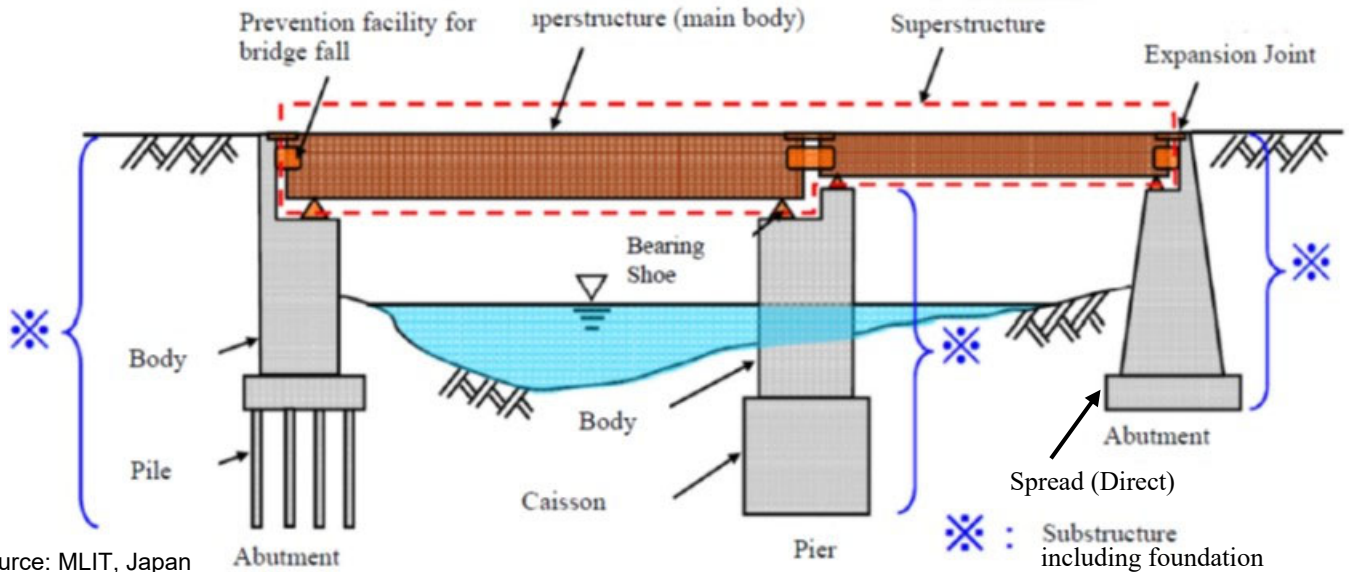
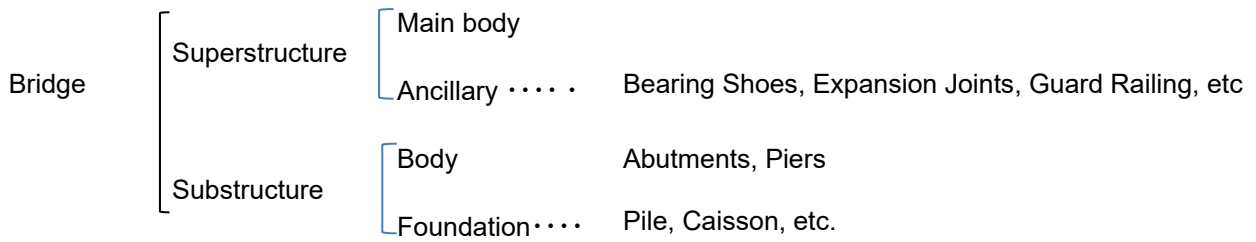


# Appendix-1 Basic Contents of Bridge

[Note: Source of all materials is published by MLIT, Japan (Ministry of Land, Infrastructure, Transport and Tourism, Japan)]

# 1. Basic Compositions of Bridge

## (1) Nomenclature of the structural elements of the bridge



Source: MLIT, Japan

Fig. 1.1 Composition of bridge structure

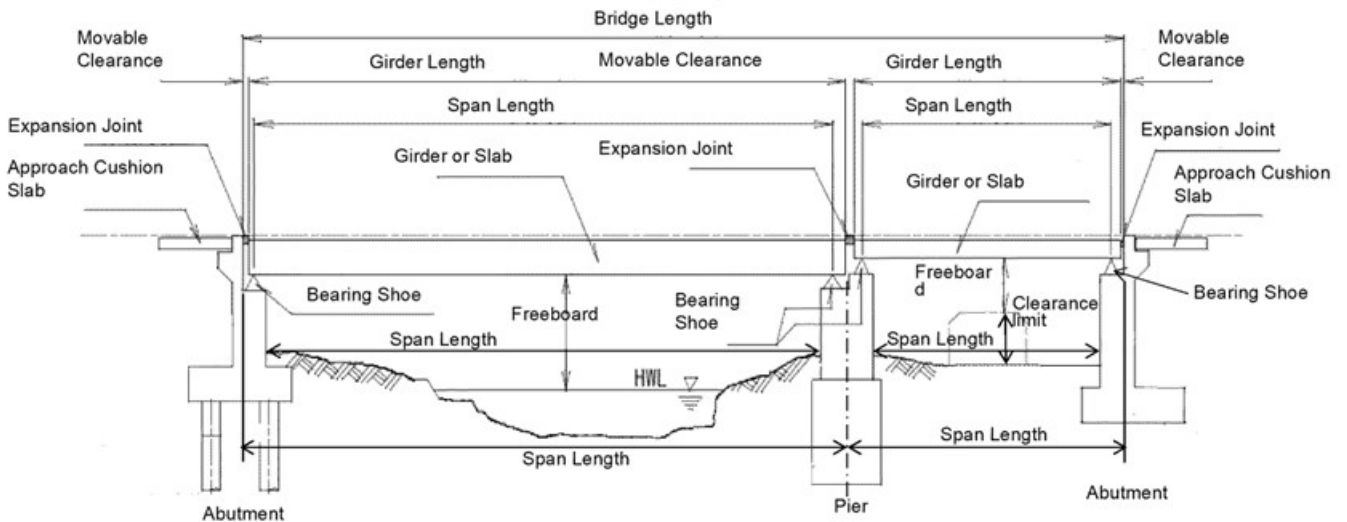
## (2) Bridge length

Bridge Length - - - Length between the front of both parapet walls on abutment

Girder Length - - - Length of girder or slab

Span Length - - - -Length between bearing shoes

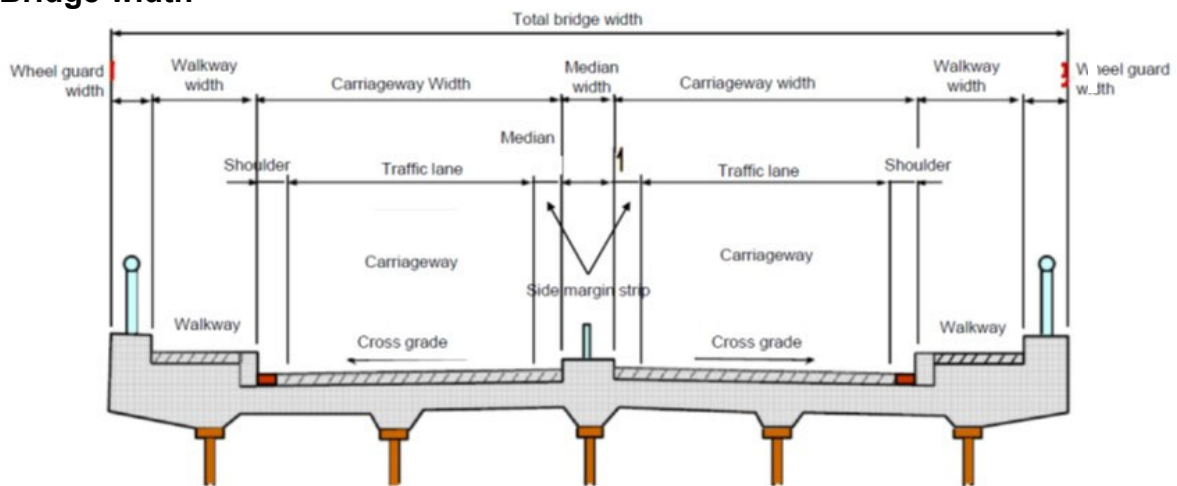
Bridge Span Length - - Length between the front of parapet wall and the center of pier (for river)/ or length between the front of abutment wall and the front of pier (bridge engineering)



Source: MLIT, Japan

Fig. 1.2 Bridge length and others

## (3) Bridge width



Source: MLIT, Japan

Fig. 1.3 Bridge width of cross section

## 2. Type of Bridge

In general, the types of bridge are classified into seven (7) with having various purposes such as structural functions and structural characteristics.

Seven types of bridges are as follows;

- a) Girder Bridge
- b) Slab Bridge
- c) Truss Bridge
- d) Rigid-frame Bridge
- e) Arch Bridge
- f) Cable-stayed Bridge
- g) suspension Bridge

### (a) Girder Bridge

Definition: A girder bridge is a bridge that uses girders as the means of supporting its deck. A material of the girder may be made of concrete or steel. The two most common types of girder bridges are plate or I or T and box.

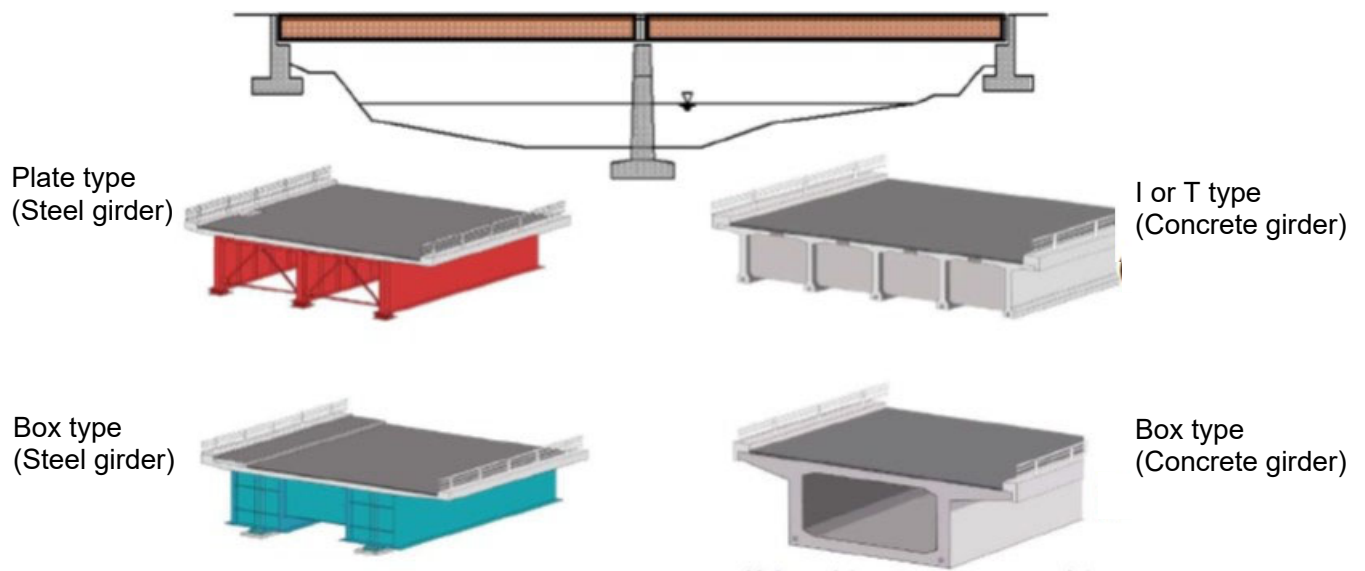
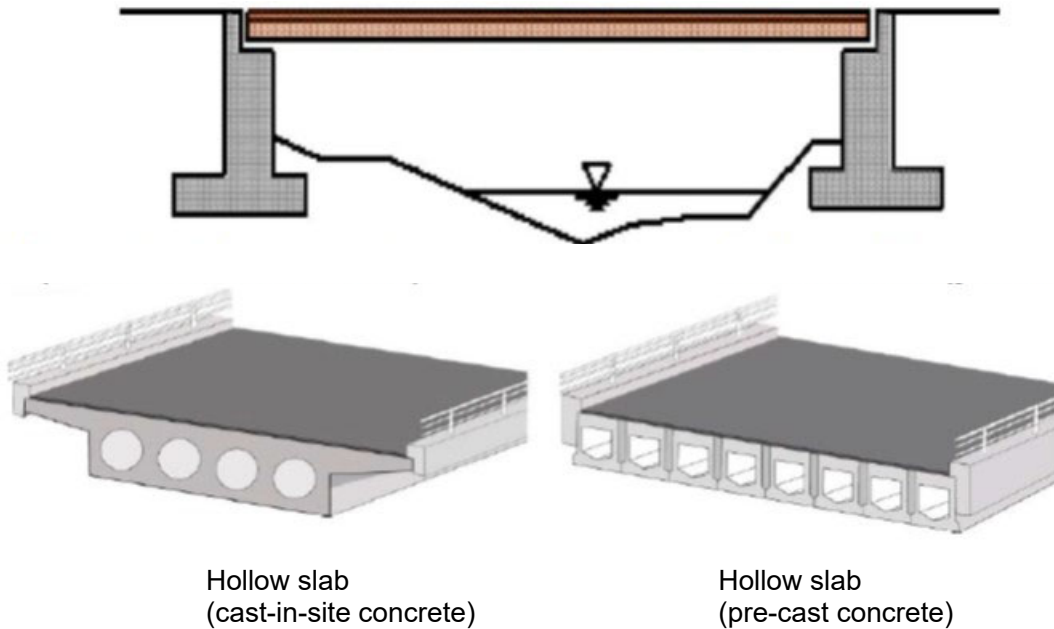


Fig. 2.1 Type of girder bridge

Source: MLIT, Japan

## (b) Slab Bridge

Definition: A slab bridge is a bridge without girders that uses a short-span bridge consisting of a reinforced concrete slab resting on abutments and/or piers. A slab bridge is monolithic, flat concrete slab with reinforcing bars in the lower portion and at either end of the slab, where tensile and shear forces are the greatest.

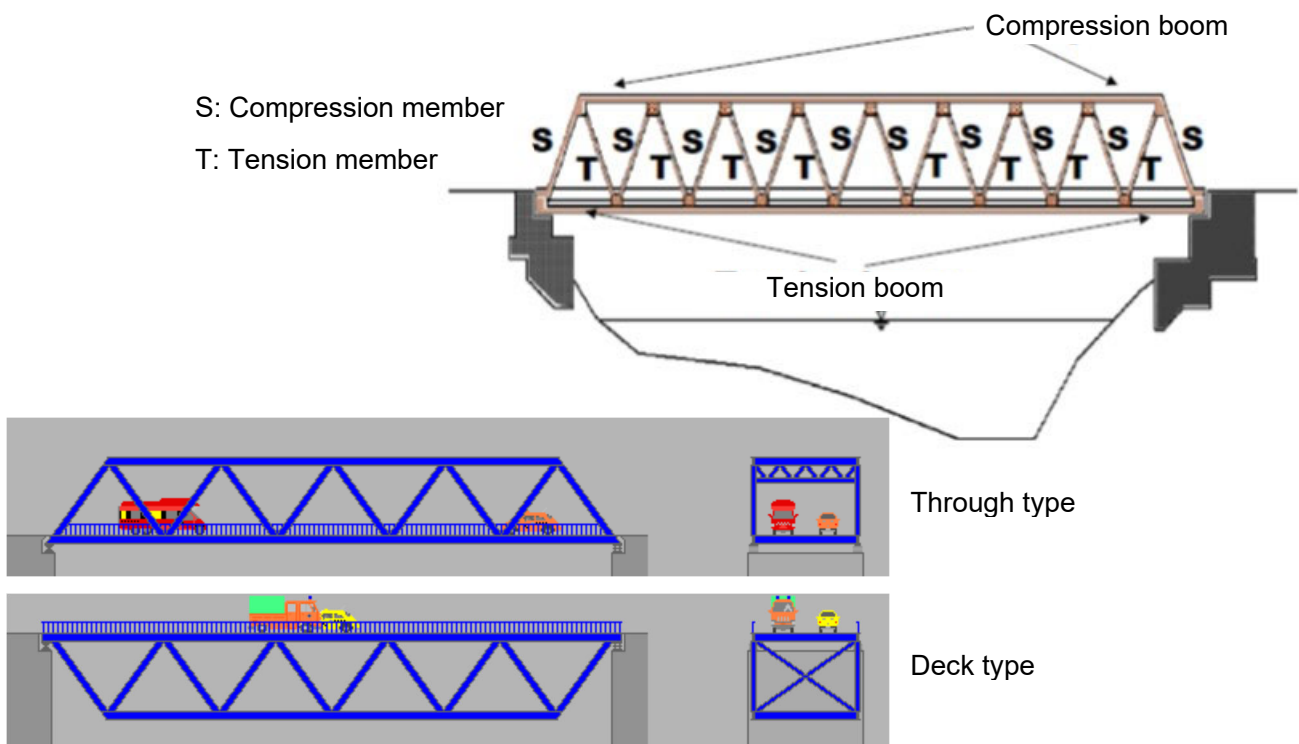


Source: MLIT, Japan

Fig. 2.2 Type slab bridge

## (c) Truss Bridge

Definition: A truss bridge is a bridge whose load-bearing superstructure is composed of a truss, a structure of connected elements, usually forming triangular units. The connected elements (typically straight) may be stressed from tension, compression, or sometimes both in response to dynamic loads. A truss bridge is economical to construct because it uses materials efficiently. **The bailey bridge is one of a truss bridge.**



Source: MLIT, Japan

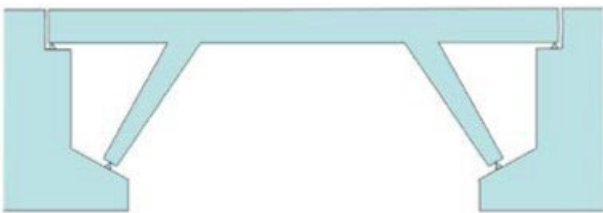
Fig. 2.3 Type of truss bridge

**(d) Rigid-frame Bridge**

Definition: A Rigid-frame bridge is a bridge in which the superstructure and substructure are rigidly connected to act as a continuous unit. Typically, the structure is cast monolithically, making the structure continuous from deck to foundation.



Portal type



π type (Concrete)



V type



π type (Steel)

Source: MLIT, Japan

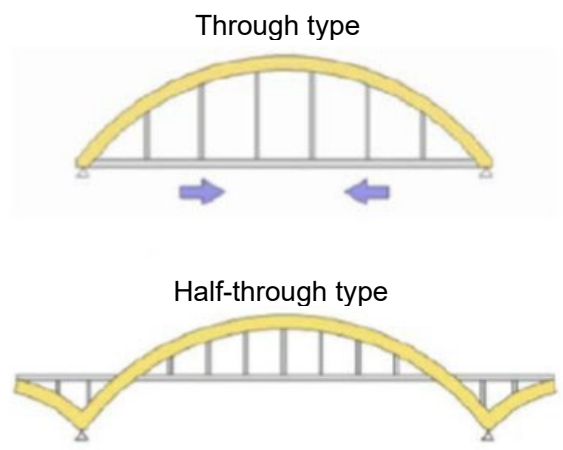
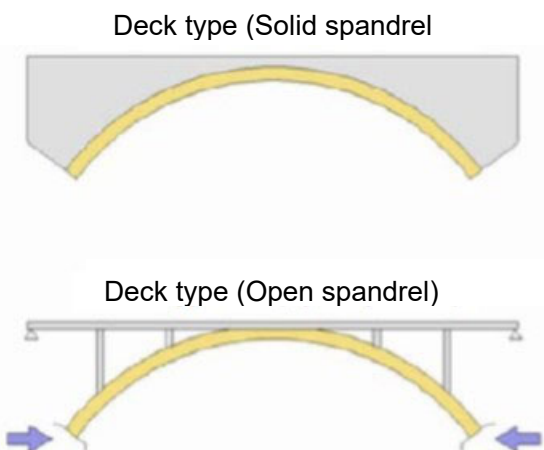


T type

Fig. 2.4 Type of rigid frame bridge

**Arch Bridge**

Definition: A arch bridge is a bridge with abutments at each end shaped as a curved. Arch bridges work by transferring the weight of the bridge and its loads partially into a horizontal thrust held by the abutment at either side.

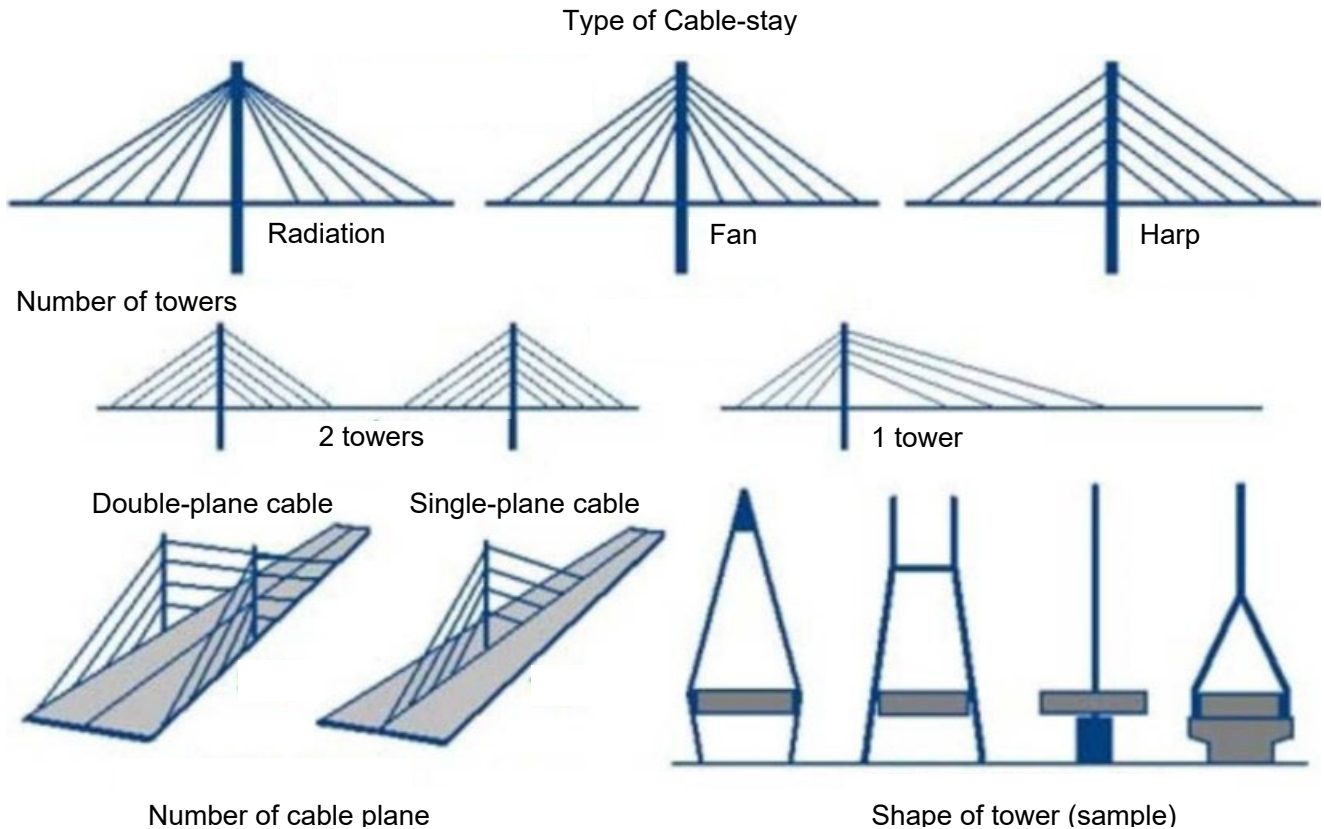


Source: MLIT, Japan

Fig. 2.5 Type of arch bridge

**(e) Cable-stayed Bridge**

Definition: A cable-stayed bridge has one or more *towers* (or *pylons*), from which cables support the bridge deck. A distinctive feature are the cables or stays, which run directly from the tower to the deck, normally forming a fan-like pattern or a series of parallel lines. The towers transfer the cable forces to the foundations through vertical compression. The tensile forces in the cables also put the deck into horizontal compression.

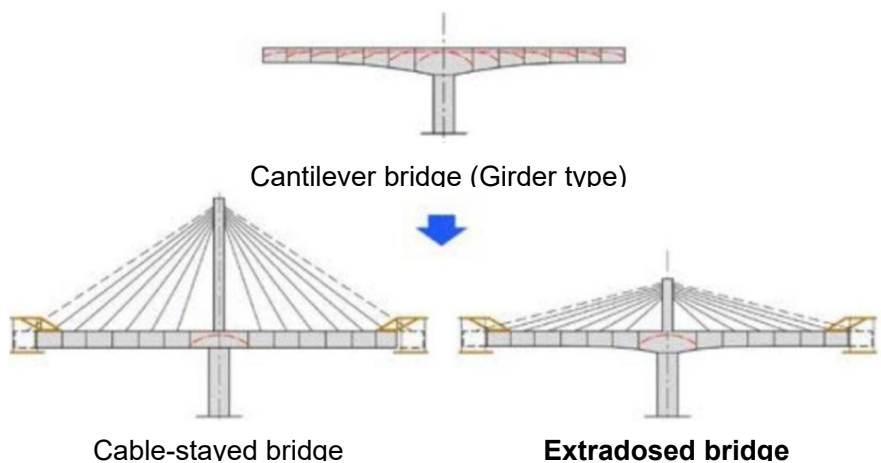


Source: MLIT, Japan

Fig. 2.6 Type of cable-stayed bridge

An extradosed bridge employs a structure that combines the main elements of both a prestressed box girder bridge and a cable-stayed bridge. The name comes from the word *extrados*, the exterior or upper curve of an arch, and refers to how the "stay cables" on an extradosed bridge are not considered as such in the design, but are instead treated as external prestressing tendons deviating upward from the deck. In this concept, they remain part of (and define the upper limit of) the main bridge superstructure.<sup>1</sup>

Compared to a cable-stayed or cantilever-girder bridge of comparable span, an extradosed bridge uses much shorter stay-towers or pylons than the cable-stayed bridge, and a significantly shallower deck/girder structure than used on the girder bridge. This arrangement results in the typical extradosed "look" of a fan of low, shallow-angle stay cables, usually with a pronounced "open window" region extending from the sides of each tower.



Source: MLIT, Japan

Fig. 2.7 Difference of extradosed bridge and cable-stayed bridge

### (f) Suspension Bridge

Definition: A suspension bridge is a type of bridge to carry vertical loads through curved cables in tension. These loads are transferred both to the towers, which carry them by vertical compression to the ground, and to the anchorages, which must resist the inward and sometimes vertical pull of the cables. The suspension bridge can be viewed as an upside-down arch in tension with only the towers in compression. Because the deck is hung in the air, care must be taken to ensure that it does not move excessively under loading. The deck therefore must be either heavy or stiff or both.

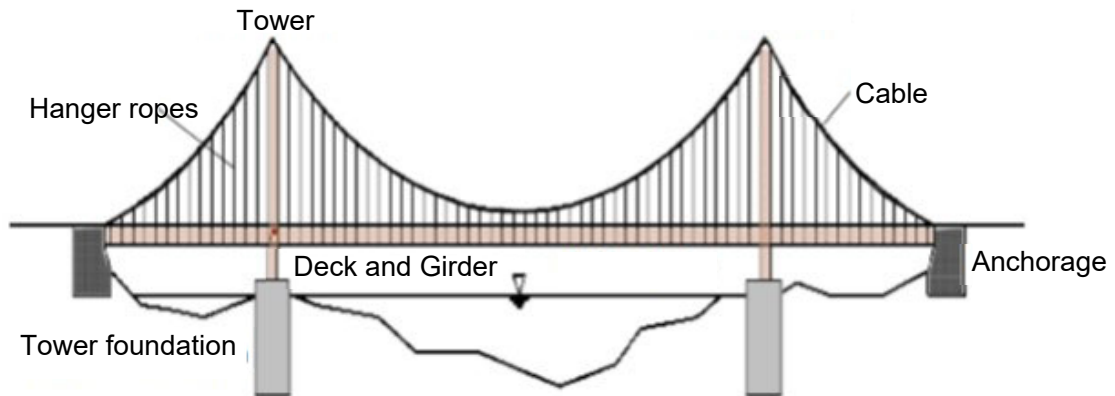


Fig. 2.8 Type of suspension bridge

Source: MLIT, Japan

### 3. Name of Structural Members

#### (1) Bridge Surface

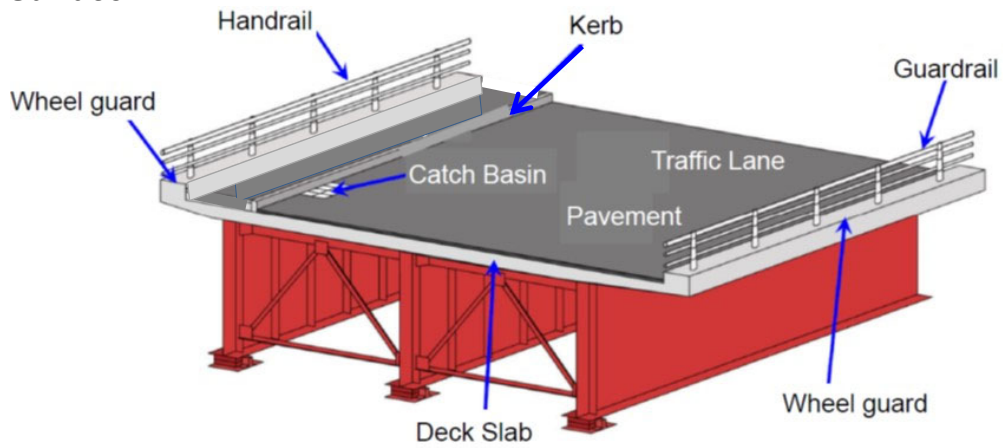
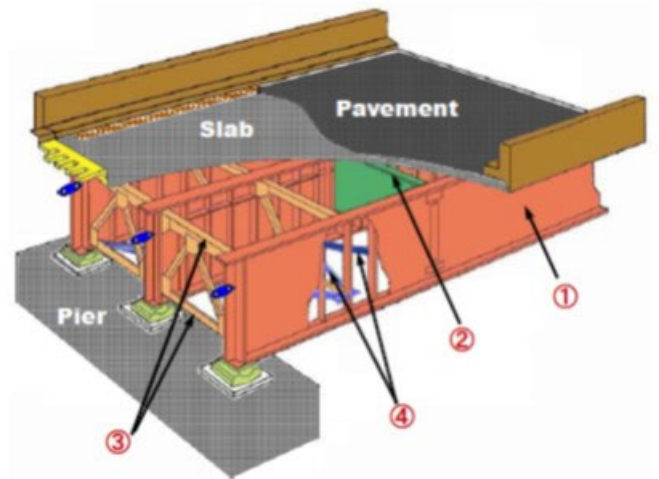


Fig. 2.9 Structure members of bridge surface

#### (2) Name of Structural Element on Superstructure

##### <Steel plate girder type>

- ① Main girder
- ② Cross girder (beam)
- ③ Cross frame
- ④ Lateral member



- ⑤ Bearing shoe
- ⑥ Expansion joint
- ⑦ Prevention device for bridge fall

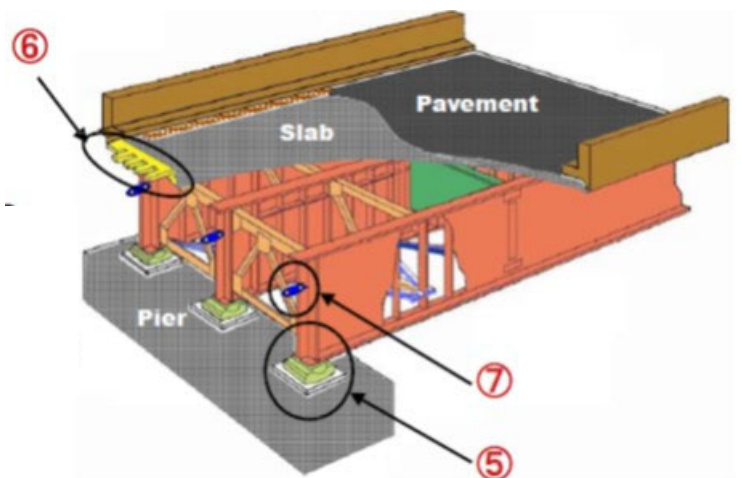
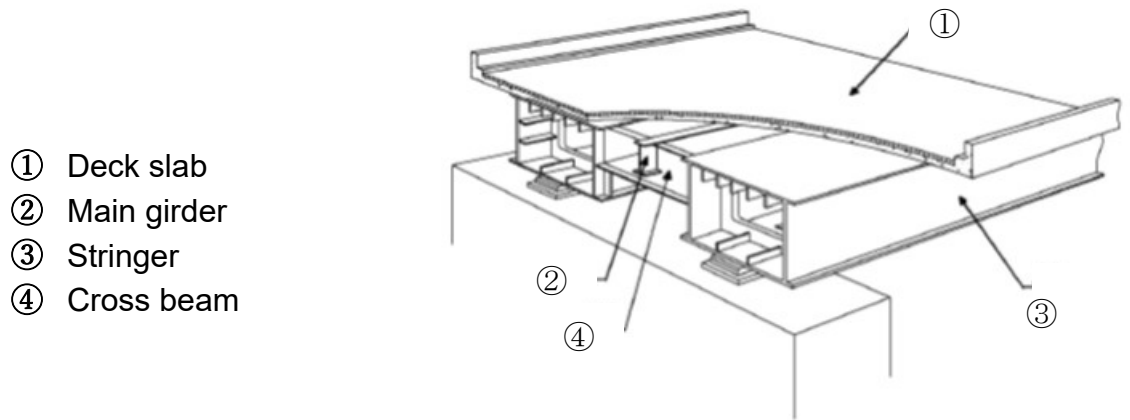


Fig. 2.10 Structure element on superstructure (Steel-1)

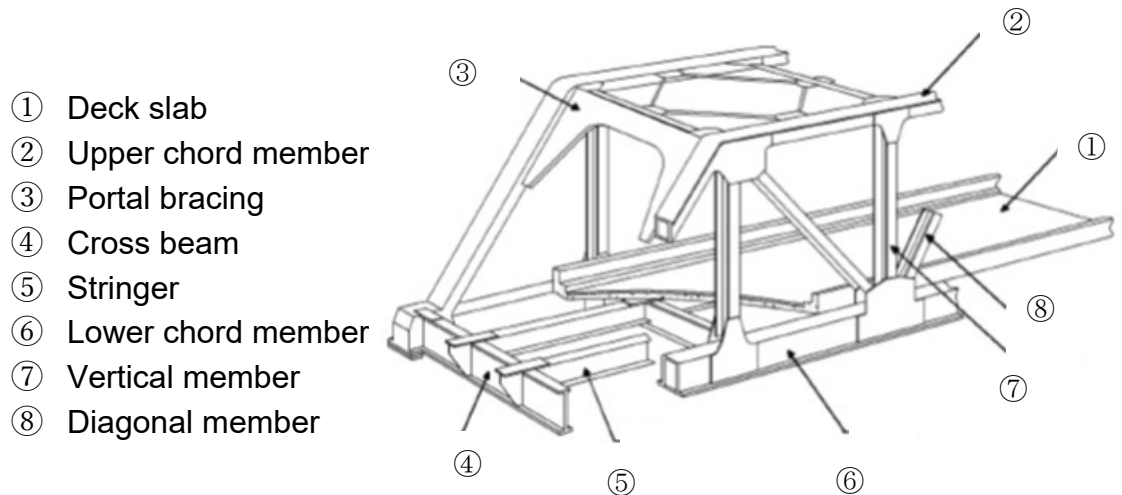
**<Steel box girder type>**



- ① Deck slab
- ② Main girder
- ③ Stringer
- ④ Cross beam

Fig. 2.11 Structure element on superstructure (Steel-2)

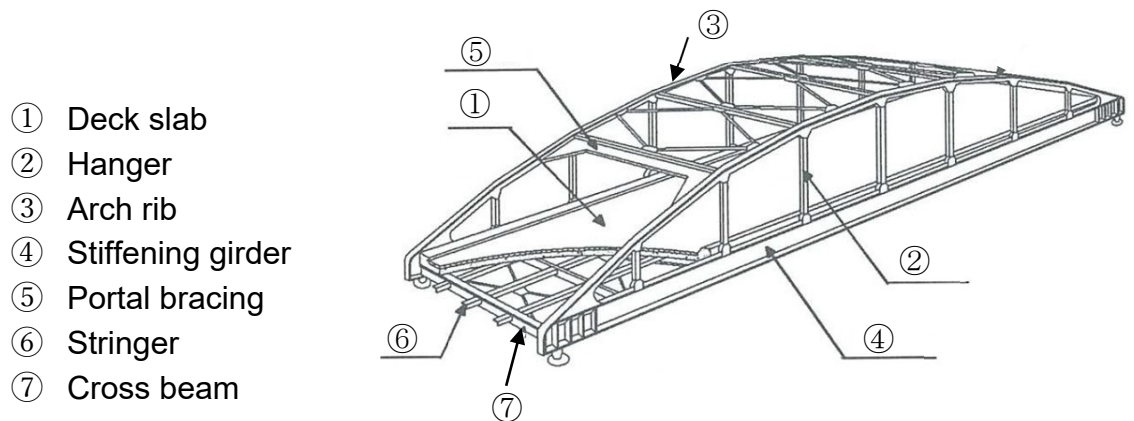
**<Steel truss girder type>**



- ① Deck slab
- ② Upper chord member
- ③ Portal bracing
- ④ Cross beam
- ⑤ Stringer
- ⑥ Lower chord member
- ⑦ Vertical member
- ⑧ Diagonal member

Fig. 2.12 Structure element on superstructure (Steel-3)

**<Steel arch type (through type)>**



- ① Deck slab
- ② Hanger
- ③ Arch rib
- ④ Stiffening girder
- ⑤ Portal bracing
- ⑥ Stringer
- ⑦ Cross beam

Fig. 2.13 Structure element on superstructure (Steel-4)

Source: MLIT, Japan

**<Steel arch type (deck type)>**

- ① Cross beam
- ② Strut
- ③ Deck slab
- ④ Stiffening girder
- ⑤ Arch rib

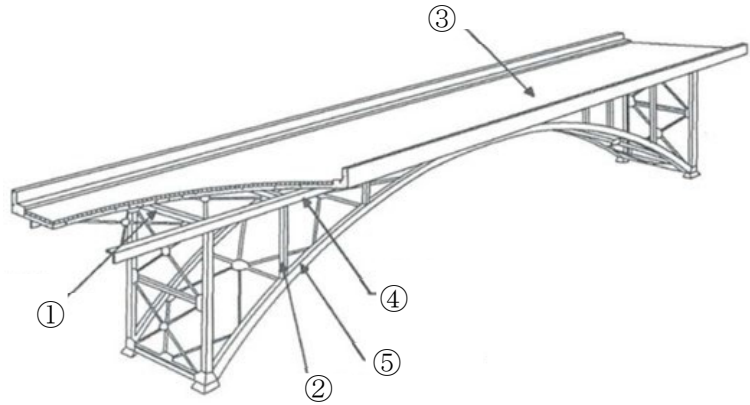


Fig. 2.14 Structure element on superstructure (Steel-5)

**<Concrete T or I girder type>**

- ① Deck slab
- ② Main girder
- ③ Cross beam

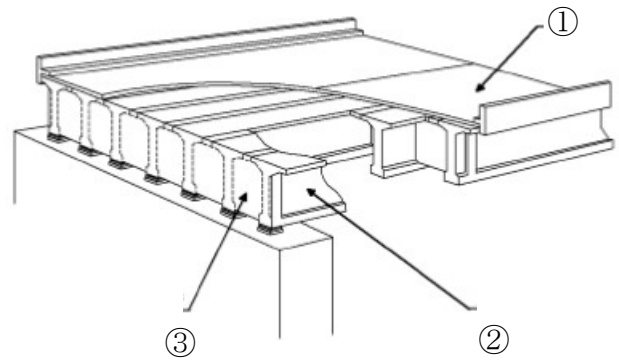
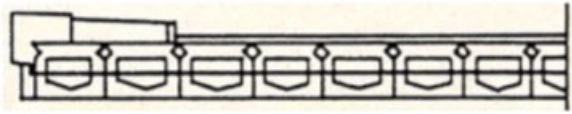


Fig. 2.15 Structure element on superstructure (Concrete-1)

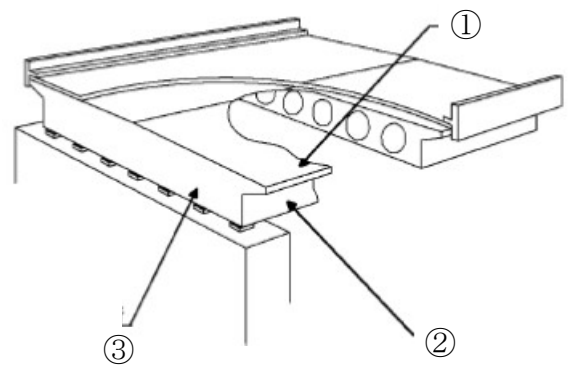
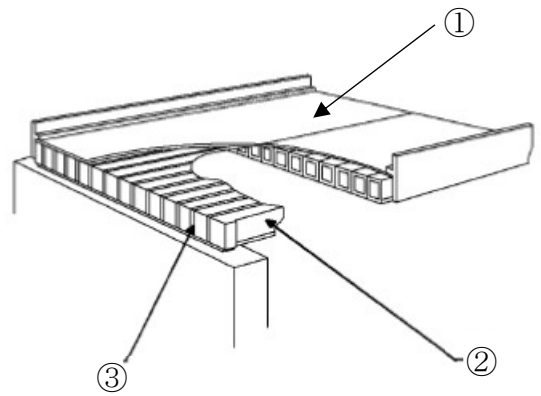
Source: MLIT, Japan

**<Concrete slab type>**



Slab bridge using precast pretensioned concrete girder

- ① Deck slab
- ② Girder
- ③ Cross beam



Solid slab bridge



Hollow slab bridge

Fig. 2.14 Structure element on superstructure (Concrete-2)

**<Concrete box girder type>**

- ① Deck slab
- ② Main girder
- ③ Cross beam

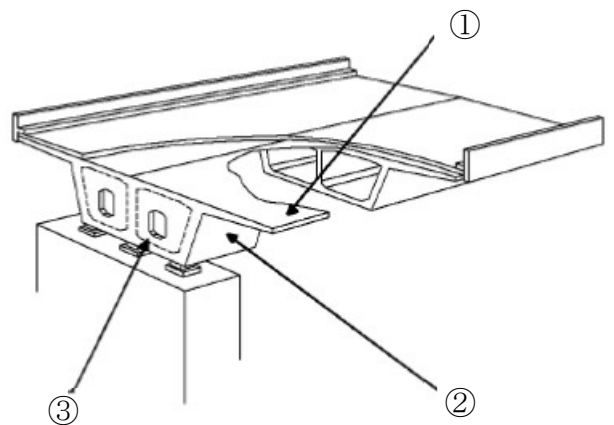
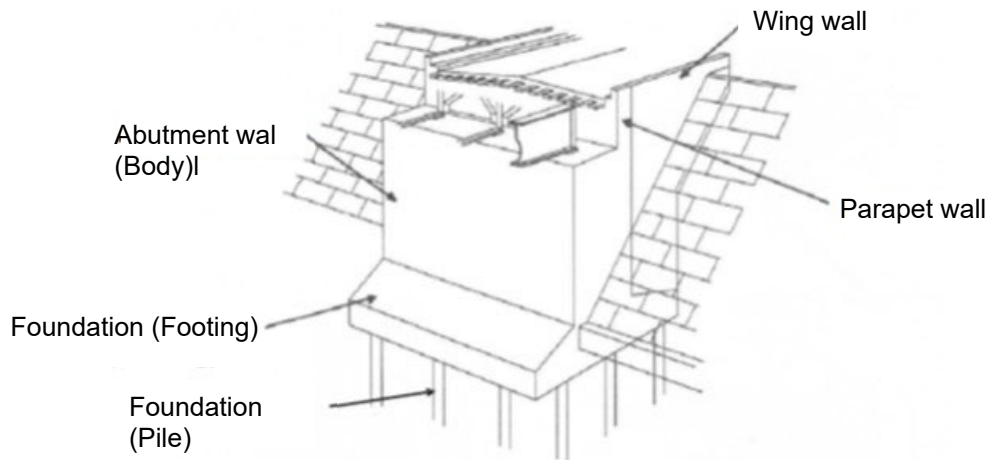


Fig. 2.15 Structure element on superstructure (Concrete-3)

Source: MLIT, Japan

### (3) Name of Structural Element on Substructure

#### <Abutment>



#### <Pier>

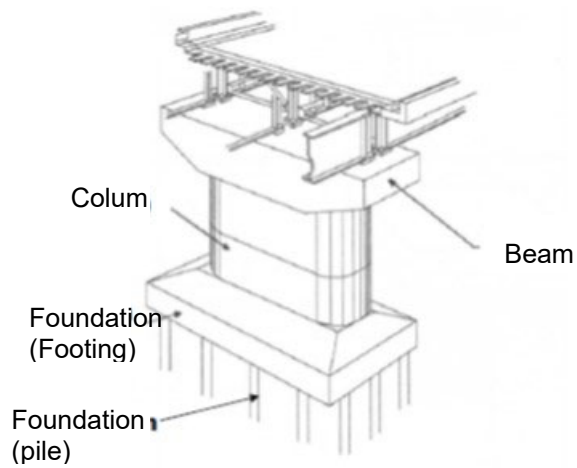
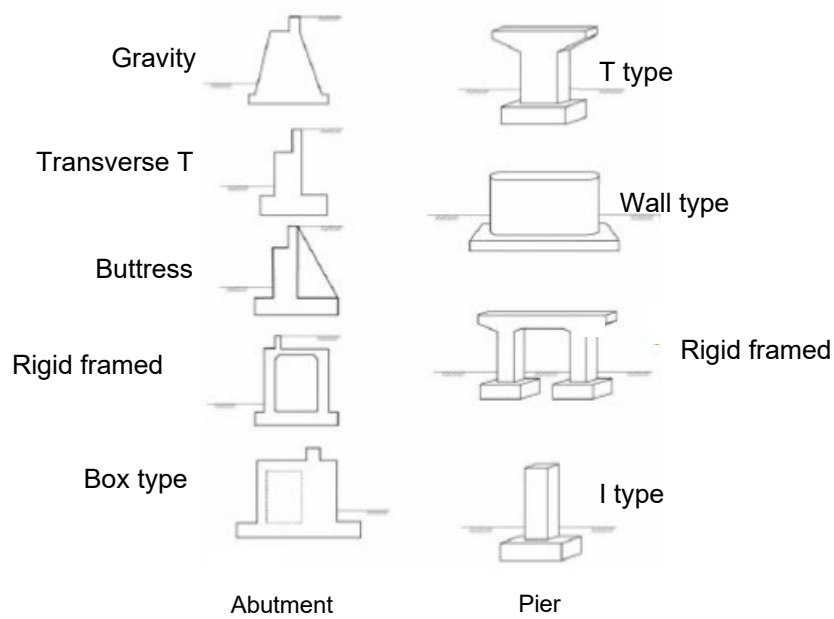


Fig. 2.16 Structure element on substructure

Source: MLIT, Japan

### <Type of Abutment and Pier>



Source: MLIT, Japan

Fig. 2.17 Type of abutment and pier

### <Name of Right Bank and Left Bank>

The right bank or side is always on the right side of the direction in which the river is flowing, i.e. facing downstream, and the left bank is always the left hand side facing downstream.

