# 2. Manual for Bridge Inspection and Diagnosis







# MANUAL FOR BRIDGE INSPECTION AND DIAGNOSIS

**EDITION 1**
**(March 2025)**




THE PROJECT FOR CAPACITY DEVELOPMENT FOR ROAD AND BRIDGE MAINTENANCE MANAGEMENT IN MADAGASCAR

# MANUAL FOR BRIDGE INSPECTION AND DIAGNOSIS




This manual was developed in the framework of the Projet de Développement des Capacités de Gestion de l'entretien des Routes et des Ponts.

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**ACKNOWLEGDEMENT**

**Background :**

The Bridge Inspection and Diagnosis Manual (hereinafter referred to as “the Manual”) was developed for standardizing Bridge Inspection and Diagnosis works to be carried out by Ministere Des Travaux Publics (hereafter referred to as “MTP”) through the Projet de Développement des Capacités de Gestion de l’Entretien des Routes et des Ponts à Madagascar.

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## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| AR | : | Agence Routière (Road Agency) |
| BA | : | Béton Armé (Reinforced Concrete) |
| BP | : | Béton Précontraint (Prestressed Concrete) |
| DRTP | : | Direction Régionale des Travaux Publics (Regional Office) |
| DAU | : | Direction d'Appuis aux Urgences (Directorate for Emergency Works) |
| DRIMS | : | Dynamic Response Intelligent Monitoring System |
| F3LTM | : | Tetikasa Fampivoarana ny Fahaiza-mitantana amin'ny Fikojakojana ny Lalana sy ny Tetezana (The Project For Capacity Development For Road And Bridge Maintenance Management In Madagascar) |
| FR | : | Fonds Routier (Road Fund) |
| GPS | : | Global Positioning System |
| ININFRA | : | Institut National de l'Infrastructure (National Institute of Infrastructure) |
| JICA | : | Japan International Cooperation Agency |
| LNTPB | : | Laboratoire Nationale des Travaux Publics et du Bâtiment (National Laboratory of Building and Public Works) |
| MTP | : | Ministère des Travaux Publics (Ministry of Public Works) |
| OJT | : | On the Job Training (Formation sur le tas) |
| PC | : | Prestressed Concrete (Béton Précontraint) |
| PEC | : | Programme d'Entretien Courant (Routine Maintenance Program) |
| PK | : | Point Kilométrique (Kilo-post) |
| RAS | : | Réaction Alcali-Silice des agrégats (Alcali-silice aggregate reaction) |
| RC | : | Reinforced Concrete (Béton Armé) |
| RN | : | Route Nationale (National Road) |
| RNP | : | Route Nationale Primaire (Primary National Road) |
| RNS | : | Route Nationale Secondaire (Secondary National Road) |
| RNT | : | Route Nationale Temporaire (Temporary National Road) |
| SIA | : | Schéma d'Itinéraire et d'Aménagement (Road Management Plan) |

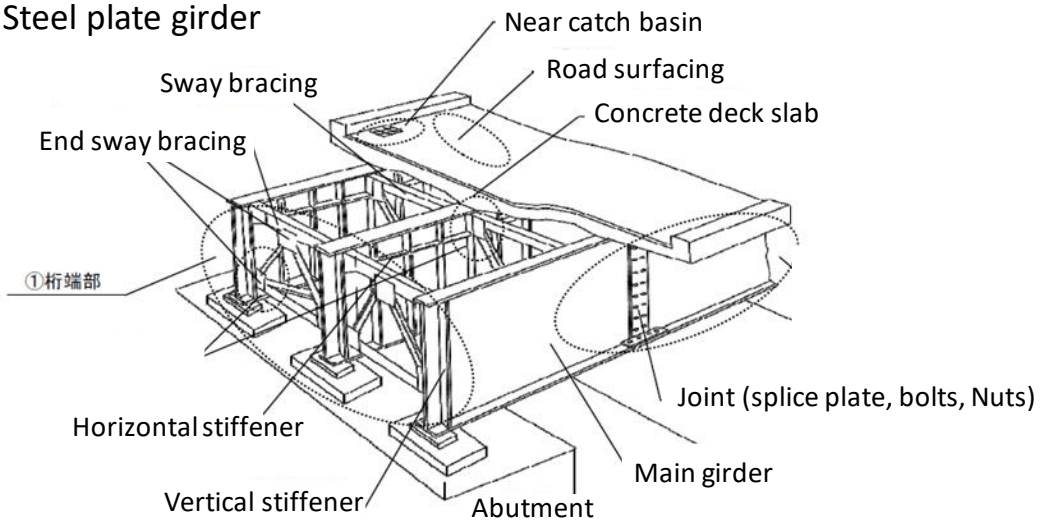
STD : Service Territorial Décentralisé (Decentralized Department)

WG : Working Group

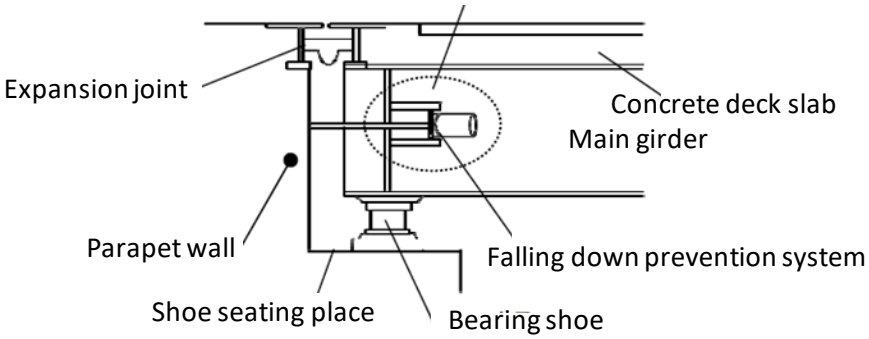
**GLOSSARY**

**Steel Bridge: General structure**

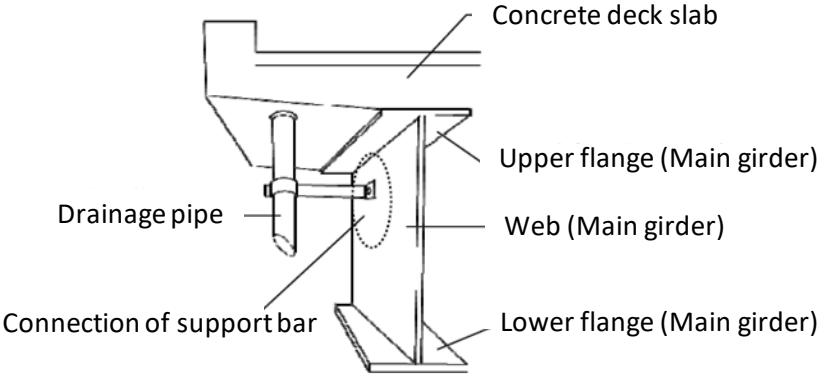
Steel plate girder



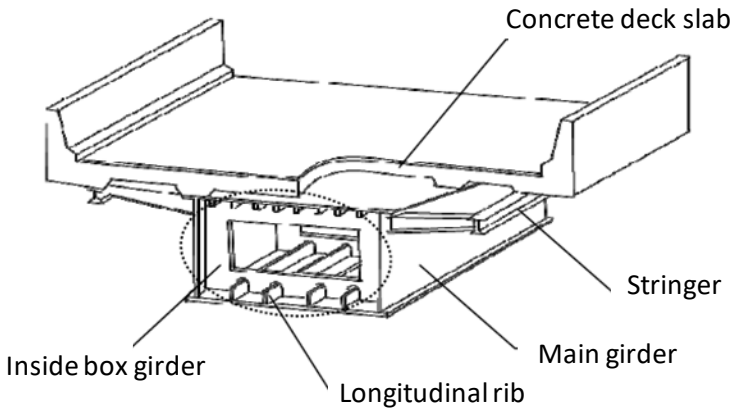

End of girder



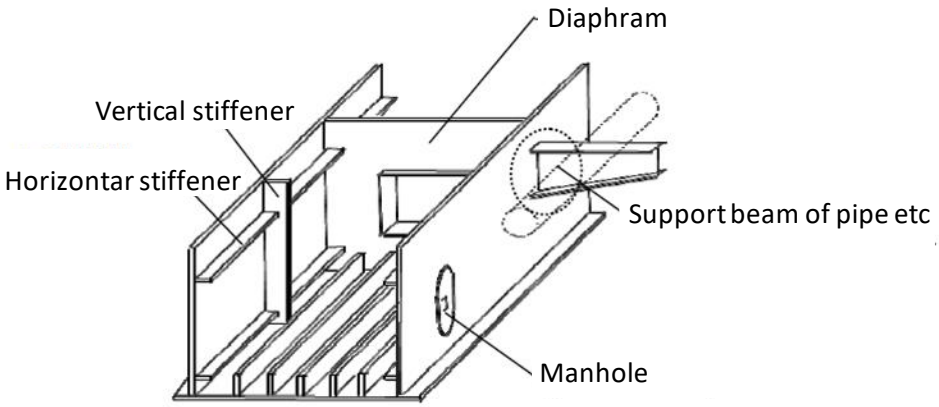

Near drainage

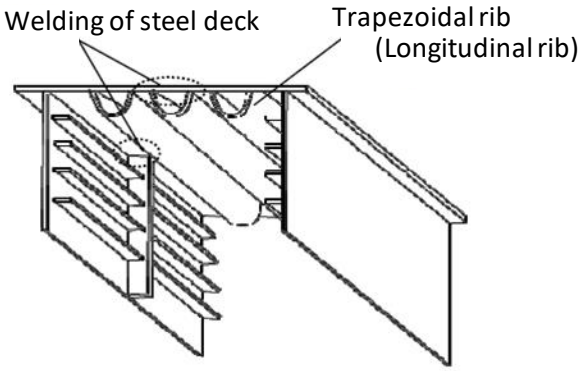


Steel box girder bridge

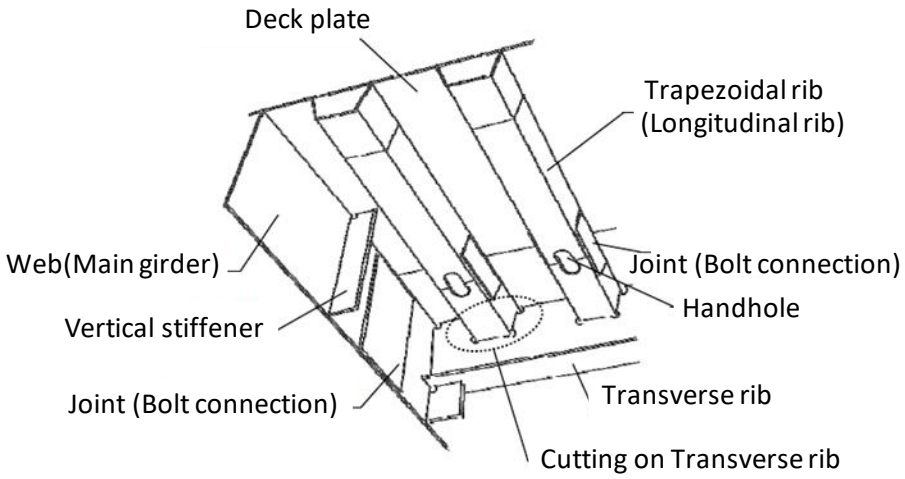



Steel box girder (Inside)

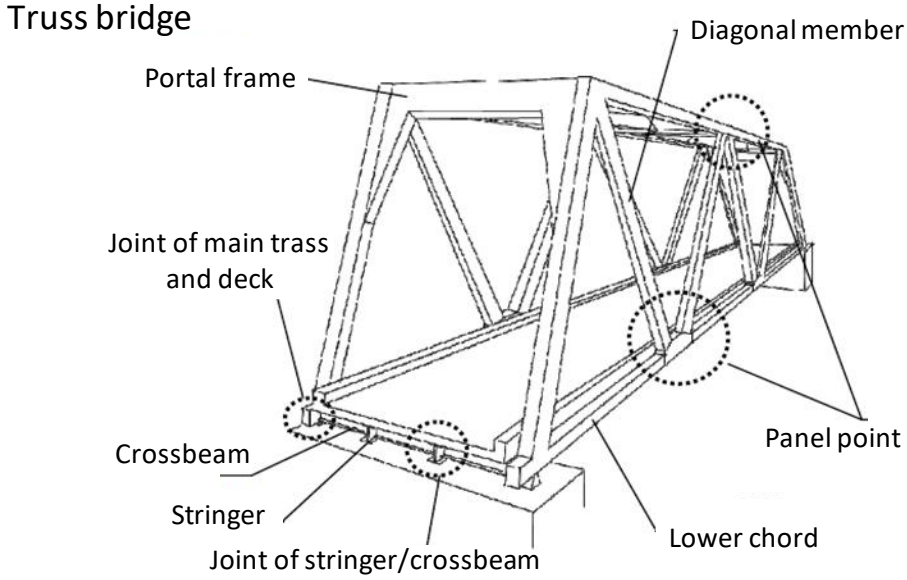


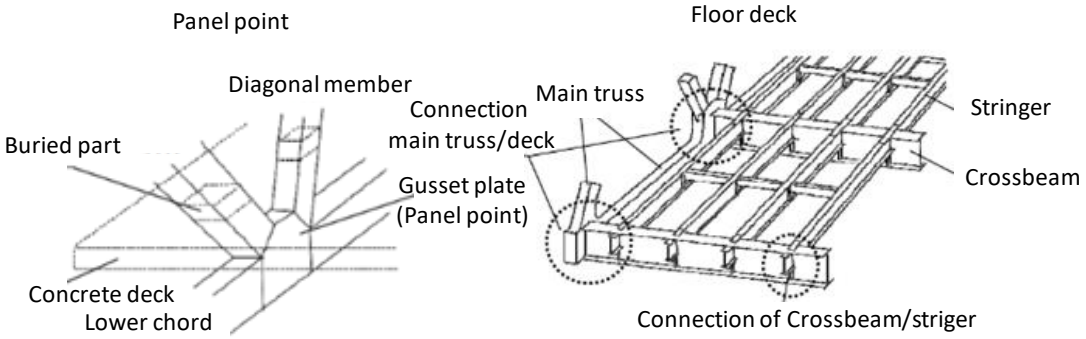



Steel deck plate

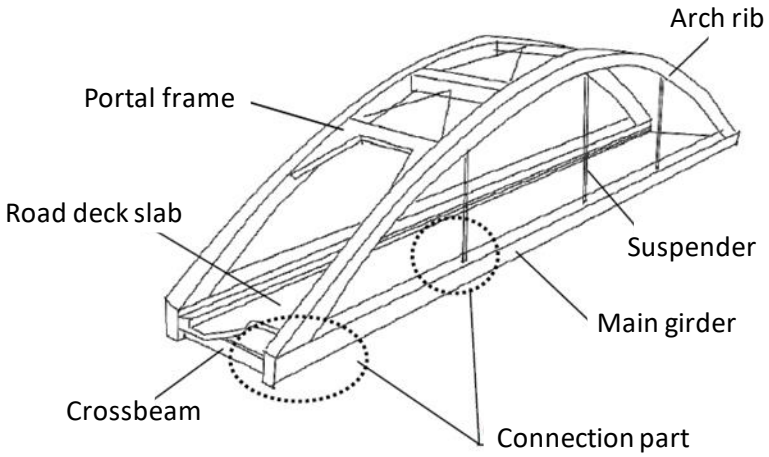



Truss bridge

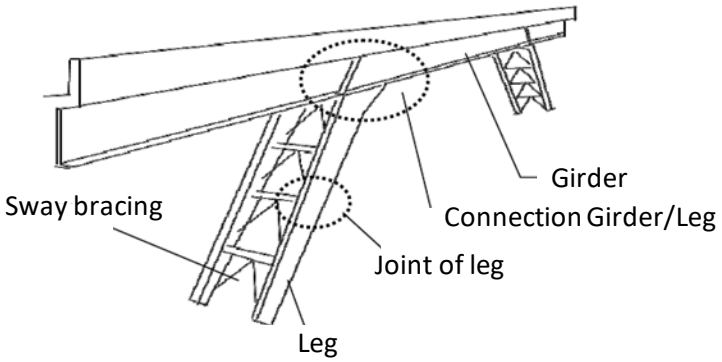


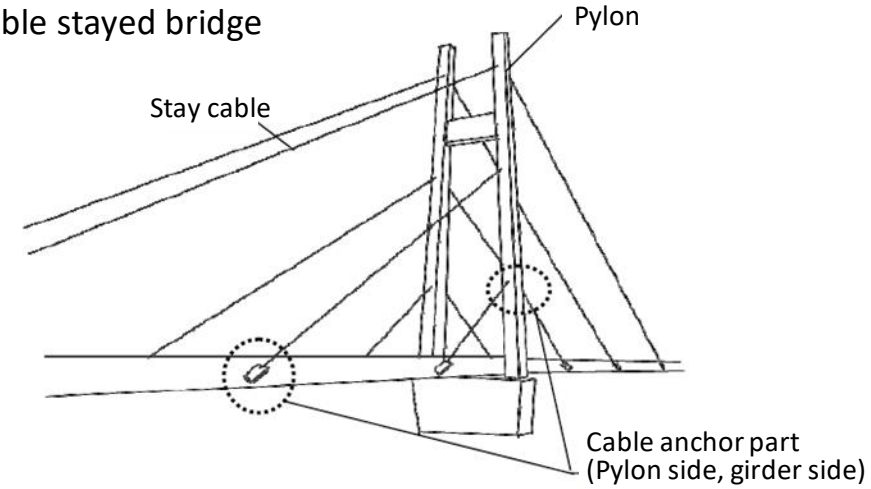
Steel arch bridge
(Through deck type)



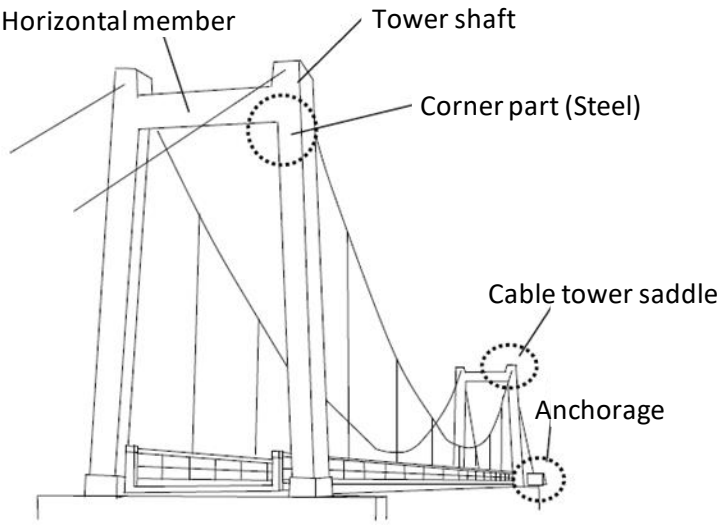

Rigid frame bridge



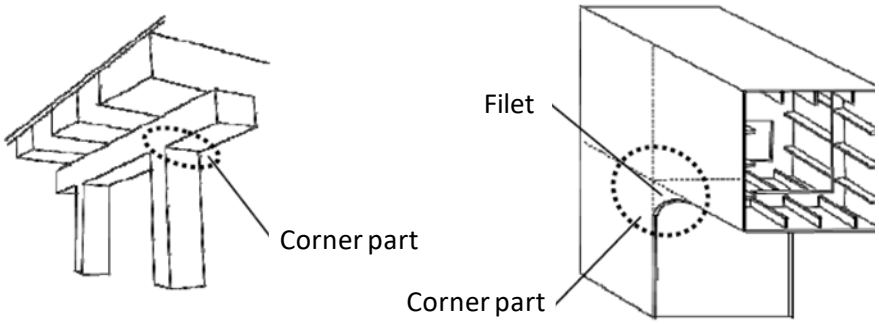

Cable stayed bridge



Suspension Bridge

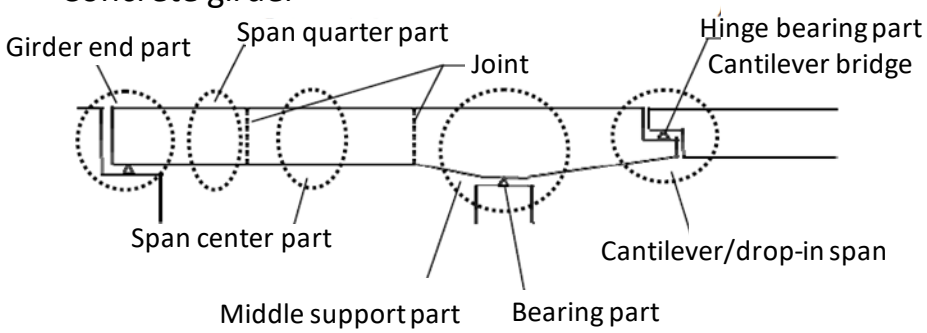



Steel pier

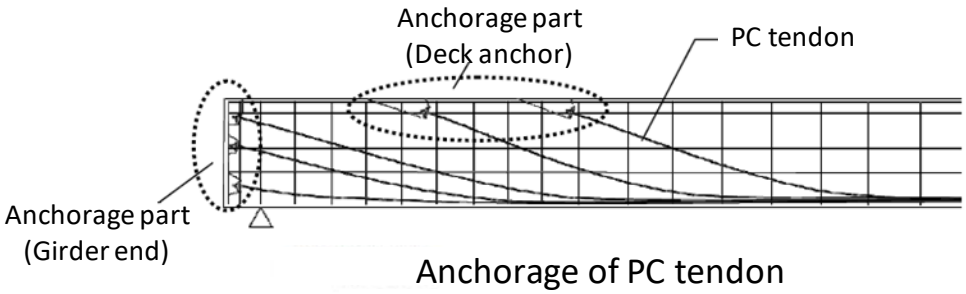


**Concrete Bridge: General structure**

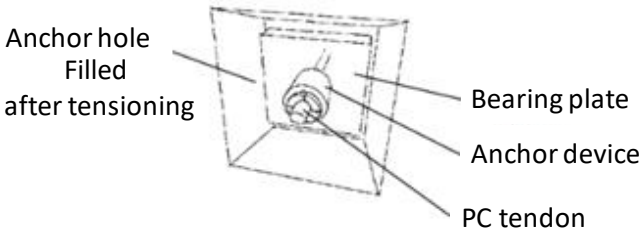
Concrete girder



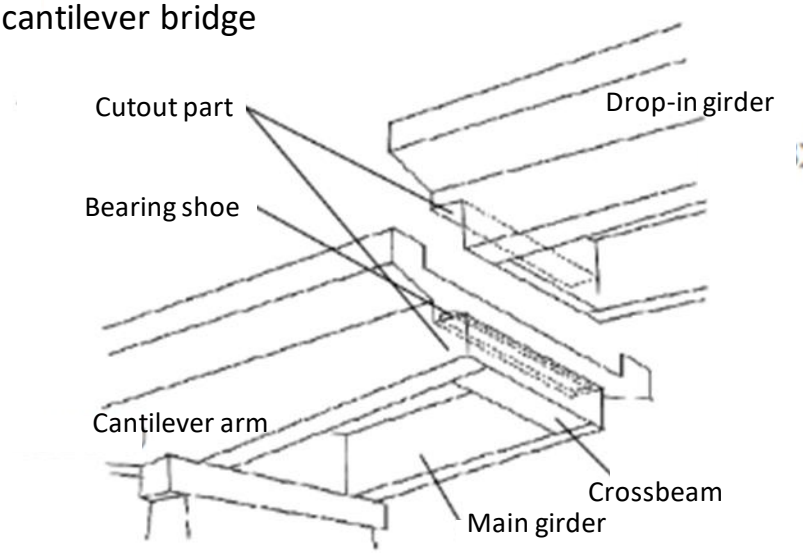

PC girder (Tendon arrangement)



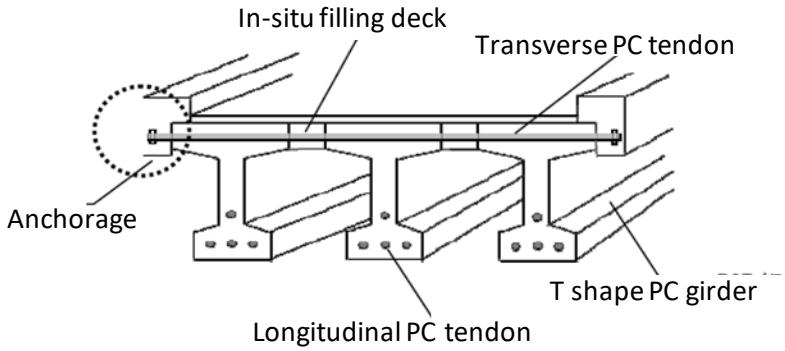

Anchorage of PC tendon



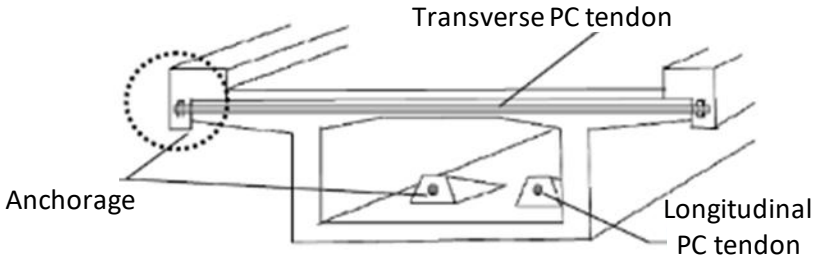

Joint of cantilever bridge



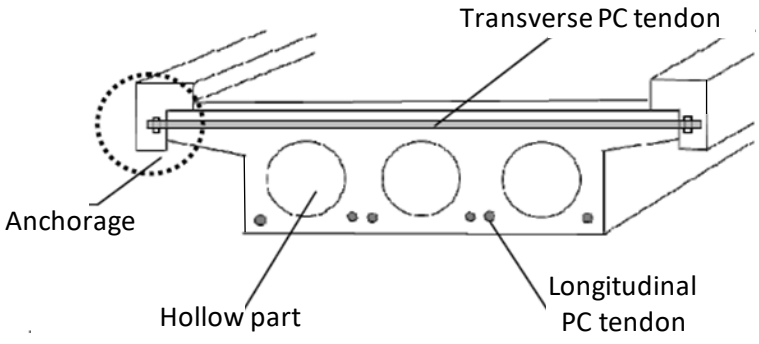
PC T-section girder bridge




PC box girder bridge

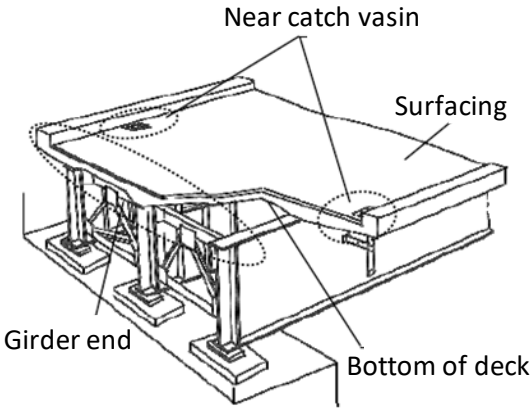


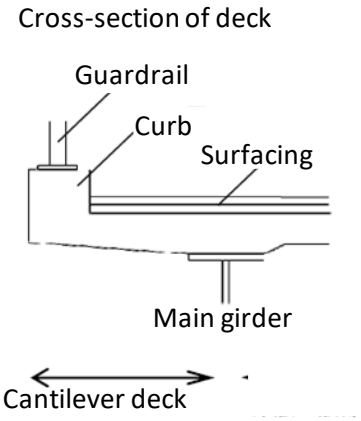

PC hollow slab bridge (Post tensioning)



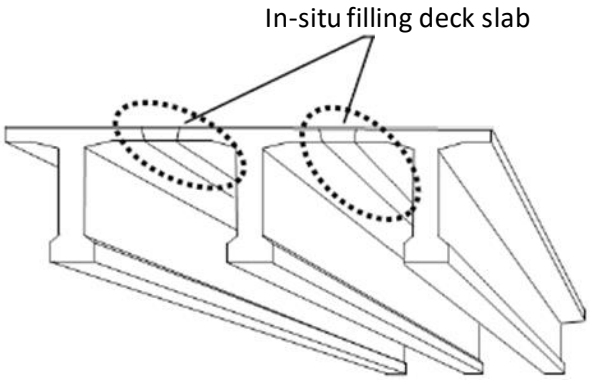
**Concrete deck slab: General structure**

Concrete deck slab

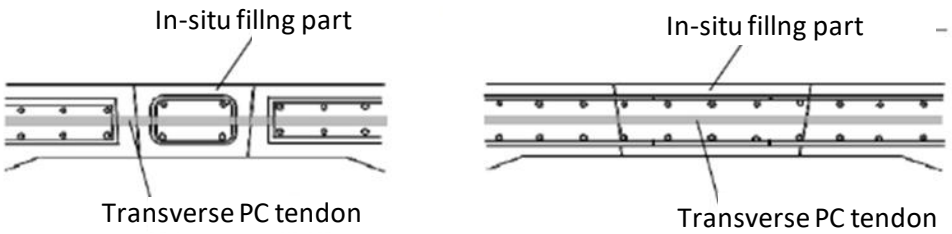



In-situ slab



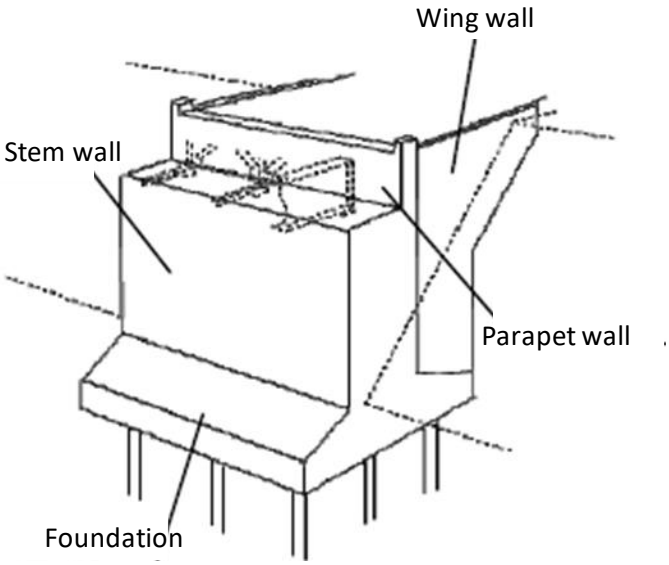

In-situ slab



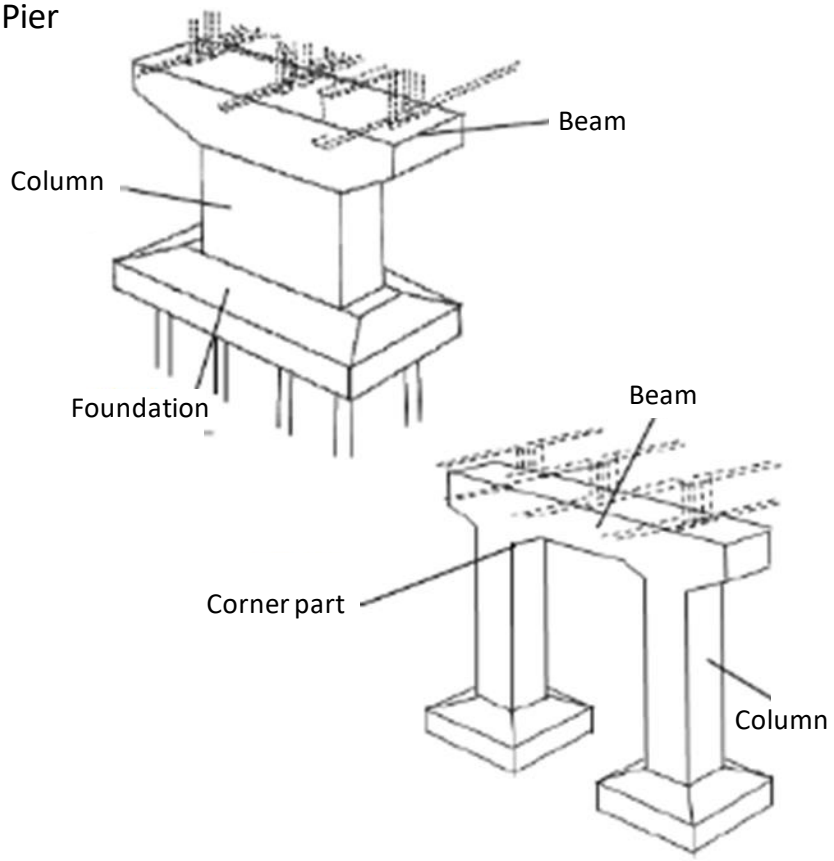

Example of rebar arrangement at filling part

Substructure (Abutment, Pier): General structure

Abutment

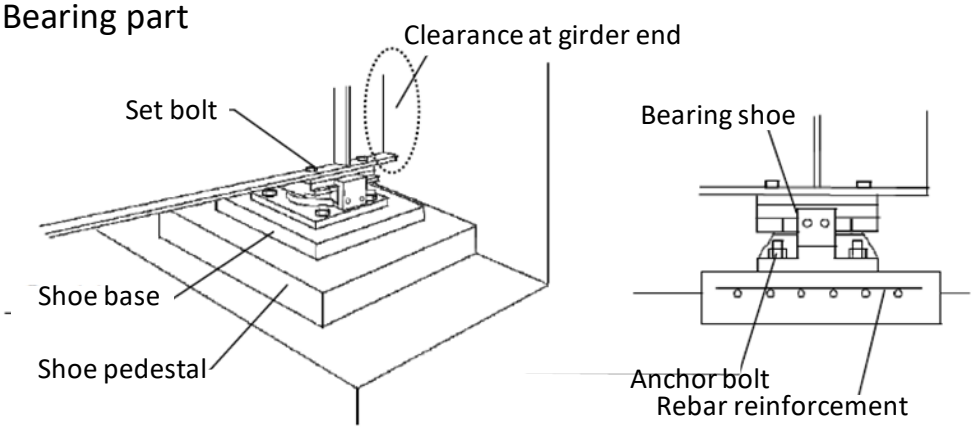



Pier



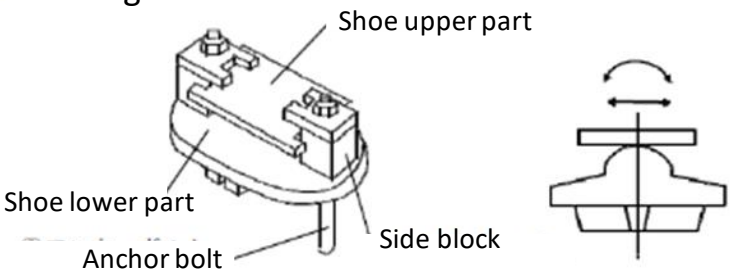
**Bearing Part: General structure**

Bearing part

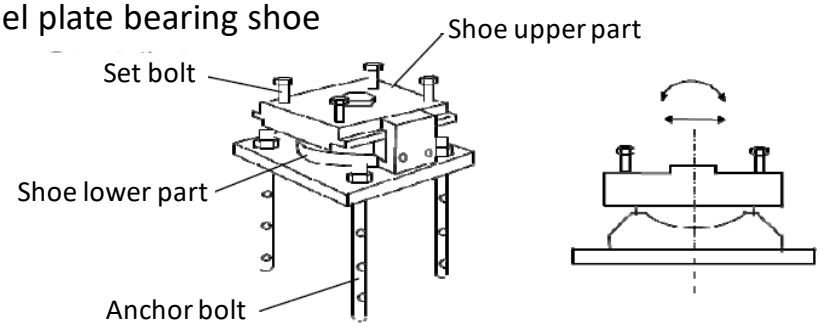



Bearing shoe

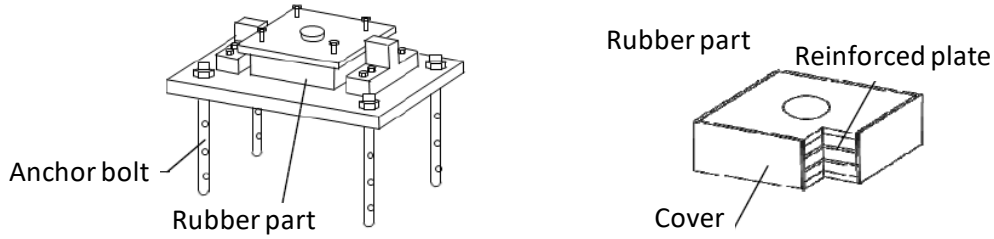
Steel line bearing




Steel plate bearing shoe




Rubber bearing shoe



## COMPARISON OF TECHNICAL TERMS (ENGLISH/ FRENCH)

| Terms in English (A-Z) | Terms in French |
|---|---|
| Abutment | Culée |
| Anchor bolt | Boulon d'ancrage |
| Anchor device | Dispositif d'ancrage |
| Anchor hole, filled after tensioning | Trou d'ancrage rebouché après la mise en tension |
| Anchorage | Ancrage |
| Anchorage | Massif d'ancrage |
| Anchorage of PC tendon | Ancrage des câbles de précontrainte |
| Anchorage part (Deck anchor) | Ancrage (dessus de poutre) |
| Anchorage part (Girder end) | Ancrage (about de poutre) |
| Arch rib | Nervure d'arc |
| Bearing part | Partie sur appui |
| Bearing plate | Plaque d'appui |
| bearing shoe | Appareil d'appui |
| Bottom of deck | Intrados de la dalle |
| Bridge Length | Portée du pont |
| Buried part | Partie encastrée |
| Cable anchor part (Pylon side,girder side) | Ancrage des câbles (côté pylône, côté poutre) |
| Cable stayed bridge | Pont à haubans |
| Cable tower saddle | Selle |
| Caisson Foundation | Fondation par puits |
| Cantilever arm | Bras cantilever |
| Cantilever deck | Dalle en console |
| Cantilever/drop-in span | Console / travée reposant sur la console |
| Clearance at girder end | Vide à l'about de la poutre |
| Column | Colonne |
| Concrete deck slab | Tablier en béton |
| Concrete deck slab, Concrete deck | Dalle en béton |
| Concrete girder | Poutre en béton |
| Concrete wall / column | Voile/colonne |
| Connection Girder/Leg | Liaison entre poutre et béquille |
| Connection of crossbeam/stringer | Liaison entre entretoise et longeron |

| Terms in English (A-Z) | Terms in French |
|---|---|
| Connection of support bar | Connexion de la barre de fixation |
| Connection part | Partie d'assemblage |
| Corner part | Chanfrein |
| Corner part | Partie d'angle |
| Corner part (Steel) | Partie d'angle (métallique) |
| Cover | Couverture |
| Cross Beam | Poutre transversale |
| Crossbeam | Entretoise |
| Curb | Bordure de trottoir |
| Cut out part | Partie coupée |
| Cutting on Transverse rib | Coupure au niveau de la nervure transversale |
| deck plate | Platelage |
| Deck Slab | Tablier |
| Diagonal member | Membrure diagonale |
| Diaphram | Diaphragme |
| Drainage pipe | Gargouille |
| Drainage System | Système de drainage |
| Drop-in girder | Poutre reposant sur la console |
| End of girder, Girder end part, Girder end | About de poutre |
| End sway bracing | Extrémités de contreventement |
| Example of rebar arrangement at filling part | Exemple de disposition des armatures au droit de la partie coulée sur place |
| Expansion joint | Joint de dilatation |
| Falling down prevention system | Dispositif anti-effondrement |
| Filet | Congé |
| Floor deck | Support de platelage |
| Footing | Semelle de fondation |
| Foundation | Fondation |
| Girder | Poutre |
| Girder Length | Longueur des poutres principales |
| Guardrail | Garde-corps |
| Gusset plate | Gousset |
| Handhole | Trou de main |

| Terms in English (A-Z) | Terms in French |
|---|---|
| Hinge bearing part Cantilever bridge | Appui en articulation du pont cantilever |
| Hollow part | Partie évidée |
| Horizontal member | Partie horizontale |
| Horizontal stiffener | Raidisseur horizontal |
| Inside box girder | Intérieur de la poutre caisson |
| In-situ filling deck | Dalle de liaison coulée sur place |
| Insitu filling deck slab | Béton de remplissage coulé sur place |
| In-situ filling part | Partie coulée sur place |
| In-situ slab | Dalle coulée sur place |
| Joint (Bolt connection) | Joint (boulon de fixation) |
| Joint (splice plate, bolts, nuts) | Joint (plat de liaison, boulons, écrous) |
| Joint of cantilever bridge | Joint cantilever |
| Joint of leg | Joint de béquille |
| Joint of main truss and deck | Liaison entre treillis principal et platelage |
| Leg | Béquille |
| Longitudinal PC tendon | Câble de précontrainte longitudinale |
| Longitudinal rib | Nervure longitudinale |
| Lower chord | Membrure inférieure |
| Lower flange (Main girder) | Aile inférieure (poutre principale) |
| Main girder | Poutre principale |
| Main truss | Treillis principal |
| Manhole | Trou d’homme |
| Middle support part | Appui intermédiaire |
| Near catch basin | Près des avaloirs |
| Near drainage | Près du drainage |
| Panel point | Nœud |
| Parapet wall | Mur garde-grève |
| PC Box girder bridge | Pont à poutre caisson précontrainte |
| PC girder (tendon arrangement) | Poutre précontrainte (disposition des câbles) |
| PC hollow slab bridge (Post tensionning) | Pont à dalle élégie précontrainte (post tension) |
| PC tendon | Câble de précontrainte |
| PC T-section girder bridge | Pont à poutres en T précontraintes |
| Pier | Pile |

| Terms in English (A-Z) | Terms in French |
|---|---|
| Pier cap / Beam | Chevêtre |
| Pile Foundation | Fondation par pieux |
| Portal frame | Portique |
| Pylon | Pylône |
| Rebar reinforcement | Armature de renforcement |
| Reinforced plate | Plaques de renforcement |
| Rigid frame bridge | Pont à portique rigide |
| Road deck slab | Dalle de chaussée |
| Road Surfacing, Surfacing | Surface de roulement |
| Rubber bearing shoe | Appareil d'appui en élastomère |
| Rubber part | Elastomère |
| Set bolt | Boulon de fixation |
| Shoe base | Semelle |
| Shoe lower part | Partie inférieure de l'appareil d'appui |
| Shoe pedestal | Dé d'appui |
| shoe seating place | Sommier |
| Shoe upper part | Partie supérieure de l'appareil d'appui |
| Side block | Bloc latéral |
| Side Clearance | Espacement latéral (entre le tablier et la culée) |
| Span center part | Milieu de travée |
| Span Length | Longueur d'une travée |
| Span quarter part | Quart de travée |
| Spread Foundation | Fondation en radier général |
| Stay cable | Hauban |
| Steel arch bridge (Through deck type) | Pont à poutres métallique en arc (arc au-dessus du tablier) |
| Steel box girder (inside) | Poutre caisson métallique (intérieur) |
| Steel box girder bridge | Pont à poutre caisson métallique |
| Steel deck plate | Platelage métallique |
| Steel line bearing | Appareil d'appui métallique |
| Steel pier | Pile métallique |
| Steel plate bearing shoe | Appareil d'appui en plaque métallique |
| Steel plate girder | Poutre métallique à âme pleine |
| Stem wall | Mur de front |

| Terms in English (A-Z) | Terms in French |
|---|---|
| stringer | Longeron |
| Substructure* | Infrastructure |
| Substructure (Abutment, Pier) : General structure | Infrastructure (Pile, culée) : Structure Générale |
| Superstructure | Superstructure |
| Support beam of pipe, etc | Poutre de support pour tuyau, etc |
| Suspender | Suspente |
| Suspension bridge | Pont suspendu |
| Sway bracing | Contreventement |
| T shape PC girder | Poutre précontrainte de section en T |
| Tower shaft | Tour |
| Transvers Prestressing | Précontraint transversal |
| Transverse PC tendon | Câble de précontrainte transversale |
| Transverse rib | Nervure transversale |
| Trapezoidal rib | Nervure trapézoïdale |
| Truss bridge | Pont à poutres en treillis |
| Upper flange(Main girder) | Aile supérieure (poutre principale) |
| Vertical stiffener | Raidisseur vertical |
| Web (Main girder) | Ame (poutre principale) |
| Welding of steel deck | Soudure du platelage métallique |
| Wing wall | Mur en aile |

***Note: “Sous-structure” is not used in Madagascar for the meaning of “substructure” in English.**

# 1. MANUAL OF PERIODIC INSPECTION

This chapter summarize a frame of periodic inspection.

## 1.1. Scope of manual

| |
|---|
| This manual is used for periodic inspection. |

*Note: See Chapter 2.*

## 1.2. Frequency of periodic inspection

| |
|---|
| Periodic inspection is carried out once a year basically. |

*Note: Periodic inspection is carried out 5 years interval in Japan and 4 years in US.*

## 1.3. Method of periodic inspection

| |
|---|
| Periodic inspection shall be done by closed visual inspection. And palpation by hands and tapping by hammer and other non-destructive tests should be done if it is possible. |

*Note: See Chapter 2.*

## 1.4. Inspection team

| |
|---|
| Inspectors (persons) who have necessary knowledge and skill shall be carried out periodic inspection of bridges. |

*Note: See Chapter 3.*

## 1.5. Soundness diagnosis of bridges

| |
|---|
| For periodic inspection, an inspection team performs not only inspection at site but also (1) Soundness diagnosis of members and (2) Soundness diagnosis of a whole bridge. |

*Note: See Chapter 5.*

### 1.5.1. Soundness diagnosis of members

(a) Judgement classification

Soundness diagnosis of members is judged by a classification of Table 1-1 .

**Table 1-1 Soundness Judgment Classification for Unit of Member**

| Classification | | State |
|---|---|---|
| **I** | Sound | State of bridge function not impaired. |
| **II** | Preventive Maintenance Phase | State of bridge function not impaired. However, It is desirable to take measures from the viewpoint of preventive maintenance. |
| **III** | Early Measures Phase | There is a possibility that the function of the bridge is being interfering. Measures should be taken as soon as possible. |
| **IV** | Emergency Measures Phase | The bridge is in a state where its function is being disturbed. Urgent measures should be taken. |

*Source : F3LTM*

*Note: See Chapter 5.*

(b) Standard member unit of judgement

Soundness diagnosis is carried out due to standard members of Table 1-2 at least.

**Table 1-2 Standard of Evaluation Member of Judgment**

| **Superstructure** | | | **Substructure** | **Bearing part** | **Others** |
|---|---|---|---|---|---|
| Main girder | Crossbeam | Deck slab | | | |

*Source : F3LTM*

*Note: See Chapter 5.*

(c) Damage type

Soundness diagnosis shall be done at least for damage type of Table 1-3

**Table 1-3 Standard type of damages**

| Type of materials | Type of damages |
|---|---|
| Steel member | ①Corrosion, ②Cracks of steel, ④Fracture, Others |
| Concrete member | ⑥Cracks of concrete, ⑪Cracks of deck slab, Others |
| Others | ⑯Malfunction of bearing part, Others |

*Source : F3LTM*

*Note: See Chapter 5.*

### 1.5.2. Soundness diagnosis of a whole bridge

Soundness diagnosis of a bridge is judged by a classification of Table 1-4.

**Table 1-4 Soundness Judgment Classification for Unit of Bridge**

| Classification | | State |
|---|---|---|
| **I** | Sound | State of bridge function not impaired. |
| **II** | Preventive Maintenance Phase | State of bridge function not impaired. However, It is desirable to take measures from the viewpoint of preventive maintenance. |
| **III** | Early Measures Phase | There is a possibility that the function of the bridge is being interfering. Measures should be taken as soon as possible. |
| **IV** | Emergency Measures Phase | The bridge is in a state where its function is being disturbed. Urgent measures should be taken. |

*Source : F3LTM*

*Note: See Chapter 5.*

## 1.6. Countermeasures

According to judgement results of member unit on1.5(1), necessary countermeasure shall be taken for effective maintenance and repair of roads.

## 1.7. Records

Results of periodic inspection, soundness diagnosis and content of countermeasure are recorded and kept during the service periods of bridges.

*Note: See Chapter 6. Inspection form is shown in Appendix 3.*

### 1.7.1. Standard inspection item (Damage type)

The following table gives the list of standard elements to be inspected.

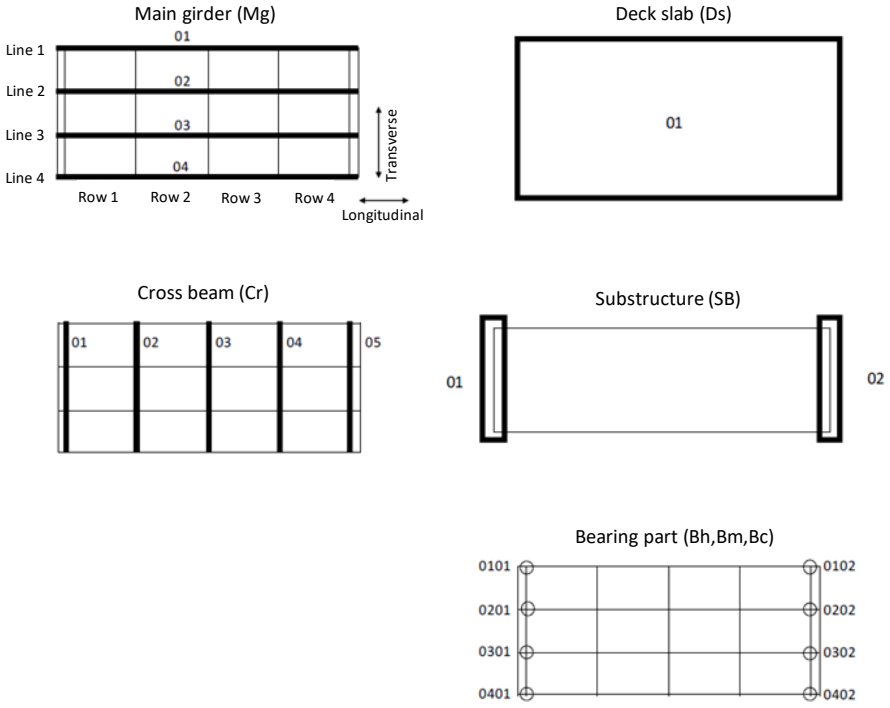
**Table 1-5 Standard inspection item (Damage type)**

| Member Unit | | Inspection item (Damage type) | | |
|---|---|---|---|---|
| | | Steel | Concrete | Others |
| Super-structure | Main girder | ①Corrosion<br>②Cracks of steel<br>④Fracture<br>〇Others | ⑥Cracks of concrete<br>⑪Cracks of deck<br>〇Others | |
| | Crossbeam | | | |
| | Stringer | | | |
| | Deck slab | | | |
| | Others | | | |
| Sub-structure | | | ⑥Cracks of concrete<br>〇Others | |
| | Pier | | | |
| | Abutment | | | |
| | Foundation | | | |
| | Others | | | |
| Bearing part | | | | ⑯Malfunction of bearing part |
| Road surface | | | | |
| Others | | | | |

*Source : F3LTM*

*Note: A shaded box is "Others" members in standard member of Table 1-2.*

*Note: Normally each member unit consists of a group of members. Photos are taken with "member number" which is defined by inspectors. A sample of method of member numbering is shown in the following figure. See Figure 1-1.*




*Note : Refer to Appendix 3 for the Bridge Defect Map.*

*Note : Refer to Appendix 3 for the Inspection sheet (summary of soundness of bridge).*

# 2. SYSTEM OF INSPECTION AND METHOD

## 2.1. Purpose of Bridge Inspection

The management of bridges covers a wide range of activities from planning, investigation, design, fabrication, transportation, construction, erection, service, maintenance, and renewal. Bridges, which are valuable social capital, must be maintained in a favourable environment, investigated as necessary, and repaired or reinforced appropriately to ensure their safety and to keep them in use as long as possible. For this reason, inspection of bridges is important.

The three main objectives of the inspection are as follows;

1) To obtain information necessary for proper maintenance and management of bridges, including avoidance of damage to road users and third parties, avoidance of bridge falls, etc., and measures to extend the service life of bridges.
2) To determine the damage status, determine the category of countermeasures, and record the inspection results.
3) Ensure safety and smoothness of general traffic.

## 2.2. System of inspection

System of inspection consists of the next type of inspections:-

- Network monitoring
- Periodic Inspection
- Interim Inspection
- Specific and/or detailed Inspection
- Abnormal Inspection

And method of each inspection is as following table.

**Table 2-1 Inspection Methods**

| TYPE OF INSPECTION | BASIC METHOD | NESESSARY EQUIPMENT |
|---|---|---|
| Network monitoring | Observation of the road surface and bridge structure with the inspection system on Tablet, completed with monitoring every month. | Patrol car.<br>A tablet. |
| Periodic Inspection | Basically, closed visual inspection of road surface, lateral view and bottom of bridges. Taking photos and making map of damages. | Inspection car.<br>Inspection vehicle of bridge underside. Boat (on the water). A camera with a pole. |
| Interim Inspection | | |
| Specific and/or Detailed Inspection | | |
| Abnormal Inspection | Level of patrol inspection or periodic inspection. | |

Detail of each inspection are shown in the following chapters. Before starting each inspections, preparation of previous records and drawings are necessary.

### 2.2.1. Preparation

This is an essential issue to do each type of inspection effective.

- Check of previous inspection records.
- Making of drawings of bridges.
- Make “Bridge Map of Defects” if it is necessary.

### 2.2.2. Network Monitoring

This is an inspection of the roadway structure to check for any obstructions or damage, mainly visually from inside the road patrol vehicle. If abnormalities are found on the road surface or near the expansion joint by the abnormal noise or vibration while driving, emergency measures are taken to keep the function of the road. Network monitoring covers all roads inspection in general. Particularly for bridges, inspection is the detection of abnormalities in the road surface, curb, railing and expansion joint that can be seen from the road, as well as abnormalities and damage of the bridge structure. For example, guard fence, railing, lighting and sign post, expansion joint, members of middle or lower truss and arch bridges, towers and cables of cable-stayed bridges, etc. are subject to inspection. Pavement conditions can indicate anomalies in deck slab, and

uneven of road surface and noise can indicate anomalies in expansion joint and bearing. (Photo-2.1)

When necessary, the inspector shall stop at the bridge and conduct a simple visual inspection. Examples would be bridges with deteriorating structures or river bridges with a lot of driftwood, etc.

A tablet system should be used for conducting those inspection and recording. Based on inspection records, the system can evaluate the bridge soundness at four levels: No-damage (N), Observation required (O), Damaged (D), and Severely damaged (SD). Bridges evaluated as Class SD by Network Monitoring require more careful Periodic Inspections. In addition, bridges whose soundness degraded from class D to class SD by the Network Monitoring should also be carefully observed during Periodic Inspections for the fact that deterioration has progressed.

Examples of focus points

- Is the area of concrete separation and rebar exposure on the backside of girders and slabs expanding?
- Is the density of cracks in the slab increased? Is the settlement of the slab progressing?
- Is the scouring area or slope of the substructure increasing?



*Source : F3LTM*

**Photo 2-1 Damage of Deck Slab**

### 2.2.3. Periodic Inspection

Periodic inspections are conducted to ascertain the current status of bridges and detect abnormalities and damage at an early stage to ensure safe and smooth traffic, prevent damage to roadside and third parties, avoid malfunctions such as bridge falls, and obtain necessary

information for appropriate bridge maintenance and management, including measures to extend the service life of bridges. This is the most important inspection in terms of maintenance. Periodic inspections are conducted once a year by engineers with the necessary knowledge and skills by closed visual inspection. Regarding the inspection results, diagnose the degree of soundness, classify the results into four categories, and record the results. The frequency of periodic inspections is determined at the responsibility and discretion of the road administrator, depending on the item and purpose of the inspections. In assessing the condition of road bridges, close visual inspection is basically conducted on members and other items using inspection scaffolds and bridge inspection vehicles(Photo-2.2). If any abnormality or damage is found in bridge members during periodic inspections, a diagnosis of soundness is made and repairs or detailed inspections are conducted after determining the category of countermeasures based on the degree and type of the damage.

- Periodic Inspection is for bridges with length of 2m or more.
- Periodic inspections shall be basically conducted by closely visual inspection, if needed, combined with non-destructive testing such as palpation and hammering test, etc.
- Engineers with the necessary knowledge and skills shall conduct periodic inspections.
- Soundness diagnosis shall be conducted for the member unit and bridge unit.
- Based on the results of the soundness diagnosis, we shall take necessary measures.
- We record and preserve the results of periodic inspections, the results of soundness diagnosis, and the measures taken.



**Photo 2-2 Closed Visual Inspection for Deck Slab (Use an inspection car)**

The Periodic Inspection plan should identify bridges to be inspected more carefully based on the Network Monitoring results. Specifically, bridges that have been rated SD for bridge soundness as a result of Network Monitoring, or bridges whose soundness has declined from D to SD in the past year.

### 2.2.4. Interim Inspection

Interim inspection is conducted between two periodic inspections for some technical reasons. The level of inspection is the same as periodic inspection.

### 2.2.5. Specific and/or detailed Inspection

Specific inspection is conducted separately from periodic inspections for specific events, such as salt damage and alkaline aggregate reaction, which are common causes of damage to bridges, and which are difficult to assess adequately only by periodic inspections.

For example, in areas where salt damage is a concern, it is desirable to conduct periodic surveys separately from periodic inspections to assess the progress of salt damage from the viewpoint of preventive maintenance against salt damage, and to take measures such as repairs at an appropriate time.

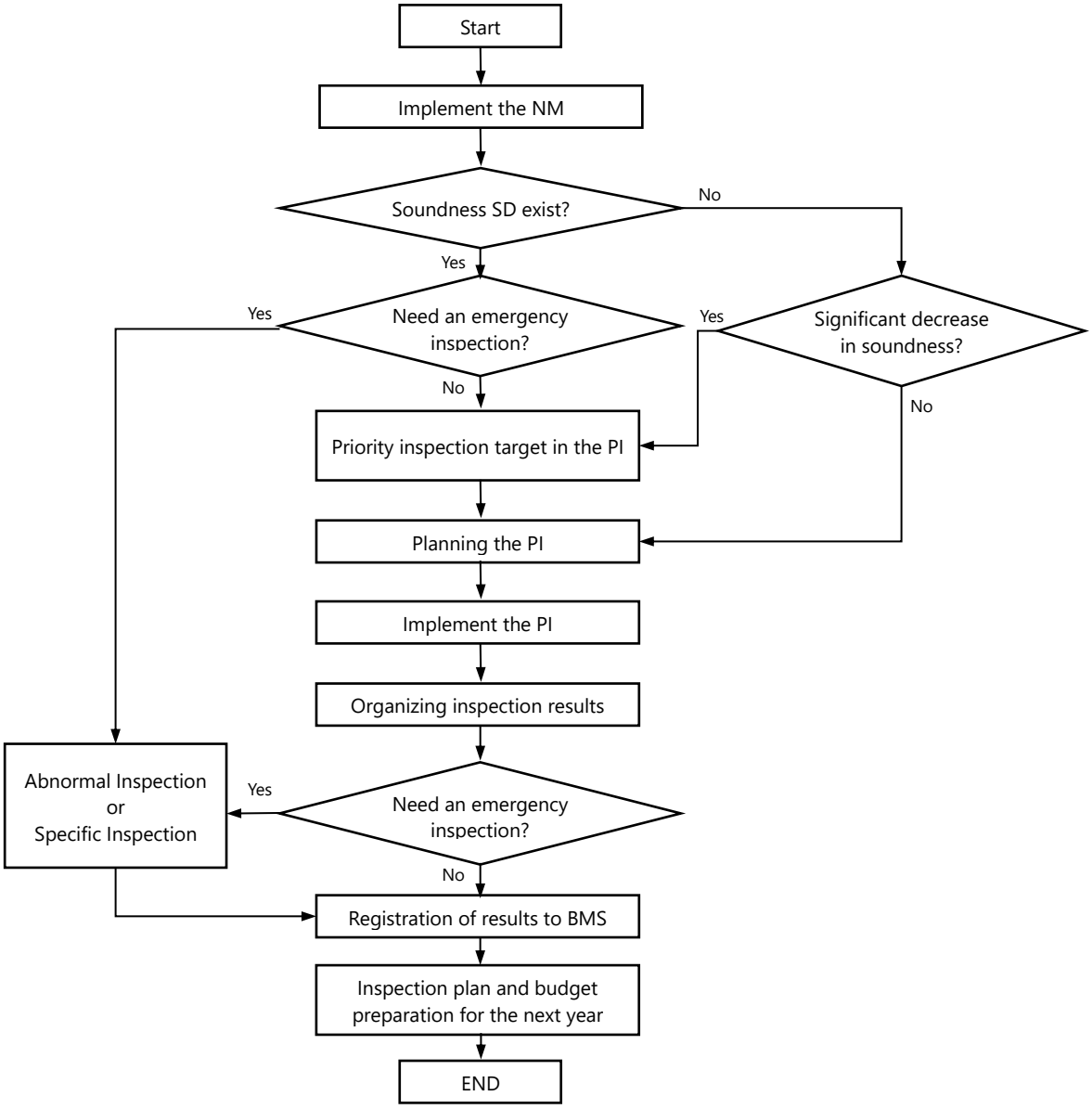
Alkali-aggregate reactions often continue to be observed for a while after damage has developed and can be the subject of specific inspections.

