Government of the People's Republic of Bangladesh
Local Government Engineering Department (LGED)

Bridge Inspection and Condition Assessment Guideline

December, 2025

Message

It is a matter of great satisfaction that the **Bridge Inspection & Condition Assessment Guideline** has been developed under the Program for Supporting Rural Bridges (SupRB), jointly funded by the Government of Bangladesh (GoB) and the World Bank. This Guideline is a milestone in LGED's journey toward strengthening its overall **Bridge Asset Management Framework.**

The Guideline provides a structured approach to inspecting the physical condition of each element of bridges and culverts within the rural road network. The collected data will be systematically entered into the RuBIMS database, enabling LGED management to generate accurate reports and tools for effective prioritization, budgeting, and maintenance programming.

The integration of the Guideline with the RuBIMS software and Mobile App ensures that bridge asset management is both modernized and institutionalized. A sequential and systematic use of this Guideline, together with the Bridge Management and Maintenance Manual, will greatly benefit LGED's officials at Upazila, District, and program levels in conducting inspections and managing maintenance operations.

I am confident that this Guideline will not only enhance LGED's bridge asset management capabilities but also strengthen institutional knowledge on bridge durability, serviceability, and long-term sustainability.

I take this opportunity to express sincere appreciation to the World Bank Task Team and subject matter experts for their valuable support and guidance in preparing this Guideline.

(Kazi Golam Mustafa)
Chief Engineer
Local Government Engineering Department

Message

It is a great pleasure to present the **Bridge Inspection & Condition Assessment Guideline**, developed under the SupRB project. This Guideline represents a significant advancement in LGED's asset management practices, ensuring that bridge and culvert inspection is carried out in a systematic, standardized, and accountable manner.

The Guideline emphasizes the fundamentals of bridge and culvert inspection, periodic updating of the RuBIMS database, and generation of reports that will support prioritization and budgeting of maintenance programs. The development of the RuBIMS software and Mobile App has further strengthened LGED's capacity, making bridge asset management more efficient and technology-driven.

This Guideline will serve as a practical tool for contractors, engineers, and LGED officials at all levels, helping them to adopt standardized practices, minimize risks, and ensure the durability and serviceability of bridge structures. It will also contribute to the future development and upgrading of LGED's Bridge Asset Management Policy.

I extend my heartfelt thanks to the World Bank Task Team and subject matter experts for their valuable comments and feedback during the preparation of this Guideline. Together, we reaffirm our commitment to building infrastructure that is not only strong and resilient but also safe, responsible, and sustainable.

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Program for Supporting Rural Bridges (SupRB)

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Acronyms and Abbreviations

ANSI	American National Standards Institute	LWC	lightweight concrete
Ap	Approaches	LGED	Local Government Engineering Department
BAM	Bridge Asset Management	MLIT	Ministry of Land, Infrastructure, Transport and Tourism
Bh	Bearings	MSC	Magnetic Sliding Collar
BHI	Bridge Health Index	MSMC	micro-silica modified concrete
Cb	Curb	NDE	Non-destructive evaluation
CIP	Cast-In-Place	NENR	Non-exist and not required
CPR	Cardiopulmonary Resuscitation	NER	Non-exist but required
CS	Condition State	OHS	Occupational Health and safety
DD	Damage Degree	Pm	Pavement
EDM	Electronic Distance Meter	QC	Quality Control
ECR	Element Condition Rating	QA	Quality Assurance
EPS	Element Priority Score	Ra	Railing
ECS	Element Condition Score	RHD	Roads and Highways Department
ECI	Element condition index	RSDMS	Road and Structure Database Management System
FHWA	Federal Highway Administration	RuBIMS	Rural Bridge Information Management Systems
FRC	Fiber Reinforced Concrete	SAE	Sub-assistant Engineer
GoB	Government of Bangladesh	SE	Superintending Engineer
GPS	Global Positioning System	SI&A	Structure Inventory and Appraisal
ISEA	International Safety Equipment Association	UE	Upazila Engineer
JSCE	Japan Society of Civil Engineers	UNR	Union Road
LMC	latex modified concrete	UZR	Upazila Road
LSDC	low slump dense concrete	Wg	Wheel Guard

CHAPTER 1
INTRODUCTION

1.1 LGED

Local Government Engineering Department (LGED) is one of the largest engineering organizations in the country. Although it has started it's journey in developing Rural Infrastructure in the 60s through Rural Works Program, its scope has been expanded momentously in course of time. Starting from the remotest localities of the country to the urban and city boundaries, LGED's huge activities are widespread.

In revitalizing the rural economy LGED's contribution through establishment of Rural Road connectivity and development of Hat-Bazars and Growth Centers in the rural areas is quite discernable today. The contribution of these infrastructures in achieving the increasing growth of the country is immense. LGED made it possible for the people of remote villages in getting the benefit of using paved roads within a maximum range of two kilometers. These rural infrastructures implemented by LGED are playing a major role in improving people's living standards and poverty alleviation. Besides, the activities mentioned above, LGED extending technical assistance to Local Government Institutions. Required technical assistance is also provided to various ministries. LGED also develops infrastructure database, maps, technical specifications, manual etc. required for development projects. Regular training courses conducted by LGED for enhancing skill of its own employees, members of the Local Government Institutions and other stakeholders.

Bangladesh has an extensive roads network (roughly 375,000 km) out of which about 94% in length covers the rural roads. Upazila roads (UZRs) and Union roads (UNRs) composed of respectively 11% and 12% of the rural road network. Over a quarter (30%) of the rural road network is paved, with 89% and 70% of the UZRs and UNRs, respectively, are paved. Bridges play an important part in Bangladesh's land transport system. This is inevitable given the country's topography – low-lying flat lands, crisscrossed by many rivers and their tributaries. Typically, the bridges connect two separate road sections to provide full connectivity to isolated rural communities. Bridges are critical for the efficient operation of the road system. The current inventory envisages that a bridge is required for every 4.5km of UZRs and UNRs. Over four-fifths of these gaps now have structures, leaving a fifth of them to be bridged. The total number of structures on Upazila Road is 40,300 and the associated length of these structures is 406,450 meter and the number of gaps is 1,372 and the combined length of these gaps is almost 80,000 meters. The total number of structures on Union Road is 37,098 and the associated length of these structures is 316,650 meter and the number of gaps is 2,145 and the combined length of these gaps is almost 81,020 meters. Until 2019, the Government does not have any dedicated bridge construction and maintenance program.

Nonetheless, none of the Development Partners were involved in rural bridge maintenance and rehabilitation activities.

In 2013, the Government of Bangladesh (GoB) adopted 'The Rural Roads and Bridges Maintenance Policy'. The objective of the policy was to develop a sustainable rural transport system through appropriate maintenance management to provide safe operation of vehicles and ensure necessary funding for maintenance. The policy document has emphasized the importance of maintenance of bridges and UZRs and UNRs. The policy also emphasized the importance of road safety, citizen participation, gender, and implementation management linked to the maintenance of rural roads and bridges.

Due to a shortage of funds, significant backlog exists in the maintenance of bridges on rural roads. Although the rural road maintenance budget has been steadily increased in the last ten years, it was not sufficient to manage the entire maintenance needs including bridge maintenance. In this context, the Government of Bangladesh has received a loan from the World Bank (WB) toward the cost of the program titled "Program for Supporting Rural Bridges (SupRB)". The program Components include Major and minor maintenance of 85,000 meters of bridges, rehabilitation of 24,000 meters of bridges, Capacity Expansion (Widened) of 5000 meters of rural bridges, replacement or newly construction of 20,000 meters of bridges, technical, fiduciary, procurement, social and environmental capacity improvement of LGED including design and implementation of climate resilient bridges and establishment and operationalize of Grievance Redress System (GRS). The bridge is identified in the prioritized annual work plan generated through the Rural Bridge Information Management System (RuBIMS).

The Program will support the LGED's strategy for the sustainable development and Bridge Asset Management. The main strategic elements include undertaking the creation of new bridge assets and the preservation of existing assets comprehensively to enhance and preserve rural connectivity. Competitive selection of rural bridge interventions under budget constraints that will ensure an optimum balance between creation and preservation of assets; replacing rural bridges that surpassed their economic lives and making unsafe bridges safer; and improving institutional capacity and core business processes including the creation of a Rural Bridge Information Management System (RuBIMS) to help LGED in well informed decision making on Rural Bridge asset to aid in the planning, design, construction, and management of bridges sustainably. The Rural Bridge Information Management System (RuBIMS) has been developed under World Bank financed Second Rural Transport Improvement Project (RTIP2). RuBIMS is a comprehensive system for collection of all-inclusive data of rural bridges and for aiding informed rural bridge management related decision making. It has a smartphone-based interface that facilitates collection of bridge data. Apart from facilitating capturing of rural bridge data by smartphone, the system has also a web interface which is capable of managing bride/culvert data, calculating bridge health condition index as well as suggesting the type of maintenance intervention that a bridge will require and produces a list of prioritized bridges under different intervention types. The system uses a detailed

algorithm in deciding the bridge health condition index, intervention types and on bridge prioritization.

The road network which serves for the national socio-economic activities such as logistics, access to services, travels and communications, is compared to the vascular network in a human-body. To maintain a healthy human body, people may check their physical condition daily, and may have some advices from their doctors periodically and then keep their body condition in well, and sometimes people may receive medical treatment or surgery. It is the same concept for road infrastructure for movement of people, transportation of goods and other logistics. Therefore, the rural road infrastructure is very important for Bangladesh economy. The Bridges are part of the road infrastructure and are important link in a road network. And they must be very well maintained for Bangladesh economy and to maximize the benefits from the investments.

Bridge inspection is one of the basic functions in the Bridge Asset Management System and play an important role in providing a safe transportation infrastructure for Rural Transportation network of Bangladesh. As the rural bridges continue to age and deteriorate, an accurate and thorough assessment of each bridge's condition is critical in maintaining a safe, functional and reliable transportation system. Bridge inspection is the most important step in the assessment process of the physical condition of a bridge in order to determine remedial action, such as maintenance, repair, rehabilitation, strengthening, or replacement. And the efficiency of assessment process depends on the quality of the inspection and the operation of a powerful database, which must be regularly updated with the input of current information on the assets under management.

This Rural Bridge Health Inspection and Condition Assessment Guidelines describes the necessary process and steps for carrying out the bridge inspection for effective management of Rural bridges, which includes all structures i.e. bridges, box culverts, arch masonry, flyovers, roadway and railway overpasses (hereinafter all of these are referred to as "Bridges").

The primary objective of bridge inspection is to find out the physical condition of the bridge and to detect any defects of the bridges at early stage that may affect safety of the users and bridge structures and to make the traffic flow smooth and comfortable. Another objective is to monitor development of the defects on the bridge continuously so that timely remedial measures can be taken to prolong the life of the bridge. In addition, the results collected from the inspection can be used to develop inspection and maintenance program, to carry out load capacity assessment, and to provide feedback to the design process.

The purposes of Bridge Inspection are as follows:

- To confirm the results of bridge condition inspection;
- To confirm as built drawings and design documents;
- To undertake additional investigations necessary for evaluation of defects including physical testing and/or structural analysis, and documentation of the observed defects with sufficient information for future design of required major maintenance works;
- To determine the cause/mechanisms of damage;

- To assess the current bridge structural condition, behavior and load capacity;
- To assess the rate of deterioration and residual life expectancy;
- To evaluate the need for repair and rehabilitation; and
- To investigate the damage for estimating maintenance cost.

The roles and responsibilities of the bridge inspector/engineer and their qualifications for bridge inspection is also very important. This Manual provides the detail procedures and requirements for inspection and rating of defects, evaluation for the necessary remedial actions, documentation and recorded data management of LGED's bridges in service. Hence, this manual will help the Inspection and Evaluation Team in performing their roles and responsibilities in Bridge Asset Management Program. Data collected from these inspections and evaluation will be used to update the bridge inventory and to develop inspection and maintenance program by using the Rural Bridge Information Management System (RuBIMS) for efficient bridge maintenance of the prevailing bridge structures under LGED.

Improvements of the Guideline, Bridge Asset Management (BAM) and its related concepts are relatively new field in Bangladesh. So, as the BAM continues to be improved; it is intended that parts of these Guidelines and information contained in this Guideline need to be reviewed and updated from time to time as necessary to take into account the organizational framework of LGED, the accumulated inspection experiences, and new knowledge and lessons learned.

CHAPTER 2

FUNDAMENTALS OF RURAL BRIDGE INSPECTION PROGRAM

2.1 Quality Management

Quality management is generally an essential terminology integrated with any system irrespective of genre, type and characteristics. Similarly, it is of prime concern to ensure overall quality management, Quality Control (QC) and Quality Assurance (QA) procedures to maintain a high degree of accuracy and consistency in the Rural bridge inspection program. Accuracy and consistency of the data is important since the bridge inspection process is the foundation of the entire bridge management operation and Rural Bridge Information Management Systems (RuBIMS). A succinct outline framework is presented here just to promote the basic essence of quality assurance in Bridge Inspection Program. *LGED may develop a framework perfectly conforming to bridge inspection QC/QA programs in course of time based on the real level learnings.*

2.1.1 Outline Framework for Quality Control (QC) and Quality Assurance (QA)

The following Log Frame (Log Frame 2.1) represents the sample outline framework for Quality Control (QC) and Quality Assurance (QA).

Log Frame 2.1: outline framework for Quality Control (QC) and Quality Assurance (QA)

Sl.	Area/Phase of Activities	Tasks to be Performed
A.	Documentation of QC/QA Program	1) Develop, document, and maintain a bridge inspection manual that contains Quality Control/Quality Assurance (QC/QA) procedures; 2) Describe the purpose, definitions, procedures and benefits of QC/QA in concerned inspection program; 3) Define and document QA and QC roles and responsibilities.
B.	Documentation of Quality Control (QC) Procedures	1) Document qualifications required for Head of the Inspection Program, Inspection Team Leader, Team Members and others integrated with the inspection program; 2) Document process for tracking how qualifications is met, including: a) Training completed; b) Years and type of experience;

		c) Certifications/registrations. 3) Document required refresher training, including: a) Bridge Inspection, other specialized training courses, and/or periodic meetings; b) Define refresher training content, frequency, and method of delivery; 4) Document special skills, training and equipment needs for specific types of inspections; 5) Document procedures for review and validation of inspection reports and data; 6) Document procedures for identification and resolution of data errors, omissions and/or changes.
C.	Quality Assurance (QA) Procedures	1) Document procedures for conducting office and field QA reviews, including: *a)* Procedures for maintaining, documenting, and sharing review results; including an annual report; *b)* Establish review frequency parameters that should include: i. Finalize number of districts/upazilas to be reviewed annually. (e.g. review each district once every second years); ii. Finalize recommended number of bridges to review. *c)* Procedures and sampling parameters for selecting bridges to review: i. Posting, Deficiency, Program (Rehabilitation/Replacement), Follow-up action status and location of Bridge; ii. Unusual changes in condition ratings w.r.t previous inspection rating; iii. Requirement special inspections (underwater, fracture critical, other special); *d)* Procedures for reviewing current inspection report, bridge ID etc.; *e)* Procedures to validate qualifications of Inspector and others; *f)* Define "Limit of tolerance" for condition rating and other related activities. (e.g. rating of +/- 1); *g)* Checklists covering typical items to review as part of QA procedures (e.g. , Structure Number/Bridge ID, Field inspection, Rating analysis etc.); *h)* Miscellaneous.

		2) Document disqualification procedures for team leaders and consulting inspection firms that have continued record of poor performance; 3) Document re-qualification procedures for disqualified individual inspection Consultants/Firms to demonstrate requalifying performance; 4) Document procedures for conducting inspections on a "control" bridge; 5) Document events to validate the QC procedures.

2.2 Inspection Types and Cycle

For successful automation of Rural Bridge Information and Maintenance Management System, it is of prime importance to formulate and utilize the most efficient bridge inspection program. It is necessary to identify the purpose of inspection and then appropriate method of inspection. This will ensure the ascertaining of accurate condition of the bridge at appropriate time. The type of inspection is classified in terms of:

1) purpose, 2) frequency, 3) major items to be inspected and 4) method of inspection.

These various types of inspection include two basic categories:

a) Scheduled Bridge Inspection
b) Non-scheduled Bridge Inspection

Types of inspections under basic categories are:

Scheduled Bridge Inspection:

i. Construction completion inspection (Initial Inspection)
ii. Routine Inspection
iii. Periodic Inspection

Non-Scheduled Bridge Inspection:

i. Interim Inspection
ii. Emergency Inspection
iii. Detailed Investigation

The type wise purpose, frequency, procedure, scope, inspector etc. are summarized in Table 2.1 and Table 2.2 at next page:

Table 2.1-a: Inspections Types and Cycles (Scheduled Bridge Inspection)

Inspection Type	Purpose of inspection	Inspection Frequency	Methods/ Procedure	Scope	Inspection Role/ Designation
Scheduled Bridge Inspection					
Construction completion inspection (Initial Inspection)	1. To provide all Structure Inventory and Appraisal (SI&A) data. 2. To provide baseline structural conditions and identification of existing problems.	After completion of construction	1. Should be carried out with a prepared inspection sheet for RuBIMS *(Visual Inspection)*.	1. Finding out any visible construction abnormality of a bridge, like construction deficiency, etc. at early stage in a routine basis. 2. Collecting required data using inspection sheet for RuBIMS.	Upazila Engineer/Assistant Engineer, XEN Office
Routine Inspection	1. To perform general check of bridge structure and non-structural condition 2. To check level of safety and ensure appropriate serviceability on and under the bridge.	12 months	1. Should be carried out with a prepared inventory sheet and check lists; *(Visual Inspection)* 2. Prior to Routine Inspection record should be reviewed to compare the: i. Characteristics and condition of the bridge; ii. Any significant maintenance/modifications since the last inspection. 3. When Routine Inspection coincides with Periodic Inspection only the latter should be undertaken	1. Finding out any visible abnormality or damage on and under the bridge i.e., elements that can be inspected without special access equipment or traffic management.	Sub-Assistant Engineer, Upazila Engineers Office
Periodic Inspection	1. To assess the physical and functional condition of every component and element of the entire bridge with close visual observation, 2. To detect defects at early stage.	Two years after the commencement of operation of the bridge	1. Periodic Inspection should be carried out with close visual observation of all external surfaces and features, and 2. Where appropriate all internal surfaces *(Visual Inspection)*	1. Reviewing the existing inventory of the bridge structure. 2. Visual inspection of all bridge elements (including measurement of crack widths, etc.) and 3. Assessment of defects using a standard condition rating system *["Types of Defects and Rating" in the Chapter 04 and Appendix-03 of this Guideline].*	Senior Inspector (Inspection team leader), Inspector, Assistant Inspector and other technical staff of the Upazila Engineer's Office.

Table 2.1-b: Inspections Types and Cycles (Non-scheduled Bridge Inspection)

Inspection Type	Purpose of inspection	Inspection Frequency	Methods/ Procedure	Scope	Inspection Role /Designation
Non-scheduled Bridge Inspection					
Interim Inspection	1. To monitor a particularly known or suspected deficiency between the periodic inspections and 2. To develop a supplement of the periodic inspection.	Depends on the type of defects	1. Should be carried out by means of visual observation. *(Visual Inspection)*	Monitor: 1. A particularly known or suspected deficiency discovered during periodic inspection, such as foundation settlement or scour, 2. Significant member deterioration, or the public use of a load-posted bridge, i.e., Bridges posted for a weight limit less than the legal weight limit. 3. The sign of rapid deterioration of a particular bridge element.	Senior Inspector
Emergency Inspection	1. To confirm that the bridges remain safe for use or 2. To determine the urgent remedial action required to i. Either ensure the safety of the bridge or ii. Restore the function of the bridge.	As required	1. An emergency inspection report of the event (Cyclone/Flood/Earthquake/ Collision/Fire/Others) Should be prepared. For Cyclone (Example): • Streambed scour around underwater bridge elements; • Bank erosion. • Lateral migrations of the channel • Sediment transport or accumulation (especially around piers). 2. Descriptions and comments on the damage shall be added in the report. *(Visual and/or Mechanical Inspection)*	1. Investigate fractured members. 2. Determine any loss of foundation support. 3. Compute the amount of any sectional loss. 4. Measure the displacement of any member out of alignment. 5. Inform the higher authority to take charge of bridge maintenance.	The inspection team leader, Inspector, Assistant Inspector and other technical staff of Upazila Engineer's Office
Detailed Investigation	1. To investigate causes of defect or structural condition, behavior or 2. To assess damaged structural components for repair/ rehabilitation.	If recommended in the result of periodical inspection by the evaluator	This is a very specialized job and it often requires use of non-destructive and minute destructive testing equipment in the inspection exercise. Mechanical inspection	1. Grasp detailed behavior and actions of defect 2. Monitor the progress of any defect 3. Investigate the cause of defect 4. Test and evaluate material quality or strength 5. Evaluate structural strength	Professional Engineers with expertise. (In case of necessity, Consultants)

2.3 Inspection Team, Skillset and Responsibilities

LGED should form Inspection Team and train members of the Inspection team and only Inspections shall be conducted by these trained personnel. The Inspection team members should have sufficient knowledge and extensive practical experience in typical construction practices and capacities of carrying out visual observations visually and by using special instruments. In addition, they shall be competent in evaluating condition of the bridge correctly and proposing appropriate countermeasures optimal to the defects. The composition, requisite skills and responsibilities are represented in the table at next page:

Table 2.2: The composition, requisite skills and responsibilities of Inspection Team

Sl. No	Position	Designation in Team	Additional Skills Required	Responsibilities	No. of Personnel/Category of Maintenance		
					New Bridge/ Culvert Acceptance Inspection	Routine Inspection	Periodic Inspection
1.	Upazila Engineer	Evaluator/ Senior Inspector /Team Leader	Trained on: "Bridge Inspection and Condition Assessment Guideline"	1. Evaluate the conditions of the bridge correctly and 2. Approve bridge inspection plan proposed by Inspection team. 3. Supervise bridge inspection works. 4. Provide bridge inspection program support. 5. Maintain accurate bridge records. 6. Establish the bridge inspection plan. 7. Post inspection data, location, schedule, tool and instrument list, vehicle & traffic safety guards list, 8. Conduct bridge inspection works on site. 9. Evaluate rating of remedial action of all bridges as Evaluator 10. Propose appropriate remedial actions for the defects.	1	-	1
2.	Upazila Assistant Engineer	Inspector	Do	1. Check submitted document/data 2. Supervise inspection works on sites and assist in: 3. Maintaining accurate bridge records; 4. Establishing the bridge inspection plan; 5. Posting inspection data, location, schedule, tool and instrument list, vehicle & traffic safety guards list; 6. Conducting bridge inspection works on site.	1	1	1
3.	Sub-Assistant Engineer	Inspector	Do	1. Confirm tool and equipment, vehicle and manpower prepared by Assistant Inspector 2. Instruct driver on planning of traveling routes 3. Implement bridge inspection works on site 4. Record inspection results on Inspection Recording Forms 5. Take photographs of the bridge and defects and to sketch defects if necessary	1	1	1

Sl. No	Position	Designation in Team	Additional Skills Required	Responsibilities	No. of Personnel/Category of Maintenance		
					New Bridge/ Culvert Acceptance Inspection	Routine Inspection	Periodic Inspection
				6. Assist Senior Inspector summarizing Inspection Recording Forms and making fair copy of Inspection Recording Forms including photos and sketches 7. Assist Senior Inspector inputting work of inspected results data into BMS			
4.	Sub-Assistant Engineer	Assistant Inspector	Do	Assist in: 1. Daily preparation of bridge inspection works; 2. Preparing necessary tool, equipment and material; 3. Loading/unloading tool, equipment and material on/off the vehicle; 4. Implementation of bridge inspection works 5. Inspection and taking photographs at narrow or high place; 6. Measuring; 7. Supporting scaffolding; 8. Cleaning bridges, if necessary; 9. Removing obstructions, if any.	1	1	1
5.	Work Assistant	Traffic Controller/ Traffic Safety Guard	Do	1. Prepare necessary tool, equipment and material for traffic safety measures at inspection sites; 2. Place necessary traffic control material on inspection sites 3. To watch and control traffic at inspection sites.	1	1	1

2.4 Inspection Tools and Access Equipment

Proper inspection equipment plays a key role in maintaining the safety of the traveling public and the inspectors. The inspector therefore, needs to be familiar with every piece of tool and/or equipment and how to use and operate them properly and safely.

2.4.1 Inspection Tools:

Standard tools that an inspector generally uses at the bridge site can be grouped into 8 (Eight) basic categories: Viz.

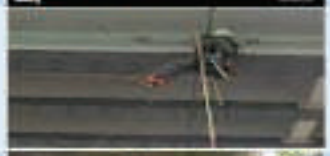
1. Tools for cleaning (Figure 2.1)
2. Tools for inspection (Figure 2.2)
3. Tools for visual aid (Figure 2.3)
4. Tools for measuring (Figure 2.4)
5. Tools for documentation (Figure 2.5)
6. Tools for Access (Figure 2.6)
7. Tools for Safety (Figure 2.7)
8. Tools for Miscellaneous use (Figure 2.8)

The following Table 2.3 presents the variety and uses of inspection tools:

Table 2.3: Standard tools of inspection and their ample use

Category	Name of Tool	Uses	Sample Photographs
Tools for cleaning	1. Wisk broom	1. Removing loose dirt and debris	 Fig-2.1
	2. Wire brush	2. Removing loose paint and corrosion from steel members	
	3. Scrapers	3. Removing corrosion or growth from member surfaces	
	4. Flat bladed screwdriver	4. General cleaning and probing	
	5. Shovel	5. Removing dirt and debris from bearing areas	
Tools for Inspection	1. Pocket knife	1. General duty	 Fig-2.2
	2. Ice pick	2. Surface examination of timber members	
	3. Hand brace and bits	3. Boring suspect areas of timber members	
	4. Timber boring tools	4. Internal examination of timber members	
	5. Chipping hammer with leather holder (16-ounce geologist's pick)	5. loosening dirt and rust scale, sounding concrete and checking for sheared or loose fasteners	 Timber Boring Tools
	6. Plumb bob	6. Measure vertical alignment of a superstructure or substructure member	
	7. Tool belt with tool pouch	7. Convenient holding and access of small tools	

Category	Name of Tool	Uses	Sample Photographs
	8. Chain drags	8. Identify areas of delamination on concrete decks	
	9. Range pole/probe	9. Probing for scour holes	
Tools for Visual Aid	1. Binoculars	1. Preview areas prior to inspection activity and for examination at distances	Drag Chain  Fig-2.3
	2. Flashlight	2. Illuminating dark areas	
	3. Lighted magnifying glass (e.g., 5 power and 10 power)	3. Close examination of cracks and areas prone to cracking	
	4. Inspection mirrors	4. inspection of inaccessible areas (e.g., underside of deck joints)	
	5. Dye penetrant	5. Identifying cracks and their lengths	
Tools for Measurement	1. Pocket tape (six-foot rule)	1. Measuring deficiencies and member and joint dimensions	 Fig-2.4
	2. 25' and 100' tape	2. Measuring component dimensions	
	3. Slide Calipers	3. Measuring the thickness of a member beyond an exposed edge	
	4. Optical crack gauge	4. Precise measurements of crack widths	
	5. Paint film gauge	5. Checking paint thickness	 Optical Crack Gauge
	6. Tiltmeter and Protractor	6. Determining tilting substructures and for measuring the angle of bearing tilt	
	7. Thermometer	7. Measuring ambient air temperature and superstructure temperature	
	8. Four-foot carpenter's level	8. Measuring deck cross-slopes, approach pavement settlement and substructure alignment	 Ultrasonic Thickness Gauge
	9. D-Meter (ultrasonic thickness gauge)	9. Measuring accurate thickness of steel	
	10. Electronic Distance Meter (EDM	10. Measuring accurate lengths and clearances of span when access is a problematic	 Electronic Distance Meter
	11. Line level and string line Level	11. Securing the string.	

Category	Name of Tool	Uses	Sample Photographs
Tools for Documentation	1. Inspection forms, clipboard, and pencil	1. Record keeping for most bridges	 Straight Edge
	2. Note books	2. additional record keeping for complex structures	
	3. Straight edge	3. Drawing readable sketches	
	4. Digital camera	4. Providing digital images of deficiencies which can be downloaded and e-mailed for instant assessment	 Digital Camera
	5. Chalk, Kiel, paint sticks, or markers	5. Identifying member and defect for improved organization and photo documentation	
	6. Center punch	6. Applying reference marks to steel members for movement documentation (e.g., bearing tilt and joint openings)	
	7. P-K (Parker Kalon) masonry survey nails	7. Establishing a reference point necessary for movement documentation of substructures and large cracks	
Tools for Access	1. Ladders	1. Climbing to substructures and various areas of the superstructure	
	2. Boat	2. Soundings and inspection; safety for over water work	
	3. Rope	3. Aiding in climbing	
	4. Waders	4. In shallow streams	
Tools for Safety	1. Hard Hat	1. Preventing protection from serious head injuries in two ways: • Against falling objects. • From accidental impact with bridge components	
	2. Reflective Safety Vest	2. Making inspector more visible to passing motorists through combination of bright color and reflectivity	

Category	Name of Tool	Uses	Sample Photographs
	3. Safety Goggles	3. Providing eye protection when the inspector is exposed to flying particles.	
	4. Gloves	4. Protecting inspector's hands from harmful effects of deteriorated members	
	5. Life Jacket	5. Protecting from accident, drowning due to unconsciousness or falling or slipping/stepping in too deep area.	
	6. Dust Mask/ Respirator	6. Protecting the inspector from harmful airborne contaminants and pollutants	
	7. Safety Harness and Lanyard	7. Acts as inspector's lifeline in the event of a fall	
	8. Manned Boats/Skiff	8. Respond to water emergencies at all times when inspection is ongoing over water and any equipment misses the position towards water.	
Tools for Miscellaneous use	1. "C"-clamps	1. Providing a "third hand" when taking difficult measurements	
	2. Penetrating oil	2. Removing fasteners, lock nuts, and pin caps when necessary	
	3. Insect repellent	3. Reducing attack by mosquitoes, ticks, and chiggers	
	4. Wasp and hornet killer	4. Eliminating nests to permit inspection	

Category	Name of Tool	Uses	Sample Photographs
	5. First-aid kit	5. Protecting small cuts, snake bites, and bee stings	
	6. Coveralls	6. Protecting cloths and skin against sharp edges while inspecting	
	7. Cell phone	7. Calling someone in emergencies	
	8. Toilet paper	8. Meeting other "emergencies" (better safe than sorry)	

2.4.2 Access Equipment

Similar to Inspection tools there are good varieties of access equipment. These includes different types of water and land vehicles and some permanent structures as well. The inspectors should be familiar with all of them along with latest developments so that they can easily cope with the new versions in near future when those will be available in the country as well as in the department. Table 2.4 presents the variety and uses of access equipment/Structure/Vehicles.

Table 2.4: Varieties and uses of access equipment/Structure/Vehicles:

Category	Name of equipment	Uses	Photographic Illustration
Common Access Equipment	1. Ladders	1. Inspecting the underside of a bridge or for inspecting substructure units only for those portions that can be reached safely, without undue leaning or reaching.	 1H: 4V Ladder  Hook Ladder
	2. Rigging (cables and platforms)	2. Gaining access to floor systems and main load-carrying members in areas where access by other means is not feasible or where special inspection procedures are required.	 Rigging for Substructure

	3. Scaffolds	3. Providing efficient and alternative access for structures that are less than 40 feet high and over level ground with little or no traffic nearby.	 Scaffolds
	4. Climbers (mobile inspection platforms)	4. Inspection of high piers and other long vertical faces of bridge members	 Climber
Special Equipment	1. Survey Equipment *(Total Station, transit level, Theodolite, an incremental rod, or other survey equipment)*	1. Establishing a component's exact location relative to other components, as well as an established reference point.	 Total Station  Theodolite
	2. Non-destructive Evaluation Equipment	2. NDE equipment allows the inspector to "see" inside a bridge member and assess deficiencies that may not be visible with the naked eye.	  Non-destructive Testing Equipment
	3. Underwater Inspection Equipment *(range pole, piece of reinforcing steel, a survey rod, a folding rule, or even a tree limb)*	3. Examining of substructure units and the channel below the water line.	 Ranging Pole  Folding Rule
Miscellaneous Special Equipment	1. Air-water jet equipment	1. Cleaning surfaces of dirt and debris	 Water Jet System-Bridge  Shot Blasting on Bridge
	2. Sand or shot blasting equipment	2. Clean steel surfaces to bare metal	
	3. Burning, drilling, and grinding equipment	3. Burning, drilling, and grinding	

Modern Equipment	1. Rotary Percussion	1. Detect the presence of concrete deficiencies	 Rotary Percussion
	2. Scour Measurement Equipment	2. Measuring depth of scour during flood flows	 Scour Monitoring Equipment
	3. Scour Monitoring Equipment: *(Side Scan Sonar, Multi-beam Sonar, Scanning Sonar)*	3. Oceanographic and hydrographic surveying *(has not been widely utilized for portable scour monitoring).*	
	4. Web-based Scour Monitoring: *Scour Monitoring Collar*	4. Monitoring scour online	 Monitoring Collar
	5. Remote Camera	5. Providing two main types of information: spatial measurements and surface analysis.	 Remote Camera

Permanent Access /Inspection Structure	1. Catwalks (an inspection platform)	1. Inspecting parts of deck, superstructure and some portions of the substructure.	 Catwalk
	2. Traveler (movable inspection platform)	2. Inspectors more numbers of elements of superstructure.	 Traveler Platform
	3. Handrails (Fig-2.18, 19)	3. Assisting the inspector for free climbing on the bridge in a number of different locations on the bridge.	 Handrail: Girder Bridge  Handrail: Suspension Bridge
Access Vehicles (Water & Land)	1. Boats (general and safety) or Barges	1. Gaining access to structures over water for inspection as well as for taking photographs	 Inspection from Berge
	2. Manlift	2. Generally used in different terrains	 Manlift  Manlift in Stream
	3. Bucket Truck	3. Generally used in different terrains and highways)	 Under bridge inspection vehicle with Bucket

2.5 Safety Fundamentals for Bridge Inspectors

2.5.1 Importance of Bridge Inspection Safety

While performing an inspection it is utmost important to perform it in a timely and efficient manner with perfect and applicable safety. As because "SAFETY FIRST" is the **burning slogan** across the world irrespective of genre and category of implementation of work. Attitude, alertness, and common sense are three important factors in maintaining safety. To reduce the possibility of accidents, bridge inspectors need to be well concerned about proper safety.

2.5.2 Safety Responsibilities

Bridge inspectors are ultimately responsible for their own safety. LGED and the Executive Engineer of concerned district should ensure the proper enforcement of safety rules and procedures related to bridge inspection, implementation of safety trainings, proper use of safety tools etc. in performing a successful, desired and standard bridge inspection.

2.5.3 Personal Safety of Inspectors

It is important to be cautious regarding dress, shoes and other safety tools perfectly matching with the type of job and climate and site condition. In this connection the inspector may wear a tool pouch to carry tools and notes with hands free for climbing and other inspection activities properly. He should use the safety tools (as described in **2.5.2**; **Table: 2.4: Safety Tools**) correctly in order to ensue personal protection.

2.5.4 Safety Precautionary Measures

It is important to follow some precautionary measures to save or prevent the inspector from potential accidents in addition to wearing/using the safety tools during inspection. Safety precautions can be divided in to following categories:

1) General, 2) Climbing, 3) Confined Spaces, 4) Vegetation, 5) Night Work, 6) Around Water, and 7) Culverts.

Table 2.5: illustrates category wise summery of safety precaution.

Category	Precautionary Steps to be followed
General	➢ Being well rested and alert to be physically fit and free from mental distractions; ➢ Using proper tools suited for the job; ➢ Keeping work areas neat and uncluttered to avoid injury; ➢ Establishing systematic methods to meet the job expectation; ➢ Use common sense and good judgment to make the job easier ➢ Do not use of intoxicants or drugs to avoid impairing in judgement, reflex and coordination; ➢ Avoid medication to remain safe from drowsiness or other unwanted and potentially dangerous side effects; ➢ Be careful about unprotected electricity to be safe from undesired electric shock.

Climbing	➢ Be organized and well panned to reduces the chance of the inspectors falling or getting stuck in a position and become unable to get down; ➢ Be conscious about the weather condition to be safe from unwanted situation; ➢ Check personal attire (Clothing, Jewelry etc.) for suitability to the job; ➢ Check inspection equipment for proper use and condition.
Confined Spaces	➢ Confined space (box girder bridges, steel box pier caps, steel arch rings, arch ties, cellular concrete structures, and long culverts) entry is regulated by Occupational Safety and Health Administration (OSHA) ➢ Requires proper training, equipment, and permission.
Vegetation	➢ Be aware of any vegetation (like Poison ivy, oak and Sumac) located around any substructures to be safe from itching, skin irritations; ➢ Be aware of any tall vegetation which could hide holes in the ground and lead to possible injury or other unknown hazards if not found;
Night Work	➢ Wear safety vest with both bright colors and reflectivity to make inspectors more visible to passing motorists;
Around Water	➢ When wading in water, be aware of any scour holes and be careful not to slip or fall on objects in the water; ➢ Be cautious to be safe from drowning whenever storms/flood appear imminent; ➢ When performing an underwater inspection, particularly in low visibility and/or high current situations, be extremely careful and be sure to watch for drift and debris at any height in the water.
Culverts	➢ Being aware of the following hazards: ➢ Inadequate Ventilation to be safe from oxygen deficiency/bad effect of toxic gas; ➢ Sandy streambeds, especially at the outlet end of the culvert to be safe from Quicksand conditions; ➢ Potentially dangerous wildlife to be safe from life threatening attacks.

2.6 Temporary Traffic Control

Relatively short-term closure or diversion/control of traffic in generally needed for Bridge inspection. Till date LGED doesn't have any standard drawings/procedures regarding traffic control/management especially for Bridge inspection program. It may need to develop and issue their own standard traffic management drawings for all maintenance, construction and inspection related work. It may be time consuming as because there are lots of stakeholders including Local Government Institutions, Transport business community, Operators and mass people as well. **As soon as it becomes possible to develop it will be incorporated in the updated/revised version of the Guideline.**

A standard outline is presented here that can help LGED in managing traffic temporarily and/or derive a standard traffic management drawing/procedure for future use.

