MINISTRY OF PUBLIC
WORKS AND TRANSPORT

General Directorate of Techniques
Road Infrastructure Department

Maintenance Expert Training Program

Bridge Inventory and Maintenance Office Phnom Penh

Table of Contents

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Part 1

ME Training Plan

Concept Paper on "Maintenance Expert Program"

1. Background
   - According to 2000Bridge Inspection results, 5% of the bridges are considered as SD Bridge (Seriously Damaged Bridges). Most of SD Bridges are wooden and Bailey or very poor old RC bridge, while these still maintain important links especially in local area. The bridges apart from SD bridges are considered as fair or good condition but regular inspection to find damage in early stage is important to reduce maintenance cost in long span.
   - Conduction of bridge maintenance works including inspection are still very limited because of limited number of experts in the ministry. Also a standard methodology (guideline) has not yet been prepared. It is highly important to increase number of experts on bridge maintenance
   - The Bridge Maintenance Expert Program is a mechanism of training and certification. By setting such program within the ministry, it is expected to make more visualize the MPWT's efforts towards bridge maintenance to Ministry of Finance as well as to the public.
   - In near future, maintenance of mega-bridges are to be critical social issues in Cambodia, this program can be expanded to such bridges requires specific technological approach.

2. Role of Maintenance Expert
   a Planning Support: Bridge inspection, preparation of maintenance plan, Database management, Technical judgement and proposition in the MOPM (Maintenance Operation Periodic Meeting)
   b Emergency Support: Providing technical support to the emergence bridge damage
   c Local Support: Providing technical support to DPWTs.

3. Mechanism
   a Setting training course
   b Certificate ME by the ministry
   c The program to be opened to private sectors in future (to make as requirement to apply for bridge maintenance projects)

4. Category of ME

Table 1 Category of Maintenance Expert (ME)

ME	Bridge ME		Road ME	
Code	BI(Bridge Inspection)	BR(Bridge Repair)	RI(Road Inspection)	RR (Road Repair)
Subject of ME	Bridge Inspection	Bridge Repair	Road Inspection	Road Repair
Competences	Bridge inspection Bridge database	Standard bridge repair	DRIMS Visual inspection	Standard road repair
Manual to be used	Bridge Inspection Manual	Bridge Repair Manual	Guidelines for Routine Maintenance Using IRI	Guidelines for Repairing Defects of Roads

Road and Bridge Maintenance Expert (ME) (Draft)

（Objective）

Article 1 This is created for better and sustainable maintenance for road and bridges under MPWT. This is to set a training program for education of Maintenance Experts in charge of road and bridges which contribute to raise the status of the engineers, providing clear requirement for maintenance work and improve quality of maintenance of road and bridges.

（Requirement of ME applicants）

Article 2 ME applicants need to meet requirement mentioned below;

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（Category of ME）

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ME Master	Identification of bridge damage, judgement of severity, ranking evaluation and recommendation for repair method
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（Certification and examination）

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2. Execution of ME system is under the responsibility of MPWT－Road Infrastructure Department.

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Article 5 MPWT set "Committee for certification of Road and Bridge Maintenance Expert" within MPWT.

2. Secretary of the committee is set in MPWT－Road Infrastructure Department.

（Issue of certificate）

Article 6 MPWT (or RID) issue certificate to ME.

（Others）

Article 7 Any items requires to be specified may be issued separately in other form.

