

Example:

A	B	C	D	E	DG	
0		30		70	**85**	*(= 30 * 0.5 + 70 *1)*
100		0		0	**0**	*(= 100 * 0)*
70	20	10	0	0	**10**	*(= 70 * 0 + 20 * 0.25 + 10 *0.5)*
80	10	10	0	0	**7.5**	*(= 80 * 0 + 10 * 0.25 + 10 *0.5)*

Damage Grade (DG) and Health Index (HI) are calculated at different levels of each bridge:

- Element level
- Component level
- Span level

Element level calculation: DGe = $\sum_{d=1}^{d=n}$ (CFd x DGd)

HIe = $100 - DGe$

Where:
CFd = Damage factor (user defined)
DGd = Damage grade (formula above)
$\sum_{d=1}^{d=n}$ = *Sum for all damage types*

Component level calculation: DGc = $\sum_{e=1}^{e=n}$ (CFe x DGe)

HIc = $100 - DGc$

Where:
CFe = Element factor (user defined)
DGe = Element Damage grade (formula above)
$\sum_{e=1}^{e=n}$ = *Sum for all elements*

Span level calculation: DGs = $\sum_{c=1}^{c=n}$ (CFe x DGe)

HIs = $100 - DGs$

Where:
CFc = Component factor (user defined)
DGc = Component Damage grade (formula above)
$\sum_{c=1}^{c=n}$ = *Sum for all components*

All factors (CFx) are user defined and applied to all bridges. Note that the values of these factors are initially drafted by referring those applied in Japan (e.g., Nagasaki Prefecture and Shizuoka Prefecture) and should be revised and fine-tuned through local engineers' judgements.

These factors are stored in specific tables in BMS as tentatively described below. Only user at administrator level can modify the set of factors. If any of these factors is changed by administrator, all DG and HI shall be recalculated for all bridge inspections.

Table 2.4.1 Damage Factor (1/2)

Component	Element	Material	Damage type	Nagasaki	Shizuoka	Laos (DRAFT)	Damage Grade				
							A	B	C	D	E
Super-structure	Deck	Steel	01: Corrosion	0.60	0.50	0.60	A	B	C	D	E
			02: Cracks	1.00	1.00	1.00	A		C		E
			04: Fracture	1.00	1.00	1.00	A				E
		Concrete	07: Peeling, Exposure of rebar	0.50	0.13	**0.75**	A		C	D	E
			08: Leaching, Free lime	0.25	0.13	**0.50**	A		C	D	E
			11: Cracks on floor slab	0.50	0.75	**0.75**	A	B	C	D	E
	Main structure	Steel	01: Corrosion	0.60	0.60	0.60	A	B	C	D	E
			02: Cracks	1.00	1.00	1.00	A		C		E
			04: Fracture	1.00	1.00	1.00	A				E
		Concrete	06: Cracks	0.33	0.33	**0.75**	A	B	C	D	E
			07: Peeling, Exposure of rebar	0.67	0.67	**0.75**	A		C	D	E
			08: Leaching, Free lime	0.33	0.17	**0.50**	A		C	D	E
	Othe than deck and main structure — Main Members	Steel	01: Corrosion	0.60	0.33	0.60	A	B	C	D	E
			02: Cracks	1.00	1.00	1.00	A		C		E
			04: Fracture	1.00	1.00	1.00	A				E
		Concrete	06: Cracks	0.25	0.40	**0.75**	A	B	C	D	E
			07: Peeling, Exposure of rebar	0.75	0.60	**0.75**	A		C	D	E
			08: Leaching, Free lime	0.50	0.40	**0.50**	A		C	D	E
	Othe than deck and main structure — Non-main memb	Steel	01: Corrosion	0.25	0.33	0.25	A	B	C	D	E
			02: Cracks	1.00	1.00	1.00	A		C		E
			04: Fracture	1.00	1.00	1.00	A				E
		Concrete	06: Cracks	0.25	0.40	**0.60**	A	B	C	D	E
			07: Peeling, Exposure of rebar	0.75	0.60	**0.60**	A		C	D	E
			08: Leaching, Free lime	0.50	0.40	**0.40**	A		C	D	E
Sub-structure	Body	Steel	01: Corrosion		0.60	0.60	A	B	C	D	E
			02: Cracks		1.00	1.00	A		C		E
			04: Fracture		1.00	1.00	A				E
		Concrete	06: Cracks	0.40	0.43	**0.75**	A	B	C	D	E
			07: Peeling, Exposure of rebar	0.60	0.57	**0.75**	A		C	D	E
			08: Leaching, Free lime	0.40	0.29	**0.50**	A		C	D	E
	Foundation	Steel	01: Corrosion		0.60	0.60	A	B	C	D	E
			02: Cracks		1.00	1.00	A		C		E
			04: Fracture		1.00	1.00	A				E
			26: Scouring		1.00	1.00	A				
		Concrete	06: Cracks	0.40	0.43	**0.75**	A	B	C	D	E
			07: Peeling, Exposure of rebar	0.60	0.60	**0.75**	A		C	D	E
			26: Scouring		1.00	1.00	A		C		E

Table 2.4.2 Damage Factor (2/2)

Component	Element	Material	Damage type	Nagasaki	Shizuoka	Laos (DRAFT)	Damage Grade				
							A	B	C	D	E
Bearings	Bearing body	Steel	01: Corrosion	0.50	0.25	0.50	A	B	C	D	E
			02: Cracks	1.00	1.00	1.00	A		C		E
			04: Fracture	1.00	1.00	1.00	A				E
	Shoe seat mortar,	Concrete	06: Cracks	0.40	0.14	0.75	A	B	C	D	E
			07: Peeling, Exposure of rebar	1.00	0.60	0.75	A		C	D	E
	Bridge fall prevention device	Steel	01: Corrosion			0.60	A	B	C	D	E
			02: Cracks			1.00	A		C		E
			04: Fracture			1.00	A				E
		Concrete	06: Cracks			0.60	A	B	C	D	E
			07: Peeling, Exposure of rebar			0.60	A		C	D	E
			08: Leaching, Free lime			0.40	A		C	D	E
On the road	Railing, Guard fence	Steel	01: Corrosion			0.30	A	B	C	D	E
			02: Cracks			1.00	A		C		E
			04: Fracture			1.00	A				E
		Concrete	06: Cracks			0.60	A	B	C	D	E
			07: Peeling, Exposure of rebar			0.60	A		C	D	E
			08: Leaching, Free lime			0.40	A		C	D	E
	Noise barrier	Steel	01: Corrosion			0.60	A	B	C	D	E
			02: Cracks			1.00	A		C		E
			04: Fracture			1.00	A				E
	Lights, Traffic signs	Steel	01: Corrosion			0.60	A	B	C	D	E
			02: Cracks			1.00	A		C		E
			04: Fracture			1.00	A				E
Road surface	Wheel guard	Steel	01: Corrosion			0.60	A	B	C	D	E
			02: Cracks			1.00	A		C		E
			04: Fracture			1.00	A				E
		Concrete	06: Cracks			0.75	A	B	C	D	E
			07: Peeling, Exposure of rebar			0.75	A		C	D	E
			08: Leaching, Free lime			0.40	A		C	D	E
	Expansion joint	Steel	01: Corrosion			0.60	A	B	C	D	E
			02: Cracks			1.00	A		C		E
			04: Fracture			1.00	A				E
		Concrete	06: Cracks			0.75	A	B	C	D	E

Table 2.4.3 Element Factor

Component	Element		Nagasaki	Shizuoka	Laos (DRAFT)
Super-structure	Deck		0.80		0.80
	Main structure		1.00		1.00
	Othe than deck and main structure	Main Members	0.20		0.40
		Non-main members			
Sub-structure	Body		1.00		1.00
	Foundation		1.00		1.00
Bearings	Bearing body		1.00		1.00
	Shoe seat mortar, Pedestal concrete		0.43		0.50
	Bridge fall prevention device				0.50
On the road	Railing, Guard fence				0.50
	Noise barrier				0.50
	Lights, Traffic signs				0.50
Road surface	Wheel guard				0.50
	Expansion joint				0.80

Table 2.4.4 Component Factor

Component	Nagasaki	Shizuoka	Laos (DRAFT)
Super-structure	1.00		1.00
Sub-structure	0.50		**1.00**
Bearings	0.50		0.50
On the road			**0.50**
Road surface			**0.50**

5. Record of Inspection Results

5.1 Registration to Bridge Management System

The inspection results shall be recorded in a specific template and registered in the database.

【Notes】

The inspection results shall be recorded in a specific template such as “Appendi-3 Inventory & Inspection sheet” and/or ODK system based on using the "Bridge Management System (BMS)".

In addition to the storing function of inspection records for each bridge, the database has a search function which can be used under specific conditions, an output function of information such as bridge soundness used for the maintenance plan, and other functions. The inspection reports prepared using the reporting function and inspection results shall be stored in the database.

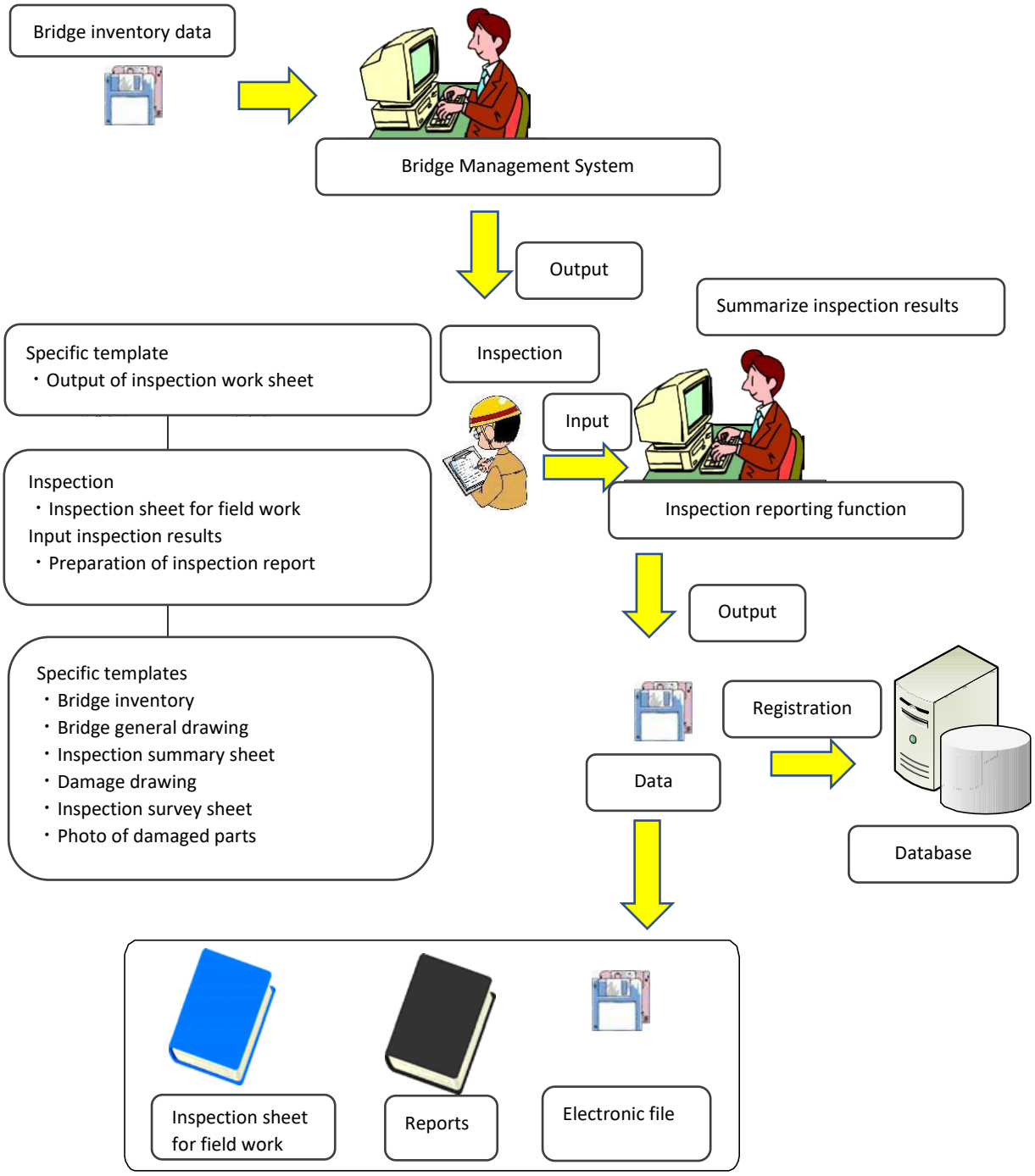


Figure 2.5.1 Flow of inspection records

5.2 Damage Requiring Emergency Measures

For damage requiring emergency countermeasures, the inspector’s comments, recommendations, measures (emergency countermeasures) shall be recorded in the "Notes" column.