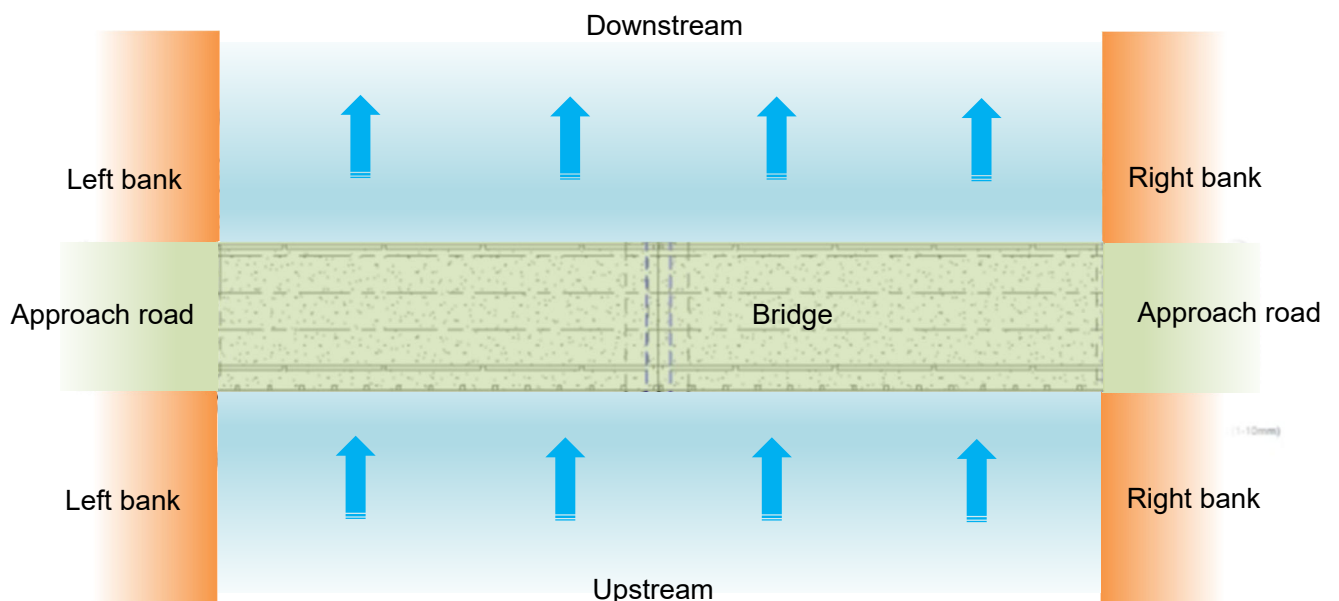


Fig. 2.18 Right bank and left bank

Source: JICA-BMM Team

## Appendix-2 Criteria for Damage Grade Evaluation

[Note: Source of all materials is published by MLIT, Japan (Ministry of Land, Infrastructure, Transport and Tourism, Japan)]

## Table of Contents

Damage on Steel members .....	1
1. Corrosion .....	1
2. Cracks .....	5
3. Loose/Drop-off .....	7
4. Fracture .....	9
5. Degradation of Anticorrosion Performance .....	10
Damage on Concrete Members .....	14
6. Cracks .....	14
7. Peeling/Exposure of Rebar .....	24
8. Leaching/Free lime .....	25
9. Fall-off .....	27
11. Cracks on Slab .....	28
12. Spalling .....	31
13. Unusual or Abnormal Gap .....	32
14. Rough Road Surface .....	33
15. Abnormal Surface (Pavement) .....	34
16. Lack of Bearing Function .....	36
17. Others .....	38
Common Damage .....	39
10. Deterioration of Repair/Reinforcement Material .....	39
18. Abnormal Anchorage .....	43
19. Discoloration and Degradation .....	45
20. Water Leakage/Surface Ponding .....	47
21. Abnormal Sound and/or Vibration .....	48
22. Abnormal Deflection .....	49
23. Deformation /Loss .....	50
24. Sediment Clogging (Drainage Problems) .....	51
25. Subsidence, Displacement, and Inclining .....	52
26. Scouring .....	53

## **Damage on Steel members**

### **1. Corrosion**

#### **【General Features and Characteristics of Damage】**

Corrosion of ordinary steel (for which anticorrosion measures such as painting or plating are performed) refers to a state in which rust is intensively generated or a state in which rust is extremely advanced, resulting in the reduction in cross section and occurrence of corrosion. In the case of Weathering steel, a corrosive state means that abnormal rust is generated without the formation of stable rust, or the cross section is significantly reduced due to extreme rust progression.

Corrosion-prone parts are the ends of girders with frequent water leakage, places where water can easily accumulate, such as the upper surface of horizontal materials, around bearings, joints with poor ventilation and drainage, upper surfaces of lower flanges where mud and dust easily accumulate, and welded parts, etc.

In a structure in which the main members of steel truss bridges and steel arch bridges (upper chords, diagonal members, vertical members, etc.) are embedded in floor slabs or the concrete of the wheel guard, rainwater travels over the members and reaches the road surface, causing water accumulation at the boundary between steel and concrete members and infiltration of water into the concrete. Attention must be paid to the possibility that such situation may cause significant partial corrosion and damage such as reduction in cross section.

Attention should also be paid to places such as panel points of arches and trusses where water/dust accumulation is likely to occur structurally, which may contribute to the partial deterioration of painting or cause significant damage. It is also possible that places with the same structure may have experienced the progress of corrosion in the same way.

Another attention must be taken when parts are covered with a cover or the like, such as the cable anchorage point, as water may enter the inside and corrode the cable inside.

#### **【Hints for Damage Judgement】**

- The occurrence of rust that accompanies a cross-sectional defect shall be evaluated as “corrosion” in principle, and the occurrence of slight rust that can be regarded as not accompanied by a cross-sectional defect shall be evaluated as “degradation of anticorrosion performance”.
- If it is difficult to determine the presence/absence of a cross-sectional defect, the rust shall be regarded as “corrosion”.
- In the case of Weathering steel, it is sometimes difficult to judge if the rust should be judged as abnormal corrosion because rust condition is not uniform up to the point when stable rust is formed. When the rust does not seem to be accompanied by a cross-sectional defect, it shall be evaluated as “degradation of anticorrosion performance”.
- In the case of bolts, too, the occurrence of rust with a cross-sectional defect shall be evaluated as “corrosion”, in principle, and the occurrence of slight rust that can be regarded as not accompanied by a cross-sectional defect shall be evaluated as “degradation of anticorrosion performance”.
- The main girder cantilever parts, panel points, and parts embedded in concrete shall be treated individually irrespective of other parts. The main girder, etc. that includes the said parts shall be evaluated for the element excluding those parts.

#### **【Other Hints】**

- When recording corrosion, it is common that corrosion protection measures such as painting have also been damaged. Therefore, the damage must be recorded at the same time.
- Attention must be taken when steel is corroded, as crack damage is often overlooked near the weld parts.
- The bottom steel plate of a steel-concrete composite floor slab and bottom formwork of a

concrete filled I-beam grid floor shall be treated as steel members.

**【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions	Depth	Width
		A	No damage
B	The rust is superficial, and no significant decrease in the plate thickness is visible. The area of the damaged part is small and partial.	Small	Small
C	The rust is superficial, and a remarkable decrease in the plate thickness cannot be visually recognized. Within the target area, however, rust is observed in the whole range, or there are multiple areas where rust is spread out.	Small	Large
D	Significant expansion has occurred on the steel surface, or a clear reduction in plate thickness is observed. However, the area of the damaged part is small and partial.	Large	Small
E	Significant expansion has occurred on the steel surface, or a clear reduction in plate thickness is observed. Within the target area, rust is observed in the whole range, or there are multiple areas where rust is spread out.	Large	Large

**【Depth of Corrosion】**

Criteria	General condition
Large	Significant expansion has occurred on the surface of the steel materials. Alternatively, a clear reduction in plate thickness can be visually recognized.
Small	Rust has occurred superficial, and no significant reduction in plate thickness is visible.

**【Area of Corrosion】**

Criteria	General condition
Large	Rust has occurred on the entire members of interest. Alternatively, there are multiple rusted areas that are widespread in the area of interest.
Small	The area of the damaged parts is small and local.

**【Evaluation of Damage Grade】**

Corrosion: girder   Grade: B	Corrosion: girder   Grade: C
	
<p>Note: Rust - superficial Area of damaged part - partial</p>	<p>Note: Rust - superficial Area of damaged part - rust is spread out in several areas of the target area (lower flange).</p>
Corrosion: girder   Grade: D	Corrosion: girder   Grade: E
	
<p>Note: Expansion has occurred on the steel surface. Area of damaged part - partial</p>	<p>Note: Expansion and sectional loss have occurred on the steel surface. Area of damaged part- whole range</p>

**【Evaluation of Damage Grade】**

Corrosion: bearing	Grade: B	Corrosion: bearing	Grade: C
			
<p>Note: Rust - superficial Area of damaged part - partial</p>		<p>Note: Rust - superficial Area of damaged part - whole range</p>	
Corrosion: bearing	Grade: D	Corrosion: bearing	Grade: E
			
<p>Note: Expansion has occurred on the steel surface. Area of damaged part - partial</p>		<p>Note: Reduction in steel plate thickness is observed. Area of damaged part - whole range</p>	

## **2. Cracks**

### **【General Features and Characteristics of Damage】**

Cracks in steel materials often appear at the sections of abrupt change or welded joints of members where stress concentration tends to occur. Since cracks may occur inside the steel material, they cannot be detected only from the appearance properties.

Most cracks are extremely small, and if the surface properties are not smooth, as in the vicinity of the weld line, it may be difficult to distinguish them from shading of irregularities due to surface flaws or rust. In addition, when there is a coating, a crack opened on the surface often accompanies the coating film cracking.

Caution should be made in places such as panel points of arch and truss where large stress fluctuations are likely to occur, as these places are where cracks are also likely to occur, and the effect to the entire structural system is enormous if damaged.

In some parts of a structure, such as a cantilever structure in which girders are cut out, etc., stress concentration is likely to be observed, making those parts susceptible to fatigue.

Attention should be paid because once cracks occur in a particular structure, the same may happen in other parts of the same structure.

### **【Hints for Damage Judgement】**

- In many cases, the cause of crack damage in steel cannot be determined from the appearance alone. As such, all flaws that appear on the steel surface shall be treated as “cracks” regardless of their location or size.
- If a member is cut due to breakage or progress of cracks in the steel, it shall be evaluated as a “fracture”.
- When cracks are found in the coating film in areas such as the cross-sections with abrupt change and welded joints, and it is strongly suspected that cracks would have occurred in the steel underneath, evaluations that are to be applied shall be both “degradation of anticorrosion performance” and “cracks” even if the cracks in the steel material are not directly confirmed.

### **【Evaluation of Damage Grade】**

#### **(1) Evaluation Category of Damage Grade**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	Coating film cracks are confirmed in cross sections with abrupt change or welded joints, etc. Cracks are not linear. Even if they are, the length of cracks is extremely short, and the number of cracks is not large.
D	—
E	Linear cracks have occurred. Or coating film cracks have occurred, by which it is strongly suspected that cracks would have occurred underneath.

Note 1: The presence of “coating film cracks” refers to the situation where it is strongly suspected that cracks would have occurred in the steel material.

Note 2: A criterion to judge if a crack’s “length is extremely short” is that the length of the crack is less than 3 mm.

(2) Others to Record

The locations of cracks and coating film cracks, as well as their range and condition, shall be recorded in sketches and photographs, and the size (length) of all damage shall be indicated in the damage diagram.



At this time, record the positional relationship between the plate assembly and the welding line as accurately as possible. For example, a photograph shall be taken of a distant view in which a cracked member and surrounding conditions can be grasped and a close view (in which the member numbers and scale are inserted) in which the positional relationship between the crack length and the welded portion can be grasped. Furthermore, in the sketch with the same angle as the close-up photo, the positional relationship between the crack and the welding line or member along with the crack length shall be entered so that they can be compared with the photo.

However, if the positions of the plate assembly and the welding line are not clear, the record must state so. Unless it is unavoidable in expressing the damage state, do not record the positional relationship between plate assembly and welding lines except when they are visually confirmed. Also, when recording estimated welding lines, it must be clearly stated that the information is estimated only from drawings and appearance characteristics.

If the opening on the steel surface is not directly confirmed, such as when the coating film is cracked, this fact shall be recorded.

If the coating film cracks suspected to have cracks underneath already underwent a magnetic particle flaw detection test, etc. at the time of regular inspection, and it has been confirmed that cracks do not exist underneath, record that fact and evaluate the degree of damage as "A". On the other hand, if a crack is confirmed, it is strictly prohibited to cut it with a grinder, etc. based on the sole decision of a bridge inspector/examiner. Cutting work must be done following the instructions of the road administrator.

【Evaluation of Damage Grade】

Cracks	Grade: C	Cracks	Grade: E
			
<p>Note: Coat film cracks are observed in weld joints, etc. Cracks are found but the length is short and they are not large in number.</p>		<p>Note: Cracks have occurred.</p>	

### **3. Loose/Drop-off**

#### **【General Features and Characteristics of Damage】**

This indicates the situation where bolts are loose, or nuts/bolts have dropped off. Broken bolts shall also be included. Here, all bolts and rivets are targeted, including normal bolts, high-tensile bolts, rivets, etc., regardless of the type and the locations where they are used.

#### **【Hints for Damage Judgement】**

- Dropping of the bearing roller shall be evaluated as “lack of bearing function”.
- Bearing anchor bolts and mounting bolts for expansion devices shall also be covered. If those bolts are damaged, however, evaluation shall also be done for “lack of bearing function” and “lack of expansion device function” respectively.

#### **【Evaluation of Damage Grade】**




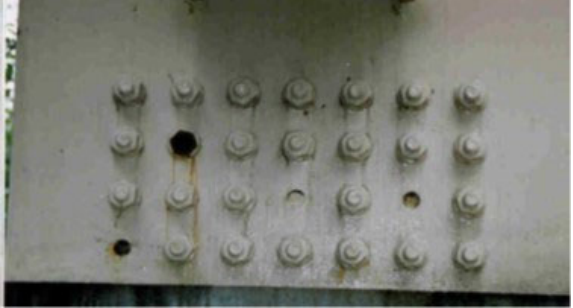
The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	Bolts are loosened or dropped off, but the number is small. (Less than 5% of the number per group)
D	—
E	Bolts are loosened or dropped off, and the number is large. (5% or more of the number per group)

Note 1: A “group” refers to, in the case of the connection part of a main girder, for example, each lower flange connecting plate, web connecting plate, and upper flange connecting plate.

Note 2: If the number of bolts per group is less than 20 in such places as panel points, etc., it shall be evaluated as “E” even when only one bolt is applicable.

**【Evaluation of Damage Grade】**

Loose	Grade: C	Drop-off	Grade C
			
<p>Note: Loosened bearing bolt. Also recorded as “lack of bearing function”.</p>		<p>Note: Less than 5% of the total number per group</p>	
Drop-off	Grade: E	Drop-off	Grade: E
			
<p>Note: 5% or more of the total number per group</p>		<p>Note: 5% or more of the total number per group</p>	

#### 4. Fracture

**【General Features and Characteristics of Damage】**

This refers to the state where a steel member is either completely fractured or ruptured to the extent that it can be regarded as fractured.

Fractures are often found in floor members, secondary members such as sway/lateral bracing, railing, guardrails, accessories, and their attachments.

**【Hints for Damage Judgement】**

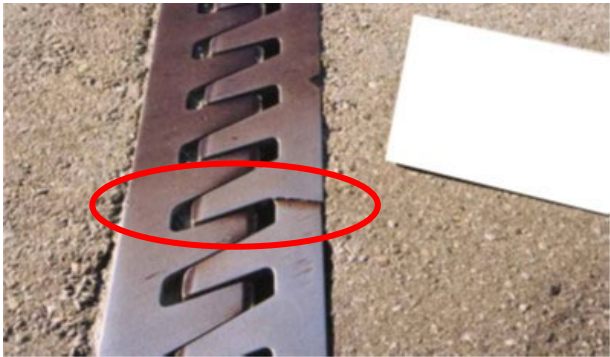

- If corrosion or cracks develop to cause a rupture on the member, and there is no crack or corrosion other than the ruptured part, it shall be evaluated only as “fracture”. If cracks or corrosion occur other than on the ruptured part, each of those damage cases shall also be evaluated.
- Fracture and breakage of bolts and rivets shall be evaluated as “loose/drop-off”.
- Bearings shall also be targeted, and in this case, they shall also be treated as “lack of bearing function”.

**【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Fractured

**【Evaluation of Damage Grade】**

Fracture	Grade: E	Fracture	Grade E
			
Note: Fracture of expansion joint		Note: Main members such as the diagonal member of the truss bridge have been broken, and a risk of the bridge collapsing will be high.	

## **5. Degradation of Anticorrosion Performance**

The classification of anticorrosion performance shall be as follows.

Classification	Anti-corrosion performance
1	Painting
2	Plating, metal spraying
3	Weathering steel

### **【General Features and Characteristics of Damage】**

A state in which discoloration, cracking, blistering, peeling, etc. are formed on steel members as a result of deterioration of the anticorrosion coating for Classification 1 and due to deterioration of the anticorrosion film for Classification 2. Classification 3 is for “Weathering steel”.

### **【Hints for Damage Judgement】**

- As for coating, hot-dip galvanizing, and metal spraying, rust generation accompanied by plate thickness reduction shall be treated as “corrosion”, and slight rust generation that can be regarded as not accompanied by plate thickness reduction shall be judged as “degradation of anticorrosion performance”.
- Coating of concrete members shall not be included. It shall be regarded as “deterioration of repair/reinforcement material”.
- Discoloration due to fire burning or soot adhesion shall also be treated as “ 17. others”.

### **【Other Hints】**

- If there is a rusted part that is treated partially as “corrosion” and a decrease in the anticorrosion function is observed in areas other than the corroded part, it shall also be treated as “degradation of anticorrosion performance”.
- While it may be difficult to determine whether the corrosion is abnormal due to unstableness of the rust condition until the protective rust is formed on the Weathering steel, if it can be considered that there is a reduction in plate thickness, etc., it shall also be treated as “corrosion”.
- When surface treatment agent is applied to the surface of Weathering steel, peeling of the surface treatment agent coating shall not be treated as damage.
- Painted parts on Weathering steel shall be treated as painting.
- White rust generated on the hot-dip galvanized surface shall not be treated as damage. (The state of white rust shall be recorded on the damage diagram).
- The bottom steel plate of a steel-concrete composite floor slab and the bottom formwork of a concrete filled I-beam grid floor shall be treated as steel members.

### 【Evaluation of Damage Grade】

The evaluation of the damage grade shall be based on the following categories.

#### Classification 1: Painting

Grade	General conditions
A	No damage
B	—
C	The outermost anticorrosion coating has discoloration or is loosened locally.
D	The anticorrosion coating is partly peeled off and the undercoat is exposed.
E	The anticorrosion film is widely deteriorated and spot rust has occurred.

Note) When the deterioration range is wide, the most obvious condition of the evaluation unit shall be judged as one of the above. (The same applies below.)

#### Classification 2: Plating, metal spraying

Grade	General conditions
A	No damage
B	—
C	The anticorrosion coating is locally deteriorated and spot rust has occurred.
D	—
E	The anticorrosion film is deteriorated in a wide range and spot rust has occurred.

Note) White rust and “chalking” do not immediately affect the corrosion resistance; therefore, they shall not be treated as damage. However, their condition shall be recorded on the damage diagram.

#### Classification 3: Weathering steel

Grade	General conditions
A	No damage (Protective rust is fine-grained, uniformly distributed, and dark brown in colour.) (During the formation of protective rust, it takes on yellow, red and brown colours.)
B	No damage. However, no protective rust is produced.
C	The size of the rust is about 1 to 5mm and its surface is rough.
D	The size of the rust is about 5 to 25mm with scaly surfaces.
E	A delamination of the rust has occurred.

Note) In general, the colour of rust changes from yellow/or red to dark brown and stabilizes. However, it is not possible to judge whether the rust is protective rust by the rust colour alone.

In addition, in the process of producing protective rust, if a stabilization treatment is done, uneven rust may produce in the state where the film remains.



"B" is newly added to clarify whether the state of no damage is in the process of producing protective rust or in the state of not being produced.

**【Evaluation of Damage Grade】**




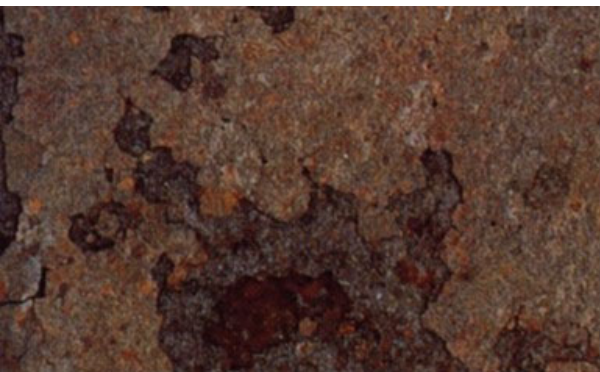
**Classification 1: Painting**

Degradation of anti-corrosion performance	Grade: C	Degradation anti-corrosion performance	Grade: D
			
<p>Note: Anticorrosion film is discolored.</p>		<p>Note: Anticorrosion film has partly peeled off with the exposure of undercoat.</p>	
Degradation of anti-corrosion performance	Grade: E	Degradation anti-corrosion performance	Grade E
			
<p>Note: Anticorrosive film is deteriorated in a wide range, accompanied by spot rust.</p>		<p>Note: Anticorrosive film is deteriorated in a wide range, accompanied by spot rust. It will continue to expand widely in the future.</p>	

**Classification 2: Plating, metal spraying**

Degradation of anti-corrosion performance	Grade: C	Degradation of anti-corrosion performance	Grade: E
			
<p>Note: The hot-dip galvanized film is partially worn away, causing red and white rusts.</p>		<p>Note: The paint on the plated surface has peeled off, and rust is also seen on the plated surface.</p>	

Classification 3: Weathering steel

Degradation of anti-corrosion performance	Grade: C	Degradation anti-corrosion performance	Grade: D
		<p>Note: Rough rust with a size of about 1 to 3 mm occurs on the weathering steel.</p>	<p>Note: The size of the rust is scaly with a size of about 5 to 15 mm.</p>
Degradation of anti-corrosion performance	Grade: E	Degradation anti-corrosion performance	Grade
		<p>Note: Delamination of rust has occurred in areas where water leakage and stagnant water are likely to occur.</p>	<p>Note: Delamination of rust has occurred. (Note: Rust colour depends on environmental conditions varies depending on. )</p>

## Damage on Concrete Members

### 6. Cracks

#### 【General Features and Characteristics of Damage】

The surface of the concrete member is cracked.

#### 【Hints for Damage Judgement】

- If there are other irregularities such as peeling of concrete or exposure of rebar in addition to cracking, they shall be evaluated separately as well.
- Cracks that occur on the floor slab shall be evaluated as “cracks on slab”, and not as “cracks”.
- Cracks in the PC anchorage part shall be treated individually. For main girders and other elements that include the anchorage part, evaluation shall be performed excluding the anchorage part.

#### 【Evaluation of Damage Grade】

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions	Crack width	Crack spacing
A	No damage		
B	Crack width is small (RC structure: less than 0.2 mm, PC structure: less than 0.1 mm) and crack spacing is large (minimum crack spacing is approx. 0.5 m or more).	Small	Large
C	Crack width is small (RC structure: less than 0.2 mm, PC structure: less than 0.1 mm) and crack spacing is small (minimum crack spacing is less than approx. 0.5 m).	Small	Small
	Or crack width is medium (RC structure: 0.2 mm or more and less than 0.3 mm, PC structure: 0.1 mm or more and less than 0.2 mm) and crack spacing is large (the minimum crack spacing is approx. 0.5 m or more).	Medium	Large
D	Crack width is medium (RC structure: 0.2 mm or more and less than 0.3 mm, PC structure: 0.1 mm or more and less than 0.2 mm) and crack spacing is small (the minimum crack spacing is approx. 0.5 m or less).	Medium	Small
	Or crack width is large (RC structure: 0.3 mm or more, PC structure: 0.2 mm or more) and crack spacing is large (the minimum crack spacing is approx. 0.5 m or more).	Large	Large
E	Crack width is large (RC structure: 0.3 mm or more, PC structure: 0.2 mm or more) and crack spacing is small (the minimum crack spacing is approx. 0.5 m or less).	Large	Small

Note) The RC structures, such as post-cast concrete of transversely-fastened section of PC bridge, shall be treated as PC structure when they are incorporated in PC structure member as a whole.

#### 【Level of maximum crack width】

Level	General conditions
Large	RC structure: 0.3 mm or more, PC structure: 0.2 mm or more
Medium	RC structure: 0.2 mm or more and less than 0.3 mm, PC structure: 0.1 mm or more and less than 0.2 mm
Small	RC structure: less than 0.2 mm, PC structure: less than 0.1 mm

#### 【Level of minimum crack spacing】

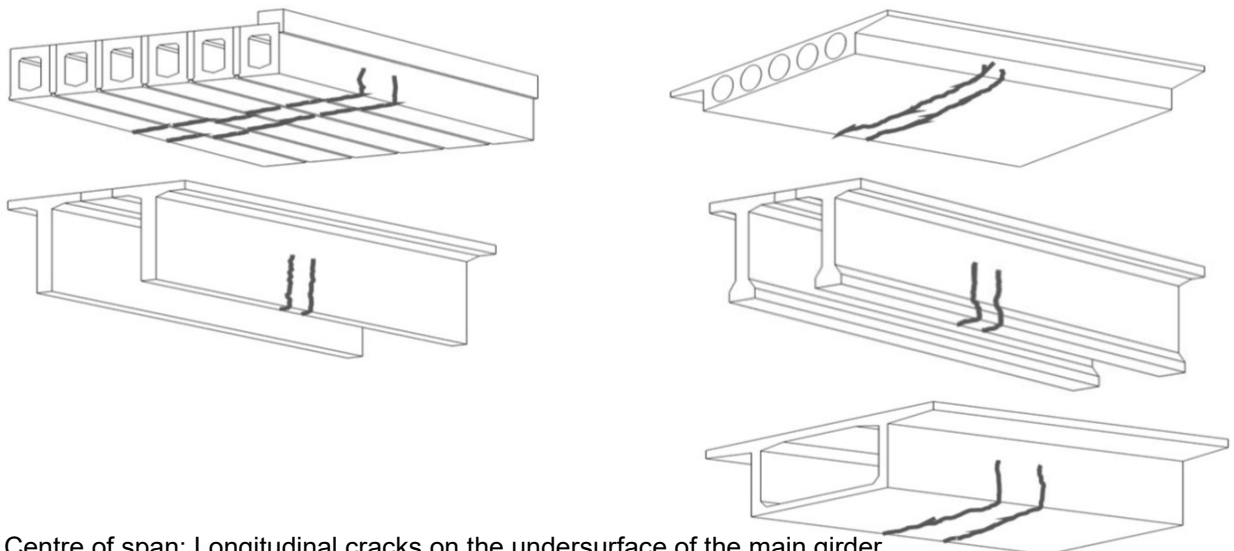
Level	General conditions
Large	minimum crack spacing is approx. 0.5 m or more
Small	minimum crack spacing is less than approx. 0.5 m

1) Category of damage patterns

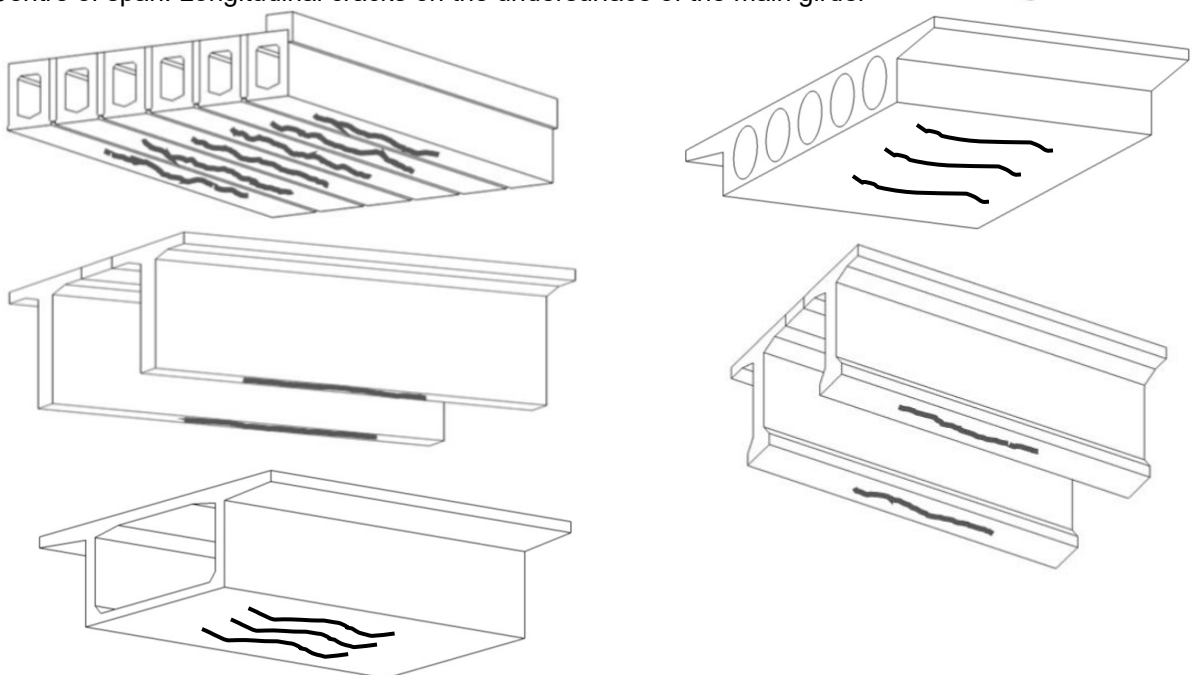
a) Superstructures (Common to RC bridges and PC bridges)

Location	Crack patterns
Centre of span	① Vertical cracks on the undersurface or side surface perpendicular to the main girder
	② Longitudinal cracks on the undersurface of the main girder
1/4 span	③ Vertical or diagonal cracks on the undersurface or side surface perpendicular to the main girder
Fulcrum	④ Diagonal cracks on the web near the fulcrum
	⑤ Vertical cracks on the undersurface or side surface of the girder on the bearing shoe
	⑥ Diagonal cracks on the side surface of the girder
	⑦ Cracks on the cantilever (gerber) portion
	⑧ Vertical cracks on the upper surface of the middle fulcrum of the continuous girder
Others	⑨ Tortoise shell-like and/or spider web-like cracks
	⑩ Vertical cracks at the regular intervals on the web of the girder
	⑪ Horizontal cracks near the joint of the web and the upper flange
	⑫ 45-degree diagonal cracks across the girder

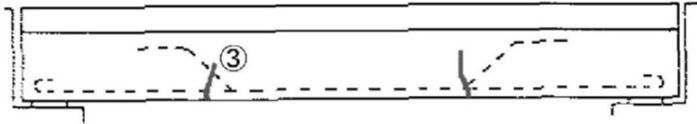
① Centre of span: Vertical cracks on the undersurface or side surface perpendicular to the main girder



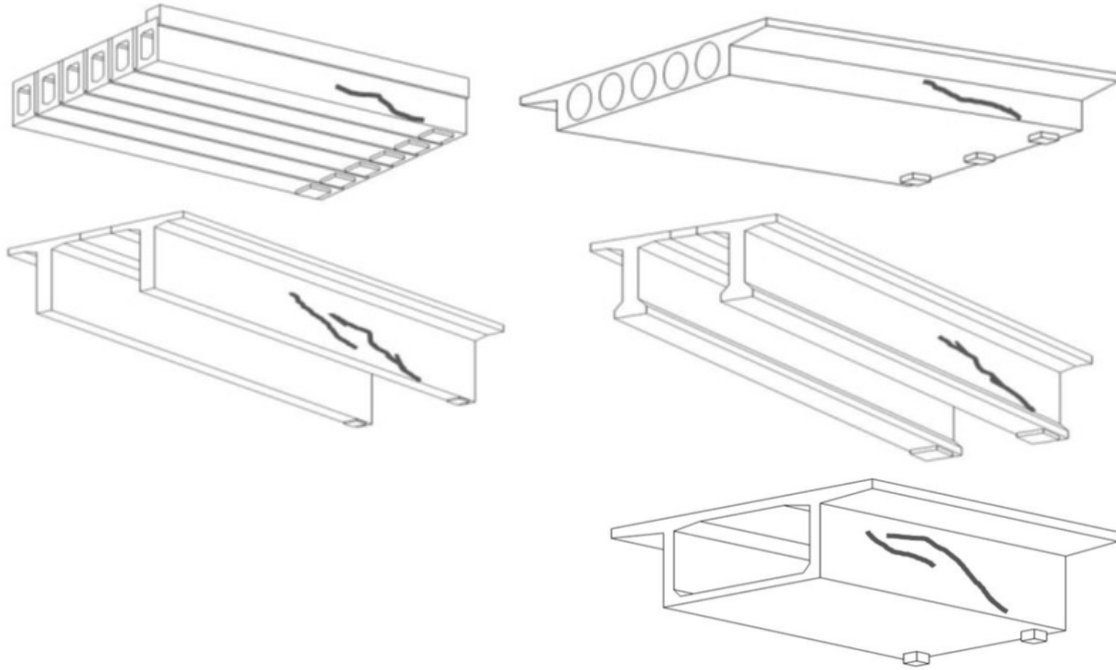
② Centre of span: Longitudinal cracks on the undersurface of the main girder



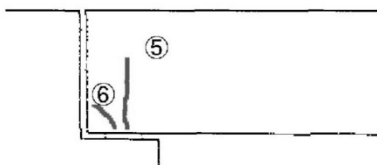
- ③ 1/4 span: Vertical or diagonal cracks on the undersurface or side surface perpendicular to the main girder



- ④ Fulcrum: Diagonal cracks on the web near the fulcrum



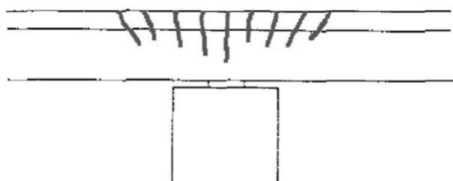
- ⑤ Fulcrum: Vertical cracks on the undersurface or side surface of the girder on the bearing shoe
- ⑥ Fulcrum: Diagonal cracks on the side surface of the girder



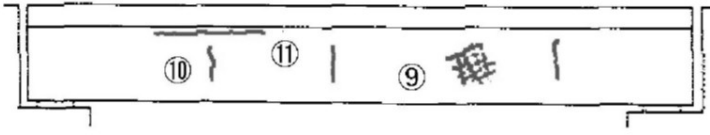
- ⑦ Fulcrum: Cracks on the cantilever (gerber) portion



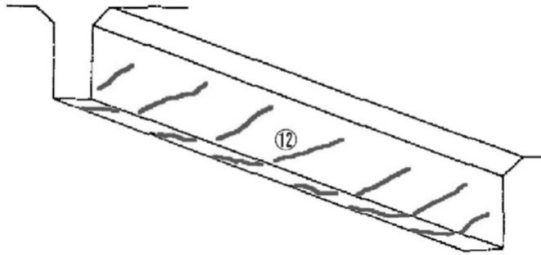
- ⑧ Fulcrum: Vertical cracks on the upper surface of the middle fulcrum of the continuous girder



- ⑨ Others: Tortoise shell-like, spider web-like cracks
- ⑩ Others: Vertical cracks at the regular intervals on the web of the girder
- ⑪ Others: Horizontal cracks near the joint of the web and the upper flange



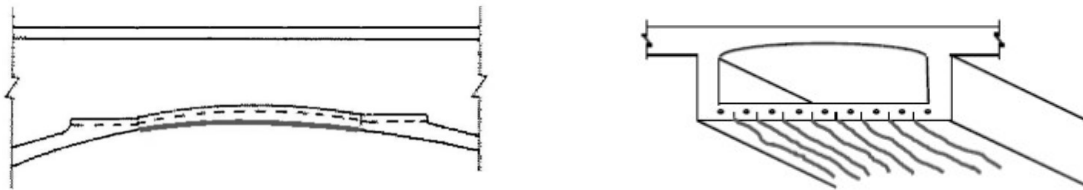
- ⑫ 45-degree diagonal cracks across the girder



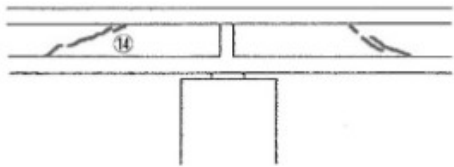
b) Superstructures (Only PC bridges)

Location	Crack patterns
Centre of span	⑬ Cracks along PC steel of the lower flange of the nonuniform section girder
	⑯ Cracks near the upper flange of the main girder
1/4 span	⑭ Cracks along PC steel near the inflection point of the continuous intermediate fulcrum
	⑮ Cracks perpendicular to PC steel near the inflection point of the continuous intermediate fulcrum
Fulcrum	⑰ Horizontal cracks on the web of the main girder
Others	⑰ Cracks near PC steel anchor portion or the deflection portion
	⑰ Cracks near concentrated PC steel
	⑳ Cracks along the sheath

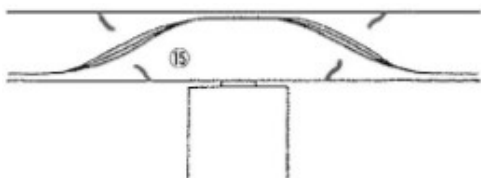
⑬ Centre of span: Cracks along PC steel of the lower flange of the nonuniform section girder



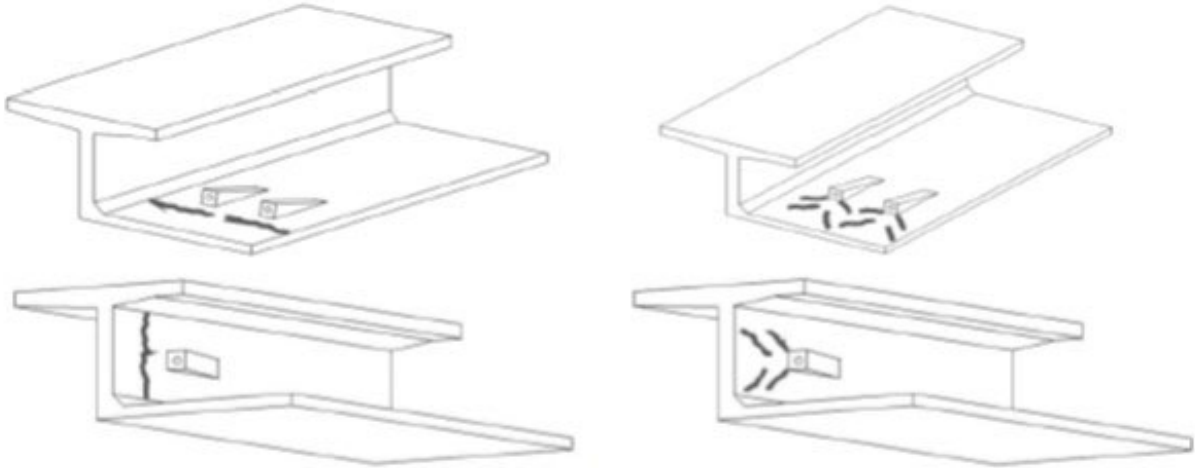
⑭ 1/4 span: Cracks along PC steel near the inflection point of the continuous intermediate fulcrum



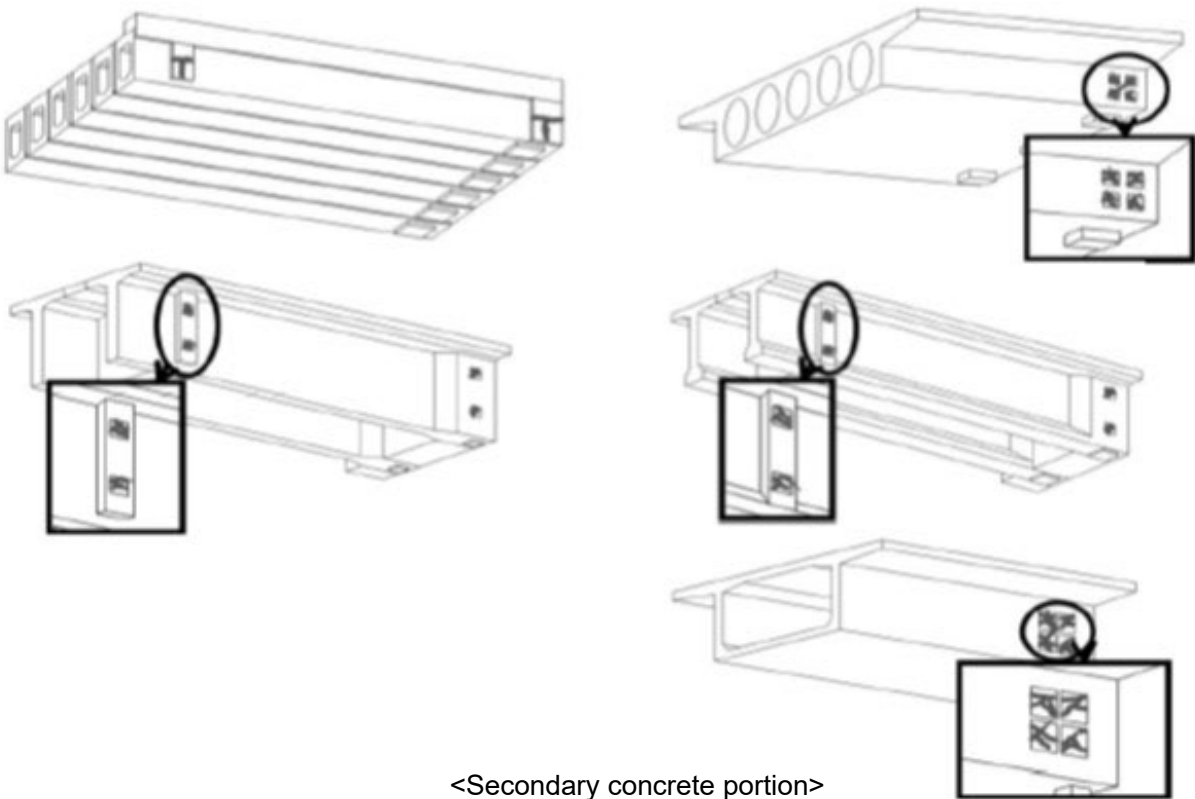
⑮ 1/4 span: Cracks perpendicular to PC steel near the inflection point of the continuous intermediate fulcrum



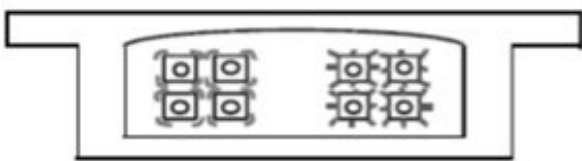
⑩ Others: Cracks near PC steel anchor portion or the deflection portion



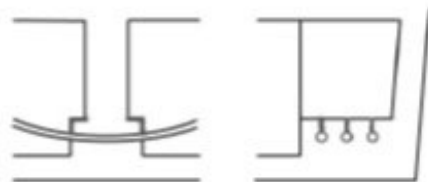
<Around anchoring deviators>



<Secondary concrete portion>



<Outer cable anchor portion>

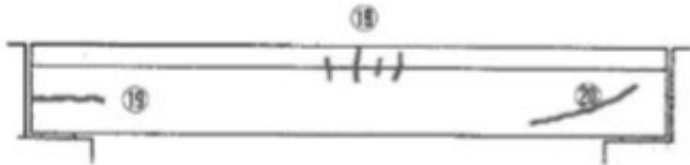


< Deflection portion >

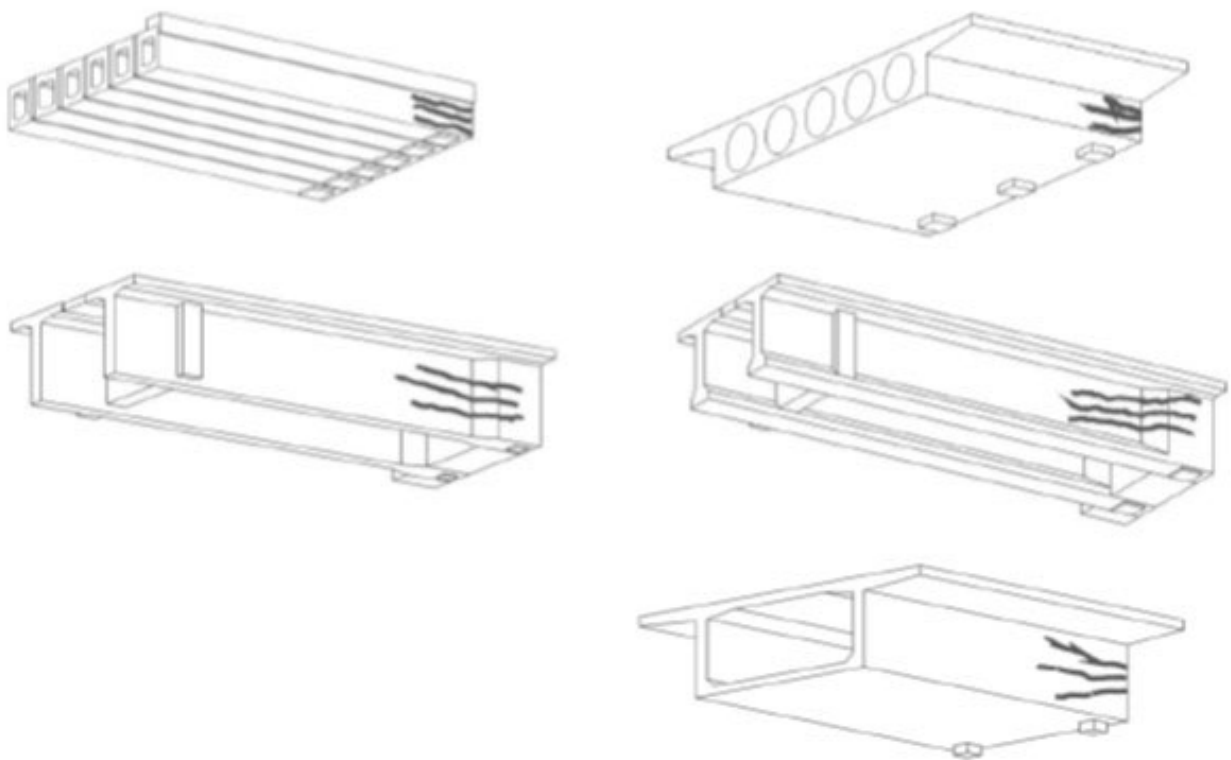
⑰ Others: Cracks near concentrated PC steel



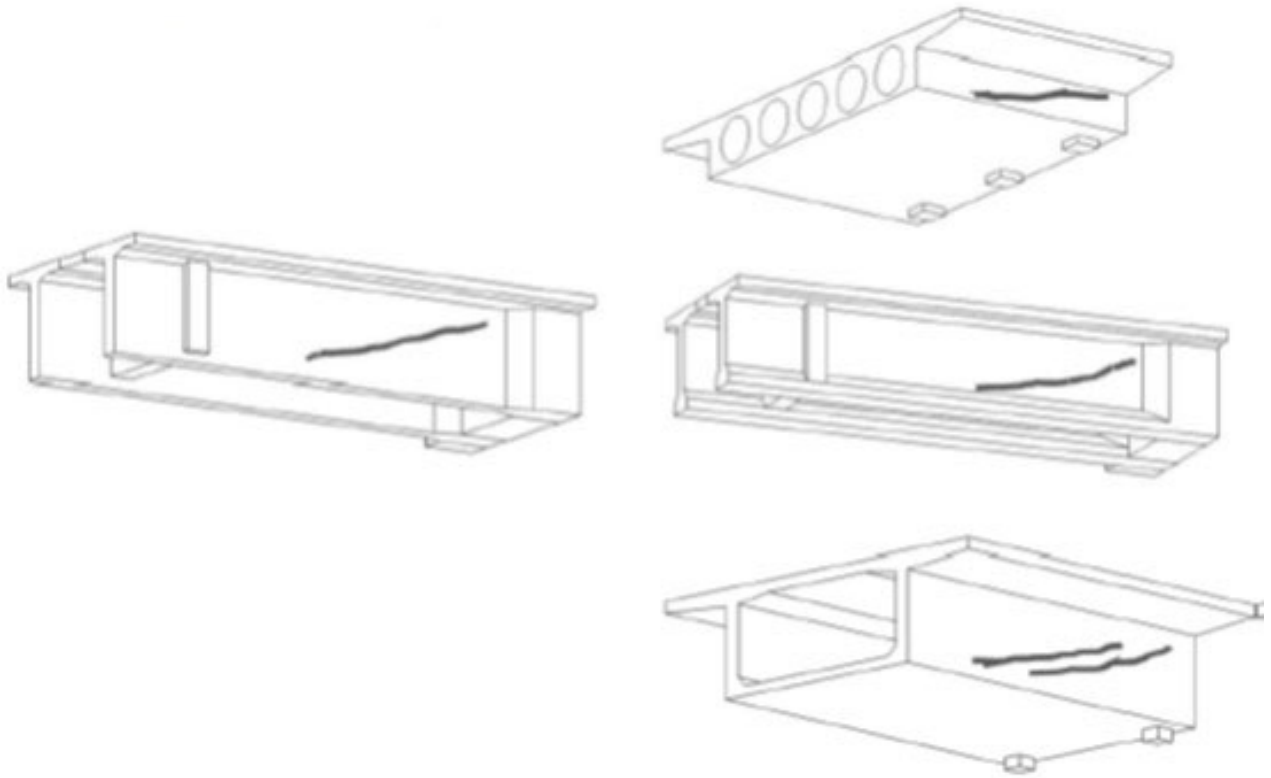
⑱ Centre of Span: Cracks near the upper flange of the main girder



⑲ Fulcrum: Horizontal cracks on the web of the main girder

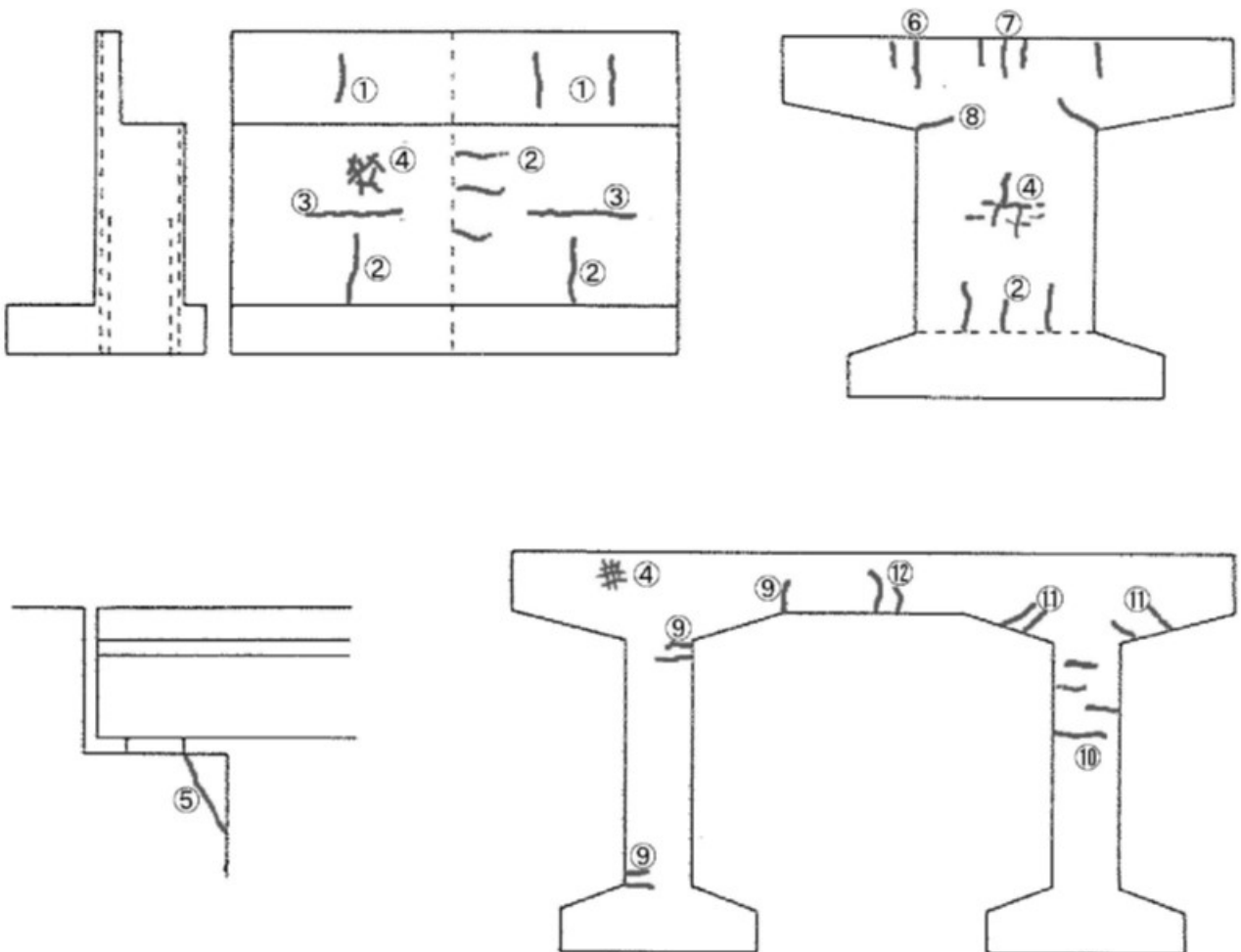


⑩ Others: Cracks along the sheath



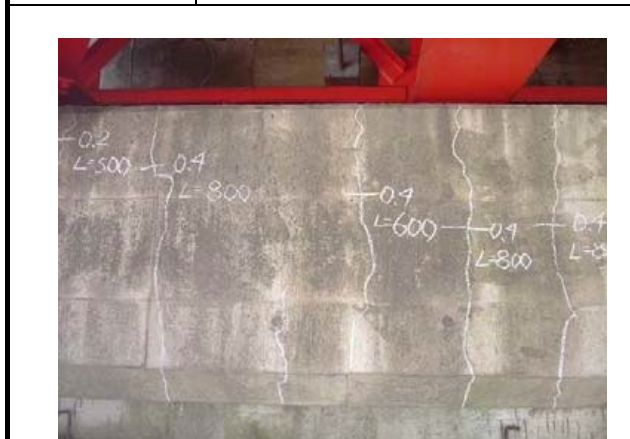



c) Substructure

Location	Crack patterns
Front surface of abutment	① Regular vertical or diagonal cracks
	② Perpendicular or diagonal cracks on construction joints
	③ Cracks near reinforcing bar step
	④ Tortoise shell-like and /or spider web-like cracks
Lower part of bearing	⑤ Cracks near the undersurface of the bearing shoe
T-type pier	② Perpendicular or diagonal cracks on construction joints
	③ Cracks near reinforcing bar step
	④ Tortoise shell-like and /or spider web-like cracks
	⑥ Cracks at the base of the overhang
	⑦ Vertical cracks of at the upper centre of the pier
	⑧ Cracks under the base of the overhang
Rigid-frame type pier	④ Tortoise shell-like and /or spider web-like cracks
	⑨ Cracks on the top and bottom of the pier and all around the haunch portion
	⑩ Cracks all around the pier
	⑪ Cracks on the top of the pier and all around the haunch
	⑫ Cracks in the lower central part of the beam



**【Evaluation of Damage Degree】**

Cracks	Grade: B	Cracks	Grade: C
			
<p>Note: &lt;Crack width&gt; Small [less than 0.2mm] &lt;Crack spacing&gt; Large [0.5m or more]</p>		<p>Note: &lt;Crack width&gt; Small [less than 0.2mm] &lt;Crack spacing&gt; Small [less than 0.5m]</p>	
Cracks	Grade: D	Cracks	Grade: E
			
<p>Note: &lt;Crack width&gt; Large [0.3 mm or more] &lt;Crack spacing&gt; Large:[0.5m or more]</p>		<p>Note: &lt;Crack width&gt; Large [0.3mm or more] &lt;Crack spacing&gt; Small [Less than 0.5m]</p>	

## 7. Peeling/Exposure of Rebar

### 【General Features and Characteristics of Damage】

The surface of the concrete member is peeled off. When the reinforcing bar is exposed at the peeling part, it shall be called “rebar exposure”.