（Application）

This order is applied from **

BRIDGE MAINTENANCE EXPERT TRAINING CURRICULUM: (Bridge Inspection) BI

Day	Training Topics	Remarks	Instructor
Day 1 (Lecture)	Outline of Bridge ME(1H)	9AM-10AM	Master Trainer (Supporting Tsukamoto)
	Chapter 1:- Introduction (2H)	10AM～12AM	
	At the end of this topic the participants should be able to: 1. Explain Purpose of Bridge Maintenance 2. Explain Process of Bridge Maintenance 3. Explain Glossary about parts of Bridge	Lecture	
	Chapter 2: - Organization for Bridge Maintenance (2H)	2PM-4PM	Master Trainer (Supporting Tsukamoto)
	At the end of this topic the participants should be able to: 1. Explain Jurisdiction of Bridge Maintenance 2. Explain Schedule of Bridge Maintenance	Lecture	
Day 2 (Lecture)	Chapter 3:- General Requirement for Bridge Inspections (2H)	9AM-11PM	Master Trainer (Supporting Tsukamoto)
	At the end of this topic the participants should be able to: 1. Understand Classification of inspection and, Plan Inspection (Routine Inspection, Periodic Inspection A, Periodic Inspection B, Emergency Inspection) 2. Understand safety at Inspection 3. Understand typical damages on Concrete Bridge 4. Understand typical damages on Steel Bridge	Lecture	
	Chapter 4:- Bridge Inspection Recording (2H)	2PM-4PM	Master Trainer (Supporting Tsukamoto)
	At the end of this topic the participants should be able to: 1. Understand how to use ipad system 2. Input Inspection data into ipad system	Lecture	
	Examination: (1H)	4PM-5PM	
	Writing test about Bridge Maintenance Purpose, Jurisdiction, Glossary, Typical damage on bridge, ipad system	Writing test	
Day 3 (Field)	Field Training -2(Instruction & Practice) (3H) (Departing MPWT at 6:30AM, Arriving MPWT at 1PM by 2 JICA car)	8:00-11:00	Master Trainer (Supporting Tsukamoto)
	At the end of this topic the participants should be able to: 1. Understand inspection and safety equipment 2. Inspect bridge 3. Input inspection data into ipad system 4. Inspect bridge with safety	Instruction Practice	
	Examination: (1H)	11:00-12:00	
	Field test about Bridge Inspection	Field Test	

BRIDGE MAINTENANCE EXPERT TRAINING CURRICULUM: (Bridge Repair) BR

Day	Training Topics		Remarks	Instructor
Day 1 (Lecture)	Outline of ME		9AM-10AM	Master Trainer (Supporting Tsukamoto)
	CHAPTER 1 Introduction	・The importance of maintenance ・Concept of Preventive Maintenance ・Glossary of bridge, damage		
	CHAPTER 2 Organization for bridge repair	・Bridge repair Schedule ・Jurisdiction of Bridge repair	10AM～12AM	
	CHAPTER 3 Safety and maintenance work	・For keeping safety repair work ・Confirmation before repair work ・Confirmation during repair work ・Routine maintenance		
	CHAPTER 4 Maintenance room and Basic knowledge of concrete	・Maintenance Room ・Knowledge of Concrete Material ・Damages due to construction failures (Concrete) ・Concrete Work ・Concrete quality verification test		
	CHAPTER 5 Repair of concrete structure	・Planning of Concrete structure repair ・Introduction of Concrete structure repair		
	Bridge Repair through Pilot Project	Crack Sealing	2PM -3PM	
		Carbon Fiber Reinforcing Plastics	3PM -4PM	
	At the end of this topic the participants should be able to: 1. Explain Purpose of Bridge Maintenance 2. Explain Process of Bridge Maintenance 3. Explain Glossary about parts of Bridge		Lecture	

BRIDGE MAINTENANCE EXPERT TRAINING CURRICULUM: (Road Inspection) RI

Introduction:

Routine road maintenance cycle using IRI (International Roughness Index) has been established in Cambodia in 2016. Accordingly, Maintenance Expert (ME) system has been introduced for improvement of road maintenance management capacities of MPWT/DPWT officials. As a part of the capacity improvement, a 3-day training program for road inspections has been formulated. The training focuses on IRI-measurement-based road inspection and subsequent data sorting.

