

**DETAILED INSPECTION  
(TOR)**

The Project  
for Capacity Development  
on Bridge Maintenance and Management  
in Lao People's Democratic Republic

Terms of Reference  
on Detailed Inspection  
for Nam Mone Bridge and Houay Pongsong Bridge  
in Vientiane Province, and  
Xe Banghiang Bridge and Xe Bangnouan Bridge  
in Savannakhet Province

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Consortium of IDCJ, Nagasaki University, OCG and KEI

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## **1 Background of the Project**

Looking at the practice of the bridge maintenance, many bridges are being damaged and deteriorated, but only "breakdown-maintenance" is in place, in which repairs are performed only after the damage to the bridge has enlarged and "planned repair" has been absent. There are 3,580 bridges and structures nationwide, including 1,350 on National Roads, of which 35% require regular maintenance and 17% require emergency repairs. In addition, 40% are temporary bridges such as wooden bridges and Bailey bridges, which usually lack durability, and there have been multiple incidents of bridge collapse due to damage to bridges mainly caused by improper bridge repair and maintenance and overloaded vehicles. Bridges in Laos have been constructed and maintained with the support of Japan, but in order to ensure safe and smooth traffic on trunk roads, well planned maintenance and repair of bridges is crucial.

Accordingly, JICA provides technical assistance program, entitled the Project for Capacity Development on Bridge Maintenance and Management (hereinafter referred to as "JICA-BMM") to establish bridge maintenance cycles (i.e., Inspection-Diagnosis-Planning-Repair) and contributes to the improvement of bridge maintenance capabilities of DOR, PTTI and DPWTs. Notably, Public-Private-Academia collaboration and adaptation of Japanese technologies to the bridge inspection and diagnosis are part of area JICA-BMM emphasizes in order to practice effective infrastructure management and lifetime extending maintenance technology and establish institutional maintenance framework and nationwide robust road network in Laos.

## **2 Purpose of the Project**

The overall project goal is that bridges in pilot provinces (Vientiane, Savannakhet and Champasak) are properly maintained. To do so the Project aims at improving bridge management capability of DOR and pilot DPWTs.

## **3 Scope of the Project**

The scope of the Project is:

1. Bridge inspection and diagnosis capability of DOR and pilot DPWTs is improved.
2. Bridge repair and maintenance capability of DOR and pilot DPWTs is improved.
3. Operational and management capability of Bridge Management System (BMS) of DOR and pilot DPWTs is improved.
4. Capability for bridge management planning of DOR and pilot DPWTs is improved.

#### 4 Terms of Reference of the detailed inspection Objective bridges Location of objective bridges

Objective bridges are Nam Mone Bridge and Houay Pongsong Bridge located on NR No.13 North in Vientiane Province, and Xe Banghiang Bridge and Xe Bangnouan Bridge located on NR No.13 South in Savannakhet Province as shown in Appedix-1 and Appendix-2.

##### 4.1.2 General view of objective bridges

Rough drawings on the general views of four (4) bridges were drawn by surveying each bridge member at the pilot inspection conducted in July 2021 as shown in Appendix -3 to Appendix-6.

#### 4.2 Proposed Inspection approach, Team formation and its responsibility

In order to smoothly perform the detailed inspection, the team would be recommended to formulate around two (2) to three (3) teams with the following member for four (4) bridges. The first team is formulated for Nam Mone Bridge and Houay Pongsong Bridge, the second team is for Xe Banghien Bridge and the third team is for Xe Bangnouan Bridge. Team member and numbers of member are same as below. Team formation of Nam Mone Bridge mentions later.

- 1) Team leader : 1 person
- 2) Inspector : 1 person
- 3) Supporting staff : 2 persons
- 4) Safety control staff : 1 person
- 5) Traffic control staff : 2 persons

Proposed experience and responsibility of the team member are shown in Table 4.3.1.

**Table 4.3.1 Proposed Experience and responsibility of each member**

Member	Skill and Experience	Role and Responsibility
Team leader	At least ten (10) years of experience in bridge structures of civil engineering	<ul style="list-style-type: none"> <li>✓ Having correct knowledge of bridge engineering</li> <li>✓ Being accurately inspect and to appropriately diagnose</li> <li>✓ Judging damage grade comprehensively</li> <li>✓ Instructing to subordinates correctly</li> </ul>
Inspector	At least seven (7) years of experience in bridge structures of civil engineering	<ul style="list-style-type: none"> <li>✓ Having correct knowledge of bridge engineering</li> <li>✓ Being accurately inspect and to appropriately diagnose</li> <li>✓ Judging damage grade purely under the Team leader</li> <li>✓ Instructing to subordinates correctly</li> </ul>
Supporting staff	At least five (5) years of experience in bridge structure of civil engineering	<ul style="list-style-type: none"> <li>✓ Having correct knowledge of bridge engineering</li> <li>✓ Being each measuring under the Inspector</li> </ul>
Safety control staff at the site	At least three (3) years of experience under his/ her boss	<ul style="list-style-type: none"> <li>✓ Controlling safely under the Team leader</li> </ul>
Traffic control staff on the road	At least three (3) years of experience under his/ her boss	<ul style="list-style-type: none"> <li>✓ Controlling traffic flow under the Team leader</li> </ul>

##### 4.2.2 Target member and item of the detailed inspection

The target members of the detailed inspection are shown in Table 4.3.2. Each member of the bridge component

should mainly be inspected by a close visual inspection. Table 4.3.3 shows the target members, damage type and status to be checked in the detailed inspection.

**Table 4.3.2 The target members for each inspection**

Component	Member	Close visual inspection	
Superstructure	Deck	◎	
	Main structure	◎	
	Other than deck and main structure	Main member	◎
		Non-main member	◎
Substructure	Body	◎	
	Foundation	◎	
Bearings	Bearing body	◎	
	Shoe seat	◎	
	Bridge fall prevention device	◎	
On the road	Railing, Guard fence	◎	
	Noise barrier	◎	
	Lights, Traffic signs	◎	
Road surface	Wheel guard	◎	
	Pavement	◎	
	Expansion joint	◎	
Others	Drainage facility	◎	
	Inspection facility	◎	
	Accessories	◎	
	Wing wall	◎	

**Table 4.3.3 The damage type and status to be checked**

《Items to be evaluated and recorded its damage status》			
Component	Element	Material	Type of damage (SN)
Superstructure	Deck	Steel	• Corrosion(01), Cracks*(02), Fracture*(04)
		Concrete	• Peeling/Exposure of rebar(07) • Leaching/Free lime(08) • Cracks on floor slab(11)
	Main structure	Steel	• Corrosion(01), Cracks*(02), Fracture*(04)
		Concrete	• Cracks(06) • Peeling/Exposure of rebar(07) • Leaching/Free lime(08)
Substructure	Body	Steel	• Corrosion(01), Cracks*(02), Fracture*(04)
		Concrete	• Cracks(06) • Peeling/Exposure of rebar(07) • Leaching/Free lime(08)
	Foundation	—	• Exposed due to scouring(26)
《Items to be checked and recorded for the presence of serious damage》			
Component	Element	Material	Serious damage

