Karnataka Public Works Department

Introduction to Bridges with Bridge Inspection Procedures






Planning and Road Asset Management Centre - PRAMC

Contents

1: Bridge Definition

What is a Bridge?

- A **Bridge** is a **structure** built to **span** physical obstacles such as a **body of water, valley, or road,** for the purpose of providing passage over the obstacle.
- Generally bridges carry a road or railway across a natural or artificial obstacle such as, a *river, canal or another railway or another road.*
- Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed, the material used to make it.
- Bridge is a structure corresponding to the heaviest responsibility in carrying a free flow of transport and is the most significant component of a transportation system in case of communication over spacings / gaps for whatever reason such as aquatic obstacles, valleys and gorges etc.

2: History of Bridges

History of Bridges

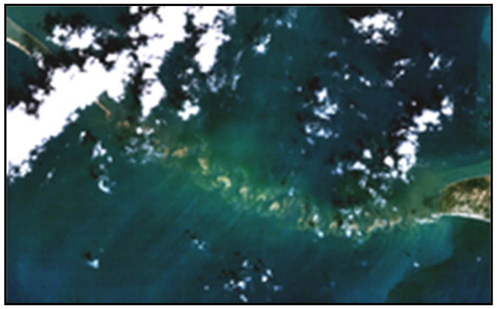
- The **first bridges** were made by nature itself — as simple as a log fallen across a stream or stones in the river. The first bridges made by humans were probably spans of cut wooden logs or planks and eventually stones.


- According to books, the earliest bridge on record is the one built on **Nile by Menes – the first king of Egypt (in about 2650 BC).**

- The **Arkadiko Bridge** designed to accommodate chariots in **Greece dating to 13th century BC** is one of the oldest arch bridges still in existence.

History of Bridges

- **Adam's Bridge** also known as **Rama's Bridge** or **Rama Setu** is a chain of limestone shoals, between Pamban Island, also known as Rameswaram Island, off the southeastern coast of Tamil Nadu, India, and Mannar Island, off the northwestern coast of Sri Lanka.
- The bridge is **18 miles (30 km) long** and separates the Gulf of Mannar (southwest) from the Palk Strait (northeast).
- It was reportedly passable on foot up to the 15th century until storms deepened the channel: temple records seem to say that Rama's Bridge was completely above sea level until it broke in a cyclone in 1480.
- The bridge was first mentioned in the ancient Indian Sanskrit epic *Ramayana* of Valmiki.


History of Bridges

- **In ancient India and China** construction of bridges was well known. **Nala, the son of Viswakarma,** was probably the **first Indian Bridge Engineer,** who, more **than 4000 years ago,** successfully constructed a causeway.

- The Primitive Bridge building perhaps started on trial and error basis, may be when a person tried to cross a stream over the broken wood log, it might have broken or dropped him into the stream. So he thought really hard and felled a bigger tree to cross the stream.

- One of the **Oldest Bridge** Built in Karnataka is **270 year** old meter gauge rail bridge across the kabini in Nanjangud, build in **1735**

- Large number of today's existing bridges have been built only during the past 75 to 100 years or so.

3: Type of Structures on Highway

Types of Structures on Highway

- Culverts (Total Span length less than 6.0m as per IRC)
- Minor Bridges (Total Span Length >= 6.0m and less than 60.0m as per IRC)
- Major Bridges (Total Span Length >= 60.0m as per IRC)
- Causeways (Irish / vented)
- ROB (Road Over Bridge)
- RUB (Road Under Bridge)
- Viaducts
- Flyovers
- Underpass (Pedestrian / Vehicular / Cattle)
- Foot Over Bridges
- Tunnel
- Interchanges
- Bridge cum Barrage

Types of Structures on Highway

Culverts

Minor Bridge

Major Bridge

Causeway

Types of Structures on Highway

PEDESTRIAN UNDERPASS


VEHICULAR UNDERPASS

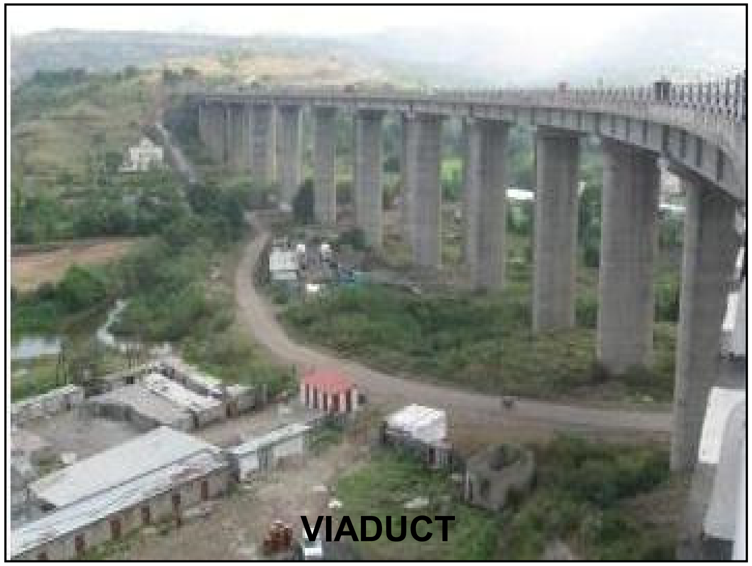

ROB


RUB

Types of Structures on Highway


FLYOVER


OVERPASS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Types of Structures on Highway

INTERCHANGES

4: Importance of Structures on Highway

Importance of Structures on Highways

- Cross Drainage structures comprising of culverts, causeways and bridges are essential components of any highway.
- In any road network they play an important role in keeping the road network free from flooding, overtopping or breaching during floods.
- Any wrong siting, sizing or design could disrupt the transportation system of the area concerned.

The purposes of CD structures in roads are:

- To divert and allow a free passage of the surface flow intercepted by the road embankment from upstream to downstream.
- To allow cross-drainage of the waste-water from village/town areas through which the road passes.
- To allow water passage for irrigation channels, watercourses etc.
- To cross over the rivers, tributaries, streams/hallas, rivulets, brooks drains etc.
- The purpose of viaduct structures (including ROBs, RUB’s etc) in highways is mainly to allow the traffic to cross the railway track / road etc eliminating any at grade crossings.

Importance of Structures on Highways

Bridge is the KEY ELEMENT in a Transportation System

It Controls the Capacity of the System

- If the width of a bridge is insufficient to carry the number of lanes required to handle the traffic volume, the bridge will be a obstruction to the flow of traffic.
- If the strength of a bridge is deficient and unable to carry heavy trucks, load limits will be posted and truck traffic will be rerouted.
- The bridge controls both the volume and weight of the traffic carried by the transportation system.

Importance of Structures on Highways

Highest Cost per Km of the Highway

- Bridges are expensive. The typical cost per km of a bridge is many times that of the approach roads to the bridge.
- Since, bridge is the key element in a transportation system, balance must be achieved between handling future traffic volume and loads and the cost of heavier and wider bridge structure.

If the Bridge Fails, the System Fails

- The importance of a Bridge can be visualized by considering the comparison between the two main components of a highway system i.e. a road and bridge itself.

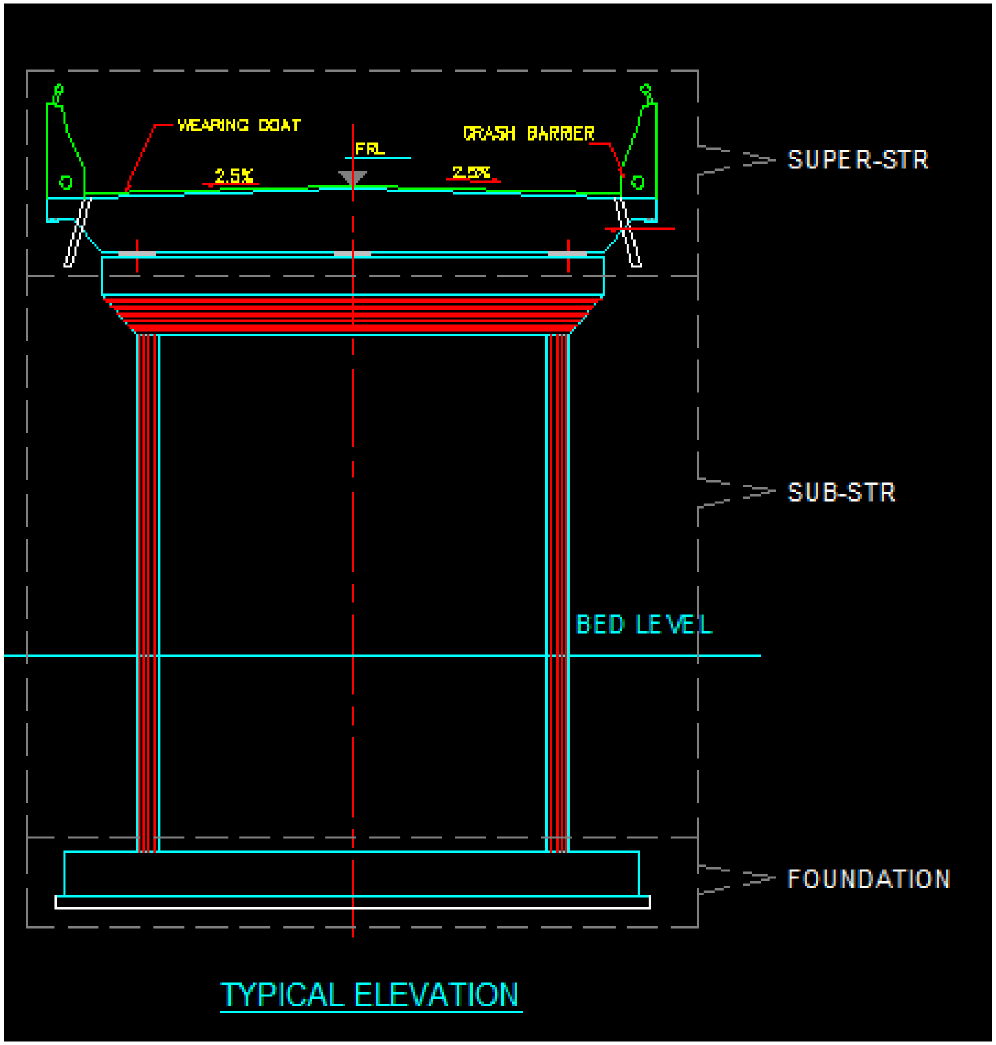
EXAMPLE: Suppose in a road there occurs deterioration and ultimately a crack, thus making a sort of inconvenience but it wont result in stopping of the flow of traffic as traffic can pass or otherwise a bypass can be provided. The traffic no doubt will pass with a slower speed but in case of a bridge the traffic flow is completely stopped incase of the failure of the bridge, that is the reason its often called "If the bridge fails the structure fails" as the function of the structure could no longer be served at all.

5: Components of Bridge Structure

Components of Bridge Structure

There are **Mainly 3 components** of the Bridge structure

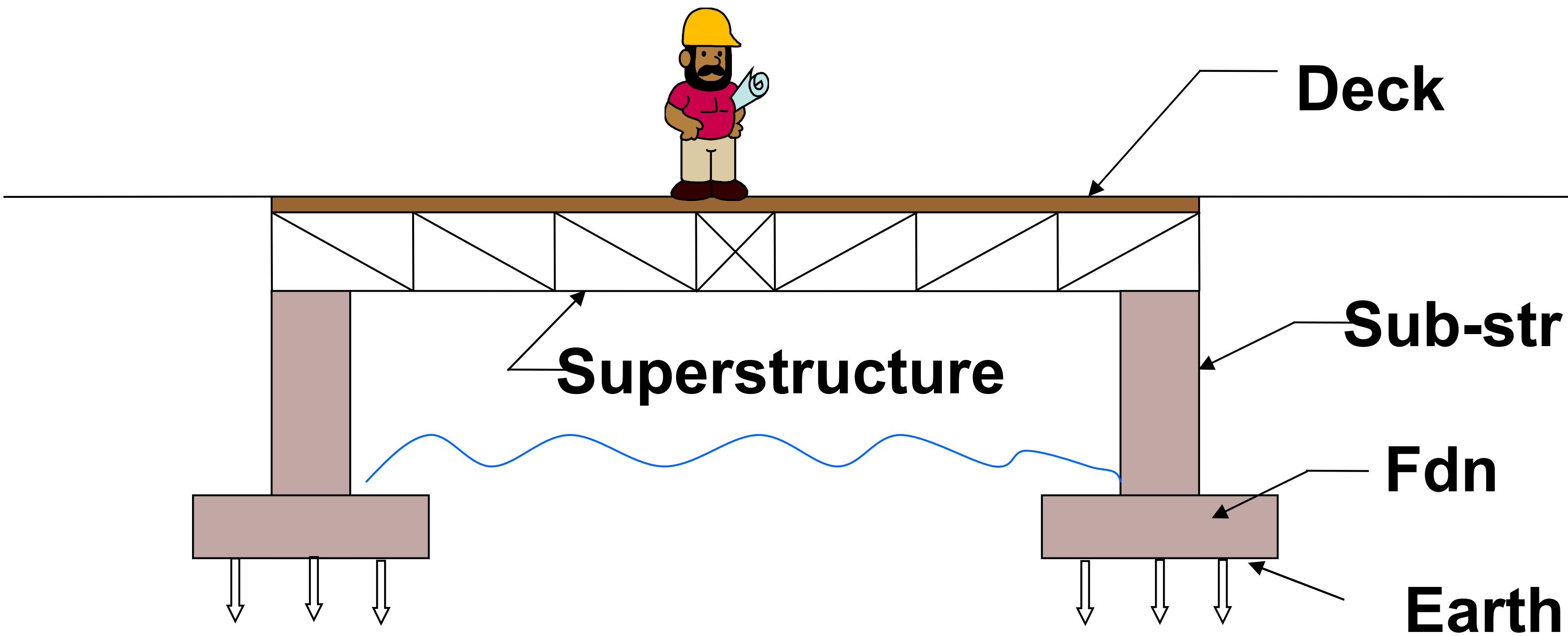
- **Superstructure:**
  The ***Superstructure*** carries loads from the **deck** to the **substructure**.
- **Sub-structure:**
  The ***Substructure*** carries loads to the Foundation
- **Foundation:**
  The Part of Bridge in direct contact with and transmitting all the above loads to the Ground / Earth.



Components of Bridge Structure

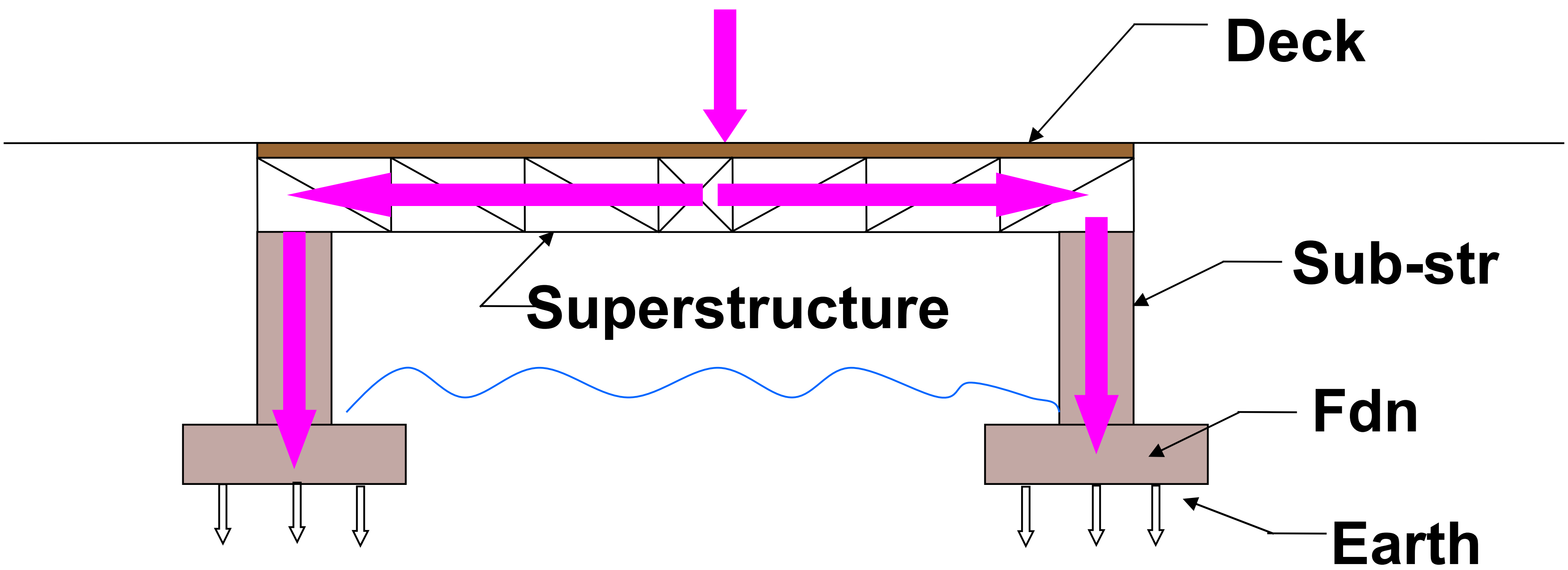
How the Bridge Works

- **Live Loads** are applied to the **DECK.**
- The **DECK** transmits live loads and deck dead load to the **SUPERSTRUCTURE.**
- The **SUPERSTRUCTURE** transmits these loads and the superstructure dead load to the **SUB-STRUCTURE.**



Components of Bridge Structure

- The **SUB-STRUCTURE** transmits all these loads and the substructure dead load to the **FOUNDATION** which is in direct contact with earth.
- The **EARTH** supports the bridge and all its loads
- It's all about **LOAD PATHS.**



Components of Bridge Structure

Components of Bridge Structure

- **Bridge Deck:** The load bearing floor of a bridge which carries and spreads the loads to the main beams.
- **Superstructure:** Transmits the Load from Deck surface to the Sub-structure, It is either of reinforced concrete, pre-stressed concrete, steel etc.
- **Bearings:** These are supports on a bridge Abutment / pier, which carry the weight of the bridge superstructure and control the movements at the bridge supports, including the temperature expansion and contraction.
- **Bridge Cap (Abutment / Pier Cap):** The highest part of a bridge Abutment / Pier on which the bridge bearings are seated.
- **Abutment:** The End Supports of the Deck (Superstructure) of the Bridge, which also retains earth, fill of approaches behind.
- **Pier:** Intermediate supports of the Deck (Superstructure of the Bridge).
- **Retaining wall:** A wall designed to resist the pressure of earth filing behind.
- **Foundation :** The Part of Bridge in direct contact with and transmitting all the above loads to the Ground / Earth.