### 【Hints for Damage Judgement】





- In addition to peeling and rebar exposure, those that are deformed or damaged (collision marks) shall also be evaluated.
- “Peeling/exposure of rebar” shall include corrosion and fracture of exposed rebar, and shall not be evaluated as damage such as “corrosion” and “fracture”.
- Peeling and rebar exposure that occur on the floor slab shall be evaluated here in addition to “cracks on slab”.

### 【Evaluation of Damage Grade】

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	Only peeling appears.
D	Rebar is exposed with minor corrosion.
E	Rebar is exposed and corroded.

### 【Evaluation of Damage Grade】

Peeling/exposure of rebar	Grade C	Peeling/exposure of rebar	Grade D
			
Note: Peeling only.		Note: Rebar is exposed with minor corrosion.	
Peeling/exposure of rebar	Grade E	Peeling/exposure of rebar	Grade E
			
Note: Rebar is exposed and corroded.(Pier)		Note: Rebar is exposed and corroded.(Girder)	

## **8. Leaching/Free lime**

### **【General Features and Characteristics of Damage】**

The condition in which water or lime is leached or leaked from concrete joints or cracks.

### **【Hints for Damage Judgement】**

- Precipitates generated by water traveling on the surface of concrete members due to poor drainage, etc. shall be evaluated as “17. others” in distinction from free lime. Water supplied from the outside and flowing on the surface of the concrete member as it is shall be evaluated separately as poor drainage or ponding.
- For concrete damage such as cracking, spalling, and peeling, they shall be evaluated also for the respective items.
- Leaching and free lime generated in the floor slab shall also be evaluated here in addition to “cracks on slab”.


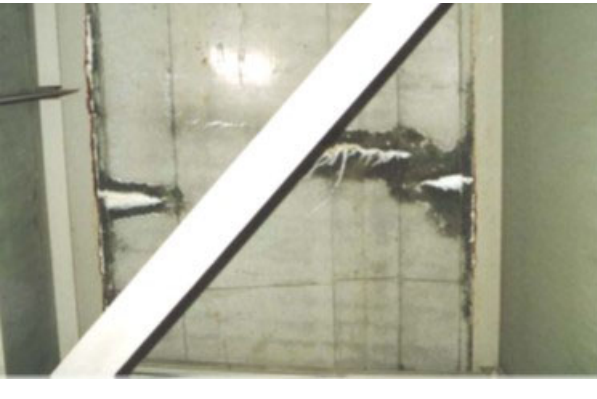


### **【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	Leaching is observed from cracks, but no free lime and rust fluid is seen.
D	Free lime is produced from cracks, but almost no rust fluid is seen.
E	Cracks have caused significant leaching and free lime. Or the presence of mud and rust fluid is remarkable in the leaching.

Note) Leaching and free lime from splices and joints shall be evaluated in the same way as cracks.

**【Evaluation of Damage Grade】**

Leaching/free lime	Grade C	Leaching/free lime	Grade D
			
<p>Note: Leaching is observed from cracks, but no free lime and rust fluid is seen.</p>		<p>Note: Free lime is produced from cracks, but almost no rust fluid is seen.</p>	
Leaching/free lime	Grade D	Leaching/free lime	Grade E
			
<p>Note: Free lime is produced from cracks, but almost no rust fluid is seen.</p>		<p>Note: Cracks have caused significant leaching and free lime. The presence of mud and rust fluid is remarkable in the leaching.</p>	

**9. Fall-off**

**【General Features and Characteristics of Damage】**

“Fall-off” refers to a situation where a chunk of concrete falls out of a concrete floor slab (including filling concrete).

Alligator cracks are often involved in the case of a floor slab. In case of filling concrete or overhanging concrete, concrete chunks may fall out between steel materials without significant cracks in the surrounding area.

**【Hints for Damage Judgement】**



- In the case of a floor slab, and even when significant cracks exist, the evaluation shall be “cracks on slab” until immediately before the concrete chunk falls out.
- When peeling progresses significantly and penetrates the member, evaluation shall be “fall-off”.

**【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Concrete chunk has fallen off.

**【Evaluation of Damage Grade】**

Fall-off	Grade E	Fall-off	Grade E
			
Note: Fall-off is observed in concrete slab.		Note: Fall-off is observed in concrete slab.	

## **11. Cracks on Slab**

### **【General Features and Characteristics of Damage】**

This refers to cracks on a concrete floor slab of a steel bridge, indicating a state in which unidirectional or bidirectional cracks are generated on the bottom surface of the slab.

The cracks between the webs of the T-girder bridge of a concrete bridge (including the filling concrete parts), the inner upper surface of the box girder of a box girder bridge, and the overhanging parts of a hollow slab bridge and a box girder bridge shall also be included.

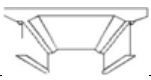



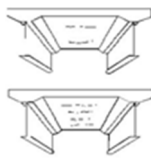

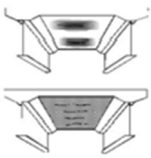
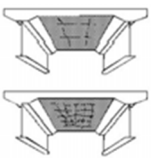
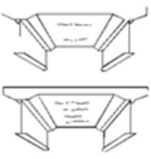

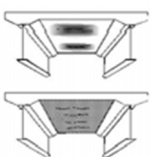
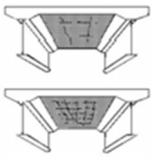
### **【Hints for Damage Judgement】**

- Regardless of the characteristics of cracks in the floor slab, if concrete peeling or exposed rebar is present, those parts shall also be treated as damaged parts in their respective items.
- Leaching, free lime, and rust fluid, etc. from floor slab cracks shall be dealt with in each item as well as in the item of “leaching/free lime”.
- When a concrete chunk falls out due to significant cracking, it shall be treated as “fall-off” in this element.


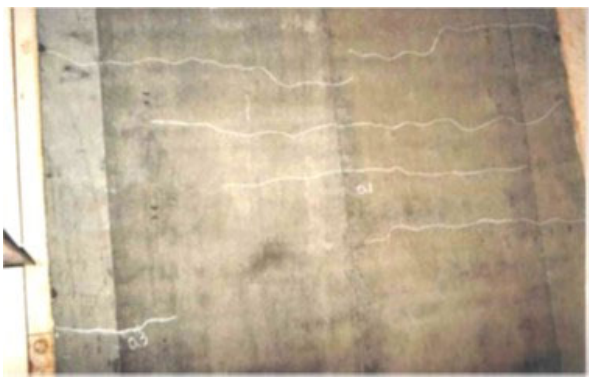


**【Evaluation of Damage Grade】**

(1) Evaluation of Damage Grade

The evaluation of the damage grade shall be based on the following categories.

Condition	Unidirectional crack			Bidirectional crack		
	Properties	Crack	Leaching, free lime	Properties	Crack	Leaching, free lime
A		No damage	No	—		No
B		<ul style="list-style-type: none"> <li>• Minimum crack spacing is approx. 1 m or more</li> <li>• Maximum crack width is 0.05 mm (about the size of a hairline crack)</li> </ul>	No	—		No
C		<ul style="list-style-type: none"> <li>• Crack space not a concern.</li> <li>• Crack width is mainly 0.1 mm or less. (Some are 0.1 mm or more).</li> </ul>	No		<ul style="list-style-type: none"> <li>• Size of grid is approx. 0.5 m.</li> <li>• Crack width is mainly 0.1 mm or less. (Some are 0.1 mm or more).</li> </ul>	No
D		<ul style="list-style-type: none"> <li>• Crack space not a concern.</li> <li>• Crack width is mainly 0.2 mm or less. (Some are 0.2 mm or more).</li> </ul>	No		<ul style="list-style-type: none"> <li>• Size of grid is 0.5 to 0.2 m.</li> <li>• Crack width is mainly 0.2 mm or less. (Some are 0.2 mm or more).</li> </ul>	No
		<ul style="list-style-type: none"> <li>• Crack space not a concern.</li> <li>• Crack width is mainly 0.2 mm or less. (Some are 0.2 mm or more).</li> </ul>	Yes		<ul style="list-style-type: none"> <li>• Size of grid not a concern.</li> <li>• Crack width is mainly 0.2 mm or less. (Some are 0.2 mm or more).</li> </ul>	Yes
E		<ul style="list-style-type: none"> <li>• Crack space not a concern.</li> <li>• Crack width of 0.2 mm or more is remarkable. Corner falls are observed partially.</li> </ul>	No		<ul style="list-style-type: none"> <li>• Size of grid is 0.2 m or less.</li> <li>• Crack width of 0.2 mm or more is remarkable. Corner falls are observed partially.</li> </ul>	No
		<ul style="list-style-type: none"> <li>• Crack space not a concern.</li> <li>• Crack width of 0.2 mm or more is remarkable. Corner falls are observed partially.</li> </ul>	Yes		<ul style="list-style-type: none"> <li>• Grid size not a concern.</li> <li>• Crack width of 0.2 mm or more is remarkable. Corner falls are observed partially.</li> </ul>	Yes

**【Evaluation of Damage Grade】**

Cracks on slab	Grade B	Cracks on slab	Grade C
			
<p>Note: Minimum crack spacing is approx. 1m or more. Maximum crack width is less than 0.05 mm (about the size of a hairline crack)</p>		<p>Note: Crack spacing not a concern. Crack width is mainly 0.1 mm or less. (Some are 0.1 mm or more).</p>	
Cracks on slab	Grade D	Cracks on slab	Grade E
			
<p>Note: Size of grid not a concern. Crack width is mainly 0.2 mm or less. (Some are 0.2 mm or more).</p>		<p>Note: Grid size not a concern. Crack width of 0.2 mm or more is remarkable. Corner falls are observed partially.</p>	

## 12. Spalling

### 【General Features and Characteristics of Damage】

Spalling means that the area near the surface of a concrete member is in a loose state.

Even if spalling cannot be visually judged from the swelling or other irregularities that occur on the concrete surface, it may be possible to detect it by performing a hammering test that produces a dull sound if spalling exists.

### 【Hints for Damage Judgement】

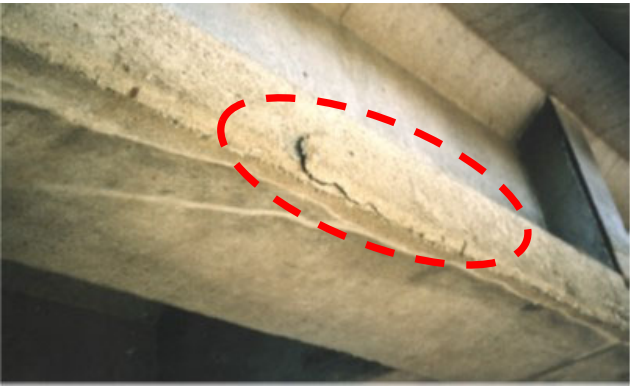

- If the concrete in the loosened portion peels off, it shall be evaluated as “peeling/exposure of rebar”.
- The same evaluation shall apply in the case of floor slab concrete.

### 【Evaluation of Damage Grade】

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Spalling exists

### 【Evaluation of Damage Grade】

Spalling	Grade E	Spalling	Grade E
			
<p>Note: Spalling exists on PC girder.</p>		<p>Note: Spalling exists on PC girder (Lower surface)</p>	

### 13. Unusual or Abnormal Gap

#### 【General Features and Characteristics of Damage】

A state where there is an abnormality in the spacing between girders. When the gap between girders or the gap between the girder and abutment is unusually wide or if they are in contact with each other without any gap, they shall be considered to be abnormal. The abnormality of spacing can sometimes be confirmed with the presence of abnormal deformation of the bearing or damage to the expansion devices and parapet.

#### 【Hints for Damage Judgement】

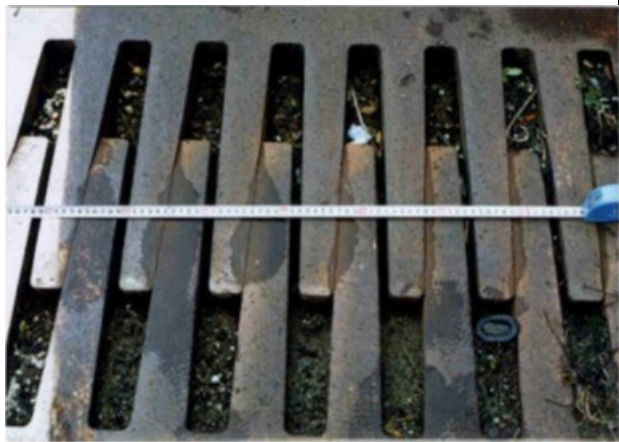

- If an abnormal gap is found to be accompanied by other irregularities such as damage in the expansion devices or the bearing, that damage shall also be evaluated separately.
- The level difference (abnormality in the perpendicular direction) of the expansion device shall be evaluated as “rough road surface”.
- If there is a deviation or abnormality in the movement of the seismic coupling device or the bearing, or if there is an abnormality in the gap at the expansion part of the railing, they shall be evaluated as “unusual or abnormal gap”.

#### 【Evaluation of Damage Grade】

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	The left and right gaps are extremely different from each other, or the gaps are misaligned at right angles.
D	—
E	The gap is abnormally wide and the teeth of the expansion joint are completely separated. Or the girder and parapet or the girders are in contact with each other (or there is a trace of contact).

#### 【Evaluation of Damage Grade】

Unusual or abnormal gap	Grade C	Unusual or abnormal gap	Grade E
			
<p>Note: the gaps are misaligned at right angles.</p>		<p>Note: The gap is abnormally wide and the teeth of the expansion joint are completely separated.</p>	

## 14. Rough Road Surface

### 【General Features and Characteristics of Damage】

Unevenness or steps that occur on the road surface in the longitudinal direction, which serves as the cause for increased impact force.

### 【Hints for Damage Judgement】



- Unevenness/steps in the longitudinal direction shall all be covered regardless of the cause or location.
- Pavement corrugations, potholes and cave-ins, and steps on expansion joints and on the back of the abutment parapet shall also be covered.
- Unevenness in the perpendicular direction (rutting) shall be treated as “abnormal surface of pavement”.

### 【Evaluation of Damage Grade】

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	Unevenness exists in the longitudinal direction, but the amount of step is small (less than 20 mm).
D	—
E	Unevenness exists in the longitudinal direction, and the amount of step is large (20 mm or more).

### 【Evaluation of Damage Grade】

Rough road surface	Grade C	Rough road surface	Grade E
			
<p>Note: There are steps less than 20mm and potholes on the pavement. Step is small.</p>		<p>Note: Step at the cantilever [Gelber] part more than 20mm. Step is large.</p>	

## **15. Abnormal Surface (Pavement)**

### **【General Features and Characteristics of Damage】**

Abnormality of pavement surface refers to a condition in which damage of the top surface of the concrete floor slab (where concrete on the top surface of the floor slab has been loosened into earth, sand, and mud) manifests externally in the form of loosened pavement or potholes, etc. It should be noted that the damage to be covered should not be limited to the aforementioned causes.

Since abnormality observed on the pavement surface could possibly be related to the damage of the floor slab, the repair marks of potholes shall also be treated as “abnormal pavement surface”.

### **【Hints for Damage Judgement】**

- The phenomena to be inspected include cracks, looseness, and potholes in the pavement, but the inspection shall not be intended for the evaluation to be used to judge the maintenance and repair of the pavement itself. Instead, the evaluation shall be for judging the soundness of the concrete floor slab.
- If the damage of the top surface of the floor slab affects the bottom surface, other types of damage observed (e.g. cracking of the floor slab, peeling, rebar exposure, leaching, and free lime) shall be evaluated in each respective item.

### **【Evaluation of Damage Grade】**

1) The evaluation of the damage grade shall be based on the following categories.



Grade	General conditions
A	No damage
B	—
C	The pavement is slightly damaged with cracks of approx. less than 5 mm in width.
D	—
E	The crack width of the pavement is 5 mm or more, and the top surface concrete of a floor slab directly under the pavement has been loosened into earth and sand. Or excessive deflection has possibly occurred due to fatigue cracks on a steel slab.

2) Damage pattern classification

In the case of a steel deck, the damage pattern shall be classified according to the following table and the corresponding pattern number shall be recorded. If more than one type of damage pattern is found in an element, all pattern numbers shall be recorded.

Pattern	Damage
1	Cobweb-like (or fine grid) cracks
2	Cave-in is found locally in the pavement.
3	Cracks that extend continuously and vertically in the direction of the lane
4	Local cracks that appear regularly in the lane direction
5	Remarkable rutting and potholes (incl. repair marks) have occurred.

**【Evaluation of Damage Grade】**

Abnormal surface (pavement)	Grade C	Abnormal surface (pavement)	Grade E
	<p>Note: Cracks are progressing like a spider web. Crack width is less than 5mm.</p>		<p>Note: Cracks of spider web and more than 5mm width</p>

## **16. Lack of Bearing Function**

### **【General Features and Characteristics of Damage】**

A state in which some or all of the load support and displacement tracking function that a bearing should possess are impaired. The fall of the bearing roller shall also be covered.

In addition, it refers to a state in which some or all functions of the elements of a bridge fall prevention system (excluding bridge girder seating length), such as girder movement restrictions and shock absorber, etc. are impaired.

### **【Hints for Damage Judgement】**

- Damage cases of the elements constituting a bearing such as those of bearing anchor bolts (corrosion, fracture, and loosening, etc.) and of shoe seat concrete (cracking, peeling, and chipping, etc.), etc. shall be evaluated separately for each item.
- In principle, sedimentation around bearings shall be treated as “sediment clogging”. If the sedimentation is found to be causing the impaired bearing function, however, it shall also be treated as “lack of bearing function”. In addition, it is desirable to remove the accumulated sediment at the time of inspection in order to understand the damage condition of the bearing.

### **【Evaluation of Damage Grade】**

1) The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Changes that indicate the possibility of the function of the bearing being lost or significantly impaired have occurred.

2) Damage pattern classification

The damage pattern shall be classified according to the following table and the corresponding pattern number shall be recorded. If more than one type of damage pattern is found in an element, all pattern numbers shall be recorded.

Pattern	Damage
1	Loss of shoe seat mortar or pedestal concrete
2	Remarkable corrosion
3	Drop-off of bearing roller
4	Breakage, rupture or abnormal deformation of rubber bearing
5	Loosening or breakage of anchor bolts or set bolts
6	Inclination, deviation, or detachment
7	Large amount of sediment
8	Loss of damper functions
9	Others

**【Evaluation of Damage Grade】**

Loss of bearing function	Grade E	Loss of bearing function	Grade E
			
Note: Pattern 1 (Loss of shoe seat mortar or pedestal concrete)		Note: Patter 2 (Remarkable corrosion)	
Loss of bearing function	Grade E	Loss of bearing function	Grade E
			
Note: Pattern 3 (Drop-off of bearing roller)		Note: Pattern 4 (Breakage, rupture or abnormal deformation of rubber bearing)	
Loss of bearing function	Grade E	Loss of bearing function	Grade E
			
Note: Pattern 5 (Loosening or breakage of anchor bolts or set bolts)		Note: Pattern 6 (Inclination, deviation, or detachment)	
Loss of bearing function	Grade E	Loss of bearing function	Grade E
			
Note: Pattern 7 (Large amount of sediment)		Note: Pattern 8 (Loss of damper functions with corrosion and displacement)	

## 17. Others

### 【General Features and Characteristics of Damage】

Damage cases that fall under none of 1. to 16. nor 18 to 26. of “types of damage”, such as bird droppings, graffiti, illegal use of bridges, and various types of damage caused by fire, shall be treated as “others”.

### 【Evaluation of Damage Grade】

1) The evaluation of the damage grade shall be based on the following categories.




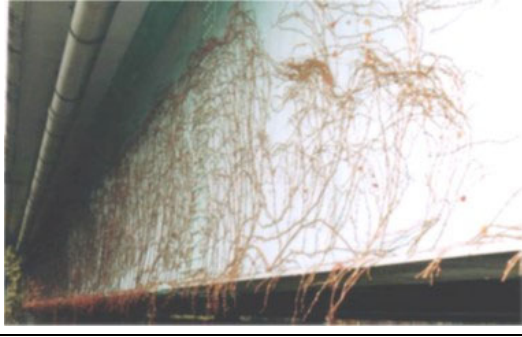
Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Damage exists.

2) Damage pattern classification

“Types of damage” refers to damage that does not fall under any of ① to ⑬ and ⑱ to ㉔. For example, damage caused by bird droppings, graffiti, illegal occupation of bridges, fires, etc., are treated as “(17) other” damage.

Pattern	Damage
1	Illegal occupation
2	Graffiti
3	Bird droppings
4	Misalignment or falling off of joint materials, etc.
5	Damage by fire
6	Others (e.g. entanglement of plants, etc.)

### 【Evaluation of Damage Grade】

Others	Grade E	Others	Grade E
			
Note: Pattern 1 (Illegal occupation)		Note: Pattern 3 (Bird droppings)	
Others	Grade E	Others	Grade E
			
Note: Pattern 5 (Damage by fire)		Note: Pattern 6 Others (Entanglement of plants, etc.)	

## Common Damage

### 10. Deterioration of Repair/Reinforcement Material

The classification of repair/reinforcement material shall be as follows.

#### I. Repair/reinforcement material for concrete members

Classification	Repair/reinforcement material
1	Steel plate
2	Fiber
3	Concrete material
4	Painting

#### II. Repair/reinforcement material for steel members

Classification	Repair/reinforcement material
5	Steel plate (cover plate, etc.)

#### **【General Features and Characteristics of Damage】**

A state in which reinforcing material installed on the surface of a concrete member such as a steel plate, carbon fiber sheet, or glass fiber cloth, or coating material such as painting exhibits abnormalities such as loosening, deformation, and peeling, etc.

It also refers to the state where damage such as corrosion has occurred in the repair/reinforcement material such as a steel plate (cover plate, etc.) installed on steel members.

#### **【Hints for Damage Judgement】**

- Damage of reinforcement material appears in various forms depending on material and structures. In some cases, the damage of reinforcement material is the manifestation of the damage of the concrete member itself that has undergone reinforcement work, such as leaching or free lime. These cases of damage shall be regarded as functional deterioration and evaluated as “deterioration of repair/reinforcement material”, and shall be distinguished from the damage of the bridge body itself.
- If there are damage cases such as cracks, peeling, or exposed rebar for Classification 3, they shall also be evaluated for each respective item.
- Classification 4 shall not be treated as “degradation of anticorrosion performance”.
- For classification 5, damage on the steel plate (cover plate, etc.) installed on a steel member shall be treated only in this item, and not in other items such as “degradation of anticorrosion performance” or “corrosion”.

If damage is observed on the main body along with the damage of a steel plate (cover plate, etc.), the evaluation shall also be done for the main body that is damaged.

### 【Evaluation of Damage Grade】

The evaluation of damage grade shall be based on the following categories.

#### Classification 1: Steel plate

Grade	General conditions
A	No damage
B	—
C	Although the steel plate in a repaired part is not loosened, the sealing part is partially peeled/rusted, or leaching is observed.
D	—
E	One of the following damage cases is observed: <ul style="list-style-type: none"> <li>• The steel plate of a repaired part is loosened.</li> <li>• Sealing part is almost peeled off. Concrete anchor is partially loosened and remarkable rust or leaching is observed.</li> <li>• Concrete anchor is corroded.</li> <li>• Concrete anchor is partially loosened.</li> </ul>

#### Classification 2: Fiber

Grade	General conditions
A	No damage
B	-
C	Reinforcement has some minor damage such as partial blistering, or leaching or free lime is generated from the reinforced concrete member.
D	-
E	Reinforcement is severely damaged or ruptured, or a large amount of leaching or free lime is generated from the reinforced concrete member.

#### Classification 3: Concrete material

Grade	General conditions
A	No damage
B	—
C	Leaching and free lime are generated from the reinforced concrete members, or slight damage is observed on the reinforcing material.
D	—
E	Large amount of leaching and free lime is generated from the reinforced concrete members, or significant damage is observed on the reinforcing material.

#### Classification 4: Painting



Grade	General Conditions
A	No damage
B	—
C	Painting is peeling off.
D	—
E	Rust fluid is observed on the reinforced concrete member with peeled paint, or a large amount of leaching or free lime is generated.

Classification 5: Steel plate (cover plate, etc.)



Grade	General conditions
A	No damage
B	—
C	Minor damage (degradation of anticorrosion performance, partial corrosion, or part of bolts being loosened, etc.) is observed on steel plate (cover plate, etc.).
D	—
E	Remarkable damage (corrosion covering the whole range, many bolts being loosened, or cracks, etc.) is observed on steel plate (cover plate, etc.).

【Evaluation of Damage Grade】



Classification 1: Steel plate

Deterioration of Repair/Reinforcement Material	Grade C	Deterioration of Repair/Reinforcement Material	Grade E
			
Note: Rust is observed on the steel plate of repaired part.		Note: Remarkable rust is observed on the reinforcement.	



Classification 2: Fiber

Deterioration of Repair/Reinforcement Material	Category: C	Deterioration of Repair/Reinforcement Material	Category: E
			
Note: Reinforcement is partially blistered. Free lime is generated from concrete member.		Note: Fiber sheet is ruptured.	

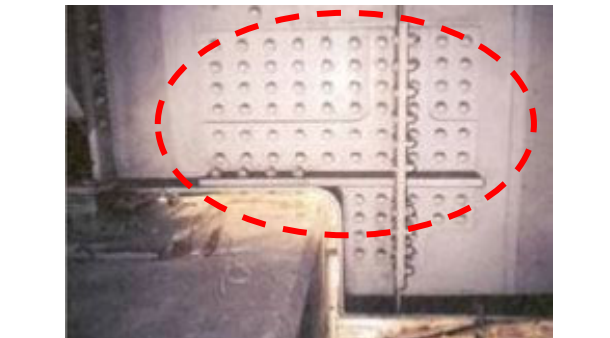
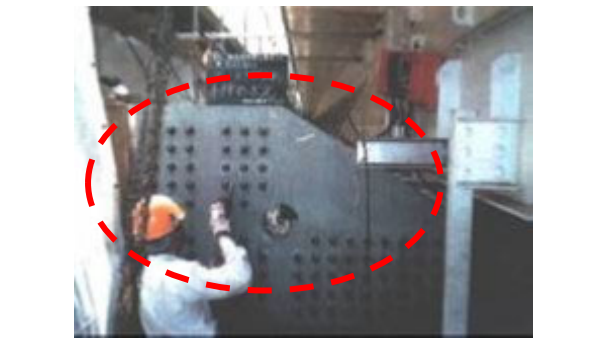
Classification 3: Concrete material

Deterioration of Repair/Reinforcement Material	Grade C	Deterioration of Repair/Reinforcement Material	Grade E
		<p>Note: Minor cracks are observed on the lining concrete.</p>	<p>Note: Peeling/loosening is observed in a wide range on the lining concrete.</p>

Classification 4: Painting

Deterioration of Repair/Reinforcement Material	Grade C	Deterioration of Repair/Reinforcement Material	Grade E
		<p>Note: Painting is peeling.</p>	<p>Note: Rust fluid is found on the concrete member.</p>

Classification 5: Steel plate (cover plate, etc.)

Deterioration of Repair/Reinforcement Material	Grade A	Deterioration of Repair/Reinforcement Material	Grade A
		<p>Note: Example in which a cover plate (steel plate) and stiffeners in both horizontal and vertical directions are installed in the notch at the end of the steel main girder</p>	<p>Note: Example of reinforcement of steel plates at corners of steel piers (Under construction)</p>

## **18. Abnormal Anchorage**

### **【General Features and Characteristics of Damage】**

This is with reference to a state in which rust fluid is generated from the cracks of the concrete of the anchorage of PC tendons, or the concrete of the anchorage of PC tendons has peeled off.

For the anchorage of a cable, this refers to a state where damage such as corrosion or cracks, etc. has occurred to the anchorage. The damage of all parts that constitute the anchorage structure (waterproof cover, fixing blocks, metal fittings, and cushioning material, etc.) shall be evaluated regardless of the material those are made of.

The cable body shall be evaluated as a general steel member, and the connecting cable between girders be evaluated as a bridge fall prevention device.

### **【Classification of Anchorage】**

The classification of the anchorage is as follows.

Classification	Type of anchorage
1	Longitudinal prestressing of PC steel
2	Transverse prestressing of PC steel
3	Others
4	Anchorage of the outer cable or deflection part

### **【Hints for Damage Judgement】**

- If evaluated as other types of damage as well (such as corrosion, peeling/exposure of rebar, cracking, etc.), evaluation shall be done for relevant items at the same time.

### **【Evaluation of Damage Grade】**

1) The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	Damage to the concrete of the anchorage of PC tendon is observed. Damage to the cable anchorage is observed.
D	—
E	Remarkable damage to the concrete of the anchorage of PC tendon is observed. Remarkable damage to the cable anchorage is observed.

2) Damage pattern classification

The damage pattern shall be classified according to the following table and the corresponding pattern number shall be recorded. If more than one type of damage pattern is found in an element, all pattern numbers shall be recorded.

Pattern	Damage
1	Cracks
2	Leaching/free lime
3	Peeling/exposure of rebar
4	Spalling
5	Corrosion
6	Damage on protection tube
7	Protrusion of PC tendon
9	Others

**【Evaluation of Damage Grade】**

Abnormal anchorage	Grade C	Abnormal anchorage	Grade C
			
<p>Note: Cracks occur on the concrete anchorage by the transverse prestressing at the end of the girder.</p>		<p>Note: The antirust agent (grease) inside the protective cap for the anchorage part of the outer cable is leaking.</p>	
Abnormal anchorage	Grade C	Abnormal anchorage	Grade
			
<p>Note: Rust leachate is produced from cracks in the concrete of the anchorage area.</p>		<p>Note: The cable anchorage of the extradosed bridge has remarkably corroded.</p>	
Abnormal anchorage	Grade E	Abnormal anchorage	Grade E
			
<p>Note: Concrete at anchorage has peeled off. The exposed part is remarkably corroded.</p>		<p>Note: Concrete at the anchorage part of the fulcrum cross-beam transverse prestressing PC steel material has peeled off, and the PC steel material has broken and slipped out.</p>	

## **19. Discoloration and Degradation**

### **【General Features and Characteristics of Damage】**

A state in which the original color of a member has changed, such as discoloration of concrete, or a state in which the original material of a member has changed, such as rubber hardening or plastic deterioration.

### **【Classification by Materials】**

The classification of the materials is as follows.

Classification	Materials [Quality of materials]
1	Concrete
2	Rubber
3	Plastic
4	Others

The classification here is based on the material of the member body, not the coating material. If the main body of the member is steel, the coating material is "degradation of anticorrosion performance", and if it is the concrete, the coating material is "deterioration of repair/reinforcement material" of the concrete.

### **【Hints for Damage Judgement】**

- Discoloration of painting or plating on steel members shall not be targeted.
- Cases of discoloration not caused by a change in the material itself, such as dirt generated by water traveling on the surface of concrete members, solidification of concrete precipitate, dirt caused by exhaust gas or soot, etc., shall not be included. (They shall be evaluated as "17. others".)
- Discoloration caused by fire shall not be included. (It shall be evaluated as "17. others".)

### **【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

<Classification 1: Concrete>

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Milky white/yellowish discoloration has observed. Member has hardened/cracked.



<Classification 2: Rubber>



Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Member has hardened/cracked.

<Classification 3: Plastic>

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Material has embrittled/cracked.

【Evaluation of Damage Grade】

Discoloration and Degradation	Grade E	Discoloration and Degradation	Grade E
			
	Note: Concrete surface has discoloured yellowish.		Note: The covering rubber of the bearing has discoloured, and fine cracks has appeared on the surface.

Discoloration and Degradation	Grade E	Discoloration and Degradation	Grade E
			
	Note: The joint material (sealant) of the expansion joint has peeled off.		Note: Discolouration has been widely seen on the lower surface of the deck slab around the drainage pipe.

## 20. Water Leakage/Surface Ponding

### 【General Features and Characteristics of Damage】

This refers to a state where rainwater leaks from expansion devices or drainage facilities, etc. instead of going through the original drainage mechanism as expected, or the case where rainwater infiltrates and accumulates inside the girder, the top of a beam, or a bearing.

In some cases, drainage capacity can exceed and water may remain in some parts of a structure at the time of heavy rain, etc. If that kind of phenomenon occurs only temporarily and when it is obvious that the structure will not be hindered, it shall not be evaluated as damage.

### 【Hints for Damage Judgement】



- Water that passes through the inside of concrete members and flows out from cracks, etc. shall be evaluated as “leaching/free lime”.
- Damage to drainage pipes shall not be included as a target. It shall be evaluated as the damage of drainage equipment.

### 【Evaluation of Damage Grade】

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Water leaks from such places as expansion devices or where a drainage basin is installed. Surface ponding is observed in the vicinity of the bearing and inside the box girder.

### 【Evaluation of Damage Grade】

Water leakage/ surface ponding	Grade E	Water leakage/ surface ponding	Grade E
			
	Note: Surface ponding in the vicinity of the bearing		Note: Water has been leaking from the extension device.

## **21. Abnormal Sound and/or Vibration**

### **【General Features and Characteristics of Damage】**

This refers to a situation where abnormal sound/vibration that does not normally occur is generated.

### **【Hints for Damage Judgement】**

- Abnormal sound/vibration is usually caused by structural defects or damage to a bridge, and may be attributable to a combination of defects/damage. Therefore, when other types of damage are accompanied by abnormal sound/vibration, evaluation shall be done not only for the types of damage observed but for “abnormal sound and/or vibration”.

### **【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Abnormal sound from the bridge fall prevention system, expansion devices, bearings, sound insulation walls, girders, or inspection facilities, etc. is heard. Abnormal vibration/shaking is confirmed.

## 22. Abnormal Deflection

### 【General Features and Characteristics of Damage】

This refers to a situation where abnormal deflection that is not normally observed is generated.

### 【Hints for Damage Judgement】



- Abnormal deflection is usually caused by structural defects or damage to a bridge, and may be attributable to a combination of defects/damage. Therefore, when other types of damage are accompanied by abnormal deflection, evaluation shall be done not only for the types of damage observed but for “abnormal deflection”.
- The “abnormal deflection” that can be judged by an inspection is the sagging due to dead load. Since the temporary deflection due to live load cannot be evaluated as abnormal, it shall not be regarded as “abnormal deflection”.

### 【Evaluation of Damage Grade】

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Abnormal deflection is observed on the main girder or inspection facilities, etc.

### 【Evaluation of Damage Grade】

Abnormal deflection	Grade E	Abnormal deflection	Grade E
			
Note: An abnormality in the substructure has caused abnormal deflection to the superstructure.		Note: Due to the excessive contraction of the PC girder, the girder at the central hinge part has hanged down abnormally.	

### 23. Deformation /Loss

**【General Features and Characteristics of Damage】**

This refers to a state in which a member is partially deformed regardless of its cause, such as a car collision, a collision during construction, etc., or a part of a member is lost.

**【Hints for Damage Judgement】**



- If a concrete member suffers peeling and rebar exposure along with deformation and loss, it shall also be evaluated as “peeling/exposure of rebar”.
- If a steel member exhibits damage such as cracks or fracture, etc. at the same time, evaluation shall also be made for that damage.

**【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	A member is partially deformed and a part of it is lost.
D	—
E	A member is significantly deformed partially and a significant part of it is lost.

**【Evaluation of Damage Grade】**

Deformation/loss	Grade C	Deformation/loss	Grade E
			
Note: Part of the lower horizontal structure has deformed.		Note: Some of the steel girders have severely deformed.	

**24. Sediment Clogging (Drainage Problems)**

**【General Features and Characteristics of Damage】**

This refers to a condition where the drainage basins and drainage pipes are clogged with sediment, a condition where sediment is deposited around the bearing, and a condition where sediment is accumulated on the pavement shoulder.

**【Hints for Damage Judgement】**



It is desirable that the sediment accumulated around the bearing shall be removed at the time of inspection so that the damage condition of the bearing can be grasped.

**【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Sediment clogging is observed at the drainage basin and around the bearing, etc.

**【Evaluation of Damage Grade】**

Sediment clogging	Grade E	Sediment clogging	Grade E
			
Note: Sediment clogging is observed at the drainage basin.		Note: Sediment has accumulated around the bearing.	

**25. Subsidence, Displacement, and Inclining**

**【General Features and Characteristics of Damage】**

This refers to subsidence, displacement, and inclining that occur to the foundation and bearings.

**【Hints for Damage Judgement】**



- If subsidence/displacement/inclining is accompanied by other damage such as abnormal spacing or steps at expansion devices, evaluation shall also be done for those items.

**【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	—
D	—
E	Support is subsided. Substructure is displaced/inclined.

**【Evaluation of Damage Grade】**

Subsidence, Displacement, and Inclining	Grade E	Subsidence, Displacement, and Inclining	Grade E
			
<p>Note: The scouring of the foundation has caused the substructure to subside, move, and incline, and the superstructure to bend abnormally. It is dealt with in three (3) categories "Subsidence/Displacement/Inclining", "Extraordinary deflection", and "Scouring".</p>		<p>Note: Bearings have subsided and inclined.</p>	

**26. Scouring**

**【General Features and Characteristics of Damage】**

This refers to a situation where the foundation body and the surrounding soil are scrubbed away by running water and disappear.



**【Hints for Damage Judgement】**

**【Evaluation of Damage Grade】**

The evaluation of the damage grade shall be based on the following categories.

Grade	General conditions
A	No damage
B	—
C	The foundation of substructure is scoured by running water.
D	—
E	The foundation of substructure is scoured significantly by running water.

**【Evaluation of Damage Grade】**

Scouring	Grade C	Scouring	Grade E
			
Note: The substructure foundation has scoured by running water.		Note: The substructure foundation has severely scoured due to many years of running water.	