Objective:

In order for trainees to master a series of IRI-measurement-based road inspection, subsequent data sorting, and data storage procedure through the training program

Program:

Day	Time	Activities	Reference*
Day1		**[Lecture]**	
	9:00-9:25	1.1 Routine road maintenance system using IRI	Guide-2: P.1-23
	9:35-9:50	1.2 Outline of DRIMS* operation (instructions for checklist)	Guide-1: P.1-5,45-46
	10:00-10:25	1.3 Basic operation of DRIMS	Guide-1: P.15-21
	10:30-10:50	1.4 Hump Calibration	Guide-1: P.24-28
		[DRIMS operation (with trainer's instructions)]	
	11:00-11:15	1.4 Instruction for checklist application (for 1-5, 1-6)	Guide-1: P. 46
	Lunch break & move to hump calibration site		
	14:00-14:30	1.5 Installation of DRIMS equipment into vehicles	Guide-1: P.2, 12-14
	14:30-16:00	1.6 Hump calibration at site	Guide-1: P.24-28
Day2		**[DRIMS operation (with trainer's instructions)]**	
	9:00-9:15	2.1 Instruction for checklist application (for 2-2, 2-3)	Guide-1: P.46
	9:15-9:45	2.2 Installation of DRIMS equipment into vehicles	Guide-1: P.2, 12-14
	9:45-11:45	2.3 IRI measurement	Guide-1: P.30-32
	Lunch break		
		[Lecture]	
	13:00-13:30	2.4 Analysis for IRI estimation & data storage in database	Guide-1: P.33-40
		[DRIMS operation (with trainer's instructions)]	
	13:40-14:10	2.5 Analysis for IRI estimation	Guide-1: P.33-40
	14:20-15:30	2.6 Preparation of inspection outputs & data storage in database	Guide-1: P.41-44
Day3		**[DRIMS operation (without trainer's instructions)]**	
	9:00-9:30	3.1 Installation of DRIMS equipment into vehicles	Guide-1: P.2, 12-14
	9:40-10:40	3.2 IRI measurement	Guide-1: P.30-32
	10:50-11:50	3.3 Analysis for IRI estimation	Guide-1: P.33-40
	Lunch break		
	13:00-14:10	3-4 Preparation of inspection outputs & data storage in database	Guide-1: P.41-44
		[Lecture]	
	14:20-14:50	3.5 Instructions for reviewing inspection results	Guide-2: P.23-37
	15:00-15:15	3.6 Recommendation & trouble shooting	Guide-1: 16, 20, 29, 31,32

*DRIMS: Dynamic Response Intelligence Monitoring System

*Guide-1: Guideline for Operation of Dynamic Response Intelligent Monitoring System (DRIMS)

*Guide-2: Guideline for Routine Maintenance Using IRI

BRIDGE MAINTENANCE EXPERT TRAINING CURRICULUM: (Road Repair) RR

Day	Training Topics		Remarks	Instructor
Day 1 (Lecture)	Outline of ME		9AM-10AM	Master Trainer
		·		
	CHAPTER 1 Introduction and Outline of Guideline	· Importance of Maintenance · Effect of Road Roughness on Vehicle Operation Cost · Purpose of Guideline for Repair of Road Defect	10AM～12AM	
	CHAPTER 2 Job Codes	· Explanation of major job codes		
	CHAPTER 4 Guideline Road Marking	· Explanation of major job codes	2PM-4PM	
	Test	·	4PM-5PM	
	At the end of this topic the participants should be able to: 1. Explain Purpose of Road Maintenance 2. Explain Process of Road Maintenance			

Part 2

ME Training Material

Maintenance Expert Program (ME)

Maintenance Expert (ME)

* This is created for better and sustainable maintenance for road and bridges under MPWT.
* This is to set a training program for education of Maintenance Experts in charge of road and bridges which contribute to raise the status of the engineers, providing clear requirement for maintenance work and improve quality of maintenance of road and bridges.

