IMPROVEMENT OF QUALITY MANAGEMENT FOR HIGHWAY AND BRIDGE CONSTRUCTION AND MAINTENANCE, PHASE II

BRIDGE INSPECTOR'S HANDBOOK

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Department of Public Works and Highways

Japan International Cooperation Agency

IMPROVEMENT OF QUALITY MANAGEMENT FOR HIGHWAY AND BRIDGE CONSTRUCTION AND MAINTENANCE, PHASE II

BRIDGE INSPECTOR'S HANDBOOK

2nd Edition

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DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

JAPAN INTERNATIONAL COOPERATION AGENCY

Republic of the Philippines
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
OFFICE OF THE SECRETARY
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FOREWORD

Together with the Japan International Cooperation Agency (JICA), the Department of Public Works and Highways have developed the Second Edition of **Bridge Inspector's Handbook** that provides measures in conducting efficient inspection of bridges.

The collaborative effort of DPWH and JICA did not only produce a manual that instructs, it also serves as a guidebook for our engineers to enrich their technical knowledge and proficiency in bridge inspection that matches up with international standards and the latest technological advancements.

The production of this guidebook jointly prepared by Japan International Cooperation Agency (JICA) and DPWH's bridge experts will enhance the technical knowledge and capability of our technical staff in the repair and maintenance of bridges nationwide.

Our sincerest gratitude to JICA for their technical and funding assistance and the dedicated DPWH personnel who both worked hard in the realization of this Manual.

I enjoin all those concerned to use this as easy reference and proper guide in inspecting national bridges in the country.

ROGELIO L. SINGSON
Secretary

ACKNOWLEDGEMENT

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TABLE OF CONTENTS

LIST OF FIGURES

REFERENCES

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ABOUT THIS HANDBOOK

The main purpose of this **Bridge Inspection Handbook** is to provide Accredited BMS Inspectors, Maintenance Engineers and other users with guidelines and procedures on how to undertake effective bridge inspections.

BEFORE INSPECTOR INSPECTS A BRIDGE, HE/SHE MUST READ PART 1 AND PART 2 OF THIS HANDBOOK AND UNDERSTAND EVERYTHING IN IT.

Part 1 of this handbook tells the inspector the names of different parts of bridges. It explains the different kinds of bridges and how bridges can be damaged. It also gives basic information about concrete, steel, masonry and timber, as they are used in bridges.

Part 2 of this handbook helps the inspector on how to inspect a bridge and accomplish an inspection report form. Inspector must read Part 1, so that he/she can understand the engineering terms used in Part 2. This book shall be brought by all bridge inspectors during inspections.

What is a Good Bridge Inspector?

The success of a bridge inspection depends on the ability of the Bridge Inspectors. A good inspector possesses the following general traits:

1) Reliability

A bridge inspector must be a dependable person to carry out a task as instructed; and can be counted on to take all the necessary actions in emergency circumstances.

2) Technical and communication Skills

A bridge inspection, regardless of the type or purpose, should include the following steps:

a) determine if there is a problem
b) assess the severity and extent of the problem
c) evaluate any possibility of further deterioration
d) identify the probable causes of the problem
e) report the inspection
f) propose solutions to the problem and/or recommend a more detailed and specialized type of inspection

To be able to do the above requires that bridge inspectors be technically knowledgeable. The amount of technical knowledge needed depends on the type and purpose of the inspection. In addition, a bridge inspector must be able to write, draw or verbally communicate his observations to the Supervisor / District Engineer / Regional Director.

3) Health

A bridge Inspector must be physically fit and has good eyesight. This would enable him to inspect difficult places without taking unnecessary risks as well as detecting small defects in conditions of varying light and shade. Safety is very important and inspectors must never take unnecessary risks.

4) Attitude

Bridge inspectors often find themselves in a dangerous, dirty and/or difficult environment. A good inspector must have the right attitude and enthusiasm to do a good job in inspection. He must be willing to inspect items thoroughly and critically in difficult or unusual environment.

5) Inquisitive Minds

Bridge inspection is like a detective work in which the presence of a problem, its severity and extent , and its probable causes; etc. are deduced based on whatever tell-tales found on the bridge structure. An effective bridge inspector should thus possess an inquisitive mind to probe into the problem and establish a logical link between what he sees and what had probably happened.

PART I – ABOUT BRIDGES

1.1 INTRODUCTION

Bridges are important links in a road network. They must be very well maintained in order to keep the roads open to traffic. Most of the bridges to be inspected carry a road over a river. Culverts are not included in this book.

A bridge inspector will be searching for defects which have happened, or will soon happen. He will be observing the type of materials for all the bridge elements and also the river. The river flow it can damage the bridge.

To understand about damage to bridges, the bridge inspector must know something about the materials used in bridges. The most commonly used materials for bridge construction are concrete, steel, masonry and timber.

1.2 GLOSSARY

List of engineering words used in this book and their meanings:

Abutment – end support of the superstructure of bridges and usually have additional functions or retaining earth fill for the bridge approaches.

Alkali Silica Reaction - some aggregates react adversely with the alkalis in cement to produce a highly expansive alkali-silica gel.

Approach Embankment – the earth work or earth fill that forms a transition road up to the bridge abutment.

Approach Road – the road near abutting the bridge.

Arch – a curved bridge structure.

Bailey Bridge – a "through" type of steel Deck Girder; the roadway is being carried between the two main girders. The main girders are formed from modular elements 3m long pinned together end to end for quick assembly.

Bank Seat Abutment – an abutment set well up the river bank; above the usual river level.

Barrel – the main part of an arch which supports fill and roadway.

Beam – a narrow structural member such as girders, stringers, floor beams, cross beams (diaphragms), edge beams, etc.

Bearing – the part between the superstructure and the coping of pier or abutment. It transmits the load from the superstructure to the substructure and may be movable or fixed depending on the allowed degree of movement .

Bearing Bolt – type of fixing for joints in steel or timber.

Bearing Shelf – part of the abutment, where the superstructure rests.

Bed (River Bed) – the bottom of the river.

Bed (As in bedded in mortar) – fix in place with mortar.

Boom – the upper (top chord) and lower (bottom chord) longitudinal members extending the full length of a truss.

Box Girder – a hollow beam with box shape.

Bracing – parts of a bridge which help to resist lateral forces and keep it stiff so as not to change shape, e.g., lateral braces and sway braces in steel truss and steel Deck Girders.

Bulging – where a flat surface changes shape and is bent.

Camber – the slight convexity (curve) required for construction of bridges, provided to compensate for the dead load deflection.

Caisson – type of masonry or concrete foundation, built like a tube.

Cantilever – a beam, fixed at one end and free to move at the other.

Carbonation - Carbon dioxide in the atmosphere can dissolve in moisture within the concrete pores and react with calcium hydroxide in the cement paste to form a neutral calcium carbonate.

Compression – being pushed together.

Corrode (Steel) – to be attacked by rust.

Corrosion – defect of steel caused by air, water, salt, etc.

Corrugated Steel – thin sheet of steel which have been shaped to it make strong.

Cold Joint – a joint in concrete be made if there is a delay between the placement of successively pouring of concrete

Concrete Cover – the thickness measured from the surface of the concrete to the face of the nearest reinforcing bar.

Cracking (in Concrete) - a linear fracture in concrete that extends partly or completely through the member.

Cracking (in Steel) - a linear fracture in the steel that are mainly produced due to fatigue and can, under certain conditions, lead to brittle fracture.

Cross Beam – commonly called FLOOR BEAMS, the beams that connect two trusses wherein the stringers are connected.

Curb – the step between the road and sidewalk.

Debris – rubbish and other unwanted things.

Decay – rotting of wood, making it soft and weak; caused by dampness and fungus.

Deck Slab – top of bridge superstructure.

Deformation - Permanent deformation of steel members can take the form of bending, buckling, twisting or elongation, or any combination of these.

Delamination - defined as a discontinuity in the surface concrete which is substantially separated but not completely detached from concrete below or above it.

Diaphragm – a beam connecting the girders of concrete and steel deck girder bridge.

Disconnection - Loose or damaged joints that can seriously affect the strength of the timber bridge.

Disintegration - the physical deterioration or breaking down of the concrete into small fragments or particles.

Downstream – where the river flows away from a bridge.

Drainage – system to convey water away (usually rainwater) from bridge deck

Embankment – soil bank which supports the roadway pavement.

Erosion – wearing away of soil caused by the action of wind, rain or flowing water.

Fill – soil placed in front of the abutment.

Fixed (Fixed Bearing) – not able to move.

Flange – the top and bottom plates of a girder; the enlarged top/bottom portion of a concrete Deck Girder e.g., an AASHTO Standard I-section and steel I-Beam for steel girder bridge.

Foundations – the lowest part of the bridge which sits or in the ground.

Fretting -This defect is caused by the loss of mortar or binding agents by leaching due to the percolation of water through the structures.

Fungus – type of plant which grows on decayed timber.

Gabion – box made of wire basket filled with stones.

Gabion Mattress – gabion box units where plan area is large compared to its height. Typical sizes are 3m x 2m x 0.30m supplied in zinc or PVC-zinc coated wires.

Galvanizing (Zinc-coating) – a thin layer of zinc on steel to protect it against corrosion.

Girder – a beam usually made of steel and reinforced concrete.

Groyne (Spurdike) – a wall built to change the flow of a river and protect the river bank from scour.

Headwall – a wall at the end of a culvert to hold the soil fill above the culvert pipe.

Honeycombing – lack of mortar in spaces between coarse aggregates in concrete.

Impact – to hit hard, as when a vehicle hits a bridge parapet.

Landslide – soil and rocks slipping down the side of a mountain or hill.

Loose connections - Loose tightening or missing in bolted or riveted connections

Lubrication System – a system to supply oil or grease to a mechanical bridge bearing.

Maintain (as in Well Maintained): to look after carefully and repair when it is necessary

Masonry – bricks or stones set together with mortar.

Mass Concrete – concrete without any steel in it.

Moisture – some water or dampness.

Overloading – carrying weight which is more than the design capacity.

Panel – a flat frame or plate.

Parapet – a wall or rail along the edge of bridge.

Pier – a support between abutments for bridges with more than one span.

Pile – a long, thin, foundation driven deep into the ground; bored pile - a cast-in-place pile.

Piled Walls – walls made of long pieces of material driven into the ground.

Plate – a flat, stiff piece of steel.

Pointing – the mortar between bricks or stones on masonry.

Prestressed –concrete made stronger by using prestressing steel bars or cables.

PTFE – PolyTetraFlouroEthelyne, a slippery white material used in bearings.

Rebar – (Short for reinforcing steel bar) used in reinforced concrete.

Rendering – a thin layer of mortar put on masonry or brickwork to protect it.

Retaining Wall – a wall to hold back soil.

Riprap – layer of loose rocks to protect the river bank from scour.

Safety Pins – the small clips on a bailey bridge, that stop the panel pins from falling out.

Scaling - the local flaking or loss of the surface portion of concrete or mortar.

Scour – erosion of the river bed or bank caused by the flow of the river.

Seating – the place where one part rest on another part. For example the place where a bearing is set on a pier or abutment.

Services – cables and pipes for service facilities and utilities such as water, electricity and tele-communication belonging to other authorities.

Settlement – small movement downwards of a structure.

Sheet Piled Wall - a wall made from steel panels, concrete piles or timber bored hammered into the ground to form a wall.

Shrinkage (in Timber) - Shrinkage happens when the timber dries up below its fiber saturation point.

Slab – a large piece of concrete (For example a bridge deck).

Spacer Plates – plates which are put between two other parts.

Spalling – an area where concrete has broken away; e.g. due to corrosion of reinforcing steel bars.

Span – the part of a bridge, or the distance, between the supports; span length refers to the length of a bridge.

Spandrel Walls – the side walls of a masonry arch bridge.

Splitting - Splitting happens when the interior member remains above the fiber saturation point while the outer layers shrink.

Spread Foundations – wide base to a pier or abutment, usually made of reinforced concrete.

Stiffener – in a steel plate girder, in prevents buckling of the web due to bending; also bearing stiffeners which are provided directly over the bearing in a steel plate Deck Girder to prevent buckling of web as well as to prevent bending failure of the bottom flange.

Stone Pitching – stones set in cement mortar to cover a sloping or an invert.

Stringer – a horizontal deck member.

Structural Member – all members which contribute to the structural integrity of a bridge.

Substructure – all parts of a bridge below the bridge seats, or below the springing line of arches, and including abutments, piers, wingwalls and bents below the level of the top of cap.

Superstructure – all of the deck, including parapets, trusses, beams and running surface.

Suspended Span (or Drop-in Span) – the middle span of a cantilever bridge.

Tension – pulling apart.

Truss Bridge – a bridge consisting of truss spans.

Upstream – the direction where the water is coming from.

Vibration – repeated small movements caused by a heavy vehicle or perhaps an earthquake.

Water bar – a seal to stop water in expansion joint.

Web – the part of a girder that joins the top and bottom flanges.

Weephole – a hole to allow water to come through.

Wingwalls – walls which are at the side of the abutments and part of it.

1.3 PARTS OF BRIDGES

1.3.1 GENERAL

The parts of a bridge include the superstructure (deck slab, girders, railings), substructure (pier, abutment and bearings) and approach roads as shown in the following figures.

The bridge approach is provided to make a smooth transition between the bridge deck and roadway pavement so as to minimize the impact forces on the abutment from vehicles and provide safe driving conditions for the motorists.

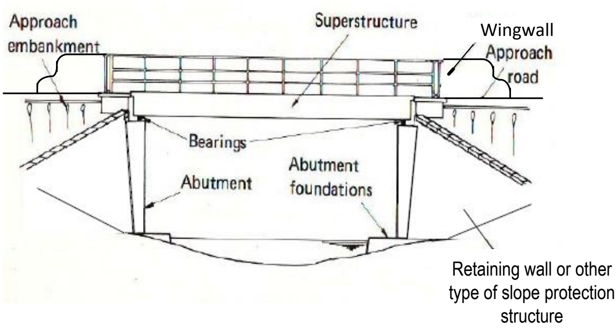


Fig. 1.3.1 Single Span Bridge

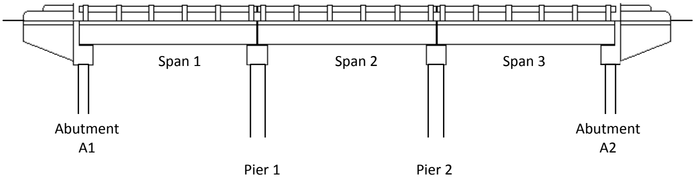
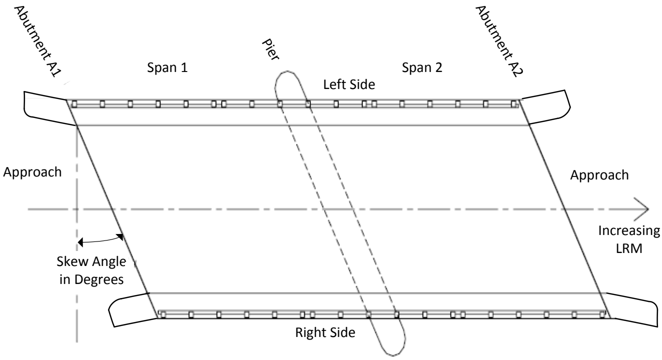
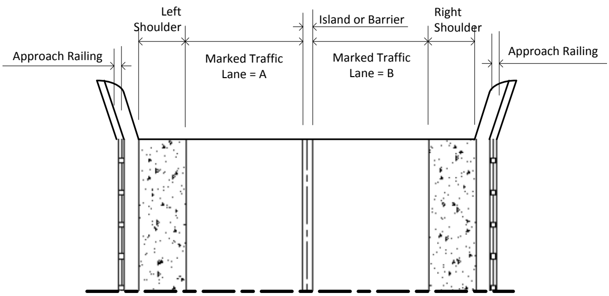


Fig. 1.3.2 Multi Span Bridge





Carriageway width = A+B
Note: Applicable only for bridges with shoulders

Fig. 1.3.3 Carriageway Width

1.3.2 SUPERSTRUCTURE

The superstructure is the main structural component that spans the obstacle; it transmits the load to the substructure.

1.3.2.1 Deck Girder Bridge

The most common type of bridge is the Deck Girder Bridge as shown in Fig. 1.3.4. This type of bridge comes in different forms such as simple span, continuous spans and cantilever spans.

The basic sectional stresses present in this type of bridge are flexural. Since the development of reinforced concrete and prestressed concrete, the girder type superstructure has become economical for spans of up to 40 m. The most common reinforced concrete deck bridges are the Slab Bridge, Concrete Deck Girder, Box Girder and Prestressed Concrete Bridge.

The primary function of the deck is to carry traffic load and transfer it to the main structural systems. The concrete slab is the most common deck type.

The substructures consisting of piers and abutments transfer the loads to the ground.

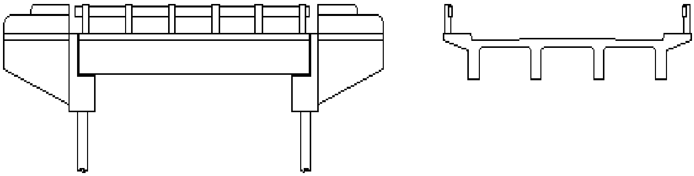
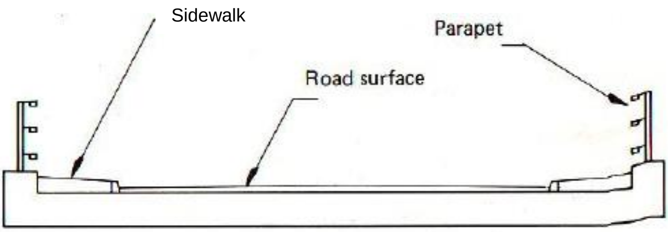


Fig. 1.3.4 Deck Girder Bridge

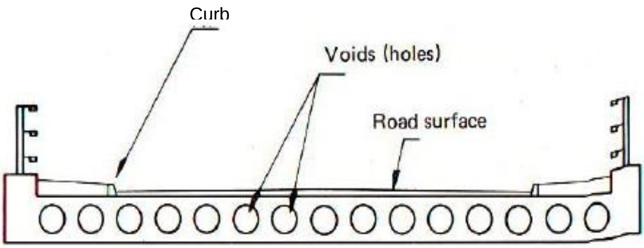
1.3.2.1.1 Reinforced Concrete Slab (RCS) Bridge

Slab bridges are usually suitable for bridges with end spans of up to about 12m and interior spans proportionally longer. The span length can be increased by using the haunched or voided slab.