Bearings	Bearing body	—	<ul style="list-style-type: none"> <li>• Makes extraordinary sound when a vehicle runs over it.</li> <li>• Severely corroded; some parts are missing; rubber is damaged, hardened, or lost</li> </ul>
	Shoe seat, Mortar	—	<ul style="list-style-type: none"> <li>• Sediment accumulates; water is pooled</li> <li>• Mortar is cracked and partially lost.</li> </ul>
On the Road	Railing, Guard fence	—	<ul style="list-style-type: none"> <li>• Damaged due to vehicle collision, etc.</li> <li>• Some places are considered dangerous for road users.</li> </ul>
Road surface	Pavement	—	<ul style="list-style-type: none"> <li>• Potholes, large bumps, or cracks</li> <li>• Some places are considered dangerous for road users.</li> </ul>
	Expansion joint	—	<ul style="list-style-type: none"> <li>• Step (about 2 cm or more)</li> <li>• Damaged, makes extraordinary sound when a vehicle runs over it</li> </ul>
	Drainage facility	—	<ul style="list-style-type: none"> <li>• Clogged with sediment, pavement overlay, etc.</li> <li>• Damaged and drained water is affecting girders</li> </ul>

[Note]

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 Damage Sketch (Superstructure), Damage Sketch (Substructure) and Damage Photo Data of Inventory/Inspection Sheet attached in Appendix.

The same shall be applied to the damage of members not listed in the tables above.

As a reference, serial numbers of each damage type are shown in Table 4.3.4.

**Table 4.3.4 Serial Number and damage type**

Material	Serial number/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

### 4.2.3 Equipment and tools for the detailed inspection

JICA Expert has already prepared equipment and tools as shown in Table 4.3.5. The inspection team member is able to borrow all the equipment and tools for the detailed inspection from the JICA Expert.

**Table 4.3.5 Equipment and tools to be lent from JICA Expert**

Purpose	Tools/equipment	Quantity	Reference Model	Remarks
Avannakhet Province (2) Inspection tools	Ultrasonic measuring meter	2	Leica DISTO D510	Savannakhet Province
	Telescopic pole camera with WiFi	3	Vividia WPC-600	Vientiane Province (1) Savannakhet Province (2)
	Expansion ladder	3	No specific model	Vientiane Province (1) Savannakhet Province (2)
	Caliper scale	3	No specific model	Vientiane Province (1) Savannakhet Province (2)
	Crack scale	3	No specific model	Vientiane Province (1) Savannakhet Province (2)
Diagnosis tools	Schmidt Hammer	3	Humbolt HT-225Q	Vientiane Province (1) Savannakhet Province (2)
	Carbonization measuring test kit	3	CARBONTEST	Vientiane Province (1) Savannakhet Province (2)
	Salinity measuring test kit	3	Chloride-Meter	Vientiane Province (1) Savannakhet Province (2)
	Rebar probe test kit	3	HILTI PS50 Multidetector	Vientiane Province (1) Savannakhet Province (2)
Safety tools	Safety Cone	20	No specific model	Vientiane Province (5) Savannakhet Province (15)

The bridge inspection vehicle is possible to use in the detailed inspection.

However, drilling machine and boring machine for testing the concrete must be prepared by the consultant.

### 4.3 Implementation of detailed inspection

#### 4.3.1 Inspection manner of the inspector

In order to smoothly perform the detailed inspection, the inspectors are requested to prepare but not limit to the items shown in Figure 4.4.1.