2.6.1 Principles to Control Traffic

Temporary traffic controlling/management generally aims at to minimize inspection time in reducing exposure to potential hazards without compromising the thoroughness of the inspection. Principles and procedures that have been shown to enhance the safety of vehicle operators, pedestrians, and bridge inspectors in the vicinity of work areas generally include the following:

- Informing the vehicle operators (Drivers): From planning stage to performance of the inspection program traffic safety is an integral and high priority element. Therefore, safety of the drivers, pedestrian, inspectors and workers should be given prime priority. The notice of work site locations and guidance should clearly be communicated to drivers.
- Guiding the Traffic:
    - ✓ Pretension of traffic movement should be as minimum as practical.
    - ✓ Temporary traffic control in work sites should be designed on the assumption that drivers only reduce their speeds if they clearly observe a necessity to do so.
    - ✓ Reducing speed zoning should be avoided as much as practical.
    - ✓ Especially on busy roads, i.e., Upazila roads provisions should be made for the safe operation of work/service vehicles. This includes:
        - Use of roof mounted flashing lights or flashers when entering or leaving the work zone.
        - Number of lanes may be closed at one time for an operation.
        - Inspecting the entire floor system from left to right might be most cost efficient.
        - Dictating working in partial width, a few stringers at a time while controlling traffic temporary.
- Provide a Clearly Marked Path - An appropriate traffic control plan must provide for safe and efficient movement of drivers and pedestrians and expected protection of inspectors at work areas. Therefore:
    - ✓ Sufficient warning, demarcation and channelization should be provided to assure the drivers positive guidance in advance through the work area.
    - ✓ Proper signing and other devices which are effective under varying conditions of light and weather should be used.
    - ✓ Temporary traffic control devices should be removed immediately when no longer needed.
    - ✓ An unencumbered roadside recovery area should be provided to accommodate run-off-the-road incidents, disabled vehicles or other emergency situations.
    - ✓ Use of cones, barricades, and other lightweight devices (that yield when hit by errant vehicles) should be accomplish to channelize the traffic.
    - ✓ Equipment and materials should be stored in such a manner as not to be vulnerable to run-off the-road vehicle impact, whenever practical.
    - ✓ When safe storage is not available adequate attenuation devices should also be provided.

2.6.2 Safety Practices in Work Zones for Inspectors

Moving traffic on a road track is more threatening than climbing operation for an inspector. Therefore, the working area/zone should be a utterly safe from traffic so that the inspectors can concentrate on performing their jobs. It is desirable that the working area/zone:

- Should be clearly marked so as to guide the traffic around it;
- Should be prevented from entering errant vehicles to the possible extent;
- Should be as compact as possible to minimize traffic disruption;
- Should be wide and long enough to permit access to the area to be inspected and allow for safe movement of workers and equipment;
- The boundary or end line of the working area should be clearly marked as a civility to the moving traffic.

2.6.3 Temporary Traffic Control Devices/Signs

Principles: In any location of inspection, the inspectors may need to handle unique pattern of inspection task and different traffic concerns. Therefore, selection of appropriate temporary traffic control devices for each location depends on so many factors. Irrespective of the types of temporary traffic control devices, there are some basic principles for efficient ones. Temporary traffic control devices:

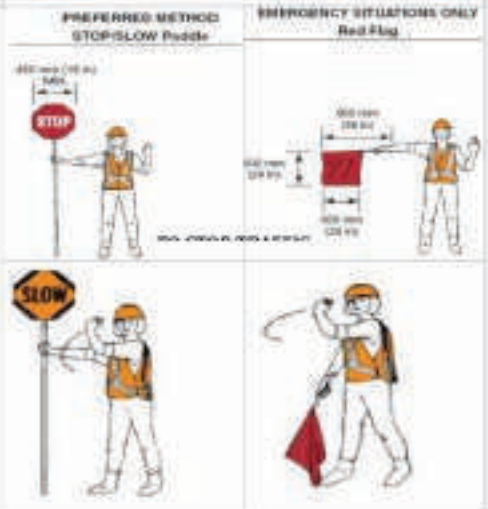
- Should to be visible and attracting to the drivers/commuters.
- Should be in good condition. Preferable concerns:
  - Bright colors make devices easier for motorists to see (Standard colors are orange and white);
  - Readable and color distinguishable signs day and night;
  - Properly sized for the roadway easily visible from the moving traffic.
- Should provide clear direction to the drivers/commuters/pedestrians;
- Should be respect worthy and official;
- Should be professional and geared to the class of roadway, speeds and traffic involved;
- Should be standard enough to prompt proper response at proper time applicable for drivers/vehicle operators.

2.6.3.1 Types and Purposes

There are huge numbers and varieties of devices/signs used in a diverge range of purposes. The following table (Table 2.6) illustrates a standard set of devices/signs with potential/realistic purposes:

Table 2.6: standard set of temporary traffic control devices/signs with potential/realistic purposes

Type/ Variety	Example Signs/Devices	Uses/Purposes	Photographic Illustration
Regulatory	▪ SPEED LIMIT ▪ DO NOT PASS (Authorized by the public agency or official)	▪ Inspecting the underside of a bridge or for inspecting substructure units only for those portions that can be reached safely, without undue leaning or reaching.	 
Warning	▪ BRIDGE INSPECTION AHEAD ▪ WORK AREA AHEAD ▪ SLOW	▪ Alert road users of specific situations/conditions on or adjacent to the roadway that might not be obvious; ▪ May be used individually/in combination with other warning signs	 
Guide Signs	▪ PARKING ▪ FREEWAY ENTRANCE (Generally not used in Controlling Bridge Inspection traffic)	▪ Generally used to provide drivers/operators with information to help them through a temporary traffic control zone	
Diversion Device	▪ Arrow Boards (May be used individually or in combination with appropriate signing, channelization devices and other temporary traffic control devices)	▪ Generally used to advise drivers/operators about a lane closure/diversion along multi-lane highways/ roadways for: o Heavy traffic volumes; and/or o Limited sight distances	
Changeable Message Signs	▪ MEN AND EQUIPMENT WORKING ▪ CONSIDER ALTERNATE ROUTE	▪ To provide drivers with the warning of: o Unexpected situations; o Complex messages; o Important information; and o Real time conditions.	 

Type/ Variety	Example Signs/Devices	Uses/Purposes	Photographic Illustration
Channelizing Devices	▪ Cones o Generally orange and while; o Can be struck without causing damage to the impacting vehicle; o Used in day time	▪ To channelize vehicles/drivers: o Divide opposing traffic lanes; o Divide lanes when two or more lanes are kept open in the same direction; o Demarcate short duration bridge inspections/utility works.	
	▪ Drums o Made of lightweight, deformable materials; o Portable enough to accommodate within a working area	▪ To channelize or warn vehicles/road users ▪ To provide the drivers a highly visible and upright warning of imminent conditions;	
	▪ Vertical panels (Diagonal orange and white stripes pointing downward indicate drivers the direction to follow)	▪ To channelize vehicular traffic; ▪ To divide opposing lanes; ▪ To replace portable lightweight barricades.	
Flaggers	Hand signalizing devices, such as STOP/SLOW paddles, flashing lights, flashlights, and red flags. ▪ Flaggers, should maintaining color contrast between the work area background his	The sign paddle bearing the clear messages "STOP" or SLOW" provides: ▪ Drivers with more positive guidance than flags; ▪ Generally, the primary hand signal through device. ▪ Flaggers provide assistance: o To stop traffic at work sites intermittently as necessitated by conforming to work progress. o To maintain continuity of traffic passing a work site at	

Type/ Variety	Example Signs/Devices	Uses/Purposes	Photographic Illustration	
	protective garments ▪ The flaggers should stand either on the shoulder adjacent to the traffic being controlled or in the barricaded lane	reduced speeds to help protect inspectors		

CHAPTER 3

INSPECTION PROCEDURE

Inspection program of Bridge plays an important role in providing a safe transportation system in the country. Like all other transportation infrastructure Rural bridges continue to age and deteriorate. An accurate and thorough condition assessment of each bridge is significant in maintaining a dependable rural transportation system. This chapter presents the duties of the bridge inspection team. It also describes the activities and tasks that inspection team can follow as preparation for the inspection. There are five basic duties of the bridge inspection team:

- Planning the inspection;
- Preparing for the inspection;
- Performing the inspection;
- Preparing the report;
- Identifying items for repairs and maintenance;
- Communicate the need for immediate follow-up for critical findings.

3.1 Inspection Planning

Any inspection program of Bridge always incepts with decent and upright planning. Appropriate planning is essential for implementation of a safe, efficient and cost-effective inspection that results in a systematic and complete inspection of in-service bridges.

While planning an inspection, it is a good practice to include a qualified Team Leader for all categories of inspections. Evaluation of the requirement of activities (e.g., non-destructive evaluation, traffic control, use of flaggers, utilities, permits, hazardous materials such as lead paint and asbestos removal etc.) should be performed. To perform the inspection methodically and systematically, the Inspection Team Leader should develop appropriate programs necessary for an efficient, cost-effective effort in advance. This will result in an accurate, thorough and complete inspection. Main activities are as follows:

- Listing of all the bridges to be inspected;
- Selecting the type of inspection;
- Finalizing a time schedule for selected inspection work;
- Ensuring the availability of inspection team members;
- Arrangement of available tools and equipment
- Coping with seasonal restrictions.

It is important to keep a schedule flexible taking account for delays caused by weather, shutting down traffic lanes and working over railroads, equipment breakdown, and absence of Team Member(s).

3.2 Preparing for the Inspection

Prior to commencing inspections, the inspection team shall ensure that they have all relevant documentation, inspection and safety tools and equipment and has made the appropriate arrangements with the relevant road, railway or other authorities for temporary access to carry out the inspection. No structure should be inspected without some measure of preparation. The major preparation activities include:

Before inception of the inspection, it is important form the part of inspection team to ensure the availability of all the relevant documents, tools and equipment essential for the sake of inspection as well as safety. The team should make all the necessary arrangements with related authorities (Administration, RHD, Railway etc.) for temporary access and/or other issues (if any). It will not be wise to initiate any inspection without assuring minimum preparation measures. The major preparation activities include:

1. Reviewing the bridge inventory files (from inventory/RSDMS/RuBIMS);
2. Identifying the elements and components;
3. Developing an inspection sequence;
4. Preparing and organizing sketches, forms, and notes;
5. Collecting and Organizing equipment & tools;
6. Arranging for temporary traffic control;
7. Reviewing the safety precaution measures;
8. Communicating Information to concerned authorities;
9. Reserve/Alternate planning.

The following table illustrates activity wise task summary of the preparation phase:

Table 3.1: Activity wise task summary of the preparation

Sl. No	Preparation Activity	Task Summary
1.	Reviewing the bridge inventory files (from inventory/ RSDMS/ RuBIMS)	➢ Reviewing the available sources of information like: ▪ Plans (Construction plans, as built drawings, Specifications), Materials and tests (Material test Reports, test data, load test data etc.) ▪ Correspondence on the Bridge Structure ▪ Photographs, Maintenance and repair history ▪ Accident records, Rating records & Load Posting and Permitted loads (if available) ▪ Flood and scour data (if available) ▪ Traffic data (if available) ▪ Inspection history and Inspection requirements ▪ Structure Inventory and Appraisal sheets ➢ Hydrological data: ▪ Shape and location of the channel ▪ Presence of protection device ▪ Flood frequencies ▪ Water elevations at different intervals (If available)

Sl. No	Preparation Activity	Task Summary
2.	Identifying the elements and components (System of numbering of Components/Elements is illustrated in **Chapter-5**)	➢ Formulating a system to: ▪ Identify the structure orientation and ▪ Identifying different components/elements of the bridge; ➢ Chainage based route direction: ▪ To identify the starting and ending point of the bridge;
3.	Developing an inspection sequence;	➢ Starting with deck and superstructure elements then to proceeding to substructure. ➢ Progression Sequence: ▪ Roadway Elements: (Approach roadways, Traffic safety features, General alignment, Approach alignment, Deflections, Settlement); ▪ Deck Elements: (Bridge deck: top and bottom, Expansion joints, Sidewalks and railings, Drainage, Signing, Electrical-lighting: If any, Barriers, gates, and other traffic control devices); ▪ Super-structure Elements: (Primary load-carrying members, Secondary members and bracings, Anchorages, Bearings); ▪ Sub-structure Elements: (Abutments, Piers, Footings, Piles, Curtain walls, Skewbacks/arches: if any, Slop protection); ▪ Channel and Waterway Elements: (Channel profile and alignment, Channel streambed, Channel embankment protection, Hydraulic opening Fenders);
4.	Preparing and organizing sketches, forms, and notes	➢ Obtaining copies of the standard inspection form to: ▪ Eliminate unnecessary work in the field; ▪ Use in recordkeeping; And ▪ As a checklist to ensure that the condition of all elements is noted. ➢ Making a copy of previous inspection report along with photographs and other relevant information available in site;
5.	Collecting and Organizing equipment & tools;	➢ Collecting and arranging for necessary tools and equipment conforming to the **Location** and **Type** of bridge
6.	Arranging for temporary traffic control	➢ Checking and following the prevailing and governing procedures when working in exposed traffic; ➢ Adjusting the schedule to accommodate temporary traffic control needs;
7.	Reviewing the safety precaution measures	➢ Taking safety precautions with extreme seriousness; ➢ Following the general guidelines for safety precautions as a must **(Section: 2.6.4; Table 2.5)**;
8.	Communicating Information to concerned authorities	➢ Informing concerned authority (Local Administration, Police, RHD/Railway etc.) if temporary stopping of traffic movement or similar step is mandatory; ➢ Following the procedures of owning authority (if applicable);
9.	Provisional planning	➢ Being known whom to notify or where to go in case of emergency, and ➢ Having the office and home phone numbers of all concerned in the inspection program.
10.	Special Consideration	➢ Consider dry seasons for Bridge Inspection

Sl. No	Preparation Activity	Task Summary
		➢ Avoid traffic Pick-hours including Hat-days ➢ Avoid flooding season for sub-structure inspection ➢ Avoid high-tide time for sub-structure inspection

3.3 Execution of the Inspection

The inspector shall perform the inspection in a systematic way at the bridge site. It should be started at the deck surface and approaches. After that, proceeding from the starting point of the bridge should be accelerated down through the superstructure and substructure. The inspector shall complete the following activities:

1. Alignment of Site: The inspector shall:
    a. Confirm the compass directions, the waterway direction of flow and the inventory route direction;
    b. Record the detail of inspection team, weather conditions, air temperature and time.
2. Management Meeting: The inspector shall arrange for a management meeting with team members for:
    a. Clear understanding of what is to be done;
    b. How to do it safely up to the completion of the inspection; and
    c. How to handle the possible safety risks.
3. Inspection On the Site: The inspection on the site is the actual jobs to be done in performing the inspection program. These includes quite a good number and varieties of activities and tasks. The followings table (Table 3.2) illustrates activity wise task summary:

Table 3.2: activity wise task summary of On-Site Inspection

Sl. No	Inspection Activity	Task Summary
1.	Avoiding any mistake in identifying the bridge	❖ Checking: ▪ Number of the Bridge, if any; ▪ Name of the Bridge, if any; ▪ Name of the River/Canal, if any; ▪ Number of Road section and distance to the bridge; ▪ If none of the above information is available then other identification mark. ❖ Carried out marking components and elements of the structure for: ▪ Keeping track of the location of inspector; ▪ Guarding against overlooking any portion of the structure
2.	Inspecting and assessing the condition of each standard component and element (up to the extent to which the rating applies) (Rating is discussed in Chapter-6)	❖ Observing the work at hand carefully and attentively; ❖ Clear and specific noting (when problems are found): ▪ The location, size, and severity of the deterioration or distress; And ▪ Probable cause(s) of deterioration or distress ❖ Determining the types of defects and the rating of them; ❖ Ensuring noting as soon as any observation is made without overlooking.
3.	Compiling appropriate photographic and sketch	❖ Ensuring inventory photographs (mandatory) of: ▪ Both sides elevation of structure;

	record (For Periodic Inspection)	▪ Both directions general view of carriageway over deck; ▪ Clear view from approach road (along with bridge number or other identification made earlier) ❖ Photographs of major defects and defective Components must: ▪ Be taken for the worst condition for each span of bridges; ▪ Include all information in terms of defects; ▪ Show measurement by measuring tape/ribbon rod (if possible) ❖ Taking photographs of undefined components.

3.3.1 Procedure of Periodic Inspection

Following table (Table 3.3) illustrates activity wise Procedure of Periodic Inspection:

Table 3.3: Activity wise Procedure of Periodic Inspection

Sl. No.	Activity	Procedure (Tasks)
1.	Annual Planning	Sub-Assistant Engineer (Senior) in consultation with Upazila Engineer shall first prepare annual plan for periodic inspections. Following issues shall be given priority when planning: ❖ Selecting workable season to understand actual condition of bridges; ❖ Rational deployment of members of Inspection Committee to ensure implementation of targeted work load; ❖ Ensuring availability of necessary inspection equipment; ❖ Formulating a repairing schedule based on inspection findings.
2.	Implementation of Plan	A monthly/Fortnightly/Weekly implementation plan shall be made for: ▪ Deploying manpower; ▪ Organizing inspection teams and routes
3.	Checking for Defect	❖ Before starting the inspection, the inspectors shall: ▪ Formulate visual inspection data sheets to record their observations of defects; ▪ Review previous inspection records to understand the nature of defects ❖ During inspection, if any defect is identified, then the inspector(s) shall determine whether any further measurement is needed or not.
4.	(Condition) Rating by Inspectors	After identifying a defect, the inspector shall: ▪ Clearly describe the condition of defect; And ▪ Give a rating as per rating rule of this Guideline (Chapter 6 Section6.2); ▪ Prepare a clarified inspection report regarding the defect; ▪ Attach an illustrating photograph with the report.
5.	Evaluating Whether Urgent Repair is needed	❖ Check whether the defect is in primary element that bears vehicle load; ❖ If so, examine extent of possibility of further deterioration of the defect; ❖ Judge the extent of risk related to the safety of vehicular traffic; ❖ Evaluate and decide as soon as possible whether urgent and cost-effective remedial measures are necessary for safety.
6.	Taking decision about Further Inspection	If after visual inspection it becomes difficult to an inspector to ascertain the extent of rating /cause of defect then he shall decide whether further inspections such as: ▪ Special inspection; ▪ Re-inspection; ▪ Detail investigation; Or ▪ Monitoring is necessary.
7.	Planning Further Inspection	If decision of further inspection along with type is finalized: ▪ Formulating a realistic and easily implementable inspection plan.
8.	Performing Detail Investigation	Carrying out Detail Investigation as per inspection methods based on characteristics and defect of the bridge.

Sl. No.	Activity	Procedure (Tasks)
9.	Finalizing Need of Repair	Finalizing the type of repair (remedial measures) for damaged element by Upazila Engineer/Executive Engineer (District).
10.	Data Entry into RuBIMS	Entering Inspected results on the issues mentioned above into RuBIMS software as soon as possible.
11.	Generating Report from RuBIMS	❖ Generating inspection report from (shall be treated as official report) RuBIMS based on the data entered; ❖ Checking for input errors immediately after generating report; ❖ Attaching Photographs with the report.
12.	Preservation of Periodic Inspection Report	❖ In addition to entry into RuBIMS, periodic inspection report shall be preserved in separate office file as **reference**; And ❖ Copying/using for other official purposes.
13.	Preparing Maintenance Plan	Formulating (by Upazila Engineer in consultation with District Executive Engineer) a realistic maintenance plan based on: ▪ The date of completion; ▪ Maintenance Category and design; ▪ Office/Officer/Staff in charge, and ▪ Budget allocation.

3.3.2 Activity wise Flow-Chart for Periodic Inspection:

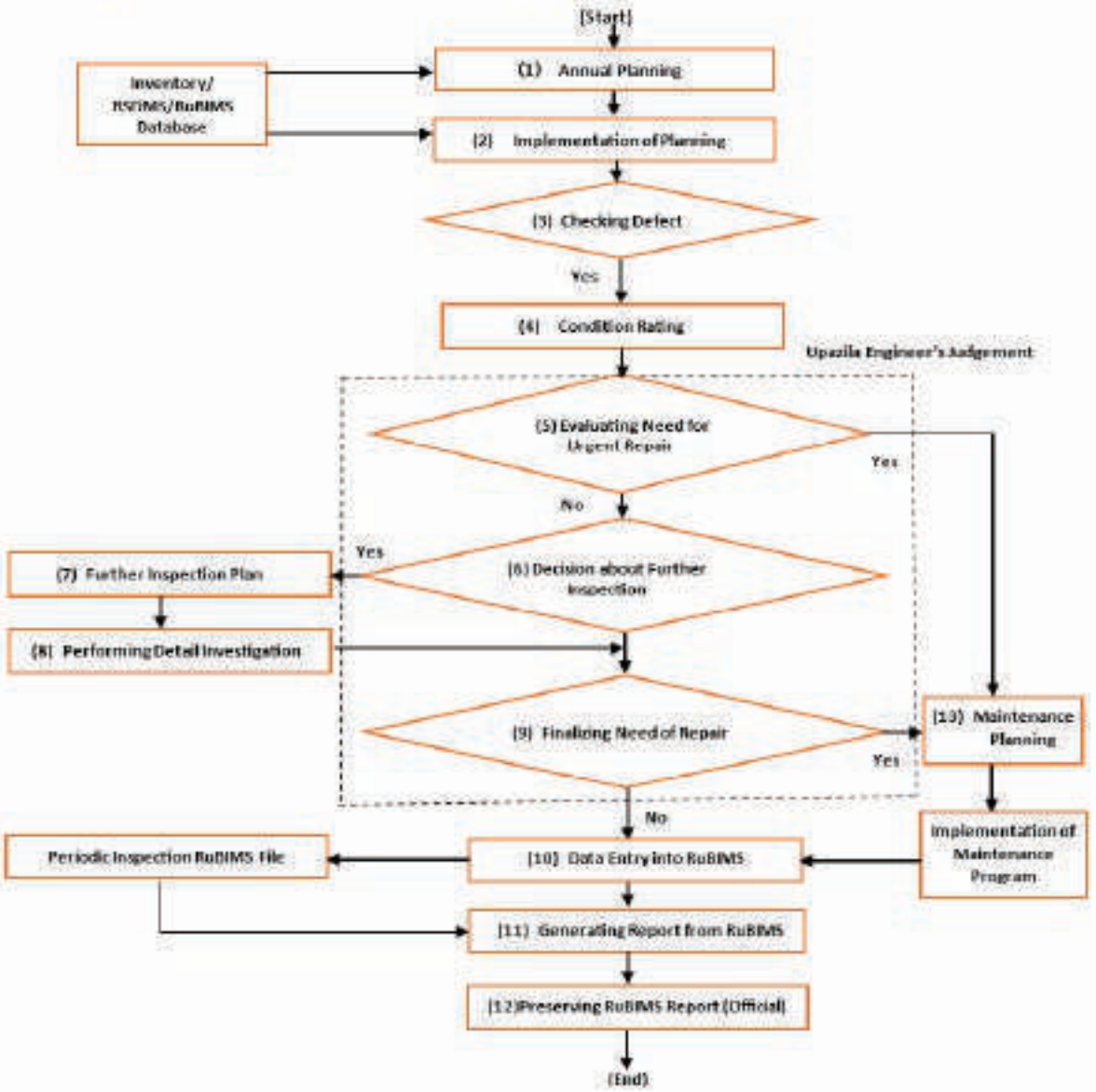


Figure 3.1: Activity wise Flow-Chart for Periodic Inspection

3.3.3 Procedure of Emergency Inspection (Detail & Flow-Chart)

Following table (Table 3.4) illustrates activity wise Procedure of Emergency Inspection:

Table 3.4: Activity wise Procedure of Periodic Inspection Conveying

Sl. No.	Activity	Procedure (Tasks)
1.	Checking for Defect	Before starting the inspection, the inspectors shall formulate visual inspection data sheets to record their observations of defects;
2.	Examining Need for Emergency Actions	If significant hindrances to vehicular traffic (due to damage to the bridge element) is identified, the Inspector/Upazila Engineer shall determine whether or not emergency actions are needed to: ▪ Ensure public safety; And ▪ Avoid further accidents.

3.	Taking Emergency Initiatives	Conveying necessary information regarding appropriate emergency actions (by the inspection team/Upazila Engineer) to the Executive Engineer of District Inspectors.
4.	(Condition) Rating by Inspectors	After identifying a defect, the inspection team/Upazila Engineer shall: ▪ Give a rating to the defect(s) as per rating rule of this Guideline (Chapter: 6 (Section 6.2); ▪ Taking an illustrating photograph to show the extent of defect to the Executive Engineer/Upazila Engineer as the case may be.
5.	Evaluating Whether Urgent Repair is needed	❖ Check whether the defect is in primary element that bears vehicle load; ❖ If so, examine extent of possibility of further deterioration of the defect; ❖ Judge the extent of risk related to the safety of vehicular traffic; ❖ Evaluate and decide as soon as possible whether urgent and cost-effective remedial measures are necessary for safety.
6.	Taking decision about Further Inspection	If after visual inspection it becomes difficult to an inspector to ascertain the extent of rating /cause of defect then he shall decide whether further inspections such as: ▪ Special inspection; ▪ Re-inspection; ▪ Detail investigation; Or ▪ Monitoring is necessary.
7.	Planning Further Inspection	If decision of further inspection along with type is finalized: ▪ Formulating a realistic and easily implementable inspection plan.
8.	Performing Detail Investigation	Carrying out Detail Investigation as per inspection methods based on characteristics and defect of the bridge.
9.	Finalizing Need of Repair	Finalizing the type of repair (remedial measures) for damaged element by Upazila Engineer/Executive Engineer (District).
10.	Data Entry into RuBIMS	Entering Inspected results on the issues mentioned above into RuBIMS software as soon as possible.
11.	Generating Report from RuBIMS	❖ Generating inspection report from (shall be treated as official report) RuBIMS based on the data entered; ❖ Checking for input errors immediately after generating report; ❖ Attaching Photographs with the report.
12.	Preservation of Emergency Inspection Report	❖ In addition to entry into RuBIMS, emergency inspection report shall be preserved in separate office file as reference; And ❖ Copying/using for other official purposes.
13.	Preparing Maintenance Plan	Formulating (by Upazila Engineer in consultation with District Executive Engineer) a realistic maintenance plan based on: ▪ The date of completion; ▪ Maintenance Category and design; ▪ Office/Officer/Staff in charge, and ▪ Budget allocation.

3.3.4 Activity wise Flow-Chart for Emergency Inspection:

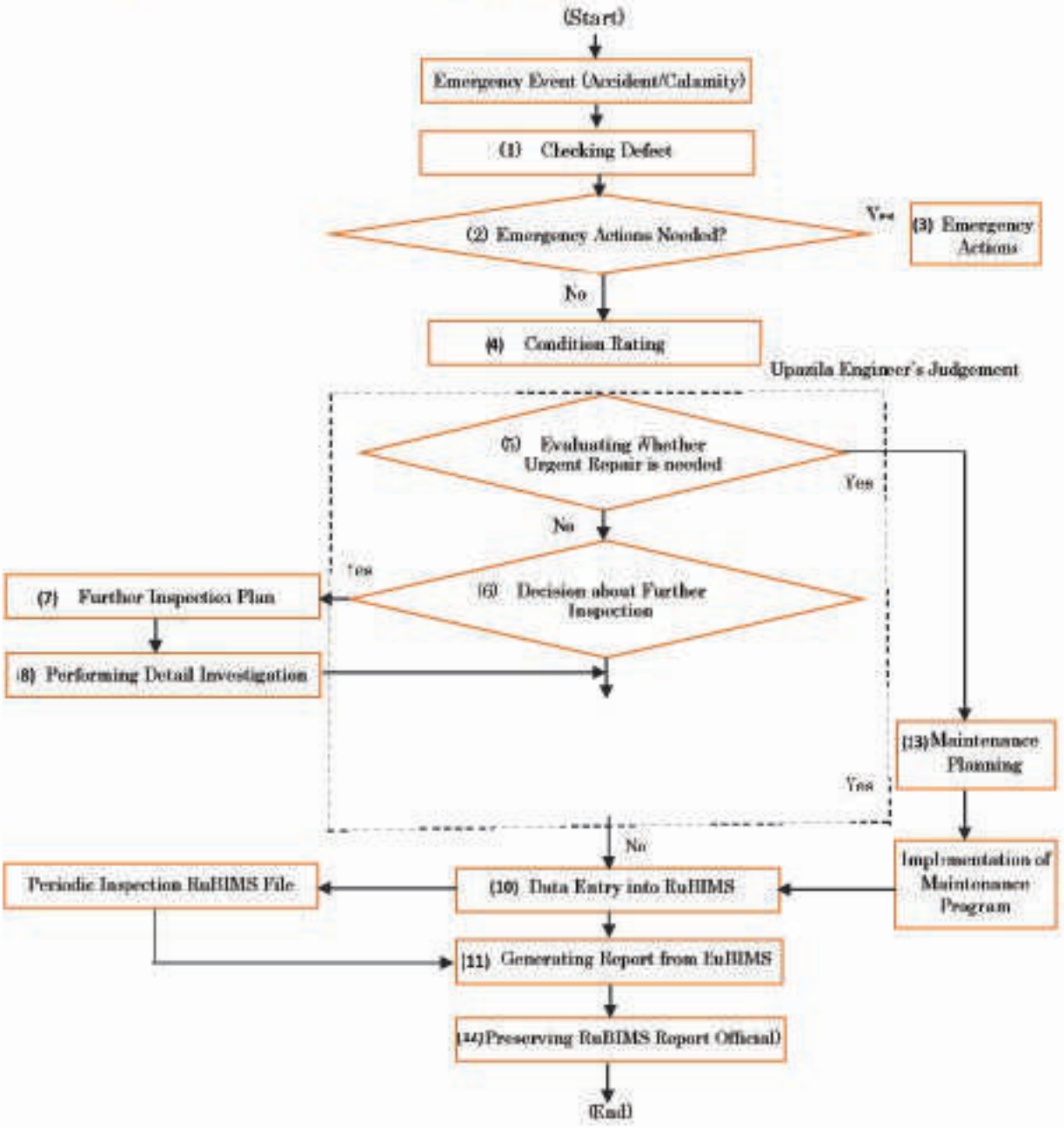


Figure 3.2: Activity wise Flow-Chart for Emergency Inspection

The objective of detail investigation is to acquire specific information about degradation of a structure. Following table (Table 3.5) illustrates the objectives of Detail Investigation with sample photographs:

Table 3.5: Objectives of Detail Investigation with Sample Photographs

Sl. No	Objectives	Sample Photograph
1.	During previous inspection; ▪ Signs of deterioration; ▪ Changes in performance level are identified	 Dangerous conditions by chloride attack
2.	When the reason(s) for damage is uncertain, Detailed Investigation is necessary to specify the cause of the damage	
3.	To determine the scope and the degree/category of repair and/or strengthening.	 Spalling. Exposed rebar by chloride attack

3.3.5.2 Selection of the Method of Detail Investigation

Method of investigation is generally selected based on the type of damage and assumed reason(s) of damage. There are many types of Detailed Investigation Method. are listed in. The inspectors responsible for the investigation shall select the appropriate method by applying their experiences, engineering judgment and considering other issues related to the investigation process. Following table (Table 3.6) presents the methods of Detail Investigation:

Table 3.6: Methods of Detail Investigation

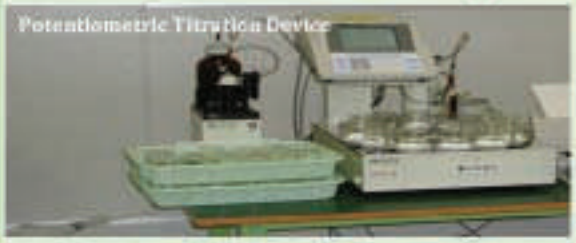
Assumed Damage	Method of Investigation	Factor of Damage									Note
		Fire	Collision	Temperature	Settlement	Section Loss	Overloading	Carbonation	Chloride Attack	Chemical Corrosion	
Confirmation of damage	Visual investigation	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Interior hollow and internal flaw	Tapping inspection	✓						✓	✓	✓	Non-Destructive Test
Shape and size	Shape and size investigation		✓	✓		✓					
Compressive strength	Strength test by core extraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	Minute Destructive Test
	Rebound hammer	✓	✓	✓	✓	✓	✓	✓	✓	✓	Non-Destructive Test
Modulus of Elasticity	Strength test by core extraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	Minute Destructive Test

Assumed Damage	Method of Investigation	Factor of Damage									Note
		Fire	Collision	Temperature	Settlement	Section Loss	Over loading	Carbonation	Chloride Attack	Chemical Corrosion	
Rebar Corrosion	Visual inspection of taken out rebar							✓	✓	✓	Minute Destructive Test
Investigation of Rebar	Electromagnetic wave	✓	✓	✓	✓	✓	✓	✓	✓	✓	Non-Destructive Test
	Electromagnetic induction	✓	✓	✓	✓	✓	✓	✓	✓	✓	Non-Destructive Test
Carbonation depth	Phenolphthalein method (Core Extraction)							✓			Minute Destructive Test
	Phenolphthalein method (Drilling)							✓			Minute Destructive Test
	Phenolphthalein method (Taken out rebar)							✓			Minute Destructive Test
Chloride ion concentration	Core extraction						✓	✓			Minute Destructive Test
	Concrete powder by drilling						✓	✓			Minute Destructive Test
Physical character (Physical investigation)	Dead-load stress			✓	✓	✓	✓		✓	✓	
	Stress on loading	✓	✓			✓	✓		✓	✓	
	Stress frequency					✓	✓				
	Displacement for loading	✓	✓			✓	✓		✓	✓	
	Frequency of Displacement					✓	✓				
	Measurement of Vibration					✓	✓		✓		

3.3.5.3 Procedures of Some Leading Investigation

Quite a good number of investigation methods have been mentioned in the table above. The following table (Table 3.7) presents procedures of some of the important investigations that inspectors should have a fair idea along with photographs:

Table 3.7: Procedures of Leading Investigations

Investigation		Procedure	Photograph
1. Compressive Strength Test of Concrete	Core Extraction Method	▪ Measured by a Compressive Strength testing machine using an extracted core; ▪ From stress-strain diagram of compressive strength test, the modulus of elasticity of concrete can be calculated; ▪ From the spalling part no core is extracted for compression test; ▪ A core is extracted from sound part of the structure/member; ▪ Core diameter must be more than 3 times of maximum size of coarse aggregate; And ▪ Core length must be more than 2 times of core diameter.	
	Ex. Schmidt Rebound Hammer Method	▪ Measured by the repulsion hardness method *(Striking a blow at concrete surface);* ▪ Using the arithmetic expression derived from the repulsion hardness method, Compressive Strength is calculated; ▪ Repulsion hardness method is an effective way to obtain relative strength; ▪ It should not be used to investigate the absolute strength of concrete.	
2. Chloride ion concentration	Core extraction method	▪ In this method total amount of chloride ion present in the concrete is determined ▪ By potentiometric titration method Chloride Density test analyzes chloride ion concentration; ▪ Chloride density test is done in the depth direction; Salinity is measured at 4(four) points of different depths	 
	Concrete powder by drilling	▪ For chloride density tests some concrete powder is extracted by drilling as sample; ▪ From 4 (four) different depths *(in depth direction)* samples are extracted; ▪ This test method analyzes chloride ion concentration using potentiometric titration method; And ▪ Total amount of chloride ion present in the concrete is also determined by this method.	
3. Carbonation depth	Phenolphthalein method (Core Extraction)	▪ In Phenolphthalein method *(By core extraction)* an extracted core is washed with water; ▪ 1% Phenolphthalein solution is sprayed over the core surface; ▪ The depth of the purple red colored part of the core is then measured from concrete surface at 8 points around the circumference of the circular core; ▪ Carbonation depth of the concrete is the mean of these depths measured at 8 points mentioned above.	 
	Phenolphthalein method by drilling	▪ Location of rebar and PC tendon is confirmed by a rebar detector; ▪ The test is conducted at a location where rebar or PC tendon is not underneath	

Investigation		Procedure	Photograph
		▪ 1% Phenolphthalein solution is sprayed on a filter paper ▪ The filter paper is kept holding just below the drilling location; ▪ Thus, concrete powder extracted from the hole drops onto it. ▪ As soon as the filter paper starts to turn red, drilling is stopped; ▪ Then the depth of the hole is measured with a Slide Caliper which is the carbonation depth.	 
	Phenolphthalein method by exposed rebar	▪ In this method, the location of rebar and PC tendon is confirmed by a rebar detector; ▪ Then concrete is cut in such a way that a considerable portion of rebar is exposed; ▪ The exposed portion is then cleaned thoroughly by brushes syringes, etc.; ▪ 1% Phenolphthalein is then sprayed into that area of exposed rebar; ▪ The depth of red/purple colored part of concrete surface is measured, which is carbonation depth.	
Rebar corrosion (Exposed rebar)		▪ In this method, the location of rebar and PC tendon is confirmed by a rebar detector; ▪ Then concrete is cut in such a way that a significant portion of rebar is exposed; ▪ Then the part of element with stain of rusty water flow, partial spalling, exposed rebar or big corrosion crack etc. are investigated; ▪ In applicable cases partial loss of area of a rebar measured by calipers and after removing stains.	
Degradation prediction	Carbonation	▪ Carbonation is a degrading phenomenon originated from CO_2 infiltration into concrete; ▪ To estimate carbonation depth in concrete, following formula (1) is used: $y = b\sqrt{t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$ formula (1) Where, y: estimated carbonation depth (mm) b : coefficient of *carbonation speed (mm/√year)* t : time (year)	

Investigation		Procedure	Photograph
	Chloride Attack	▪ Spreading of chloride ion stuck in concrete surface is predicted from diffusion equation derived from Fick's Law; Fick's Law is shown is as below: $J_A = -D\frac{dCl}{dx}$ .....(2) J_A = Mass flux which is a material flow through a unit cross-sectional area in unit time D = Diffusivity constant Ci = Concentration of the substance x= Distance coordinate ▪ The diffusion equation indicated below is obtained from continuity of a material flow: $\frac{\partial Ci}{\partial x} = D\frac{\partial^2 Ci}{\partial t^2}$ .....(3) t: Time ▪ When the boundary condition is given and the differential equation is solved, formula for chloride ion concentration diffusion is obtained as below: $Ci(x,t) = C_0\left(1 - erf\left(\frac{x}{\sqrt{4Dt}}\right)\right)$ .....(4) D = Diffusivity constant C_i (x, t) = Chloride ion concentration at 'x' location (kg/m3) C_0 = Chloride ion concentration at x=0 (concrete surface) (kg/m3) x = Distance coordinate(cm) t = Time (Year) erf(x) = Error function $erf(x) = \frac{2}{\sqrt{\pi}}\int_0^x e^{-t^2}\,dt$	

3.4 Reporting the Findings of Inspection

3.4.1 Preparation of Inspection Report

An Inspection Report essentially be prepared on completion of every periodic inspection of a Bridge for:

- ❖ Recording the findings of inspection; And
- ❖ Delivering a descriptive details of site conditions of the bridge.

3.4.2 Who will prepare the Report

Inspector (Sub-Assistant Engineer: SAEs) shall be responsible for recording and putting the findings of the inspection concerned to the Team Leader/Senior Inspector/Upazila Engineer. They shall use the Reporting Form generating from RuBIMS.

3.4.3 Data for Identification of the Bridge

To confirm the identification of the Bridge, the Bridge Inspection Report form will contain the following information:

- ❖ latitude/longitude or Global Positioning System (GPS) coordinates;
- ❖ Name of the Bridge;
- ❖ The frequency of inventory route followed over/under the bridge;

- ❖ The chainage of the bridge on inventory route;
- ❖ Intersecting feature(s) with the bridge like road, river, canal, railway etc.

3.4.4 Essential Content of Report

The report must describe the severity and extent of the defects and deterioration as inspected. (Chapter: 5 illustrates typical deteriorations; Chapter: 6 explains the procedures for assessing the severity and extent of defects found along with the method for printing Reports).