This type of bridge has particular advantage when vertical clearance is critical. The optimum depth to span ratio is 1/25.



CONCRETE SLAB (SOLID)



CONCRETE SLAB (VOIDED)

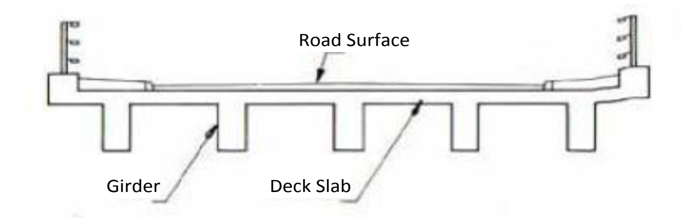
Fig. 1.3.5 Reinforced Concrete Slab Bridge

1.3.2.1.2 Concrete Girder (RCDG/PSCG) Bridge

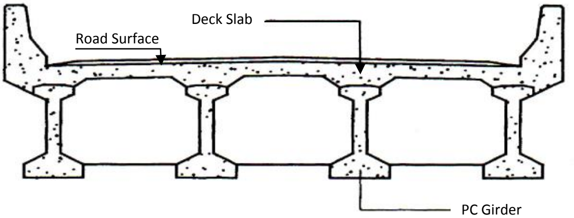
The main problems with Concrete Girder Bridges are maintaining vertical clearance and false work during construction and deck replacements after many years of service. Deck replacement of a Concrete Girder structure requires extensive engineering analysis to be compatible with the monolithically constructed existing bridge system.

The Concrete Girder Bridge is used for longer spans however, construction cost are greatly increased as the spans are increased.

Prestressed concrete girders are competitive from a standpoint and they require little maintenance. Optimum depth to span ratio is 1/18 to 1/20.



(RCDG)



(PSCG)

Fig.1.3.6 Concrete Girder Bridge (RCDG/PSCG)

1.3.2.1.3 Concrete Box Girder (RC/PC) Bridge

The Concrete Box Girder Bridge is structurally desirable and aesthetically suitable for urban areas, where roadways have a high degree of horizontal curvature as well as large skew angles. This type of bridge is often used in multi-level interchanges where horizontal clearance is limited.

The disadvantages of concrete box girders are initial high cost, cracks over the piers and problems of deck replacements requiring shoring and extensive design analysis. The generally used depth to span ratio are 1/18 and 1/20 for simple and continuous spans, respectively.

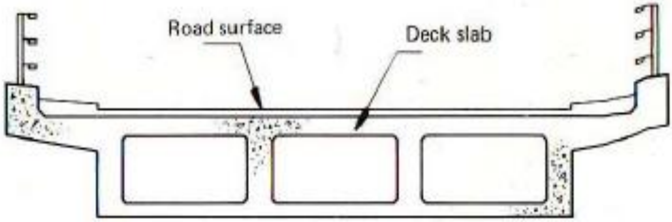


Fig. 1.3.7 Concrete Box Girder Bridge

1.3.2.1.4 Steel Plate Girder/I-Beam Bridge

The major characteristics and advantages of structural steel over other materials are strength and ductility. In addition to the increased structural capacity, steel makes more efficient and economic use of material. As a result, structural steel bridges offer simplicity and beauty. The emphasis of highway safety and sight distance requirements has favored the use of steel girders due to their ability to support longer span lengths.

To achieve further economy, composite construction with the concrete deck slab as an integral part of the beam section is used.

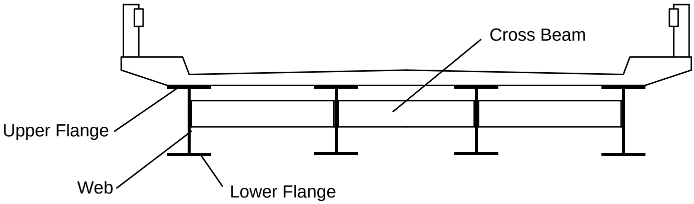


Fig. 1.3.8 Steel Plate Girder Bridge

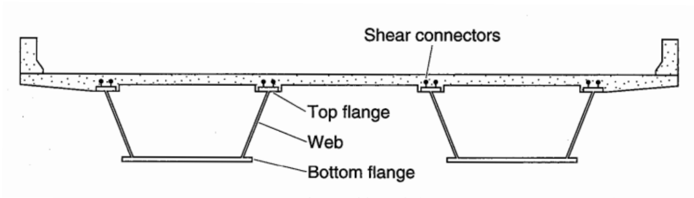


Fig. 1.3.9 Steel Box Girder Bridge

1.3.2.2 Steel Truss Bridge

When the bridge span is longer than the span limit for Deck Girder, Steel Truss is applied. The through type truss is normally selected.

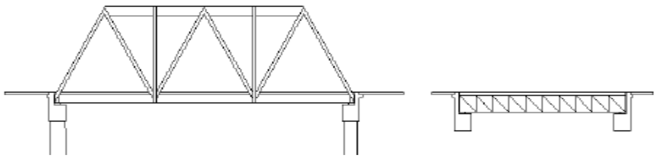


Fig. 1.3.10 Steel Truss Bridge

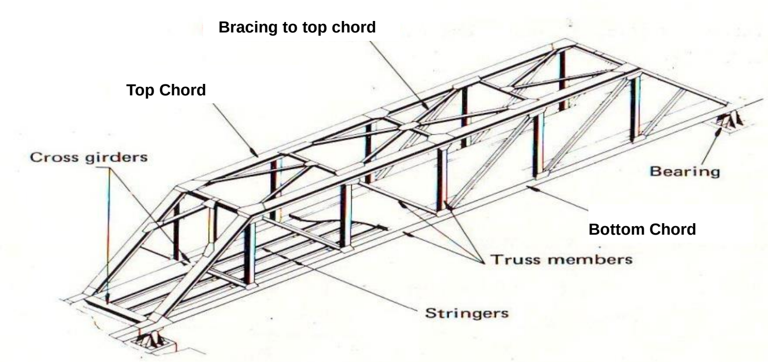


Fig. 1.3.11 Parts of Through Truss Bridge

1.3.2.3 Bailey Bridge

The Bailey Bridge is a “through” type of truss bridge which is prefabricated for urgent use during disasters. The main girders are formed from modular panels 10 ft. long pinned together end to end for quick assembly.

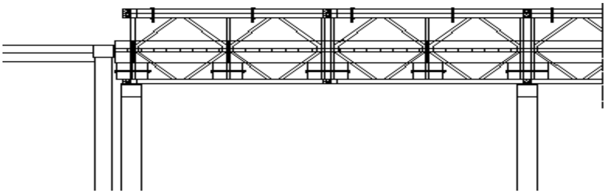


Fig. 1.3.12a Bailey Bridge Elevation

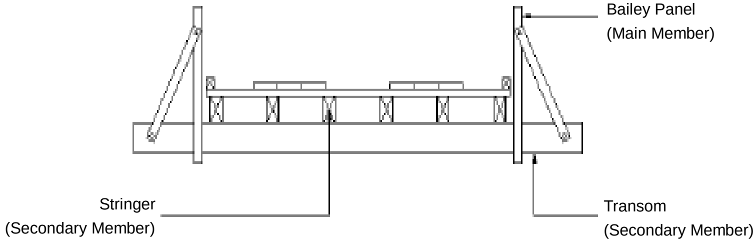


Fig. 1.3.12b Bailey Bridge Cross-section

1.3.2.4 Arch Bridge

The Arch Bridge has a very long history because arches have good performance in a long span structure. It is by far, the most popular type preferred by bridge builders. Compared with the Deck Girder Bridge where loads are resisted by flexure, the arch bridge has compression as its primary stresses. The arch form is intended to reduce bending moments in the superstructure and is more economical in material compared with an equivalent straight, simply supported girder or truss.

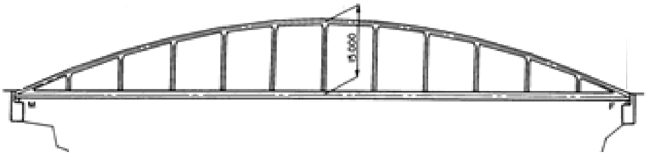


Fig. 1.3.13 Langer Arch Bridge

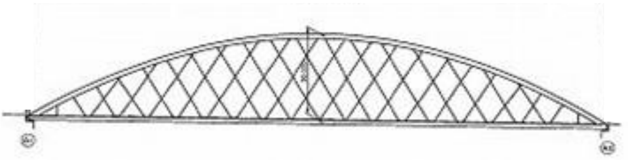


Fig. 1.3.14 Nielsen Arch Bridge

1.3.2.5 Suspension Bridge

The suspension bridge reigns supreme for spans in excess of 600 meters. A suspension bridge is a reversed arch bridge, incorporating cables of high strength wires which have a much higher economic-resistant coefficient than that of typical steel. This economic resistant coefficient is one of the greatest advantages of the suspension bridge.

Fig. 1.3.15 Suspension Bridge

1.3.2.6 Cable-Stayed Bridge

The Cable-Stayed Bridge has straight cables between tower top and girder. The range of span is between Deck Girders and suspension bridge. Mostly, the range of span is from 200 to 600 meters.

Fig. 1.3.16 Cable-Stayed Bridge

1.3.2.7 Extradosed Prestressed Concrete (PC) Bridge

The Extra dosed PC Bridge is a kind of outer cable PC Bridge. The range of span is between Deck Girder and Cable-stayed Bridge. The range of span is mainly 150 to 300 meters.

Fig. 1.3.17 Extra Dosed PC Bridge

1.3.3 ABUTMENTS, WING WALLS AND RETAINING WALLS

The substructure, which is the lower structural portion of a structure, transmits the dead load and live load and other forces to the supporting foundation. Main components of the substructure are bearings, pier or abutment and foundation.

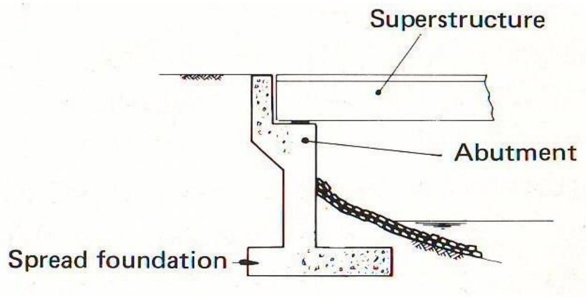


Fig. 1.3.18 Abutment

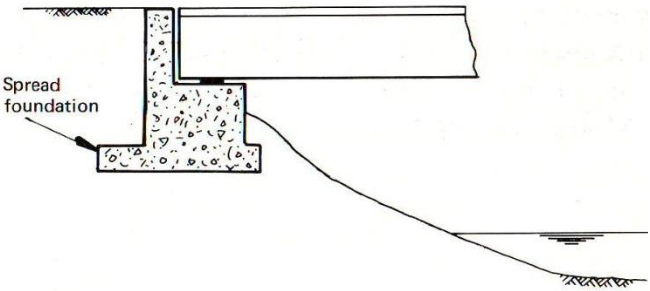


Fig. 1.3.19 Abutment on Spread Foundation

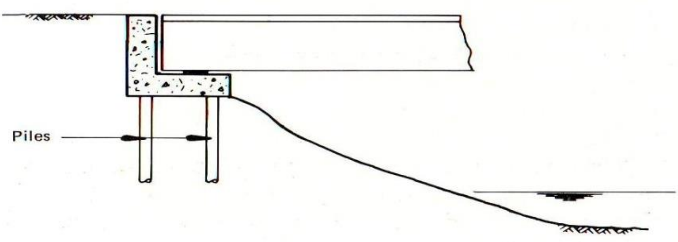


Fig. 1.3.20 Abutment on Piles

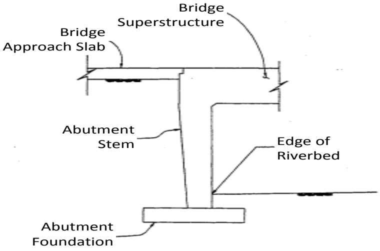


Fig. 1.3.21 Monolithic Type Abutment

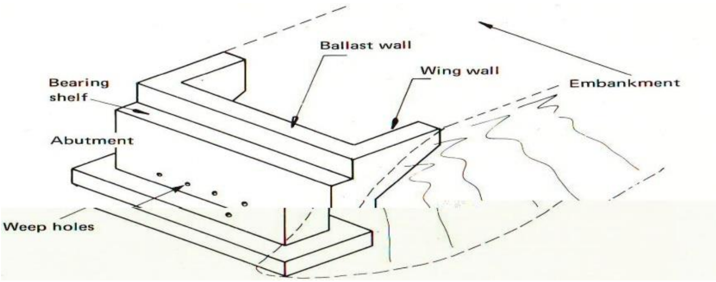


Fig. 1.3.22 Abutment and Wing Walls

1.3.4 PIERS

The pier supports the bridge spans and is located to minimize the constriction of traffic or flow of water underneath the bridge. Abutments are used at the ends of bridges, where it connects with the approach roadway, to retain the embankment and carry vertical and horizontal loads from the superstructure.

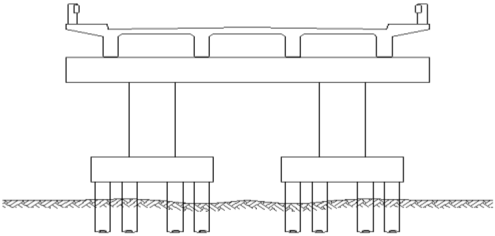


Fig. 1.3.23 Multiple Columns with Pile Foundation

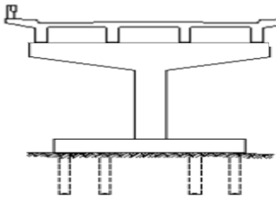


Fig. 1.3.24 Single Column with Pile Foundation

1.3.5 FOUNDATIONS

All vertical loads and horizontal forces from the superstructure and substructure are ultimately supported by foundations.

There are three (3) types of foundation that are commonly used: spread footings, piles and caisson. Spread footings are supported on suitable soil or rock without piles. If not, Pile foundation is added with spread footing.

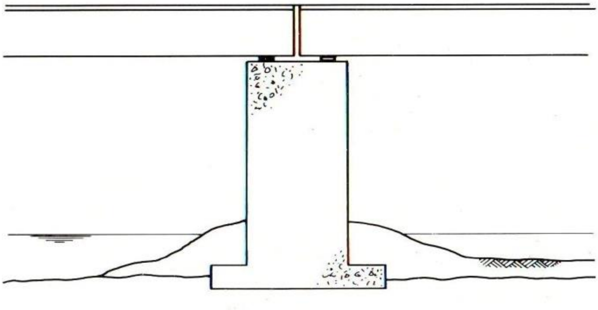


Fig. 1.3.25 Spread Foundation

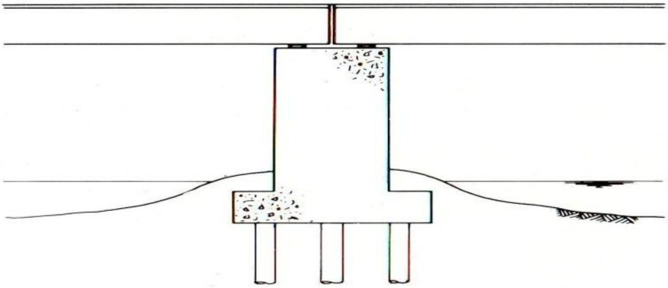


Fig. 1.3.26 Pile Foundation

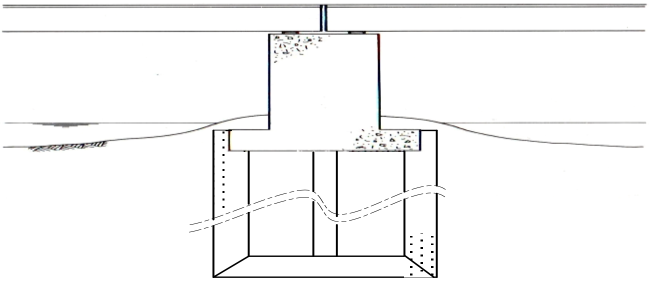
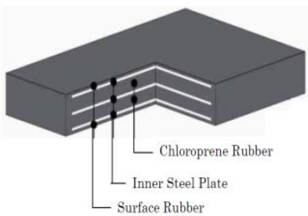
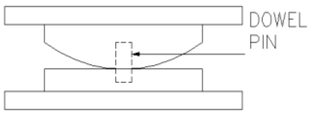


Fig. 1.3.27 Caisson Foundation

1.3.6 BEARINGS

Bearings are designed to provide free movement of girders and should be cleared of debris. These movements are accommodated by flexible materials, rockers, sliding plates and rollers. There are two (2) types of Bearings as used in bridges.





RUBBER TYPE BEARING STEEL TYPE BEARING

Fig. 1.3.28 Bearings

1.3.7 EXPANSION JOINT

Expansion joint is located between the ends of deck slabs and the ballast wall of abutments. There are many different types of expansion joints.

The simplest joints are made by using steel angles in the end of the deck, and in the top of the abutment ballast wall.