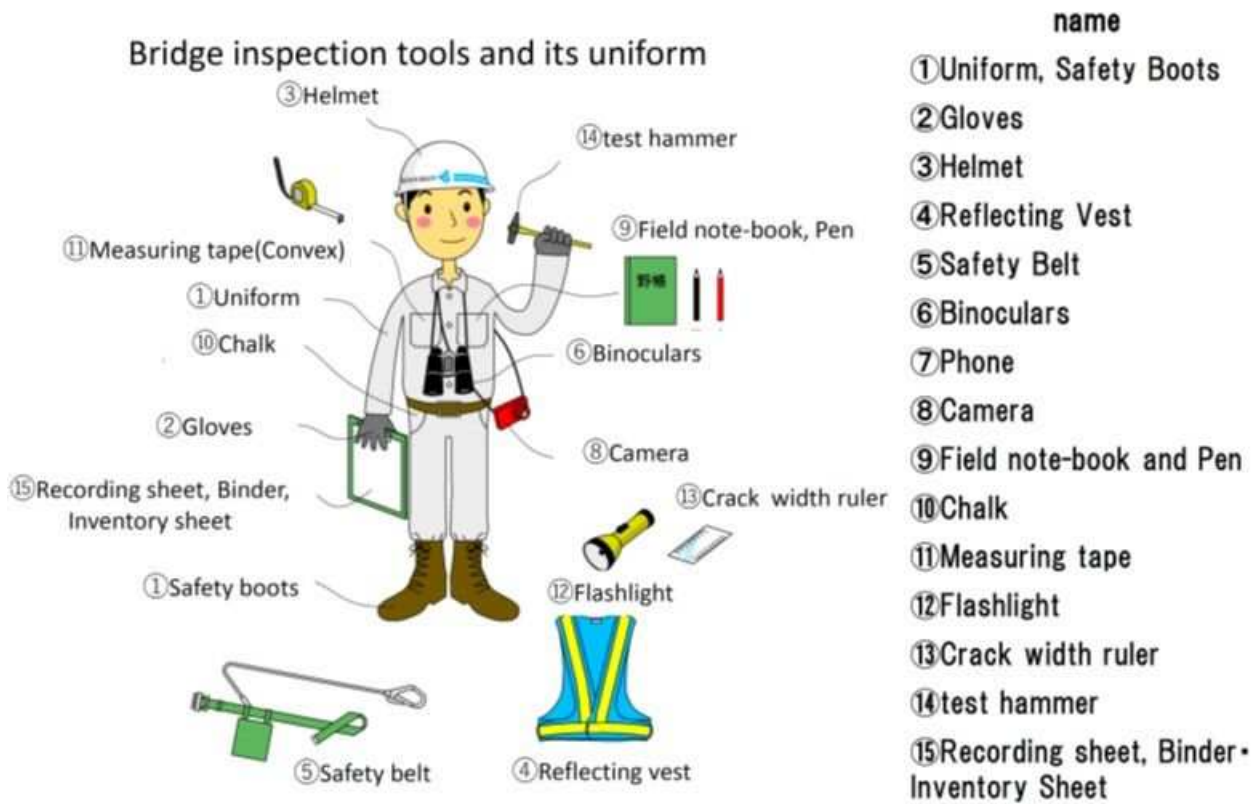
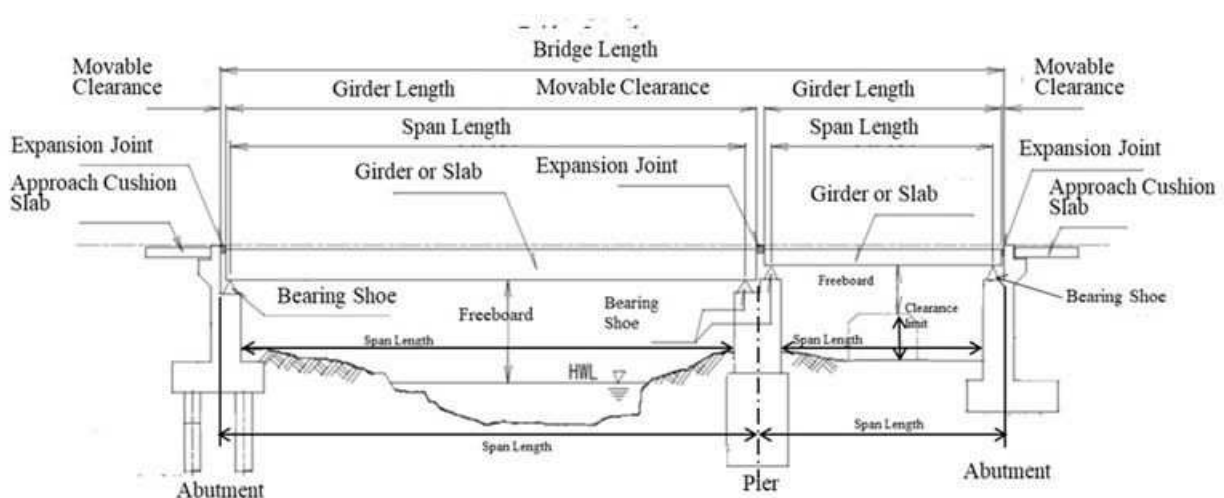
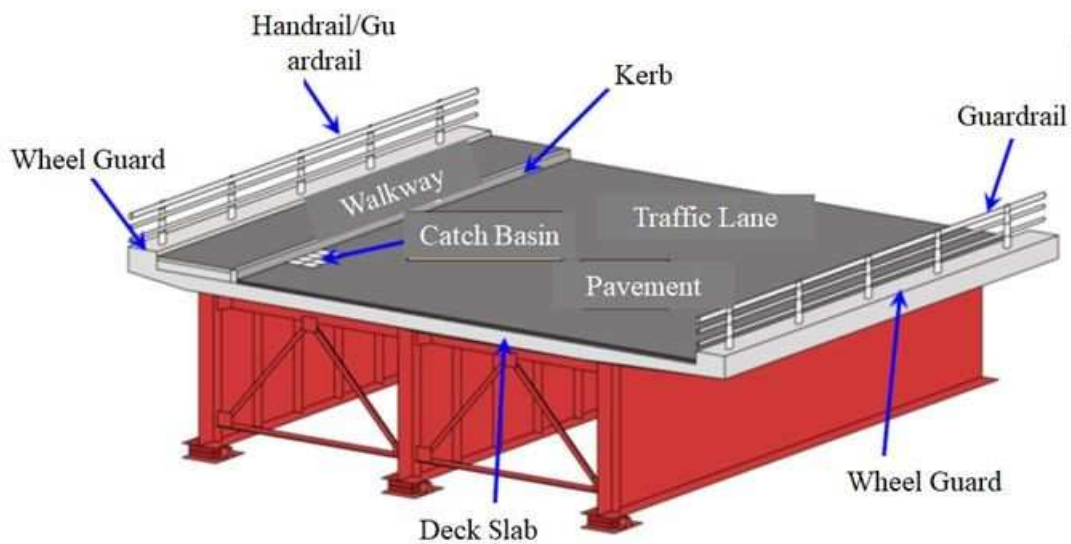
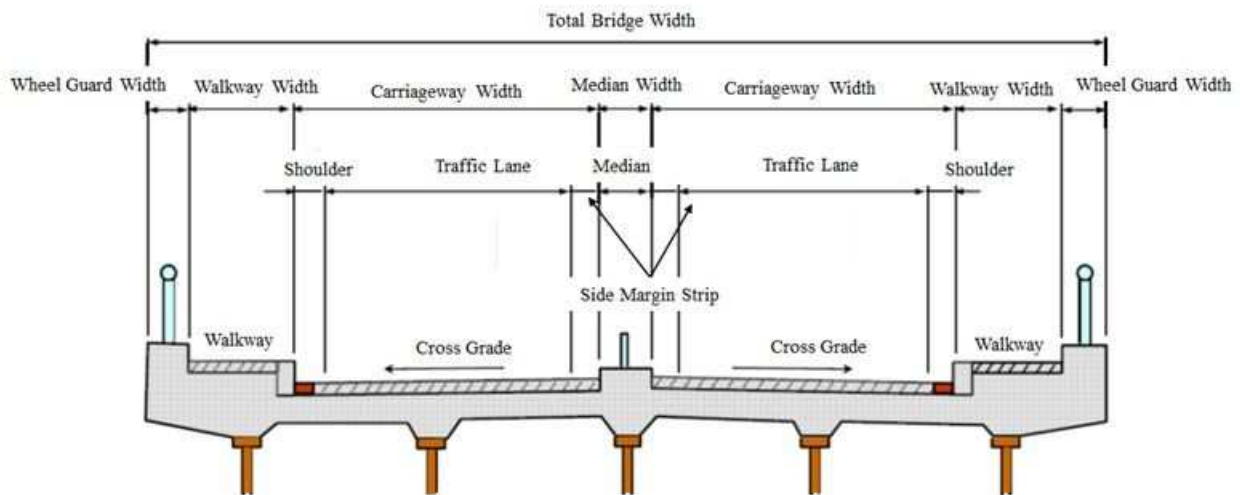


Figure 4.4.1 Inspector's manner

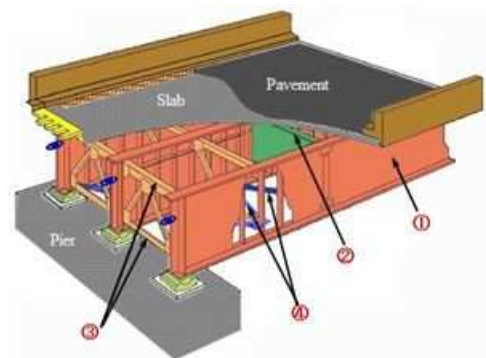
#### 4.3.2 Measurement for each member size of bridge components

Each size of all of the members of bridge components including the thickness of the deck slab must be measured as shown in Figure 4.4.2.