3.4.5 Accuracy and Consistency in Data Entry

While entering data in the Data Sheet of RuBIMS for preparing the report, the Officer/Staff concerned shall be extremely careful and conscious. This is because:

- ❖ An accurate and consistent regarding record of defects found is essential for comparison with previous sheets (Data Entered); And
- ❖ It facilitates tracking the changes of condition of Bridge concerned through comparison of previous data sheets with the current one.

Last Paragraph is decently covered in previous Tables and Charts (**Activity and Tasks: 7,8 &9**)

3.5 Safety While Performing Inspection (A succinct summary)

The safety of inspectors as well as pedestrians/traffic using the bridge or passing through alternate bypass (may trail under the bridge) are of prime importance during performing an inspection. For a specific inspection, inspectors should adopt certain technique(s) conforming to the type/category of inspection. He (they) should assess to is (their) best the risks involved and potential to the job.

3.5.1 Elementary Rules of Safety (for Upazila Engineer/Team Leader/The Senior Inspector)

Before inception of inspection, Upazila Engineer/Team Leader/The Senior Inspector shall:

- ❖ Realistically evaluate the risks potential and integrated with inspection procedures and prevailing site-specific circumstances;
- ❖ Ensure appropriate and safe environment as per evaluation;
- ❖ Prepare a safety plan based on the evaluation and safety precaution measures (Chapter-2: Table-2.5); In addition

The plan should include site-specific safety needs like:

- Temporary controlling of traffic;
- Need based and Emergency Contacts (Relevant Officer/Staff/Local people);
- Need based and Emergency phone numbers;
- The plan should be discussed in the coordination meeting; And
- Should be distributed to all members including equipment operators and other relevant persons.

While performing the inspection, Upazila Engineer/Team Leader/The Senior Inspector should:

- ❖ Follow the standard safety rules and "safety precaution guidelines" hard and fast;
- ❖ Prefer safe operating procedure while using site-specific, high profile and complex equipment.

3.5.2 Standard Safety Provision to be Followed by Inspection Team

The following table illustrates step by step safety provisions to be followed by the inspection team:

Sl. No	Inspection Step	Provisions to be followed
1.	Before Accessing to Site	❖ Arrange for implementing the realistic traffic control measures; ❖ Be aware of the changing pattern of layout of traffic control measures with respect to the progress of inspection; ❖ Parking vehicles and equipment not obstructing other users.
2.	Accessing to Site	❖ The team must made themselves satisfied with adequate and safe access facilities; ❖ Carrying communicating device/system while inspecting confined space and/or distant area; ❖ Remaining safety-conscious to be safe from probability of accidents all the way
3.	Using Tools and Instruments	❖ Wearing protective cloth, helmet, safety boots etc.; ❖ Wearing high visibility reflective vest while working around traffic-plying road lane; ❖ Be determined and physically adjusted while using high/deep ladders; ❖ Using waist band/hanging bags to carry camera etc., access, measurement and recording tools while using scaffolding, ladders etc. ❖ Using tools/instruments with extreme care to avoid dangers borne from dropping/slipping.

3.5.3 Measures for Temporary Control of Traffic

When bridge inspection needs partial and temporary closure of the roadway, measures for temporary traffic control is a must needed step to be implemented. For instance, erection of under-bridge platforms or operating equipment like scaffolding etc. for dismantling. Traffic condition including speed and number of vehicles passing the inspection spot should be taken into account.

If appears advantageous, flagmen should be considered. Trained persons should be deployed to temporarily control moving traffic and implementing other traffic control measures in applicable cases.

CHAPTER 4

BRIDGE CATEGORY COMPONENTS & ELEMENTS RELATED TERMINOLOGIES ELEMENT NUMBERING AND DEFECTS

For inspectors it is important to be familiar with Bridge Category, Components, elements, related terminologies and defects. Similarly, identification of elements is an inevitable measure in order to perfectly operate the inspection. Therefore, numbering of elements bears prime importance as far as successful inspection program is concerned. This chapter chronologically and categorically illustrates the sections and subsections so as to make the inspectors capable to accurately identify, and describe the condition of a bridge after inspection. First of all, Bridge Category is explained briefly. Then the major components and component wise classification of elements of a bridge are introduced where terminologies are described contextually. Finally, the numbering system of elements and the defects associated with them are presented.

4.1 Bridge Category

Generally, Bridges are categorized as per:

- The material by which the structure is constructed;
- The purpose of the Bridge; And
- Category of structure.

The inspector needs to prepare a comprehensive report mandatorily after completion of an inspection. Therefore, he must have appropriate knowledge regarding categories of bridge.

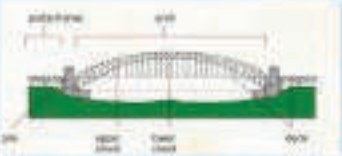
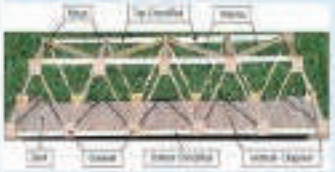
Typically, Bridge Categories are defined according to the basic types of materials (concrete, steel, stone, timber, masonry etc.) by which the structure is constructed, purposes and the type of superstructure. They are summarized in Table 4.1 *as per LGED's jurisdiction*.

Table 4.1: Bridge Category and Shape with leading Characteristics and Sample Picture

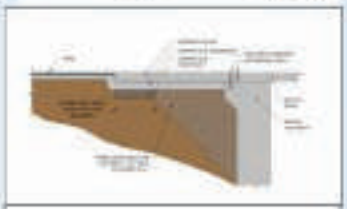
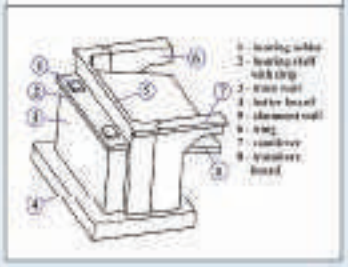
Category	Identity	Leading Characteristic(s)	Sample Picture
Reinforced Cement Concrete (RCC) Bridge	1. RCC Slab Bridge	▪ Slab(s) supported on abutments/piers without girders; and The span length is less than 16m (Normally).	 
	2. RCC Girder Bridge	▪ Normally, span length is less than 20m; ▪ In special cases may be less than 30m.	
	3. Light Traffic Bridge	▪ Like as RCC Girder Bridge and ▪ Carriageway width is less than 3.00m	
	4. RCC Girder Bridge with Brick Abutment	▪ Like as RCC Girder Bridge with Brick Abutment	
	5. a. Continuous RCC Girder Bridge	▪ Like as RCC Girder Bridge with multiple spans and ▪ No expansion joint in the Girders	
	b. Continuous RCC Box Girder Bridge	▪ RCC Bridge, section continuous top slab, bottom slab and vertical wall ▪ No prestressing cable use exists	

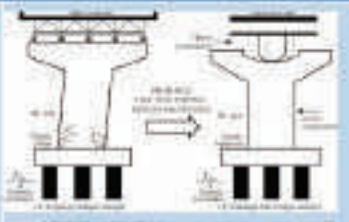
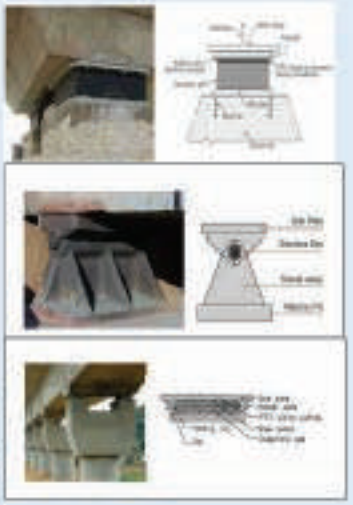
Category	Identity	Leading Characteristic(s)	Sample Picture
	6. PC (Prestressed Concrete) Girder Bridge	▪ Initial compression is given in the concrete before applying the external load to counteract stress from external load; ▪ This initial compression is introduced by high-strength steel wire or alloys (called 'tendons'); ▪ Generally, span length is more than 20m.	
	7. PC (Prestressed Concrete) Box Girder Bridge	▪ Concrete sections forming a boxed shape (rectangular or trapezoidal) supported by prestressed strands; ▪	
	8. Concrete Arch Bridge	▪ Bridges with a curved/straight element; which are connected with deck/girder ▪ Some curved/straight members may be subject to tension and others are compression with little bending ▪ Distribute the load (weight) instead of just pushing it straight down; ▪ Have abutments, supports on the ground at both ends, on either side of the arch for added support; ▪ Generally, the Span length of modern arch bridge is between 60-250 meter	
	9. Cantilever Bridge with Hinge	▪ Generally made with three spans ▪ Usually outer spans are both anchored down at the shore; and ▪ Cantilever span out over the channel to be crossed. ▪ Central span rests on the cantilevered arms extending from the outer spans; ▪ It can span distances of over (460 m)	
	10. Rigid Frame Bridge	▪ Bridge in which the superstructure and substructure are rigidly connected to act as a continuous unit; ▪ Typically, the structure is cast monolithically, continuous from deck to foundation. ▪	

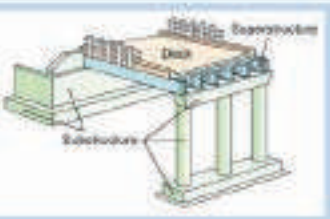
Category	Identity	Leading Characteristic(s)	Sample Picture
	11. Cable-Stayed Bridge	▪ Has one or more towers (or pylons), from which cables support the bridge deck; ▪ A distinctive feature is that cables or stays, run directly from the tower to the deck, normally forming a fan-like pattern or a series of parallel lines. ▪ There are four major classes of rigging on cable-stayed bridges: *mono, harp, fan, and star;* ▪ Cable-stayed bridges are practical for spans up to around 1 kilometer	 
	12. Suspension Bridge	▪ Carries vertical loads through curved cables in tension. ▪ The main cables suspend the deck (girder, roadway); ▪ These loads are transferred both to the towers; ▪ Towers carry loads by vertical compression to the ground and to the anchorages; ▪ They resist the inward and sometimes vertical pull of the cables; ▪ Steel cables are both strong and flexible.	  
	13. Extradosed Bridge	▪ An extradosed bridge is a type of bridge that combines features of both a cable-stayed bridge and a box girder bridge. ▪ It's characterized by external cables that act as prestressing cables, meaning they reinforce the concrete deck, and shorter towers compared to traditional cable-stayed bridges.	
Steel Bridge	1. Steel Plate Girder Bridge	▪ Consist of steel beams shaped to an I-section; ▪ Called a plate girder bridge with I-section: And ▪ Comprised of deck slabs, on which vehicles and people pass, and of main girders supporting the deck slabs.	

Category	Identity	Leading Characteristic(s)	Sample Picture
	2. Steel box Girder Bridge	▪ Consist of steel beams shaped to a box section ▪ Called Box girder bridge with box section; And ▪ Comprised of deck slabs, on which vehicles and people pass, and of main girders supporting the deck slabs.	
	3. Steel Arch Bridge	▪ Abutments at each end shaped as a curved arch; ▪ Works by transferring the weight of the bridge and its loads partially into a horizontal thrust restrained by the abutments at either side; ▪ Can be made of stone, concrete, iron, or steel; and ▪ Typically require less material than a beam bridge of the same span.	 
	4. Truss Bridge with Steel Deck	▪ Trusses are generally used for bridge spans between 30m and 150m; ▪ The construction depth (deck soffit to road level) is limited; ▪ The deck of the bridge is composed of primary and secondary steel beam members.	
	5. Truss Bridge with RC slab	▪ RCC deck slabs in deck type composite truss bridges provides lateral support to the compression members of the truss, and ▪ Increases the cross section; ▪ Deck are generally continuous RCC slab.	
	6. Truss Bridge with Timber Deck	▪ Timber truss bridges are deck bridges; ▪ The individual span width is reduced by oblique supports; ▪ The supporting structure is situated under a water-tight road surface and is protected against weathering; ▪ Ideal for cuttings such as roads or farm tracks. ▪ Optimum cross-section is used for span widths up to 35.0 m.	 

Category	Identity	Leading Characteristic(s)	Sample Picture
	7. Portable Steel Bridge with Steel Deck (Origin: Baily Bridge)	▪ The design of the Bridge is modular; ▪ Allows full spans up to 60 meters in 3.048 m increments; ▪ Highways Loads up to HS25-44 have been proven during extensive during extensive testing; ▪ Have been widely used in various fields; ▪ Most important features are: o Variety of spans, o Bear considerably high carrying capacity, o Light and handy components, o Easy to dismantle and strong adaptability, o Can be quickly completed with simple tools and manpower. ▪ The surface protection can be paint or hot-dip galvanized.	 
	8. Portable Steel Bridge with Timber Deck	▪ Almost similar characteristics except the material of deck.	
Masonry Arch Bridge	1. Masonry Arch Bridge	▪ Bridge with abutments at each end shaped as a curved arch. ▪ Works by transferring the weight of the bridge and its loads partially into a horizontal thrust restrained by the abutments at either side. ▪ Bridges of stone or brick are the most genuine type, some lasting a thousand years. ▪ Masonry arches come in three main types (i.e., coursed ashlar, random ashlar, and rubble) and ▪ Can be constructed of either brick or stone.	 
	1. Slab Culvert	▪ Slab normally supported on brick abutments without girders; ▪ No intermediate support and ▪ Total length 6.0m or less.	

Category	Identity	Leading Characteristic(s)	Sample Picture
	2. Open Foundation Culvert (OFC)	▪ Slab(s) normally supported on brick abutments/Piers without girders and ▪ Total length above 6.0m	
Culvert	3. Box Culvert	▪ The box culvert is a rigid frame structure (single or multiple cell); and ▪ Very simple in construction; ▪ Suitable for non-perennial streams where scrub depth is not significant but the soil is weak; ▪ The bottom slab of the box culvert reduces pressure on the soil; ▪ Typically used for shorter spans ▪ Might include toe walls, headwalls, wing walls, manhole openings, pipe openings, V-bottoms, keyed-ends, sloped-faced ends and water tight joints (in applicable cases)	  
Type of Sub-structure	1. Abutment	▪ Supporting structure on either side of a bridge; ▪ Purpose is to support the bridge by carrying self-weight, vehicles and pedestrians weight passing over it; ▪ Connects the bridge to the approach roadway, gives the bridge vertical support; ▪ Five parts of bridge abutment are as follows: o A seat at the top of the abutment; o Wing walls on each side of the abutment, o Back wall that supports the approach slab on the backside of the abutment, o Stub Abutments partially resists the horizontal earth pressure as well o Piles, and footing which provides foundation stability to the abutment and safely supports to it.	  

Category	Identity	Leading Characteristic(s)	Sample Picture
	2. Pier	▪ Structures located at the ends of bridge spans at intermediate points between the abutments; ▪ Functions are two-fold: o To transfer the vertical loads to the foundation; and o To resist all horizontal forces and transverse forces acting on the bridge. ▪ Contribute to the aesthetic appearance of the bridge; ▪ Can be cellular, wall type, solid, trestle or hammerhead type. ▪ Solid piers can be masonry or concrete single or multiple vertical members up to a height of about 6.0 m and span about 20m.	 
	3. Bearings	▪ Typically provides a resting surface between bridge sub-structure (Abutment/piers) and the bridge super-structure (Girder/deck etc.); ▪ The purpose is *to*: o Allow controlled movement and thereby reduce the stresses involved; o Carry loads both vertical and horizontal directions; and o Transfer vehicular and external loads from the superstructure down to the substructure; o Ensure adequate mutual connection of different parts of a bridge; ▪ Divided into two major categories: o Expansion bearings; and o Fixed bearings.	
Expansion Joint	1. Steel Expansion Joint	▪ Allow the concrete to naturally expand and contract without cracking; ▪ Stainless steel expansion joints allow bridges to effectively handle pressure and movement without compromising structural integrity.	

Category	Identity	Leading Characteristic(s)	Sample Picture
	2. Rubber Expansion Joint	▪ Allow the concrete to naturally expand and contract without cracking; ▪ Rubber expansion joints are placed at the end of a bridge where it meets up with the freeway; ▪ These connectors give the concrete just enough space to move and avoid concrete cracks.	
Miscellaneous	1. Deck Surface	▪ Deck is the surface of a bridge; ▪ A structural element of its superstructure; ▪ May be constructed of concrete, steel, open grating, or wood; ▪ Primary function of a bridge deck is to: o Support the vehicular vertical loads and distribute these loads to the superstructure. ▪ Typically continuous along the length, and across the width, of the span of the bridge.	 

4.2 Components and Elements of Bridge

The automation and standardization of information and procedures of inspection as well as effective maintenance, it is inevitable to define specifically the objectives of bridge along with their components and potential defects that may be associated with them.

To qualify a structure wholistically sustainable in carrying all sorts of loads (Dead & Live) each and every component of the bridge plays individual significant role(s). Therefore, it is vital to have appropriate knowledge regarding the behavior of bridge component and identity thereby.

4.2.1 Components of Bridge

Typically, the components of bridge are classified based on structural behavior as: a) Primary components and b) Secondary (Non-structural) components. Primary components have a further classification as: i) Superstructure Components, ii) Substructure Components, iii) Bearing. Table 4.2 describes the detail.

Table 4.2: Components of Bridge

Sl. No	Component	Elements
1.	**Primary (Structural) Components**	
	i. Super-structure Components	1. Deck slab 2. Girder 3. Truss etc.
	ii. Sub-structure Components	1. Piers 2. Abutment and 3. Foundation
	iii. Bearings	1. Bearings
2.	**Secondary (Non-Structural) Components**	1. Deck surface 2. Expansion joints 3. Drainage system 4. Approaches 5. Miscellaneous elements: ▪ wheel guard ▪ Railing ▪ Light post etc.

4.3.2 Elements of Bridge

Components are further classified into elements i.e.; any component of a bridge may have more than one element. Like Component (also sometimes nomenclated as Member) identification of elements are of prime importance to the inspectors as the defects basically initiates at element level and propagates/accelerates/extends up to the component level. Following table (Table 4.3) illustrates component wise classification of elements:

Table 4.3: Component wise Elements of Bridge

Sl. No	Class ID	Sub-Class ID	Bridge Category	Name of Component	Name of Element
1.	Primary Component	Superstructure Component	RCC Girder	1. Girder	a. Main Girders b. Diaphragm c. Cross Beam/Girder
				2. Deck slab	a. Deck Slab
			Truss	1. Vertical/Diagonal Component	a. Vertical /Diagonal Element
				2. Upper/Lower Chord	a. Upper/Lower Chord
				3. Panel Point	a. Panel Point
				4. Sway Bracing	a. Sway Bracing
				5. Lateral Bracing	a. Lateral Bracing
			Arch	1. Arch Rib	a. Arch Rib
				2. Stiffening Member	a. Stiffening Element
				3. Suspender/Support	a. Suspender/Support
				4. Panel point	a. Panel point
			Rigid Frame	1. Main Girder	a. Main Girder
			Cable-stayed	1. Diagonal Component	a. Diagonal Component
				2. Tower Columns	a. Tower Columns
				3. Outer Cable	a. Outer Cable
				4. PC Anchorage	a. PC Anchorage

Sl. No	Class ID	Sub-Class ID	Bridge Category	Name of Component	Name of Element
				5. Horizontal Component of Tower Column	a. Horizontal Component of Tower Column
				6. Diagonal Component of Towers	a. Diagonal Component of Towers
		Substructure Components	All	1. Pier	a. Cap Beam b. Pier Cap c. Pier Bent d. Supporting columns
				2. Abutment	a. Bridge Seat b. Wing Walls c. Front Wall/Stem d. Back Wall d. Integral Backwall
				3. Foundation	a. Pile (Abutment/Pier) b. Footing/Pile Cap (Abutment/ Pier)
		Bearings	All	1. Bearings	a. Main Body of Bearings b. Anchor Bolts c. Seat Mortar d. Bed Concrete
2.	**Secondary (Non-Structural) Components**	Superstructure Components	All Girder	1. Deck Surface	a. Guard Fence b. Median c. Railing d. Lighting Facilities e. Pavement f. Curb g. Signs h. Wearing Course i. Wheel guard j. Bridge Railing k. Pedestrian Railing l. Light post
				2. Expansion Joints	a. Sealer Materials
				3. Drainage system	a. Grade and cross slope b. Inlets and Outlet pipes c. Downspout pipes d. Cleanout plugs e. Drainage troughs f. Support brackets/ hardware
				4. Approaches	a. Approach roadways b. General alignment

Sl. No	Class ID	Sub-Class ID	Bridge Category	Name of Component	Name of Element
					c. Traffic safety features d. Approach alignment

4.4 Numbering System of Bridge Elements

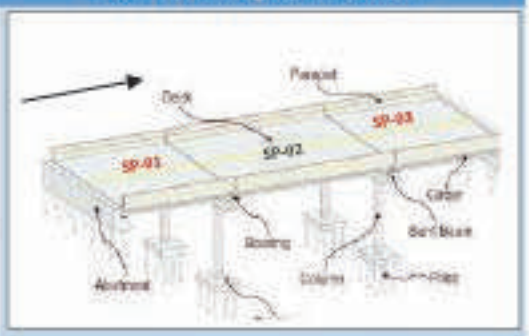
While preparing for an inspection it is inevitably significant for an inspector to formulate an easy and realistic system to identify the components and elements of bridge. The inspector may follow alternate options base on the available of sources of information. If reference drawings or earlier inspection reports are available, the inspector should follow the same identification system that has been used in these sources. If it is not the case i.e., no previous drawing or report(s) is available, then it is a must for the inspector to formulate an easily followable identification system.

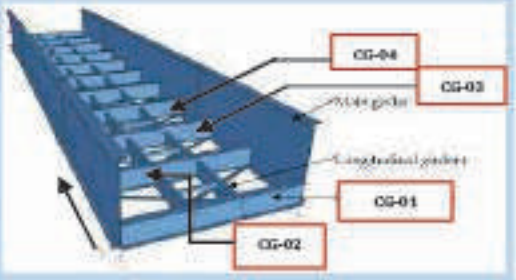
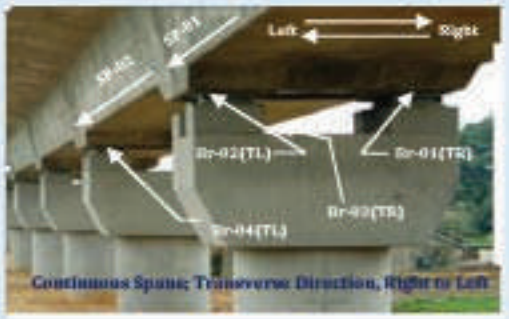
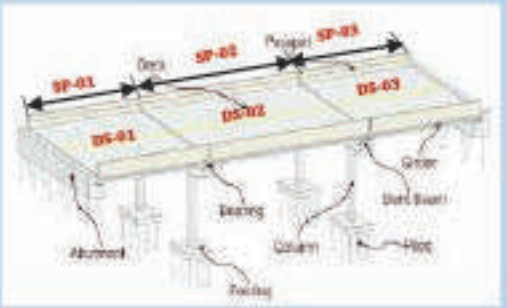
Using the chainage of route direction will certainly be helpful for identifying the starting and ending of a bridge.

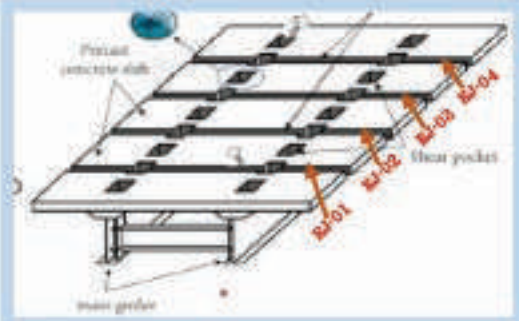
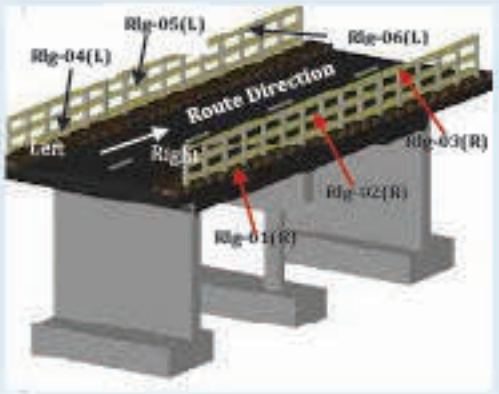
4.4.1 Numbering System for Components and Element

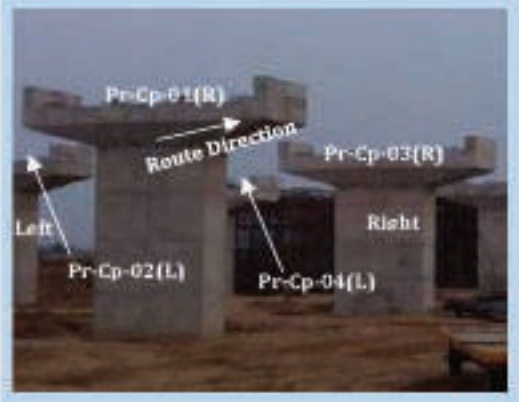
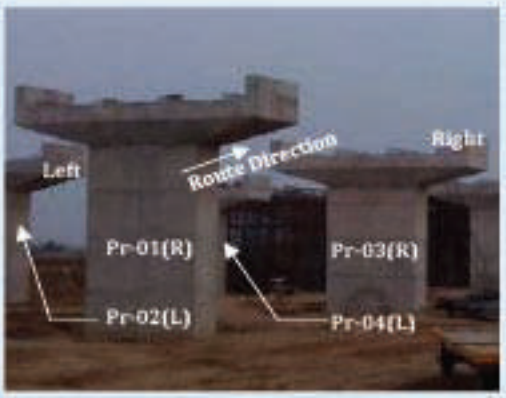
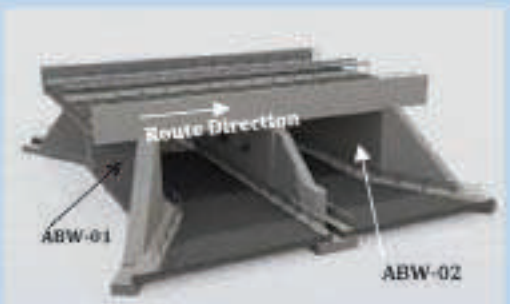
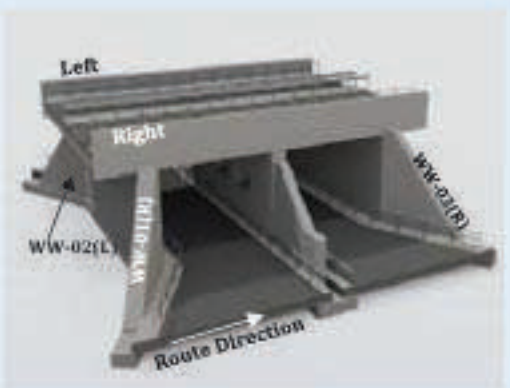
To make the reporting system standard and the inspection report easily interpretable, a system of identifying the bridge components and elements is developed. Nevertheless, this is just exemplary version just to provide a clear and straight forward conception of element numbering system. The inspector concerned may follow his own pursuit. The following Table illustrates the numbering system along with photographic representation:

Table 4.4: Illustration of Numbering System of Components and Elements

	Component	Element	Procedure	ID Number	Sketch/Photographic Sample
Superstructure	RCC Girders	1. Span	Start from Back Approach	1st Span: SP-01 2nd Span: SP-02 3rd Span: SP-03 ..... Last Span: SP: LS or N *(N=last number as per progression)*	
		2. Main Girders	Start from either end (left/right) or East/West/ North/South as applicable as per route/location)	1st Girder: Mg-01 2nd Girder: Mg-02 3rd Girder: Mg-03 ..... Last Span: Mg: LS or N *(N=last number as per progression)*	

	3. Cross Girders / Beams	Start from beginning (SP-01) as per route direction	1st Girder/Beam: CG/CB-01 2nd Girder/Beam: CG/CB-02 3rd Girder/Beam: CG/CB-03 ..... Last Span: CG/CB: LS or N (N=last number as per progression)	
	4. Bearings	▪ Start from beginning (SP-01) as per route direction ▪ Consider Longitudinal(L)/ Transverse (T) AND Right (R)/ Left (L)	1st Span: Br-01(TR) : Br-02(TL) 2nd Span: Br-03(TR) : Br-04(TL) ..... Last Span: Br (TL): LS or N (N=last number as per progression)	
Deck	1. Deck Slab	Start from beginning span (SP-01) as per route direction	1st Deck: DS-01 2nd Deck: DS-02 3rd Deck: DS-03 ..... Last Span: DS-LS or N (N=last number as per progression)	
	2. Pavement	Start from beginning span (SP-01) as per route direction	1st Pavement: Pav-01 2nd Pavement: Pav-02 3rd Pavement: Pav-03 ..... Last Pavement: Pav-LS or N (N=last number as per progression)	

	3. Expansion Joints	Start from beginning between span (SP-01 & SP-02) as per route direction	1st Expansion Joint: EJ-01; 2nd Expansion Joint: EJ-02; 3rd Expansion Joint: EJ-03; ..... Last Span: DS: LS or N (N=last number as per progression)	
	4. Railings	▪ Start from beginning (SP-01) as per route direction ▪ Consider Right (R) OR Left (L)	1st Railing: Rlg-01(R); 2nd Railing: Rlg-02(R); 3rd Railing: Rlg-03(L): 4th Railing: Rlg-04(L); ..... Last Railing: Rlg: L(L/R) or N (L/R) (N=last number as per progression)	
	5. Wheel Guard	▪ Start from beginning span (SP-01) as per route direction ▪ Consider Right (R) OR Left (L)	Right Wheel Guard: Wg-01(R); Left Wheel Guard: Wg-02(L)	
	6. Approach Road	Start from beginning span (SP-01) as per route direction	Starting Approach: Appr-01; Ending Approach: Appr-02;	

Sub-Structure	Pier	1. Pier Cap	▪ Start from beginning span (SP-01) as per route direction ▪ Consider Right (R) OR Left (L)	1st Pier Cap: Pr-Cp-01(R) for (SP01); 2nd Pier Cap: Pr-Cp-02(L) for (SP01); 3rd Pier Cap: Pr-Cp-03(R) for (SP02); 4th Pier Cap: Pr-Cp-04(L) for (SP02); ..... Last Pir Cap: Pr-Cp-L(L/R) or N (L/R) (N=last number as per progression)	
		2. Pier (Column)	▪ Start from beginning span (SP-01) as per route direction ▪ Consider Right (R) OR Left (L)	1st Pier: Pr-01(R) for (SP-01); 2nd Pier: Pr-02(L) for (SP-01); 3rd Pier: Pr-03(R) for (SP-02); 4th Pier: Pr-04(L) for (SP-02); ..... Last Pir Cap: Pr-Cp-L(L/R) or N (L/R) (N=last number as per progression)	
	Abutment	1. Back Wall	Start from beginning span (SP-01) as per route direction	1st Abutment Back Wall: ABW-01 for (SP01); 2nd Abutment Back Wall: ABW-02 for (SP-N); (N=last number as per progression)	
		2. Wing Wall	▪ Start from beginning span (SP-01) as per route direction ▪ Consider Right (R) OR Left (L)	1st Wing Wall: WW-01(R) for (SP-01); 2nd Wing Wall: WW-02(L) for (SP-01); 3rd Wing Wall: WW-03(R) for (SP-N); 4th Wing Wall: WW-04(L) for (SP-N); (N=last number as per progression)	

4.5 Defects Associated with Components and Elements

Inspection method must be selected carefully in line with features of the bridges, components and elements targeted for inspection, situation and environment in which the target bridge stands so that any possible defects of bridge components and elements can be identified.

4.5.1 Defects of Structural Elements

Table 4.5-1 to Table 4.5-2 show potential defects of structural (superstructure, substructure elements, which are listed against the types, components and elements to enable an inspector in identifying them while performing an inspection program.

Table 4.5-1: Possible Defects associated with the Super-structures (Components & Elements)

Super-Structure					
Component/ Member	Element	ID	Category of Defect Based of Construction Material		
			Concrete	Steel	Others
Girders	Main Girder	Mg	6) Crack 7) Scaling / Spalling / Exposed rebar 8) Water leakage/ Efflorescence 9) Fallen out of deck slab 10) Crack of deck slab 11) Delamination 12) Abnormal Spacing 16) Other Types of Defects (a. Illegal Occupation, b. Plant Growth, c. Fire Damage, d. Missing of Sealing material, e. Bird's Waste etc.) 17) Defects of reinforced materials for rehabilitation / strengthening 18) Abnormal anchorage 19) Discoloration /Deterioration 20) Water leakage/Puddle 21) Abnormal noise /Vibration 22) Abnormal deflection 23) Deformation/Break	1) Corrosion 2) Crack in steel 3) Loose connection/Missing bolts 4) Fracture 5) Deterioration of protective function 12) Abnormal Spacing 16) Other Types of Defects 17) Defects of reinforced materials for rehabilitation/strengthening 18) Abnormal Anchorage 20) Water Leakage/Puddle 21) Abnormal Noise/Vibration 22) Abnormal deflection 23) Deformation/Break	
	Arch	Ar			
	Hanger of Arch	Ha			
	Floor Beam	Fb			
	Bottom Bracing	Bb			
	Cross Beam	Cr			
	Stringer	St			
	Rigid Frame Girder	Rg			
Deck Slab	Deck Slab Top	Ds			
	Deck Slab Sofit	Dss			
Truss (Steel)/ Baily Bridge	Vertical/ Diagonal Component	Dt	N/A		
	Upper/Lower Chord	Lc			
	Sway Bracing	Sb			
	Upper Lateral Bracing	Lu			
	Lower Lateral Bracing	Li			
	Vertical Post	Vp			

Super-Structure Component/ Member	Element	ID	Category of Defect Based of Construction Material		
			Concrete	Steel	Others
	Top Cord/Bottom Cord	Tc/Bc			
	Strut	St			
PC Anchorage			6) Crack 7) Scaling/Spalling / Exposed rebar 8) Water leakage / Efflorescence 12) Delamination 18) Abnormal anchorage 19) Discoloration / Deterioration 20) Water leakage/Puddle 21) Abnormal noise /Vibration 22) Abnormal deflection 23) Deformation/Break	1) Corrosion 5) Deterioration of protective function 23) Deformation/Break	
Other Elements					

Table 4.5-2: Possible Defects associated with the Sub-structures (Components & Elements)

Sub-structure Component/ Member	Element	ID	Category of Defect Based of Construction Material		
			Concrete	Steel	Others
Abutment	Back Wall	Bw	6) Crack 7) Scaling/Spalling / Exposed rebar 8) Water leakage / Efflorescence 11) Delamination 16) Other Types of Defects (a. Illegal Occupation, b. Plant Growth, c. Fire Damage, d. Missing of Sealing material, e. Bird's Waste etc.) 17) Defects of reinforced materials for rehabilitation/ strengthening 18) Abnormal Anchor 19) Discoloration/ Deterioration 20) Water Leakage/Puddle 21) Abnormal Noise/Vibration 22) Abnormal Deflection 23) Deformation/Break	1) Corrosion 2) Crack in steel 3) Loose connection/Missing bolts 4) Fracture 5) Deterioration of protective function 17) Defects of reinforced materials for rehabilitation/strengthening 20) Water Leakage/Puddle 21) Abnormal Noise/Vibration 22) Abnormal Deflection 23) Deformation/Break	
	Wing Wall	Ww			
	Retaining Wall	Rw			
	Top Slab of Box Culvert	Ts			
	Base/B. Slab of Box	Bs			
Piers	Pier Column	PiC			
	Pier Cap	PrC			
	Pier Bent	PrBt			
	Pier Bracing	PrBg			
	Top slab of Box Culvert	TS			
	Intermediate Walls	IW			
Foundation	Footing	Fg	6) Crack	1) Corrosion	

Sub-structure Component/ Member	Element	ID	Category of Defect Based of Construction Material		
			Concrete	Steel	Others
	Base/B. Slab of Box	BS	7) Scaling/Spalling/Exposed rebar 25) Settlement/ Tilt/Movement 26) Scouring	2) Crack in steel 5) Deterioration of protective function 25) Settlement / Tilt / Movement 26) Scouring	
	Piles	P			
	Pile cum Pier	PcP			
	Exposed Pile	ExP			
	Projected Pile	PjP			
	Pile Cap	PC			
	Well Foundation	WF			
Other Elements					

4.5.2 Defects of Bearing and its Components

Table 4.5-3: Possible Defects associated with Bearings

Bearings (B)					
Component/ Member	Element	ID	Category of Defect Based of Construction Material		
			Concrete Material	Steel Material	Others
*Bearings	Bearing Main Body	Bh	N/A	1) Corrosion 2) Crack in steel 3) Loose connection/Missing bolts 4) Fracture 5) Deterioration of protective function 12) Abnormal spacing 15) Functional Disorder of bearings 20) Water leakage/Puddle 21) Abnormal noise/Vibration 23) Deformation/Break 24) Accumulation of debris 25) Settlement/Tilt/Movement	4) Fracture 12) Abnormal spacing 15) Functional disorder of bearings 19) Discoloration / Deterioration 20) Water leakage/Puddle 21) Abnormal noise/Vibration 23) Deformation /Break 24) Accumulation of debris
	Anchor Bolts	Ba			N/A
	Bearing Seat Mortar	Bm	6) Crack 7) Scaling /Spalling/Exposed rebar 11) Delamination 20) Water leakage/ Puddle 23) Deformation /Break	N/A	N/A
	Bearing Bed Concrete	Bc			
Other Elements					

*Note: All possible defects of Bearings are listed here for understanding of the inspectors; however, for the inspection and evaluation programing in RuBIMS purpose only defect no. 15) Functional Disorder of bearings will be used.