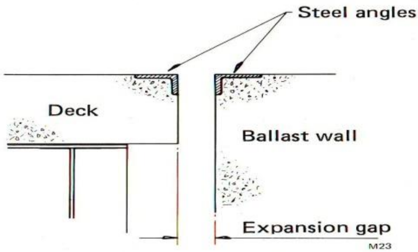


Fig. 1.3.29 Drawing of Steel Angle Joint

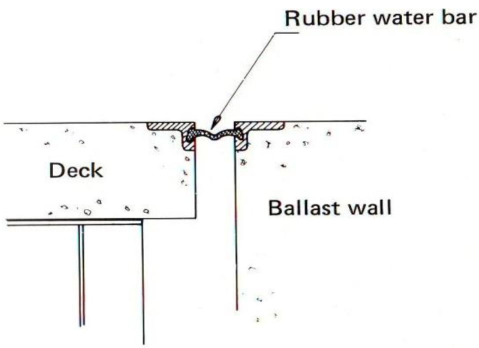


Fig. 1.3.30 Steel Angle Joint with Water Bar

Fig. 1.3.31 Steel Finger Joint

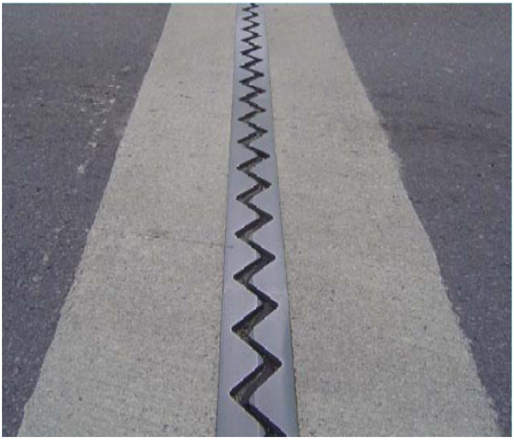


Fig.1.3.32 Steel and Rubber Composite Joint

Fig.1.3.33 Photo of Steel Angle Joint

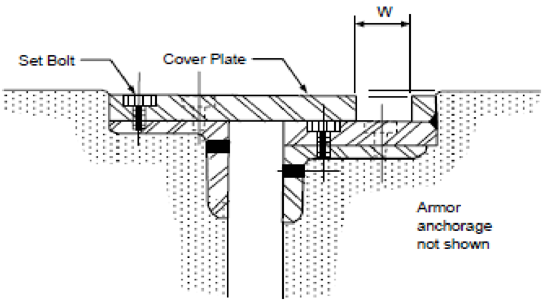


Fig.1.3.34 Steel Plate Slide Joint

1.3.8 DRAINAGE PIPE

The run-off flows through drainage pipe from the road surface. The drainage pipe is embedded in concrete slab. It is important that girder surface should not be reached by rain water.

Fig.1.3.35 Drainage Pipe

1.3.9 RAILINGS

Railings are made for the safety of vehicles and pedestrians from accidents.

Fig.1.3.36 Railings

1.4 COMMON DEFECTS OF BRIDGES

Common defects of bridges are defined by **Condition Rating Criteria of the DPWH Bridge Management System**.

1.4.1 DECK SLAB

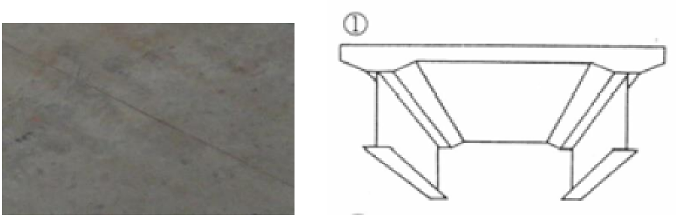
There are 2 kinds of deck slab mainly used for bridges: Concrete Deck and Steel Deck.

1.4.1.1 Concrete Deck Slab

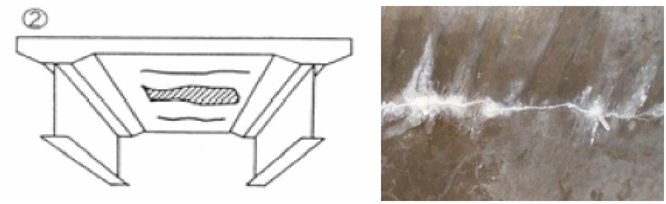
Concrete deck Slabs are mostly used not only in concrete bridges but also in steel bridges.

1.4.1.1.1 Cracking

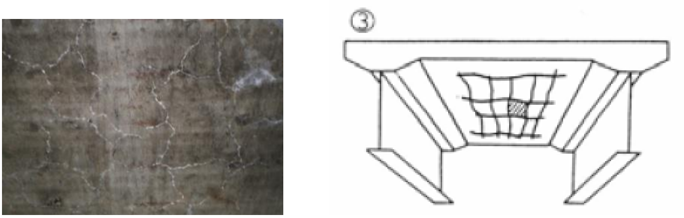
Cracks of deck slab are usually caused by drying/shrinkage and vehicular traffic load. The stages of development of cracks on deck slab is as follows:



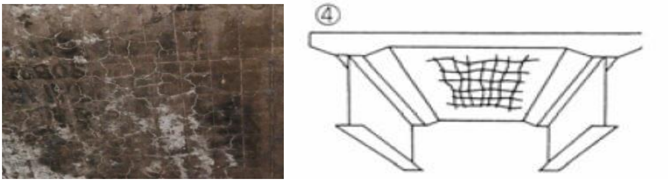
① Good Condition



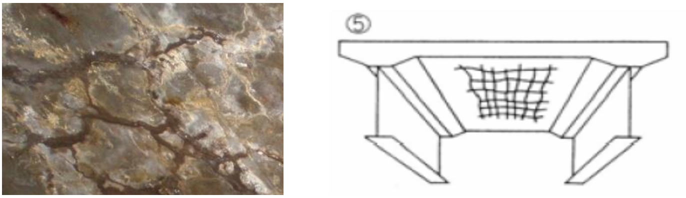
② Transverse Crack



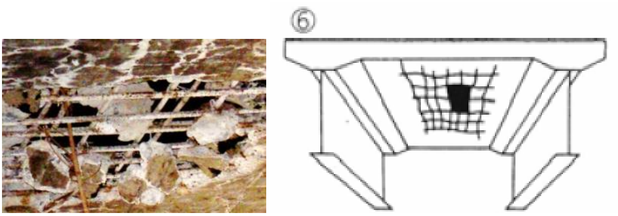
③ Orthogonal Crack



④ Alligator Crack



⑤ Increasing Crack/ Water Penetration



⑥ Spalling and Disintegration /
Rebar Exposure / Rebar Corrosion

Fig. 1.4.1 Stages of Cracking on Deck Slab

1.4.1.1.2 Spalling/Scaling/Disintegration

Spalling is an area where concrete was broken off; e.g. due to corrosion of reinforcing steel bars. A spall is a fragment, which has been detached from a larger concrete mass.

Vehicular or other impact forces on exposed concrete edges, deck joints or construction joints, may also result in the spalling or breaking off of pieces of concrete locally.

Scaling is the local flaking or loss of the surface portion of concrete or mortar by vehicle's tires.

Disintegration is the physical deterioration or breaking down of the concrete into small fragments or particles. The deterioration usually starts in the form of scaling and if allowed to progress beyond the level of very severe scaling is considered as disintegration.

Fig. 1.4.2 Spalling at Concrete Slab Surface

Fig. 1.4.3 Scaling at Concrete Slab Surface

1.4.1.1.3 Rebar Exposure/Corrosion

Corrosion is the deterioration of rebar by electrolysis. The alkali content in concrete protects the rebar from corrosion but when moisture, air and/or chloride ions above a certain concentration are dissolved in water and penetrate through the concrete to rebar this protection breaks down and corrosion starts. In the initial stages, corrosion may appear as rust stain on the concrete surface. In the advanced stages, the surface concrete above the rebar cracks, delaminates and spalls off exposing heavily rusted rebar.

Corrosion will happen more quickly when the concrete bridge is in, or near, salt water.

Fig. 1.4.4 Rebar Exposure

1.4.1.1.4 Honeycomb

Honeycombing is caused by the improper or incomplete vibration of the concrete that results in voids being left in the poured concrete where the cement mortar failed to completely fill the spaces between the coarse aggregate particles.

Fig. 1.4.5 Honeycomb on Deck Slab

1.4.1.1.5 Water Leakage

As a result of continuous progress of cracking, cracks penetrate slab thickness, then water leakage starts.

Fig. 1.4.6 Water leakage on Deck Slab

1.4.1.2 Steel Deck Slab

1.4.1.2.1 Corrosion

Corrosion will only occur if the steel is not protected or if the protective coating wears or breaks off. Corrosion is the deterioration of steel by chemical or electro-chemical reaction resulting from exposure to air, moisture, industrial fumes, other chemicals and chloride ions near seashore.

Fig. 1.4.7 Corrosion under Steel Deck Plate

1.4.1.2.2 Cracking

Crack is a linear fracture in the steel. Cracking are mainly due to fatigue stress caused by vehicle's loads.

The primary factors leading to fatigue cracking are: number of applied stress cycles, which is a function of the volume of traffic; magnitude of the stress range, which depends on the applied live load; and fatigue strength in the connection detail. Welded details are more prone to cracking than bolted or riveted details. Once cracking occurs in a welded connection, it can extend into other components due to a continuous path provided at the welded connection, and may lead to a brittle fracture.

Fig. 1.4.8 Cracking on Steel Deck Plate

1.4.1.2.3 Deformation/Buckling

Permanent deformation of steel members can take the form of bending, buckling, twisting or elongation, or any combination of these. Permanent deformations may be caused by overloading, vehicular impact or damaged intermediate lateral supports or bracing.

Fig. 1.4.9 Deformation of Steel Deck Plate

1.4.1.2.4 Loose Connection

Loose connections can occur in bolted or riveted connections; and, may be caused by corrosion of the connector plates or fasteners, excessive vibration, overstressing, cracking, or the failure of individual fasteners.

1.4.1.3 Timber Deck Slab

1.4.1.3.1 Decay/Splitting/Cracking

The main forms of biological defects are caused by fungi, termites and marine organisms. These defects are indicated by decay and deterioration thus, they reduce the structural strength of timber structures.

Fungal attack is characterized by discoloration or staining when mild but wood becoming soft and spongy when decay is more advanced. Decay can be found at locations where water could penetrate the members or where high moisture levels are encountered.

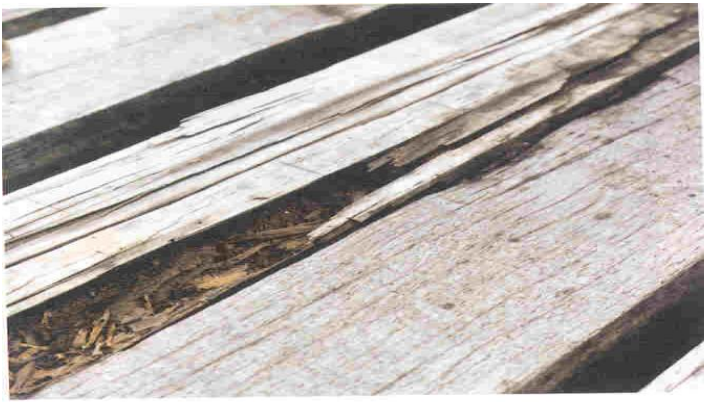


Fig. 1.4.10 Decay of Timber Deck Slab

1.4.1.3.2 Disconnection

The timber deck is structurally very weak after decay, splitting and cracking. Disconnection in timber deck will occur due to traffic load.

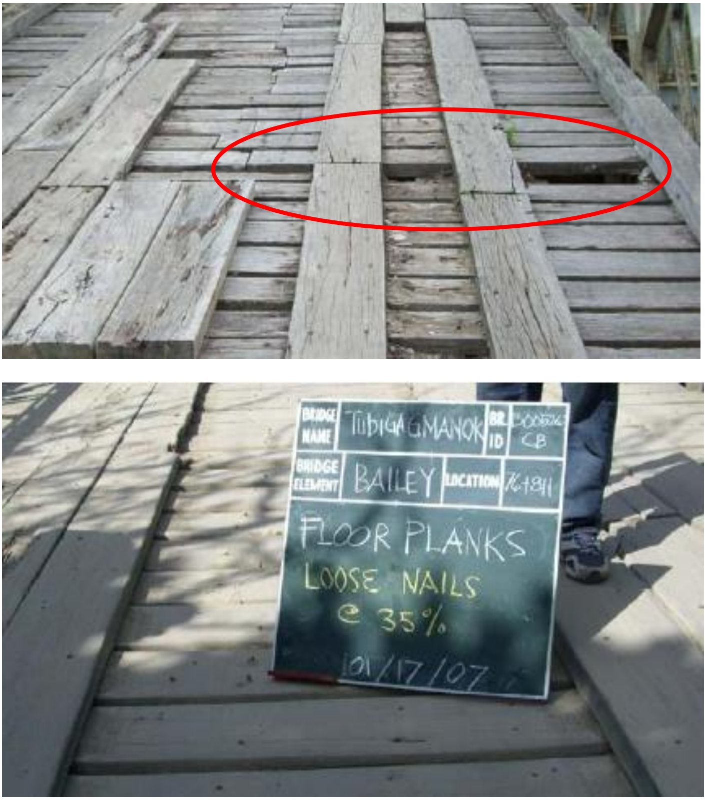


Fig. 1.4.11 Disconnection of Timber Deck

1.4.3 Concrete Bridge

1.4.2.1 Cracking

A crack is a linear fracture in concrete that extends partly or completely through the member. Cracks in concrete occur as a result of tensile stresses introduced in the concrete.

The severity of cracking is defined as follows:

Condition state 0 - Good Hairline or no-crack

Condition state 1 - Fair w ≤ 0.3mm, 1 direction

Condition state 2 - Poor > 0.3mm to ≤ 1.0 mm, 2 directions

Condition state 3 - Bad > 1.0 mm, 2 directions

Typical cracking patterns observed in reinforced concrete structures and the typical cause of each type of cracking is illustrated in the following figures.

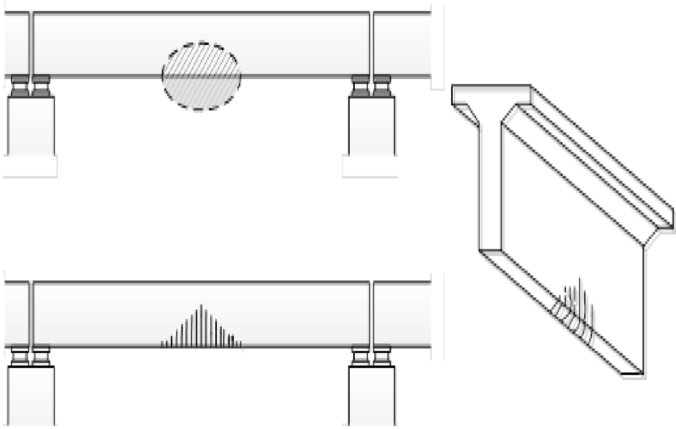


Fig. 1.4.12 Flexural Cracking in the Center Span

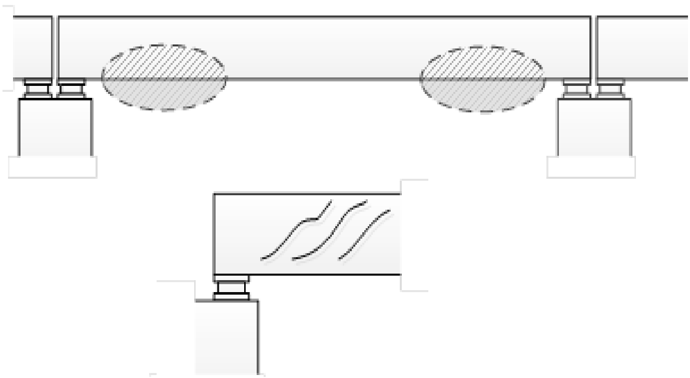


Fig. 1.4.13 Shear Cracking at L/4 of Span

Fig. 1.4.14 Shear Crack in Concrete Girder

Fig. 1.4.15 Shear Crack near Bearing

1.4.2.2 Spalling/Scaling/Disintegration

Spalling/Scaling/Disintegration are explained in detail at 1.4.1.1.2.

The spalled area left behind is characterized by sharp edges.

Vehicular or other impact forces on exposed concrete edges, deck joints or construction joints, may also result in the spalling or breaking off of pieces of concrete locally.

Fig. 1.4.16 Spalling at Bottom of Concrete Girder

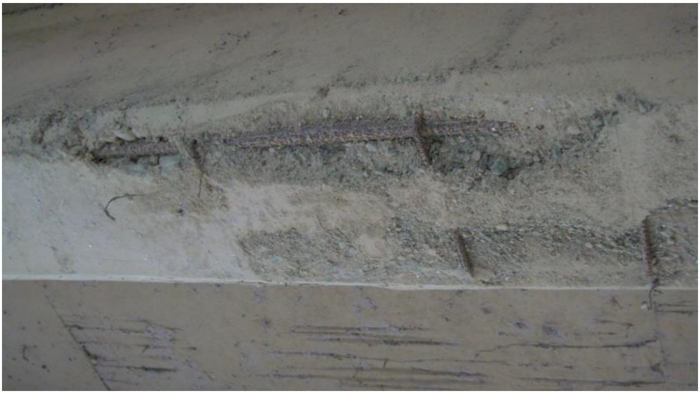


Fig. 1.4.17 Disintegration

1.4.2.3 Delamination

Delamination is defined as a discontinuity in the surface concrete which is substantially separated but not completely detached from concrete below or above it. Visibly, it may appear as a solid surface but can be identified as a hollow sound by tapping. Delamination begins with the corrosion of rebar and subsequent cracking of the concrete. However, in the case of closely spaced bars, the cracking extends in the plane of the rebar parallel to the exterior surface of the concrete.

Fig. 1.4.18 Delamination of Concrete Girder

1.4.2.4 Rebar Exposure/Corrosion

Rebar exposure /corrosion is explained in detail in 1.4.1.1.3.

Fig. 1.4.19a Rebar Exposure/Corrosion

Fig. 1.4.19b Rebar Exposure/Corrosion

1.4.2.5 Honeycomb

Honeycomb is explained in detail in 1.4.1.1.4.

Fig. 1.4.20a Honeycomb

Fig. 1.4.20b Honeycomb

1.4.2.6 Water Leakage

Water leakage is explained in detail in 1.4.1.1.5.

Fig. 1.4.21 Water Leakage on Concrete Girder

1.4.2.7 Deformation/Sagging

Sagging is caused by mistakes during construction. The following photograph shows the sagging of PC Deck Girder after project completion. Of the four (4) spans with same type of girders, sagging occurred only in one span. It is perceived to be caused by construction mistake. The girders are now supported by steel columns.