【Notes】

If the safety of the bridge structure is significantly impaired, or if there is concern that the traffic of vehicles and pedestrians may be hindered or that third parties may be injured, such emergency status (damage corresponding to the category "E") shall be firstly inform to the road administrator, and noted in the "Notes" column of inspection report by judging the factors that may affect bridge functions, such as the importance of members, progress of damage, etc. comprehensively. Examples of serious damage are shown below for reference.

Examples of serious damage

- In case that the bridge is at risk of collapse due to significant damage of superstructure and/or substructure.
- In case that pedestrians or vehicles may fall/run off of the road due to damage or loss of members such as railings and guard fences.
- In the case that a driver may lose control due to flat tire, etc. caused by significant deformation of expansion joint.
- In the case that a driver may mishandle due to large bumps on the road or loss of expansion joint.
- In the case that concrete blocks may fall off from wheel guards, railings, or deck slabs and cause injury to people and vehicles passing along the road under the bridge.
- In the case that the pavement may cave in due to significant damage of deck slab.
- In the case that extraordinary noise or vibration is generated from girders, inspection pass, etc. and may adversely affect the residents in the area.

6. Judgment of Soundness

The soundness shall be judged based on the degree of deformation and abnormalities confirmed in inspection.

【Notes】

First, bridges are roughly classified by the soundness of members calculated from the inspection results. After that, the bridges are classified into "I to IV" of Table 2.6.1 judging the damage status recorded on photos. (See Fig. 2.6.1)

Note that the range of HI and its soundness level (e.g., HI of over 80 is evaluated as 'Sound' bridge and HI of less than 30 as 'Stage of emergency countermeasure') should be defined through local engineers' judgement. The range of HI and its soundness level are stored in specific tables in BMS and should be adjusted once these ranges are defined.

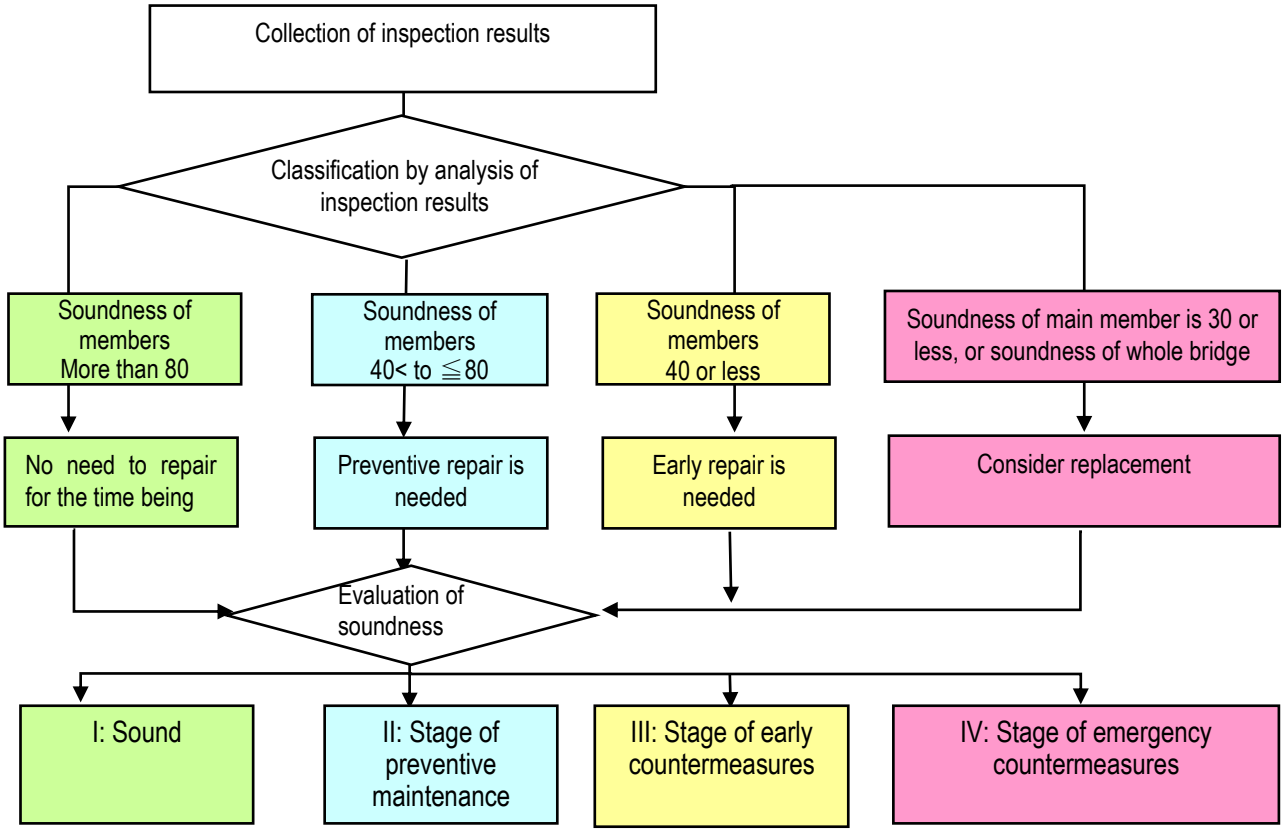


Figure 2.6.1 Judgement flow of soundness

【Reference】

Inspected bridges are classified into the categories as shown in the table below.

Table 2.6.1 Evaluation categories

	Category	Damage state
I	Sound	The structural function is not impaired.
II	Stage of preventive maintenance	Although the structural function is not impaired yet, it is desirable to take measures from the perspective of preventive maintenance.
III	Stage of early countermeasures	The structural function is likely to be impaired, and it is desirable to take early countermeasures.
IV	Stage of emergency measures	The structural function has been impaired or is highly likely to be impaired, and emergency measures must be taken.

Chapter 3 Inspection B

1. Flow of Inspection Work

The Inspection B shall generally be conducted according to the flow below.

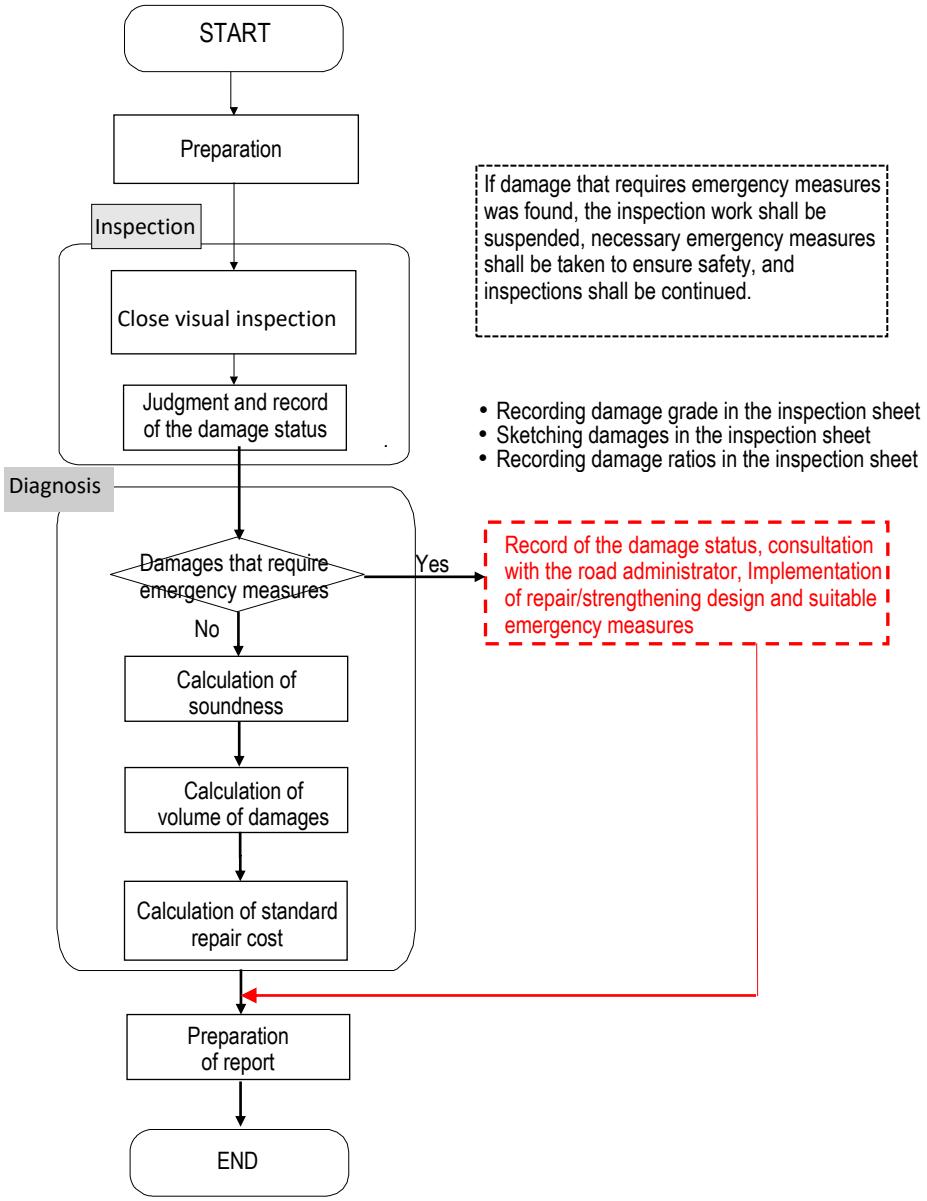


Figure 3.1.1 Flow of inspection work

【Notes】

The flow chart above shows the standard procedure of Inspection B. The inspection work shall include not only “inspection” to grasp the damage degree, but also “evaluation” to determine response and measures based on the inspection results of the target bridge.

2. Contents of Inspection

2.1 Type of Damage

The types of damage are the following 26 types shown in Table 3.2.1.

Table 3.2.1 Type of damage

Material	Type of damage		Material	Type of damage	
Steel	01	Corrosion	Others	13	Extraordinary gap
	02	Cracks		14	Rough road surface
	03	Loose, Drop off		15	Extraordinary pavement
	04	Fracture		16	Lack of bearing function
	05	Degradation of anti-corrosion performance		17	Others
Concrete	06	Cracks	Common	10	Deterioration of repair/ reinforcement material
	07	Peeling, Exposure of rebar		18	Extraordinary anchorage
	08	Leaching, Free lime		19	Discoloration, Degradation
	09	Fall off		20	Water leakage, Surface ponding
	11	Cracks on slab		21	Extraordinary sound/vibration
	12	Spalling		22	Extraordinary deflection
				23	Deformation, Loss
				24	Sediment clogging
				25	Subsidence, Displacement, Inclining
				26	Scouring

【Notes】

As mentioned in the previous Clause Chapter 1, 4 ‘Type of Inspection”, all 26 types of damage are targeted because the type of damage in Periodic Inspection B are required more detailed inspections to all members from the time of Periodic Inspection A.