① Inbound direction	② Outbound direction
③ Upstream direction	④ Downstream direction
⑤ From the right bank direction of upstream	⑥ from the left bank direction of upstream
⑦ From the right bank direction of downstream	⑧ From the left bank direction of downstream
Remarks ----- ----- ----- ----- ----- -----	





Bridge General View

Road No.		Bridge location (Chainage)	Km	Mm
Road name		Bridge location (Province)		
Bridge ID/No.		Coordinates (Latitude)	°	' "
Bridge name		Coordinates (Longitudu)	°	' "

## Damage Sketch (Superstructure)

Road No.		Bridge location (Chainage)	Km	Mm
Road name		Bridge location (Province)		
Bridge ID/No.		Coordinates (Latitude)	°	' "
Bridge name		Coordinates (Longitudu)	°	' "
Span No., Girder No.	1/	1/	Damage sketch No.	1/

Damage Sketch (Substructure)

Road No.		Bridge location (Chainage)	Km	Mm
Road name		Bridge location (Province)		
Bridge ID/No.		Coordinates (Latitude)	°	' "
Bridge name		Coordinates (Longitudu)	°	' "
Span No., Girder No.	1/	1/	Damage sketch No.	1/

Damage Photo Data

		Inspection date	dd/mm/yyyy
Road No.		Bridge location (Chainage)	Km      Mm
Road name		Bridge location (Province)	
Bridge ID/No.		Coordinates (Latitude)	°   '   ''
Bridge name		Coordinates (Longitudu)	°   '   ''

Photo No.		Component		Photo No.		Component	
Element name				Element name			
Damage type		Damage grade		Damage type		Damage grade	

Photo No.		Component		Photo No.		Component	
Element name				Element name			
Damage type		Damage grade		Damage type		Damage grade	


Photo No.		Component		Photo No.		Component	
Element name				Element name			
Damage type		Damage grade		Damage type		Damage grade	


Bridge Inspection Sheet (Superstructure - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Span No.	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type		Damage state (%)					Photo No.
					A	B	C	D	E	
Super-structure	Deck	Steel	<input type="checkbox"/> 01	Corrosion						
			<input type="checkbox"/> 02	Cracks						
			<input type="checkbox"/> 03	Loose, Drop off						
			<input type="checkbox"/> 04	Fracture						
			<input type="checkbox"/> 05	Degradation of anticorrosion performance						
			<input type="checkbox"/> 17	Others						
			<input type="checkbox"/> 21	Extraordinary sound/vibration						
		<input type="checkbox"/> 23	Deformation, Loss							
		Concrete	<input type="checkbox"/> 07	Peeling, Rebar exposure						
			<input type="checkbox"/> 08	Leaching, Free lime						
			<input type="checkbox"/> 09	Fall off						
			<input type="checkbox"/> 10	Deterioration of repair/reinforcement material						
			<input type="checkbox"/> 11	Cracks on slab						
			<input type="checkbox"/> 12	Spalling						
	<input type="checkbox"/> 17		Others							
	<input type="checkbox"/> 18	Extraordinary anchorage								
	<input type="checkbox"/> 19	Discoloration, Degradation								
	Main structure	Steel	<input type="checkbox"/> 01	Corrosion						
			<input type="checkbox"/> 02	Cracks						
			<input type="checkbox"/> 03	Loose, Drop off						
			<input type="checkbox"/> 04	Fracture						
			<input type="checkbox"/> 05	Degradation of anticorrosion performance						
			<input type="checkbox"/> 13	Extraordinary gap						
			<input type="checkbox"/> 17	Others						
<input type="checkbox"/> 21		Extraordinary sound/vibration								
<input type="checkbox"/> 22		Extraordinary deflection								
<input type="checkbox"/> 23		Deformation, Loss								
Concrete	<input type="checkbox"/> 06	Cracks								
	<input type="checkbox"/> 07	Peeling, Rebar exposure								
	<input type="checkbox"/> 08	Leaching, Free lime								
	<input type="checkbox"/> 10	Deterioration of repair/reinforcement material								
	<input type="checkbox"/> 12	Spalling								
	<input type="checkbox"/> 13	Extraordinary gap								
<input type="checkbox"/> 17	Others									
<input type="checkbox"/> 18	Extraordinary anchorage									
<input type="checkbox"/> 19	Discoloration, Degradation									
<input type="checkbox"/> 21	Extraordinary sound/vibration									
<input type="checkbox"/> 22	Extraordinary deflection									
<input type="checkbox"/> 23	Deformation, Loss									

Legend  : Target for "Periodic Inspection A" and deterioration prediction

 : Not Applicable


Steel : 05, [Coating: A,C,D,E], [Plating, Metallic spraying: A,C,E], [Weathering steel: A,B,C,D,E]

Bridge Inspection Sheet (Other than deck & main structure - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Span No.	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Damage state (%)					Photo No.	
				A	B	C	D	E		
Super-structure	Other than deck and main structure	Main members	Steel	<input type="checkbox"/> 01 Corrosion						
				<input type="checkbox"/> 02 Cracks						
				<input type="checkbox"/> 03 Loose, Drop off						
				<input type="checkbox"/> 04 Fracture						
				<input type="checkbox"/> 05 Degradation of anticorrosion performance						
				<input type="checkbox"/> 10 Deterioration of repair/reinforcement material						
				<input type="checkbox"/> 17 Others						
				<input type="checkbox"/> 20 Water leakage, surface ponding						
				<input type="checkbox"/> 21 Extraordinary sound/vibration						
				<input type="checkbox"/> 22 Extraordinary deflection						
				<input type="checkbox"/> 23 Deformation, Loss						
	Main members	Concrete	<input type="checkbox"/> 06 Cracks							
			<input type="checkbox"/> 07 Peeling, Rebar exposure							
			<input type="checkbox"/> 08 Leaching, Free lime							
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material							
			<input type="checkbox"/> 12 Spalling							
			<input type="checkbox"/> 17 Others							
			<input type="checkbox"/> 18 Extraordinary anchorage							
			<input type="checkbox"/> 19 Discoloration, Degradation							
			<input type="checkbox"/> 20 Water leakage, surface ponding							
			<input type="checkbox"/> 21 Extraordinary sound/vibration							
			<input type="checkbox"/> 22 Extraordinary deflection							
			<input type="checkbox"/> 23 Deformation, Loss							
Non-main members	Steel	<input type="checkbox"/> 01 Corrosion								
		<input type="checkbox"/> 02 Cracks								
		<input type="checkbox"/> 03 Loose, Drop off								
		<input type="checkbox"/> 04 Fracture								
		<input type="checkbox"/> 05 Degradation of anticorrosion performance								
		<input type="checkbox"/> 10 Deterioration of repair/reinforcement material								
	Concrete	<input type="checkbox"/> 17 Others								
		<input type="checkbox"/> 20 Water leakage, surface ponding								
		<input type="checkbox"/> 21 Extraordinary sound/vibration								
		<input type="checkbox"/> 22 Extraordinary deflection								
		<input type="checkbox"/> 23 Deformation, Loss								
		<input type="checkbox"/> 06 Cracks								
Concrete	<input type="checkbox"/> 07 Peeling, Rebar exposure									
	<input type="checkbox"/> 08 Leaching, Free lime									
	<input type="checkbox"/> 10 Deterioration of repair/reinforcement material									
	<input type="checkbox"/> 12 Spalling									
	<input type="checkbox"/> 17 Others									
	<input type="checkbox"/> 19 Discoloration, Degradation									
<input type="checkbox"/> 20 Water leakage, surface ponding										
<input type="checkbox"/> 22 Extraordinary deflection										
<input type="checkbox"/> 23 Deformation, Loss										

Legend  : Target for "Periodic Inspection A" and deterioration prediction

 : Not Applicable


Steel : 05, [Coating: A,C,D,E], [Plating, Metallic spraying: A,C,E], [Weathering steel: A,B,C,D,E]


Bridge Inspection Sheet (Substructure - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Span No.	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Damage state (%)					Photo No.
				A	B	C	D	E	
Sub-structure	Body	Steel	<input type="checkbox"/> 01 Corrosion						
			<input type="checkbox"/> 02 Cracks						
			<input type="checkbox"/> 03 Loose, Drop off						
			<input type="checkbox"/> 04 Fracture						
			<input type="checkbox"/> 05 Degradation of anticorrosion performance						
			<input type="checkbox"/> 17 Others						
			<input type="checkbox"/> 20 Water leakage, surface ponding						
			<input type="checkbox"/> 21 Extraordinary sound/vibration						
			<input type="checkbox"/> 22 Extraordinary deflection						
		<input type="checkbox"/> 23 Deformation, Loss							
		Concrete	<input type="checkbox"/> 06 Cracks						
			<input type="checkbox"/> 07 Peeling, Rebar exposure						
			<input type="checkbox"/> 08 Leaching, Free lime						
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material						
	<input type="checkbox"/> 12 Spalling								
	<input type="checkbox"/> 17 Others								
	<input type="checkbox"/> 18 Extraordinary anchorage								
	Foundation	Steel	<input type="checkbox"/> 01 Corrosion						
			<input type="checkbox"/> 02 Cracks						
			<input type="checkbox"/> 03 Loose, Drop off						
			<input type="checkbox"/> 04 Fracture						
			<input type="checkbox"/> 05 Degradation of anticorrosion performance						
			<input type="checkbox"/> 17 Others						
		Concrete	<input type="checkbox"/> 20 Water leakage, surface ponding						
			<input type="checkbox"/> 21 Extraordinary sound/vibration						
			<input type="checkbox"/> 22 Extraordinary deflection						
<input type="checkbox"/> 23 Deformation, Loss									
<input type="checkbox"/> 25 Subsidence, displacement, inclining									
<input type="checkbox"/> 26 Scouring									
Foundation	Concrete	<input type="checkbox"/> 06 Cracks							
		<input type="checkbox"/> 07 Peeling, Rebar exposure							
		<input type="checkbox"/> 08 Leaching, Free lime							
		<input type="checkbox"/> 10 Deterioration of repair/reinforcement material							
		<input type="checkbox"/> 12 Spalling							
		<input type="checkbox"/> 17 Others							
		<input type="checkbox"/> 18 Extraordinary anchorage							
		<input type="checkbox"/> 19 Discoloration, Degradation							
		<input type="checkbox"/> 20 Water leakage, surface ponding							
		<input type="checkbox"/> 23 Deformation, Loss							
<input type="checkbox"/> 25 Subsidence, Displacement, inclining									
<input type="checkbox"/> 26 Scouring									

Legend  : Target for "Periodic Inspection A" and deterioration prediction

 : Not Applicable


Steel : 05, [Coating: A,C,D,E], [Plating, Metallic spraying: A,C,E], [Weathering steel: A,B,C,D,E]


Bridge Inspection Sheet (Bearings - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Span No.	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Damage state (%)					Photo No.
				A	B	C	D	E	
Bearings	Body	Steel	<input type="checkbox"/> 01 Corrosion						
			<input type="checkbox"/> 02 Cracks						
			<input type="checkbox"/> 03 Loose, Drop off						
			<input type="checkbox"/> 04 Fracture						
			<input type="checkbox"/> 05 Degradation of anticorrosion performance						
			<input type="checkbox"/> 16 Lack of bearing function						
			<input type="checkbox"/> 17 Others						
			<input type="checkbox"/> 20 Water leakage, Surface ponding						
			<input type="checkbox"/> 23 Deformation, Loss						
			<input type="checkbox"/> 24 Sediment clogging						
			<input type="checkbox"/> 25 Subsidence, Displacement, Inclining						
		Rubber	<input type="checkbox"/> 16 Lack of bearing function						
			<input type="checkbox"/> 17 Others						
			<input type="checkbox"/> 19 Discoloration, Degradation						
	<input type="checkbox"/> 20 Water leakage, Surface ponding								
	<input type="checkbox"/> 23 Deformation, Loss								
	<input type="checkbox"/> 24 Sediment clogging								
	Shoe seat mortar, pedestal concrete	Concrete	<input type="checkbox"/> 06 Cracks						
			<input type="checkbox"/> 07 Peeling, Rebar exposure						
			<input type="checkbox"/> 12 Spalling						
			<input type="checkbox"/> 20 Water leakage, Surface ponding						
			<input type="checkbox"/> 23 Deformation, Loss						
	Bridge fall prevention device	Steel	<input type="checkbox"/> 01 Corrosion						
			<input type="checkbox"/> 02 Cracks						
			<input type="checkbox"/> 03 Loose, Drop off						
<input type="checkbox"/> 04 Fracture									
<input type="checkbox"/> 05 Degradation of anticorrosion performance									
<input type="checkbox"/> 17 Others									
<input type="checkbox"/> 21 Extraordinary sound/vibration									
<input type="checkbox"/> 23 Deformation, Loss									
Concrete		<input type="checkbox"/> 06 Cracks							
		<input type="checkbox"/> 07 Peeling, Rebar exposure							
		<input type="checkbox"/> 08 Leaching, Free lime							
		<input type="checkbox"/> 12 Spalling							
		<input type="checkbox"/> 17 Others							
		<input type="checkbox"/> 23 Deformation, Loss							
	<input type="checkbox"/> 24 Sediment clogging								

Legend  : Target for "Periodic Inspection A" and deterioration prediction

 : Not Applicable


Steel : 05, [Coating: A,C,D,E], [Plating, Metallic spraying: A,C,E], [Weathering steel: A,B,C,D,E]


Bridge Inspection Sheet (On the road - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Span No.	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Damage state (%)					Photo No.
				A	B	C	D	E	
On the road	Railing/ Guard fence	Steel	<input type="checkbox"/> 01 Corrosion						
			<input type="checkbox"/> 02 Cracks						
			<input type="checkbox"/> 03 Loose, Drop off						
			<input type="checkbox"/> 04 Fracture						
			<input type="checkbox"/> 05 Degradation of anticorrosion performance						
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material						
			<input type="checkbox"/> 17 Others						
		<input type="checkbox"/> 23 Deformation, Loss							
		Concrete	<input type="checkbox"/> 06 Cracks						
			<input type="checkbox"/> 07 Peeling, Rebar exposure						
			<input type="checkbox"/> 08 Leaching, Free lime						
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material						
			<input type="checkbox"/> 12 Spalling						
			<input type="checkbox"/> 17 Others						
	<input type="checkbox"/> 19 Discoloration, Degradation								
	<input type="checkbox"/> 23 Deformation, Loss								
	Noise barrier	Steel	<input type="checkbox"/> 01 Corrosion						
			<input type="checkbox"/> 02 Cracks						
			<input type="checkbox"/> 03 Loose, Drop off						
			<input type="checkbox"/> 04 Fracture						
			<input type="checkbox"/> 05 Degradation of anticorrosion performance						
			<input type="checkbox"/> 17 Others						
			<input type="checkbox"/> 21 Extraordinary sound/vibration						
	<input type="checkbox"/> 23 Deformation, Loss								
	Lights, Traffic signs	Steel	<input type="checkbox"/> 01 Corrosion						
			<input type="checkbox"/> 02 Cracks						
			<input type="checkbox"/> 03 Loose, Drop off						
			<input type="checkbox"/> 04 Fracture						
<input type="checkbox"/> 05 Degradation of anticorrosion performance									
<input type="checkbox"/> 17 Others									
<input type="checkbox"/> 21 Extraordinary sound/vibration									
<input type="checkbox"/> 23 Deformation, Loss									
Pavement	Concrete	<input type="checkbox"/> 14 Rough road surface							
		<input type="checkbox"/> 15 Extraordinary pavement							
		<input type="checkbox"/> 17 Others							
		<input type="checkbox"/> 20 Water leakage, Surface ponding							
	Asphalt	<input type="checkbox"/> 14 Rough road surface							
		<input type="checkbox"/> 15 Extraordinary pavement							
		<input type="checkbox"/> 17 Others							
		<input type="checkbox"/> 20 Water leakage, Surface ponding							

Legend  : Target for "Periodic Inspection A" but not for deterioration prediction

 : Not Applicable



Steel : 05, [Coating: A,C,D,E], [Plating, Metallic spraying: A,C,E], [Weathering steel: A,B,C,D,E]

Bridge Inspection Sheet (Road surface - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Span No.	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Damage state (%)					Photo No.	
				A	B	C	D	E		
Road surface	Wheel guard	Steel	<input type="checkbox"/> 01 Corrosion							
			<input type="checkbox"/> 02 Cracks							
			<input type="checkbox"/> 03 Loose, Drop off							
			<input type="checkbox"/> 04 Fracture							
			<input type="checkbox"/> 05 Degradation of anticorrosion performance							
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material							
			<input type="checkbox"/> 17 Others							
			<input type="checkbox"/> 23 Deformation, Loss							
			Concrete	<input type="checkbox"/> 06 Cracks						
				<input type="checkbox"/> 07 Peeling, Rebar exposure						
	<input type="checkbox"/> 08 Leaching, Free lime									
	<input type="checkbox"/> 10 Deterioration of repair/reinforcement material									
	<input type="checkbox"/> 12 Spalling									
	<input type="checkbox"/> 17 Others									
	<input type="checkbox"/> 19 Discoloration, Degradation									
	<input type="checkbox"/> 23 Deformation, Loss									
	Pavement	Concrete	<input type="checkbox"/> 14 Rough road surface							
			<input type="checkbox"/> 15 Extraordinary pavement							
			<input type="checkbox"/> 17 Others							
			<input type="checkbox"/> 20 Water leakage, Surface ponding							
	Asphalt	<input type="checkbox"/> 14 Rough road surface								
		<input type="checkbox"/> 15 Extraordinary pavement								
		<input type="checkbox"/> 17 Others								
		<input type="checkbox"/> 20 Water leakage, Surface ponding								
	Expansion joint	Steel	<input type="checkbox"/> 01 Corrosion							
			<input type="checkbox"/> 02 Cracks							
			<input type="checkbox"/> 03 Loose, Drop off							
			<input type="checkbox"/> 04 Fracture							
			<input type="checkbox"/> 05 Degradation of anticorrosion performance							
			<input type="checkbox"/> 13 Extraordinary gap							
			<input type="checkbox"/> 14 Rough road surface							
			<input type="checkbox"/> 17 Others							
			<input type="checkbox"/> 20 Water leakage, Surface ponding							
			<input type="checkbox"/> 21 Extraordinary sound/vibration							
		Concrete	<input type="checkbox"/> 06 Cracks							
			<input type="checkbox"/> 12 Spalling							
			<input type="checkbox"/> 20 Water leakage, Surface ponding							
			<input type="checkbox"/> 21 Extraordinary sound/vibration							
			<input type="checkbox"/> 23 Deformation, Loss							
			<input type="checkbox"/> 24 Sediment clogging							
Rubber		<input type="checkbox"/> 13 Extraordinary gap								
		<input type="checkbox"/> 14 Rough road surface								
		<input type="checkbox"/> 17 Others								
		<input type="checkbox"/> 19 Discoloration, degradation								
	<input type="checkbox"/> 20 Water leakage, Surface ponding									
	<input type="checkbox"/> 21 Extraordinary sound/vibration									
	<input type="checkbox"/> 23 Deformation, Loss									
	<input type="checkbox"/> 24 Sediment clogging									

Legend  : Target for "Periodic Inspection A" but not for deterioration prediction  
 : Not Applicable



Steel : 05, [Coating: A,C,D,E], [Plating, Metallic spraying: A,C,E], [Weathering steel: A,B,C,D,E]

Summary of Bridge Inspection Sheet (Superstructure - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Number of span	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Span No. with Damage state (%)										
				1	2	3	4	5	6	7	8	9	10	
Super-structure	Deck	Steel	<input type="checkbox"/> 01 Corrosion											
			<input type="checkbox"/> 02 Cracks											
			<input type="checkbox"/> 03 Loose, Drop off											
			<input type="checkbox"/> 04 Fracture											
			<input type="checkbox"/> 05 Degradation of anticorrosion performance											
			<input type="checkbox"/> 17 Others											
			<input type="checkbox"/> 21 Extraordinary sound/vibration											
			<input type="checkbox"/> 23 Deformation, Loss											
			<input type="checkbox"/> 07 Peeling, Rebar exposure											
	<input type="checkbox"/> 08 Leaching, Free lime													
	<input type="checkbox"/> 09 Fall off													
	<input type="checkbox"/> 10 Deterioration of repair/reinforcement material													
	<input type="checkbox"/> 11 Cracks on slab													
	<input type="checkbox"/> 12 Spalling													
	<input type="checkbox"/> 17 Others													
	<input type="checkbox"/> 18 Extraordinary anchorage													
	<input type="checkbox"/> 19 Discoloration, Degradation													
	Main structure	Steel	<input type="checkbox"/> 01 Corrosion											
			<input type="checkbox"/> 02 Cracks											
			<input type="checkbox"/> 03 Loose, Drop off											
			<input type="checkbox"/> 04 Fracture											
			<input type="checkbox"/> 05 Degradation of anticorrosion performance											
			<input type="checkbox"/> 13 Extraordinary gap											
<input type="checkbox"/> 17 Others														
<input type="checkbox"/> 21 Extraordinary sound/vibration														
<input type="checkbox"/> 22 Extraordinary deflection														
<input type="checkbox"/> 23 Deformation, Loss														
Concrete		<input type="checkbox"/> 06 Cracks												
		<input type="checkbox"/> 07 Peeling, Rebar exposure												
		<input type="checkbox"/> 08 Leaching, Free lime												
		<input type="checkbox"/> 10 Deterioration of repair/reinforcement material												
	<input type="checkbox"/> 12 Spalling													
<input type="checkbox"/> 13 Extraordinary gap														
<input type="checkbox"/> 17 Others														
<input type="checkbox"/> 18 Extraordinary anchorage														
<input type="checkbox"/> 19 Discoloration, Degradation														
<input type="checkbox"/> 21 Extraordinary sound/vibration														
<input type="checkbox"/> 22 Extraordinary deflection														
<input type="checkbox"/> 23 Deformation, Loss														

Legend  : Target for "Periodic Inspection A" and deterioration prediction  
 : Not Applicable

Summary of Bridge Inspection Sheet (Other than deck & main structure - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Number of span	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Span No. with Damage state (%)											
				1	2	3	4	5	6	7	8	9	10		
Super-structure	Other than deck and main structure	Steel	<input type="checkbox"/> 01 Corrosion												
			<input type="checkbox"/> 02 Cracks												
			<input type="checkbox"/> 03 Loose, Drop off												
			<input type="checkbox"/> 04 Fracture												
			<input type="checkbox"/> 05 Degradation of anticorrosion performance												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 20 Water leakage, surface ponding												
			<input type="checkbox"/> 21 Extraordinary sound/vibration												
			<input type="checkbox"/> 22 Extraordinary deflection												
			<input type="checkbox"/> 23 Deformation, Loss												
		Concrete	<input type="checkbox"/> 06 Cracks												
			<input type="checkbox"/> 07 Peeling, Rebar exposure												
			<input type="checkbox"/> 08 Leaching, Free lime												
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material												
			<input type="checkbox"/> 12 Spalling												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 18 Extraordinary anchorage												
			<input type="checkbox"/> 19 Discoloration, Degradation												
			<input type="checkbox"/> 20 Water leakage, surface ponding												
			<input type="checkbox"/> 21 Extraordinary sound/vibration												
		Steel	<input type="checkbox"/> 01 Corrosion												
			<input type="checkbox"/> 02 Cracks												
			<input type="checkbox"/> 03 Loose, Drop off												
			<input type="checkbox"/> 04 Fracture												
			<input type="checkbox"/> 05 Degradation of anticorrosion performance												
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 20 Water leakage, surface ponding												
			<input type="checkbox"/> 21 Extraordinary sound/vibration												
			<input type="checkbox"/> 22 Extraordinary deflection												
		Concrete	<input type="checkbox"/> 06 Cracks												
			<input type="checkbox"/> 07 Peeling, Rebar exposure												
			<input type="checkbox"/> 08 Leaching, Free lime												
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material												
			<input type="checkbox"/> 12 Spalling												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 19 Discoloration, Degradation												
			<input type="checkbox"/> 20 Water leakage, surface ponding												
			<input type="checkbox"/> 22 Extraordinary deflection												
			<input type="checkbox"/> 23 Deformation, Loss												

Legend  : Target for "Periodic Inspection A" and deterioration prediction  
 : Not Applicable

Summary of Bridge Inspection Sheet (Substructure - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Number of span	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Span No. with Damage state (%)											
				1	2	3	4	5	6	7	8	9	10		
Sub-structure	Body	Steel	<input type="checkbox"/> 01 Corrosion												
			<input type="checkbox"/> 02 Cracks												
			<input type="checkbox"/> 03 Loose, Drop off												
			<input type="checkbox"/> 04 Fracture												
			<input type="checkbox"/> 05 Degradation of anticorrosion performance												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 20 Water leakage, surface ponding												
			<input type="checkbox"/> 21 Extraordinary sound/vibration												
			<input type="checkbox"/> 22 Extraordinary deflection												
		<input type="checkbox"/> 23 Deformation, Loss													
		Concrete	<input type="checkbox"/> 06 Cracks												
			<input type="checkbox"/> 07 Peeling, Rebar exposure												
			<input type="checkbox"/> 08 Leaching, Free lime												
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material												
			<input type="checkbox"/> 12 Spalling												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 18 Extraordinary anchorage												
			<input type="checkbox"/> 19 Discoloration, Degradation												
	<input type="checkbox"/> 20 Water leakage, surface ponding														
	<input type="checkbox"/> 23 Deformation, Loss														
	Foundation	Steel	<input type="checkbox"/> 01 Corrosion												
			<input type="checkbox"/> 02 Cracks												
			<input type="checkbox"/> 03 Loose, Drop off												
			<input type="checkbox"/> 04 Fracture												
			<input type="checkbox"/> 05 Degradation of anticorrosion performance												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 20 Water leakage, surface ponding												
			<input type="checkbox"/> 21 Extraordinary sound/vibration												
			<input type="checkbox"/> 22 Extraordinary deflection												
		<input type="checkbox"/> 23 Deformation, Loss													
		Concrete	<input type="checkbox"/> 06 Cracks												
			<input type="checkbox"/> 07 Peeling, Rebar exposure												
			<input type="checkbox"/> 08 Leaching, Free lime												
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material												
			<input type="checkbox"/> 12 Spalling												
			<input type="checkbox"/> 17 Others												
<input type="checkbox"/> 18 Extraordinary anchorage															
<input type="checkbox"/> 19 Discoloration, Degradation															
<input type="checkbox"/> 20 Water leakage, surface ponding															
<input type="checkbox"/> 23 Deformation, Loss															
<input type="checkbox"/> 25 Subsidence, Displacement, Inclining															
<input type="checkbox"/> 26 Scouring															

Legend  : Target for "Periodic Inspection A" and deterioration prediction

Summary of Bridge Inspection Sheet (Bearings - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Number of span	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Span No. with Damage state (%)											
				1	2	3	4	5	6	7	8	9	10		
Bearings	Body	Steel	<input type="checkbox"/> 01 Corrosion												
			<input type="checkbox"/> 02 Cracks												
			<input type="checkbox"/> 03 Loose, Drop off												
			<input type="checkbox"/> 04 Fracture												
			<input type="checkbox"/> 05 Degradation of anticorrosion performance												
			<input type="checkbox"/> 16 Lack of bearing function												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 20 Water leakage, surface ponding												
			<input type="checkbox"/> 23 Deformation, Loss												
			<input type="checkbox"/> 24 Sediment clogging												
	<input type="checkbox"/> 25 Subsidence, Displacement, inclining														
	Rubber	<input type="checkbox"/> 16 Lack of bearing function													
		<input type="checkbox"/> 17 Others													
		<input type="checkbox"/> 19 Discoloration, Degradation													
		<input type="checkbox"/> 20 Water leakage, surface ponding													
		<input type="checkbox"/> 23 Deformation, Loss													
		<input type="checkbox"/> 24 Sediment clogging													
	Shoe seat mortar, pedestal concrete	Concrete	<input type="checkbox"/> 06 Cracks												
			<input type="checkbox"/> 07 Peeling, Rebar exposure												
			<input type="checkbox"/> 12 Spalling												
			<input type="checkbox"/> 20 Water leakage, surface ponding												
	Bridge fall prevention device	Steel	<input type="checkbox"/> 01 Corrosion												
			<input type="checkbox"/> 02 Cracks												
			<input type="checkbox"/> 03 Loose, Drop off												
			<input type="checkbox"/> 04 Fracture												
<input type="checkbox"/> 05 Degradation of anticorrosion performance															
<input type="checkbox"/> 17 Others															
<input type="checkbox"/> 21 Extraordinary sound/vibration															
<input type="checkbox"/> 23 Deformation, Loss															
Concrete		<input type="checkbox"/> 06 Cracks													
		<input type="checkbox"/> 07 Peeling, Rebar exposure													
		<input type="checkbox"/> 08 Leaching, Free lime													
		<input type="checkbox"/> 12 Spalling													
		<input type="checkbox"/> 17 Others													
		<input type="checkbox"/> 23 Deformation, Loss													
	<input type="checkbox"/> 24 Sediment clogging														

Legend  : Target for "Periodic Inspection A" and deterioration prediction

Summary of Bridge Inspection Sheet (On the road - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Number of span	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Span No. with Damage state (%)										
				1	2	3	4	5	6	7	8	9	10	
On the road	Railing/ Guard fence	Steel	<input type="checkbox"/> 01 Corrosion											
			<input type="checkbox"/> 02 Cracks											
			<input type="checkbox"/> 03 Loose, Drop off											
			<input type="checkbox"/> 04 Fracture											
			<input type="checkbox"/> 05 Degradation of anticorrosion performance											
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material											
			<input type="checkbox"/> 17 Others											
		<input type="checkbox"/> 23 Deformation, Loss												
		Concrete	<input type="checkbox"/> 06 Cracks											
			<input type="checkbox"/> 07 Peeling, Rebar exposure											
			<input type="checkbox"/> 08 Leaching, Free lime											
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material											
			<input type="checkbox"/> 12 Spalling											
			<input type="checkbox"/> 17 Others											
	<input type="checkbox"/> 19 Discoloration, Degradation													
	<input type="checkbox"/> 23 Deformation, Loss													
	Noise barrier	Steel	<input type="checkbox"/> 01 Corrosion											
			<input type="checkbox"/> 02 Cracks											
			<input type="checkbox"/> 03 Loose, Drop off											
			<input type="checkbox"/> 04 Fracture											
			<input type="checkbox"/> 05 Degradation of anticorrosion performance											
			<input type="checkbox"/> 17 Others											
			<input type="checkbox"/> 21 Extraordinary sound/vibration											
	<input type="checkbox"/> 23 Deformation, Loss													
Lights, Traffic signs	Steel	<input type="checkbox"/> 01 Corrosion												
		<input type="checkbox"/> 02 Cracks												
		<input type="checkbox"/> 03 Loose, Drop off												
		<input type="checkbox"/> 04 Fracture												
		<input type="checkbox"/> 05 Degradation of anticorrosion performance												
		<input type="checkbox"/> 17 Others												
		<input type="checkbox"/> 21 Extraordinary sound/vibration												
<input type="checkbox"/> 23 Deformation, Loss														
Pavement	Concrete	<input type="checkbox"/> 14 Rough road surface												
		<input type="checkbox"/> 15 Extraordinary pavement												
		<input type="checkbox"/> 17 Others												
		<input type="checkbox"/> 20 Water leakage, Surface ponding												
	Asphalt	<input type="checkbox"/> 14 Rough road surface												
		<input type="checkbox"/> 15 Extraordinary pavement												
		<input type="checkbox"/> 17 Others												
		<input type="checkbox"/> 20 Water leakage, Surface ponding												

Legend  : Target for "Periodic Inspection A" but not for deterioration prediction

Summary of Bridge Inspection Sheet (Road surface - )

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Number of span	
Bridge type	
Span length (m)	

Component	Element	Material	Damage type	Span No. with Damage state (%)											
				1	2	3	4	5	6	7	8	9	10		
Road surface	Wheel guard	Steel	<input type="checkbox"/> 01 Corrosion												
			<input type="checkbox"/> 02 Cracks												
			<input type="checkbox"/> 03 Loose, Drop off												
			<input type="checkbox"/> 04 Fracture												
			<input type="checkbox"/> 05 Degradation of anticorrosion performance												
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 23 Deformation, Loss												
		Concrete	<input type="checkbox"/> 06 Cracks												
			<input type="checkbox"/> 07 Peeling, Rebar exposure												
			<input type="checkbox"/> 08 Leaching, Free lime												
			<input type="checkbox"/> 10 Deterioration of repair/reinforcement material												
			<input type="checkbox"/> 12 Spalling												
			<input type="checkbox"/> 17 Others												
	Pavement	Concrete	<input type="checkbox"/> 14 Rough road surface												
			<input type="checkbox"/> 15 Extraordinary pavement												
		Asphalt	<input type="checkbox"/> 14 Rough road surface												
			<input type="checkbox"/> 15 Extraordinary pavement												
	Expansion joint	Steel	<input type="checkbox"/> 01 Corrosion												
			<input type="checkbox"/> 02 Cracks												
			<input type="checkbox"/> 03 Loose, Drop off												
			<input type="checkbox"/> 04 Fracture												
			<input type="checkbox"/> 05 Degradation of anticorrosion performance												
			<input type="checkbox"/> 13 Extraordinary gap												
		Concrete	<input type="checkbox"/> 14 Rough road surface												
			<input type="checkbox"/> 17 Others												
			<input type="checkbox"/> 20 Water leakage, Surface ponding												
			<input type="checkbox"/> 21 Extraordinary sound/vibration												
			<input type="checkbox"/> 23 Deformation, Loss												
			<input type="checkbox"/> 24 Sediment clogging												
Rubber	<input type="checkbox"/> 06 Cracks														
	<input type="checkbox"/> 12 Spalling														
	<input type="checkbox"/> 20 Water leakage, Surface ponding														
	<input type="checkbox"/> 21 Extraordinary sound/vibration														
	<input type="checkbox"/> 23 Deformation, Loss														
	<input type="checkbox"/> 24 Sediment clogging														

Legend  : Target for "Periodic Inspection A" but not for deterioration prediction



① #Lqerxqg#gluh	② Outbound direction
③ Upstream direction	④ Downstream direction
⑤ From the right bank direction of upstream	⑥ from the left bank direction of upstream
⑦ From the right bank direction of downstream	⑧ From the left bank direction of downstream
<p>Remarks</p> <p>-----</p> <p>-----</p> <p>-----</p> <p>-----</p> <p>-----</p> <p>-----</p>	<p>The diagram shows a central rectangle. On the left side, there are three arrows pointing right: the top one is labeled ⑤, the middle one ①, and the bottom one ⑦. On the right side, there are three arrows pointing left: the top one is labeled ⑥, the middle one ②, and the bottom one ⑧. On the top side, there is a blue arrow pointing up labeled ③. On the bottom side, there is a blue arrow pointing down labeled ④. To the left of the rectangle, the text 'Inbound direction' is written with an arrow pointing right towards the rectangle. To the right of the rectangle, the text 'Outbound direction' is written with an arrow pointing right away from the rectangle.</p>





## Bridge General View

Road No.		Bridge location (Chainage)	Km	Mm
Road name		Bridge location (Province)		
Bridge ID/No.		Coordinates (Latitude)	°	' "
Bridge name		Coordinates (Longitudu)	°	' "

## Damage Sketch (Superstructure)

Road No.		Bridge location (Chainage)	Km	Mm
Road name		Bridge location (Province)		
Bridge ID/No.		Coordinates (Latitude)	°	' "
Bridge name		Coordinates (Longitudu)	°	' "
Span No., Girder No.	1/	1/	Damage sketch No.	1/

Damage Sketch (Substructure)

Road No.		Bridge location (Chainage)	Km      Mm
Road name		Bridge location (Province)	
Bridge ID/No.		Coordinates (Latitude)	°   '   "
Bridge name		Coordinates (Longitudu)	°   '   "
Span No., Girder No.	1/	1/	Damage sketch No. 1/

Damage Photo Data

		Inspection date	dd/mm/yyyy
Road No.		Bridge location (Chainage)	Km      Mm
Road name		Bridge location (Province)	
Bridge ID/No.		Coordinates (Latitude)	°   '   ''
Bridge name		Coordinates (Longitude)	°   '   ''

Photo No.		Component		Photo No.		Component	
Member name				Member name			
Damage type		Damage grade		Damage type		Damage grade	

Photo No.		Component		Photo No.		Component	
Member name				Member name			
Damage type		Damage grade		Damage type		Damage grade	

Photo No.		Component		Photo No.		Component	
Member name				Member name			
Damage type		Damage grade		Damage type		Damage grade	





① #Lqerxqg#gluh	② Outbound direction
③ Upstream direction	④ Downstream direction
⑤ From the right bank direction of upstream	⑥ from the left bank direction of upstream
⑦ From the right bank direction of downstream	⑧ From the left bank direction of downstream
<p>Remarks</p> <p>-----</p> <p>-----</p> <p>-----</p> <p>-----</p> <p>-----</p> <p>-----</p>	





## Bridge General View

Road No.		Bridge location (Chainage)	Km	Mm
Road name		Bridge location (Province)		
Bridge ID/No.		Coordinates (Latitude)	°	' "
Bridge name		Coordinates (Longitudu)	°	' "

## Damage Sketch (Superstructure)

Road No.		Bridge location (Chainage)	Km	Mm
Road name		Bridge location (Province)		
Bridge ID/No.		Coordinates (Latitude)	°	' "
Bridge name		Coordinates (Longitudu)	°	' "
Span No., Girder No.	1/	1/	Damage sketch No.	1/

Damage Sketch (Substructure)

Road No.		Bridge location (Chainage)	Km      Mm
Road name		Bridge location (Province)	
Bridge ID/No.		Coordinates (Latitude)	°   '   "
Bridge name		Coordinates (Longitudu)	°   '   "
Span No., Girder No.	1/	1/	Damage sketch No. 1/

Damage Photo Data

		Inspection date	dd/mm/yyyy
Road No.		Bridge location (Chainage)	Km      Mm
Road name		Bridge location (Province)	
Bridge ID/No.		Coordinates (Latitude)	°   '   ''
Bridge name		Coordinates (Longitude)	°   '   ''

Photo No.		Component		Photo No.		Component	
Member name				Member name			
Damage type		Damage grade		Damage type		Damage grade	

Photo No.		Component		Photo No.		Component	
Member name				Member name			
Damage type		Damage grade		Damage type		Damage grade	

Photo No.		Component		Photo No.		Component	
Member name				Member name			
Damage type		Damage grade		Damage type		Damage grade	

## Inspection at Extraordinary Conditions Sheet

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Span No.	
Bridge type	
Span length (m)	

Component	Member	Damage state* <sup>1</sup>	Presence		Photo No.
			Yes	No	
Bridge as a whole		Collapsed	<input type="checkbox"/>	<input type="checkbox"/>	
Superstructure	Deck slab, main girder	Damaged (deflection, deformation, crack)	<input type="checkbox"/>	<input type="checkbox"/>	
Substructure	Body, Foundation	Damaged (Subsidence, displacement, inclining, scouring, cracks)	<input type="checkbox"/>	<input type="checkbox"/>	
Bearings	Body, Shoe sheet, Bridge fall prevention device	Damaged (Fall off, Fracture)	<input type="checkbox"/>	<input type="checkbox"/>	
Road surface		Significant bump(s) on the road surface	<input type="checkbox"/>	<input type="checkbox"/>	
		Extraordinary sound/vibration	<input type="checkbox"/>	<input type="checkbox"/>	
	Wheel guard, Kerb, Median strip, Pavement	Seriously damaged	<input type="checkbox"/>	<input type="checkbox"/>	
	Expansion joint	Extraordinary wide gap	<input type="checkbox"/>	<input type="checkbox"/>	
		Seriously damaged	<input type="checkbox"/>	<input type="checkbox"/>	
On the road	Railing, Guard fence, Noise barrier, Lights, Traffic signs	Damaged or deformed and considered to be dangerous to road users	<input type="checkbox"/>	<input type="checkbox"/>	
Others	Drainage facility	Seriously damaged, or stagnates water/flows on the surface	<input type="checkbox"/>	<input type="checkbox"/>	
	Inspection facility, Accessories, Wing wall	Seriously damaged	<input type="checkbox"/>	<input type="checkbox"/>	
	Others	Risk to road users	<input type="checkbox"/>	<input type="checkbox"/>	
Overall evaluation		Necessity of emergency measures	<input type="checkbox"/>	<input type="checkbox"/>	



## Appendix-4 Stone Arch Bridge

[Note: Source of all materials is published by MLIT, Japan (Ministry of Land, Infrastructure, Transport and Tourism, Japan)]

## Table of Contents

<b>1. Purpose of Inspection</b> .....	1
<b>2. Type of Inspection</b> .....	2
<b>3. Frequency of Inspection</b> .....	3
<b>4. Target members</b> .....	4
<b>5. Inspection methos</b> .....	6
<b>6. Evaluation of damage</b> .....	11
<b>7. Record of inspection result</b> .....	22

# 1. Purpose of Inspection

This manual is applied to the inspection work of existing stone bridges, grasping the current state of stone bridges and early detection of damage that may affect load-carrying capacity and durability and damage that may affect third parties. By doing so, the stone bridge aims to be maintained in good condition at all times, ensure safe and smooth traffic, and carry out efficient maintenance and management by storing information obtained from inspection results.

### 【Notes】

Here is the general purpose of inspections on stone bridges.

The primary purpose of the stone bridge inspection is to grasp the current status of the stone bridge under management, to detect damage that is likely to have a negative impact on the safety and use of the stone bridge at an early stage, to enable appropriate measures, and to ensure safe and smooth traffic.

The second purpose is to stockpile basic materials indispensable for efficient maintenance and management, and to conduct continuous and effective inspections, planned repairs and reinforcements. In addition, by analyzing the stockpiled inspection results, it is necessary to clarify the problems and improvement points in design and construction from the viewpoint of maintenance and management.

The third objective is to maintain the function of the stone bridge from the viewpoint of cultural value, and to comprehensively evaluate it as a valuable regional cultural resource, in addition to maintaining its function as a road bridge. Therefore, in stone bridges, it is also important from the viewpoint of obtaining basic materials from the viewpoint of the road administrator, the viewpoint of the user, and the viewpoint of the region.

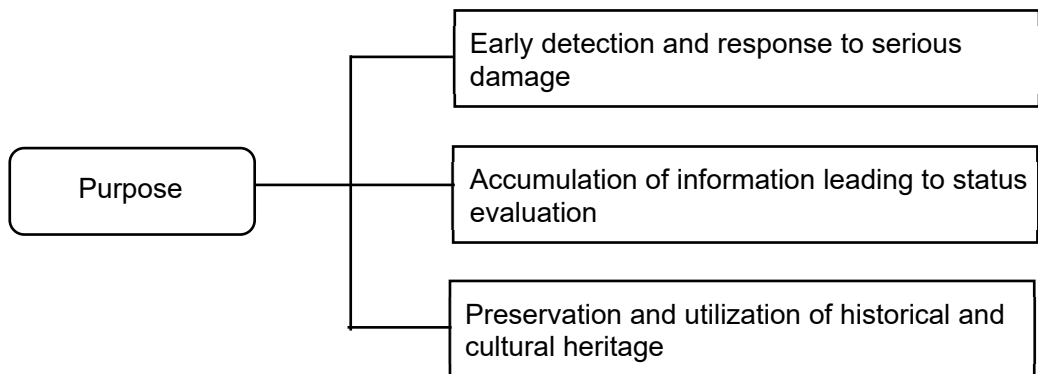


Fig. 1.1 Objective of inspection

## 2. Type of Inspection

---

The types of inspection are as follows.

- (1) Routine Inspection  
Routine inspections refer to inspections that are carried out mainly by visual inspection from a distance, to the extent that stone bridges are patrolled on a routine basis.
- (2) Periodic Inspection  
Periodic inspections are carried out regularly to maintain the stone bridges, and are inspections aimed at identifying damaged areas in detail through close visual inspections and inspection from a distance.
- (3) Inspection for extraordinary conditions  
Mainly to confirm traffic safety when damage caused by abnormal natural phenomena such as typhoons, torrential rains, floods, (earthquakes) has occurred or is likely to occur, or when an abnormality has been discovered refers to an emergency inspection.

### 【Notes】

- (1) Routine inspections are essential to maintain and manage stone bridges in good condition. At the same time, vegetation and moss adhering to the main body of the stone bridge, clogging of water distribution facilities with earth and sand, etc. shall be removed to the extent possible.
- (2) The current status of all parts shall be grasped in detail through periodic inspections. The detailed inspection method must be carried out according to this manual.
- (3) Inspection for extraordinary conditions is conducted when disasters occur due to abnormal natural phenomena such as typhoons, torrential rains, floods, (earthquakes), or when there is a risk of such a disaster, or when an abnormality is found in stone bridges. This is done temporarily or urgently in order to confirm safety and prevent damage to third parties.

### 3. Frequency of Inspection

---

The types of inspection are as follows.

Table 3.1 Frequency of Inspection

Type	Frequency	Method	Target members
Routine inspection	Routinely	Visual inspection from a distance	<ul style="list-style-type: none"><li>• All members</li><li>• Members that can be confirmed from the ground</li></ul>
Periodic inspection	Once a year	<ul style="list-style-type: none"><li>• Close visual inspection</li><li>• Visual inspection from a distance</li></ul>	<ul style="list-style-type: none"><li>• All members</li><li>• If it is possible to go down to the riverbed, the inspection should also be carried out from the river area.</li></ul>
Inspection for extraordinary conditions	As needed	After confirming a safety condition by a visual inspection from a distance, then a close visual inspection shall be carried out.	Members which abnormalities can be confirmed.

## 4. Target members

### 4-1. Target members

The target members for each inspection are as follows.

Table 4.1 Target members for each inspection

Component	Member	Routine inspection	Periodic inspection	Inspection for extraordinary conditions	Remarks
Superstructure	Guard post (Guardrail)	◎	◎	◎	
	Newel post	◎	◎	◎	
	Arch stone	○	◎	◎	
	Keystone	○	◎	◎	
	Spandrel	○	◎	◎	
Substructure	Embedment	○	◎	◎	
	Pier/ Abutment	○	◎	◎	
	Others (Dewatering)	○	◎	◎	
Road surface	Wheel guard	○	◎	◎	
	Flagstone	○	◎	◎	
	Pavement	○	◎	◎	
Waterway	Waterway facilities	○	◎	◎	
Revetment of riverbank	Revetment	○	◎	◎	
Others	Natural boulder in the riverbed	○	○	○	
	Lighting/ Signing and safety facilities	○	◎	◎	
	Drainage facilities	○	◎	○	
	Inspection facilities	○	◎	○	
	Utilities (water pipe, etc.)	○	◎	○	
	Surrounding vegetation	○	◎	—	
	Obstacles for landscape	○	◎	—	

◎: Mainly close visual inspection (Damage status)

○: Mainly visual inspection from a distance (Damage status, presence/absence of serious damage)

—: Not applicable

#### 【Notes】

In the inspection, if there is a possibility that damage or abnormality has occurred, take a picture of the situation, and regardless of the inspection target parts, for damage that may cause damage to a third party, urgently as a measure, road closures, etc. will be taken to ensure safety, and detailed inspections will be conducted. In addition, during inspections, remove any attachments such as plants and moss that can be managed on a daily basis, as well as clogging of drainage facilities.

4-2. Name of members

The elements to be inspected are as bellows.

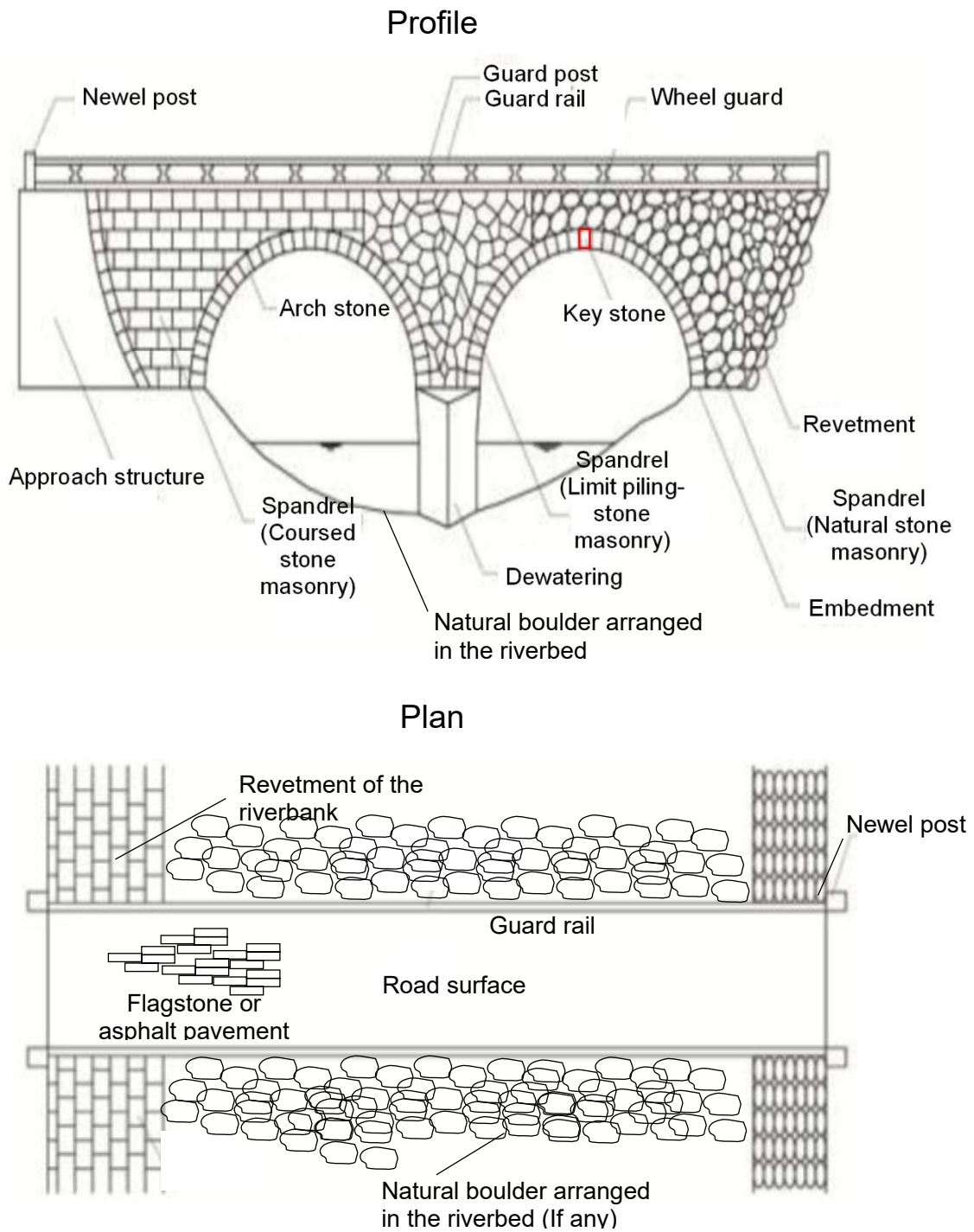


Fig. 4.1 Outline drawings of Stone Arch Bridge

## 5. Inspection methods

### 5-1. Flow of inspection work

Routine Inspection and Periodic Inspection shall generally be conducted according to the flow below.

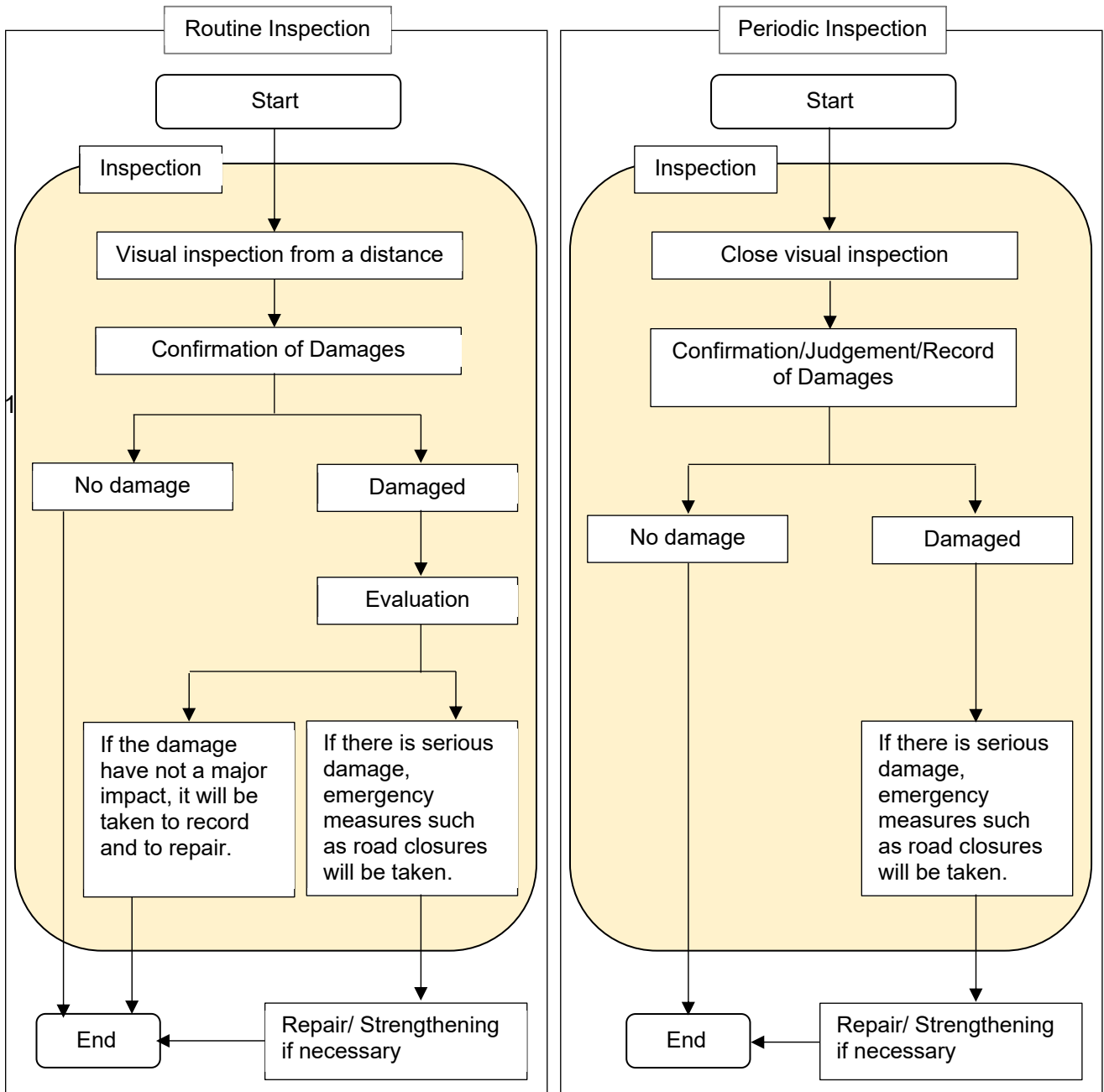


Fig. 5.1.1 Flow of inspection work

## 5-2. Team organization during inspection

Team organization during inspection conforms to the main manual.