### 2.2.6. Abnormal Inspection

Abnormal inspections are emergency inspections conducted to check the condition of bridges in the event of a disaster or major accident, such as cyclone or earthquake, or when unexpected abnormalities occur.

When an abnormality is found in a bridge that is not expected in the past, necessary investigations must be conducted immediately to clarify the cause, and necessary inspections must also be conducted for bridges that may experience the same type of event to ensure bridge safety and to prevent damage to third parties.

### 2.2.7. Bridge Inspection Workflow




*Source : F3LTM*

**Figure 2-1 Bridge Inspection Workflow**

### 2.2.8. Relationship between Network Monitoring and Periodic Inspection

**Table 2-2 Network Monitoring and Periodic Inspection**

| Item | Network Monitoring | Periodic Inspection |
|---|---|---|
| Supervision | DER | DER |
| Execution | DRTP | DRTP |
| Frequency | Monthly (use of tablet system will be 3 times per year) | Yearly |
| Methodology | Visual inspection | Closed visual inspection |
| Tool | Tablet inspection system | Inspection hummer, crack scale, chalk, etc. (pole camera, concrete test hummer, RC radar can be utilized when necessary) |
| Purpose | ・ Monitoring of road network (Early detection of abnormalities and deformities)<br>・ Identification of priority bridges for Periodic Inspection | ・ Inspection of deterioration and damage<br>・ Evaluation of bridge soundness<br>・ Formulate necessary measures, quantities, urgency, and maintenance costs<br>・ Preparation of budget for the next fiscal year |
| Inspection target | 【All bridges】<br>・ Road surface, expansion joint<br>・ Curb, railing, lighting, traffic sign.<br>・ Structural components (strings, towers, cables) visible from the road surface<br>【Seriously Damaged bridge】<br>・ e.g. deck and girder, etc.<br>【Bridges with a high risk of scour】<br>・ Riverbank protection, riverbed, driftwoods, etc. | 【All bridges】<br>・ Superstructure, substructure<br>・ Pavement, deck slab<br>・ Expansion joint, bearing<br>・ Curb, railing, lighting, traffic sign<br>・ Utilities on bridge<br>・ Riverbank protection, riverbed, driftwood,<br>・ Approach road, le to viewing (trees, weeds) |

*Source : F3LTM*

# 3. FREQUENCY AND INSPECTORS

## 3.1. Frequency of Inspections

Basically inspections of road bridges are carried out in the following intervals.

**Table 3-1 Frequency of Inspections**

| TYPE OF INSPECTIONS | FREQUENCY |
|---|---|
| Network monitoring | Once every 4 months by using the inspection tablet, completed with a monitoring work every month. |
| Periodic Inspection | Every year |
| Interim inspection | Between two periodic inspections |
| Specific Inspection | In case of necessary condition |
| Abnormal Inspection | Time of inspection are, such as cyclone or earthquake, or when unexpected abnormalities occur. |

*Source : F3LTM*

The frequency of network monitoring and periodic inspections is illustrated below. The actual frequency and timing of the inspections should be set appropriately in consultation with the parties involved in the inspection activities.

| Calendar | 1st year | | | | | | | | | | | | 2nd year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inspection Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Network Monitoring | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| (with tablet) | x | | | x | | | x | | | | | | x | | | x | | | x | | | | | |
| Periodic Inspection | | | | | | | | | ← | | → | | | | | | | | | | ← | | → | |

*Source : F3LTM*

**Figure 3-1 Network Monitoring and Periodic Inspection frequencies**

## 3.2. Inspectors

To carry out appropriate inspections, persons who have necessary knowledge and skills have to do necessary inspections.

There are a lot of types of damage that can occur to bridges, some of which may have a significant impact on bridge safety, some of which may cause damage to bridge users or third parties, and some of which may cause serious consequences in the future. Therefore, in inspecting bridges, the knowledge and skills required of an inspection engineer are described below.

1) Necessary knowledge

① Laws and regulations of roads / bridges

② Road management (maintenance) to ensure traffic safety

③ Periodic bridge inspections

④ Bridge structures and design methods

⑤ Material properties, fabrication and construction methods (steel, concrete, other)

⑥ Types of damage

⑦ Methods on repair and reinforcement (steel, concrete, effects on third parties)

⑧ Measuring instruments

### 3.3. Inspection tools

For reference, general inspection tools are as shown in Table Table 3-2 and Figure 3-1.

**Table 3-2 Recommended list of inspections tools.**

| | |
|---|---|
| **Inspection tools** | Binocular, inspection hammer (Approx. 230g), convex measure , crack gauge, spirit level, plum-bob, pole, etc. |
| **Documents** | Recording form, as-built drawings, daily log, maps, documents, etc. |
| **Recording tools** | Inspection notebook, digital camera, video camera, chalk, blackboard, magic marker, scale, pens, and pencils. A tablet. |
| **Supplementary inspection tools** | Cleaning tools, traffic regulators, rope, saw, and packaging tape |
| **Approaching tools** | Inspection mirror, flashlight, ladder, boat or barge |
| **Safety** | Safety vest, helmet, safety full harness, work shoes, work gloves, life jacket (for operation onboard or water), ropes, etc. |

*Source : F3LTM*




*Source : Inspection System on Tablet*

**Figure 3-2 Required Inpection tools**

# 4. TYPE OF DAMAGE TO BE EVALUATED

## 4.1. Evaluation of the Degree of Damage

Unlike determining the countermeasure classification or diagnosing the soundness, the evaluation of the degree of damage is an objective and symbolized record of the external condition of each part of the bridge. The evaluation categories of the degree of damage are determined so that the relative differences in appearance of damage can be easily distinguished visually, without relating the degree of damage to the impact of external forces or the cumulative effect of factors on the bridge's load-bearing capacity. On the other hand, in the judgment of countermeasure classification and evaluation of soundness, engineering estimation and judgment are taken into account, such as the internal condition of the member and the cause of damage estimated from the external appearance, and the estimated impact of the damage on the load capacity of the member and the durability of the bridge when the cause and location of the damage are also taken into account. However, in the evaluation of the degree of damage, it is required to record the fact that the damage was observed as an external appearance without including these estimates and judgments.

## 4.2. Damage Type and Evaluation Classification

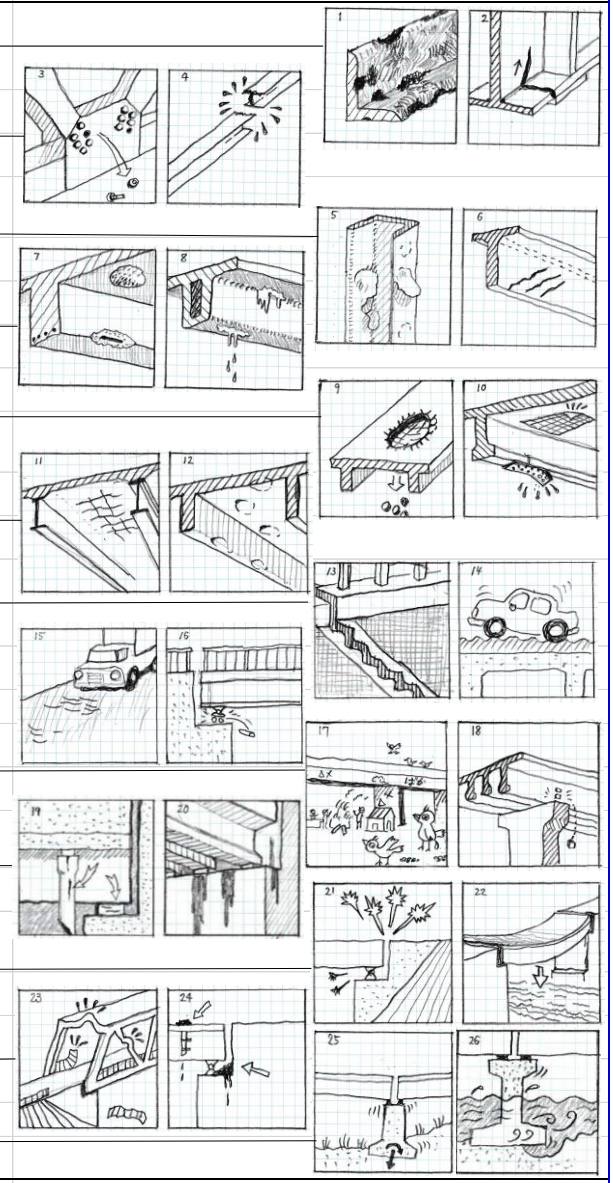
Total 26 types of damage are listed in this manual. Those damage are necessary to be recorded, and efforts should be made to find all of them during inspections. These 26 types of damage are listed in the following figure:

① Corrosion , ② Crack (Steel) , ③ Loose, Dropout of bolt , ④ Fracture, ⑤Deterioration of Corrosion Protection, ⑥ Crack (Concrete), ⑦ Spalling, Exposed Rebar, ⑧ Water Leakage, Free Lime, ⑨ Fall out, ⑩ Damage of repair or reinforcement member, ⑪ Crack of Deck Slab , ⑫ Delamination, ⑬ Abnormal End Clearance/Gap , ⑭ Uneven Road Surface, ⑮ Defect of Pavement , ⑯ Malfunction of Bearing Part , ⑰ Others, ⑱ Defect of Anchorage , ⑲ Discoloration, Deterioration , ⑳ Water Leakage, Puddle , ㉑Extraordinary Noise, Unusual Vibration, ㉒Unusual Deflection, ㉓Deformation, Break, ㉔Accumulation of Sediment, ㉕ Settlement, Movement, Tilt, ㉖Scouring

## Damage Type of Bridges

| No. | Type of Damage | Materials: Steel | Materials: Concrete | Materials: Others |
|---|---|---|---|---|
| ① | Corrosion | ● | | |
| ② | Crack | ● | | |
| ③ | Loose, Drop out of bolts | ● | | |
| ④ | Fracture | ● | | |
| ⑤ | Deterioration of Crrossion Protection | ● | | |
| ⑥ | Crack | | ● | |
| ⑦ | Spalling, Exposed Rebar | | ● | |
| ⑧ | Water leakage, Free Lime | | ● | |
| ⑨ | Fall out | | ● | |
| ⑩ | Damage of repair/ reinforcement members | ● | ● | |
| ⑪ | Crack of Deck Slab | | ● | |
| ⑫ | Delamination | | ● | |
| ⑬ | Abnormal Gap at E.J. | | | ● |
| ⑭ | Uneven Road Surface | | | ● |
| ⑮ | Defect of Pavement | | | ● |
| ⑯ | Mulfanction of Bearing Part | | | ● |
| ⑰ | Other Factors | | | ● |
| ⑱ | Defect of Anchorage | ● | ● | |
| ⑲ | Discoloration, Deterioration | ● | ● | |
| ⑳ | Water leakage, Puddle | ● | ● | |
| ㉑ | Extraordinary Noise, Unusual Vibration | ● | ● | |
| ㉒ | Unusual Defrection | ● | ● | |
| ㉓ | Deformation, Break | ● | ● | |
| ㉔ | Accumlation of Sediment | ● | ● | |
| ㉕ | Settlement, Movement, Tilt | ● | ● | |
| ㉖ | Scouring | ● | ● | |

Image



*Note: Above 26 types of damages are not directly connected to bearing capacity of bridges. Therefore, standard damage type (6 of them basically) are selected for soundness diagnosis of members and a bridge.*

**Table 4-1 Relation between damage type and classification**

| Material | No. | Damage degree | Good > > > > > Bad | | | | |
|---|---|---|---|---|---|---|---|
| | | | Degree | | | | |
| | | | a | b | c | d | e |
| | | | Classification | | | | |
| | | Type of Damage | I | I - II | II - III | | III - IV |
| Steel Member | ① | Corrosion | ● | ● | ● | ● | ● |
| | ② | Cracks of Steel | ● | | ● | | ● |
| | ③ | Loose, Dropout of bolt | ● | | ● | | ● |
| | ④ | Fracture | ● | | | | ● |
| | ⑤ | Deterioration of Corrosion Protection | ● | | ● | | ● |
| Concrete Member | ⑥ | Cracks of Concrete | ● | ● | ● | ● | ● |
| | ⑦ | Spalling, Exposed Rebar | ● | | ● | ● | ● |
| | ⑧ | Water Leakage, Free Lime | ● | | ● | ● | ● |
| | ⑨ | Fall out | ● | | | | ● |
| | ⑪ | Cracks of Deck Slab | ● | ● | ● | ● | ● |
| | ⑫ | Delamination | ● | | | | ● |
| Others | ⑬ | Abnormal End Clearance/Gap | ● | | ● | | ● |
| | ⑭ | Uneven Road Surface | ● | | ● | | ● |
| | ⑮ | Defect of Pavement | ● | | ● | | ● |
| | ⑯ | Malfunction of Bearing Part | ● | | | | ● |
| | ⑰ | Others | ● | | | | ● |
| Common | ⑩ | Damage of repair or reinforcement member | ● | | ● | | ● |
| | ⑱ | Defect of Anchorage | ● | | ● | | ● |
| | ⑲ | Discoloration, Deterioration | ● | | | | ● |
| | ⑳ | Water Leakage, Puddle | ● | | | | ● |
| | ㉑ | Extraordinary Noise, Unusual Vibration | ● | | | | ● |
| | ㉒ | Unusual Deflection | ● | | | | ● |
| | ㉓ | Deformation, Break | ● | | ● | | ● |
| | ㉔ | Accumulation of Sediment | ● | | | | ● |
| | ㉕ | Settlement, Movement, Tilt | ● | | | | ● |
| | ㉖ | Scouring | ● | | | | ● |

**Degree of damage**

a: No damage, b→c→d→e: Damage proceeding (from good to bad condition)

**Classification (See Soundness Diagnosis)**

I : sound, II : Preventive Maintenance Phase, III : Early Measures Phase,

IV: Emergency Measure Phase

# 5. SOUNDNESS DIAGNOSIS

This chapter is for periodic inspection.

## 5.1. Soundness Diagnosis

The purpose of the inspection is to evaluate whether the road is in proper condition for general traffic, and if necessary, appropriate measures are taken to maintain the road so that safe and smooth traffic is ensured. Therefore, the definitions of the classification categories for soundness diagnosis are not classified according to the size of damage or the stage of progression as a deterioration phenomenon, but rather focus on the measures that should be taken to keep the functions as a road structure. In this manual, diagnosis is performed based on the judgment classification for unit of member and unit of bridge. (Table-2.1) See “DIAGUNOSIS SHEET” in Appendix 3.

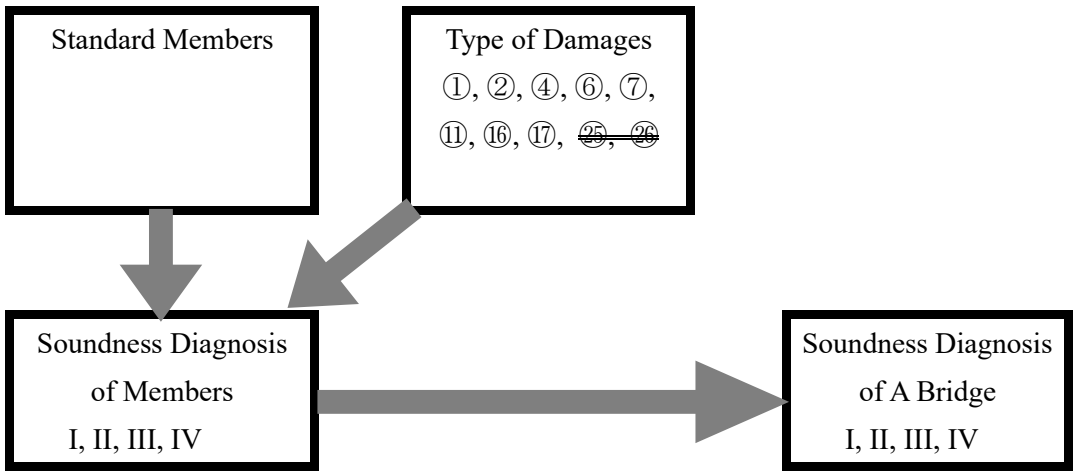



**Figure 5-1 Flow of Soundness Diagnosis from Confirmation of Defects**

## 5.2. Diagnosis of Members

Diagnosis for unit of member will be conducted by judgment classification as shown in Table 5-1.

**Table 5-1 Soundness Judgment Classification for Unit of Member**

| Classification | | State |
|---|---|---|
| **I** | Sound | State of bridge function not impaired. |
| **II** | Preventive Maintenance Phase | State of bridge function not impaired. However, It is desirable to take measures from the viewpoint of preventive maintenance. |
| **III** | Early Measures Phase | There is a possibility that the function of the bridge is being interfering. Measures should be taken as soon as possible. |
| **IV** | Emergency Measures Phase | The bridge is in a state where its function is being disturbed. Urgent measures should be taken. |

If there is any swell or peeling during periodic inspections, emergency measures shall be implemented from the viewpoint of preventing third-party damage, and then a judgment of I - IV shall be made. If it is determined that a judgment of I - IV cannot be made without conducting a detailed investigation, the detailed investigation shall be conducted promptly, after that, judgment of I - IV shall be made based on the results of the detailed investigation.

### 5.3. Standard of Evaluation Members of Judgement

Road bridges are composed of many members, and the impact of unusual state or functional failure of each member affecting to the entire bridge function is different between bridge types and other factors. In general, necessary measures for repair and reinforcement are taken on a member-by-member basis. For this reason, it is recommended that the diagnosis of soundness shall be made on a member-by-member basis, and that the evaluation of member judgment be classified at least as shown in Table 5-2 below.

**Table 5-2 Standard of Evaluation Member of Judgment**

| Superstructure | | | Substructure | Bearing part | Others |
|---|---|---|---|---|---|
| Main girder | Crossbeam | Deck slab | | | |

Note: This table is for girder bridge. Other type of bridges such as arch, cable stayed and suspension bridges should be selected standard members in accordance with technical characters.

Based on the member-by-member diagnosis, necessary measures shall be taken to ensure efficient maintenance and repair of the road. Necessary measures include repair and reinforcement, removal and periodic monitoring. In the case that emergency measures cannot be taken, traffic restriction and road closure shall be made.

## 5.4. Evaluation of the Degree of Damage

Unlike determining the countermeasure classification or diagnosing the soundness, the evaluation of the degree of damage is an objective and symbolized record of the external condition of each part of the bridge. The evaluation categories of the degree of damage are determined so that the relative differences in appearance of damage can be easily distinguished visually, without relating the degree of damage to the impact of external forces or the cumulative effect of factors on the bridge's load-bearing capacity. On the other hand, in the judgment of countermeasure classification and evaluation of soundness, engineering estimation and judgment are taken into account, such as the internal condition of the member and the cause of damage estimated from the external appearance, and the estimated impact of the damage on the load capacity of the member and the durability of the bridge when the cause and location of the damage are also taken into account. However, in the evaluation of the degree of damage, it is required to record the fact that the damage was observed as an external appearance without including these estimates and judgments.

## 5.5. Damage Type and Evaluation Classification

There are 26 of various damage that shows in a chapter of this manual. All damage should be checked and necessary to be recorded. However, for the soundness diagnosis, the next standard type of damages is selected as important phenomena to be checked at least.

**Table 5-3 Standard type of damages**

| Type of materials | Type of damages |
|---|---|
| Steel member | ①Corrosion, ②Cracks of steel, ④Fracture, Others |
| Concrete member | ⑥Cracks of concrete, ⑪Cracks of deck slab, Others |
| Others | ⑯Malfunction of bearing part, Others |

During inspection, the following 26 of damage types should be checked carefully and are necessary to record. However, some damages in shaded boxes are not serious for diagnosis of basic members and of a whole bridge. Therefore basic 10 damages should be evaluated for diagnosis of members and a whole bridge. Basic 10 damages are, ①、②、④、⑥、⑦、⑪、⑯ and ⑰.

**Table 5-4 The 26 damage types**

| Material | No. | Damage degree / Type of Damage | Good > > > > > Bad | | | | |
|---|---|---|---|---|---|---|---|
| | | | Degree of damage | | | | |
| | | | a | b | c | d | e |
| | | | Classification (Members) | | | | |
| | | | I | I - II | II - III | II - III | III - IV |
| Steel Member | ① | **Corrosion** | ● | ● | ● | ● | ● |
| | ② | **Cracks of Steel** | ● | | ● | | ● |
| | ③ | Loose, Dropout of bolt | ● | | ● | | ● |
| | ④ | **Fracture** | ● | | | | ● |
| | ⑤ | Deterioration of Corrosion Protection | ● | | ● | | ● |
| Concrete Member | ⑥ | **Cracks of Concrete** | ● | ● | ● | ● | ● |
| | ⑦ | Spalling, Exposed Rebar | ● | | ● | ● | ● |
| | ⑧ | Water Leakage, Free Lime | ● | | ● | ● | ● |
| | ⑨ | Fall out | ● | | | | ● |
| | ⑪ | **Cracks of Deck Slab** | ● | ● | ● | ● | ● |
| | ⑫ | Delamination | ● | | | | ● |
| Others | ⑬ | Abnormal End Clearance/Gap | ● | | ● | | ● |
| | ⑭ | Uneven Road Surface | ● | | ● | | ● |
| | ⑮ | Defect of Pavement | ● | | ● | | ● |
| | ⑯ | **Malfunction of Bearing Part** | ● | | | | ● |
| | ⑰ | **Others** | ● | | | | ● |
| Common (Steel/ Concrete) | ⑩ | Damage of repair or reinforcement member | ● | | ● | | ● |
| | ⑱ | Defect of Anchorage | ● | | ● | | ● |
| | ⑲ | Discoloration, Deterioration | ● | | | | ● |
| | ⑳ | Water Leakage, Puddle | ● | | | | ● |
| | ㉑ | Extraordinary Noise, Unusual Vibration | ● | | | | ● |
| | ㉒ | Unusual Deflection | ● | | | | ● |
| | ㉓ | Deformation, Break | ● | | ● | | ● |
| | ㉔ | Accumulation of Sediment | ● | | | | ● |
| | ㉕ | Settlement, Movement, Tilt | ● | | | | ● |
| | ㉖ | Scouring | ● | | | | ● |

a: No damage, b→c→d→e: Damage proceeding

## 5.6. Diagnosis of a Bridge

The diagnosis for each bridge is made according to the judgment categories in Table 5-5.

**Table 5-5 Soundness Judgment Classification for Unit of Bridge**

| Classification | | State |
|---|---|---|
| **I** | Sound | State of bridge function not impaired. |
| **II** | Preventive Maintenance Phase | State of bridge function not impaired. However, It is desirable to take measures from the viewpoint of preventive maintenance. |
| **III** | Early Measures Phase | There is a possibility that the function of the bridge is being interfering. Measures should be taken as soon as possible. |
| **IV** | Emergency Measures Phase | The bridge is in a state where its function is being disturbed. Urgent measures should be taken. |

The soundness diagnosis of each bridge is to assign comprehensive evaluation to each bridge apart from each member unit. This shall be conducted to understand the condition of overall road bridges owned by the road administrator.

In the case of national road, the influence of the soundness of each unit of member on the soundness of the entire bridge is different between the structural characteristics, cause of unusual states, progress of unusual states, bridge erection conditions, etc. Therefore, a comprehensive evaluation is made for each bridge in accordance with the definition of judgment classification taking into account of the results of the above "2.6.1 Diagnosis for Unit of Member".

In general, the major members that affect the performance of the structure shall be focused on, the evaluation of worst state member can be assumed as representative of all members.

## 5.7. Action according to Inspection

MTP shall consult with experts for bridge engineering and determine action plan for damaged structures based on the results (damage degree, “a” to ”e”, then “I”” to “IV”) of inspection. Relation between “Condition”, “Action” and ”Diagnosis” are shown in the next table.

**Table 5-6 Relation between condition and action**

| Condition to be checked | | Action to be taken | | Diagnosis |
|---|---|---|---|---|
| No work is required. | Or small repair work is required. | Continuing observation is required. Or repair work may be required depending on the situation. | ⇒ | **I** |
| Repair work is required. | Repair work is done as maintenance work. | Repair work shall be done as a part of maintenance work | ⇒ | **II** |
| | Repair work is required until next inspection. | No structural safety issue: Prompt repair work should be required for preventive maintenance. | ⇒ | |
| | | Structural safety issue: Prompt repair work shall be required for structural safety. | ⇒ | **III** |
| Need for detailed inspection/ Tracking observation for proper judgement. | | Detailed inspection<br>Or Tracking observation shall be done. | ⇒ | - |
| Emergency action is required. | No structural safety issue. | Appropriate emergency action shall be done. | ⇒ | **IV** |
| | Structural safety issue. | Emergency repair work shall be done for structural safety. | ⇒ | |

### 5.7.1. Detailed Survey

Detailed surveys are conducted to understand the damage in more detail, estimate the cause, evaluate the progression, or determine the need for repair or reinforcement before the next periodic inspection.

For example, the Item of survey is as follows;

- Fatigue and material deterioration in steel members
- Fatigue and alkali-aggregate reaction in concrete members is suspected the cause of damage.

### 5.7.2. Follow-up Survey

A follow-up survey shall be conducted by collects information such as continual field measurements and inspections and condition monitoring as a result of periodic inspections and detailed surveys.

For example, in the case that the crack of steel member, crack of concrete member, abnormal

displacement, the settlement movement and tilting of substructure and other progressive damages are observed, follow-up survey shall be conducted to understand the progress state. If there is not the possibility of rapid progress, or progress of damage doesn't affect to the safety and usability of bridge, this survey can be substituted to progress state confirmation at the time of interim inspection and periodic inspection.

# 6. INSPECTION RECORD

## 6.1. Procedure for filling in the inspection results

The following is the procedure for filling in the Inspection Record Forms.

Designated Periodic Inspection Record Form are to be filled in with the findings on the condition, causes and countermeasures, the condition of the bridge as the basis for the findings, and the results of the judgment of countermeasure classification, soundness diagnosis of each member and soundness diagnosis of each road bridge. See Appendix-3.

Notes

(1) Latitude and longitude

The latitude and longitude of a bridge is defined as the starting point of the bridge length.

Although it is necessary to avoid overlaps between bridges, excessive accuracy is not required.

The latitude and longitude are information that the names of bridges can be confirmed by identifying the location by GPS when the names of bridges are unclear at the site.

(2) Bridge name

In some cases, the name of a bridge at the time of construction may differ from the name after the completion. In such cases, the names should be the same as those in the bridge inventory to avoid unnecessary confusion.

(3) Route name (Numbering of road)

The name of the route is an important item that may promptly remind the location of the bridge. By including the name of the bypass in addition to the name of the route, it is possible to prevent misunderstandings such as the existence of two bridges at the same kilometre post.

(4) Location

The location of the bridge is also an important item that may allow the user to quickly recall the location of the bridge in question. The location of the bridge can be precisely identified by including the address where the bridge is located.

(5) Applicable standards

In the design and construction of bridges, clarification of the criteria applied to the bridge is important information for various inspections.

(6) Bridge drawings, damage maps and photos

In case of old bridges, there are no drawings. In such cases, responsible engineers and inspectors

must prepare drawings by themselves. Measurement and surveying are necessary to make drawings before starting of inspection. Span configuration, width, type of superstructure, height of piers & abutments is necessary information.

After confirmation of bridge structure, “Bridge Map of Defects” should be prepared to indicate location and type of defects.

Photos are necessary to get actual condition of defects. The engineers/inspectors should write notes on actual bridge members by chalks and markers. Normally memo consists of “draw lines along cracks or sphere of damaged area”, width of cracks, length of cracks, date of inspection and bridge name and direction. A small white board is useful to show bridge name and inspection date within photos.



**Photo 6-1　An example of photo of cracks (with memo by chalk)**

## APPENDIX

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Appendix 1 Inspection Essentials

Appendix 2 Judgement Manual for Degree of Damages

Appendix 3 Inspection Form

Appendix 4 Check Points on Steel Bridges

Appendix 5 Check Points on Concrete Bridge

Appendix 6 Check Points on Substructure and Foundation

Appendix 7 How to do Inspection ?

## Appendix 1 : Inspection Essentials

### A1.1 Inspection Essentials

1) Unusual State of Steel Member

Focus on Appearance: Corrosion, Cracked and peeling paint, Rust fluid, Deformation, Crack (Photo A. 1), Rupture

Cause: Water retention, fatigue, vehicle collision, buckling, etc.

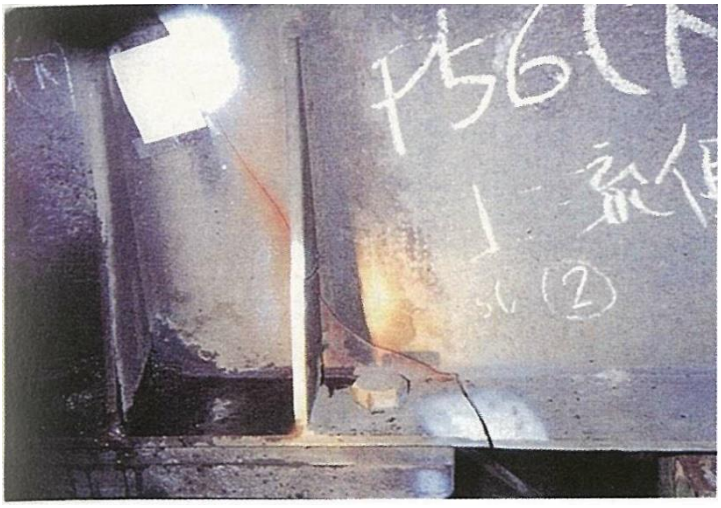


**Photo A. 1 Crack of Steel Girder**

- Cracking or peeling of the paint is a damage that belongs to the deterioration of the corrosion protection function, but it should be noted that there may be cracks in the steel in the vicinity.
- Rust fluid itself is not damage, but it is a phenomenon that should be noted because it often originates from damaged areas such as corrosion, cracks, bolt dropouts, and ruptures.

2) Unusual State of Concrete Member

Focus on Appearance: Cracks, Delamination, Defect, Rust fluid, Abnormal deflection, Discoloration, Leaks, Free lime, etc.

Cause: Corrosion of rebar, Poor workmanship, Salt damage, Alkali-aggregate reaction (ASR), Neutralization, etc.

- Although the locations and causes of cracks vary, we will investigate the causes by focusing on the crack width, crack shape (pattern), location, time of occurrence, and with

or without transfixion.

- Rust fluid, free lime, and leakage marks after rain are good clues for finding cracks.
- Cracks in the post-fill mortar at the PC steel anchorage should be noted. This is because water may penetrate through the cracks and corrode the steel inside.

3) Unusual State of Bearing and Expansion Joint

Focus on Appearance:

[Bearing] Corrosion, cracks, deformation, settlement/movement, tilting, roller ejection, rubber deterioration, rubber cracks, rubber ejection, anchor bolt loosening, cracks in the mortar of the shoe seat, cracks in the pedestal concrete

[Expansion Joint] Stepped surface, abnormality of side clearance, cracks, breaks, abnormal noise, vibration, leaks, drainage problems, etc.

Cause: Malfunction, stagnant water, faulty drainage system, movement, settlement, tilting, lateral flow of substructure, etc.

- Various types of damage occur to the bearings. Therefore, the area around the bearings must be kept clean and easily visible for inspection.
- Note that if the bearing is unusual state, the girders and substructure in the vicinity may also be affected.
- Among the unusual states found in expansion joint, stepped surface and abnormality of side clearance are unusual states that should not be overlooked because they can directly damage vehicular traffic.
- If an abnormal sound is generated from the expansion joint when a vehicle passes by, the expansion joint, girder, or slab may have been subjected to a large impact.
- If there are steps or unevenness in the expansion joint itself or in front of or behind it, abnormal shaking may be felt when passing by a vehicle. Therefore, the inspector should be aware of such sensations.

## A1.2 Decisions to be made by the Inspectors

Since the inspection engineer may sometimes have to make judgments during or after the inspection, he or she should always be aware of the problem when inspecting and also be aware of the "Key Points for Reasoning and Judgment" shown in Table-A.1. In inspections, it is important to accurately deduce not only the cause of damage, but also the effects of the damage, in order to prevent a serious situation from occurring.

**Table A. 1 : Key Point of Reasoning and Judgment**

| Item to be deduced and judged | Key point |
|---|---|
| Serious Damage | ● Is it safe as a bridge structure?<br>● Is it safe for bridge users or third parties?<br>● What is the degree of urgency? |
| Estimation of cause of damage | ● Carefully observe the damage and determine the exact cause of the occurrence.<br>● Estimate the mechanism of occurrence of the damage.<br>● Do not make prejudgments (assumptions). |
| Characteristics of the damage and how to deal with it | ● Comparison with previous inspection<br>● Progressive or not, speed of progression<br>● Occurrence of similar damage in other members<br>● Investigation of damage cases<br>● Policy for follow-up and detailed study |
| Consideration of time for next inspection | ● Damage is progressive or not, Determine the speed of progression<br>● The magnitude of the impact (traffic volume, the road is a residential road or not, existence of other rote, utilization of under girder space)<br>● Construction using new construction methods and materials |

### A1.3 Countermeasure in the case of encountering serious damage

(1) Type of Serious Damage

1) Safety of Bridge Structure

- Whether it is safe as a bridge structure?
- Is there a risk of the bridge becoming unstable or collapse of bridge?

2) Safety for bridge users

- Whether it is safe for passing vehicles and sidewalk users?
- Is there cave-in on the road surface or the bridge member protruding above the road surface?

3) Safety for third parties

- Whether it is safe for third parties using the area under the girder?
- Is any piece of member fall onto the road, railway, ship, or neighbouring houses under

the girder?

(2) Measures

1) In the event of an emergency that may result in human casualties, take immediate measures to avoid damage.

2) Immediately notify the relevant ministries and agencies of the situation, and the way of treatment, parties to be contacted, the need for traffic restrictions, the scope of the restrictions, etc. will be discussed.

3) Do not make decisions on your own.

## A1.4 Estimation of Damage Cause

There are various causes of damage and a wide variety of damage cases that appear as phenomena. It is necessary to estimate those causes and take appropriate measures corresponding to the cause of damage. The following items should be focused on.

1) Identification of the position, type and degree of damage

- Identification of the location (part) of damage, type of damage, and progress of damage. Selection of representative damaged parts.

2) Structural Property

- Material used: Steel, Concrete (RC, PC), others
- Bridge Type: Girder Bridge, Truss Bridge, Arch Bridge, Suspension Bridge, Cable Stayed Bridge, etc.
- Design Year: Applied Standards and Regulations

3) Traffic Condition

- Traffic volume, Mixing rate of large vehicles

4) Location and Environmental Condition

- Coastal Area (Salt damage), Crossing Condition (River, Railway, Road), Landslide Area, Factory areas (Sulfureous acid gas, etc.)

Based on 1) to 4) above, cause of damage shall be estimated. For example, fatigue, insufficient load-bearing capacity, salt damage, neutralization, rainwater leakage or water retention, etc. are estimated for each damaged area.

## A1.5 Damage Property and Approach

1) In the case of damage found only on specific bridges

- Poor construction, service environment, etc. are considered as possible causes, and investigation will be limited to the subject bridges.

2) In the case of damage found on bridges of the same type, same position and same member

- The cause is considered to be structural characteristics, and investigation will be conducted on bridges of the same type, members or position.

3) In the case of damage seen on bridges designed or constructed in the same years

- Design standards, construction methods, quality of materials, etc. shall be considered as a causes, then the bridges of same age shall be investigated.

4) Significant damage that could lead to bridge collapse

- Fatigue cracking, buckling and shear cracking of the main members, and movement and tilting of the substructure are considered to be the cause, and investigation should be conducted immediately.

5) Damage that should be repaired or monitored for the time being

- Crack of secondary members
- Cracks with no free lime or rust fluid
- Cracks inside secondary members due to confining stresses

### A1.6 Consideration of next inspection time

1) If there is no special damage, normal periodic inspection intervals are acceptable.

2) In the following case, appropriate inspection intervals should be established or monitoring should be conducted by follow up inspection.

- Repairs were made using new construction methods or new materials for which reliability has not been established.
- Repairs were carried out and their effectiveness should be check.
- Damage cause is unknown.
- The likelihood or rate of progression of the damage is unknown.
- Collisions or minor fire damage often occur.

### A1.7 Preparedness in the field

(1) Inspection on bridge surface

The inspector shall inspect for overall abnormalities on the bridge face. In addition, check have to be done for abnormalities in the area or members that may be apparent on the bridge surface. The following points should be noted in the inspection.

1) Are there any abnormality on overall appearance and longitudinal and transverse configuration?

2) Are there abnormal sound by vehicle passing, oscillation and abnormal deflection?

3) Are there any unusual states in the pavement? Are there any localized abnormalities? (It has a possibility of slab sinking)

4) Are there any unusual states (Stepped surface, Damage, abnormal side clearance, noise, etc.) in the expansion joint? (This relates to the bearing displacement and tilting of substructure.)

5) Are there any unusual states (member of truss and arch, hanging member, sign post, lighting post, handrail, barrier, noise prevention wall, falling object prevention wall, etc.) for the structure above bridge surface?

6) Are there any abnormality on slope face around pier and abutment and approach road? (This relates to the side clearance abnormality of expansion joint and abnormal state of bearing.)

If any of the above phenomena are observed, record the location and observe the corresponding area/member and the lower side of the girder. If anomalies are found, observe the area that may be affected.

(2) Inspect the bridge lower side from the ground

The inspector looks at the lower side of the bridge from ground level to check for any abnormalities. If an abnormality is found during the inspection at the road face, the corresponding area should be inspected well from under the girder.

1) Are there any settlement, tilting and displacement for substructure?

2) Which part or member has abnormal sounds, oscillation and deflection on road surface?

3) Is there significant damage to the lower side of the slab?

4) Is there unusual state for the bearing or shoe bed?

5) Are there any abnormality for girder end, end sway bracing?

6) Are there any rest fluid, drop-off of bolt and abnormal oscillation of main structure?

7) Is there abnormal water leakage after reining?

Although it depends on the nature of the inspection and its circumstances, as a general rule, inspections should be conducted as close as possible.

## Appendix 2 Judgement Manual for Degree of Damages

### A2.1 General Description and Judgment Category

This Judgment manual describes for recording use symbol based on objective judgement of damage appearance of each member. Judgement is described as classification from I to IV.

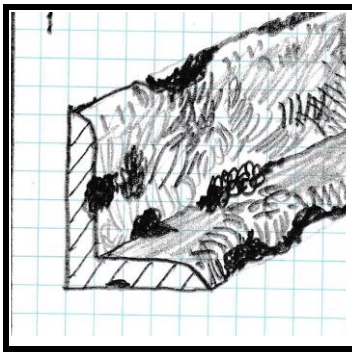
### A2.2 Damage of Steel Member

The damage types for steel member are :

① Corrosion
② Cracks of Steel
③ Loose, Dropout of bolt
④ Fracture
⑤ Deterioration of Corrosion Protection

#### ① Corrosion

**[General description and defect characteristics]**

| | |
|---|---|
|  | Corrosion is a state in which rusting occurs intensively in ordinary steel (with anti-corrosion measures such as painting and plating), rust progresses to such an extent that a reduction in plate thickness or loss of cross-section (hereinafter referred to as "Reduction in plate thickness"). |

The most likely locations for corrosion are at the ends of girders, where water tends to stagnate such as the tops of horizontal members, around bearings, at continuous joints with no ventilation and poor drainage, at the top surface of lower flanges where mud and dust tend to accumulate, and at welding joints.

In places where water stagnation and dust accumulation are likely to occur structures, such as at the girder panel points of Arch Bridge and Truss, localized deterioration and significant damage to the paint film may occur. Therefore caution shall be required.

In the case of identical continuous structures, such crossbeam ties (PT bar), damage at one place

may progress to other, so caution shall be required.

When the cable anchorage part is covered in the concrete, etc., water may enter the inside and corrosion of the internal cables occur, so caution shall be required.

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition | |
|---|---|---|---|---|
| | | | Depth of Damage | Area of Damage |
| Good >>>Bad | **I** | a | No Damage | |
| | **I - II** | b | small | small |
| | **II – III** | c | small | large |
| | **II - III** | d | large | small |
| | **III - IV** | e | large | large |

Note: General condition of each factor are:-

2) Depth of damage: [large] means, there are significant swelling on steel surface, or, significant plate thickness decrease by visual contact. While, [small] means, there are rust only on surface, and there are not significant plate thickness decrease by visual contact.
3) Area of Damage: [large] means, the corrosion is occurred on whole of focused part, or, there are some extensive corrosion parts. While [small] means, the damaged area is small and local.

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure.

  Emergency response shall be reasonable in situations, where significant corrosion has occurred on the cable materials of the cable structure, and the corrosion is seriously impairing the structural safety. In some cases, significant plate thickness reduction has occurred in the girder-end webs, arches, and panel points of trusses, the structural safety is seriously compromised due to the loss of load-bearing capacity of the members.

- **Judgment is difficult:** Damage requiring **further investigation or follow-up**

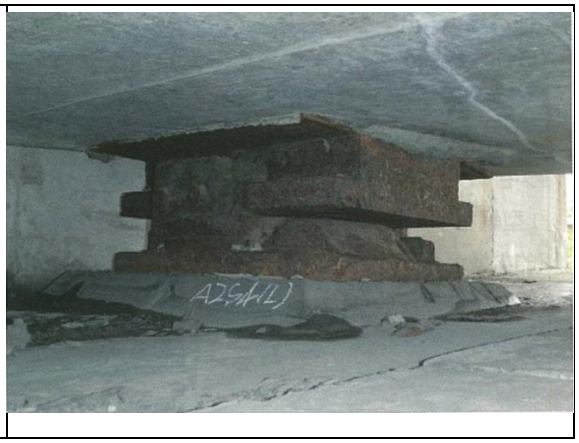
  In situations where there is a large difference in the degree of damage, when compared to bridges constructed during the same period and in the same route.

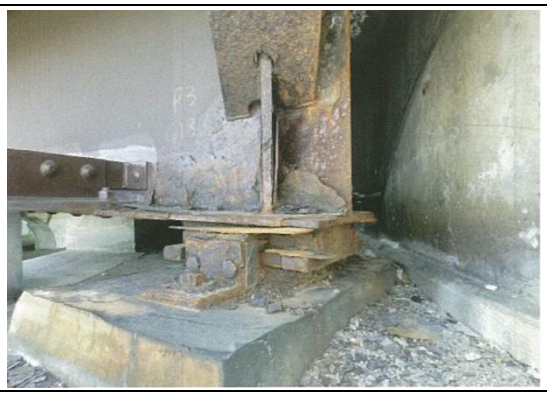
  The damage cause cannot be explained using the general factors such as environmental or local conditions alone. I such situations, in order to accurately examine the damage, such as evaluating the progression of the damage and identifying the cause, it shall be appropriate to

conduct a detailed investigation.

- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work.**

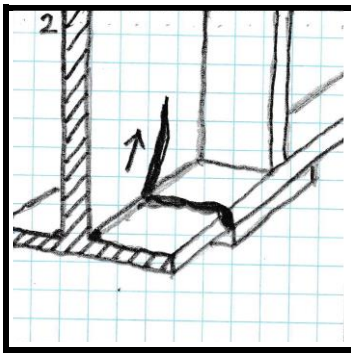
  Although there is no overall damage, but partial corrosion caused by small defects in some areas, etc. In situations where the damage small in scale and in an easily accessible area, it shall be appropriate to deal with the damage along with the maintenance work.

| | |
|---|---|
| Sample photo: ① **Corrosion**<br>Main Girder, Degree ”b” (Depth small, Area small)> “**II**”, (Relationship with other Damage: ⑤ **Deterioration of Corrosion protection)** There are local corrosion on the Main Girder. The significant plate thickness decrease is not recognized. |  |
| Sample photo: ① **Corrosion**<br>Main Girder, Degree ”c” (Depth small, Area large) >> “**II**”, (Relationship with other Damage: ⑤ **Deterioration of Corrosion protection)** There are multiple broaden corrosion on the whole of main girder. The significant plate thickness decrease is not recognized. |  |
| Sample photo: ① **Corrosion**<br>Whole Bearing, Degree ”c” (Depth small, Area large)>>”**II**”, (Relationship with other Damage: ⑤ **Deterioration of Corrosion protection)** There are corrosion on whole of bearing. The significant plate thickness decrease is not recognized. |  |

| | |
|---|---|
| Sample photo: ① **Corrosion**<br>Main Girder, Degree ”e” (Depth large, Area large)>>”**IV**”, (Relationship with other Damage: ⑤ **Deterioration of Corrosion protection)** There are significant corrosion with swelling on whole of main girder. The obvious plate thickness decrease can be visually recognized. |  |

### ② Cracks of Steel

**[General description and defect characteristics]**

| | |
|---|---|
|  | Cracks that occurs in the steel material. Cracks are likely generated at welding joint or connections and stress concentrated point due to sudden sectional change caused by fatigue phenomena.<br>Cracks may occur inside the steel material and usually difficult to find cracks with visual inspection alone. |

Most of the cracks are extremely small, and if the surface is not smooth, such as close to weld lines, it may be difficult to distinguish them from uneven shadows caused due to surface scratches, rust, etc. In addition, cracks that open on the surface when there is a coating are often accompanied by cracks in the coating.

Cracks are likely to occur in stress concentrated point due to sudden sectional change, such as girder panel points of Arch Bridge and Truss. In addition to being a crack-prone area, it has a large impact on the entire structural system in the event of damage.

Notched girders in a Gerber structure can be stress concentration point and a weak point in terms of fatigue.

In the same structural section, cracks are possible to occur, so care shall be required.

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good > > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | Paint surface crack is observed on sudden section change part and welding part. It is not line type crack. Or, it is a short line crack. |
| | **II - III** | d | - |
| | **III - IV** | e | There are long line type crack. There is paint surface breaking suspected the crack under the coating. |

**[Criteria for Judgment and Category type]**

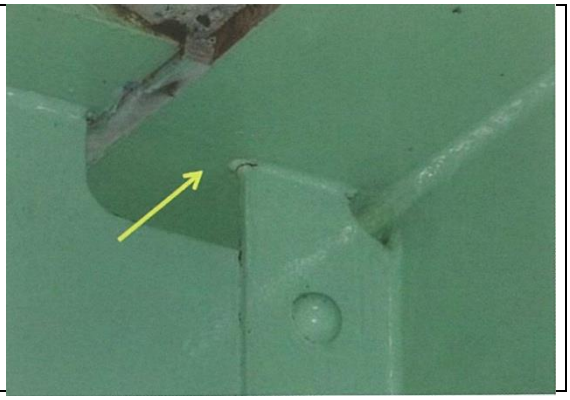
- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. It is appropriate to consider emergency measures, when the rapid growth of the cracks impairs structural safety in the specific parts of structure such as main girder web, steel pier, crossbeam, received beam of Gerber beam, etc.

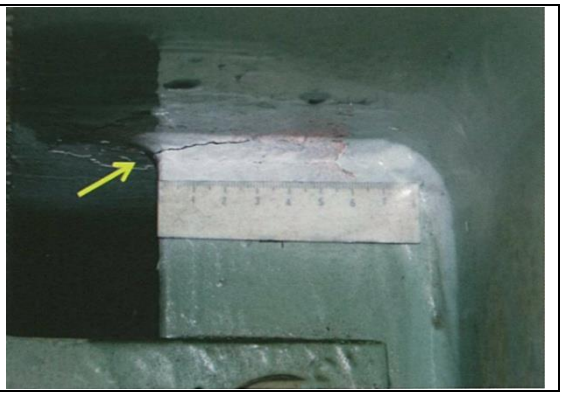
  In situations where there is a risk of rapid crack progress in main member, which gives high impact to structural function such as main girder, specific parts where large stress variations may occur, such as arches and truss members, notched girders, received beam of cantilever beam, etc.

  - **Judgment is difficult:** Damage requiring **further investigation or follow-up.** In order to estimate the cause of the crack and to determine the soundness of the concern member, it is necessary to comprehensively examine the stress generated. In addition to the surface characteristics of the crack length, aperture width, depth of the crack, (presence or absence of internal defects, type of welding, plate assembly and groove). Therefore, unless the cause of the crack and the extent of the crack can be easily determined, a detailed examination shall be implemented.

  If cracks are suspected in paint film and not be possible to confirm, suppose it as cracks are found, taking into consideration the risk of the cracks progress. It is best to confirm the cracks by detailed examinations.

- **Judgment Category I, II, III:** Damage that requires repair, etc. In general, it is often appropriate to take measures to prevent the progress of cracks and judge as repairs are necessary, regardless of the degree of damage.

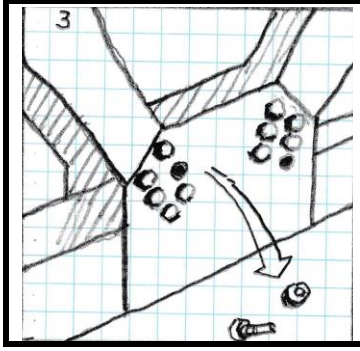
| | |
|---|---|
| Sample photo: ② **Cracks of Steel**<br>Main Girder, Degree ”c”>>”**II**”, There is a paint cracking on the welding part between vertical stiffener of main girder and upper flange. |  |

| | |
|---|---|
| Sample photo: ② **Cracks of Steel**<br>Main Girder, Degree ”e”>>”**IV**” , The liner crack is occurred on welding part between vertical stiffener of main girder and upper flange. |  |

| | |
|---|---|
| Sample photo: ② **Cracks of Steel**<br>Main Girder (Cantilever, connection with drop-in span), Degree ”e” >>”**IV**”, The crack is recognized on connection part of main girder. The prompt measure shall be necessary. |  |

**③ Looseness, Drop-off**

**[General description and defect characteristics]**

| | |
|---|---|
|  | Loosening of bolts or missing nuts or bolts. Including bolt failure or fractured bolt. |

Here all bolts and rivets are covered, regardless of the part where they are used or the type of bolt, high-strength bolt, rivet, etc.

**[Judgement of damage degree]**

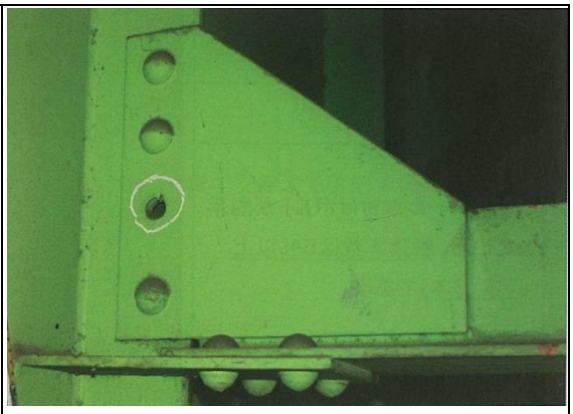
1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good > > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | Looseness and drop-off is occurred on bolt. The number of damaged bolt is a few. (less than 5% of 1 batch) |
| | **II - III** | d | - |
| | **III - IV** | e | Looseness and drop-off is occurred on bolt. The number of damaged bolt is a lot. (more than 5% of 1 batch) |

**[Criteria for Judgment and Category type]**

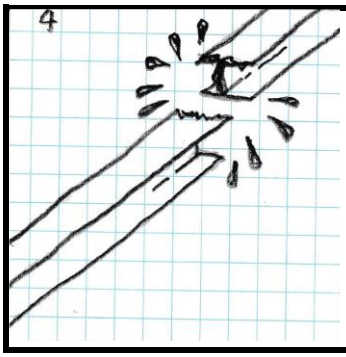
- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be reasonable, when large number of bolts have dropped out at a joint and the structural safety is impaired due to insufficient joint strength.
- **Judgment Category IV:** Other damage requiring emergency response. It is appropriate to consider emergency measures, in the case of a loose anchor bolt in a pedestal bearing, which always exerts an uplift dynamic force, and which may lead to a situation that immediately affects the serviceability, such as an uneven road surface.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**
  It shall be appropriate to conduct a detailed investigation, when some type of bolts loosens or drops off and there is a risk that other bolts with similar conditions (F11T HT bolts or stainless bolts for example), such as bolts from the same lot as the damaged bolt or bolts installed at the same time, bolts may also rupture due to chain reaction.
- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In situations where the scale of the damage is small, such as when ordinary bolts of railings or accessories are loosened, it shall be appropriate to deal with the damage along with the maintenance work (however, if loosening or drop off occurs in multiple places, it is desirable to examine the cause of the problem and take action.)

| | |
|---|---|
| Sample photo: ③ **Looseness, Drop-off,** Anchor bolt, Degree ”e”>> “**IV**” , (Relationship with other Damage: ⑯ Malfunction of Bearing**)** The nut of bearing anchor bolt has looseness. The number of looseness bolt is more than 5%. |  |

| | |
|---|---|
| Sample photo: ③ **Looseness, Drop-off,** Sway bracing, Degree ”e” >>”**IV**”, The rivet of sway bracing is dropping off. The number of drop-off rivet per 1 group is more than 5%. |  |

### ④ Fracture

**[General description and defect characteristics]**

| | |
|---|---|
|   | A steel member is either completely ruptured or broken to the extent that it is considered to be ruptured.<br>It is often seen in secondary members such as floor assembly members, sway bracing, lateral bracing, and so on, as well as in railings, guardrails, accessory or mountings members. |

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Class | General Condition |
|---|---|---|---|
| Good < > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | Fracture |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be reasonable in situations where structural safety is seriously impaired by the rupture of arch bridge supports or suspension members, truss bridge diagonals members, PC bridge cables, pedestal bearing anchor bolts, and so on.

  The failure of arches, truss girders, and other areas where large stress variations occur, such as the failure of notched girders in cantilever structures, may have a significant impact on the entire structural system. Emergency response shall be appropriate in situations where there is a risk of rapid crack progress.
- **Judgment Category IV:** Other damage requiring emergency response. In some cases emergency response shall be reasonable in situations, such as when there is a risk of damage to road users or passing vehicles from the bridge due to a broken railing.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. It shall be reasonable to conduct a detailed investigation, where ruptures have occurred in Arch Bridge supports, suspension members, truss bridge diagonals and vertical members, sway braces, lateral bracing, bearings bolts, etc., and the cause cannot be clearly identified, such as due to wind, traffic vibration, normal traffic loads, fatigue, corrosion, etc.
- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In situations where the scale of damage is small, such as a localized rupture of a bracket, support metal fittings, it shall be appropriate to deal with the damage along with the maintenance work.
- **Judgment Category I, II, III:** Damage that requires repair, etc. In general, when a fracture occurred, it is often appropriate to judge that repair is necessary.

| | |
|---|---|
| Sample photo: ④ **Fracture**<br>Diagonal Member of Truss , Degree ”e” >>”**IV**”, The diagonal member of truss has fracture by car collision. It is the state that the emergency measure is needed. |  |

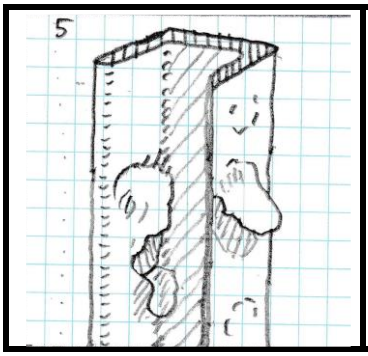
| | |
|---|---|
| Sample photo: ④ **Fracture**<br>Hand Rail , Degree ”e”>>”**IV**”, (Relationship with other Damage: ① **Corrosion,** ⑤ **Deterioration of Corrosion protection)** The fracture is occurred by corrosion progress of hand rail. |  |

### ⑤ Deterioration of Corrosion protection

The classification of corrosion protection is as follows.

| Type | Corrosion protection |
|---|---|
| 1 | Painting |

**[General description and defect characteristics]**

| | |
|---|---|
|  | For steel members, paint (coating film) is in the state of deterioration such as discoloration, chalking, cracking, blistering, peeling. |

**[Judgement of damage degree]**

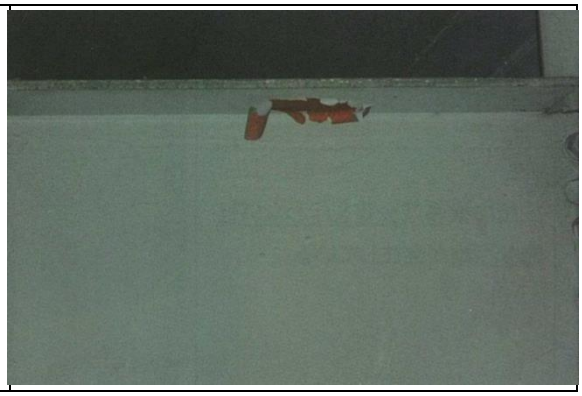
1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good < < < Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | Change of color is occurred on outer layer paint coating. There is local swelling. |
| | **II - III** | d | The peeling is occurred on local paint coating, and under coating layer is exposed. |
| | **III - IV** | e | The area of paint coating deterioration is large. |

**[Criteria for Judgment and Category type]**

- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. It shall be appropriate to conduct a detailed investigation. When large scale delamination or peeling has occurred and there is fear about suddenly fall off due to poor workmanship, Nonconformity of paint systems with respect to the environment, abnormal discolor, mismatching of the coating environment, defective materials, risk due to effects of fire disaster, etc.,
- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In some cases, such as where there is no overall damage, but there is peeling or rusting of the paint caused by a small damage, and the size of the damage is small and in an easily accessible location, it shall be appropriate to deal with the damage along with the maintenance work.

| | |
|---|---|
| Sample photo: ⑤**Deterioration of Corrosion protection**<br>Main Girder, Degree ”c”>> “**II**”, The local peeling is occurred on painting final layer of main girder. |  |

| | |
|---|---|
| Sample photo: **⑤Deterioration of Corrosion protection**<br>Cross beam, Degree ”d”>>”**III**”, The coating has locally peeling and undercoat is exposed on upper flange of cross beam. |  |

| | |
|---|---|
| Sample photo: **⑤Deterioration of Corrosion protection**<br>Main Girder, Degree ”e” >>”**IV**”, The coating has peeling and undercoat is exposed. The deterioration area is so wide. |  |

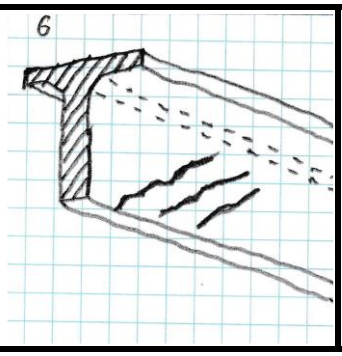
### A2.3 Damage of Concrete Member

The damage types for concrete member are :

⑥ Cracks of Concrete
⑦ Spalling, Exposed Rebar
⑧ Water Leakage, Free Lime
⑨ Fall out
⑪ Crack of Deck Slab
⑫ Delamination

### ⑥ Cracks of Concrete

**[General description and defect characteristics]**

| | |
|---|---|
|  | This refers to the condition in which cracks occur on the surface of a concrete member. |

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Class | Maximum crack width | Minimum crack interval |
|---|---|---|---|---|
| Good >> Bad | **I** | a | No Damage | |
| | **I - II** | b | small | small |
| | **II – III** | c | small | large |
| | | | middle | large |
| | **II - III** | d | large | small |
| | | | middle | large |
| | **III - IV** | e | large | large |

Note: General condition of each factor are:-

2) Maximum crack width: [large] means, **Width of crack is large**. (**RC structure: more than 0.3 mm**, PC structure: more than 0.2 mm), [middle] means, Width of crack is middle. (RC structure: more than 0.2 mm less than 0.3 mm, PC structure: more than 0.1 mm less than 0.2 mm), and [small] means, **Width of crack is small.** (**RC structure: less than 0.2 mm**, PC structure: less than 0.1 mm).
3) Minimum crack interval: [large] means, Interval of crack is small. (Minimum crack interval is about less than 0.5 mm). While [small] means, Interval of crack is large. (Minimum crack interval is about more than 0.5 mm).