2.2 Inspection Target

Table 3.2.2 shows the standard target members of periodic inspection.

Table 3.2.2 Target members of periodic inspection

Component	Member		Remarks
Super-structure	Deck		Filling between deck slab and girder
	Main structure		Main girder, Main structure (Upper/Lower chord, Diagonal member, Vertical member Arch rib, stiffening girder, Hanger, Bent, etc.)
	Other than deck and main structure	Main members	Stringer, Floor beam, Cross beam, Sway bracing
		Non-main members	Lateral bracing
Sub-structure	Body		
	Foundation		Scouring
Bearings	Bearing body		
	Shoe seat		Shoe seat mortar, Pedestal concrete
	Bridge fall prevention device		
On the road	Railing, Guard fence		
	Noise barrier		
	Lights, Traffic signs		
Road surface	Wheel guard		Wheel guard, Median strip, Kerb
	Pavement		
	Expansion joint		
Others	Drainage facility		
	Inspection facility		
	Accessories		

【Notes】

Although there is another way to classify members by structural function, this manual classifies the target members from the viewpoints of their influence on soundness, bearing capacity, and durability, in order to use the inspection results for various management purposes such as judging priority for repair and maintenance.

2.3 Inspection Item

Table 3.2.3 shows the standard types of damage to be inspected.

Table 3.2.3 Types of damage to be inspected

Component	Member		Material	Damage type
Super-structure	Deck		Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance 10: Deterioration of repair/ reinforcement material 17: Others 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 23: Deformation, Loss
			Concrete	07: Peeling, Exposure of rebar 08: Leaching, Free lime 09: Fall off 10: Deterioration of repair/ reinforcement material 11: Cracks on deck slab 12: Spalling 17: Others 18: Extraordinary anchorage 19: Discoloration, Degradation 20: Water leakage, Surface ponding
	Main structure		Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance 10: Deterioration of repair/ reinforcement material 13: Extraordinary gap 17: Others 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 22: Extraordinary deflection 23: Deformation, Loss
			Concrete	06: Cracks 07: Peeling, Exposure of rebar 08: Leaching, Free lime 10: Deterioration of repair/ reinforcement material 12: Spalling 13: Extraordinary gap 17: Others 18: Extraordinary anchorage 19: Discoloration, Degradation 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 22: Extraordinary deflection 23: Deformation, Loss
	Other than deck and main structure	Main members	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance 10: Deterioration of repair/ reinforcement material 17: Others 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 22: Extraordinary deflection 23: Deformation, Loss
			Concrete	06: Cracks 07: Peeling, Exposure of rebar 08: Leaching, Free lime 10: Deterioration of repair/ reinforcement material 12: Spalling 17: Others 18: Extraordinary anchorage 19: Discoloration, Degradation 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 22: Extraordinary deflection 23: Deformation, Loss
		Non-main members	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance 10: Deterioration of repair/ reinforcement material 17: Others 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 22: Extraordinary deflection 23: Deformation, Loss
			Concrete	06: Cracks 07: Peeling, Exposure of rebar 08: Leaching, Free lime 10: Deterioration of repair/ reinforcement material 12: Spalling 17: Others 19: Discoloration, Degradation 20: Water leakage, Surface ponding 22: Extraordinary deflection 23: Deformation, Loss

Component	Element	Material	Damage type	
Sub-structure	Body	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance	10: Deterioration of repair/reinforcement material 17: Others 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 23: Deformation, Loss
		Concrete	06: Cracks 07: Peeling, Exposure of rebar 08: Leaching, Free lime 10: Deterioration of repair/ reinforcement material 12: Spalling	17: Others 18: Extraordinary anchorage 19: Discoloration, Degradation 20: Water leakage, Surface ponding 23: Deformation, Loss
	Foundation	Steel	01: Corrosion 02: Cracks 05: Degradation of anti-corrosion performance	25: Subsidence, Displacement, Inclining 26: Scouring
		Concrete	06: Cracks 07: Peeling, Exposure of rebar	25: Subsidence, Displacement, Inclining 26: Scouring
Bearings	Bearing body	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance 13: Extraordinary gap	16: Lack of bearing function 17: Others 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 23: Deformation, Loss 24: Sediment clogging 25: Subsidence, Displacement, Inclining
		Rubber	16: Lack of bearing function 17: Others 19: Discoloration, Deterioration	20: Water leakage, Surface ponding 23: Deformation, Loss 24: Sediment clogging 25: Subsidence, Displacement, Inclining
	Shoe seat mortar, Pedestal concrete	Concrete	06: Cracks 07: Peeling, Exposure of rebar 12: Spalling	20: Water leakage, Stagnant water 23: Deformation, Loss
	Bridge fall prevention device	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance	13: Extraordinary gap 17: Others 21: Extraordinary sound/vibration 23: Deformation, Loss
		Concrete	06: Cracks 07: Peeling, Exposure of rebar 08: Leaching, Free lime 12: Spalling	17: Others 23: Deformation, Loss 24: Sediment clogging
On the road	Railing, Guard fence	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture	05: Degradation of anti-corrosion performance 10: Deterioration of repair/reinforcement material 17: Others 23: Deformation, Loss
		Concrete	06: Cracks 07: Peeling, Exposure of rebar 08: Leaching, Free lime 10: Deterioration of repair/ reinforcement material	12: Spalling 17: Others 19: Discoloration, Degradation 23: Deformation, Loss
	Noise barrier	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture	05: Degradation of anti-corrosion performance 17: Others 21: Extraordinary sound/vibration 23: Deformation, Loss
	Lights, Traffic signs	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture	05: Degradation of anti-corrosion performance 17: Others 21: Extraordinary sound/vibration 23: Deformation, Loss

Component	Element	Material	Damage type	
Road surface	Wheel guard, Median strip, Kerb	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture	05: Degradation of anti-corrosion performance 10: Deterioration of repair/reinforcement material 17: Others 23: Deformation, Loss
		Concrete	06: Cracks 07: Peeling, Exposure of rebar 08: Leaching, Free lime 10: Deterioration of repair/ reinforcement material	12: Spalling 17: Others 19: Discoloration, Degradation 23: Deformation, Loss
	Pavement	Asphalt, Concrete	14: Rough road surface 15: Extraordinary pavement 17: Others	20: Water leakage, Surface ponding 24: Sediment clogging
	Expansion joint	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance 13: Extraordinary gap	14: Rough road surface 17: Others 20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 23: Deformation, Loss 24: Sediment clogging
		Concrete	06: Cracks 12: Spalling 20: Water leakage, Surface ponding	21: Extraordinary sound/vibration 23: Deformation, Loss 24: Sediment clogging
		Rubber	13: Extraordinary gap 14: Rough road surface 17: Others 19: Discoloration, Degradation	20: Water leakage, Surface ponding 21: Extraordinary sound/vibration 23: Deformation, Loss 24: Sediment clogging
Others	Drainage facility	Steel, Others	01: Corrosion 04: Fracture 05: Degradation of anti-corrosion performance 17: Others	19: Discoloration, Degradation 20: Water leakage, Surface ponding 23: Deformation, Loss 24: Sediment clogging
	Inspection facility	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance	17: Others 21: Extraordinary sound/vibration 22: Extraordinary deflection 23: Deformation, Loss
	Accessories	Steel	01: Corrosion 02: Cracks 03: Loose, Fall off 04: Fracture 05: Degradation of anti-corrosion performance	17: Others 21: Extraordinary sound/vibration 22: Extraordinary deflection 23: Deformation, Loss

【Notes】

Since the inspection is conducted separately for each member, the inspection items (damage types) for each member are selected considering the material of the member.

3. Evaluation of Damage

3.1 Basic Concept

Damage is evaluated by judging its progress according to “Appendix-2 Criteria for Damage Grade Evaluation”.

【Notes】

In this manual, only the progress of the damage is objectively evaluated.

3.2 Damage Grade Standards

Damage is evaluated into the following five damage grades for each damage type in principle. For the damage type on the member whose extent is easily evaluated, the occurrence ratio shall be recorded in the unit of 10% for each member of each span according to the inspector’s subjective assessment.

For the damage type of on the member whose extent is difficult to evaluate, record only the presence or absence of the damage.

Table 3.3.1 Damage grade standards

Grade	Evaluation	Timing of repair
A	No damage	No repair work required
B	Minor damage	Repair when convenient
C	Moderate damage	Repair soon
D	Severe damage	Repair immediately
E	Ultimate damage	Element has failed

【Notes】

The basic procedure of the evaluation on the damage state is shown in Figure 3.2.1.

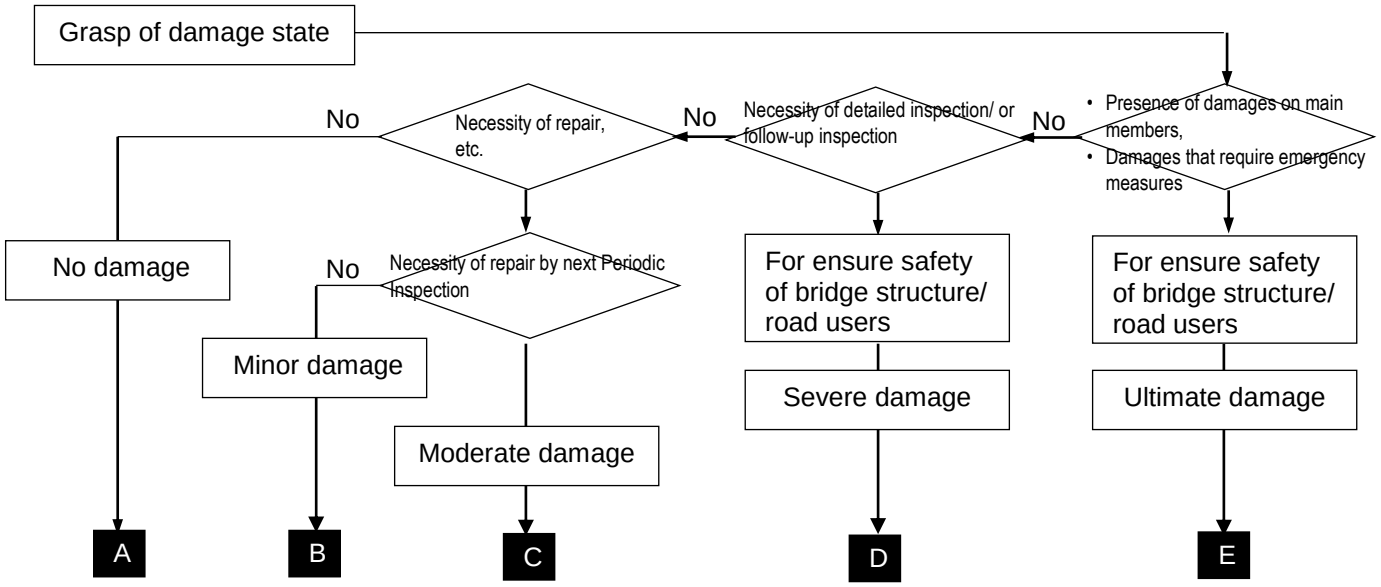


Figure 3.2.1 Example of record of damage grade (main girders)

For example, in the evaluation of corrosion of main girders, the condition shown in the drawing below (the damage grade is B as a whole, but there is one segment with a D grade) shall be recorded as [A: 0%, B: 90%, C: 0%, D: 10%, E: 0%]. However, this ratio is determined by the inspector's subjective assessment calculating the [number of damaged elements / total number of elements] as a guide, and it is not necessary to count the total number of members and the number of damaged members accurately.

B	B	B	B
B	B	B	B
D	B	B	B

Figure 3.2.2 Example of record of damage grade (main girders)

【Calculation example of the ratio of damage grade】

Some calculation samples of damage grade in the case of Figure 3.2.2 are shown below.
As previously mentioned, the calculation shall be made in the unit of 10% based on the inspector's subjective assessment. At the time of inspection, it is necessary to not only focus on local damage but also to capture the overall damage grade.