Fig. 1.4.22 Sagging of PC girders

1.4.2.8 Impact/Accident Damage

Post broken and totally shifted out of position by accident damage. The rebar is severely damaged.

Fig. 1.4.23 Impact/ Accident Damage

1.4.3 STEEL BRIDGE

1.4.3.1 Corrosion

Corrosion is the deterioration of steel by chemical or electro-chemical reaction resulting from exposure to air, moisture, industrial fumes and other chemicals and contaminants in the environment in which it is placed. The terms rust and corrosion are used inter-changeably in this sense. Corrosion, or rusting, will only occur if the steel is not protected or if the protective coating wears or breaks off.

Rust on carbon steel is initially fine grained, but as rusting progresses it becomes flaky and delaminates exposing a pitted surface. The process thus continues with progressive loss of section. Corrosion is very severe near sea shore due to wind-borne sea water spray.

Fig. 1.4.24 Steel Girder Corrosion near Sea Shore

Fig. 1.4.25 Truss Member Corrosion

1.4.3.2 Cracking

Crack is explained in detail in 1.4.1.2.2. Fatigue cracks may occur in the gusset plate and lateral member connection due to repeated vibrations.

Fig. 1.4.26 Cracking in Steel Member

A fatigue crack at bottom flange progresses to the web plate of the cross beam. It is caused by traffic load.

Fig. 1.4.27 Fatigue Crack in Steel Member

1.4.3.3 Deformation/Buckling

Deformation/Buckling is explained in detail in 1.4.1.2.3. Permanent bending deformation may occur in the direction of the applied loads and are usually associated with flexural members; however, vehicular impact may produce permanent deformations in bending in any other member.

Permanent buckling deformations normally occur in the direction perpendicular to the applied load and are usually associated with compression members. Buckling may also produce local permanent deformations of webs and flanges of beams, plate girder and box girders.

Fig. 1.4.28 Deformations/Buckling

1.4.3.4 Abnormal Vibration

Steel bridge is flexible structure than concrete bridge. Steel bridge is easy to vibrate by passing traffic on the bridge. It's normal. But if the vibration is felt too much and it is occurred some sound from structure, it is abnormal vibration.

1.4.3.5 Loose Connection

Loose connections are explained in detail in 1.4.1.2.4. Loose connections may sometimes not be detected by visual inspection. Cracking or excessive corrosion of the connector plates or fasteners, or permanent deformation of the connection or members framing into it, may be indications of a loose connection. The picture below shows the improper method of installation of the missing bolts on the lower flange. Replacement of High Strength Bolts (HTB) should be applied with torque control.

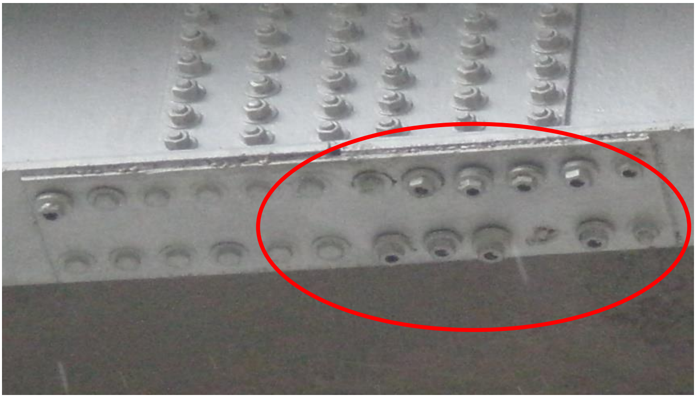


Fig. 1.4.29 Loose Bolts (improperly tightened)

This picture below shows missing bolts in the web plate connection. In this case, there are two (2) missing bolts. The percentage (%) of damage is very small, but the condition of tightening should be tested as soon as possible.

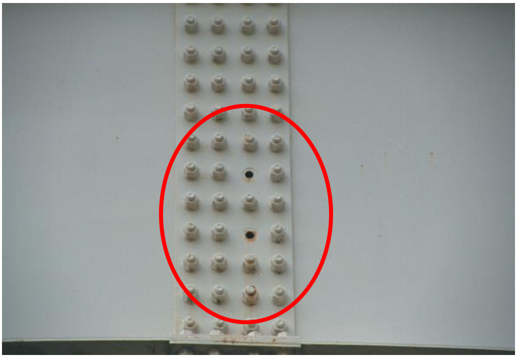


Fig. 1.4.30 Missing Bolts

1.4.3.6 Paint Peel Off

The picture below shows that the aluminum paint is almost entirely peeled off from the steel surface. Some percentage (%) of steel surface is damaged. Repainting should be done as soon as possible.

Fig. 1.4.31 Paint Peel off of Truss Bridge Member

Fig. 1.4.32 Paint Peel off at Truss Bridge

1.4.4 BAILEY BRIDGE

1.4.4.1 Corrosion

The paint of the lower chord is severely peeled off. Total repainting should be done as soon as possible so that the bridge' service life can be extended to another decade.

Fig.1.4.33a Corrosion of Bailey Panels

Fig.1.4.33b Corrosion of Bailey Panels

1.4.4.2 Loose Connection

As shown by the picture below, the loose bolt is almost detached. Tightening should be done as soon as possible.

Fig.1.4.34 Loose Connection

1.4.4.3 Deformation/Buckling

The left side truss member seems to be inclined to the left. Upper chord member should be straight not, buckling action occurs easily during full loading. If such condition is noticed, inspect carefully as soon as possible.

Fig.1.4.35 Deformation/Buckling (left side panels)

1.4.5 MASONRY ARCH

1.4.5.1 Fretting/Abrasion

Fretting at the right side of arch wall was repaired by plastering.

Fig.1.4.36 Fretting/Abrasion

1.4.5.2 Cracking

Cracking between stones is repaired by mortar patching.

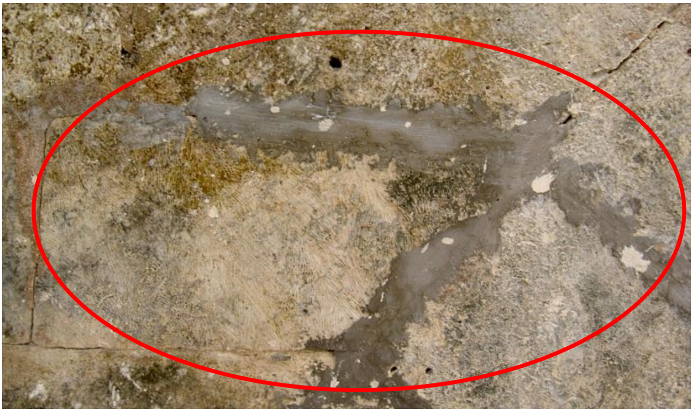


Fig.1.4.37 Cracking in Masonry Arch

1.4.5.3 Material Displacement/Loss

The masonry arch material is detached due to compressive stress.

Fig.1.4.38 Material Displacement/Loss

1.4.5.4 Bulging

The masonry arch is bulging in the right side as shown in picture below.

Fig.1.4.39 Bulging

1.4.6 PIERS, ABUTMENTS AND CONCRETE PILE

1.4.6.1 Cracking (See 1.4.2.1 Cracking)

These cracks are caused by the effect of salt water. Rebars inside the concrete were corroded and later on expanded to develop cracks.

Fig.1.4.40 Cracking at Pier

Shear crack is caused by the bearing reaction.

Fig.1.4.41 Shear Crack in Concrete Pier

1.4.6.2 Spalling (See 1.4.2.2 Spalling)

Spalling was caused by impact force on exposed concrete edge.

Fig.1.4.42 Spalling in Pier

1.4.6.3 Scaling

As scaling was caused by impact force during flood. This pier has rectangular section which is not suitable considering river flow.

Fig.1.4.43 Scaling in Pier

1.4.6.4 Disintegration See 1.4.2.2

1.4.6.5 Delamination

Delamination is caused by rebar corrosion.

Fig.1.4.44 Delamination in Pier

1.4.6.6 Rebar Exposure/Corrosion

Rebar corrosion due to saltwater caused concrete to delaminate and spall.

Fig.1.4.45 Rebar Exposure in Pile

1.4.6.7 Tilt/Settlement

Spread foundation has settled due to scouring.

Fig.1.4.46 Tilt/Settlement in Pier

Pile has settled due to impact force.

Fig.1.4.47 Tilt/Settlement in pile

Abutment settled due to earth pressure.

Fig.1.4.48 Tilt/Settlement in Abutment

1.4.6.8 Scouring

Pile foundation is severely scoured.

Fig.1.4.49 Scouring (pile at right side is broken)

Fig.1.4.50 Scouring

1.4.6.9 Honeycomb

Honeycomb is caused by insufficient vibration of during concrete pouring.

Fig.1.4.51 Honeycomb in Pier

1.4.7 STEEL PILE

1.4.7.1 Corrosion

Steel pile is corroded by eroded slope.

Fig.1.4.52 Corrosion at Steel Pile under Abutment

1.4.7.2 Cracking

1.4.7.3 Deformation (See 1.4.7.4)

1.4.7.4 Tilt/Settlement

Steel piles settled due to lateral force.

Fig.1.4.53 Tilt/Settlement in Steel Pile

1.4.7.5 Scouring

This pile foundation is heavily scoured.

Fig.1.4.54 Scouring of Steel Pile Foundation

1.4.8 BEARING

1.4.8.1 Steel type

1.4.8.1.1 Corrosion

Steel bearing is corroded and paint is peeled-off.

Fig.1.4.55 Corrosion in Bearing

1.4.8.1.2 Loose Connection

Anchor bolt is without anchor nut.

Fig.1.4.56 Missing Anchor Nut

1.4.8.1.3 Abnormal Displacement

The girder end is not resting on the bearing anymore.

Fig.1.4.57a Abnormal Displacement

Fig.1.4.57b Abnormal Displacement

1.4.8.1.4 Paint Deterioration

This red color paint is primer only. Original paint had already peeled off.

Fig.1.4.58 Paint Deterioration

1.4.8.1.5 Bed (Support) Damage

Bearing seat is damaged by reaction forces and seismic loading.

Fig.1.4.59 Bed Damage

1.4.8.2 Rubber type

1.4.8.2.1 Bulging

Rubber bearing is bulging due to aging and contamination.

Fig.1.4.60 Bulging of Rubber Bearing

1.4.8.2.2 Abnormal Displacement

1.4.8.2.3 Bed (Support) Defect (See 1.4.8.1.5)

1.4.9 EXPANSION JOINT

a) Defective joint seals. Seals are intended to keep out sand, dirt, and stones.

b) Inadequate space for movement in expansion joints.

c) Signs of distress in structural members at joints.

1.4.9.1 Pourable Seals (Asphalt Sealant)

1.4.9.1.1 Water Leakage

Joint seals are defective. Seals are intended to keep out sand, dirt, and stones.

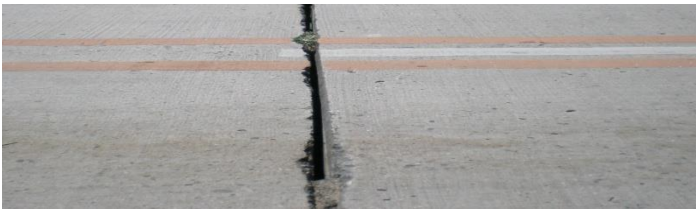


Fig.1.4.61 Missing Sealant (cause of water Leakage)

1.4.9.1.2 Abnormal Space/Noise

Concrete gap is too wide. Edge of concrete is broken due traffic load,

Fig.1.4.62 Abnormal Space

1.4.9.1.3 Difference in Elevation

The expansion joint is designed for horizontal movement, but it moved in vertical direction which is abnormal.

Fig.1.4.63 Difference in Elevation

1.4.9.1.4 Deteriorated Sealant

Asphalt sealant is deteriorated due to traffic load.

Fig.1.4.64 Deteriorated Sealant

1.4.9.2 Steel Type

1.4.9.2.1 Water Leakage

Section loss in the steel slide plate due to severe corrosion. Water leakage occurred.

Fig.1.4.65 Water Leakage

1.4.9.2.2 Abnormal Space/Noise

Steel slide plate lost section due to severe corrosion as bridge is located near the sea.

Fig.1.4.66 Abnormal Space (due to Severe Corrosion)

Steel slide plate is missing due to damaged connection bolts

Fig.1.4.67 Abnormal Space (missing slide plate)

1.4.9.2.3 Difference in Elevation

Difference in elevation at expansion joint due to bearing problems.

Fig.1.4.68 Difference in Elevation

1.4.9.2.4 Displacement

1.4.9.2.5 Cracking

Cracking and spalling at curb

Fig.1.4.69 Cracking

1.4.9.3 Rubber Type

1.4.9.3.1 Water Leakage

Deteriorated rubber sealant.

Fig.1.4.70 Water Leakage

1.4.9.3.2 Abnormal Space/Noise

1.4.9.3.3 Difference in Elevation

Fig.1.4.71 Difference in Elevation (Rubber Joint)

1.4.9.3.4 Rupture

Rubber joint is severely deteriorated and has ruptured in some places.

Fig.1.4.72 Rupture (rubber joint)

1.4.10 DRAINAGE

The drainage pipe was lost due to severe corrosion which caused water from bridge deck to leak unto the concrete members below.

Fig.1.4.73a Water Leakage (drainage pipe)

Fig.1.4.73b Water Leakage (Drainage Pipe)

Lower flange of steel girder was corroded by water leaking through corroded drainage pipe.

Fig.1.4.73c Water Leakage (Drainage Pipe)

1.4.11 CONCRETE/MASONRY/GROUTED RIPRAP SCOUR PROTECTION FOR PIERS

1.4.11.1 Cracking

1.4.11.2 Material Loss/Disintegration

Steel plate and concrete scour protection was destroyed by abrasion with stones carried by flood waters. Damage should be repaired with new scour protection as soon as possible.

Fig.1.4.74a Material Loss/Disintegration

Fig.1.4.74b Material Loss/Disintegration

1.4.12 Gabion/Mattress Scour Protection for Piers

1.4.12.1 Damage of Gabion Wire

Fig.1.4.75 Damaged Gabion Wire

1.4.12.2 Material Loss/Disintegration

Fig.1.4.76 Material Loss/Disintegration

1.4.13 CONCRETE/MASONRY/GROUTED RIPRAP SCOUR PROTECTION FOR ABUTMENTS

1.4.13.1 Cracking

This defect is caused by the factors affecting the stability of a masonry structure which include:

1) Differential settlement across an abutment which may cause longitudinal cracks along the masonry.

2) Movement or settlement of the foundations of an abutment which may cause transverse cracks

across the masonry structure and settlement in the roadway.

3) Outward movement of the spandrel walls due to lateral pressure which may cause longitudinal cracking near the edge of the arch.

4) Settlement at the sides of an abutment which may cause diagonal cracks from the side extending to the center at the crown of the arch.

5) Movement of wing walls which may cause cracking and loss of the road surfacing materials.

Fig.1.4.77 Cracking in Slope Protection

1.4.13.2 Bank Erosion

The soil materials are completely washed out by flood

Fig.1.4.78 Bank Erosion

1.4.13.3 Slope Erosion

Slope protection is completely eroded by flood.

Fig.1.4.79 Slope Protection Erosion

1.4. 13.4 Material Loss/Disintegration

The soil materials are washed out from back of parapet.

Fig.1.4.80a Material Loss/Disintegration

Fig.1.4.80b Material Loss/Disintegration

1.4.14 GABION/MATTRESS SLOPE PROTECTION FOR ABUTMENTS

1.4.14.1 Defect of Gabion Wire (See 1.4.12.1)

1.4.14.2 Material Loss/Disintegration

1.4.15 STEEL SHEET PILE SLOPE PROTECTION

1.4.15.1 Corrosion

1.4.15.2 Material Loss/Disintegration

1.4.15.3 Bank Erosion

1.4.15.4 Slope Protection Erosion

1.4.16 BRIDGE APPROACH (EMBANKMENT)

1.4.16.1 Depression

Depression occurred due to sinking of approach road.

Fig.1.4.81 Depression (at approach road)

PART 2 - THE INSPECTION

2.1 INTRODUCTION

The following notes will make an effective bridge inspector. Inspections should be done using **Condition Rating Criteria** of Bridge Management System.

2.2 PREPARATION FOR GOOD INSPECTORS

Before you go, You have to prepare all you will need in the site before you start.

The first step in planning inspections is to make an inspection program. This program should list all bridges to be inspected in the Regional Office and/or District Engineering Office and the time period in which this is to be completed. These include:

- Traffic restrictions,
- Access difficulties, e.g. waterways, terrain, buildings, built-up areas, combined bridges,
- Safety of staff undertaking the inspection,
- Specialized equipment or personnel such as divers that may need to be called upon,
- Seasonal or tidal restrictions,

- Copy of previous inspection report and any other relevant information/reference

2.2.1 CLOTHES AND EQUIPMENT

Inspector need to wear the proper clothes for the Inspection.

Inspectors should always bring a hammer, a digital camera and the condition rating card.

Fig.2.2.1 Clothes and Equipment for Inspection

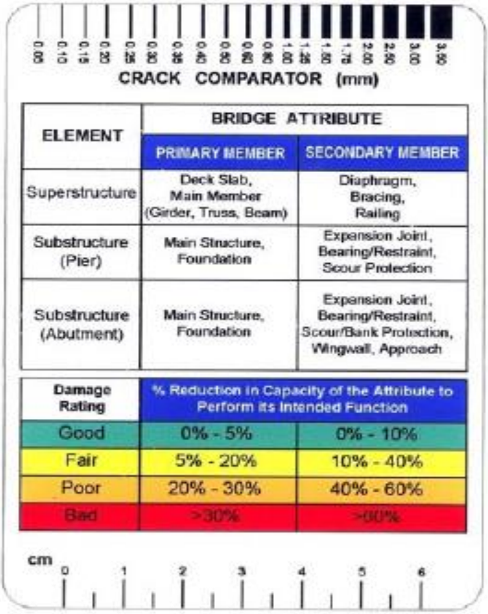


Fig.2.2.2 Condition Rating Card

Fig.2.2.3 Inspector is fully equipped for inspection

2.3 ARRIVING AT THE BRIDGE

Reminder - It is easy to make a mistake and inspect the wrong bridge.