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be reasonable in situations such as damage is expected to progress rapidly, where there is a high risk of severely impairing

structural safety. In the sites affected by Salt damage, if the rust has reached the concrete internal rebar, when cracks has occurred due to uneven settlement of pier near the support of the main girder, etc.

- **Judgment Category IV:** Other damage requiring emergency response. When the situation progresses to an early stage delamination and there is a high risk of injury to pedestrians and passing vehicles, an emergency response shall be appropriate.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. A detailed investigation shall be appropriate when there is a significant difference in the degree of damage compared to bridges constructed in the same year along the same route, and when general damage factors such as environmental and local conditions alone cannot explain the cause of the damage.

In addition, a detailed investigation is basically required for the following specific events.

**［Conditions there is a risk of alkali silica reaction]**

- Mesh shaped cracks are observed on the concrete surface.
- Cracks along the direction of the main reinforcement bars or PC steel member has occurred.
- White gel-like substance into micro cracks has appeared.

**［Conditions there is a risk of chloride attack]**

- It has been built in the area, where bridges have attacked by sea salty winds and caused salt damages.
- Installed on road sections where anti-freezing agents (NaCl: Salt) are sprayed (very cold area in winter).
- The use of sea sand has been confirmed in the materials at the time of construction.
- Damaged bridges by chloride attack have been confirmed within radius of 100m from the seashore.
- The damage of specific chloride attack has appeared during inspection, such as rust fluid.

**A follow-up investigation** shall be appropriate when the cause of the cracks is clearly due to the dry shrinkage and it is sufficient to determine the need for repair after examining the progress of the cracks. Additional investigation shall be justified. For cantilever sections, the location of damage differs depending on the internal rebar arrangement, etc., and it shall be difficult to obtain a complete picture just by looking at the cracks from exterior cracks alone.

| | |
|---|---|
| Sample photo: ⑥ **Cracks of Concrete**<br>Main Girder, Degree ”c”>>”**III**” (Width Middle, Interval small), (Relationship with other Damage: ⑱ **Defect of Anchorage)** The 0.1mm width of diagonal crack is occurred from bearing part to girder end of PC T-shape girder. |  |

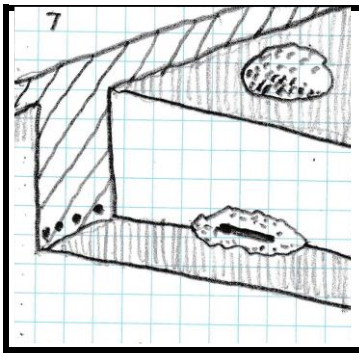
| | |
|---|---|
| Sample photo: ⑥ **Crack of Concrete**<br>Main Girder, Degree ”c” >>”**III**” (Width Middle, Interval small), The 0.15mm width crack is occurred for longitudinal direction of PC hollow slab girder. |  |

| | |
|---|---|
| Sample photo: ⑥ **Crack of Concrete**<br>Main Girder, Degree ”d”>”**III**” (Width Large, Interval small), (Relationship with other Damage: ⑧ **Water leakage / Free Lime)** The 0.2mm width crack along the sheath is occurred on PC T-shape girder. |  |

| | |
|---|---|
| Sample photo: ⑥ **Cracks of Concrete,** Main Girder, Degree ”e”>>”**IV**” (Width Large, Interval Large), (Relationship with other Damage: ⑩ **Defect of reinforcement / repair material / strengthening)** The diagonal crack is occurred near the bearing part side surface of PC T-shape girder. The crack width is more than 1.0mm and the minimum crack interval is about 0.1mm. The prompt repair shall be necessary. |  |

### ⑦ Spalling / Exposed Rebar

**[General description and defect characteristics]**




Spalling is defined as a fragment, which has been detached from the surface of concrete member. The reinforcement steel exposed at spalled part is called as exposure of rebar.

**[Judgement of damage degree]**

2) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | There are only spalling. |
| | **II – III** | d | The rebar is exposed and its corrosion is slightly. |
| | **III - IV** | e | The rebar is exposed and its corrosion is severe. |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. In chloride attack areas, where the PC steel material is exposed on the underside of the slab structure and has reached the point of cross-sectional loss, and where the damage is expected to progress rapidly, and where there is a high risk that the structural safety will be seriously compromised, emergency measures shall be deemed appropriate.
- **Judgment Category IV:** Other damage requiring emergency response. Delamination has occurred, there is an extremely high risk of delamination and falling in other areas as well. There is concern about damage to pedestrians and passing vehicles, an emergency response shall be judged appropriate.

- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. In some cases, it shall be appropriate to conduct a detailed investigation if there are areas of delamination due to corrosion of the rebar can be seen and risk of continuous delamination due to the corrosion state of the rebar.

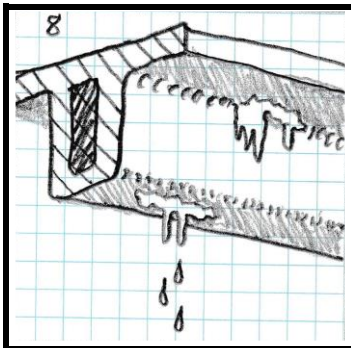
- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In situations where there is no overall damage, but partial delamination has occurred and the scale of the damage is small, and the location is easily accessible, it shall be appropriate to deal with the damage along with the maintenance work.
  In addition, it is recommended to deal with the exposed reinforcing bars for corrosion prevention by maintenance work, but separately for mortar repair and sectional restoration.

| | |
|---|---|
| Sample photo: ⑦ **Spalling / Exposed Rebar,** Beam of Pier, Degree ”d” >>”**III**”, The concrete of cantilever part on T-shape pier has spalling and the rebar is exposed. The corrosion of rebar is minor. |  |

| | |
|---|---|
| Sample photo: ⑦ **Spalling / Exposed Rebar,** Main Girder, Degree ”e” >>”**IV**”, (Relationship with other Damage: ⑩ **Defect of reinforcement / repair material / strengthening)** The concrete of PC main girder lower flange has spalling and the rebar is exposed. The corrosion of rebar is quite major. |  |

### ⑧ Water leakage / Free Lime

**[General description and defect characteristics]**

| | |
|---|---|
|  | Water leakage / free lime (efflorescence) is defined as the situation in which water seepage or efflorescence from the concrete joints or cracks. |

**[Judgement of damage degree]**

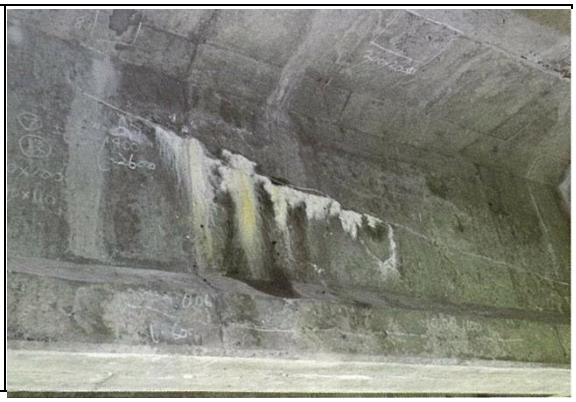
1) Classification of damage degree

| | Classfication | Degree | General Condition |
|---|---|---|---|
| Good >>> Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | The leakage water is observed from crack. Rust juice and free lime is not observed. |
| | **II - III** | d | Free lime is observed from crack. Rust juice is not observed. |
| | **III - IV** | e | Leakage water and free lime is significantly observed from crack. Mud and rust juice are mixed in leakage water. |

**[Criteria for Judgment and Category type]**

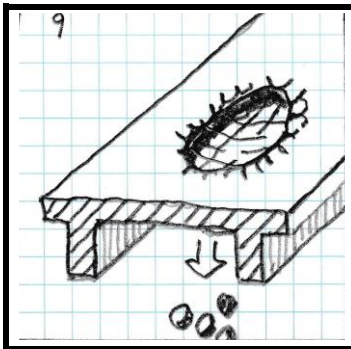
- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate in situations where the efflorescence from the deck slab is mixed with sediment, waterproof layer of the slab is damaged. So it is judged that the damage will progress quickly in the future, and there is a high risk of structural safety will be greatly impaired.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**.
  A detailed investigation shall be appropriate, when it is not possible to determine whether the water leakage or efflorescence is occurring through surface cracks from poor drainage.

| | |
|---|---|
| Sample photo: ⑧ **Water leakage / Free Lime,** Main Girder, Degree ”e” >>”**IV**”, (Relationship with other Damage: ⑥ **Cracks of Concrete)** The icicle free lime is leaked from crack of main girder. |  |

| | |
|---|---|
| Sample photo: ⑧ **Water leakage / Free Lime,** Main Girder, Degree ”e” >>”**IV**” , (Relationship with other Damage: ⑥ **Cracks of Concrete)** The free lime with rust liquid is leaked from crack along sheath of main girder. |  |

**⑨ Fall out**

**[General description and defect characteristics]**

| | |
|---|---|
|  | This defect is defined as the fallen out of concrete mass of concrete deck slab. (Including concrete fragrance break out of the surface)<br>Webbed pattern cracks are often found in case of deck slab. |

With concrete filling and overhanging concrete, concrete lumps may fall out between steel materials without any noticeable cracking around them.

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good >> Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | There are fall out of concrete block. |

**[Criteria for Judgment and Category type]**

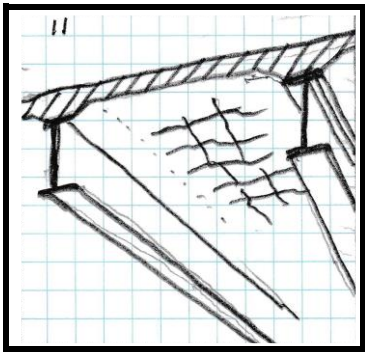
- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate in situations where the fallen out of concrete mass of concrete deck slab. (Including concrete fragrance break out of the surface)
- **Judgment Category IV:** Other damage requiring emergency response. In the unlikely event, emergency measures shall be considered appropriate in situations where there is concern that traffic may be disrupted due to road sagging and fall out occurs.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. In situations where cracking, leakage, efflorescence has occurred in the longitudinal joints part of PC T-girders and there is a possibility of unreinforced concrete falling out, it shall be appropriate toper form detailed investigation as a measures for such damage.

| | |
|---|---|
| Sample photo: ⑨ **Fall out**<br>Deck Slab, Degree ”e” >>”**IV**”, (Relationship with other Damage: ⑮ **Defect of Pavement)** The fall out is occurred on PC hollow slab girder. The prompt repair shall be needed. |  |

| | |
|---|---|
| Sample photo: ⑨ **Fall out**<br>Deck Slab, Degree ”e” >>”**IV**”, (Relationship with other Damage: ⑦ **Spalling / Exposed Rebar,** ⑧ **Water leakage / Free Lime,** ⑫ **Delamination)** The fall out is occurred at inter filling concrete of PC T-shape girder. |  |

### ⑪Cracks of deck slab

**[General description and defect characteristics]**

| | |
|---|---|
|  | This crack is defined as the longitudinal / transverse or in both directional cracks at concrete deck slab of steel / Concrete bridges. |

Also this includes the crack at concrete deck slab of T-girder bridge, the crack at upper surface inside box girder bridge, and the crack at overhanging slab of hollow slab bridge and box girder bridge.

If an abnormality is observed in the top slab of a box culvert, it is necessary determine the measure of cracks for deck slab shall be made by considering the abnormalities observed and the effects of repeated live loading

**[Judgement of damage degree]**

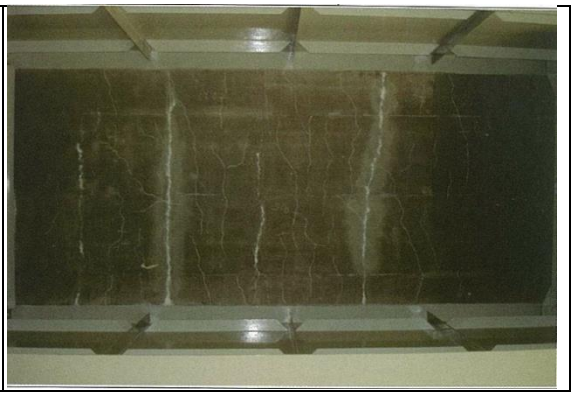
1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good > > > Bad | **I** | a | No Damage |
| | **I - II** | b | Only one direction small crack |
| | **II – III** | c | Small two direction crack |
| | **II - III** | d | Two direction crack (crack width: less than 0.2 mm) |
| | **III - IV** | e | Two direction crack (crack width: more than 0.2 mm) |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate in situation where significant cracking has occurred and the structural safety is seriously impaired due to a reduction in the rigidity of the entire superstructure.

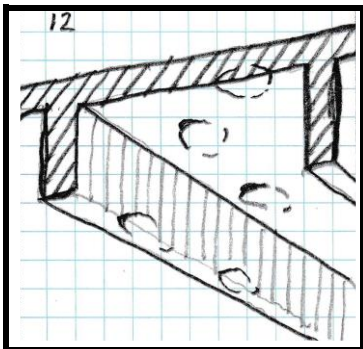
- **Judgment Category IV:** Other damage requiring emergency response. Crack which leading up to falling out of the deck slab and there are possibility of harm to pedestrians and passing vehicles under the girder then emergency response is determined to be reasonable.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. It shall be appropriate to conduct a detailed investigation. If there are widespread cracks or efflorescence spreading over wide area, there is a possibility that deterioration is progressing that is not solely due to fatigue.

| | |
|---|---|
| Sample photo: ⑪ **Cracks of deck slab,** Deck Slab, Degree ”b” >> “**II**”, (Relationship with other Damage: ⑧ **Water leakage / Free Lime)** There is one direction crack with free lime on RC deck slab between girders. The width of crack is less than 0.2mm. |  |

| | |
|---|---|
| Sample photo: ⑪ **Cracks of deck slab,** Deck Slab, Degree ”e” >>”**III**” , (Relationship with other Damage: ⑧ **Water leakage / Free Lime)** There is one direction crack with free lime on RC deck slab overhanging part. The interval of crack is about 0.5m and width of crack is 0.3mm. |  |

### ⑫ Delamination

**[General description and defect characteristics]**

| | |
|---|---|
|   | Delamination occurs when layers of concrete separate at or near the level of the top or outermost layer of reinforcing steel. It is defined as surface area of concrete members including deck slab is bulging and likely with delamination. |

Visibly, it may appear as sound surface but may be identified as a hollow sound by tapping.

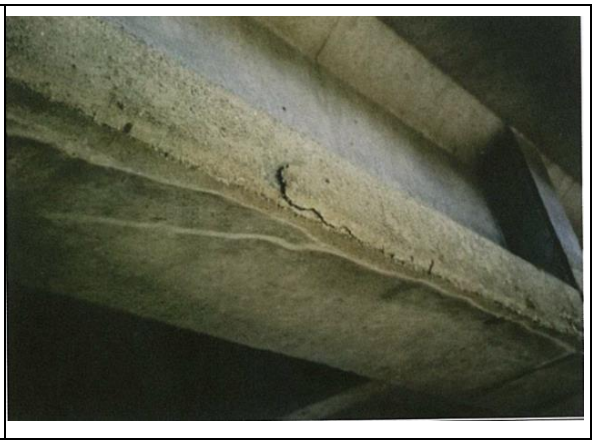
**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good <<< Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | There is a delamination. |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate. Delamination occurred in salt-damaged areas, corrosion of PC cables was also observed, and if it left unattended, it could seriously impair structural safety.
- **Judgment Category IV:** Other damage requiring emergency response. In some cases, emergency response shall be appropriate, for example, when concrete curb, railings, deck slabs, etc. are subject to delamination, and there is a high risk of concrete mass falling out and may cause serious harm to people and vehicles passing below the road.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. In some cases, it shall be appropriate to conduct a detailed investigation when corrosion is observed and the cause cannot be identified because of corrosion condition of the rebar is unclear, or when corrosion related to the breakage or overhang of a PC steel bar is suspected but the corrosion state is unknown and therefore cause cannot be identified.

| | |
|---|---|
| Sample photo: ⑫ **Delamination**<br>Main Girder, Degree ”e” >>”**IV**”, (Relationship with other Damage: ⑦ **Spalling / Exposed Rebar)** The delamination is occurred on the side surface of PC main girder. |  |

| | |
|---|---|
| Sample photo: ⑫ **Delamination** Main Girder, Degree ”e” >>”**IV**”, (Relationship with other Damage: ⑦ **Spalling / Exposed Rebar,** ⑥ **Crack,** ⑩ **Defect of reinforcement/repair material/strengthening)** The delamination is occurred on the lower surface of PC main girder. |  |

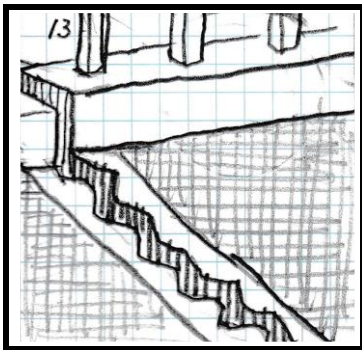
## A2.4 Other Damages

The damage types categorized as other damages are :

⑬ Abnormal End Clearance/Gap
⑭ Uneven Road Surface
⑮ Defect of Pavement
⑯ Malfunction of Bearing Part
⑰ Others

### ⑬ Abnormal clearance / gap (Spacing at Expansion Joint)

**[General description and defect characteristics]**

| | |
|---|---|
|   | Abnormal clearance / gap refers to the condition where the normal prescribed clearance is either abnormally widened between girders or between girder and abutment, or where there is no provision for movement. |

In addition, abnormal spacing could be identified by abnormal distortion of bearing or the defects related to expansion joint and parapet.

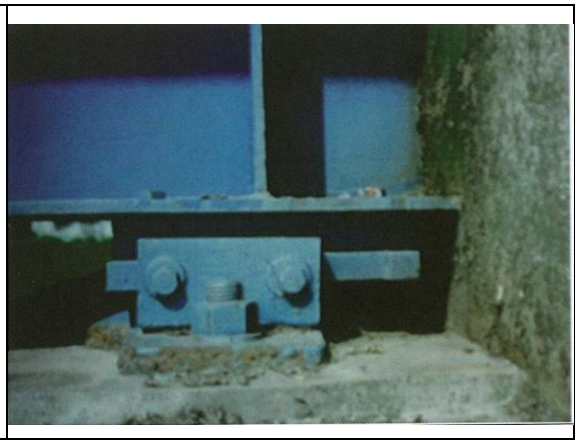
**[Judgement of damage degree]**

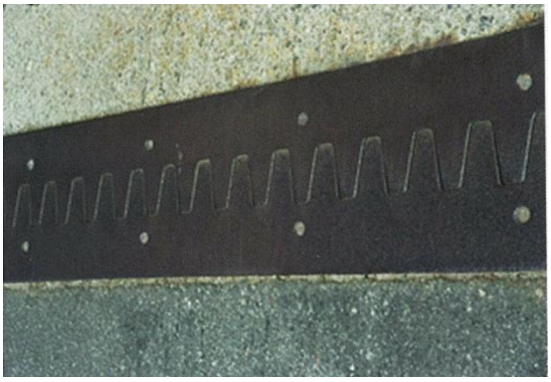
1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good >>> Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | There is a deferent gap length between both side. |
| | **II - III** | d | - |
| | **III - IV** | e | The side clearance is so large and expansion joint is completely separated. Or, the girder contact with parapet. |

**[Criteria for Judgment and Category type]**

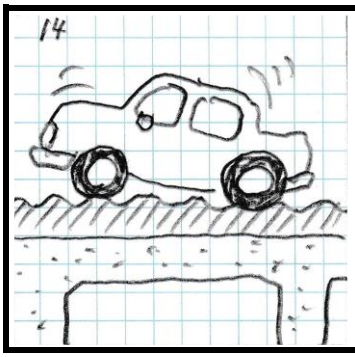
- **Judgment Category IV:** Other damage requiring emergency response. It shall be appropriate to take emergency measures. When there is a concern that the road users may get injured, causing bicycles and motorcycles to overturn due abnormal gap.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. It shall be appropriate to conduct a detailed investigation, where movement or tilting of the substructure is suspected to be assumed cause, but visual inspection does not show movement or tilting of the substructure.

| | |
|---|---|
| Sample photo: ⑬ **Abnormal clearance / gap (Spacing at Expansion Joint)**、Main Girder, Bearing, Degree ”e” >>”**IV**”, (Relationship with other Damage: ⑯ **Malfunction of bearing,** ㉕ **Settlement / Movement / Tilt)** The main girder and bearing get contact with parapet. |  |

| | |
|---|---|
| Sample photo: ⑬ **Abnormal clearance / gap (Spacing at Expansion Joint)**、Expansion Joint, Degree "e" >>"**IV**" , (Relationship with other Damage: ㉕ **Settlement / Movement / Tilt)** The finger of expansion joint is completely under contact. |  |

**⑭ Uneven road surface**

**[General description and defect characteristics]**

| | |
|---|---|
|   | Unevenness or level difference in longitudinal direction that occurs on the road surface, which increases the impact force caused by passing traffic. |

**[Judgement of damage degree]**

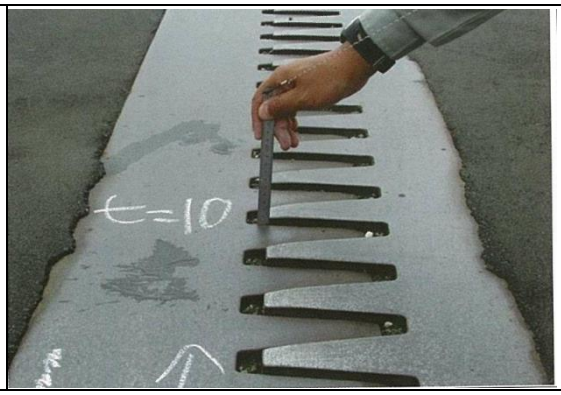
1) Classification of damage degree

| | Classification | Class | General Condition |
|---|---|---|---|
| Good > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | The amount of uneven is small (less than 20 mm) |
| | **II - III** | d | - |
| | **III - IV** | e | The amount of uneven is large (more than 20 mm) |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Other damage requiring emergency response. It shall be appropriate to take emergency measures. In situations when there is a concern that the road users may get injured, causing bicycles and motorcycles to overturn due uneven road surface

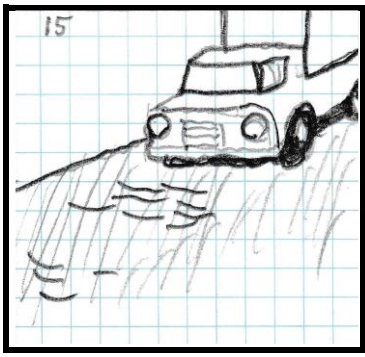
- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In situations where the irregularities are small, the damage is only partial, and the area of occurrence is small. It shall be appropriate to deal with the damage along with the maintenance work, such as a part overlay of the pavement.

| | |
|---|---|
| Sample photo: ⑭ **Uneven road surface** Expansion Joint, Degree ”c” >>”**III**” (Depth small, Area small), (Relationship with other Damage: ㉕ **Settlement / Movement / Tilt (Bearing)** There is uneven on expansion joint. (10mm) |   |

| | |
|---|---|
| Sample photo: ⑭ **Uneven road surface** Pavement, Degree ”e” >>”**III**”, (Relationship with other Damage: ⑮ **Defect of Pavement)** There are uneven (about 20cm) and crack on pavement of approach section. |   |

### ⑮ Defect of Pavement

**[General description and defect characteristics]**

| | |
|---|---|
|   | Defect of pavement is defined as deterioration or pot-hole of pavement caused by the defects on top of deck slab such as segregation, deterioration of concrete. |

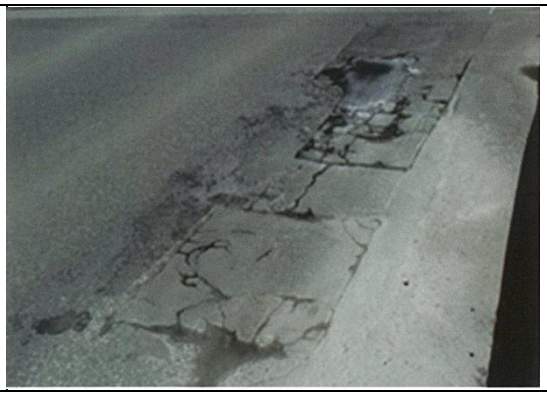
**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good >>> Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | The width of pavement crack is less than 5 mm. |
| | **II - III** | d | - |
| | **III - IV** | e | The width of pavement crack is more than 5 mm. |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Other damage requiring emergency response. It shall be appropriate to take the emergency measures. In situations where the top side of the concrete slab is on the verge of falling out due to sedimentation, and where there is concern that road sagging might cause traffic obstruction.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. It shall be appropriate to conduct a detailed investigation, when damage to the upper surface of the concrete slab is concern, but cannot be visually confirmed.
- **Judgment Category I, II, III:** Damage that requires repair, etc. In general, it is often appropriate to determine that requires repair or other measures are necessary regardless of the degree of damage. In addition, it is important to confirm the repair records of the pavement in maintenance works, etc., together with the damage status of the under surface of the slab, when evaluating the pavement.

| | |
|---|---|
| Sample photo: ⑮ **Defect of Pavement** Pavement, Degree ”c” >>”**III**”, (Relationship with other Damage: ⑧ **Water leakage / Free Lime,** ⑪ **Crack for deck slab (RC Slab))** There are mesh type crack with leak water. It is assumed that slab upper concrete is changed into dirt phase. |  |

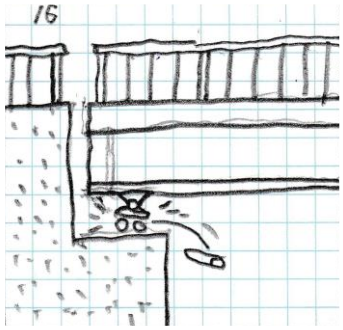
| | |
|---|---|
| Sample photo: ⑮ **Defect of Pavement**<br>Pavement, Degree "c" >>"**III**" , (Relationship with other Damage: ⑪ **Crack for deck slab)**<br>There are cracks less than 5mm on pavement. |  |

### ⑯ Malfunction of bearing

Bearing can be categorized as shown in the following.

| Category | Component / Element |
|---|---|
| 1 | Body of bearings, anchor bolts |

**[General description and defect characteristics]**

| | |
|---|---|
|  | A state referred as some or all functions of bearing shoes are spoiled, such as loss of support of loading and displacement control, which are to be originally functioned. This defect includes the fall out of bearing roller, and also includes the functional loss of movement restriction of girder |

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good <<> Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | The function of bearing is lost. |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Other damage requiring emergency response. In some cases, emergency measures shall be deemed appropriate, such as when there is concern that the bearings may settle due to rollers falling off, causing a step in the surface of the road that may cause bicycles or motorcycles to fall over, injury to road users, etc.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. A detailed investigation shall be appropriate in situations where there are concerns about buckling of steel girders or fatigue damage to welds, at the same time abnormality observed in the movable state of bearings or support condition.

| | |
|---|---|
| Sample photo: ⑯ **Malfunction of bearing** Bearing, Degree ”e” >>”**IV**”, The roller of roller bearing is dropped off. The bearing and movement function is lost. |  |

| | |
|---|---|
| Sample photo: ⑯ **Malfunction of bearing** Bearing, Degree ”e” >>”**IV**”, (Relationship with other Damage: ① **Corrosion,** ⑤ **Deterioration of Corrosion protection)** The significant corrosion is occurred on bearing. The bearing and movement function is lost. |  |

**⑰ Other factors**

The factors that disturb the bridge inspection work are :

- Illegal use : unlawful construction
- Scribble
-Pollution of bird dropping
-Bee nest

-Vegetation invasion
-Dropout or declination of joint filler material
-Damage due to fire
-Others

**[General description and defect characteristics]**

| | |
|---|---|
|  | The factors that disturb the bridge inspection work such as 1) Illegal use, unlawful construction, 2) Scribble, 3) Pollution of bird dropping, 4) Bee nest, 5) Vegitation invasion, 6) Dropout or declination of joint filler material, 7) Damage due to fire, 8) Others |

This type of defects which are not categorized under (No. 1 Corrosion ～No. 16 Malfunction of bearing) and (No. 18 Defect of anchorage ～ No. 24 Accumulation of sediments)

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | Damage |

**[Criteria for Judgment and Category type]**

- **Judgment is not necessary:** Damage requiring **further investigation or follow-up**. In some cases, there is concern that the main girder may be subject to heat degradation due to open fire under the girder, it shall be appropriate to conduct a detailed investigation.
- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In cases where the surface of a member is covered with bird droppings,

plants, dirt generated by water running over the surface, etc., and the member cannot be inspected, it shall be appropriate to deal along with the maintenance work.

| | |
|---|---|
| Sample photo: ⑰ **Others**<br>Pier, Abutment, Degree ”e” >>”**IV**”, Illegal Occupation: The small house was built around the pier. | |

| | |
|---|---|
| Sample photo: ⑰ **Others**<br>Main Girder, Degree ”e” >>”**III**”, Vegetation: The plants are growing along the main girder. It will interfere the inspection work. |  |

## A2.5 Common (Steel/Concrete)

The damage types categorized as Common damage for concrete and steel are :

⑩ Damage of repair or reinforcement member
⑱ Defect of Anchorage
⑲ Discoloration, Deterioration
⑳ Water Leakage, Puddle
㉑ Extraordinary Noise, Unusual Vibration
㉒ Unusual Deflection
㉓ Deformation, Break
㉔ Accumulation of Sediment
㉕ Settlement, Movement, Tilt
㉖ Scouring

### ⑩ Defect of reinforcement / repair material / strengthening

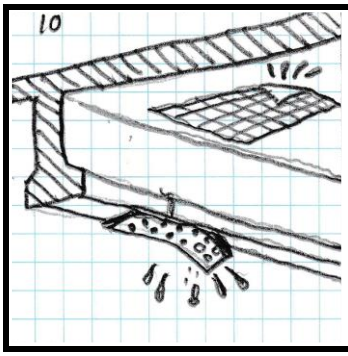
a) Repair and reinforcement materials for concrete members

| Type | repair |
|---|---|
| 1 | Steel plate |
| 2 | Fiber |
| 3 | Concrete |
| 4 | Paint |

b) Repair and reinforcement materials for steel members

| Type | repair |
|---|---|
| 5 | Steel plate (cover plate, etc.) |

**[General description and defect characteristics]**




This is defined as the delamination, deformation, peeling of strengthening materials such as steel plate, carbon fiber sheet, and glass cloth covered the surface of concrete members. And corrosion of steel plate for strengthening is also included.

This also refers to the state of corrosion or other damage to repair or reinforcement materials such as steel plates installed on steel members.

Where measures have been taken to prevent concrete mass from falling out or where prevention measures of PC-T girders adjacent joints part fall out. Palpation and hammering tests shall be performed when it is difficult to grasp only by visual inspection of the surface.

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good < < < < Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | There is not swelling of steel plate, but either of sealing part swelling, corrosion or leakage is observed. |
| | **II - III** | d | - |
| | **III - IV** | e | |

**[Criteria for Judgment and Category type]**

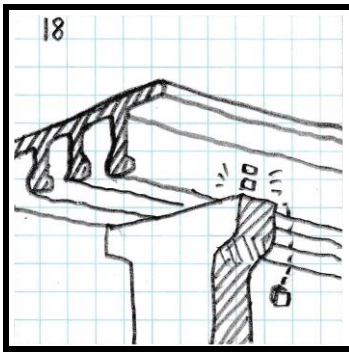
- **Judgment Category VI:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate. In situations where the adhesive steel plates of the main girders and slab structure are corroded, the effectiveness of the reinforcement is significantly reduced, and there is a high risk of seriously structural safety.
- **Judgment Category VI:** Other damage requiring emergency response. It shall be appropriate to take emergency measures, when the reinforcement is delaminated and there is concern about injury to the persons and vehicles passing below the roadway due to delamination and falling.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. A detailed investigation shall be appropriate, if there is remarkable water leakage, efflorescence, spalling of the reinforcement, and the extent of the spalling cannot be identified by visual inspection. Even if there is no other external damage, the condition of other members, vibration, and noise may lead to suspect the loss or decline of reinforcement effect. Further investigation may be judged to be necessary.

### ⑱ Defect of Anchorage

Defects of anchorage shall be categorized as shown below.

| Category | Types of anchoring |
|---|---|
| 1 | Prestressing tendon vertically-fastened type |
| 2 | Prestressing tendon transversely-fastened type |
| 3 | Other types of anchorage |
| 4 | Anchor/ Deviator of out-cable |

**[General description and defect characteristics]**




This is defined as a state of rust stain from the cracks or spalling can be found in the concrete of the anchorage surrounding area of Prestressing tendon or the condition that concrete is detached at anchorage area. In addition it also includes corrosion of Prestressing tendons or concrete cracks occurred in the anchorage area.

Regardless of the material of anchoring structure, all defects of this part related to anchorage

structure (such as water proofing cover, block for anchoring, metal device for anchor, buffer material, etc.) are covered as “Defect of anchorage”.
In case of cable anchorage protection cap is covered and cannot be seen, corrosion of cable inside is possible due to water intrusion, so attention is required.

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good > > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | Damage of PC tendon anchorage is observed, or damage of cable anchorage is observed. |
| | **II - III** | d | - |
| | **III - IV** | e | Severe damage of PC tendon anchorage is observed, or severe damage of cable anchorage is observed. |

**[Criteria for Judgment and Category type]**

- **Judgment Category VI:** Other damage requiring emergency response. Emergency response shall be appropriate. In some cases, such as when there is a concern that the concrete in the anchorage block may spalling and cause concrete lumps to fall, injury to the persons and vehicles passing below the roadway.

- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. It shall be appropriate to conduct a detailed investigation, when PC steel member has fractured and coming out and there is concern that other PC steel members may also corrode or fracture due to grout deficiency.

- **Judgment Category I, II, III:** Damage that requires repair, etc. In general, regardless of the degree of damage, it is often appropriate to judge that repairs are necessary.

| | |
|---|---|
| Sample photo: ⑱ **Defect of Anchorage**<br>Anchorage of PC , Degree ”e” >>”**IV**” , (Relationship with other Damage: ① **Corrosion,** ⑤ **Deterioration of Corrosion protection,** ⑦ **Spalling / Exposed Rebar)**<br>The spalling is occurred on PC transverse tensioning anchorage concrete, and the PC steel is pull out by corrosion and fracture. |  |

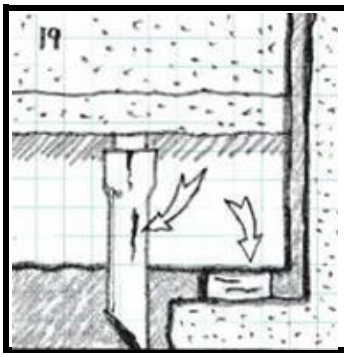
### ⑲ Discoloration, deterioration of Materials

Discoloration / deterioration shall be categorized based on the materials as shown.

| Category | Material |
|---|---|
| 1 | Concrete |
| 2 | Rubber |
| 3 | Plastic |
| 4 | Others |

***Note:*** *The object of this defect category is based on the material or quality of bridge components, and covering material for protective function is not included. The deterioration of covering material for protective function of steel member is recorded as ”Deterioration of Corrosion Protection”, and for concrete component it is recorded as “Defects of Reinforcement repair / strengthening”.*

**[General description and defect characteristics]**

| | |
|---|---|
|  | A state in which the original material color or quality is changed such as discoloration of concrete, hardened / cracked rubber or embrittlement / cracking of plastics due to deterioration. |

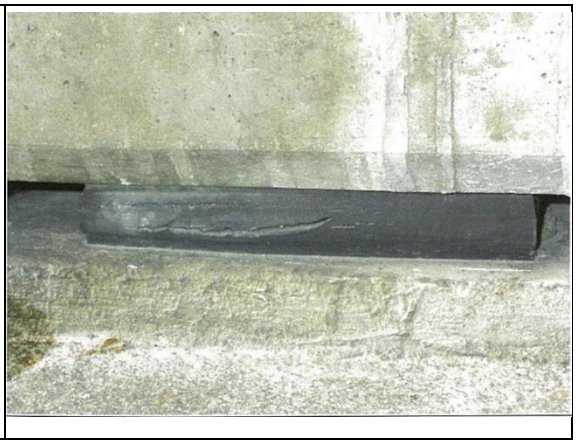
**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Class | General Condition |
|---|---|---|---|
| Good < > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | Unusual state |

**[Criteria for Judgment and Category type]**

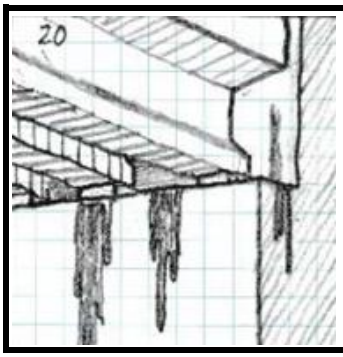
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. A detailed investigation shall be appropriate in situations where there is concern about water infiltration or retention, frost damage, or alkaline aggregate reaction, such as yellowish discoloration of the concrete.

| | |
|---|---|
| Sample photo: ⑲ **Discoloration, deterioration of Materials** Main Bearing, Degree ”e” >>”**IV**”, (Relationship with other Damage: ⑯ **Malfunction of bearing)** The bearing become deteriorated and the crack is occurred side surface. |  |

| | |
|---|---|
| Sample photo: ⑲ **Discoloration, deterioration of Materials** Drainage Pipe , Degree ”e”>> “**III**”, (Relationship with other Damage: ⑳ **Water Leakage / Puddle)** The drainage pipe has some cracks. |  |

## ⑳ Water Leakage / Puddle

**[General description and defect characteristics]**

| | |
|---|---|
|  | A state in which rainwater improperly leaks from the expansion joint or defective drainage system where, accumulation of rainwater inside girders, remain on top surface of beams, and rainwater infiltrates and accumulated in bearings, etc. |

When heavy rainfall occurs, the drainage capacity may be exceeded and puddle or water may be accumulate in each part. This is temporary phenomenon, and this is not covered by the defect when it is evident that the water does not interfere with the function of bridge structure.

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good > > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | Leakage water from expansion joint and drainage basin, ponding water near supporting point and inside box girder |

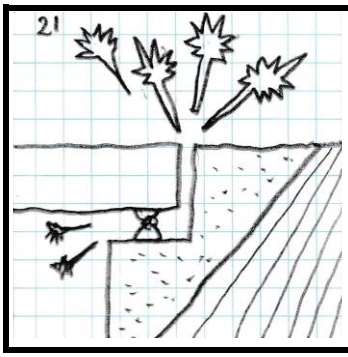
**[Criteria for Judgment and Category type]**

- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In situations where water leaks from a portion of the expansion joint and the scale of the leakage is small, it shall be appropriate to deal with the damage along with the maintenance work.

| | |
|---|---|
| Sample photo: ⑳ **Water Leakage / Puddle** Expansion Joint, Pier, Degree ”c” >>”**II**” , The leakage water flows from the top of pier by defect of expansion joint. |  |

### ㉑ Extraordinary noise / Unusual vibration

**[General description and defect characteristics]**

| | |
|---|---|
|   | Noise and vibration that does not occur under normal conditions is identified. |

**[Judgement of damage degree]**

1) Classification of damage degree

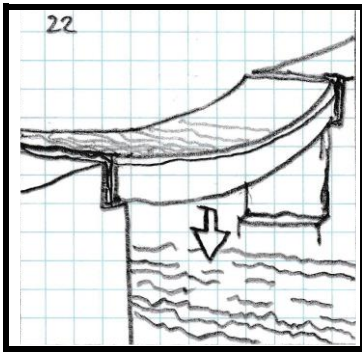
| | Classification | Class | General Condition |
|---|---|---|---|
| Good > > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | Abnormal noise and vibration from expansion joint, bearing, girder and inspection way |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Other damage requiring emergency response. Emergency response shall be appropriate, in situations when a vehicle is passing by and a loud abnormal noise is generated, and there is also concern that nearby residents be effected.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. In situations where abnormal noise or vibration of unknown cause is occurring and the source or cause cannot be identified, it shall be appropriate to conduct a detailed investigation.
- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work.** In situations where there is vibration noise due to loosening of the accessory support brackets and the magnitude of the noise is small, it shall be appropriate to deal with the damage along with the maintenance work.

## ㉒ Abnormal Deflection

**[General description and defect characteristics]**

| | |
|---|---|
|   | Unusual deflection that does not occur under normal conditions is identified. |

**[Judgement of damage degree]**

1) Classification of damage degree

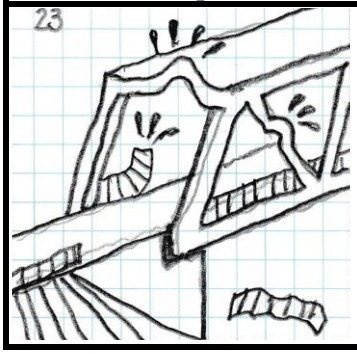
| | Classification | Class | General Condition |
|---|---|---|---|
| Good > > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | Abnormal deflection of main girder |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate, in situations where deflection of the main girder occurs and the loss of structural function seriously impairs structural safety.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. In situations where the mid-span of a concrete girder is sagging and the cause cannot be determined, it shall be appropriate to conduct a detailed investigation.

### ㉓ Deformation / Break

**[General description and defect characteristics]**




It is defined as state in which localized permanent deformation or chip of member or break of members are observed, regardless of the causes such as collision force of vehicles, hit during construction, seismic activity and others.

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Class | General Condition |
|---|---|---|---|
| Good > > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | Local deformation of bridge member |
| | **II - III** | d | - |
| | **III - IV** | e | Large local deformation of bridge member |

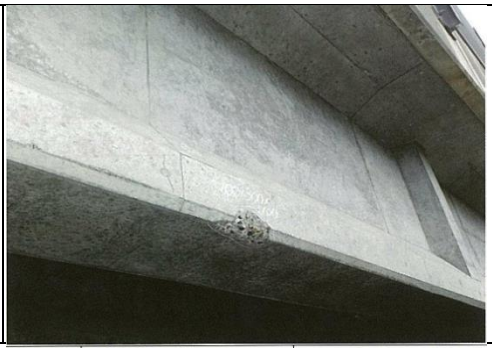
**[Criteria for Judgment and Category type]**

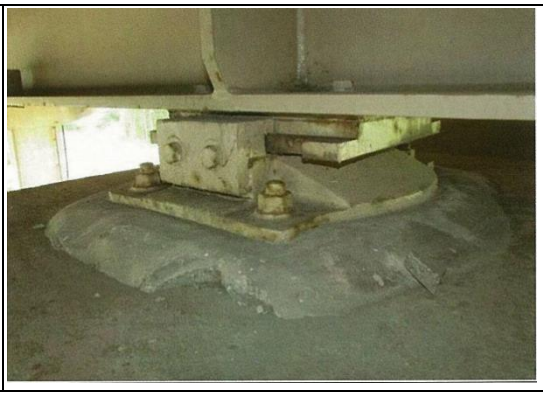
- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate, where the main girder has been severely deformed due to a vehicle collision or avalanche, and the structural safety is significantly impaired.

  Deformation on members with large stress variations may occur, such as panel point of arches and truss that significantly impair the structural safety. Therefore, emergency response is determined to be reasonable.
- **Judgment Category IV:** Other damage requiring emergency response. It shall be appropriate to take emergency measures, when a railing has been severely deformed and there is concern that pedestrians, passing vehicles, or other road users may be disturbed.
- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In some cases, such as small localized deformation of the balustrade, it shall be appropriate to deal with the damage along with the maintenance work.

**Table A. 2 : Reference for describing the structure damage**

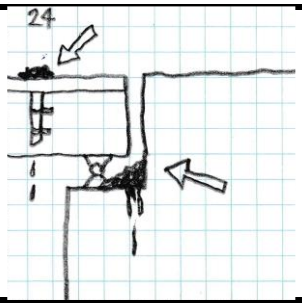
| Damaged part | Examples of typical damage causes | Examples of concern on the structure damage |
|---|---|---|
| The member in general | ・ Insufficient cover<br>・ Concentration of local stress<br>・ Crash or contact | ・ Secondary disaster<br>・ Reduction of the load-bearing capacity due to defective cross-section.<br>・ Corrosion of the steel member |

| | |
|---|---|
| Sample photo: ㉓ **Deformation / Break** Main Girder, Degree ”c” >> “**III**”, (Relationship with other Damage: ⑦ **Spalling / Exposed Rebar)** The corner of PC main girder has defect. |  |

| | |
|---|---|
| Sample photo: ㉓ **Deformation / Break** Mortal of Bearing Base , Degree ”c”>> “**II**”, (Relationship with other Damage: ⑦ **Spalling / Exposed Rebar)** The part of bearing base mortar has defect. |  |

### ㉔ Sediment deposition / Accumulation of Debris

**[General description and defect characteristics]**

| | |
|---|---|
|  | Drainage facilities such as catch basin or scupper, pipes are blocked with soil or sand. Bearings are covered with sediment deposition. Sediment is accumulates on pavement shoulder. |

**[Other points to be remembered]**

- It is recommended that the accumulation of sediments around the bearing is removed during inspection, in order to identify the actual situation of bearings.

**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good > > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | Soil sedimentation of drainage basin and around bearing |

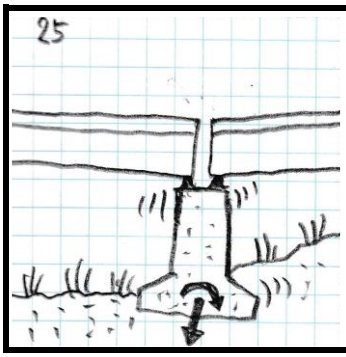
**[Criteria for Judgment and Category type]**

- **Judgment is not necessary:** Damage that needs to be addressed along with the **maintenance work**. In the situation where a sediment blockage occurs only in the drainage basin and the scale of the blockage is small, it shall be appropriate to deal with the damage along with the maintenance work.
- **Judgment Category I, II, III:** Damage that requires repair, etc. This may be the case when the entire length of the drainage pipe is blocked with sediment and maintenance work is not feasible due to the scale of the problem.

| | |
|---|---|
| Sample photo: ㉔ **Sediment deposition / Accumulation of Debris**, Drainage Basin , Degree ”e”, >>”**III**”, There are soil sedimentation in drainage basin. |  |

## ㉕ Settlement / Movement / Tilt

**[General description and defect characteristics]**

| | |
|---|---|
|   | A state in which substructure or bearings undergo settlement, tilt or movement. |

**[Judgement of damage degree]**

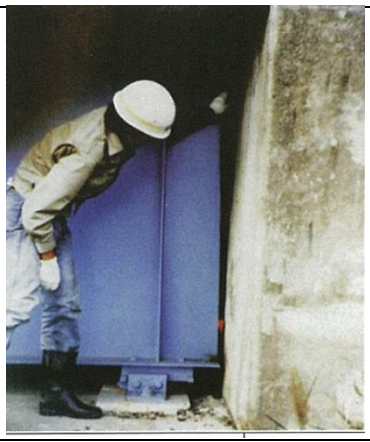
1) Classification of damage degree

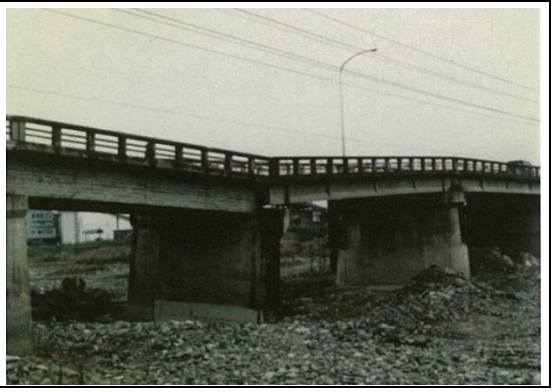
| | Classification | Degree | General Condition |
|---|---|---|---|
| Good >> Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | - |
| | **II - III** | d | - |
| | **III - IV** | e | Settlement, movement and tilt for bearing or substructure |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate in situations where the substructure has settled, moved, or tilted so much that structural safety is significantly affected.
- **Judgment Category IV:** Other damage requiring emergency response. It shall be appropriate to take emergency measures, when there is concern that bicycles or motorcycles may overturn or otherwise injury to road users due to a difference in the level of the expansion device caused by the settlement of the substructure.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. It shall be appropriate to perform a detailed investigation. In situations where the substructure is

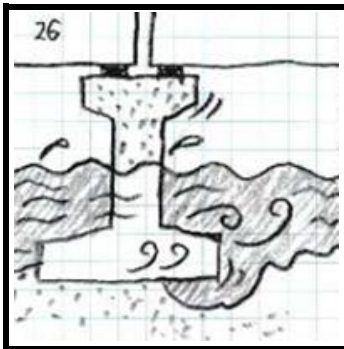
expected to settle, move, or tilt based on its relative position to other members, but this cannot be confirmed visually.

| | |
|---|---|
| Sample photo: ㉕ **Settlement / Movement / Tilt**<br>Foundation , Degree ”e” >>”**IV**”, (Relationship with other Damage: **⑬, ⑭, ⑯)** The tilting is occurred on abutment. The movement and tilting of foundation is guessed. |  |

| | |
|---|---|
| Sample photo: ㉕ **Settlement / Movement / Tilt**<br>Foundation , Degree ”e” >>”**IV**”, (Relationship with other Damage: ㉖ **Scoring)** The settlement and tilting is occurred by scouring of foundation. |  |

### ㉖ Scouring

**[General description and defect characteristics]**

| | |
|---|---|
|  | Scouring of foundations is the removal of material from the stream bed or bank due to the erosive action of moving water in the stream. |

Scouring of foundations can result in progressive settlement or movement or tilt of abutments and piers, if not rectified may ultimately cause total failure of the bridge.

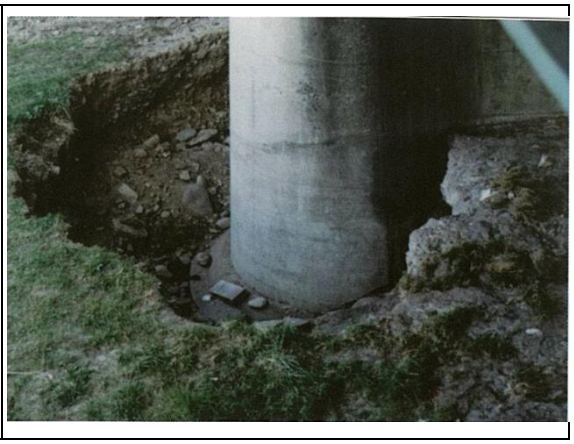
**[Judgement of damage degree]**

1) Classification of damage degree

| | Classification | Degree | General Condition |
|---|---|---|---|
| Good < > Bad | **I** | a | No Damage |
| | **I - II** | b | - |
| | **II – III** | c | Scoring |
| | **II - III** | d | - |
| | **III - IV** | e | Large scoring |

**[Criteria for Judgment and Category type]**

- **Judgment Category IV:** Damage that requires emergency response from the viewpoint of safety of bridge structure. Emergency response shall be appropriate. In situations where there is a high risk of scour up to the lower surface of the footing, resulting in settlement or tilting of the piers.
- **Judgment is difficult:** Damage requiring **further investigation or follow-up**. It shall be appropriate to conduct a detailed investigation, when scouring has been confirmed in past periodic inspections and the condition is such that the water level is always high and cannot be visually confirmed.

| | |
|---|---|
| Sample photo: ㉖ **Scouring** Foundation, Degree ”c” >>”**IV**”, (Relationship with other Damage: ㉕ **Settlement / Movement / Tilt)** The scouring is occurred by water flow. |  |

# Appendix 3 Inspection Form

## A3.1 Inventory form

**(1)** Inventory sheet (Source: Note d'orientation, P.E.C. Campagne 2020-2021)

## A3.2 Inspection form

**(1)** Inspection sheet (Steel Bridge) (Source: Note d'orientation, P.E.C. Campagne 2020-2021)

**(2)** Inspection sheet (PC and RC Bridge) (Source: Note d'orientation, P.E.C. Campagne 2020-2021)

## A3.3 Soundness Diagnosis form

**(1)** Evaluation sheet

**(2)** Sample of drawings

**(3)** Sample of Bridge Defect Map (Concrete bridge)

**(4)** Sample of Bridge Defect Map (Steel truss bridge)

**(5)** Sample of photos (Sample of periodic inspection methods)

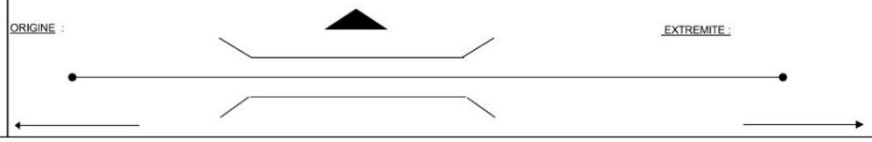
## A3.1 Inventory form

### (1) Inventory sheet (Source: Note d'orientation, P.E.C. Campagne 2020-2021)

| MINISTERE DE L'AMENAGEMENT DU TERRITOIRE ET DES TRAVAUX PUBLICS | INVENTAIRE DES PONTS |
|---|---|
| GESTION DES OUVRAGES D'ART | FICHE SIGNALETIQUE |

| DESIGNATION DE LA ROUTE / RN | | |
|---|---|---|
| PK ancien : | PK référence : | PK ouvrage : |
| 1 REGION : | | 3 - Géolocalisation |
| 2 GESTIONNAIRE DE L'AXE : | | Longitude : |
| 4 NATURE ET NOM DU FRANCHISSEMENT : | | Latitude : |
| 5 LOCALISATION DE L'OUVRAGE : | | |

ORIGINE : EXTREMITE :



| CONDITION DE L' INVENTAIRE | |
|---|---|
| établi le : | par : |
| Condition météo : | |
| Conditions particulières : | |
| (difficultés, incidents ) | |

| A | PARTIE ADMINISTRATIVE | |
|---|---|---|
| 6 | Conception de l' ouvrage | |
| 7 | Règlement de calcul utilisé | |
| 8 | Règlement de charge utilisé | |
| 9 | Financement de travaux | : |
| 10 | Référence du marché de travaux | : |
| 11 | Date de construction de l' ouvrage | : |
| 12 | Entreprise de construction | |
| 13 | Organisme ayant controlé les travaux | : |
| 14 | Date de réception provosoire | : |
| 15 | Limitations imposées à la circulation | |
| 16 | Type de surveillance de l' ouvrage | |
| | Investigations antérieures | : |
| | (*) | : |
| 17 | Dispositifs nécessaires pour la visite | |
| 18 | Archives disponibles (*) | : |

* : si nécessaire joindre la feuille annexe F, et préciser "voir annexe"

| B | CARACTERISTIQUES FONCTIONNELLES | | |
|---|---|---|---|
| | TYPE D'OUVRAGE (nature) | | |
| 19 | Longueur totale de tablier | | |
| 20 | Nombre de travées ou arches | | |
| 21 | Distribution des portées (ml) | | |
| 22 | Largeur utile | | |
| 23 | Largeur roulable | | |
| 24 | Largeur totale/utile des trottoirs (ml) | | |
| 25 | Pente longitudinale maximale (gr) | | |
| 26 | Garde corps ou barrières | | |
| 27 | Biais de l' ouvrage (gr) | | |
| 28 | Nombre de voies de circulation | | |
| 29 | Revêtement de l' ouvrage | | |
| 30 | Type de système de dilatation | | |
| 31 | Dalle de transition | | |
| 32 | Tirant d' air observé et en crue | | |
| 33 | Type de la route d' accès | | |
| 34 | Signalisation | | |
| 35 | Autres caractéristiques / Particularités | | |

| C | CARACTERISTIQUES TECHNIQUES GENERALES |
|---|---|
| 36 | Appareils d' appui |
| 37 | Type et nature des piles |
| 38 | Type et nature des culées |
| 39 | Fondations |

| | |
|---|---|
| 40 | Type de protection |
| 41 | Affouillabilité |
| 42 | Nature des matériaux au franchissement |
| | Type d ' ouvrage |
| 43 | Type de tablier |
| 44 | Coupe en travers |
| 45 | Mode de construction |
| 46 | Type de poutre |
| 47 | Matériaux du tablier |
| 48 | Type d' assemblage |
| 49 | Type de dalle |
| 50 | Aménagements postérieurs |
| 51 | Particularités de l'ouvrage |

| NOTE D'EVALUATION RELATIVE A L'ETAT DE L'OUVRAGE | |
|---|---|
| Equipements et éléments de protection | Commentaires éventuels: |
| Appuis et Appareils d' appuis : | |
| Tablier : | Global : |

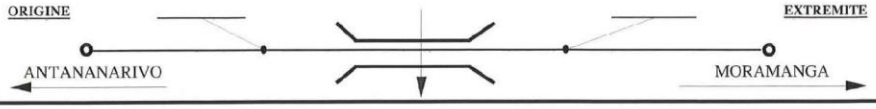
## EXAMPLE

| MINISTERE DES TRAVAUX PUBLICS | INVENTAIRE DES PONTS |
|---|---|
| GESTION DES OUVRAGES D'ART | FICHE SIGNALETIQUE |

**DESIGNATION DE LA ROUTE /** **R.N. : 2**

**PK ancien :** 30+300 **PK référence :** 29+000 **PK ouvrage :** 29+900

| | | |
|---|---|---|
| 1 | D.R.T.P. : ANTANANARIVO | 3 / Subdivision (éventuel.) : |
| 2 | S.T.T.P. : Antananarivo | Antananarivo Est |
| 4 | NATURE ET NOM DU FRANCHISSEMENT : rivière de Mahavoky | |
| 5 | LOCALISATION DE L'OUVRAGE : | |




**CONDITION DE L'INVENTAIRE**

établit le : 22-mars-97 par : **Europe Etudes Gecti / Espace Ingéniérie**

Conditions météo : beau temps

Conditions particulières ) _____

difficultés, incidents ) _____

**A PARTIE ADMINISTRATIVE**

| | | |
|---|---|---|
| 6 | Conception de l'ouvrage (organisme) | : _____ |
| 7 | Règlement de calcul utilisé | : _____ |
| 8 | Règlement de charge utilisé | : _____ |
| 9 | Financement des travaux | : _____ |
| 10 | Référence du marché de travaux | : _____ |
| 11 | Date de construction de l'ouvrage | : _____ |
| 12 | Entreprise de construction | : _____ |
| 13 | Organisme ayant contrôlé les travaux | : _____ |
| 14 | Date de réception provisoire | : _____ |
| 15 | Limitations imposées à la circulation | : _____ |
| 16 | Type de surveillance de l'ouvrage | : _____ |
| | Investigations antérieures | : _____ |
| 17 | Dispositifs nécessaires pour la visite | : _____ |
| 18 | Archives disponibles | : _____ |

| B | CARACTERISTIQUES FONCTIONNELLES | R.N. : 2 | PK : 29+900 |
|---|---|---|---|
| | TYPE D'OUVRAGE (nature) : pont à poutres et nervures en béton armé | | |
| 19 | Longueur totale de tablier : 8.50 | | |
| 20 | Nombre de travées ou arches : 1 | | |
| 21 | Distribution des portées (m) : 8.00 | | |
| 22 | Largeur utile (m) : 7.00 | | |
| 23 | Largeur roulable (m) : 6.10 | | |
| 24 | Largeur totale/utile des trottoirs (m) : 2 x 0.70 / 2 x 0.45 | | |
| 25 | Pente longitudinale maximale (%) : 0 | | |
| 26 | Garde-corps ou barrières : poteaux en béton armé et lisses tubulaires métalliques | | |
| 27 | Biais de l'ouvrage (gd) : 100 | | |
| 28 | Nombres de voies de circulation : 2 | | |
| 29 | Revêtement de l'ouvrage : enrobé | | |
| 30 | Type de système de dilatation : ? | | |
| 31 | Dalle de transition : ? | | |
| 32 | Tirant d'air observé et en crue (m) : 3.40 | | |
| 33 | Type de la route d'accès : bitumée | | |
| 34 | Signalisation : nom de la rivière | | |
| 35 | Autres caractéristiques / particularités : | | |

| C | CARACTERISTIQUES TECHNIQUES GENERALES | |
|---|---|---|
| 36 | Appareils d'appui | : inaperçu |
| 37 | Type et nature des piles | : néant |
| 38 | Type et nature des culées | : remblayée avec murs en retour / maçonnerie |
| 39 | Fondations | : |
| 40 | Type de protection | : |
| 41 | Affouillabilité | : sans risque |
| 42 | Nature des matériaux au franchissement | : matériaux meubles |
| | Type d'ouvrage | codification / **TI PM(N) BA** |
| 43 | - Type de tablier | : travée indépandante |
| 44 | - Coupe en travers | : poutres multiples sous chaussée et nervures |
| 45 | - Mode de construction | : coulé en place |
| 46 | - Type de poutre | : âme pleine |
| 47 | - Matériaux du tablier | : béton armé |
| 48 | - Type d'assemblage | : |
| 49 | - Type de dalle | : béton armé |
| 50 | - Aménagements postérieurs | : |
| 51 | Particularités de l'ouvrage | : |

| NOTE D'EVALUATION RELATIVE A L'ETAT DE L'OUVRAGE | | |
|---|---|---|
| **Equipements et éléments de protection :** | 2 | Commentaires éventuels : |
| **Appuis et Appareils d'appui :** | 2 | |
| **Tablier :** | 1 | **Global :** 2 |

## A3.2. Inspection form

**(1)** Inspection sheet (Steel Bridge) (Source: Note d'orientation, P.E.C. Campagne 2020-2021)

**ANNEXE 3.2**

FICHE DE DIAGNOSTIC (OUVRAGE METALLIQUE) ROUTE : ..... PK : ..... DATE : ..... Nom de franchissement : .....