Components of Bridge Structure

- **Expansion joints:** These are provided to accommodate the translations due to possible shrinkage and expansions due to temperature changes. These make the deck joint leak proof, protect the edges of slab / girder and also allow smooth passage of loads from one span to another by bridging the gap.
- **Crash Barrier / Railings:** Traffic barriers (called as crash barriers) keep vehicles within their roadway and prevent vehicles from falling off the bridge.
- **Wearing coat:** A layer of Bitumen / Concrete provided over the Deck to prevent the damage to the deck.
- **Approach Slab:** These are provided behind the dirt wall at approaches of the bridge structure to allow smooth passage of vehicular loads on to the main bridge structure.
- **Protection Works:** These are provided for ensuring the safety of bridges and their approaches on either side.

6: Types of Bridges

Types of Bridges

Classification of Bridges

Material	Concrete, Wood, Steel, Stone, Brick, Composite
Function	Road, Rail, Pedestrian, Pipe line, Water conveying (Aqueduct)
Span	Short, Medium, Large
Structural Form	Slab, Girder, Truss, Arch, Suspension, Cable Stayed
Type of support	Simply supported, Continuous, Cantilever`

Types of Bridges

Classification of Bridges

Classification	Types
Usage	Temporary, Permanent, Service (Army)
With respect to water level	Causeway, Submersible, High level (normal case)
Grade Separated	Road Over, Road under (subway), Flyover (road over road)

7: BMS

Road Network in Karnataka

Total road network length in Karnataka is more than 90,000 kilometers comprising 7,652 km of National Highways, 28,939 km of State Highways and 56,448 km of Major District Roads.

The existing number of major and minor bridges on the Karnataka road network are as below

Bridges on the Karnataka Road Network[1]

Classification	Karnataka		
Bridge	Minor	Major	All
Span (meters)	>6<60	>60	
National Highways	1,207	66	1,273
State Highways	5,504	309	5,813
Major District Roads	11,016	276	11,292
Total Numbers	**17,727**	**651**	**18,378**

1 Source: as per Bridge Statistics-2019

Requirement of BMS

WHY IS A BMS REQUIRED?

As the bridges in a road network becomes older, following questions become more difficult to answer:

- What are the needs?
- What type of Maintenance/repair should be performed?
- What is the impact of deferring work?
- Which bridges should be replaced first?

Solution - Implementation of BMS

Requirement of BMS

- Existing Inspection procedures has been established and managed within the constraints of other demands on limited resources.
- As a consequence there had been a large variation in the extent and frequency of bridge inspections and the format and consistency of the inspection results and records.
- In order that the network may be managed effectively a systematic statewide inspection and condition rating and monitoring system is required to enable engineers to identify maintenance needs, assess the effectiveness of treatments, model patterns of deterioration and forecast future maintenance, rehabilitation and replacement budget needs.
- The purpose of BMS is to ensure that the condition of all structures is systematically monitored to ensure that conditions which may lead to severe structural damage or collapse are identified as soon as possible in order that the appropriate intervention or remedial action may be undertaken.

Requirement of BMS

The deterioration of a bridge commences on completion of its construction.

The Main objectives related to the BMS application are

- To establish statewide procedures for inspection and condition rating which includes requirements for inspection scope and frequency, documentation, data management and approval levels
- To provide a computerised Inventory and Condition data store for cross-drainage structures (Bridges)
- To provide a simplified, user friendly and sustainable BMS software application
- To implement a methodology to identify, justify and prioritise the need for new or replacement of Bridges.
- To generate systematic, justifiable and prioritised maintenance, rehabilitation and replacement programmes.
- To integrate with Road Asset Management System (RAMS) systems so that the BMS References data are consistent with RAMS;

Bridge Management ensures that the bridges remain fit for their intended purpose over long period at minimum life cycle cost.

Requirement of BMS

The overall BMS planning process generally includes

- Data Collection
- Database Management
- BMS Analysis
- BMS Reporting (including prioritisation of Bridges as per BCI)

8: Data Collection – Tools and Equipments

Tools and Equipments

- Several factors play a role in determining what type of equipment is necessary to undertake a bridge inspection.
- The bridge location and the type of bridge are two of the main factors in determining equipment needs.
- Standard tools that an inspector should have available at the bridge site are:
  - Cleaning tools
  - Inspection equipment
  - Visual assessment aids
  - Measuring equipment
  - Documentation equipment
  - Equipment to assist access
  - Miscellaneous equipment

Tools and Equipments

- Cleaning tools
  - Wisk broom for removing loose dirt and debris.
  - Wire brush for removing loose paint.
  - Scrapers for removing corrosion.
  - Flat bladed screwdriver for general cleaning and probing.
  - Shovel for removing dirt and debris from bearing areas.
- Inspection Equipment
  - **Pocketknife** for general duties.
  - **Plumb line** to measure the vertical alignments of elements of super-structure or sub-structure.
  - **Tool belt** with tool pouch for the convenience of ‘having to hand’ and storing all small tools.
  - **Range pole / probe** for probing for scour holes.
  - **Chipping hammer** for the loosening of dirt and rust, sounding of concrete and, the checking for sheared or loose fasteners.

Tools and Equipments

- Visual assessment aids
  - **Binoculars** to provide the user the means of inspecting from a distance when close inspection is not possible.
  - **Flashlight** for illuminating dark areas and areas with no natural light.
  - **Back lit magnifying glass** to provide the means for closer examination of cracks and areas prone to cracking.
  - **Inspection mirrors** for inspection of inaccessible areas, for example, the underside of deck joints.
  - **Dye penetrant** for identifying cracks and their length

Tools and Equipments

- Measuring equipment
  - **Pocket tape** for measuring defects, bridge elements and, joint dimensions.
  - **Measuring tape** (30m) for measuring the dimensions of components.
  - **Calipers** for measuring the thickness of an element beyond an exposed edge.
  - **Optical crack gauge** for precise measurement of crack widths.
  - **Resistivity meter**
  - **Rebound hammer**
  - **Tilt meter and protractor** for determining the tilt of sub-structures and for measuring the angle of tilt.

Tools and Equipments

❑Crack width ruler

- ➢This simple gauge has been designed to provide inspectors with a low cost alternative to a graduated microscope for determining the width of a crack in a concrete or other building materials.
- ➢Similar in size to a standard credit card, this transparent gauge is marked with a range of graded lines. Each line is a specified width.
- ➢To use, position the gauge over the crack and identify which line is a similar width to the crack. Read off the width value.

Tools and Equipments

❑Rebound Hammer

- Rebound hammer test is done to find out the compressive strength of concrete. When the plunger of the rebound hammer is pressed against the surface of the concrete, the pring-controlled mass rebounds and depends upon the surface hardness of the concrete. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete.

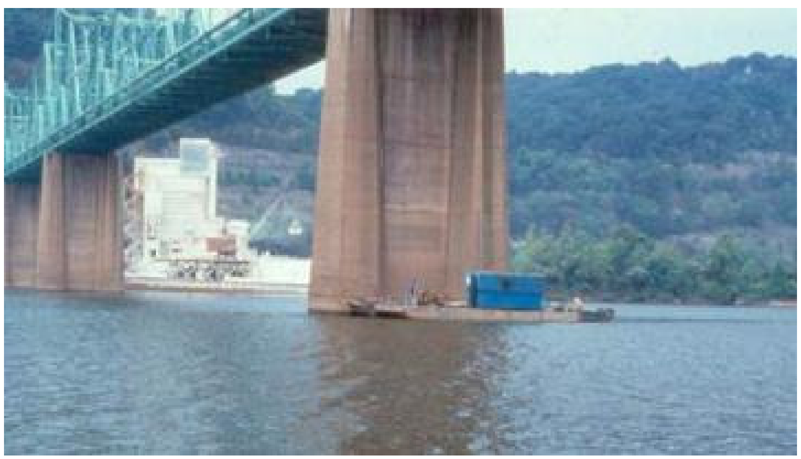
❑Resistivity Meter

- This is designed to measure the electrical resistivity of concrete.
- Resistivity measurements can be used to estimate the likelihood of corrosion. When the electrical resistivity (ρ) of the concrete is low, the likelihood of corrosion increases

Tools and Equipments

- Documentation equipment
  - **Inspection forms, clipboard, and pencil** for recording data at site
  - **Field books** for additional record keeping for complex structures.
  - **Straight edge** an aid for drawing sketches.
  - **Camera** to provide visual evidence of the bridge site and condition.
  - **Chalk, paint sticks, or markers** for element/defect identification and photograph documentation
- Equipment to assist in access
  - **Ladder:** be used for the inspecting of the underside of a bridge or sub-structure units.
  - **Boat:** A boat may be needed for structures over water. A boat can be used for some inspection, as well as for taking photographs
  - **Under bridge inspection vehicle:** An under bridge inspection vehicle is a specialised bucket type / platform type vehicle with an articulated boom designed to reach under a structure.

Tools and Equipments



9: Data Collection Procedure (Inventory Data)

Data Collection

Collection of the Inventory data is the first step of the data collection process.

Once Inventory data is available in the BMS database, only updating and verification of data will be required.

Hence the data required for BMS can be split into 2 Inspection Categories-

- General Inventory Inspection Data and
- Condition Inspection Data.

Data Collection

General Inventory Inspection Data : This data generally includes the general information as it applies to any particular bridge and is unlikely to change until a physical change (such as reconstruction or widening) is done.

The general bridge inventory module data can be split into;

- Administrative / General Data
- Geometrical Data
- Technical Data (includes Structural details, Geotechnical details and Hydraulic details)
- Structural drawings (if any) and Photographs

Condition Inspection Data: The importance of the Condition Inspection is that this determines the baseline structural conditions and also identifies any existing problems in the Structure.

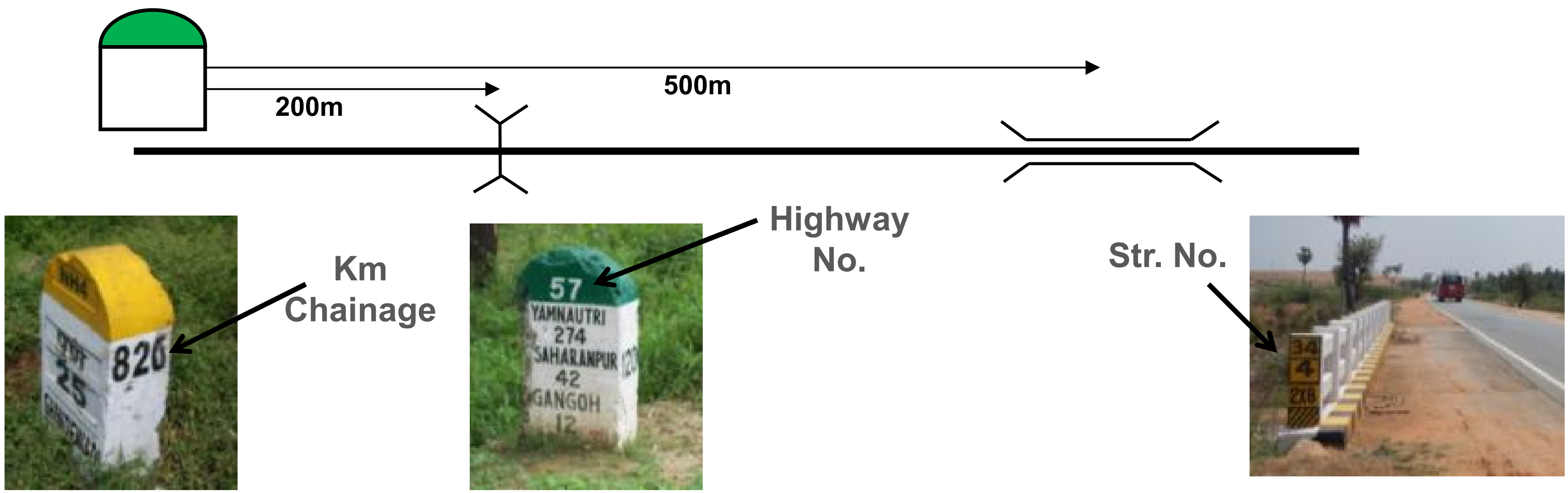
Detailed condition survey of individual elements like piers, abutments, bearings, expansion joints, spans, approaches, bridge protection works, training works etc. for each of the above elements, including individual defects, with severity and extent.

Data Collection – Inventory Inspection Data

Administrative / General Data

Kilometric Point (PWD Chainage): The Centre-line chainage of the Bridge with respect to Existing PWD kilometer Stone.

Bridge Identification Number / Structure Number : The Structure Number has two components, first one indicating the next increasing chainage and the following number indicates the serial number of the structure in that particular kilometer. For example structure Number 18/2 indicates that the structure is in between kilometer 17 and 18 and this is the second cross drainage structure in that kilometer (i.e. between 17 and 18) in the direction of increasing chainage.



Data Collection – Inventory Inspection Data

Administrative / General Data

Name of Bridge: The Name of River / Stream / Nala across which the Bridge is built.

District / Taluk: Name of the District /Taluk in which the Bridge is located

Division/Circle: PWD Divisional office / PWD Circle responsible for Maintaining the Bridge

Category of Road: Category of Road on which the Bridge is located (such as NH / SH / MDR) .

Road Number: Road Number on which the Bridge is located, such as National Highway Number / State Highway Number

Road Name: Nomenclature of Highway on which the Bridge is located

Location: Name of nearby place / settlements to the Bridge

Year of construction: The year in which the bridge was built.

Repairs done prior to the inventory: A list / details of previous repair work carried before inspection.

Name of Builder / Contractor /Consultant: The contractor/firm who constructed the bridge and the name of the consultant associated with the design or supervision of construction (if any).

Data Collection – Inventory Inspection Data

Geometric Data

Bridge Roadway Width / Carriageway width : The width between the inner face of kerb to kerb

Bridge Deck Width out to out (m) : the Total width of Bridge (including Footpath, kerb, Railings)

Details of Footpath: the width of footpath

Flow Direction: Generally L to R or R to L, in the increasing chainage of the road.