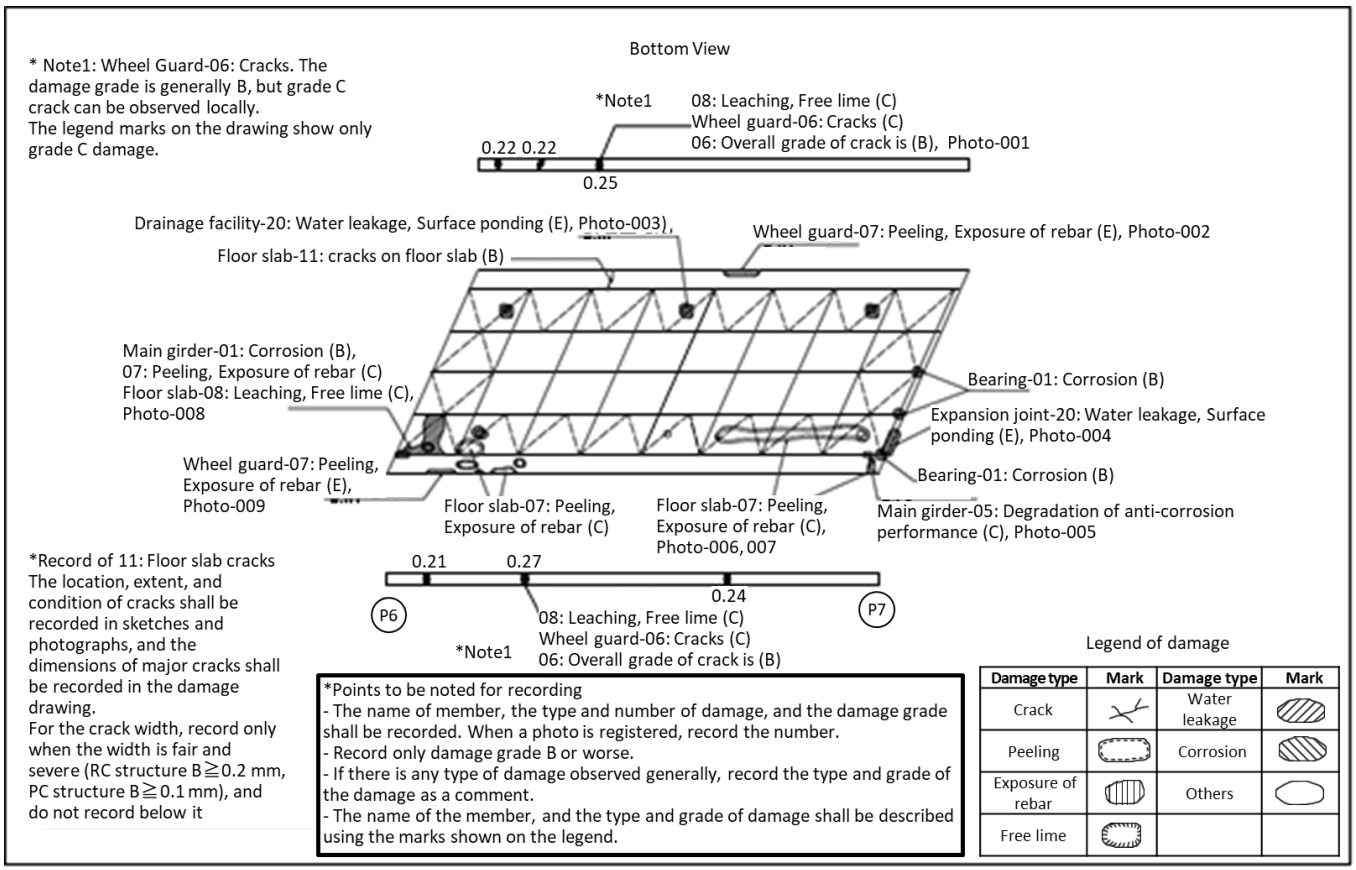


Figure 3.2.3 Damage drawing

Regarding the damage drawing of Figure 3.2.3, the calculation of damage grade ratio of the three items: "Main girder-01: Corrosion", "Deck-07: Peeling, Exposure of rebar", and "Wheel guard-06: cracks", are shown below as reference samples.

- Main girder-01: Corrosion
  Local damage of grade B is observed in one location, but overall damage grade is A. In this case, evaluate and record the damage grade ratio as [A: 90%, B: 10%, C: 0%, D: 0%, E: 0%].
- Deck slab-07: Peeling, Exposure of rebar
  Local damage of grade C is observed in three locations. In this case, record the damage grade ratio as [A: 0%, B: 0%, C: 100%, D: 0%, E: 0%] according to the locations, extent, and condition of the damage sketched on the damage drawing.
- Wheel guard-06: Cracks
  Local damage of grade C is observed in six locations, and overall damage grade is B. In this case, record the damage grade ratio as [A: 0%, B: 90%, C: 10%, D: 0%, E: 0%].

3.3 Record of Damage Grade

The types of damage to be evaluated and grades for each type of damage are shown in the table below.

Table 3.3.2 Types of damage to be evaluated and damage grade

Material	Type of damage		Damage grade					Remarks
			A	B	C	D	E	
Steel	01	Corrosion	●	●	●	●	●	
	02	Cracks	○	—	○	—	○	
	03	Loose, fall-off	○	—	○	—	○	
	04	Fracture	○	—	—	—	○	
	05	Degradation of anti-corrosion performance	●	—	●	●	●	Coating
			●	—	●	—	●	Plating, metallic spraying
			●	●	●	●	●	Weathering steel
Concrete	06	Cracks	●	●	●	●	●	
	07	Peeling, Exposure of rebar	●	—	●	●	●	
	08	Leaching, Free lime	●	—	●	●	●	
	09	Fall-off	○	—	—	—	○	
	11	Cracks on deck slab	●	●	●	●	●	
	12	Spalling	○	—	—	—	○	
Others	13	Extraordinary gap	○	—	○	—	○	
	14	Rough road surface	○	—	○	—	○	
	15	Extraordinary pavement	○	—	○	—	○	
	16	Lack of bearing function	○	—	—	—	○	
	17	Others	○	—	—	—	○	
Common	10	Deterioration of repair/reinforcement material	○	—	○	—	○	
	18	Extraordinary anchorage	○	—	○	—	○	
	19	Discoloration, Degradation	○	—	—	—	○	
	20	Water leakage, Surface ponding	○	—	—	—	○	
	21	Extraordinary sound/vibration	○	—	—	—	○	
	22	Extraordinary deflection	○	—	—	—	○	
	23	Deformation, Loss	○	—	○	—	○	
	24	Sediment clogging	○	—	—	—	○	
	25	Subsidence, Displacement, Inclining	○	—	—	—	○	
	26	Scouring	○	—	○	—	○	

●: The damage type whose extent is easily evaluated; record the ratio by each grade.
○: The damage type whose extent is difficult to evaluate; record only presence/absence of the damage as (presence ⇒ 100%, absence ⇒ 0%) for convenience.
—: Not applicable

【Notes】
The evaluation for each damage type is based on "Appendix-2 Criteria for Damage Grade Evaluation".

3.4 Record of Damage Drawings

The inspection results of each member shall be recorded on damage drawings by each damage grade presented in “Appendix-3 Inventory and Inspection Sheet” in principle.

【Notes】

The inspection results are used not only for indicating the degree of damage, but also in various ways as basic information for efficient maintenance and management. For example, damage drawings provide important information when examining alkali- aggregate reaction based on the crack state, or determining damage causes based on the damage state around the crack; therefore, the degree of damage shall be recorded in detail in an appropriate manner. Of the information indicating the damage status, the information that cannot be expressed in qualitative evaluation criteria shall be explained by text or recorded in damage drawings.

Some examples of recording methods for damage information that cannot be expressed by the qualitative evaluation criteria are shown below.

- Sketch the condition of cracks on concrete members (also record the crack width on the sketch).
- Sketch the location and extent of abnormalities such as peeling, spalling, and discoloration of concrete members.
- Sketch the location and progress of cracks on steel members.
- Sketch the location and situation of deformation of steel members.
- Sketch the location of abnormalities such as water leakage.
- Describe damage that cannot be recorded with photos such as Extraordinary sound or vibration.

【How to keep records on a damage drawing】

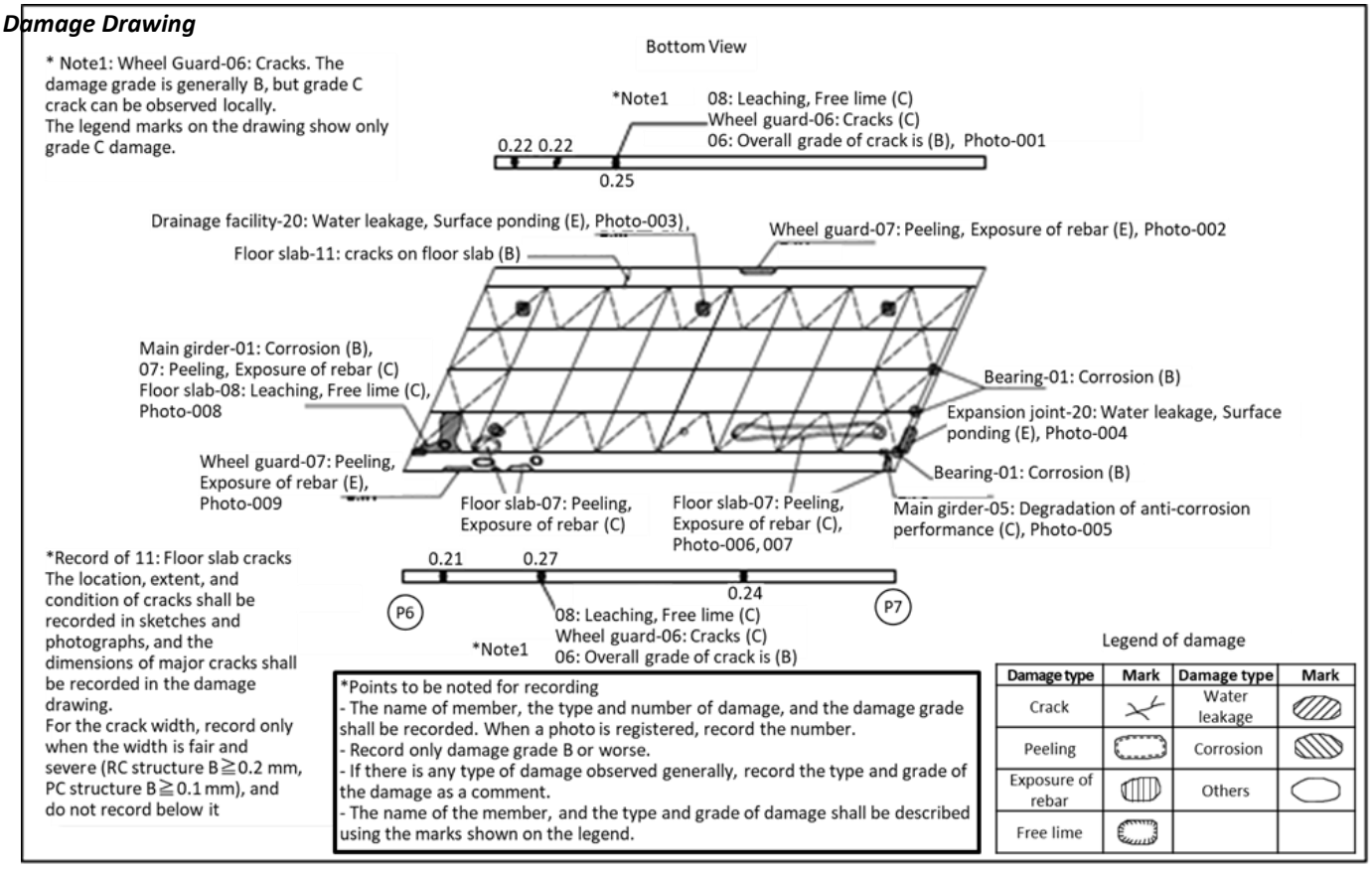
Records shall be kept on a damage drawing according to the following procedures.