- ① Main girder  
To set on a bearing shoe of a pier or an abutment, to support a slab for a vehicle load and passenger, mainly.
- ② Cross girder (beam)  
An element to connect a main girder
- ③ Cross frame (except concrete bridge)  
An element to resist against lateral loads such as wind/ earthquake loads connected vertically to a main girder
- ④ Lateral member  
An element to resist against lateral loads such as wind/ earthquake loads connected horizontally to a main girder



- ⑤ Bearing Shoe  
To support the superstructure, to transmit the loads of superstructure
- ⑥ Expansion joint  
An equipment for absorbing expansion/contraction of the girder caused by temperature change and so on
- ⑦ Prevention device for bridge fall  
To prevent for falling down from the substructures (abutments or piers) caused by earthquake and so on

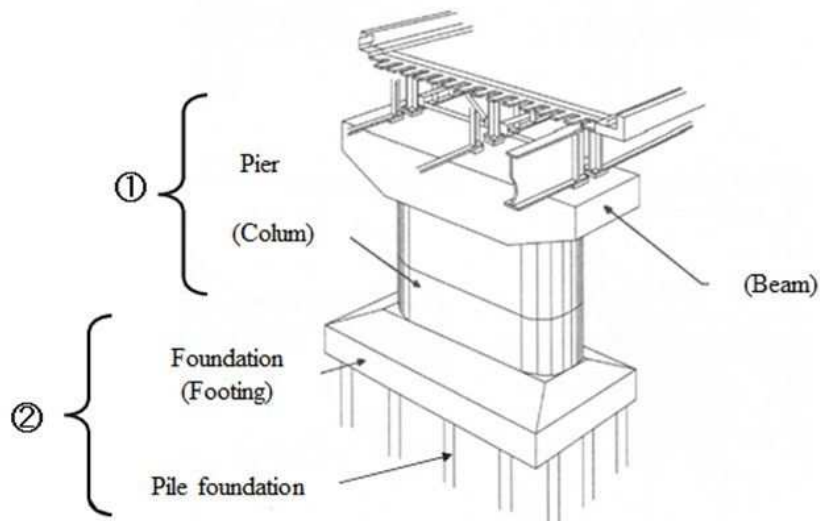
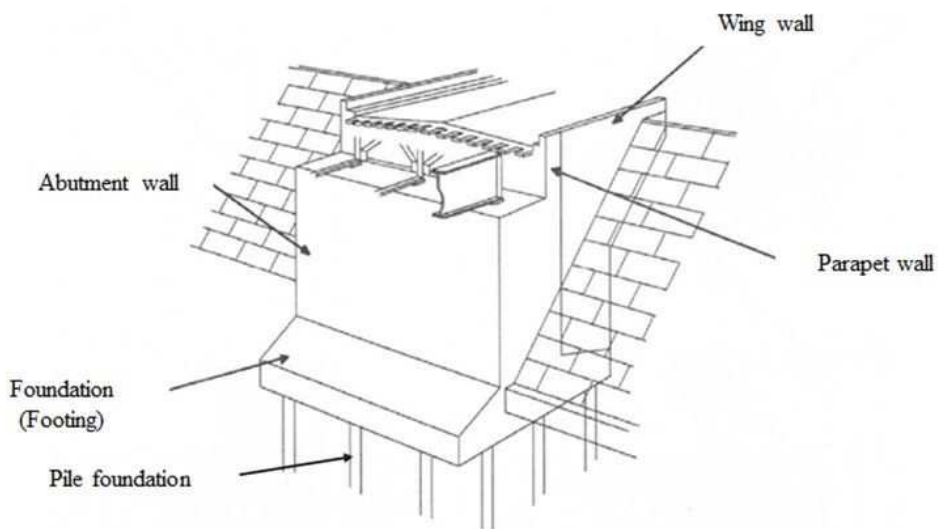
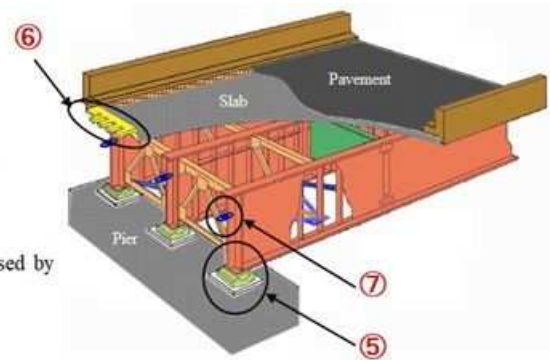


Figure 4.4.2 Sample of Each member Size of Bridge Components

### 4.3.3 Evaluation of damage grade

The damage grade inspected by the consultant must be evaluated as follows and filled in the Inventory and Inspection Data Sheet in Appendix-7.

Damage is evaluated into the following five damage grades for each damage type in principle as shown in Table 4.4.1. 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 4.4.1 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