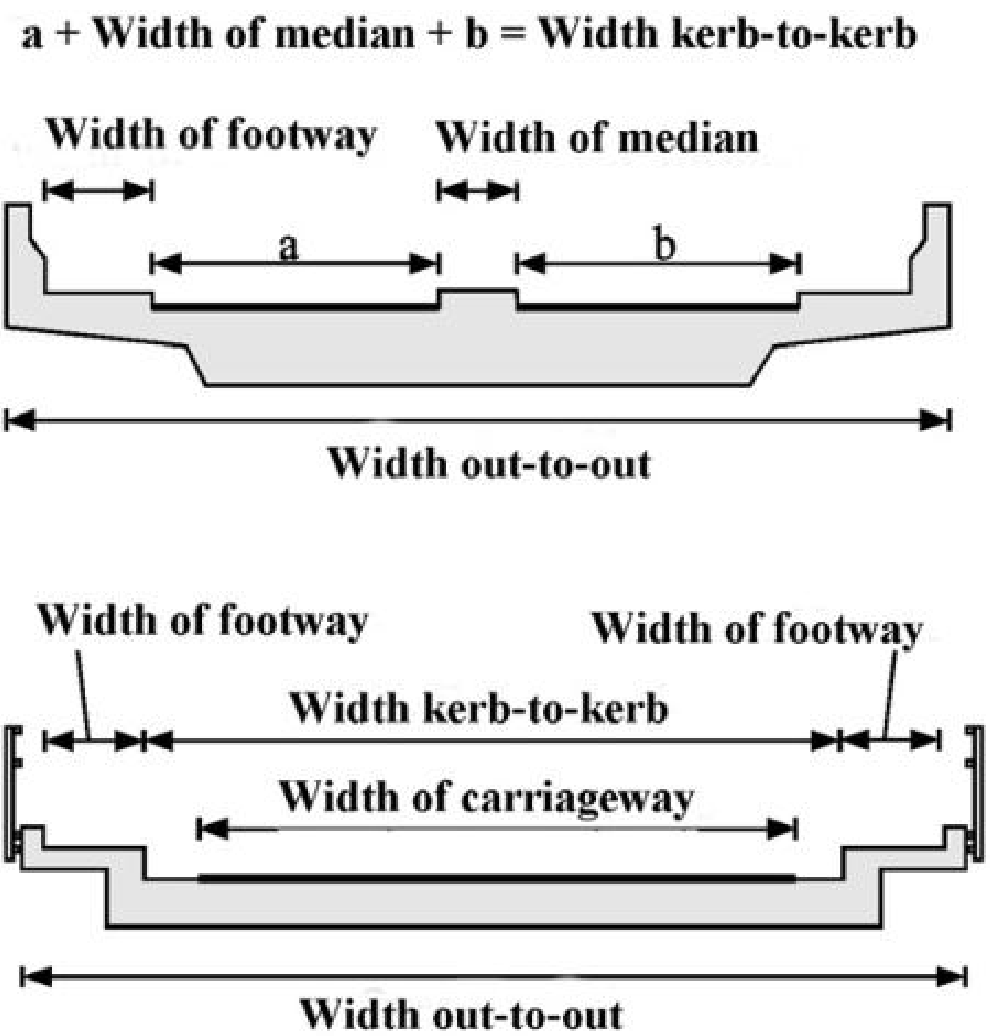
Skew Angle: The angle between the Centre-line of Road / Bridge and Centre-line of River / Nala.

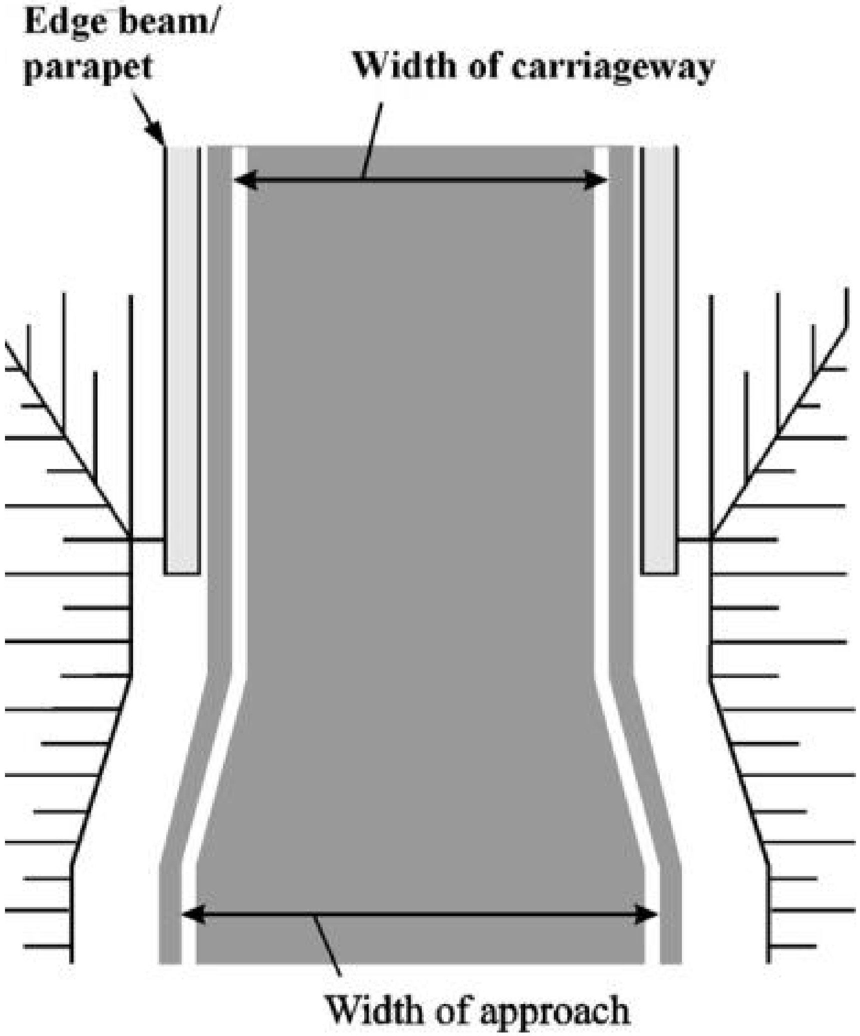
Gradient / Curve: Whether the Bridge is in curve /Gradient or not.

Spatial Details: Details of Latitude, Longitude and Altitude.

Data Collection – Inventory Inspection Data

Geometric Data





Data Collection – Inventory Inspection Data

Technical Data

Type of the Bridge: The appropriate type of bridge to be selected, namely; Major Bridge, Minor Bridge, ROB (Road Over railway line), RUB (Road Under railway line), High Level Bridge, Submersible Bridge / Causeway.

Span: Total Number of spans, Length of each span (Center to center of exp. Joints), Overall length of Bridge from inner face to inner face of dirt wall.

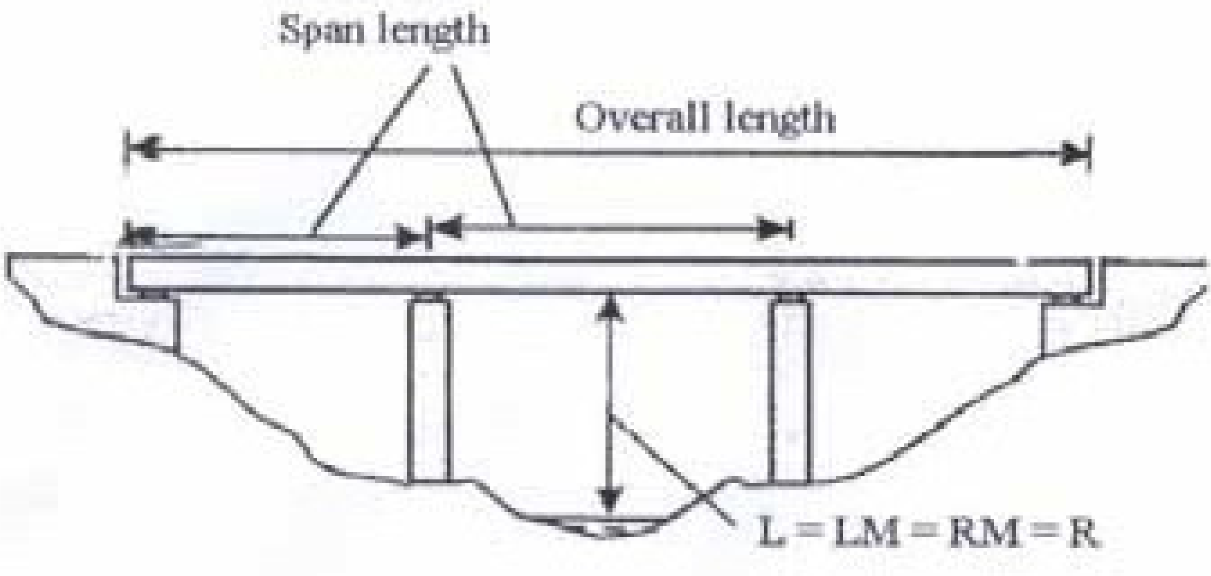
Width: Total Width, Carriageway Width, Footpath width.

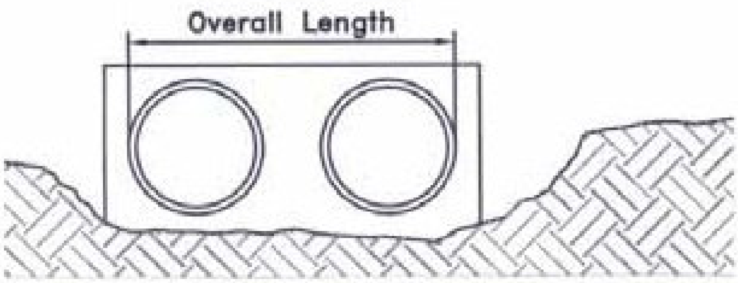
Design Loads: at the time of Design (if available)

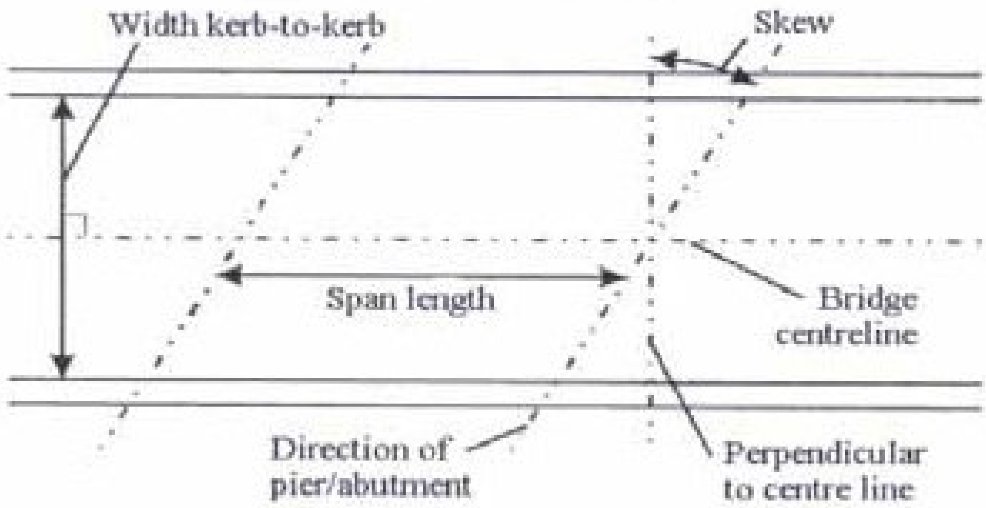
Waterway: Whether stream is perennial / seasonal / navigable

Data Collection – Inventory Inspection Data

Technical Data







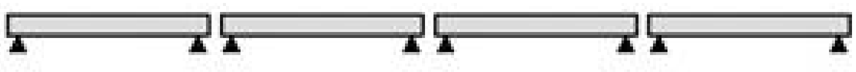
Data Collection – Inventory Inspection Data

Technical Data - SUPERSTRUCTURE

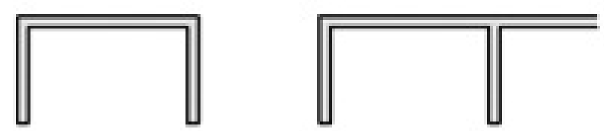
Material: Concrete (RCC, PSC), Steel, Composite, Stone Masonry / Brick Masonry

Span Arrangement: Simply Supported, Balance Cantilever, Continuous span, Integral, Others

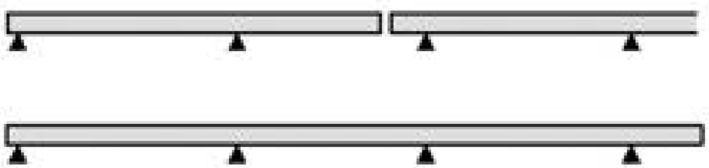
Cross Section Type: RC Solid slab, RC Girder, PSC I Girder, Arch etc.



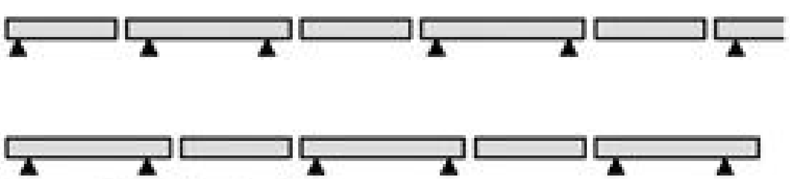
Type 10–11: Simple Span



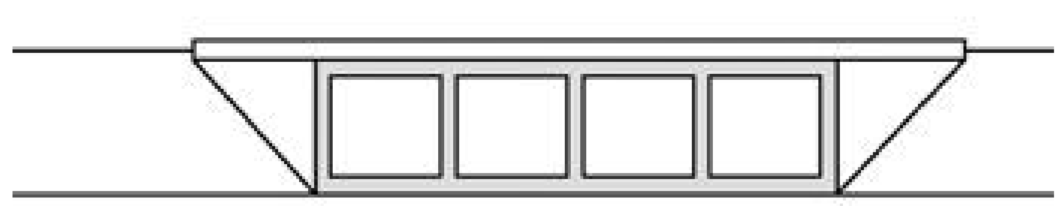
Integral



Type 20–21: Continuous



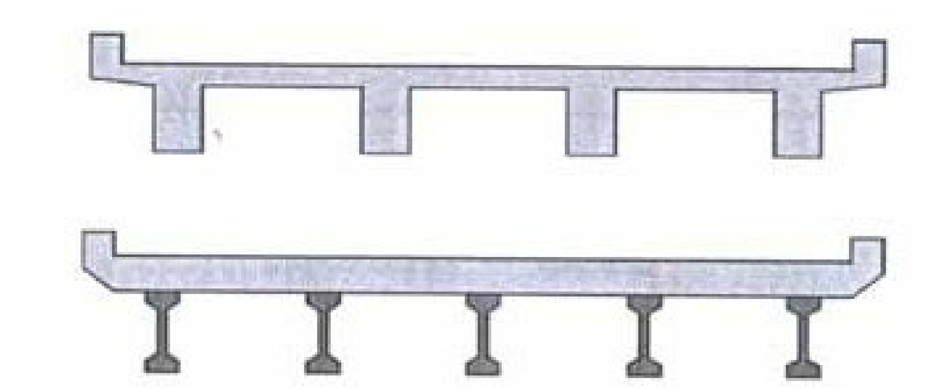
Type 30–31: Cantilever

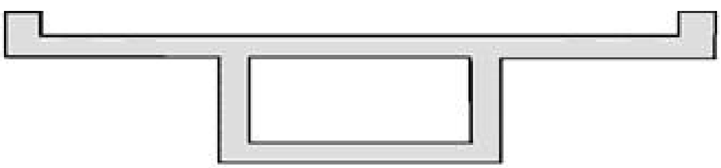


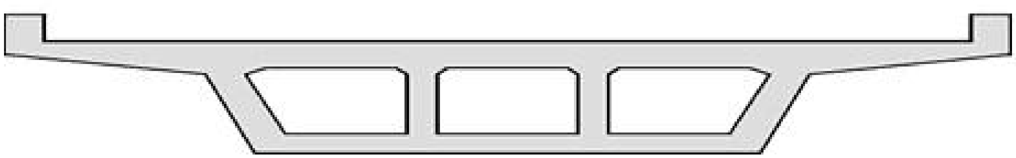
Type 42: Box Culvert

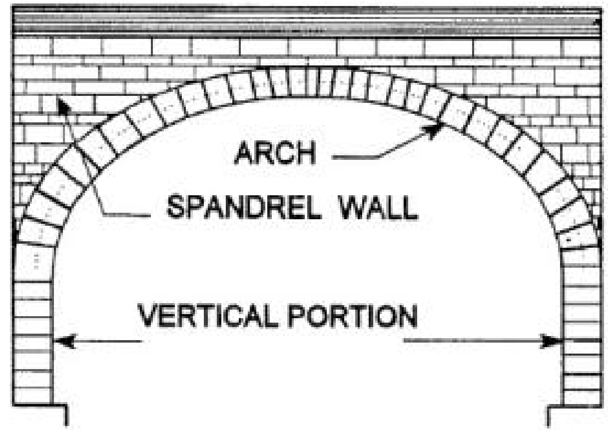
Data Collection – Inventory Inspection Data