- Prepare a drawing for superstructure, substructure, and road surface separately for every span.
- Record the name of member; the damage type number and name; and damage grade (See "Appendix-2" for "the number/name of damage type" and "damage grade").
- Record the photo number corresponding to each damaged part (it should be the same number as the registration number).
- Describe the information that cannot be expressed by qualitative evaluation criteria.
- Record only damage grade B or worse.
- For damage observed generally, record the damage type number/name, and damage grade as comments.
- The name of member, damage types, and grades shall be indicated using the marks shown on the legend.

Examples of damage drawings are shown on the following pages.

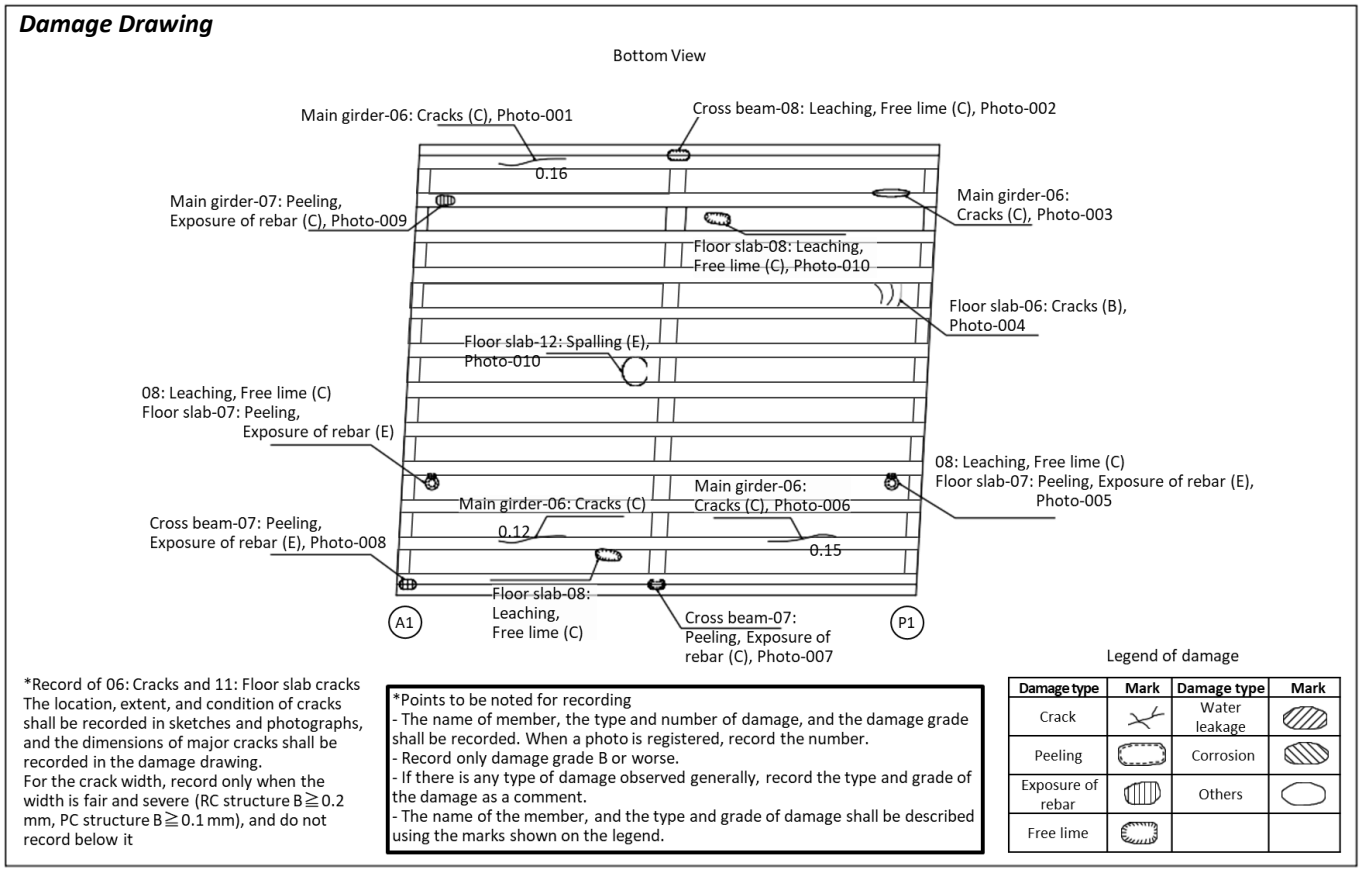
【Example 1: Steel superstructure】

Damage Drawing



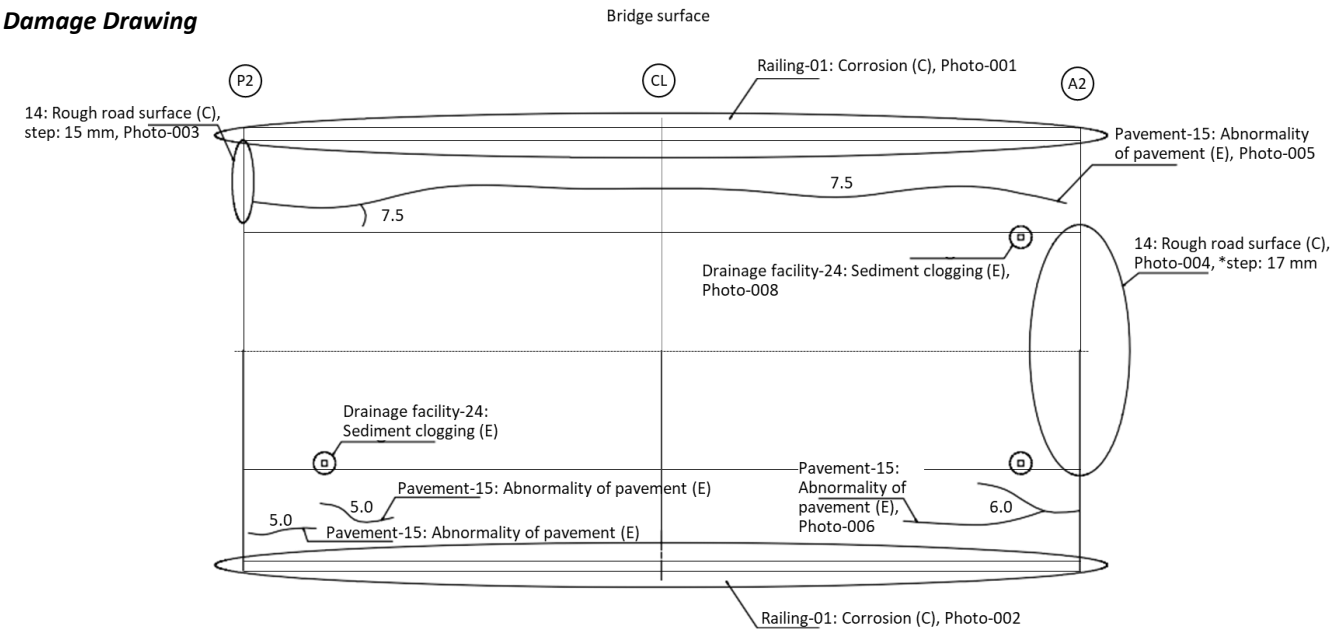
【 Example 2: PC Superstructure】

Damage Drawing



【Example 3: Bridge surface】

Damage Drawing



*About 15: Abnormality of pavement
The damage to be inspected are cracks, peelings, and potholes of the pavement. The evaluation of such damage is used only for judging the soundness of the pavement, not for determining repair or maintenance. For the crack width, record only when the width is 5 mm or wider.

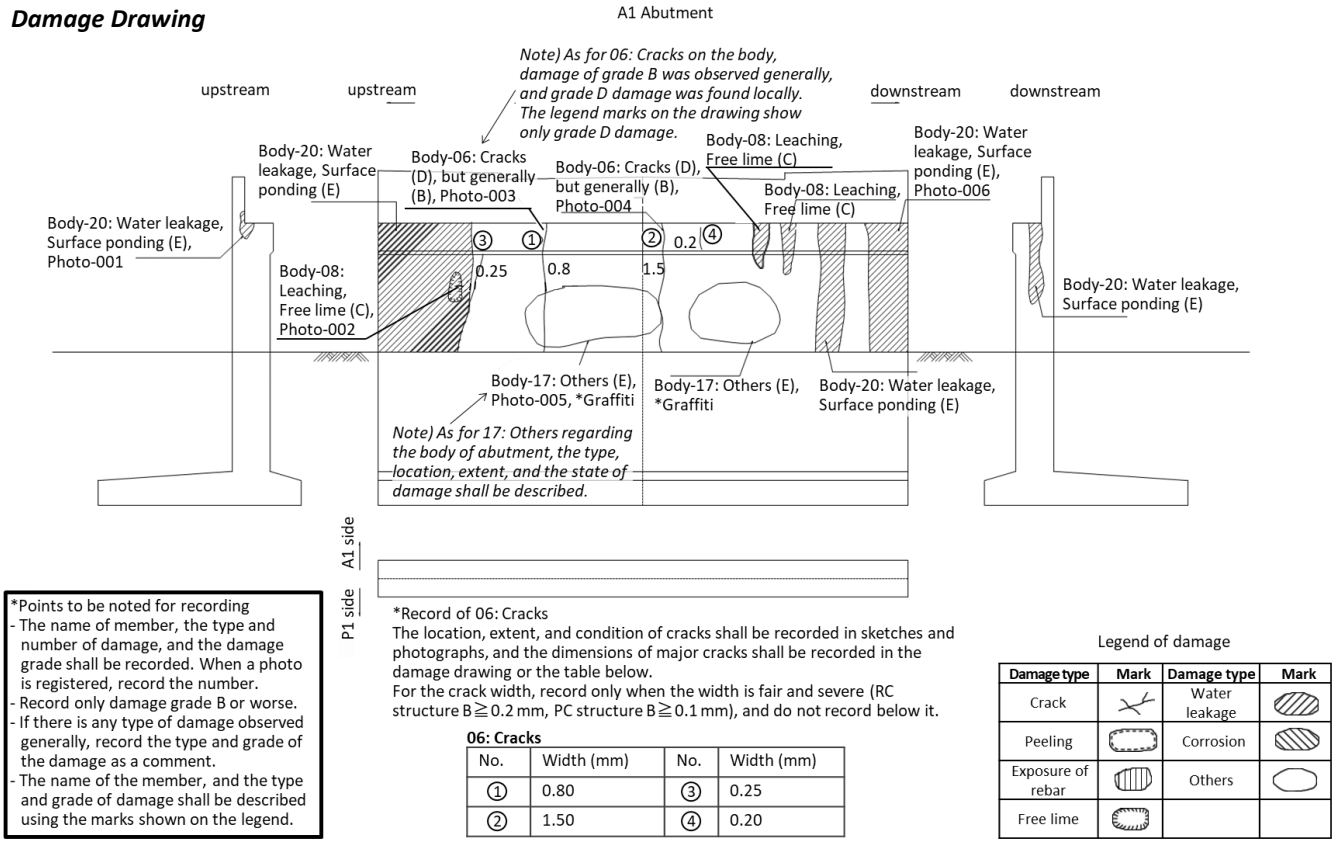
*Points to be noted for recording
- The name of member, the type and number of damage, and the damage grade shall be recorded. When a photo is registered, record the number.
- Record only damage grade B or worse.
- If there is any type of damage observed generally, record the type and grade of the damage as a comment.
- The name of the member, and the type and grade of damage shall be described using the marks shown on the legend.