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| 1 - **ACCES DE L'OUVRAGE** | | | | | ECI | ECP | R/r |
| 11 Visibilité | | | | | | | |
| 12 Dispositifs de sécurité | | | | | | | |
| 13 Chaussée et Abords du Pont | | | | | | | |
| 14 Accotements et trottoirs (sur accès) | | | | | | | |
| 15 Evacuation des eaux | | | | | | | |
| 16 Protection des remblais | | | | | | | |
| 17 Ouvrages annexes | | | | | | | |
| 2 - **SUPERSTRUCTURES / EQUIPEMENTS** | | | | | | | |
| 21 Signalisation | | | | | | | |
| 22 Appareils d'appui | | | | | | | |
| 23 Drainage et évacuation des eaux | | | | | | | |
| 24 Gargouilles | | | | | | | |
| 25 Chape d'étanchéité | | | | | | | |
| 26 Chaussée et revêtement | | | | | | | |
| 27 Trottoirs | | | | | | | |
| 28 Bordures de trottoirs | | | | | | | |
| 29 Joints de chaussée | | | | | | | |
| 210 Joints de trottoir | | | | | | | |
| 211 Corniches | | | | | | | |
| 212 Garde-corps | | | | | | | |
| 213 Dispositifs de sécurité | | | | | | | |
| 214 Butte - roues | | | | | | | |
| 215 Bornes de guidage | | | | | | | |
| 216 Ouvrages accessoires et divers (réservations, réseaux, éclairage) | | | | | | | |
| 217 Continuité de l'étanchéité au droit des joints de chaussée | | | | | | | |

ECI : Entretien Courant Immédiat, ECP : Entretien Courant à Programmer, R/r : Réhabilitation/réparation

*Annexe 3.2_PEC 2020-2021_ Page 1 sur 4*

## ANNEXE 3.2

FICHE DE DIAGNOSTIC (OUVRAGE METALLIQUE) ROUTE : ..... PK : ..... DATE : ..... Nom de franchissement : .....

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| 3 - **TABLIER METAL, MIXTE ou SUSPENDU** | | | | | ECI | ECP | R/r |
| ***3-1 TABLIER*** *:* | | | | | | | |
| 31 Fermes ou poutres principales | | | | | | | |
| 32 Poutres de rigidité | | | | | | | |
| 33 Contreventements | | | | | | | |
| 34 Pièce de pont | | | | | | | |
| 35 Longerons | | | | | | | |
| 36 Couverture du tablier | | | | | | | |
| 37 Dalle orthotrope | | | | | | | |
| 38 Assemblages : - rivets | | | | | | | |
| 39 - soudures | | | | | | | |
| 310 - boulons ordinaires/ HR | | | | | | | |
| 311 - goussets | | | | | | | |
| 312Peinture | | | | | | | |
| ***3-2 : Câbles et suspentes*** | | | | | | | |
| 313 Massif d'ancrage | | | | | | | |
| 314 Pylônes | | | | | | | |
| 315 Câbles | | | | | | | |
| 316 Ancrage des câbles | | | | | | | |
| 317 Appareils d'appui des câbles | | | | | | | |
| 318 Suspentes | | | | | | | |
| 319 Attaches des suspentes - haut | | | | | | | |
| 320 - bas | | | | | | | |
| 321 Protection anticorrosion | | | | | | | |
| 322 Haubans | | | | | | | |
| 323 Etat de réglage de la suspension | | | | | | | |

ECI : Entretien Courant immédiat, ECP : Entretien Courant à Programmer, R/r : Réhabilitation/réparation

## ANNEXE 3.2

FICHE DE DIAGNOSTIC (OUVRAGE METALLIQUE) ROUTE : ..... PK : ..... DATE : ..... Nom de franchissement : .....

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| **4 - APPUIS** : | | | | | ECI | ECP | R/r |
| 41 Culées (ou Piles - culées) Piédroits | | | | | | | |
| 42 Barbacanes | | | | | | | |
| 43 Murs (en aile ou en retour) | | | | | | | |
| 44 Perrés et talus | | | | | | | |
| 45 Piles (fût, voile, colonne, palées) | | | | | | | |
| 46 Sommier et chevêtre des appuis | | | | | | | |
| 47 Enrochements, gabion | | | | | | | |
| 48 Garde - grève des culées | | | | | | | |
| 49 Autres | | | | | | | |
| **5 -LIT DU COURS D'EAU** (éventuel) | | | | | | | |
| 51 Etat du lit | | | | | | | |
| 52 Berges | | | | | | | |
| 53 Ouvrages de protection des berges | | | | | | | |
| 6 - **FONDATIONS** | | | | | | | |
| 61 Fondations des culées | | | | | | | |
| 62 Fondations des piles | | | | | | | |
| 63 Affouillements éventuels | | | | | | | |
| **7 - DIVERS :** | | | | | | | |
| 71 Circulation lourde et inhabituelle | | | | | | | |
| 72 Travaux divers au voisinage de l'OA | | | | | | | |

ECI : Entretien Courant Immédiat, ECP : Entretien Courant à Programmer, R/r : Réhabilitation/réparation

## ANNEXE 3.2

FICHE DE DIAGNOSTIC (OUVRAGE METALLIQUE) ROUTE : ..... PK : ..... DATE : ..... Nom de franchissement : .....

**COMMENTAIRES SUR L'ETAT GENERAL DE L'OUVRAGE, SUR L'AGGRAVATION DES DESORDRES**

Cet ouvrage présente les principaux désordres suivants : (synthèse de l'inspection)

**TRAVAUX D'ENTRETIEN ET INVESTIGATIONS A ENTREPRENDRE**

Entretien courant à programmer

Réhabilitation / réparation

Investigations et études complémentaires : (étude, inspection, diagnostic,.....)

Mesures d'exploitation : (limitation de tonnage, circulation, signalisation,.....)

Fiche remplie par : Vu par le Chef hiérarchique :

**EXAMPLE**

ANNEXE 3.1 - FICHE DE DIAGNOSTIC (OUVRAGE METALLIQUE)

ROUTE : RNP 2 PK : 326+883 DATE: 9 Novembre 2024
Nom de franchissement : FANANDRANA

1/4

| PARTIE D'OUVRAGES | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| **1 - ACCES DE L'OUVRAGE** | | | | | ECI | ECP | R/r |
| 11 Visibilité | RAS | | | | | | |
| 12 Dispositifs de sécurité | Néant | | | | | | |
| 13 Abords du Pont et Chaussée | 15-c-1AD-5AG | | | | | X | |
| 14 Accotements et trottoirs (sur accès) | 24-e-D/G | | | | | X | |
| 15 Evacuation des eaux | RAS | | | | | X | |
| 16 Protection des remblais | RAS | | | | | | |
| 17 Ouvrages annexes | pont mixte rail/route | | | | | | |
| **2 - SUPERSTRUCTURES / EQUIPEMENTS** | | | | | | | |
| 21 Signalisation | RAS | | | | | | |
| 22 Appareils d'appui | 8-d-2P et 4P ; 1-d-2P | | | | | | |
| 23 Drainage et évacuation des eaux | 24-e | | | | | X | |
| 24 Gargouilles | 24-e | | | | | X | |
| 25 Chape d'étanchéité | RAS | | | | | | |
| 26 Chaussée et revêtement | 15-c-2P a 4P D/G 24-e- D/G | | | | | X | |
| 27 Trottoirs | RAS | | | | | | |
| 28 Bordures de trottoirs | RAS | | | | | | |
| 29 Joints de chaussée | 7-e-1A et 5A D/G 17-e-D/G | | | | | X | |
| 210 Joints de trottoir | RAS | | | | | | |
| 211 Corniches | Néant | | | | | | |
| 212 Garde corps | 1-c-D/G 4-e- 400 a 402 D | | | | | X | |
| 213 Dispositifs de sécurité | RAS | | | | | | |
| 214 Butte - roues | RAS | | | | | | |
| 215 Bornes de guidage | Néant | | | | | | |
| 216 Ouvrages accessoires et divers (réservations, réseaux, éclairage) | 17-e | | | | | X | |
| 217 Continuité de l'étanchéité au droit des joints de chaussée | RAS | | | | | | |

a -> b -> c -> d -> e : degré de dégradation
D : droite ; G : Gauche ; D/G : Droite et Gauche

ECI : Entretien courant immédiat : ECP : Entretien Courant à programmer : R/r : Réhabilitati

ANNEXE 3.1 - FICHE DE DIAGNOSTIC (OUVRAGE METALLIQUE) ROUTE : RNP 2 PK : 326+883 DATE: 9 Novembre 2024

Nom de franchissement : **FANANDRANA**



| PARTIES D'OUVRAGES | | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|---|
| **3 - TABLIER METAL, MIXTE ou SUSPENDU** | | | | | | ECI | ECP | R/r |
| **3 - 1 TABLIER :** | | | | | | | | |
| 31 Fermes ou poutres principales | | 1-c-200 a 316 D/G | | | | | | |
| 32 Poutres de rigidité | | RAS | | | | | | |
| 33 Contreventements | | 1-d-312 sup | | | | | | |
| 34 Pièce de pont | | 1-c-201 a 316 | | | | | | |
| 35 Longerons | | RAS | | | | | | |
| 36 Couverture du tablier | | 15-c-2P a 4P D/G 24-e- D/G | | | | | | |
| 37 Dalle | | RAS | | | | | X | |
| 38 Assemblages | Rivets | 1-b-201 a 316 | | | | | | |
| 39 | Soudures | RAS | | | | | | |
| 310 | Boulons ordinaires/ HR | 1-b-201 a 316 | | | | | | |
| 311 | Goussets | 4-e 201 a 316 | | | | | | |
| 312 Peinture | | 5-c | | | | | X | |
| **3 - 2 : Câbles et suspentes** | | | | | | | | |
| 313 Massif d'ancrage | | néant | | | | | | |
| 314 Pylônes | | néant | | | | | | |
| 315 Câbles | | néant | | | | | | |
| 316 Ancrage des câbles | | néant | | | | | | |
| 317 Appareils d'appui des câbles | | néant | | | | | | |
| 318 Suspentes | | néant | | | | | | |
| 319 Attaches des suspentes - haut | | néant | | | | | | |
| 320 - Bas | | néant | | | | | | |
| 321 Protection anticorrosion | | néant | | | | | | |
| 322 Haubans | | néant | | | | | | |
| 323 Etat de réglage de la suspension | | néant | | | | | | |

a -> b -> c -> d -> e : degré de dégradation

D : droite ; G : Gauche ; D/G : Droite et Gauche

ECI : Entretien courant Immédiat : ECP : Entretien Courant à programmer : R/r : Réhabilitation/réparation

ANNEXE 3.1 - FICHE DE DIAGNOSTIC (OUVRAGE METALLIQUE)

ROUTE : RNP 2 PK : 326+883 DATE: 9 Novembre 2024
Nom de franchissement : FANANDRANA

3/4

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| **4 - APPUIS :** | | | | | ECI | ECP | R/r |
| 41 Culées (ou Piles - culées) Piédroits | 8-d- 4P | | | | | | |
| 42 Barbacanes | Néant | | | | | | |
| 43 Murs (en aile ou en retour) | Néant | | | | | | |
| 44 Perrés et talus | Néant | | | | | | |
| 45 Piles (fût, voile, palées) | RAS | | | | | | |
| 46 Sommier et chevêtre des appuis | RAS | | | | | | |
| 47 Enrochements | Néant | | | | | | |
| 48 Garde - grève des culées | Néant | | | | | | |
| **5 - LIT DU COURS D'EAU (éventuel)** | | | | | | | |
| 51 Etat du lit | 24-e 3P | | | | | | |
| 52 Berges | 24-e | | | | | X | |
| 53 Ouvrages de protection des berges | Néant | | | | | | |
| **6 - FONDATIONS** | | | | | | | |
| 61 Fondations des culées | RAS | | | | | | |
| 62 Fondations des piles | RAS | | | | | | |
| 63 Affouillements éventuels | Néant | | | | | | |
| **7 - DIVERS** | | | | | | | |
| 71 Circulation lourde et inhabituelle | RAS | | | | | | |
| 72 Travaux divers au voisinage de l'OA | Néant | | | | | | |

a -> b -> c -> d -> e : degré de dégradation
D : droite ; G : Gauche ; D/G : Droite et Gauche
ECI : Entretien courant immédiat : ECP : Entretien Courant à programmer : R/r : Réhabilitation/réparation

ANNEXE 3.1 - FICHE DE DIAGNOSTIC (OUVRAGE METALLIQUE)

ROUTE : RNP 2 PK : 326+883 DATE: 9 Novembre 2024
Nom de franchissement : FANANNDRANA 4/4

**COMMENTAIRE SUR L'ETAT GENERAL DE L'OUVRAGE, SUR L'AGGRAVATION DES DESORDRES**
Cet ouvrage présente les principaux désordres suivants : (synthèses de l'inspection)

*Vue d'ensemble de l'ouvrage*



**TRAVAUX D'ENTRETIEN ET INVESTIGATION A ENTREPRENDRE**
Entretien courant à programmer

Réhabilitation / réparation

Investigation et études complémentaires : (étude, inspection, diagnostic,..... )

Mesures d'exploitation : (limitation de tonnage, circulation, signalisation,..... )

Fiche remplie par : Projet F3LTM - GT2

Vu par le chef hierarchique :

RAZEFASON Ando

ECI : Entretien courant Immédiat : ECP : Entretien Courant à programmer : R/r : Réhabilitation/réparation

**(2)** Inspection sheet (PC and RC Bridge) (Source: Note d'orientation, P.E.C. Campagne 2020-2021)

**ANNEXE 3.3**

FICHE DE DIAGNOSTIC (OUVRAGE BA, BP) ROUTE : ..... PK : .....DATE : ..... Nom de franchissement : .....

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| 1 - **ACCES DE L'OUVRAGE** | | | | | ECI | ECP | R/r |
| 11 Visibilité | | | | | | | |
| 12 Dispositifs de sécurité | | | | | | | |
| 13 Chaussée et Abords du Pont | | | | | | | |
| 14 Accotements et trottoirs (sur accès) | | | | | | | |
| 15 Evacuation des eaux | | | | | | | |
| 16 Protections des remblais | | | | | | | |
| 17 Ouvrages annexes | | | | | | | |
| 2 - **SUPERSTRUCTURES / EQUIPEMENTS** | | | | | | | |
| 21 Signalisation | | | | | | | |
| 22 Appareils d'appui | | | | | | | |
| 23 Drainage et évacuation des eaux | | | | | | | |
| 24 Gargouilles | | | | | | | |
| 25 Chape d'étanchéité | | | | | | | |
| 26 Chaussée et revêtement | | | | | | | |
| 27 Trottoirs | | | | | | | |
| 28 Bordures de trottoirs | | | | | | | |
| 29 Joints de chaussée | | | | | | | |
| 210 Joints de trottoir | | | | | | | |
| 211 Corniches | | | | | | | |
| 212 Garde-corps | | | | | | | |
| 213 Dispositifs de sécurité | | | | | | | |
| 214 Butte - roues | | | | | | | |
| 215 Bornes de guidage | | | | | | | |
| 216 Ouvrages accessoires et divers (réservations, réseaux, éclairage) | | | | | | | |
| 217 Continuité de l'étanchéité au droit des joints de chaussée | | | | | | | |

ECI : Entretien Courant Immédiat ; ECP : Entretien Courant à Programmer ; R/r : Réhabilitation/réparation

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## ANNEXE 3.3

FICHE DE DIAGNOSTIC (OUVRAGE BA, BP) ROUTE : ..... PK : .....DATE : ..... Nom de franchissement : .....

| PARTIES D'OUVRAGES | | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|---|
| **3 - TABLIER BA, BP, ou MACONNERIE** | | | | | | ECI | ECP | R/r |
| 31 Poutres | | | | | | | | |
| 32 Entretoises d'about | | | | | | | | |
| 33 Entretoises intermédiaires | | | | | | | | |
| 34 Dalle ou hourdis | | | | | | | | |
| 34 Cachetage (about poutre et dalle) | | | | | | | | |
| 36 Voûtes | Intrados | | | | | | | |
| 37 | Piédroit | | | | | | | |
| 38 | Bandeaux | | | | | | | |
| 39 | Tympans | | | | | | | |
| 310 Murs garde-grève (pont console) | | | | | | | | |
| 311 Voussoirs | Faces ext | | | | | | | |
| 312 | Faces int. | | | | | | | |
| **4 - APPUIS** : | | | | | | | | |
| 41 Culées (ou Piles - culées) Piédroits | | | | | | | | |
| 42 Barbacanes | | | | | | | | |
| 43 Murs (en aile ou en retour) | | | | | | | | |
| 44 Perrés et talus | | | | | | | | |
| 45 Piles (fût, voile, colonne, palées) | | | | | | | | |
| 46 Sommier et chevêtre des appuis | | | | | | | | |
| 47 Enrochements, gabions, | | | | | | | | |
| 48 Garde - grève des culées | | | | | | | | |
| 49 Autres | | | | | | | | |

ECI : Entretien Courant Immédiat ; ECP : Entretien Courant à Programmer ; R/r : Réhabilitation/réparation

## ANNEXE 3.3

FICHE DE DIAGNOSTIC (OUVRAGE BA, BP) ROUTE : ..... PK : .....DATE : ..... Nom de franchissement : .....

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTIONS A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| | | | | | ECI | ECP | R/r |
| **5 -LIT DU COURS D'EAU** (éventuel) | | | | | | | |
| 51 Etat du lit | | | | | | | |
| 52 Berges | | | | | | | |
| 53 Ouvrages de protection des berges | | | | | | | |
| 6 - **FONDATIONS** | | | | | | | |
| 61 Fondations des culées | | | | | | | |
| 62 Fondations des piles | | | | | | | |
| 63 Affouillements éventuels | | | | | | | |
| **7 - DIVERS :** | | | | | | | |
| 71 Circulation lourde et inhabituelle | | | | | | | |
| 72 Travaux divers au voisinage de l'OA | | | | | | | |

ECI : Entretien Courant Immédiat ; ECP : Entretien Courant à Programmer ; R/r : Réhabilitation/réparation

## ANNEXE 3.3

FICHE DE DIAGNOSTIC (OUVRAGE BA, BP) ROUTE : ..... PK : .....DATE : ..... Nom de franchissement : .....

**COMMENTAIRES SUR L'ETAT GENERAL DE L'OUVRAGE, SUR L'AGGRAVATION DES DESORDRES**

Cet ouvrage présente les principaux désordres suivants : (synthèse de l'inspection)

**TRAVAUX D'ENTRETIEN ET INVESTIGATIONS A ENTREPRENDRE**

Entretien courant à programmer

Réhabilitation / réparation

Investigations et études complémentaires : (étude, inspection, diagnostic,.....)

Mesures d'exploitation : (limitation de tonnage, circulation, signalisation,.....)

Fiche remplie par : Vu par le Chef hiérarchique :

## EXEMPLE

FICHE DE DIAGNOSTIQUE (OUVRAGE BA, BP) ROUTE : RNS1 PK : 15+850 Date : 12 Septembre 2024 Nom de franchissement : ANDROMBA

DESCRIPTION : PONT A 2 TRAVEES DE 26 ML LONGUEUR TOTALE : 52,00 ML

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTION A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| | | | | | ECI | ECP | R/r |
| **1 - ACCES DE L'OUVRAGE** | | | | | | | |
| 11 Visibilité | RAS | | | | | | |
| 12 Dispositif de securité | RAS | | | | | | |
| 13 Chaussée et Abords du Pont | 15-e-100 ; 15-e-202 | | | | | X | |
| 14 Accotements et trottoirs (sur accès) | RAS | | | | | | |
| 15 Evacuation des eaux | RAS | | | | | | |
| 16 Protection des remblais | 17-e-100-D | | | | | X | |
| 17 Ouvrages annexes | RAS | | | | | | |
| **2 - SUPERSTRUCTURES/EQUIPEMENTS** | | | | | | | |
| 21 Signalisation | RAS | | | | | | |
| 22 Appareil d'appui | 19-e-100-D/G | | | | | X | |
| 23 Drainage et évacuation des eaux | 24-e-100 à 202 - D/G | | | | | X | |
| 24 Gargouilles | 24-e-100 à 202 - D/G | | | | | X | |
| 25 Chape d'étancheité | RAS | | | | | | |
| 26 Chaussée et revetement | 14-e-201,202-D | | | | | X | |
| 27 Trottoirs | RAS | | | | | | |
| 28 Bordure de trottoirs | RAS | | | | | | |
| 29 Joint de chaussée | 13-c-100,200,202<br>23-c-201-202-D | | | | | X | |
| 210 Joits de trottoirs | RAS | | | | | | |
| 211 Corniches | RAS | | | | | | |
| 212 Garde-corps | 5-c-100 à 202-D/G | | | | | X | |
| 213 Dispositifs de sécurité | RAS | | | | | | |
| 214 Butes-roues | RAS | | | | | | |
| 215 Borne de guidage | RAS | | | | | | |
| 216 Ouvrages accessoires et divers (réservations réseaux, eclairage) | RAS | | | | | | |
| 217 Continuité de l'étancheité au droit des joints de chaussées | 13-c-100 à 202-D/G | | | | | X | |

**ECI : Entretien courant immédiat; ECP : Entretien courant à programmer; R/r : Réhabilitation/réparation**

FICHE DE DIAGNOSTIQUE (OUVRAGE BA, BP) ROUTE : RNS1 PK : 15+850 Date : 12 Septembre 2024 Nom de franchissement : ANDROMBA

DESCRIPTION : PONT A 2 TRAVEES DE 26 ML LONGUEUR TOTALE : 52,00 ML

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTION A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| | | | | | ECI | ECP | R/r |
| **3 - TABLIER BA, BP OU MACONNERIE** | | | | | | | |
| 31 Poutre | 6-b-G1,G2,G3-100 à 101 - D | | | | | X | |
| 32 Entretoises d'about | RAS | | | | | | |
| 33 Entretoises intermediaires | RAS | | | | | | |
| 34 Dalle ou hourdis | 11-b-101 à 102 | | | | | X | |
| 35 Cachetage (about poutre et dalle) | RAS | | | | | | |
| 36 Voutes Intrados | RAS | | | | | | |
| 37 Piédroit | RAS | | | | | | |
| 38 Bandeaux | RAS | | | | | | |
| 39 Tympans | RAS | | | | | | |
| 310 Mur garde grève (pont console) | RAS | | | | | | |
| 311 Vvoussoirs Faces ext | RAS | | | | | | |
| 312 Faces int | RAS | | | | | | |
| **4 APPUIS** | | | | | | | |
| 41 Culées (ou piles-culées) Piedroits | 6-b-100-G ; 24-e-100-D/G | | | | | X | |
| 42 Barbacanes | RAS | | | | | | |
| 43 Murs (en aile ou en retour) | RAS | | | | | | |
| 44 Perrés et talus | RAS | | | | | | |
| 45 Piles (fut, voile, colonne, palées) | 7-c-102-G | | | | | X | |
| 46 Sommier et chevetre des appuis | 24-e-100-D/G , 102-D/G | | | | | X | |
| 47 Enrochements, gabions | 17-e-100-D | | | | | X | |
| 48 Garde - grève de culées | RAS | | | | | | |
| 49 Autres | NEANT | | | | | | |

**ECI : Entretien courant immédiat; ECP : Entretien courant à programmer; R/r : Réhabilitation/réparation**

FICHE DE DIAGNOSTIQUE (OUVRAGE BA, BP) ROUTE : RNS1 PK : 15+850 Date : 12 Septembre 2024 Nom de franchissement : ANDROMBA

DESCRIPTION : PONT A 2 TRAVEES DE 26 ML LONGUEUR TOTALE : 52,00 ML

| PARTIES D'OUVRAGES | DEGRADATIONS | INTERVENTION A FAIRE | UNITE | QUANTITE | PRIORISATION | | |
|---|---|---|---|---|---|---|---|
| | | | | | ECI | ECP | R/r |
| **5 - LIT DU COURS D'EAU** | | | | | | | |
| 51 Etat du lit | RAS | | | | | | |
| 52 Berges | RAS | | | | | | |
| 53 Ouvrage de protection des berges | RAS | | | | | | |
| **6 - FONDATIONS** | | | | | | | |
| 61 Fondations des culées | RAS | | | | | | |
| 62 Fondations des piles | 17-a-102 à 200-G | | | | | X | |
| 63 Affouillements éventuels | RAS | | | | | | |
| **7 - DIVERS** | | | | | | | |
| 71 Circulation lourde et inhabituelle | RAS | | | | | | |
| 72 Travaux divers au voisinage de L'OA | RAS | | | | | | |
| ECI : Entretien courant immédiat; ECP : Entretien courant à programmer; R/r : Réhabilitation/réparation | | | | | | | |

**FICHE DE DIAGNOSTIQUE (OUVRAGE BA, BP)** **ROUTE : RNS1** **PK : 15+850 Date : 12 Septembre 2024** **Nom de franchissement : ANDROMBA**

**DESCRIPTION : PONT A 2 TRAVEES DE 26 ML** **LONGUEUR TOTALE : 52,00 ML**

## COMMENTAIRES SUR L'ETAT GENERAL DE L'OUVRAGE, SUR L'AGGRAVATION DES DESORDRES

Cet ouvrage présente les principaux désordres suivants : (synthèse de l'inspection

## TRAVAUX D'ENTRETIEN ET INVESTIGATIONS A ENTREPRENDRE

Entretien courant à programmer

Réhabilitation/réparation

Investigations et études complémentaires :(etude, inspection, diagnostic ….)

Mesures d'exploitation : limitation de tonnage, circulation, signalisation ……)




**Fiche rempli par :**
Projet F3LTM - GT2

**Vu Le Chef hiérarchique**
RAZEFASON Ando

### A3.3 Soundness Diagnosis form

**(1)** Evaluation sheet

| NOM DU PONT | DESIGNATION DE LA ROUTE | LOCALISATION | GESTIONNAIRE | DATE D'INSPECTION | REMARQUE |
|---|---|---|---|---|---|
| Pont OOOO | RN O | PK OO +OO | | OO,OO,2024 | |

**Diagnostics des Eléments** (L'état le plus sévère pour chaque élément)

Fiche remplie par : xxxxx xxxxxx Vérifié par le chef hiérarchique : xxxxx xxxxxxx

| | Données d'Inspection | | | |
|---|---|---|---|---|
| Désignation de l'élément | | Classification (**I - IV**) | Type de dégradation (Cas II -IV) | Remarques (Photo #, Localisation) |
| Super-structure | Poutre principale | **I** | Fissure | Photo 1, Poutre principale 02 |
| | Poutre transversale | **N/A** | | Photo 1, Poutre 02 |
| | Tablier | **I** | Fissure | Photo 1, Platelage 01 |
| Infrastructure | | **N/A** | | |
| Appareil d'appuis | | **N/A** | | |
| Autres | | N/A | | |

Note : Le plus mauvais classement devrait être indiqué dans le nom de chaque élément.

**Diagnostic du pont** (Classification I - IV )

| Données d'Inspection | |
|---|---|
| (Classe) **I** | (Remarque) |

Vue d'ensemble du pont (Photo)

| Année de construction | Longueur du pont | Largeur du pont |
|---|---|---|
| 1984 | 107m | 11.8m |

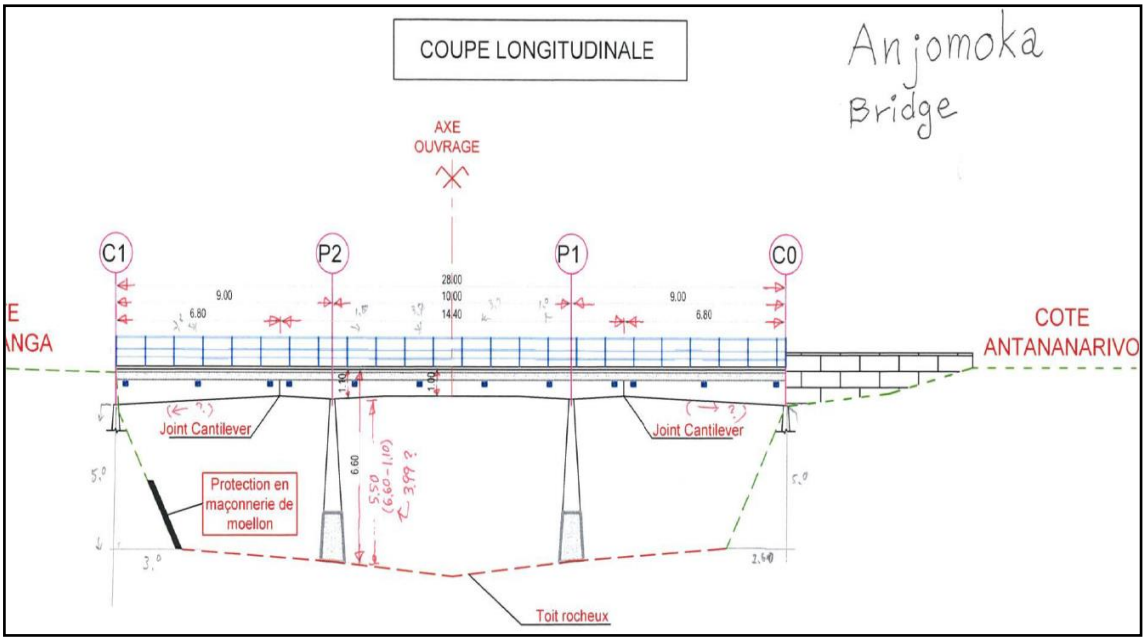
Côté xxxxx Coté xxxxxx

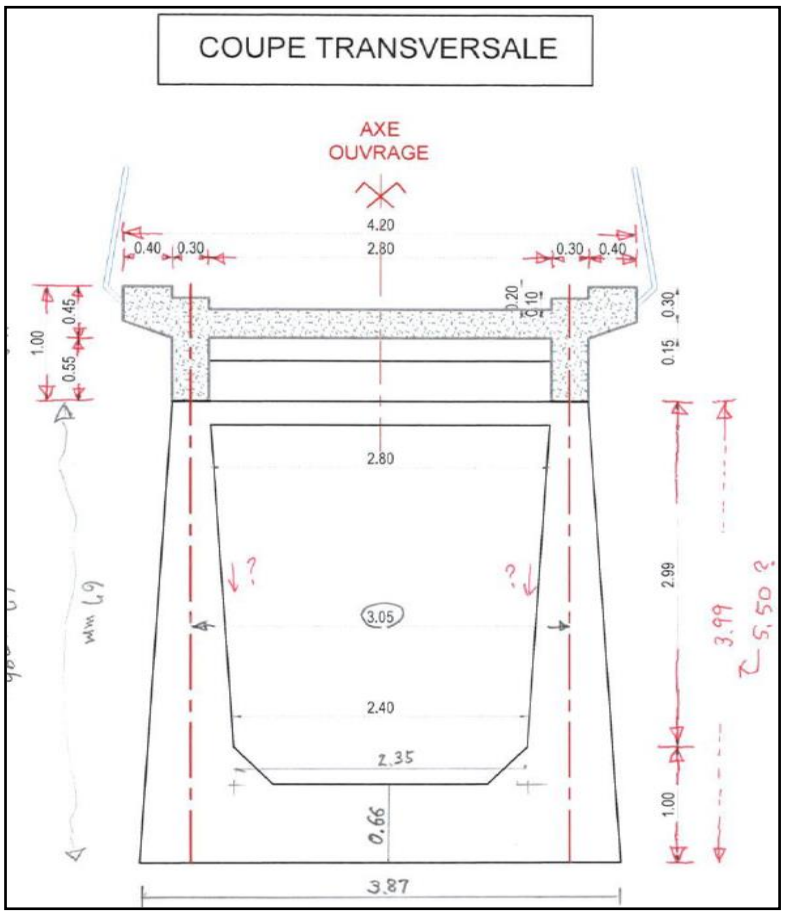


Photo (Etat des dégradations) 【Classification】 : Diagnostics des éléments

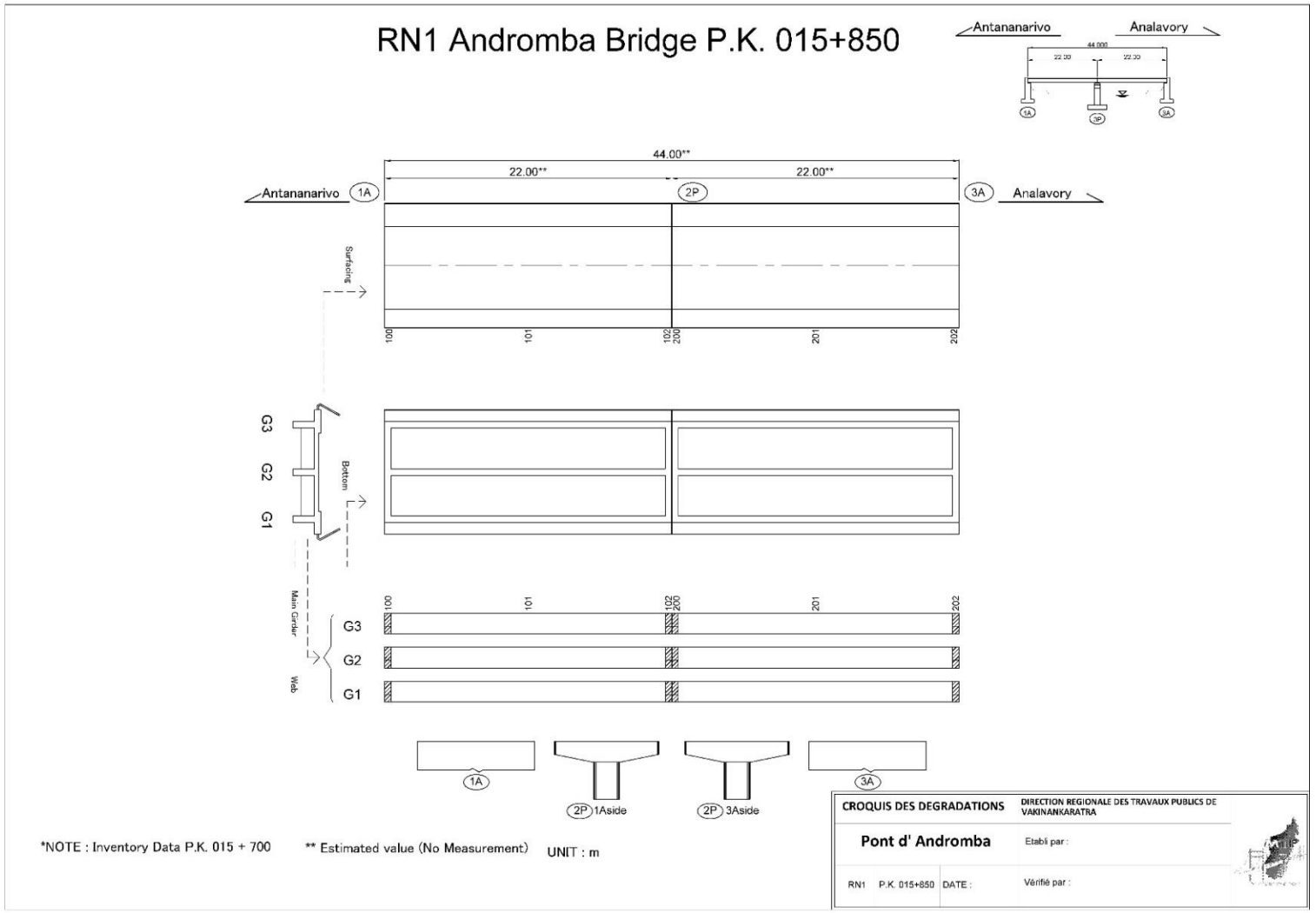
| Superstructure (Poutre principale, transversale) 【II 】 | Superstructure (Platelage) 【III 】 |
|---|---|
| Photo-1<br>  <br>Poutre principale02 | Photo -2<br>  <br>Poutre transversale02 |
| Appareil d'appui 【 】 | Infrastructure 【 】 |
| | |

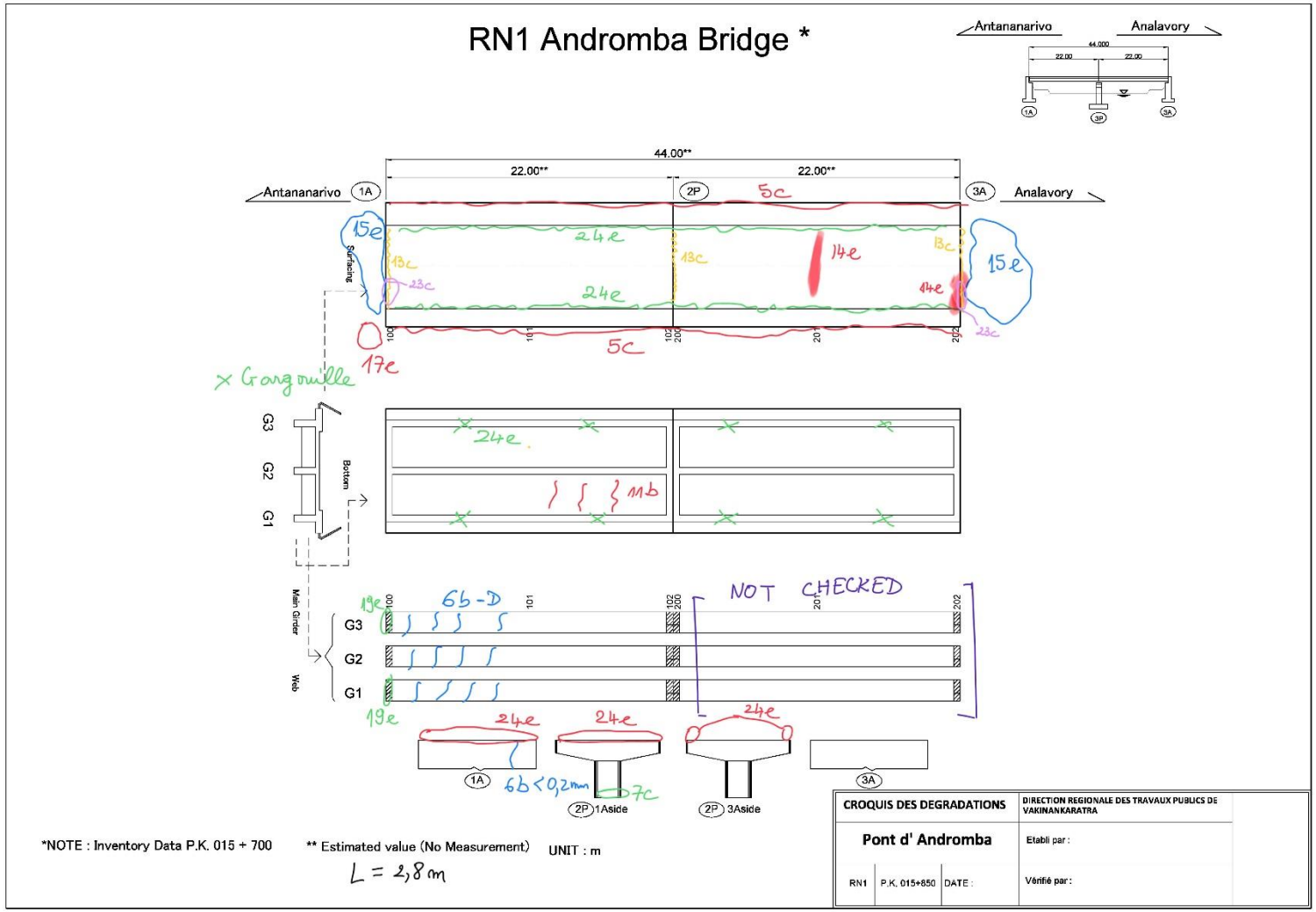
**(2)** Sample of drawings

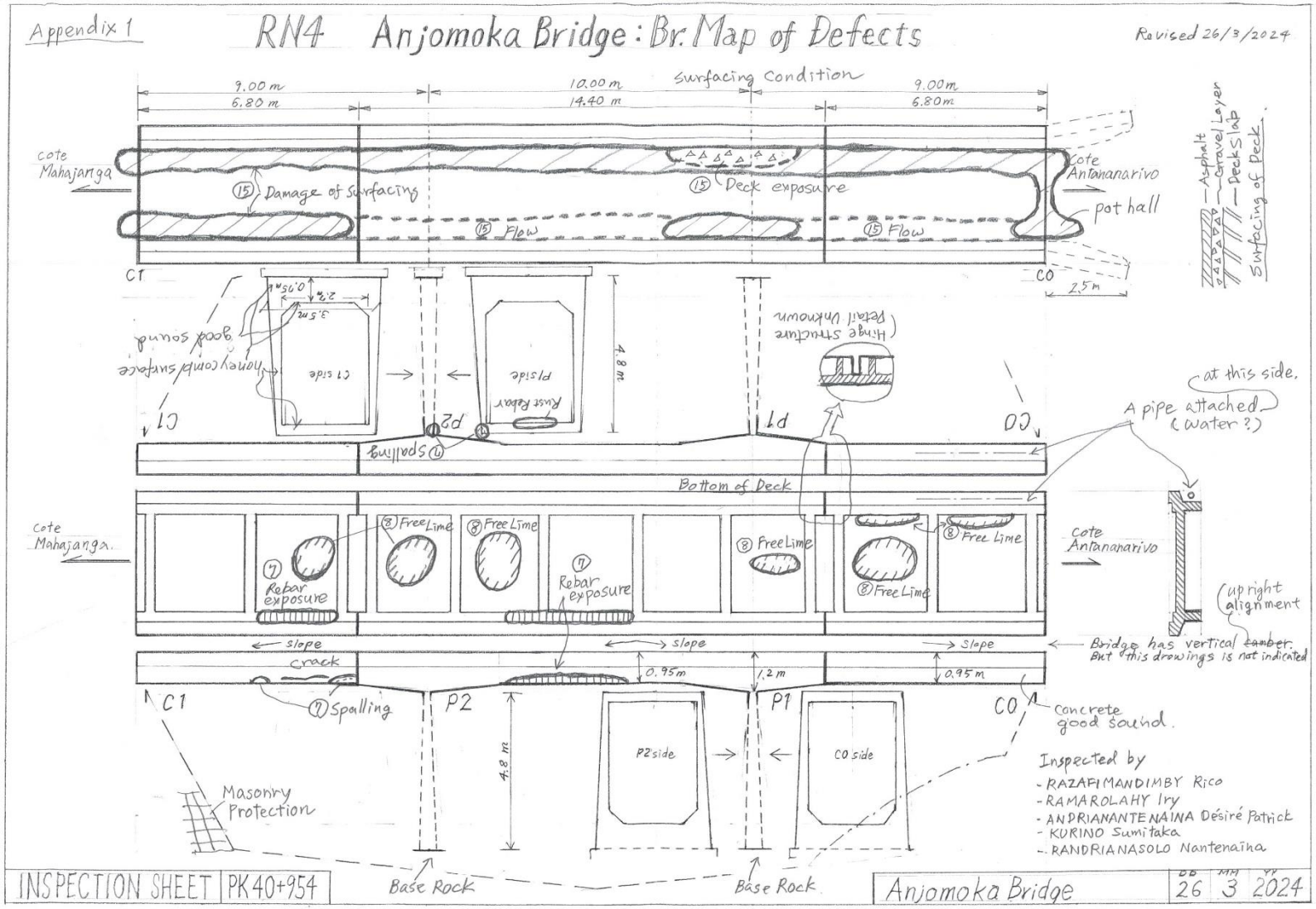


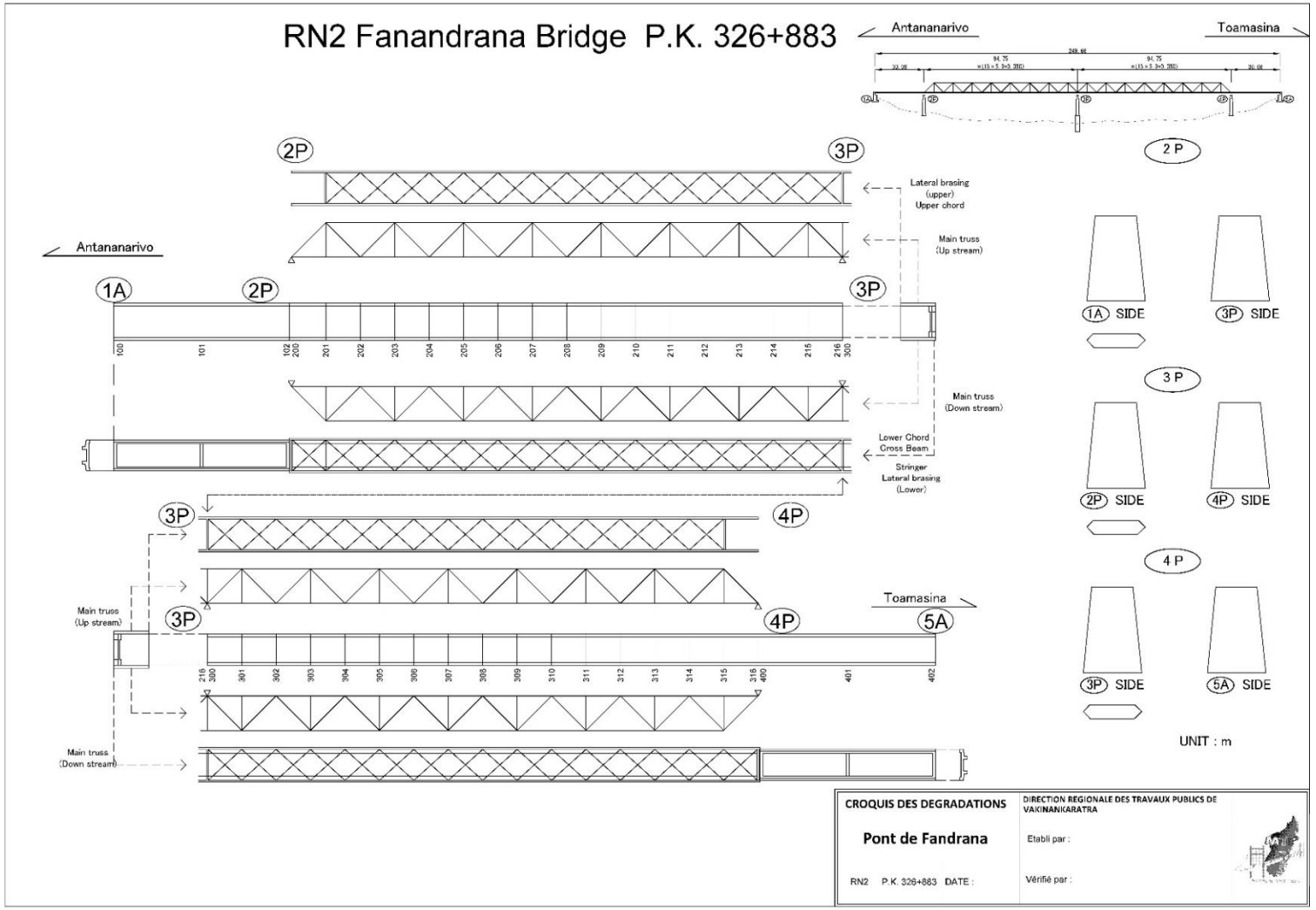
**(3)** Sample of Bridge Defect Map (Concrete bridge)

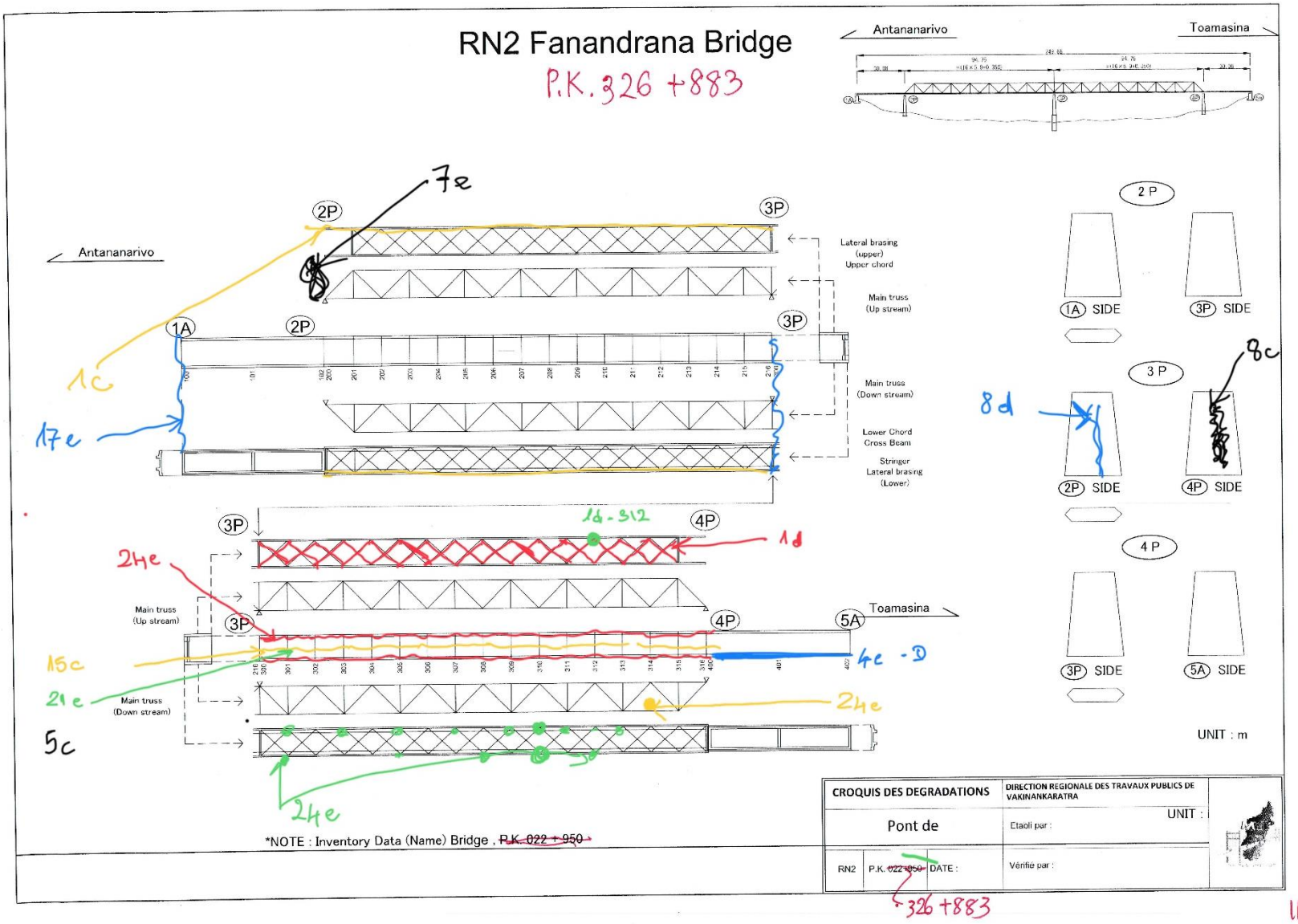


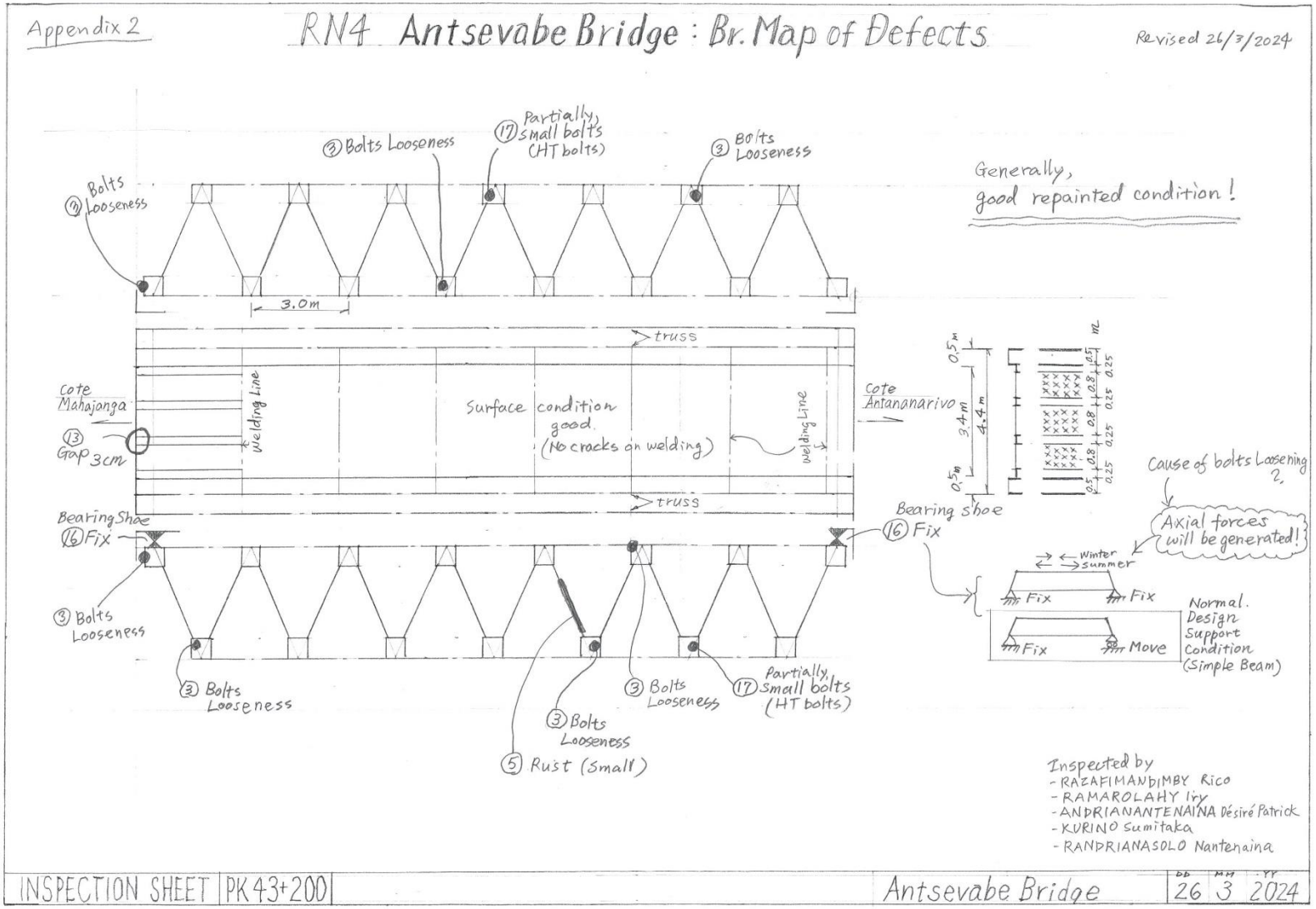

RN1 Andromba Bridge *
Antananarivo
Analavory
44.00**
22.00**
22.00**
1A
2P
3A
5c
15e
24e
13c
14e
23c
17e
Gargouille
Surfacing
Bottom
G3
G2
G1
Main Girder
Web
1mb
6b-D
NOT CHECKED
19e
6b<0,2mm
7c
1Aside
3Aside
*NOTE : Inventory Data P.K. 015 + 700
** Estimated value (No Measurement)
UNIT : m
L = 2,8 m
CROQUIS DES DEGRADATIONS
DIRECTION REGIONALE DES TRAVAUX PUBLICS DE VAKINANKARATRA
Pont d' Andromba
Etabli par :
RN1
P.K. 015+850
DATE :
Vérifié par :


Appendix 1
RN4 Anjomoka Bridge : Br. Map of Defects
Revised 26/3/2024
9.00 m
6.80 m
10.00 m
14.40 m
9.00m
6.80m
Surfacing condition
cote Mahajanga
cote Antananarivo
(15) Damage of surfacing
(15) Deck exposure
(15) Flow
(15) Flow
pot hall
Asphalt
Gravel Layer
Deck Slab
Surfacing of Deck
C1
C0
2.5m
honey comb/surface
good sound
C1 side
P1 side
Rust Rebar
4.8 m
Hinge Structure
(Detail Unknown)
P2
P1
(17) Spalling
Bottom of Deck
at this side.
A pipe attached
(water ?)
cote Mahajanga.
(8) Free Lime
(7) Rebar exposure
cote Antananarivo
(upright alignment
slope
crack
0.95m
1.2m
Bridge has vertical ~~timber~~.
But this drawings is not indicated
C1
(17) Spalling
P2
P1
C0
Concrete good sound.
4.8 m
P2 side
C0 side
Masonry Protection
Inspected by
- RAZAFIMANDIMBY Rico
- RAMAROLAHY Iry
- ANDRIANANTENAINA Désiré Patrick
- KURINO Sumitaka
- RANDRIANASOLO Nantenaïna
INSPECTION SHEET
PK 40+954
Base Rock
Base Rock
Anjomoka Bridge
DD 26
MM 3
YY 2024

**(4)** Sample of Bridge Defect Map (Steel truss bridge)




RN2 Fanandrana Bridge
P.K. 326 +883
Antananarivo
Toamasina
Lateral brasing (upper) Upper chord
Main truss (Up stream)
Main truss (Down stream)
Lower Chord Cross Beam
Stringer Lateral brasing (Lower)
Main truss (Up stream)
Main truss (Down stream)
2P
3P
1A
4P
5A
2 P
3 P
4 P
1A SIDE
3P SIDE
2P SIDE
4P SIDE
5A SIDE
UNIT : m
7e
1c
17e
1d - 312
1d
24e
15c
21e
5c
4c - D
8c
8d
*NOTE : Inventory Data (Name) Bridge , P.K. 022 + 950
CROQUIS DES DEGRADATIONS
DIRECTION REGIONALE DES TRAVAUX PUBLICS DE VAKINANKARATRA
Pont de
UNIT :
Etaoli par :
RN2
P.K. 022+950 DATE :
Vérifié par :
326 +883


Appendix 2
RN4 Antsevabe Bridge : Br. Map of Defects
Revised 26/3/2024
Generally, good repainted condition!
(3) Bolts Looseness
(17) Partially, small bolts (HT bolts)
(3) Bolts Looseness
(3) Bolts Looseness
3.0m
truss
Cote Mahajanga
(3) Gap 3cm
welding Line
Surface condition good. (No cracks on welding)
welding Line
Cote Antananarivo
truss
Bearing Shoe
(16) Fix
(3) Bolts Looseness
(3) Bolts Looseness
(3) Bolts Looseness
(5) Rust (Small)
(3) Bolts Looseness
(17) Partially, small bolts (HT bolts)
0.5m
3.4m
4.4m
0.5m
0.25 0.25 0.25 0.25
0.8 0.8 0.8
0.5
Bearing Shoe
(16) Fix
Cause of bolts Loosening
2.
Axial forces will be generated!
Winter
Summer
Fix
Fix
Fix
Move
Normal. Design Support condition (Simple Beam)
Inspected by
- RAZAFIMANDIMBY Rico
- RAMAROLAHY Ivy
- ANDRIANANTENAINA Désiré Patrick
- KURINO Sumitaka
- RANDRIANASOLO Nantenaina
INSPECTION SHEET
PK43+200
Antsevabe Bridge
DD 26 MM 3 YY 2024

**(5)** Example de photos
*Source : F3LTM*




Note the damage of the element with marker →




Note the damage →

Photo of damage with chalk note↓






Note of the rebars location found with RC radar



Measurement of the pothole

# Appendix 4 Check Points on Steel Bridges

## A4.1 Damage to Steel Bridges

### A4.1.1 Corrosion of Steel and Deterioration of Corrosion Protection

The corrosion phenomenon can be divided into several stages. In the initial stage, the coating film deteriorates and its performance that is the function of coating film to block corrosion factors will decrease. Next, water and oxygen are supplied to the steel surface by repetitive wetting and drying, a local battery is formed. Iron is dissolved at the anode and the rust are formed under the coating film. The rust under the coating gradually grows as it is supplied with water and oxygen, and finally breaks through the coating and appears on the surface.