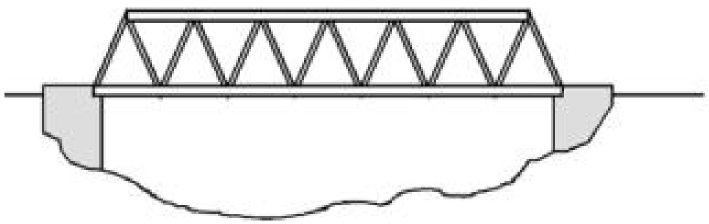
Technical Data - SUPERSTRUCTURE

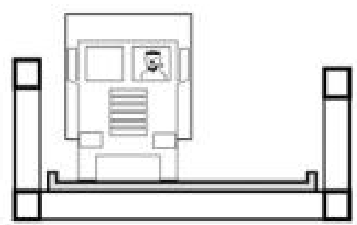










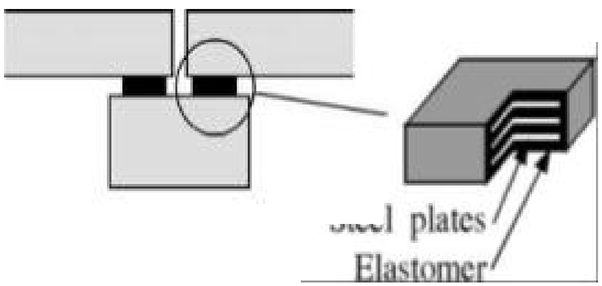


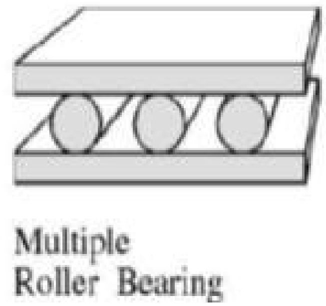
Data Collection – Inventory Inspection Data

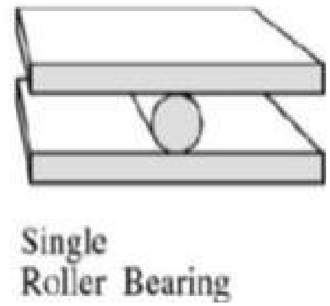
Technical Data - BEARINGS

Type: Metallic, Elastomeric, POT/PTFE, Roller Bearings

Number of Bearings: at Abutment / at Pier

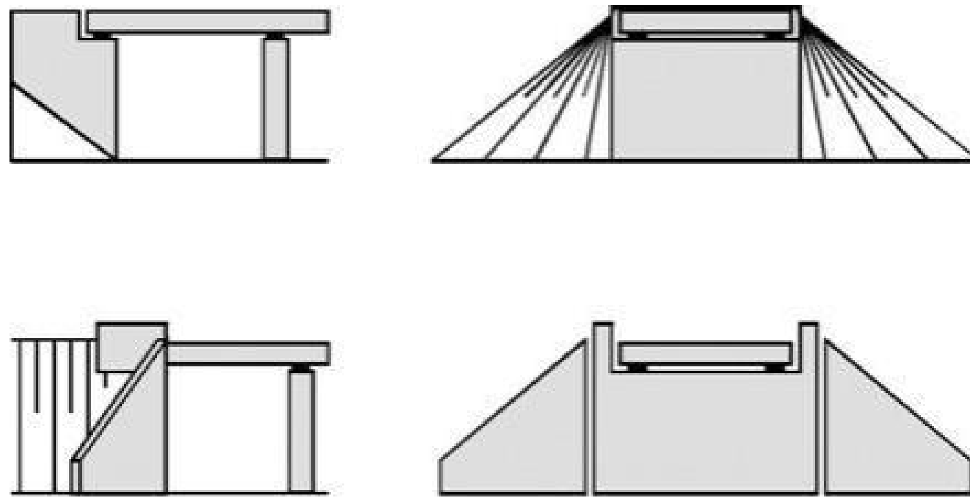






Data Collection – Inventory Inspection Data

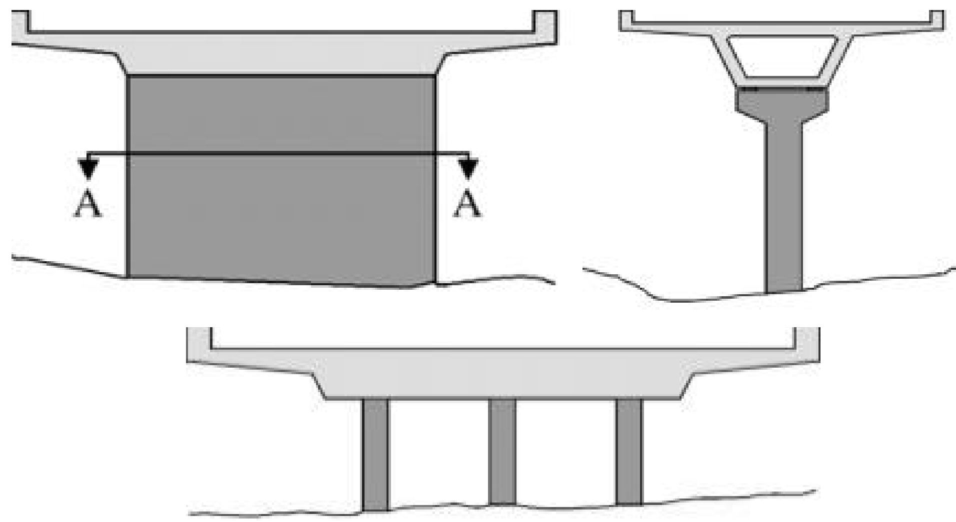
Technical Data



ABUTMENT

Material: Stone Masonry / Brick Masonry, PCC, RCC

Type: Solid Abutment, Spill Through, Slope Protected, other types.



PIER

Material: Stone Masonry / Brick Masonry, PCC, RCC

Type: Wall Type, Circular (Single / Multi), Cellular, other types.

RETURNWALL

Material: Stone Masonry / Brick Masonry, PCC, RCC

Type: Retaining wall, Wing wall

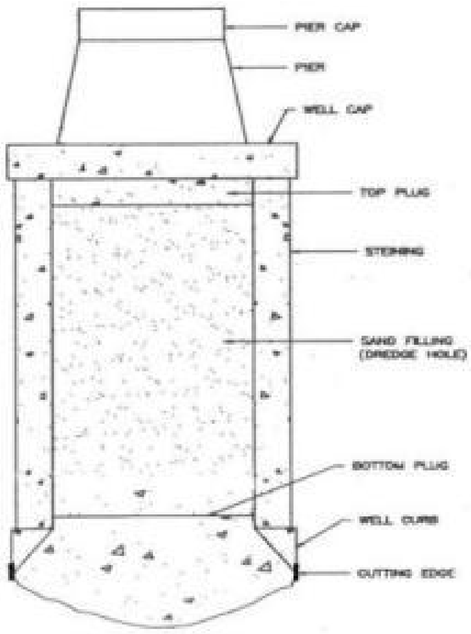
Data Collection – Inventory Inspection Data

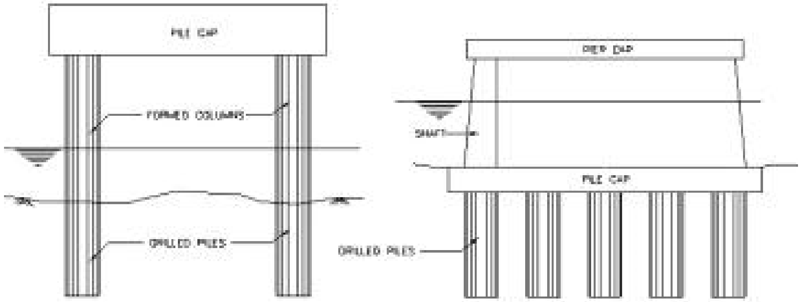
Technical Data

FOUNDATION

Material: Stone Masonry / Brick Masonry, PCC, RCC

Type: Open Foundation, Pile Foundation, Well Foundation..





Data Collection – Inventory Inspection Data

Technical Data – Geo-technical and Hydraulic

GEO-TECHNICAL DATA – Type of Bed Material

Sandy, Gravelly, Boulders, Rocky

HYDRAULIC DETAILS

Water Way – Excessive Scour / Blockages in waterway

Stream / Nalla – Perennial / Seasonal / Navigable

Stream / Nalla – Alluvial, Quasi Alluvial, Rigid

HFL – From Records / Local enquiry

Protection works – Bank Protection (Side Slope Pitching), Bed protection (Floor Apron, Apron on U/S and D/S side, Curtain / Cut-off Wall)

Data Collection – Inventory Inspection Data

Technical Data – Miscellaneous

Wearing Coat: Concrete or Asphaltic.

Expansion Joint: Filler type / Strip Seal Type, Compression Seal type, Buried

Railing / Parapet: Crash Barrier / Railing / Parapet – Concrete / Steel / Brick, Stone Masonry.

Approach Slab: length and width

Drainage Spouts: number in each span

Footpath: the type with length and width.

Service Lines: If there is any service crossing, the number and type of service lines such as Electrical lines/ Telephone cables / Water lines / Sewage lines / Gas pipe line etc.

Sign Board: whether any sign board is provided on the bridge or at bridge approaches.

10: Condition Data Collection Procedure

Data Collection – Condition Inspection Data

Various Types of Bridges on road network in Karnataka

- Hume Pipe / MCPC Bridge
- Stone Slab Bridge
- Stone Masonry / Brick Masonry Arch Bridge
- RC Multi-Cell Box Bridge
- RC Solid Slab Bridge
- RC Girder Bridge
- RC Box Girder Bridge
- Composite I Girder Bridge
- Steel Truss Bridge

Data Collection – Condition Inspection Data

HUME PIPE (HP)

- These are generally provided with 900mm, 1000mm or 1200mm dia pipes.
- These type of structures are generally proposed where the design discharge is less.

Most Common Defects observed

- **Cracks in Pipes:** Cracks may be defined as separating media in the body of concrete, this may be caused by overloading, vibration due to traffic loads, settlement of foundations Inadequate Cushion above Pipe, etc.

Headwall: is generally constructed with Stone / Brick Masonry or PCC, The main defects observed are

- Loosening of Pointing in between the stones / Bricks.
- Deterioration of bricks, stones or concrete blocks and
- Cracking due to failure or settlement of Foundations.

Data Collection – Condition Inspection Data

HUME PIPE

Cracks in Pipes

Loosening of Pointing

Deterioration of Stones or concrete

Crack in HW due to Settlement

Data Collection – Condition Inspection Data

HUME PIPE

- Pipe Structures Constructed 15 to 20 years back were with NP2 pipes which are designed for Light Traffic.
- Recently Constructed Pipe structures are with NP4 pipes which are designed to carry Heavy traffic (such as Present day vehicle loads / Railway loads).
- Structures with NP2 pipes will have to be replaced based on the condition as these are not designed for the present day loading conditions.

NP-2 Pipe

NP-4 Pipe

Data Collection – Condition Inspection Data

HUME PIPE

How to Differentiate between NP2 and NP4 Pipes

Class	Description	Conditions where Normally used
NP1	Unreinforced concrete non-pressure pipes	For drainage and irrigation use, above ground or in shallow trenches
NP2	Reinforced concrete, light-duty, non-pressure pipes	for drainage and irrigation use, for cross drains/culverts carrying light traffic
NP3	Reinforced and also unreinforced (in case of pipes manufactured by vibrated casting process) concrete, medium-duty. Non-pressure pipes	For drainage and irrigation use, for cross drains/culverts carrying medium traffic
NP4	Reinforced and also unreinforced (in case of pipes manufactured by vibrated casting process) concrete, heavy-duty, non-pressure pipes	Fur drainage and irrigation use, for cross drains/culvert carrying heavy traffic

Pipe Dia (Inner)	NP2 (Thickness of Pipe)	NP4 (Thickness of Pipe)
900	55	100
1000	60	115
1200	70	120

Data Collection – Condition Inspection Data

HUME PIPE - Observations

- Check whether the pipe is **NP2 or NP4**.
- Check for any signs of settlement on road surface, this may be due to settlement of Pipes.
- Check for cracks in the Pipe barrel, this may be due to insufficient Cushion, Lesser load carrying capacity of Pipes or due to settlement (to be quantified in no. of pipes cracked).
- Check of any loss of Pointing / Plastering in headwall (to be quantified in sqm)
- Check for any Tilt in the Headwall, Any spalling / Deterioration of Stones from Headwall.
- Check for Cracks in Headwall (this may be due to Settlement).
- Check for Scour at Inlet and out let

Data Collection – Condition Inspection Data

HUME PIPE - Overall Rating

Overall rating for Pipes

S. No.	Defects	Condition rating	BCI Valves
1	Cracks in Pipes	Reconstruction	< 30
2	Cracks in pipes at edges	Moderate Repairs Required	65-45
3	Pipes in good condition	Minor Repairs Required	80-65

Overall rating for Headwall

S. No.	Defects	Condition rating	BCI Valves
1	Serious weathering of stones, adjoining stones split, signs of slight tilt in Headwall, Severe scour at inlet or Outlet	Reconstruction	< 30
2	Loss of a significant amount of mortar with between 40 to 60 percent of mortar missing, slight scour at inlet / outlet	Moderate Repairs Required	65-45
3	Minor cracks being observed in the headwall, up to 10-20 percent of mortar may be missing	Minor Repairs Required	80-65
4	No sign of deterioration in masonry or mortar	Routine Maintenance Required	100-80

Data Collection – Condition Inspection Data

MASS CONCRETE PIPE CULVERT (MCPC)

- These are generally with higher diameter varying from 2000mm to 3000mm in diameter
- These are generally proposed where the foundation soil has less bearing capacity.

Most Common Defects observed

- **Cracks in Pipes:** Cracks may be defined as separating media in the body of concrete, this may be caused by overloading, vibration due to traffic loads, settlement of foundations, etc.
- Concrete cracks are due to thermal gradients (the difference between internal and external temperatures) in massive sections immediately following placement, and for a period of time thereafter
- **Headwall:** There is no separate headwall constructed for these type of structures as the entire structure is constructed monolithic with pipes.

Data Collection – Condition Inspection Data

MASS CONCRETE PIPE CULVERT (MCPC)

Structure in Good Condition

Minor Cracks in Pipes

Wider Cracks in Pipes

Poor Concrete in Pipes

Data Collection – Condition Inspection Data

MASS CONCRETE PIPE CULVERT (MCPC)

- These type of structures are Constructed 15 to 20 years back.
- These types of structure needs to be proposed for Reconstruction if the structure is narrow or if the cracks in the pipes are beyond repair.
- These types of structures cannot be widened and hence these have to be proposed for Reconstruction
- Presently these type of structures are not proposed, as an alternative RC Box structure are proposed.

Observations

- Check for any signs of settlement on road surface, this may be due to settlement of Pipes.
- Check for cracks in the Pipe barrel, this may be due to thermal variation in Concrete, Lesser load carrying capacity of Pipes.
- The Cracks in the Pipes have to be carefully observed (whether the Cracks are minor or Wider cracks.

Data Collection – Condition Inspection Data

MASS CONCRETE PIPE CULVERT (MCPC) - Overall Rating

S. No.	Defects	Condition rating	BCI Valves
1	Wider Cracks more than 3 to 4mm all along the length of the Pipes which is beyond repair, severe scour at inlet / outlet	Reconstruction	< 30
2	Wider Cracks which can be arrested by further grouting and Minor Cracks at substantial locations, slight scour at inlet / outlet	Moderate Repairs Required	65-45
3	Minor cracks being observed in the Pipes, up to 1mm crack at few locations	Minor Repairs Required	80-65
4	No sign of deterioration / cracks in pipes	Routine Maintenance Required	100-80

Data Collection – Condition Inspection Data

SUPER STRUCTURE

Most Commonly type of Super structures are

- ***Stone Slabs***
- ***RC Slab***
- ***RC Girder***
- ***Arch (Stone Masonry / Brick Masonry)***
- PSC I Girder
- Box Girder / Composite Steel structures

Data Collection – Condition Inspection Data

Super Structure – STONE SLAB

- These type of structure were constructed in earlier days, presently these are not proposed for any highway project.
- Stone slabs approximately of 200 mm thick have been used as superstructure in some bridges.
- Many were cracked and displaced as these type of slabs are not capable of withstanding IRC Class AA, Class A and Class 70 R live loading.
- The stress at the superstructure base, which is tensile in nature, is very high especially where the earth cushion is either negligible or non-existent.
- **These type of structure are to be proposed for Re-construction or the stones slabs can be replaced with RC Slabs if the sub-structure is in good condition**

Data Collection – Condition Inspection Data

Super Structure – STONE SLAB

Stone Slabs Cracked

Stone Slabs in Good Condn .