4.5.3 Defects of Non-Structural Elements

Table 4.5.4: Possible Defects for Non-Structural Elements

Non-Structural Elements of Deck Surface					
Component/Element	Element	ID	Category of Defect Based of Construction Material		
			Concrete Material	Steel Material	Others
Deck	Median	MED	6) Crack 7) Scaling / Spalling / Exposed rebar 8) Water Seepage/ Efflorescence 11) Delamination 17) Defects of reinforced materials for rehabilitation/strengthening 19) Discoloration/ Deterioration 23) Deformation/Break	1) Corrosion 2) Crack in steel 3) Loose connection/Missing bolts 4) Fracture 5) Deterioration of protective function 17) Defects of reinforced materials for rehabilitation/strengthening 23) Deformation/Break	N/A
Railing	Rail Post	Rp			
	Rail Bar	Rb			
Sidewalk	Wheel Guard	Wg		N/A	N/A
	Curb	Cu			
Drainage System	Drain Opening	Dr	N/A	1) Corrosion 4) Fracture 5) Deterioration of protective function 19) Discoloration/ Deterioration 20) Water leakage/Puddle 23) Deformation/Break 24) Accumulation of debris	4) Fracture 19) Discoloration / Deterioration 20) Water leakage /Puddle 23) Deformation /Break 24) Accumulation of debris
	Drain Pipe	Dp			
Expansion Joint	Expansion Joints	Ej	6) Crack 11) Delamination 21) Abnormal noise /Vibration 23) Deformation/Break	1) Corrosion 2) Crack 3) Loose connection/Missing bolts 4) Fracture of road surface 5) Deterioration of protective function 12) Abnormal spacing 13) Difference in level of road surface 20) Water leakage/Puddle 21) Abnormal noise /Vibration 23) Deformation/Break 24) Accumulation of debris	12) Abnormal Spacing 13) Difference in Level 19) Discoloration/ Deterioration 20) Water leakage/Puddle 21) Abnormal noise/ Vibration 23) Deformation/Break 24) Accumulation of debris
	Checker plates	Ckp			
	Nut-boults	Nb			
Surface	Pavement	Pv	13) Difference in level of road surface	N/A	13) Difference in level
	Backside Approaches	Ba			

	Front Approaches	Fa	14) Bituminous pavement crack 24) Accumulation of debris		14) Bituminous pavement crack 24) Accumulation of debris
Safety Facilities	Signs	Si	N/A	1) Corrosion 2) Crack in steel 3) Loose connection/ Missing bolts 4) Fracture 5) Deterioration of protective function 19) Discoloration/ Deterioration 23) Deformation/Break	3) Loose connection / Missing bolts 19) Discoloration / Deterioration 23) Deformation /Break
	Lighting Facility	Lt			
Retaining Wall					
Retaining Wall adjacent to Abutment	Retaining Wall	Rw	6) Crack 7) Scaling/Spalling / Exposed rebar 8) Water leakage / Efflorescence 19) Discoloration / Deterioration 23) Deformation/Break 25) Settlement /Tilt / Movement	N/A	N/A
Other Element					

CHAPTER - 5

Tips to Facilitate the Inspection and Finding/Detecting Defects

5.1 Crucial Points to be Remembered in Detecting Probable Defects During Inspection

It is a systematic guide for the inspectors for the expected inspection of all the components and elements of a bridge. It is of unavoidable importance for the inspector to be most careful and observant during inspection. He should not ignore any member or element of a bridge. The members and elements those are critical and bear structural integrity should be given and Those portions that are most critical to the structural integrity of the bridge should be given distinct care while operating an inspection. In this case the inspector should follow a generic sequence of inspection in finding the defects. The following table (Table 5.1) presents the sequence and members/components coverage in inspection of a bridge with typical length and complexity:

Table 5.1: General/Side View: Purpose and Photographic Tips

Sl. No	Sequence	Coverage Members/Components
1.	General/Side View	Complete structure of the bridge
2.	Bridge/Road/Approach Road Surface	Railing, Curbs, Wheel guard, Signs, Lighting facilities, Pavement, Expansion joint, Drainage System and Approaches behind abutment.
3.	Underneath the Slab/Girder of Bridge	▪ Superstructure ▪ Deck Slab ▪ Substructure (Abutment, Piers) ▪ Bearings ▪ Utilities

General/Side View: The following table (Table 5.2) illustrates the General/Side View sequence along with purpose and photographic tips:

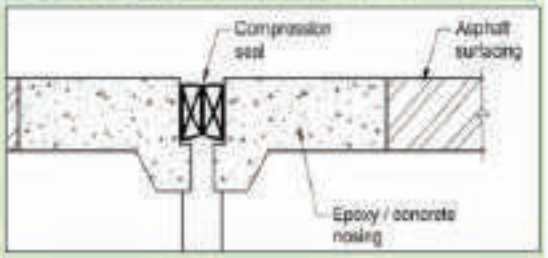
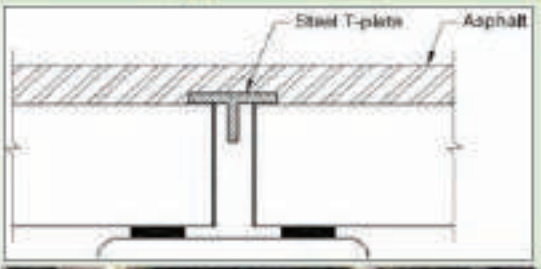
Table 5.2: General/Side View: Purpose and Photographic Tips

Sl. No	Purpose	Photographic Tips
1.	To detect misalignment or settlement (If any).	

The following table (Table 5.3) illustrates the Bridge/Road/Approach Road Surface sequence along with purpose and photographic tips:

Table 5.3: Bridge/Road/Approach Road Surface: Inspection Points and Photographic Tips

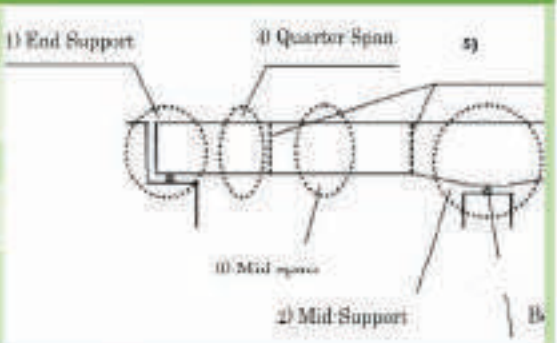
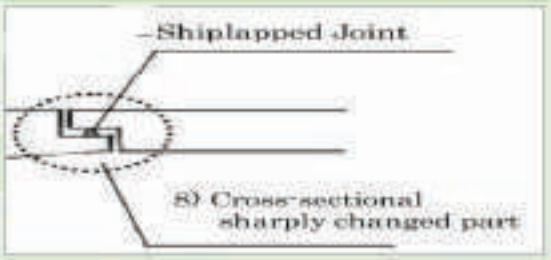
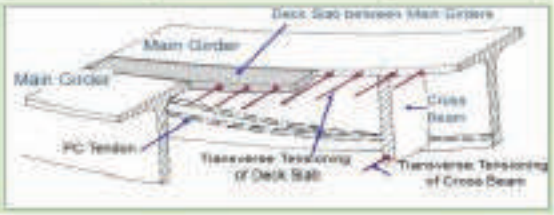
Members/Elements	Purpose/Inspection Points	Photographic Tips
Bridge Surface	Should note: ▪ General approach; ▪ Roadway alignment; ▪ Sight along the railing And ▪ edge of the deck or girder. To detect misalignment or settlement (if any).	
Pavement Surface	▪ Subsidence and ▪ Cracks of pavement surface of bridge deck.	 
Railing, Curb and Wheel Guard	▪ Defects in rail bars and rail posts; ▪ Straightness of alignment; ▪ Looseness of bolts and clamps; ▪ Missing bolts and clamps; ▪ Damages of spacer blocks; ▪ Corrosion borne defect; ▪ Collision borne defects; ▪ Deterioration borne/other forms of weaknesses; ▪ Defects of connecting points between deck and rail posts; ▪ Hazardous projection to pedestrians; ▪ Any other types of hazards on railing bars	   
Expansion Joints (All)	▪ Mud/dust or objects obstructing free movement and appropriate functioning; ▪ Abnormal spacing; ▪ Difference in level; ▪ Loose or missing bolts and ▪ Missing components.	   

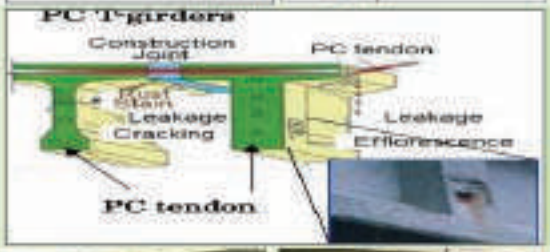
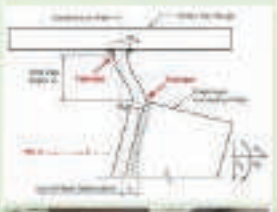
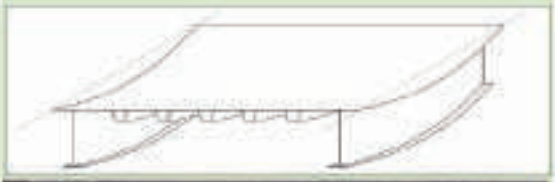
Members/Elements		Purpose/Inspection Points	Photographic Tips
Expansion Joints (Type Based)	Finger Joint (Steel)	▪ Corrosion/Breaking; ▪ Cracks on anchors/concrete; ▪ Loosening of bolts; ▪ Separation/Cracks in the vicinity of pavement; ▪ Difference in Level (Undulation); ▪ Unusual noise during traffic movement; ▪ Irregular Spacing; ▪ Seepage of Water.	
	Butt Joint (Rubber)	▪ Difference in level; ▪ Failure of sealing material; ▪ Breaking of rubber; ▪ Settlement; ▪ Subsidence/Cracks in the vicinity of pavement.	
	Buried Joint	▪ Failure of sealing materials; ▪ Separation/Cracks of pavement material; ▪ Seepage of Water.	
	Elastomeric Joint	▪ Rubber becoming Scratched/ deteriorated; ▪ Difference in Level (Undulation); ▪ Missing of Bolts; ▪ Loosening of bolts; ▪ Breaking of anchors; ▪ Settlement; ▪ Separation/Cracks in the vicinity of pavement; ▪ Unusual noise during traffic movement.	
Bridge Drainage System		▪ Deposition of wreckages on deck slab, in gutters etc.; ▪ Damages in drains; ▪ Obstruction in free drainage system; ▪ Ponding of water etc.; ▪ Damage of drain pipe; ▪ Disintegration with deck.	 Ponding, deposition of wreckages, disintegration with deck, obstruction in free drainage

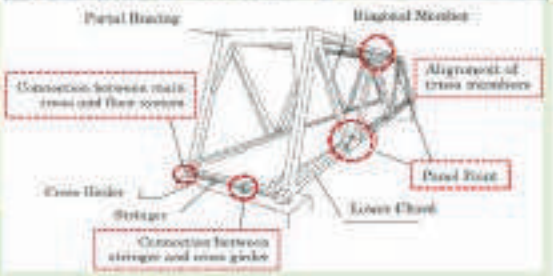
Members/Elements	Purpose/Inspection Points	Photographic Tips
Approaches behind abutment	▪ Settlement of approach pavement; ▪ Difference in level of deck surface/pavement with approach pavement surface; ▪ Roughness of approach pavement surface; ▪ Condition of slopes and shoulders; ▪ Functionality of the drainage system of approach embankment.	 

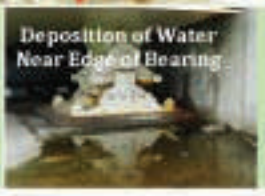
The following table (Table 5.4) illustrates the underneath the Bridge for Superstructure, Deck Slab, Substructure (Abutment, Piers), Bearings, Utilities sequence along with purpose and photographic tips:

Table 5.4: Superstructure, Deck Slab, Substructure (Abutment, Piers), Bearings: Inspection Points and photographic tips

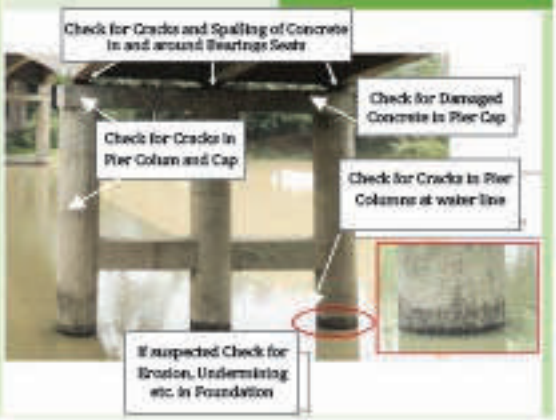
Sequence	Members/ Elements/ Location		Purpose/Inspection Points	Photographic Tips
Superstructure	Concrete Bridges (Main Girder)	End (1st/Last) Support	▪ Vertical and/or Diagonal cracks.	
		Mid Support (Continuous girders)	▪ Cracks and bending.	
		Mid-span	▪ Cracks and bending.	
		Quarter Span	▪ Vertical Cracks/ Damages.	
		Segment/Expansion Joint (if any)	▪ Water Seepage; ▪ Cracks/Spalling of Concrete; ▪ Delamination	
		Construction Joint	▪ Water Seepage; ▪ Cracks; ▪ Spalling of Concrete; ▪ Delamination.	
		Anchorage	▪ Cracks; ▪ Corrosion.	
		Sharply changed Cross-sections	▪ Cracks.	
	Prestressed Concrete	▪ Pre-stressing tendon	▪ Cracks along pre-stressing tendon.	

Sequence	Members/ Elements/ Location	Purpose/Inspection Points	Photographic Tips
	▪ Anchorage (Post-cast Concrete)	▪ Crack; ▪ Efflorescence; and ▪ Corrosion stain.	
	▪ Pre-stressing Steels	▪ Breaking.	
	▪ Construction joints (Cast-in-situ concrete)	▪ Water Seepage ▪ Corrosion stain	
	▪ Camber of the box girders	▪ Loss of positive camber (Indication of loss of Prestress)	
Steel Bridges (Main Girder)	▪ General alignment (Along the members)	▪ Misalignment ▪ Distortion	 
	▪ Upper flange (Along) ▪ Rivet heads, bolts (Around) ▪ Bracing connections ▪ Gusset diaphragm ▪ Pin connections ▪ Cantilever hanger ▪ Possible Water Seeping Contact points of two face-to-face plates ▪ Fitted end of stiffeners	▪ Missing bolts; ▪ Corrosion; ▪ Weakening of protective function.	  
	▪ Under Passage of heavy loads	▪ Abnormal deflection	
	▪ Top side of the bottom flange	▪ Cleanliness; ▪ Deposition of debris	

Sequence		Members/ Elements/ Location	Purpose/Inspection Points	Photographic Tips
		▪ Rusting Members	▪ Amount of Reduction in cross-sectional area	 
		▪ Cracking prone welding ▪ Torsion/moment transmitting Connections ▪ Inward corners ▪ Coped sections ▪ Intersection of horizontal/vertical fillet joints. ▪ Buckled connections ▪ Stiffeners	▪ Weld Expiring ▪ Welding ▪ Cracks (in adjacent metals)	  
	Steel Trusses and Portable Steel Bridge	▪ Truss members	▪ Weakening of protective function ▪ Corrosion ▪ Moisture o On the lower chord members o The member adjacent to the curb o Connections of adjacent faces of plates	
		▪ Truss members Alignment (End posts/interior members)	▪ Damage (Possibly borne from passing vehicles) ▪ Buckling ▪ Torn ▪ Misalignment	
		▪ Over-stressed members	▪ Local buckling ▪ Waves in: o Flanges o Webs o Cover Plates	
		▪ Loose connections	▪ Displaced paint coatings around the joints ▪ Cracks in the paint ▪ Layers of gusset plates and other bolt fixed connections	

Sequence	Members/ Elements/ Location		Purpose/Inspection Points	Photographic Tips
	Deck Slab	▪ Under-side of Deck Slab	▪ Cracks ▪ Corrosion stain ▪ Efflorescence ▪ Water Seepage from upper deck ▪ Difference in level ▪	
Sub-structure	Abutment		▪ Settlement; ▪ Scour or erosion around the abutment; ▪ Sign of any movement; ▪ Sliding, rotation, etc.	
			▪ Signs of possible movement. ▪ Unusual/Inadequate or clearances between connecting point of parapet wall and girder	
			Through joints: ▪ Water seepage; ▪ Cracks; ▪ Efflorescence.	 

Sequence	Members/ Elements/ Location	Purpose/Inspection Points	Photographic Tips
		Behind the abutment: ▪ Deposition of water. Near the edges of bearing seats ▪ Cracks; ▪ Spalling ▪ Deposition of debris and ▪ Deposition of water	
		Vertical wall of Abutment wall: ▪ Vertical Cracks; For Foundations: ▪ Differential Settlement	 
		Around abutments (Instability of river channel): ▪ Tilting or movement due to the ▪ Damage of revetments Between connecting wing walls: ▪ Open cracks;	  
	Piers and Foundations	▪ Settlement; ▪ Tilting; ▪ Erosion; ▪ Scouring; ▪ Undermining of the foundation (as effect of scour) ▪ Breaking into pieces especially: o In the splash zone; o At the water line; o At the ground line	

Sequence	Members/ Elements/ Location	Purpose/Inspection Points	Photographic Tips
			 
		Pier columns, Pier Caps and Bearing seats: ▪ Cracks; ▪ Spalling; ▪ Presence of debris; ▪ Structural damage; ▪ Standing Water; ▪ Unusual movement (in any of the bent members while passing heavy loads)	  

CHAPTER 6
SUMMARY OF DEFECTS AND RATING OF DEFECTS

This chapter will summarize the defects of bridges discussed up to previous chapter. As the ultimate target of this manual is to devise the tools to evaluate the intensity of defects and thereby define and utilize it finalize the rating of defects using RuBIMS. Ultimately these ratings will be determining the type of interventions i.e. No interventions/Minor Maintenance/Major Maintenance/Rehabilitation/Capacity Enhancement/Replacement/New Construction of a bridge.

6.1 Types of Defects

The types of defects (Based on materials/genre) discussed in this manual are summarized in the following table (Table 6.1):

Table 6.1: Summary of the Types of Defects

Genre/Material	Sl. No	Defect
Steel	1)	Corrosion
	2)	Crack in Steel
	3)	Loose or Missing Bolts
	4)	Fracture
	5)	Deterioration of Paint
Concrete	6)	Crack
	7)	Scaling/Spalling / Exposed Rebar
	8)	Water Leakage / Efflorescence
	9)	Fallen out of Deck Slab
	10)	Cracking of Deck Slab
	11)	Delamination
Other Materials	12)	Abnormal Spacing
	13)	Difference in Level
	14)	Abnormal Bituminous Pavement
	15)	Functional Disorder of Bearing
	16)	Other Types of Defects (a. Illegal Occupation, b. Plant Growth, c. Fire Damage, d. Missing of Sealing material, e. Bird's Waste etc.)
Common Defects	17)	Defects of Reinforcing Material for Rehabilitation /Strengthening
	18)	Abnormal Anchorage
	19)	Discoloration / Deterioration of Materials
	20)	Water Leakage / Puddle
	21)	Abnormal Noise / Vibration
	22)	Abnormal Deflection
	23)	Deformation / Break
	24)	Accumulation of Debris
	25)	Settlement / Tilt / Movement
	26)	Scouring

6.2 Types of Defects and Rating as used in RuBIMS

General condition ratings in RuBIMS are assessed for the Deck, Super-structure, Sub-structure, and Culvert. All these items are assessed in RuBIMS based on a range of 1 (Low/None) to 9 (Maximum/Failed) rating system. The reported ratings after analyses in RuBIMS will represent the overall condition of the component/element. Defects have varying impact on ratings depending on the genre/material of the component (For example: Defect of Fracture can't be assessed with "1-9" range; it belongs 2 stages: No Presence of fracture: Rating-1 and Presence of Fracture: Rating-9). Table 6.2 can be used an aid in understanding the RuBIMS condition ratings.

Table 6.2: Generalized RuBIMS Condition Ratings

Rating as Per RuBIMS	Condition Code	Level of Intensity
1	Not Appear	No significant defect
2	Satisfactory	Slight *(not more than 5% of surface area of concerned Member/Element)*
3	Fair	Not Wide *(6%-20% of surface area of concerned Member/Element)*
4	Moderate	Moderately Wide *(21%-35% of surface area of concerned Member/Element)*
5	Poor	Wide *(36%-50% of surface area of concerned Member/Element)*
6	Severe	Severe *(51%-60% of surface area of concerned Member/Element)*
7	Critical	Extensive *(61%-70% of surface area of concerned Member/Element)*
8	Immediate Failure	Almost Failed *(More than 70% of surface area of concerned Member/Element)*
9	Non-Functional	The element is non-functional/failed

6.3 Defect wise Rating Code

Defect wise rating code as defined in this manual are summarized in Table 6.3 as follows:

Table 6.3: Summary of Defects wise Rating Code

Genre/ Material	Sl. No	Defect	Rating Code (1-9)									Remarks
Steel	1)	Corrosion	1	2	3	4	5	6	7	8	9	Standard of rating should be based on Depth & Extent
	2)	Crack in Steel	1	-	3	-	-	-	-	-	9	
	3)	Loose or Missing Bolts	1	-	3	-	-	-	-	8	-	
	4)	Fracture	1	-	-	-	-	-	-	-	9	
	5)	Deterioration of Paint:										General Paint System, Metal Spraying, Weathering of Steel
		5.1 General Paint System	*1*	-	*3*	-	-	*6*	-	-	*9*	
		5.2 Plating, Metal Spraying	*1*	-	*3*	-	-	-	-	-	*9*	
		5.3 Weathering Steel	*1*	*2*	*3*	-	-	-	*7*	-	*9*	
Concrete	6)	Crack	1	2	3	4	5	6	7	8	9	Should be rated as per Crack Width & Crack Spacing
	7)	Scaling/Spalling/Exposed Rebar	1	-	3	-	-	6	-	8	-	
	8)	Water Seepage/ Efflorescence	1	-	3	-	5	-	-	8	-	
	9)	Fallen out of Deck Slab	1	-	-	-	-	-	-	8	-	

Genre/ Material	Sl. No	Defect	Rating Code (1-9)									Remarks
	10)	Cracking of Deck Slab	1	2	3	-	5	-	-	8	-	Should be rated as per Crack Width & Crack Spacing
	11)	Delamination	1	-	-	-	-	-	-	8	-	
Other Materials	12)	Abnormal Spacing in Expansion Joint	1	-	3	-	-	-	-	8	-	
	13)	Difference in Level	1	-	3	-	-	-	-	8	-	Level Difference ≧20mm or not
	14)	Abnormal Bituminous Pavement	1	-	3	-	-	-	-	8	-	
	15)	Functional Disorder of Bearing	1	-	-	-	-	-	-	8	-	
	16)	Other Types of Defects	1	-	-	-	-	-	-	8	-	Missing of Sealing material, Illegal Occupation, Other Damage etc.
Common Defects	17)	Defects of Reinforcing Material for Rehabilitation /Strengthening										Steel Plate, Fiber, Concrete, Paint System, Steel plate for strengthening
		17.1: Steel Plate	1	-	3	-	-	-	-	8	-	
		17.2: Fiber	1	-	3	-	-	-	-	8	-	
		17.3: Concrete	1	-	3	-	-	-	-	8	-	
		17.4: Paint System	1	-	3	-	-	-	-	8	-	
		17.5: Steel plate for strengthening	1	-	3	-	-	-	-	8	-	
	18)	Abnormal Anchorage	1	-	-	-	-	-	-	8	-	Anchorage of PC Tendon
	19)	Discoloration / Deterioration of Materials										Plastics, Concrete, Rubber,
		19.1: Concrete	1	-	-	-	-	-	-	8	-	
		19.2: Rubber	1	-	-	-	-	-	-	8	-	
		19.3: Plastics	1	-	-	-	-	-	-	8	-	
	20)	Water Leakage / Puddle	1	-	-	-	-	-	-	8	-	
	21)	Abnormal Noise / Vibration	1	-	-	-	-	-	-	8	-	
	22)	Abnormal Deflection	1	-	-	-	-	-	-	8	-	
	23)	Deformation/Break of Structural Elements	1	-	3	-	-	-	-	8	-	
	24)	Accumulation of Debris	1	-	-	-	-	-	-	8	-	
	25)	Settlement /Tilt / Movement	1	-	-	-	-	-	-	8	-	
	26)	Scouring	1	-	3	-	-	-	-	8	-	

6.4 Detail Process of Defect Rating of Structural Elements

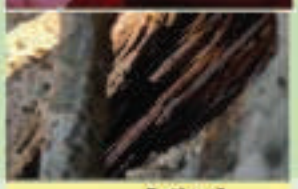
After inspection the defects should be judged and rating should be recorded as per following procedures.

6.4.1 Detail Process of Defect Rating for Steel Elements/Members

The location, situation of "Corrosion", "Crack in Steel", "Loose or Missing Bolts", "Fracture and "Deterioration of Paint" shall be recorded with field sketch, photographs and notes etc. Following table (Table 6.4) presents the defect wise process of rating after inspection for STEEL elements with photographic illustrations:

Table 6.4: Process of Defect Rating for Steel Elements

Rating/Area of Defect/ Detail						Photographic Illustration
	Rating	Extent/Criteria		Detail/Extent of Criteria		
		Depth of Corrosion	Corroded Area	Depth of Corrosion	Corroded Area	
1. Corrosion	1	No Corrosion	No Corrosion	**Large:** Significant plate thickness expansion/ reduction is found; **Medium:** Moderate plate thickness expansion/ reduction is found; **Small:** Corrosion is superficial and no significant plate thickness expansion/reduction is found.	**Large:** Widely spread or multiple corroded places; **Medium:** Moderately spread or some corroded places; **Small:** Not wide but Local	
	2	Very Small	Very Small			
	3	Small	Small			
	4	Small	Large			
	5	Medium	Medium			
	6	Large	Medium			
	7	Large	Large			
	8	Very Large	Very Large			
	9	Failed	Failed			
2. Crack in Steel	1	Excellent condition; No crack in steel				
	3	Crack of coating film at sharply changed section and welded connection is found; Crack is minor and not linear or short length; and Small crack is found;				
	9	Suspected crack *(Possibly coating film)*/Linear crack is found.				

3. Loose or Missing Bolts	1	Excellent condition; No loose or missing bolts	
	3	Loose or Missing Bolts (Number of bolts < 5 %)	Rating 3 
	8	Loose or Missing Bolts (Number of bolts ≧ 5 %)	Rating 8 
4. Fracture	1	No Presence Fracture	Rating 9 
	9	Presence of Fracture	
5. Deterioration of Paint System — Paint System	1	Excellent condition; No deterioration.	Rating 3 
	3	Outer coating of paint is discolored, or partial shedding is found.	
	6	Layers of protective paint are detached and undercoat is exposed.	
	9	Layers of protective paint are widely deteriorated and spot corrosion is spread.	
Plating, Metal Spraying	1	Excellent condition; No deterioration.	Rating 6 
	3	Layer of Protective paint is partially deteriorated and spot corrosion is found.	Rating 7 
	9	Layers of Protective paint are widely deteriorated and spot corrosion is spread.	

	Weathering Steel	1	Excellent condition; No deterioration of surface protecting layer *(Corrosion consists of uniformly distributed and blackish brown-colored fine particles which during formation generally remains yellow, red, or brown)*	Rating 9 
		2	Layer of Surface protecting paint has started to corrode	
		3	Coarse particle of corroded metal expands to a width of 1-5 mm	
		7	Flaking rust of protecting layer of paint expands up to a width of 5-25 mm	
		9	The protecting layers have severely corroded and are delaminated to multiple layers.	

6.4.2 Detail Process of Defect Rating for Concrete Elements/Members

6.4.2.1 Crack

What is a Crack: A crack is a linear fracture in concrete surface that extends partially or completely through the member.

How the Defect should be considered for rating:

- Defect like Spalling or Exposed Rebar should be considered for rating separately;
- The crack at concrete deck slab should be considered for rating as "Crack at Deck Slab" (not as "Crack");
- At PC anchorage, crack should be considered for rating for the affected area only;
- At girders the crack should be considered for rating for the area except PC anchorage area.

6.4.2.2 Scaling/Spalling/Exposing Rebar

What is Spalling/Exposed Rebar: Spalling is a fragment detached from a bigger concrete mass. Exposed Rebar is that the reinforcement steel is exposed in the spalled part of concrete.

How the Defect should be considered for rating:

- When "Deformation/Break" presents with "Scaling/Spalling /Exposed Rebar", defects are considered for rating separately.
- "Scaling/Spalling /Exposed Rebar" in concrete includes corrosion of exposed rebar and fracture. These defects should not be considered for rating as "Corrosion" or "Fracture" in case of concrete.
- "Scaling/Spalling /Exposed Rebar" at concrete deck slab should be considered for rating as "Spalling /Exposed Rebar". However, it may also be considered for rating as "Crack of Deck Slab".

6.4.2.3 Water Seepage/Efflorescence

What is Seepage/Efflorescence: Water Seepage/Efflorescence is the phenomenon of water leakage or efflorescence from the concrete joint or crack.

How the Defect should be considered for rating:

- The deposition of water resulted from seepage due to insufficient drainage system should be considered for rating as "Other Types of Defects". Water flowing on the concrete surface sourced from outside is considered for rating as "Water leakage/Puddle".
- "Water Seepage/ Efflorescence" at concrete deck slab should be considered for rating as "Water leakage/ Efflorescence" in addition to "Crack of Deck Slab".

6.4.2.4 Crack of Deck Slab

What is Crack of Deck Slab: Crack of Deck Slab is the longitudinal/transverse or both directional cracks in concrete deck slab of steel bridges. This also includes cracks in concrete deck slab of T-girder bridge, in (upper surface) inside box girder bridge, in overhanging slab of hollow slab bridge and box girder bridge.

How the Defect should be considered for rating:

- Irrespective of the state of the "crack of deck slab", if "Spalling/Exposed Rebar" is found these should be considered for rating separately.
- Water seepage, efflorescence and rust stain from crack of deck slab are also included in this defect, and like "Spalling/Exposed Rebar", they should be considered for rating as "Water Seepage/ Efflorescence".
- Fallen out of concrete mass due to substantial crack in deck slab should be considered for rating as "Fallen out of deck slab".

6.4.2.5 Delamination

What is Delamination: Delamination the significant separation of a concrete mass but not completely detached from concrete below or above it.

How to Identify: Visibly, it may appear as a solid surface and may not be identified by visual inspection. In such cases it may be identified from hollow sound through beating.

How the Defect should be considered for rating:

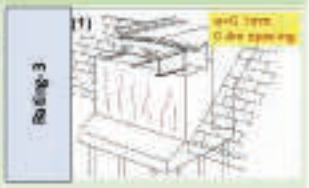
- If through beating or by inspection it is identified that there is spalling of delaminated portion then this should be considered for rating as "Spalling/Exposed rebar".
- Similarly, the delamination in deck slab should be considered for rating as "Delamination".

The location, situation of "Crack", "Spalling /Exposed Rebar", "Water Leakage/ Efflorescence", "Fallen out of Deck Slab", "Cracking of Deck Slab" and "Delamination" shall be considered for rating with field sketch, photographs and notes etc.

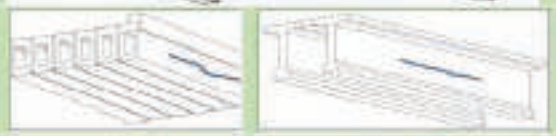
How to Rate the Defect:

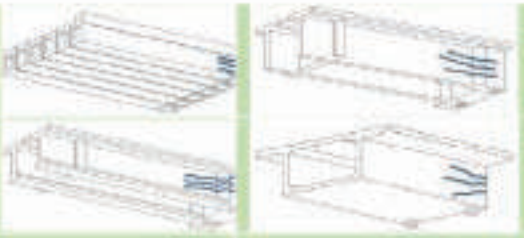
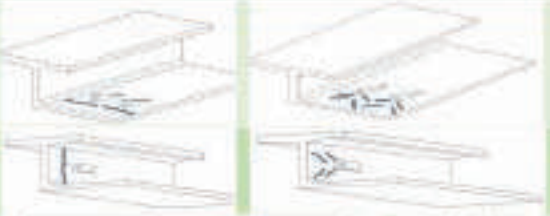
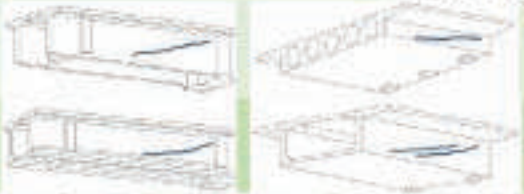
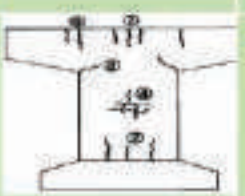
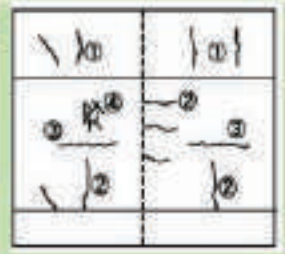
The inspected results for Crack should be rated based on the combination with the extent of "small" or "large" for crack width and that of "mild" and "severe" for crack spacing, related to the extent of the defect. There are various patterns in crack. Following table (Table 6.5) presents the defect wise process of rating including Crack patterns in Super-structure (RCC structure, PC structure) and Sub-structure after inspection for CONCRETE elements with photographic illustrations:

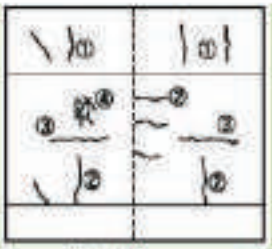
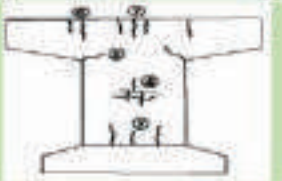
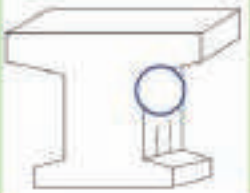
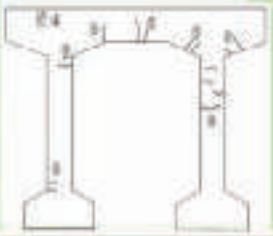
Table 6.5: Process of Defect rating (including Defect Pattern) for Concrete Elements

		Rating/Grade/Extent of Defect/ Detail Criteria						Photographic Illustration
6. Crack	Rating Process	Rating	Grade/Extent/Criteria: Maximum Crack Width	Grade/Extent/Criteria: Minimum Crack Width	Detail/Grade (Crack Width)/Criteria: Maximum Crack Width – RCC Structure	Detail/Grade (Crack Width)/Criteria: Maximum Crack Width – PC Structure	Detail/Grade (Crack Width)/Criteria: Minimum Crack Width – Grade / Crack Spacing	
		1	No Damage	No Damage	**Large:** 0.3 mm or more; **Medium:** 0.3 mm> Width>= 0.2 mm; **Small:** Less than 0.2 mm	**Large:** 0.2 mm or more **Medium:** 0.2 mm> Width>= 0.1 mm **Small:** Less than 0.1 mm	**Severe:** Wide **Mild:** Narrow; **Severe:** 0.5 m or more *(Roughly)* **Mild:** *Less than 0.5 m (Roughly)*	
		2	Small	Small				
		3	*Small*	*Mild*				
		4	*Medium*	*Severe*				
		5	*Large*	*Mild*				
		6	*Large*	*Severe*				
		7	Very Large	Severe				
		8	Very Large	Very Severe				
		9	Failed	Failed				

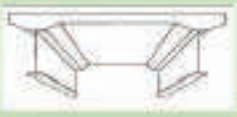
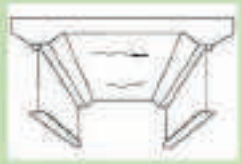
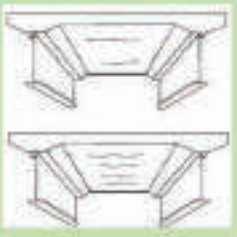
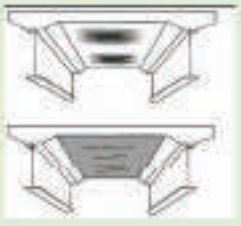
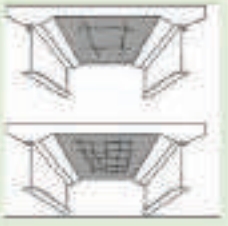
		Sl. No	Location	Pattern of Crack	Sample Photograph
6. Crack	Defect Pattern – Super-Structure (RCC)	1)	Span Center	1) Transverse crack at bottom surface or side of the main girder 2) Longitudinal crack at bottom surface of the main girder	   

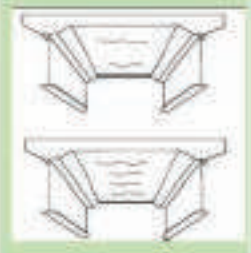
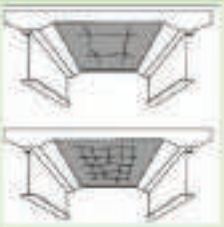
Super-structure (PC)	2)	Quarter Span	3)	Vertical or diagonal crack at lower surface or web surface	
	3)	Support Point	4)	Diagonal crack at web surface near the support point	
			5)	Vertical crack at lower surface or web surface of the girder on the bearing	
			6)	Diagonal crack at web surface of the girder on the bearing	
			7)	Crack at Gerber Type hinge	
			8)	Vertical crack on the mid-support of continuous girder	
	4)	Others	9)	Map crack, web of crack	
			10)	Regularly shaped vertical crack at girder web	
			11)	Horizontal crack near the connection between web and upper flange	
			12)	Crack spread throughout the girder diagonally formed in 45° direction	
	5)	Quarter Span or Support Point	13)	Longitudinal Crack at the lower surface of flange or the surface of web	
			14)	Crack at upper flange	
	6)	Whole Span	15)	Horizontal Crack at girder web in whole girder	
	7)	Cross Girder	16)	Crack at Cross girder	
	1)	Span Center	1)	Crack along with PC tendon at lower flange *(non-uniform cross section)*	
			2)	Crack at upper flange	
	2)	Quarter Span	3)	Crack along with PC tendon near inflection point at mid- support	
			4)	Crack orthogonalized with PC tendon near inflection point at mid-support	

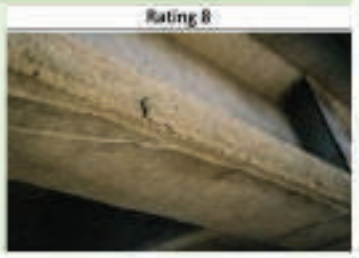
6. Crack		3)	Support Point	5) Horizontal crack at web of main girder	
				6) Crack at cross beam	
		4)	Others	7) Crack near PC anchorage or inflection point of PC tendon	
				8) Crack near the PC tendon concentrated point	
				9) Crack along a covering	
				10) Narrow opening at the connection of cross section segment	
				11) Crack at the sharply changed part of cross-section	
	Sub-structure	1)	Overall abutment	1) Vertical/diagonal crack with regular spacing	 
				2) Vertical/diagonal crack at concrete joint	
				3) Crack in the vicinity of termination point	
				4) Web of crack/Map crack,	
		2)	Lower Part of Bearing	5) Crack in lower part of bearing	
		3)	T-shaped pier	6) Vertical/diagonal crack at concrete joint	
				7) Crack in the vicinity of termination point	
				8) Web of crack/Map crack	

					9) Crack at upper part *(close to the root of overhanging beam)*	
					10) Vertical crack at the center of upper pier 11) Crack at lower part *(close to the root of overhanging beam)*	
					12) Vertical crack in pier side	
				Rigid Frame Pier	13) Map crack, web of crack 14) Crack at upper /lower part and haunch perimeter 15) Crack at circumference of column 16) Crack at circumference of upper column or haunch perimeter 17) Crack at lower part of beam center	

7. Scaling/ Spalling/ Exposed Rebar	1	Rating Criteria	Photograph
	3	No spalling/Exposed rebar but presence of Scaling	
	5	Spalling is present but rebar/corrosion not visible	
	6	Spalling is present and rebar is exposed with minor corrosion	
	8	Spalling is present and rebar is exposed with significant corrosion or fracture	
8. Water Seepage/ Efflorescence	1	No water seepage/efflorescence	
	3	▪ Water seepage is present resulted from concrete crack; ▪ Small amount of rust stain or efflorescence is found.	
	5	▪ Efflorescence resulted from concrete crack is present. ▪ Small amount of rust stain is found.	
	8	▪ Substantial amount of water seepage/efflorescence from concrete crack is found. Or ▪ Substantial amount of ingredients like mud or rust stain in seeped water are found	

9. Fallen out of Deck Slab	1		▪ No fallen out of deck slab				
	8		▪ Fallen out of deck slab is present				
		Crack (one direction)			Crack (Two direction)		
	Rating	Sketch	Crack Characteristics	Water Seepage	Sketch	Crack Characteristics	Water Seepage
10. Crack of Deck Slab	1		No crack	No	Not Applicable	Not Applicable	N/A
	2		▪ One direction ▪ Min^{m} spacing ≧1m ▪ Max^{m} width ≦0.05mm (Hair crack)	No	Not Applicable	Not Applicable	N/A
	3		▪ One direction ▪ Min^{m} spacing *(any)* ▪ Max^{m} width ≦0.1mm	No		▪ Like Mesh ▪ Min^{m} spacing ≧0.5m ▪ Max^{m} width ≦0.1mm	No
10. Crack of Deck Slab	5		▪ One direction ▪ Min^{m} spacing *(any)* Max^{m} width ≦0.2mm	No		▪ Two directions ▪ Min^{m} spacing *(any)* ▪ Max^{m} width ≦0.2mm	No
			▪ One direction ▪ Min^{m} spacing *(any)* ▪ Max^{m} width ≦0.2mm	Yes		▪ Two directions ▪ Min^{m} spacing *(any)* ▪ Max^{m} width ≦0.2mm	Yes

			▪ One direction ▪ Min^{m} spacing *(any)* ▪ Max^{m} width ≧0.2mm ▪ Partial deterioration at corner	No		▪ Two directions ▪ Min^{m} spacing *(any)* ▪ Max^{m} width ≧0.2mm ▪ Partial deterioration at corner	No
	8		▪ One direction ▪ Min^{m} spacing any ▪ Max^{m} width ≧0.2mm ▪ Partial deterioration at corner	Yes		▪ Two directions ▪ Min^{m} spacing *(any)* ▪ Max^{m} width ≧0.2mm ▪ Partial deterioration at corner	Yes

	Rating	Criteria	Photograph
	1	No delamination	
11. Delamination	8	Delamination is present	 

6.4.3 Detail Process of Defect Rating for Other Elements/Members (Other than Concrete or Steel)

6.4.3.1 Abnormal Spacing at Expansion Joint

What is Abnormal Spacing at Expansion Joint: Abnormal spacing is the abnormal widening of the normal spacing between girders or between girder and abutment or where there is no provision for movement.