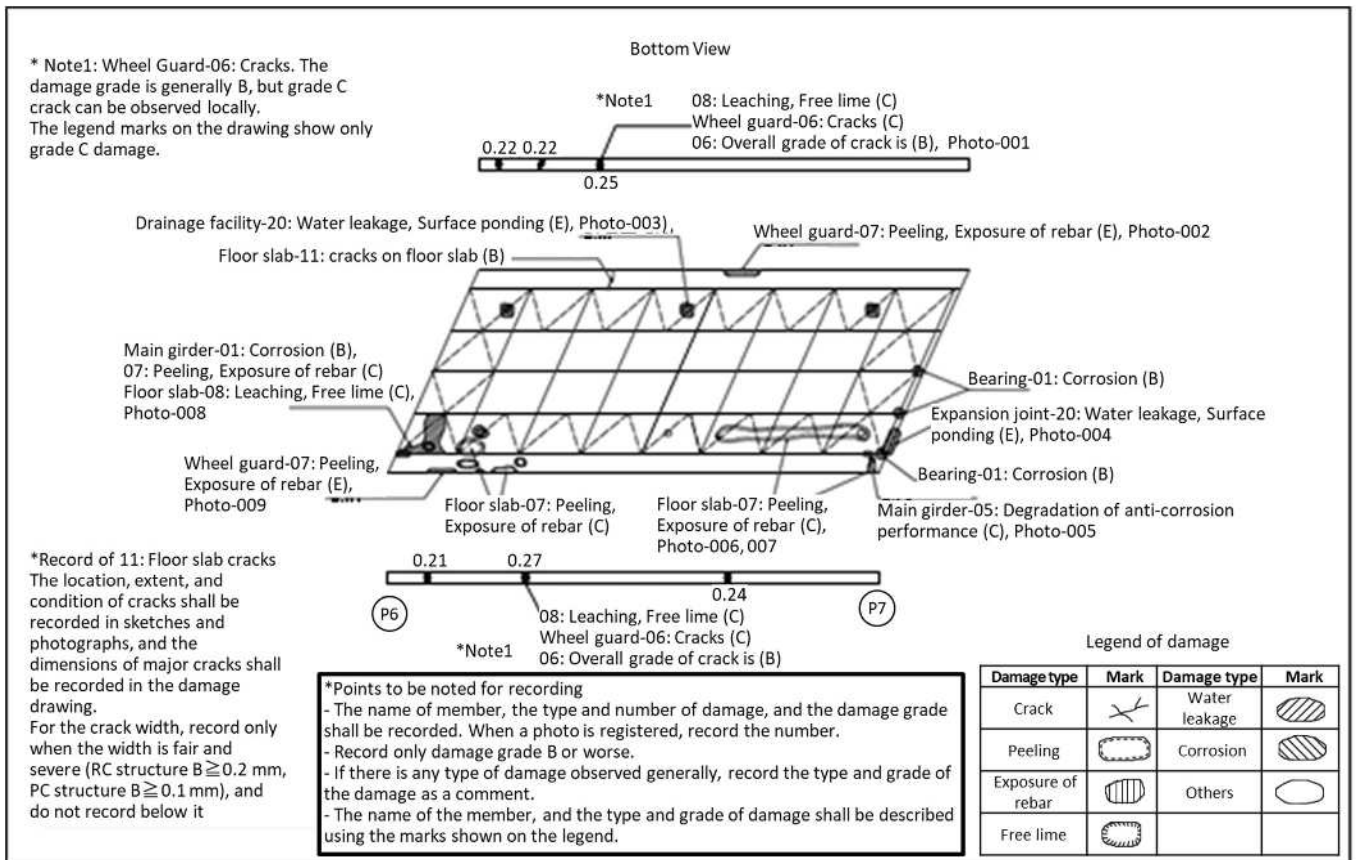
For example, in the evaluation of corrosion of main girders, the condition shown in the drawing below Figure 4.4.3 (the damage grade is B as a whole, but there is one segment with a D grade) shall be recorded as [A: 0%, B: 90%, C: 0%, D: 10%, E: 0%]. However, this ratio is determined by the inspector's 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 4.4.3 Example of the 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 4.4.4 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 4.4.4 Damage drawing**

Regarding the damage drawing of Figure 4.2.2, 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%].
- **Floor slab-07: Peeling, Exposure of rebar**  
Local damage of grade C is observed in three locations, but overall damage grade is A. In this case, record the damage grade ratio as [A: 80%, B: 0%, C: 20%, 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%].

### 4.3.4 Record of damage drawings

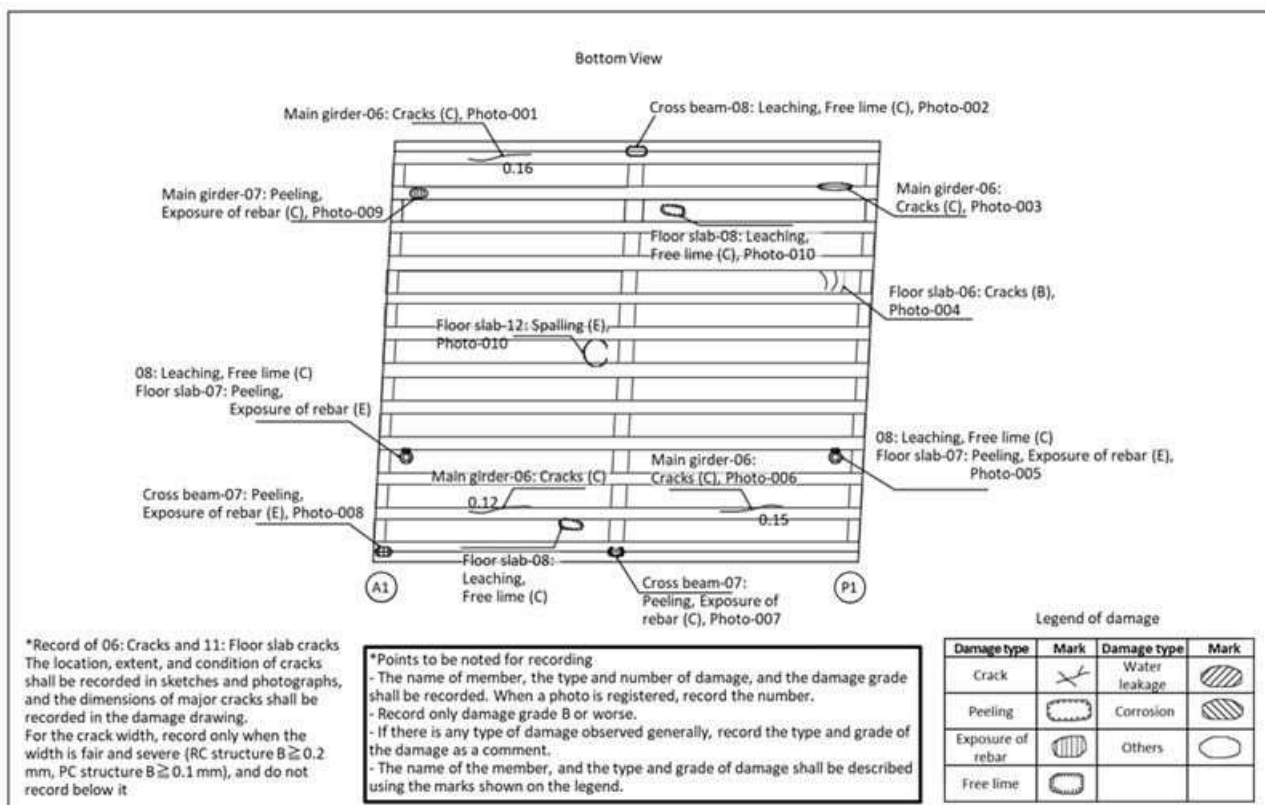
The inspection results of each member shall be recorded on damage drawings by each damage grade in principle. The inspection results are used not only for indicating the degree of damage, but also in various ways as basic information for efficient maintenance and management. For example, damage drawings 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 (Appendix-1) 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.