#### A4.1.1.1 Corrosion

The rate of corrosion is affected by environmental conditions. For example, the progression rate of corrosion is faster in coastal areas where the influence of airborne salts is observed than in inland areas. Even if the same bridge, the corrosion progression rate is faster in the member which is in the condition of rain fall or other water accumulated than in the member of dry condition.
Corroded areas have a distinctive color and size, so unlike microscopic fatigue cracks, corroded areas are identify from the outside easily.
In inspections, taking the surrounding environment into consideration, attention should be paid to corrosion-prone part, the importance of the member, and the degree and progress of corrosion.
Based on the inspection results to date, in depends on surrounding condition, corrosion as well as deterioration of the anti-corrosion coating film can be seen after the construction more than 20 years. In addition, corrosion tends to progress at a faster rate when salt is supplied due to environmental influences.

#### A4.1.1.2 Example Corrosion of Each Part

As corrosion progresses, the thickness of the plate decreases and the load-bearing capacity of the member decreases, cracks and ruptures are caused. Therefore, the importance of the corroded member or part is a considerable issue. Even with sectional loss corrosion, the main girder near the fulcrum may affect safety and load carrying capacity as shown in Photo-5.1, while the gusset plate of the transverse structure may have little possibility of immediately affecting safety and load carrying capacity as shown in Photo-5.2.

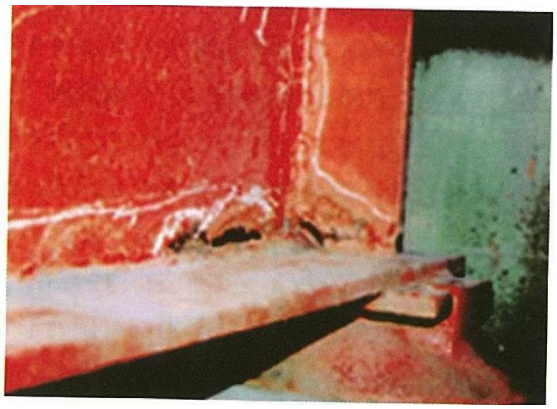


**Photo A. 2 : Corrosion of the main girders near supporting point**



**Photo A. 3 : Corrosion of lateral bracing gusset plates.**

### A4.1.1.3 Corrosion Prevention Methods

Typical corrosion protection methods for steel bridges include (1) coating, (2) galvanizing.
The above methods are corrosion protection by coating, which shields steel materials from water, oxygen, and other corrosion-causing elements. When the corrosion protection function deteriorates, deterioration of the anticorrosion coating is observed in the case of painting, discoloration, cracking, blistering, peeling, etc. are observed by deterioration of the anticorrosion coating in the case of galvanizing.
The characteristics of the corrosion protection method and points to be considered are described below.

**(1) Painting**

Painting is one of the anticorrosion methods to cover steel materials with a coating film to shield them from water and oxygen but basically, at a certain point in time, the painting needs to be replaced.
In salt-affected areas, it is necessary to shorten the repainting cycle, and if the surface salt is not removed sufficiently, corrosion and cross-sectional reduction will occur at an early stage that will affect the load-bearing capacity of the structure. In general, salt deposit of 50 mg/m$^2$ or more on the old coating film are likely to cause coating film defects early after painting. In such cases, it is necessary to remove the salt by high-pressure water rinsing or other device until the salt content is reduced to 50 mg/m$^2$ or less.

**(2) Galvanizing**

The principle of corrosion protection is that zinc, which has a higher ionization tendency than steel, is used as a coating material. If there are pinholes or scratches in the coating, a positive

battery is created in the steel and a negative battery in the zinc, so even if the zinc coating rusts, the steel material will not rust. Therefore, if the zinc is consumed, the steel surface will be eventually corroded, it is said to have a life span of 30 years or more. The other is that the dense zinc oxide film formed on the surface of the galvanizing inhibits the corrosion rate of the zinc inside, thus preserving its durability.

Both hot-dip galvanizing and electroplating are used for bridges. Hot-dip galvanizing is used for relatively large members such as girders and inspection way, while electroplating is used for bolts and small screws by depositing nickel and chromium. Hot dip galvanizing uses zinc with a melting point of around 440°C, and is performed by immersing the material in a galvanizing bath called a "bath.

Durability varies greatly depending on the environment of use, and is affected by sulfurous acid gas, nitrogen oxides, and salt. In areas near coastlines where the amount of airborne salt is high, the durability is superior to that of painted surfaces. A combination of galvanizing and coating is also used as one of the anticorrosion method.

During installation, residual stress in the welded part is released by immersion in a high-temperature galvanizing bath. The deformation of the member is caused, it may result in cracks at the ends of the stiffeners. During inspection, it is important to carefully observe the weld joints and check for the presence of rust.

In zinc galvanizing, a phenomenon called "whitening" or "chalking" occurs, in which the surface loses its bulky zinc oxide with white or white and some light brown spots is formed on the surface. It occurs when the zinc bright plated surface is wetted by rain or dew and does not dry easily, and is particularly noticeable when strongly acidic substances, organic acids, salts, or other substances that corrode zinc adhere to the surface. In addition, the oxide may peel off in the form of a film, so care should be taken.

### A4.1.2 Fatigue Cracking

Fatigue cracks are often observed at abrupt cross-sectional changes and welded joints of members (such as notches at girder ends and hinges of cantilever beam and truss girder), where stress concentrations are likely to occur under repeated loading of live loads.

The fatigue strength of member is not same as static strength, fatigue strength of a member is almost the same in similar structural part of stress concentration regardless of the strength of the steel material and fatigue strength is not improved by using high strength steel.



**Photo A. 4 : Crack at Gerber hinge**

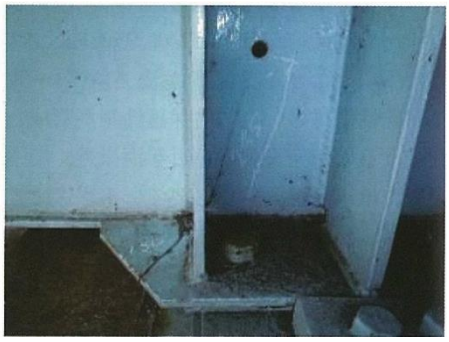


**Photo A. 5 : Crack near the fulcrum at the girder end**

### A4.1.2.1 Main factors of fatigue damage

The following factors are said to make it difficult to estimate the occurrence of fatigue damage at the design stage. The total management from design to fabrication, erection and maintenance shall be needed to prevent from fatigue damage.

① Relationship between acting stress and fatigue strength

As shown in Figure A. 1, S/N diagram, the main factor that causes fatigue damage is the range of cyclic stress (the maximum value of the acting stress is almost no relation to fatigue damage), and the life is determined by the number of cycles.

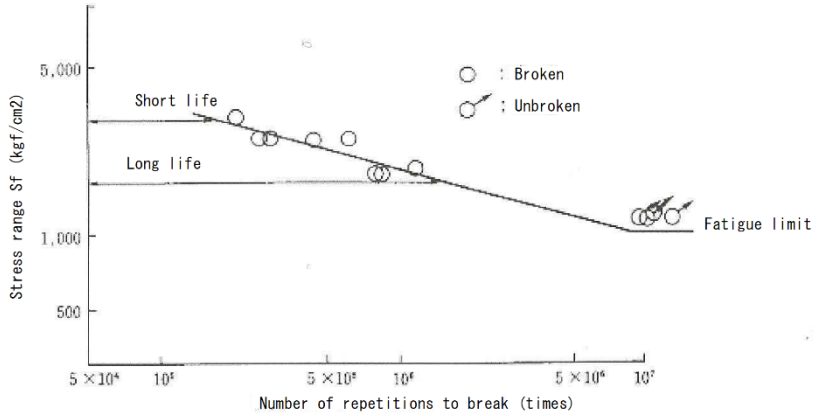



**Figure A. 1 : Example of S/N diagram (Fatigue test results of welded joint specimen)**

② Relationship between material strength and fatigue strength

Fatigue strength is almost independent of the static strength of the material. Therefore, bridges using high tensile strength steel which is high static strength are not favourable for fatigue because the dead load is reduced, resulting in an increase in the ratio of the live load stress that acts

repeatedly and increases deflection vibration and a larger stress range.

③ Factors during design

Secondary stresses caused by differences between the simplified analytical model and the actual structure at the time of design, such as eccentricity and boundary conditions, and stress concentration due to improperly detailed structures are the cause of fatigue damage.

④ Factors during construction

Weld defects (root gap fabrication errors, cracks, poor shape, insufficient throat thickness, etc.) caused by the use of inappropriate steel or welding materials, welding position, welding condition, or inadequate welding management can also cause fatigue cracks due to the effects of stress concentration.

Other than welding, poor workmanship such as gas cut edges that are easily notched or bolt holes that have insufficient burr removal can also cause fatigue cracks.

⑤ Factors during maintenance

Insufficient maintenance of the bearing, such as fatigue damage at the weld between the sole plate and the bottom flange, will inhibit the bearing function, restrain the rotation and horizontal movement of the girder end, and cause high stress at the sole plate weld.

#### A4.1.2.2 Part and Characteristics of Fatigue Damage

The common characteristics of fatigue-damaged steel road bridges are listed below, and special attention should be paid at the time of weld inspection of the applicable bridges.

① The bridge has been in service for a number of years due to heavy vehicle traffic. (Generally, there are more than 1,000 large vehicles per day per lane, and more than 20 to 30 years passed.)

② Welded joints with low fatigue strength (type of joint, G, H, H', etc.) are used.

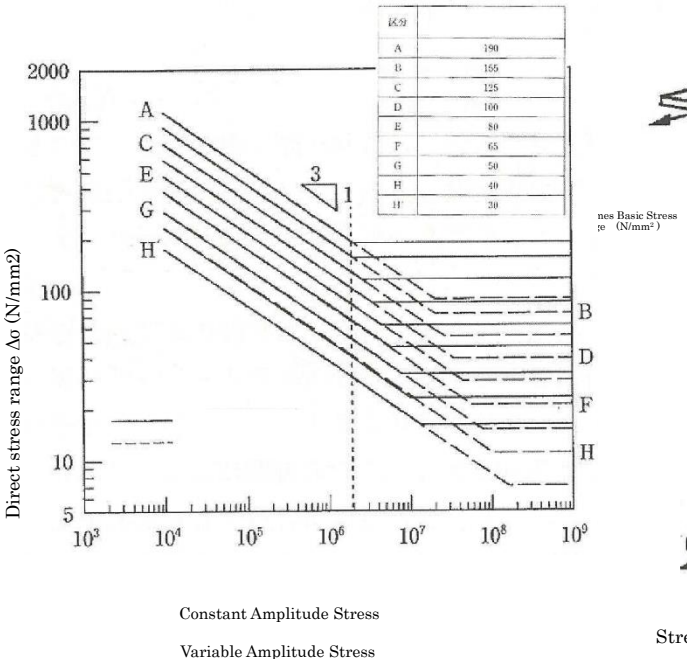



**Figure A. 2 : Fatigue design curve for weld joint subjected to direct stress**

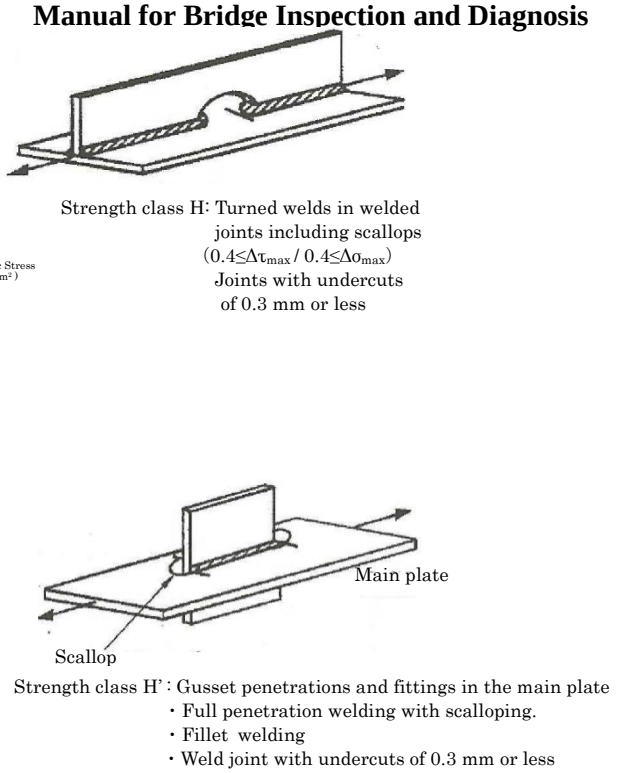



**Figure A. 3 : Example of strength grade of joints**

Figure A. 4 shows the main locations where fatigue cracks frequently occur in plate girder bridges. the joint between main girder and cross beam, gusset weld between main girder and gusset plate of lateral sway bracing and sole plate welding are the corresponding locations.

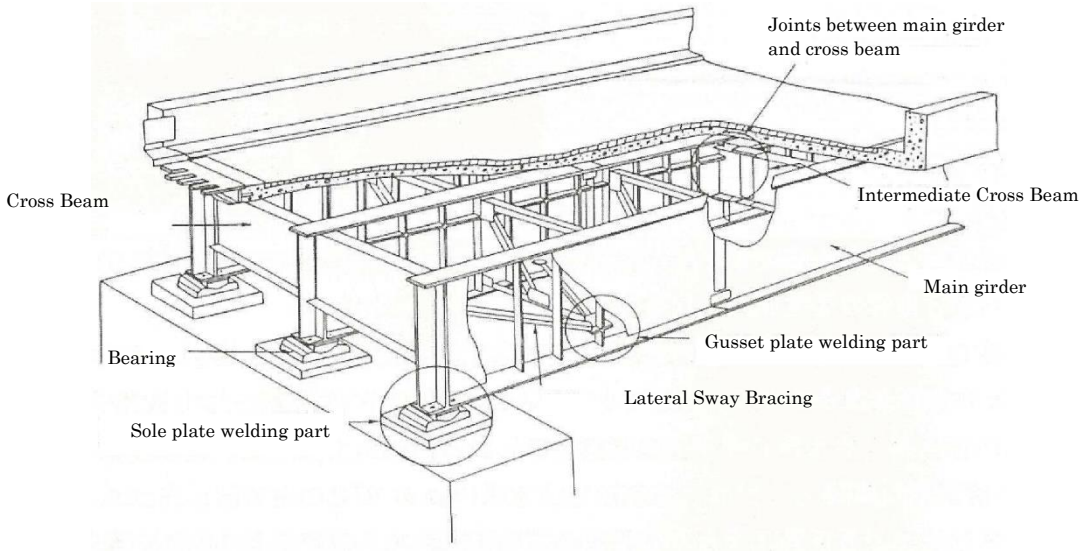



**Figure A. 4 : Crack map Plate girder bridges**

Figure A. 5 shows the main locations of fatigue cracks in steel plate deck. In steel plate deck girder with heavy vehicle traffic, fatigue crack may occur after about 10 years. The deck plate and U-rib

welding part, transverse rib and U-rib intersection, and U-rib joint welding part are the location of crack.

The crack was progressed from the weld root to the deck plate have been reported for combinations of U-rib 8mm thicknesses and deck plate 12, 13, and 15 mm thickness. The crack at the welding bead between deck plate and U-rib have been reported for combinations of U-rib thicknesses of 6 and 8 mm and deck plate thickness of 12mm. The cause of these cracks is said that the high torsional stiffness of the U-ribs is concentrated locally as deformation of the deck plate due to the axle load on the deck top surface.

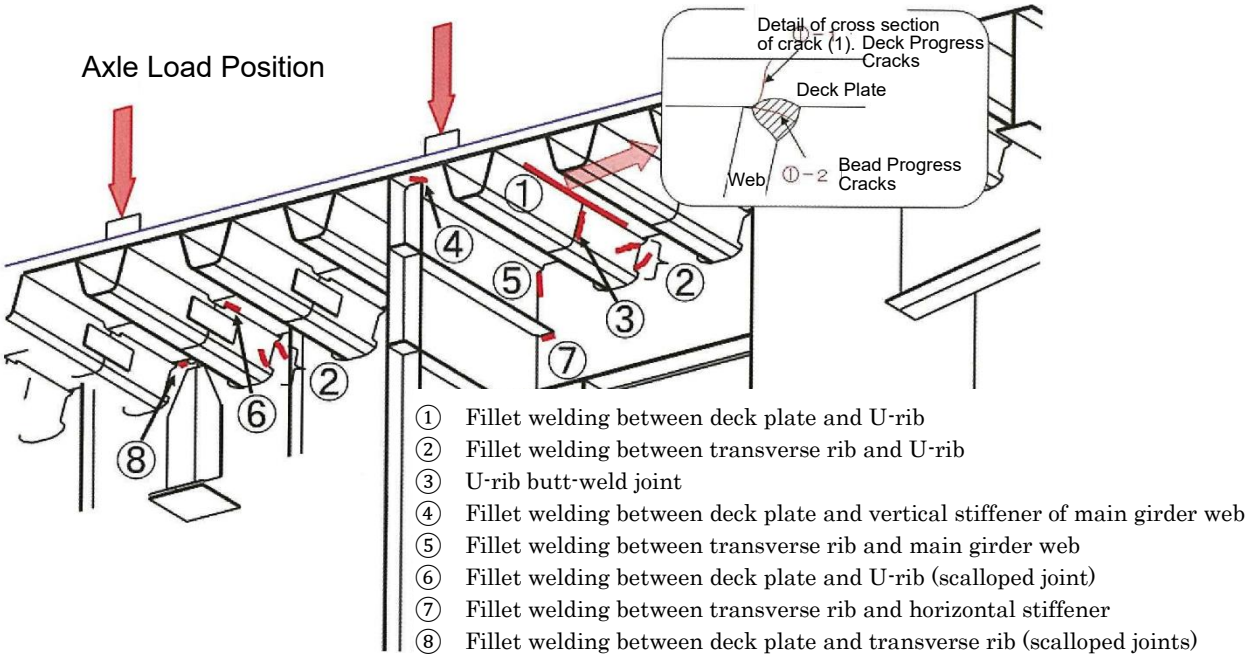



**Figure A. 5 : Crack Map Sheet Girder Bridge**

### A4.1.2.3 Consideration on inspection

According to the Japanese paper, fatigue damage in steel piers may lead to brittle fracture if fatigue damage develops. The crack length at the time of brittle fracture is 23mm, assuming that the residual stress is the yield stress when the residual stress is considered and evaluated on the safe side. This is an example of a study on steel piers, but inspectors must be aware of this in their inspections.

Most fatigue crack are happened at welding joint especially at fillet welds. Fatigue crack in welding part are generally classified into two types according to the location of occurrence, as shown in Figure A. 5 : one is a crack occurred from the weld end as shown in Photo A. 6, and the other is a crack occurred from the root. The location of the crack is closely related to the external force acting on it.

Fatigue crack of root end is occurred from the surface, however, the root crack grow from inside welding defect, the crack that appears on the surface is smaller than the crack length inside the weld. In both cases, it takes a lot of experience to detect crack from the paint surface.

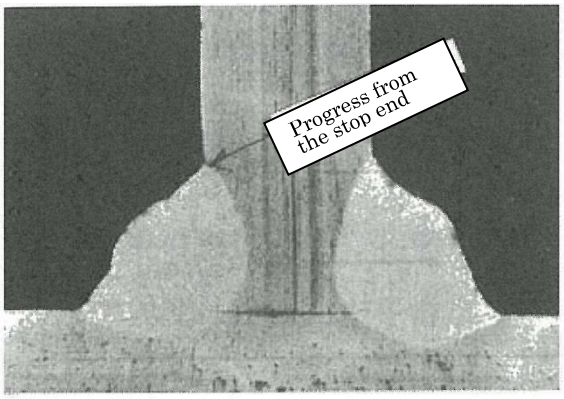



**Photo A. 6 : Fatigue crack from weld end**

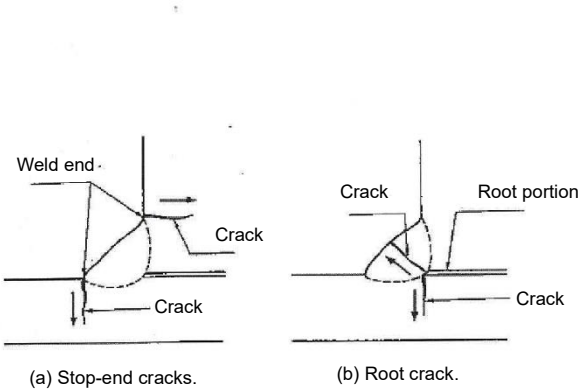



**Photo A. 7 : Fatigue Crack of fillet welding part**

The above is an explanation of fatigue damage of welding part, but fatigue crack is not only occurred from welding part, but also in bolt holes, rivet holes, and gas cut arc edges. These cracks are caused by stress concentration due to burr on the edge of hole that have not been grinded clean or notch on the gas cut edge. If corrosion progresses and pitting corrosion occurs, stress overload or stress concentration may cause crack from there.

### A4.1.3 Damage of bolt connection (looseness and fall off).

Joint other than welded joint of steel member have been riveted in the past, and since 1960, high tension bolts have been used.

#### A4.1.3.1Rivet

Rivet was used for member assembly in factories and for field joint and member connection, but are no longer used due to noise problem. If coating crack is appeared around the rivet head and rust juice is seen, there is a high possibility that the rivet have loosened, and it is advisable to inspect them by tapping them with an inspection hammer. Even if the rivet head is corroded and missing, there is no need to replace the rivet with a high tension bolt if there is no loosening. When replacing the rivet with high strength bolt, it is noted that the stress transmission mechanism is different between rivet and high strength bolt, and that the rivets do not have the required slip coefficient of 0.4 for high strength bolts because the contact surfaces are coated with anticorrosive paint.

### A4.1.3.2 High Tension Bolt

The high tension bolt is generally used for friction joints.



**Photo A. 8 : F10T and F11T punch mark seams**

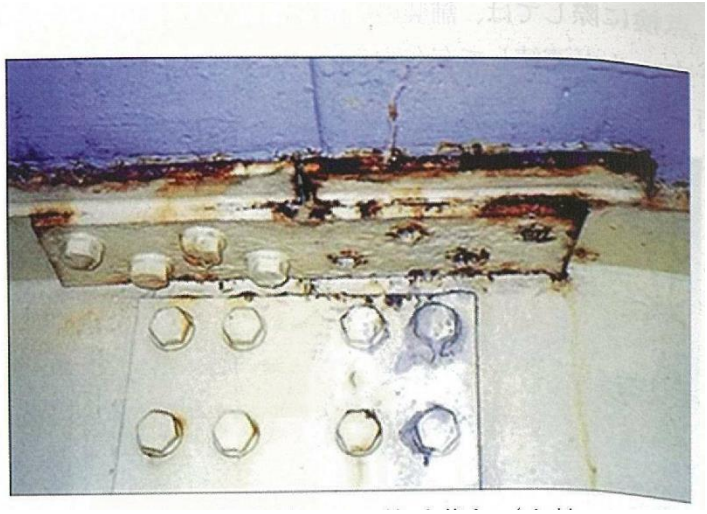


**Photo A. 9 : High Tension bolt falling out (looseness/fall out)**

### A4.1.4 Damage to Reinforced Concrete Deck Slab

#### A4.1.4.1 Crack of slab, Turning into soil and fall out, etc.

The majority of steel bridge slab are reinforced concrete slab (hereinafter referred to as RC slab), and in recent years, in addition to fatigue cracking of slab, turning into soil and fall out have also been reported. (Photo A. 10, Photo A. 11) Bridges that shown a tendency toward turning into soil and fall out often have overlay road surfaces and re-paved areas, and in many cases, there are two-way cracks with leakage and free lime on the lower side of the slab.

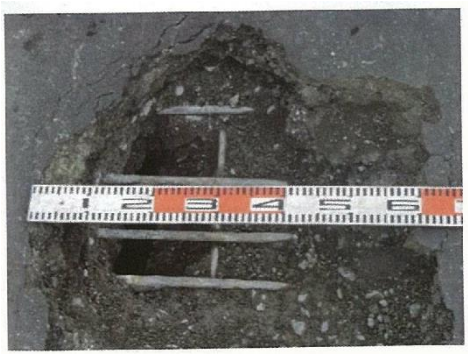


**Photo A. 10 : Sedimentation of concrete**



**Photo A. 11 : Concrete slab falling out**

### A4.1.4.2 Consideration on Inspection

In inspection for RC slab, it is important to pay attention for below items;

(1) The relationship between the damage on the road surface and the lower side of the slab

(2) In addition to the width and spacing of cracks, the direction of cracks and the presence or absence of corner dropouts, etc.

(3) Existence and effectiveness of waterproofing on the bridge surface, and presence or absence of free lime or rust juice (influence of water)

(4) Year of bridge construction (in relation to the applicable specifications)

Upon inspection, the condition of the pavement should also be checked. In many cases, where there is net shaped crack or potholes in the pavement, or where there are many repair marks, the lower side of the deck slab corresponding to that location is damaged.

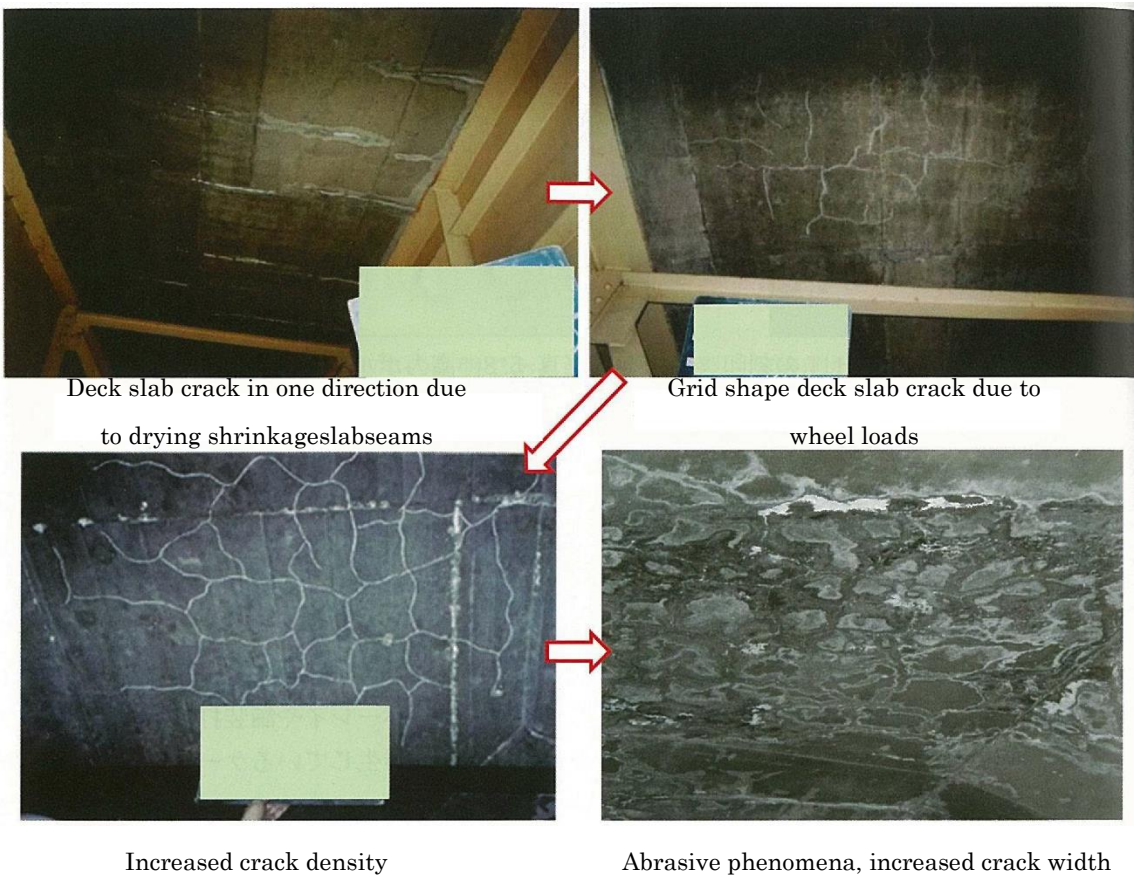



**Photo A. 12 : Damage beliefs of floor slab**

RC slab are designed as nearly isotropic slab with load distribution in two directions, but in the initial stage, fine cracks occur in the transverse direction to the bridge axis due to drying shrinkage and other factors. After cracking, the slab becomes an anisotropic slab, and if it is repeatedly

subjected to live load from large vehicles, etc., the bearing capacity decreases, and fine cracks appear in the direction perpendicular to the initial cracks (bridge axis direction), and grid (two-directional) cracking begins to progress. Next, the floor slab with reduced bending rigidity due to cracking in two directions gradually develops crack that expand and increase in size, leading to angular dropout and other damage that eventually results in concrete spalling and falling out. (Photo A. 12 : Damage progression of cracks in slab)

The speed of damage progression of RC slab increases when water is existing. This is said to be because water seeping through cracks in the road surface contributes to abrasion of the cracked surface and rapidly increases the width of the crack. Water penetration also corrodes the rebar inside the slab and causes further cracks in the slab due to the expansion of the mackerel. Therefore, preventing water penetration is extremely important in preventing damage progression. Changes in design standards as well as the environment and other factors have a significant impact on the damage of slabs. In particular, design loads and design methods have a significant influence. For example, the effect of live load is a power of 3 for steel members, but a power of 12 for RC slabs.

## A4.2 Inspection of steel bridge and focus point

### A4.2.1 Consideration by each structural type

The main damage items by type of steel bridge are listed below.

**Table A. 3 : Main damage items by type (1)**

| Structural Type | Main Points of Inspection |
|---|---|
| Plate girder | * Deformation of main girder<br>* Vibration and deflection of main girder<br>* Looseness or fall out of bolt<br>*Crack and fracture in gusset plate, stiffener and sole plate welding part |
| | *Damage of girder end notch<br>*Water ponding at girder end, etc.<br>*Abnormality of bearing<br>*Deformation of secondary members, etc.<br>* deterioration and corrosion of paint |
| Box girder | *Deformation of main girder<br>*Vibration or deflection of main girder<br>*Looseness or fall out of bolt<br>*Crack and fracture in gusset plate, stiffener and sole plate welding part |
| | *Fillet welding between horizontal and vertical stiffeners<br>*Damage of girder end notch<br>*Water ponding at girder end, etc.<br>*Abnormality of bearing<br>*Deformation of secondary member, etc.<br>*Deterioration and corrosion of paint |

| Structural Type | Main Points of Inspection |
|---|---|
| Steel pate deck slab girder | *Deformation of main girder<br>*Vibration or deflection of main girder<br>*Looseness or fall out of bolt<br>*Cracks and ruptures in gussets, stiffeners, and sole plate welds<br>*Crack and fracture in gusset plate, stiffener and sole plate Welding part<br>*Damage of girder end notch<br>*Cracks at the intersection welding part of longitudinal and transverse ribs<br>*Cracks of on-site welding part of longitudinal ribs<br>*Water ponding at girder end, etc.<br>*Abnormality of bearing<br>*Deterioration and corrosion of paint<br>*Abnormality of bearing section<br>*Deterioration of coating, corrosion |

It is important to carefully inspect the underlined items.

**Table A. 4 : Main damage items by type (2)**

| Structural Type | Main Points of Inspection |
|---|---|
| Truss | *Deformation due to collision by vehicle, etc.<br>*Deformation and buckling of compression member<br>*Vibration and deflection of main structure<br>*Looseness or fall out of bolt<br>*Crack on crossing part between floor system, cross beam and main structure, etc.<br>*Water ponding, etc. on the main structure<br>*Abnormality of bearing<br>*Deterioration and corrosion of paint<br>*Corrosion at the joint between the diagonal member and the walkway slab of through truss. |
| Arch<br>Langer Girder | *Vibration and deflection of main structure<br>*Vibration of vertical member<br>*Looseness or fall out of bolt<br>*Crack at the top and bottom edges of vertical members and at joint between main girder and cross beam<br>*Crack on crossing part between floor system, cross beam and main structure, etc.<br>*Deformation, etc. at corners<br>*Water retention, etc. on main structure<br>*Abnormality of bearing<br>*Deterioration and corrosion of paint<br>*Corrosion of joint between vertical member and walkway slab of through girder bridge |

It is important to carefully inspect the underlined items.

**Table A. 5: Main damage items by type (3)**

| Structural Type | Main Points of Inspection |
|---|---|
| Steel piers | *Tilt of column *Beam deflection<br>*Abnormality of base plate at bearing position<br>*Crack at pier corner *Looseness or fall out of bolt *Water ponding at the edge |

| Structural Type | Main Points of Inspection |
|---|---|
| | *Cracks in welds between diaphragm and longitudinal ribs, corner flange and girth<br>*Paint deterioration, corrosion *Vehicle collision mark |
| Bearing | *Functional failure *Hardness roller rupture<br>*Abnormal movement of roller *Abnormality of rubber shoes (tilt, deformation)<br>*Loose, broken or deformed bolt |
| Expansion Joint | *Deformation (rupture, crack) of steel fingers<br>*Abnormal noise, vibration, deformation and uneven of faceplate<br>*Abnormality (rupture, crack) of rubber expansion device |

### A4.2.1.1 Plate Girder Bridges

The main types of damage in plate girder bridge is corrosion and crack, and the damage of interest and the site of occurrence are as follows

**(1) Corrosion** (refer to Figure A. 6, Corrosion Map of Plate Girder Bridge)

Leakage and rainwater are the most common causes of corrosion of plate girder. The main corrosion factors are

① Corrosion due to water leakage from expansion joint at the girder end (refer to Photo A. 14)

② Corrosion due to rainwater penetration from damaged deck slab (refer to Photo A. 15)

③ Corrosion due to deterioration of corrosion prevention function such as coating deterioration (refer to Photo A. 16, Photo A. 17)

④ Corrosion due to defect drainage facilities such as drainpipe (refer to Photo A. 18, Photo A. 19)

⑤ Corrosion due to salt damage (especially, sea salt particles flying near the coast accelerate corrosion).

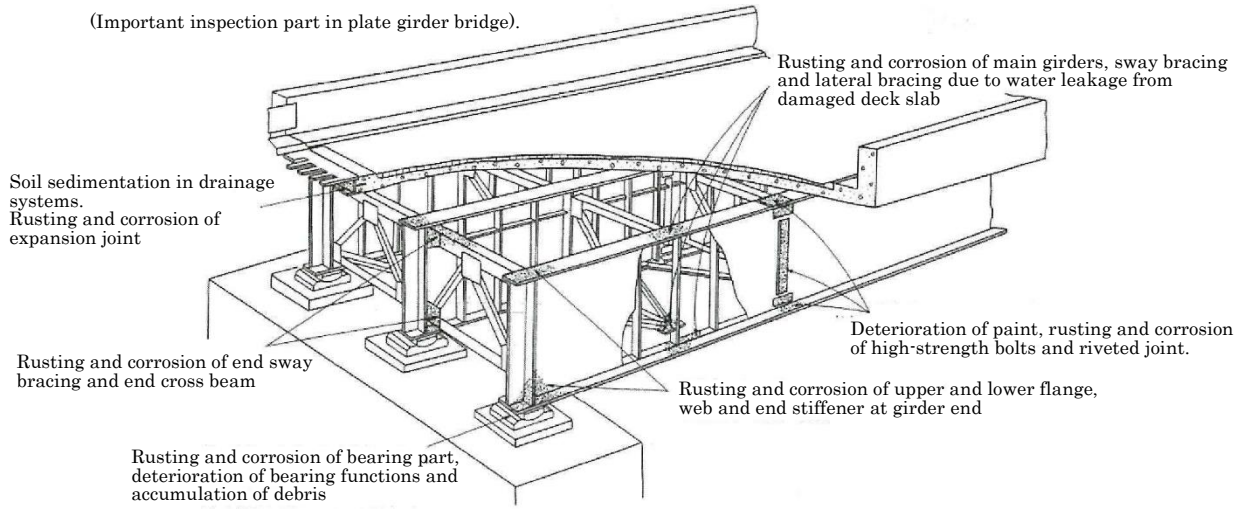



**Figure A. 6 : Corrosion map plate girder bridge**



Photo A. 13 :Corrosion of girder end gusset



Photo A. 14 : Corrosion of the receiving girder of expansion joint

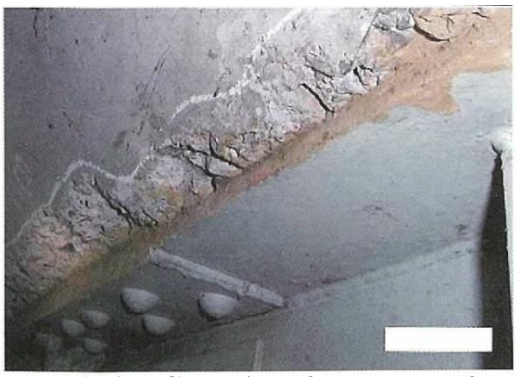


Photo A. 15 : Corrosion of the edge surface of upper flange (Caused by water leakage from deck slab due to waterproofing defect)

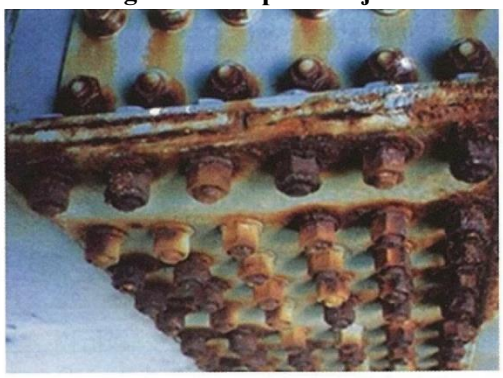


Photo A. 16 : Corrosion of high-strength bolt at joint

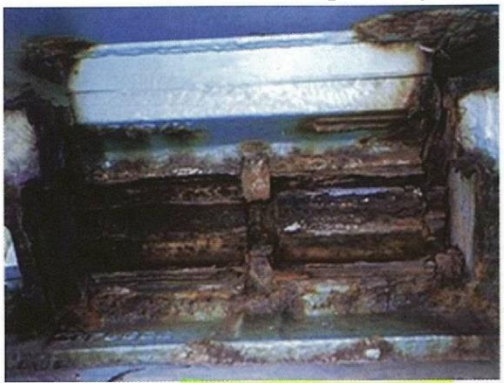


Photo A. 17 : Corrosion of roller bearing



Photo A. 18 : Corrosion of drainage pipe



Photo A. 19 : Corrosion of main girder caused by leakage from drainage pipe

**(2) Crack**

Crack are caused by repetitive load from large vehicles acting on stress concentration part which is originated from structural design, welding defects, functional failure of bearing and other factors.

As shown in Figure A. 7, these cracks are found at the weld of the web gap plate joint part between the main girder and the cross beam (refer to Photo A. 19 and Photo A. 20), the sole plate welding part (refer to Figure A. 8 and Photo A. 21), the gusset plate welding part of sway bracing (refer to Photo A. 22), and the girder end cut portion (refer to Figure A. 11)

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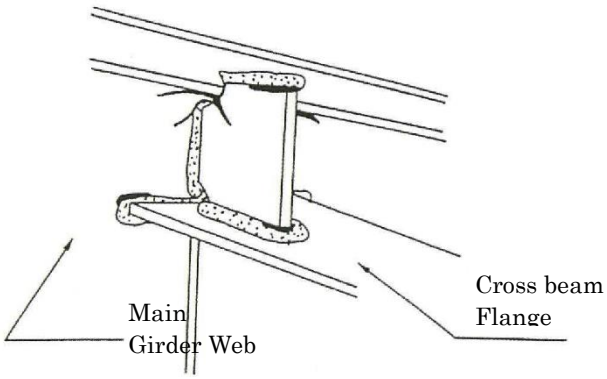



**Figure A. 7 : Web Gap**

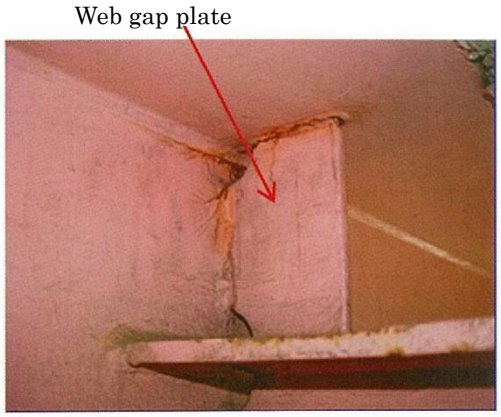



**Photo A. 20 : Crack in the joint between main girder and cross beam**

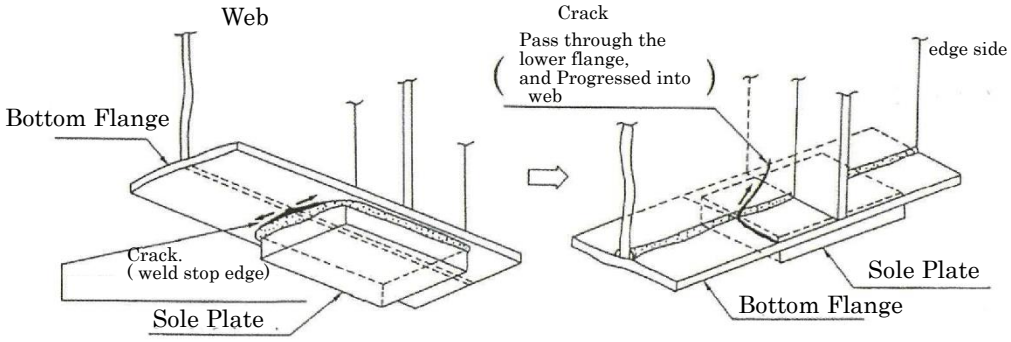



**Figure A. 8 : Sole plate welding part**



**Photo A. 21 : Crack propagated from sole plate welding part**



**Photo A. 22 : Crack in gusset plate welding part of sway bracing**

### A4.2.1.2 Box girder bridge

The main damage to box girder bridge is corrosion and cracking same as that of plate girder bridge. Corrosion is occurred by leakage from expansion joint at the girder end, water ponding at the bottom due to leakage from drainage pipe (joints and pitting) installed in the box girder (refer to Photo A. 23) and dew condensation water inside the box girder and rainwater from joint. Cracks are often observed in steel plate deck girder bridge. (refer to Figure A. 5 Crack Map of Steel deck Slab)

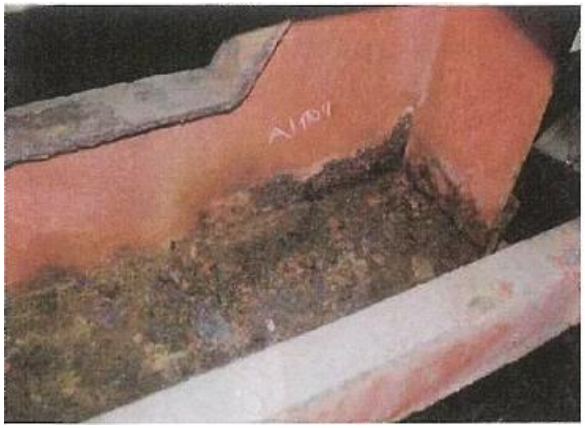


**Photo A. 23 : Corrosion due to ponding at the bottom of the box girder**

### A4.2.1.3 Other bridges type (truss, arch, langer)

Corrosion and crack are also observed in other bridge types, and since the periodic inspection guideline for bridges in June 2014 clarified the concrete embedded section, nodal point of arch and truss, so it is necessary to pay attention to damage such as corrosion, crack and fracture that occur in these part (refer to Figure A. 12,Photo A. 24).

Damage has also been reported to occur at the following part.

① girder end cut portion (including the cantilever part) (refer to Figure A. 12 ,Photo A. 23)

② Both end of vertical members (refer to Figure A. 13)

③ Langer suspension member attached point (refer to Photo A. 25)

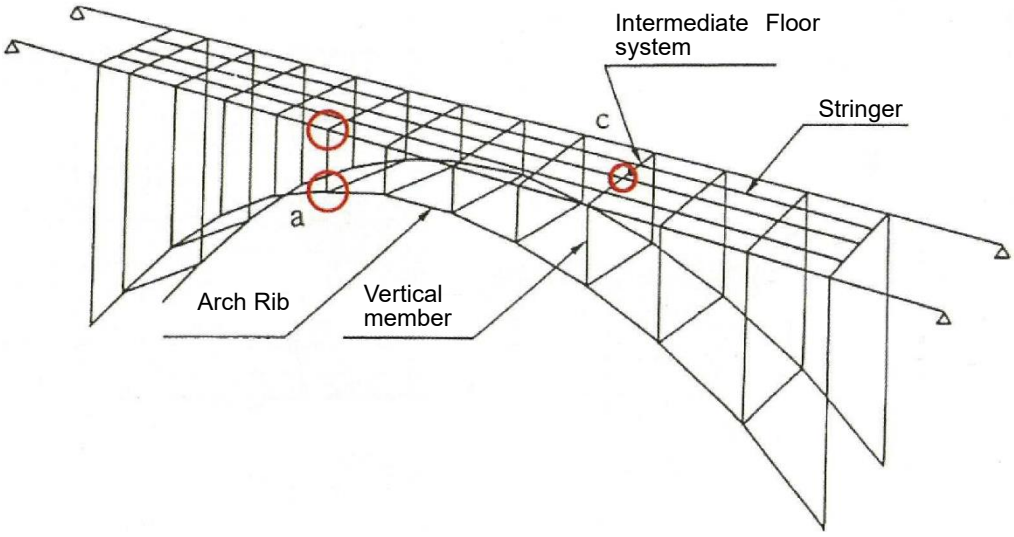



**Figure A. 9 : Deck type Arch bridge Crack map**

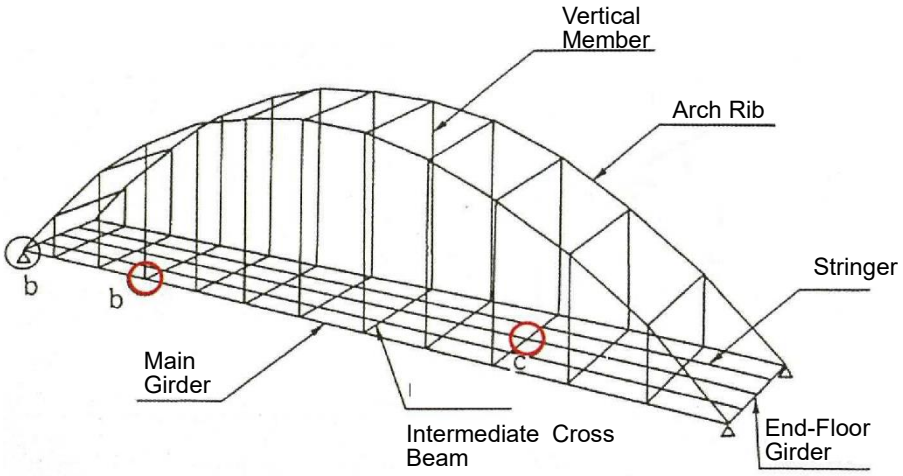



**Figure A. 10 : Through type Arch bridge Crack map**

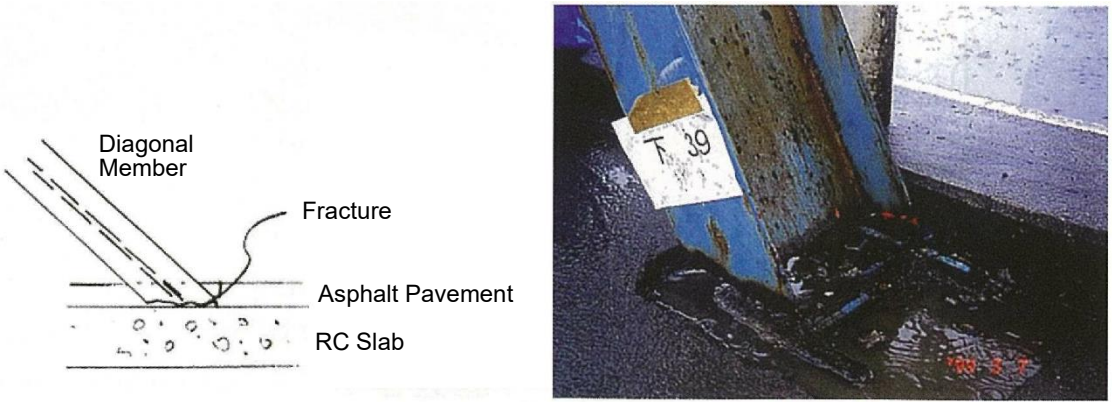



**Photo A. 24: Fracture of diagonal member of through truss bridge by corrosion**

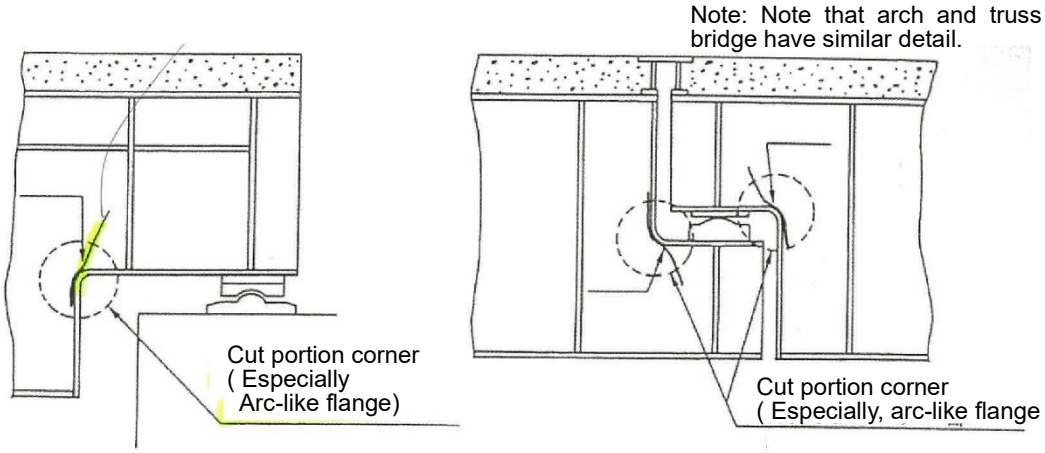



**Figure A. 11 : Girder end cut portion(including Gelber hinge)**

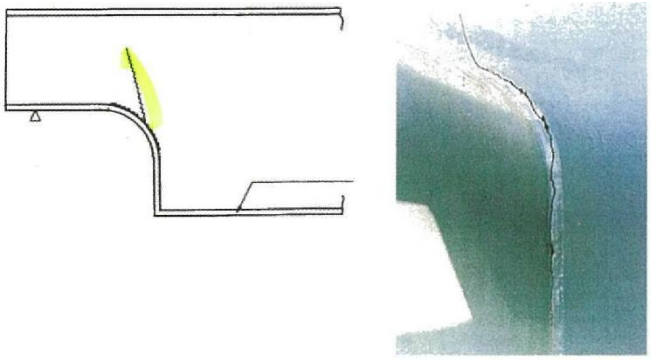


**Figure A. 12 : Crack of web cut portion**

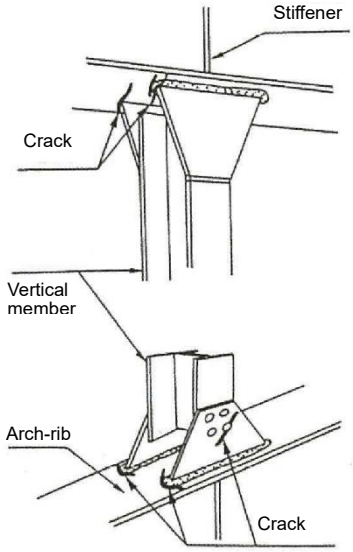
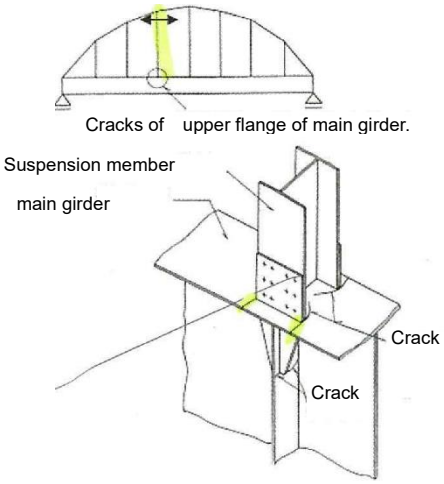



**Figure A. 13 : Both end of Vertical member**



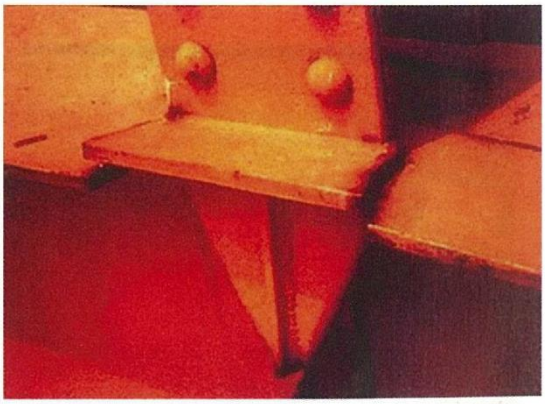



**Photo A. 25 : Cracks of langar-suspension attached part**

### A4.2.2 Considerations for each part

#### A4.2.2.1 Bridge surface (pavement surface, expansion joint, etc.), guardrail, railing, curb, median, kerbstone

After arrival at the bridge to be inspected, it is important to observe for overall abnormalities on the bridge surface rather than starting the inspection immediately. Deformations (abnormalities) in portion not normally visible may appear on the bridge surface. The following points should be observed on the bridge surface.

① Check the overall straightness and vertical gradient of the bridge for any abnormalities by confirmation for the railing and curb (relation to displacement of the substructure and abnormality of main girder). If it is rain, also observed the water ponding state on the road surface (normally, this is confirmed by sediment accumulation, etc.).
② Are there any abnormal noise, vibration or abnormal deflection when large vehicles, etc., pass?
③ Whether the pavement has any deformation (crack larger than 5 mm, swelling, delamination, pothole, rutting) or abnormal state or repair marks (e.g., signs of bed slab sinking).
④ Are there any abnormal state (uneven, damage, abnormal noise, etc.) on the expansion joint or the back side of the structure? (Deformation of the bearing, damage to the edge of the slab, settlement of the embankment or bearing, etc.)
⑤ Are there any signs of damage to structures on the bridge surface (sign bord, lighting pole, railing, fence, noise insulation facility, drainage system, etc.) that could cause damage to third parties?
⑥ Are there any abnormal state on abutment, embankment slope, or approach road? (e.g., effects of earthquake, abnormal of side clearance, etc.)
⑦ Are there any signs of rebar exposure or swelling of concrete guardrail or railing due to poor construction (insufficient cover, etc.)?

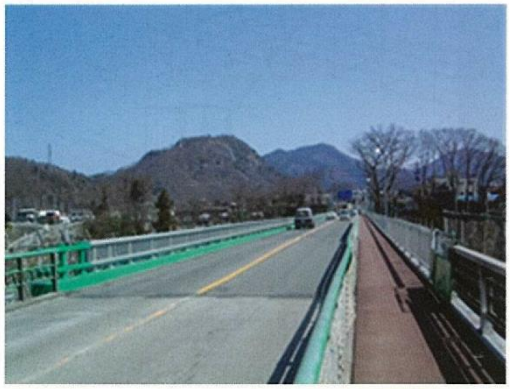


**Photo A. 26 : Abnormal straightness of railing**



**Photo A. 27 : Pavement crack in the direction of bridge axis due to deflection differences of steel plate deck.**



**Photo A. 28 : Abnormal Pavement (Pavement depression)**

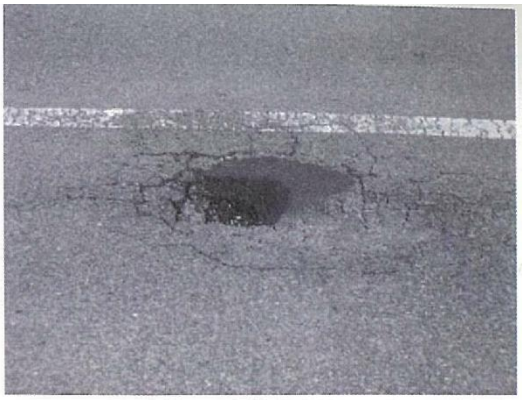


**Photo A. 29 : Abnormal Pavement (Pavement pothole)**



**Photo A. 30 : Crack of pavement due to damage of slab**

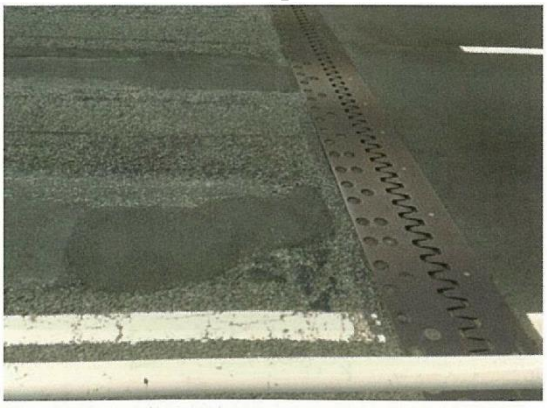


**Photo A. 31 : Damage of pavement on steel plate deck (Left side).**

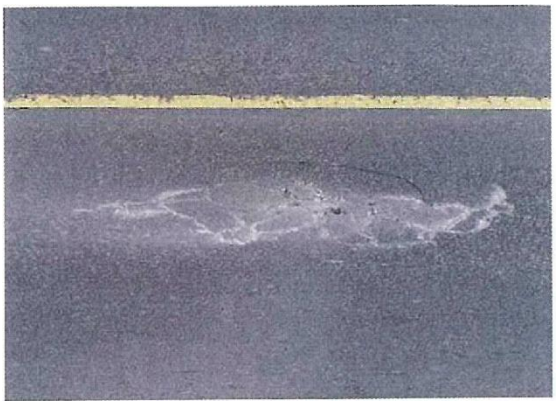


**Photo A. 32 : Abnormal Pavement (White cracks.)**



**Photo A. 33 : Abnormal Pavement (Pavement turning into soil)**

### A4.2.2.2 Bridge lower side

Observation for overall abnormalities by looking at the underside of the girder shall be needed (mainly the main girder, bearing, underside of expansion joint, etc.). It is important to carefully inspect for anomalies under the girder at the same location, taking into account any deformation

at the bridge face. Observations should be made at the following points

① Is there any settlement, movement or tilting of substructure? Are there any effects of earthquakes?