### 5-3. Type of damage

The following 19 types of damage are determined by inspection and shall be arranged in the Inventory and Inspection sheet.

Table 5.3.1 Type of damage

Material	Type of damage		Status of damage
Stone material	01	Crack	Cracks on the stone materials
	02	Reduced cross-sectional area	Reducing of cross-sectional area on the stones
	03	Gap of arch stones	Gaping between arch stones
	04	Fall-off	Falling-off of the stone materials
	05	Deformation/Swelling	Deformation/swelling of spandrel and/or revetment
	06	Cracks on flagstones	Cracks on the flagstones
	07	Deformation of arch shape/normal line	Deformation on arch shape/normal line
	08	Discolouration/degradation	Discolouration/degradation on the surface of stone materials
Others	09	Leaching/stagnant water	Rainwater has been leaching/ or stagnant in each member regardless of its original drainage function
	10	Sediment clogging	Sediment clogging in the drainage facilities
	11	Subsidence/Displacement/Inclining	Subsidence/ Displacement/ Inclining on the foundation materials
	12	Scouring	Scouring surrounding the foundation
	13	Unusual of discharge cross-section	Obstruction within cross-sectional area of the waterway by sediment/ driftwood/ boulders
	14	Rough road surface	Rough road surface on the arch bridge section
	15	Cracks on the pavement	Cracks on the pavement of the arch bridge section
	16	Overgrowth of vegetation and moss	Overgrowth of vegetation and moss surrounding the arch bridge
	17	Corrosion	Corrosion on the steel materials
	18	Damage of masonry joints	Spalling/ or peeling of joints caused by the mortar placed between stone materials
	19	Surrounding landscape	Obstructing landscape surrounding the bridge

#### 5-4. Inspection item

The types and conditions of damage that should be confirmed for each member to inspection are as follows.

Table 5.4.1 Types of damage to be inspected

Component	Member	Damage type
Superstructure	Guard post (Guardrail)	01 Crack 02 Reduced cross-sectional area 11 Subsidence/Displacement /Inclining 16 Overgrowth of vegetation and moss 17 Corrosion 18 Damage of masonry joints
	Newel post	01 Crack 02 Reduced cross-sectional area 11 Subsidence/Displacement /Inclining 16 Overgrowth of vegetation and moss
	Arch stone	01 Crack 02 Reduced cross-sectional area 03 Gap of arch stones 04 Fall-off 07 Deformation of arch shape/normal line 08 Discolouration/degradation 09 Leaching/stagnant water 16 Overgrowth of vegetation and moss 18 Damage of masonry joints
	Keystone	01 Crack 02 Reduced cross-sectional area 03 Gap of arch stones 04 Fall-off 08 Discolouration/degradation 09 Leaching/stagnant water 16 Overgrowth of vegetation and moss 18 Damage of masonry joints
	Spandrel	01 Crack 02 Reduced cross-sectional area 03 Gap of arch stones 04 Fall-off 05 Deformation/Swelling 08 Discolouration/degradation 09 Leaching/stagnant water 16 Overgrowth of vegetation and moss 18 Damage of masonry joints
Substructure	Foundation (Embedment)	11 Subsidence/Displacement /Inclining 12 Scouring
	Pier/ Abutment	01 Crack 02 Reduced cross-sectional area 04 Fall-off 05 Deformation/Swelling 08 Discolouration/degradation 11 Subsidence/Displacement /Inclining 12 Scouring 18 Damage of masonry joints
	Others (Dewatering)	01 Crack 02 Reduced cross-sectional area 04 Fall-off 05 Deformation/Swelling 08 Discolouration/degradation 11 Subsidence/Displacement /Inclining 12 Scouring 18 Damage of masonry joints
Road surface	Wheel guard	01 Crack 05 Deformation/Swelling
	Flagstone	02 Reduced cross-sectional area 06 Cracks on flagstones 18 Damage of masonry joints
	Pavement	14 Rough road surface 15 Cracks on the pavement
Waterway	Waterway facilities	01 Crack 09 Leaching/stagnant water 18 Damage of masonry joints
Revetment of riverbank	Revetment	01 Crack 02 Reduced cross-sectional area 03 Gap of arch stones 04 Fall-off 05 Deformation/Swelling 08 Discolouration/degradation 09 Leaching/stagnant water 12 Scouring 16 Overgrowth of vegetation and moss 18 Damage of masonry joints
Others	Natural boulder in the riverbed	11 Subsidence/Displacement /Inclining 13 Unusual of discharge cross-section
	Lighting/ Signing and	17 Corrosion

	safety facilities	
	Drainage facilities	10 Sediment clogging
	Inspection facilities	16 Overgrowth of vegetation and moss      17 Corrosion
	Utilities (water pipe, etc.)	09 Leaching/stagnant water
	Surrounding vegetation	16 Overgrowth of vegetation and moss
	Obstacles for landscape	19 Obstacle landscape surrounding the bridge

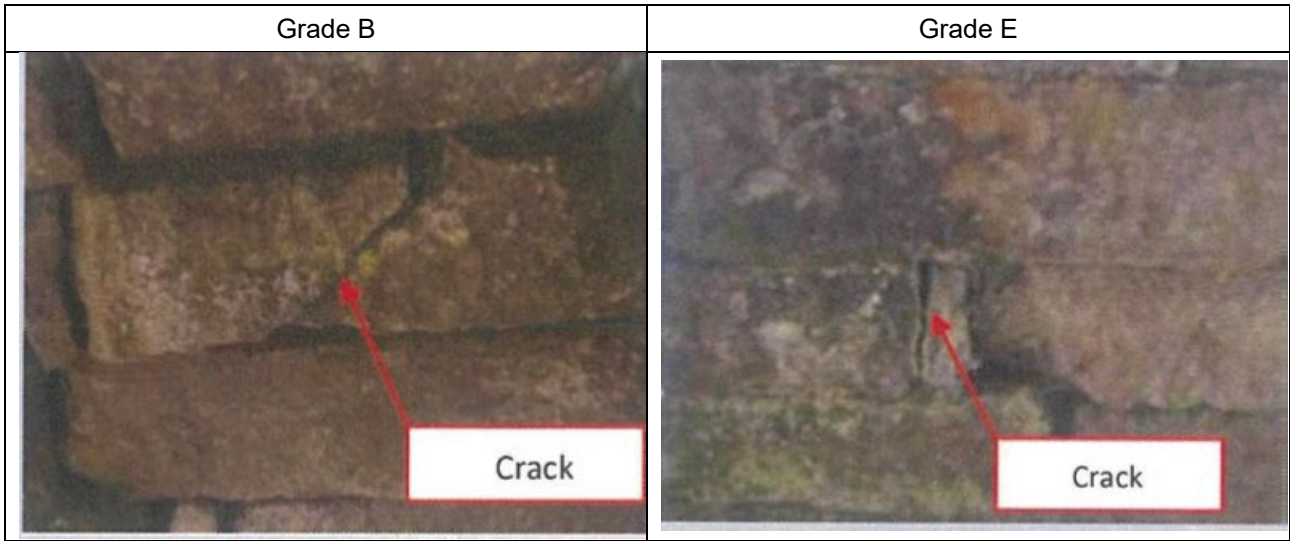


6-23 Damage grade and evaluation

01 Crack

Status that cracks have occurred on the stone materials.

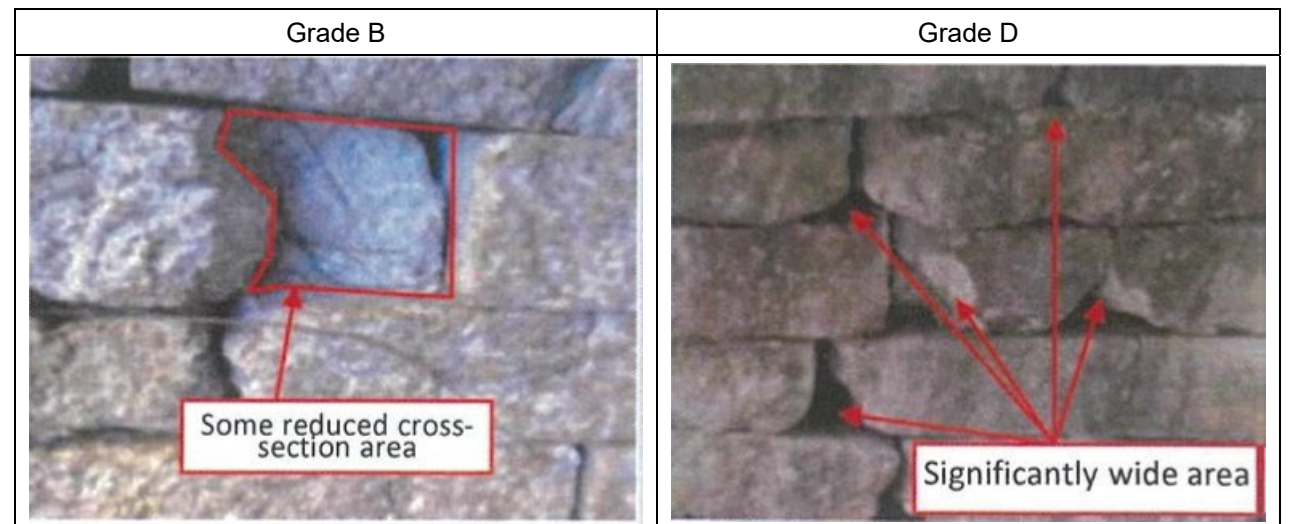
Grade	Damage status
A	No damage
B	Some cracks on stone materials are observed.
C	--
D	Many cracks are observed over wide areas.



02 Reduced cross-sectional area

Status that reduced cross-sectional areas have occurred on the stone materials.

Grade	Damage status
A	No damage
B	Some reduced cross-sectional areas on stone materials are observed.
C	Significantly reduced cross-sectional areas are observed.
D	There are observed wide ranges where reduced cross-sectional areas are significantly.



03 Gap of arch stones

Status that the gap has occurred between the arch stones.

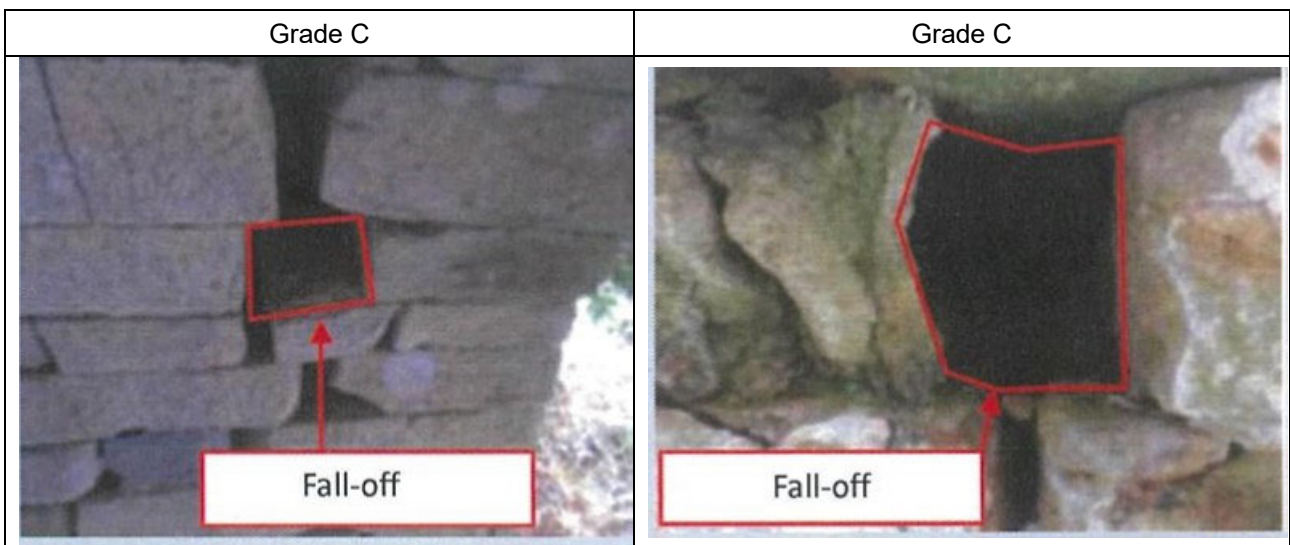
Grade	Damage status
A	Gap of arch stones < 1cm open
B	1cm ≤ Gap < 5cm open
C	5cm open ≤ Gap
D	5cm open ≤ Gap, continuously and widely



04 Fall-off

Status that the stone materials has fallen off.

Grade	Damage status
A	No damage
B	--
C	Falling-off of the stones are observed.
D	Falling-off of the stones are observed widely.



05 Deformation/ Swelling

Status that spandrel and/ or revetment has deformed and/ or swelled.

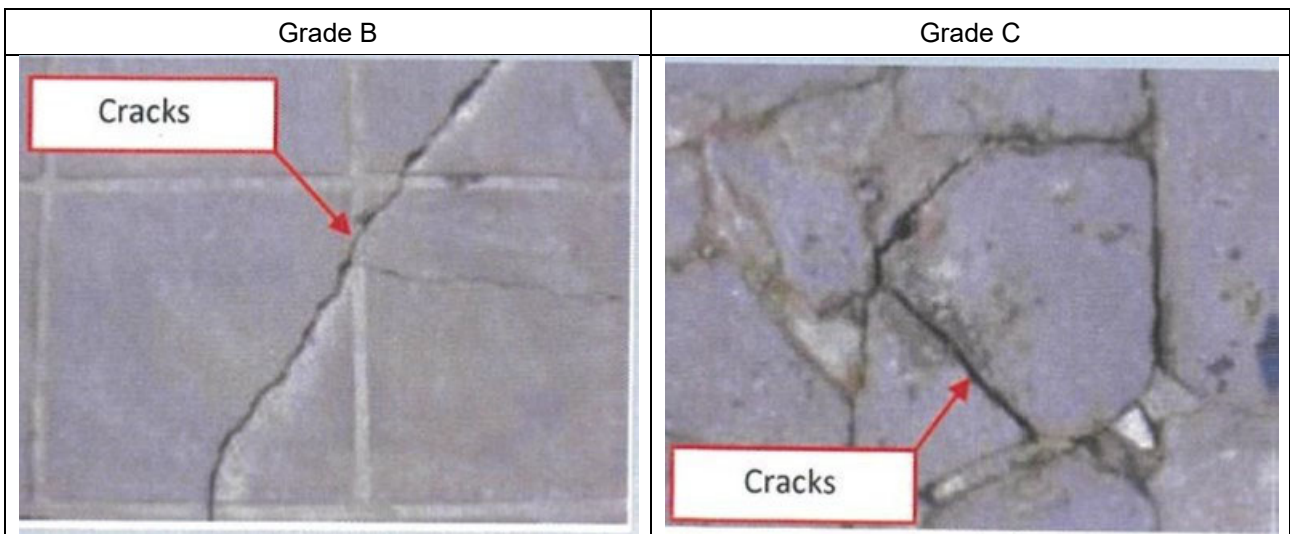
Grade	Damage status
A	No damage
B	Deformation/ Swelling on spandrel and/ or revetment is observed slightly.
C	Significant deformation/ swelling on spandrel and/ or revetment is observed partially.
D	Significant deformation/ swelling on spandrel and/ or revetment is observed totally.



06 Cracks on flagstones

Status that cracks has occurred on the flagstones.

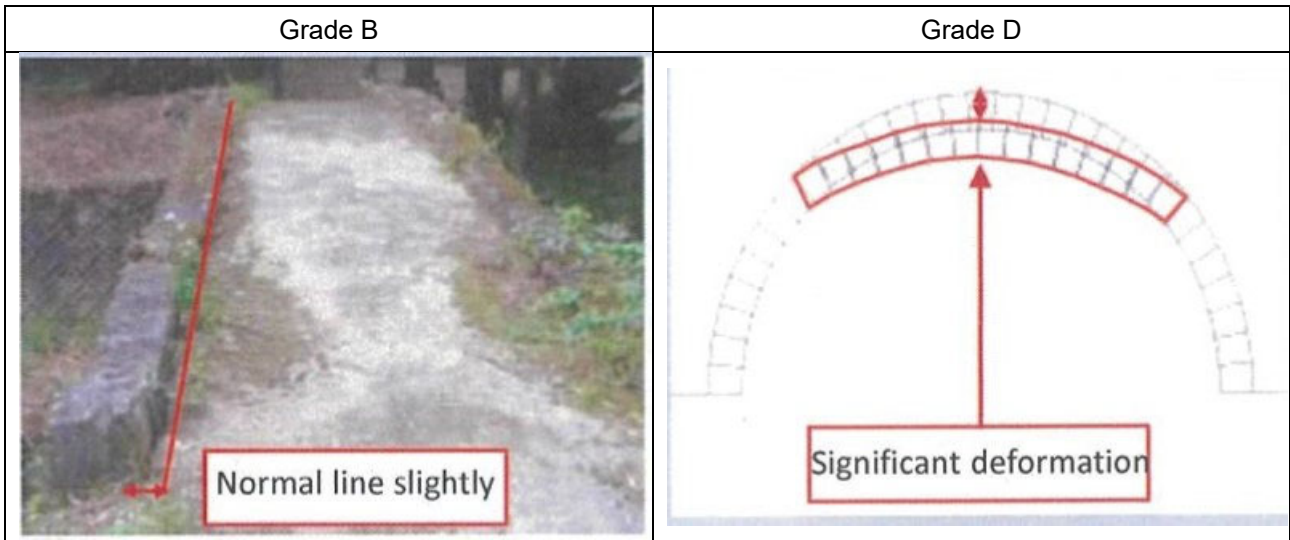
Grade	Damage status
A	No damage
B	Small cracks on the flagstones are observed.
C	Large cracks on the flagstones are observed partially.
D	Many cracks on the flagstones are observed widely.



07 Deformation of arch shape/ normal line

Status that deformation of the arch shape and/ or normal line has occurred.

Grade	Damage status
A	No damage
B	Slight deformation of arch shape and/ or nominal line
C	--
D	Significant deformation of arch shape and/ or nominal line



08 Discolouration/ Degradation

Status that the stone materials have occurred discolouration and/ or degradation.

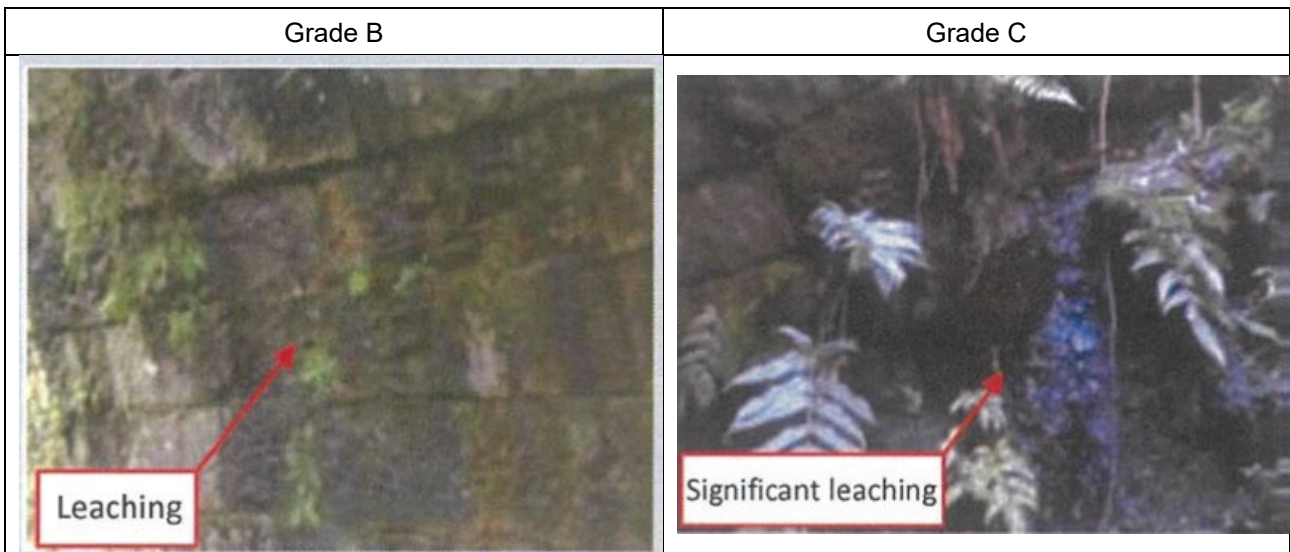
Grade	Damage status
A	No damage
B	Partial discolouration and/ or degradation
C	Partially significant discolouration and/ or degradation
D	Widely significant discolouration and/ or degradation



09 Leaching/ Stagnant water

Status that rainwater has been leaching or has been stagnant in each member regardless of its original drainage function.

Grade	Damage status
A	No damage
B	Partial leaching and/ or stagnant
C	Partially significant leaching and/ or stagnant
D	Widely significant leaching and/ or stagnant



10 Sediment clogging

Status that sedimentation has clogged in the drainage basins and/ or drainage pipes.

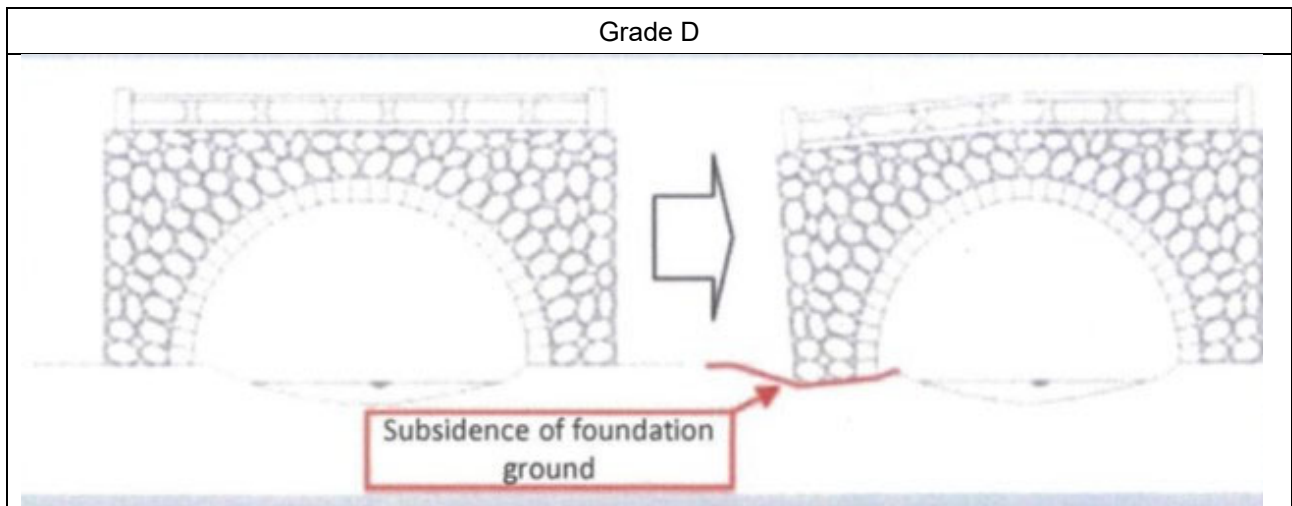
Grade	Damage status
A	No damage
B	--
C	Sediment clogging is able to observed in the drainage basins and/ or drainage pipes.
D	--



### 11 Subsidence/ Displacement/ Inclination

Status that the foundation has subsided, displaced and/ or inclined.

Grade	Damage status
A	No damage
B	--
C	--
D	Subsidence/ Displacement/ Inclining of the foundation are observed.



### 12 Scouring

Status that the foundation and the surrounding ground have been scoured by the running water.

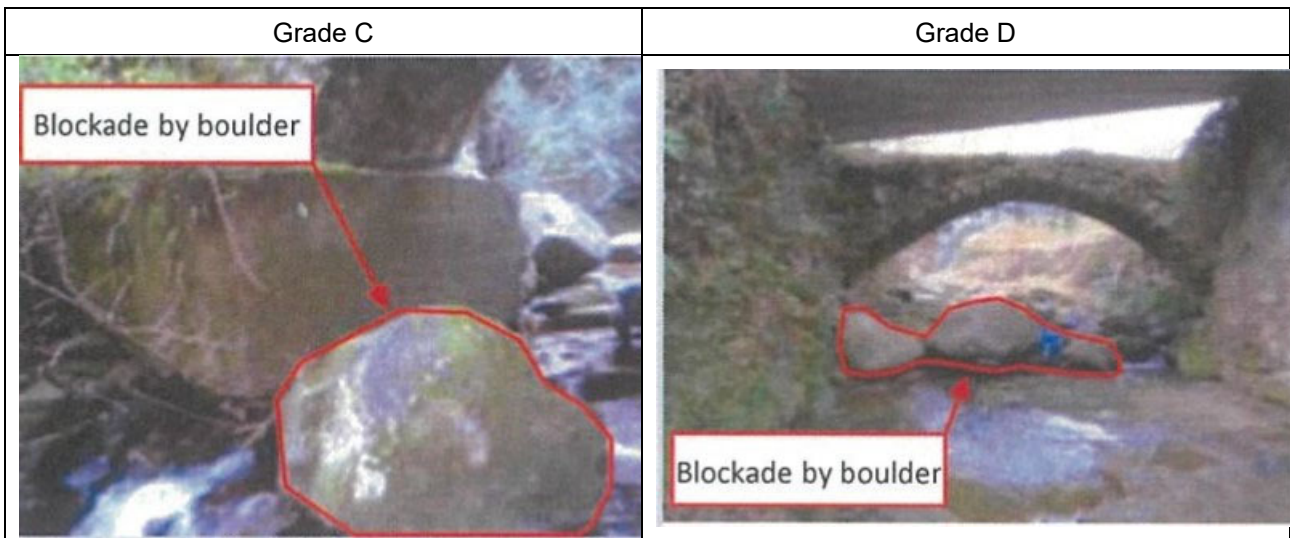
Grade	Damage status
A	No damage
B	The foundation and the surrounding ground have been scoured by the running water.
C	The foundation and the surrounding ground have been partially scoured by the running water.
D	The foundation and the surrounding ground have been significantly scoured by the running water.



13 Unusual of discharge cross-section

Status that water flow has been obstructed by sediment, driftwood, or boulders within the cross-sectional area of the waterway.

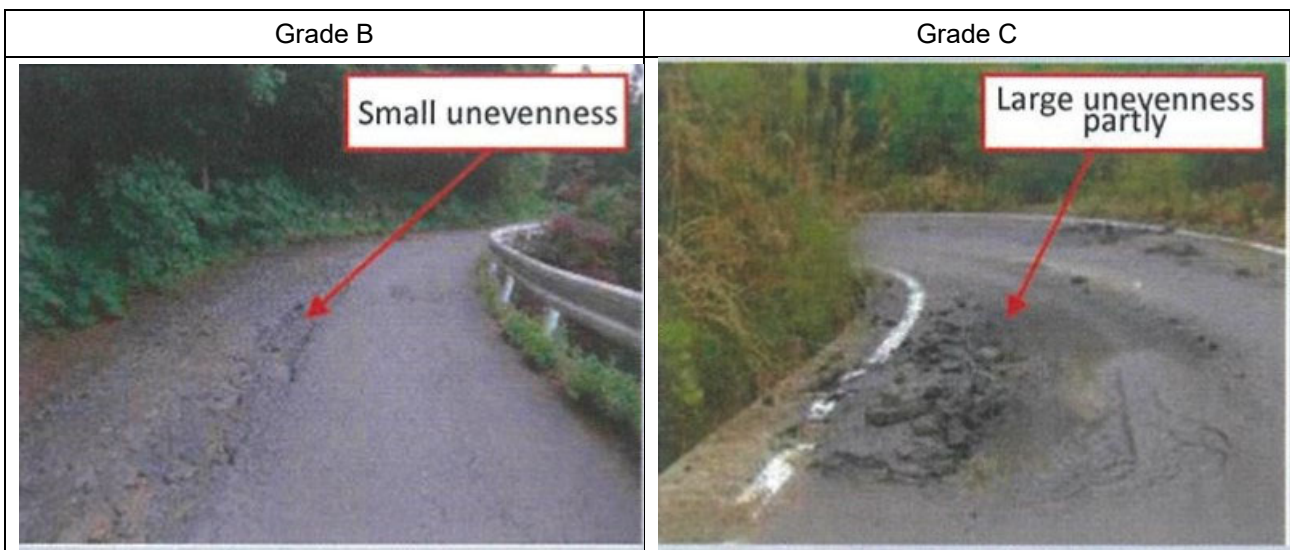
Grade	Damage status
A	No damage
B	--
C	Obstacles of the water flow have been partially observed within the cross-sectional area of flow.
D	The cross-sectional area of flow has not been enough.



14 Rough road surface

Status that the road surface has been uneven.

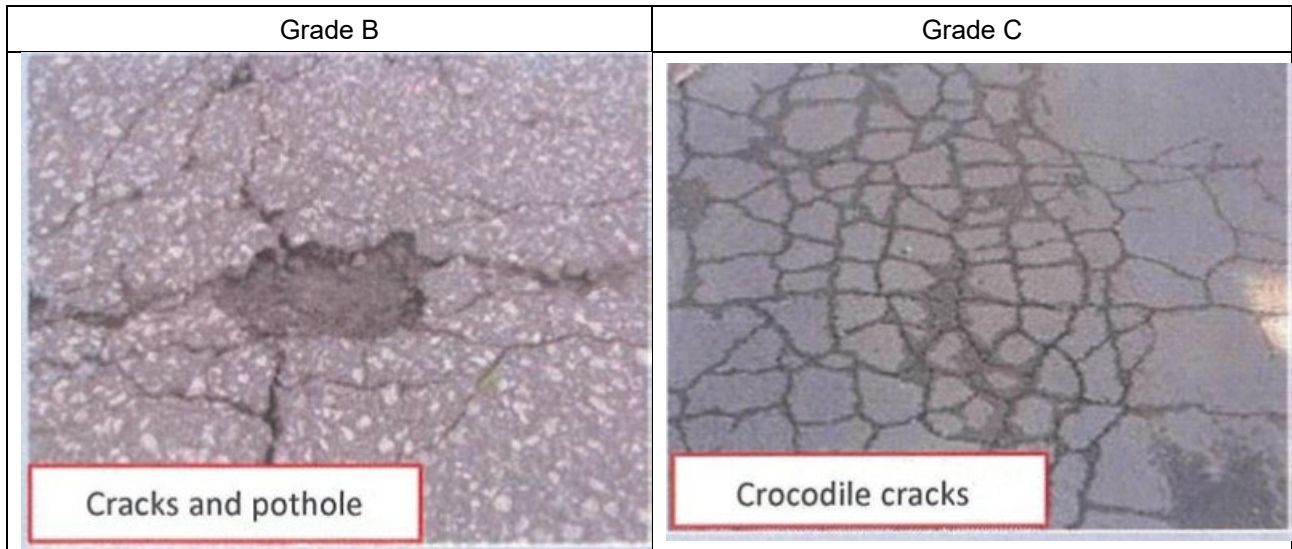
Grade	Damage status
A	No damage
B	Unevenness step has been small. (Less than 2cm step)
C	Unevenness step has been small partially. (More than 2cm step)
D	Unevenness step has been large widely. (More than 2cm step)



15 Cracks on the pavement

Status that cracks has occurred on the road surface.

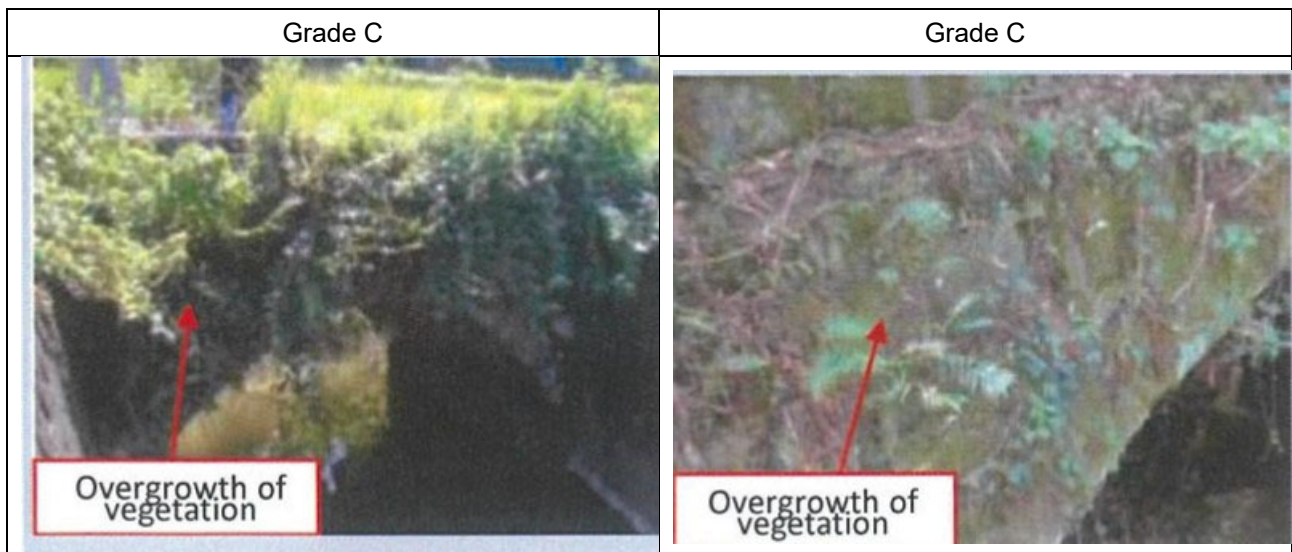
Grade	Damage status
A	No damage
B	Cracks are observed on the pavement partially.
C	Crocodile cracks are observed on the pavement.
D	Crocodile cracks are observed on the pavement widely.



16 Overgrowth of vegetation and moss

Status that vegetation and moss have flourished.

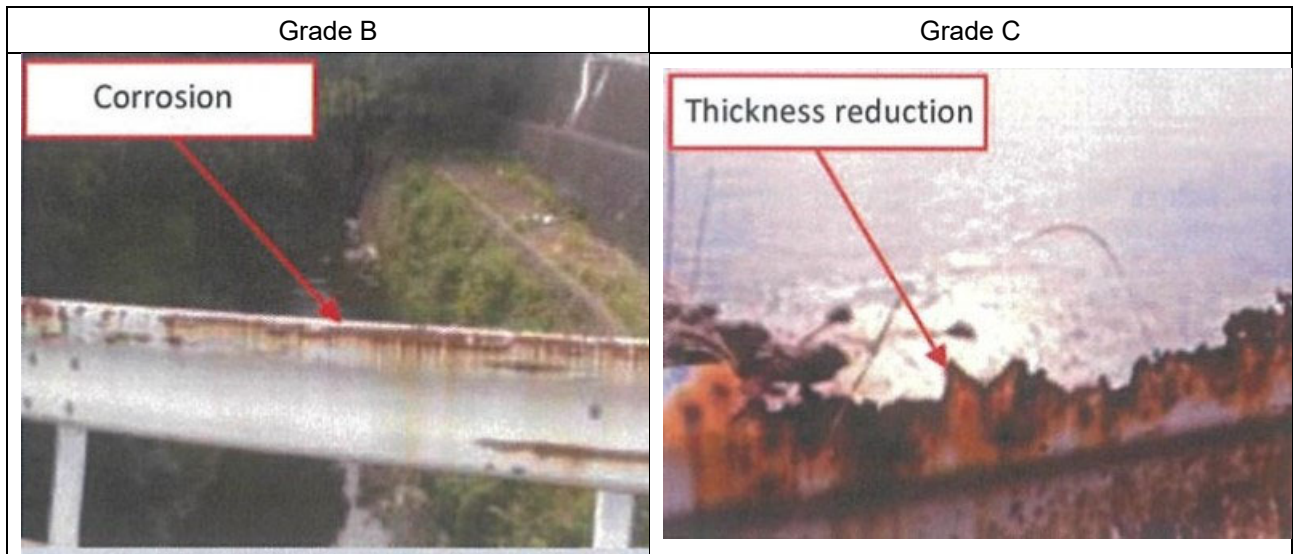
Grade	Damage status
A	No damage
B	--
C	Overgrowth of vegetations and/ or mosses are observe.
D	--



### 17 Corrosion

Rusts on steel materials has occurred.

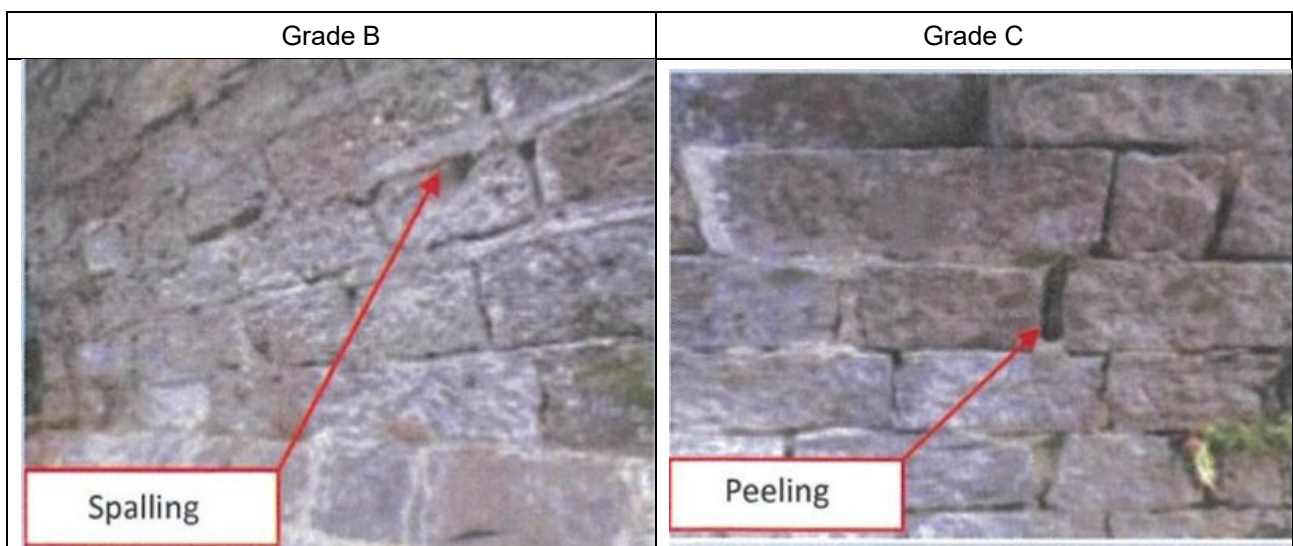
Grade	Damage status
A	No damage
B	A significant reduction of the steel plate thickness due to rust is not able to visually observed, however, rust occurs at multiple locations.
C	A clear reduction of the steel plate thickness due to rust is able to visually observe in some areas.
D	A clear reduction of the steel plate thickness due to rust is able to visually observe in widely spread.



### 18 Damage of masonry joints

Status that deformation such as spalling or peeling of joints has caused by the mortar placed between stone materials.

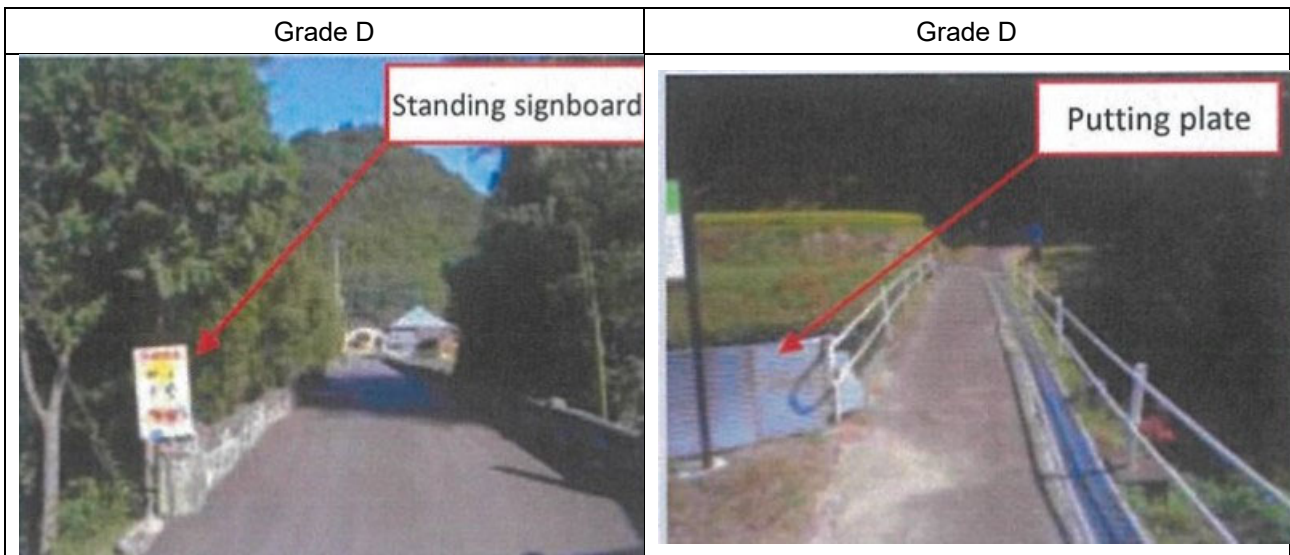
Grade	Damage status
A	No damage
B	Spalling is able to be observed partially.
C	Spalling and peelings are able to be observed partially.
D	Peelings are able to be observed widely.



### 19 Surrounding landscape

Status that the scenery around the stone bridge has obstructed.

Grade	Damage status
A	No hindrance
B	--
C	--
D	Inhibition factor present



## 7. Record of inspection result

The inspection results shall be recorded so that the location of the damage can be identified for each span of each stone bridge. In addition, sketches and photographs of the damage situation will be taken as necessary. Inspection results shall be recorded the damage grade [A to D] in the following mark.

The Inspection Sheet is attached on the last page of this manual as the reference.

Table 7.1 Item of inspection result

Component	Element	Stone materials								Others									Remarks	
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17		18
		Crack	Reduced cross-sectional area	Gap of arch stones	Fall-off	Deformation/ Swelling	Cracks on flagstones	Deformation of arch shape/ normal line	Discolouration/ degradation	Leaching/ stagnant water	Sediment clogging	Subsidence/ displacement/ inclining	Scouring	Unusual of discharge cross-section	Rough road surface	Cracks on the pavement	Overgrowth of vegetation and moss	Corrosion	Damage of masonry joints	Surrounding landscape
Superstructure	Gurd Post/ Guard railing	●	●									●					●	●	●	
	Newel post	●	●									●					●			
	Arch stone	●	●	●	●			●	●	●							●		●	
	Key stone	●	●	●	●				●	●							●		●	
	Spandrel	●	●	●	●	●			●	●							●		●	
Substructure	Foundation (Embedment)											●	●							
	Pier/ abutment	●	●		●	●			●			●	●						●	
	Others (Dewatering)	●	●		●	●			●			●	●						●	
Road surface	Wheel guard	●				●														
	Flagstone	●	●				●													●
	Pavement														●	●				
Waterway	Waterway facilities	●								●									●	
Revetment of riverbank	Revetment	●	●	●	●	●			●	●		●					●		●	
Others	Natural boulder arranged in the riverbed											●		●						
	Lighting/ Signing and safety facilities																	●		
	Drainage facilities										●									
	Inspection facilities																●	●		
	Utilities (water pipe, etc.)									●										
	Surrounding vegetation																●			
	Obstacles for landscape																			●

# Inspection Sheet as reference

Bridge Inspection Sheet (Inspection A/B/R)		Inspection date	
Road No.		Inspection type	
Road name		Span No.	
Bridge ID/No.		Bridge type	
Bridge name		Span length (m)	

Component	Element	Damage type	Damage state (%)				Photo No.
			A	B	C	D	
Superstructure	Guard post (Guardrail)	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 11 Subsidence/displacement/inclining					
		<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
		<input type="checkbox"/> 17 Corrosion					
		<input type="checkbox"/> 18 Damage of masonry joints					
	Newel post	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 11 Subsidence/displacement/inclining					
		<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
		<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
	Arch stone	<input type="checkbox"/> 03 Gap of arch stones					
		<input type="checkbox"/> 04 Fall-off					
		<input type="checkbox"/> 07 Deformation of arch shape/nominal line					
		<input type="checkbox"/> 08 Discoloration/degradation					
		<input type="checkbox"/> 09 Leaching/stagnant water					
		<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
Key stone	<input type="checkbox"/> 18 Damage of masonry joints						
	<input type="checkbox"/> 01 Crack						
	<input type="checkbox"/> 02 Reduced cross-sectional area						
	<input type="checkbox"/> 03 Gap of arch stones						
	<input type="checkbox"/> 04 Fall-off						
	<input type="checkbox"/> 08 Discoloration/degradation						
Spandrel	<input type="checkbox"/> 09 Leaching/stagnant water						
	<input type="checkbox"/> 16 Overgrowth of vegetation and moss						
	<input type="checkbox"/> 18 Damage of masonry joints						
	<input type="checkbox"/> 01 Crack						
	<input type="checkbox"/> 02 Reduced cross-sectional area						
	<input type="checkbox"/> 04 Fall-off						
Substructure	Foundation (Embedment)	<input type="checkbox"/> 05 Deformation/Swelling					
		<input type="checkbox"/> 08 Discoloration/degradation					
	<input type="checkbox"/> 09 Leaching/stagnant water						
Pier/Abutment	<input type="checkbox"/> 16 Overgrowth of vegetation and moss						
	<input type="checkbox"/> 18 Damage of masonry joints						
	<input type="checkbox"/> 11 Subsidence/displacement/inclining						
	<input type="checkbox"/> 12 Scouring						
	<input type="checkbox"/> 18 Damage of masonry joints						
	<input type="checkbox"/> 01 Crack						
Substructure	Others (Dewatering)	<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 04 Fall-off					
		<input type="checkbox"/> 05 Deformation/Swelling					
		<input type="checkbox"/> 08 Discoloration/degradation					
		<input type="checkbox"/> 11 Subsidence/displacement/inclining					
		<input type="checkbox"/> 12 Scouring					
Road surface	Wheel guard	<input type="checkbox"/> 18 Damage of masonry joints					
		<input type="checkbox"/> 01 Crack					
	<input type="checkbox"/> 05 Deformation/Swelling						
Flagstone	<input type="checkbox"/> 01 Crack						
	<input type="checkbox"/> 02 Reduced cross-sectional area						
	<input type="checkbox"/> 06 Cracks on flagstones						
Pavement	<input type="checkbox"/> 18 Damage of masonry joints						
	<input type="checkbox"/> 14 Rough road surface						
	<input type="checkbox"/> 15 Cracks on the pavement						
Waterway	Waterway facilities	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 09 Leaching/stagnant water					
		<input type="checkbox"/> 18 Damage of masonry joints					
Revetment of riverbank	Revetment	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 03 Gap of arch stones					
		<input type="checkbox"/> 04 Fall-off					
		<input type="checkbox"/> 05 Deformation/Swelling					
		<input type="checkbox"/> 08 Discoloration/degradation					
		<input type="checkbox"/> 09 Leaching/stagnant water					
		<input type="checkbox"/> 12 Scouring					
		<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
		<input type="checkbox"/> 18 Damage of masonry joints					
Others	Natural boulder in the riverbed	<input type="checkbox"/> 11 Subsidence/displacement/inclining					
		<input type="checkbox"/> 13 Unusual of discharge cross-section					
	Lighting/Signaling & Safety facilities	<input type="checkbox"/> 17 Corrosion					
	Drainage facilities	<input type="checkbox"/> 10 Sediment clogging					
	Inspection facility	<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
		<input type="checkbox"/> 17 Corrosion					
	Utilities (Water gas, etc)	<input type="checkbox"/> 09 Leaching/stagnant water					
Surrounding vegetation	<input type="checkbox"/> 16 Overgrowth of vegetation and moss						
Disturbance for landscape	<input type="checkbox"/> 19 Surrounding landscape						

Legend  : Not Applicable

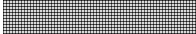
Bridge Inspection Sheet (Inspection A/B/R)

Road No.	
Road name	
Bridge ID/No.	
Bridge name	

Inspection date	
Inspection type	
Span No.	
Bridge type	
Span length (m)	

Component	Element	Damage type	Damage state (%)				Photo No.
			A	B	C	D	
Superstructure	Guard post (Guardrail)	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 11 Subsidence/displacement/inclining					
		<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
		<input type="checkbox"/> 17 Corrosion					
		<input type="checkbox"/> 18 Damage of masonry joints					
	Newel post	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 11 Subsidence/displacement/inclining					
		<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
	Arch stone	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 03 Gap of arch stones					
		<input type="checkbox"/> 04 Fall-off					
		<input type="checkbox"/> 07 Deformation of arch shape/nominal line					
		<input type="checkbox"/> 08 Discoloration/degradation					
		<input type="checkbox"/> 09 Leaching/stagnant water					
		<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
	Key stone	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 03 Gap of arch stones					
		<input type="checkbox"/> 04 Fall-off					
		<input type="checkbox"/> 08 Discoloration/degradation					
		<input type="checkbox"/> 09 Leaching/Stagnant water					
		<input type="checkbox"/> 16 Overgrowth of vegetation and moss					
		<input type="checkbox"/> 18 Damage of masonry joints					
	Spandrel	<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
<input type="checkbox"/> 04 Fall-off							
<input type="checkbox"/> 05 Deformation/Swelling							
<input type="checkbox"/> 08 Discoloration/degradation							
<input type="checkbox"/> 09 Leaching/Stagnant water							
<input type="checkbox"/> 16 Overgrowth of vegetation and moss							
<input type="checkbox"/> 18 Damage of masonry joints							
Substructure	Foundation (Embedment)	<input type="checkbox"/> 11 Subsidence/displacement/inclining					
		<input type="checkbox"/> 12 Scouring					
Pier/Abutment		<input type="checkbox"/> 01 Crack					
		<input type="checkbox"/> 02 Reduced cross-sectional area					
		<input type="checkbox"/> 04 Fall-off					
		<input type="checkbox"/> 05 Deformation/Swelling					
		<input type="checkbox"/> 08 Discoloration/degradation					
		<input type="checkbox"/> 11 Subsidence/displacement/inclining					
		<input type="checkbox"/> 12 Scouring					
<input type="checkbox"/> 18 Damage of masonry joints							

Substructure	Others (Dewatering)	<input type="checkbox"/> 01	Crack				
		<input type="checkbox"/> 02	Reduced cross-sectional area				
		<input type="checkbox"/> 04	Fall-off				
		<input type="checkbox"/> 05	Deformation/Swelling				
		<input type="checkbox"/> 08	Discoloration/degradation				
		<input type="checkbox"/> 11	Subsidence/displacement/inclining				
		<input type="checkbox"/> 12	Scouring				
		<input type="checkbox"/> 18	Damage of masonry joints				
Road surface	Wheel guard	<input type="checkbox"/> 01	Crack				
		<input type="checkbox"/> 05	Deformation/Swelling				
	Flagstone	<input type="checkbox"/> 01	Crack				
		<input type="checkbox"/> 02	Reduced cross-sectional area				
		<input type="checkbox"/> 06	Cracks on flagstones				
		<input type="checkbox"/> 18	Damage of masonry joints				
	Pavement	<input type="checkbox"/> 14	Rough road surface				
		<input type="checkbox"/> 15	Cracks on the pavement				
	Waterway	Waterway facilities	<input type="checkbox"/> 01	Crack			
<input type="checkbox"/> 09			Leaching/Stagnant water				
<input type="checkbox"/> 18			Damage of masonry joints				
Revetment of riverbank	Revetment	<input type="checkbox"/> 01	Crack				
		<input type="checkbox"/> 02	Reduced cross-sectional area				
		<input type="checkbox"/> 03	Gap of arch stones				
		<input type="checkbox"/> 04	Fall-off				
		<input type="checkbox"/> 05	Deformation/Swelling				
		<input type="checkbox"/> 08	Discoloration/degradation				
		<input type="checkbox"/> 09	Leaching/Stagnant water				
		<input type="checkbox"/> 12	Scouring				
		<input type="checkbox"/> 16	Overgrowth of vegetation and moss				
		<input type="checkbox"/> 18	Damage of masonry joints				
Others	Natural boulder in the riverbed	<input type="checkbox"/> 11	Subsidence/displacement/inclining				
		<input type="checkbox"/> 13	Unusual of discharge cross-section				
	Lighting/Signing & Safety facilities	<input type="checkbox"/> 17	Corrosion				
		<input type="checkbox"/> 10	Sediment clogging				
	Inspection facility	<input type="checkbox"/> 16	Overgrowth of vegetation and moss				
		<input type="checkbox"/> 17	Corrosion				
	Utilities(Water pipe.etc)	<input type="checkbox"/> 09	Leaching/Stagnant water				
	Surrounding vegetation	<input type="checkbox"/> 16	Overgrowth of vegetation and moss				
Obstacles for landscape	<input type="checkbox"/> 19	Surrounding landscape					

Legend  : Not Applicable

# Appendix-5 Inspection for Bridges with Hanging Members and Tension Members

[Note: Source of all materials is published by MLIT, Japan (Ministry of Land, Infrastructure, Transport and Tourism, Japan)]

## Table of Contents)

1. Definition of Bridge with Hanging/ Tension Members .....	-1
2. Inspection Stance.....	-9
3. Target Members.....	-10
4. Other Necessary Items.....	-11
5. Example of Damage.....	-11

# 1. Definition of Bridge with Hanging Members and Tension Members

Bridges with hanging members and tension members are clearly different from ordinary girder bridges in the behaviour of the whole bridge due to loads during vehicle traffics and storms. Bridges of these types include suspension bridges, cable-stayed bridges, extradosed bridges and arch bridges, etc..