How to Identify Abnormal Spacing: Abnormal spacing can also be identified by abnormal distortion of bearing or the defects related to expansion joint and parapet.

How the Defect should be considered for Rating:

- If during inspection deformation/break in expansion joint or bearing, or functional disorder in bearing is identified, the defects should be considered for rating accordingly.
- If vertical difference of elevation of pavement of bridge deck at expansion joint is identified then it should be considered for rating as "Difference in level at pavement surface".
- If abnormality at bridge fall prevention device or abnormal movement of bearing and abnormal spacing at the railing or curb is identified then these defects should also be considered for rating as "Abnormal Spacing".

6.4.3.2 Difference in Level

What is Difference in Level: This is longitudinal unevenness or difference of level on road surface that increases due to load impact imposed by passing traffic.

How the Defect should be considered for Rating:

- All the difference in level and unevenness of bridge in longitudinal direction shall be considered for rating as Difference in Level" irrespective of cause and location.
- Unevenness at expansion joint or parapet of abutment, Corrugation, pot hole and cave-in of pavement shall also be considered for rating in this category.
- Transverse Difference in Level (Rutting) shall be considered for rating as "Abnormal Pavement Surface".

6.4.3.3 Abnormal Bituminous Pavement

What is Abnormal Bituminous Pavement: Abnormal bituminous pavement is defined as the delamination or pot-hole of pavement caused by the defects at top of deck slab such as:

- Segregation at top surface of deck slab
- Defects at steel orthotropic steel deck slab such as Cracks at deck plate or connection of bolts.

How the Defect Should be Considered for Rating:

- Target defects to be inspected are pavement crack, delamination and pot-holes.
- These are not applied for the rating of repair/rehabilitation of pavement, but are applied for the rating of the physical condition of concrete deck slab.

- Defects on the top of deck slab affecting the lower part of it corresponding to abnormal pavement (such as crack of deck slab, spalling/exposed rebar and water leakage/efflorescence etc.) should be considered for rating separately.
- The repaired pot-hole should also be considered for rating as "Abnormal Pavement".

6.4.3.4 Functional Disorder of Bearings

What is Functional Disorder of Bearings: This is the loss of functional capability of bearing in supporting the loading and controlling the movement of girder as designed.

This defect includes the defect of fall out of bearing roller, functional disability of restricting the movement of girder and absorption of shock at collapse prevention device of bridge.

The components and elements of bearings are categorized as:

Category-1: Body of bearings, Anchor bolts

Category-2: Bridge fall prevention device

How the Defect Should be Considered for Rating:

- The defects in bearing anchor bolts like corrosion, break and loosened bolts and the defect at bearing seat mortar should be considered for rating separately.
- Deposited debris are basically considered for rating as "Accumulated Debris". If applicable this type of defect should also be considered for rating under this category.

6.4.3.5 Other Types of Defects

What are Other Types of Defects: This type of defects are the defects that are not categorized in the summary of defects (i.e. from 1-15 & 17-26).

"Other Types of Defects" are categorized as follows:

Category	Defects
16.a	Illegal Occupation
16.b	Plant Growth
16.c	Fire Damage
16.d	Missing of Sealing material,
16.e	Bird's Waste
16.f	Scrawl
16.g	Others

How the Defect Should be Considered for Rating: The defects should be considered for rating category wise if identified.

How to Rate the Defect:

The inspected results for Other Materials should be rated based on the identification during inspection as described above. Following table (Table 6.6) presents the defect wise process of rating) for elements other than Concrete and Steel with photographic illustrations:

Table 6.6: Process of Defect Rating for other Elements (Other than Concrete & Steel)

Defect	Rating	Rating Criteria	Sample Photograph
12. Abnormal Spacing at Expansion Joint	1	No abnormal spacing	Rating 8 
	3	Exists abnormal spacing but doesn't include adequate transverse spacing between the teeth of the combs of expansion joint	
	8	Exists abnormal spacing such that: ▪ The teeth of the comb of expansion joint are separated, OR ▪ The contact of both girder and parapet or neighboring two girders is identified; OR ▪ Trace evidence of abnormal spacing is identified.	Rating 8 
13. Difference in Level	1	No difference in level	
	3	Longitudinal difference of level < 20 mm	Rating 3  Level difference < 20mm Rating 3  Level difference < 20mm
	8	Longitudinal difference of level ≧ 20 mm	Rating 8  Level difference ≧ 20mm Rating 8  Level difference ≧ 20mm
14. Abnormal Bituminous Pavement	1	No abnormality in pavement	
	3	Defect is negligible like crack in pavement (W<5 mm)	Rating 3 
	8	▪ Defects are significant like pavement crack (W>5 mm), and ▪ Segregation of aggregates in the concrete at top of deck slab (below the layer).	Rating 3 

14. Abnormal Bituminous Pavement

Defects Pattern
(The corresponding number of defects should be recorded. If multiple patterns are included in same element; all numbers should be recorded).

Pattern	Type of Defect
1	Crack like Cobweb *(Mesh)*
2	Partially depressed crack
3	Longitudinal crack
4	Regularly formed longitudinal partial crack
5	Significant rutting and pot hole (including trace of repair)

Rating 8

Rating 8

15. Functional Disorder of Bearings

Rating	Criteria	Sample Photograph
1	No functional disorder of bearing	Rating 8
8	▪ Functional disorder; OR ▪ Substantially abnormal function of bearing is found	

Defects Pattern
(The corresponding number of defects should be recorded. If multiple patterns are included in same element; all numbers should be recorded).

Pattern	Type of Defect
1	Any deficit at bearing seat mortar or bearing bed concrete
2	Significant corrosion
3	Drop out of bearing roller
4	Damage, breakage or abnormal distortion of elastomeric bearing
5	Loosening or breaking of anchor bolts or set bolts
6	Tilting, abnormal gap, separation of bearing parts
7	Significant accumulation of debris
8	Loss of damping function
9	Other

Rating 8

Rating 8

Rating 8

16. Other Types

Rating	Criteria	Sample Photograph

	1	No defects		
	8	These types of defects are present		

6.4.4 Detail Process of Defect Rating for Common Defect (Other than defects discussed earlier)

6.4.4.1 Defects of Reinforcing Materials for Rehabilitation/Strengthening

What are Defects of Reinforcing Materials for Rehabilitation/Strengthening: These are basically the delamination, deformation, shedding of strengthening materials (like steel plate, carbon fiber sheet, and glass cloth covered the surface of concrete members) and corrosion of steel plate used for strengthening is also included in this category.

Categories of these defects: Defects of Reinforced Materials for rehabilitation/ strengthening are categorized as follows:

Element/Member to be Rehabilitated/Repaired/Strengthened Made of	Category	Material used for Repair/reinforcement
Concrete	1	Steel Plate
	2	Fiber
	3	Concrete
	4	Paint System
Steel	5	Steel Plate (For Strengthening

How the Defects Should be Considered for Rating:

- The defects of the materials for strengthening are the functional deterioration. Therefore, this these defects (which are different from the defects of bridge body) should be considered for rating under this type of defect. For example, if **crack and spalling/exposed rebar** are identified in category 3 (Concrete material), these defects should be considered for rating under the categories concerned.
- In category 4 (Paint system), the defects should be considered for rating as "Functional Deterioration of Paint System" but should be considered for rating as this type of defect.

- In category 5 (Steel plate for strengthening), the defects in additional steel plate for strengthening should be considered for rating as this type of defect not as "Functional Deterioration of Paint System" or "Corrosion". On the other hand, if the defects in bridge structure are occurred, these defects should be considered for rating under the categories concerned.

6.4.4.2 Abnormal Anchorage

What is Abnormal Anchorage: Abnormal anchorage is the **corrosion** of **prestressing tendon** or **concrete crack** at the anchorage area.

Regardless of the material of anchoring structure, all defects of this part related to anchorage structure (such as water proofing cover, block for anchoring, metal device for anchor, buffer material) should be rated as "Abnormal anchorage".

Note: Cables should be treated as **steel material**, and **connection cables between neighboring girders for seismicity** should be treated as **bridge fall prevention apparatus**.

Category/Variety of Abnormal Anchorage: Abnormal anchorage is categorized as follows:

Category	Variety
1	Vertically-fastened Prestressing Tendon type
2	Transversely-fastened Pre-stressing Tendon type
3	Anchorage of other types
4	Anchor/Deviator of out-cable Type

How the defect should be Considered for Rating

If corrosion, spalling /exposed rebar, cracking etc. are found at the anchorage of PC Tendon or anchorage of outer cable, these defects should be rated separately as per their genre summarized above.

6.4.4.3 Discoloration/Deterioration of Materials

What is Discoloration/Deterioration of Materials: "Discoloration/Deterioration of Materials" deals with the changed state of original color or quality of the material like discoloration of concrete, hardened/cracked rubber or embrittlement/cracking of plastics due to aging/extensive/overuse.

Category/Variety of Material: The material of discoloration/deterioration of elements is categorized as follows:

Category	Material
1	Concrete
2	Rubber
3	Plastic
4	Others

How the defect should be Considered for Rating:

- The object of this defect is the material or quality of bridge components, **not covering material for protective function.**

- The deterioration of covering material for protective function of steel member should be **rated as "Deterioration of Paint System"** and for concrete component it should be **rated as "Defects of Reinforcing materials for rehabilitation/ strengthening"**.
- Discoloration of paint or plating of steel members is not applicable for this defect.
- Discoloration of other than original material, such as dirt due to water on the concrete surface, solid deposit on concrete surface or dirt due to exhaust gas or soot, is not applicable.
- Discoloration due to soot-covered concrete caused by fire is not applicable.

6.4.4.4 Water Leakage/Seepage/Puddle (Ponding)

What is Water Leakage/Puddle (Ponding): "Water Leakage/Puddle (Ponding)" applies for defective expansion joint or drainage system where flow of rainwater is restricted by inadequate drainage and deposition of rainwater results inside girders, top surface of beam or bearings. Deposition due to heavy rainfall or other temporary deposition of water doesn't hampering the normal function of bridge shouldn't be considered under this defect.

How the defect should be Considered for Rating:

- Water seeping out from concrete crack through inside concrete should be categorized as "Water leakage/ Efflorescence".
- No Defect of drain pipe should be categorized as "Water Leakage/Puddle", rather should be considered as "Fracture", "Deformation/Break", "Loose or Missing" or "Corrosion".

6.4.4.5 Abnormal Noise/Vibration

What is Abnormal Noise/Vibration: Noise and vibration is the unusual sounds that does not occur under normal conditions in joints/bearings and elsewhere of the bridge.

How the defect should be Considered for Rating:

- Generally, abnormal noise and vibration occurs due to structural deficiency or defects of bridge. Sometimes it happens as a composite action. In such cases these defects (bridge structural deficiency or defects) that results abnormal noise and vibration should be considered as the appropriate category of structural defect.

6.4.4.6 Abnormal Deflection

What is Abnormal Deflection: Abnormal deflection is the vertical bend due to dead load generally identifiable during inspection that does not occur under normal conditions.

How the defect should be Considered for Rating:

- Generally, abnormal deflection results from structural deficiency or defects of bridge. Sometimes it occurs as a composite action. In such cases these defects (bridge structural deficiency or defects) that results abnormal deflection should be considered as per the appropriate category of structural defect that they belong.
- Temporary deflection due to live load should not be classified as abnormal deflection.

6.4.4.7 Deformation/Break of Structural Elements

What is Deformation/Break of Structural Elements: Deformation/Break of Structural Elements is the localized permanent deformation, break or chip of members that generally results from vehicular collision, born defect that occurs during construction or effect of earthquake or similar occurrences.

How the defect should be Considered for Rating:

- When spalling/exposure of rebar is identified in addition to deformation/break in concrete members. In such cases, these defects should be considered as per the appropriate category of structural defect that they belong.
- If crack or break of steel members is identified in addition to permanent deformation, then these defects should be considered as per the appropriate category of structural defect.

6.4.4.8 Accumulation of Debris

What is Accumulation of Debris: Wreckage or Debris generally use to accumulate in drainage basins/ drainpipe and bearing area. It may also be accumulated on pavement surface.

How the defect should be Considered for Rating:

- Deposition of debris or wreckage in and around bearing accelerates material degradation. Sometimes it hides serious defects. Such condition may lead to excessive hindrance against movement resulting spalling in concrete and ultimately local buckling in steel members. In such cases these defects should be considered as per the appropriate category of structural defect.

6.4.4.9 Settlement/Tilt/Movement

What is Settlement/Tilt/Movement: Generally, Foundations or bearings undergo settlement, tilt or movement for various reasons (Discussed earlier in Chapter-5).

How the defect should be Considered for Rating:

- IF abnormal spacing and difference in level at expansion joints and functional disorder of bearings are identified with settlement, tilt or movement in foundation or bearings, these defects should be considered as per the appropriate category of structural defect.

6.4.4.10 Scouring

What is Scouring: Scouring is the condition of removal of earth/protective material from foundation/stream bed/bank due to the erosive action of flowing water or wave action in the stream.

How the defect should be Considered for Rating:

- Scouring of foundations may result in progressive settlement or movement of abutments and piers. If not rectified Such condition may ultimately cause total failure of the bridge. Therefor it should be rated as per intensity.

How to Rate the Defect:

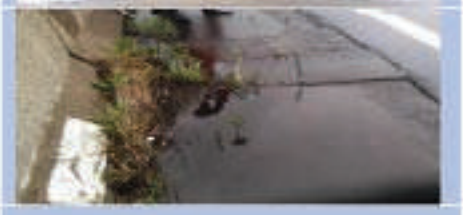
The inspected results for Common Defects should be rated based on the identification during inspection as described above. Following table (Table 6.7) presents the defect wise process of rating for "Common Defects" along with photographic illustrations that doesn't match with the material-based defects:

Table 6.7: Process of Defect Rating for Common Defect (Other than defects discussed earlier)

Defect		Rating	Rating Criteria	Sample Photograph
		1	Found no defect of reinforcing materials	
17. Defects of Reinforcing materials for	17.1 Steel Plate	3	Separation, corrosion or water leakage is present (no gap between strengthening steel plate and bridge body	Rating 3 
		8	If any of the following defects is found: ▪ Gap between strengthening steel plate and bridge body. ▪ Separation of sealed part ▪ Gap at concrete anchor ▪ Significant rust and water leakage ▪ Corrosion at concrete anchorage ▪ Gap in anchorage part.	
	17.2 Fiber	1	Reinforcing fiber bears no defect	

		3	▪ Minor defects like swelling of fiber found ▪ Water seepage/Efflorescence from strengthened concrete found	Rating 3 
		8	▪ Substantial defect or break at reinforcing material found ▪ Considerable water seepage/ efflorescence found	
	17.3 Concrete	1	Reinforcing concrete have no defect	
		3	▪ Water seepage/efflorescence from strengthened concrete member identified ▪ Minor defects in strengthening material identified	Rating 8 
		8	Substantial water seepage/efflorescence from strengthened concrete member identified	
	17.4 Paint System	1	No defect in reinforcing paint system	
		3	Shedding of paint is found	
		8	▪ Shedding of paint system ▪ Rust stain at reinforced material OR ▪ Substantial amount of water seepage/efflorescence identified	
	17.5 Steel Plate for Strengthening System	1	▪ No defect in Steel Plate for strengthening	Rating 8 
		3	▪ Minor defects (like corrosion, a little loosened bolts) are found.	
		8	▪ Substantial defects (heavy corrosion, considerable numbers of loosened bolts, crack) are found.	
18. Abnormal Anchorage		1	No defects	Rating 3 

	3	▪ Non-significant defect of concrete at anchor of PC Tendon is found ▪ Non-significant defect at anchor of cable is found	Rating 3	
	8	▪ Significant defect of concrete at anchor of PC Tendon is found ▪ Significant Defect at anchor of cable is found	Rating 8	
	Pattern	**Type of Defect**		
	1	Cracks		
	2	Seepage/efflorescence of water	Rating 8	
	3	Scaling/Spalling/Exposed rebar		
	4	Delamination		
	5	Corrosion		
	6	Defect of protective pipe		
	7	Detachment of PC tendon		
	8	Other Types of defects		
19. Discoloration/Deterioration of Materials	**Rating**	**Rating Criteria**	**Sample Photograph**	
19.1 Concrete	1	No discoloration or deterioration	Rating 8	
	8	Concrete surface is discolored: ▪ Milky ▪ White or ▪ Yellow		
19.2 Rubber	1	No discoloration or deterioration		
	8	Rubber is: ▪ Hardened OR ▪ cracked	Rating 8	
19.3 Plastics	1	No discoloration or deterioration		
	8	Plastic material: ▪ Embrittled ▪ Cracked		

20. Water Leakage (Seepage)/Puddle	1	No water leakage (Seepage) or puddle	Rating 8 
	8	Water leakage (Seepage) from: ▪ Expansion joint ▪ Connection of drainage system ▪ (Deposition of water (Puddle) around bearings ▪ Deposition of rainwater inside of girders	 Rating 8  
21. Abnormal Noise/Vibration	1	No abnormal noise or vibration	
	8	Abnormal noise or vibration is traced at: ▪ Bridge fall prevention device ▪ Expansion joints ▪ Bearings ▪ Noise barriers ▪ Girders OR ▪ Inspection facilities	Rating 8  Abnormal noise occurred due to the break of the expansion joint face plate  Abnormal vibration occurred at the support of RC T-girder hinge Rating 8  Abnormal noise occurred due to the interference of noise barrier and lighting pole

22. Abnormal Deflection	1	No abnormal deflection	Rating 8 
	8	Abnormal deflection is found at: ▪ Main girders OR ▪ Inspection facilities	Rating 8 
23. Deformation/Break of Structural Elements	1	No deformation or Break	
	3	▪ Partial missing of member OR ▪ Limited deformation/break is found	
	8	▪ Partial and significant missing of member OR ▪ Severe local deformation/break is found	Rating 8  Rating 8  Rating 8  
24 - Ac 3	1	No Accumulation (Deposition) of Debris	

	8	Accumulation (Deposition) of Debris is identified at: ▪ Drainage basins ▪ Drainpipe OR ▪ Around bearing	Rating 8  Rating 8 
25. Settlement/Tilt/Movement	1	No Settlement/Tilt/Movement	
	8	Settlement/Tilt/Movement is identified at: ▪ Support of bearings OR ▪ Foundation	Rating 8   Rating-8 Rating 8   Rating-8
26. Scouring	1	No scouring	
	3	Due to flow of river or water, minor scouring at foundation is identified	Rating 3  Minor scouring of foundation due to river flow

			Rating 3 
	8	Due to flow of river or water, major scouring at foundation is identified	Rating 8  Significant scouring around the substructure Rating 8 

6.5 Detail Process of Defect Rating of Non-Structural Elements

The Rating of the Non-Structural Elements will be complete using a different Rating Scale discussed in this section as follows:

Table-6.8 : List of Non-Structural Elements

Sl. No.	Element
1.	Lighting Facilities
2.	Embankment Slopes of Approach Roads
3.	Longitudinal Slope of Approach Road
4.	Pavement of Approaches
5.	Wearing Course
6.	Expansion Joint Nosing, Sealing
7.	Checker Plates, Nut-Bolts
8.	Wheel guard, Walkway, Median
9.	Rail Bar, Rail Post
10.	Guide Post, Traffic Sign, Electric Post
11.	Protective Works of Abutment/Pier
12.	Surface of Wing Wall and Abutment Wall
13.	Painting of Guide Post, Traffic Sign, Road Marking, Electric Post.
14.	Painting of Railing, Rail Posts, Wheel guard
15.	Painting of Steel Members of Truss & Bailey Bridges
16.	Water Drainage and Waterways of Deck Slab, Top Slab of Box, Verges Ducts & D-spouts
17.	Water Drainage and Waterways of Surface of Abutment, End wall, Intermediate wall & Wing Wall, Weep Holes, Drain Outlet
18.	Water Drainage and Waterways of Water flow of Slab/ Box/ Pipe-Culverts
19.	Water Drainage and Waterways of River/Cannel/Water Ways

20.	Water Drainage and Waterways of River Training Works
21.	Others

6.5.1 Overall Visual Observation on Condition of Non-Structural Elements except Approach Road:

Table: 6.9 Inspection Rating and Detail of Severity of Damage/Defect of Non-Structural Elements (Except Approach Road)

Observed Condition	Inspection Ratings	Descriptions of Condition
The Non-Structural Element is non-exist	NENR	Not Exist & Not Required
The Non-Structural Element is non-exist but required for safety of the Traffic or for proper functioning of the Bridge/Bridge Member	NER	Not Exist but Required
No significant Defects observed	G	Good
The Non-Structure element is in functioning condition	F	Fair
The Non-Structure Element or a significant portion of the element is in poor/critical condition	P	Poor
The Non-Structure Element is almost failed or partially failed	S	Severe
The Non-Structure Element is blocked and non-functioning	B	Blocked

6.5.2 Overall Visual Observation on Condition of Longitudinal Slope of Approach Road

Table 6.10: Inspection Rating and Detail of Severity of Damage/Defect of Approach Road

Observed Condition	Inspection Ratings	Descriptions of Condition
Approach Road is not complete	NER	Not Exist but Required
Flat, Slope is 0%	G	Good
Slope is less than 3%	F	Fair
Slope is more than 3% but less than 5%.	P	Poor
Slope is more than 5%	S	Severe
Approach Road is partially Blocked	B	Blocked

CHAPTER 7: ANALYSIS, EVALUATION AND REQUIRED INTERVENTIONS

7.1 Analysis and Evaluation of Bridge Inspection Data

As part of the Bridge Asset Management the primary objective of bridge inspection is to find out the physical condition of the bridge and to detect any defects of the bridges at early stage that may affect safety of the users and bridge structures and to make the traffic flow smooth and comfortable. Another objective is to monitor development of the defects on the bridge continuously so that timely remedial measures can be taken to prolong the life of the bridge. In addition, the results collected from the inspection can be used to develop inspection and maintenance program, to carry out load capacity assessment, and to provide feedback to the design process. In order to achieve these objectives, we must evaluate the structure condition data collected during the inspection of the structure elements, components and the entire bridge properly. To make the overall Bridge Asset Management effective and efficient this evaluation must be completed using modern computer-based programing/software. LGED will be using RuBIMS software for these evaluations.

7.1.1 Types of Elements for Analysis and Evaluation

The elements of Bridge are classified into Structural Element and Non-structural Element based on the importance i.e., structural Safety/Functionality. For the purpose of evaluation, the Structural Elements (SE) are emphasized more as those affect the Safety/Functionality. Non-structural Elements (NSE) have insignificant level of effect to the structural safety of a Bridge.

Not only that, all the elements don't play same/similar role to perfectly deliver the expected functionality of the bridge. Therefore, it is mandatory to consider the importance of each element considered for inspection under this Guideline and RuBIMS as well. Following tables ***(Table-7.1)*** represents the list of Structural Elements with **Importance Coefficient (IC)** and ***Table-7.2*** represents the list of Non-structural Elements.

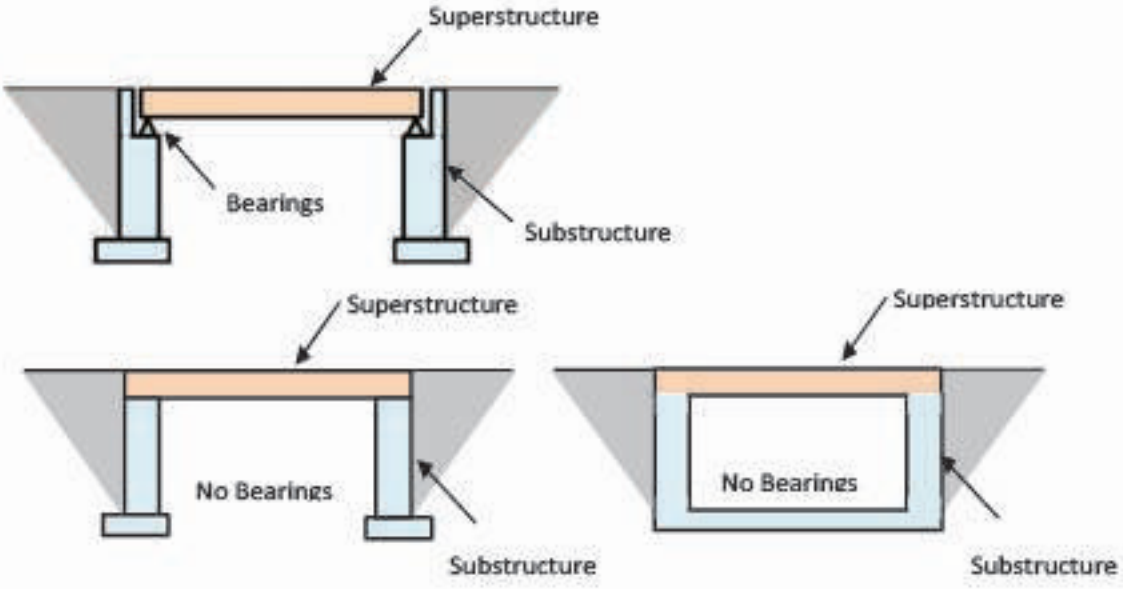


Figure 7.1: Major Components of Bridges

Table-7.1: List of Structural Elements and their Importance Coefficient

Component		Element	Importance Coefficient (IC)*
Type	**Material Type**		
Super Structure	RCC/PC Bridge	Deck Slab	0.80
		Main Girder/Beam	1.00
		Cross Girder/Beam	0.25
		Box Girder	1.00
		Arch	1.00
		Hanger of Arch	0.80
	Steel Truss/Baily	Stringer	0.25
		Floor Beam	0.25
		Checker Plates (Deck)	0.25
		Bottom Bracing	0.50
		Bottom Chord	0.50
		Connector	0.25
		Vertical Panel	0.25
		Vertical Post	0.25
		Diagonal	0.50
		Top Bracing	0.50
		Strut	0.50
		Top Chord	0.50
Bearing Assembly	Steel Truss/ RCC/PC Bridge	Hinge	0.5
		Main Body of Bearing	0.50
		Anchor Bolt	0.5
		Seat Morter	0.5
Sub-Structure	Steel Truss/ RCC/PC Bridge	Abutment/End wall/Back Wall/Retaining Wall	0.80

Component		Element	Importance Coefficient (IC)*
Type	Material Type		
		Wing Wall	0.67
		Top Slab of Box Culvert	1.00
		Bottom Slab of Box Culvert	1.00
		Abutment Base/ Base Slab	1.00
		Pier Cap	1.00
		Pier/Intermediate Wall	1.00
		Bracing of Pier	0.80
		Pile Cap/Footing	1.00
		Exposed Pile (if any)	1.00
		Projected Pile	1.00

**Adapted from provisions of Local Government of Japan with few modifications*

Table-7.2: List of Non-structural Elements

Sl. No.	Element
1.	Lighting Facilities
2.	Embankment Slopes of Approach Roads
3.	Longitudinal Slope of Approach Road
4.	Pavement of Approaches
5.	Wearing Course
6.	Expansion Joint Nosing, Sealing
7.	Checker Plates, Nut-Bolts
8.	Wheel guard, Walkway, Median
9.	Rail Bar, Rail Post
10.	Guide Post, Traffic Sign, Electric Post
11.	Protective Works of Abutment/Pier
12.	Surface of Wing Wall and Abutment Wall
13.	Painting of Guide Post, Traffic Sign, Road Marking, Electric Post.
14.	Painting of Railing, Rail Posts, Wheel guard
15.	Painting of Steel Members of Truss & Bailey Bridges
16.	Water Drainage and Waterways of Deck Slab, Top Slab of Box, Verges Ducts & D-spouts
17.	Water Drainage and Waterways of Surface of Abutment, End wall, Intermediate wall & Wing Wall, Weep Holes, Drain Outlet
18.	Water Drainage and Waterways of Water flow of Slab/ Box/ Pipe-Culverts
19.	Water Drainage and Waterways of River/Cannel/Water Ways
20.	Water Drainage and Waterways of River Training Works
21.	Others

7.1.2 Weight Coefficient of Defects:

The identified defects also impact differently on elements to elements and affect the structural functionality or on its performance. So, for proper analysis and evaluation of the Components and the Structure in calculating its their Damage Degree following Importance Coefficients are assigned based on these defects' location:

Table 7.3a: Defects and related Weight coefficient of Super-Structure Elements

Material	Element	Type of defects	Importance coefficient
Super-structure			
Steel	Deck	1. Corrosion	0.50
		2. Crack in Steel	1.00
		3. Loose or Missing Bolts	0.17
		4. Fracture	1.00
		5. Deterioration of Paint	0.17
		16. Other Types (a. Illegal Occupation/ b. Plant Growth /c. Fire Damage	0.45
		21. Abnormal Noise / Vibration	0.17
		23. Deformation / Break	0.17
	Main Girder/Girder Elements	1. Corrosion	0.60
		2. Crack in Steel	1.00
		3. Loose or Missing Bolts	0.20
		4. Fracture	1.00
		5. Deterioration of Paint	0.20
		12. Abnormal Spacing	0.20
		16. Other Types (a. Illegal Occupation/ b. Plant Growth /c. Fire Damage	0.45
		21. Abnormal Noise / Vibration	0.20
		22. Abnormal Deflection	0.20
		23. Deformation / Break	0.20
	Cross Beam	1. Corrosion	0.33
		2. Crack in Steel	1.00
		3. Loose or Missing Bolts	0.17
		4. Fracture	1.00
		5. Deterioration of Paint	0.17
		21. Abnormal Noise / Vibration	0.33
		23. Deformation / Break	0.17
Concrete	Deck	7. Scaling/Spalling / Exposed rebar	1.0
		8. Water leakage /Efflorescence	0.10
		9. Fallen out of Deck Slab	1.00

	Main Girder/Box Girder/Arch/Hanger of Arch	17. Defects of Reinforcing Material for Rehabilitation / Strengthening	0.25
		10. Crack of Deck Slab	0.75
		11. Delamination	0.03
		16. Other Types (a. Illegal Occupation/ b. Plant Growth /c. Fire Damage	0.45
		18. Abnormal Anchorage	0.25
		19. Discoloration / Deterioration of Material	0.03
		6. Crack	0.33
		7. Scaling/Spalling / Exposed rebar	0.80
		8. Water leakage /Efflorescence	0.17
		16. Other Types (a. Illegal Occupation/ b. Plant Growth /c. Fire Damage	0.45
		17. Defects of Reinforcing Material for Rehabilitation / Strengthening	0.30
		11. Delamination	0.17
		12. Abnormal Spacing	0.17
		18. Abnormal Anchorage	0.67
		19. Discoloration / Deterioration of Material	0.03
		21. Abnormal Noise / Vibration	0.50
		22. Abnormal Deflection	0.30
		23. Deformation / Break	0.03
		6. Crack	0.40
		7. Scaling/Spalling / Exposed rebar	0.60
		8. Water leakage /Efflorescence	0.40
		17. Defects of Reinforcing Material for Rehabilitation / Strengthening	0.40
	Cross Girder	11. Delamination	0.20
		18. Abnormal Anchorage	0.80
		19. Discoloration / Deterioration of Material	0.05
		21. Abnormal Noise / Vibration	1.00
		23. Deformation / Break	0.05

Table7.3b: Defects and related Weight coefficient of Sub-Structure Elements

Materials	Element	Type of defects	Importance coefficient
Substructure including Bearing Assembles			
Rubber	Bearing Pad	15. Functional Disorder of Bearings	1.0
		20. Water Leakage / Puddle	0.25
		23. Deformation / Break	0.13

		24. Accumulation of Debris	0.13
		25. Settlement / Tilt / Movement	0.88
Concrete	Bearing Seat/Bed	6. Crack	0.14
		11. Delamination	0.29
		23. Deformation / Break	1.00
Steel	Bearing Plate	1. Corrosion	0.25
		2. Crack in Steel	1.00
		3. Loose or Missing Bolts	0.50
		4. Fracture	1.00
		5. Deterioration of Paint	0.25
		15. Functional Disorder of Bearings	0.75
		20. Water Leakage / Puddle	0.25
		23. Deformation / Break of Structure	0.25
		24. Accumulation of Debris	0.25
		25. Settlement / Tilt / Movement	0.50
Steel	Abutment / Pier	1. Corrosion	0.60
		2. Crack in Steel	1.00
		3. Loose or Missing Bolts	0.20
		4. Fracture	1.00
		5. Deterioration of Paint	0.20
		20. Water Leakage / Puddle	0.20
		21. Abnormal Noise / Vibration	0.20
		23. Deformation / Break	0.20
Concrete	Abutment / Pier	6. Crack	0.43
		7. Scaling/Spalling / Exposed rebar	0.57
		8. Water leakage /Effloresence	0.29
		16. Other Types (a. Illegal Occupation/ b. Plant Growth /c. Fire Damage	0.45
		17. Defects of Reinforcing Material for Rehabilitation / Strengthening	0.57
		11. Delamination	0.14
		19. Discoloration / Deterioration of Material	0.14
		20. Water Leakage / Puddle	0.14
		23. Deformation / Break of Structure Element	0.14

	Foundation	16. Other Types (a. Illegal Occupation/ b. Plant Growth /c. Fire Damage	0.45
		25. Settlement / Tilt / Movement	0.25
		26. Scouring	1.00

7.2 Condition Classification of Bridge Elements by the Severity of Defects

7.2.1 Structural Elements

The severity of defect/damage of Structural Elements (SE) of a bridge may vary. Accordingly, the necessity of intervention for elements under consideration will also vary. Under this situation, two phenomena can happen:

i. Any specific member/element may have more than one defect with varying level of severity;

ii. Among the elements of any specific member/element within a span unit, one specific element may have higher/highest level of severity.

Specific member/element with high severity shall need sound evaluation of the bridge members to determine the necessity for appropriate intervention (Minor maintenance/ Major Maintenance/Rehabilitation or Replacement). Specific determination method is divided from the 9 (nine) Inspection Rating categories after comprehensive evaluation of Structural Importance or progress level of damage of the member concerned. Following table (Table-7.4) represents the inspection rating details.

Table: 7.4 Inspection Rating and Detail of Severity of Damage/Defect

Inspection Rating	Visual Status of Defect/Damage	Description of Severity of Defect/Damage
1	Not Appear	Nonsignificant Defects
2	Satisfactory	Slight *(not more than 5% of surface area of concerned Member/Element)*
3	Fair	Not Wide *(6%-20% of surface area of concerned Member/ Element)*
4	Moderate	Moderately Wide *(21%-35% of surface area of concerned Member/Element)*
5	Poor	Wide *(36%-50% of surface area of concerned Member/ Element)*
6	Severe	Severe *(51%-60% of surface area of concerned Member/Element)*
7	Critical	Extensive *(61%-70% of surface area of concerned Member/Element),*
8	Immediate Failure	Almost Failed *(More than 70% of surface area of concerned Member/Element)*

9	Non-Functional	The element is non-functional/failed

The classification of the necessity for intervention of structural Members shall be carried out by the 4 (Four) Condition State of Evaluation Category (CS1-CS4) discussed in the following Section.

(1) Damage Degree and Condition State of bridge Sub-structure and Super-Structure types

Soundness evaluation of the bridge members determines the necessity for identifying the maintenance (Minor Maintenance, Major Maintenance, Rehabilitation, Replacement or emergency response) need to any member by analysing and evaluating each damage type found on the member during the inspection. The classification of the maintenance necessity is carried out by Evaluating the Bridge Sub-structure, Super-structure into 4 Category (CS1-CS4) using the Inspection Rating (1 to 9) shown below in Table 7.5. A separate evaluation process will be used for the Non-Structural Elements. Specific determination of these four categories will be completed using a comprehensive analysis and evaluation of structural importance and damage progress level of the damaged member (defects associated with the structural elements as per Table 7.3a and Table 7.3b) following the step by step described in the following sections:

Table 7.5 Inspection Rating and corresponding given Damage Degree (DD) of bridge elements (Sub-Structure and Super-Structure)

Inspection Rating	Corresponding Damage Degree	Band of Damage Degree *)	Condition State (CS) Band	Expected Intervention
1	0	0 ~ 20	CS1	Minor Maintenance/No Maintenance
2	20			
3	30	21 ~ 59	CS2	Major Maintenance
4	40			
5	59			
6	70	60 ~ 79	CS3	Rehabilitation
7	79			
8	90	80 ~ 100	CS4	Replacement/Emergency Repair
9	100			

Reference: *) Adopted by the local government of Japan with few modifications

7.2.2 Non- Structural Elements

As discussed in the Inspection Chapter 6 (Section 6.5) Non-Structure Elements are rated using a different rating scale as follows:

Table: 7.6 Inspection Rating and Detail of Severity of Damage/Defect of Non-Structural Elements

Inspection Ratings	Descriptions of Condition
NENR	Not Exist & Not Required
NER	Not Exist but Required

G	Good
F	Fair
P	Poor
S	Severe
B	Blocked

(1) Damage Degree and Condition State of bridge Non-structure Elements

The Analysis and Evaluation of the No-Structural Elements will also be completed differently than the Structural Elements. The Non-Structural Elements Ratings will be assigned a Damaged Degree directly as follows:

Table 7.7 Inspection Rating and corresponding given Damage Degree (DD) of bridge elements (Non-Structure Elements)

Descriptions of Condition	Inspection Ratings	Assigned Damaged Degree	Condition State (CS) Band	Expected Maintenance Intervention
Not Exist & Not Required	NENR	0	-	No Maintenance is Required
Not Exist but Required	NER	20	CS1	Minor Maintenance is Required
Good	G	0	CS1	No Maintenance is Required
Fair	F	10	CS1	No Maintenance is Required
Poor	P	15	CS1	Minor Maintenance is Required
Severe	S	20	CS1	
Blocked	B	20	CS1	

Based on these assigned Element Damaged Degree of the Non-Structural Elements a Condition State (CS) will be assigned as per Table No. 7.7

The basic idea of classifying each condition category is as per following table:

Table 7.8 Condition Categories and their description

Condition State (CS)	Description of Condition State	Expected Intervention
CS1	The damages were not recognized in the Structural components during the visual inspection, but defects were identified at the Non-Structural Elements. As a result, no repair work may be required for	Minor Maintenance/No Maintenance

	the structural elements, but Non-Structural Elements required some maintenance work.	
CS2	The damages require repair work though it is not emergency like immediate repair, even if left as it is, the safety of structure will not significantly impaired until the next periodic inspection (= within 5 years). However, from the point of view of preventive maintenance, it is desirable to do "Major Maintenance" in that part of the bridge.	Major Maintenance
CS3	It can be determined that it is necessary to do early repair (= approximately within 2 years), due to the significant progress of the damage, function and safety factor of the part and the member decreases remarkably.	Rehabilitation
CS4	Structural safety of the bridge has been significantly impaired, and it is necessary to take urgent preventive measures, to avoid severe damages such as bridge collapse or high risk of user safety.	Replacement/Emergency Repair

7.3 Analysis and Evaluation method of bridge element types

In the soundness evaluation of the bridge element, judgment of condition category is carried out by span unit to each defect type (Table 7.3a and Table 7.3b) in the structural element types (Table 7.1) (Figure 7.1). If there are more than one kind of damage types on the same structural element then the calculated Damage Degree (DD) for that element is the sum of the DD for all damages of that element. And if there are more than one element of same types, then the determination of the DD for that element type is carried out considering the highest calculated damage degree of that element type.