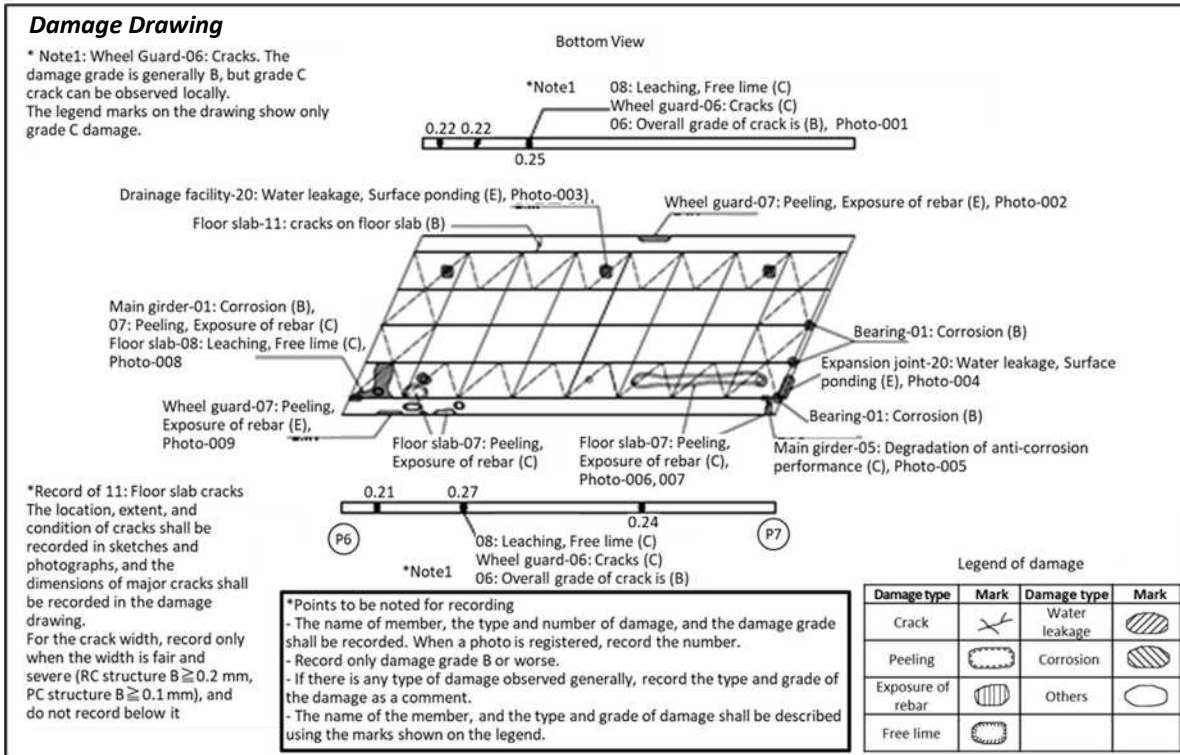
- Sketch the condition of cracks on concrete members (also record the crack width on the sketch).
- Sketch the location and extent of abnormalities such as peeling, spalling, and discoloration of concrete members.
- Sketch the location and progress of cracks on steel members.
- Sketch the location and 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.

The example of sketches is shown in Figure 4.4.5.