② The abnormal noise, vibration or deflection at the road surface are caused from where of girder lower side?

③ Are there any significant damage of the underside of the slab? (e.g., crack, drop-off slab, corner drop-off, leakage, free lime, etc.)

④ Are there any areas affected by leakage due to a defective waterproofing layer on the slab?

⑤ Are there any deformities in the bearing? (Including settlement and functional failure)

⑥ Are there any abnormalities such as corrosion of lateral sway bracing or cross beam at the girder end?

⑦ Are there any abnormalities of side clearance at the girder ends?

⑧ Are there any bolt falling out, rust juice, abnormal vibration or abnormal noise of the main structure?

⑨ Are there any collision marks, deformation or defect caused by vehicles? Are there any signs of under girder clearance limitation?

#### A4.2.2.3 Slab

The main inspection of slab is crack inspection, and attention should be paid to crack width and direction as well as crack spacing. For steel plate bonded slab, it is advisable to check for abnormal state, such as swelling, by sound inspection in combination with visual inspection. (refer to Photo A. 34 and Photo A. 35)



**Photo A. 34 : Delamination of steel plate (Damage of concrete member repair and reinforcement)**



**Photo A. 35 : Corrosion and swelling of steel plate bonding**

### A4.2.2.4 Bearing and Expansion Joint

**(1) Outline of Bearing**

The functions of bearing generally include vertical force and horizontal force support function as load transfer function, and horizontal movement and rotation functions as displacement-following function. Damage to bearing may affect the safety of the bridge In addition, various types of damage to the bearing body are likely to induce damage to other members. Bearing inspection shall be conducted in narrow space, it is difficult to inspect due to the influence of bridge fall prevention device, soil sedimentation, and muddy water runoff. It is important to use mirror to inspect area where direct visual inspection is not possible.

In some cases, it is necessary to check not only visually but also functionally, such as the horizontal movement caused by temperature changes, the rotational displacement when large vehicle pass through and the function for earthquake. If the function cannot be checked directly with a movable bearing, it may be necessary to confirm the function by detailed investigation using a micrometre or displacement meter.

If side clearance abnormal, crack and fracture (side block) are found in the bearing, check for abnormalities in the gap between the bearing and the girder, it is considered that movement amount is large. The contact of girder end and parapet by earthquake, movement, tilt and settlement of substructure and clearance of expansion joint shall be inspected. (refer to Photo A. 36, Photo A. 37)

**(2) Steel bearing**

In the inspection of steel bearings, the load-transmitting and displacement-following functions should be understand, and the abnormal sound or vibration should be checked.

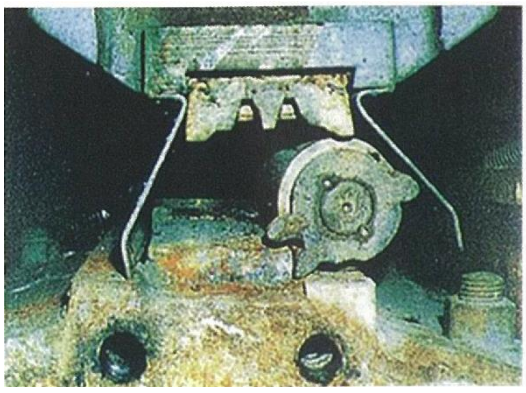


**Photo A. 36 : Malfunction (Deviation of one roller)**

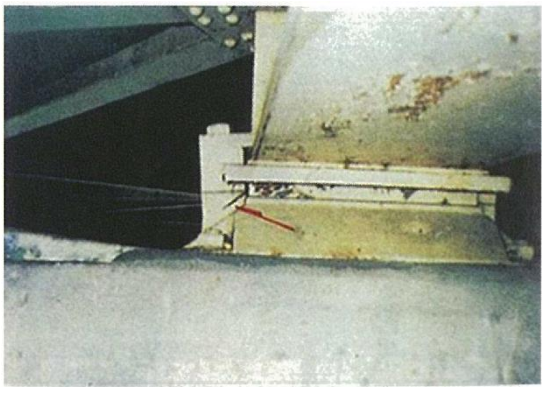


**Photo A. 37 : Crack of the bearing body**



**Photo A. 38 : Abnormal clearance of bearing**



**Photo A. 39 : Stopper contact with upper bearing. Rotation of pinch plate**





**Photo A. 40 : Malfunction of bearing (corrosion, deformation)**

### (3) Rubber Bearing

Rubber bearing is made of layers of rubber and steel plates at first, and their condition could be checked from outside. Many of the recent rubber bearings are entirely rubber-coated, so the steel plates sandwiched between them cannot be seen from the outside.

The rubber plate and steel plate are moulded and integrated through the process of heating and pressurization and vulcanization, but there is a report that the rubber layer peeling off and the rubber part cracking are occurred after deformation due to temperature contraction. There have been few cases of such rubber bearings being checked to see if they have the prescribed deformation performance, but they are being replaced early.

Photo A. 41 shows the structure of a rubber bearing and Photo A. 42, Photo A. 43, Photo A. 44 show examples of damaged rubber bearing.

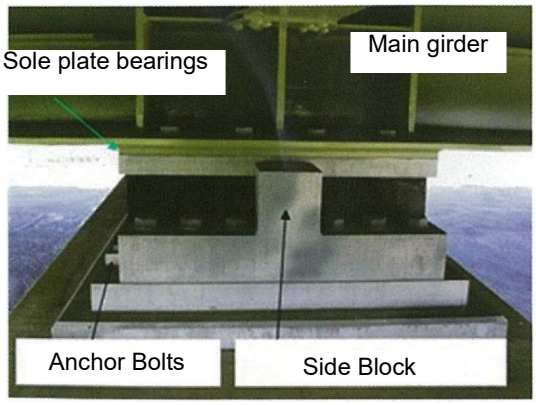



**Photo A. 41 : Structure of rubber bearing**



**Photo A. 42 : Horizontal crack in rubber bearing. (Malfunction of bearing)**



**Photo A. 43 : Vertical crack in rubber bearing. (Malfunction of bearing)**



**Photo A. 44 : Deformation of rubber bearing (Malfunction of bearing)**

**(4) Bearing base mortar and pedestal concrete**

Bearing base mortar is used to adjust the bearing installation height by inserting a liner into the underside of the bearing and filling the space between the underside of the bearing and the lower concrete, so that the upper reaction forces can be transferred to the lower concrete after the mortar has casted. A steel liner was used for height adjustment until around 1970, but due to the difference in modulus of elasticity, reaction forces were concentrated on the steel liner rather than the mortar, and the face mortar around the bearing was subjected to the same strain as the bearing itself. Eventually, the mortar broke into small pieces, exposing the steel liner to corrosion, resulting in sectional defects and causing the bearing to tilt and settle in many cases. After that, Plastic liners and mortar blocks were used, but the freezing and thawing action of water seeping through the cracks caused the mortar to fail.

When bearing tilt and settlement is occurred, the reaction force balance of the overall bearing is affected and damage is extended to adjacent bearings. In addition, tilting or settlement of the bearing is likely to affect bridge safety by leading to anchor bolt dislodgement, sliding plate dislodgement, sole plate stopper failure, gusset plate fracture in the end lateral sway bracing,

cracking of the RC slab at the girder end, and abnormal settlement.

Damage of bearing base mortar or pedestal concrete, such as 'cracking' or 'floating', is often observed, but it is necessary to determine whether or not the bearing functions such as tilting, settlement, load transfer and rotation are retained.



**Photo A. 45 : Malfunction of the bearing due to deformation and defect in the pedestal concrete.**

**(5) Expansion joint**

Expansion joint directly support wheel load, and has function of connection between different stiffness member from approach road or adjacent span to slab, and are subjected to severe conditions such as impacts. There are two main types that is steel and rubber type.

The following basic items for expansion joint is required in design.

① Adaptable to expansion and contraction of bridge girders due to temperature changes, etc.

② Adaptable to displacement such as bridge girder deflection

③Ensure the flatness of the bridge surface so that it does not affect the driving safety

④Durability by ensuring a stiffness of structure integrated with the bridge

⑤The structure shall have waterproof and drainage property.

⑥ The edge of the slab shall have sufficient reinforcement for installation position of expansion joint.

Older bridges and bridges with short span may use angle-type steel or, in some cases, buried joints with continuous pavement. In the case of buried joint, the pavement is often cracked and rainwater runs down the girder, contaminating the members with muddy water and depositing sediment at the bearing, resulting in the loss of the above functions.

In the case of steel expansion joint, the overlap plate type is often used for meddle span, while the steel finger type is often used for span with large expansion. In either type, if there is an abnormal noise when the vehicle runs, it is necessary to identify the location where the noise is generated.

If the faceplate moves up and down when the vehicle passes, the fillet weld of faceplate may be broken or the anchor bar may be fractured. In many of these cases, the concrete under the faceplate is not sufficiently filled. It is necessary to tap the faceplate and inspect to see if there are any unfilled areas.

If the fingers are narrow and there is uneven between the fingers, the load may be concentrated on one of the fingers and break at the base of the finger.



**Photo A. 46 : Abnormal gap due to substructure movement.**



**Photo A. 47 : Deformation・Defect**



**Photo A. 48 : Deformation and defect of shield rubber material, leaks and ponding**

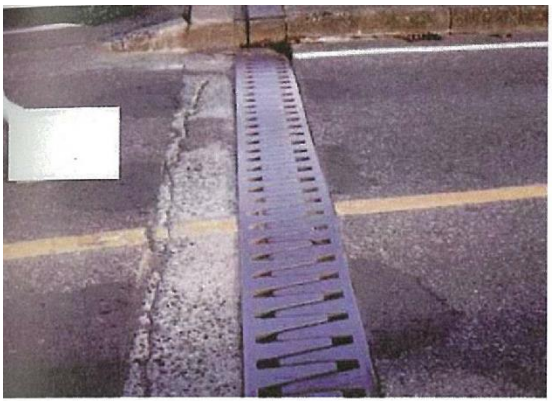


**Photo A. 49 : Crack of post casted concrete**

If the finger of expansion joint has a large uneven, the base of the finger should be inspected to make sure that no cracks have formed. If the finger break and fly off, there is a high risk of third-party damage.

In one recently reported case, a part of a finger-type faceplate broke off, and tire puncture accident happened.

Rubber joint has good driving performance and high water sealing performance, but they have their own advantages and disadvantages in terms of wheel load support methods, and their durability is far inferior to that of steel joint. Rubber joint is often installed after the concrete slab has been poured. Therefore, if the joint between the new and old concrete are not properly treated, they will not be integrated and the loading capacity will be reduced, resulting in problems such as cracking of the cover concrete. Furthermore, if there is a gap in the back of the post-placed concrete, water leakage from this area can cause water leakage on the bridge face, which may affect the bearing and other members.

#### A4.2.2.5 Drainage system (drain pipe, drainage basin, etc.)

Based on the inspection results to date, particular attention should be paid to the corrosion of drainage pipes (refer to Photo A. 18), since, a small defect is occurred and it expands, the period of time until leakage begin is short. In addition, leakage from drainage pipe may cause corrosion of the surrounding members.

In the vicinity of drainage basin, waterproofing defects in drainage pipe connections and poured asphalt are often cause of leakage. In addition, it is necessary to pay attention to the overall capacity and flow gradient as well as the soil sedimentation at the water ponding.

Missing of drain pipes and supporting metals are observed occasionally. This cause is stealing; road operator calls as “vandalism” which means steal acts of any of parts of bridge facility.

## A4.3 Maintenance of Suspension Bridge (Cable Stayed Bridge)

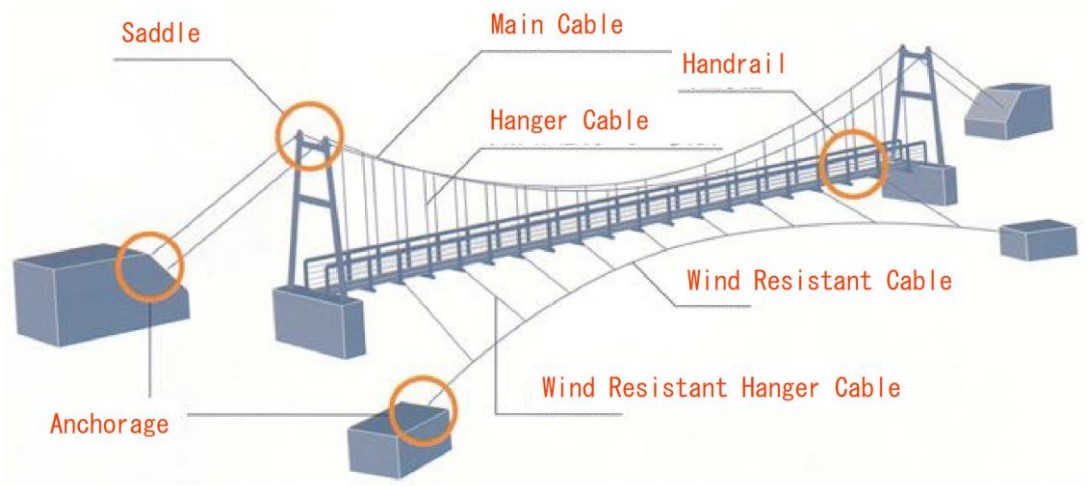



**Figure A. 14 : Conceptional Figure of Suspension Bridge**

### A4.3.1 Anchorage

Main cable anchorage is likely to progress the corrosion by wet condition of mud sedimentation and fallen leaves. In the case that main cable is covered by concrete or main cable is buried in concrete, water will come into inside the concrete by conducting the main cable. Therefore, the attention will be needed for the corrosion progress of invisible part.

### A4.3.2 Saddle

For the saddle part, it is difficult to inspect and to find the damage. The access method to the saddle shall be established and inspector have to be climb up to saddle to periodic inspection.
In the case that the saddle is covered by covering device, inside of the cover will be wet condition. Then, the corrosion progress rapidly more than main cable.

### A4.3.3 Hanger Cable

We have to pay attention to the relaxation of hanger cable. The cause of relaxation is slide of cable band and sag fall down of main cable. Relaxation of hanger cable cause the too much bending for the stiffening girder and buckling of upper chord member. The attachment part of stiffening girder is likely to corroded, the attention will be needed at the time of inspection.

### A4.3.4 Wind Resistant Cable

Wind resistant cable is likely to relax, the tensioning will be conducted at the time of inspection.

## Appendix 5 : Check Points on Concrete Bridge

### A5.1 General

While there are various mechanisms and factors that deteriorate concrete structures as shown in Table-A.6, the phenomena that appear on the surface of concrete due to deterioration are also diverse, including cracking, delamination, spalling, free lime, rust soup, gel exudation, rebar exposure, scaling, and discoloration.

**Table A. 6 : Relationship between degradation mechanisms and factors, indicators, and phenomena**

| Degradation mechanism | Deterioration Factors | Degradation phenomenon | Deterioration target |
|---|---|---|---|
| Carbonatation | carbon dioxide | A degradation phenomenon in which carbon dioxide causes a carbonation reaction with cement hydrates and lowers the pH in the pore solution, which accelerates corrosion of steel, causing cracking and delamination of concrete and cross-sectional reduction of steel. | Neutralization depth Steel corrosion amount Corrosion cracks |
| salt-air damage | chloride ion | Deterioration phenomenon in which chloride ions accelerate the corrosion of steel in concrete, causing cracking and spalling of the concrete and reduction in the cross-sectional area of the steel. | Chloride ion concentration Steel corrosion amount Corrosion cracking |
| chemical erosion | Acidic substance technique acid ion | A phenomenon in which hardened concrete decomposes upon contact with acidic substances or sulphate ions, or concrete deteriorates due to expansion pressure during compound formation. | Penetration depth of degradation factors Neutralization depth Steel corrosion amount |
| Alkali aggregate reaction (alkali-silica reaction) | Reactive aggregate | A deterioration phenomenon in which aggregates containing reactive silica minerals or carbonate rock in the aggregate react with the alkaline solution in the concrete, causing abnormal expansion and cracking of the concrete. | Expansion (Cracks) |

| Degradation mechanism | Deterioration Factors | Degradation phenomenon | Deterioration target |
|---|---|---|---|
| Fatigue of slab | Cyclic loading of large vehicle traffic | A phenomenon in which reinforced concrete slabs of a bridge crack and cave in due to the repeated action of cyclic loading. | Crack density, deflection |
| Fatigue of Beam Members | cyclic load | A deterioration phenomenon in railroad bridges in which repeated loading causes cracks in tensile steel that lead to rupture. | Cumulative damage degree Crack length of copper material |
| wear and tear | wear | The gradual loss of concrete cross sections over time due to the abrasion action of running water, wheels, etc. | Amount of abrasion speed |
| Sedimentation of slab | Flooding of concrete | A phenomenon in which aggregate separates and is converted into sediment due to the repeated action of wheel loads caused by rainwater intrusion into the bridge slab. | Cracks in floor slab Leakage |

When inspecting concrete bridges, it is advisable to consider the environment in which the bridge is located (e.g., proximity to the sea, cold and snowy regions, etc.), the materials used, and the conditions of use (e.g., heavy vehicle traffic), and compare them to deterioration indicators to determine the cause of damage. After identifying the cause of the damage, repair or reinforcement should be carried out.

- Deterioration of concrete structures depending on the environment
  Salt damage, neutralization (rainwater), frost damage
- Deterioration phenomena that appear depending on the quality of the concrete material
  Alkali aggregate reaction (alkali-silica reaction)
- Deterioration due to external forces
  Fatigue of slab (slab cracking), sedimentation

## A5.2 Causes and main damages of concrete bridges

Major damage to concrete bridges includes "cracking," "swelling," and "delamination/exposed rebar. These damage causes include fatigue, salt damage, alkali aggregate reaction, frost damage, and neutralization, and the types and causes of damage are described below.

### A5.2.1 Main Causes of Damage

#### A5.2.1.1 Salt Damage

**(1) What is salt damage?**

Salt damage is a phenomenon in which chloride ions penetrate and accumulate in concrete, corrode the rebar and PC steel inside, and cause cracks due to the expansion pressure of rust.

Further penetration of chloride ions through the cracks accelerates the corrosion of the internal steel materials, causing delamination and spalling of the concrete cover, and exposing the internal copper material. Since chloride ions adhere directly to the exposed copper material, corrosion progresses rapidly, the steel cross section is reduced, and the load-bearing capacity of the entire structure deteriorates rapidly.

Chloride ions can enter the concrete in two ways

1) If already contained in the material used (internal factor)

① When sea sand that has not been sufficiently de-salted is used as fine aggregate or when the mixing water contains chloride ions.

② When a large amount of chloride ion is contained in the admixture used for the purpose of expecting early onset of strength

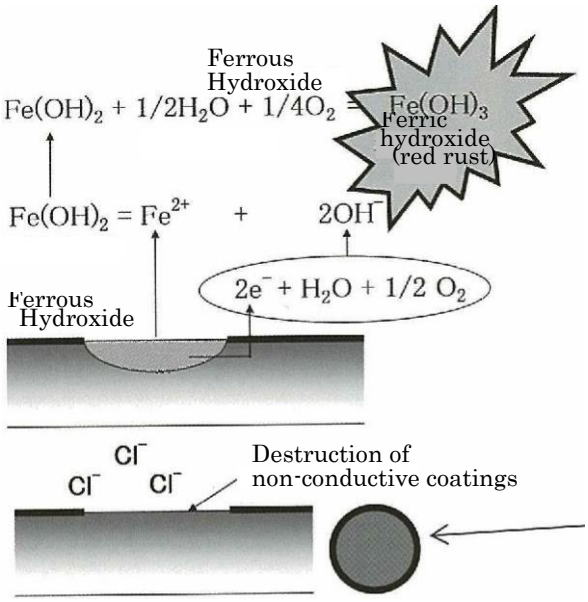
2) When the salt enters from the outside after the structure is completed (external factors)

① When sea salt particles flying into a structure built near the coast adhere to the concrete surface and chloride ions permeate into the concrete over time.

**(2) Corrosion of copper materials in concrete**

Steel materials such as reinforcing bars in sound concrete are protected by a passive film on the steel surface because of the strong alkalinity of the concrete. When chloride ions enter the concrete from the outside or are contained in the concrete, the passive film on the steel surface is destroyed and the steel bars corrode due to the supply of oxygen and water, as shown in Figure 6-1. Furthermore, in the case of neutralization, chloride enrichment is observed and the corrosion rate is accelerated.

Such corrosion of steel due to chloride ions is different from steel corrosion due to neutralization of concrete, which often results in severe partial corrosion. The limiting concentration for the occurrence of steel corrosion in concrete depends on the type of cement and the water-cement ratio (Figure A. 15).




Oxidized by dissolved oxygen to ferric hydroxide and rusts. The volume expands.

Iron ionizes and elutes. Hydroxide ions (OH-) are generated.

Chloride ions (Cl-) permeate the concrete. The passive film is destroyed by chloride ions.

Steel embedded in concrete is protected by a passive coating on the surface.

**Figure A. 15 : Corrosion mechanism of steel in concrete**

**(4) Examples of damage caused by salt damage**

Examples of damage caused by flying salt (Photo A. 52 ~ Photo A. 57)





**Photo A. 50 : Spalling of overlay concrete.**



**Photo A. 51 : Exposed axial rebar (PC post-tensioned T girder)**



**Photo A. 52 : Exposed main rebar (RCT girders)**

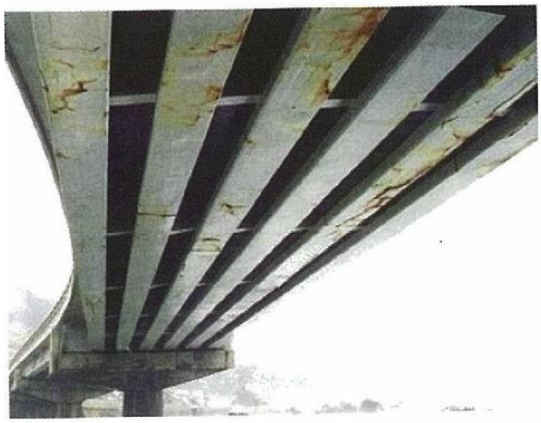


**Photo A. 53 : Significant rust juice generation. (Kuretsubo Bridge, 26 years after erection)**



**Photo A. 54 : Rupture de l'acier du BP (Pont Kuretsubo, 26 ans après sa construction)**

1) Examples of redegradation



**Photo A. 55 : Peeling of surface coating material**



**Photo A. 56 : Blistering of surface coating Material**





**Photo A. 57 : Paint blistering, peeling, leakage, free lime, rust exudation, or other damage has occurred.**

2) Points to keep in mind when inspecting concrete girders exposed to salt damage

When inspecting concrete girders exposed to salt damage, the following points should be noted.

① Since deterioration progresses quickly due to salt damage, even minor cracks should be

accurately recorded so that the progress can be determined at the next inspection.

② Cracks with rust juice may be caused by corrosion of the internal steel material, so inspect by tapping around the cracks to check for float and peeling. If there is a possibility of delamination, it is advisable to knock off the cracks according to the condition under the girder, and apply anti-corrosion treatment to the exposed steel.

③ If a PC bridge is found to have ruptured PC steel wires, a detailed investigation to determine the load-bearing capacity should be conducted as soon as possible in order to determine the need for emergency measures such as traffic control.

④ Since the environment may change between the next inspection and the next inspection, it is advisable to record the route of chloride ion intrusion and the distance from the shoreline.

⑤ For those that have already been repaired for salt damage, the blistering, swelling, peeling, cracking, etc. of the surface coating material should be accurately recorded so that the progress of damage can be determined at the time of the next inspection.

#### A5.2.1.2 Carbonatation

**(1) What is neutralization?**

Sound concrete exhibits strong alkalinity. Carbon dioxide (carbon dioxide gas, etc.) in the air enters the concrete and causes a neutralization reaction with the calcium hydroxide in the concrete. The decrease in the alkaline content of concrete and its approach to neutrality is called neutralization.

As neutralization of concrete progresses, steel materials such as reinforcing steel in concrete become susceptible to corrosion.

**(2) Mechanism of neutralization**

1) Cement hydration

Hydration is initiated by the reaction of the constituent compounds in cement with water. The majority of hydrate products in ordinary Portland cement are calcium silicate hydrate and calcium hydroxide. Calcium hydroxide is 1/3 and has a strongly alkaline pH of 12-13.

Calcium hydroxide [Ca(OH)2] interacts with carbon dioxide gas in the air to form calcium carbonate and water, as shown in Figure A. 16. This reaction proceeds and calcium hydroxide becomes carbonated, which is called neutralization (pH 8.5 to 10)

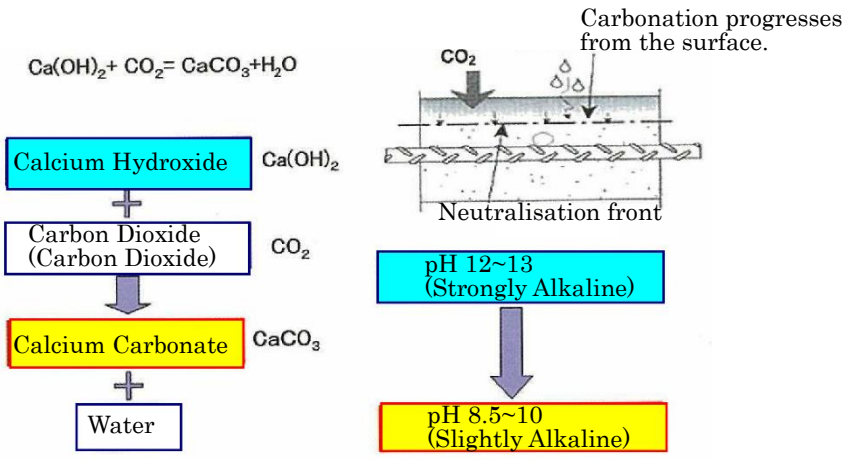



**Figure A. 16 : Neutralisation degradation process (Part 1).**

### (3) Deterioration due to neutralization

Neutralization of concrete progresses from the surface to the interior of the concrete, causing very fine cracks, but neutralization does not directly cause physical deterioration and is not a problem. The problem caused by neutralization is the rusting of steel materials in the concrete.

### (4) Characteristics of Damage Caused by Neutralization

When the pH falls below 11 due to neutralization, the passive film is destroyed and corrosion of the steel bars begins. Cracks occur along the reinforcing bars in the concrete, and the covered concrete becomes detached and spalls as shown in Figure A. 17.

Areas with insufficient cover are susceptible to neutralization. Although the damage caused by cracking and spalling of the cover concrete due to neutralization does not affect the load-bearing capacity of the structure, the spalling of the cover concrete may lead to damage by a third party.

Examples of deterioration due to neutralization are shown in Photo A. 58 and Photo A. 59.

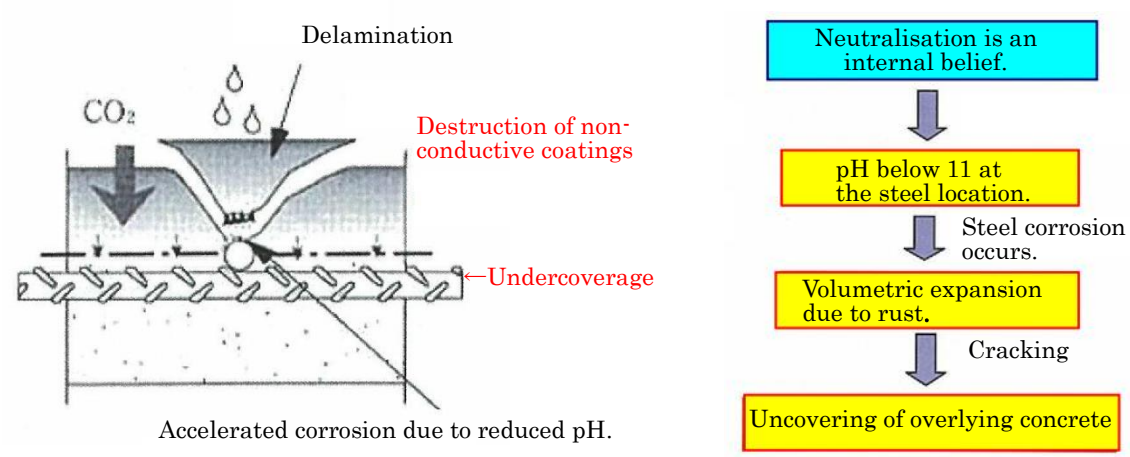



**Figure A. 17 : Deterioration process of neutralization (Part 2).**



**Photo A. 58 : RC slab underside with Delamination and exposed reinforcing steel bars**



**Photo A. 59 : Delamination and exposed rebar on the concrete**

**(5) Points to keep in mind when inspecting for neutralization**

The following points should be considered when conducting a neutralization inspection of concrete girders. .

1) Damage due to neutralization is often caused by corrosion of the internal steel due to insufficient cover. In this case, it is advisable to knock off any floating or peeling areas that may cause damage to third parties due to peeling by using a hammer, etc., and to apply anti-corrosion treatment to the exposed steel.

2) For areas that have already been treated to prevent neutralization, it is advisable to record the progress of blistering, float, delamination, and cracking of the surface coating material by using a tapping inspection.

**(6) Detailed investigation of neutralization**

To measure the depth of neutralization of concrete, phenolphthalein solution is applied as shown in Photo A. 60. The areas where the colour has not changed are judged as neutralized areas, and the areas where the colour has changed to red are judged as unneutralized areas. In areas determined to be neutralized, corrosion progression of reinforcing bars and steel materials is considered, and cross-sectional restoration, etc., should be considered.




**Photo A. 60 : Measurement of neutralization depth with phenolphthalein solution**

The relationship between the depth of neutralization and the age of the elapsed time can generally be estimated by the following neutralization rate equation.

$y=b\sqrt{t}$

y: Neutralization depth (mm)

t:Neutralization period (years)

b: Neutralization rate coefficient (mm/√year)

When considering repair measures against salt damage, it is necessary to take into account the remaining neutralization thickness (the difference between the cover thickness of the rebar and the depth of neutralization) shown in Figure A. 18. The progress of neutralization may accelerate the onset of corrosion because chloride ions immobilized in cement hydrates dissociate and concentrate in the unneutralized area.

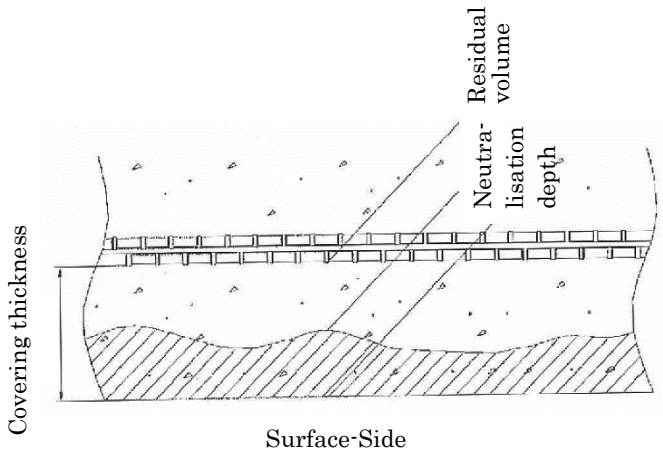



**Figure A. 18 : Image of remaining neutralization**

### A5.2.1.3 Alkali-aggregate reaction

**(1) Alkali-aggregate reaction**

Alkali-aggregate reaction of concrete is a chemical reaction between the alkali content of cement and certain minerals in reactive aggregate, and the reaction products expand due to moisture supply.

① Alkali-silica reaction (ASR)

② Alkali carbonate reaction

③ Alkali-silicate reaction



**Photo A. 61 : Abutment stiff-wall section, wing-wall section**

Alkali such as sodium (Na) and potassium present in cement and reactive silica in aggregate form alkali-silica gel in the presence of water. This alkali-silica gel absorbs water, causing expansion and cracking of the concrete.

Cracking due to alkali aggregate reaction (Photo A. 61) occurs several years after construction and later, 10 to 20 years after construction, compared to drying shrinkage, which occurs relatively early after construction, and cracking due to thermal stress. These years depend on the amount of alkali in the concrete, mix conditions, and environmental conditions such as temperature and water supply.

Expansion due to alkali reactions is thought to progress and subside over time, although some of the longest ones may take 10 to 20 years from the onset of expansion to subside.

Unlike salt damage and neutralization, alkaline aggregate reaction occurs even in unreinforced concrete, and the strength and modulus of elasticity of the concrete itself will decrease.

**(2) Characteristics of Damage Caused by Alkali-Aggregate Reaction**

① Random reticulated cracks often occur over the entire surface of unreinforced concrete or concrete with a small amount of reinforcing steel. (Photo A. 62)

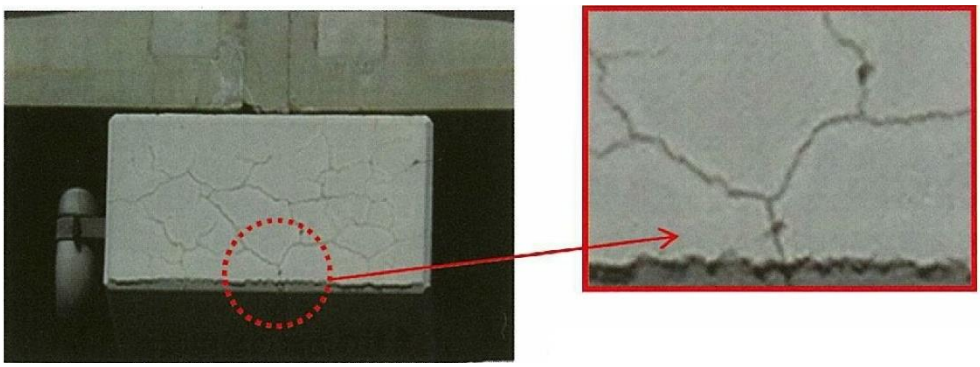


**Photo A. 62 : Damage to end face of pier beam section (Expand).**

② Since the internal expansion force acts in the direction of the smaller restraining force, cracks occur in the direction of the restraining force if there is an external restraining force. In reinforced concrete structures, cracks occur along the direction of the main rebar where the restraining force is large (Photo A. 63, Photo A. 64).

③ In PC structures, the cracks occur along the direction of the main bars where the restraining force is small.

In PC structures, cracks occur along the direction of the PC steel member where the restraining force is large (direction of prestress introduction). However, they do not necessarily occur directly above the main steel member.

Discoloration, white gel, and rust elution may be observed at the cracks (Photo A. 65), and the concrete surface may be raised and stepped at the cracks due to internal expansion forces.



**Photo A. 63 : Column section of a bridge pier**



**Photo A. 64 : Beam section of a bridge pier.**



**Photo A. 65 : Column section of a bridge pier (expand)**



**Photo A. 66 : Beam section of a bridge pier (expand).**

Crack widths are larger than those caused by drying shrinkage, as shown in Photo A. 66.

Cracks are more likely to occur in areas of the same structure that are exposed to a high moisture supply.

Since alkali-silica gel expands when it absorbs water, it is necessary to carefully inspect areas that are in direct contact with rainwater or leakage from expansion devices (Photo A. 67, Photo A. 68).



**Photo A. 67 : Damage to the side (outside) of the abutment.**

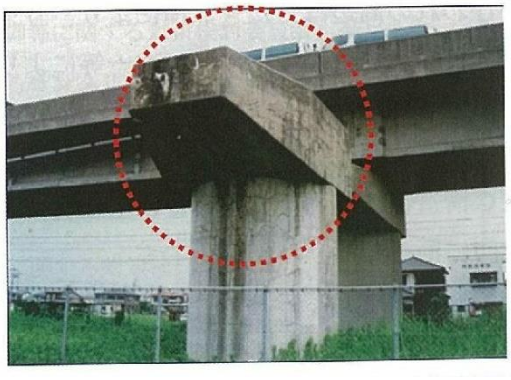


**Photo A. 68 : Damage to beam sections of piers without superstructure construction**

An example of a cracked rebar due to alkaline aggregate reaction in a pier beam shown in Photo A. 71 and Figure was reported.



**Photo A. 69 : Cracks in the beams of RC piers**

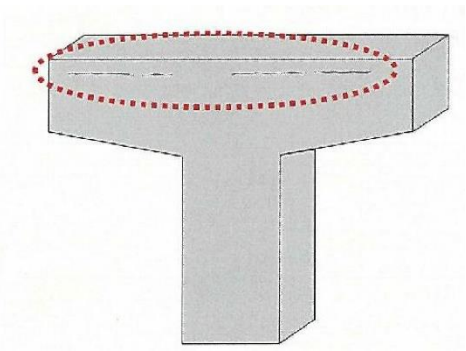


**Photo A. 70 : Cracks in the beams of RC piers**

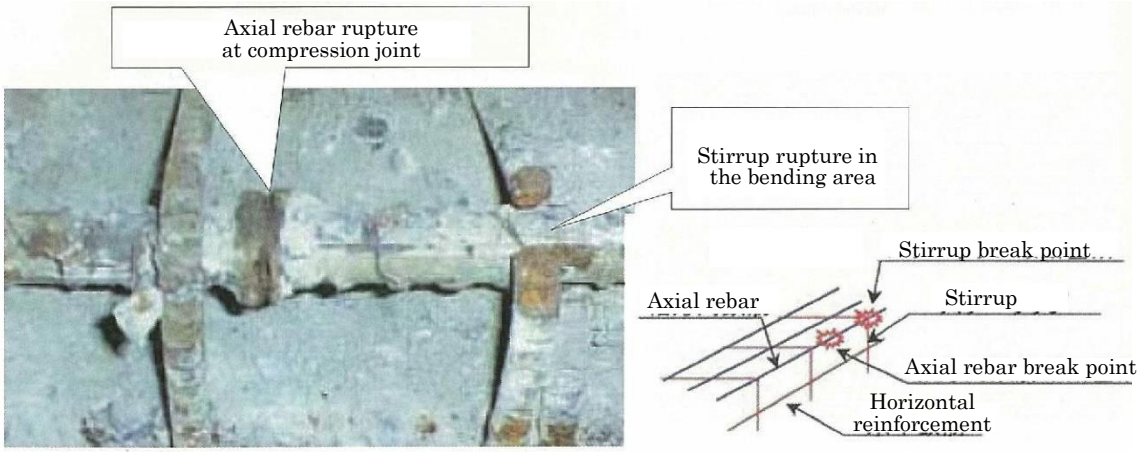



**Photo A. 71: Rebar breakage at pier beam section (from JSCE HP)**

**(3) Points to note when inspecting for alkali aggregate reaction**

① Observe the shape of the cracks and the presence or absence of exudates.

② Touch the cracks by hand to determine whether or not they are piled up.

③ Grasp the route of entry of moisture.

④ Check for floaters and delamination by tapping around the cracks, and knock off floaters and delamination in areas where third-party damage is anticipated, using a hammer or similar tool during the inspection.

⑤ Even unreinforced concrete can be subject to this problem.

⑥ Cracks occur along the direction of the main rebar, which has a large restraining force in RC structures, and along the direction of the PC steel member, which has a large restraining force in PC structures.

⑦ Cases have been reported in which steel bars were broken due to alkaline aggregate reaction. In such cases, it is necessary to conduct a detailed investigation by removing the concrete and observing the status of the rebar inside.

**(4) History of alkali-aggregate reaction**

**(5) Detailed investigation of alkali-aggregate reaction (ASR)**

For concrete that is suspected of alkali-aggregate reaction, the following detailed investigation methods should be used to confirm whether the concrete is affected by ASR and to establish a policy for repair, etc.

① Checking for the presence of reaction rims (annular or band-like discoloration areas at the periphery of the aggregate and at cracks inside the aggregate) on the fracture surface of the aggregate.

② Checking for the presence of reactive aggregate using a polarized light microscope, etc.

③ Checking the residual expansion of the aggregate

④ Method to examine the change in strength and Young's modulus

⑤ Measuring the amount of alkali in concrete

⑥ Test of ultrasonic propagation velocity of concrete (non-destructive test)

Core sample collection may damage the structure, so multiple use is not desirable.

In addition, when deciding on the location and position of the sampling site, the structural safety of the structure must be carefully considered.

In particular, a large amount of residual expansion (≧0.05%) indicates that ASR damage will continue in the future, so care should be taken to repair the damage.

### A5.2.2 Major Damages

#### A5.2.2.1 Cracking

The most common damage in concrete bridges is "cracking", which is the cracking of the surface of concrete members.
The inspection should be carried out to check for damage other than cracks, especially if any damage such as "leakage/free lime", "swelling", "delamination/exposed rebar", etc., occurs at the same time.
If any of these damages occur, they should be treated as a separate damage from the cracks.
If they occur, treat them as separate damage from cracks.

**(1) "Cracks" in members such as floor slabs and anchorage areas are treated differently from normal "cracks".**

① Cracks in floor slabs are treated as "floor slab cracks" and not as "cracks".
② Cracks in PC anchorage sections shall be treated only at the relevant section, while cracks in main girders and other structures that include such sections shall be evaluated at all elements except the relevant section.

**(2) "Cracks" in concrete reinforcement (e.g., seismic reinforcement) shall be evaluated under Category 3 (Concrete Damage) of "Damage to Repair/Strengthening Materials". In addition, "cracks" are also evaluated.**

In addition to the above, "cracks" in the superstructure and substructure should be entered by determining the crack pattern based on the location of the cracks and the form of crack initiation.
The following procedure is recommended for determining the cracking pattern based on the cause of cracks in the superstructure.

① Selection of girder type
Determine whether the cracks are common to PC and RC or limited to PC.

② Limitation of the cracking area
Determine whether the cracking occurs on the top or bottom flange of the main girder. Flange or web of main girder, lower flange or anchorage, or joint of connecting girders.

③ Limitation of cracking location
Cracks may occur at the entire girder, the center of a strut, 1/4 strut, a fulcrum, or the upper part of a bearing.

④ Direction of cracking
Crack direction: vertical, horizontal, bridge axis, perpendicular to the bridge axis, multi-directional (reticular), or total

⑤ Other
Gerber section (fulcrum): Pattern ⑦ applies.
If it is difficult to select from ① to ⑤, select the closest match from each item.

### A5.2.2.2 Cracks between webs of T-girder main girders

Cracks between the webs of a T-girder main girder, including the spaced slab sections, are treated as "slab cracks" (Figure A. 19).
In addition, cracks in the box girders of box girder bridges, hollow slab bridges and box girder bridges are treated as "slab cracks. In addition, cracks in the inner face of box girders, hollow slab bridges, and overhangs of box girder bridges are also evaluated as "slab cracks" (Figure A. 19).
Cracks in the webs and lower flanges of girder bridges shall be evaluated under ⑥ Cracks.

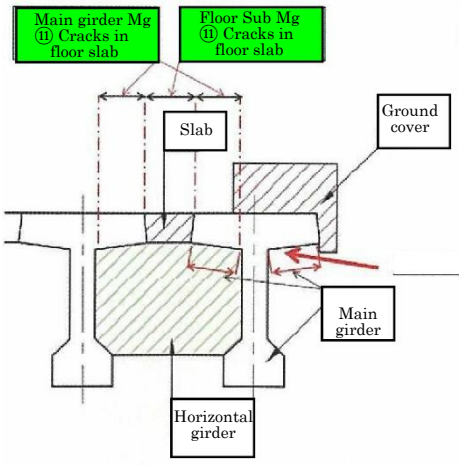



**Figure A. 19 : Between webs of T-girder bridges (including spanned sections)**

### A5.2.2.3 Spalling, exposed rebar and "floating

The main cause of "delamination and rebar exposure" is the progression of corrosion and expansion of the rebar due to neutralization (poor workmanship) caused by insufficient cover, leakage including anti-freezing agents, and clay damage, which causes the cover concrete to delaminate and the rebar to be exposed. In addition, the expansion of the gel of reactive aggregate due to ASR causes the covered concrete to flake off.
If steel or other materials are exposed on the concrete surface, it should be treated as "spalling and rebar exposure" and the nature of the exposed material should be noted. Foreign materials such as wood chips should be treated as "Other".

**(1) Relationship to other damage**

① "Peeling and exposed rebar" includes corrosion and rupture of exposed rebar, and is not treated as "corrosion" or "rupture" damage.

② Deformation and loss (collision scar) caused by collision or earthquake as well as delamination and exposure of rebar shall be separately treated as such damage.

③ Delamination and exposed rebar in floor slabs shall be included in this section in addition to "cracks in floor slabs".

④ Delamination and exposed rebar in seismic reinforcement members and PC anchorage areas shall be separately recorded in "Damage of repair/reinforcement materials" and "Abnormality of anchorage areas" in addition to this item.

The "floating" state is a state in which the surface of the concrete member floats and is not detached by tapping or other means. If the concrete is detached by tapping, it should be treated as "detached/exposed rebar.

### A5.2.2.4 Leakage/free lime' and 'leakage/water retention'

'Leakage/free lime' refers to leakage of water or lime exudates from joints and cracks in concrete. The presence or absence of dragon juice is an important factor in the assessment of free lime. Depending on the condition of the pavement, there may be a risk of corrosion of the reinforcing steel, etc. Therefore, inspect with caution.

**(1) Relationship with other damage**

① Precipitates observed due to water running on the concrete surface as a result of poor drainage, etc., are dealt with in item ⑰ 'Others'.

② Water leakage from the concrete surface or from expansion devices or drainage facilities, etc., which is not caused by the original drainage function, should be treated as 'leakage and stagnant water'. If leakage from drain pipes in floor slabs affects the corrosion of the main girders, etc., the damage is recorded as 'water injection and water retention'.

③ Damage to concrete that falls under other categories, such as cracking, swelling and delamination, should also be dealt with under the respective categories.

④ Leakage and free lime on slabs should also be dealt with in this item, in addition to 'slab cracks'.

### A5.2.2.5 Abnormality of anchorage

The term 'abnormal anchorage' refers to the state in which water is found in cracks in the concrete

at the anchorage of the PC steel, or in which the PC steel and concrete are separated from each other. treated separately as those damages as well.

Fixings include main girder fixings (mainly longitudinally tightened), transverse girder fixings (transversely tightened) and floor slab transverse fixings as well as cable fixings on special bridges. Damage to these fixations is differentiated into PC longitudinal fixations (Category 1), transverse fixations (Category 2) and fixations of outer cables (Category 4).

In addition, any cable fixations on special bridges, such as cable-stayed bridges, extrados tachibana, Nielsen bridges and suspension bridges, are dealt with in Classification 3 'Other'.

## A5.3 Inspection of Concrete Bridges and Focus Points

### A5.3.1 Basics of inspection

**(1) Identification of damage such as cracks, exudation of free lime or rust juice, delamination, spalling, exposed rebar, etc.**

Visually inspect the damage (Photo A. 72) and record it. Do not overlook even minor damage in a salt-affected environment. In a salt-affected environment, even minor damage should not be overlooked.



**Photo A. 72 : Cracks in the lower flange of PC girders**

**(2) Identification of damage requiring first aid measures**

Damage that may cause damage to third parties should be knocked off with a stone hammer or the like (Photo A. 73 : Rebar exposed at the drainage at the tip of the overhanging slab (after knocking off)



**Photo A. 73: Exposed rebar at the overhanging floor slab tip drainage (after tapping off)**

**(3) Understanding the Environmental Conditions of the Structure**

Pay attention to salt damage in coastal areas and mountainous areas where spraying of anti-freeze is expected in winter (Photo A. 74).

(4) Assess the overall deformation, settlement, and sway of the structure.

Photo-6.34 Viaduct by the seashore



**Photo A. 74 : Seaside viaducts.**

Look at the entire bridge from a distance (Photo A. 75) and check for any abnormalities in the ground cover and abutment parapet passages. Check the gap between the abutment parapet and the main girder.

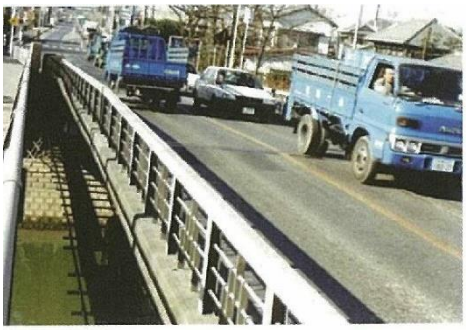


**Photo A. 75 : Distant view from bridge oblique slope.**

### A5.3.2 Main Girder Focused Points

#### A5.3.2.1 Main Girder Cracks

The following sections describe the cracking damage in reinforced concrete (RC) and prestressed concrete (PC) main girders at different locations where structural damage is most likely to occur.

(1) Centre of main girder support (Crack pattern ①)

The main steel members are arranged in a concentrated manner around the lower edge of the main girder at the location of the maximum bending moment due to the wheel load (Figure A. 20).

Note that PC girders generally do not allow bending cracks (Photo A. 76).

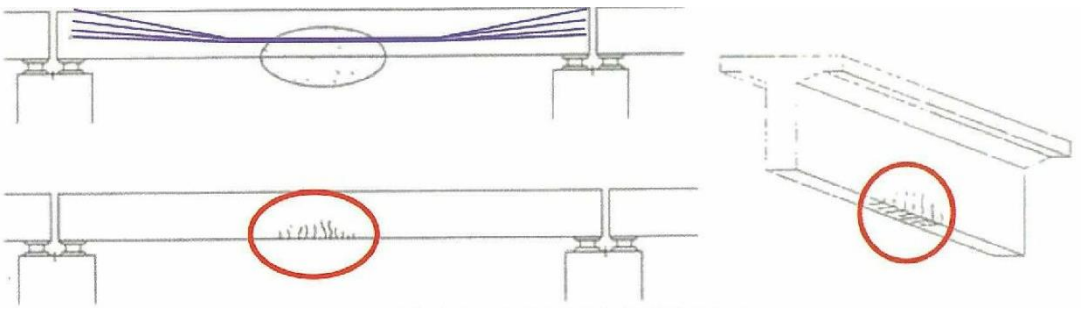


**Figure A. 20 : Bending cracks in the lower edge of the main girder**

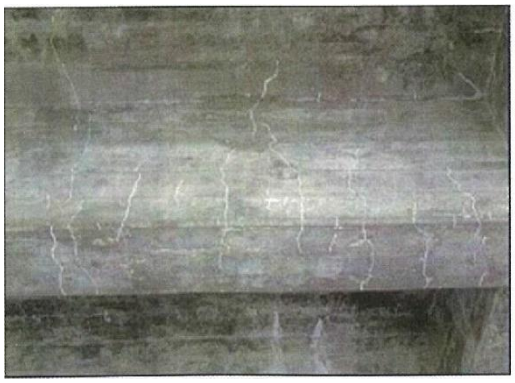


**Photo A. 76 : Bending cracks in the center of the main girder supports**

(2) Near 1/4 of the main girder support (cracking pattern ③)

Be careful of diagonal cracks in girders with large shear forces and thin web thicknesses. Also, pay attention to the bending up part of the main bar in RC girders (Figure A. 21, Photo A. 77, Figure A. 22).

Diagonal cracks on the fulcrum and abdomen near the fulcrum (crack pattern ④)

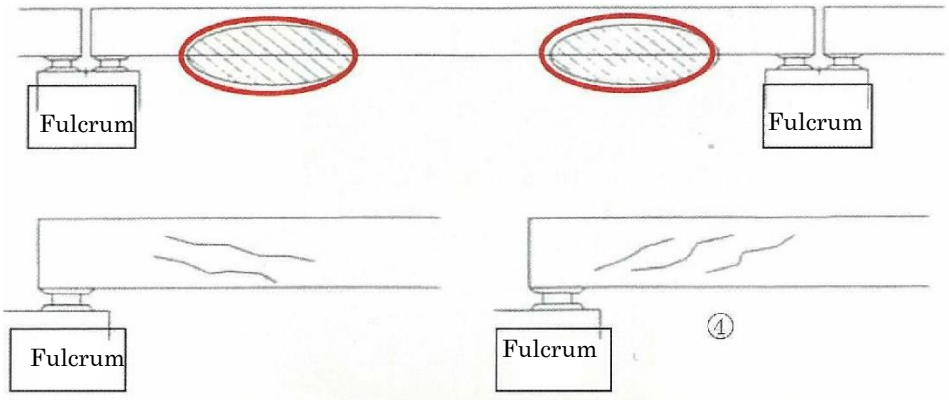



**Figure A. 21 : Cracks along PC steel (left) and shear cracks ④ (right) girder oblique slope.**



**Photo A. 77 : Diagonal cracking of the main girder due to shear forces ④ (fulcrum on the right)**

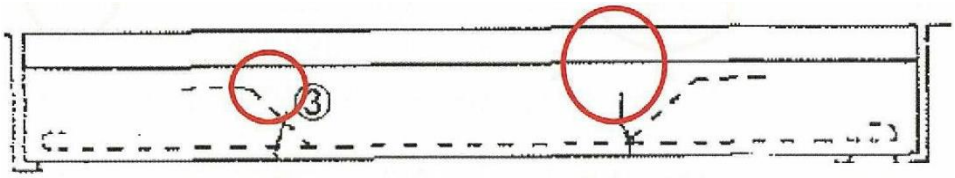



**Figure A. 22 : Cracks in the main rebar bend-up of RC girders (crack pattern ③)**

### A5.3.2.2 Cracks around the bearing (Crack pattern ⑤, ⑥)

The cracks are where the reaction force on the upper part of the girder is concentrated, but also where the steel is densely packed and the concrete placement is prone to honeycomb and other construction defects. Focus on the intermediate girders of continuous girders, the underside of the main girders, the mortar on the footrests, and the area around the girders. In addition, rainwater and sand can easily accumulate, and functional failure and deterioration of the bearings should also be noted (Figure A. 23, Photo A. 78, Photo A. 79.).

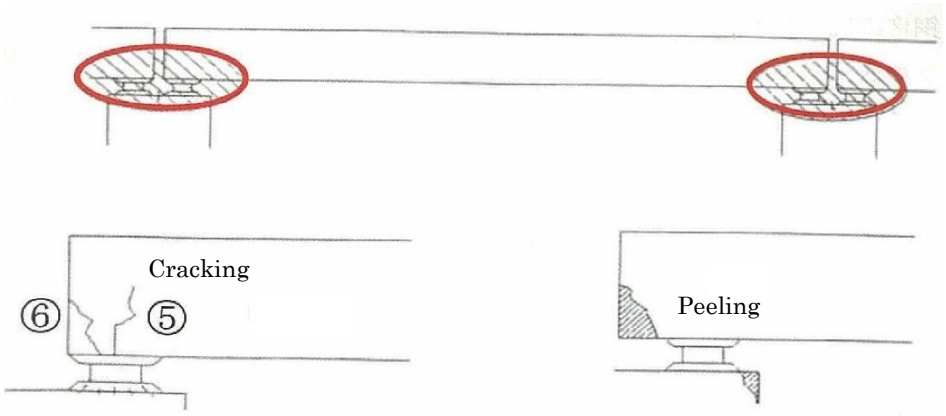



**Figure A. 23 : Damage (cracking, peeling) occurring in the bearing periphery**



**Photo A. 78 : Cracks in the periphery of the bearing**



**Photo A. 79 : Exfoliation of the bearing periphery (girder ends)**

### A5.3.3 Damage Characteristics of Concrete Bridges by Structural Type

#### A5.3.3.1 PC bridges

Damage specific to PC bridges is shown in Figure A. 24 : Unique damage occurring on PC bridges.Figure A. 24, with the exception of cracks in the main girders.

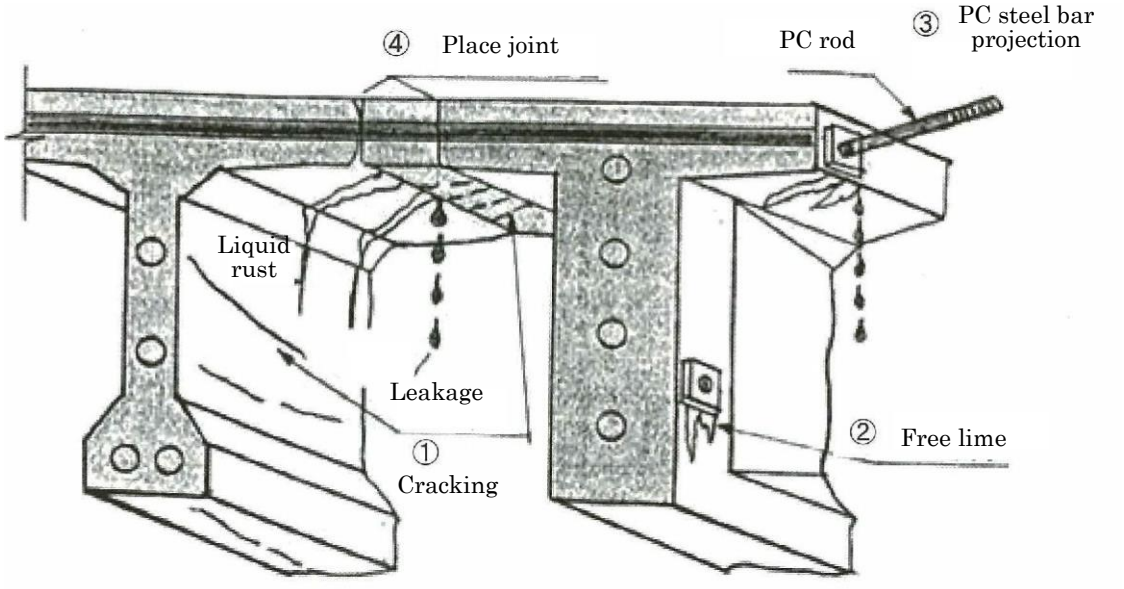



**Figure A. 24 : Unique damage occurring on PC bridges.**

① Cracks along PC steel members and cracks near anchorage areas

・Cracks along PC steel members and cracks near anchorage points caused by rainwater penetration from the bridge surface into sheaths that have not been filled with grout, which then freezes and expands.

・The cause of damage is thought to be when grout injected before the grout hardens freezes.

② Free lime and rust juice in the protective concrete behind the PC steel members.

・If free lime is generated from these cracks, it is considered that rainwater seepage from the bridge face has flowed through the sheathing, causing leakage and elution of free lime.

・In particular, if free lime with rusty juice is eluted from the cracks, corrosion of the PC steel is a concern, and a detailed investigation is required.

③ Rupture and protrusion of PC steel

・If the deformation progresses further, PC steel rupture, protrusion of PC steel rods, and concrete separation due to expansion pressure caused by rebar corrosion may occur, so care should be taken.

④ Leakage and water infiltration from joints in the padded slab section

The penetration points of rainwater on the bridge surface are as follows.

・The main cables should be connected to the upper edge of the main girder at the anchorage.