CHECK that you are at the right bridge:

- **Check the bridge number (ID code)**
- **Check the bridge name**
- **Check the distance** from the beginning of the road, or use the kilometers posts

These three things to check are at the top of page 1 of the Inventory Inspection form of Bridge Management System.

Read carefully the INSTRUCTIONS FROM THE ENGINEER TO THE INSPECTOR.

On the small sketch of the bridge write the names of the towns or villages on each side of the bridge. Mark and indicate which way the river flows, and write numbers on the spans and piers (if there are more than one). Identify at what abutment or affix if necessary the name of barangay or village where it belongs. The engineer must know which part of the bridge you are reporting on. The sketch will help identify location of defect or damage.

See example shown below.

Fig.2.3.1 Sketch on black board

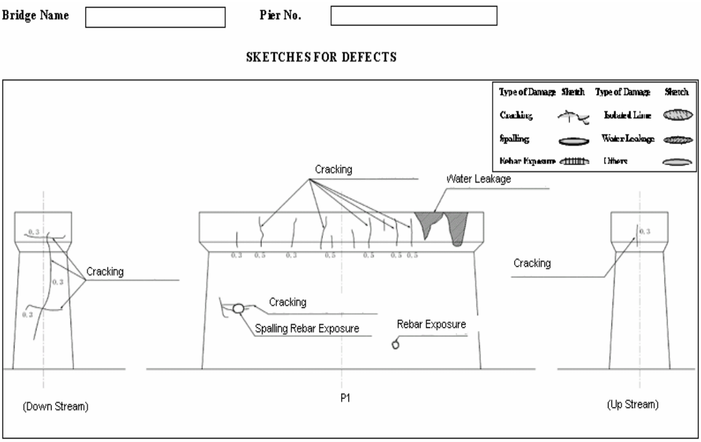


Fig.2.3.2 Sketch of Defects

2.4 FOCUS POINTS FOR THE BRIDGE INSPECTION

After verifying that it is the right bridge, inspector can start inspection in accordance with the suggested focus points as follows:

1) Observe the Entire Bridge from the Approach Road

Fig.2.4.1 Approach Road

2) Observe the Entire Bridge from the Sides

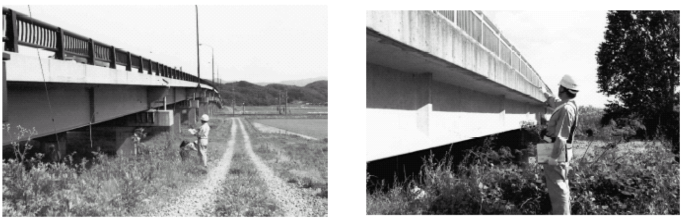


Fig.2.4.2 Inspect Side View

3) Inspect the Curb

Look at the curb. Observe if there are defects. In photo below, rebars are already exposed.

Fig.2.4.3 Inspect the Curb

4) Inspect the Pavement

Fig.2.4.4 Inspect the Pavement

5) Inspect the Expansion Joint

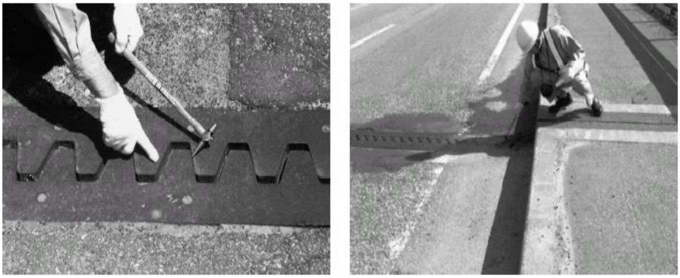


Fig.2.4.5 Inspect Expansion Joint

6) Inspect the Drainage

Look at inside the drainage. If there are many debris, Clean it as soon as possible

Fig.2.4.6 Inspect Drainage

7) Inspect Entire Deck Slab

Fig.2.4.7 Inspection of Deck Slab

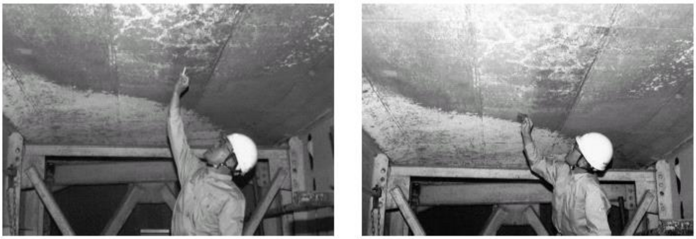


Fig.2.4.8 Inspect Deck Slab (center of span)

8) Inspect all Concrete Girders

8.1) Inspect all Girders

Fig.2.4.9 Inspect all Concrete Girders

8.2) Inspect Concrete Girder at Center of Span


Fig.2.4.10 Inspect Concrete Girder (center of span)

Look for the transverse direction's cracks at bottom of concrete girder. These are flexural cracks.

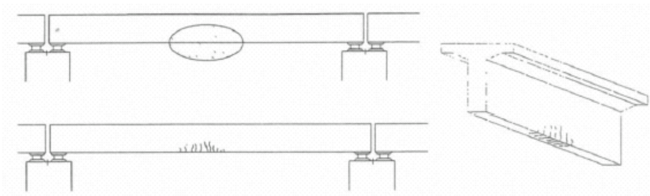


Fig.2.4.11 Flexural cracks of concrete girder

8.3) Inspect Concrete Girder at 1/4 Point of Span


Fig.2.4.12 Inspect Concrete Girder at 1/4 Point of Span

Look for the inclined crack line on the web near 1/4 point of span. These are shear cracks.

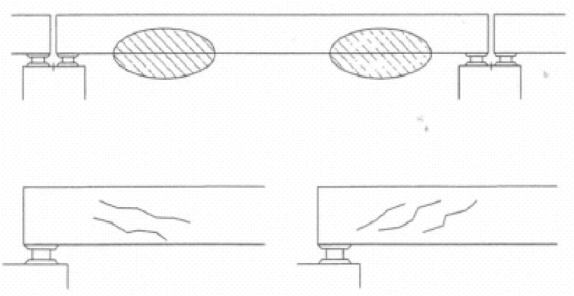


Fig.2.4.13 Shear cracks in Concrete Girder at 1/4 Point Of Span

8.3) Inspect Concrete Girder at Supporting Point

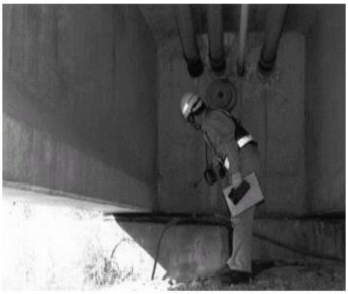


Fig.2.4.14 Inspect Concrete Girder at Supporting Point

Look for shear cracks near the bearing up to edge

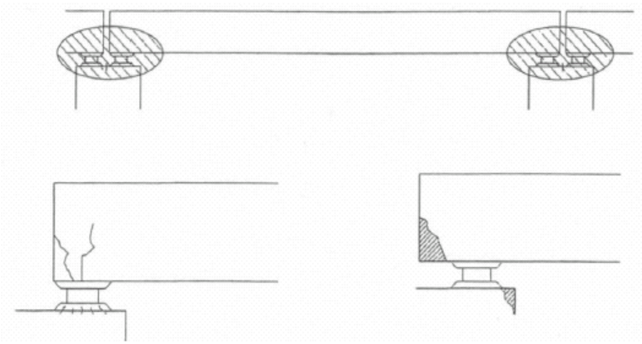


Fig.2.4.15 Shear Cracks in Supporting Point

9) Inspect Substructure

9.1) Abutments and Piers

Fig.2.4.16 Inspect Abutments and Piers

9.2) Foundations

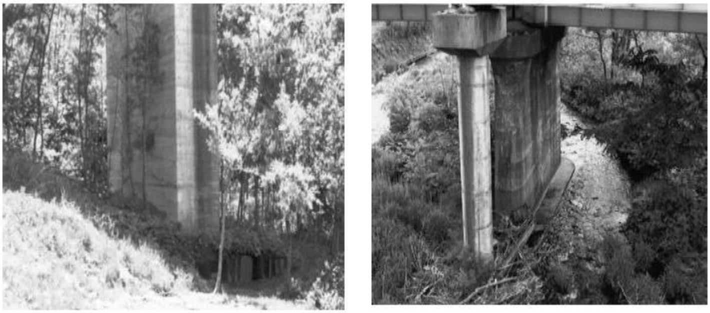


Fig.2.4.17 Inspect Foundation

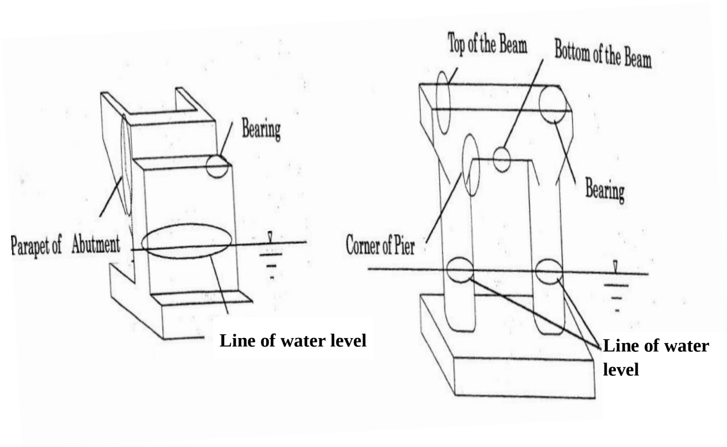


Fig.2.4.18 Defects at the focus points of Pier and Abutments and Foundations

10) Inspect Steel Structure

10.1) Entire Structure

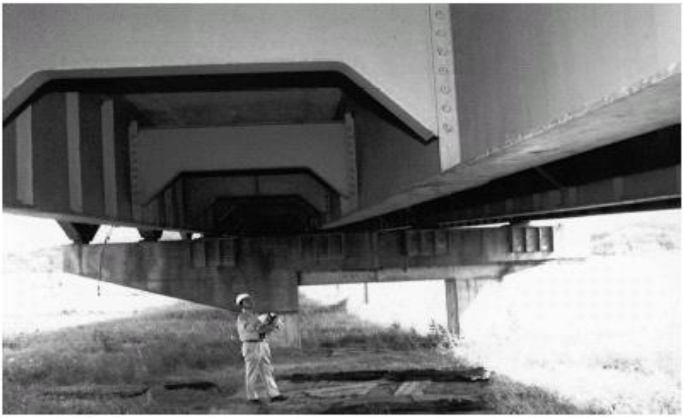


Fig.2.4.19 Inspect Entire Steel Structure

10.2) Center of Span

Fig.2.4.20 Inspect Center of Span

10.3) End of Girder

Fig.2.4.21 Inspect Ends of Girders

10.4) Supporting Point

Fig.2.4.22 Inspect Supporting Points of Steel Structure

10.5) Splice Plate

Fig.2.4.23 Inspect Splice Plates of Steel Structure

10.6) Cross Beams and Gusset Plates

Fig.2.4.24 Inspect Cross Beam and Gusset Plates

11) Bearings

11.1) Rubber Bearing

Fig.2.4.25 Inspect Rubber Bearing

11.2) Bearing Mortar


Fig.2.4.26 Inspect Bearing Mortar

11.3) Anchor Bolts of Bearings

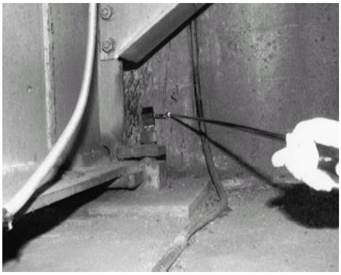



Fig.2.4.27 Inspect Anchor Bolts of Bearings

12) Expansion Joints

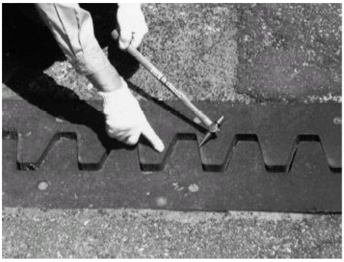



Fig.2.4.28 Inspect Expansion Joints

2.5 AT THE END OF THE INSPECTION

After finishing inspection of the bridge, review the report carefully.

- **Have you filled in all the sections?**
- **Have you made all the notes and sketches that you need to?**
- **Have you numbered all your notes and sketches?**
- **Have you written these numbers in the correct place on the form?**
- **Will the engineer be able to understand?**
- **Are there any problems not on the form, which you should tell the engineer about by writing a note?**
- **Have you taken photographs that you need to?**

When you are sure you have finished, sign the Inventory Inspection form of BMS. Also write the date of the inspection and the number of pages in your report. Make sure that the pages, including any notes and sketches, are fixed together. Then take it back to the office.

2.6 CONSTRUCTION DETAILS, SERVICES AND SIGNS

2.6.1 CONSTRUCTION DETAILS

CHECK each construction detail as well as you can and tick it as CORRECT: YES or NO.

2.6.2 SERVICE UTILITIES

The report form lists all SERVICE UTILITIES fixed to the bridge. These include electricity or telephone cables (as in the picture below), or gas, water, oil or sewage pipes.

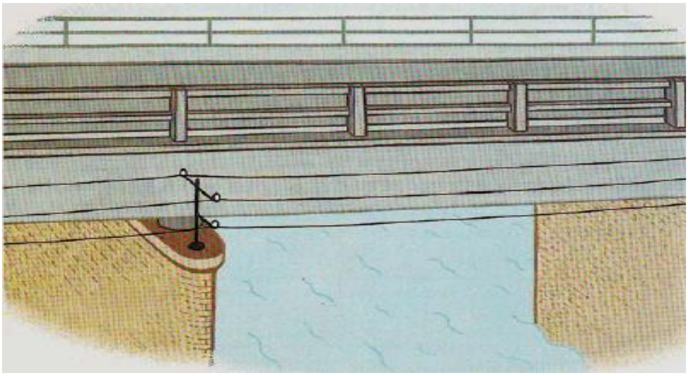


Fig. 2.6.1 Service Utility lines

CHECK that the service utility is still there. Tick under YES if it is, or ticks under NO if the service has been removed.

CHECK for new service utilities. If inspector finds out that any new services that are not written on the form, write a note to state what new services are there and note if it causes a problem.

CHECK for damage caused by the service utilities. If there is a problem make a note on the form, especially if it causes damage to the bridge. For example, a leak from a water pipe can cause deterioration.

Write a note if there is damage to the bridge and inform the service utility authority.

2.6.3 SIGNS

Signs give very important information on limits on height, width, weight and speed. The bridge can be badly damaged and may fall if a vehicle hits part of it or if a very heavy vehicle overloads it. Drivers must be able to read the signs.

Fig.2.6.2 Load Posting Sign

CHECK that each of the signs is still there. Tick under YES if the sign is still there or tick under NO if you cannot find it.

CHECK for damage to the signs. Make sure each sign is still fixed firmly and that it can still be read by drivers. Make a note of any defect on the report form.

Make a note if you find any signs that are not written on the form.

2.7 ROAD APPROACHES AND DRAINAGE

2.7.1 ROAD SURFACE NEAR BRIDGE

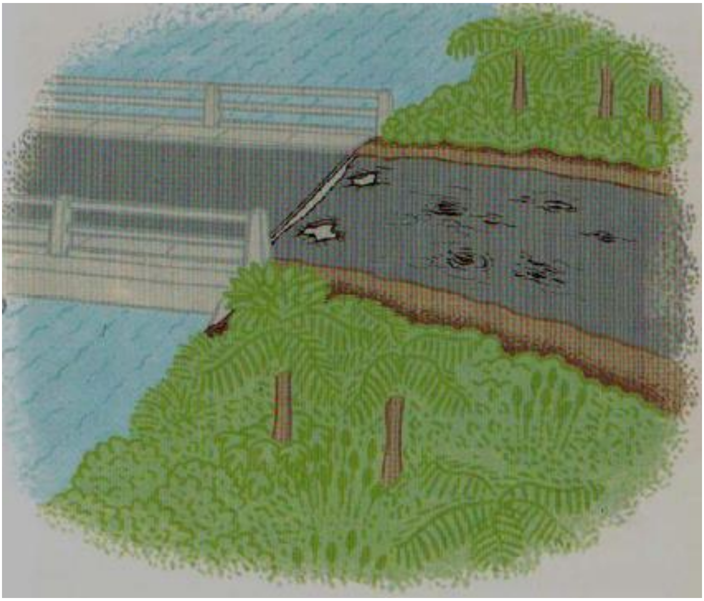


Fig.2.7.1 Surface of Approach Road

If bridge approach is not smooth, vehicles bounce up and down as they cross the bridge. This bouncing effect can damage the bridge.

CHECK for bumpy road surface. On the report form make a note if the road surface is bumpy for up to 50 meters on either side of the bridge. Look carefully at the area behind the backwall of the bridge. There is often a pothole there.

2.7.2 DRAINAGE

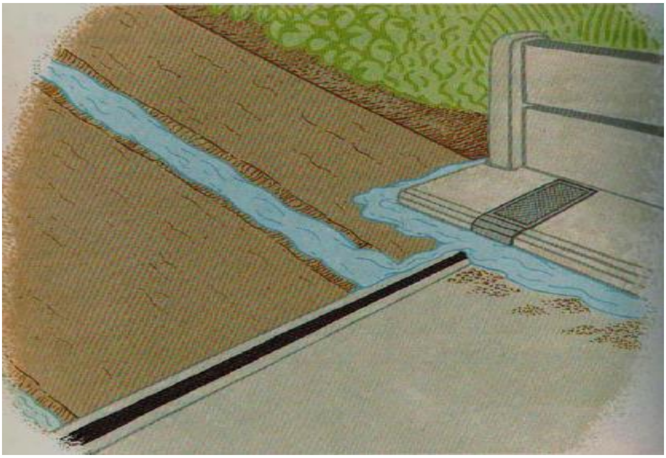


Fig.2.7.2 Drainage

Drainage is important because if water spreads to the bridge deck it may cause damage. Water can also carry small pieces of stone which may fall into the expansion joints and also cause damage. Water from the road can erode the approach embankment.