Legend of damage

Damage type	Mark	Damage type	Mark
Crack		Water leakage	
Peeling		Corrosion	
Exposure of rebar		Others	
Free lime			

【Example 4: Substructure - Abutment】

Damage Drawing



*Points to be noted for recording
- The name of member, the type and number of damage, and the damage grade shall be recorded. When a photo is registered, record the number.
- Record only damage grade B or worse.
- If there is any type of damage observed generally, record the type and grade of the damage as a comment.
- The name of the member, and the type and grade of damage shall be described using the marks shown on the legend.

*Record of 06: Cracks
The location, extent, and condition of cracks shall be recorded in sketches and photographs, and the dimensions of major cracks shall be recorded in the damage drawing or the table below.
For the crack width, record only when the width is fair and severe (RC structure B≧0.2 mm, PC structure B≧0.1 mm), and do not record below it.

06: Cracks

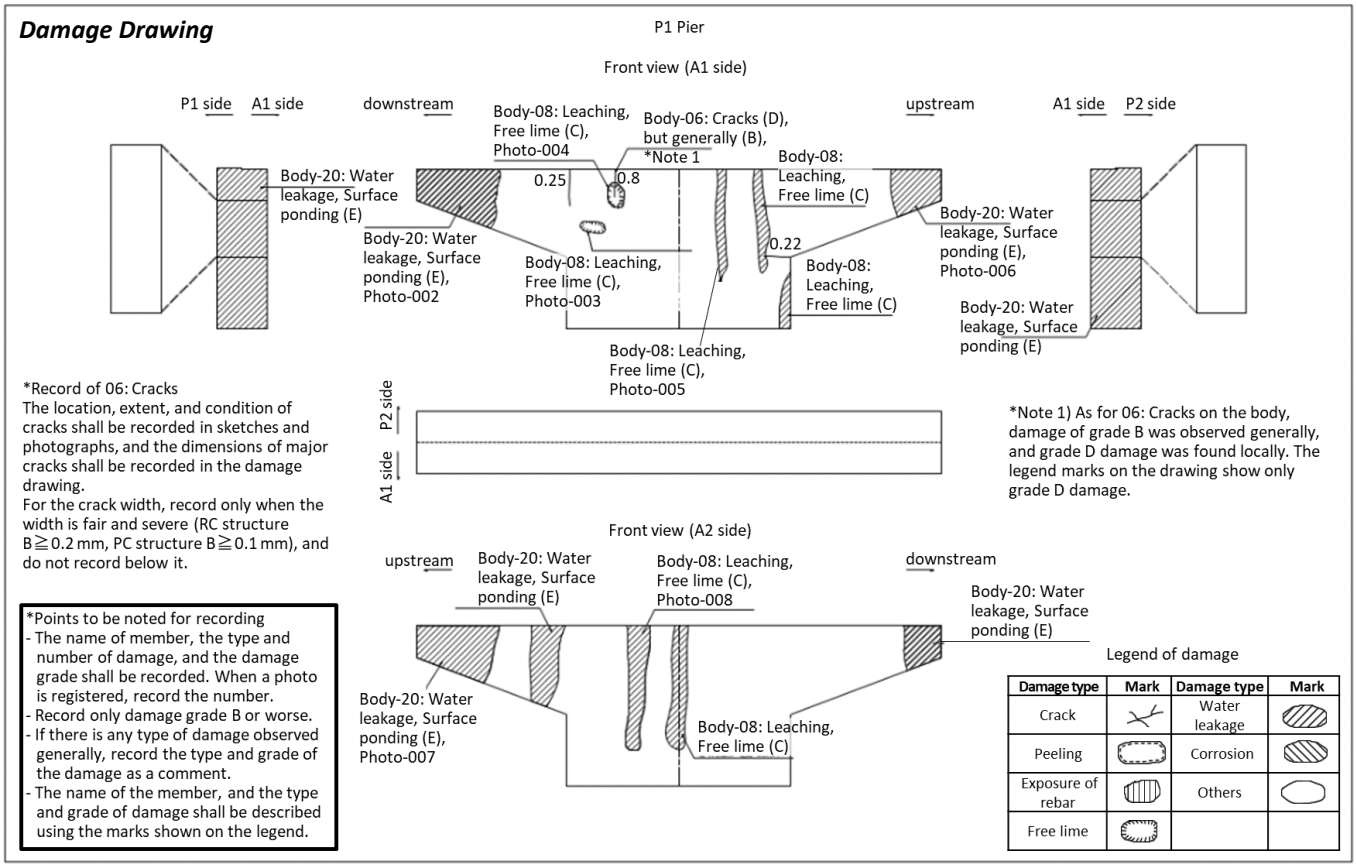
No.	Width (mm)	No.	Width (mm)
①	0.80	③	0.25
②	1.50	④	0.20

Legend of damage

Damage type	Mark	Damage type	Mark
Crack		Water leakage	
Peeling		Corrosion	
Exposure of rebar		Others	
Free lime			

【Example 5: Substructure - Pier】

Damage Drawing



*Record of 06: Cracks
The location, extent, and condition of cracks shall be recorded in sketches and photographs, and the dimensions of major cracks shall be recorded in the damage drawing.
For the crack width, record only when the width is fair and severe (RC structure B≧0.2 mm, PC structure B≧0.1 mm), and do not record below it.

*Points to be noted for recording
- The name of member, the type and number of damage, and the damage grade shall be recorded. When a photo is registered, record the number.
- Record only damage grade B or worse.
- If there is any type of damage observed generally, record the type and grade of the damage as a comment.
- The name of the member, and the type and grade of damage shall be described using the marks shown on the legend.

*Note 1) As for 06: Cracks on the body, damage of grade B was observed generally, and grade D damage was found locally. The legend marks on the drawing show only grade D damage.

Legend of damage

Damage type	Mark	Damage type	Mark
Crack		Water leakage	
Peeling		Corrosion	
Exposure of rebar		Others	
Free lime			

3.5 Precaution in Photography

The condition of damage shall be recorded by sketches and photographs of the damage.
It must be taken notes of the location, extent, angle and precision when taking photographs, since photography is a source of information for judging the extent of damage.

【Notes】

<Location>
The inspector must check the record of the previous inspection and as much as possible, take from the same location and from the same angle. However, this shall not apply if it is difficult to judge the damage from the previous inspection report.

<Extent>
The inspector must take photos from the distant view to grasp damaged members and locations of the damage, and from the close-up to grasp the damage status.

Distant view

Close-up

<Angle>
The inspector must take photos of the deformation, displacement, cracks, etc. so that the situation of damages is able to be grasped by adjusting the angles of photo's direction. In addition, the inspector must in advance prepare an inspection pole, convex, etc. so that the deformation, etc. are able to be grasped.

Easy to grasp deformation

Easy to grasp displacement

<Precision>
In order for the inspector to grasp the size of the damage, it is necessary to put a measuring gauge, write the damage size by chalks on the damage part and on the white board, etc., and to take photos.
In addition, it is necessary to check the photos on the spot for out-of-focus and/or camera shake.

To put measuring gauge

To write by chalks

To write on the white board

4. Record of Inspection Result

4.1 Inspection Result

Inspection results shall be recorded pursuant to previous Chapter 2, Sub-Clause 5.1 Registration to Bridge management System. Same to other inspection results, the existing Bridge Management System only allows to input the result of Inspection A and the result of Inspection B should be stored by both hard copy and any format of the soft copy.

4.2 Damage Requiring Emergency measures

Damage requiring emergency measures shall be performed pursuant to previous Chapter 2, Sub-Clause 5.2 Damaged Requiring Emergency measures.

5. Judgement of Damage, Soundness and Countermeasures

The damage and soundness of the deteriorated bridge and its countermeasures shall be judged by local expertise and if necessary, international experts, by forming technical committee or special task force.

5.1 Implementation of Inspection B and Judgement of Damage

Inspection B requires comprehensive knowledge of bridge and structural engineering, especially that of various damage types and causes these damages and effects for deterioration of the bridge. Like other countries, these knowledge, know-how and experiences within public agencies in Laos are still limited. Thus, this manual recommends DOR to hire local expertise (e.g., engineering consultant, contractor, research institute) and outsource to implement Inspection B by the local expertise.

The TOR of 3D scanning (for preparation of 3D CAD detailed drawing), detailed inspection as well as destructive and non-destructive test applied to Nam Mone Bridge (Vientiane Province) and Xe Bangnouan (Savannakhet Province) is attached to Appendix-XX.

5.2 Judgement of Soundness and Countermeasures

Similarly, the judgment of soundness based on the damage type and grade and study on the countermeasures for repair and retrofitting of deteriorated bridge require technical and engineering knowledge and know-how. This manual recommends DOR to form a technical committee or special task force, involving local expertise including DOR, DPWT of concerned province, research institute (PTI and NUOL), engineering consultant as well as contractor to authorize the judgement of soundness evaluation and provide recommendation on its countermeasures based on the soundness evaluation. In addition, this manual recommends DOR to consider to include international expert(s) in the technical committee in order to seek for technical advices when the knowledge and know-how of specific damages and required counter measures are considered beyond local capacity.

Chapter 4 Routine Inspection

1. Flow of Inspection Work

The routine inspection shall generally be conducted according to the flow below.

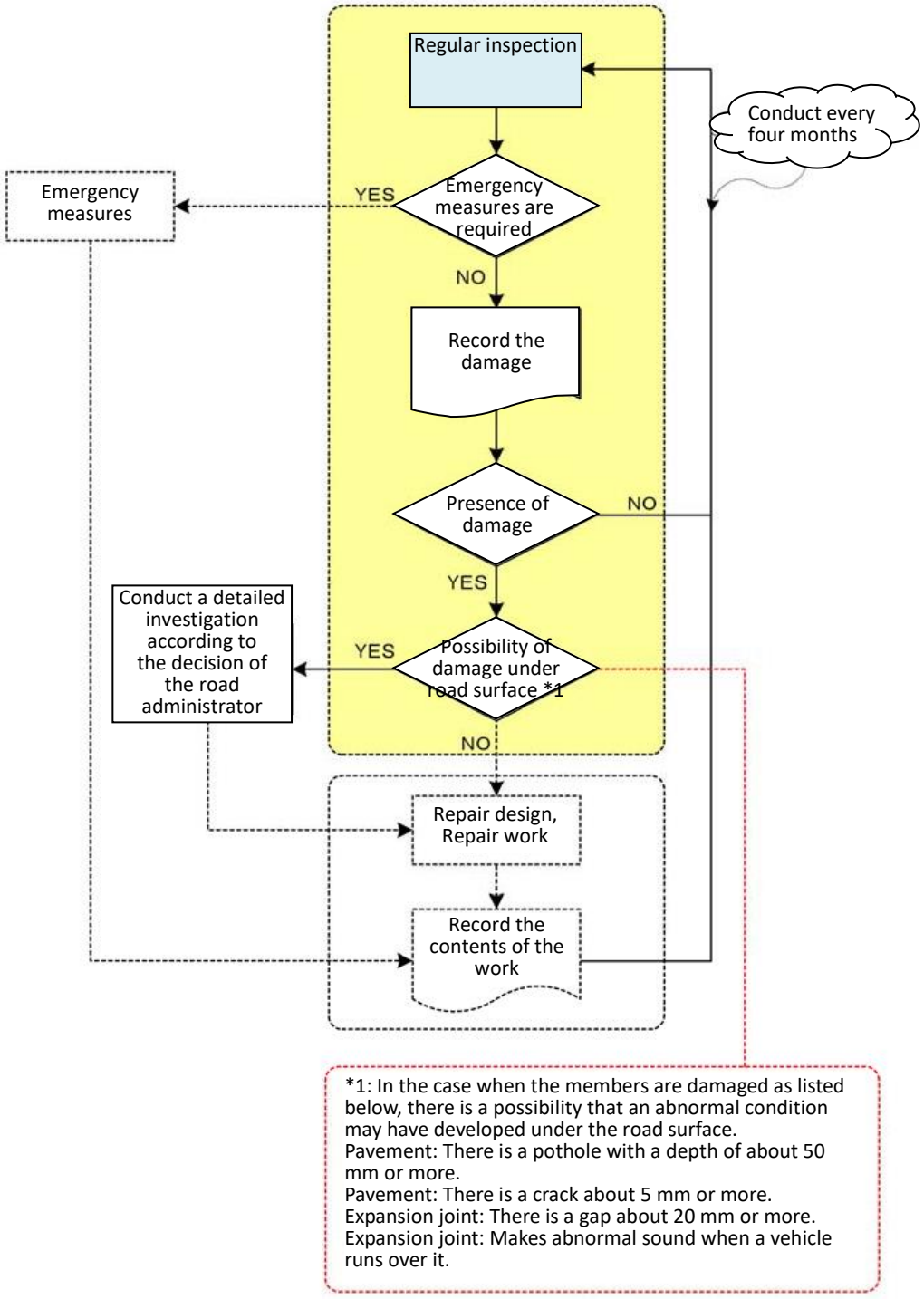


Figure 4.1.1 Flow of regular inspection work

2. Contents of Inspection

2.1 Frequency, Method, and System

The regular inspection shall generally be conducted visually on foot, not less than every four months by at least two persons.