ME Training Program

ME	Bridge ME		Road ME	
Subject of ME	Bridge Inspection	Bridge Repair	Road Inspection	Road Repair
Competences	Bridge inspection Bridge database	Standard bridge repair	DRIMS Visual inspection	Standard road repair
Manual to be used	Bridge Inspection Manual	Bridge Repair Manual	Guidelines for Routine Maintenance Using IRI	Guidelines for Repairing Defects of Roads
Number of days	3 days	1 day	3 days	1 day
Remark	1 day for field training	Lecture only	Theory and field training	Lecture only

Bridge ME : Bridge Inspection

Contents	Key Concepts
CHAPTER 1 Introduction	・The importance of maintenance ・Concept of Preventive Maintenance ・Glossary of bridge, damage
CHAPTER 2 Organization for bridge repair	・Bridge repair Schedule ・Jurisdiction of Bridge repair
CHAPTER 3 General Requirement for Bridge Inspections	・Preparation before Inspection ・Consideration for safety work ・Classification of inspection ・Inspection Record ・Inspection Methods ・General view points for bridge inspection ・Inspection evaluation

Bridge ME : Bridge Inspection

Contents	Key Concepts
CHAPTER 4 Bridge Inspection Recording	・How to use Bridge Inspection Database System ・Hot to send input data
CHAPTER 5 Non-Destructive Testing	・Non-Destructive Tests
Field Training -1 （Instruction）	
Examination （Writing test & Field test）	

Bridge ME: Bridge Repair

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CHAPTER 1 Introduction	・The importance of maintenance ・Concept of Preventive Maintenance ・Glossary of bridge, damage
CHAPTER 2 Organization for bridge repair	・Bridge repair Schedule ・Jurisdiction of Bridge repair
CHAPTER 3 Safety and maintenance work	・For keeping safety repair work ・Confirmation before repair work ・Confirmation during repair work ・Routine maintenance

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CHAPTER 4 Maintenance room and Basic knowledge of concrete	・Maintenance Room ・Knowledge of Concrete Material ・Damages due to construction failures (Concrete) ・Concrete Work ・Concrete quality verification test
CHAPTER 5 Repair of concrete structure	・Planning of Concrete structure repair ・Introduction of Concrete structure repair
CHAPTER 6 Repair of steel structure	・Planning of Steel structure repair ・Introduction of Steel structure repair
CHAPTER 7 Repair of foundation or other structure	・Introduction of foundation or other structure

Road ME: Road Inspection

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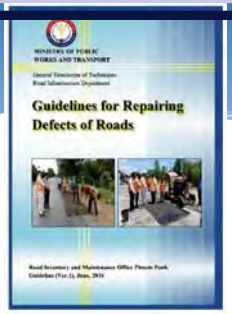
Examination	• Writing test

Road ME: Road Repair



Part 2

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Maintenance Expert Program

Bridge Inspection

ME-BI
Lecture Material

ME Training Program

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TRAINING CURRICULUM FOR BRIDGE MAINTENANCE EXPERT

Based on Bridge Maintenance Manual

* Chapter 1:- Introduction
* Chapter 2: - Organization for Bridge Maintenance
* Chapter 3:- General Requirement for Bridge Inspections
* Chapter 4:- Bridge Inspection Recording
* Field Training -1 （Instruction）
* Examination （Writing test & Field test）

5

Day 1

Keynote Lecture

Why and How should bridges require maintenance.

* Purpose of Bridge Maintenance
* Types of defect in bridges
* Cause of defect
* Critical damage

6

Day 1

Chapter 1:- Introduction

* Purpose of Bridge Maintenance
* Process of Bridge Maintenance
* Glossary

Chapter 2: - Organization for Bridge Maintenance

* Jurisdiction
* Schedule of Bridge Maintenance

7

Day 2

Keynote Lecture by JICA Expert

Introduction of Japanese Bridge Maintenance.

8

Day 2

Chapter 3:- General Requirement for Bridge Inspections

* Scope of Bridge Inspection
* Inspection and Typical damage of Concrete Bridges
* Inspection and Typical damage of Steel Bridges
* Diagnosis of Inspection results

9

Day 2

Chapter 4:- Bridge Inspection Recording

* Input Results of Bridge Inspection into iPad

Examination:- Writing Test

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Day 3

Field Training

* Instruction to Officials by Master Trainers
* Points of Inspection
* Visual Inspection
* Hammering Test
* Inspection with equipment
* Practice of Inspection by Officials