Data Collection – Condition Inspection Data

CONCRETE and MASONRY STRUCTURE

CONCRETE STRUCTURES

- Common reinforced concrete structures will not fail without an early warning such as coarse cracks and visible deflections.

Common concrete defects

The following main defects are associated with the concrete elements of bridges.

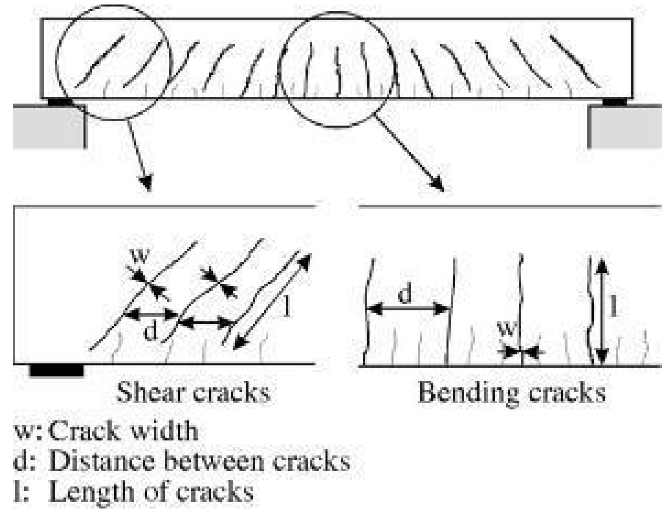
- Cracking
- Scaling / Leaching
- Spalling
- Honeycombing / Exposed reinforcement
- Concrete surface erosion
- Porosity
- Efflorescence, dampness, leakage

Data Collection – Condition Inspection Data

CONCRETE STRUCTURES

Cracking; Defined as separating media in the body of concrete. Most concrete elements develop cracks, can be classified as **Structural Cracks** and **Non-Structural Cracks**

- **Structural cracks** can be further divided into
- **Flexure cracks:** are caused by tensile forces induced in concrete elements due to bending and therefore develop in the tension zones, often at mid-span and at bottom of member for simply supported span.
- **Shear cracks:** Shear cracks are caused by diagonal tensile forces that typically occur in the web of a member near the supports, these cracks initiate near the bearing area, beginning at the bottom of the member and extending diagonally upward



Data Collection – Condition Inspection Data

CONCRETE STRUCTURES

- **Bearing cracks: mainly occurs at bearing location in Girder Bridges,** caused due to failure of concrete at Bearing location under direct compression
  - Tensioned cracks
  - Compression cracks
  - Torsional cracks
  - Splitting cracks

Data Collection – Condition Inspection Data

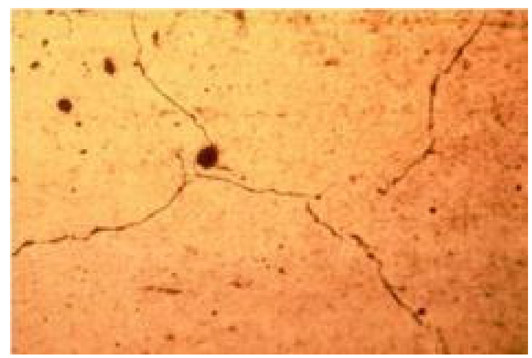
CONCRETE STRUCTURES

Non-structural cracks

- **Non-structural cracks** result from internal stress due to dimensional changes. Non-structural cracks are divided into four categories:
  - Temperature cracks
  - Shrinkage cracks
  - Mass concrete cracks
  - Corrosion cracks

These cracks are non-structural and relatively small in size but they do provide an opening for water and contaminants which can lead to serious problems.

Temperature Cracks



Shrinkage Cracks

Data Collection – Condition Inspection Data

CONCRETE STRUCTURES

Orientation of Cracks

The orientation of the crack, with respect to the load and supporting members, is an important feature that must be recorded accurately to ensure the proper evaluation of the cracking.

- **Transverse cracks:** Fairly straight cracks that is roughly perpendicular to the centerline of the bridge or a bridge member.
- **Longitudinal cracks:** Fairly straight cracks that run parallel to the centerline of the bridge or a bridge member.
- **Diagonal cracks:** Cracks that are skewed (at an angle) to the centerline of the bridge or a bridge member, either vertically or horizontally.
- **Map cracking:** Inter-connected cracks that form networks of varying size. They vary in width from barely visible fine cracks to cracks with a well-defined opening. Map cracking resembles the lines on a road map.`

Data Collection – Condition Inspection Data

CONCRETE STRUCTURES

Classification and measurement of cracks

- Crack size is very important in assessing the condition of an ‘in-service’ bridge.
- Cracks may extend partially or completely through the concrete member.
- Cracks can be classified as hairline, narrow, medium, or wide.
- On pre-stressed structures, all cracks are significant

Definition	Reinforced Concrete	Prestressed Concrete
HAIRLINE (HL)	< 1.6mm	**< 0.1mm**
NARROW (N)	1.6 to 3.2mm	**0.1 to 0.23mm**
MEDIUM (M)	3.2 to 4.8mm	**0.25 to 0.76mm**
WIDE (W)	**> 4.8mm**	**> 0.76mm**

** - Classification of Cracks with respect to their Width (as per Federal Highway Administration of US Department)*

Data Collection – Condition Inspection Data

CONCRETE STRUCTURES

Scaling / Leaching

- Scaling is the gradual and continual loss, over an area, of surface cement paste and aggregate due to the chemical breakdown of the cement bond.
- Scaling is accelerated when the member is exposed to a harsh environment.

Scaling is classified under the following four categories:

- **Minor scaling** - loss of surface cement paste up to 6 mm deep, with surface exposure of coarse aggregates.
- **Medium scaling** - loss of surface cement paste from 6 to 13 mm deep, with cement paste loss between the coarse aggregates.
- **Heavy scaling** - loss of surface cement paste from 13 to 25 mm deep; coarse aggregates are clearly exposed.
- **Severe scaling** - loss of coarse aggregate particles, as well as surface cement paste and the mortar surrounding the aggregates; depth of the loss exceeds 25 mm; reinforcing steel is usually exposed.




Data Collection – Condition Inspection Data

CONCRETE STRUCTURES

Spalling

- A spall is a depression in the concrete.
- Spalls result from the separation and removal of a portion of the surface concrete.
- Spalls can be caused by corrosion of reinforcement, friction from thermal movement, and over stress in concrete.

Spalls are classified as follows:

- **Small spalls** – not more than 25 mm deep or approximately 150 mm in diameter
- **Large spalls** – more than 25 mm deep or greater than 150 mm in diameter



Data Collection – Condition Inspection Data

CONCRETE STRUCTURES

Honey Combing / Exposed Reinforcement

- The quality of concrete depends upon many factors, the major ones being, water / cement ratio and workmanship.
- An improper water cement ratio leads to porous and honey combed concrete.
- In general, honey combing in concrete may occur due to: grout loss; inadequate compaction; congestion of reinforcement; the using of course aggregate not properly graded and, the using of less fine aggregates resulting in less mortar being available to fill the voids between the course aggregates

Data Collection – Condition Inspection Data

CONCRETE STRUCTURES

Concrete surface erosion

- Wherever water at high velocity carries suspended gravel, sand or silt, then erosion of the concrete surface can be expected (in Sub-structure)

Porosity

- Porosity in concrete may occur due to high water loss, inadequate compaction, congestion of reinforcement, the use of coarse aggregates not properly graded or, the use of non-fine aggregates thus leaving less mortar to fill the voids between the coarse aggregates, etc

Efflorescence, dampness, leakage

- Efflorescence is the formation of whitish porous powder on a concrete surface. This indicates that the concrete is porous or cracked and provides for an increase in the acidity in the moisture content of the concrete due to a reduction of pH value

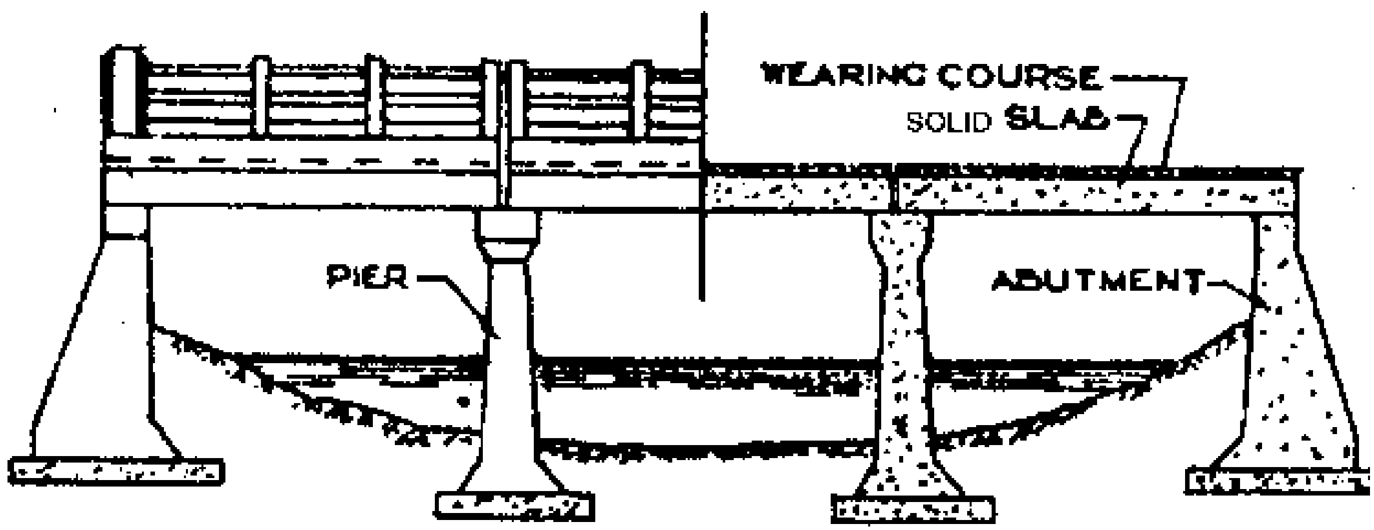
Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC SLAB

- A 'cast-in-place' reinforced concrete slab is the simplest type of bridge and is generally used for bridges with a span length of up to 10 metres. These are widely used in Karnataka.

Components of RCC solid slab

- Normally the slab has a uniform thickness throughout the span although in some bridges the slab thickness may be reduced at the edges



Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC SLAB

Common defects

It should be noted that only the soffit and the side faces of the slab are visible as the wearing coat normally covers the top surface of the slab.

- Honeycombing of concrete
- Spalls in concrete
- Efflorescence, dampness, leakage in concrete
- Cracking in concrete
- Corrosion of exposed reinforcement
- Deflection: Vertical movement of structural elements is known as deflection
- Limitations are generally expressed as a deflection to span ratio. generally live load bridge deflection for bridges are 1/800 to 1/1000

Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC SLAB

Where to look

- **Bearing Areas:** Examine each of the bearing areas for spalling, this being where the friction from thermal movement, or bearing pressure, could cause the concrete to crack or spall.
- **Shear zones:** Investigate areas near the supports for shear cracking.
- **Tension zones:** Tension zones should be examined for flexure cracks which will be vertical on the sides and transverse across the slab.
- **Areas exposed to drainage:** Inspect areas exposed to carriageway drainage for deteriorated concrete. This includes the entire riding surface of the slab, particularly around drains. Spalling or scaling may also be found along the kerb.

Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC SLAB

How to Quantify the Defects

- **Honey Combing -** Hit the slab with a hammer at a rate of 10 blows per 1 square meter area. Listen to the sound carefully. A hollow sound indicates poor concrete / honeycombing / voids, whereas, a metallic sound indicates good quality concrete.
- **Spalls in Span**

Number of spalls	Can be counted
Area of spalls	Can be measured with a measuring tape
Depth of spalls	Can be measured
Number of bars exposed	Can be counted
% of corrosion	Arithmetic calculation

- **Efflorescence, dampness and leakage Honey Combing -** Number of affected locations at each span can be inspected visually and recorded
- **Cracks in Span**

Nature of crack	Inspect to ascertain if the cracks, are horizontal, inclined, mesh or diagonal
Length of crack	Use a measuring tape
Width of crack	Use a crack gauge
Total area	Arithmetic calculation
Section of Super-structure	Locate visually

Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC SLAB

❑ Corrosion of Exposed Reinforcement

Number of location	Can be counted
Location	Can be identified with respect to span length and width
% with respect to bar diameter	Simple arithmetic calculation
Pit corrosion	Visual inspection

❑ Deflection

No deflection	By observation
Moderate deflection	By observation / measurement and with the aid of a string line
Excessive deflection	By observation / measurement and with the aid of a string line

❑ **Water ponding -** Number of locations where ponding of water occurs can be visually inspected. If the ponding occurs at mid span it is an indicator of span deflection

❑ Defects w.r.t Severity

Types / Defects	High	Moderate	Low
Spalling	More than 50% of total area	Btw 25% and 50% of total area	Less than 25% of total area
Deflection	Greater than 10mm	5mm to 10mm	Less than 5mm
Corrosion	Diameter of the bar reduced more than 20% of original diameter	Diameter of the bars reduced to 10% to 20% of original bar dia.	Diameter of the bars reduced to less than 10% at the original bar dia.

Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC SLAB

Overall Observation

The elements detailed on the data form should be assessed, depending on the severity of damage at the time of inspection. The following should therefore be checked by the Engineer and Quantified for each element

- Inspect for honeycombing or disintegration, spalling etc.
- Inspect efflorescence, dampness and leakage if any. Any evidence of water passing through cracks in the slab.
- Inspect cracking, nature of cracks and location, should be explained, preferably by drawing a sketch, detailing whether these are longitudinal, horizontal, diagonal, etc.
- Report corrosion of reinforcement and reduction in bar diameter, if any.
- Report excessive deflection or loss of camber, if any.
- Observe ponding and also identify where the concrete has been discolored.
- In the case of an asphaltic wearing surface, the real condition of the slab may not be visible. In such cases, large cracking in the wearing surface are often indications of slab damage.

Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC SLAB

Overall Guidelines for Rating

S. No.	Defects	Condition rating	BCI Values
1	Excessive vertical deflection due to live load, Crack Width more than 4mm, heavily corroded reinf.	Re-construction / New Construction	< 30
2	Crack Width around 2 to 3mm	Requires Strengthening / Rehabilitation	45 - 30
3	Excessive spalling of concrete with moderately corroded reinforcement		
4	Moderate vertical deflection	Moderate Repairs Required	65 - 45
5	Moderate spalling of concrete		
6	Small spalling of concrete	Minor Repairs Required	80 - 65
7	Pit corrosion of reinforcement		
8	Efflorescence, dampness, discoloration of concrete		

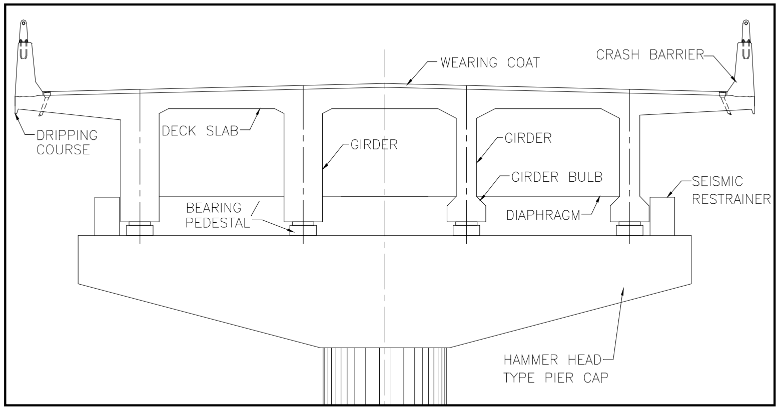
Data Collection – Condition Inspection Data

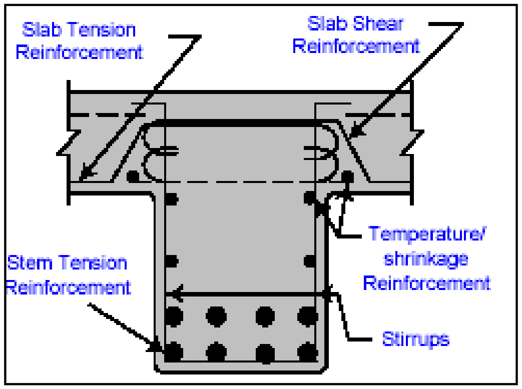
SUPER STRUCTURE – RC GIRDER

- The concrete tee-beam, a predominant bridge type for the last 50 years,
- Is generally a ‘cast-in place’ monolithic slab and stem system formed in the shape of the letter ‘T’. The ‘cast-in-place’ T-beam is the most common type of T-beams.
- RCC T-beam and slab super-structure is widely used for span ranges of 12 to 24 metres, mainly in the form of simply supported bridges

Components of RC Girder

- The main (primary) components of a T-beam bridge are the
- T-beam stem (web) and slab (flange).
- The only secondary members of an RCC T-beam super-structure are diaphragms (or cross-girders), which support the free edge of the beam flanges





Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC GIRDER

Common Defects

- Similar defects as discussed in RC Slab

Where to look - Bearing Areas, Shear zones, Tension zones and Areas exposed to drainage

Leaching

Honey Combing

Spalling

Severe Crack in Gir

Longitudinal Crack in Gir. Bottom

Bearing Crack

Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC GIRDER

How to Quantify the Defects

- **Honey Combing** – Similar to RC Slab
- **Spalls in Span** – Similar to RC Slab
- **Efflorescence, dampness and leakage Honey Combing** – Similar to RC Slab
- **Cracks in Span** – Similar to RC Slab
- **Corrosion of Exposed Reinforcement** – Similar to RC Slab
- **Deflection** – Similar to RC Slab
- **Water ponding** – Similar to RC Slab

- **Defects w.r.t Severity**

Types / Defects	High	Moderate	Low
Spalling	More than 50% of total area	Btw 25% and 50% of total area	Less than 25% of total area
Deflection	Greater than 20mm	10mm to 15mm	Less than 10mm
Corrosion	Diameter of the bar reduced more than 20% of original diameter	Diameter of the bars reduced to 10% to 20% of original bar dia.	Diameter of the bars reduced to less than 10% at the original bar dia.