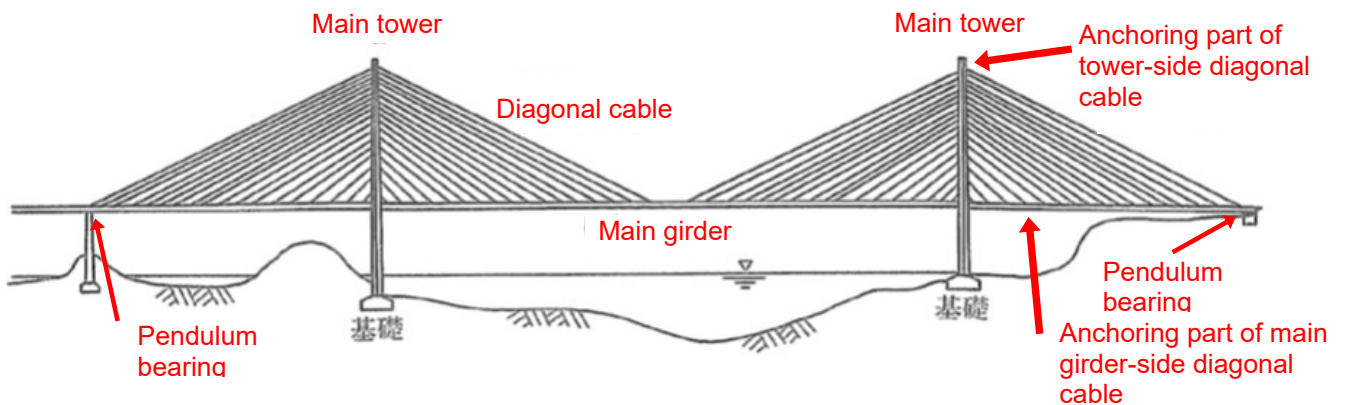
In this chapter, these types of bridges with hanging members and tension members are defined as the bridges with hanging members and tension members when conducting inspections and diagnoses.

## 【Notes】

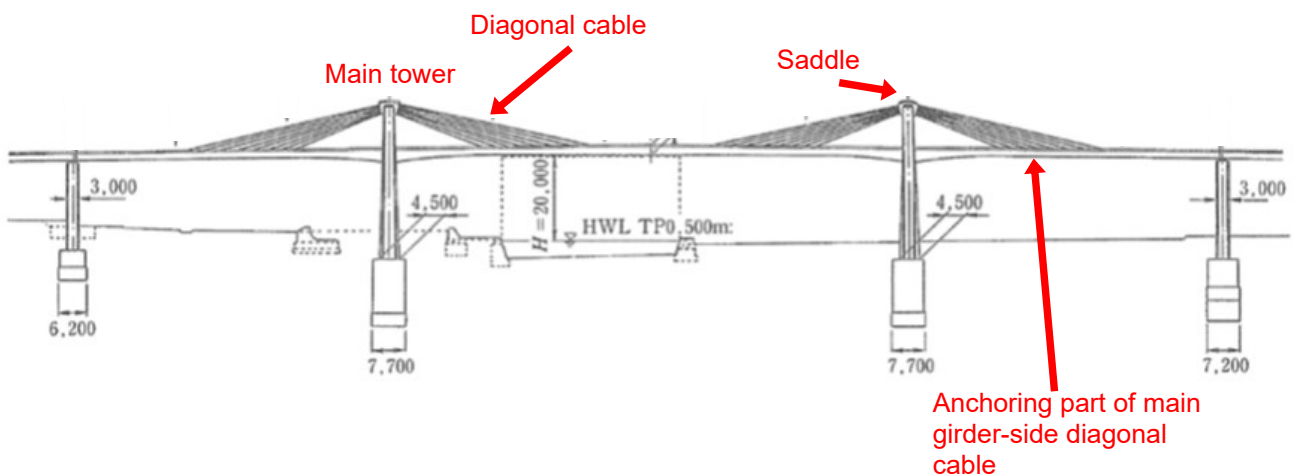
Extradosed bridges have also been used on the national highways in Laos, and it is expected that the number of large-scale bridges with hanging members and tension members, etc. will increase in the future, so this appendix also deals with them.

### 1-1. Cable-stayed Bridge, Extradosed Bridge

#### Cable-stayed Bridge

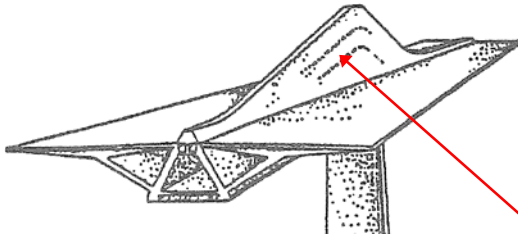


#### Extradosed Bridge

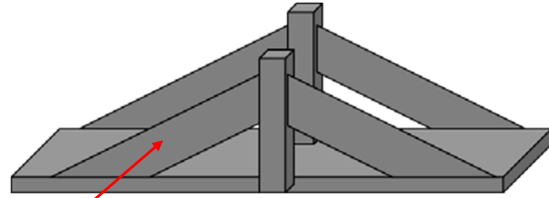


## Other structure types

Finback types



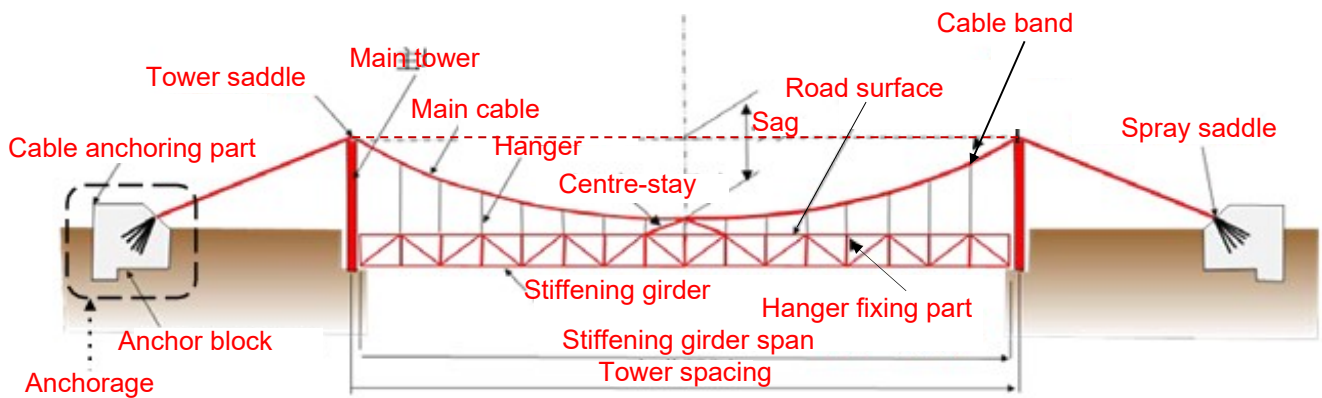
Triangular concrete wall types



Diagonal cable covered by concrete for protecting a cable corrosion

- 1) Tension member : Diagonal cable  
Pendulum bearing
- 2) Anchoring part of tension member : Anchoring part of main girder-side diagonal cable  
Anchoring part of tower-side diagonal cable  
Anchoring part of pendulum bearing
- 3) Members that affect the behaviour of 1 and 2 above : Saddle

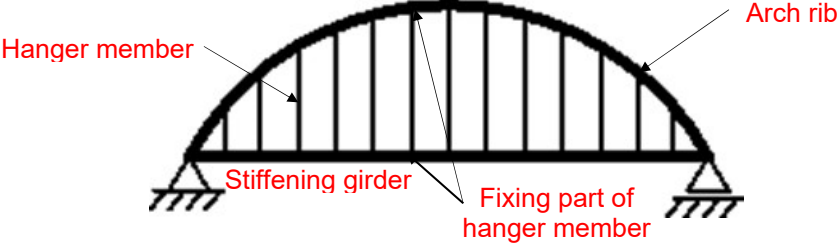
## 1-2. Suspension Bridge



- 1) Tension member : Main cable  
Hanger
- 2) Anchoring part of a tension member : Anchorage (Anchoring part of the main cable)  
Hanger fixing part (Fixing part of hanger (Main girder-side))  
Cable band (Fixing part of hanger (Main cable side))
- 3) Members that affect the behaviour of 1 and 2 above : Tower saddle, Splay saddle

### 1-3. Arch Bridge

Arch bridge (Lohse type)



- 1) Tension member : Hanger member
- 2) Fixing part of tension member : Fixing part of hanger member

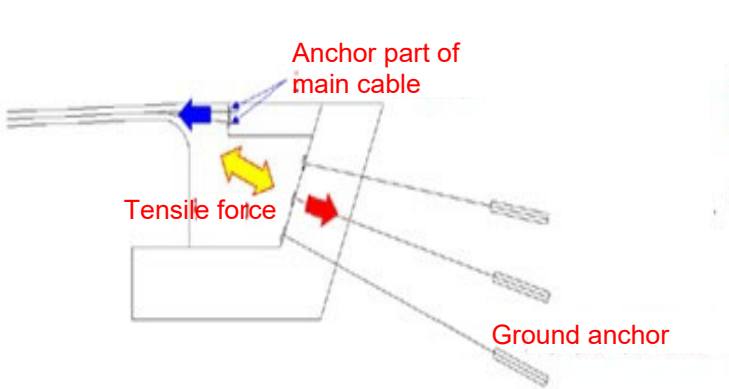
### 1-4. Stressed Ribbon Bridge



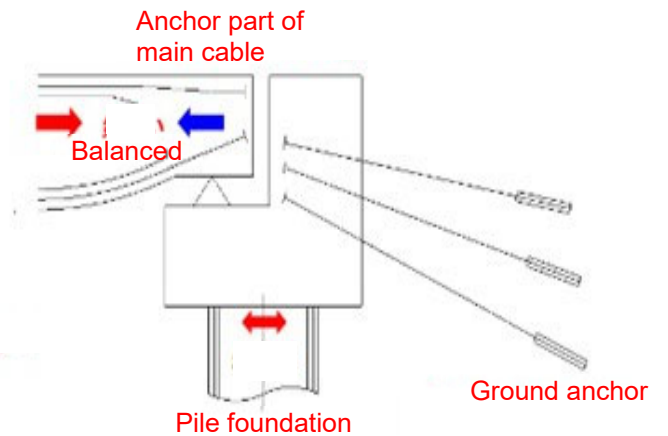
Straight road-type stressed ribbon bridge



Deck type stressed ribbon bridge

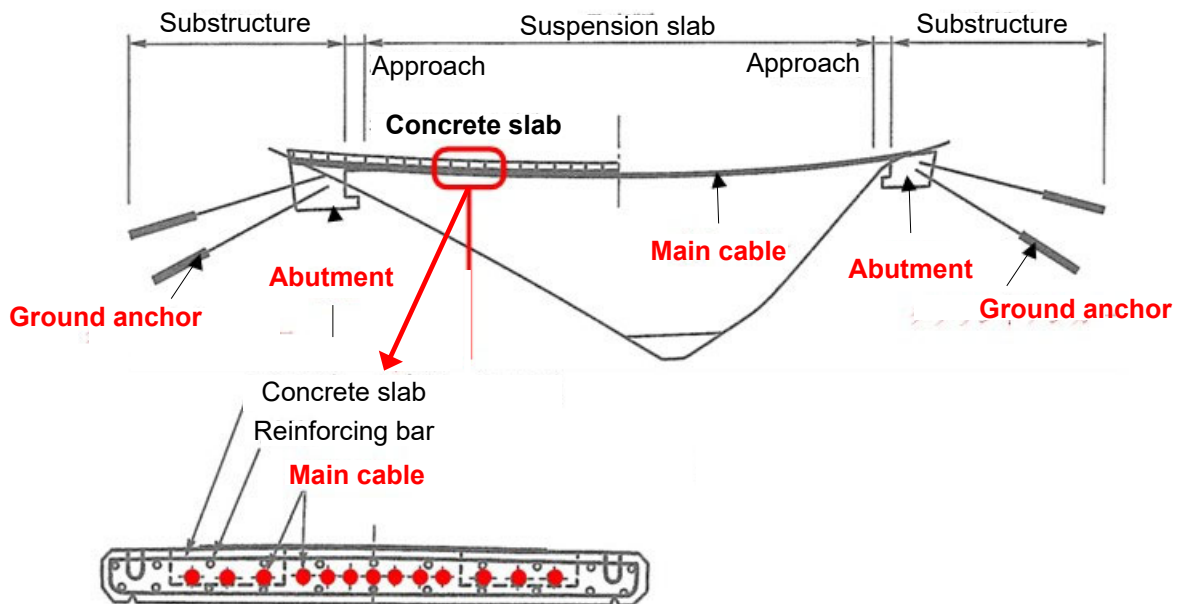


Anchoring structure of other-anchor type



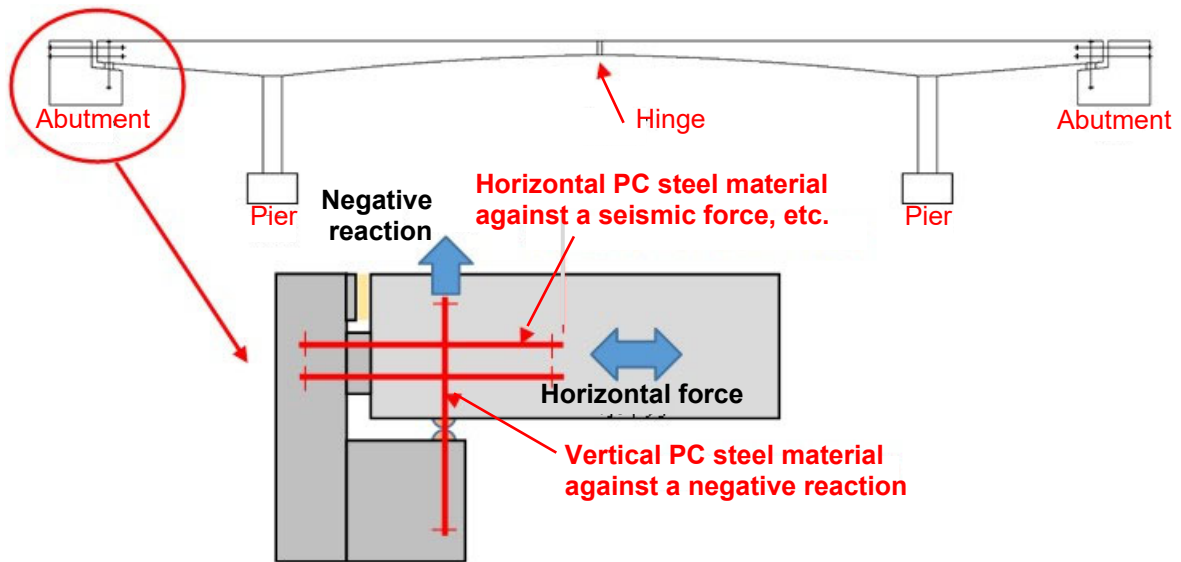
Anchoring structure of self-anchor type

#### Example of straight-road type stressed ribbon bridge (Anchoring-structure of other-anchor type)



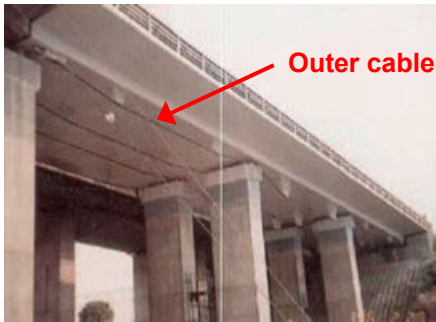
- 1) Tension member : Main cable  
Ground anchor
- 2) Anchoring part of tension member : Anchoring part of a main cable  
Anchoring part of a ground anchor
- 3) Members that affect the behaviour of 1 and 2 above : Abutment

## 1-5. Duluk Band Bridge



- 1) Tension member : Vertical PC steel material  
Horizontal PC steel material
- 2) Anchoring part of tension member : Anchoring part of a vertical PC steel material  
Anchoring part of a horizontal PC steel material
- 3) Members that affect the behaviour of 1 and 2 above : Abutment

## 1-6. Bridge Structure reinforced with outer cables



**Example of a bridge structure reinforced with outer cables**



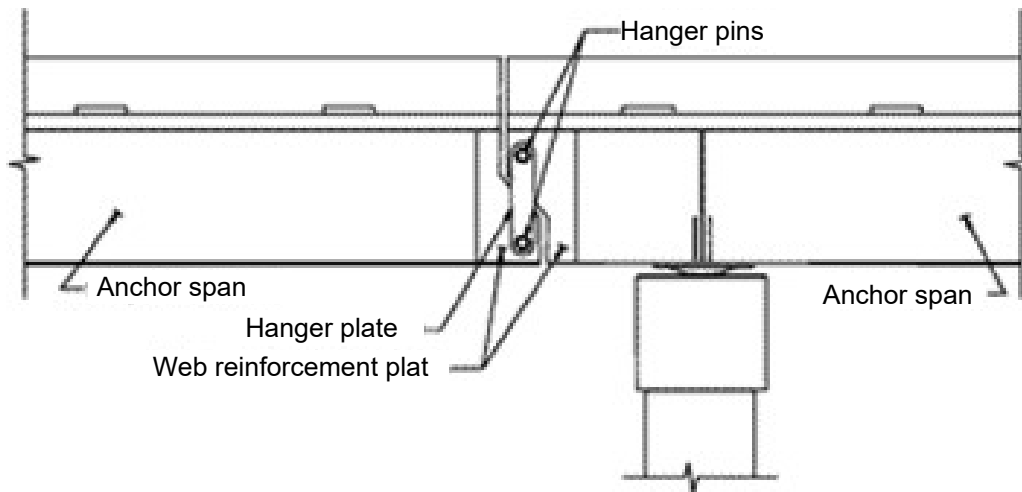
**Example of a steel bridge reinforced with outer cables**

- 1) Tension member : Outer cable
- 2) Anchoring part of tension member : Anchoring part of an outer cable
- 3) Members that affect the behaviour of 1 and 2 above : Deflection part

## 1-7. Other

As an example, a case where suspension materials (pins and hangers) are used to connect girders in the middle of spans.

In addition to these, periodic inspections of tension members should be conducted in consideration of the impact on the bridge if they fracture.



**Example of a structure with pins and hangers**

## 2. Inspection Stance

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It is important to conduct inspections of large-scale bridges after knowing the members and parts to be inspected, even if there are no advanced inspection techniques.

### 【Notes】

It is desirable to patrol the bridge surface on foot, conduct regular visual inspections on a daily basis, and conduct periodic inspections closer to members and parts that are difficult to inspect on foot. It is important to grasp the signs of damages by periodic inspections for details that are not able to be grasped by visual inspection alone, and to inspect high places using a drone or to prevent damage to a third party. Furthermore, periodic inspections are treated as Inspection B.

It is also important to promptly confirm safety of the road in the event of a natural disaster such as torrential rain or typhoon, etc. and to confirm the necessity of traffic regulation and whether detailed inspections are necessary by inspection for extraordinary conditions.

### 3. Target Members

Target members are main cables [stay cables], hanger materials and tension materials, and their jigs and fixing tools are also targeted.

Inspections of the members that constitute other bridges shall be in accordance with the inspection methods described in the previous chapters.

#### 【Notes】

In some road bridges, there is a concern that the breakage of the tension member may lead to a fatal situation of the whole bridge and also the behaviour of the whole bridge may be significantly affected. For example, a bridge using the following members may be classified into this category.

- 1) Tension member: Cables, hanger ropes, underground anchor
- 2) Fixing jigs of the above 1) [fixing tools for fixing the tension members and reinforced parts [for example, cable anchor parts, etc.] for arranging the fixing tool]
- 3) Members that affect to behaviour of the above 1) and 2)

The members covered by each inspection are shown in Table 3.1.

Table 3.1 The target members for each inspection

Type of Bridge	Member/Part	Routine	Periodic inspection		extraordinary
			A	B	
Suspension Bridge	Main cable	○	◎	◎	◎
	Hanger rope	○	◎	◎	◎
	Tower saddle	—	○	◎	—
	Hanger clamps	△	○	◎	△
	Hanger fixed bracket, jigs, etc.	—	○	◎	△
	Main tower	○	◎	◎	○
Cable-stayed Bridge	Stay cable	○	◎	◎	◎
	Tower saddle	—	○	◎	—
	Cable fixed bracket, jigs, etc.	△	○	◎	△
	Tower	○	◎	◎	○
Extradosed Bridge	Outer cable	○	◎	◎	◎
	Tower saddle	—	○	◎	—
	Cable fixed bracket, jigs, etc.	△	○	◎	△
	Tower	○	◎	◎	○
Arch Bridge	Hanger member	○	◎	◎	◎
	Fixing part of hanger member	△	○	◎	△

◎: Mainly close visual inspection    ○: Mainly visual inspection from a distance  
 —: Not applicable    △: Take a photo if extraordinary condition may have developed

#### **4. Other Necessary Items**

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The maintenance system and work descriptions, the frequency and standard of inspections, safety measures at the time of inspections, and records of the status of damages shall be in accordance with the contents described in the main manual.

#### **5. Example of Damage**

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Damage examples such as cables, hangers, anchoring parts and fixing parts, etc., are presented in this clause

Based on the results of periodic inspections and the results of diagnosis, examples of damage to bridges and the members and points to note in especially periodic inspections are presented in the following pages.

In addition, since it is a limit to grasp deformation by the close visual inspection, it is necessary to consider actively applying non-destructive test technologies and drones and the like as necessary.

- The cable supports the dead load of the girder and the live load acting on the girder. In the case of a bridge with a suspended structure, the cable is a member that transmits the tension to the tower and anchorage.

- Due to the fracture of the cable, the influence of the supported load and impact affects other members and cables, which may affect the safety of the entire bridge, such as the balance of the cable structure being disrupted or damage to other members and cables.

- Typical examples of cables and their corrosion protection methods include:

- Example of stranded wire

Galvanizing  
(1 strand)



Rust preventive oil  
+ Polyethylene coat

Galvanizing  
(multiple strands)



Concrete coating

Galvanizing + Wrapping wire  
+ Painting



Example of a joint in  
the middle of a cable

Source: Porchevera viaduct  
<https://www.autostrade.it/it/autotrade-per-genova/vero-falso>

Example of a main cable  
anchored in the rod

- Example of locked coil

Galvanizing



- Example of parallel wire cable

Galvanizing + Wrapping wire  
+ coating

- In addition, there are various types such as steel core cables.

**Remarks**

■ Various types of cables are used generally, and each type has different mechanical properties, safety factors, corrosion protection specifications, etc. When inspecting, it is necessary to accurately judge the type of cable and its characteristics after grasping its structure, and accurately determine the abnormalities and signs related to soundness.



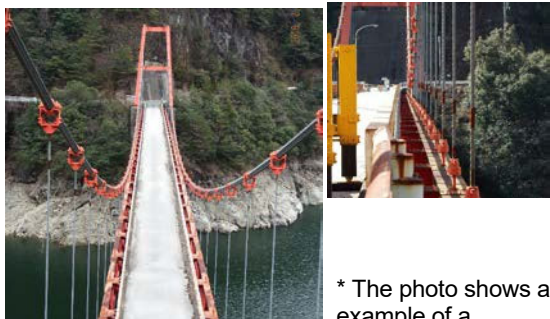
**Example**  
 A case where a diagonal cable coated with concrete broke and fell the bridge (Shimadabashi Bridge).  
 (Source: Construction Accident, Nikkei BP, Japan)



**Example**  
 A case where a cable-stayed bridge with a diagonal cable coated with concrete fell (Porchevera Viaduct).  
 (Source: <http://www.mit.gov.it/>)







**Example**  
 A case where a stressed ribbon bridge with cables inside concrete fell (Trojan Footbridge).  
 (Source: <https://structurae.net/structures/Troja-Footbridge>)





\* The photo shows an example of a suspension bridge.

**Example**  
 In a structure using a cable, since the fracture of the member and the abnormality of the anchoring part tend to affect the overall shape, abnormal signs may be detected from the longitudinal alignment or the like.  
 If abnormal deflection or the like is observed, not only the main cable but also other members may be the cause.

**Remarks**

 <p style="text-align: center;">* The photo shows a cracked case of the underside of a stressed ribbon bridge</p>	<p><b>Example</b></p> <p>A case of a cracked slab of a stressed ribbon bridge where the main cable is located inside the concrete.</p> <p>For internal cables, it needs to check if the concrete has been damaged or if there have been any alterations that might indicate water seeping into the main cable.</p>
 <p style="text-align: center;">* The photo shows an example of a crack on the lower surface of the PC girder</p>	<p><b>Example</b></p> <p>A case where a concrete coated with PC steel material has cracked along the PC steel material.</p>
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;"> <p>Before chipping</p>  </div> <div> <p>After chipping</p>  </div> </div> <p style="text-align: center;">* The photo shows an example of a crack on the lower surface of the PC girder</p>	<p><b>Example</b></p> <p>A case where a cable placed in concrete corroded or broke due to insufficient grout filling or water ingress.</p> <p>When the cables of cable-stayed bridges and extra-dosed bridges are covered with concrete, the deformation of the internal steel material may appear as concrete spalling, peeling, rust juice, and free lime, so it is better to check the state of the concrete by hammering test or the like.</p>
<p><b>Remarks</b></p> <ul style="list-style-type: none"> <li>■ If corrosion is suspected of the steel material inside the concrete, it may be possible to check the inside by chipping or non-destructive inspection.</li> </ul>	

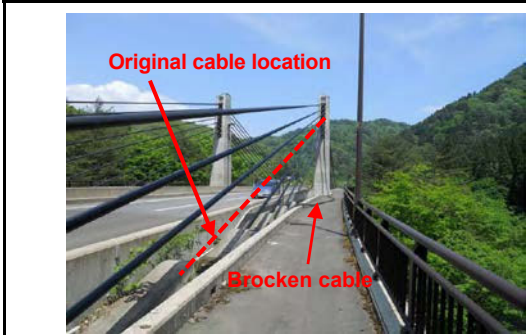
 <p>* The photograph shows an example of damage to the lower surface of the PC girder</p>  <p>* The photograph shows an example of damage to the lower surface of the PC girder</p>	<p><b>Example</b></p> <p>A case of regular damages to the concrete girder arranged PC steel material.</p> <p>Even if there is no cracking, damages such as discolouration, spalling, and peeling may be scattered due to corrosion of spacers, assembled rebars, shear reinforcement rebars or the like, and further internal steel material of the concrete may be suspected of being deformed. It is necessary to comprehensively judge the information obtained from the exterior and estimate the internal state.</p>
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	<p><b>Example</b></p>
--	-----------------------

	<p><b>Example</b></p>
--	-----------------------

**Remarks**

- If corrosion is suspected of the steel material inside the concrete, it may be possible to check the inside by chipping or non-destructive test.



**Example**

A case where water penetrated into the vicinity of the anchoring part of the diagonal cable of the polyethylene-coated extra-dosed bridge, rotted and broke (Yukizawa Ohashi Bridge).



**Example**

Photograph of the break in the bridge above.  
It is necessary to be careful because signs do not necessarily appear on the outside that can be seen, and there are cases where significant damage occurs inside than assumed from external signs.



**Example**

A case of damage to the coating material of PC steel material of a Stressed ribbon bridge where the main cable is located outside the concrete. In the case of an external cable, a corrosion protection against corrosion is provided by a coating such as polyethylene. It needs to check for damage to the sheath of the cable or a displacement that may indicate water penetration into the main cable.



**Example**

An example of the PC anchoring part on the main girder side of the bridge above where the diagonal cable was broken. If the anchoring part has a structure that makes it easy for accumulating water, It needs to care because water may penetrate into the anchoring part and corrode the cable.

**Remarks**

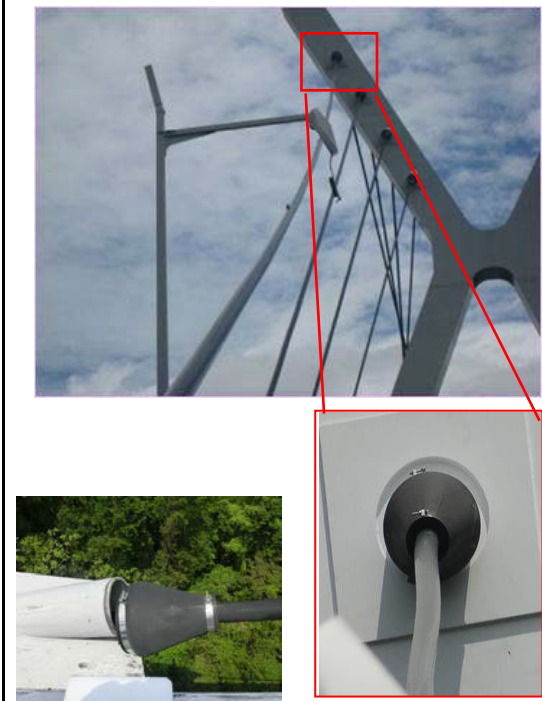
■ Since the cause of fracture is not only the effect of corrosion, but also the influence of fatigue due to live load and wind load, or the composite of the same, it is necessary to pay attention to whether damage has occurred to the peripheral members installed for wind resistance measures, etc., and to confirm the possibility of fatigue effect.



**Example**

An example of inspection near the main girder side anchoring part.

In some cases, after remove the protective cover of the cable, it may be effective to check for water infiltration, stagnation and internal corrosion conditions.



**Example**

An example of an abnormal deflection occurred on the diagonal cable of a cable-stayed bridge.

It needs to check whether abnormal deflection has occurred in the cable due to a violent wind or the like, or whether there has been an abnormality in the cable tension.



**Example**

An example of damage to the covering of a diagonal cable on a cable-stayed bridge.

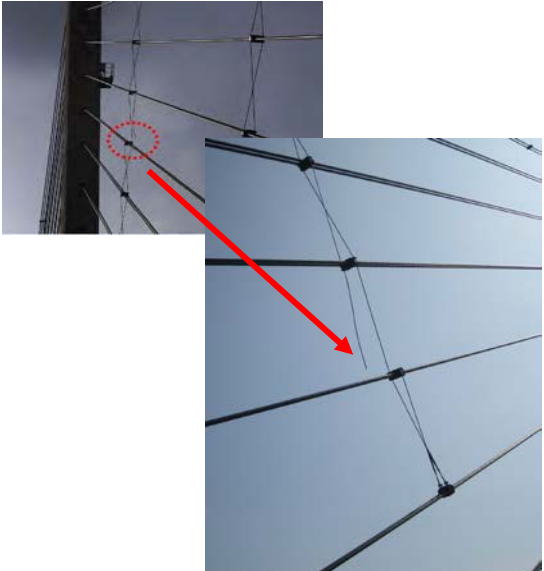
In the case of a cable, corrosion protection against corrosion is provided by a coating such as polyethylene. It needs to check for damage to the sheathing or a deformation that suspects water infiltration into the main cable.

**Remarks**

- It also needs to consider how to grasp the detailed state of the inside of the cable.



Example of damage to the protective cover of the saddle part



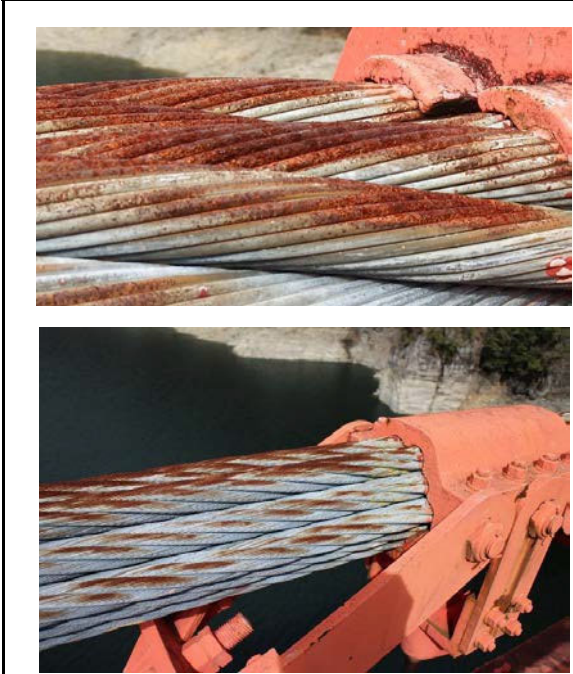
Example of damage to a damping wire.

Example

The damage factor of the cable is considered not only by the influence of corrosion, but also by the effect of fatigue due to the live load and wind load, or by its combined action. For this reason, it is much better to pay attention not only to the cable body but also to whether damage has occurred to the peripheral member or not.

Example

Remarks



**Example**

An example which galvanizing of the main cable of a suspension bridge is worn out.

It is difficult to accurately judge abnormalities such as corrosion inside the cable only by appearance, and it is necessary to estimate the internal state that cannot be seen by comprehensively judging various information obtained from the exterior, such as the corrosion situation of the surface, the leakage of rust juice from the inside, the deterioration of the rust prevention oil and the state of wear and tear.





**Example**


A case where local corrosion (pitting corrosion) is seen in the main cable.


**Example**

**Remarks**

	<p><b>Example</b></p> <p>A case where corrosion prevention function deterioration and corrosion can be seen in the entire main cable.</p>
---	---

	<p><b>Example</b></p> <p>A case of corrosion accompanied by a decrease in cross-section of the main cable (A hanger also has already rusted).</p>
--	---

	<p><b>Example</b></p> <p>A case where a fracture in the main cable can be seen.</p>
---	---

	<p><b>Example</b></p> <p>A case where corrosion of the main cable has progressed and a broken wire is seen in the elemental wire.</p>
---	---

<b>Remarks</b>	<p>■ When a different metal such as stainless steel is used for fasteners, etc., there is a risk that significant corrosion due to heterogeneous metal contact will occur on the steel material. In this case, care must be taken because corrosion may occur simultaneously and frequently to other parts of the same structure.</p>
----------------	---



#### Example

An examples of damage to the wrapping wires of the main cable of the suspension bridge and the caulking of the cable band .

There are cases where a steel wire (wrapping wire) is wrapped around the surface of the bundled strand, and corrosion protection such as painting is applied from the top. Since the cables cannot be seen unless the wrapping wire is removed, it is necessary to check the soundness of the wrapping wire and check whether there are any signs indicating internal abnormalities on the wrapping wire surface.



#### Example

An example of corrosion in the cable band of a suspension bridge.

Even in the case of the main cable with wrapping wires, the cable band part has no wrapping wire, and the surface of the strand of the main cable is exposed. There is a gap between the inner surface of the cable band and the main cable surface, and the water stop at the end of the cable band is not sufficient and rainwater may reach the inside, so that the bare wire of the cable band part may corrode. Although it is difficult to directly check the inside of the cable band, if corrosion such as leakage of rust juice is suspected, it is necessary to carefully evaluate including temporarily releasing the band.

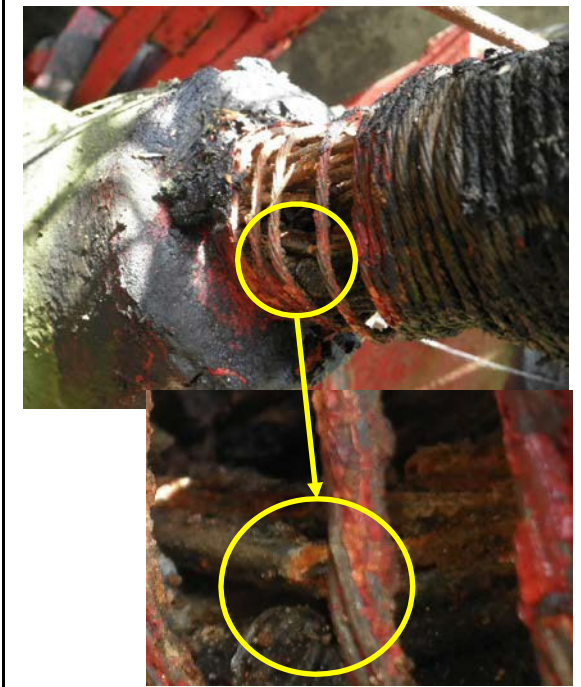
#### Remarks

- If abnormalities inside the cable are suspected, it is necessary to check whether there is a technology that can be applied with non-destructive inspection technology, and if necessary, it is necessary to consider removing part of the wrapping wire or driving a wedge into the wire to check the inside directly visually.



**Example**

A case where it is suspected that the rust inhibitor of the main cable of the suspension bridge has been deteriorated and the corrosion preventive function has been lost.



**Example**

An example of breaking of the wire inside a wrapping wire.  
 Since the surface of the cable is strictly protected from corrosion, it is often difficult to find abnormalities such as internal corrosion from the exterior. If an abnormality inside is suspected, it may be necessary to remove the corrosion preventive (rust preventive material, protective wire, etc.) and check the inside.



**Example**

A case where a rupture occurs in the wire of the main cable near the end of the cable band of a suspension bridge.

**Remarks**

- If abnormalities inside the cable are suspected, it is necessary to check whether there is a technology that can be applied with non-destructive inspection technology, and if necessary, it is necessary to consider removing part of the wrapping wire or driving a wedge into the wire to check the inside directly visually.



**Example**

A example of the main girder side anchoring part of a cable-stayed bridge.

(Note: Because there is a protective cover, it is not possible to check the mouth area of the anchoring part.)

Yes. Note that some covers provided at the mouth of the anchoring part do not have a structure that can completely prevent the ingress of water into the anchoring portion.



**Example**

An example of a protective cover in the anchoring part of a cable-stayed bridge.

If there is a drain to prevent water from accumulating in the cable anchoring part, it needs to check whether it is functioning.



**Example**

A case where a gap occurred in the anchoring part on the main girder side of a cable-stayed bridge due to corrosion.

It needs to be careful because rubber and the like used to alleviate broken cable corners may not be designed and constructed with the expectation of active waterproofing. It needs to be careful because water may infiltrate into the anchoring part and corrode the cable.



**Example**

A case where the filling material in the anchoring tool protection cover is insufficiently filled, and the steel material of the anchoring part is partially corroded.

There is also a concern that water will infiltrate through the diagonal material and corrode. In the inspection, it is also effective to check whether there are voids in the protective cover by hammering test or the like.

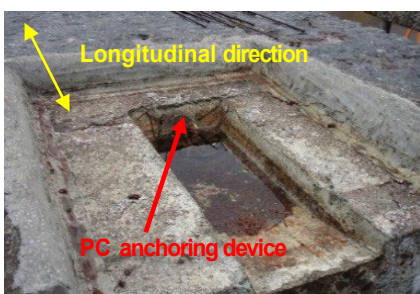
**Remarks**



**Example**

A case where corrosion occurred in the anchoring part of a cable.

It needs to be careful because there is a possibility that corrosion factors may have infiltrated from the anchoring part to the inside. It should also be paid attention to deterioration of the drainage function of other members, such as water infiltration from the telescopic device.



**Example**

If the anchoring part is embedded in the concrete, the construction joint becomes water infiltration route, and there is a possibility that water will collect in the anchor part where there is no drainage. It needs to be careful because the accumulated water is assumed to be a factor in the corrosion of the PC steel material (the photograph shows the anchoring part of the upper edge of the removal girder).



**Example**

A case where free lime is generated in the anchoring part. In order to determine whether corrosion preventive of PC steel material is properly performed, it is important to check the state of the protective cover and protected concrete, as well as to confirm the water infiltration route.

**Example**

**Remarks**

■ It is difficult to accurately judge abnormalities such as corrosion and fracture of the tensile material in the anchoring part only by appearance, and it is necessary to comprehensively judge various information obtained from the exterior such as the leakage of rust juice from the inside and the status of water infiltration from the anchoring part, and to estimate the internal state that can not be seen.

- If a fracture in the pendulum support or a fracture of the anchoring part occurs, the bridge will rise at the end fulcrum, and it will be remarkably difficult to restore the function of the bridge.



Fracture

**Example**

An example of a fracture of the anchor bolt on a pendulum bearing.

From the photographs, it can be seen that the fracture part had a structure that made it easy to accumulate water.



Lifting out of the girder

**Example**

An example of slipping off of an anchor bolt to prevent lifting out and fracturing it, causing the support function against negative reaction forces to be lost, and the girder was lifted up. We will also check whether there are any disfigurements that can be a sign of slip off, such as cracks in the concrete of the anchoring part.



**Example**

An example of corrosion on the pendulum bearings. It is necessary to check not only for corrosion, but also for the presence of cracks.

In addition, there are many cases where there is a joining member such as a pin, and it tends to be a weak point both as a stress state and a corrosion environment, so it is necessary to check the state of the joint.

**Remarks**

- The saddle is a member that secures slip resistance by pushing of cable tension and maintains the cable position.
- If the cable slips off, loosens, or slips in the saddle, the cable length between the spans will change, which will disrupt the balance of the cable structure and affect the safety of the whole bridge .

- Typical examples of saddles are as follows:

- Example of a tower saddle



In a small suspension bridge, the pushing force of the main cable itself is insufficient to obtain the necessary frictional force, so there are cases where the pushing force is reinforced by tightening it from above with a plate.

- Example of a spray saddle

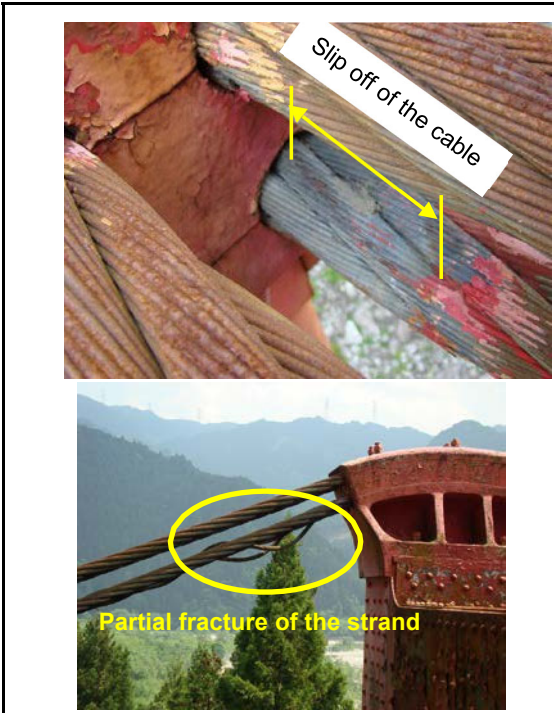


- There are other saddles of various shapes.

remarks

- The inside of the saddle is often not directly visible, and it is necessary to carefully check whether corrosion has occurred in the main cable inside or near the saddle.

□



**Example**

A case where a cable slips off in the tower top saddle due to a partial rupture of the bare wire of the main cable.

If the cable slips in the saddle, the length of the cable between the spans will change, so it is necessary to pay attention because there is a risk of a fatal effect on the entire bridge, such as imbalance of the cable structure.

In suspension bridges, since the fracture of the member, and the abnormality of the anchoring part tend to affect the overall shape, abnormal signs may be detected from linear or the like.



**Example**

An example of a bolt that secures the tower saddle falling off.

It is necessary to pay attention to loosening of bolts, abnormalities of plates, and whether there are any slip-out marks.



**Example**

Corrosion can be seen in the tower saddle.

**Remarks**

• The cable band of the suspension bridge is a connection member for attaching the suspension material to the main cable. Generally, it is fixed by friction due to the tightening force of the band bolt, and if the friction force decreases, such as when the axial force of the band bolt decreases, slippage may occur between the band and the main cable.

\* If the cable band slips, the balance of the cable structure may be lost, which may affect the safety of the entire bridge.

• Typical examples of the cable bands of the suspension bridge are as follows:



• There are other cable bands of various shapes.

• Factors that cause the axial force of band bolts to decrease include bolt relaxation, creep of the wire of cable, and reducing of voids associated with cable rearrangement, and may also decrease when the tension increases due to changes in load conditions after cable band tightening. Especially in large-scale bridges, the thicker the cable diameter, the greater the risk, and it may be necessary to increase tightening, so it is necessary to perform appropriate management.