7.3.1 Procedure of Calculating Damage Degree for Structural Elements

Bridge Damage Degree is the barometer of structural risk of the bridge, calculated as follows. New bridge has 0 damage degree, and each time, if any defect occurs in any of the element, damage degree will increase

During analysis and evaluation of the bridge elements, RuBIMS will consider:

1. Governing Damage Degree and corresponding Condition State (CS) will be carried out by Sub-Structure, Super-Structure and Non-Structure Unit;
2. The Impotence Co-efficient (IC) of each Element will be taken into account;
3. The Defect Weightage (DW) of each defect of Element will be taken into account;
4. The Inspection Rating will be converted to corresponding given Damage Degree (DD) as per Table 7.5;
5. The span consideration for the purpose of inspection and data collection should be considered as follows (Fig-7.1):

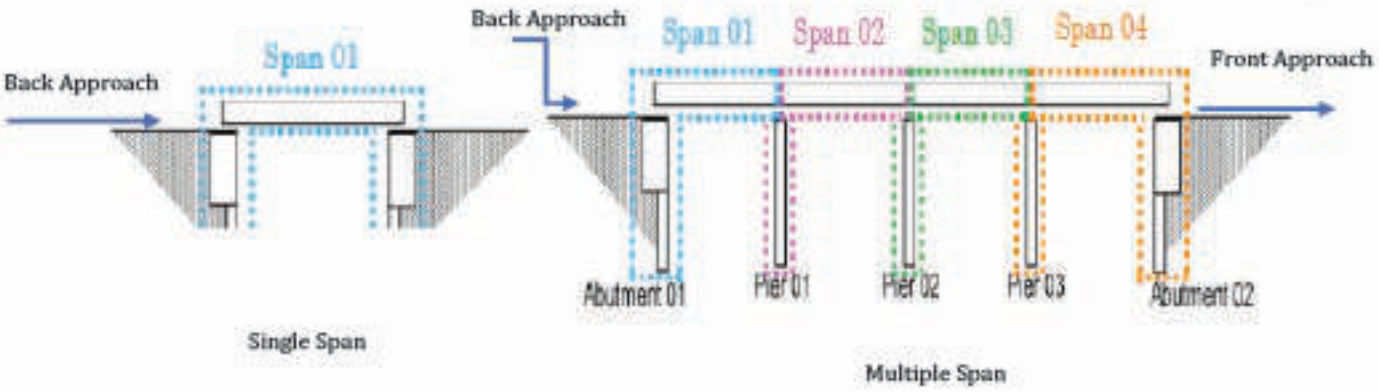


Fig-7.2

6. If more than one kind of damage/defect exist on any structural element, the determination of the DD and CS will be carried out by adding the calculated DD for each defect types for the same Element.
7. The Governing DD of Sub-Structure or Sper-Structure will be determined considering the most severe DD from all the Elements of the Sub-Structure and Super-Structure respectively.

Above all 26 types of damages/defects are considered in this Guidelines for inspection and Evaluation purposes. Possible defects/damages (out of these 26 damage/defect types) associated with structural elements are presented in Table-7.3a and 7.3b as above.

Calculation of Damage Degree: Damage Degree is calculated for each element of Sub-Structure and Super-Structure separately.

Step 1: The Damage Degree of each element for each defect is calculated with Inspected Rating corresponding Damage Degree from Table 7.5, "Element Importance Coefficient" from Table 7.1, "Importance coefficient of the defect" from Table 7.3a or 7.3b as follows:

Element defect Damage Degree = Rating Related DD (Table 7.5) X Element Importance Coefficient" (Table 7.1) X Importance coefficient of the defect (Table 7.3a or 7.3b)

Step 2: Element Total DD is the Sum of all calculated DD for different defects for the same element

Step 3: The governing DD for the element is the highest total DD for that element types

Step 4: Governing DD of Sub-Structure is the highest value of DD calculated for all Sub-Structure elements.

Similarly, Governing DD of Super-Structure is the highest value of DD calculated for all Super-Structure elements

From these calculations we will obtain the overall DD value and corresponding Condition State CS of Sub-Structure and Super-Structure.

7.3.2 Calculation of Damage Degree and CS of the Non-Structure Elements

The determination of Damage Degree and Corresponding Condition State will be completed directly from the Inspection Rating for the Non-Structural Elements from Table 7.7 It is evident

that the Maximum Damage Degree for Non-Structural Element will be 20 and corresponding CS will be CS1.

7.4 Analysis and Evaluation of the Entire Bridges

Soundness analysis of the inspect data and evaluation of the whole bridge is carried out in order to understand the overall Damage Degree and Condition State (CS) of the whole bridge which is used for determination of Maintenance category. A total Bridge Damage Degree (0~100) for the entire bridge is considered and the overall DD of the entire bridge is the governing calculated DD from Sub-Structure, Super-Structure and Non-Structure. This Damage Degree (DD) score will be used to formulate the priority order of candidate element for Minor Maintenance/Major Maintenance/Rehabilitation/Replacement and it will be calculated automatically by the RuBIMS.

7.5 Special Category Bridges: The following categories of bridges were built following a sub-standard specification which is not meeting the current geometrical, loading and other requirements:

- Light Traffic Bridge
- Wooden Bridge
- Iron Bridge
- Brick Masonry Bridge

LGED decided to replace these bridges gradually. As a result, the above bridges don't require a detailed Condition Inspection. However, these bridge needs to be considered into the prioritization process. So, to participate with the prioritization process these bridges need to have governing Damage Degree (DD). Based on the condition and other requirement following DD has been assigned to the bridges as follows:

Bridge Type	Assigned Damaged Degree (DD)
Light Traffic Bridge	95
Wooden Bridge	100
Iron Bridge	85
Brick Masonry Bridge	90

Note: DD Score 80-100 Eligible for Replacement

7.6 Determination of Final Intervention of the Bridge:

As Discussed in the above sections RuBIMS will calculate the DD and corresponding CS of the Sub-Structure, Super-Structure and Non-Structure Elements of each inspected bridge. Finally, RuBIMS will determine the overall Condition State and the Required Maintenance Interventions using the following Operational Strategic Flowchart:

LGED Operational Strategy Flowchart:

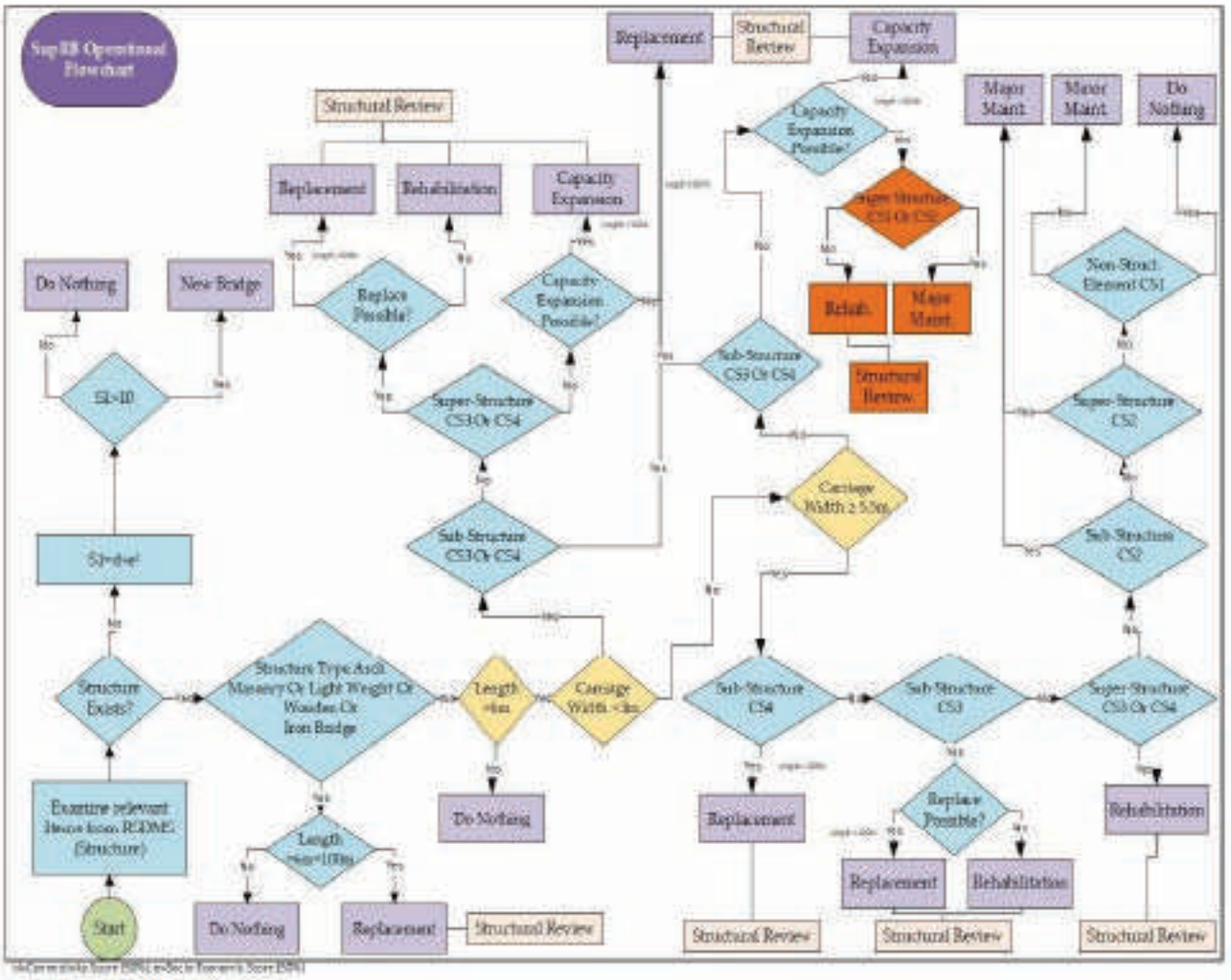


Figure 7.3. LGED Operational Strategy Flowchart

Source: Program for Supporting Rural Bridges (SupRB) Program Operational Manual (POM) Version 2, July 21, 2020

Firstly, the relevant items from RSDMS (structure) are examined. There can be two possible outcomes:

(i) The structure does NOT exist: S1 is calculated as the summation of d and e1. If the S1 is more than 10, then a new bridge is to be constructed; otherwise, there is nothing to do.

(ii) The structure exists: the structure type is checked to be arch masonry or light weight or wooden or iron bridge:

a. Obtaining positive result, if the length is less than 6m as well as 100m, there will be replacement with structural review; otherwise, there is nothing to do.

b. With a negative result, if the length is greater than 6m, there is nothing to do; otherwise, if check the carriage width:

i. If the carriage width is less than 3m, the sub-structure is examined. If t is CS3 or CS4, there will be replacement with structural review; otherwise, the super-structure is checked:

1. If it is CS3 or CS4, there will be replacement with structural review, if possible, otherwise there will be rehabilitation with structural review.

2. If it is NOT CS3 or CS4, there will be capacity expansion with structural review, if possible, otherwise there will be replacement with structural review.

ii. If the carriage width is less than or equal to 5.5 m, the sub-structure is examined. If sub-structure is CS3 or CS4, there will be replacement with structural review, otherwise:

1. If possible, there will be capacity expansion with structural review.

2. If capacity expansion is NOT possible, the super-structure is checked:

a. If the super-structure is CS1 or CS2, there will be rehabilitation with structural review.

b. If the super-structure is NOT CS1 or CS2, there will be major maintenance.

iii. If the carriage width is greater than 5.5 m, the sub-structure is examined. If sub-structure is CS4, there will be replacement with structural review; otherwise:

1. If the substructure CS3, there will be replacement with structural review, if possible, otherwise there will be rehabilitation with structural review.

2. If the sub-structure is NOT CS3, the super-structure is examined. If the super-structure is CS3 or CS4, there will be rehabilitation with structural review. Otherwise:

a. If the sub structure is CS2, there will be major maintenance.

b. If the sub structure is NOT CS2 and the super-structure is CS2, there will be major maintenance.

c. If the sub-structure and super-structure both are NOT CS2 and the non-structural element is CS1, there will be minor maintenance, otherwise, there is nothing to do.

Table 7.9 Final Intervention Categories

Condition State (CS)	Description of Condition State	Expected Intervention
CS1	As discussed in Table 7.8	Minor Maintenance/No Maintenance
CS2	As discussed in Table 7.8	Major Maintenance
CS3	As discussed in Table 7.8	Rehabilitation
CS1, CS2 (Sub and Super-Structure)	If the existing structure is in Good (CS1) to Fair (CS2) and carriage width >3.0 meter but <5.5 meters. Capacity expansion by expanding the width of the bridge or including additional new bridge construction parallel to existing structure and Rehabilitation of the existing Bridge	Capacity Expansion
CS1, CS2 (Sub-Structure and CS3, CS4 Super-Structure)	If the sub-structure is in Good (CS1) to Fair (CS2) and super-structure is CS3 or CS4 and carriage width > 3.0 meter but <5.5 meters. Capacity expansion by expanding the width of the bridge or including additional new bridge construction parallel to existing structure and Rehabilitation of the existing Bridge	Capacity Expansion
CS4	As discussed in Table 7.8	Replacement/Emergency Repair

7.7 Illustration of Analysis and Evaluation of a Sample Bridge

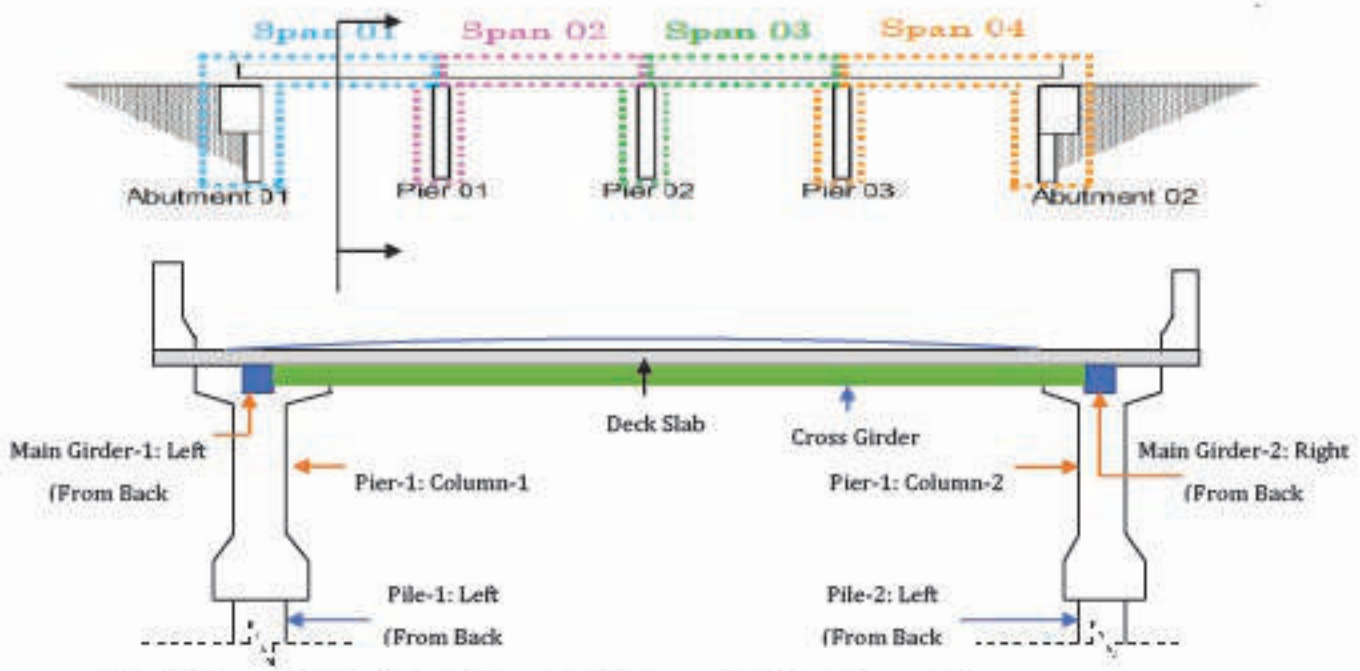


Fig. 7.4 Cross Section (Span-1: From Back Approach to Front Approach)

Bridge under consideration: Multiple Span (4 Span) Bridge

Table 7.8: Bridge Damage Inspection Ratings (extracted from the Inspection Form)

Main Component	Elements	Element No.	Defect	Defect Rating
Super Structure	Main Girder	1	6. Crack	5
			7. Scaling/Spalling / Exposed rebar	6
			22. Abnormal Deflection	3
		2	6. Crack	4
			7. Scaling/Spalling / Exposed rebar	5
			22. Abnormal Deflection	5
	Cross Girder	1	6. Crack	4
			7. Scaling/Spalling / Exposed rebar	5
			23. Deformation / Break	7
	Deck Slab	1	7. Scaling/Spalling / Exposed rebar	4
			9. Fallen out of Deck Slab	5
			10. Crack of Deck Slab	7

Main Component	Elements	Element No.	Defect	Defect Rating
		2	7. Scaling/Spalling / Exposed rebar	4
			9. Fallen out of Deck Slab	6
			10. Crack of Deck Slab	4
Sub-Structure	Abutment	1	6. Crack	3
			11. Delamination	3
		2	6. Crack	4
			11. Delamination	5
	Pier	1	7. Scaling/Spalling / Exposed rebar	2
			6. Crack	2
		2	7. Scaling/Spalling / Exposed rebar	3
			6. Crack	3
	Pier Cap	1	6. Crack	1
			7. Scaling/Spalling / Exposed rebar	1
			8. Water leakage /Efflorescence	2
	Pile Cap	1	26. Scouring	1
			25. Settlement / Tilt / Movement	4
		2	26. Scouring	1
			25. Settlement / Tilt / Movement	3
	Bearings	1	15. Functional Disorder of Bearings	5
		2	15. Functional Disorder of Bearings	5
		3	15. Functional Disorder of Bearings	8

DD and CS of Super-Structure and Sub-Structure:

Step 1: The Damage Degree of each element for each defect is calculated with Inspected Rating corresponding Damage Degree from Table 7.5, "Element Importance Coefficient" from Table 7.1, "Importance coefficient of the defect" from Table 7.3a or 7.3b as follows:

The Calculated DD

Element defect Damage Degree = Rating Related DD (Table 7.5) X Element Importance Coefficient" (Table 7.1) X Importance coefficient of the defect (Table 7.3a or 7.3b)

From the above Table for Main Girder the inspected defects and calculated DD are Crack is 19.47, Scaling /Spalling / Exposed rebar is 46.90 and Abnormal Deflection is 9.00,

Step 2: Element Total DD is the Sum of all DD for different defects for the same element

So, the total calculated DD for Main Girder is (19.47+46.90+9.00) 75.37.

Similarly, the total calculated DD for Main Girder of Span 2 is 70.43

Step 3: The governing DD for the element is the highest total DD for that element types

Hence, the governing DD of Main Girder element (highest value among 75.37 and 70.43) is 75.37.

Step 4: Governing DD of Super-Structure is the highest value of DD calculated for all Super-Structure elements.

From the above Table the total calculated DD for Main Girder is 75.37, Cross Girder is 13.84 and for Deck Slab is 97.80.

So, the governing DD of Super-Structure (the highest value of super-structure elements) is 97.80

Similarly, Governing DD of Sub-Structure is the highest value of DD calculated for all Sub-Structure elements, which is 60.75

DD and CS of Non-Structure:

The Maximum Damage Degree for Non-Structural Element will be 20 and corresponding CS will be CS1

DD and CS of the Overall Bridge

From these calculations we can see the overall DD value and corresponding Condition State CS of Sub-Structure, Super-Structure and Non-Structure as follows:

The DD of Super-Structure is 97.80 (CS4), DD of Sub-Structure is 60.75 (CS2) and DD of Non-Structure is 20 (CS1). The Super-Structure DD is governing (> than Sub-Structure DD and Non-Structure DD) so, the overall DD of the Bridge is 97.80 and required Intervention required for this Bridge is CS4 (Replacement). However, as per the second Test (Flow Chart) The CS of Super-Structure is CS4 and CS of Sub-Structure is CS2. So, the Super-structure needs to be Replaced Only (Rehabilitation) and the corresponding Overall CS is CS3

7.8 Detailed Investigation

7.8.1 The purpose of detailed investigation

The objective of detail investigation is to acquire specific information about degradation of a structure.

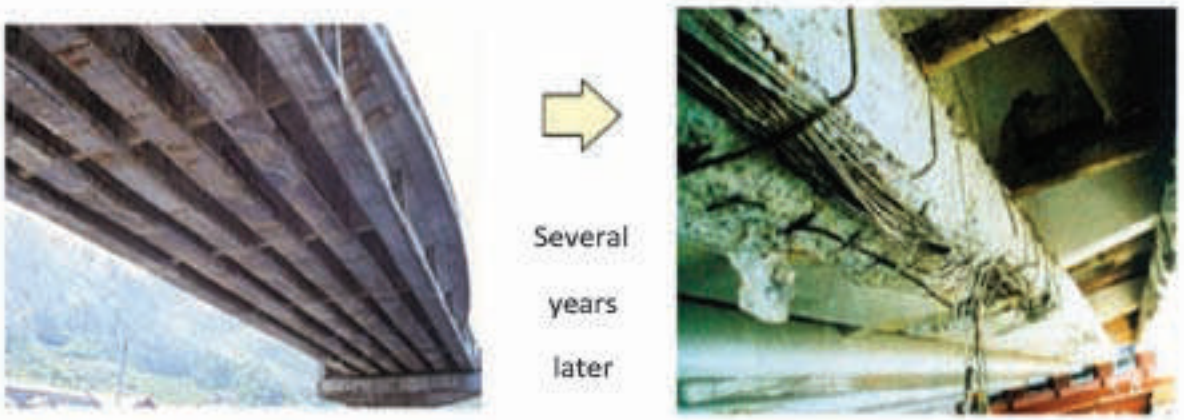
The following are the causes of detail investigation of a structure.

a) Some signs of deterioration or a change in the performance level are observed during last inspection.

b) When the cause of damage is unclear, detailed investigation is required to specify the cause of the damage.

c) To decide the scope and the degree of repair and strengthening.

Some examples of damages require detailed investigation are shown in Photo-7.7.1.



Dangerous conditions by chloride attack

Spalling, Exposed rebar by chloride attack

Photo-7.7.1 Examples of damages require detailed investigation

7.8.2 Selection of the method of detail investigation

Investigation method is selected considering the kind of damage and presumed cause of damage. Many types of Detailed Investigation Method are listed in Table-6.3.1. The responsible persons for the investigation will decide the appropriate method by applying their experiences, engineering judgment and considering other issues related to the investigation process.

Table 7.10: Exemple of Investigation Method

Factor of damage		Fire	Collision	Settlement	Temperature	Lack of section	Over loading	Carbonation	Chloride attack	Chemical corrosion	Note
Confirmation of damage	Visual investigation	◎	◎	◎	◎	◎	◎	◎	◎	◎	
Interior hollow and Internal flaw	Tapping inspection	◎						◎	◎	◎	Non-destructive test
Shape and size	Shape size investigation		◎	◎		◎					
Compressive strength	Strength test by core extraction	◎	◎	◎	◎	◎	◎	◎	◎	◎	Minute destructive test
	Rebound hammer (Ex. Schmidt rebound hammer)	◎	◎	◎	◎	◎	◎	◎	◎	◎	Non-destructive test
Modulus of Elasticity	Strength test by core extraction	◎	◎	◎	◎	◎	◎	◎	◎	◎	Minute destructive test
Rebar corrosion	Taken out rebar and visual observation							◎	◎	◎	Minute destructive test
Rebar investigation	Electromagnetic wave (Ex. RC radar)	◎	◎	◎	◎	◎	◎	◎	◎	◎	Non-destructive test
	Electromagnetic induction (Ex. Prophometer)	◎	◎	◎	◎	◎	◎	◎	◎	◎	Non-destructive test
Carbonation depth	Phenolphthalein method by core extraction							◎			Minute destructive test
	Phenolphthalein method by drilling							◎			Minute destructive test
	Phenolphthalein method by taken out rebar							◎			Minute destructive test
Chloride ion concentration	Core extraction Potentiometric Titration Device							○	◎		Minute destructive test
	Concrete powder by drilling Potentiometric Titration Device							○	◎		Minute destructive test
Physical character (Physical investigation)	Dead-load stress			◎	◎	◎	◎		◎	◎	
	Stress when loading	◎	◎			◎	◎		◎	◎	
	Stress frequency					◎	◎				
	Displacement due to loading	◎	◎			◎	◎		◎	◎	
	Displacement frequency					◎	◎				
	Vibration measurement					◎	◎		◎		

7.8.3 Core extraction

A core is extracted by an electric core drill.

Required core diameter for testing Chloride density and Carbonation depth: More than 50 mm and for Compressive strength: More than 75 mm Work procedure is described below.

a) Rebar location is confirmed by a rebar detector.

b) The location of core extraction is selected.

c) A core-drill is installed and fixed in position; then core drilling is started.

d) If core drill encounters rebar, PC tendon etc., boring is canceled and the boring location is changed.

e) A core is extracted after the completion of boring.

f) The core is kept sealed until tested.

7.8.4 Compressive strength of concrete structure

(1) Compressive Strength test by core extraction

Compressive strength of concrete is measured by a compressive strength testing machine using an extracted core.

The modulus of elasticity of concrete can be calculated from stress-strain diagram of compressive strength test.

Core extraction for compression test avoids the spalling part and the crack part. Rather a core is extracted from a sound part.

Core diameter must be more than 3 times of the maximum size of coarse aggregate and core length must be more than 2 times of core diameter.

(2) Compressive Strength test by Rebound hammer (Ex. Schmidt rebound hammer)

Compressive strength of concrete is measured by the repulsion hardness method when striking a blow at concrete surface.

Compressive strength is obtained from the arithmetic expression from the repulsion hardness method.

The repulsion hardness method is an

effective way to know the relative strength, not the way to investigate the absolute strength of concrete.

Schmidt rebound hammer is being used as

a measuring instrument of repulsion

hardness method.

Photo-7.7.2 Schmidt rebound hammer

7.8.5 Chloride ion concentration

(1) Core extraction method

Chloride density test analyzes chloride ion concentration by potentiometric titration method. In this method total amount of chloride ion present in the concrete is determined.

Chloride density test is done in the depth direction. Salinity is measured at 4(four) points of different depths. Figure-6.3.3 illustrates the basic idea of the test method.

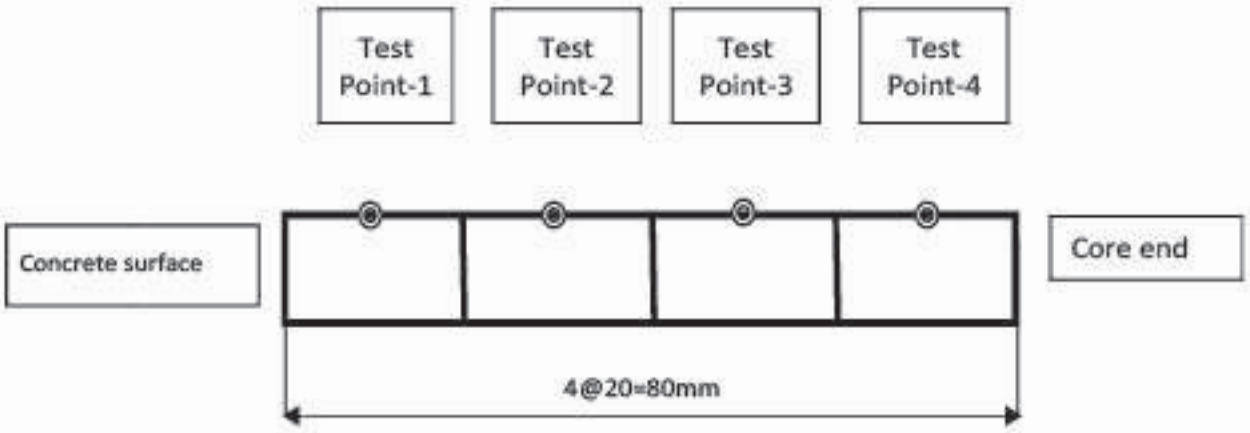


Figure-7.7.3 Example of core division for chloride density test

(2) Concrete powder by drilling

As sample for chloride density tests, some concrete powder is extracted by drilling.

Sample from 4(four) different depths in depth direction are extracted for the test. This test method also analyzes chloride ion concentration by potentiometric titration method and total amount of chloride ion present in the concrete is determined.

Photo-7.7.4 A potentiometric titration device

7.8.6 Carbonation depth

(1) Phenolphthalein method by core extraction

An extracted core is washed with water.

1% Phenolphthalein solution is sprayed on the core surface.

Then the depth of the purple red colored part of the core is measure from concrete surface at 8 points around the circumference of the circular core.

Carbonation depth of the concrete is the mean of these depths measured at 8 points.

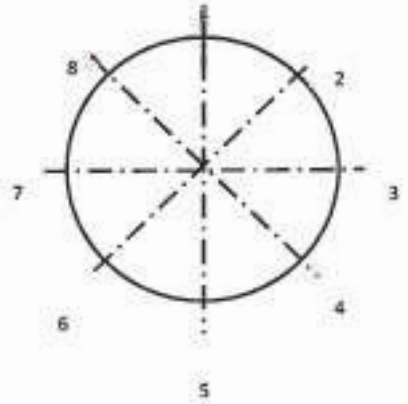


Figure-7.7.5 Estimation of carbonation depth by core extraction

(2) Phenolphthalein method by drilling

Location of rebar and PC tendon is confirmed by a rebar detector and the test is conducted at a location where rebar or PC tendon is not underneath.

1% Phenolphthalein solution is sprayed on a filter paper and it is kept holding just below the drilling location so that concrete powder extracted from the hole can drop onto it. As soon as the filter paper starts to turn red, drilling is stopped. Then the depth of the hole is measured with a slide caliper which is the carbonation depth.

Drilling

If the color of filter paper changes to red purple, drilling is stopped.

Measurement of carbonation depth

Photo-7.7.6 Phenolphthalein method by drilling

(3) Phenolphthalein method by exposed rebar

The location of rebar and PC tendon is confirmed by a rebar detector and concrete is cut in such a way that a significant portion of rebar is exposed.

The point/area is cleaned thoroughly by brushes and syringes, etc.

1% Phenolphthalein is sprayed into the point/area of exposed rebar.

The depth of red purple colored part from concrete surface is measured, which is carbonation depth.

7.8.7 Rebar corrosion (Exposed rebar)

The location of rebar and PC tendon is confirmed by a rebar detector and concrete is cut in such a way that a significant portion of rebar is exposed.

The state of corrosion of rebar is observed visually.

Generally, the part of element in which stain of rusty water flow, partial spalling, exposed rebar or big corrosion crack etc. are visible indicates high possibility of rebar corrosion; and that part of the element must be investigated.

In some cases, partial loss of area of a rebar occurs. The loss is determined by measuring rebar diameter by calipers after removing patina by steel brush and comparing new area with original one.

Photo-7.7.7 Phenolphthalein method by exposed rebar and Rebar corrosion

7.8.8 Degradation prediction

(1) Carbonation

Carbonation is a degrading phenomenon caused by CO_2 infiltration into concrete. To estimate carbonation depth in concrete, formula (1) is presented here as follows:

$$y = b\sqrt{t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots formula\ (1)$$

y : estimated carbonation depth (mm)

b : coefficient of carbonation speed (mm/√year)

t : time (year)

(2) Chloride attack

The spread of chloride ion stuck in concrete surface is predicted from diffusion equation derived from Fick's Law.

Fick's Law is shown in formula (2).

$$J_A = -D \frac{dCi}{dx} \quad \text{----------formula (2)}$$

J_A: Mass flux which is a material flow through a unit cross-sectional area in unit time

D: Diffusivity constant

C_i: Concentration of the substance

x: Distance coordinate

The diffusion equation indicated in formula (3) is obtained from continuity of a material flow.

$$\frac{\partial Ci}{\partial t} = D \frac{\partial^2 Ci}{\partial t^2} \text{---------- formula (3)}$$

t: Time

When the boundary condition is given and the differential equation is solved, chloride ion concentration diffusion formula is obtained, and presented here as formula (4).

$$C_i(x, t) = C_0 \left(1 - \text{erf}\left(\frac{x}{\sqrt{4Dt}}\right)\right) \quad \text{----------formula (4)}$$

D: Diffusivity constant

$C_i(x,t)$: Chloride ion concentration at 'x' location(kg/m^3)

C_0: Chloride ion concentration at x=0 (concrete surface) (kg/m^3)

x: Distance coordinate (cm)

t: Time (Year)

erf(x): Error function

$$erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$$

7.9 Approval of Bridge Inspection Data

The purpose of the Approval Process is to ensure objectivity accuracy and transparency of bridge inspection Data, and to facilitate smooth approval procedure in the District and Regional level by the involvement of District and Regional Official.

CHAPTER 8
DOCUMENTATION OF INVENTORY AND INSPECTION RESULTS

8.1 Introduction

A standard and quality system of documentation is indispensable to record bridge inspection data and evaluate the condition of a structure appropriately and efficiently. Doubtlessly, bridge inventory and inspection data are an integral part of the lifelong record file of the bridge. A clear, accurate, and complete set of inspection data is therefore inevitable for entire process of documentation and processing. The results (Information/Data Set) achieved from inspections will be used to plan, coordinate, implement and manage maintenance operations on the bridges. Comprehensive bridge inventory and inspection results (Data Set) will be recorded in the RuBIMS. Chief Inspector (UE) shall ensure that the inventory and periodic inspection data are in the correct format and compatible with existing entries. These data and any recommended actions including inspection inventory amendments and the need for Detailed Investigation or maintenance requirements shall be entered into the RuBIMS accordingly.

It is a valuable aid in establishing maintenance and replacement priorities as well as in determining capacity of structure and the cost of maintenance of rural bridges. Consequently, the documentation system should be operated with extreme care so that unexpected or irrelevant output borne from operational error can hinder the total system and software. This documentation system is therefore playing the leading role towards the success of Bridge Inspection program sponsored by LGED. Details of the documentation and data recording requirements for the inventory, routine and periodic inspections are described sequentially in succeeding paragraphs.

8.2 The Role of Inventory Items in RuBIMS

In the near past event, the authority concerned/implementing agency (i.e) used to identify problems of a particular bridge and then apply those problems as standard inventory items to search for the same potential problems that might exist on other bridges.

Inventory items are therefore part and parcel of Rural Bridge Information Management System (RuBIMS). The implementing Agencies use the inventory items to help plan inspection, maintenance and reconstruction as well as classify their bridges.

8.2.1 Condition and Appraisal

- The reported/documented condition of an element or component of a bridge is an evaluation of its current physical state compared to what it was on the day it was built;
- Appraisal rating items are used to evaluate a bridge in relation to the level of service it provides on the road network system of which it is a mandatory part.

8.2.1.1 Condition Rating Items:

Super-structure and Sub-structure

Accurate assignment of condition ratings is significantly dependent on the ability of inspector of the bridge to identify the bridge components and their elements. Bridge components are the major parts comprising a bridge including the deck, superstructure, and substructure. Bridge elements are individual members comprised of basic shapes and materials connected together to form bridge components. The overall condition rating of bridge components is directly related to the physical deficiencies of bridge elements.

Evaluating Elements

The inspector is responsible for rating all related defects (26 types of defects) using the rating scale (1 to 9) of all elements as discussed in Chapter 6. RuBIMS will evaluate each element of each component and assigning to it a Damage Degree for Sub-Structure, Super-Structure and Non-Structure Elements as discussed in Chapter 7.

To ensure a comprehensive record keeping and documentation, an inspector is responsible for recording the location, type, size, quantity, and severity of deterioration and deficiencies for each component of a given element. The following major components of bridges are broadly considered for an overall Structure Inventory and Appraisal (SI&A) elements condition rating:

- **Super-structure**
- **Sub-structure and**
- **Non-Structure**

8.3 Recording/Documenting Inspection Results

Inspection data should be recorded in a format that gives a clear and accurate description of the bridge condition. The standardized format used for inspection data should be clear, follow a logical sequence and incorporate all the necessary information of the bridge structure's condition. The inspection reports support maintenance planning and management and should assist this process by adopting a relatively consistent format from one inspection cycle to the next. The inspection record shall:

- Identify what parts of the bridge were inspected and the location of the defected component. (To be shown on a defect photographs or sketches of the bridge)
- Provide the following details on any defects identified
  - ✓ What the defect is.
  - ✓ Where the defect is located (a sketch may be used to illustrate its location).
  - ✓ Summarize the inspection findings if necessary (addressing how individual defects affect other element's condition).

Sketches (defect figures) of super-structure or deck slab are described as a general plan of the bridge. The point of view for sketch is shown in Figure 8.1

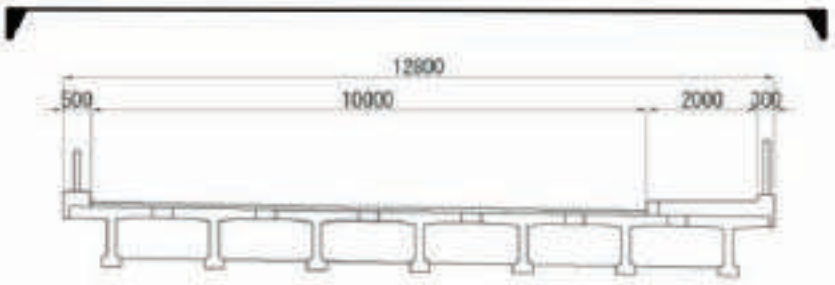


Figure 8.1: Point of View for Sketches of Superstructure or Deck Slab

All the inspection results must be recorded on LGED's Rural Bridge Information Management System (RuBIMS) within (30) days of the inspection so that concerned engineers/personnel in LGED can browse and find out the exact situation of the bridges and take relevant actions.