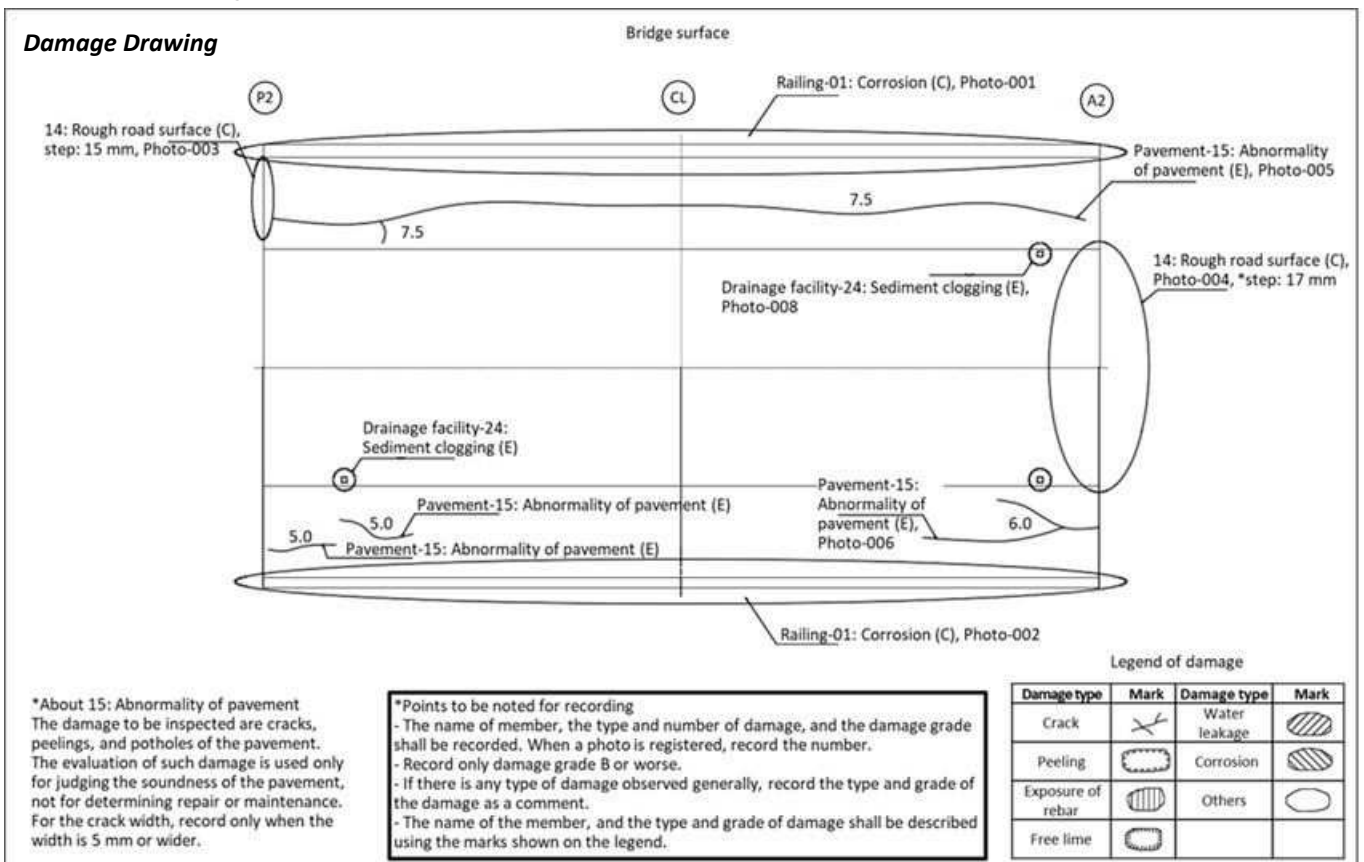
【 Example 1: PC Superstructure】



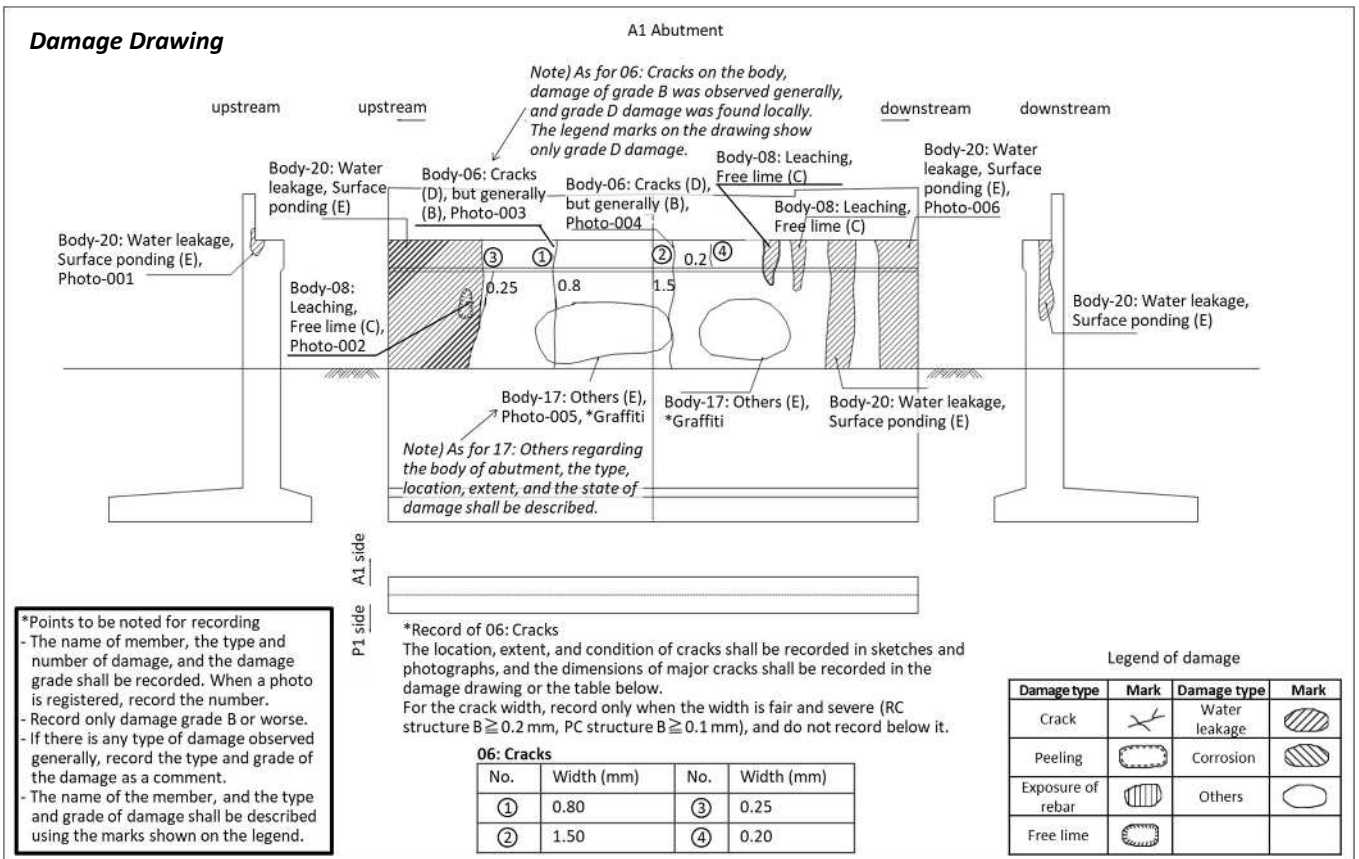
**[Example 2: Steel superstructure]**



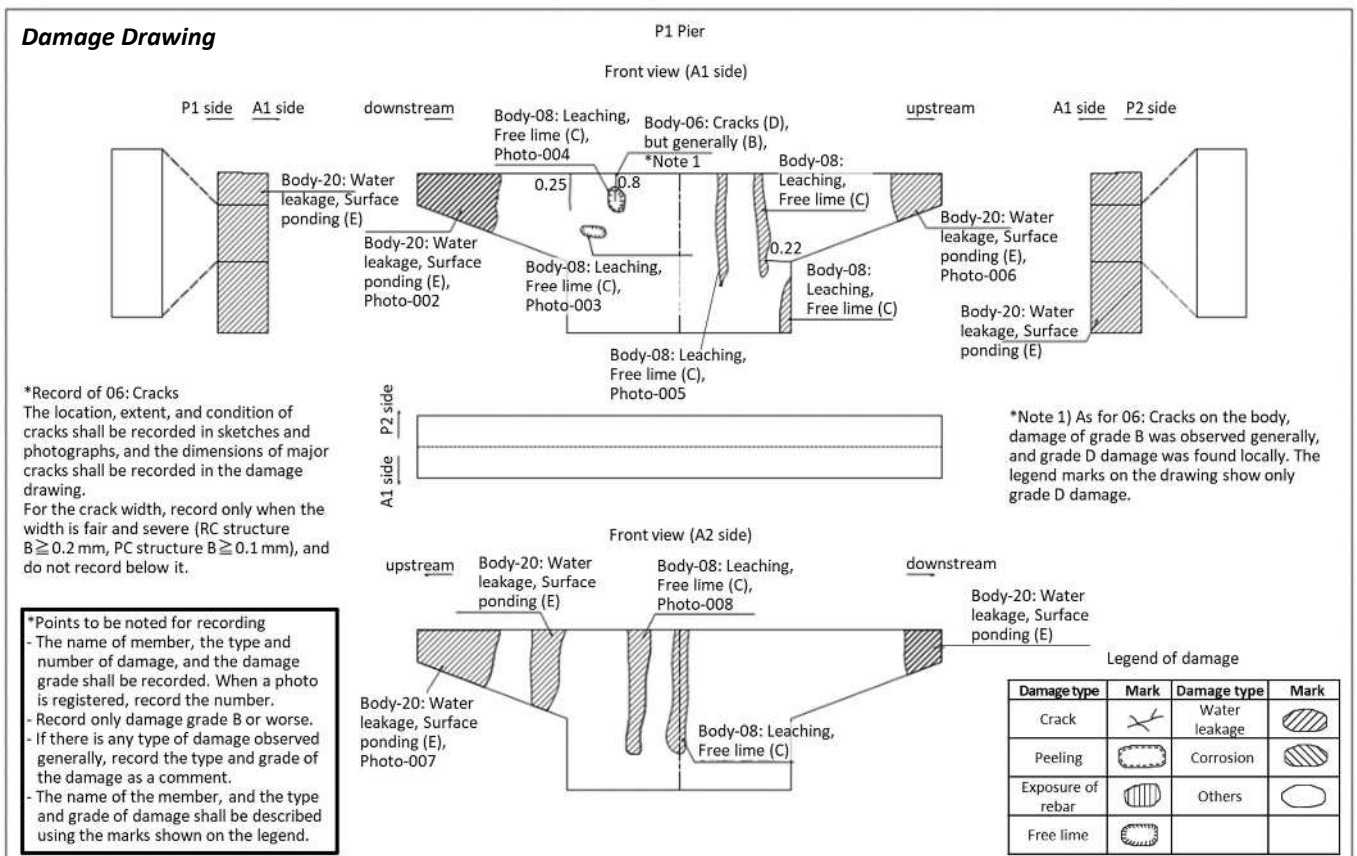
**[Example 3: Bridge surface]**



**[ Example 4: Substructure - Abutment ]**



**[ Example 5: Substructure - Pier ]**



**Figure 4.4.5 Example of Damage Drawings**

### 4.3.5 Quantity of damages

The quantity of damages must be summarized as shown in Table 4.4.2. However, the quantity of damages must be not only summarized but also sketched and taken photos at the same time.