・To the cables, at the joints between the packed slab and the main girder.

・The cable may flow into the cable at the joints between the girder and the main girder. Figure A. 25 shows the girder configuration of a PC bridge.

It is necessary to confirm in advance whether the waterproofing works applied or not.

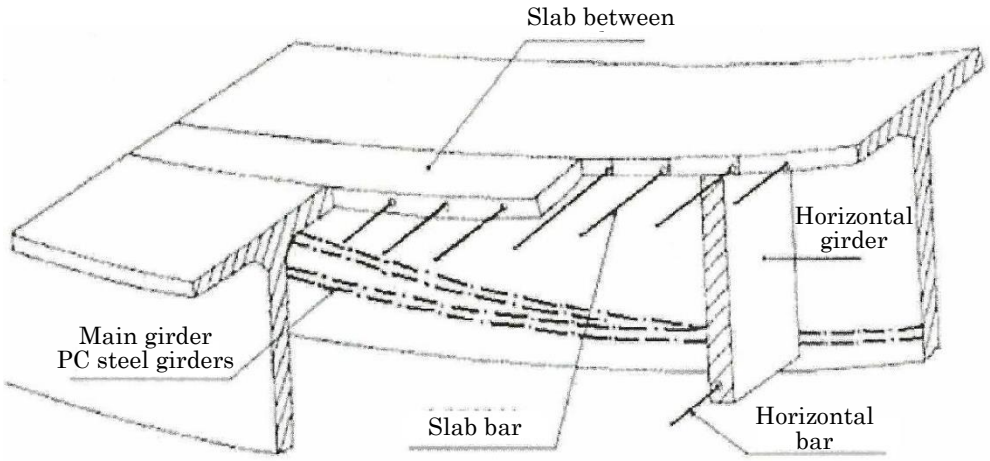



**Figure A. 25 : Girder configuration diagram for PC bridges**

### (1) Cracks in PC bridges

① Side of main girder (web)

Cracks along the main girder cables (Photo A. 80) are thought to be caused by rainwater, road surface water, etc. that have percolated into the sheath over a period of time and frozen in the hollows in the sheath due to insufficient grouting. In this case, rust juice, free lime, etc. due to leakage occur (Photo A. 81), so care should be taken.



**Photo A. 80 : Cracks and free lime along the main girder sides (webs)**




**Photo A. 81 : Rust juice is identified**

In particular, as shown in Figure A. 26, post-tensioned T-girder bridges constructed before 1993 should be inspected with caution because the main steel members are likely to be anchored to the upper edge of the main girder.

In addition, it is necessary to inspect not only the upper edge anchorage but also the water infiltration path from the girder ends with attention.

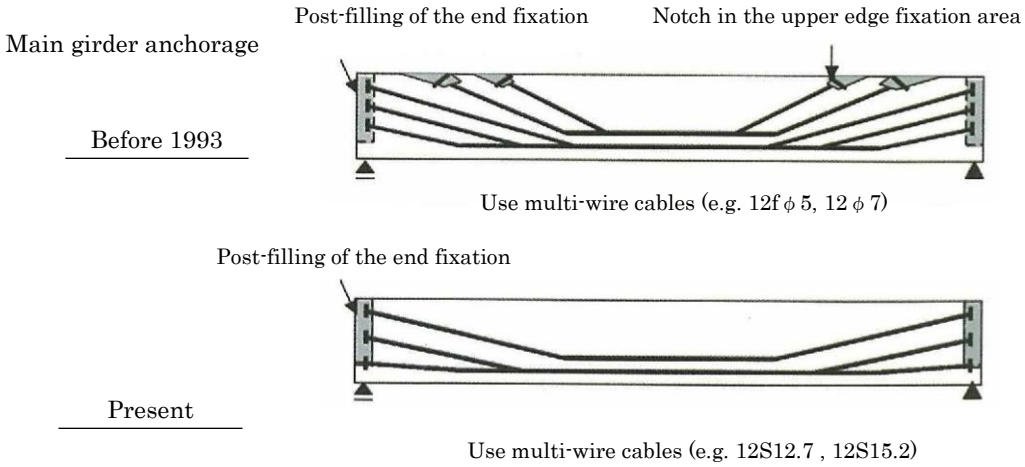



**Figure A. 26 : Changes in PC steel fixing methods (Upper edge fixation → Girder end fixation)**

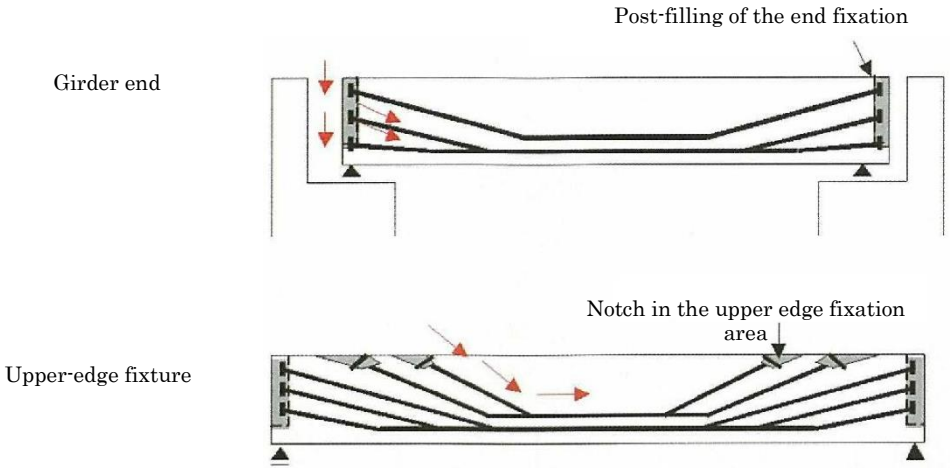



**Figure A. 27 : Changes in PC steel fixing methods Water ingress pathways (marked in red)**

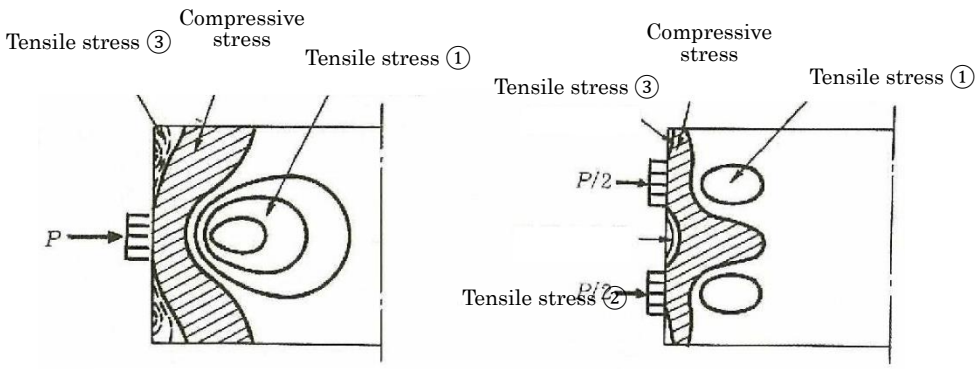
The location of the anchorage has a significant impact on the "anchorage abnormality" of the longitudinal anchorage of the PC steel.

However, it was determined that there was a risk of drainage from the bridge surface entering the fixture or sheathing through the post-filled concrete joint surface of the upper edge, leading to corrosion or rupture of the PC steel. When identifying the cause of damage, the year of construction should be noted. (Figure A. 28)

② Cracks near the anchorage area

Figure A. 28 shows the stress state of the PC steel at the anchorage point at the end of the girder. Large stresses are concentrated at the anchorage area, and the cracks near the PC steel anchorage area and damage along the PC steel should be noted.

In both Photo A. 82 and Photo A. 83, it is presumed that cracking stresses occurred between parallel anchors, causing the cracks. It seems that the reinforcement bars were insufficiently placed to resist the local stresses occurring at the backs of the anchorage bars.




*Source: Concrete road bridge design handbook*

**Figure A. 28 : Stress intensity lines due to concentrated loads in the fusing zone.**



**Photo A. 82：Cracks in the web of PC box girder bridges extending horizontally from the girder ends.**



**Photo A. 83：Cracks in the web of a PCT girder bridge extending horizontally from the girder ends.**

### (2) Free lime and rust at the anchorage of PC girder

① Horizontally tightened fixing section of floor slab

Rust juice is generated in the concrete at the anchorage area of the floor slab. If the anchorage hardware is exposed due to insufficient concrete cover, corrosion progression of PC steel and other materials is also possible, so careful inspection is especially necessary (Photo A. 84).

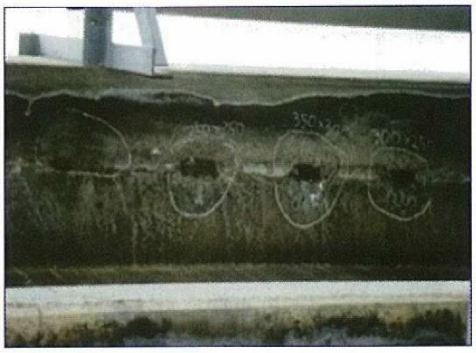


**Photo A. 84：Fixtures at the end of overhanging slabs**

② Horizontal girder anchorage area

Rainwater can penetrate through the joints and cracks in the backfilled concrete at the anchorage area of the PC copper material, causing cracks, peeling, and swelling in the concrete (Photo A. 86). In addition, if grouting is defective, rainwater and other water may seep in from the anchorage area, causing free lime, juice, etc. to seep out and corrode the PC steel. (Photo A. 85)



**Photo A. 85 : Corrosion of transverse girder cross-tightened PC steel**

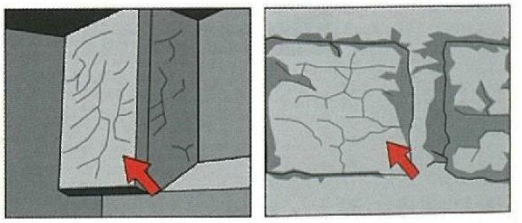


**Photo A. 86 : Cracks in the anchorage of transverse girders**

**(3) Examples of P C steel bar breakage and protrusion**

① Lateral clamping of floor slab

When PC steel rods are used for horizontal fastening of floor slabs, there is a high risk of PC steel rod rupture and protrusion in areas where grout filling is defective. . Since brittle steel bar rupture occurs in corroded or otherwise damaged sections of PC steel bars, sufficient attention must be paid to this issue, including the assumption of third-party damage (Photo A. 87).

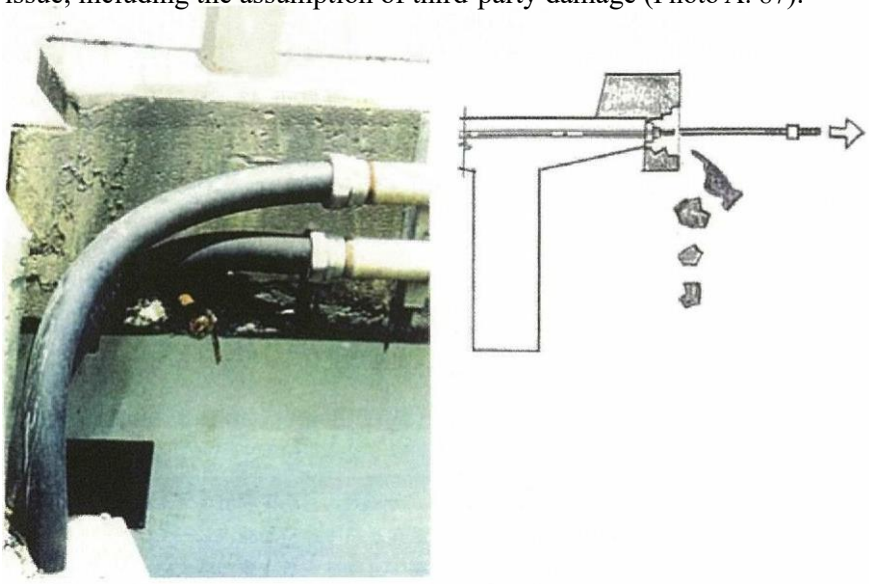


**Photo A. 87 : Protrusion due to rupture of floor slab cross-tightening steel bars**

② Horizontal girder cross-tightening section

PC steel bar in the cross girder was broken and fell to the bottom edge of the pier (Photo A. 88),



**Photo A. 88 : Cases of PC steel rods falling to the bottom edge of piers**

### (4) Leakage and Rust at Cast-in-Place Joints

Leakage of bridge surface water from the cast-in-place concrete joints of the main girder slab piling (Figure A. 29) caused free lime and rust juice (Photo A. 89).



**Photo A. 89 : Spalling of concrete at spacing.**

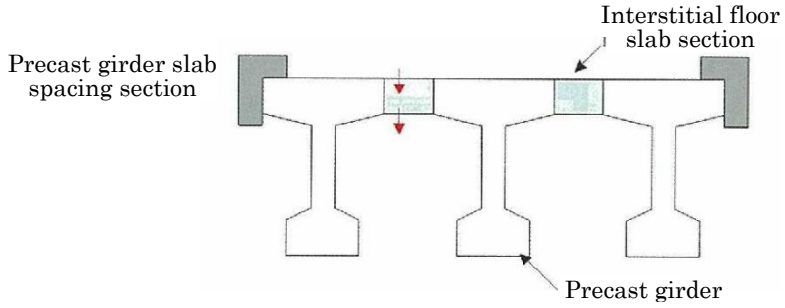



**Figure A. 29 : Leaks at main girders and location joints.**

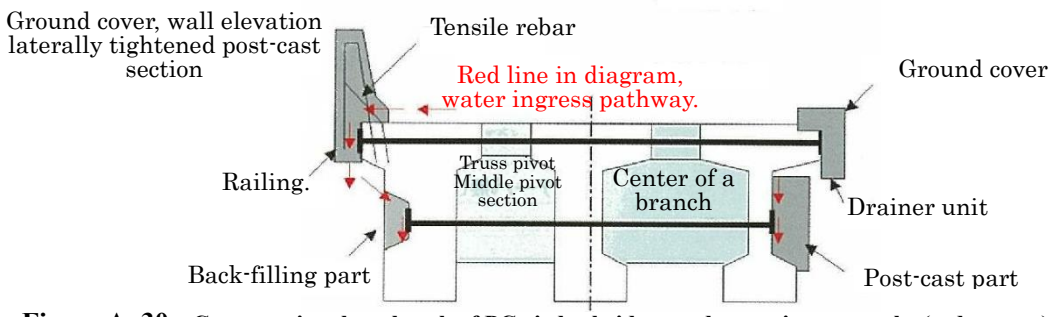



**Figure A. 30 : Cross-sectional steelwork of PC girder bridges and water ingress paths (red arrows).**

The cross-sectional shape of a PC girder bridge is composed of braced main girders installed in parallel, combined with poured-in-between concrete (currently uplifted slab).
For this reason, the poured-in-place concrete section should have
① The upper flange of the main girder. (2) The joint between the main girder and the padding is vertical.
② There is no connecting steel bar (insert bar) between the main girder and the padding.
③ There is no axial reinforcement in the spacing.
④ Structural weaknesses such as large spacing between the horizontal tightening bars (1 m between the horizontal tightening bars).

There have been reports of cases where the adhesion between the upper flange of a T-girder and the padding is broken by the impact load of a large vehicle, causing the poured concrete to fall.
① Cracks in the right-angled direction of the padding concrete
② Leakage and free lime precipitation from the above cracks
Water leakage and free lime precipitation from the above cracks.

(5) Structure of the slab
The history of the structure of the slab is shown in Figure A. 31 to Figure A. 33 , they show the structure of the spacing slab, and Table A. 7 shows the specifications of the standard design of the Ministry of Construction.

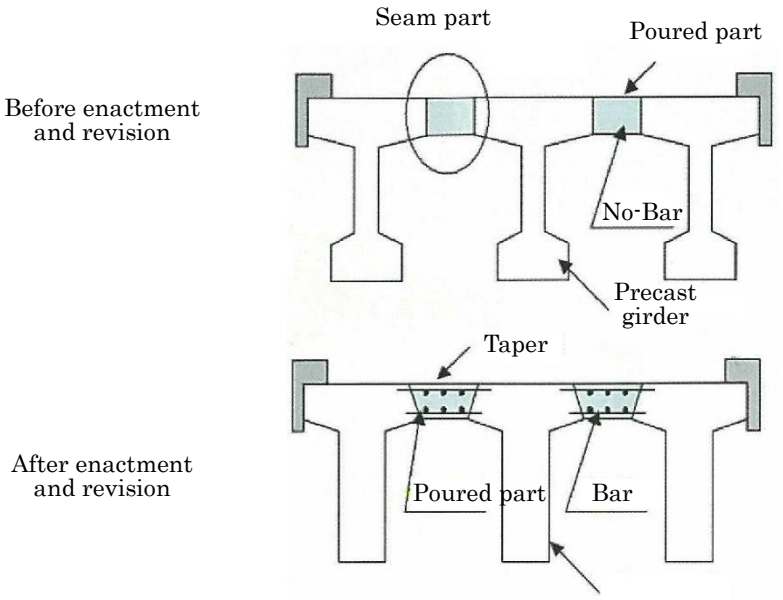



**Figure A. 31 : Reinforcement drawings for spaced floor slabs.**

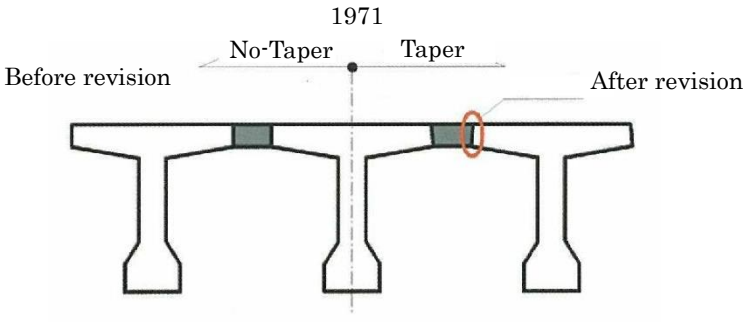



**Figure A. 32: Structural diagram of a Pre-tensioned T-girder spacing slab**

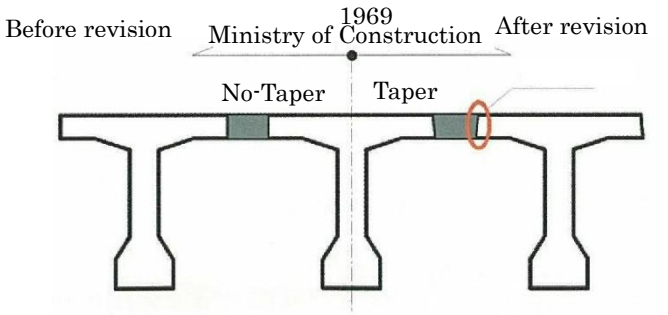



**Figure A. 33 : Structural diagram of a Post-tensioned T-girder spacing slab.**

**Table A. 7 : Ministry of Construction Standard Design**

| | Pretensioned T girder | Post-tensioned T girder |
|---|---|---|
| Enactment | 1971 years | 1969 years |
| Digit width | *750mm* | *1,200mm*、*1,500mm* |
| Top flange thickness | 160mm(Tapered) | 180mm(Non-tapered) |
| At intervals of one's work | 300mm<br>(circling land) | 250～600mm<br>(meridians) |
| Lateral tightening interval | Within 500mm | |

### A5.3.3.2 Hollow slab bridges

For hollow slab bridges, the inspection should focus on cracks and rutting in the pavement surface, cracks in the underside of the slab, leaks and free lime, exposed rebar and around drainage holes (located along the void in the underside) (Figure A. 34).

The sinking of the slabs is likely to be due to the failure of the cylindrical booster frame to lift during construction and the prescribed slab thickness, or to combined deterioration and sedimentation due to salt and frost damage from cracks in the slabs. (Photo A. 90)

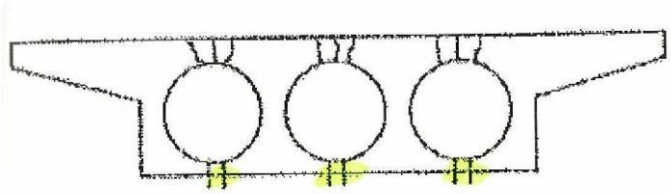


**Figure A. 34 : Cracks on top and bottom surfaces in hollow slab bridge sections**

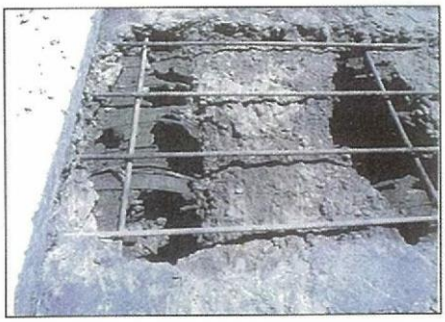


**Photo A. 90 : Sinking due to bedplate sedimentation over hollow voids in hollow slab bridges and pavements.**

Since the progress of deterioration cannot be confirmed directly under the pavement, damage is estimated by cracks in the pavement or water leakage from drainage holes on the underside of the girder. A CCD camera can be inserted through the drainage hole to indirectly confirm the damage from the image.

The construction of hollow slab bridges involves burying cylindrical formwork during concreting and making the main girder members partially

hollow in order to reduce weight. It is essential that the cylindrical formwork is fixed and installed so that it does not lift up during the concrete pouring (Photo A. 91). During inspections, the cylindrical formwork Should be checked to see if drainage holes have

been installed and if they have been opened.



**Photo A. 91 : Construction of hollow bed version of bridge (reference)**

### A5.3.3.3 Other bridges

**(1) Bridges with cantilever hinges**

Concrete cantilever hinge sections are prone to localised stresses due to sudden changes in the soil girder cross-section, and attention should be paid to the occurrence of cracks at the main girder corner corners and near the bearings (damage near the bearings where the hinge has lost its function). The extent of this type of damage must be carefully ascertained as it concerns the safety of the structure. Examples of damage at the Gerber hinge are shown in Figure A. 35, Photo A. 92 and Photo A. 93, and examples of reinforcement are shown in Photo A. 94.

It should be noted that there was an example of a support member falling off at a location where reinforcement of a cantilever girder was implemented, which was found during a periodic inspection in 2010 and was in an extremely dangerous condition. In the inspection, the integrity of the members constituting the reinforcing structure should be carefully checked.

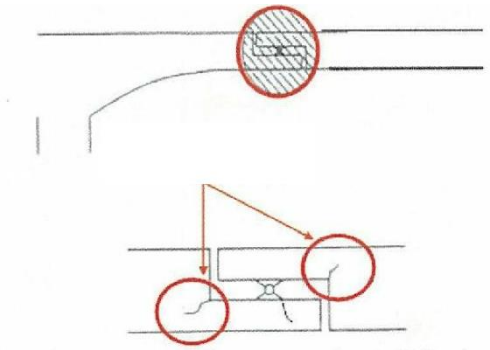


**Figure A. 35 : Damage occurring around the gerber hinge area**

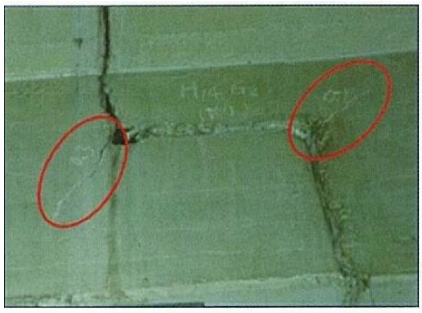


**Photo A. 92 : Gerber hinge sections: Damage at main girder corner corners.**



**Photo A. 93 : Gerber hinge sections : Damage to the receiving girder section (front of the bearing).**



**Photo A. 94 : Example of reinforcement of a gel bar section**

(2) Bridges with precast PC slabs in the footway section

Precast PC slabs used for the superstructure of walkway sections sometimes show exposed rebar due to insufficient cover at the time of slab fabrication (Photo A. 95). Along with the progression of the reduction of the province due to corrosion of the reinforcement, these damages require repair with a view to renewal or replacement after considering safety and economic efficiency.



**Photo A. 95 : Exposed rebar in precast slab bridges (renewal, replacement, component replacement).**

## Appendix 6 Check Points on Substructure and Foundation

### A6.1 Preface

The substructure of a bridge consists of a combination of abutment and pier, each of which is divided into a main body section and a foundation section, as shown in Figure A. 36.

Substructure can be classified into pier, abutment and foundation, and as most piers and abutments are made of concrete, they are treated as damage to concrete members. In terms of damage to the substructure, damage to concrete is described in Appendix 5 “Check Points on Concrete Bridge”. Therefore, the explanation is omitted from this chapter.

Regarding to abnormality of abutment, if abutment is constructed on soft ground and then subjected to unbalanced loading such as embankment on the rear side, lateral flow of the abutment, bulging of the surrounding ground and settlement may be occurred.

Settlement, movement and tilting' and 'scour' - damage specific to substructures - are dealt with in foundation. There are three types of foundation: direct foundation, pile foundation and caisson foundation, therefore effect of damages are different due to foundation types.

Liquefaction and lateral flow phenomena may be occurred as a result of earthquake-induced ground deformation, which may cause foundation settlement, movement and tilting. Such phenomena can affect not only the foundation and substructure but also the superstructure. In addition, by the rapid scouring during floods, settlement, movement and tilting of pier will be caused. Although this is generally referred to as 'piers tilting due to scour', but this is treated as 'scour of the foundations'. This specific treatment is understood and appropriate inspection shall be carried out. In the Japanese Guideline, the scour is treated as a cause of damage.

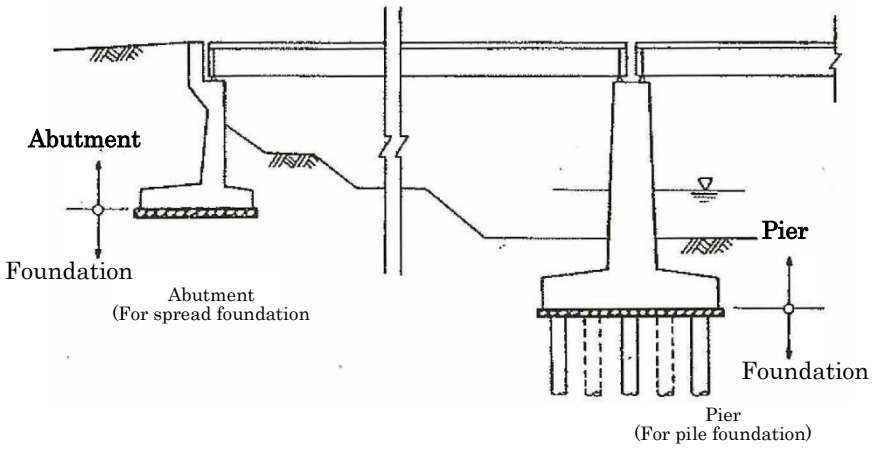



**Figure A. 36 : Substructure concept**

## A6.2 Substructure damage

### A6.2.1 Inspection basics

#### A6.2.1.1 Characteristics of damage

Damage to the substructure is caused by live load, dead load, earth pressure, hydraulic pressure, wave pressure, lateral ground flow, settlement, earthquake-induced movement, settlement and tilting. These damages often show abnormality in the superstructure, and the effect on not only substructure but also superstructure should be checked during inspection. By contraries, if anomalies are found on the bridge external surface, the substructure should be checked for abnormality. If there are some abnormalities, a detailed investigation should be carried out.
It should also be noted that if the superstructure shows damage such as 'cracks ', 'corrosion' or 'delamination/exposed rebar' caused by salt damage, frost damage or alkaline aggregate reaction, it is possible that damage under the same environment may also be found in the substructure.

### A6.2.2 Main damage to substructure and foundations

The main types of damage of substructure is 'cracks ', 'delamination/exposed rebar', 'leaking/free lime', 'spalling', 'water leakage' and 'discoloration/deterioration'. The main types of damage to foundation is 'settlement/movement/tilting' and the specific damage of 'scouring'.

#### A6.2.2.1 Crack

Some cracks of substructure affect to the structure and shape. The cause of the crack can generally be estimated by the direction and regularity of the crack. The inspection shall be conducted taking into account of these causes.

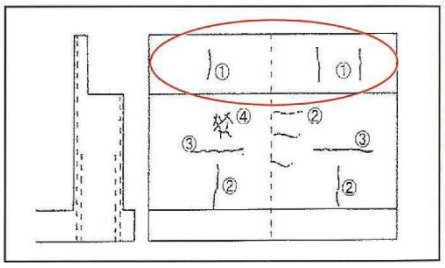



**Figure A. 37 : Cracks on abutment**

[Cracking pattern and cause].

① Regular vertical crack

Parapet is damaged by temperature stress, drying shrinkage, vehicle load and poor workmanship (Figure A. 38).

② Vertical crack at joint

Regular vertical crack is occurred at horizontal construction joint of the wall base or column. Vertical construction joint also have equally spaced crack in the horizontal direction (Figure A. 39).

Both are caused by thermal stress and drying shrinkage due to restraint at the construction joint. In the case of abutment, the crack passing through the abutment may cause the water leakage from the back and contribute to reinforcement corrosion.

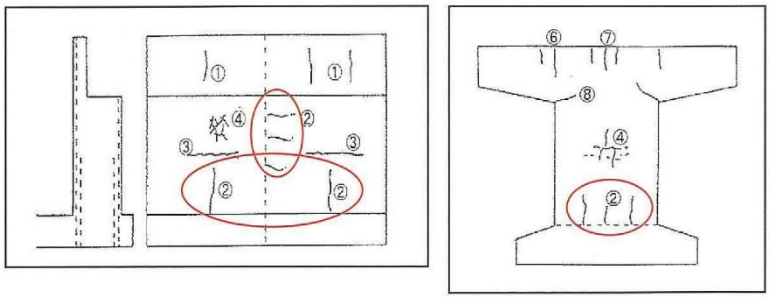


**Figure A. 38 : Vertical crack in vertical wall and column**

③ Crack near down-stepped rebar

Horizontal crack are likely to occur during earthquakes in area where down-stepped rebar (Figure A. 39).

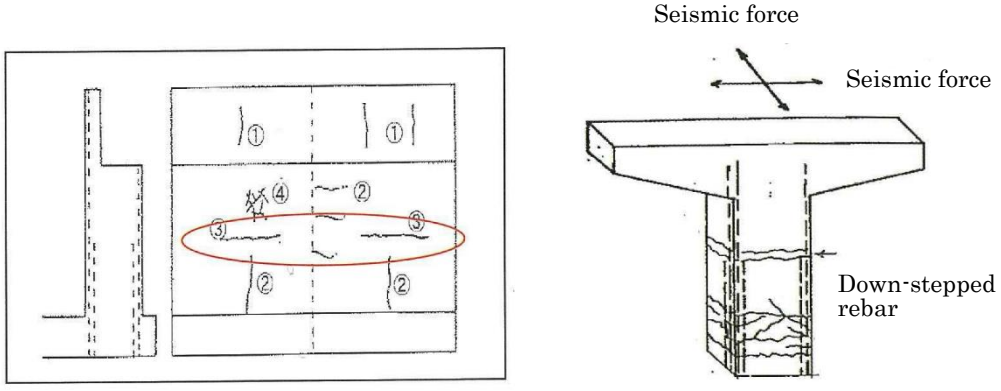



**Figure A. 39 : Typical crack in the frame due to earthquake**

④ Map Crack and Spider Web Crack

Due to the reinforcement ratio of substructure is small, the shrinkage of concrete is large and map crack and spider web crack is occurred frequently. Those cracks are also observed on concrete surfaces damaged by alkaline aggregate reaction (Figure A. 40).

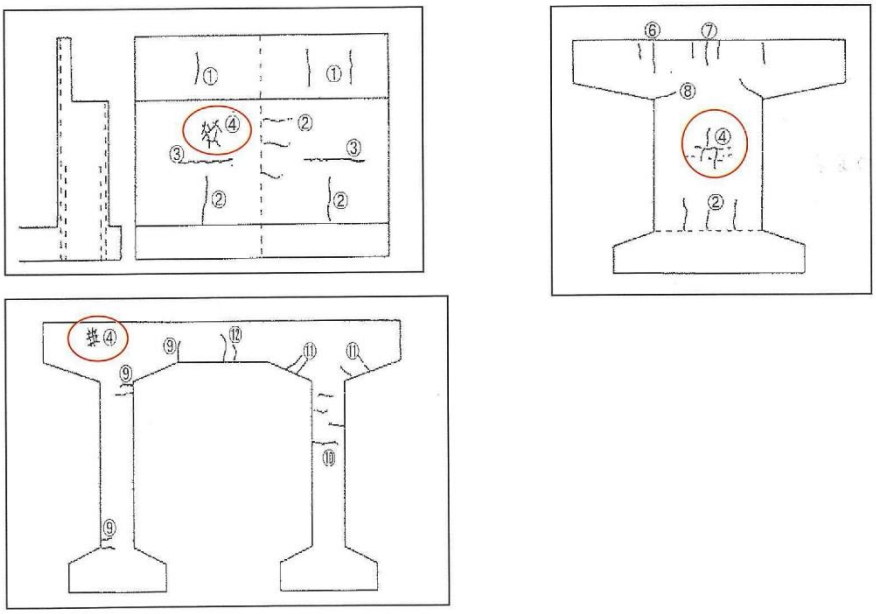


**Figure A. 40 : Map Crack and Spider Web Crack**

⑤ Crack near the underside of the bearing

Diagonal crack will be occurred near the bearing due to insufficient shear capacity (Figure A. 41). This may be caused by damaged, malfunction of bearing or insufficient rebar. The area around the bridge seat generally has a low amount of reinforcement, and horizontal forces due to earthquake and temperature change may cause large crack around the bridge seat.

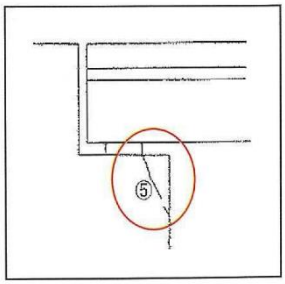


**Figure A. 41 : Crack on the underside of the bearing**

⑥ Crack of overhang root side

Crack may be occurred on the top surface near the root of T-shaped pier lateral beam which are directly subjected superstructure load. This may be caused by increased loading, creep by sustained load, lack of load bearing capacity by insufficient reinforcement, settlement or tilting of the foundation or settlement of the supporting structure during construction. It is more likely to occur in ramen piers with long transverse beam (Figure A. 42).

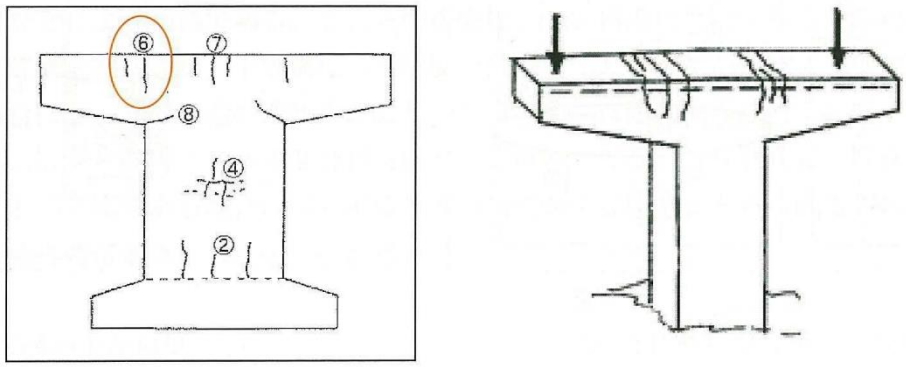



**Figure A. 42 : Crack of pier lateral beam**

⑦ Vertical crack at the top of pier centre

Vertical crack may be occurred at the top of the pier centre from the front to the top. This may be caused by insufficient bearing capacity against bearing pressure, temperature stress (internal restraint) and drying shrinkage (Figure A. 43).

⑧ Crack at underside of overhang root

Crack may be occurred at the underside of overhung root. This may be due to insufficient bearing capacity against bending moment caused by earthquake, insufficient compaction during concrete casting or (in the case of rapid casting) settlement after casting. (Figure A. 44)

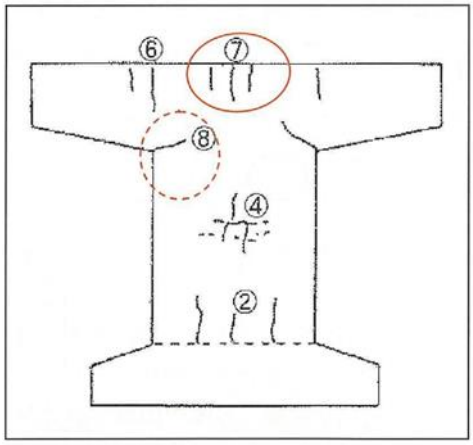



**Figure A. 43: Vertical crack at the top of the pier center, cracks on the root side of the overhang.**

⑨ Crack of top and bottom edge of column and all-around of haunch.

Crack may be occurred in rigid frame structure, due to unequal settlement, movement or tilting of the foundation. (Figure A. 43)

⑩ Crack all around the column.

Crack is likely to occur at corner and section change part (Figure A. 44, Photo A. 96) due to stress concentration. The cause is considered as stress concentration at the haunch, insufficient amount of reinforcement, foundation settlement and tilting due to scouring and consolidation settlement.

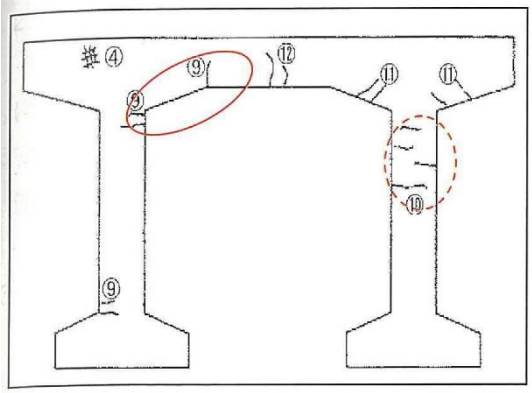



**Figure A. 44 : Crack of top and bottom edges of column and all around haunch, crack all around columns**



**Photo A. 96 : Crack of section change area**

⑪ Crack top of column and all around haunch

Crack may be occurred at corner due to unequal settlement, movement or tilting of foundation of non-static structure as shown in Figure A. 45 (Figure A. 46).

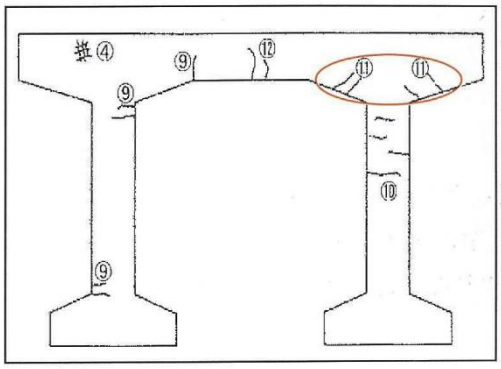
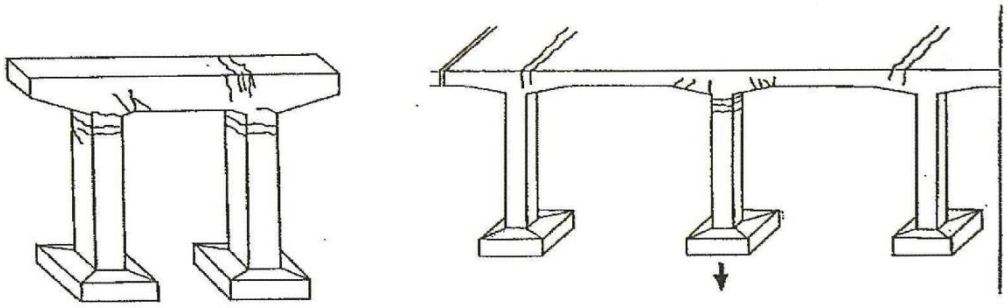



**Figure A. 45 : Crack of top and haunch of column**



a) Bridge transverse axis direction (Single footing foundation)

b) Bridge axis direction (Rigid-frame bridge)

**Figure A. 46 : Crack due to foundation settlement of rigid flame structure**

⑫ Crack on underside of beam centre

Crack is occurred on underside of beam centre where is directly loaded by the superstructure due to insufficient load-bearing capacity against bending moment or due to settlement, movement or tilting of the foundation (Figure A. 47,Photo A. 97).

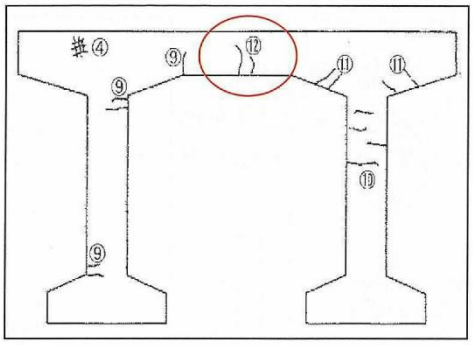



**Figure A. 47 : Crack of lateral beam center**

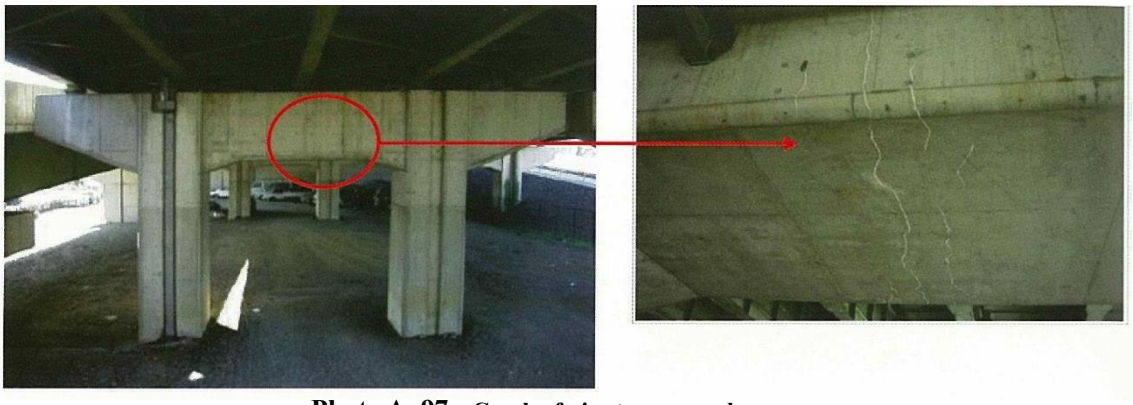


**Photo A. 97 : Crack of pier transverse beam**

### A6.2.2.2 Delamination, exposed rebar and float on concrete surface

If there is potential for third-party damage such as 'delamination/rebar exposure' and 'float', a damage test (hammering test) should be carried out and emergency measures (tapping off work) should be carried out for area identified as abnormal (Photo A. 98, Photo A. 99). In the case that corrosion of steel in concrete due to salt damage is considered, the progress of corrosion shall be checked.



**Photo A. 98 : Exposed rebar of bridge abutment**



**Photo A. 99 : Exposed rebar of bridge pier**

### A6.2.2.3 Leakage, free lime and ponding water

'Leakage and ponding water' should be investigated to determine whether it is affecting other damage (e.g. corrosion, free lime) and to determine the cause of the leakage, e.g. whether the bridge surface water proofing defect, leakage from expansion joint or rainwater blowing or seeping in from the side.

In the case of 'leakage and free lime' from crack as shown in Photo A. 100, remark whether there is only free lime or whether there is rust juice shall be recorded.

Precipitates such as those seen in alkaline aggregate reactions as shown in Photo A. 101 should be classified as 'Other' rather than 'Leakage/free lime'.



**Photo A. 100 : Free lime mixed with rust from pier column joints.**

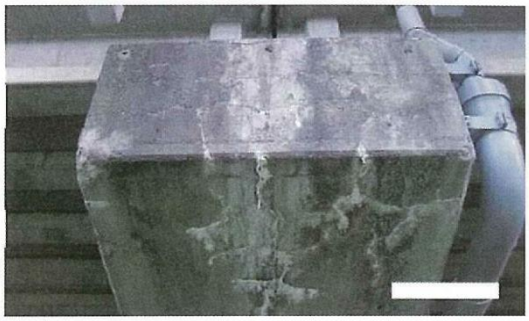


**Photo A. 101 : Deposits on piers (Alkali-aggregate reaction)**

### A6.2.2.4 Failure of bearings

See Appendix 4 “Check points on steel bridge”.

### A6.2.2.5 Settlement, movement and tilting

Settlement, movement and tilting are usually not visible only by visual inspection of the foundation. It is then often known from damage in other parts and components, generally in the superstructure, expansion joint, bearing, etc.

**(1) Lateral flow**

For bridge abutments on soft ground, the unbalanced loading of backfill etc. can cause plastic flow of soft layer, then abutment (including foundation) move laterally as shown in Figure A. 48. The pile head displacement of abutment, bearing failure, functional failure of expansion joint, crack of parapet, tilting of abutment and local buckling of the main girder are caused by lateral flow.

These lateral movement progress gradually, so the progress of the movement should be monitored carefully. There is also flow due to liquefaction of sandy ground.

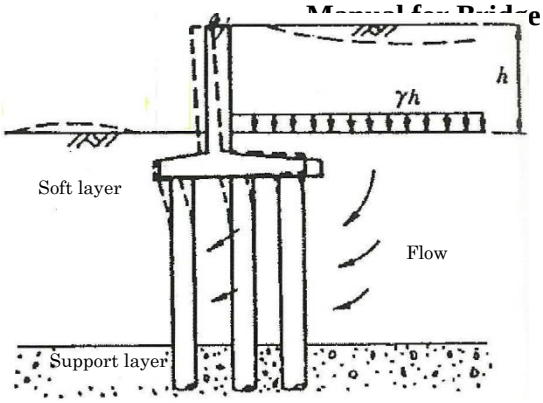



**Figure A. 48 : Lateral movement of abutment**

**(2) Consolidation settlement**

In the case that there is soft cohesive soil layer below the support layer, the direct foundation may settle and tilt as a result of consolidation settlement of the cohesive soil layer (Figure A. 49). In the case of pile foundations, the void of underside of the footing caused by the consolidation settlement of the surrounding ground are not serious problem at normal loading state, but during seismic load, the lateral resistance of the ground will not be as expected, increasing the likelihood of pile failure and consequent overturning of the substructure (Figure A. 50).

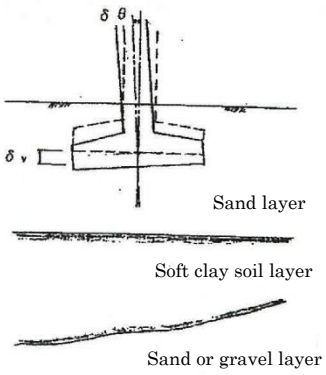



**Figure A. 49 : Consolidation of the ground beneath the support layer**

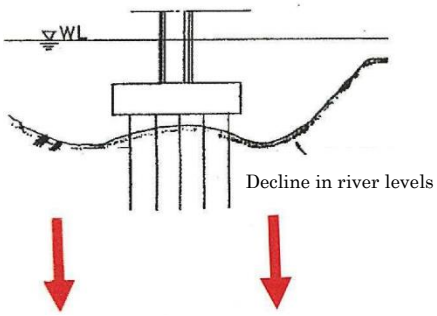



**Figure A. 50 : Void on the underside due to consolidation settlement of support layer**

In piled foundation through the consolidation layer and reach the bearing layer, negative friction around the piles due to consolidation settlement caused by groundwater elevation decrease or increase of acting load may cause failure of the pile body or failure of the pile tip ground, then resulting in settlement .

**(3) Loss of front side resistance of foundation**

Sloping ground is generally unstable and ground displacement and slip will be easily happened. Slope stability is particularly low when the slope of the supporting ground is in the same direction as the slope, when the surface layer is weak, or when groundwater go into the layer boundary. In addition, when the foot of the slope is eroded by river water or waves as shown in Figure A. 49 and Figure A. 50, the slope is likely to deform and the stability of the foundation is reduced

accordingly. Therefore, during inspections, it is necessary to keep in mind the three slope characteristics shown below and to note the deformations in the area shown in Figure A. 51 and Figure A. 52 to catch any early abnormality. An example of abutment movement is shown in Photo A. 102.

① Horizontal resistance on the valley side is lower than that of mountain side.

② Slope stability is low when water is seeping out.

③ The substructure that is eroded the slope by rainwater is likely to make displacement.

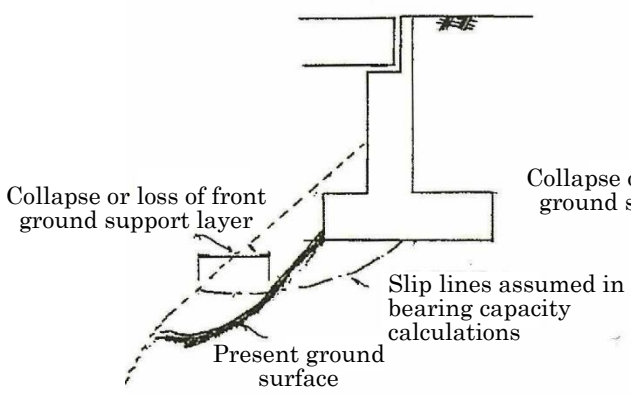



**Figure A. 51 : Inclination due to insufficient vertical force support**

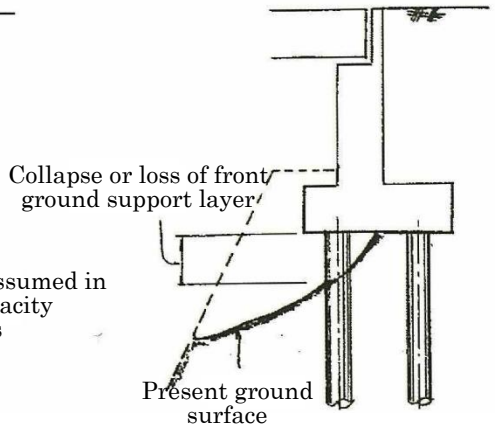



**Figure A. 52 : Inclination due to insufficient horizontal force**

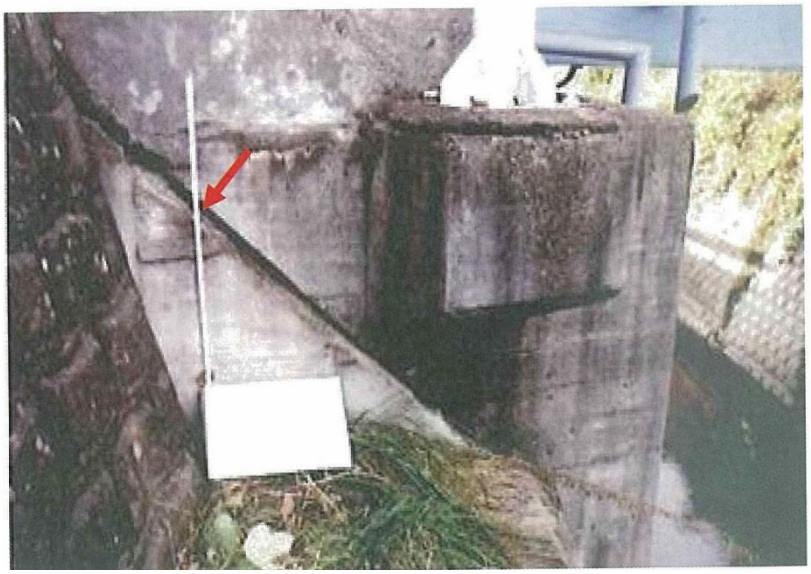


**Photo A. 102 : Moving abutment**

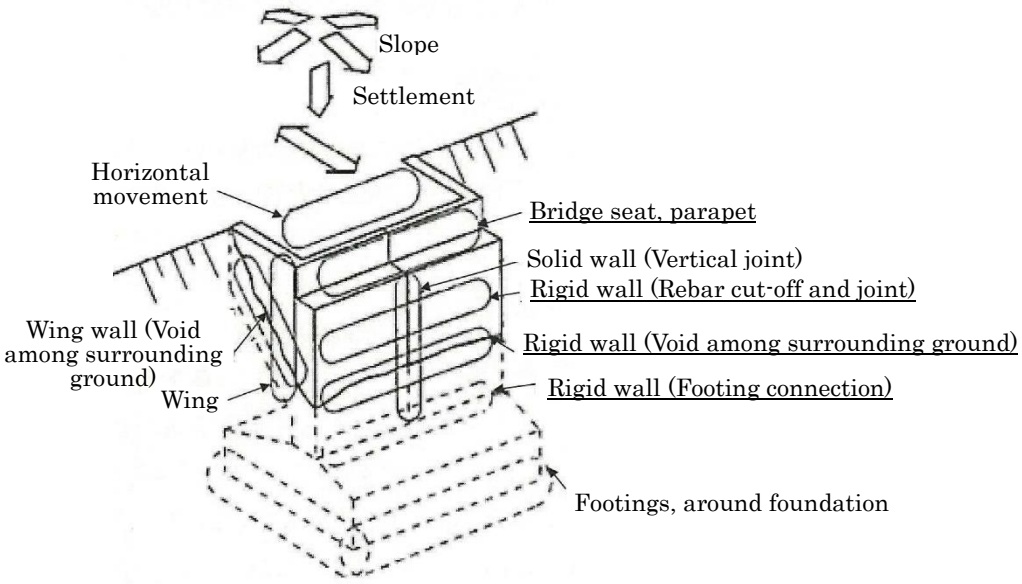



**Figure A. 53 : Settlement, movement and tilting of substructure ①**

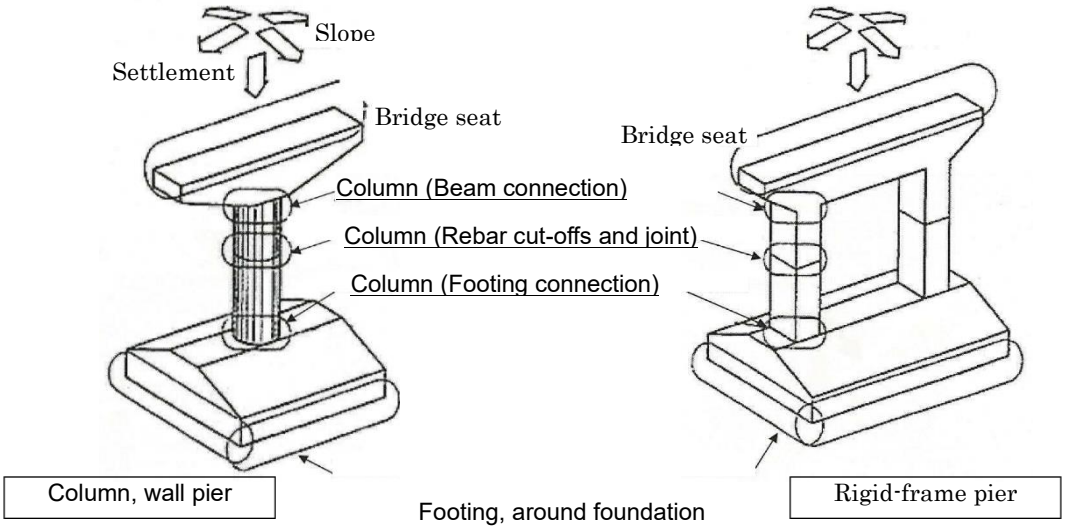



**Figure A. 54 : Settlement, movement and tilting of substructure ②**

### A6.2.2.6 Scouring

**(1) Damage caused by scour**

Scour is a condition in which the soil around the bridge foundation is eroded away and lost due to running water. Erosion of the concrete surface at the bottom of abutments and piers in contact with running water is not considered as 'scouring' but 'delamination/exposed reinforcement'.

Direct foundations are more significantly less stable than other types of foundations due to the effect of scouring. In particular, voids in the bottom of the footing can cause the pier settle and tilt. Deformation of entire bridge will be occurred and it will be unstable. This can be led to road close. It is therefore important to assess the scouring situation before settlement or tilting is occurred.

Scouring of the side of caisson-type foundation may cause settlement, movement, tilting and overturning of the substructure because the lateral resistance of the ground does not work as expected during earthquake. (Figure A. 55)

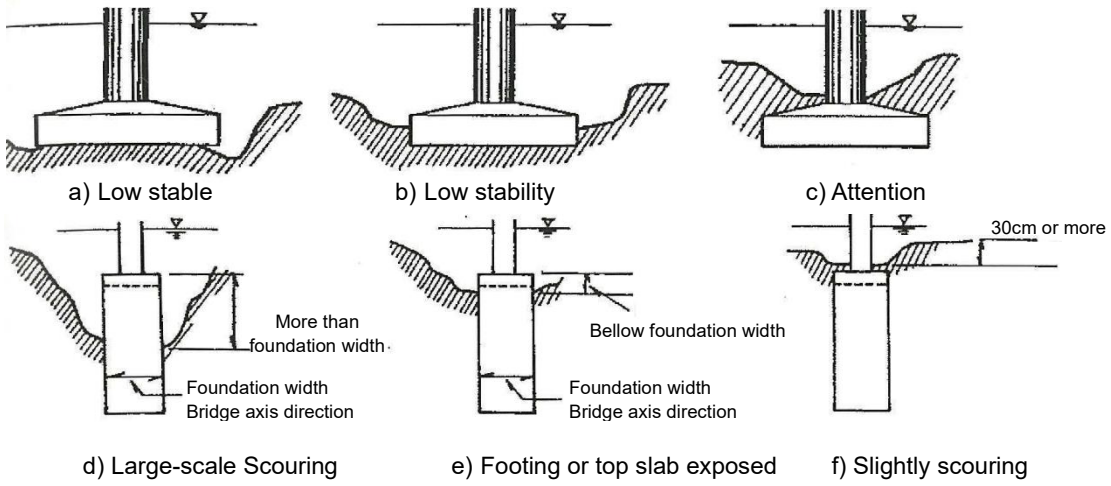



**Figure A. 55 : Abnormality around foundation due to scouring**

**(2) Assessing the condition against scour**

The following procedure should be used to assess the condition of the bridge foundation against scouring.

① Investigation of existing data.

Investigate existing data on river condition, river improvement history, water discharge records, ground condition and bridge condition (e.g. dimensions, foundation type, depth of rooting, etc.).

② Confirmation of site condition

The condition of the flow channel, abnormality of revetment and nearby structures, abnormality of back road pavement, etc. are to be observed.

③ On-site measurement

Visually assess shall be conducted for displacement of the bridge axis, inclination, settlement, crack and other abnormality of the substructure body, riverbed degradation around abutment and piers, exposure of the top surface of footings, progression of scouring depth, etc.

If necessary, the deformations should be identified by direct visual observation by diver or by underwater camera, etc.

## A6.3 Inspection of substructure and focus points

### A6.3.1 Consideration of substructure inspection

#### A6.3.1.1 Entire bridge

By the view of all over the bridge from a distance and check for any abnormalities (Photo A. 103 - Photo A. 105).

① Are there any deformities such as tilting or settlement of the piers or abutments?

② Are there any settlement or gap in the back embankment?

③ Is there any change between abutment and front revetment?



**Photo A. 103 : Anomalies in longitudinal alignment (Inclination for the bridge transverse axis)**

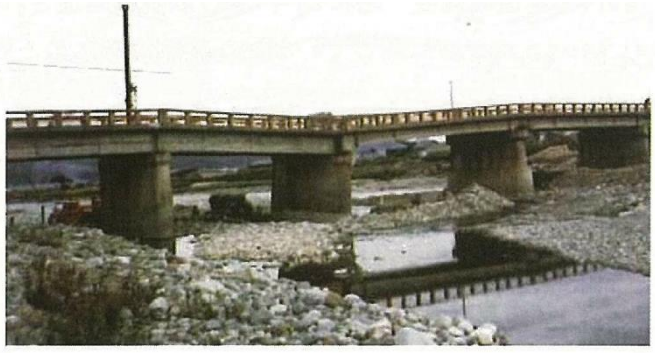


**Photo A. 104 : Deflection of superstructure due to settlement of substructure**



**Photo A. 105 : Deflection of superstructure observed in handrail**

### A6.3.1.2 Abutment and pier

**(1) Considerations focused on members**

① If there is damage in the seismic reinforcement section (steel plate-wrapped or concrete-wrapped section: Photo A. 106, Photo A. 107), the section/component category 'repair/reinforcement material' does not exist in the inspection procedure, and is indicated by the name of the member such as breast wall, vertical wall, column/wall section or beam section where the reinforcement section is located.