【Notes】

In conventional road patrols, a bridge is visually checked only from inside a patrol vehicle, and damage that cannot be seen from the vehicle has been inspected only at the time of periodic inspection. However, periodic inspection, particularly Inspection A, is conducted once every year, and it is sometimes difficult to find serious damage that may develop during that period of time in its early stage due to insufficient capacity of the inspector(s); therefore, the frequency and the method of regular inspection have been set as described above as a basic rule in order to detect damage at an early stage.

Generally, the inspection shall be conducted by at least two persons for the sake of safety management. The inspection team members shall be appropriately determined considering the local conditions, etc.

2.2 Target Members

The target members of regular inspection are mainly those relating to road and road surface. The standard target members are shown in Table 4.2.1.

Table 4.2.1 Target members of inspection

Component	Element		Target	Remarks
Superstructure	Deck		◎	
	Main structure		△	
	Other than deck and main structure	Main members	△	
		Non-main members	△	
Substructure	Body		△	
	Foundation		◎	Inspection for scouring
Bearings	Body		△	
	Shoe seat		△	
	Bridge fall prevention device		––	
On the road	Railing, Guard fence		◎	
	Noise barrier		◎	
	Lights, Traffic signs		◎	Inspect only the foundation.
Road surface	Wheel guard		◎	
	Kerb, Median strip		◎	
	Pavement		◎	
	Expansion joint		◎	Inspect only the area that can be seen on the road surface.
Others	Drainage facility		◎	Inspect only the area that can be seen on the road surface, such as drainage basin.
	Inspection facility		–	
	Accessories		–	

◎: Mainly close visual inspection ○: Mainly visual inspection from a distance

－：Not applicable

△：Take a photo if there is a possibility that an Extraordinary condition may have developed

【Notes】

The target members of regular inspection are those relating to roads and road surfaces that directly affect traffic safety. The state of the damage that has occurred on these members shall be grasped through routine inspection and always kept in good condition. The damage on a road surface and foundation sometimes indicates the possibility of abnormality of members beneath it; therefore, take a photo of such members depending on the damage state.

2.3 Evaluation and Recording Methods of Damage

The bridge inspectors shall check the presence or absence of each damage type referring to “2.6 Damage Examples” and record them for evaluation presented in “Appendix-3.1 Routine Inspection Sheet”.

【Example: Inspection sheet for regular inspection】

Inspection sheet for regular inspection

component	Member	Damage state *1	Presence		Location of the damage				Photo file No.
			Yes	No	Span No.	Position in the width *2			
						Left	Middle	Right	
Road surface	Wheel guard, Curb, Median strip	Damage due to vehicle collision, etc.	☐	■		☐	☐	☐	
	Pavement	Pothole with a depth of about 50 mm or more	☐	■		☐	☐	☐	
		Dent (rut) about 30 mm or more	☐	■		☐	☐	☐	
		Crack about 5 mm or more mm	■	☐	1	☐	■	☐	001.jpg
	Expansion joint （including the back wall of abutment）	Hight gap about 20 mm or more	■	■	2	☐	☐	☐	002.jpg
		Extraordinary sound when a vehicle runs over it	☐	■		☐	☐	☐	
		Damage to expansion joint	☐	■		☐	☐	☐	
	Drainage facility	Clogged with sediment or overlay of pavement	■	☐	1,2	■	☐	■	003.jpg,004jpg
On the road	Railing, Guard fence, Noise barrier	Damage or deformation due to vehicle collision, etc.	☐	■		☐	☐	☐	
	Lights, Traffic signs	Extraordinary swing when the pole is pushed	☐	■		☐	☐	☐	
		Hole due to corrosion	☐	■		☐	☐	☐	
		Loose bolt	☐	■		☐	☐	☐	
Others		Risk to road users	☐	■		☐	☐	☐	

*1: The results of measurement shall be recorded in the column below.

*2: The position of the damage in the width shall be determined by dividing the width into three segments facing toward the A2 abutment direction from A1 abutment.

*3: If one type of damage is found in multiple locations, record the span number, position in the width, and photo number of them all in the column below.

Special remarks

Gap of expansion joint: No gap on A1 and P1; 25 mm on A2

2.4 Measures against Damage

When damage is found, appropriate measures shall be taken immediately.

【Notes】

The damage found in regular inspection usually directly affects traffic safety; therefore, measures shall be taken immediately. However, if it is difficult to judge the necessity of repair or detailed investigation, appropriate responses such as consulting with experts, etc. are needed. The following shows the measures to be taken for the damage found during regular inspection.

Table 4.2.2 Measures to be taken for damage

Component	Member	Damage state	Countermeasures	Remarks
Road surface	Wheel guard, Curb, Median strip	Damaged due to vehicle collision, etc.	Sectional repair	
	Pavement	Pothole with a depth of about 50 mm or more*1	Partial re-pavement	Deck slab may have abnormalities
		Dent (rut) about 30 mm or more	Partial re-pavement	
		Crack about 5 mm or more *1	Crack repair or partial re-pavement	Deck slab may have abnormalities
	Expansion joint (including the back wall of abutment)	Hight gap about 20 mm or more *1	Eliminate the gap by partial re-pavement (emergency measure)	Bearings, superstructure, and substructure may have abnormalities
		Extraordinary sound when a vehicle runs over it *1	Replacement of the joint	Bearings, superstructure, and substructure may have abnormalities
		Expansion joint is damaged	Replacement of the joint	
	Drainage facility	Clogged with sediment or overlay of pavement	Removal of sediment, etc.	
On the road	Railing, Guard fence, Noise barrier	Damaged or deformed due to vehicle collision, etc.	Replacement of the member	
	Lights, Traffic signs	Swings extraordinarily when the pole is pushed.	Re-tightening the bolts, or removal of the pole	If the cause is the cradle, remove the pole.
		Hole due to corrosion	Repair with a patch plate, or removal of the pole	If the loss due to corrosion is large, the pole may be removed.
		Loose bolt	Re-tightening the bolts	
Others		Risk to road users	Necessary measures	Consult with experts if judgment is difficult

Note: *1 is the type of damage that may have abnormalities under the road surface; therefore, take photos of the members beneath it near the damage. The photos shall be submitted to the road administrator for them to grasp the situation of the site and judge the necessity of detailed investigations.

2.5 Record of Inspection

The inspection results shall be recorded in a specific template presented in “Appendix-3 Inventory and Inspection Sheet” and registered in the database.

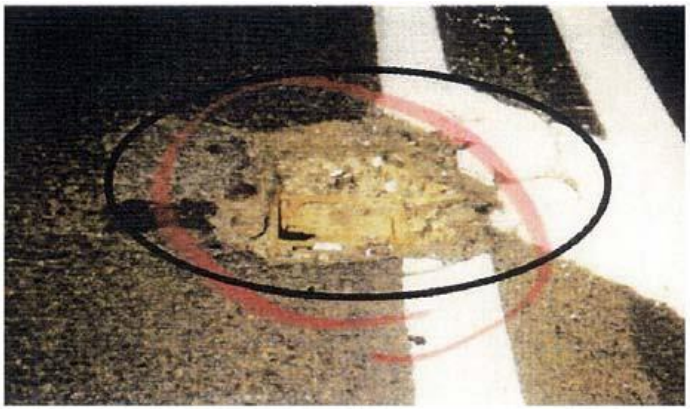
【Notes】

The inspection results can be important data for rational maintenance and management; therefore, the results shall be recorded in a specific template and registered in the database.

The inspection results shall be recorded, and the inspection reports shall be prepared according to the following procedures.

i. Output an inspection sheet specified for regular inspection from the “Bridge Management System (BMS)”.
ii. Understand the outline of the target bridge and points of inspection based on existing data before conducting an inspection. For recording the inspection results on the site, use the inspection sheet for regular inspection.
iii. Input the inspection results to the “Bridge Management System (BMS)” and output the documents relating to the inspection results in order to file them as reports.
iv. Take measures against the damage referring to the documents output from the system, etc.
v. After taking the measures, input the repair records to the “Bridge Management System (BMS)” and output related documents in order to file them as reports. Same to other inspection results, the existing Bridge Management System only allows to input the result of Inspection A and the result of routine inspection should be stored by both hard copy and any format of the soft copy.
vi. Register them in the database.

2.6 Damage Examples

Damaged part	Damage example	Damage state
Wheel guard		The wheel guard is damaged with cracks and loss due to a vehicle collision, etc. If a vehicle crashes to it, the vehicle may fall off the bridge. There is also a risk that an accident may occur if there is a road or pedestrian underneath the bridge.
Pavement	 	There is a hole with a depth of about 50 mm or more on the pavement. This may hinder traffic and cause an accident. In this case, there might be an abnormality under the surface (damage to the deck slab, etc.); therefore, appropriate measures such as conducting a detailed investigation, etc. are required.

Damaged part	Damaged example	Damage state
Pavement		There are cracks on the pavement. This may hinder traffic and cause an accident. In this case, there might be an abnormality under the surface (damage to the deck slab, etc.); therefore, appropriate measures such as conducting a detailed investigation, etc. are required.
		
Expansion joint		There is a gap about 20 mm or more in the expansion joint. This may hinder traffic and cause an accident. In this case, there might be abnormality under the girders (subsidence of bearing, etc.); therefore, appropriate measures such as detailed investigation, etc. are required.

Damaged part	Damaged example	Damage state
Expansion joint		The expansion joint is damaged. This may hinder traffic and cause an accident.
Drainage facility		Drainage is clogged with sediment. This makes a puddle during rainfall and may hinder traffic and cause an accident.
Railing, Guard fence		The railing and guard fence are deformed and damaged due to a collision of vehicle, etc. If a vehicle crashes into them, the vehicle may run off the bridge. There is also a risk that an accident may occur if there is a road or pedestrian underneath the bridge.

Chapter 5 Inspection at Extraordinary Conditions

1. Flow of Inspection Work

The inspection shall generally be conducted according to the flow below.