**Table 4.4.2 Quantity of Damages**

Component	Element	Material	Type of damage
Superstructure	Deck	Steel	<ul style="list-style-type: none"> <li>• Corrosion: m<sup>2</sup></li> <li>• Cracks: Number of damage</li> <li>• Fracture; Number of damage</li> </ul>
		Concrete	<ul style="list-style-type: none"> <li>• Peeling/Exposure of rebar: m<sup>2</sup></li> <li>• Leaching/Free lime: m<sup>2</sup></li> <li>• Cracks on floor slab: length(m), width(0.2mm≥t, 0.2mm&lt;t&lt;1mm, 1mm ≤t)</li> </ul>
	Main structure	Steel	<ul style="list-style-type: none"> <li>• Corrosion: m<sup>2</sup></li> <li>• Cracks: Number of damage</li> <li>• Fracture; Number of damage</li> </ul>
		Concrete	<ul style="list-style-type: none"> <li>• Cracks: length(m), width(0.2mm≥t, 0.2mm&lt;t&lt;1mm, 1mm ≤t)</li> <li>• Peeling/Exposure of rebar: m<sup>2</sup></li> <li>• Leaching/Free lime: m<sup>2</sup></li> </ul>
Substructure	Body	Steel	<ul style="list-style-type: none"> <li>• Corrosion: m<sup>2</sup></li> <li>• Cracks: Number of damage</li> <li>• Fracture; Number of damage</li> </ul>
		Concrete	<ul style="list-style-type: none"> <li>• Cracks length(m), width(0.2mm≥t, 0.2mm&lt;t&lt;1mm, 1mm ≤t)</li> <li>• Peeling/Exposure of rebar: m<sup>2</sup></li> <li>• Leaching/Free lime: m<sup>2</sup></li> </ul>
	Foundation	—	• Scouring depth: Depth(m), Both widths( m)

Component	Element	Material	Type of damage
Bearings	Bearing body	—	<ul style="list-style-type: none"> <li>• Makes extraordinary sound when a vehicle runs over it (which part: sketch, photos)</li> <li>• Severely corroded(m<sup>2</sup>); some parts are missing(number of parts); rubber is damaged(damaged volume: Height x Width x Length: m<sup>3</sup>), hardened: Height x Width x Length: m<sup>3</sup>), or lost (Number of lost)</li> </ul>
	Shoe seat, Mortar	—	<ul style="list-style-type: none"> <li>• Sediment accumulates (sketch, photos); water is pooled (sketch, photos)</li> <li>• Mortar is cracked and partially lost (sketch, photos)</li> </ul>
On the Road	Railing, Guard fence	—	<ul style="list-style-type: none"> <li>• Damaged. etc (Length: m, Show photos).</li> <li>• Some places are considered dangerous for road users (Length: m, sketch, photos).</li> </ul>
Road surface	Pavement	—	• Potholes(depth: m, area: m <sup>2</sup> ), large bumps(length: m, step: cm), or cracks(length: m, width: mm)
	Expansion joint	—	• Step(m, length: m)
	Drainage facility	—	<ul style="list-style-type: none"> <li>• Clogged with sediment (number of clog, photos), pavement overlay (number of overlay, photos)</li> <li>• Damaged and drained water is affecting girders( sketch, photos)</li> </ul>

Furthermore, quantities must be calculated element by element, and summarized component by component, and also span by span. Then total quantities of damages must be summarized.

#### **4.3.6 Reporting**

The result of detailed inspections must be submitted as the report as follows.

- ❖ Original report: 1 set
- ❖ Copy of report: 2 set
- ❖ Original data file: 1 set

The report must be included the following contents.

- ❖ Location of the objective bridges,
- ❖ Drawings of general views which are “Profile”, “Plan”, “Standard cross section” and other detailed drawings of each bridge member measured the detailed inspection,
- ❖ Inspection results evaluated damage grade and filled in Inspection Sheet in Appendix-4,
- ❖ Damaged sketches,
- ❖ Damaged photos,
- ❖ Quantities of each damage.

#### **4.3.7 Period of detailed inspection**

The period of detailed inspections is as follows.

- ❖ Detailed drawings including the general view of Xe Banghian Bridge and Xe Bangnouan Bridge: Not later than 15<sup>th</sup> February 2022
- ❖ Detailed drawings including the general view of Nam Mone Bridge and Houay Pongsong Bridge: Not later than 15<sup>th</sup> March 2022
- ❖ Damage drawings of the objective bridges: Not later than 15<sup>th</sup> March 2022
- ❖ Quantities of damages of the objective bridges: Not later than 15<sup>th</sup> March 2022

## 5. Cost estimate and evaluation

The following cost items should include but not limiting to for the cost estimate of the above mentioned tasks and should be quoted in LAK. Following JICA's procurement rule, at least three (3) short-listed local consultants will be invited for the bidding and the least bidder will be awarded for this detailed inspection works.

Items	UP (in LAK)		Unit	Deliverables
1. Preparation and mobilization work	All bridges		LS	Survey implementation plan
2. Detailed measurement survey	Nam Mone		LS	Detailed drawings
	Houay Pongsong		LS	
	Xe Banghian		LS	
	Xe Bangnouan		LS	
3. Detailed inspection survey	Nam Mone		LS	Damage drawings
	Houay Pongsong		LS	
	Xe Banghian		LS	
	Xe Bangnouan		LS	
4. Preparation of BOQ of damages	Nam Mone		LS	BOQ of damages
	Houay Pongsong		LS	
	Xe Banghian		LS	
	Xe Bangnouan		LS	
5. Reporting	All bridges		LS	Survey completion report
Total				

## 6. Appendices

Appendix-1 Location Map (1 sheet)

Appendix-2 Location Map (1 sheet)

Appendix-3 General View of Nam Mone Bridge (1 sheet)

Appendix-4 General View of Houay Pongsong Bridge (1 sheet)

Appendix-5 General View of Xe Banghiang Bridge (1 sheet)

Appendix-6 General View of Xe Bangnouan Bridge (1 sheet)

Appendix-7 Inventory & Inspection Data Sheet (19 sheets)

Appendix-8 Criteria for Damage Grade Evaluation (Annex to Draft Bridge Inspection and Diagnosis Manual)