• The safety factor against slippage of the cable band is often considered to be 3 ~ 4 or more in the design, but in reality there are various uncertainties such as variation in construction and changes in the voidage of the cable to be bundled, so it is necessary to confirm that there is always no misalignment of the band during service and to be careful whether there are signs of a decrease in the tightening force.

#### Remarks

■ There are various shapes of cable bands, and the properties differ depending on the shape. When inspecting, it is necessary to accurately judge abnormalities related to soundness and their signs after grasping the characteristics.

**Example**

A case where the bolt of the cable band of a suspension bridge has been corroded.

It is necessary to check whether corrosion (including heterogeneous metal catalytic corrosion) has occurred in the cable band, and whether looseness or slippage has occurred.

**Example**

This is an example of clips being used for the cable side fixing part of a hanging material. If the clip is not properly set, the efficiency will be significantly reduced, so care must be taken in how to stop it.

**Example**

This is a case where corrosion has occurred in the cable side fixing part of the hanging material.

**Example**

This is a case where corrosion has occurred in the cable side fixing part of the hanging material.

**Remarks**

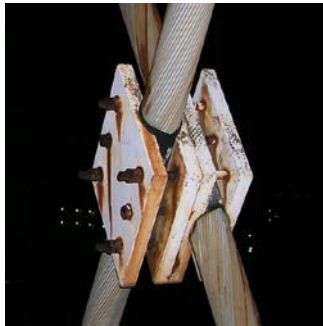
■ When a different metal such as stainless steel is used for fasteners, etc., there is a risk that significant corrosion due to heterogeneous metal contact will occur on the steel material. In this case, care must be taken because corrosion may occur simultaneously and frequently to other members of the same structure.



Example

An example of connecting hanging materials with wire clips.

If slippage occurs due to corrosion of the wire clip, the hanging material may fracture, so it is necessary to check whether the bolt is loose or corroded.



Example

A case where corrosion has occurred in the bolt of the hanging material fixture of the arch bridge.

If the anchoring bracket loosens, excessive vibration will occur in the cable, which may cause fatigue damage, and the cables may come into contact with each other and be damaged, so it is necessary to care it.

Example

Example

Remarks

- There are various types of fixing methods in the fixing part of cables and hanging materials.

- If the cable slips out or loosens in the fixing part, the balance of the cable structure may be lost, and the safety of the entire bridge may be affected.

\* Due to the fracture of the cable in the fixing part, the influence of the supported load and impact affects other members and cables, which may affect the safety of the entire bridge, such as imbalance of the cable structure or damage to other members and cables.

- Typical examples of fixing/ anchoring methods for cables and hanging materials include the following.

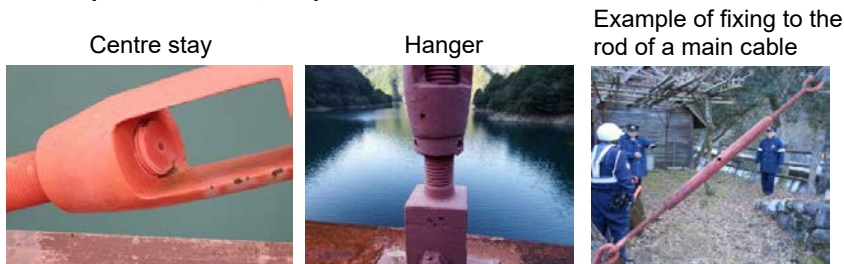
**Examples of socket**



**Examples of pin**



**Examples of screws, couplers and turnbuckles**



**Other examples**



- There are various other fixation methods.

**Remarks**

■ Since the corrosion environment, corrosion prevention specifications, and stress distribution differ depending on the anchoring/ fixing method, it is necessary to pay attention to the fact that the weak points of corrosion prevention and fatigue are also different for each anchoring/ fixing method.



Example

A case where corrosion has occurred in the girder side anchoring part of the hanging material

If the fixing part that is expected to be movable causes a decrease in the movable function due to corrosion or the like, local stress not assumed in the design may occur, and it is necessary to pay attention to the occurrence of fatigue cracks in the cable wire at the thread part of the rod or the mouth of the socket fixing part.



Example

A case where the hanger material fixing part is connected by welding.

Since the girder side fixing part of the hanger material is prone to repeated stress due to vehicle load, wind load, etc., it is necessary to pay particular attention to fatigue cracks in the welded part.



Example

This is a case where corrosion has occurred in the bolt of the girder side fixing part of the hanger material.

Example

Remarks

- The anchorage is a member in which the main cable is anchored, and is a member that bears all of the tension of the main cable.

- In the anchorage of a large suspension bridge, most of the anchor frame is embedded in the concrete, and the main cable is anchored by dividing it into the anchor frame for each unit. However, small-scale suspension bridges have no spray rooms or saddles, and some structures are directly integrated into the ground.

- Examples of typical anchoring structures in suspension bridge anchorage are as follows.

**Example of the main cable anchoring part divided into multiple parts**

Directly embedded into the ground



Anchoring with wire clip



Directly embedded into the concrete



Anchoring to the anchor frame



Connecting by turnbuckle



Anchor frame

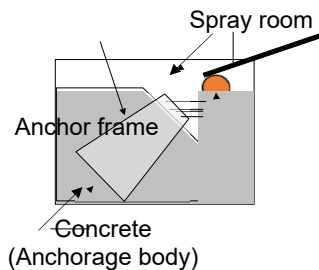


**Example of one main cable anchoring part**

Distributed and fixed to the anchor frame



Even if the anchoring parts has been housed in the spray room, it may corrode due to dew



- There are various other kinds of anchorage

**Remarks**

- Anchorage has a saddle, anchor frame, spray room, etc., the configuration varies from bridge to bridge.
- When inspecting, it is necessary to confirm the presence or absence of abnormalities and signs of the anchoring part as a whole including the inside of the embedded part.



## Example

A case where a cable is anchored to the ground.

Even if multiple cables are arranged, it is necessary to care when in a similar corrosive environment, as corrosion may proceed simultaneously.



## Example

A case where it is fixed with a wire clip.

If one wire clip loosens due to corrosion, there is a concern that it will slip in a chain reaction and lose the support capacity of the load. In addition, it is necessary to care because it is in a similar corrosive environment and corrosion may proceed simultaneously.



## Example

Turnbuckle breaking case.

When a different metal such as stainless steel is used for fasteners and the like, significant corrosion due to heterogeneous metal contact may occur in the steel material. In this case, it is necessary to care because corrosion may occur simultaneously and frequently to other members of the same structure. In addition, it is necessary to check whether there is any water infiltration or stagnation inside the turnbuckle.

## Remarks



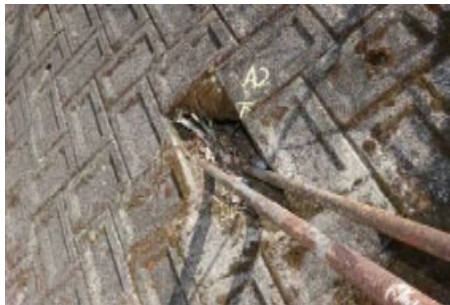
## Example

A case where a broken wire can be seen at the anchor part of the main cable.



## Example

A case where a broken bare wire can be seen in the anchoring part of the main cable.



## Example

A case where sediment accumulation can be seen in the anchoring part of the wind-resistant cable.

## Example

Remarks

• In the case of a stressed ribbon bridge or the like, if the abutment is a structure that constantly resists tensile force, if the rebar breaks due to corrosion and loses its integrity as a structure, the safety of the entire bridge may be affected.



**Example**

The abutment of a fallen stressed ribbon bridge (Mizutori Bridge).

As a result of water infiltration in from the construction joint and corroding the reinforcing bar fracture, the abutment has rotated greatly on the branch side.



**Example**

An example of an abutment moving.

If water infiltrates from the water infiltration route and the reinforcing bar corrodes, it is considered that it will lose its integrity as a structure.



**Example**

A case where water leakage has occurred at the construction joint of the abutment.

In the case of an abutment in which the cable anchoring part is embedded and always resists the tensile force, the integrity as a member is lost due to corrosion and fracture of the reinforcing bar, and the safety of the entire bridge may be lost.






**Example**

A case of water leakage in the filling part after construction of the abutment.

The openings provided during the construction of concrete members are often filled with concrete or non-shrinkable mortar, but it is necessary to pay attention because the construction joints has become water infiltration route and the internal reinforcing bar has corroded.

**Remarks**

• Due to the breakage of the ground anchor, the influence of the supported load and impact affects other ground anchors, leading to damage to other ground anchors, etc., and the stability of the abutment is lost, which may affect the safety of the whole bridge.

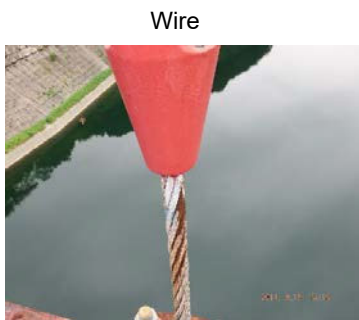
	<p><b>Example</b></p> <p>A case where a filling material has leaked from the protective cover of a ground anchor.</p> <p>If the filling material such as rust oil in the protective cover leaks, it is necessary to pay attention because corrosion of the steel material of the anchoring part may proceed.</p>
	<p><b>Example</b></p> <p>A case where a lift has occurred in the head of the ground anchor.</p> <p>If the head concrete of the ground anchor is raised or misaligned, it is necessary to be careful because it may be possible that damage to the PC steel material or deformation of the ground has occurred.</p>
	<p><b>Example</b></p> <p>A case where precipitate is generated from the anchoring part of the ground anchor.</p> <p>If water leakage or precipitate has occurred in the anchoring part of the ground anchor, it is necessary to pay attention because the PC steel material may be corroded inside the anchoring part or in the soil.</p>
<p><b>Remarks</b></p>	<p><b>Example</b></p>

• The hanger material is a member for suspending girders, and is a member that transmits loads such as dead loads of stiffening girders and live loads acting on stiffening girders to the main cable in suspension bridges and arch ribs in arch bridges.

• Due to the fracture of the hanger material, the influence of the support load and impact affects other hanger materials, which may affect the safety of the whole bridge, such as the imbalance of the cable structure and damage to other members and hanger materials.

• Typical examples of hanger materials are as follows.

**Example of wire type**



Example in which a vibration control rope is placed on the coated hanger



• Examples of steel rods



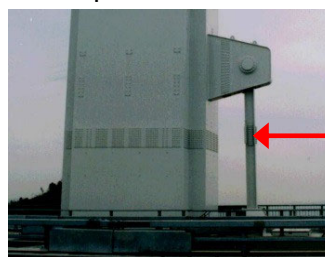
Turnbuckle

- Example of PC steel bar,



Protected by stainless steel tube

Example of tower link



Link body

It is a mechanism that hangs girders directly from the tower at the tower position, and "double-pin" members using large steel plates are common.

• There are various other kinds of hangers.

**Remarks**

■ Various types of hanger materials are used, and the mechanical properties, safety factor, corrosion preventive specifications, etc. differ for each type. In the inspection, it is necessary to accurately judge the type of suspension material, grasp its characteristics and structure, and accurately judge the abnormalities and signs related to soundness.

- Stay materials and storm cables are members for suppressing wind vibrations of suspension bridges.
- Loosening or breaking of the stay material or storm cables installed to suppress vibration may lead to a decrease in aerodynamic stability and a decrease in fatigue durability of each part.

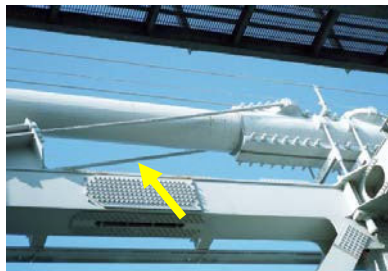
- Typical examples of stay materials and storm cables are as follows.

### Example of stay materials (A member that connects the main cable and the girder diagonally)

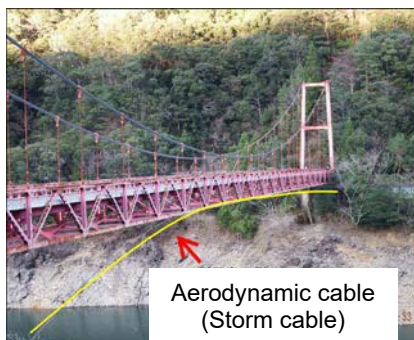
Steel rod



Wire (galvanizing + painting)



Example of wind resistant cable (a member that suppresses the movement of the girder by pulling girder diagonally downward and collaborating with the hanger that pulls it upward)



- There are various other kinds of stay materials and storm cables.

### Remarks

- Since damage (breakage, loosening) of the stay material and the storm cable may lead to a decrease in fatigue durability of each part of the bridge, it is necessary to confirm whether there is a decrease in ability due to breakage, corrosion, etc., a decrease in ability due to relaxation, etc.



Example

An example of Corrosion of the surface of the hanger of the cable type, which is also suspected of internal corrosion.

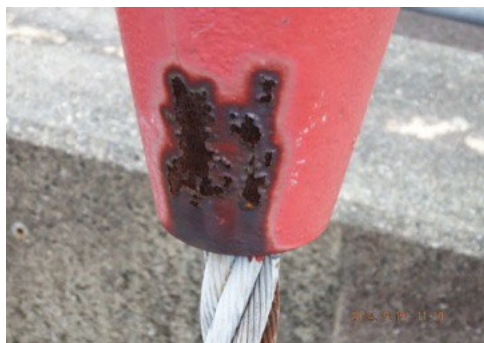
Hangers often become a severe corrosive environment due to vibration and rainwater flowing down and stagnating, and it is necessary to pay attention not only to checking the corrosion status of the surface but also to the occurrence of internal corrosion.



Example

A case where corrosion has occurred inside the cable of a hanger of a suspension bridge.

It must be paid attention not only to checking the corrosion status of the surface in the hanger wires but also to the occurrence of internal corrosion.



Example

An example of corrosion occurring in the socket of a hanger on a suspension bridge.

It is necessary to pay attention because the deterioration of the corrosion preventive function may cause rainwater to infiltrate into the inside of the socket or hanger and corrosion may progress.

Remarks



Example

An example of a crack in the threaded part of a steel rod on a hanger of a suspension bridge.

The threaded part of the steel rod whose paint has been damaged by tightening is likely to be a weak point of corrosion protection. When corrosion occurs due to the deterioration of the corrosion prevention function of the threaded part, it is necessary to pay attention because it may become a weak point that causes cracks in the threaded part where high stress such as the mouth area and the rod occurs.

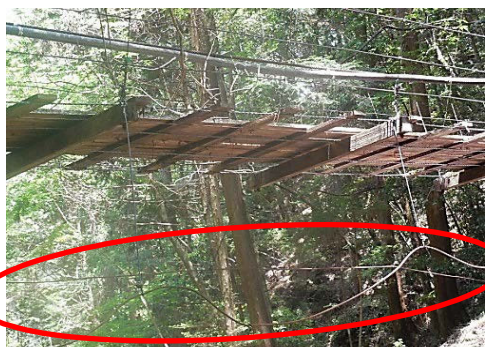
When the coating deteriorates and the coating film cracks occur, it becomes difficult to easily detect damage such as cracks.



Example

A case where a steel rod on a hanger of a suspension bridge has been broken.

The threaded part of the rod is prone to cracking due to stress concentration. Cracks are more likely to occur when there is vibration or stress fluctuations due to wind or live load. It is necessary to pay attention because cracks are likely to occur further if corrosion prevention function is deteriorated or corrosion occurs.



Example

A case where a fracture occurred in the storm cable of a suspension bridge.

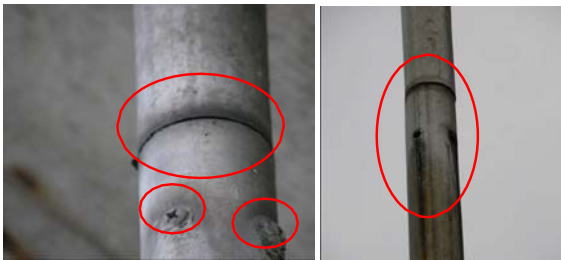
Loosening or breaking of storm cables installed as vibration damping measures may lead to a decrease in aerodynamic stability and fatigue durability of each part of the bridge, so it is necessary to pay attention.

Remarks



Cross-sectional defect due to corrosion

Status of stagnant water in the protective pipe



Deformation that suggests internal corrosion

Leakage status from protective pipe

Example

A case where a cross-sectional defect due to corrosion occurs in the hanger material of an arch bridge.

When there is a gap between the protective pipe and the steel material due to construction defects, deterioration, etc., and the waterproofing treatment at the seam of the protective pipe is insufficient, or when a material that is prone to deterioration is used, corrosion occurs in the internal steel material due to water infiltrate. In particular, in the lower part, rainwater or the like that has seeped into the inside of the protective pipe flows down and accumulates, and significant corrosion may occur in the steel material.

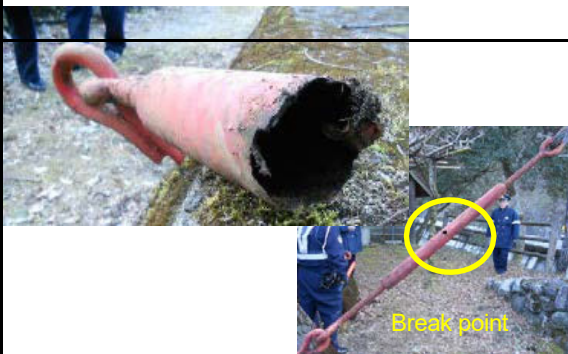
When it is not possible to directly check the inside of the protective pipe, it is necessary to guess the internal situation from surrounding situation, such as damage to the protective pipe or leakage from the protective pipe.



Example

This is a case of water leakage or cracking in the concrete recessed part of the hanger material of an arch bridge.

The embedded part is prone to disfigurements such as gaps and cracks, which may cause internal steel damage. It is also necessary to estimate the damage inside the embedded part that cannot be visually seen from the water leakage situation and the like.



Break point

Example

Turnbuckle breaking case (reposting).

It is necessary to check whether there is any water ingress or stagnation inside the turnbuckle.

Remarks

■When a different metal such as stainless steel is used for a protective pipe or fastener, there is a risk that significant corrosion due to touch with different metals may occur in the steel material. In this case, it is necessary to pay attention because corrosion may occur simultaneously and frequently to other members of the same structure.





**Example**

A case where cracks occurred due to the prestress force in the anchoring part of the outer cable reinforcement method.

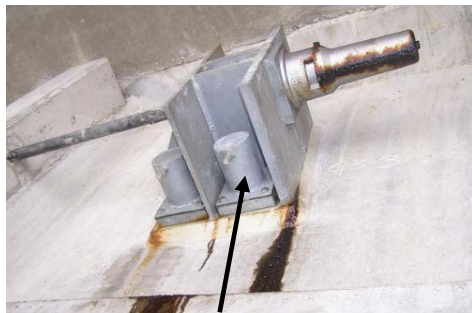
In addition to cracks, corrosion, etc. of the anchoring part itself, it is also important to check whether there is a rifting or deformation from the existing member.



**Example**

A case where corrosion can be seen in the steel anchoring part of the outer cable reinforcement method.

It is necessary to pay attention because there is a possibility that corrosion factors may have infiltrated from the anchoring part to the inside. It is necessary to pay attention to whether the structure does not allow water to infiltrate or whether the structure is easy to accumulate.



Steel bar for tightening

**Example**

In this case, a filler leaks from the protective cover of the anchoring tool of the outer cable reinforcement method.

If the filling material such as rust oil in the protective cover leaks, it is necessary to pay attention because corrosion of the steel material of the anchoring part may proceed.



**Example**

A case where the deflection part of the outer cable is cracked.

If the deflection part is damaged, it is necessary to pay attention because it is possible that a corner break may occur in the outer cable or a predetermined prestress may not be added.

**Remarks**

In the external cable reinforcement method, complex stresses are generated due to prestress even on existing members provided with anchoring parts and deflection portions, so it is necessary to confirm that the soundness of both the newly constructed part and the existing part is maintained.

• In the duluk band bridge type, due to the fracture of the vertical PC steel material, the influence of the supported load and impact affects the other PC steel materials, leading to damage to other PC steel materials. If the load support function is lost, the bridge may lift up at the end fulcrum, which may affect the stability of the whole bridge.



\* The photograph shows an abnormal deflection of a bridge with a central hinge.

**Example**

A case where abnormal deflection occurred near the center of the span.

If abnormal deflection occurs in the superstructure, it is possible that the PC steel material is damaged, so a careful evaluation such as considering the implementation of detailed grasping of the condition is necessary.



Check for lifting

**Example**

Situation at the end fulcrum of the duluk band bridge type.

If a lifting occurs at the end fulcrum, it is possible that the PC steel material is damaged, so a careful evaluation such as considering the implementation of grasping the detailed state is required.



**Example**

An example of corrosion of the exposed part of vertical PC steel material at the base of the duluk band bridge.

PC steel is often protected against corrosion by coating rubber or resin. If the PC steel material can be seen directly, check whether corrosion has occurred. It is also effective to confirm the reduction in cross section with calipers and the like.

When it is not possible to directly see due to coating or the like, it is necessary to check for water infiltration by paying attention to whether the structure is such that water tends to accumulate and whether damage has occurred to the coating.

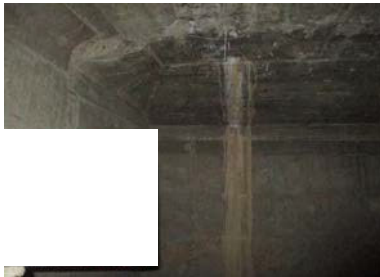
**Remarks**

- It is also effective to visually inspect narrow areas such as around the bearings using a hand mirror or the like.



Example

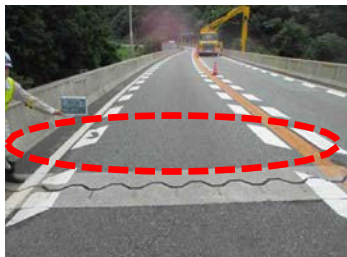
An example of the horizontal PC steel material of the duluk band bridge being fixed in the girders.  
Even in the girders, it is necessary to pay attention because water may infiltrate from the cracks.



Example

A case where a perforated crack occurs in the deck slab and water leaks into the girders.  
Since water may infiltrate into the girder of the concrete girder, it is necessary to pay attention against corrosion even if the PC steel material is fixed in the girder.

\* The photograph shows the state inside the box girder of the duluk band bridge.



Example

When the anchoring portion of the PC steel material of the duluk band bridge is set on the upper edge of the girders, the anchoring part cannot be directly seen, so it is necessary to check the state of the pavement and whether there is any water infiltrate from the bridge surface.

\* The photo shows the state of the pavement near the anchoring part of the duluk band bridge. No anomalies are observed.

Example

Remarks

# Appendix-5 Inspection for Large-scale Bridge with Hanging Members and Tension Members

[Note: Source of all materials is published by MLIT, Japan (Ministry of Land, Infrastructure, Transport and Tourism, Japan)]

## Table of Contents)

1. Definition of Large-scaled Bridge	-1
2. Inspection Stance	-9
3. Target Members	-10
4. Other Necessary Items	-11
5. Example of Damage	-11

# 1. Definition of Large-scaled Bridge with Hanging Members and Tension Members

Bridges with hanging members and tension members are clearly different from ordinary girder bridges in the behaviour of entire bridge due to loads during vehicle traffics and storms. Bridges of these types include suspension bridges, cable-stayed bridges, extradosed bridges and arch bridges, etc..

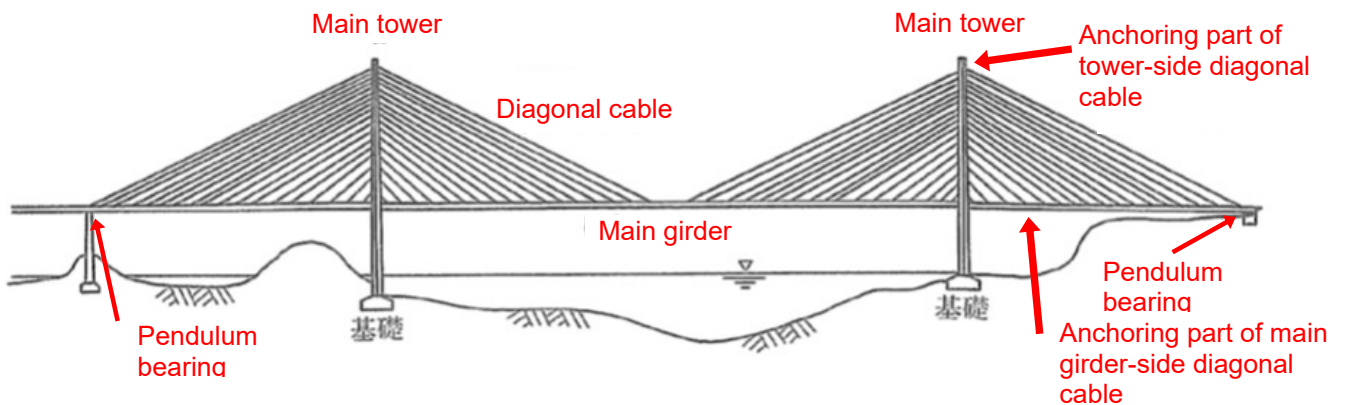
In this chapter, these types of bridges with hanging members and tension members are defined as large-scale bridges when conducting inspections and diagnoses.

## 【Notes】 Suspension Bridge

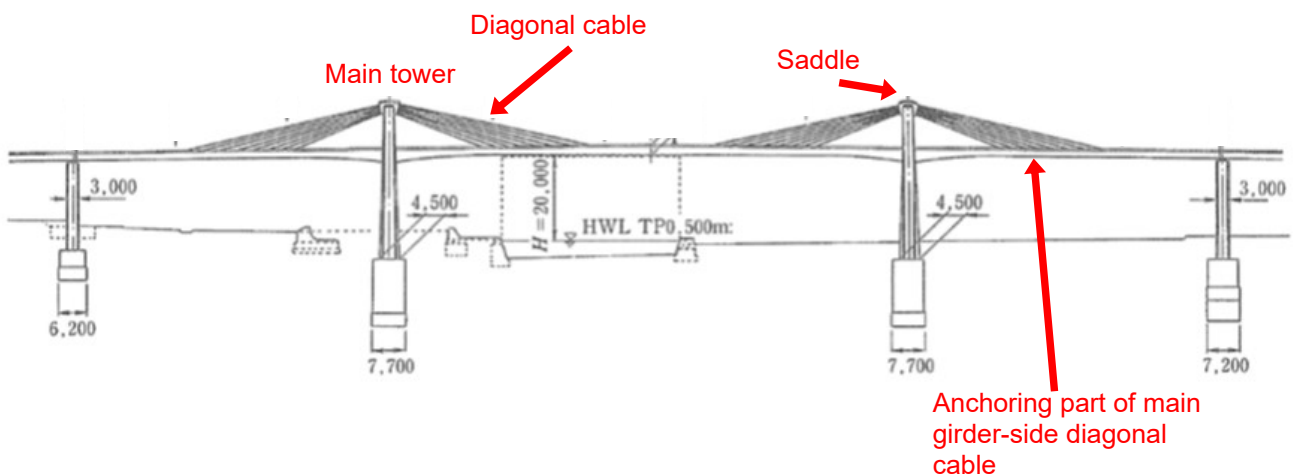
Extradosed bridges have also been used on the national highways in Laos, and it is expected that the number of large-scale bridges with hanging members and tension members, etc. will increase in the future, so this appendix also deals with them.

### 1-1. Cable-stayed Bridge, Extradosed Bridge

#### Cable-stayed Bridge

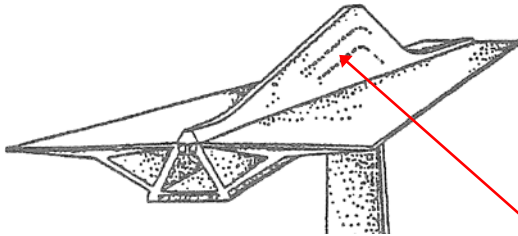


#### Extradosed Bridge

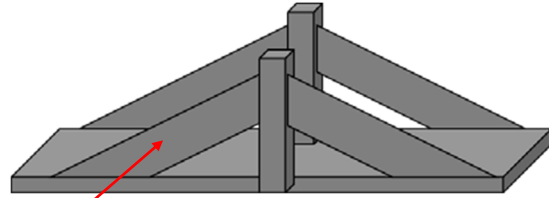


## Other structure types

Finback types



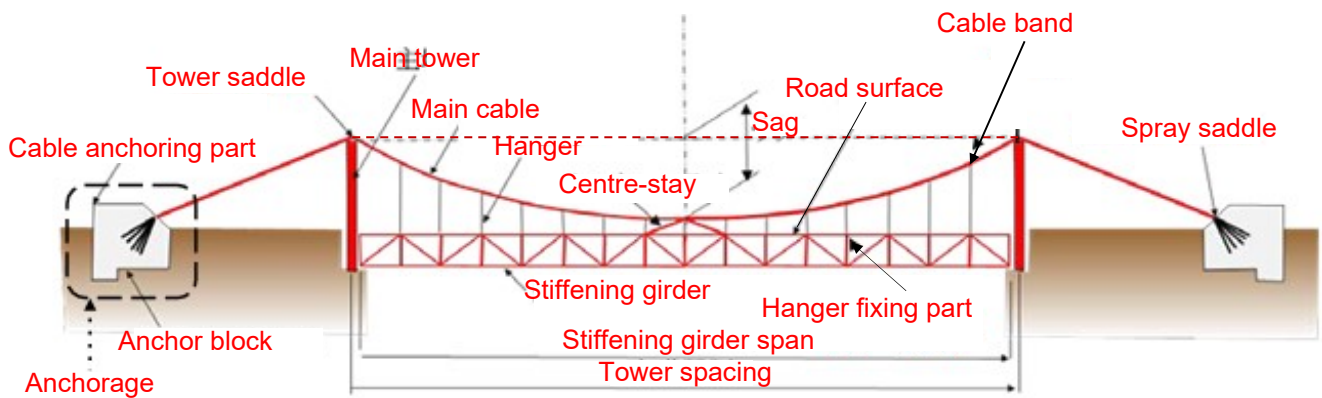
Triangular concrete wall types



Diagonal cable covered by concrete for protecting a cable corrosion

- 1) Tension member : Diagonal cable  
Pendulum bearing
- 2) Anchoring part of tension member : Anchoring part of main girder-side diagonal cable  
Anchoring part of tower-side diagonal cable  
Anchoring part of pendulum bearing
- 3) Members that affect the behaviour of 1 and 2 above : Saddle

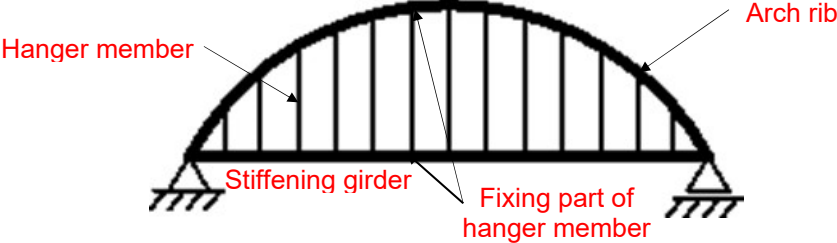
## 1-2. Suspension Bridge



- 1) Tension member : Main cable  
Hanger
- 2) Anchoring part of a tension member : Anchorage (Anchoring part of the main cable)  
Hanger fixing part (Fixing part of hanger (Main girder-side))  
Cable band (Fixing part of hanger (Main cable side))
- 3) Members that affect the behaviour of 1 and 2 above : Tower saddle, Splay saddle

### 1-3. Arch Bridge

Arch bridge (Lohse type)



- 1) Tension member : Hanger member
- 2) Fixing part of tension member : Fixing part of hanger member

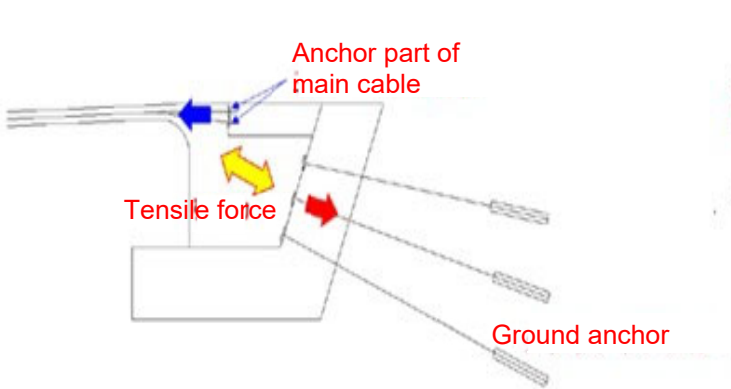
### 1-4. Stressed Ribbon Bridge



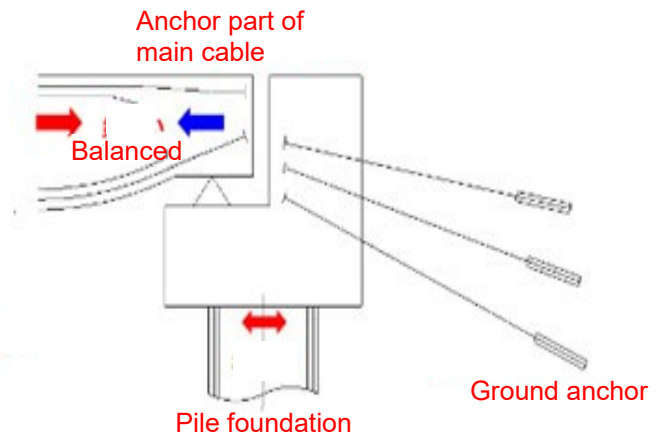
Straight road-type stressed ribbon bridge



Deck type stressed ribbon bridge

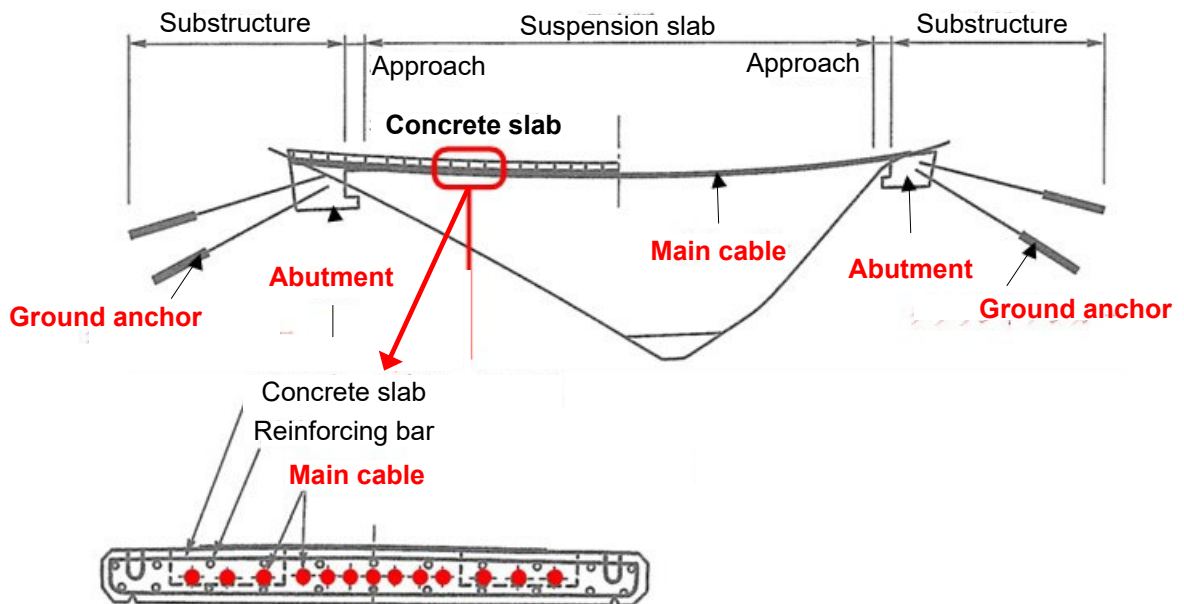


Anchoring structure of other-anchor type



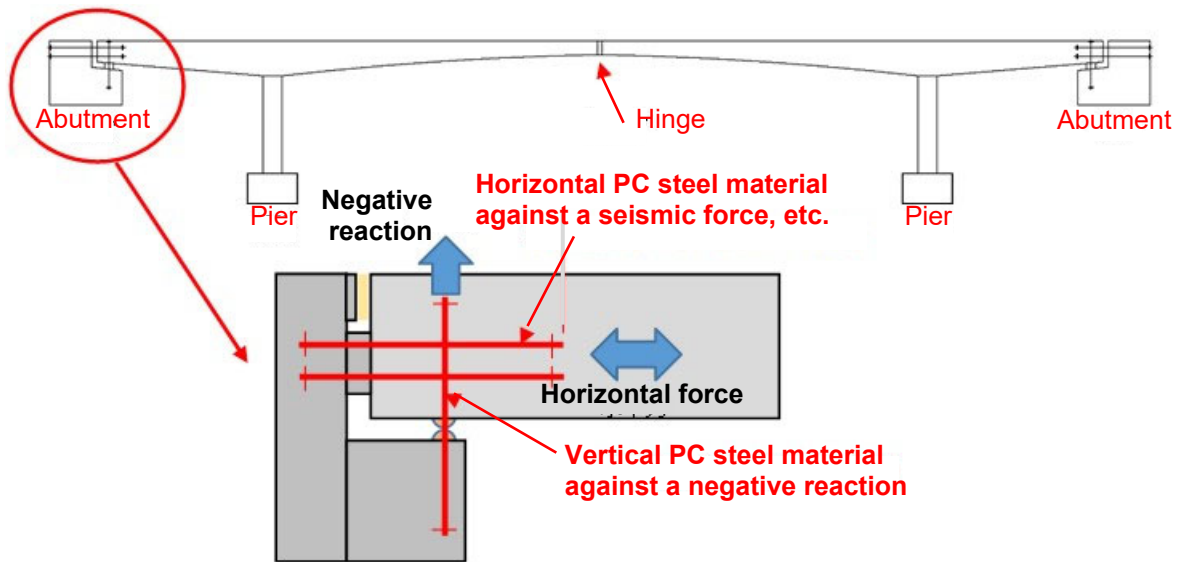
Anchoring structure of self-anchor type

#### Example of straight-road type stressed ribbon bridge (Anchoring-structure of other-anchor type)



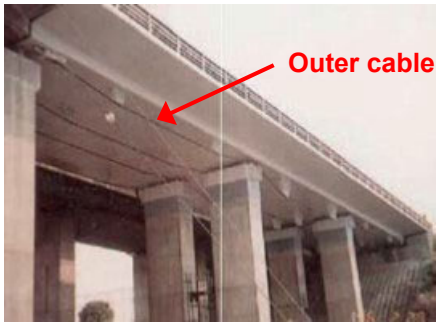
- 1) Tension member : Main cable  
Ground anchor
- 2) Anchoring part of tension member : Anchoring part of a main cable  
Anchoring part of a ground anchor
- 3) Members that affect the behaviour of 1 and 2 above : Abutment

## 1-5. Duluk Band Bridge



- 1) Tension member : Vertical PC steel material  
Horizontal PC steel material
- 2) Anchoring part of tension member : Anchoring part of a vertical PC steel material  
Anchoring part of a horizontal PC steel material
- 3) Members that affect the behaviour of 1 and 2 above : Abutment

## 1-6. Bridge Structure reinforced with outer cables



**Example of a bridge structure reinforced with outer cables**



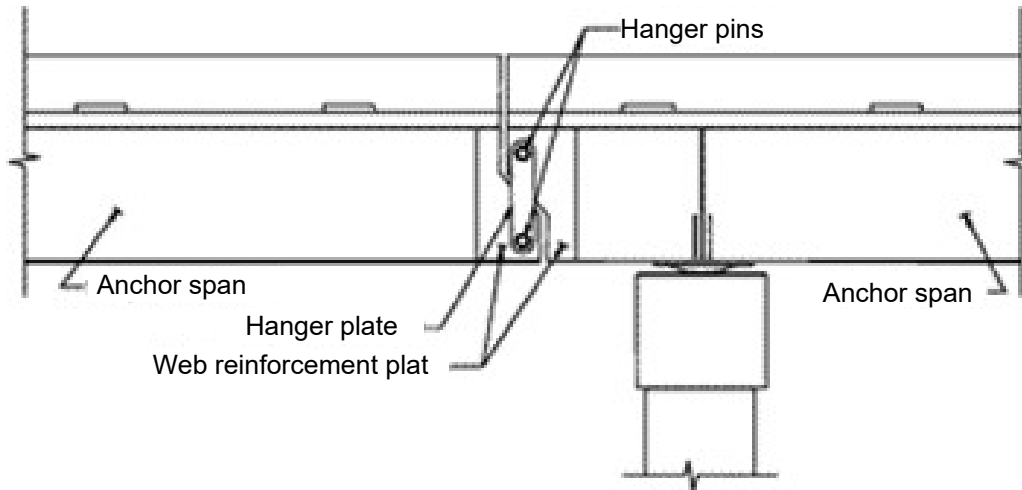
**Example of a steel bridge reinforced with outer cables**

- 1) Tension member : Outer cable
- 2) Anchoring part of tension member : Anchoring part of an outer cable
- 3) Members that affect the behaviour of 1 and 2 above : Deflection part

## 1-7. Other

As an example, a case where suspension materials (pins and hangers) are used to connect girders in the middle of spans.

In addition to these, periodic inspections of tension members should be conducted in consideration of the impact on the bridge if they fracture.



**Example of a structure with pins and hangers**

## 2. Inspection Stance

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It is important to conduct inspections of large-scale bridges after knowing the members and parts to be inspected, even if there are no advanced inspection techniques.

### 【Notes】

It is desirable to patrol the bridge surface on foot, conduct regular visual inspections on a daily basis, and conduct periodic inspections closer to members and parts that are difficult to inspect on foot. It is important to grasp the signs of damages by periodic inspections for details that are not able to be grasped by visual inspection alone, and to inspect high places using a drone or to prevent damage to a third party. Furthermore, periodic inspections are treated as Inspection B.

It is also important to promptly confirm safety of the road in the event of a natural disaster such as torrential rain or typhoon, etc. and to confirm the necessity of traffic regulation and whether detailed inspections are necessary by inspection for extraordinary conditions.

### 3. Target Members

Target members are main cables [stay cables], hanger materials and tension materials, and their jigs and fixing tools are also targeted.

Inspections of the members that constitute other bridges shall be in accordance with the inspection methods described in the previous chapters.

#### 【Notes】

In some road bridges, there is a concern that the breakage of the tension member may lead to a fatal situation of the whole bridge and also the behaviour of the whole bridge may be significantly affected. For example, a bridge using the following members may be classified into this category.

- 1) Tension member: Cables, hanger ropes, underground anchor
- 2) Fixing jigs of the above 1) [fixing tools for fixing the tension members and reinforced parts [for example, cable anchor parts, etc.] for arranging the fixing tool]
- 3) Members that affect to behaviour of the above 1) and 2)

The members covered by each inspection are shown in Table 3.1.

Table 3.1 The target members for each inspection

Type of Bridge	Member/Part	Routine	Periodic inspection		extraordinary
			A	B	
Suspension Bridge	Main cable	○	◎	◎	◎
	Hanger rope	○	◎	◎	◎
	Tower saddle	—	○	◎	—
	Hanger clamps	△	○	◎	△
	Hanger fixed bracket, jigs, etc.	—	○	◎	△
	Main tower	○	◎	◎	○
Cable-stayed Bridge	Stay cable	○	◎	◎	◎
	Tower saddle	—	○	◎	—
	Cable fixed bracket, jigs, etc.	△	○	◎	△
	Tower	○	◎	◎	○
Extradosed Bridge	Outer cable	○	◎	◎	◎
	Tower saddle	—	○	◎	—
	Cable fixed bracket, jigs, etc.	△	○	◎	△
	Tower	○	◎	◎	○
Arch Bridge	Hanger member	○	◎	◎	◎
	Fixing part of hanger member	△	○	◎	△

◎: Mainly close visual inspection    ○: Mainly visual inspection from a distance  
 —: Not applicable    △: Take a photo if extraordinary condition may have developed

#### **4. Other Necessary Items**

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The maintenance system and work descriptions, the frequency and standard of inspections, safety measures at the time of inspections, and records of the status of damages shall be in accordance with the contents described in the main manual.

#### **5. Example of Damage**

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Damage examples such as cables, hangers, anchoring parts and fixing parts, etc., are presented in this clause

Based on the results of periodic inspections and the results of diagnosis, examples of damage to bridges and the members and points to note in especially periodic inspections are presented in the following pages.

In addition, since it is a limit to grasp deformation by the close visual inspection, it is necessary to consider actively applying non-destructive test technologies and drones and the like as necessary.

- The cable supports the dead load of the girder and the live load acting on the girder. In the case of a bridge with a suspended structure, the cable is a member that transmits the tension to the tower and anchorage.

- Due to the fracture of the cable, the influence of the supported load and impact affects other members and cables, which may affect the safety of the entire bridge, such as the balance of the cable structure being disrupted or damage to other members and cables.

- Typical examples of cables and their corrosion protection methods include:

- Example of stranded wire

Galvanizing  
(1 strand)



Rust preventive oil  
+ Polyethylene coat

Galvanizing  
(multiple strands)



Concrete coating

Galvanizing + Wrapping wire  
+ Painting



Example of a joint in  
the middle of a cable

Source: Porchevera viaduct  
<https://www.autostrade.it/it/autotrade-per-genova/vero-falso>

Example of a main cable  
anchored in the rod

- Example of locked coil    • Example of parallel wire cable

Galvanizing



Galvanizing + Wrapping wire  
+ coating

- In addition, there are various types such as steel core cables.

**Remarks**

■ Various types of cables are used generally, and each type has different mechanical properties, safety factors, corrosion protection specifications, etc. When inspecting, it is necessary to accurately judge the type of cable and its characteristics after grasping its structure, and accurately determine the abnormalities and signs related to soundness.



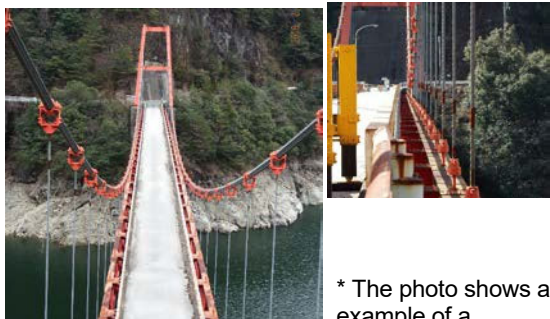
**Example**  
 A case where a diagonal cable coated with concrete broke and fell the bridge (Shimadabashi Bridge).  
 (Source: Construction Accident, Nikkei BP, Japan)



**Example**  
 A case where a cable-stayed bridge with a diagonal cable coated with concrete fell (Porchevera Viaduct).  
 (Source: <http://www.mit.gov.it/>)



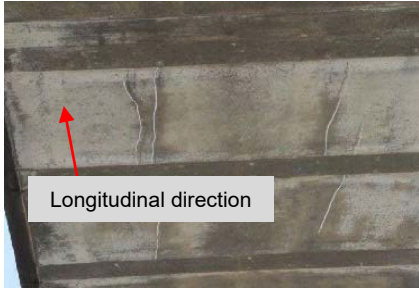



**Example**  
 A case where a stressed ribbon bridge with cables inside concrete fell (Trojan Footbridge).  
 (Source: <https://structurae.net/structures/Troja-Footbridge>)





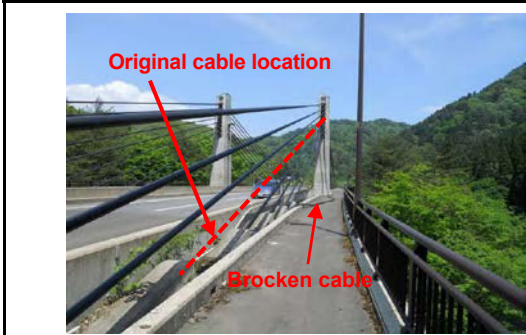
\* The photo shows an example of a suspension bridge.

**Example**  
 In a structure using a cable, since the fracture of the member and the abnormality of the anchoring part tend to affect the overall shape, abnormal signs may be detected from the longitudinal alignment or the like.  
 If abnormal deflection or the like is observed, not only the main cable but also other members may be the cause.