CHECK for road drainage near the bridge. Look on both sides of the bridge. Note where the drainage is bad.

CHECK for blocked or defective road drains.

Fig.2.7.3 Water Pounding on the Deck

CHECK for presence of water ponding on the deck. If the water remains on the deck, it can be a safety hazard and may cause deterioration of deck slab.

CHECK for blocked or defective deck drains. If you can see deck drains under the deck but not on top, they could be covered by asphalt surfacing or dirt. Make a note if the deck drains are blocked by road surfacing.

2.8 BRIDGE DECK SLAB AND SIDEWALK

The bridge deck can be made of concrete or steel. The surface can be sealed with asphalt.

2.8.1 ASPHALT SURFACE

At deck joints where very small movements are expected, the surfacing material may cover the joint. Often, the sealed surface cracks or breaks-up over these joints.

CHECK if the surface is breaking-up. Look very carefully near the expansion joints and near the drain holes.

CHECK for cracking of the surface above seamless joints

Fig.2.8.1 Inspect the Surface of Asphaltic Plug Joints

Some modern bridges have waterproof layer between the concrete and the sealed surface. The bridge record will indicate if a bridge has a waterproof layer. If the bridge deck surface is in good condition, this waterproof layer cannot be seen. When the sealed surface is broken, the waterproof layer may be damaged.

If you see any signs of defects to the waterproof layer, write a report.

2.8.2 CONCRETE SURFACE

CHECK for cracking of the concrete. Look again at the notes on **1.4.1.1 Concrete Deck Slab** if you are not sure how to do this.

Any cracks which begin in spalled areas of the deck are serious.

CHECK for spalling of the concrete.

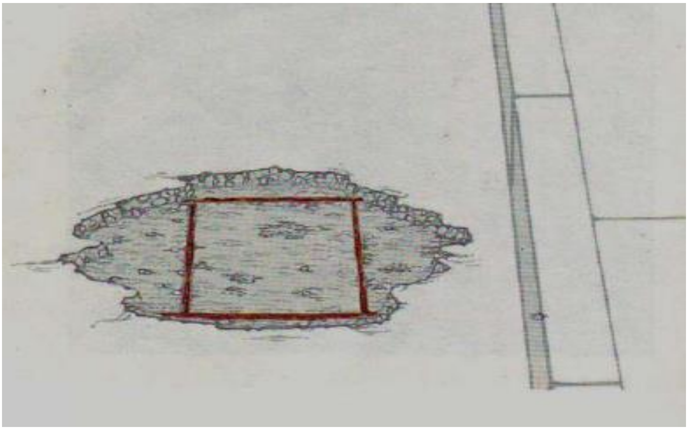


Fig.2.8.2 Spalling on the Concrete Surface

CHECK if rebar is exposed. If it is, measure and make a note of the original concrete cover to the rebars. Also, measure and make a note on how much of the reinforcing bar diameter has been lost. (More notes on this area on **1.3.1.1.3 Rebar Exposure/Corrosion**).

CHECK for quality of concrete. Look for honey-comb and other signs of poor quality concrete.

If the carriageway of the bridge is not overlain with asphalt, small stones in vehicle tires can damage the concrete surface.

CHECK for wear on the surface due to small stones wedged in the tires.

Fig.2.8.3 Defects on Concrete Surface

2.8.3 STEEL SURFACE

There are two types of steel surface used in bridges:

- Stiffened steel panels.
- Ribbed steel panels

CHECK to see if the fixings are loose or defective.

CHECK for bends in the steel panels.

CHECK for corrosion of the steel surface. Look carefully at areas near curbs and deck drains.

2.8.4 TIMBER SURFACE

Dirt, debris and plants in corners and between the boards hold water in the timber. This will damage the deck.

Fig.2.8.4 Check Debris on the Timber Surface

CHECK for dirt or plants growing between the boards. Look carefully close to curbs or running strips.

CHECK for decay of the deck timber. Look at all parts of the timber deck.

CHECK for splitting of timbers. For deck timbers, small splits are not important, but large splits should be reported.

Loose deck timbers are very dangerous on any bridge and could cause an accident.

On some bridges, the deck timber helps to strengthen the whole bridge. On these bridges it is very important that the deck fixings are good. The engineer will tell you if you are inspecting this kind of bridge.

CHECK for loose or defective fixings.

Timber running strips are often damaged, and must be replaced with new running strips.

Defective or loose running strips can cause bad accidents.

CHECK for defects (decay, insect attack, splitting) of the running strips.

Fig.2.8.5 Defects on Timber Deck Surface

This timber deck shows decay in some cross members and running strips.

2.8.5 CURBS

Curbs separate the roadway from the sidewalk.

CHECK for defective or loose curbs.

2.8.6 SIDEWALKS

Defective paving slabs or boards can be a danger for people walking across the bridge.

CHECK for defective sidewalks.

2.9 RAILINGS AND GUARD RAILS

2.9.1 GENERAL

If the bridge you are inspecting does not have a railing, tick the 'ALL CHECKED'-NO' box and write a note to say if it was not built, or if it was taken away.

Fig.2.9.1a Defects on Concrete Railings

Fig.2.9.1b Defects on Steel Railings

Railings can be damaged by vehicles. Sometimes, a part of the bridge railing is also damaged.

CHECK for impact damage to railings. Make a note if a part of the bridge next to the railing is also damaged. For steel railings, look at holding down bolts at post bases, joints in rails, and joints between rails and posts.

CHECK for loose or defective parts.

CHECK for loose post bases where steel or aluminum railings are set in holes in concrete.

Sometimes, railings are made of two materials. For example, if there are concrete posts with steel rails, report on the posts using the concrete section and the rails in the steel section.

2.9.2 CONCRETE RAILINGS

CHECK for cracking.

CHECK for spalling of the concrete. Look carefully at the corners of the posts and rails.

CHECK for corrosion of rebar. Look where concrete has spalled. Look for rust stains from cracks, especially near the corners of the posts and rails.

CHECK for deteriorated concrete.

2.10 EXPANSION JOINTS

There are many different types of expansion joints that can be used on bridges. Check the bridge record in the office, before going out to the site, to find out what kind of joint is used and where the joints are located.

Checking can be done from above, as you stand on the deck, but remember the joints when you go under the deck. Look for signs of problems and listen when vehicles pass over the bridge. You might hear the sound of loose plates or see signs of damage.

CHECK for damage on the deck end near the joint.

Joints on long bridges sometimes have several moving parts. Stones or other debris can stop some of the parts from moving.

CHECK for debris or vegetation in the joints.

CHECK for loose or defective fixings. With steel parts, this is a common problem.

CHECK for defect or corrosion to metal parts of the joint. Some joints have a rubber water-bar to stop water and debris from the deck falling through the joint. Stones falling into the joint can cut the water bar.

CHECK for defect to the rubber water-bars.

CHECK for water leakage under the expansion joint

2.11 THE RIVER

Look carefully for changes in the river. You will be able to see most problems from the deck of the bridge or standing under it by the abutments and you may walk along the banks to check the condition of the river.

2.11.1 BLOCKAGES IN THE WATERWAY

The waterway under the bridge should always be clear. Any blockage is bad because:

1. It can make the water scour a hole in the river bed and,
2. Debris can get stuck on it and make a bigger blockage.

Fig. 2.11.1 Blockage by Debris

CHECK that debris carried by a flood has not piled up against piers or abutments blocking the waterway.

Sometimes, when a new bridge is built, the old bridge is not totally demolished and cleared. Parts of the old bridge can catch debris or cause the river to scour holes around the new abutments.

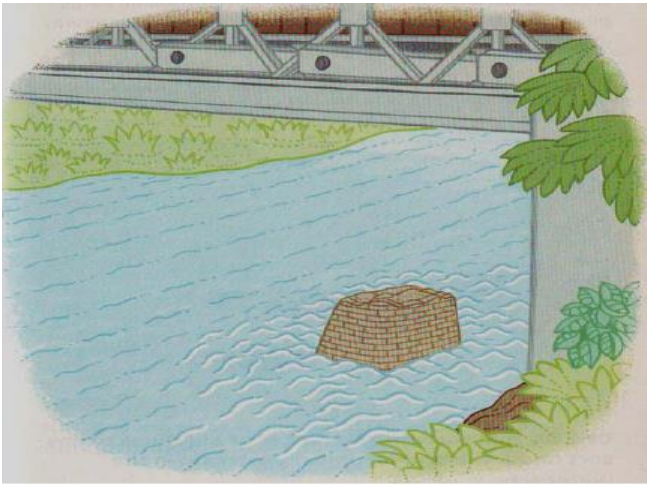


Fig. 2.11.2 Blockage in the river

CHECK that the waterway is not affected by the remains of old bridges

For many bridges, some of the waterway is usually dry, except during floods. Sometimes, people put fences and buildings on the dry areas of the waterway. These must be removed because they will block the waterway. The dry areas of the waterway are often covered with grass and small plants, such as rice which do not pose problems. However, large plants and trees can block the waterway during floods. They must be removed.

Fig. 2.11.3 Blockage under the Bridge

CHECK that there are no fences or buildings of any sort under the bridge, or just upstream of the waterway.

CHECK that there are no trees or bushes growing under the bridge or just upstream where a flood can wash them under the bridge.

2.11.2 CHANGE OF RIVER PATH

If the river changes its path it can destroy the bridge.

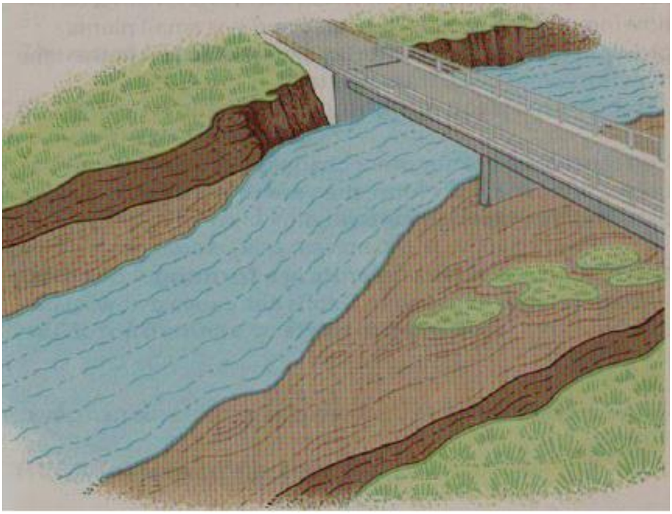


Fig. 2.11.4 Check the River Path

CHECK if the river is changing its path upstream from the bridge.

To find out if a river is changing its path:

- Ask the local people.
- Look at the bends in the river upstream from the bridge.
- Look at the river banks on the bends.

Usually you can see far enough upstream from the bridge. Sometimes you may need to go further upstream a short distance.

If the bank is steep and there are trees at the edge of the bank, but nothing is growing on the bank, then the river is moving towards that bank. When there is a lot of water flowing and the bank is not steep and has small plants growing on it and some mud or small stones on it, then the river is moving away from that bank.

You must also look for other changes upstream of the bridge. If new islands form, then the river may change its path and may damage the bridge.

CHECK to see if new islands are forming. Look if there is debris in the river. Debris can cause a new island to form.

2.12 SUPERSTRUCTURE

Bridge superstructure such as concrete/steel beams and girders, trusses and deck slab must be inspected thoroughly. Inspector must take special attention on truss bridges whether supports are above or below the deck slab.

While doing inspections above or below the bridge, observe structural defects of other bridge elements.

2.12.1 GENERAL

Bridges are often damaged by vehicles hitting the girders or trusses. Even small bends and cracks in steel/concrete girders and trusses can be serious. Sometimes, during floods, boats or other floating debris like logs hit a bridge and damage it.

CHECK for impact damage to girders, beams, trusses or bracings by vehicles, boats or logs. Take note of how the damage was caused

CHECK for debris or vegetation on beams, girders, trusses, bracings or in joints. These may cause serious damage to the bridge.

If the underside of the bridge deck is wet, this may cause further deterioration.

CHECK that there is no water leaking through the bridge deck, except through the proper drains.

If the underside is dry, there may still be a problem. Look for signs of water leakage:

- On steel parts, look for rusty marks.
- On timber, look for dark water run marks.

- On concrete, look for dark areas and buildup of white marking (efflorescence) on the surface.

CHECK if water from the deck drainage flows to the girders, beams, trusses or bracings.

For a bridge which carries a road over another road, it is important that there is enough vertical clearance.

Adding more layers of bituminous surfacing materials on the road shortens the vertical clearance.

CHECK the vertical clearance for flyover. Measure the vertical clearance from the surface of the road below to the underside of the bridge superstructure. Write the least measurement in the box on the inventory inspection form.

2.12.2 GIRDERS, MAIN BEAMS, TRUSSES AND BRACINGS

2.12.2.1 Concrete Girders/Beams

CHECK for cracks on the concrete. If there are cracks, trace and measure the length and width and record the crack with maximum width. Make a sketch and include it in the report. On the tracings of the crack on surface of concrete member, mark and put date at the end of the crack. Check if any crack have progressed since last inspection.

Look carefully for:

1. Cracks at the girder ends which spread up from the bearings as shown in the figure below. These cracks pose serious problem.

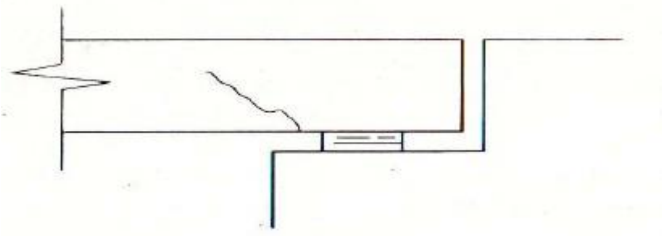


Fig. 2.12.1 Shear Crack on the Girder

2. Check for cracks on the face of the girder. These types of cracks that happen at the corner of the girder start spalling. Look carefully at these cracks and tap the concrete firmly to see if there is spalling. Mark the ends of the crack and make a sketch.

CHECK for spalling of the concrete.

Fig. 2.12.2 Spalling of Concrete

CHECK for signs of corrosion of rebar. If rebar is visible, measure and record depth of concrete cover. Measure and compute section loss of the rebar.

CHECK for signs of honeycomb. Look especially at the bottom corners of deep concrete girders:

Fig. 2.12.3 Honeycomb of Concrete Girder

2.12.2.2 Steel Girders and Bracings

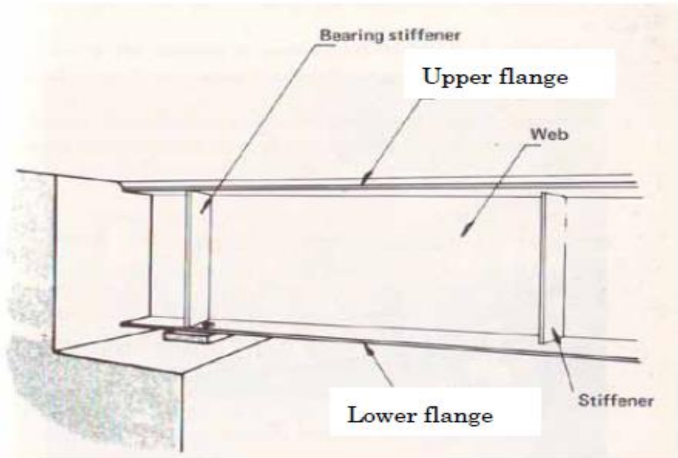


Fig. 2.12.4 Parts of a Steel Girder

CHECK for deterioration of paint or zinc-coating on all main girders and cross beams.

CHECK for corrosion of the steel. Inspect thoroughly any wet areas. On most bridges, there are debris on the bearing shelves that keep areas wet. Look very carefully at the girder ends. **Most steel Deck Girders corrode badly at the ends near the bearings.**

The picture below shows serious corrosion which might cause buckling of bearing stiffener due to section loss of web plate.

Fig. 2.12.5 Serious Corrosion at the Bearing

Three (3) major problems caused by corrosion are:

- Laminations in steel (see 1.4.4.1 Corrosion).
- Buckling of bearing stiffener.
- Steel sections joined by rivets or bolts being forced apart. If this has happened, check all bolts or rivets in the joint. Take note of flaking and delamination or other defects caused by corrosion.

Overloading can cause deformation of girders. Deformation can be observed at the edges of girder flanges. Deformation in girders or beams is a critical structural problem. Look for deformation in the STIFFENERS above the bearing. Make a sketch of the defect and show which part is damaged.

CHECK for deformation in webs and flanges of girders, stiffeners and bracings. If possible, measure the size of all deformations. Place a straight edge or string line next to the defective member and measure from this to the girder.

CHECK for loose bolts or rivets. Mark on the structure all loose bolts or rivets with a waterproof pencil or paint. Make a sketch of the girders and mark the joints which have loose bolts or rivets.

CHECK for cracking especially at welds and rivet holes. If there are any cracks, record and draw a sketch. Cracking is a serious defect.

2.12.2.3 Steel Truss

This section covers through trusses and half-through trusses, excluding Bailey bridge panels.

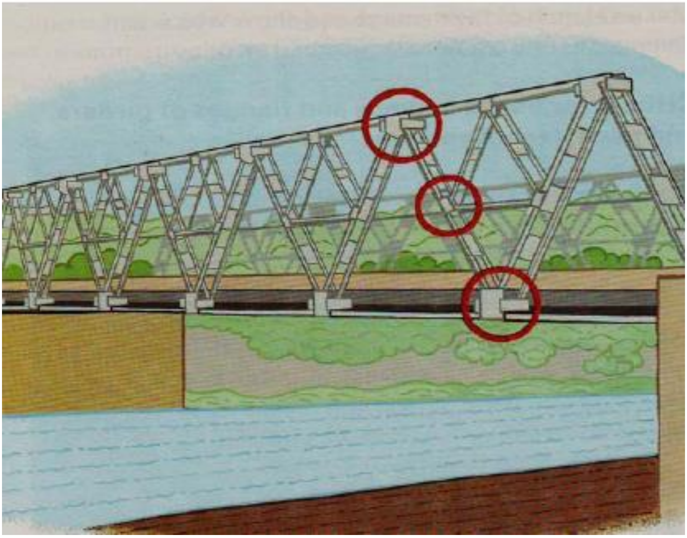


Fig. 2.12.6 Steel Truss Bridge

CHECK for deterioration of paint or zinc-coating. Look carefully at all parts like the ones circled on the figure above.