Data Collection – Condition Inspection Data

SUPER STRUCTURE – RC GIRDER

Overall Guidelines for Rating – RC Girder

S. No.	Defects	Condition rating	BCI Values
1	Excessive vertical deflection of a girder	Re-Construction / New Construction	<30
2	Shear crack in any T-Girder of a width more than 2mm	Requires Strengthening / Rehabilitation	45 - 30
3	Bearing crack in any T-Girder of width of more than 2mm		
4	Excessive spalling of concrete with heavily corroded reinforcement in any girder.		
5	Moderate deflection in T-Girder or shear crack of width less than 2mm	Moderate Repairs Required	65 - 45
6	Bending cracks in any T-Girder.		
7	Moderate spalling cavities in any T-Girder.		
8	Low deflection	Minor Repairs Required	80 - 65
9	Low spalling		
10	Pot corrosion of reinforcement		
11	Efflorescence, dampness, honeycombing, discolouration of concrete.		

Overall Guidelines for Rating – RC Slab Over Girder

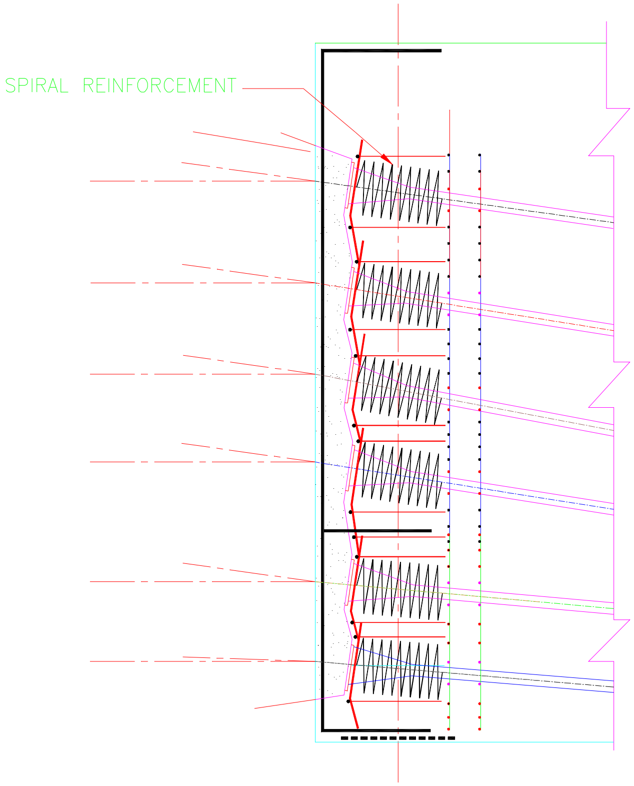
S. No.	Defects	Condition rating	BCI Values
1	Heavy spalling in deck slab	Strengthening / Rehabilitation	45 – 30
2	Low spalling in deck slab	Moderate Repairs Required	65 – 45
3	Cracks of width of more than2mm		
4	Cracks of width less than 2mm	Minor Repairs Required	80 - 65
5	Efflorescence, dampness, discoloration of concrete		

Data Collection – Condition Inspection Data

SUPER STRUCTURE – PSC I GIRDER

- Used for Long Span Bridges,
- steel tendons with high tensile strengths are located in the bottom bulb. These tendons are used to induce compression across the entire section of the beam prior to and during the application of live loads. This results in a crack free beam



Data Collection – Condition Inspection Data

SUPER STRUCTURE – PSC I GIRDER

Common defects

Similar to defects associated with RCC Girder bridges, In addition the following defect may also occur

- **Anchor:** In pre-stressed concrete girders, anchorages are very important and the main concern. They are located at the end blocks with the latter being designed to distribute the concentrated pre-stressing force to the anchorage locations. They should be inspected for damage and corrosion

Where to look - Bearing Areas, Shear zones, Tension zones and Areas exposed to drainage and **Anchor zone** (Inspect the area for damage to the anchor and ducts, loose strands and corrosion)

Data Collection – Condition Inspection Data

SUPER STRUCTURE – PSC I GIRDER

Additional possible problems include:

- Any sagging of individual members could indicate overloading or loss of pre-stress.
- Horizontal deflections (sweep) may indicate asymmetric loading from either non-uniform pre-stressing forces or tendon failure.
- Efflorescence, leakage, and staining indicate the likelihood of pre-stressed steel corrosion and a diminished load carrying capacity.
- Concrete delamination or spalling is definitive signs of pre-stressed steel corrosion and diminished capacity.
- Check for tendon damage if any of the beams have been impacted. Cracks spreading from the damaged area indicate the extent of pre-stress loss.
- Longitudinal cracks in the wearing surface may indicate that the shear keys of the primaries are not working as designed.
- Check drain holes for rust stains which could possibly indicate deterioration that is currently not visible until it becomes more serious

Data Collection – Condition Inspection Data

SUPER STRUCTURE – PSC I GIRDER

How to Quantify the Defects

- Similar to RC Slab and RC Girder, in addition the following shall be inspected w.r.t Anchorages

Number of damaged anchorage pans	Can be counted
Description of damage	Based on visual inspection
Degree of corrosion of the anchorage end	Noted as serious or Minor
Number of loose strands	Can be counted
Total number of strands in each anchorage	Can be counted

Data Collection – Condition Inspection Data

SUPER STRUCTURE – PSC I GIRDER

Overall Guidelines for Rating – PSC I Girder

S. No.	Defects	Condition Rating	BCI Values
1	Excessive vertical deflection	Re-construction / New Construction	< 30
2	Shear cracks of a width of more than 1mm.		
3	Exposure corrosion of PSC cables		
4	Moderate vertical deflection	Strengthening / Rehabilitation	45 – 30
5	Torsional cracks in girder.		
6	Spalling of concrete and corrosion of PSC cable ducts		
7	Bending cracks in girder		
8	Excessive spalling of Cantilever deck slab concrete.	Moderate Repairs Required	65 – 45
9	PSC anchors damaged/corroded		
10	Efflorescence, dampness, honeycombing, discolouration of concrete.	Minor Repairs Required	80 - 65

Data Collection – Condition Inspection Data

SUPER STRUCTURE – COMPOSITE STEEL STRUCTURE

- These type of structures are generally used in Railway Bridges. These are proposed for Long spans or if the Steel Material is available at lesser cost.
- In Karnataka there are few river bridges built with steel structures.
- Presently all ROBs (Railway Span for ROB) are being proposed with Composite Steel Girders.

Components of Composite Steel Sections

- The main (primary) components of a Steel-beam bridge are the
- The Main Primary components is the Steel Girder / Steel Truss and the Slab over the Girder
- The secondary members of Steel Structure are the Stiffeners, Bracings and Diaphragms

Data Collection – Condition Inspection Data

SUPER STRUCTURE – COMPOSITE STEEL STRUCTURE

Common defects

- The common defects of concrete are same as discussed in previous section.
- The defects associated with Steel structure are
  - Cracking
  - Deterioration of paint or galvanizing
  - Bends in webs, flanges, stiffeners or bracings
  - Loose bolts or rivets
  - Vertical deflection

Data Collection – Condition Inspection Data

SUPER STRUCTURE – COMPOSITE STEEL STRUCTURE

Where to look

- The Main Steel Structure, Bearing areas, Shear Zones, Tension Zones and Areas exposed to drainage

Overall Guidelines for Rating – Steel Girder

S. No.	Defects	Condition rating	BCI Values
1	Excessive vertical deflection of a girder, Severe Corrosion, Wide Cracks of the Main Components of the Steel Structure	Re-Construction / New Construction	< 30
2	Bends in webs, flanges, stiffeners or bracings, Excessive spalling of concrete with heavily corroded reinforcement in Slab.	Requires Strengthening / Rehabilitation	45 – 30
3	Moderate deflection in Steel Structure, Deterioration of Anti- corrosive paint or galvanizing, Loose bolts or rivets	Moderate Repairs	65 – 45
4	Low deflection, Small spalling of concrete	Minor Repairs Required	80 - 65

Data Collection – Condition Inspection Data

MASONRY STRUCTURES

- Since bricks and stones are durable and low maintenance materials, they have been both previously and frequently used in the construction.
- Well maintained masonry bridges and culverts have lasted for more than a century

Types of Masonry Works

- Stone Masonry, Brick Masonry

Type of Defects

- Cracking
- Bulging
- Loss of pointing
- Deterioration of stone, concrete blocks or bricks
- Defects in plaster
- Cavities

Data Collection – Condition Inspection Data

MASONRY STRUCTURES

Cracking

- Cracking is an indication of distress in masonry.
- It can be caused by over-loading, vibration or impact from traffic.
- Failure or settlement of foundations, change in temperature or
- alternate wetting and drying can also cause cracking.
- The cracks normally pass only through mortar joints. However, cracks which cross bricks, stones or concrete blocks, are usually serious.

Cracks should be considered `serious' when:

- Cracks cross the masonry element (i.e. Stones, bricks, or concrete blocks)
- A step occurs in the face of masonry
- Cracks are about 5mm and wider
- The crack crosses the entire thickness of the structural component (e.g. through the pier wall)

Data Collection – Condition Inspection Data

MASONRY STRUCTURES

Bulging

- Bulging is a change in the shape or curving of the face of the masonry element. It is usually caused by excessive back-pressure.

Loss of pointing

- Mortar between bricks, stones or concrete blocks. The mortar can be eroded or deteriorated through the action of a river or by rain.

Deterioration of bricks, stones or concrete blocks

- Many weaker types of bricks or stones have a shorter life. They can be worn away by weathering, rainwater or river flow

Defects in plaster

- The plaster cover normally shows non-structural defects which are not serious
- The defects which affect and deteriorate the plaster cover (such as bulging, spalling, through cracks, etc.) should be deemed “serious” structural defects

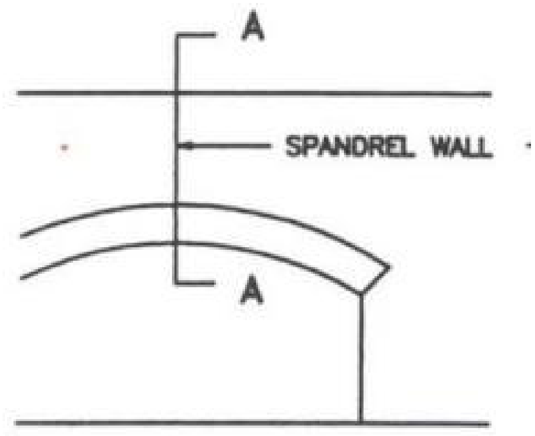
Cavities

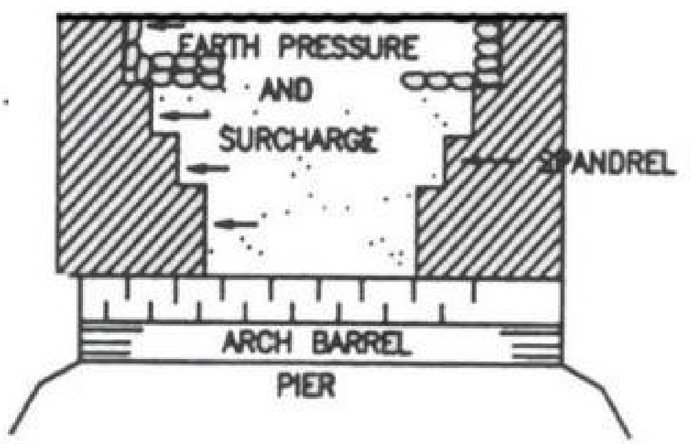
- The presence of cavities in masonry work is normally a construction defect. This occurs due to poor workmanship. Improper pointing can also result in missing and/or splitting of stones or brick units.

Data Collection – Condition Inspection Data

SUPER STRUCTURE – MASONRY ARCH BRIDGES

- Masonry arches are closed spandrel arches.
- The spandrel area, the area between the arch and the roadway, contains ‘fill’ which is retained by vertical walls.
- The arch section is called a ‘ring’ or ‘barrel’ and is continuous member between the spandrel walls



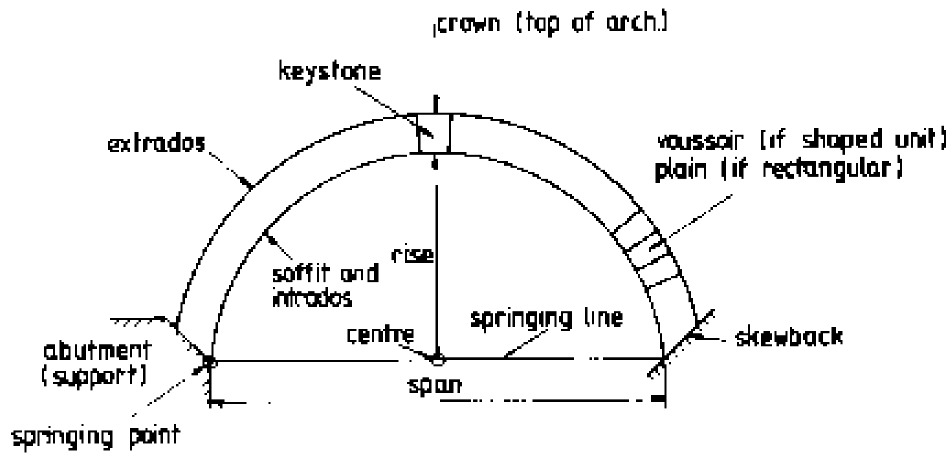


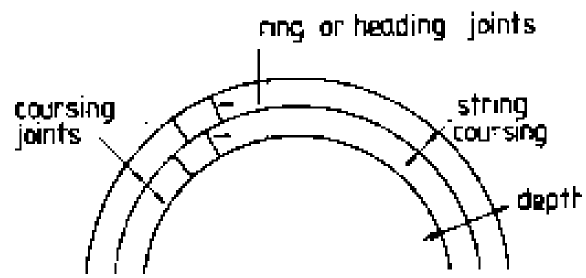
Data Collection – Condition Inspection Data

SUPER STRUCTURE – MASONRY ARCH BRIDGES

Arch Components

Abutments	Portions of a wall supporting the arch
Coursing joints	Joints between rings
Crown	Highest point of extrados
Depth	The normal distance between intrados and extrados
Extrados	The external curve of the arch, sometimes termed the back of the arch
intrados	The inner curve of the arch
Keystone	The keystone is the top and is placed last in the construction of the arch.
Ring(s)	Course(s) comprising the arch.
Ring or bed joints	Joints between voussoirs
Rise	Vertical distance between the 'springing' line and highest point on the intrados
Skewbacks	Prepared or inclined surfaces of abutments from which the arch 'springs'
Soffit	The under surface of the arch. Both soffit and intrados are accepted as having the same meaning.
Span	Horizontal distance between 'springing' points
Springing line	Horizontal line between 'springing' points
Springing points	Points of intersection between skewbacks and the intrados
Intermediate Stones	The wedge-shaped units comprising the arch.