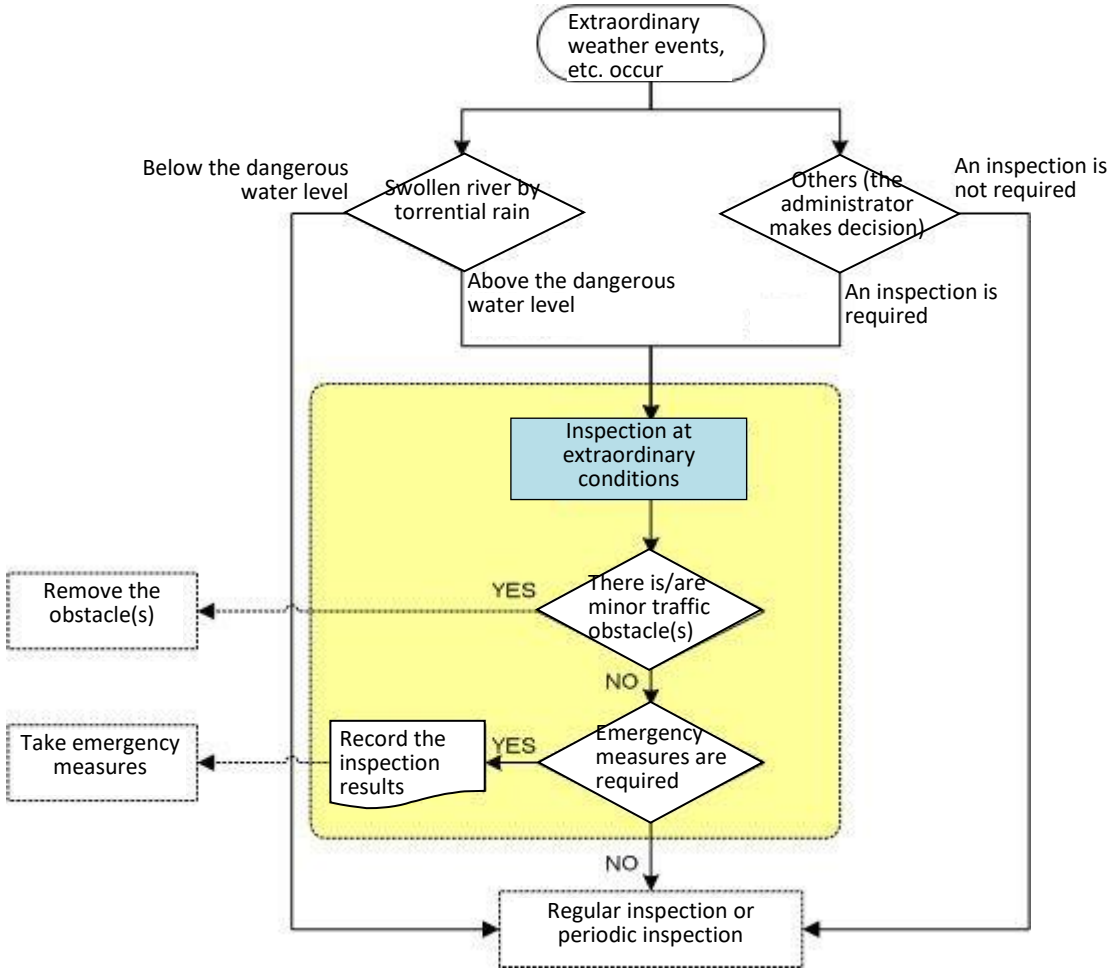


Figure 5.1.1 Flow of inspection work at abnormal conditions

【Notes】

The case that “There is/are minor traffic obstacle(s)” refers to the state when traffic is hindered due to an obstacle on the road (fallen rocks, stones placed intentionally, fallen trees, weeds, signboards, etc.) but can be restored when the obstacle is removed. Appropriate measures shall be taken against such minor traffic obstacle(s) on the site.

The necessity of emergency measures shall be determined by judging whether the bridge maintains its function for ensuring traffic safety or not.

2. Contents of Inspection

2.1 Frequency, Method, and System

The inspection at extraordinary conditions shall immediately be conducted by appropriate number of persons before and after the occurrence of extraordinary weather events by the methods of visual inspection from a vehicle and physical sense of roughness of the road on a vehicle.

【Notes】

In order to respond promptly to traffic obstacles caused by extraordinary weather events, the inspection for extraordinary conditions shall be conducted by the method and frequency described above in principle for the early detection of damage.

The reference criteria for judging the necessity of inspection due to extraordinary weather events are shown below.

i. Torrential rain: rainfall of 50 mm or more per hour, continuous rainfall of 200 mm or more per day
ii. Flood (swollen river): above the dangerous water level
iii. Typhoon: maximum wind speed is 17.2 m/s or more liked to a typhoon
iv. Combined case: if the phenomenon listed in **i** and **iii** occurs the same time
v. Extraordinary weather: which is applied to the restricted road section according to the Traffic Regulation Standards for Extraordinary Weather

The inspection at extraordinary conditions shall be conducted by at least three persons for the safety management. The inspection team members shall be appropriately determined considering the local conditions, etc.

The inspection is aimed at quickly grasping the presence of damage on and the trafficability of the road, and it is conducted in principle by the means of visual inspection and physical sense of roughness of the road while driving in a vehicle. However, after the occurrence of extraordinary weather, when damage is found, go to the damaged area or the target members as close as possible on foot, take photos, conduct visual inspection, and carry out simple measurement using a tape or other device.

2.2 Target Members

The standard target members of the inspection at extraordinary conditions are shown in Table 5.2.1.

Table 5.2.1 Target members of inspection

Component	Member		Inspection target	Remarks
			extraordinary weather events	
Bridge as a whole	Collapse		◎	
Superstructure	Deck		△	
	Main structure		◎	Drift deposition
	Other than deck and main structure	Main members	◎	Ditto
		Non-main members	◎	Ditto
Substructure	Body		◎	Ditto
	Foundation		◎	Scouring
Bearings	Bearing body		◎	Drift Deposition
	Shoe seat		◎	Ditto
	Bridge fall prevention device		◎	Ditto
On the road	Railing, Guard fence		◎	Collapse
	Noise barrier		◎	Ditto
	Lights, Traffic signs		◎	Ditto
Road surface	Wheel guard		△	
	Kerb, Median strip		△	
	Pavement		△	
	Expansion joint		◎	Deformation, etc.
Others	Drainage facility		◎	Ditto
	Inspection facility		◎	Ditto
	Accessories		◎	Ditto

◎: Mainly close visual inspection ○: Mainly visual inspection from a distance

－：Not applicable

△：Take a photo if there is a possibility that an Extraordinary condition may have developed

【Notes】

The target members of the inspection at extraordinary conditions shall be divided into the case of an extraordinary weather events as shown in the table above. The inspection shall be conducted in principle by the methods of visual inspection from a vehicle (distant view) and physical sense of roughness of the road on a vehicle, while focusing on the damage to bridge surface, bearings, superstructure/substructures, etc., that is likely to occur at the time of extraordinary weather events. If any abnormalities are confirmed by visual inspection from a distance, the target members shall be checked by close visual inspection as much as possible.

2.3 Evaluation and Recording Methods of Damage

The bridge inspectors shall check the presence or absence of each damage type for evaluation and record them presented in “Appendix-3 Inventory and Inspection Sheet” and in “Appendix-3.2 Inspection at Extraordinary Condition Sheet”.

【Notes】

As mentioned above, the bridge inspectors shall check the presence or absence of each damage type for target members for evaluation and record them on the inspection sheet at extraordinary conditions

The inspection sheet shall be prepared for extraordinary weather events on a regular basis so that inspectors can conduct an inspection, judge the presence of damage, and record the results promptly. In addition, the damaged area shall be photographed and measured in a simple method with a tape or other device, and the results shall be recorded on the inspection sheet.

If damage not attributable to the extraordinary weather events is found, the information shall be recorded as special remarks.

Some examples of the inspection sheet at extraordinary conditions are shown below.

【Example: Extraordinary weather event: Torrential rain】

Inspection sheet at extraordinary conditions

Bridge code	D0240-0	Name of Branch	Isahaya Civil Engineering Office
Bridge name	YYYYYYY		

Date of inspection	20〇〇/〇〇/〇〇
Type of inspection	Inspection for extraordinary

Component	Element	Damage state *1	Presence		Photo file No.
			Yes	No	
Bridge as a whole		Collapsed	☐	■	
Superstructure	Main girder, Deck slab	Damaged (deflection, deformation, crack)	☐	■	
Substructure	Body, Foundation	Damaged (Subsidence, displacement, inclining, scouring, crack)	☐	■	
Bearings	Body, Shoe seat, Bridge fall prevention device	Damaged (Fall off, fracture)	☐	■	
Road surface		Significant bump(s) on the road surface	☐	■	
		Extraordinary sound/vibration	☐	■	
	Wheel guard, Curb, Median strip, Pavement	Seriously damaged	☐	■	
	Expansion joint	Extraordinarily wide gap	☐	■	
		Seriously damaged	☐	■	
On the road	Railing, Guard fence, Noise barrier, Lights, Traffic signs	Damaged or deformed and considered to be dangerous to road users	☐	■	
Others	Drainage facility	Seriously damaged, or water stays/overflows on the surface	■	☐	001.jpg, 002.jpg
	Inspection facility, Accessories, Wing wall	Seriously damaged	■	☐	003.jpg,004jpg
	Others	Risk to road users	☐	■	
Overall evaluation		Necessity of emergency measures	☐	■	

*1 The results of measurement shall be recorded in the column below

Special remarks

・There is/are puddle(s) on the bridge surface, and water overflows from the drainage basin.

・The attached water pipe is damaged and water is leaking.

2.4 Measures against Damage

When damages are found, appropriate measures shall be taken immediately.

【Notes】

The damage found in inspection at extraordinary conditions usually directly affects traffic safety; therefore, countermeasures shall be taken immediately. However, if it is difficult to judge the necessity of repair or detailed investigation, appropriate responses such as consulting with experts, etc. are needed.

2.5 Record of Inspection

The inspection results shall be recorded in a specific template and registered in the database.

【Notes】

The inspection results can be important data for rational maintenance and management; therefore, the results shall be recorded in a specific template and registered in the database.
The inspection reports shall be prepared and the inspection results shall be recorded according to the following procedures.

i. Output an inspection sheet for extraordinary conditions from the “Bridge Inspection Support System”.
ii. Understand the outline of the target bridge and points of inspection based on existing data before conducting an inspection. For recording the inspection results on the site, use the inspection sheet at extraordinary conditions.
iii. Input the inspection results to the “Bridge Management System” and output the documents relating to the inspection results in order to file them as reports. Same to other inspection results, the existing Bridge Management System only allows to input the result of Inspection A and the result of emergent inspection should be stored by both hard copy and any format of the soft copy.
iv. Take measures against the damage referring to the output documents, etc.
v. Register them in the database.

2.6 Report of Inspection

The inspection results shall be reported to the Road Administration Division, Department of Roads by using presented in “Appendix-3.3 List of Inspection Results at Extraordinary Conditions”.

【Notes】

It is necessary for the prefectural government to collect necessary information from each local organization which actually conducts the inspection without delay in order to take appropriate measures based on the inspection results. It should be noted that a careless report may lead to a fatal result.
Regarding the inspection at extraordinary conditions, the following reports shall be submitted to the Road Administration Division, Department of Roads after the inspection.

i. Inspection status report
Regardless of the occurrence of damage, report the inspection status and results as needed. (List of inspection results at extraordinary conditions)

ii. Inspection results and damage status report
If damage is found in the inspection, report the cause, damaged area, damage status, etc.

An example of the list of inspection results at extraordinary conditions is shown below.

【 Example of the list of inspection results at extraordinary conditions】

The list of inspection results for extraordinary conditions,
Iaaaa Office, All routes, Inspection date: 2006/12/25～2006/12/31

Bridge code	Name of the bridge	Route No.	Date of inspection	Type of Extraordinary event	Level of the Extraordinary event	Presence/absence of damage							Necessity of emergency measures
						Bridge as a whole	Super-structure	Sub-structure	Bearings	Road surface	On the road	Others	
D0240	XXXXXX	ZZZ	2006/12/25	Flooding		○	○	○	●	○	○	○	No
D0000	○○	○○	2006/12/25	Heavy Rain		○	○	○	●	○	○	○	No
D0000	○○	○○	2006/12/26	Flooding		○	○		○	○	○		No
D0000	○○	○○	2006/12/26	Typhoon		○	○		○	○	○		No
D0000	○○	○○	2006/12/31	Flooding		●	○	●	○	○	●	●	Yes