Examination:- Field Test

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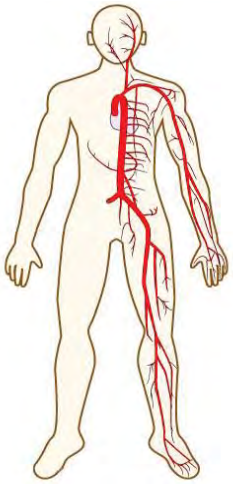
Chapter 1:- Introduction

Road Infrastructure = Human body



Blood vessel = Road
Nutrient, Oxygen = Goods

2

Regular Inspection, Early Repair

■Regular Inspection
■Early Treatment
(Early Repair)

■No Inspection
■Belated Treatment

3

Road Maintenance & Human Health Care Cycle

Regular physical examination

Monitoring

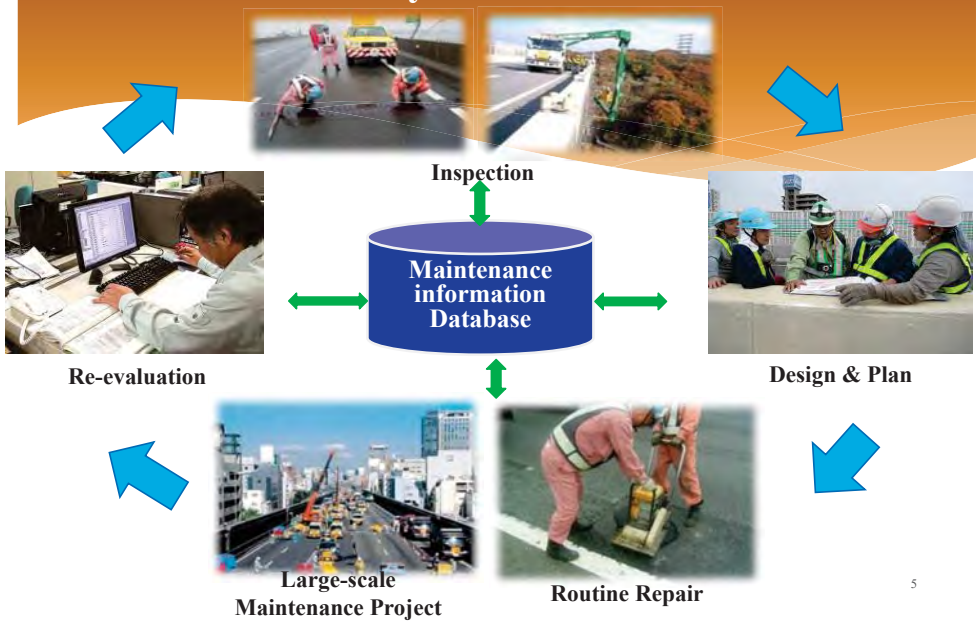
Electronic Clinical Records

Diagnosis

Surgical operation

4

Road Maintenance Cycle



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Mianus River Bridge

Federal Highway Administration HP

Mianus River Bridge (June, 1983, collapsed)

■The collapse was caused by a hangar pin connection fatigue.

6

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Cambodian Bailey Bridge

Referenced by Phnom Penh Post HP.

Bailey Bridge in Kampot province (10th, June, 2016, collapsed)

■The collapse was caused by overloaded vehicle.

7

Cambodian Bridge

Some bridges have serious defects.

8

Objectives of Bridge Inspection

1) To confirm the results of bridge condition;
2) To confirm As-built Drawings and design documents;
3) 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;

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Objectives of Bridge Inspection

4) To determine the cause/mechanisms of damage;
5) To assess the current bridge structural condition, behavior and load capacity;
6) To assess severity of deterioration and residual life expectancy;
7) To evaluate the need for repair and rehabilitation;
8) To investigate the damage for estimating repair cost.

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Objectives of Bridge Inspection

* **The objective of this manual** is to describe and to introduce **the standard inspection** of defects commonly found in bridges **maintained by MPWT** (Ministry of Public Work and Transport) **and DPWT** (Department of Public Work and Transport).