However, in the event that a defective structure is identified, all inspection data should be entered as soon as is practicably possible.

8.3.1 Routine Inspection Form

Routine Inspection is conducted using the "Routine Inspection Report" form included in **Appendix 7.3.**

The inspector shall submit a completed Routine Inspection Report to the Chief Inspector and Chef Inspector will take steps to record inspection data and any relevant actions, including the need for a specific inspection, special points to be inspected at the next routine inspection or detailed investigation or maintenance requirements in the Bridge Management System within (30) days of the inspection.

Photographs taken can be attached to the report as required. Advice for further inspection should be clear and these should be included in the next annual inspection plan.

In addition, the inspector shall submit a completed "Inventory Form" so that the current RuBIMS data may be positively verified or amended within (30) working days of the Routine Inspection.

8.3.2 Periodic Inspection Form of the Bridge Elements

Inspectors shall carry out the bridge inspection through this condition rating of defects form. Inspector should prepare the records for this form for each bridge element. The record of the condition of defect should be renewed when the inspection is carried out.

An appropriate photographic and sketch record must be compiled for inspection record to illustrate and clarify conditions of structural elements.

Photographic record - Entire condition and defects condition on the bridges exactly

- Defects for the worst condition
- Any information in terms of defects

Sketch record - Defects with necessary plan and elevation views of the feature

- Dimensions showing its length, width, and depth if applicable

In the column of "Remarks and Recommendation" a brief summary of the inspection findings should be made by the inspector. Problem areas, those requiring immediate attention should be pointed out.

The evaluation of inspected data will be completed using RuBIMS evaluation according to evaluation Criteria of the defects for bridge elements (Structural and Non-Structural). Inspection and evaluation report may include any recommendations for maintenance or remedial actions and for scheduling of follow-up Detailed Investigations in the comment section of the visual inspection form, if necessary. The form should be completed according to each span unit.

For Emergency Inspection, no special reporting forms are used as the form developed for routine and periodic inspection can be utilized. The ratings are transferred to the relevant item of the inspection form **Chapter-6: Types of Defects and Rating.**

For Special Inspection, the results of a special inspection will generally not be in a format that can be input in the inspection database using the **visual inspection report form.** The special inspection report will supplement either routine or emergency inspection and will normally be carried out on one or two major primary structural components of the bridge.

Recording Forms

A set of inventory and inspection forms to be stored on RuBIMS is listed below:

- **Form – 1: Bridge Inventory Record Form**
- **Form - 2: New Bridge/Culvert Acceptance Inspection Form**
- **Form – 3: Routine Inspection Report Form**
- **Form – 4: Periodic Inspection Report Form**
- **Form – 5: Bridge Evaluation Report Form**
- **Form – 6: Sample Inspection /Evaluation Report Form**

All these forms are available in Appendix-1.

8.4 Structure Inventory & Appraisal of Condition Ratings

Bridge inventory data is a standardized series of data items that enables the geometry, construction pattern and function of a bridge to be identified and documented. All information collected during an initial inspection are recorded or referenced on an inventory form (sheet). The Structure Inventory and Appraisal (SI&A) sheet is a tabulation of information that should be submitted and documented for each individual structure using RuBIMS.

8.5 Data Entry Requirements

For routine, in-depth, critical members with fracture, underwater, damage and special inspections, LGED should ensure entry of the SI&A data in RuBIMS within:

- 90 days of the date of inspection for all UZR bridges; and
- 180 days of the date of inspection for all other bridges.

For modifications of existing bridge for which previously recorded data has been altered and for new bridges, LGED should confirm entry of the SI&A data in RuBIMS within:

- 90 days after the completion of the work for UZR bridges; and
- 180 days after the completion of the work for all other bridges.

For changes in load restriction or closure status, LGED should confirm entry of the SI&A data in RuBIMS within:

- 90 days after the change in status of the structure.

8.5.1 Inventory Items

Inventory items reflect the overall characteristics of a bridge. For the most part, these items are permanent characteristics, which only change when the bridge is altered in some way, such as reconstruction or load restriction. There are two forms with similar style namely, SI&A Form-1 (for Non-structural Members/Elements) and SI&A Form-2 (For Structural Members/ Elements). The following Table (Table 8.1) illustrates the detail of Inventory items that should be included in SI&A forms:

Table 8.1: detail of Inventory Items that Should be Included in SI&A Form (Sheet)

Sl. No.	Inventory Item	Detailed Description
1.	**Identification of Structure**	Identifies the structure using: ▪ GIS location (ordinates); ▪ Description of Geographic locations like, Division, District, Upazila etc.; ▪ Description of Road (on which the bridge is constructed) like, Name of Road, Category of Road (UZR/UNR etc.), ID of Road; ▪ Structural description of the bridge like, Chainage, Year of construction, Code of the bridge, Load restriction for the bridge (if any);
2.	**Type of Structure**	Specifies the Type of Bridge/Culvert/Gap etc., the material of construction, and design as follows: ▪ Culvert: Box Culvert, Slab Culvert, Open Foundation Culvert, Pipe Culvert, U-Drain etc. ▪ Bridge: ✓ RCC/Prestressed Concrete: Girder Bridge, Box Girder Bridge, Continuous Bridge, PC Girder Bridge, Slab Bridge, Light Traffic Bridge etc. ✓ Steel: Arch Bridge, Truss Bridge, Bailey Bridge etc. ✓ Other/Special Type: Suspension Bridge, Cable Stayed Bridge, Arch Masonry Bridge, Wooden Bridge, Iron Bridge, Hydraulic Structure etc. ▪ GAPs: Existing Gap, Gap Length etc.
3.	**Type of Waterway**	Specifies the type of water body on which the structure is constructed like:

Sl. No.	Inventory Item	Detailed Description
		▪ Channels: Open Field Channel, Ill-defined Chanel, Defined Channel etc.; ▪ Canal: Navigation Canal, Drainage Canal, Irrigation Canal etc. ▪ River: River in General, Navigable River etc.
4.	**Details of Super-Structure**	Specifies the information of super-structural members, e.g.: ▪ Number of Spans/Slabs/Arches/Girders/Cross Girders etc. length of span; ▪ Types of wearing surface (e.g., Bitumen, Concrete etc.) ▪ Information related to Dimensions (e.g., Length/Width of Bridge, Carriageway Width etc.) ▪ Miscellaneous/Information: ✓ Type of Railing (e.g., RCC Railing-Post & Bar, RCC Wall, Steel, Masonry, Composite etc.); ✓ Tie/Hanger (e.g., Steel, Wire, Concrete etc.); ✓ Bracing (e.g., Steel, Concrete etc.) ✓ Source of Electricity (REB, PDB, Solar etc.)
5.	**Details of Sub-Structure**	Specifies the information related to sub-structural elements such as: ▪ Abutment/End Wall/Pier/Intermediate Wall/Wing Wall: RCC, Masonry, Steel etc. ▪ Foundation of Abutment/Wing Wall/Pier: Spread Footing, Pile Foundation, Well Foundation etc. ▪ Number/Quantity of: Pile, Pile Cap, Exposed Pile, Pier Cap, Abutment etc.
6.	**Detailed information of Non-Structural Element**	Specifies the information regarding non-structural elements of sub-structure, Such as: ▪ Type of Protection for Both Front and Back Approach (e.g., Brick Palisading Wall, Brick Retaining Wall, RCC Retaining Wall, Toe Wall with CC Block, Toe Wall with Rip-Rap etc.); ▪ Drainage System (Front and Back Approach): Outlet, Cut-off Wall, Apron, Required LENGTH OF Approach Road, Approach Slab etc. ▪ Type of Material of Approach (e.g., Bituminous Carpeting, RCC Slab, Cement Concrete, Herring Bone Bond, Blocks, Earth etc.)
7.	**Structural Condition Code (Notation) of Bridge**	Specifies the Coding System of the Defects in the light of Condition Rating and Evaluation Rating along with sample Appraisal Approach of Non-structural Elements of Bridge

Bridge Inventory Record Form (Form-1):

Local Government Engineering Department

Rural Bridge Information Management System (RuBIMS)

Bridge/Culvert Inventory Form

Inspected By (Name)		Inspection Date	
Designation		Organization	

Basic Inventory Data (Sl. 1 to 7)

1. Location:

Climate Region:

Division		District		Upazila	
Road ID		Road Name		Construction Year	
Structure ID		Chainage (m)		Load Restriction (Tons)	
Latitude		Longitude		Altitude (If required)	
Detour Road Available	Y / N	Detour Lenth	KM		

2. Type of Waterway and Characteristic of Flow

Type of Waterway	Name	Observed Flood Level (m) *HFL and NFL can be determined from Altitude reading using related mobile apps. and water marks (if available)*				Width (m)	Flow Type (Mark ✓ mention)			
		Highest Flood Level (HFL)	Normal Flood Level (NFL)	Standard High Flood Level (SHFL)	Source of Information		Tidal	Non-Tidal	Flash Flood	Others (mention)
Ill-defined Channel										
Drainage Canal										
Navigable Canal										
Navigable River										
Non-Navigable River										
Hight of available Freeboard			meter	Bank to Bank width			meter			

3. Structure Type [(☑) Tick Mark Only]:

Pipe Culvert (Dia >1.0m)		RCC Girder Bridge		Box Girder Bridge		Bailey Bridge		Truss with Steel Deck	
U-Drain		RCC Continuous Girder Bridge		PC Girder Bridge		Iron Bridge		Bailey with Steel Deck	
Box Culvert		Slab Bridge		Truss with RCC Slab		Hydraulic Structure		Others Type	
Slab Culvert		Arch Bridge		Steel Beam & RCC Slab		Suspension Bridge		Existing Gap	
OFC		Light Traffic Bridge		Arch Masonry		Wooden Bridge		Gap Length (m)	

4. Construction, Re-Construction and Maintenance History:

Construction		Re-Construction		Maintenance			
Year		Year		Year	Maintenance Type	Source of Found	Maintenance Cost
Cost (Lakh Taka)		Cost (Lakh Taka)					
Source of Fund		Source of Fund					

Design Information:

General				Design Traffic	
Design Load (Ton)		Design NFL		Traffic Volume (AADT)	
Design Method		Design HFL		Average Vehicle Width (m)	
Load Bearing Capacity		Design SHFL		Max Assessed Vehicle Load (Ton)	
Design Life					

5. Super-Structure Details [Numeric Value or (☑) Tick Mark Only]:

Width (m)		Carriageway Width (m)		Sidewalk (L/S) (m)		Sidewalk (R/S) (m)	

Total No. of Span							No. of Girders in Each Span		
No. of Similar Span							No. of Boxes in each Girder		
Length of Each Similar Span (m)							No. of Similar Girders		
Length of other Span (m)									
Total Length (m)							Total No. of Girders		

No. of Slab in Each Span							Wearing Course		
No. of Similar Slab in each Span							Nil		
Length of Each Similar Slab (m)							Bitumen		
Total No. of Slab							Concrete		
Length of Each Similar Span (m)							Bank to Bank Distance at Bridge Site (m)		

Types of Railing	Nil		RCC Railing (Bar & Post)		RCC Wall		Masonry		Steel		Composite		Other Information (If required)	
Tie/Hanger	Nil		Concrete		Steel		Wire							
Source of Electricity	N/A		REB		PDB		Solar							

Bracing	Nil		Concrete		Steel	
No. of Light Posts	Left Side		Right Side			

6a. Sub-Structure Details [(☑) Tick Mark Only]:

Description	RCC	Masonry	Steel	Weep Hole
Abutment/End Wall				
Wing Wall				
Pier/Intermediate Wall				

6b. Foundation Type [(☑) Tick Mark Only]:

Abutment	Footing		Piled		Well		Box		Others		Unknown	
Wing Wall	Footing		Piled		Well		Others		Unknown			
Pier	Footing		Piled		Well		Others		Unknown			
No. of Pile Known	Y		N									

Position of Abutment/Pier	Back App.	Pier 1	Pier 2							Pier n	Front App.	Total
No. of Column in Each Pier/Abut.												
No. of Piles in Each Pier/Abut.												

7a. Approach Information [Numeric Value or (☒) Tick Mark Only]:

Approach Protection (B-App.)	Y	N	Protection Type	Brick Pala Wall		Brick Retaining Wall		RCC Retaining Wall		Toe Wall with CC Block		Toe Wall with Rip-Rap		Others	
Approach Protection (F-App.)	Y	N	Protection Type	Brick Pala Wall		Brick Retaining Wall		RCC Retaining Wall		Toe Wall with CC Block		Toe Wall with Rip-Rap		Others	
Approach Safety Barrier	Y	N	Safety Barrier Type			Concrete Post		Concrete Post & Metal W-Beam				Concrete Post & Rail Bar		Other Type	

Drainage System	Back Approach	Y	N	Front Approach	Y	N	Outlet	Back App.	Y	N	Front App.	Y	N	Cut-off Wall	Y	N	Apron	Y	N

Approach Road	Y	N	Material Type	BC		RCC/CC		HBB		Uni-Block		Earthen		Req. Length of Approach Road (m)	Back Approach		Front Approach	

Approach Slab	Y	N

7b. Protection Work Information [Numeric Value or (☒) Tick Mark Only]:

Non- Structural Elements	Protective works of Abt./Pier						Other River Training Works				
Location	Back Abt.	Pier 1	Pier 2	Pier 3	Pier n	Front Abt.	Back Abt. U/S	Back Abt. D/S	Front Abt. U/S	Front Abt. D/S	Other

Inspection Conditions Data (Sl. 8 to 11)

8. Non- Structural Elements

Non- Structural Elements	Lighting Facilities [G/F/P/S/B]		Embankment Slopes of Approach Roads [G/F/P/S/B]		Pavement of approaches [G/F/P/N/ER/S]		Wearing course [G/F/P/S]	Wheel guard, Walkway, median [HDM/G/F/P/NER/S]		Rail Bar, Rail Post [G/F/P/NER/S]		Safety Barriers [NDM/G/F/P/NER/S]	
Location	Left Side	Right Side	Back App.	Front App.	Back App.	Front App.	Deck Top	Left Side	Right Side	Left Side	Right Side	Back App.	Front App.
☐													

9. Component of Structure

Super-Structure (RCC/PC Bridge)	Expansion-joint/Nosing/Sealing	☐ Yes	☐ No	
	Checker Plates, Nut-Bolts	☐ Yes	☐ No	
	Deck Slab (Top & Soffit) - 1	☐ Yes	☐ No	
	Deck Slab - 2	☐ Yes	☐ No	
	Deck Slab - 3	☐ Yes	☐ No	
	Deck Slab - 4	☐ Yes	☐ No	
	Main Girder/Beam - 1	☐ Yes	☐ No	
	Main Girder/Beam - 2	☐ Yes	☐ No	
	Main Girder/Beam - 3	☐ Yes	☐ No	
	Main Girder/Beam - 4	☐ Yes	☐ No	
	Main Girder/Beam - 5	☐ Yes	☐ No	
	Main Girder/Beam - 6	☐ Yes	☐ No	
	Cross-Girder - 1	☐ Yes	☐ No	
	Cross-Girder - 2	☐ Yes	☐ No	
	Cross-Girder - 3	☐ Yes	☐ No	
	Box Girder	☐ Yes	☐ No	
	Arch	☐ Yes	☐ No	
	Hangar of Arch	☐ Yes	☐ No	
Super Structure (Steel Truss/Bailey)	Common: Stringer	☐ Yes	☐ No	
	Common: Floor Beam	☐ Yes	☐ No	
	Common: Checker Plates (Deck)	☐ Yes	☐ No	
	Common: Bottom Bracing	☐ Yes	☐ No	
	Common: Bottom Chord	☐ Yes	☐ No	
	Arch: Connector	☐ Yes	☐ No	
	Arch: Vertical Panel	☐ Yes	☐ No	
	For Steel Truss: Vertical Post	☐ Yes	☐ No	
	For Steel Truss: Diagonal	☐ Yes	☐ No	
	For Steel Truss: Top Bracing	☐ Yes	☐ No	
	For Steel Truss: Strut	☐ Yes	☐ No	
	For Steel Truss: Top Chord	☐ Yes	☐ No	
Bearings Assembly - 1	Hinges	☐ Yes	☐ No	
	Main Body of bearings	☐ Yes	☐ No	
	Anchor Bolt	☐ Yes	☐ No	
	Seat Mortar	☐ Yes	☐ No	

Bearings Assembly - 2	Hinges	☐ Yes	☐ No
	Main Body of Bearings	☐ Yes	☐ No
	Anchor Bolt	☐ Yes	☐ No
	Seat Mortar	☐ Yes	☐ No
Sub-Structure	Abutment / End Wall - 1	☐ Yes	☐ No
	Abutment / End Wall - 2	☐ Yes	☐ No
	Wing Wall - 1	☐ Yes	☐ No
	Wing Wall - 2	☐ Yes	☐ No
	Wing Wall - 3	☐ Yes	☐ No
	Wing Wall - 4	☐ Yes	☐ No
	Top Slab of Box - 1	☐ Yes	☐ No
	Top Slab of Box - 2	☐ Yes	☐ No
	Top Slab of Box - 3	☐ Yes	☐ No
	Top Slab of Box - 4	☐ Yes	☐ No
	Intermediate Wall - 1	☐ Yes	☐ No
	Intermediate Wall - 2	☐ Yes	☐ No
	Intermediate Wall - 3	☐ Yes	☐ No
	Base/B-Slab - 1	☐ Yes	☐ No
	Base/B-Slab - 2	☐ Yes	☐ No
	Base/B-Slab - 3	☐ Yes	☐ No
	Base/B-Slab - 4	☐ Yes	☐ No
	Abutment Base/B-Slab - 2	☐ Yes	☐ No
	Pier Cap	☐ Yes	☐ No
	Pier	☐ Yes	☐ No
	Pile cum Pier	☐ Yes	☐ No
	Pier Column - 1	☐ Yes	☐ No
	Pier Column - 2	☐ Yes	☐ No
	Pier Column - 3	☐ Yes	☐ No
	Pier Column - 4	☐ Yes	☐ No
	Bracing of Pier	☐ Yes	☐ No
	Pile Cap	☐ Yes	☐ No
	Exposed Pile (If any)	☐ Yes	☐ No
	Projected Pile (If any)	☐ Yes	☐ No
	Well Foundation	☐ Yes	☐ No

8.6 Prioritization of Bridges under Different Intervention Categories

As discussed in chapter 7 (Section 7.4 and 7.5) based on the inspection data all inspected bridge will be analyzed, evaluated and an overall bridge damage degree (DD) (Bridge Structural Deficiency) Score will be determined and all the bridges will be grouped under corresponding maintenance categories. The final grouping will be completed following the SupRB Operational Strategy Flowchart (Fig. 7.3). The Prioritization of Bridges under Different Intervention Categories will be completed by RuBIMS using the following criteria:

- Bridge Damage Degree (Structural Deficiency) Score
- Traffic Volume Score and
- Socio-Economic Score of the Road Alignment
- Climate Parameters Factor (explained in details in the following section)

The priority score will be calculated using the following Formula:

Total Score = Bridge Damage Degree (65%) + Traffic Volume (15%) + Socio-Economic (10%) + Climate Factor 10%

(Note: The Maximum Score of any bridge will be 100 and the above formula may be adjusted as per LGED Funding/Project requirements).

This Climate factor shall be considered based on climate risk and vulnerability parameter ranking based on existing bridge inventory data items (from RuBIMS):

The proposed approach is based on already available data items in RuBIMS bridge inventory. These Environmental sub-parameters are:

a) **Exposure Categories:** Vulnerable 19 districts including the coastal districts including salt exposure will get maximum value 5, Flood prone/flash flood area = 5, Dry Area = 0, other categories scored based on flood exposure.

Proposed Score for Different Climate Zones and Exposure Score

Climate Zone/Hotspot	Districts	Exposure Score
Coastal Districts (19)	Bagerhat, Barguna, Barishal, Bhola, Chandpur, Chattogram, Cox's Bazar, Feni, Gopalganj, Jashore, Jhalkati, Khulna, Lakshmipur, Narail, Noakhali, Patuakhali, Pirojpur, Satkhira, Shariatpur.	5
Haor and Flash Flood Areas (7)	Brahmanbaria, Habiganj, Kishoreganj, Moulvibazar, Netrokona, Sunamganj, Sylhet	4
Chattogram Hill Tracts (3)	Bandarban, Khagrachhari, Rangamati	4
River Systems & Estuaries (20)	Bogura, Cumilla, Dhaka, Faridpur, Gaibandha, Jamalpur, Kurigram, Lalmonirhat, Madaripur, Manikganj, Munshiganj, Narayanganj, Natore, Chapai Nawabganj, Pabna, Rajshahi, Rajbari, Sirajganj, Tangail, Khulna	3

Climate Zone/Hotspot	Districts	Exposure Score
Relatively Less Hazard Prone (RLHP) Areas (6)	Gazipur, Jhenaidah, Magura, Mymensingh, Nilphamari, Sherpur	3
Barind and Drought Prone Areas (9)	Chuadanga, Dinajpur, Joypurhat, Kushtia, Meherpur, Naogaon, Panchagarh, Rangpur, Thakurgaon	2

Source - Source: BDP 2100 Analysis, GED, 2015 and ICZM Policy, 2005 (with few modification)

b) **Riverbank protection** as YES/NO:

Ranking as NO = 5 points, YES = 0 (if there is a condition parameter for this element, potentially it can have a higher point even if there is a riverbank protection, however, this will complicate the approach unnecessarily and the objective is to keep it very simple and improve it in future if more relevant data becomes available)

c) **Freeboard height** can be considered as < 0.6m = 5 points, 0.6-2m = 3 points, >2m = 0 points,

Final Score calculated as **Climate Factor = Exposure Category score + River Protection + Freeboard height score**

The min max values will be 0 and 15

Appendix-1: Recording Report Forms

Appendix 1.1 Bridge Inventory Form

Position of Abutment/Pier	Back App.	Pier 1	Pier 2							Pier n	Front App.	Total
No. of Column in Each Pier/Abut.												
No. of Piles in Each Pier/Abut.												

7a. Approach Information (Numeric Value or (8) Tick Mark Only)

Approach Protection (B-App.)	Y	N	**Protection Type**	Brick Pala Wall		Brick Retaining Wall		RCC Retaining Wall		Toe Wall with CC Block		Toe Wall with Rip-Rap		Others	
Approach Protection (F-App.)	Y	N	**Protection Type**	Brick Pala Wall		Brick Retaining Wall		RCC Retaining Wall		Toe Wall with CC Block		Toe Wall with Rip-Rap		Others	
Approach Safety Barrier	Y	N	Safety Barrier Type			Concrete Post		Concrete Post & Metal W-Beam				Concrete Post & Rail Bar		Other Type	

Drainage System	Back Approach	Y	N	Front Approach	Y	N	**Outlet**	Back App.	Y	N	Front App.	Y	N	**Cut-off Wall**	Y	N	**Apron**	Y	N

Approach Road	Y	N	**Material Type**	BC		RCC/CC		HBB		Uni-Block		Earthen		**Req. Length of Approach Road (m)**	Back Approach		Front Approach	

Approach Slab	Y	N

7b. Protection Work Information (Numeric Value or (8) Tick Mark Only)

Non- Structural Elements	Protective works of Abt./Pier						Other River Training Works				
Location	Back Abt.	Pier 1	Pier 2	Pier 3	Pier n	Front Abt.	Back Abt. U/S	Back Abt. D/S	Front Abt. U/S	Front Abt. D/S	Other

Inspection Conditions Data (Sl. 8 to 11)

8. Non- Structural Elements

Non- Structural Elements	Lighting Facilities (G/F/P/S/R)		Embankment Slopes of Approach Roads (G/F/P/S/R)		Pavement of approaches (G/F/P/NER/S)		Wearing course (G/F/P/S)	Wheel guard, Walkway, median (M/W/G/F/P/NER/S)		Rail Bar, Rail Post (G/F/P/NER/S)		Safety Barriers (M/W/G/F/P/NER/S)	
Location	Left Side	Right Side	Back App.	Front App.	Back App.	Front App.	Deck Top	Left Side	Right Side	Left Side	Right Side	Back App.	Front App.
☐													

9. Component of Structure

Super Structure (RCC/PC Bridge)	Expansion-Joint/Nosing/Sealing	☐ Yes	☐ No	
	Checker Plates, Nut-Bolts	☐ Yes	☐ No	
	Deck Slab - 1	☐ Yes	☐ No	
	Deck Slab - 2	☐ Yes	☐ No	
	Deck Slab - 3	☐ Yes	☐ No	
	Deck Slab - 4	☐ Yes	☐ No	
	Main Girder/Beam - 1	☐ Yes	☐ No	
	Main Girder/Beam - 2	☐ Yes	☐ No	
	Main Girder/Beam - 3	☐ Yes	☐ No	
	Main Girder/Beam - 4	☐ Yes	☐ No	
	Main Girder/Beam - 5	☐ Yes	☐ No	
	Main Girder/Beam - 6	☐ Yes	☐ No	
	Cross-Girder - 1	☐ Yes	☐ No	
	Cross-Girder - 2	☐ Yes	☐ No	
	Cross-Girder - 3	☐ Yes	☐ No	
	Box Girder	☐ Yes	☐ No	
	Arch	☐ Yes	☐ No	
	Hanger of Arch	☐ Yes	☐ No	
Super Structure (Steel Truss/Rly)	Stringer	☐ Yes	☐ No	
	Floor Beam	☐ Yes	☐ No	
	Checker Plates (Deck)	☐ Yes	☐ No	
	Bottom Bracing	☐ Yes	☐ No	
	Bottom Chord	☐ Yes	☐ No	
	Connector	☐ Yes	☐ No	
	Vertical Panel	☐ Yes	☐ No	
	Vertical Post	☐ Yes	☐ No	
	Diagonal	☐ Yes	☐ No	
	Top Bracing	☐ Yes	☐ No	
	Strut	☐ Yes	☐ No	
	Top Chord	☐ Yes	☐ No	
Bearings Assembly - 1	Hinges	☐ Yes	☐ No	
	Main body of bearings	☐ Yes	☐ No	
	Anchor Bolt	☐ Yes	☐ No	
	Seat Mortar	☐ Yes	☐ No	

Bearings Assembly - 2	Hinges	☐ Yes	☐ No
	Main Body of Bearings	☐ Yes	☐ No
	Anchor Bolt	☐ Yes	☐ No
	Seat Mortar	☐ Yes	☐ No
Sub-Structure	Abutment / End Wall - 1	☐ Yes	☐ No
	Abutment / End Wall - 2	☐ Yes	☐ No
	Wing Wall - 1	☐ Yes	☐ No
	Wing Wall - 2	☐ Yes	☐ No
	Wing Wall - 3	☐ Yes	☐ No
	Wing Wall - 4	☐ Yes	☐ No
	Top Slab of Box - 1	☐ Yes	☐ No
	Top Slab of Box - 2	☐ Yes	☐ No
	Top Slab of Box - 3	☐ Yes	☐ No
	Top Slab of Box - 4	☐ Yes	☐ No
	Intermediate Wall - 1	☐ Yes	☐ No
	Intermediate Wall -2	☐ Yes	☐ No
	Intermediate Wall -3	☐ Yes	☐ No
	Base/B-Slab - 1	☐ Yes	☐ No
	Base/B-Slab - 2	☐ Yes	☐ No
	Base/B-Slab - 3	☐ Yes	☐ No
	Base/B-Slab - 4	☐ Yes	☐ No
	Abutment Base/B-Slab - 2	☐ Yes	☐ No
	Pier Cap	☐ Yes	☐ No
	Pier	☐ Yes	☐ No
	Pile cum Pier	☐ Yes	☐ No
	Pier Column - 1	☐ Yes	☐ No
	Pier Column - 2	☐ Yes	☐ No
	Pier Column - 3	☐ Yes	☐ No
	Pier Column - 4	☐ Yes	☐ No
	Bracing of Pier	☐ Yes	☐ No
	Pile Cap	☐ Yes	☐ No
	Exposed Pile (If any)	☐ Yes	☐ No
	Projected Pile (If any)	☐ Yes	☐ No
	Well Foundation	☐ Yes	☐ No

Local Government Engineering Department
Rural Bridge Information Management System (RuBIMS)
Bridge/Culvert Inventory Form

Inspected By (Name)		Inspection Date	
Designation		Organization	

Basic Inventory Data (Sl. 1 to 7)

1. Location:

Climate Region:

Division		District		Upazila	
Road ID		Road Name		Construction Year	
Structure ID		Chainage (m)		Load Restriction (Tons)	
Latitude		Longitude		Altitude (If required)	
Detour Road Available	Y / N	Detour Lenth	KM		

2. Type of Waterway and Characteristic of Flow

Type of Waterway	Name	Observed Flood Level (m) *HFL and NFL can be determined from Altitude reading using related mobile apps, and water marks (if available)*				Width (m)	Flow Type (Mark ✓ mention)			
		Highest Flood Level (HFL)	Normal Flood Level (NFL)	Standard High Flood Level (SHFL)	Source of Information		Tidal	Non-Tidal	Flash Flood	Others (mention)
Ill-defined Channel										
Drainage Canal										
Navigable Canal										
Navigable River										
Non-Navigable River										
Right of available Freeboard		(+m/-m)		Bank to Bank width			(+m/-m)			

3. Structure Type [(✓) Tick Mark Only]

Pipe Culvert (Dia >1.0m)		RCC Girder Bridge		Box Girder Bridge		Bailey Bridge		Truss with Steel Deck	
U-Drain		RCC Continuous Girder Bridge		PC Girder Bridge		Iron Bridge		Bailey with Steel Deck	
Box Culvert		Slab Bridge		Truss with RCC Slab		Hydraulic Structure		Others Type	
Slab Culvert		Arch Bridge		Steel Beam & RCC Slab		Suspension Bridge		Existing Gap	
DPC		Light Traffic Bridge		Arch Masonry		Wooden Bridge		Gap Length (m)	

4. Construction, Re-Construction and Maintenance History:

Construction		Re-Construction		Maintenance			
Year		Year		Year	Maintenance Type	Source of Found	Maintenance Cost
Cost (Lakh Taka)		Cost (Lakh Taka)					
Source of Fund		Source of Fund					

Design Information:

General				Design Traffic	
Design Load (Ton)		Design MFL		Traffic Volume (AADT)	
Design Method		Design HFL		Average Vehicle Width (m)	
Load Bearing Capacity		Design SHFL		Max Assessed Vehicle Load (Ton)	
Design Life					

5. Super-Structure Details [Numeric Value or (✓) Tick Mark Only]

Width (m)		Carriageway Width (m)		Sidewalk (L/S) (m)		Sidewalk (R/S) (m)	

Total No. of Span		No. of Girders in Each Span	
No. of Similar Span		No. of Boxes in each Girder	
Length of Each Similar Span (m)		No. of Similar Girders	
Length of other Span (m)			
Total Length (m)		Total No. of Girders	

No. of Slab in Each Span		Wearing Course	
No. of Similar Slab in each Span		Nil	
Length of Each Similar Slab (m)		Bitumen	
Total No. of Slab		Concrete	
Length of Each Similar Span (m)		Bank to Bank Distance at Bridge Site (m)	

Types of Railing	Nil		RCC Railing (Bar & Post)		RCC Wall		Masonry		Steel		Composite		Other Information (If required)
Tie/Hanger	Nil		Concrete		Steel		Wire		Bracing	Nil		Concrete		Steel	
Source of Electricity	N/A		REB		POB		Solar		No. of Light Posts	Left Side		Right Side	

6a. Sub-Structure Details [(✓) Tick Mark Only]:

Description	RCC	Masonry	Steel	Weep Hole
Abutment/End Wall				
Wing Wall				
Pier/Intermediate Wall				

6b. Foundation Type [(✓) Tick Mark Only]:

Abutment	Footing		Piled		Well		Box		Others		Unknown			
Wing Wall	Footing		Piled		Well		Others		Unknown					
Pier	Footing		Piled		Well		Others		Unknown					
No. of Pile Known	Y		N											

Position of Abutment/Pier	Back App.	Pier 1	Pier 2							Pier n	Front App.	Total
No. of Column in Each Pier/Abut.												
No. of Piles in Each Pier/Abut.												

7a. Approach Information [Numeric Value or (If) Tick Mark Only]:

Approach Protection (B-App.)	Y	N	Protection Type	Brick Pala Wall		Brick Retaining Wall		RCC Retaining Wall		Toe Wall with CC Block		Toe Wall with Rip-Rap		Others	
Approach Protection (F-App.)	Y	N	Protection Type	Brick Pala Wall		Brick Retaining Wall		RCC Retaining Wall		Toe Wall with CC Block		Toe Wall with Rip-Rap		Others	
Approach Safety Barrier	Y	N	Safety Barrier Type			Concrete Post		Concrete Post & Metal W-Beam				Concrete Post & Rail Bar		Other Type	

Drainage System	Back Approach	Y	N	Front Approach	Y	N	Outlet	Back App.	Y	N	Front App.	Y	N	Cut-off Wall	Y	N	Apron	Y	N

Approach Road	Y	N	Material Type	BC		RCC/CC		HBB		Uni-Block		Earthen		Req. Length of Approach Road (m)	Back Approach		Front Approach	

Approach Slab	Y	N

7b. Protection Work Information [Numeric Value or (If) Tick Mark Only]:

Non- Structural Elements	Protective works of Abt./Pier						Other River Training Works				
Location	Back Abt.	Pier 1	Pier 2	Pier 3	Pier n	Front Abt.	Back Abt. U/S	Back Abt. D/S	Front Abt. U/S	Front Abt. D/S	Other

Inspection Conditions Data (Sl. 8 to 11):

8. Overall Visual Observation on Condition of Non-Structural Elements [Write **NENR/G/F/P/NER/S/B** Only] **NENR**: Not Exist & Not Required;

NER: Not Exist but Required. **Note**: **G**=Good (No Maintenance Required); **F**=Fair (Minor Maintenance); **P**=Poor (Major/Re-hab.); **S**=Severe (Re-Construction); **B**=Blocked.

Non- Structural Elements	Lighting Facilities [G/F/P/S/B]		Embankment Slopes of Approach Roads [G/F/P/S/B]		Pavement of approaches [G/F/P/NER/S]		Wearing course [G/F/P/S]	Wheel guard, Walkway, median [NENR/G/F/P/NER/S]		Rail Bar, Rail Post [G/F/P/NER/S]		Safety Barriers [NENR/G/F/P/NER/S]	
Location	Left Side	Right Side	Back App.	Front App.	Back App.	Front App.	Deck Top	Left Side	Right Side	Left Side	Right Side	Back App.	Front App.
Condition													

Overall Visual Observation on Condition of Longitudinal Slope of Approach Road:

Note: **G**=Good (Flat, Slope is 0%); **F**=Fair (Slope is less than 3%); **P**=Poor (Slope is more than 3% but less than 5%.); **S**=Severe (Slope is more than 5%); **B**= Approach Road is partially Disabled.

Non- Structural Elements	Longitudinal Slopes of Approach Roads [G/F/P/S/B]	
Location	Back App.	Front App.
Condition		

Elements	Conditions of Protective works										
Non- Structural Elements	Protective works of Abt./Pier [NENR/G/F/P/NER/S/B]						Other River Training Works [G/F/P/S]				
Location	Back Abt.	Pier 1	Pier 2	Pier 3	Pier n	Front Abt.	Back Abt. U/S	Back Abt. D/S	Front Abt. U/S	Front Abt. D/S	Other
Condition											

Elements	Surface Condition		Condition of Painting					Condition of water drainage and Waterways					
Non-Structural Elements	Surface of Wing Wall and Abutment Wall [G/F/P/S]		Guide Post, Traffic Sign, Road Marking, Electric Post [NENR/G/F/P/NER/S]		Railing, Rail Posts, Wheel guard [NENR/G/F/P/NER/S]		Steel members of Truss & Bailey bridges [NENR/G/F/P/NER/S]	Deck Slab, Top Slab of Box, Vergo, Ducts & Ch-spouts [G/F/P/S]	Surface of Abutment, End wall, Intermediate wall & Wing Wall, Weep Holes, Drain outlet [G/F/P/S]		Water flow of Slab/ Box/ P-Culverts [G/F/P/S/B]	River Channel/Water Ways [G/F/P/S/B]	
Location	Back App.	Front App.	Back App.	Front App.	Left Side	Right Side	Above Deck	Above Deck/Slab	Back App.	Front App.	Inside of Structure	Up Stream	D- Stream
Condition													

Comments on Approach Road Right of Way Availability: Is there sufficient land available on both approach for Capacity expansion of the Bridge if required?