Data Collection – Condition Inspection Data

SUPER STRUCTURE – MASONRY ARCH BRIDGES

What to look for:

- Stone masonry should be rated as a primary member only when it is structural masonry.
- Some of Karnataka's oldest bridges are masonry arches. In rating primary members, consideration should be given to the condition of: the brick/stone; the masonry work and, the overall behaviour of the arch and spandrel walls.
- In assessing stone/brick condition, it is necessary to look for weathering, splits, de-lamination or cracks in individual stones/bricks, spalling, and crumbling.
- The mortar should be examined for soundness, signs of leakage, and associated efflorescence, with the missing percentage of mortar being estimated.
- The masonry arch and spandrel walls should be examined as a part of main structural system for signs of distress, such as: moved or shifted stones, cracks, or splits through adjoining stones and, leakage that quickens deterioration

Data Collection – Condition Inspection Data

SUPER STRUCTURE – MASONRY ARCH BRIDGES

Structural Defects:

- **Defects in arch barrel:** Due to both ageing and weathering
- **Extension of cracks from the sub-structure to the arch barrel:** due to differential settlement in sub-structure.
- **Transverse or diagonal cracks in arch barrel (intrados):** These cracks are serious in nature and indicate the presence of tensile stresses at the intrados.
- **Crushing of masonry:** Leaching of mortar in the joints, Weathering of masonry, Excessive loading, Inadequate cushioning over the arch
- **Loose of keystone and Other stones in Arch;** This can occur due to the settlement/titling of an abutment or pier.
- **Spandrel Wall:** The sliding of spandrel walls over the arch barrel, bulging or poor fitting of the spandrel wall
- Plastering / Pointing defects, Vegetative Growth

Data Collection – Condition Inspection Data

SUPER STRUCTURE – MASONRY ARCH BRIDGES

Observations:

- For arches, the most important point to look for is any change in the shape of the arch.
- Standing a long distance away, compare the shape on the left of the arch centre with that on the right.
- Look for any shifts in the key stone at the centre of the face walls.
- From under the arch look for any change, local or otherwise, to the shape of barrel.
- The arch barrel should also be checked for any cracking. Cracks across the road are usually a dangerous sign.
- There may also be bulging of face walls. Any bulge in the face walls should be documented.
- Check any spalling of stones or bricks in the arch or in spandrel walls.
- Quality and loss of pointing should be documented.
- Leakage through the arch: If the leakage is excessive then the arch will become damaged by the loosening of mortar and the decay of masonry

Data Collection – Condition Inspection Data

SUPER STRUCTURE – MASONRY ARCH BRIDGES

Loosening of Mortar Joints

Spandrel wall Damaged

Change in Arch Shape

Vegetative Growth in Spandrel wall

Severe loss of Bricks in Arch

Data Collection – Condition Inspection Data

SUPER STRUCTURE – MASONRY ARCH BRIDGES

Overall Guidelines for Rating – Masonry Arch

Sl. No	Defects	Condition rating	BCI Values
1	Significant movement of the key stone creating structural instability in the arch, Serious weathering of stones	Re-construction / New Construction	< 30
2	Signs of slight movement along arch or wall lines and/or, serious leakage causing deterioration of stones and mortar	Strengthening / Rehabilitation	45 – 30
3	Loss of a significant amount of mortar with around 40 percent of mortar missing	Moderate Repairs Required	65 – 45
4	With minor cracks being observed in the masonry, up to 15 percent of mortar maybe missing and leakage may be occurring but this is neither serious nor causing progressive deterioration. There may also be minor weathering of stones	Minor Repairs Required	80 - 65

Data Collection – Condition Inspection Data

BEARINGS

- A bridge bearing is an element of a bridge that provides an interface between the superstructure and substructure

The three primary functions of a bridge bearing are:

- To transmit horizontal and vertical loads from the superstructure to the substructure
- To permit longitudinal movement of the superstructure due to thermal expansion and contraction at designated support locations
- To allow rotation caused by dead and live load deflection

Types of Bearing

- Metal bearings and PTFE Pot Bearings
- Elastomeric bearings.

Data Collection – Condition Inspection Data

BEARINGS

Types of Metal Bearing

- **Roller bearings :** A roller bearing consists of a cylinder which "rolls" between the sole and masonry plate as the superstructure expands and contracts.
- **Rocker bearing:** A bearing essentially consists of a curved surface in contact with a flat or curved surface and is constrained to prevent relative horizontal movement
- **Knuckle bearing:** A bearing essentially consisting of two or more members with curved surfaces. The curved surfaces may be spherical or cylindrical.
- **Sliding bearing :** A bearing consisting of two surfaces sliding one on the other

POT / PTFE Bearings :

- A bearing consisting of a metal piston supported by a disc of un-reinforced elastomer that is confined within a metal cylinder or "Pot".

Elastomeric bearing:

- An elastomeric bearing comprises a block of elastomer that may be reinforced internally with steel plates (i.e. steel laminates) which makes it a laminated or restrained elastomeric bearing.

Data Collection – Condition Inspection Data

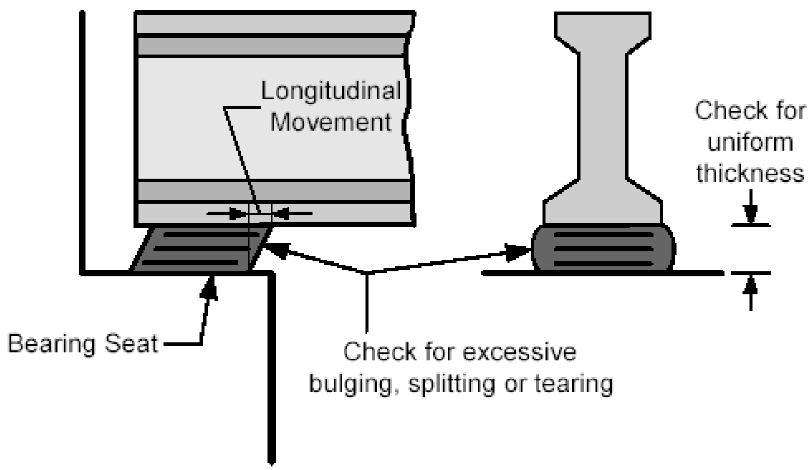
BEARINGS

Bearing pedestals

- The pedestals function is to support the bearings, transfer loads to the sub-structure and to make up any differences in elevation between the top of the cap or pier and the bottom of the bearing

What to look for:

- **Elastomeric bearing:** Compression bulging of sides, Excessive longitudinal or transverse deformation
- **Metallic and pot bearings:** Deformity in the bearing, Damaged anchor bolt, Free movement of the bearing, Rusting of a metal bearing.



Data Collection – Condition Inspection Data

BEARINGS

Overall Guidelines for Rating – Bearings

For Elastomeric Bearings

S. No.	Defects	Condition rating	BCI Values
1	Surface cracking	Replace	< 30
2	Radial cracking	Replace	< 30
3	Excessive shear deformation	Replace	< 30
4	Spalling of concrete in pedestal	Rehabilitate	45 – 30
5	Compression bulging of sides	Rehabilitate	45 – 30
6	Splitting of concrete in pedestal	Rehabilitate	45 – 30
7	Cracks in pedestal	Moderate Repairs	65 - 45

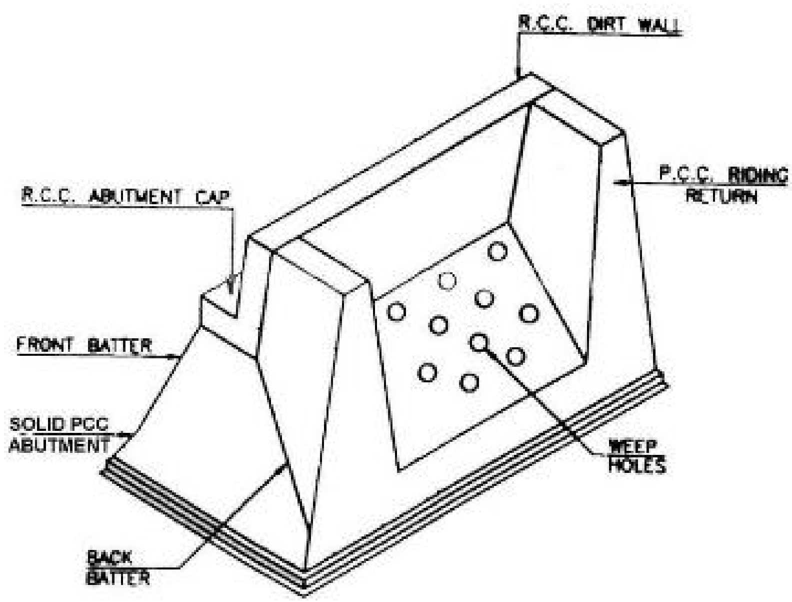
For Metal Bearings

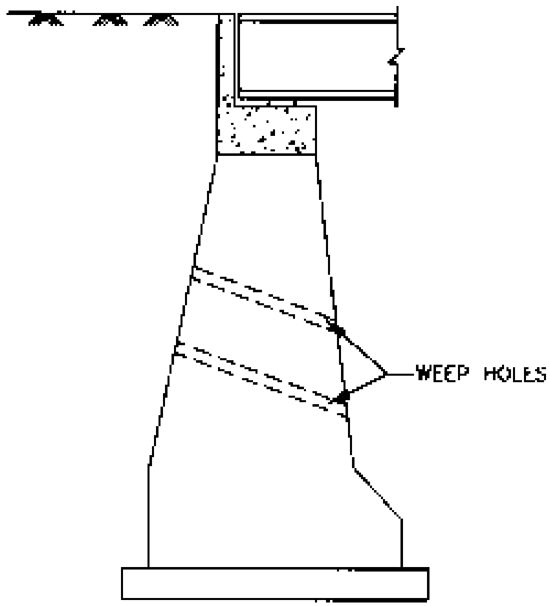
S. No.	Defects	Condition rating	BCI Values
1	Deformity or cracks in the bearing	Replace	< 30
2	Heavy rusting of bearing	Replace	< 30
3	Restricted free movement of bearing	Rehabilitate	45 – 30
4	Spalling of concrete in pedestal	Rehabilitate	45 – 30
5	Splitting of concrete in pedestal	Moderate Repairs	65 – 45
6	Bearing not sitting in full length	Moderate Repairs	65 – 45
7	Cracks in pedestal	Moderate Repairs	65 – 45
8	Damaged Anchor bolt	Minor Repairs	80 – 65
9	Missing or loose nuts for anchors	Minor Repairs	80 - 65
10	Nominal Rusting of bearing	Minor Repairs	80 - 65

Data Collection – Condition Inspection Data

SUB STRUCTURE : ABUTMENT

❑**Abutment:** The End Supports of the Deck (Superstructure) of the Bridge, which also retains earth, fill of approaches behind.





Data Collection – Condition Inspection Data

SUB STRUCTURE : ABUTMENT

❑ **Common Defects – Material**

Concrete – Cracking, Delamination, Spalling, Scaling, Crushing, Exposure of reinforcement.

Masonry – Weathering, Spalling, Cracking, Splitting, Mortar cracking and Deterioration

In addition to the above stability is of paramount concern, the checking for various forms of movement is also required.

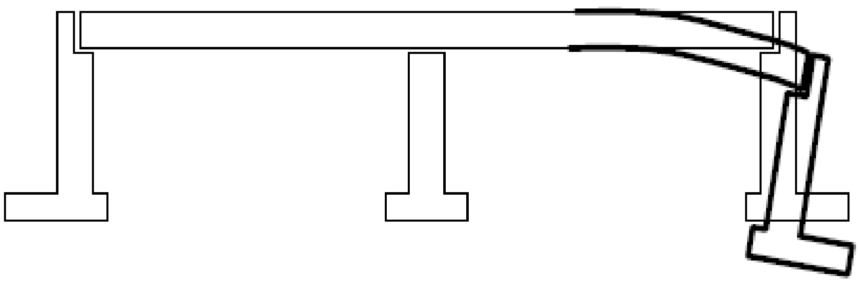
The most common problems likely to be observed during an inspection of abutments are:

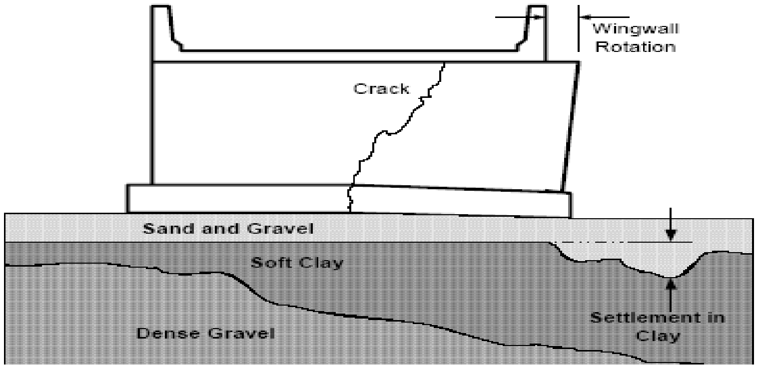
- Vertical movement
- Lateral movement
- Rotational movement
- Material defects
- Scour of the foundation
- Drainage system malfunction

Data Collection – Condition Inspection Data

SUB STRUCTURE : ABUTMENT

- **Vertical Movement -** Vertical movement can occur in the form of uniform or differential settlement.
- The most common causes of vertical movement are soil bearing failure, consolidation of soil, scour, and deterioration of the abutment foundation material.

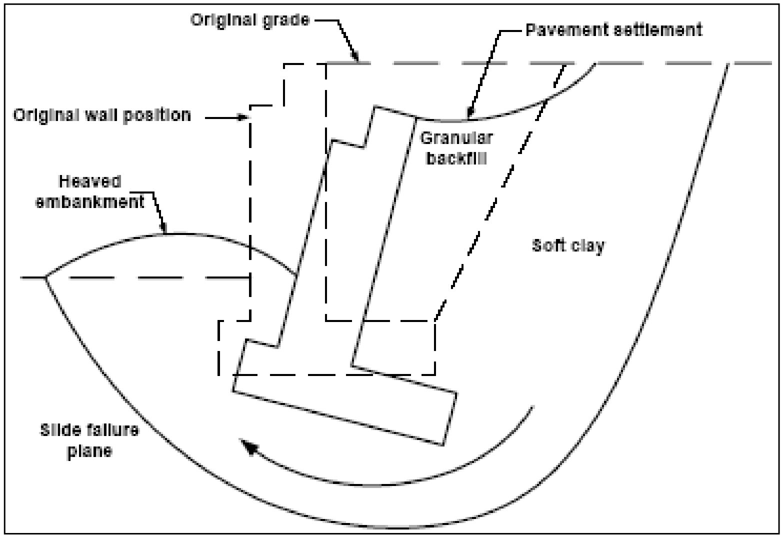


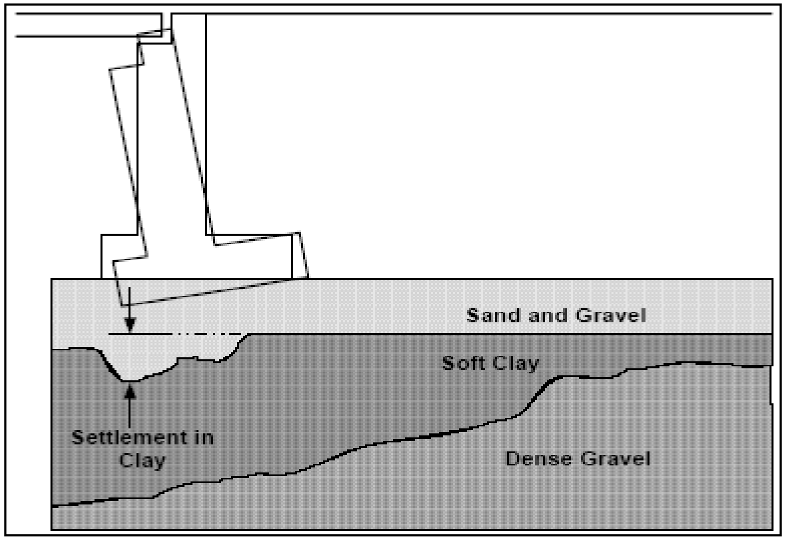


Data Collection – Condition Inspection Data

SUB STRUCTURE : ABUTMENT

- **Lateral Movement** - occurs when the horizontal earth pressure acting on the wall exceeds the friction forces that hold the structure in place.
- The most common causes of lateral movement are slope failure, seepage, changes in soil characteristics, and time consolidation of the original soil.
- **Rotational movement** - Rotational movement, or tipping of sub-structure units, is generally the result of unsymmetrical settlement or lateral movement due to horizontal earth pressure.