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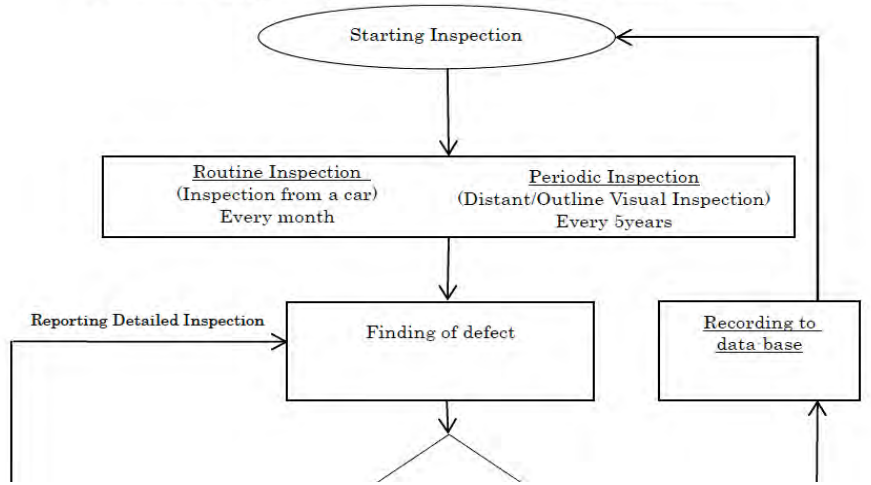
Process of Maintenance Operation

Process of Bridge Inspection and Planning for Maintenance



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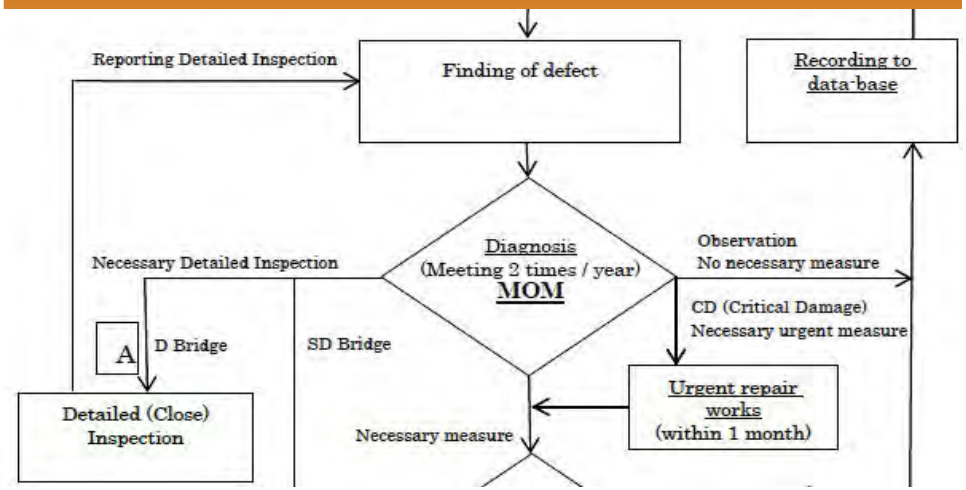
Process of Maintenance Operation



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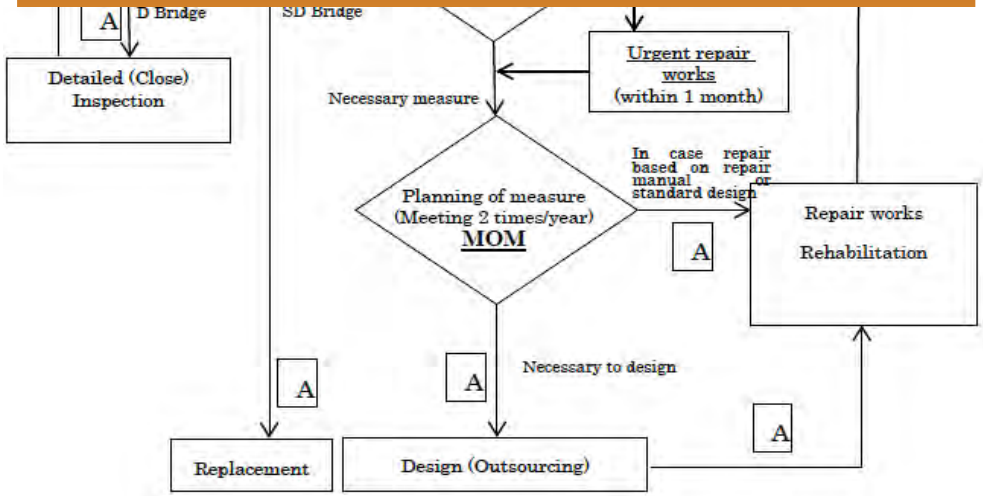
Process of Maintenance Operation