**Remarks**

 <p style="text-align: center;">* The photo shows a cracked case of the underside of a stressed ribbon bridge</p>	<p><b>Example</b></p> <p>A case of a cracked slab of a stressed ribbon bridge where the main cable is located inside the concrete.</p> <p>For internal cables, it needs to check if the concrete has been damaged or if there have been any alterations that might indicate water seeping into the main cable.</p>
 <p style="text-align: center;">* The photo shows an example of a crack on the lower surface of the PC girder</p>	<p><b>Example</b></p> <p>A case where a concrete coated with PC steel material has cracked along the PC steel material.</p>
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;"> <p style="border: 1px solid black; padding: 2px;">Before chipping</p>  </div> <div> <p style="border: 1px solid black; padding: 2px;">After chipping</p>  </div> </div> <p style="text-align: center;">* The photo shows an example of a crack on the lower surface of the PC girder</p>	<p><b>Example</b></p> <p>A case where a cable placed in concrete corroded or broke due to insufficient grout filling or water ingress.</p> <p>When the cables of cable-stayed bridges and extra-dosed bridges are covered with concrete, the deformation of the internal steel material may appear as concrete spalling, peeling, rust juice, and free lime, so it is better to check the state of the concrete by hammering test or the like.</p>
<p><b>Remarks</b></p> <ul style="list-style-type: none"> <li>■ If corrosion is suspected of the steel material inside the concrete, it may be possible to check the inside by chipping or non-destructive inspection.</li> </ul>	

 <p>* The photograph shows an example of damage to the lower surface of the PC girder</p>  <p>* The photograph shows an example of damage to the lower surface of the PC girder</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Example</div> <p>A case of regular damages to the concrete girder arranged PC steel material.</p> <p>Even if there is no cracking, damages such as discolouration, spalling, and peeling may be scattered due to corrosion of spacers, assembled rebars, shear reinforcement rebars or the like, and further internal steel material of the concrete may be suspected of being deformed. It is necessary to comprehensively judge the information obtained from the exterior and estimate the internal state.</p>
	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Example</div>
	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Example</div>
<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Remarks</div> <ul style="list-style-type: none"> <li>■ If corrosion is suspected of the steel material inside the concrete, it may be possible to check the inside by chipping or non-destructive test.</li> </ul>	



**Example**

A case where water penetrated into the vicinity of the anchoring part of the diagonal cable of the polyethylene-coated extra-dosed bridge, rotted and broke (Yukizawa Ohashi Bridge).



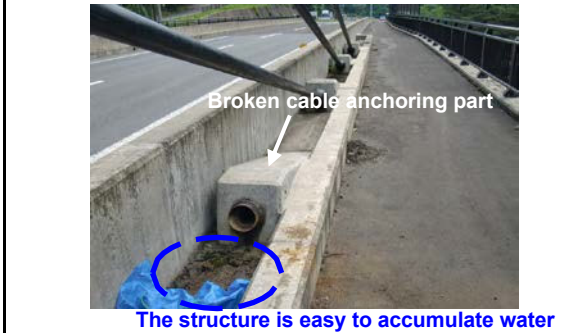
**Example**

Photograph of the break in the bridge above.  
It is necessary to be careful because signs do not necessarily appear on the outside that can be seen, and there are cases where significant damage occurs inside than assumed from external signs.



**Example**

A case of damage to the coating material of PC steel material of a Stressed ribbon bridge where the main cable is located outside the concrete. In the case of an external cable, a corrosion protection against corrosion is provided by a coating such as polyethylene. It needs to check for damage to the sheath of the cable or a displacement that may indicate water penetration into the main cable.



**Example**

An example of the PC anchoring part on the main girder side of the bridge above where the diagonal cable was broken. If the anchoring part has a structure that makes it easy for accumulating water, It needs to care because water may penetrate into the anchoring part and corrode the cable.

**Remarks**

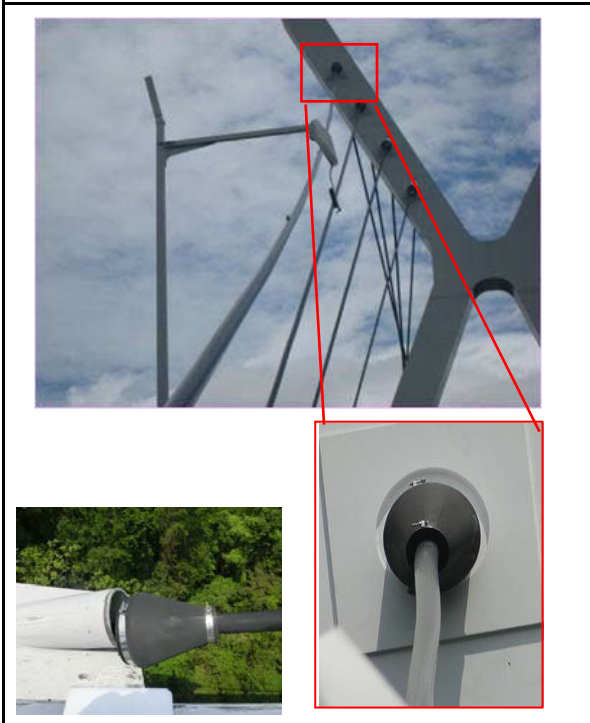
■ Since the cause of fracture is not only the effect of corrosion, but also the influence of fatigue due to live load and wind load, or the composite of the same, it is necessary to pay attention to whether damage has occurred to the peripheral members installed for wind resistance measures, etc., and to confirm the possibility of fatigue effect.



**Example**

An example of inspection near the main girder side anchoring part.

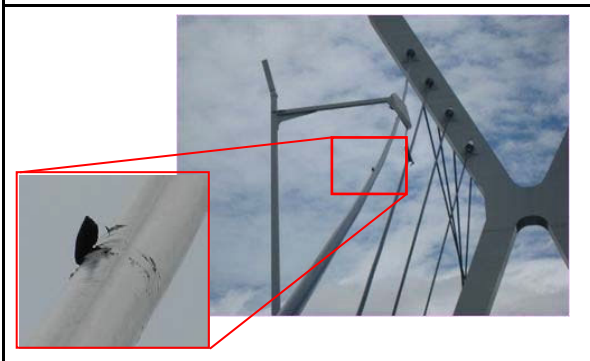
In some cases, after remove the protective cover of the cable, it may be effective to check for water infiltration, stagnation and internal corrosion conditions.



**Example**

An example of an abnormal deflection occurred on the diagonal cable of a cable-stayed bridge.

It needs to check whether abnormal deflection has occurred in the cable due to a violent wind or the like, or whether there has been an abnormality in the cable tension.



**Example**

An example of damage to the covering of a diagonal cable on a cable-stayed bridge.

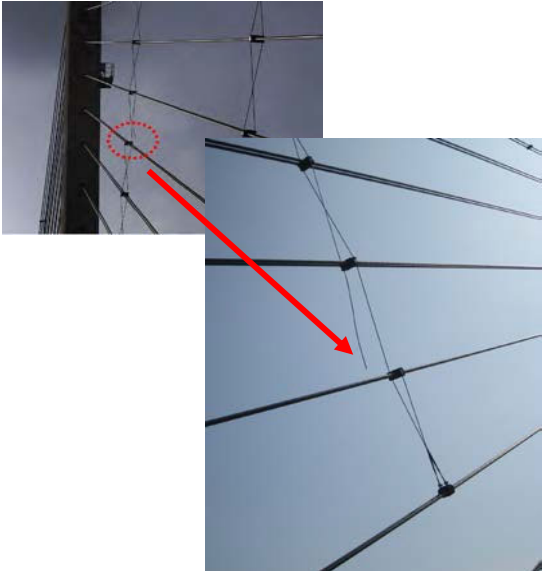
In the case of a cable, corrosion protection against corrosion is provided by a coating such as polyethylene. It needs to check for damage to the sheathing or a deformation that suspects water infiltration into the main cable.

**Remarks**

- It also needs to consider how to grasp the detailed state of the inside of the cable.



Example of damage to the protective cover of the saddle part



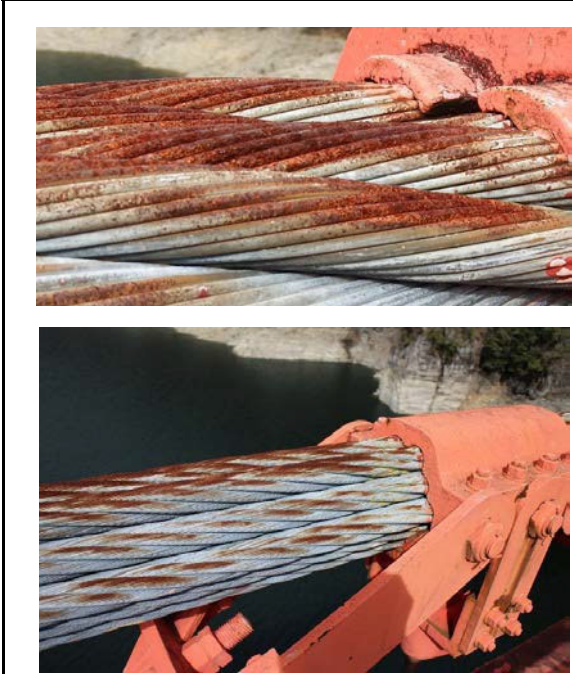
Example of damage to a damping wire.

Example

The damage factor of the cable is considered not only by the influence of corrosion, but also by the effect of fatigue due to the live load and wind load, or by its combined action. For this reason, it is much better to pay attention not only to the cable body but also to whether damage has occurred to the peripheral member or not.

Example

Remarks



**Example**

An example which galvanizing of the main cable of a suspension bridge is worn out.

It is difficult to accurately judge abnormalities such as corrosion inside the cable only by appearance, and it is necessary to estimate the internal state that cannot be seen by comprehensively judging various information obtained from the exterior, such as the corrosion situation of the surface, the leakage of rust juice from the inside, the deterioration of the rust prevention oil and the state of wear and tear.







**Example**

A case where local corrosion (pitting corrosion) is seen in the main cable.

**Example**

**Remarks**

	<p><b>Example</b></p> <p>A case where corrosion prevention function deterioration and corrosion can be seen in the entire main cable.</p>
	<p><b>Example</b></p> <p>A case of corrosion accompanied by a decrease in cross-section of the main cable (A hanger also has already rusted).</p>
	<p><b>Example</b></p> <p>A case where a fracture in the main cable can be seen.</p>
	<p><b>Example</b></p> <p>A case where corrosion of the main cable has progressed and a broken wire is seen in the elemental wire.</p>

**Remarks**

- When a different metal such as stainless steel is used for fasteners, etc., there is a risk that significant corrosion due to heterogeneous metal contact will occur on the steel material. In this case, care must be taken because corrosion may occur simultaneously and frequently to other parts of the same structure.



#### Example

An examples of damage to the wrapping wires of the main cable of the suspension bridge and the caulking of the cable band .

There are cases where a steel wire (wrapping wire) is wrapped around the surface of the bundled strand, and corrosion protection such as painting is applied from the top. Since the cables cannot be seen unless the wrapping wire is removed, it is necessary to check the soundness of the wrapping wire and check whether there are any signs indicating internal abnormalities on the wrapping wire surface.



#### Example

An example of corrosion in the cable band of a suspension bridge.

Even in the case of the main cable with wrapping wires, the cable band part has no wrapping wire, and the surface of the strand of the main cable is exposed. There is a gap between the inner surface of the cable band and the main cable surface, and the water stop at the end of the cable band is not sufficient and rainwater may reach the inside, so that the bare wire of the cable band part may corrode. Although it is difficult to directly check the inside of the cable band, if corrosion such as leakage of rust juice is suspected, it is necessary to carefully evaluate including temporarily releasing the band.

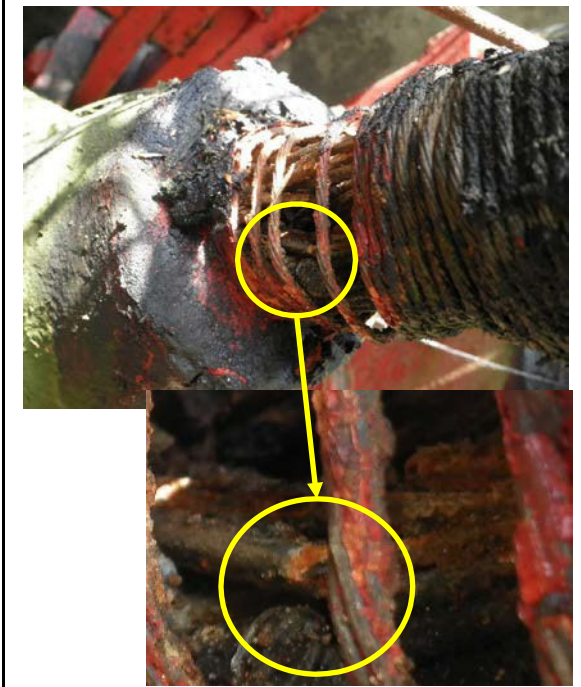
#### Remarks

- If abnormalities inside the cable are suspected, it is necessary to check whether there is a technology that can be applied with non-destructive inspection technology, and if necessary, it is necessary to consider removing part of the wrapping wire or driving a wedge into the wire to check the inside directly visually.



**Example**

A case where it is suspected that the rust inhibitor of the main cable of the suspension bridge has been deteriorated and the corrosion preventive function has been lost.



**Example**

An example of breaking of the wire inside a wrapping wire.  
 Since the surface of the cable is strictly protected from corrosion, it is often difficult to find abnormalities such as internal corrosion from the exterior. If an abnormality inside is suspected, it may be necessary to remove the corrosion preventive (rust preventive material, protective wire, etc.) and check the inside.



**Example**

A case where a rupture occurs in the wire of the main cable near the end of the cable band of a suspension bridge.

**Remarks**

- If abnormalities inside the cable are suspected, it is necessary to check whether there is a technology that can be applied with non-destructive inspection technology, and if necessary, it is necessary to consider removing part of the wrapping wire or driving a wedge into the wire to check the inside directly visually.

**Example**

A example of the main girder side anchoring part of a cable-stayed bridge.

(Note: Because there is a protective cover, it is not possible to check the mouth area of the anchoring part.)

Yes. Note that some covers provided at the mouth of the anchoring part do not have a structure that can completely prevent the ingress of water into the anchoring portion.

**Example**

An example of a protective cover in the anchoring part of a cable-stayed bridge.

If there is a drain to prevent water from accumulating in the cable anchoring part, it needs to check whether it is functioning.

**Example**

A case where a gap occurred in the anchoring part on the main girder side of a cable-stayed bridge due to corrosion.

It needs to be careful because rubber and the like used to alleviate broken cable corners may not be designed and constructed with the expectation of active waterproofing. It needs to be careful because water may infiltrate into the anchoring part and corrode the cable.

**Example**

A case where the filling material in the anchoring tool protection cover is insufficiently filled, and the steel material of the anchoring part is partially corroded.

There is also a concern that water will infiltrate through the diagonal material and corrode. In the inspection, it is also effective to check whether there are voids in the protective cover by hammering test or the like.

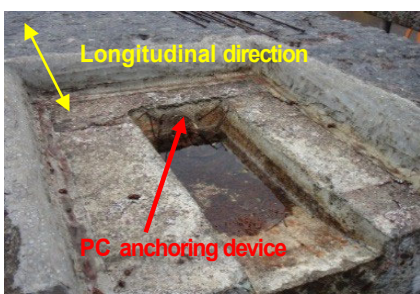
Remarks



**Example**

A case where corrosion occurred in the anchoring part of a cable.

It needs to be careful because there is a possibility that corrosion factors may have infiltrated from the anchoring part to the inside. It should also be paid attention to deterioration of the drainage function of other members, such as water infiltration from the telescopic device.



**Example**

If the anchoring part is embedded in the concrete, the construction joint becomes water infiltration route, and there is a possibility that water will collect in the anchor part where there is no drainage. It needs to be careful because the accumulated water is assumed to be a factor in the corrosion of the PC steel material (the photograph shows the anchoring part of the upper edge of the removal girder).



**Example**

A case where free lime is generated in the anchoring part. In order to determine whether corrosion preventive of PC steel material is properly performed, it is important to check the state of the protective cover and protected concrete, as well as to confirm the water infiltration route.

**Example**

**Remarks**

■ It is difficult to accurately judge abnormalities such as corrosion and fracture of the tensile material in the anchoring part only by appearance, and it is necessary to comprehensively judge various information obtained from the exterior such as the leakage of rust juice from the inside and the status of water infiltration from the anchoring part, and to estimate the internal state that can not be seen.

- If a fracture in the pendulum support or a fracture of the anchoring part occurs, the bridge will rise at the end fulcrum, and it will be remarkably difficult to restore the function of the bridge.



Fracture

**Example**

An example of a fracture of the anchor bolt on a pendulum bearing.

From the photographs, it can be seen that the fracture part had a structure that made it easy to accumulate water.



Lifting out of the girder

**Example**

An example of slipping off of an anchor bolt to prevent lifting out and fracturing it, causing the support function against negative reaction forces to be lost, and the girder was lifted up. We will also check whether there are any disfigurements that can be a sign of slip off, such as cracks in the concrete of the anchoring part.



**Example**

An example of corrosion on the pendulum bearings. It is necessary to check not only for corrosion, but also for the presence of cracks.

In addition, there are many cases where there is a joining member such as a pin, and it tends to be a weak point both as a stress state and a corrosion environment, so it is necessary to check the state of the joint.

**Remarks**

- The saddle is a member that secures slip resistance by pushing of cable tension and maintains the cable position.
- If the cable slips off, loosens, or slips in the saddle, the cable length between the spans will change, which will disrupt the balance of the cable structure and affect the safety of the whole bridge .

- Typical examples of saddles are as follows:

- Example of a tower saddle



In a small suspension bridge, the pushing force of the main cable itself is insufficient to obtain the necessary frictional force, so there are cases where the pushing force is reinforced by tightening it from above with a plate.

- Example of a spray saddle

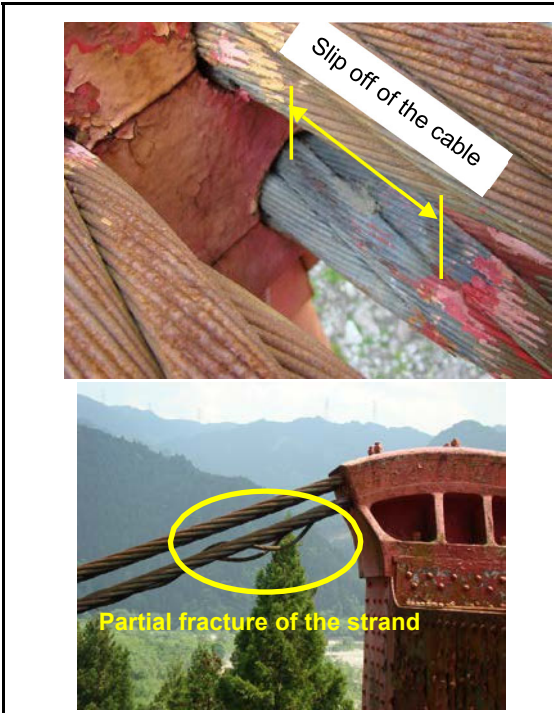


- There are other saddles of various shapes.

remarks

- The inside of the saddle is often not directly visible, and it is necessary to carefully check whether corrosion has occurred in the main cable inside or near the saddle.

□



**Example**

A case where a cable slips off in the tower top saddle due to a partial rupture of the bare wire of the main cable.

If the cable slips in the saddle, the length of the cable between the spans will change, so it is necessary to pay attention because there is a risk of a fatal effect on the entire bridge, such as imbalance of the cable structure.

In suspension bridges, since the fracture of the member, and the abnormality of the anchoring part tend to affect the overall shape, abnormal signs may be detected from linear or the like.



**Example**

An example of a bolt that secures the tower saddle falling off.

It is necessary to pay attention to loosening of bolts, abnormalities of plates, and whether there are any slip-out marks.



**Example**

Corrosion can be seen in the tower saddle.

**Remarks**

• The cable band of the suspension bridge is a connection member for attaching the suspension material to the main cable. Generally, it is fixed by friction due to the tightening force of the band bolt, and if the friction force decreases, such as when the axial force of the band bolt decreases, slippage may occur between the band and the main cable.

\* If the cable band slips, the balance of the cable structure may be lost, which may affect the safety of the entire bridge.

• Typical examples of the cable bands of the suspension bridge are as follows:



• There are other cable bands of various shapes.

• Factors that cause the axial force of band bolts to decrease include bolt relaxation, creep of the wire of cable, and reducing of voids associated with cable rearrangement, and may also decrease when the tension increases due to changes in load conditions after cable band tightening. Especially in large-scale bridges, the thicker the cable diameter, the greater the risk, and it may be necessary to increase tightening, so it is necessary to perform appropriate management.

• The safety factor against slippage of the cable band is often considered to be 3 ~ 4 or more in the design, but in reality there are various uncertainties such as variation in construction and changes in the voidage of the cable to be bundled, so it is necessary to confirm that there is always no misalignment of the band during service and to be careful whether there are signs of a decrease in the tightening force.

#### Remarks

■ There are various shapes of cable bands, and the properties differ depending on the shape. When inspecting, it is necessary to accurately judge abnormalities related to soundness and their signs after grasping the characteristics.

**Example**

A case where the bolt of the cable band of a suspension bridge has been corroded.

It is necessary to check whether corrosion (including heterogeneous metal catalytic corrosion) has occurred in the cable band, and whether looseness or slippage has occurred.

**Example**

This is an example of clips being used for the cable side fixing part of a hanging material. If the clip is not properly set, the efficiency will be significantly reduced, so care must be taken in how to stop it.

**Example**

This is a case where corrosion has occurred in the cable side fixing part of the hanging material.

**Example**

This is a case where corrosion has occurred in the cable side fixing part of the hanging material.

**Remarks**

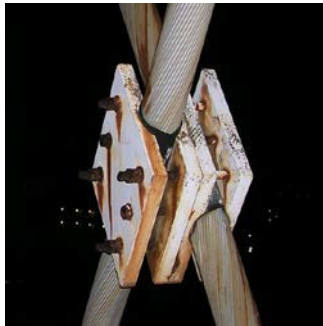
- When a different metal such as stainless steel is used for fasteners, etc., there is a risk that significant corrosion due to heterogeneous metal contact will occur on the steel material. In this case, care must be taken because corrosion may occur simultaneously and frequently to other members of the same structure.



Example

An example of connecting hanging materials with wire clips.

If slippage occurs due to corrosion of the wire clip, the hanging material may fracture, so it is necessary to check whether the bolt is loose or corroded.



Example

A case where corrosion has occurred in the bolt of the hanging material fixture of the arch bridge.

If the anchoring bracket loosens, excessive vibration will occur in the cable, which may cause fatigue damage, and the cables may come into contact with each other and be damaged, so it is necessary to care it.

Example

Example

Remarks

- There are various types of fixing methods in the fixing part of cables and hanging materials.
- If the cable slips out or loosens in the fixing part, the balance of the cable structure may be lost, and the safety of the entire bridge may be affected.
- \* Due to the fracture of the cable in the fixing part, the influence of the supported load and impact affects other members and cables, which may affect the safety of the entire bridge, such as imbalance of the cable structure or damage to other members and cables.

• Typical examples of fixing/ anchoring methods for cables and hanging materials include the following.

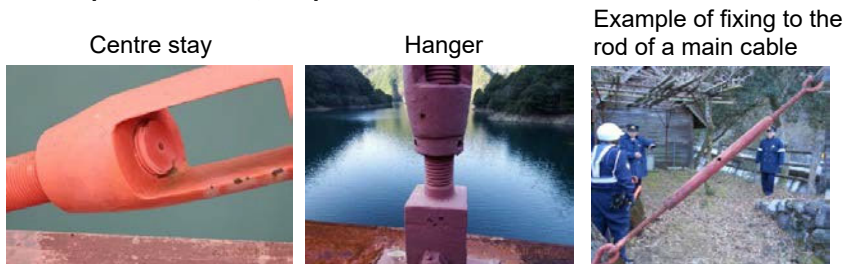
**Examples of socket**



**Examples of pin**



**Examples of screws, couplers and turnbuckles**



**Other examples**  
Pressurized



- There are various other fixation methods.

**Remarks**

■ Since the corrosion environment, corrosion prevention specifications, and stress distribution differ depending on the anchoring/ fixing method, it is necessary to pay attention to the fact that the weak points of corrosion prevention and fatigue are also different for each anchoring/ fixing method.



Example

A case where corrosion has occurred in the girder side anchoring part of the hanging material

If the fixing part that is expected to be movable causes a decrease in the movable function due to corrosion or the like, local stress not assumed in the design may occur, and it is necessary to pay attention to the occurrence of fatigue cracks in the cable wire at the thread part of the rod or the mouth of the socket fixing part.



Example

A case where the hanger material fixing part is connected by welding.

Since the girder side fixing part of the hanger material is prone to repeated stress due to vehicle load, wind load, etc., it is necessary to pay particular attention to fatigue cracks in the welded part.



Example

This is a case where corrosion has occurred in the bolt of the girder side fixing part of the hanger material.

Example

Remarks

- The anchorage is a member in which the main cable is anchored, and is a member that bears all of the tension of the main cable.

- In the anchorage of a large suspension bridge, most of the anchor frame is embedded in the concrete, and the main cable is anchored by dividing it into the anchor frame for each unit. However, small-scale suspension bridges have no spray rooms or saddles, and some structures are directly integrated into the ground.

- Examples of typical anchoring structures in suspension bridge anchorage are as follows.

**Example of the main cable anchoring part divided into multiple parts**

Directly embedded into the ground



Anchoring with wire clip



Anchoring to the anchor frame



Connecting by turnbuckle



Anchor frame

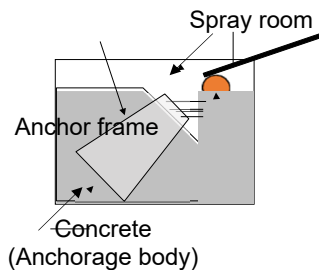


**Example of one main cable anchoring part**

Distributed and fixed to the anchor frame



Even if the anchoring parts has been housed in the spray room, it may corrode due to dew



- There are various other kinds of anchorage

**Remarks**

- Anchorage has a saddle, anchor frame, spray room, etc., the configuration varies from bridge to bridge.
- When inspecting, it is necessary to confirm the presence or absence of abnormalities and signs of the anchoring part as a whole including the inside of the embedded part.



## Example

A case where a cable is anchored to the ground.

Even if multiple cables are arranged, it is necessary to care when in a similar corrosive environment, as corrosion may proceed simultaneously.



## Example

A case where it is fixed with a wire clip.

If one wire clip loosens due to corrosion, there is a concern that it will slip in a chain reaction and lose the support capacity of the load. In addition, it is necessary to care because it is in a similar corrosive environment and corrosion may proceed simultaneously.



## Example

Turnbuckle breaking case.

When a different metal such as stainless steel is used for fasteners and the like, significant corrosion due to heterogeneous metal contact may occur in the steel material. In this case, it is necessary to care because corrosion may occur simultaneously and frequently to other members of the same structure. In addition, it is necessary to check whether there is any water infiltration or stagnation inside the turnbuckle.

## Remarks



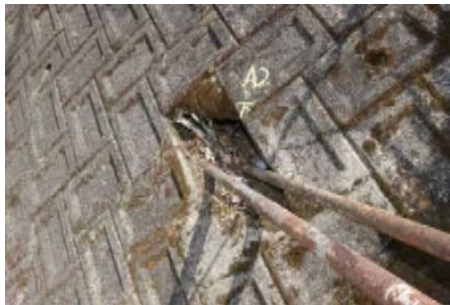
Example

A case where a broken wire can be seen at the anchor part of the main cable.



Example

A case where a broken bare wire can be seen in the anchoring part of the main cable.



Example

A case where sediment accumulation can be seen in the anchoring part of the wind-resistant cable.

Example

Remarks

• In the case of a stressed ribbon bridge or the like, if the abutment is a structure that constantly resists tensile force, if the rebar breaks due to corrosion and loses its integrity as a structure, the safety of the entire bridge may be affected.



**Example**

The abutment of a fallen stressed ribbon bridge (Mizutori Bridge).

As a result of water infiltration in from the construction joint and corroding the reinforcing bar fracture, the abutment has rotated greatly on the branch side.



**Example**

An example of an abutment moving.

If water infiltrates from the water infiltration route and the reinforcing bar corrodes, it is considered that it will lose its integrity as a structure.



**Example**

A case where water leakage has occurred at the construction joint of the abutment.

In the case of an abutment in which the cable anchoring part is embedded and always resists the tensile force, the integrity as a member is lost due to corrosion and fracture of the reinforcing bar, and the safety of the entire bridge may be lost.






**Example**

A case of water leakage in the filling part after construction of the abutment.

The openings provided during the construction of concrete members are often filled with concrete or non-shrinkable mortar, but it is necessary to pay attention because the construction joints has become water infiltration route and the internal reinforcing bar has corroded.

**Remarks**

• Due to the breakage of the ground anchor, the influence of the supported load and impact affects other ground anchors, leading to damage to other ground anchors, etc., and the stability of the abutment is lost, which may affect the safety of the whole bridge.

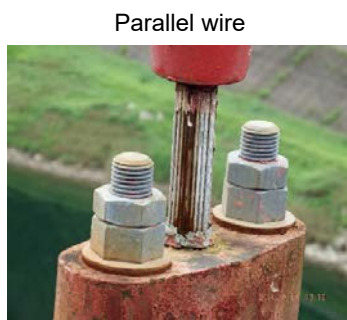
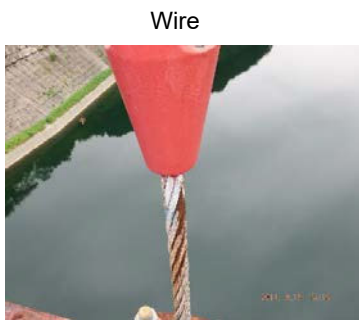
	<p><b>Example</b></p> <p>A case where a filling material has leaked from the protective cover of a ground anchor.</p> <p>If the filling material such as rust oil in the protective cover leaks, it is necessary to pay attention because corrosion of the steel material of the anchoring part may proceed.</p>
	<p><b>Example</b></p> <p>A case where a lift has occurred in the head of the ground anchor.</p> <p>If the head concrete of the ground anchor is raised or misaligned, it is necessary to be careful because it may be possible that damage to the PC steel material or deformation of the ground has occurred.</p>
	<p><b>Example</b></p> <p>A case where precipitate is generated from the anchoring part of the ground anchor.</p> <p>If water leakage or precipitate has occurred in the anchoring part of the ground anchor, it is necessary to pay attention because the PC steel material may be corroded inside the anchoring part or in the soil.</p>
<p><b>Remarks</b></p>	<p><b>Example</b></p>

• The hanger material is a member for suspending girders, and is a member that transmits loads such as dead loads of stiffening girders and live loads acting on stiffening girders to the main cable in suspension bridges and arch ribs in arch bridges.

• Due to the fracture of the hanger material, the influence of the support load and impact affects other hanger materials, which may affect the safety of the whole bridge, such as the imbalance of the cable structure and damage to other members and hanger materials.

• Typical examples of hanger materials are as follows.

**Example of wire type**



Example in which a vibration control rope is placed on the coated hanger



• Examples of steel rods



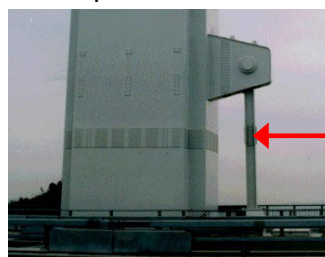
Turnbuckle

- Example of PC steel bar,



Protected by stainless steel tube

Example of tower link



Link body

It is a mechanism that hangs girders directly from the tower at the tower position, and "double-pin" members using large steel plates are common.

• There are various other kinds of hangers.

**Remarks**

■ Various types of hanger materials are used, and the mechanical properties, safety factor, corrosion preventive specifications, etc. differ for each type. In the inspection, it is necessary to accurately judge the type of suspension material, grasp its characteristics and structure, and accurately judge the abnormalities and signs related to soundness.

- Stay materials and storm cables are members for suppressing wind vibrations of suspension bridges.
- Loosening or breaking of the stay material or storm cables installed to suppress vibration may lead to a decrease in aerodynamic stability and a decrease in fatigue durability of each part.

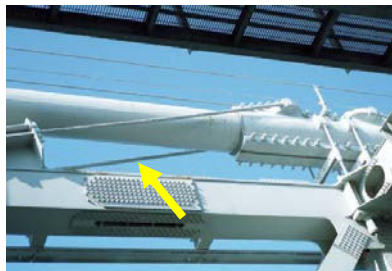
- Typical examples of stay materials and storm cables are as follows.

### Example of stay materials (A member that connects the main cable and the girder diagonally)

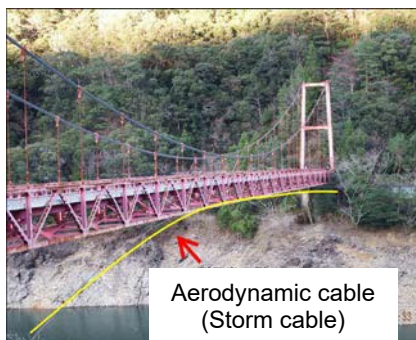
Steel rod



Wire (galvanizing + painting)



Example of wind resistant cable (a member that suppresses the movement of the girder by pulling girder diagonally downward and collaborating with the hanger that pulls it upward)



- There are various other kinds of stay materials and storm cables.

### Remarks

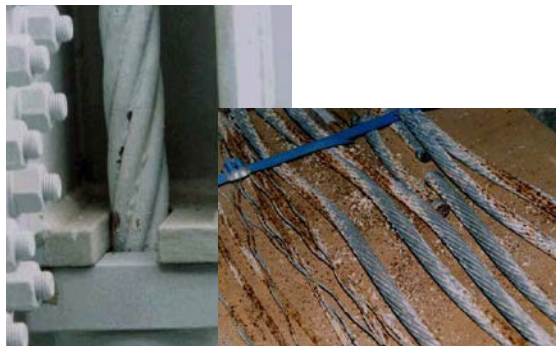
- Since damage (breakage, loosening) of the stay material and the storm cable may lead to a decrease in fatigue durability of each part of the bridge, it is necessary to confirm whether there is a decrease in ability due to breakage, corrosion, etc., a decrease in ability due to relaxation, etc.



## Example

An example of Corrosion of the surface of the hanger of the cable type, which is also suspected of internal corrosion.

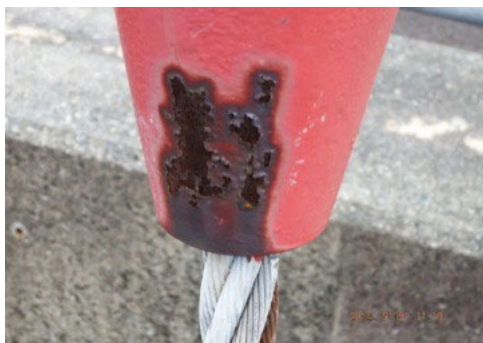
Hangers often become a severe corrosive environment due to vibration and rainwater flowing down and stagnating, and it is necessary to pay attention not only to checking the corrosion status of the surface but also to the occurrence of internal corrosion.



## Example

A case where corrosion has occurred inside the cable of a hanger of a suspension bridge.

It must be paid attention not only to checking the corrosion status of the surface in the hanger wires but also to the occurrence of internal corrosion.



## Example

An example of corrosion occurring in the socket of a hanger on a suspension bridge.

It is necessary to pay attention because the deterioration of the corrosion preventive function may cause rainwater to infiltrate into the inside of the socket or hanger and corrosion may progress.

## Remarks



Example

An example of a crack in the threaded part of a steel rod on a hanger of a suspension bridge.

The threaded part of the steel rod whose paint has been damaged by tightening is likely to be a weak point of corrosion protection. When corrosion occurs due to the deterioration of the corrosion prevention function of the threaded part, it is necessary to pay attention because it may become a weak point that causes cracks in the threaded part where high stress such as the mouth area and the rod occurs.

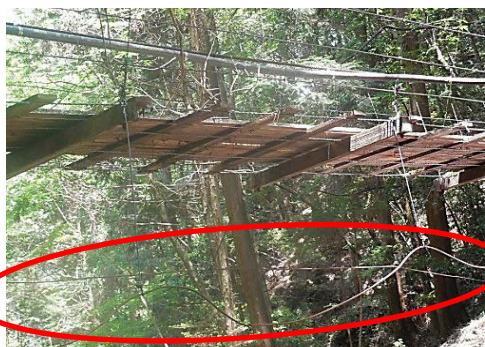
When the coating deteriorates and the coating film cracks occur, it becomes difficult to easily detect damage such as cracks.



Example

A case where a steel rod on a hanger of a suspension bridge has been broken.

The threaded part of the rod is prone to cracking due to stress concentration. Cracks are more likely to occur when there is vibration or stress fluctuations due to wind or live load. It is necessary to pay attention because cracks are likely to occur further if corrosion prevention function is deteriorated or corrosion occurs.



Example

A case where a fracture occurred in the storm cable of a suspension bridge.

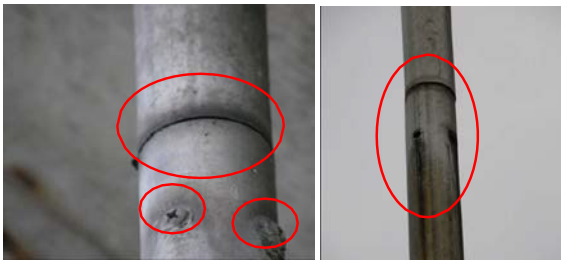
Loosening or breaking of storm cables installed as vibration damping measures may lead to a decrease in aerodynamic stability and fatigue durability of each part of the bridge, so it is necessary to pay attention.

Remarks



Cross-sectional defect due to corrosion

Status of stagnant water in the protective pipe



Deformation that suggests internal corrosion

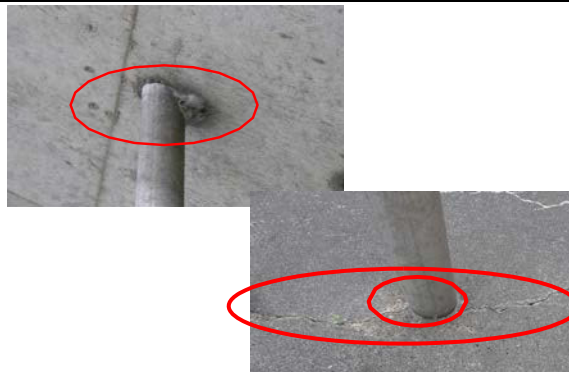
Leakage status from protective pipe

Example

A case where a cross-sectional defect due to corrosion occurs in the hanger material of an arch bridge.

When there is a gap between the protective pipe and the steel material due to construction defects, deterioration, etc., and the waterproofing treatment at the seam of the protective pipe is insufficient, or when a material that is prone to deterioration is used, corrosion occurs in the internal steel material due to water infiltrate. In particular, in the lower part, rainwater or the like that has seeped into the inside of the protective pipe flows down and accumulates, and significant corrosion may occur in the steel material.

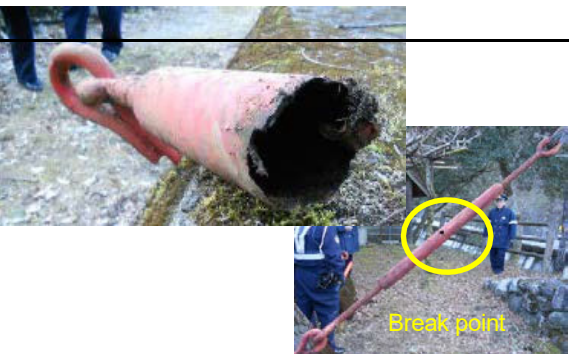
When it is not possible to directly check the inside of the protective pipe, it is necessary to guess the internal situation from surrounding situation, such as damage to the protective pipe or leakage from the protective pipe.



Example

This is a case of water leakage or cracking in the concrete recessed part of the hanger material of an arch bridge.

The embedded part is prone to disfigurements such as gaps and cracks, which may cause internal steel damage. It is also necessary to estimate the damage inside the embedded part that cannot be visually seen from the water leakage situation and the like.



Break point

Example

Turnbuckle breaking case (reposting).

It is necessary to check whether there is any water ingress or stagnation inside the turnbuckle.

Remarks

■When a different metal such as stainless steel is used for a protective pipe or fastener, there is a risk that significant corrosion due to touch with different metals may occur in the steel material. In this case, it is necessary to pay attention because corrosion may occur simultaneously and frequently to other members of the same structure.





**Example**

A case where cracks occurred due to the prestress force in the anchoring part of the outer cable reinforcement method.

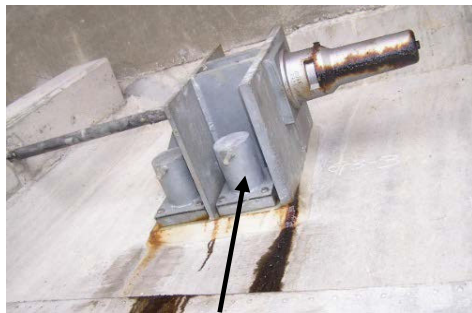
In addition to cracks, corrosion, etc. of the anchoring part itself, it is also important to check whether there is a rifting or deformation from the existing member.



**Example**

A case where corrosion can be seen in the steel anchoring part of the outer cable reinforcement method.

It is necessary to pay attention because there is a possibility that corrosion factors may have infiltrated from the anchoring part to the inside. It is necessary to pay attention to whether the structure does not allow water to infiltrate or whether the structure is easy to accumulate.



Steel bar for tightening

**Example**

In this case, a filler leaks from the protective cover of the anchoring tool of the outer cable reinforcement method.

If the filling material such as rust oil in the protective cover leaks, it is necessary to pay attention because corrosion of the steel material of the anchoring part may proceed.



**Example**

A case where the deflection part of the outer cable is cracked.

If the deflection part is damaged, it is necessary to pay attention because it is possible that a corner break may occur in the outer cable or a predetermined prestress may not be added.

**Remarks**

In the external cable reinforcement method, complex stresses are generated due to prestress even on existing members provided with anchoring parts and deflection portions, so it is necessary to confirm that the soundness of both the newly constructed part and the existing part is maintained.

• In the duluk band bridge type, due to the fracture of the vertical PC steel material, the influence of the supported load and impact affects the other PC steel materials, leading to damage to other PC steel materials. If the load support function is lost, the bridge may lift up at the end fulcrum, which may affect the stability of the whole bridge.



\* The photograph shows an abnormal deflection of a bridge with a central hinge.

**Example**

A case where abnormal deflection occurred near the center of the span.

If abnormal deflection occurs in the superstructure, it is possible that the PC steel material is damaged, so a careful evaluation such as considering the implementation of detailed grasping of the condition is necessary.



Check for lifting

**Example**

Situation at the end fulcrum of the duluk band bridge type.

If a lifting occurs at the end fulcrum, it is possible that the PC steel material is damaged, so a careful evaluation such as considering the implementation of grasping the detailed state is required.



**Example**

An example of corrosion of the exposed part of vertical PC steel material at the base of the duluk band bridge.

PC steel is often protected against corrosion by coating rubber or resin. If the PC steel material can be seen directly, check whether corrosion has occurred. It is also effective to confirm the reduction in cross section with calipers and the like.

When it is not possible to directly see due to coating or the like, it is necessary to check for water infiltration by paying attention to whether the structure is such that water tends to accumulate and whether damage has occurred to the coating.

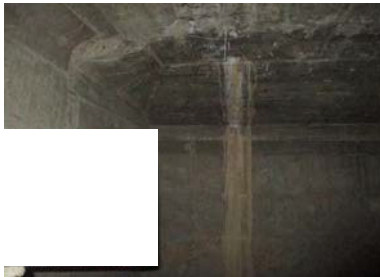
**Remarks**

- It is also effective to visually inspect narrow areas such as around the bearings using a hand mirror or the like.



Example

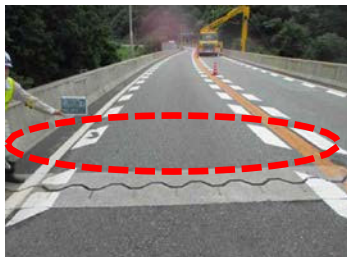
An example of the horizontal PC steel material of the duluk band bridge being fixed in the girders.  
Even in the girders, it is necessary to pay attention because water may infiltrate from the cracks.



Example

A case where a perforated crack occurs in the deck slab and water leaks into the girders.  
Since water may infiltrate into the girder of the concrete girder, it is necessary to pay attention against corrosion even if the PC steel material is fixed in the girder.

\* The photograph shows the state inside the box girder of the duluk band bridge.



Example

When the anchoring portion of the PC steel material of the duluk band bridge is set on the upper edge of the girders, the anchoring part cannot be directly seen, so it is necessary to check the state of the pavement and whether there is any water infiltrate from the bridge surface.

\* The photo shows the state of the pavement near the anchoring part of the duluk band bridge. No anomalies are observed.

Example

Remarks

## Appendix-6 Application on Tools/ Equipment of NDTs

[Note: Source of all materials is published by MLIT, Japan (Ministry of Land, Infrastructure, Transport and Tourism, Japan)]

# Table of Contents

<b>1. Definition of Large-scaled Bridge</b> .....	-1
<b>2. Inspection Stance</b> .....	-2
<b>3. Target Members</b> .....	-3
<b>4. Other Necessary Items</b> .....	-4
<b>5. Example of Damage</b> .....	-5

## 1. Definition and Method of Non-Destructive Testing (NDT)

### (1) What is Non-Destructive Testing (NDT)?

The non-destructive testing referred to in this chapter is one of the test methods included in the detailed inspection, and is performed when the characteristics of the members are unclear even though the bridge inspection was performed in Inspections A and B. For this reason, it is a test and its analysis technology that is carried out for defects in quality, performance, and characteristics using special equipment and chemicals without destroying the concrete and /or steel bridge members themselves.

### (2) What Kind of Methods of Non-Destructive Testing (NDT) are there?

As presented in Table 1.4.2 of Chapter 1 in Inspection/Diagnosis Manual, some examples of NDT's methods that can be adopted according to needs and purposes are shown in it. However, these examples mainly are the flaw detection testing (FDT) methods to detect flaws, so that the NDT mainly is the methods to confirm the dimension of members, quality and condition of materials and so on.






## 2. Purposes of NDT

The NDT is very effective method when bridge members are deteriorated or when the grade and condition of damage inside the bridge members are unclear. If the grade of damage is judged to be "C" or "D" (moderate damage - repair soon or severe damage - repair immediately) in "Routine Inspection", "Periodic Inspection A and B", and "Inspection at Extraordinary Condition", it is necessary to conduct the non-destructive testing without hesitation. For this reason, the non-destructive testing is intended as a judgment method for appropriately repairing or strengthening bridge members.

## 3. List of NDT

JICA provided the following NDT equipment and tools. As shown in the Table 3.1, each equipment has included the operation guideline how to operate them.

Table 3.1 List of NDT

No.	Name of equipment	Photo	Model	Application	Operation guideline
1	Ultrasonic measuring meter		DISTO D510	Steel bridge	Included
2	Rebound hammer		HT-225Q	Concrete bridge	Ditto
3	Carbonization measuring test kit		CARBONTEST	Concrete bridge	Ditto
4	Salinity measuring test kit		DY-2501B	Concrete bridge	Ditto
5	Rebar probe test		PS50	Concrete bridge	Ditto

## 4. Reliability of NDT

Concrete strength, reinforcing bar status, painting conditions of steel members, etc. on existing bridges and other structures can be checked by NDT. NDT result may not always be perfect. There is a possibility that the accuracy of NDT outcome could differ depending on the degree of compliance of the prescribed preparatory works and the technical operation of the NDT apparatus. NDT operator has to undergo proper training. The result therefore of NDT has to be sufficiently evaluated by the Inspector (Team Leader) from the objective and technical point of view.

## 5. Key points of each testing

### (1) Ultrasonic measuring meter test

The object that has to be detected needs to be reflective. This allows the emitted sound to be reflected. The following rule applies to this.

- a. Angle of incidence equals angle of reflection,
- b. The sensor has to be positioned perpendicular to the object in order to receive a reflected sound pulse and thus perform a good detection. A rule of thumb for mounting the sensor is: a maximum of a 3° angle relative to the object, and
- c. When the surface of an object is uneven, the angle of incidence can be greater. This is because the sound diverges and is deflected into multiple directions. Accordingly, it needs to keep a smooth surface.

### (2) Rebound hammer test

- a. The concrete surface should be smooth, clean and dry,
- b. Loose particles should be rubbed off from the concrete surface with a grinding wheel or stone, before hammer testing,
- c. Rebound hammer test should not be conducted on rough surfaces as a result of incomplete compaction, loss of grout, spalled or tooled concrete surface,
- d. The point of impact of rebound hammer on concrete surface should be at least 20mm away from edge or shape discontinuity, and
- e. More than twenty (20) readings of rebound number is taken at each point of testing and an average of value of the readings is taken as rebound index for the corresponding point of observation on concrete surface.

### (3) Carbonation measuring test

- a. The measured depth of carbonation may be influenced by the time of measuring after application of the indicator solution. A stable reading may be obtained after about five (5) to ten (10) minutes after spraying.
- b. If only a weak, colouration or none at all appears, it is better to repair the spray after the surface has dried.

### (4) Salinity measuring test

- a. The total chloride content in concrete can be extracted by dissolving with acid.
- b. Since the chloride content distribution in the depth direction from the concrete surface, especially the chloride content at the position of the reinforcing bar, is important, when drilling powder is used, the depth from the surface is separated and collected.

### (5) Rebar probe test

- a. The instrument is laid at the surface of the column, slab or any other surface.
- b. An instrument is moving from left to right and then from the bottom to top to get the position of the reinforcing bar.