② The edge widener is the 'bridge fall prevention system' of the bearing section. However, edge wideners that are integrated with abutments or piers at the time of new construction are not included in the system.

However, edge wideners that are integrated with abutments or piers at the time of new construction may have the same name as the name of the abutment or pier member.

③ 'Bridge fall prevention system' is a generic term that includes displacement limiting devices other than edge wideners and belongs to the bearing section, not the abutment or pier.

**(2) Points to note with regard to damage**

① Damage in areas that have been repaired or reinforced (repaired/reinforced sections) due to seismic reinforcement or previous damage.

If there is damage

i) Treat as ⑩ Damage to repaired/reinforced material'.

ii) If damage such as ⑥ Cracks, ⑦ Delamination/exposed rebar, ⑫ Upset, etc. is found, it should be recorded separately.



**Photo A. 106 : Edge edge widening to secure the girder span of abutment stiffening walls (bridge fall prevention system) and seismic reinforcement.**



**Photo A. 107 : Seismic strengthening of piers (columns and stiff sections)**

② “Swelling” found in Pier

Inspect piers and other structures for swellings, such as those found on the sides of pier columns and the underside of beam, to prevent third-party damage and to ensure that tapping inspections are carried out.

③ 'Cracks' found near the bearing

Particular attention should be paid to the causes, crack, defect and delamination may occur in the vicinity of the bearing due to high stress generation based on displacement constraint caused by seismic effects or bearing failure.

### A6.3.2 Inspection Consideration focused on each part

#### A6.3.2.1 Bridge surface

When deformations are observed at the lower e, abnormalities in the play of elastic devices, steps and soil blockages, abnormalities in the passage of high railings, corrosion and deformation are likely to be observed, as well as damage to the girder ends and bearing sections. It is also possible to observe similar damage at adjacent piers in similar areas.

1) Axial misalignment of girders and ground cover

The photograph below shows an example of a simple steel rice girder viaduct with a broken bridge axis line. It is expected that the piers are moving perpendicular to the bridge axis. (Photo A. 108). Thus, overall settlement, tilting and movement can be inspected by looking through the street of the viaduct to see if the axis line of the superstructure, such as the viaduct and ground cover, is bent.



**Photo A. 108 : Broken bridge axis line**

2) Abnormalities in the clearance between expansion joint and uneven

If there are uneven in the expansion joint, the abutment may have moved.

In addition, damage to the bearing or base mortar may have occurred, it should be checked. (Photo A. 109)



**Photo A. 109 Abnormal uneven and clearance of expansion joint**

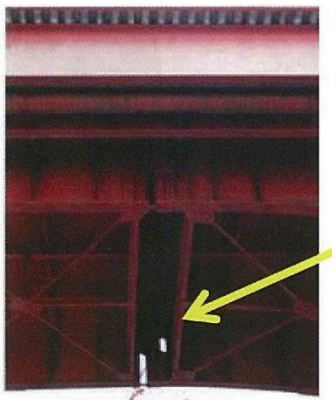


**Photo A. 110 : Clearance abnormality of Gelber part**

The play between the cantilever hinges looking up from under the girders appears different on the left and right road sides. Damage to the substructure on the suspension girder side or the receiving girder side is to be expected. (Photo A. 110)

3) Contact between girder ends and breastwork (parapet)

In the photograph below (left), the girder and parapet are in contact with each other due to the loss of clearance between the girder and the parapet, as a result of abnormal clearance between the expansion device and the bearing body. In the photograph (right), the gap between the girder and parapet is different at the top and bottom. This may indicate that the abutment has moved and tilted. (Photo A. 111)

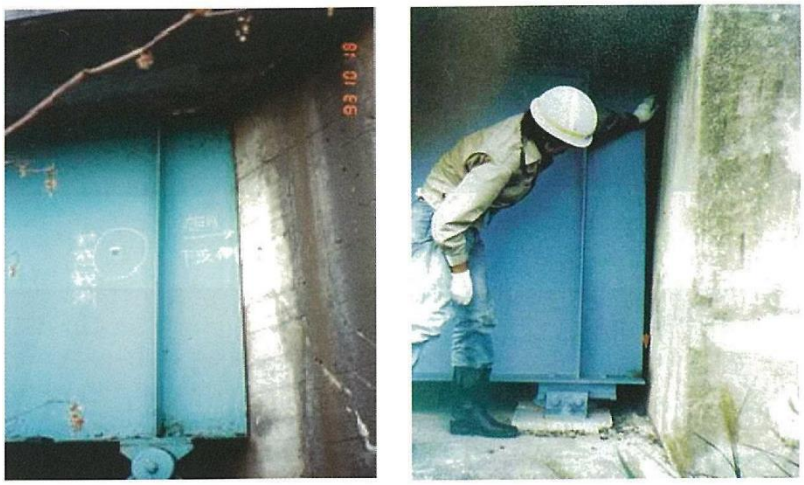


**Photo A. 111 : Abnormality of girder end gap**

4) Failure of the ground cover

The photograph shows a fracture in the ground cover caused by the torsion of the superstructure (Photo A. 112). The lower works may also have been affected.



**Photo A. 112 : Crack generated by torsion of earthquake**

### A6.3.2.2 Deformation of revetments and sleeve retaining walls

Where damage is observed in the sleeve retaining wall or revetment on the side of the abutment (Photo A. 113,Photo A. 115), the damage is recorded under the component names 'Abutment (other)' and 'Sleeve retaining wall'. The main types of damage include 'cracking', 'delamination/exposed rebar', 'leakage/free lime', 'discolouration/degradation', 'deformation/defect' and 'settlement/shift/tilting'.

Damage may occur to abutment frames, wing walls, revetments and sleeve retaining walls around abutments due to changes in the channel bars and river bed lowering.



**Photo A. 113 : Sleeve retaining wall void.**

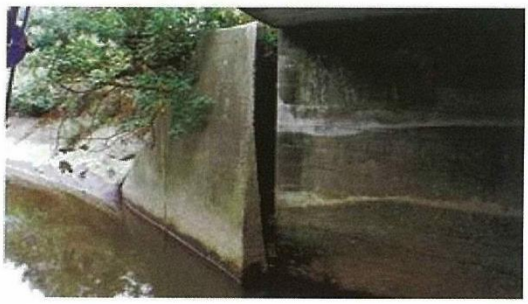


**Photo A. 114 : Gap in abutment frames and wing walls.**



**Photo A. 115 : Cracking and settlement of the revetment in front of the abutment.**

### A6.3.2.3 Settlement of the back embankment

In addition to the deformation of the bridge face, the condition of the back embankment and side slopes should be assessed and inspected (Photo A. 116). As steps in the bridge face can hinder the passage of vehicles, pedestrians and cyclists, it is necessary to monitor the conditions of vehicular traffic, pedestrian and cyclist traffic (vibration, rubbing, noise generation), etc.



**Photo A. 116 : Uneven caused by settlement of back side of abutment**

### A6.3.2.4 Anomalies at anchorage points

If the beam members of the piers are of PC construction, the PC steel anchorage (Figure A. 56) is an area that must be inspected with the same care as the upper section.
Abnormalities at the anchorage are defined as cracks in the concrete at the PC steel anchorage where sheaf are visible, or where the concrete at the PC steel anchorage is delaminated.
Corrosion of the PC steel in the transverse beams of PC piers can cause them to break and come loose, or cause third-party damage due to falling or splashing of the backfill concrete.

Inspections involve visual inspection of the backfill concrete and the anchorage itself. In addition, as measures to prevent the stripping of the rear-fill concrete have been taken since 1994, the inspection should also check for the presence of pith and leakage from those measures covers.

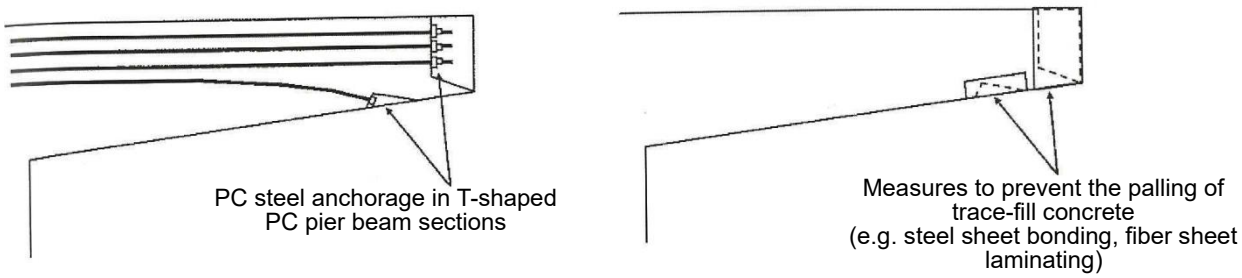
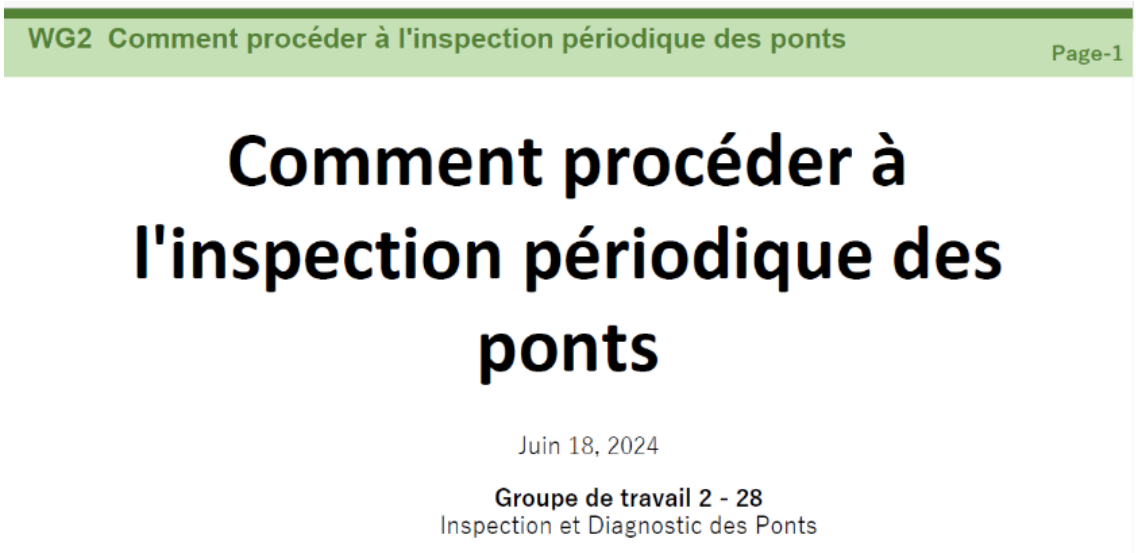


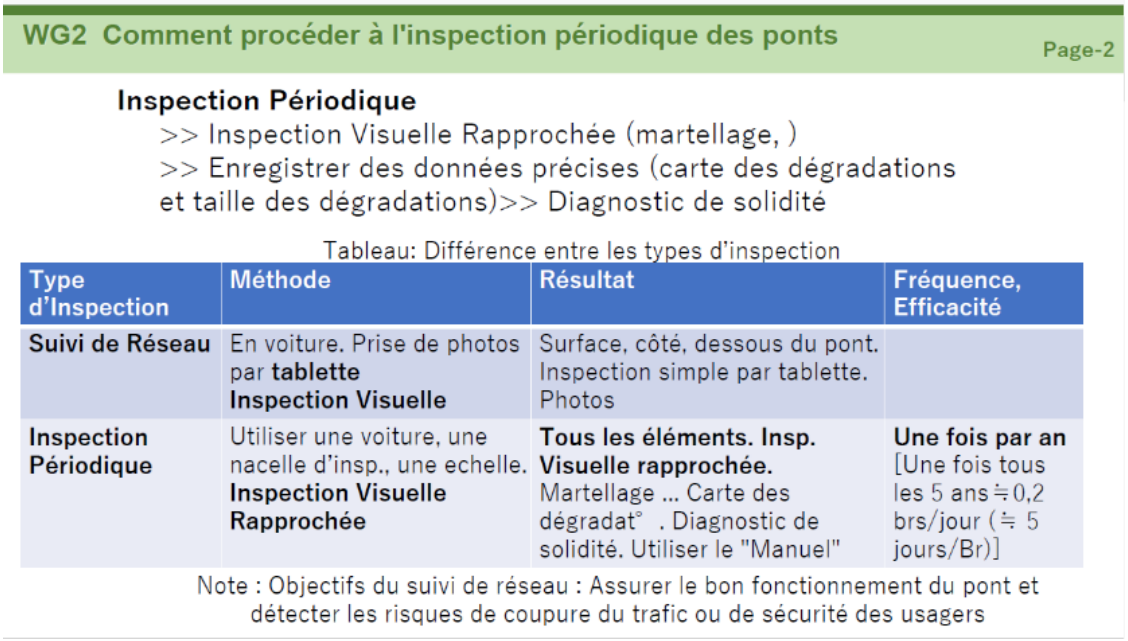

**Figure A. 56 : PC steel anchorage in T-shaped PC pier beam section**

## Appendix 7 How to do inspection ?

The following text is a short description how to inspection do. This contents considers Madagascar' s situation.




This manual is described about Periodical Inspection. Periodical inspection is closed visual inspection, that why it takes much time than network monitoring.



## WG2 Comment procéder à l'inspection périodique des ponts

Page-3

### Procédure

| No. | Action à faire? |
|---|---|
| ① | **Travaux de nettoyage** (Enlever les débris, la terre, la végétation) |
| ② | Mesure du pont, Recherche des dessins d'origine |
| ③ | Vérification des documents d'archives |
| ④ | Dessin et **la carte des dégradations**(+ numérotation des éléments) |
| ⑤ | **Inspection Visuelle Rapprochée** (craie, marqueur) |
| ⑥ | Dimensions des dégradations(surface, longueur, largeur..) |
| ⑦ | Prise de photos |
| ⑧ | **Fiches d'inspection** (chaque élément) |
| ⑨ | **Diagnostic de la solidité** des éléments |
| ⑩ | Diagnostic de solidité du pont entier |
| ⑪ | Réalisation d'un **rapport d'inspection** (saisie BMS) |
| ⑫ | Réalisation d'un plan D'entretien (Utilisation BMS) |



Procedure is shown this slide.

## WG2 Comment procéder à l'inspection périodique des ponts

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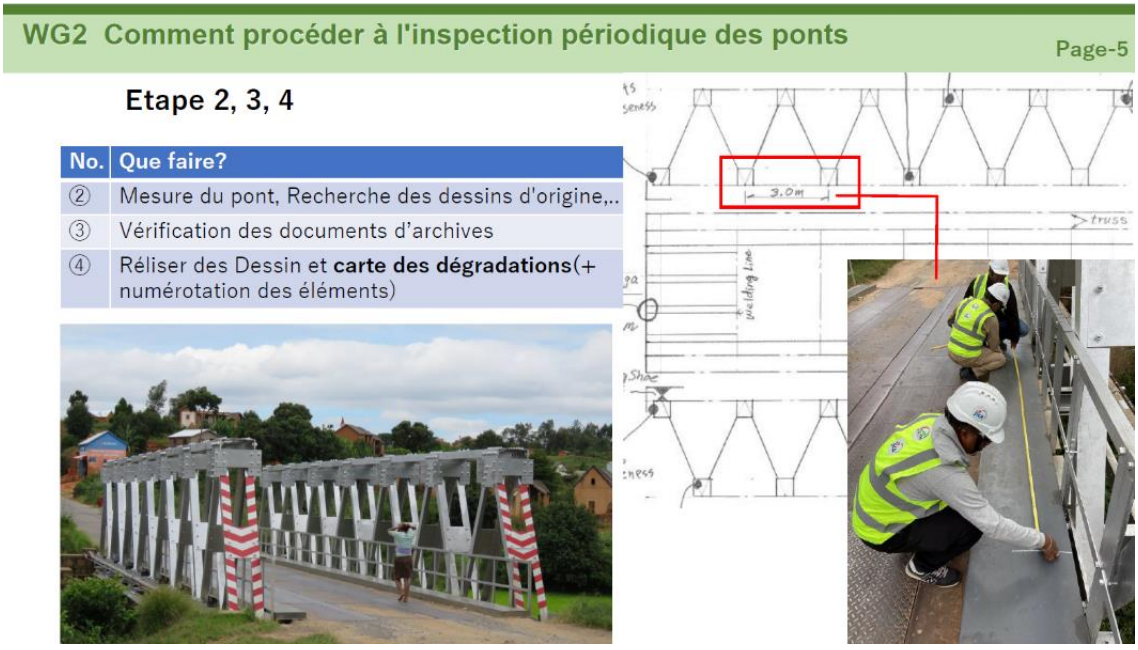
### Etape 1

| No. | Que faire? |
|---|---|
| ① | **Travaux de nettoyage** (Enlever les débris, la terre, la végétation) |





Firstly, all bridge member is necessary to keep clean condition. This means all members are cleaned by maintenance work regularly or before periodical inspection. Garbage, trash, sand deposits, vegetation are necessary to remove not to accelerate deterioration or corrosion.

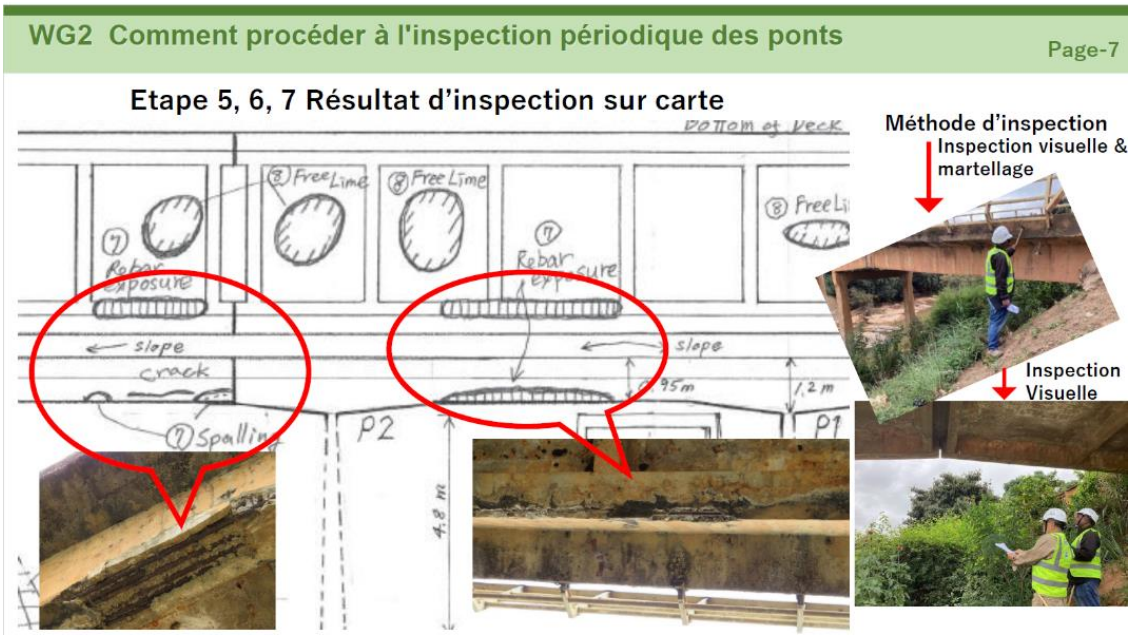



Then, we need original drawings for inspection. If there are no drawings, we need to produce drawing by ourselves. Using these drawings, we need make “Bridge Map for defects”. This map is necessary to record actual damage condition and those place and its size and seriousness.

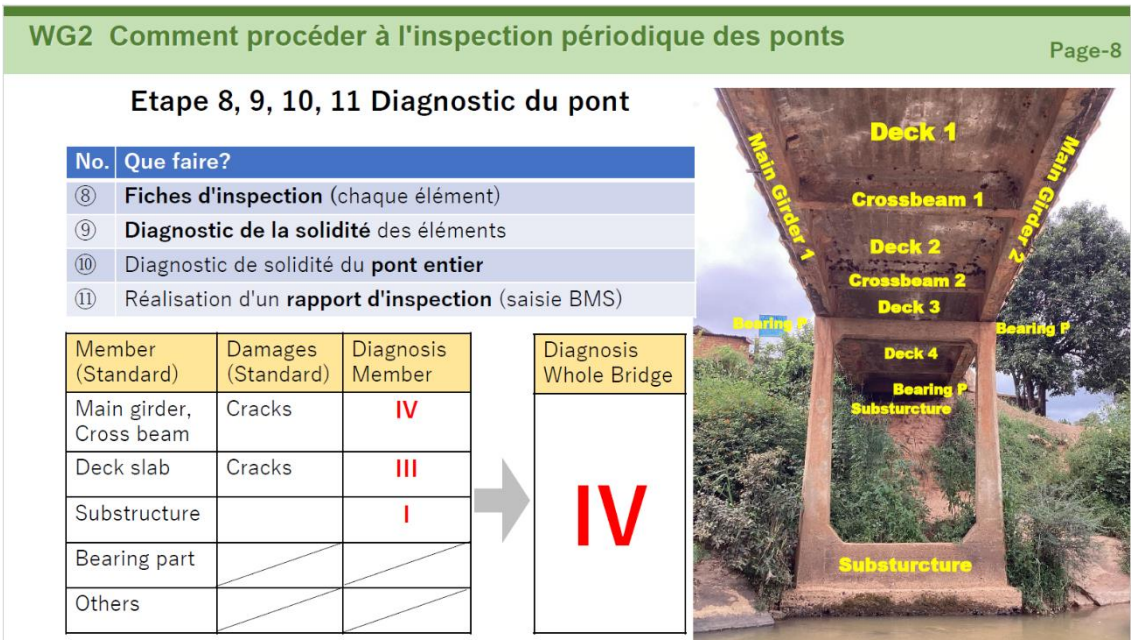



Then, we do closed visual inspection. We need tool and vehicle to check bottom of deck or top of truss structure and part that is not check If we find defects, we need to indicate such phenomenon.

For example, if we found cracks, we need to indicate cracks direction, crack width, crack length and inspection date by chalk or magic pen. The we take photos.




Defects part and location is necessary to record on map and photos for every members.




After inspection record making, we do diagnosis of bridge members then whole bridge. There are 26 of damage types. However we select “standard member” and “Standard damages” for diagnosis. Then we decide standard members’ evaluation in accordance with classification from

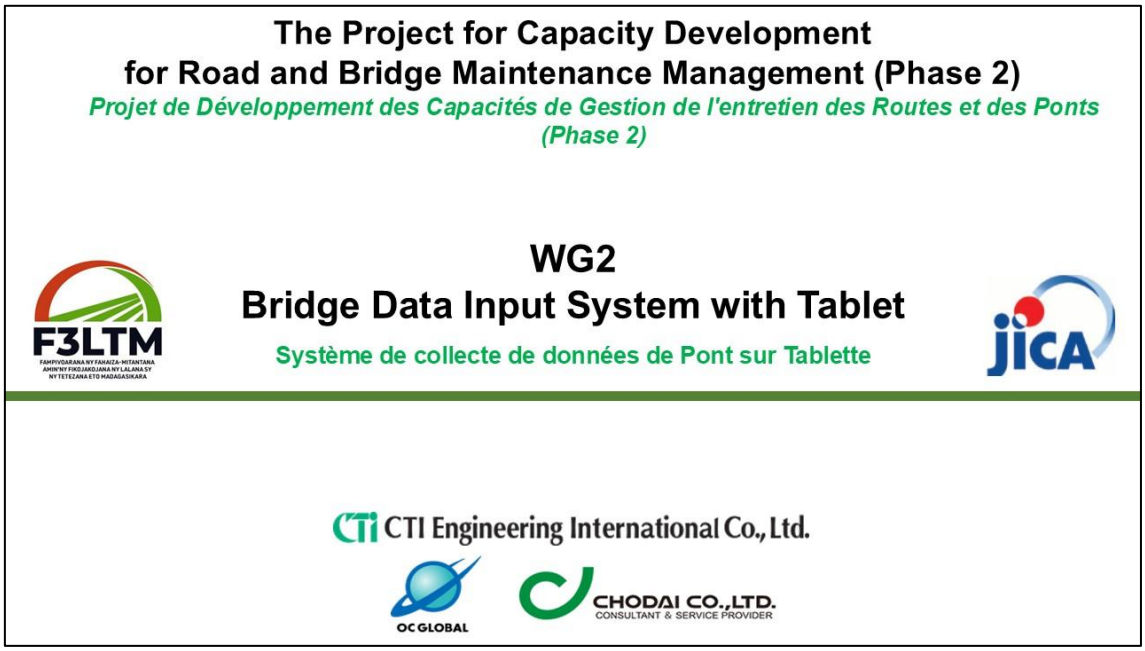
I to IV. Then most serious classification of members is considered as classification of a whole bridge condition. If classification is evaluated as “IV”, we should take appropriate action immediately. Serious action is, traffic restriction of total weight of cars, lane closure or, closure of all traffic road.

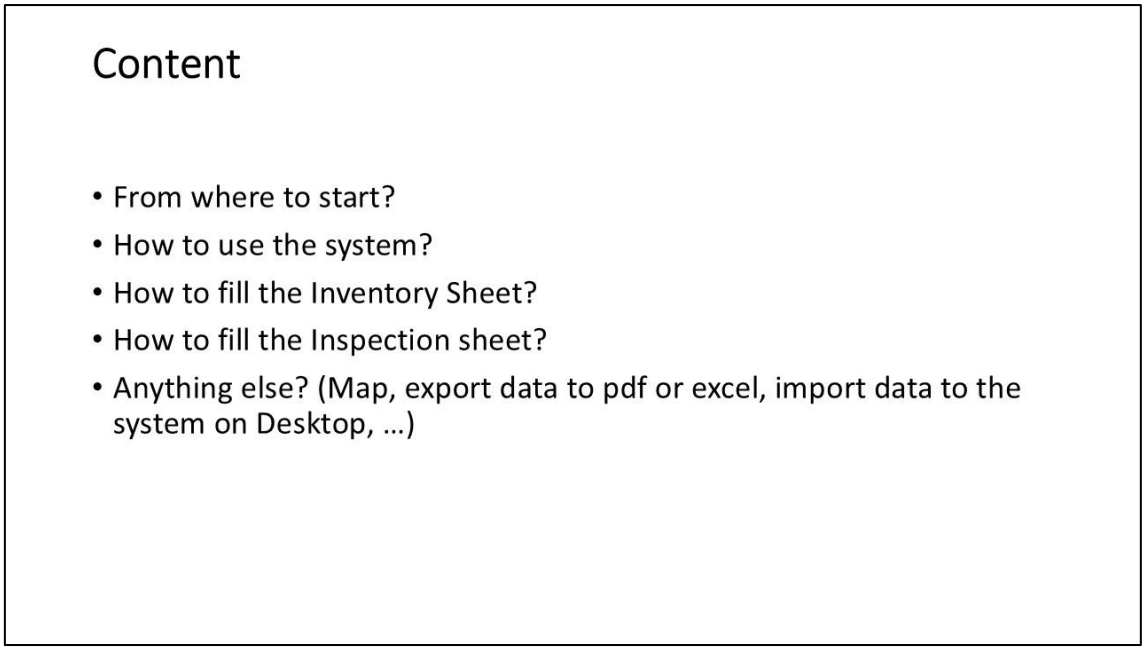
**WG2 Comment procéder à l'inspection périodique des ponts** Page-9

**Etape 12**

| No. | Que faire? |
|---|---|
| ⑫ | Réalisation d'un plan D'entretien (Utilisation BMS) |

## Appendix 8 How to use the Tablet Inspection System?



From where to start?

***For the very first use of the system, this step is mandatory.***

# Setting

- Equipment :
  - **iPad with integrated GPS or iPad + external GPS**

  (In this guideline, we consider an iPad with external GPS)





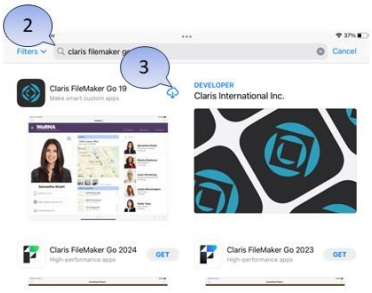
- Apps :
  - **FileMaker** : you can find it on App Store 
  - **Maps.me** : you can find it on App Store 
- File :
  - Bridge data collection system main file (filemaker format .FMP12)

# Installation

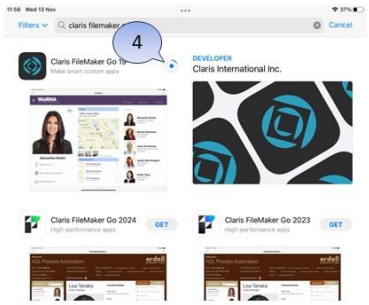
• Install 'FileMaker' on the tablet (Application only available on App Store)




1- Open App Store




2 - Type **'claris filemaker go 19'** in the search bar. Then search.
3 - Click on the Download icon as shown in the photo.

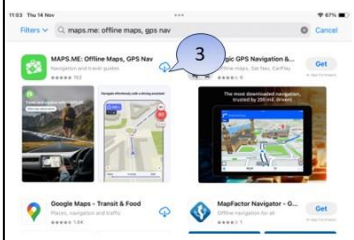



4-Wait until the download is complete.

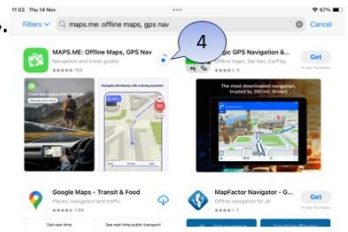
• Install « Maps.me » on the tablet



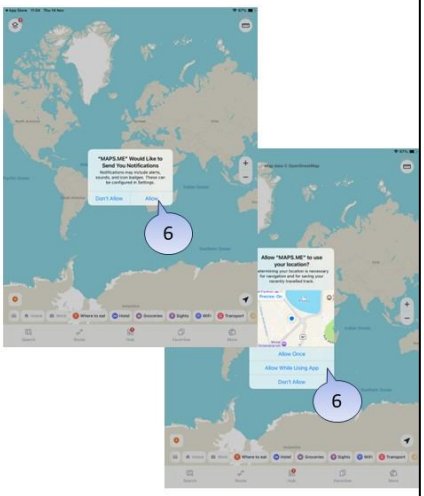

1 – Open App Store
2 – Type on the search bar **« maps.me ».**
- Then search




3 – Click on the Download icon as shown in the photo.




4-Wait until the download is complete.




5 – Open the app
6 – And allow all requests

- Then download the **Map of Madagascar** from Maps.me.



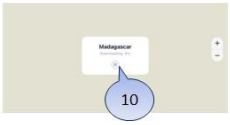

7 – Once all requests have been allowed, **zoom in** on the map of Madagascar.




8- If you receive notification as shown in the photo, clic on « **Continue**» .




9 – Keep zooming in until a dialog box like the one in the photo appears. Click on '**Download Map**' to start downloading.



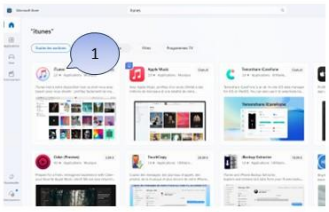

10 – Wait until the Download is complete.



11 – Once the download is complete, you can **use Maps.me without internet connection.**

- Copy the system file into the FileMaker application on the tablet (the extension is '.fmp12'). Currently, the latest version is named 'MDGSystem2407.fmp12'

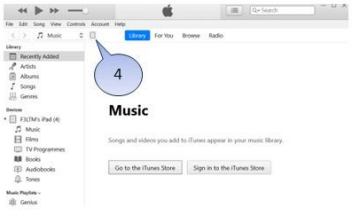
Copying the file (.fmp12) from your store ( a computer with Windows system) to an iPad is a bit complicated. Please refer to the following steps:




1- Download and **install iTunes** on your computer if you don't already have it (available from the Microsoft Store or online, it's free).




2- Connect your iPad to your computer using a **Lightning to USB cable**.
3- Accept any accessibility requests that appear on your iPad,
- **Open iTunes** on your computer.




4- If your iPad is correctly connected to your computer, a **tablet icon** will appear at the top left of the iTunes window, as shown in the photo. **Click on this icon**



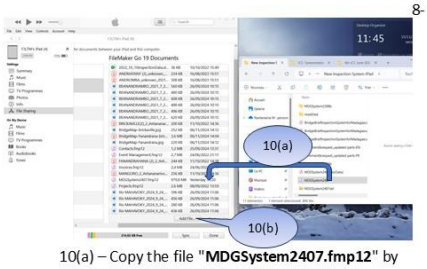

5- A window same as the one in the photo above will appear.
6- Click on the '**File sharing**' icon



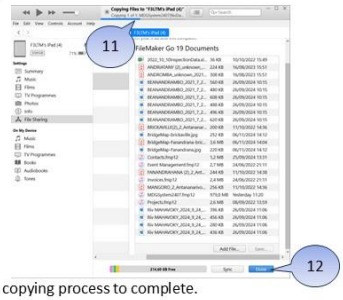

7- A window similar to the one shown in the photo above will appear. Please ensure that FileMaker is already installed on your tablet for this step.
8- Click on the '**FileMaker Go 19**' icon.




9- The **FileMaker window** will open.




10(a) – Copy the file "**MDGSystem2407.fmp12**" by dragging it directly into the FileMaker window.
Or
10(b) – Locate the file by selecting **"Add file..."** and navigating to its location.




11- Wait for the copying process to complete.
12- Once finished, click on **"Done"** to safely disconnect the iPad from your computer.

# How to use the system (System overview)

# System operation

- Linking the Tablet to the External GPS Device






1- Go to **Settings**




2- Choose ***Bluetooth***




3- Enable Bluetooth on the Tablet




4- Locate the GPS device in the list of available Bluetooth devices and select it to pair.
5- The devices are successfully paired when **"Connected"** appears next to Garmin Glo in the list.

**Recommendations for using the External GPS (Garmin Glo) :**

- ***Charge the Devices****: Fully charge the GPS before use. A flashing orange light indicates charging, which stops once the battery is full. Similarly, ensure the iPad is fully charged to prevent interruptions during inspections.*
- ***Pair Before Use****: Before starting any inspection or data collection, pair the iPad with the GPS unit.*
- ***Powering On the GPS****: Press and hold the on/off button until the device lights up.*
- ***GPS Signal Acquisition****: A flashing yellow light means the device is searching for its GPS position. Once the yellow light stops flashing, the device has successfully acquired its location.*
- ***Pairing with an iPad****: A flashing blue light indicates the device is searching for an iPad to pair with. When the blue light stops flashing, the device is successfully paired with at least one iPad.*
- ***Multiple Pairing****: A Garmin Glo device can be paired with up to three (3) iPads simultaneously.*
- ***Maintain Close Proximity:*** *To ensure a stable connection, keep the GPS device within 10 meters of the paired iPad.*

- Start using the bridge data collection system on the iPad




1- Open **FileMaker** on your iPad



2- Enter your tablet code when prompted



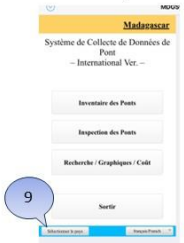

3- Open the **"MDGSystem2407"** system.
4- The first time you use the system, enter the following credentials:
•**Account Name:** ctii
•**Password:** Kenya




5- You have now reached the **Main System Menu**.
6- To change the system language, select your preferred option from the **drop-down list** at the bottom right.




7- We recommend that you choose either **English or French**.




8- This is the main screen displayed in French.
9- You can also select **the country** by clicking the button at the bottom left.




10- In this version of the system, only **three countries** are available in the selection list.

## ‘Search’ function in the system

The system offers three ways to search for previously inventoried or inspected bridges:

### A - Search Using Inventory Data

- Look up bridges based on recorded inventory details such as KP, name, RN,...

### B - Search by Inspection Data

- Retrieve bridges based on past inspection records.

### C - Search by Location/Position

- Find bridges near your current GPS position using the system’s geolocation feature.

## A- Search using inventory data




1- **Main menu**
2- Choose **Inventory data**




3- Choose **Search from the inventory data**




4- Specify your search here




5- Scroll to the bottom of the page and click on the **search icon** to initiate the search.




6- The list of bridges matching your search criteria will be displayed.

## B- Search by inspection data



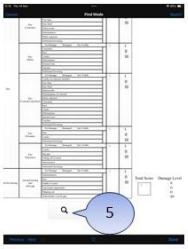

1- Main menu
2- Choose ***Search/Graph/Cost***




3- Choose **Search using inspection data**



4- Specify your search here.




5- Scroll to the bottom of the page and click on the **search icon** to launch the search.




6- The list of bridges matching your search criteria will be displayed.

## C- Search by location/position

For this type of search, the iPad must be connected to a GPS device to detect the current position. This function will search for bridges closest to the inspector, within a specified radius such as 2km, 5km, etc., depending on your settings.




1- Main Menu
2- Choose ***Bridge inspection***




3- Click **here** and select a specific distance (**d = from 2 to 20,000 km**) from the list to search for bridges within a radius of **d** km from your current location.




4- Click on **Refresh your position** to start the search



5- The tablet will refresh your position. Please make sure that the tablet is connected to the GPS to ensure a concrete result of your search.




6- A list of bridges within a ***10 km*** radius will be provided if you select ***d = 10*** in the distance range.

# How to fill in the inventory sheet?

## New inventory data



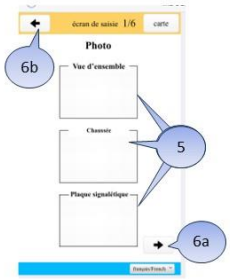

1- Main Menu
2- Choose **Bridge *Inventory***



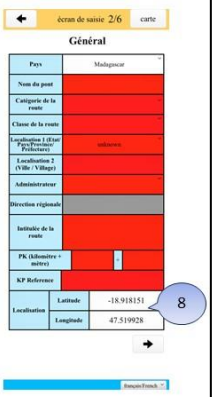

3- Choose **Input bridge inventory data**



4- The system will automatically record your geographical coordinates (GPS). Make sure your tablet is connected to the GPS device.



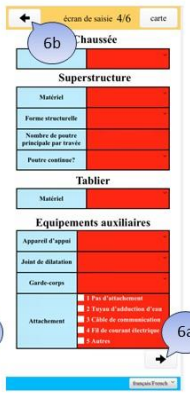

5- Start collecting data by taking the photos as indicated. Click on each **frame** to take the corresponding photo, and click on '**Use photo**' to accept the photo.
6a- Click on the **right arrow to continue** the inspection.
6b- Click on the **left arrow to return** to the previous page.

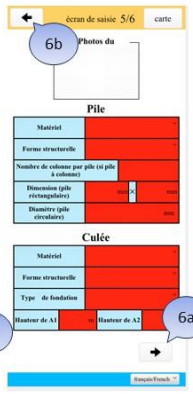


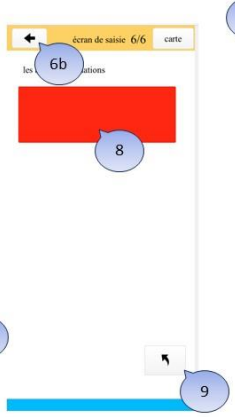

7-Fill in the fields according to your data.
8- The GPS coordinates are generated automatically, but you can change them here if needed.

## New inventory data




6a- Click on **the right arrow to continue** the inspection.
6b- Click on the **left arrow to return** to the previous page.
7-Fill in the cells according to your data.

8- Add your **comments or other information** here.
9- Click on the **curved arrow to end** the inspection.




10- A preview of the inventory sheet will appear.
11- Go to the bottom of the page and click on **Change to modify** the form.
12- Go to the bottom of the page and click on **Finish to save** the file.

# How to fill in the inspection form?

## New inspection

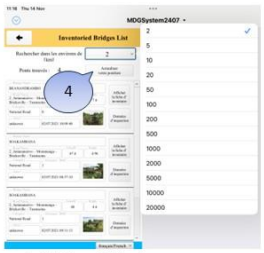
The inspection cannot be conducted if the bridge does not have inventory data in the system.
There are several ways to start inputting new inspection data. However, the method outlined in the following explanation is the most practical when you are on-site, i.e., when you are near the bridge to be inspected.




1- Main menu
2- Choose **Bridge *Inspection***




3- Click here and choose a specific distance (d= 2) from the list of distances to search for bridges within a radius of 2 km of your position.




4- Click on **Refresh your position** to start the search



5- The tablet will refresh your position. Please ensure that the tablet is connected to the GPS and that you are within 2km of the bridge you wish to enter the inspection data.




6- The list of bridges inventoried within a 2km radius of your position will be displayed. Click on "**Inspection data**" button of the bridge you wish to inspect.

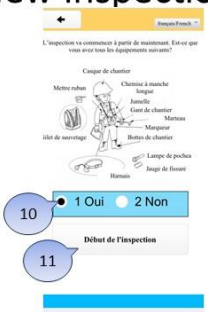
## New Inspection




7- A list of previously conducted bridge inspections will be displayed.
8- Click on **New Inspection** to begin entering a new inspection.




9- Ensure you are properly equipped before starting the inspection. The necessary tools and equipment are listed in the photo.




10- Check **"1 Yes"** if you have the necessary equipment for the inspection.
11- Then click on Start inspection to begin.

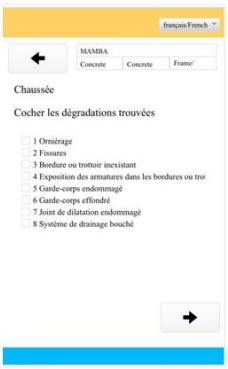



12 - Click on the name of the element you want to inspect

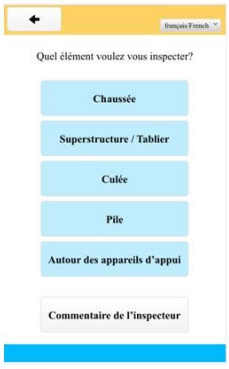



13- Click on "**Damage exists**" if the item is damaged, and on **"No damage"** if it is not.

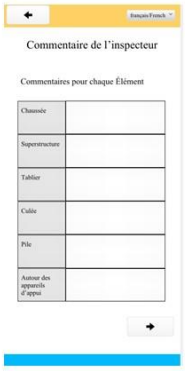
## New inspection




14- If you have selected "**Damages exist**", a list of damages corresponding to the item will be displayed. Please check in the list the types of damage found.




15- Repeat the process for all the elements. The inspected frames will turn blue once the inspection is complete. Once all five elements have been inspected, the **Inspector's Comment** button will be activated. Click on it to continue.

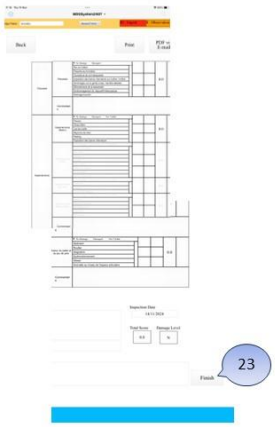



16- A comment box is reserved for each item. You can enter information specific to each item here.
17- Click on the **right arrow to continue**.




18- A general comment box is available for any general information.
19- Click on the signature box to enter your signature.
20- Click on the inspector's name box to enter your name.

## New inspection




21- A preview of the inspection form will appear for review.
22- You can make any necessary changes to the form here.
23- Scroll to the bottom of the page and click **Finish** to save the form.

## Anything else?

# Map Function

- The system is equipped with a MAP function that allows you to view the bridge's location on a map.
- This function is linked to the Maps.me application, so make sure that Maps.me is installed and that any requests for authorization to use it have been accepted.




1- Open the inspection sheet for the bridge you want to view on the map.
2- Click on **"Map"** in the top right-hand corner.




3- The **Maps.me** application will open and display the location of the bridge.
(If the location does not appear, return to the system and click the **Map** button again.)




4- You can zoom in or out as you wish.

# Import/export data (inventory sheet, inspection sheet)

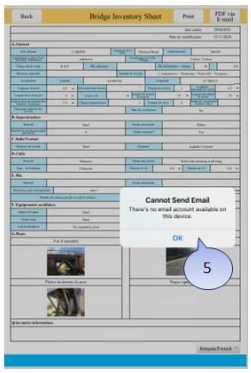
- Export to a PDF file
- Print forms
- Export to Excel file
- Import from tablet to a system on computer

## • Export to a pdf file

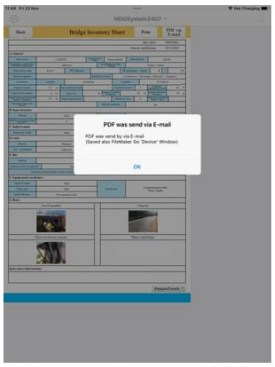
- **Export to a pdf file and send by email :**




1- Open the sheet to be exported
2- Click on PDF via E-mail




3- If your iPad is linked to an email address, an email window (e.g., Gmail) will open.
4- If your iPad is not linked to an email address, you will receive an error message.
5- Click **OK** to continue exporting the file as pdf.



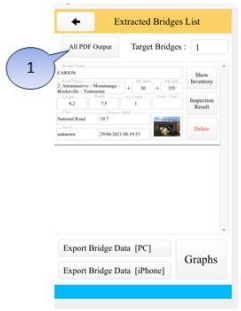

6- A message will appear confirming that the email has been sent and that the PDF has also been saved in the **FileMaker** app, outside the system.




7- You can view the PDF file once you exit the system. It will be saved under the name of the concerned bridge and listed in the **FileMaker PDF files**.

## • Export to a PDF file

- **Export a pack of bridge sheets to PDF files :**




1- In the window displaying the list of bridges matching your search, click on **All PDF Output** to import as PDF files the inspection and inventory sheets for all the bridges listed in your search results.

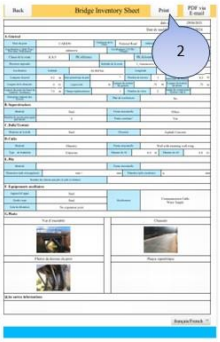



2- A message will appear confirming that the inspection and inventory sheets have been exported successfully.




3- You can view the exported PDF files once you exit the system. They will be saved under the name of each concerned bridge with the specific inspection or inventory details and will be listed in the **FileMaker PDF files**.

## • Print an inspection sheet / inventory sheet




1- Open the form to be printed
2- Click on **Print**

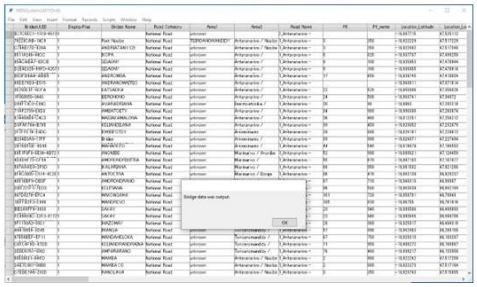



3- A print window will open. Set your printing options here. Your tablet must be connected to a printer in order to print.
4- The Print button will be activated if your tablet is connected to a printer. Click on it to start printing

## • Exporting data to an Excel file



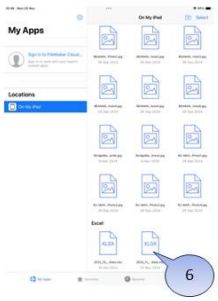

1- In your search result.
2- If you are working on a computer, click on **Export Bridge Data [PC].**
3- If you are using a tablet, click **on Export Bridge Data [iPhone].**



4- A message will appear confirming that the inspection and inventory sheets have been exported successfully.




5- If you are working on a computer, the exported Excel file will be saved to the **Desktop** with a default name that includes the export date.



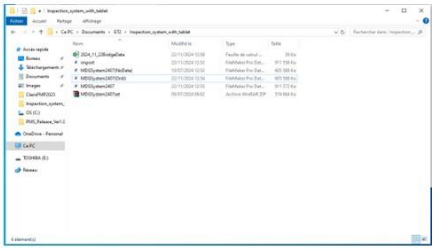

6- For the tablet, you can view the exported Excel files outside the system. The file will be listed in **FileMaker Excel files** with a default name that includes the export date

## Computer-based bridge data system

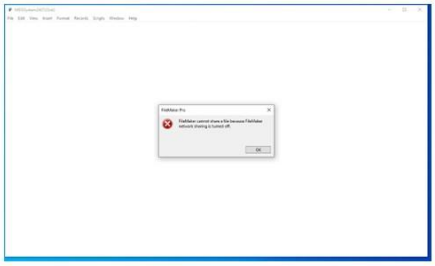
- A similar bridge data collection system has also been created for computers. The aim is to be able to gather and store all the data collected throughout the country in a single system. To use this system, **FileMaker software** must be installed on your computer. While the software is not free, the project has provided a computer with a lifetime FileMaker license to the MTP.

- The computer version of the system is almost identical to the tablet version, with one key difference:
  **The 'import bridge data' function** from the tablet to the computer system:
  - If the bridges already exist in the system, the new data will **overwrite** the existing data.
  - If the bridges do not yet exist in the system, they will be **added** without affecting the data of other bridges already in the system.

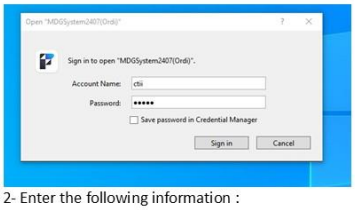
## • Import bridge data from the tablet system to a system on computer



1- The file name is MDGSystem2407(Ordi).fmp12 , double-click it.



3- If you receive this error message, simply click **OK**. The **Main Menu** will then be displayed.

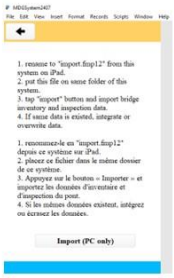



2- Enter the following information :
Account Name : **ctii**
Password : **Kenya**

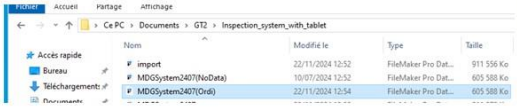



4- The system's **main menu** will open.
5- Click on **Import (PC only)**

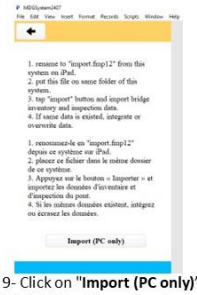
- Import bridge data from the tablet system to a system on computer

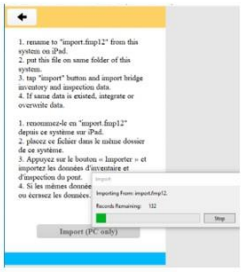



6- An instruction window will open, detailing the steps for importing the data into the system. This guide will walk you through the process to ensure the data is correctly imported and integrated.

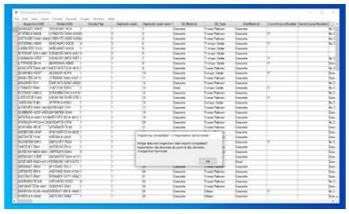



7- **Rename** the .fmp12 file containing the data to be imported to "**import**".
8- **Move** the renamed file to the same location as the MDGSystem2407(Ordi) file.




9- Click on "**Import (PC only)**".
10- Wait for the system to complete the copy.
11- But if you want to stop the copy process, you can click on "**Stop**"



12- A message will appear confirming that the data has been successfully imported, as shown in the photo.
13- You can now access and view the data in the MDGSystem2407(PC) system.

## Appendix 9 FAQ ( Frequently Ask Questions)

### 1) If a crack appears in masonry, in which damage type should it be recorded?

Since the Manual does not deal specifically with damage of masonry , a crack in masonry should be recorded under the category ⑥ *Crack of Concrete*, with a **note* specifying that it is about masonry.

### 2) How to classify and record damage in an abutment or wing wall?

If crack is find in concrete wing wall (likewise **in concrete abutment**), it should be recorded as ⑥ *Crack of Concrete* : since the concrete wing wall is continuous with the main abutment structure, crack progression could affect the latter, representing a potential danger for the bridge. Inspectors should therefore pay particular attention to this situation.

For a masonry wing wall, cracks do not have a direct impact on the main abutment. They should therefore be recorded as damage type ⑰ *Other factors.*

Similarly, a crack in a masonry abutment must also be recorded under the ⑰ *Other factors* category.

### 3) How to assess a crack observed on the deck slab?

⇨ If a crack is visible on the top surface, check the underside of the slab. If the crack is present on both sides, it likely extends through the entire thickness, indicating severe damage. This increases the risk of reinforcement contamination, especially if rust stains or free lime are observed.
This corresponds to ⑪ *Crack of the deck slab*. The degree of this damage must be assessed using the classification presented in this Manual.

⇨ If the crack appears only on the top surface and does not penetrate the underside, it is classified as degree “b” or “c”, regardless of its width.

⇨ If the crack is only on the underside, its severity should also be assessed using the classification criteria provided in this Manual.

**4) If the steel elements of the expansion joints are broken, how it should be recorded?**

If the steel elements of the expansion joints are broken, this damage should be classified as ㉓ *Deformation/Break*, which includes deformation or breakage of any bridge component such as truss elements, railings, road signs, expansion joint elements….
Additionally, since damage to expansion joints is often associated with unevenness of road surface, it should also be recorded under ⑭ *Uneven Road Surface*.

**5) How to record damage in road signs, guardrails,... or missing part in these elements,...?**

Any damage found in road signs, guardrails such as loss of elements are classified as ㉓ Deformation, break.

**6) What's the difference between ⑪crack of Deck slab and ⑥Crack of concrete element?**

The distinction between these two types of cracks, despite both being in concrete, lies in their formation, progression, and structural significance.
First,
⑪ Crack of Deck Slab initially appears perpendicular to the direction of traffic. As damage progresses, additional cracks form in the opposite direction. Over time, these cracks widen, and in advanced stages, they can lead the formation of a hole in the slab.
⑥ Crack of Concrete Element categorize the cracks in other concrete elements, such as piers, abutments, or beams. This crack typically expand by widening and extending in length but do not usually result in hole formation.
Secondly,
The crack in deck slab is a more important since it directly support traffic loads and playing a major role in the overall soundness of the bridge.
Due to its structural importance, cracks in the deck slab require more urgent assessment and repair compared to cracks in other concrete elements.

**7) How to fill a bridge defect map if, for various reasons, some part of the bridge has not been inspected?**

In the bridge defect map, if there are parts that have not been inspected, it is recommended to mark these parts and indicate “NOT INSPECTED” to avoid misinterpretation of the inspection results.

**8) How to record damage ⑲ *Discoloration, deterioration* of materials?**

This type of damage covers any discoloration of any type of material, it is not mandatory to record the type of material (e.g. rubber, concrete, steel,...) , as this is not critical information.

**9) How to fill in the inspection sheet? Is there a standard to follow?**

To record damage in the inspection sheet, it is necessary to write it according to the notations agreed in this Manual, instead of writing a text. It is agreed to write as follows:
Damage number + degree of damage + location of damage.
Ex:
⑪-c-201G means ⑪ Crack in the deck slab, degree "c", located on the second span (2), at mid-span (01), and on the left side (G).
⑥-e-100D to 102D means ⑥Crack of concrete element, of degree "e" exists on the first span(1), from the beginning of the span (00) to the end of the span(02), on the left side (D) of the bridge.

**10) When using a Schmitz hammer on a bridge, where is the best place to perform the test?**

When using a Schmitz hammer, it is recommended to perform three tests on three points of the main girder, one on each end and one in the middle. The strength of the girder is the average of the three test results.

**11) During a Schmitz hammer test, is it possible that the value measured does not reflect the real situation?**

Certain errors can occur during measurement, such as those caused by the inclination of the device during the test. It has also been noted that the presence of screed, plaster, mould, moisture, etc. on the concrete surface where the test is carried out has an impact on the result. It is therefore necessary to mention this in the report if the test is carried out in such situation.

**12) When a bearing is damaged and needs to be replaced, what action should be taken?**

When a bearing is damaged and needs to be replaced, the bearing on the other side must also be replaced, to ensure consistency and long-term performance of them.

**13) When inspecting the superstructure, what should be checked first?**

When inspecting the superstructure, the inspector should check first the areas where cracks are likely to appear (shear cracks near the supports, and deflexion cracks at mid-span).

**14) What's the difference between cracks in a RC bridge and a PC bridge?**

Cracks in PC girder are often diagonal and follow the direction of the tendons. Consequently, cracks in PC girder are generally associated with tendon (cable) damage. Longitudinal cracks can also appear in PC, a phenomenon that can be explained by the over-tensioning of the tendons, which leads to significant compression of the concrete and causes cracking.
On the other hand, cracks in RC bridges are often vertical, perpendicular to the length of the girders, which are shear or deflection cracks.

**15) What are the countermeasures of rebar exposure?**

When rebar exposure is encountered, several alternatives are possible, depending on the condition of the rebar :

- ⇨ If the rebar is not corroded, it should be treated with zinc and then covered with mortar.
- ⇨ If the rebar is corroded but not severely, the corrosion must be removed, the rebar then treated with zinc and covered with concrete.
- ⇨ In the case of severely corroded rebar with a significant loss of cross-sectional area, replacement is recommended.
  If replacement is too difficult or impossible, Japanese experts suggest reinforcing the structure with carbon fibre, although the effective application of this technology requires specialized skills.

**16) If the vertical clearance is reduced due to vegetation accumulation, what type of degradation is this?**

If the vertical clearance is reduced due to vegetation accumulation, it is recorded as ⑰ Other factors.

**17) How do you assess ⑤Deterioration of the anti-corrosion system?**

For ⑤Deterioration of the anti-corrosion system, inspectors must observe the exposed layer to assess the severity of the degradation. In Madagascar, the three-layer anti-corrosion system is

generally used, with distinct colours for each layer to facilitate identification.

**18) What does damage type ③Loosening, element loss consist of, does it include any bridge element that can be loosened or lost?**

③ Loosening, loss of element relates exclusively to bolts and rivets. Loosening and loss of other types of element fall under degradation ④ Fracture or ㉓ Deformation, breakage.

**19) What is the difference between ④ Fracture and ㉓ Deformation, breakage?**

It should be noted that ④ Fracture concerns only steel elements, whereas ㉓ Deformation, fracture concerns both concrete and steel elements. With regard to steel elements, ④ Fracture refers to structural elements such as girders, bracing, truss members,... while ㉓ Deformation, breakage deal with other steel elements such as railings, steel expansion joint,....

**20) The standard elements for soundness diagnosis listed in the manual are not clearly reflected in the inspection sheet, so how should the agent proceed about diagnosing the soundness of the elements?**

As the standard elements for soundness diagnosis listed in the manual are not clearly represented in the inspection sheet, it is the elements associated with these standard elements that must be taken into account for soundness diagnosis.
These include
- Structural components: 22-Support, 31-Main girder, 32-Cross girder, 34-Stringer, 35-Bracing.
- Connection elements: 38-Rivet, 39-Weld, 310-Bolt, 311-Gusset.
- Foundations and supports: 41-Abutment, 45-Pier, 61-Abutment foundation, 62-Pier foundation, ...

**21) Should all degradations be taken into account in a soundness diagnosis?**

According to the manual, only the following seven basic types of damage are considered for soundness diagnosis:
①Corrosion, ②Steel cracking, ④Fracture, ⑥Concrete cracks, ⑦Cracking/Exposure of reinforcing steels, ⑪Deck slab cracks, ⑰Other factors.

**22) Does the location of the bridge influence the soundness diagnosis?**

Yes, the geographical location of the bridge plays an important role in the soundness diagnosis. For example, in cyclone-prone areas, bracing should be systematically included as a standard element of the assessment.

**23) How to register advanced gusset damage?**

Severe damage affecting the gusset plate, such as corrosion accompanied by a significant loss of section, should be recorded as ①Corrosion degree “e” or ④Fracture degree “e”.


MTP

AGENCE ROUTIERE

INFRA

MADAGASCAR

fonds Routier
MADAGASCAR

JICA

CTI Engineering International Co., Lt

F3LTM

OC GLOBAL

CHODAI