CHECK for corrosion, especially at the joints in the truss. The bottom chord joints often corrode first. If there are signs of corrosion, especially near joints, check that plates are not delaminated (see 1.4.4.1 Corrosion). Look for signs that corrosion is forcing the plates apart.

CHECK for Deformation in truss members. Make a sketch of the truss and mark any deformed members. Using a straight edge or string line, measure the dimensions of the deformation and mark it on the sketch.

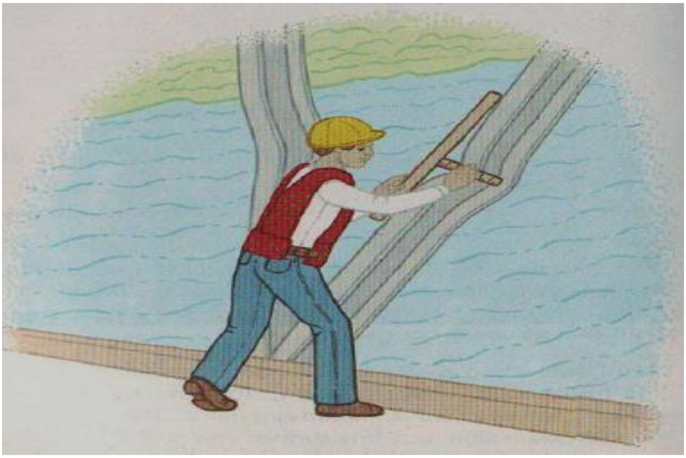


Fig. 2.12.7 Measuring the Deformation

CHECK for deformation or defective joints. Make a sketch of the truss and mark all defective joints.

CHECK for deformation or defective bracings. Measure the deformation and sketch the pattern of bracing system. Mark defective member on the sketch. Deformations can be measured as shown below.

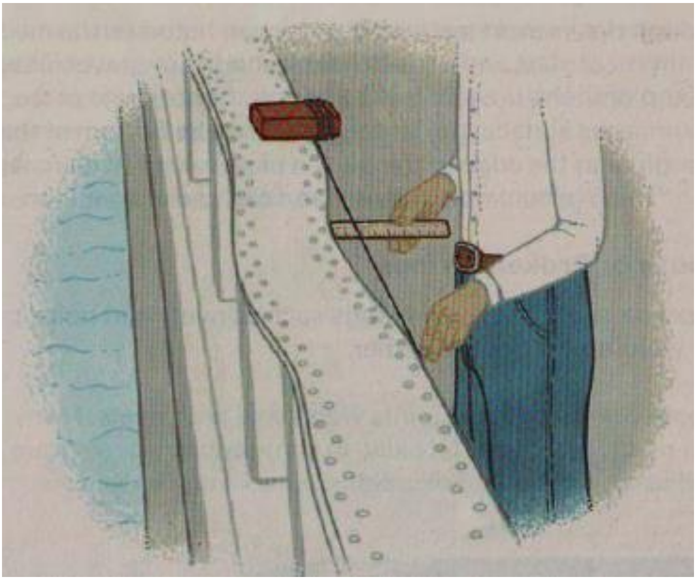


Fig. 2.12.8 Measuring the Deformation

CHECK for loose bolts or rivets. Check all bolts or rivets in defective or corroded joints. On the structure mark all loose bolts or rivets with paint. On a sketch of the truss, record the joints with loose bolts or rivets.

If there are loose, defective or missing bolts or rivets in a joint, look carefully along the line of the truss to observe if the top chord has been deformed. If there is deformation, measure and record the displacement using a string line as shown in figure above.

Cracking is very critical as it can lead to rapid collapse. The engineer should instruct which areas must be checked during each inspection.

CHECK for cracking of the steel, particularly at welds and rivet holes. If there are cracks, record and make a sketch to show the location of the cracks.

2.13 UNDERSIDE OF DECK

2.13.1 CONCRETE

CHECK for cracking of concrete. Make sketches of any cracks wider than 0.30 mm, or cracks over a wide area. Trace, mark and put date the ends of such cracks, note any white deposits (efflorescence), and check if cracks have progressed since the last inspection.

CHECK for spalling of concrete.

CHECK for corrosion of rebar. Note any rust staining. Where concrete has spalled, measure the depth of concrete cover and compute section loss of rebar due to corrosion. Make a sketch to show the location of corroded rebars, areas of spalling, the patterns of cracking and rust staining.

CHECK for honeycomb. Draw a sketch showing the location and size of honeycomb areas and areas which are wet.

CHECK for insufficient concrete cover. If the cover is insufficient, the pattern of rebar can be seen on the surface of the concrete.

2.13.2 STEEL

This section refers to the underside of stiffened steel decks, for steel arch decks (buckle plates) and for trough decks.

CHECK for deterioration of paint or zinc-coating.

CHECK for corrosion of steel. Inspect thoroughly any wet areas specially at the bottom of the troughs and edges of steel arch decks. If there are delaminations or other signs of corrosion, record on the form.

CHECK for deformation in stringers or plates. If there is deformation on the surface of the steel deck, look carefully at the underside of the deck below the deformed section. The stringers which carry the deck may have deformed.

On steel arch decks deformations in the plate of the arches are very critical.

CHECK for loose bolts or rivets.

CHECK for cracking of the steel, especially at welds and rivet holes.

2.13.3 BEARINGS

This section covers all types of bridge except Bailey bridge.

Bearing shelves are often wet places in which debris and vegetation collect.

CHECK for debris or vegetation around the bearings and on the bearing shelf. Remember, even small amounts of debris on the bearing shelf may cause damage to the bearing, especially if the drainage to the bearing shelf is not functioning properly.

CHECK for poor drainage to the bearing shelf. Look for signs that water stays on the shelf during rainy season.

CHECK if the bearings are properly seated on the bearing seats.

CHECK if the bridge span is properly seated on the bearings.

CHECK for defective bedding mortar. Look for cracks around the edges and pieces of mortar which have broken off or crushed. Remove the soil and vegetation from the bearing to see it.

2.13.3.1 Rubber Bearings

Some rubber bearings have steel plates inside. If the steel inside is visible, it is already defective.

CHECK for splitting, tearing or cracking of the rubber.

Fixed bearings usually have a pin or bolt fixing the girder to the support. On concrete bridges, it is not possible to see the pins used in the fixed bearings. They cannot, therefore, be checked. On steel girders the heads of the bolts or pins can usually be inspected.

CHECK for defective or lose bolts or pins at fixed bearings on steel girder bridges.

2.13.3.2 Steel Bearings

Look carefully at the bearings to determine the type of Steel Bearing being inspected.

The picture shows a typical simple steel sliding bearing. Note the corrosion caused by debris on the bearing shelf.

Fig. 2.13.1 Bearing Corrosion due to Debris

CHECK if any of the bearing parts are properly seated.

If debris are trapped in the moving parts of a bearing, they can cause damage and stop its movement.

CHECK if any moving parts are free to move.

Check if debris have accumulated in the bearing. Inspect the surface where the bearing should move. Usually there is a narrow clean area where the bearing moves.

Some rocker or roller type bearings, and bearings where steel slides on bronze have LUBRICATION SYSTEMS.

CHECK for problems with the lubrication system. If there is damage on the lubrication system record it on the form.

Sliding surfaces must be in good condition for a sliding bearing to work.

CHECK if the sliding surfaces are defective. Look carefully at the sliding surfaces. Even a small amount of corrosion on a sliding surface will hinder its movement that can damage the bridge.

2.14 MASONRY ARCHES

CHECK for change of shape of the arch.

1. Observe the arch from a distance. Compare if the shape of the left side of the arch is symmetrical with the right side. Any difference means the arch has changed its shape.
2. Look at the center stone on the face of the arch. If this has moved out of line, the arch is weakened.
3. Go under the arch and check if the barrel had changed shape from that of the face of the arch (This often happens)

4. Look at the other face to see if the arch has changed its shape or if the center stone has moved.

Mark the location of any change of shape on a sketch. If possible, estimate the extent of change of shape, and record it.

In this picture below, there is a crack in the spandrel wall and the arch has changed shape.

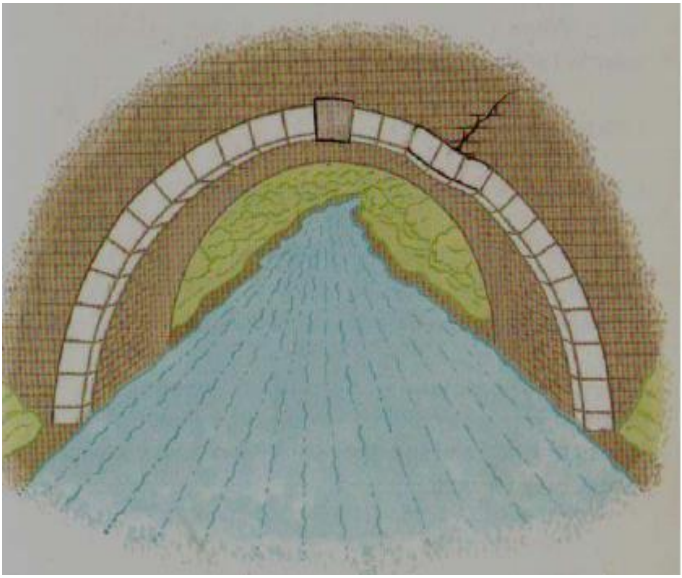


Fig. 2.14.1 Crack and Shape of the Arch

CHECK for cracking of the arch barrel. On the report form, sketch any long cracks which run through the arch.

If the parapets are damaged due to vehicle impact or traffic movement, check that the spandrel walls under the parapet have not been pushed out or cracked by the impact.

Where a road crosses an arch bridge there is sometimes a hump which when hit by fast-moving or heavy vehicles pushes the spandrel walls outside. This causes the spandrel wall to crack, bulge and separate from the arch which results in a gap in the masonry between the arch barrel and the spandrel wall.

CHECK for cracking or bulging of the spandrel walls. If there is a crack or bulge, make a sketch of each face of the arch and spandrel walls. Mark any cracks or bulges on your sketch.

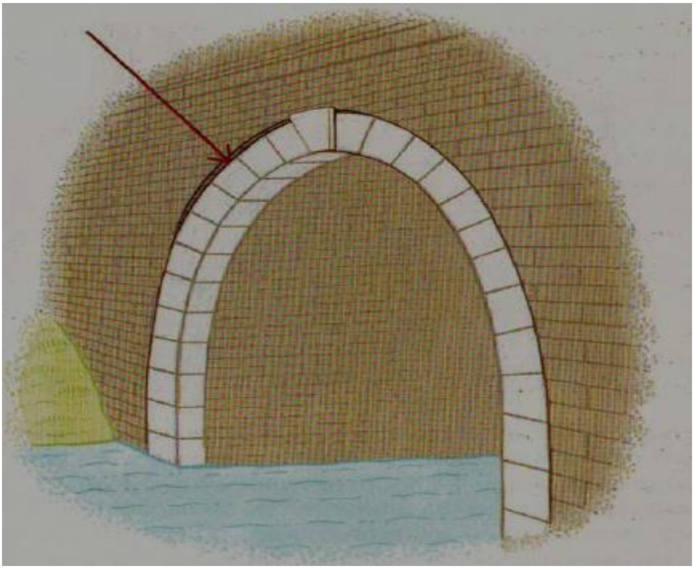


Fig. 2.14.2 Gap between Spandrel Wall and Arch

CHECK if the spandrel wall has separated from the arch, as in the picture above.
CHECK for spalling of the stones or bricks of the arch and spandrel walls.

CHECK for poor mortar.

Fig. 2.14.3 Water Leakage from Arch

The materials of an arch will gradually deteriorate due to the effects of water and temperature change. Most arches leak some water through them. A minimal amount of water may not a problem but if the leak is bad then the bridge will be damaged. If a lot of water is leaking through the arch, there will see white stains near the joints.

CHECK for water leaking through the arch. All masonry arch bridges have spread foundations. If an arch foundation settles, the bridge will be badly damaged. Scour can cause settlement.

CHECK for scour under the arch foundation. Use a long pole to feel if there is scour. If you can push the pole into the ground under the arch foundation there is a bad problem.

2.15 BAILEY BRIDGE

Fig. 2.15.1 Bailey Bridge

Different types of bridges have been made using Bailey panels. Design details have changed over the years and different strengths of steel have been used.

If some parts are removed, the Bailey bridge may still look safe but it could fall when a heavy vehicle crosses it since it is no longer structurally sound and safe. Check thoroughly to make sure no parts are missing.

The drawing below shows most of the parts of a typical Bailey bridge.

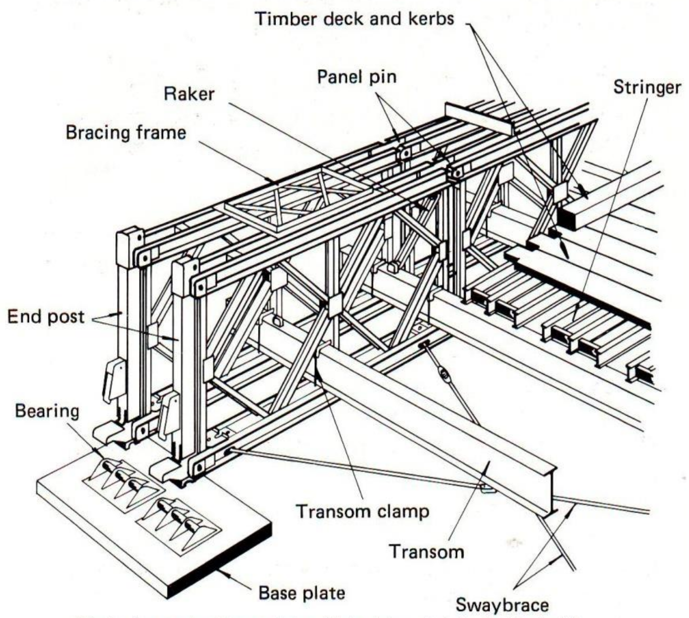


Fig. 2.15.2 Parts of a Bailey bridge

On single span Bailey bridges, panel pins usually stay in place. Unlike on multi-span bridges (two or more spans), when the bridge moves under traffic, panel pins can be moved. The panel pins can even loosened and fall out if the SAFETY PIN is missing. This is most likely to happen about one quarter of the span away from a pier.

CHECK for missing safety pins.

CHECK for missing panel pins.

CHECK for missing or loose bolts. The bolts that hold on the CHORD and hold together DOUBLE STOREY BRIDGES are very important.

CHECK for missing rakers and tie plates. Some bridges use vertical bracing frames instead of rakers.

CHECK for missing or loose sway braces. Check that the pins are in place and that the lock nuts are screwed up.

Some Bailey bridges have horizontal bracing frames on the top chords of the panels.

CHECK for missing, loose or defective horizontal bracing frames.

CHECK for missing or loose transom clamps. Bailey bridges move a lot when vehicles cross them. This causes wear, where the stringers sit on the transoms.

CHECK for wear at the stringer to transom seating.

CHECK all Bailey panels for cracking. This picture shows where you should look for cracks.

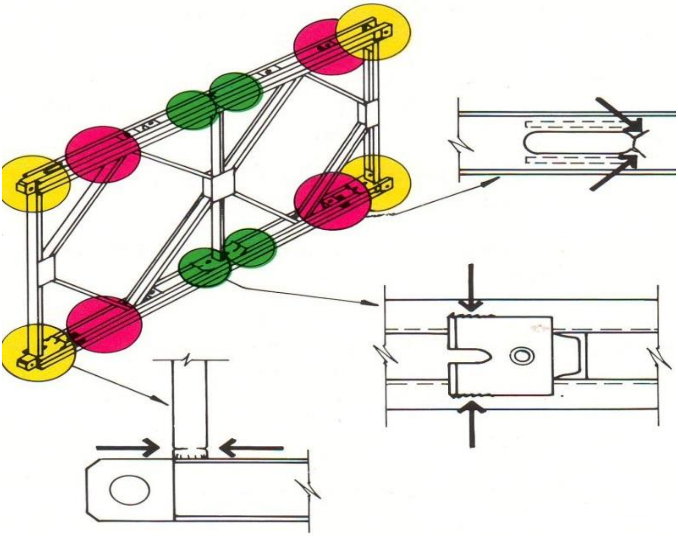


Fig. 2.15.3 Check Points of Cracks for Bailey Panels

All these places must be checked on each panel at each inspection.

CHECK for deformation in bridge members. Note where the defect is and make a sketch.

CHECK for corrosion. There are some areas on a Bailey bridge where dirt and moisture accumulate. They are usually found at the:

1. Bearings
2. Base of the rakers
3. Bottom chord near the spacer plates and where the diagonal members are hinged.
4. Panels and transoms near where the transom sits on the bottom chord.

Bailey bridges are made of series of panels, so it is not easy to make a sketch showing where a problem is found. If there is a damaged panel, or if it has any other problem, mark it with paint and assign it a number. In filling the report form write the number in the column for Inspector's Comments/Remarks.

CHECK for settlement of the bearings.

CHECK for defective bearings and base plates. All Bailey bridges sag a little at the middle of the span, and some are bent sideways. The drawings below show how to measure the vertical sag and the horizontal bend.

Look along the top of the panels on one side of the bridge. You will need an assistant to help in measuring the sag and the bend with a ruler and measuring tape.

Write on the report form the biggest measurement of vertical sag and the biggest measurement of horizontal bend on the upstream side of the bridge. Then measure the sag and bend on the downstream side of the bridge and write these measurements on the report form.

Fig. 2.15.4 Measurement of Sag & Horizontal Bend

2.16 ABUTMENTS, WING WALLS AND RETAINING WALLS

2.16.1 GENERAL

The most common major problem with abutments is scouring. If the river flow scours the foundations or the bank in front of the abutment, the abutment will move and the bridge may even fall. This photograph shows how a river can quickly scour under an abutment, causing it to move and displace the deck. Scour should be reported as soon as it starts, so that the defect can be repaired before it gets bad.