9. Observation of Individual Component of Structure [For each defect please rate 1 to 9 depending on the extent of the defect]: **Note**: Rating 1 - Not Appear (No significant defects); 2 - Satisfactory (Slight (not more than 3% of surface area of concerned Member/Element); 3 - Fair (Not Wide (6%-20% of surface area of concerned Member/Element); 4 – Moderate (Moderately Wide (21%-30% of surface area of concerned Member/Element); 5 – Poor (Wide (36%-50% of surface area of concerned Member/Element); 6 – Severe (Severe (51%-60% of surface area of concerned Member/Element); 7 - Critical (Extensive (61%-70% of surface area of concerned Member/Element); 8 - Immediate Failure (Almost Failed (More than 70% of surface area of concerned Member/Element); and 9 - Non-Functional (The element is non-functional/failed); 16 Other Types of Defects (16 a Illegal Occupation/16b Plant Growth/16 c Fire Damage/16 d Missing of Railing vertical/16 e Rail's Wanks on

Appendix 1.2 New Bridge/Culvert Acceptance Inspection Form

Local Government Engineering Department

Rural Bridge Information Management System (RuBIMS)

Bridge/Culvert New Acceptance Inspection Form

Inspected By (Name)		Inspection Date	
Designation		Organization	

Basic Inventory Data (Sl. 1 to 7)

1. Location:

Climate Region:

Division		District		Upazila	
Road ID		Road Name		Construction Year	
Structure ID		Chainage (m)		Load Restriction (Tons)	
Latitude		Longitude		Altitude (if required)	
Detour Road Available	Y / N	Detour Lenth	KM		

2. Type of Waterway and Characteristic of Flow

Type of Waterway	Name	Observed Flood Level (m) *HFL and NFL can be determined from Altitude reading using related mobile apps, and water marks (if available)*				Width (m)	Flow Type (Mark ✓ mention)			
		Highest Flood Level (HFL)	Normal Flood Level (NFL)	Standard High Flood Level (SHFL)	Source of Information		Tidal	Non-Tidal	Flash Flood	Others (mention)
Redefined Channel										
Drainage Canal										
Navigable Canal										
Navigable River										
Non-Navigable River										
Hight of available Freeboard			meter	Bank to Bank width			meter			

3. Structure Type [(☒) Tick Mark Only]

Pipe Culvert (Dia >1.0m)		RCC Girder Bridge		Box Girder Bridge		Bailey Bridge		Truss with Steel Deck	
U-Drain		RCC Continuous Girder Bridge		PC Girder Bridge		Iron Bridge		Bailey with Steel Deck	
Box Culvert		Slab Bridge		Truss with RCC Slab		Hydraulic Structure		Others Type	
Slab Culvert		Arch Bridge		Steel Beam & RCC Slab		Suspension Bridge		Existing Gap	
OFC		Light Traffic Bridge		Arch Masonry		Wooden Bridge		Gap Length (m)	

4. Construction, Re-Construction and Maintenance History:

Construction		Re-Construction		Maintenance			
Year		Year		Year	Maintenance Type	Source of Found	Maintenance Cost
Cost (Lakh Taka)		Cost (Lakh Taka)					
Source of Fund		Source of Fund					

Design Information:

General				Design Traffic	
Design Load (Ton)		Design NFL		Traffic Volume (AADT)	
Design Method		Design HFL		Average Vehicle Width (m)	
Load Bearing Capacity		Design SHFL		Max Assessed Vehicle Load (Ton)	
Design Life					

5. Super-Structure Details [Numeric Value or (☒) Tick Mark Only]

Width (m)		Carriageway Width (m)		Sidewalk (L/S) (m)		Sidewalk (R/S) (m)	

Total No. of Span						
No. of Similar Span						
Length of Each Similar Span (m)						
Length of other Span (m)						
Total Length (m)						

No. of Girders in Each Span	
No. of Boxes in each Girder	
No. of Similar Girders	
Total No. of Girders	

No. of Slab in Each Span						
No. of Similar Slab in each Span						
Length of Each Similar Slab (m)						
Total No. of Slab						
Length of Each Similar Span (m)						

Wearing Course	
Nil	
Bitumen	
Concrete	
Bank to Bank Distance at Bridge Site (m)	

Types of Railing	Nil		RCC Railing (Bar & Post)		RCC Wall		Masonry		Steel		Composite		Other Information (If required)	
Tie/Hanger	Nil		Concrete		Steel		Wire		Bracing	Nil		Concrete		Steel	
Source of Electricity	N/A		REB		PDB		Solar		No. of Light Posts	Left Side		Right Side		

5a. Sub-Structure Details [(☒) Tick Mark Only]:

Description	RCC	Masonry	Steel	Weep Hole
Abutment/End Wall				
Wing Wall				
Pier/Intermediate Wall				

6b. Foundation Type [(☒) Tick Mark Only]:

Abutment	Footing		Piled		Well		Box		Others		Unknown	
Wing Wall	Footing		Piled		Well		Others		Unknown			
Pier	Footing		Piled		Well		Others		Unknown			
No. of Pile Known		Y		N								


Segments
Defects
Bridge Elements
Steel
Concrete
Others
Common
Corrosion
Crack in Steel
Loose or Missing Bolts
Fracture
Deterioration of Paint
Crack
Scaling/Spalling/Exposed Rebar
Water Seepage/ Efflorescence
Fallen out of Deck Slab
Cracking of Deck Slab
Delamination
Abnormal Spacing in Expan Joint
Difference in Level
Abnormal Bituminous Pavement
Functional Disorder of Bearing
Other Types (ie. Illegal Occupation/ Ilv. Plant Growth /c... Fire Damage)
Defects of Reinforcing Materials(or Rehabilitation /Strengthening)
Abnormal Anchorage
Deterioration / Deterioration of Materials
Water Leakage / Puddle
Abnormal Noise / Vibration
Abnormal Deflection
Deformation/Break of Structural Elements
Accumulation of Debris
Settlement/Tilt/movement
Scouring
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Super Structure (RC/PC Bridge)
Expansion-joint/Nosing/Sealing
Checker Plates, Nut-Bolts
Deck Slab (Top & Soffit) - 1
Deck Slab - 2
Deck Slab - 3
Deck Slab - 4
Main Girder/Beam - 1
Main Girder/Beam - 2
Main Girder/Beam - 3
Main Girder/Beam - 4
Main Girder/Beam - 5
Main Girder/Beam - 6
Cross Girder - 1
Cross Girder - 2
Cross Girder - 3
Box Girder
Arch
Hanger of Arch
Super Structure (Steel Truss Bridge)
Common
Stringer
Floor Beam
Checker Plates (Deck)
Bottom Bracing
Bottom Chord
Bolt
Connector
Vertical Panel
For Steel Truss
Vertical Post
Diagonal
Top Bracing
Strut
Top Chord
Bearings Assembly - 1
Hinges
Main Body of Bearings
Anchor Bolt
Seat Mortar
Bearings Assembly - 2
Hinges
Main Body of Bearings
Anchor Bolt
Seat Mortar
Sub-Structure
Abutment / End Wall - 1
Abutment / End Wall - 2
Wing Wall - 1
Wing Wall - 2
Wing Wall - 3
Wing Wall - 4
Top Slab of Box - 1
Top Slab of Box - 2
Top Slab of Box - 3
Top Slab of Box - 4

	Intermediate Wall -1																													
	Intermediate Wall -2																													
	Intermediate Wall -3																													
	Base/B-Slab - 1																													
	Base/B-Slab - 2																													
	Base/B-Slab - 3																													
	Base/B-Slab - 4																													
	Abutment Base/B-Slab - 2																													
	Pier Cap																													
	Pier																													
	Pile cum Pier																													
	Pier Column - 1																													
	Pier Column - 2																													
	Pier Column - 3																													
	Pier Column - 4																													
	Bracing of Pier																													
	Pile Cap																													
	Exposed Pile [If any]																													
	Projected Pile (If any)																													
	Well Foundation																													

10. Over-all Observation of the Structure by the Inspector [(tl) Tick Mark Only]: **Note**: L=Low; M=Medium; H=High; VH=Very High

Carriageway Width	Length of Structure	Traffic Volume				Condition of Super Structure				Condition of Sub Structure				Is Capacity Expansion Possible?? (Y/N)		Y	N
m	m	L	M	H	VH	G	F	P	S	G	F	P	S	One Side	Both Side	Another New Str.	

Replacement Essential.!! (Y/N)	Y	N
At Existing Site	Beside the Exist. Site	

11. Over-all Comments of the Inspector (If any):

tl	All tick marks as indicated in all specific boxes have completed with required details or dimensions.	Y	N
tl	Additional information and / or Sketches are given on separate page(s)	Y	N

Signature : ..... Date : .....

Name : ..... Name of the Organization: ..... Designation : .....

Appendix 1.3: Routine Inspection Report Form

Local Government Engineering Department

Bridge Routine Inspection Form

Date: ...../...../20

Inspected by (Name): ..... Designation: .....

Division: ..... District: ..... Upazila: ..... Road ID: ..... Road Name: .....
Construction Year: ..... Structure ID: ..... Chainage(m): ..... Load Restriction (Tons): .....
Latitude: ..... Longitude: ..... Altitude (if required): .....

2. Structure Type [√ Tick Mark Only]

☐ Box Culvert	☐ Box Girder Bridge	☐ Bailey bridge	☐ Iron Bridge	☐ Others
☐ Slab Vulvert	☐ Arch Bridge	☐ Bailey with Steel Deck	☐ Wooden Bridge	☐ Existing Gap
☐ arc	☐ Suspension Bridge	☐ Truss with RCC Slab	☐ Hydraulic Structure	☐ Gap Length (m)
☐ RCC Girder Bridge	☐ Light Traffic Bridge	☐ Truss with Steel Deck	☐ Pipe Culvert	☐ RCC Continuous
☐ PC Girder Bridge	☐ Steel Beam & RCC Slab	☐ Arch Masonry	☐ U-Drain	☐ Slab Bridge

Type of water way

☐ Open Field	☐ Navigable Canal	☐ Navigable River
☐ Drainage Canal	☐ River	☐ Others

Deck Surface

Pavement, Bridge Approaches

Difference in level

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Abnormal bituminous pavement

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Accumulation of debris

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Vegetation Growth

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Expansion Joints

Material defects

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Abnormal spacing

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Difference in level

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Water leakage/puddle

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Deformation/break

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Abnormal noise/vibration

Problem	Rectified	Maintenance Required	Inspection Required	Location and Comments
☐	☐	☐	☐	

Appendix 1.4: Periodic inspection Report Form

Local Government Engineering Department
Rural Bridge Information Management System (RuBIMS)
Bridge/Culvert Periodic Inspection Form

Inspected By (Name)		Inspection Date	
Designation		Organization	

Basic Inventory Data (Sl. 1 to 7)

1. Location:

Climate Region:

Division		District		Upazila	
Road ID		Road Name		Construction Year	
Structure ID		Chainage (m)		Load Restriction (Tons)	
Latitude		Longitude		Altitude (If required)	
Detour Road Available	Y / N	Detour Length	KM		

2. Type of Waterway and Characteristic of Flow

Type of Waterway	Name	Observed Flood Level (m) HFL and NFL can be determined from Altitude reading using related mobile apps, and water marks of structures				Width (m)	Flow Type (Mark ✓ insertion)			
		Highest Flood Level (HFL)	Normal Flood Level (NFL)	Standard High Flood Level (SHFL)	Source of Information		Tidal	Non-Tidal	Flash Flood	Others (mention)
Ill-defined Channel										
Drainage Canal										
Navigable Canal										
Navigable River										
Non-Navigable River										
Hight of available Freeboard			meter	Bank to Bank width			meter			

3. Structure Type [(☑) Tick Mark Only]

Pipe Culvert (Dia >1.0m)		RCC Girder Bridge		Box Girder Bridge		Bailey Bridge		Truss with Steel Deck	
U-Drain		RCC Continuous Girder Bridge		PC Girder Bridge		Iron Bridge		Bailey with Steel Deck	
Box Culvert		Slab Bridge		Truss with RCC Slab		Hydraulic Structure		Others Type	
Slab Culvert		Arch Bridge		Steel Beam & RCC Slab		Suspension Bridge		Existing Gap	
OFC		Light Traffic Bridge		Arch Masonry		Wooden Bridge		Gap Length (m)	

4. Construction, Re-Construction and Maintenance History:

Construction		Re-Construction		Maintenance			
Year		Year		Year	Maintenance Type	Source of Found	Maintenance Cost
Cost (Lakh Taka)		Cost (Lakh Taka)					
Source of Fund		Source of Fund					

Design Information:

General				Design Traffic	
Design Load (Ton)		Design NFL		Traffic Volume (AADT)	
Design Method		Design HFL		Average Vehicle Width (m)	
Load Bearing Capacity		Design SHFL		Max Assessed Vehicle Load (Ton)	
Design Life					

5. Super-Structure Details [Numeric Value or (☑) Tick Mark Only]

Width (m)		Carriageway Width (m)		Sidewalk (L/S) (m)		Sidewalk (R/S) (m)	

Total No. of Span						No. of Girders in Each Span			
No. of Similar Span						No. of Boxes in each Girder			
Length of Each Similar Span (m)						No. of Similar Girders			
Length of other Span (m)									
Total Length (m)						Total No. of Girders			

No. of Slab in Each Span						Wearing Course			
No. of Similar Slab in each Span						Nil			
Length of Each Similar Slab (m)						Bitumen			
Total No. of Slab						Concrete			
Length of Each Similar Span (m)						Bank to Bank Distance at Bridge Site (m)			

Types of Railing	Nil	RCC Railing (Bar & Post)	RCC Wall	Masonry	Steel	Composite	Other Information (If required)	
Tie/Hanger	Nil	Concrete	Steel	Wire		Bracing	Nil	Concrete	Steel
Source of Electricity	N/A	REB	PDB	Solar		No. of Light Posts	Left Side	Right Side	

6a. Sub-Structure Details [(☑) Tick Mark Only]:

Description	RCC	Masonry	Steel	Weep Hole
Abutment/End Wall				
Wing Wall				
Pier/Intermediate Wall				

6b. Foundation Type [(☑) Tick Mark Only]:

Abutment	Footing		Piled		Well		Box		Others		Unknown
Wing Wall	Footing		Piled		Well		Others		Unknown		
Pier	Footing		Piled		Well		Others		Unknown		
No. of Pile Known	Y		N								

Position of Abutment/Pier	Back App.	Pier 1	Pier 2							Pier n	Front App.	Total
No. of Column in Each Pier/Abut.												
No. of Piles in Each Pier/Abut.												

7a. Approach Information [Numeric Value or (0)] Tick Mark Only]

Approach Protection (B-App.)	Y	N	**Protection Type**	Brick Pala Wall		Brick Retaining Wall		RCC Retaining Wall		Toe Wall with CC Block		Toe Wall with Rip-Rap		Others		
Approach Protection (F-App.)	Y	N	**Protection Type**	Brick Pala Wall		Brick Retaining Wall		RCC Retaining Wall		Toe Wall with CC Block		Toe Wall with Rip-Rap		Others		
Approach Safety Barrier	Y	N	Safety Barrier Type			Concrete Post		Concrete Post & Metal W-Beam				Concrete Post & Rail Bar		Other Type		

Drainage System	Back Approach	Y	N	Front Approach	Y	N	**Outlet**	Back App.	Y	N	Front App.	Y	N	**Cut-off Wall**	Y	N	**Apron**	Y	N	

Approach Road	Y	N	**Material Type**	BC		RCC/CC		HBB		Uni-Block		**Earthen**		**Req. Length of Approach Road (m)**	Back Approach		Front Approach	

Approach Slab	Y	N

7b. Protection Work Information [Numeric Value or (0)] Tick Mark Only]

Non- Structural Elements	Protective works of Abt./Pier						Other River Training Works				
Location	Back Abt.	Pier 1	Pier 2	Pier 3	Pier n	Front Abt.	Back Abt. U/S	Back Abt. D/S	Front Abt. U/S	Front Abt. D/S	Other

Inspection Conditions Data (Sl. 8 to 11)

8. Overall Visual Observation on Condition of Non-Structural Elements [Write **NENR/G/F/P/NER/S/B** Only] **NENR**: Not Exist & Not Required.

NER: Not Exist but Required. **Note**: G=Good (No Maintenance Required); F=Fair (Minor Maintenance); P=Poor (Major/Re-hab.); S=Severe (Re-Construction); B=Blocked.

Non- Structural Elements	Lighting Facilities [G/F/P/S/B]		Embankment Slopes of Approach Roads [G/F/P/S/B]		Pavement of approaches [G/F/P/NER/S]		Wearing course [G/F/P/S]	Wheel guard, Walkway, median [NENR/G/F/P/NER/S]		Rail Bar, Rail Post [G/F/P/NER/S/B]		Safety Barriers [NENR/G/F/P/NER/S]	
Location	Left Side	Right Side	Back App.	Front App.	Back App.	Front App.	Deck Top	Left Side	Right Side	Left Side	Right Side	Back App.	Front App.
Condition													

Overall Visual Observation on Condition of Longitudinal Slope of Approach Road

Note: G=Good (Flat, Slope is 0%); F=Fair (Slope is less than 3%); P=Poor (Slope is more than 3% but less than 5%.); S=Severe (Slope is more than 5%); B= Approach Road is partially Blocked.

Non- Structural Elements	Longitudinal Slopes of Approach Roads [G/F/P/S/B]	
Location	Back App.	Front App.
Condition		

Elements	Conditions of Protective works										
Non- Structural Elements	Protective works of Abt./Pier [NENR/G/F/P/NER/S/B]						Other River Training Works [G/F/P/S]				
Location	Back Abt.	Pier 1	Pier 2	Pier 3	Pier n	Front Abt.	Back Abt. U/S	Back Abt. D/S	Front Abt. U/S	Front Abt. D/S	Other
Condition											

Elements	Surface Condition		Condition of Painting					Condition of water drainage and Waterways					
Non-Structural Elements	Surface of Wing Wall and Abutment Walls [G/F/P/S]		Guide Post, Traffic Sign, Road Marking, Electric Post [NENR/G/F/P/NER/S]		Railing, Rail Posts, Wheel Guard [NENR/G/F/P/NER/S]		Steel members of Truss & Bailey bridges [NENR/G/F/P/NER/S]	Deck Slab, Top Slab of Box, Drainage Ducts & Drainspouts [G/F/P/S]	Surface of Abutment, End wall, Intermediate wall & Wing Wall, Weep Holes, Drain outlet [G/F/P/S]		Water flow of Khadi River in Culverts [G/F/P/S/B]		River/Canal/Water Ways [G/F/P/S/B]	
Location	Back App.	Front App.	Back App.	Front App.	Left Side	Right Side	Above Deck	Above Deck/Slab	Back App.	Front App.	Inside of Structure		Up Stream	D/ Stream
Condition														

Comments on Approach Road Right of Way Availability: Is there sufficient land available on both approach for Capacity expansion of the Bridge if required?

9. Observation of Individual Component of Structure [For each defect please rate 1 to 9 depending on the extent of the defect] **Note**: Rating 1 - Not Appear (No significant defect); 2 - Satisfactory (Slight (not more than 5% of surface area of concerned Member/Element); 3 - Fair (Not Wide (6%-20% of surface area of concerned Member/Element); 4 - Moderate (Moderately Wide (21%-35% of surface area of concerned Member/Element); 6 - Poor (Wide (36%-60% of surface area of concerned Member/Element); 6 - Severe (Severe (61%-69% of surface area of concerned Member/Element); 7 - Critical (Extensive (61%-70% of surface area of concerned Member/Element); 8 - Immediate Failure (Almost Failed (More than 70% of surface area of concerned Member/Element) and 9 - Non-Functional (The element is non-functional/failed). 16 Other Types of Defects 16.a Illegal Occupation/Hab. Plant Growth/16.c Fire Damage/16.d Missing of Sealing material/16.e Bird's Waste etc.

Segments		Bridge Elements \ Defects	Steel: Corrosion	Steel: Crack in Steel	Steel: Loose or Missing Bolts	Steel: Fracture	Steel: Deterioration of Paint	Concrete: Crack	Concrete: Scaling/Spalling/Exposed Rebar	Concrete: Water Seepage/ Efflorescence	Concrete: Fallen out of Deck Slab	Concrete: Cracking of Deck Slab	Concrete: Delamination	Others: Abnormal Spacing in Expan. Joint	Others: Difference in Level	Others: Abnormal Bituminous Pavement	Others: Functional Disorder of Bearing	Others: Other Types (i.e. Illegal Occupation & Plant Growth /C Fire Damage)	Common: Defects of Reinforcing Material for Rehabilitation /Strengthening	Common: Abnormal Anchorage	Common: Discoloration / Deterioration of Materials	Common: Water Leakage / Ponding	Common: Abnormal Noise / Vibration	Common: Abnormal Deflection	Common: Deformation/Breakage of Structure Elements	Common: Accumulation of Debris	Common: Settlement / Movement	Common: Scouring
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Super Structure (RCC/PSC Bridge)		Expansion joint/Nosing/Sealing																										
		Checker Plates, Nut Bolts																										
		Deck Slab (Top & Soffit) -1																										
		Deck Slab - 2																										
		Deck Slab - 3																										
		Deck Slab - 4																										
		Main Girder/Beam - 1																										
		Main Girder/Beam - 2																										
		Main Girder/Beam - 3																										
		Main Girder/Beam - 4																										
		Main Girder/Beam - 5																										
		Main Girder/Beam - 6																										
		Cross-Girder - 1																										
		Cross-Girder - 2																										
		Cross-Girder - 3																										
		Box Girder																										
		Arch																										
		Hinges of Arch																										
Super Structure (Steel / Truss/Baily)	Common	Stringer																										
		Floor Beam																										
		Checker Plates (Deck)																										
		Bottom Bracing																										
		Bottom Chord																										
	Baily	Connector																										
		Vertical Panel																										
	For Steel Truss	Vertical Post																										
		Diagonal																										
		Top Bracing																										
		Strut																										
		Top Chord																										
Bearings Assembly - 1		Hinges																										
		Main Body of Bearings																										
		Anchor Bolt																										
		Seat Mortar																										
Bearings Assembly - 2		Hinges																										
		Main Body of Bearings																										
		Anchor Bolt																										
		Seat Mortar																										
Sub-Structure		Abutment / End Wall - 1																										
		Abutment / End Wall - 2																										
		Wing Wall - 1																										
		Wing Wall - 2																										
		Wing Wall - 3																										
		Wing Wall - 4																										
		Top Slab of Box - 1																										
		Top Slab of Box - 2																										
		Top Slab of Box - 3																										
		Top Slab of Box - 4																										

	Intermediate Wall -1																													
	Intermediate Wall -2																													
	Intermediate Wall -3																													
	Base/S-Slab - 1																													
	Base/S-Slab - 2																													
	Base/S-Slab - 3																													
	Base/S-Slab - 4																													
	Abutment Base/S-Slab - 2																													
	Pier Cap																													
	Pier																													
	Pile cum Pier																													
	Pier Column - 1																													
	Pier Column - 2																													
	Pier Column - 3																													
	Pier Column - 4																													
	Bracing of Pier																													
	Pile Cap																													
	Exposed Pile (If any)																													
	Projected Pile (If any)																													
	Well Foundation																													

10. Over-all Observation of the Structure by the Inspector | (Ø| Tick Mark Only): **Note:** L=Low; M=Medium; H=High; VH=Very High

Carriageway Width	Length of Structure	Traffic Volume				Condition of Super Structure				Condition of Sub Structure				Is Capacity Expansion Possible??? (Y/N)		Y	N
m	m	L	M	H	VH	G	F	P	S	G	F	P	S	One Side	Both Side	Another New Str.	

Replacement/ Essential !! (Y/N)	Y	N
At Existing Site	Beside the Exist. Site	

11. Over-all Comments of the Inspector (If any):

Ø	All tick marks as indicated in all specific boxes have completed with required details or dimensions.	Y	N
Ø	Additional Information and / or Sketches are given on separate page(s).	Y	N

Signature : ..... Date : .....

Name : ..... Name of the Organization: ..... Designation : .....

Appendix 1.5: Bridge Evaluation and Priority Score Report (Sample from RuBIMS)

Local Government Engineering Department

Rural Bridge Information Management System(RuBIMS)

Bridge/Culvert Inspection Report

Inspected By (Name): **insp6.dscl.bagerhat** Designation: Inspection Date: **18-06-2025**

Basic Information:

Division: **KHULNA** District: **BAGERHAT** Upazila: **BAGERHAT-S**

Road ID: **201082086** Road Name: **Jattrapur GC (At Chapatala)-Bakherganj bazar RHD via Baburhat.**

Structure Code: **201082086036** Construction Year: **2002** Chainage (m): **9000**

Load Restriction (tons): **0** Structure Type: **RCC Girder Bridge**

Fund Source: **CARE** Latitude: **22.719729620437637** Longitude: **89.82726708064543**

Inspection Result:

Govern Damage Degree: **DD-56** Govern Condition State: **CS-2**

Sub str. Damage Degree: **DD-32.64** Sub str. CS: **CS-2**

Super str. Damage Degree: **DD-68** Super str. CS: **CS-2**

Non str. Damage Degree: **DD-20** Non str. CS: **CS1**

Waterway Information:

Waterway Name: **Unknown** Watertype Type: **Canal** Flow Type: **Perennial**

Salinity: **Moderate** Width(m): **21.2** Flood Level(m): **0**

Design Information:

Design Load (Ton): - Design Method: - Load Bearing Capacity: -

Super Structure Information:

Width (m): **4.93** Carriageway Width (m): **3.6** Bracing: **Nil**

Wearing Course: **Bitumen** Source of Electricity: **REB** Bank To Bank Distance(m): **21.2**

Sidewalk (L/S) (m): **0.49** Sidewalk (R/S) (m): **0.49** Railing Type: **RCC Railing [Bar & Post]**

NO. of Light Poels (L/S): **0** NO. of Light Poels (R/S): **0** Tie/Hanger: **Nil**

Total No Of Span: **1** No Of Similar Span(m): **1** No Of Slab Each Span: **1**

Total Length(m): **17.35** Length of Each Similar Span(m): **17.35** No of Similar Slab in Span: **1**

Length Of Each Similar Slab(m): **17.35** Total No Of Slab: **1** No Of Girder in Each Span: **0**

Total No Of Girder:**0** No Of Similar Girder:**0**

Super Structure:

Element	CRACKS(6)	SCALL/SPALL/EXPOSEDREBAR(7)	WATERSEEPAGE(8)	FALLENOUT(9)	CRACKINGOFDECKSLAB(10)	DELAMINATION(11)	ABNORMALSPACING(12)	OTHER(IDENTIFYDETECK(16)	DEFECTSOFREINFORCEMENT(17)	ABNORMALVIBHORARGE(18)	DISCOLORATION(19)	WATERLEAKAGE(20)	ABNORMALNOISE(21)	ABNORMALDEFLECTION(22)	DEFORMATION(23)
Cross Beam/C 1	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 ../0
Deck Slab Soffit-1	0 0	6 0.2sqm 	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 ../0
Deck Slab Top-1	0 0	0 0	0 0	0 0	0 0	0 0	0 0	4 0.25sqm 	0 0	0 0	0 0	0 0	0 0	0 0	0 ../0
Diaphrag 1	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 ../0
Diaphrag 2	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 ../0
Main Girder/B 1	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 ../0
Main Girder/B 2	0 0	6 0.1sqm 	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 ../0

Sub Structure:

butment/End Wall: **RCC** Wing Wall: **RCC** Pier/Intermediate Wall: **N/A**

Element	CRACKS(6)	SCALL/SPALL/EXPOSE(7)	WATERSEEPAGE(8)	DELAMINATION(11)	OTHER(10/PG/DETCK(16)	DEFECTS/DREINFORCEMENT(17)	DISCOLORATION(19)	WATERLEAKAGE(22)	DEFORMATION(23)	SETTLEMENT(25)	SCOURING(26)
Abutment-1	0 0	4 1.07sqm 	0 0	0 0	4 3sqm 	0 0	0 0	0 0	0 0	0 0	0 0
Abutment-2	0 0	4 1.2sqm 	0 0	0 0	4 0.4sqm 	0 0	0 0	0 0	0 0	0 0	0 0
Wing Wall-1	0 0	3 0.5sqm 	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Wing Wall-2	0 0	0 0	0 0	0 0	4 2.5sqm 	0 0	0 0	0 0	0 0	0 0	0 0
Wing Wall-3	0 0	4 0.65sqm 	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Wing Wall-4	0 0	0 0	0 0	0 0	4 3sqm 	0 0	0 0	0 0	0 0	0 0	0 0

Non Structure:

Non Structural Elements	Lighting Facilities		Embankment Slopes of Approach Roads		Pavement of approaches		Wearing course	Wheel Guard,Walkway,Media		Rail bar,Rail Post		Guide Post,Traffic Sign,Electric Post	
Location	Left Side	Right Side	Back App.	Front App.	Back App.	Front App.	Deck Top	Left Side	Right Side	Left Side	Right Side	Back App.	Front App.
Condition	NENR	NENR	G	G	G	G	G	P	P	S	P	NENR	NENR

Elements	Exp. Joint	Skin Wall	Condition of Protective Works								Longitudinal Slopes of Approach Roads	
Non-Structural Elements			Protective works of Abt/Pier			Other River Trainning Works						
Location			Back Abt	Pier	Front Abt	Back Abt. U/S	Back Abt. D/S	Front Abt. U/S	Front Abt. D/S	Other	Back	Front
Condition	G	NENR	NENR		NENR	NENR	NENR	NENR	NENR	NENR	G	G

Elements	Surface Condition		Condition Of Painting					Condition Of Drainage and WaterWays				
Non-Structural Elements	Surface of Wingwall and Abutment Wall		Guide Post,Traffic sign,Road Marking,Electric Post		Railing,Rail Post,Wheel Guard		Steel Member of Truss and Bailey Bridge	Deck Slab,Top Slab of Box Bargas Ducts & D-Spouts	Surface Of Abutment End Wall,Intermediate Wall,Wing Wall,Weep Holes,Drain Outlet		Water Flow of Slab/Box/Pipe Culvert	River/ Cannel Waterways	
Location	Back	Front	Back	Front	Left Side	Right	Above	Above	Back	Front	Inside Of	UP	D-Stream
Condition	F	F	NENR	NENR	NER	NER	NENR	NENR	NENR	NENR	G	G	G

Bearing:

Bearing Type	Rating

Aproach Information

Rail Bar,Rail Post(Left):Yes

Rail Bar,Rail Post(Right):Yes

Wearing Course(Deck Top):Yes

Protection Type:No

Outlet (B/A):No

Outlet (P/A):No

Gallery:

Super Structure

Top view

Super Structure

Bottom view-1

Super Structure

Bottom view-2

Sub Structure

left view

Non Structure

Railing

Sub Structure

Right view

Over-All Coments of the Inspector(If any):

Bridge Damage Description: This bridge overall condition is functional, need some maintainance for soffit of deck slab and Non-structure item raining.

Inspection Other Information

Next Inspection Date: June, 2026

Need Detailed Investigation?

Replace/Expansion Possibility

Replacement Essential

Replacement Possible

Capacity Expansion Possible

At Existing Site

Beside the Existing Site

One Side

Both Side

Another New Sructure

Signature:

Name:

Organization:

Designation:

Date:

Appendix-2

Sample Defect Photos and Corresponding Condition State

1 Corrosion

Condition State	Photos	Damage Expression
CS1 (No Maintenance)		Corrosion is superficial and no significant plate thickness reduction is found Corroded area is not wide and local (Area<50%)
CS1 (Minor Maintenance)		Corrosion is superficial and no significant plate thickness reduction is found Corroded area is widely spread or multiple corroded places (Area≧50%)
CS2 (Major Maintenance)		Significant Expansion on steel plate surface or significant plate thickness reduction is found Corroded area is not wide and local (Area<50%)

Condition State	Photos	Damage Expression
CS3 (Rehabilitation)	 	Significant Expansion on steel plate surface or significant plate thickness reduction is found Corroded area is widely spread or multiple corroded places (Area≧50%)

2 Crack in Steel

Condition State	Photos	Damage Expression
CS1 (Minor Maintenance)		Coating cracking and crack are occurred but unlikely to reach immediately main member even if it progressed
CS2 (Major Repair)		Obvious crack is occurred in except main member and there is a possibility that trouble in function of structure will occur if it progressed.

Condition State	Photos	Damage Expression
CS3 (Rehabilitation)	  	Obvious crack is occurred in main member (specific part)

3 Loose or Missing Bolts

Condition State	Photos	Damage Expression
CS1 (Minor Maintenance)		Loosing or missing Bolts, less than 5% of a bolts group e.g. 1 / 42 = 2.3%

Condition State	Photos	Damage Expression
CS2 (Major Maintenance)		Loosing or missing Bolts, more than 5% of a bolts group e.g. 1/ 8 = 12.5%
CS3 (Rehabilitation)		Loosing or missing Bolts, more than 30% of a bolts group e.g. 2 / 3 = 66.7%

4 Fracture

Condition State	Photos	Damage Expression
CS2 (Major Maintenance)		Fracture of Sway Bracing (Secondary member) Fracture of Railing Fracture of Expansion Joint

Condition State	Photos	Damage Expression
CS4 **(Replacement of the Component)**	 	Fracture of Cross Beam Fracture of Vertical member of Arch

5 Deterioration of Paint

a) Paint system, b) Plating, Metal Spraying

Condition State	Photos	Damage Expression
CS1 **(No Maintenance)**		Outer coat is discolored, or partial peeling is found
CS1 **(Minor Maintenance)**		Protective paint layer is peeled and undercoat is exposed

Condition State	Photos	Damage Expression
CS3 (Major Maintenance)		Protective paint layers are widely deteriorated (Area≧50%), and spot corrosion is spread

c) Weathering Steel

Condition State	Photos	Damage Expression
CS1 (No Maintenance)		Rough particle of corroded metal with the scale of 1-5mm

Condition State	Photos	Damage Expression
CS1 **(Minor Maintenance)**		Scaly rust of protecting layer with the scale of 5-25mm
CS2 **(Major Maintenance)**		The corroded protecting layers are multiply delaminated partially
CS3 **(Rehabilitation by Replacing the Component)**	 	The corroded protecting layers are multiply delaminated widely (Area≧50%)

6 Crack

a) Superstructure (RC, PC structure)

Condition State	Photos	Damage Expression
CS1 (No Maintenance)		Span center: Pattern 2) Crack width is small Crack spacing is large
CS1 (Minor Maintenance)	 	Span center: Pattern 1) Crack width is medium Crack spacing is large Support point: Pattern 8) Crack width is medium Crack spacing is large
CS2 (Major Maintenance)	 	Other type: Pattern 12) Crack width is large Crack spacing is large Support point: Pattern 19) Crack width is large Crack spacing is large

CS4 **(Replacement of the Girder)**		Remarkable crack has occurred at a position leading to collapse of bridge

b) Substructure

Condition State	Photos	Damage Expression
CS1 **(No Maintenance)**		T-shaped pier: Pattern 7) Crack width is small Crack spacing is large
CS2 **(Major Maintenance)**	 	T-shaped pier: Pattern 4) Crack width is large Crack spacing is large Overall abutment: pattern 2) Crack width is large Crack spacing is large

CS2 **(Major Maintenance)**	 	Rigid-frame pier: Pattern 9) Crack width is large Crack spacing is small Overall abutment: pattern 4) Crack width is large Crack spacing is small
CS4 **(Replacement)**		Remarkable crack has occurred at a position leading to collapse of bridge

7 Spalling / Exposed Rebar

Condition State	Photos	Damage Expression
CS1 (No Maint.)		Spalling is small area and no exposed rebar
CS2 (Major Maintenance)	 	Spalling is small area, and minor corrosion of rebar
CS3 (Rehabilitation)	 	Spalling is large area, and significant corrosion of rebar

8 Water Leakage / Efflorescence

Condition State	Photos	Damage Expression
CS1 **(No Maintenance)**		Presence of water leakage from concrete crack Little rust stain or efflorescence is found (Small area)
CS2 **(Major Maintenance)**	 	Presence of water leakage from concrete crack Little rust stain or efflorescence is found (Large area)
CS3 **(Rehabilitation)**	 	Presence of significant water leakage from concrete crack Significant rust stain or efflorescence is found

9 Fallen out of Deck Slab

Condition State	Photos	Damage Expression
CS4 **(Replacement)**	  	Presence of fallen of deck slab

10 Crack of Deck Slab

Condition State	Photos	Damage Expression
CS1 **(No Repair)**		Small crack (no moisture)

Condition State	Photos	Damage Expression
CS2 (Major Maint.)		Two-dimensional crack with lime moisture
CS2 (Major Maint.)	 	Severe two-dimensional crack with heavy moisture severe two-dimensional crack with heavy moisture
CS4 (Replacement)		just before the fall out of deck

11 Delamination

Evaluation Category	Photos	Damage Expression
CS2 (Major Maint.)	  	Presence of delamination

12 Abnormal Spacing

Condition State	Photos	Damage Expression
CS2 **(Minor Repair)**	 	Abnormal spacing including no adequate transverse spacing
CS3 **(Major Repair)**	  	The contact of both girder and chest wall (no space) No spacing of expansion joint Abnormal spacing that the comb of expansion joint is separated, too large spacing of expansion joint

13 Difference in Level

Condition State	Photos	Damage Expression
CS2 **(Major Maint.)**		Difference in traffic direction <20mm
CS2 **(Major Maint.)**	 	Difference in traffic direction 30mm> Difference ≧20mm
CS4 **(Replacement)**		Difference in traffic direction ≧30mm

14 Abnormal Bituminous Pavement

Condition State	Photos	Damage Expression
CS1 **(Minor Maint.)**		Minor defect such as pavement crack (width, w < 5mm)
CS1 **(Minor Maint.)**	 	Pothole Depth 30 - 50mm, and dent with a diameter of less than 20cm
CS1 **(Minor Maint.)**	 	Major defect such as pavement crack (width, w ≧ 5mm) Dent with a diameter more than 20cm

15 Functional Disorder of Bearing

Condition State	Photos	Damage Expression
CS2 (Major Maint.)		Spalling and exposed rebar of bearing bed concrete It is not difficult to attain functional recovery
CS3 (Rehabilitation)	 	Bearing function has remarkably decreased Significant corrosion Crack in rubber bearing
CS4 (Replacement)	 	There is a risk of the girder fall off

16 Other Types of Defects

Condition State	Photos	Damage Expression
CS2 (Major Maint.)		Illegal Occupation Bird's Waste Missing of Sealing material Collapses of embankments
CS2 (Major Maint.)		Fire damage without fear of strength reduction
CS4 (Replacement)		Fire damage having fear of strength reduction

17 Defects of Reinforcing Material for Rehabilitation / Strengthening

Condition State	Photos	Damage Expression
CS2 (Major Maint.)	 	Minor defect of Fiber Minor defect of Steel Plate for strengthening
CS2 (Major Maint.)	 	Severe water leakage from the strengthened concrete member Peeling of paint system

18 Abnormal Anchorage

Condition State	Photos	Damage Expression
CS2 (Major Maint.)	 	Cracking of concrete Rust fluid from anchor
CS3 (Rehabilitation)	 	Significant deficiency Cable breakage Cable breakage (fly out of a cable)

19 Discoloration / Deterioration of Materials

Condition State	Photos	Damage Expression
CS1 (Minor Maint.)	 	Discoloration / Deterioration is locally (Area<50%) Discoloration of Steel Deck Deterioration of sealing of Exp joint
CS1 (Minor Repair)	  	Discoloration / Deterioration is spread widely (Area≧50%) Discoloration of Main beams Discoloration of Abutment Discoloration of rubber bearing

20 Water Leakage / Puddle

Condition State	Photos	Damage Expression
CS1 (Minor Maint.)	 	Water leakage from drainage Puddle on pavement
CS2 (Major Maint.)	  	Water leakage from Exp joint Puddle at bearing area Puddle at inside girder

22 Abnormal Deflection

Condition State	Photos	Damage Expression
CS2 (Major Maint.)	 	Abnormal deflection is identified at center hinge of Prestressed Concrete Girder. (attention of stiffness fall down) Abnormal deflection is identified at span center of Prestressed Concrete Box girder. (attention of stiffness fall down)
CS4 (Replacement)	 	Severe abnormal deflection Severe abnormal deflection

23 Deformation / Break

Condition State	Photos	Damage Expression
CS2 (Major Maint.)	 	Local deformation / break is identified or partial missing of member
CS3 (Rehabilitation)	 	Deformation / break has occurred in the member of less effect to the load-bearing capacity
CS4 (Replacement)	 	Deformation has occurred in the member of significant effect to the main member or the load-bearing capacity Break has occurred in the member of significant effect to the main member (steel deck)

24 Accumulation of Debris

Condition State	Photos	Damage Expression
CS1 (Minor Maint.)	    	Accumulation of debris is found

25 Settlement / Tilt / Movement

Condition State	Photos	Damage Expression

CS2 **(Major Maint.)**	 	Support of bearings or foundation undergo settlement Substructure tilting / moving by the lateral flow
CS3 **(Rehabilitation)**		Substructure tilting / moving significantly by the lateral flow
CS4 **(Replacemnt)**		Support of bearings or foundation undergo severe settlement

26 Scouring

Evaluation Category	Photos	Damage Expression

CS2 **(Major Maint.)**		Minor scouring of foundation
CS3 **(Rehabilitation)**	  	Significant scouring Exposure of the upper surface of footing (Spread foundation) Exposure of top of caisson foundation Exposure of the footing underside (Pile foundation)
CS4 **(Emergency Rehabilitation/ Replacement)**	 	Exposure of the footing underside (Spread foundation) Largely exposure of the footing underside (Pile foundation)