Data Collection – Condition Inspection Data

SUB STRUCTURE : ABUTMENT

What to look for

- **Abutment cap and Dirt wall -** Deformation in Earth wall, Cracks in Cap
- **Abutment foundation:** check for scour and Settlement
- **Abutment**
  - Examination of the bearing seats for cracking and spalling, particularly near the edges
  - Inspection for the presence of debris and standing water on the bearing seats.
  - Check for deteriorated concrete in areas that are exposed to road drainage
  - Check of the back wall for cracking and possible movement.
  - Examination of the construction joint between the back wall and the abutment stem.
  - Inspection of stone masonry for mortar cracks or loss of mortar in the joints.
  - Examination of stone masonry for vegetation, water seepage through cracks, loose or missing stones, weathering, and spalled or loose blocks.

Data Collection – Condition Inspection Data

SUB STRUCTURE : ABUTMENT

Cracks due to Earth Pressure

Cracks due to Settlement

Deformation of Dirt Wall

Poor Quality of Stones and workmanship

Data Collection – Condition Inspection Data

SUB STRUCTURE : ABUTMENT

Overall Guidelines for Rating – Abutment

S. No.	Defects	Condition rating	BCI Values
1	Observed settlement at abutment location	Re-construction	< 30
2	Crack width greater than 4mm along with excessive, spalling of concrete and highly corroded reinforcement, Loose/shifted masonry.	Rehabilitation	45 – 30
3	Deformation of earth wall, Cracks in earth wall	Rehabilitation	45 – 30
5	Width of cracks in abutments is between 2mm and 4mm, Spalling / cracking / damage to Masonry	Moderate Repairs	65 – 45
6	Spalling of concrete and exposed reinforcement, Loss of joint material	Moderate Repairs	65 – 45
7	No weep holes.	Moderate Repairs	80 – 65
8	Partly blocked weep holes, Vegetation growth.	Minor Repairs	80 - 65

Data Collection – Condition Inspection Data

SUB STRUCTURE : PIER

- The function of piers is to support a bridge at intermediate intervals with minimal obstruction to the flow of traffic or water below the bridge

What to look for - Similar check as discussed for Abutment

- **Check for cracks in pier:** identify location and nature of cracks e.g. structural cracks are critical in comparison to shrinkage cracks.
- **Check for damage due to floating objects/debris:** Damage of a pier due to floating objects or debris can be identified visually. This defect is manifest by either a crack or damage.
- Check for loose joints, Check for plaster condition
- Check for damaged stone/brick masonry, Check for vegetation growth
- Check for spalling of concrete, Check for corrosion of reinforcement
- **Settlement of pier**: Check for settlement at the pier foundation.

Data Collection – Condition Inspection Data

SUB STRUCTURE : PIER

Cut Water / Pier Damaged due to Debris

Crack in pier due to Settlement

Damaged Stone Masonry due to Insufficient Mortar Joints

Road Surface settled due to settlement of Pier

Data Collection – Condition Inspection Data

SUB STRUCTURE : PIER

Overall Guidelines for Rating – Pier

S. No.	Defects	Condition rating	BCI Values
1	Observed settlement at pier location	New Construction / Reconstruction	< 30
2	Crack width greater than 4mm along with excessive spalling of concrete and highly corroded reinforcement	Rehabilitation / Strengthening	45 – 30
3	Partial collapse of pier cur water portion, Loose/shifted masonry		
4	Crack width between 2mm to 4mm	Moderate Repairs	65 – 45
5	Spalling of concrete, cracking / damage to Masonry, Loss of joint material		
6	Crack width less than 2 mm, Vegetation growth.	Minor Repairs	80 - 65

Data Collection – Condition Inspection Data

SUB STRUCTURE : PIER CAP

- The primary function of pier cap is: To transmit loads (Horizontal and Vertical) from the bridge bearing to the pier

Types of pier cap

Pier caps can be divided into three major categories based on the structural arrangements

- Pier cap over a solid shaft pier
- Cantilever pier cap or hammerhead pier cap
- Pier cap or pier beam for frame type pier

Data Collection – Condition Inspection Data

SUB STRUCTURE : PIER CAP

What to look for

- **Water marks on the pier cap:** Water marks on the pier cap are a sign of inadequate drainage, leaking expansion joints. The water marks are not an indicator of pier cap deterioration but indicate the insufficiency of other structural components.
- **Cracks in Pier cap:** Cracks are an indication of deterioration of a failed concrete section or, high corrosion of the reinforcement in the pier cap.
- **Spalling of concrete and corroded reinforcement in Pier a cap:** Spalling of concrete and the exposure of reinforcement is a major factor in the deterioration in a pier caps as these reduce the effective depth of the pier cap and the structural capacity of the section.

Data Collection – Condition Inspection Data

FOUNDATION

- Foundations are critical to the stability of a bridge since this ultimately supports the entire structure.
- All loads and forces coming from the Super/Sub-structure will ultimately need to be transferred safely to the earth below the riverbed or below any other natural soil formations.
- The load transfer should take place in such a manner that there is no unexpected total or differential settlement.
- Should not result in any damage due to scour during the design life of the bridge.
- Two major types of foundation are used for bridges, namely:
  - Shallow (open) foundations
  - Deep foundations:
    - Well foundations
    - Pile foundations

Data Collection – Condition Inspection Data

FOUNDATION

Common defects

- **Structural** – Similar as discussed in earlier chapters
  - **Masonry defects:** Cracking, Loss of Pointing, Deterioration
  - **Concrete defects:** Cracking, Spalling, Scaling, Erosion of the concrete surface, Honeycombing, Porosity, Hollow sound, Exposed reinforcement and Corrosion of bars.
- **General Defects:** Scour, Stream / river bed protection, Settlement

Scour

- Scour is defined as the removal and transport of material from the bed and banks of rivers and streams as a result of the erosive properties of running water.
- Nevertheless, some general scouring continually takes place in all stream/river beds, particularly during periods of flood.

Data Collection – Condition Inspection Data

FOUNDATION

Scour – What to Look For

- Check for the erosion of stream/river banks and increasing channel depths.
- High water velocities indicate a potential for scour.
- Check for situations that increase stream velocity, such as siltation in any part of the channel, deflection of the stream/river by protruding substructures or, inadequate openings.
- **Reasons for Scour**

S. No.	Details
1	Channel migration
2	Stream flow velocity
3	Channel opening
4	Streambed material
5	Substructure shape and orientation
6	Skew angle
7	Orientation of piers for parallel bridges
8	Protruding abutments

Data Collection – Condition Inspection Data

FOUNDATION

Observations at site for assessing the scour potential at a bridge location.

- Does the waterway area appear small in relation to the stream/river and floodplain
- Is there evidence of scour across a large portion of the streambed at the bridge
- Are sand bars, islands, vegetation and debris obstructing the flow and concentrating into one section of the bridge or is it causing the flow to the piers and abutments
- Does the superstructure, or do the piers, abutments, and fences, etc., collect debris and obstruct the flow
- Are the approach roads regularly overtopped
- If the waterway opening is inadequate, does this increase the scour potential at the bridge foundation

Other features to be checked

- Existence of upstream tributaries, bridges, dams, or other features, that may affect flow conditions at a bridge.

Data Collection – Condition Inspection Data

FOUNDATION

Excessive Scour on D/S Side of Structure

Local Scour at Pier Location

Data Collection – Condition Inspection Data

RIVER PROTECTION WORKS

- Are Provided as protection to Foundation / River bed against lateral migration of the channel and high velocity flows and scour.

Most Common protection works

Floor Apron – Below the Structure (May be with concrete and Flat stones or Wire Mattresses)

Curtain wall – Provided after the Floor Apron for depth of 2.0m on u/s and 2.50m on d/s side with Concrete or with Gabions.

Flexible Apron – Generally consisting of Stone Boulders or Wire Mattresses beyond the Curtain wall.

Side Slope Pitching – To protect the approach embankment, usually provided with Stone Pitching over filter media or with Wire Mattresses.

Guide Bunds, Spurs – To chanalise the flow.

Data Collection – Condition Inspection Data

RIVER PROTECTION WORKS

What to Look for

- Examine any river training and bank protection elements to determine their stability and condition.
- Check for any gaps or spreading that may have occurred in the protective elements.
- Check for exposure of underlying erosion sensitive material.
- Check for evidence of slippage of protection work.
- Check the condition and function of Protection works
- Check for the proper placement, condition, and function of Guide walls, or spurs.
- Check the stream/river bed in the vicinity of the channel protection work for evidence of scour under the

Data Collection – Condition Inspection Data

RIVER PROTECTION WORKS

Conventional Stone Pitching

Gabions and Mattresses for Floor Protection

Data Collection – Condition Inspection Data

FOUNDATION

Overall Guidelines for Rating – Foundation

S. No.	Defects	Condition rating	BCI Values
1	Observed settlement at foundation, Severe Cracks in foundation	Reconstruction	< 30
2	Stream/river bed protection completely washed away, Scour Criticality ‘High Risk”	Rehabilitation	45 – 30
4	Scour criticality “Medium Risk”	Moderate Repairs	65 – 45
5	River bed protection partially washed away, Crack width 2 to 4mm		
6	Observe cracks, spalling of Concrete, exposed reinforcement in the exposed portion of the footing		
7	Scour criticality “Low Risk”, Crack width less than 2mm.	Minor Repairs	80 - 65
8	Minor damage to stream/river bed protection.	Minor Repairs	80 - 65

Data Collection – Condition Inspection Data

MISCELLANEOUS COMPONENTS OF BRIDGE

Expansion Joint

- Is a gap between the end of edges of two adjacent superstructure spans, or between the end edge of a superstructure span and dirt wall at abutment.
- These are provided to accommodate the translations due to possible shrinkage and expansions due to temperature changes.
- These make the deck joint leak proof, protect the edges of slab / girder and also allow smooth passage of loads from one span to another by bridging the gap

Type of expansion joints

- Strip Seal joint.
- Modular type joint
- Asphaltic plug expansion joint.
- Filler joint.

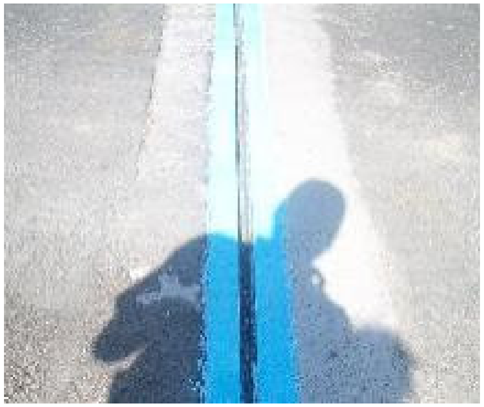
Data Collection – Condition Inspection Data

MISCELLANEOUS COMPONENTS OF BRIDGE

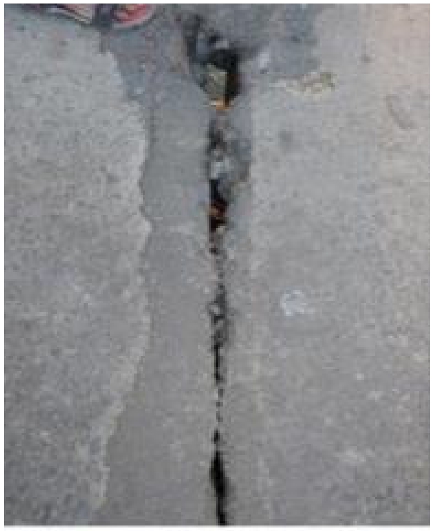
Expansion Joint

What to check for

- proper vertical alignment.
- accumulation of debris.
- water tightness (Deterioration of seal or sealant).
- cracking and spalling of concrete at expansion joint location.
- rust in the steel plates.
- loose anchorages and missing end plates or angles.
- broken components, bolts and welds.
- any sound at the expansion joint with traffic movement



Newly Laid Expansion Joint



Damaged Expansion Joint

Data Collection – Condition Inspection Data

MISCELLANEOUS COMPONENTS OF BRIDGE

Drainage Spout

- The purpose of providing a drainage system is to remove water, and all the hazards that are associated with it, from the structure without causing any damage to the system.

Deck drainage system

- In order to perform an inspection of a bridge deck drainage system, it is necessary to become familiar with its various elements:
  - Bridge deck cross slope and profile
  - Deck drains
  - Outlet pipes
  - Downspout pipes

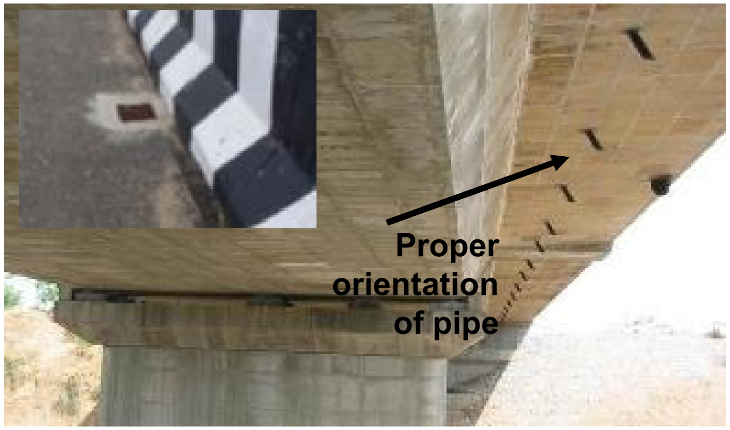
Data Collection – Condition Inspection Data

MISCELLANEOUS COMPONENTS OF BRIDGE

Drainage Spout

Check for:

- improper cross fall.
- proper orientation of the piping.
- material in the drainage pipe.
- the existence of a collection pit at the drainage location.
- grills over the drainage spout.
- the projection of the drainage pipe below the soffit of the deck slab.
- any missing drainage pipes.
- any broken pipes.
- any watermarks, delamination or spalling of concrete at the drainage locations.
- clogging by debris at drainage locations.
- corrosion of grills.



Drainage inlet clogged

Missing Drainage Pipe

Data Collection – Condition Inspection Data

MISCELLANEOUS COMPONENTS OF BRIDGE

Footpath

- A separate space provided for pedestrians confined within the total width of the bridge.
- The basic concept of providing a fp on bridge is to provide safe passage for pedestrian movement over the structure.

Types of footpaths

- Solid type footpath.
- Hollow type providing ducts for service lines.
- Separated or guarded footpath.

Check for: -

- type of footpath.
- number of service ducts in footpath.
- damaged length of footpath.
- nature of damage to footpath.
- number of blocked ducts.

Data Collection – Condition Inspection Data

MISCELLANEOUS COMPONENTS OF BRIDGE

Railings / Crash Barrier / Parapets

- Railings or crash barriers are provided at the edge of the superstructure or carriageway, parallel to the carriageway, provided for the safety of vehicles and pedestrians
- The primary function of any railing or crash barrier is to protect pedestrians and vehicles. The objectives of such are; hazard elimination, vehicle retention and vehicle redirection.

Types of Parapet, railing and crash barrier

- **Parapet:** These are with Stone Masonry, Brick Masonry or Reinforced Concrete Parapet.
- **Reinforced concrete railing:** RCC railings have vertical posts cantilevering from the kerb/deck with horizontal rails.
- **Steel pipe railing**: Steel railings have two vertical post members and horizontal rails. The vertical post may be inserted in concrete pedestals or over the bridge deck.
- **Reinforced concrete crash barrier:** Reinforced concrete crash barriers are solid sections designed to withstand the impact of vehicle of a certain weight at a certain angle whilst travelling at a specified speed.

Data Collection – Condition Inspection Data

MISCELLANEOUS COMPONENTS OF BRIDGE

Railings / Crash Barrier / Parapets

Check for

- railing with or without kerb.

Concrete railing/concrete crash barrier:

- common concrete defects.
- damage to railing/crash barrier.

Steel railing

- shape of railing.
- number of pipes missing.
- number of posts missing.
- damage to the crash barrier.

Data Collection – Condition Inspection Data

MISCELLANEOUS COMPONENTS OF BRIDGE

Wearing Coat

- The layer provided on the top of the deck, comprising either a bituminous or concrete layer.
- The wearing coat provides for a better riding quality for traffic. It also protects the bridge deck from contamination and deterioration resulting from the effects of traffic and weather.
- **Types of wearing coat;** Cement Concrete, Bituminous (Asphaltic)
- **General definition of defects:** Ravelling, Rutting, Cracking, Depression, Potholes:

Check for:

- type of wearing coat.
- fine and wide cracks.
- any depressions.
- potholes.
- ravelling.
- any marks of corrugation or rippling.

THANK YOU