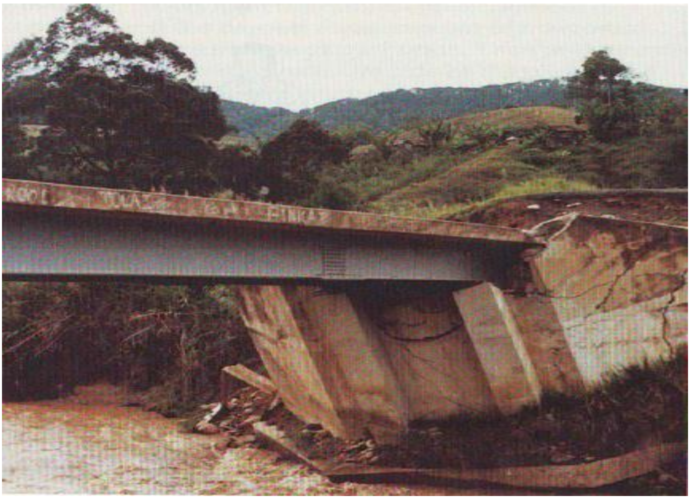


Fig. 2.16.1 Scouring of Abutment

Bank seat abutments can be easily damaged if the bank under them is scoured by the river flow or eroded by rain water, so inspector must check carefully for scour or erosion near bank seat abutments.

The picture below shows scour under a piled abutment:

Fig. 2.16.2 Scour under the Foundation

CHECK for erosion and scour near the base of the abutment, or scour of the bank in front of the abutment. If the water is not low enough or clear enough to see, then use a long pole to feel if there is scouring.

CHECK for defects of caissons, or corrosion of steel piles, if visible.

CHECK for movement of the abutment. Look for disturbance of the ground around the abutment. If the abutment has moved or settled, there are often cracks in the soil. There may even be cracks on the road behind the abutment.

In a flood, debris against the abutment can cause damage to the abutment or the bridge superstructure. Debris can also cause the river flow to scour the soil around the abutment.

CHECK for debris on or against the abutment.

Fig. 2.16.3 Vegetation on Abutment

CHECK for vegetation growing on or in the abutment. Look in cracks or drains in the abutments, or in cracks between the abutment and wing walls or retaining walls.

CHECK for scour near the retaining walls.

CHECK for signs of movement (sliding forward or settlement) of retaining walls.

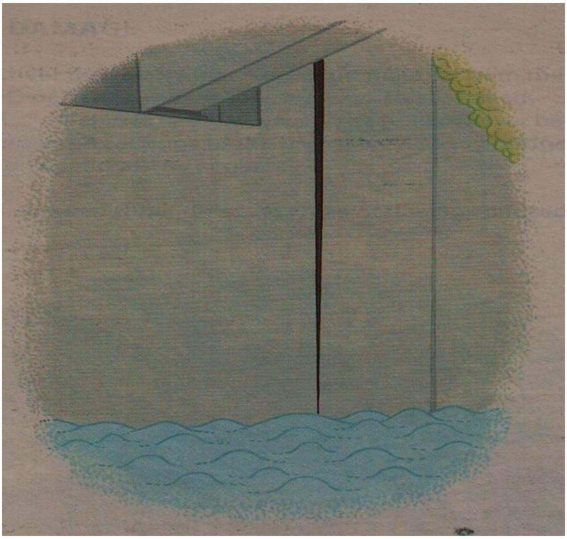


Fig. 2.16.4 Settlement of the Wall

Look for:

- a gap between the retaining wall and abutment.
- damage to the road or the embankment supported by retaining walls.

CHECK for signs of water leaking down through the expansion joint.

2.16.2 DRAINAGE SYSTEM

Look at the abutment and the retaining walls. Look for signs that the drainage system is not working properly.

CHECK if there are enough weepholes. As a general guide, weepholes should not be more than 2 meters apart, measured both horizontally and vertically in a staggered manner. If the water coming out of the weep-holes washes away the soil in front of the abutment then there are not enough weepholes.

CHECK if the weepholes are functioning. Look for signs such as:

- Insect nests in the weepholes, if there are, then the weepholes may not be functioning.
- Water stains below the weepholes, then the weepholes are functioning

Water may find other ways through the abutment if the drainage system is blocked.

CHECK for water leaking through the abutment. Look for dampness or white stains at cracks or at construction joints.

2.16.3 CONCRETE ABUTMENTS, WING WALLS AND RETAINING WALLS

CHECK for cracking of the concrete. Make a sketch showing the location of cracks which are wider than 0.3 mm or those where water has leaked through. Look carefully for cracks:

- on pile caps
- where wing walls connect to the abutment
- around parapet posts
- near bearings, even thin cracks can be significant, so draw all cracks near bearings

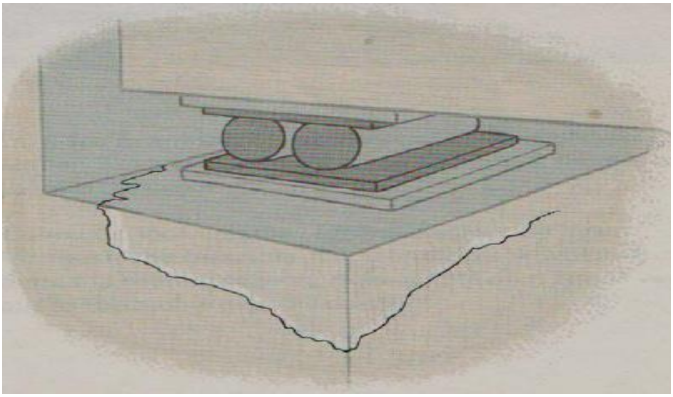


Fig. 2.16.5 Cracks near the Bearings

CHECK for spalling of the concrete. Mark spalled areas on a sketch.

CHECK for corrosion of rebar. Look for rust stains from cracks and look where concrete has spalled. Where concrete has spalled, measure the concrete covering, and compute for section loss.

CHECK for quality of concrete. Look for honeycombing and signs of chemical attack.

2.17 EMBANKMENTS AND FILL IN FRONT OF ABUTMENTS

2.17.1 GENERAL

If the base of the embankment is scoured, the slope will become unstable.

CHECK for scour at the base of slopes.

Fig. 2.17.1 Slope Erosion

Where scour happens, the embankment fill may slip down, as shown in the photograph above.

CHECK for slip of embankment fills.

If rainwater from the approaches to the bridge is not properly drained, it may run down the face of the embankment and it might wash away the embankment fill. This can damage parts of the abutment or wing walls.

CHECK for erosion of the fill near the abutment. Cracking of the road, or embankment edge, behind a retaining wall, might be a sign that the wall has moved due to water seepage.

CHECK for cracking of the road or embankment edge. If there is a deep hole in the embankment behind the abutment then, a small circular hole, called a 'pipe' will appear at the road surface, or in the embankment edge, as in the photograph below. This called a 'piping failure' and it indicates that embankment material is being lost from around the abutment.

CHECK for piping failures of the embankment fill behind the abutment.

Fig. 2.17.2 Piping Failure near Embankment

2.17.2 PILED WALLS

Piled walls are used at the toe of embankments to prevent the river flow from scouring away the fill around the abutment. Piled walls can be made of steel (usually sheet piles), or timber (usually logs), and sometimes concrete.

CHECK for forward movement of the piles caused by river scour. If large sections of the wall have significantly moved forward, the problem is serious. Small movements are not serious.

CHECK for deterioration of the piles:

Steel piles:	look for corrosion.
Timber piles:	look for decay.
Steel and timber piles:	look for damage caused by debris
Concrete:	look for cracking and exposed rebar.

2.17.3 GROUTED RIPRAP SLOPE PROTECTION

Grouted riprap is one way of protecting the surface of a slope from being washed away by surface run-off.

If the embankment significantly settles, the grouted riprap may crack and eventually collapse. Small cracks are not serious.

CHECK for cracking of the grouted riprap. Make a sketch of any cracks wider than 5 mm so that the inspector can check if the crack is getting wider or longer.

CHECK for insufficient grouting. If the mortar grout is insufficient, the grouted riprap will crack.

CHECK for scour or erosion at the edges of the grouted riprap. The bank behind the grouted riprap may be scoured by the river flow, or eroded by water running down the slope.

Fig. 2.17.3 Erosion of Grouted Riprap

CHECK for pieces broken off the grouted riprap. If the grouted riprap has been badly undermined, pieces may break off.

2.17.4 GABION SLOPE PROTECTION

Gabions mattresses are often used to protect slopes from being washed away by rain water running off the road, or by the river flow.

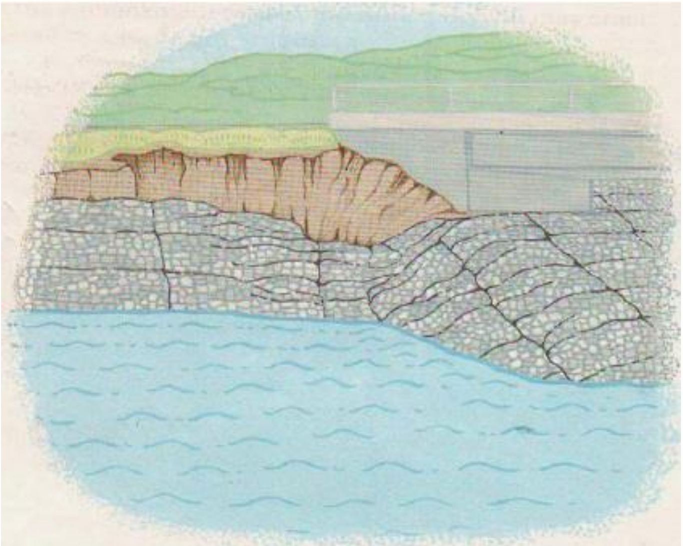


Fig. 2.17.4 Movement of Gabion Slope Protection

Gabions can move without being damaged, but the slope protection must still be stable.

CHECK for too much movement of gabions. Make a note if:

- The slope protection has settled so far that the top of the slope is not protected (the road edge may have cracked).
- There is severe scouring at the toe of the slope.

CHECK for damage of gabion wires and tie wires. The wire mesh which makes up the gabion boxes and the tie wires must be in good condition.

2.17.5 RIPRAP SLOPE PROTECTION

For riprap to be effective, the stones must heavy enough to withstand river flow.

CHECK if the riprap is being washed away.

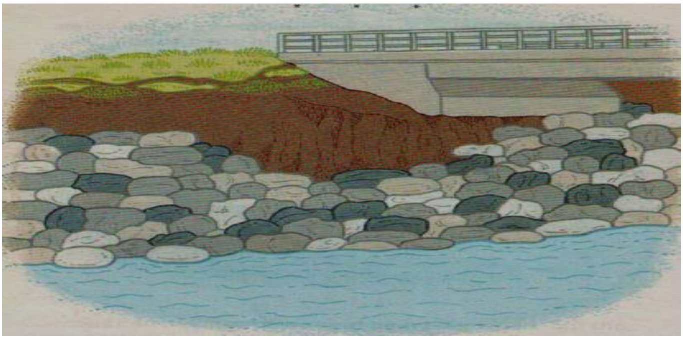


Fig. 2.17.5 Riprap Erosion

CHECK for settlement of the riprap. As the river scours the embankment the riprap will sink into the river bed.

2.18 BED PROTECTION

It is important that the river bed under a bridge is not damaged by river flow.

CHECK for large holes or cavities in the river bed under or near the bridge.

If the river flows fast and the river bed is soft, the bed may be protected with:

- concrete blocks
- gabions
- riprap

2.18.1 GROUTED RIPRAP OR CONCRETE BED PROTECTION AND APRONS

River flow often scours at the edge of the bed protection. Small scour holes are not significant but if a hole goes under the bed protection, it should be reported.

CHECK for scour at the edge of the bed protection. Make a note of where the scour is and draw a sketch.

Cracks in the surface of bed protection are usually because of settlement.

CHECK for cracking. For mass concrete and grouted riprap, report only large cracks. For reinforced concrete, report all cracks.

To find cracks, first use a spade to scrape off any sand or debris. Then look carefully for any cracks. If there are cracks, draw a sketch of them.

CHECK for any signs of spalling of concrete or stones missing from grouted riprap.

CHECK for erosion of the surface of the concrete or grouted riprap. Stones carried by the river flow often cause erosion of the surface of the concrete.

CHECK for corrosion of rebar. If there is spalling in the reinforced concrete bed protection, the rebar may be corroding.

2.18.2 GABION BED PROTECTION AND APRONS

Gabions mattresses used as river bed protection have a very big advantage due to their flexibility, so that when scour takes place, the edge of the gabion drops down to fill the scoured portion.

Because of this, scour is not usually a problem when the gabions are in good condition.

CHECK for signs that the gabions have broken away from the pier or abutment. If this happens the river could destroy the bed protection very quickly.

CHECK for damage to gabion wires or ties. Look carefully for broken wires or corrosion of the wires.

2.18.3 RIPRAP BED PROTECTION AND APRONS

Riprap is often used to prevent scouring of pier foundations. It is necessary to replace riprap lost during floods, or which has settled into the river bed.

CHECK for loss of riprap. If a portion of the riprap has been lost, make a sketch. If it is less than the last inspection, more riprap might be needed.

2.19 PIER

2.19.1 GENERAL

Different kinds of piers are shown in the BMS manual. To inspect the piers on some bridges you may have to use a boat or Bridge Inspection Vehicle.

Fig. 2.19.1 Scour of the Pier

CHECK for scour near the base of the pier. If the water is not low enough or clear enough to see, then use a long pole to feel if the river has caused scour. If you can feel under the base of the pier then the scour is serious.

The photograph above shows severe scouring under the piled piers foundation. If the caissons or steel piles are exposed they may be damaged by corrosion.

CHECK for damage to caissons or steel piles

A pier will move if its foundation fails due to scour, or due to overloading of the bridge. It may also move due to impact from a boat or due to an earthquake. Movement of the pier can cause:

– One expansion joint to close and the other expansion joint to open

– Damage to a continuous superstructure.

CHECK for movement of the pier.

To do this:

– Look along the alignment of the piers to see if one is out of line.

– Look along the top of the bridge to see if the bridge is on a smooth line. If there is a depression at a pier then there is settlement.

– Look carefully at the expansion joints and bearings.

CHECK for impact damage due to boats, floating logs, or vehicles. Boats or floating logs can damage piers. Vehicles can damage the piers of bridges over roads.

Fig. 2.19.2 Debris against the Pier

CHECK for debris against the pier. Small branches are not a problem unless there are a lot of them.

CHECK for vegetation growing on the pier. There may be an expansion joint in the bridge deck above a pier. If water leaks down past the expansion joint in the bridge deck and gathers near the bearing, it can do a lot of damage to the bridge. Water leaking through the expansion joint can be seen under the bridge.

CHECK for water leaking through the expansion joints.

2.19.2 CONCRETE PIERS

CHECK for cracking of the concrete. Make a sketch showing where significant cracks are located.

Look carefully for cracks:

- around bearing
- in pile caps
- in beams over columns.

CHECK for spalling of concrete. Mark spalled areas on a sketch.

CHECK for corrosion of rebar. Look for rust stains from cracks and look where concrete has spalled. Where concrete has spalled, measure the concrete covering, and compute for section loss.

CHECK for defective concrete. Look for honeycombing and signs of chemical attack.

2.19.3 MASONRY PIERS

Cracks in masonry piers are sometimes caused by failure of the foundation. These cracks are usually long and go deep into the pier. Cracks around bearings may be caused by traffic loads or by the ‘free’ bearing not being able to move.

CHECK for cracking of the masonry. Record any long and wide cracks, and cracks near bearings. If you find a crack which goes all round a bearing, record it on the report form. This is very serious as the bridge may collapse.

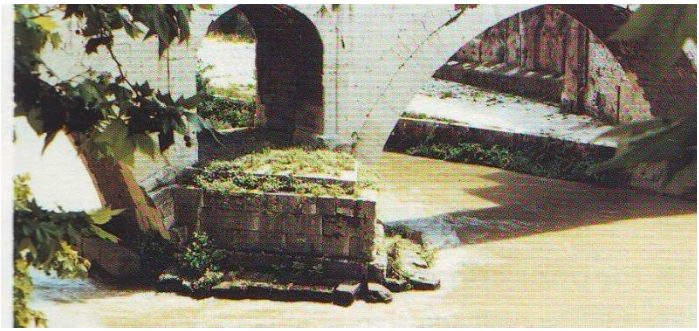


Fig. 2.19.3 Cracking of the Masonry Pier

CHECK for poor grouting. Brickwork and masonry in a pier can lose some of its mortar due to strong river flow. Later, bricks or stones may be washed out. This can be serious, as the pier is weakened.

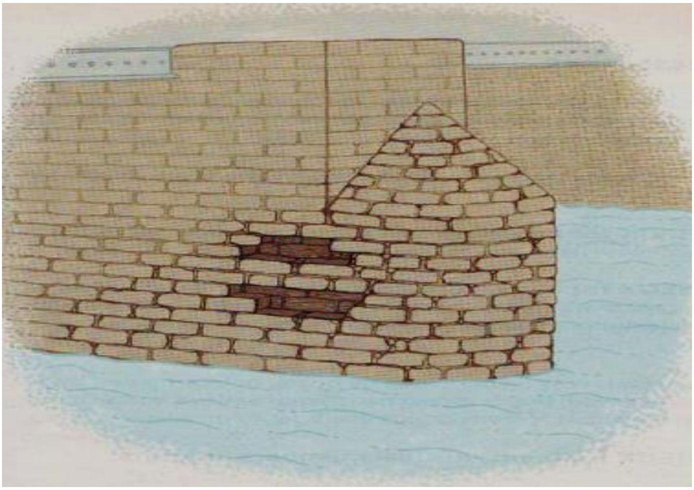


Fig. 2.19.4 Deterioration of Brickwork

The flow of water past a pier and the constant wetting and drying can, over a long period of time, damage the material of the pier.

CHECK for deterioration of bricks or masonry. Test the surface of the pier wall by hitting it (not too hard) with a hammer. If pieces of the surface fall off, the bricks or stones are in poor condition.