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A Method of Follow-up Inspection

Situation of Defect	Method of Inspection
In case possible to see progression of defect by distant/outline visual inspection	Distant/Outline Visual Inspection
In case impossible to see progression of defect by distant/outline inspection	Close/Detailed Visual Inspection

Situation of Defect	Frequency of Inspection
Damage influence to safety for third party	1 time / month
Damage influence to soundness of structure	1 time / 3 months
Others	1 time / year

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Routine and Periodic Inspection

1) Review of any previous inspection reports;
2) Determination and provision of equipment and resources required for the inspection including preparation of a safety plan;
3) To supplement the visual inspection, implementation of bridge inspection including measurements, testing and analysis if necessary.

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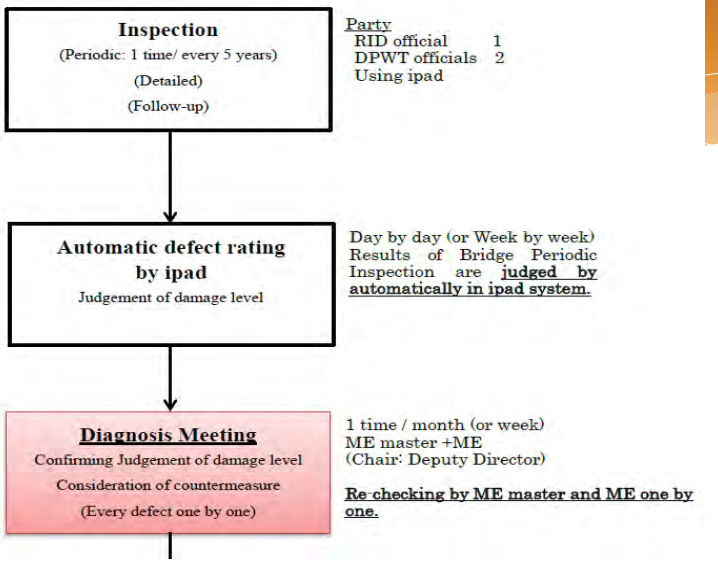
Diagnosis of inspection results flow



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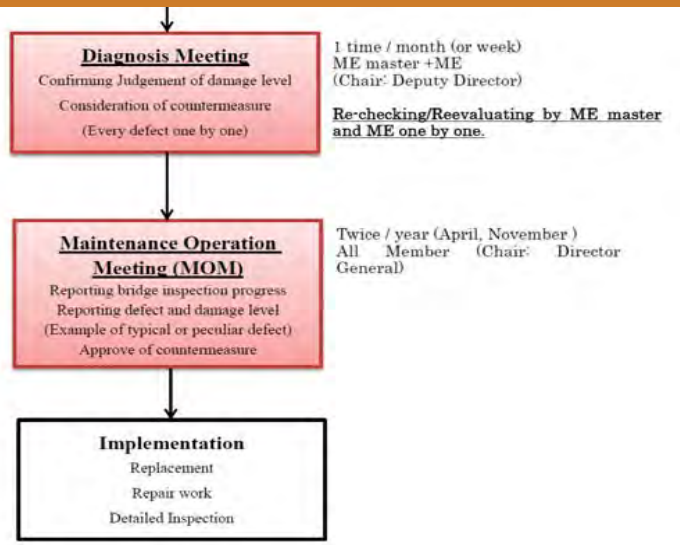
Diagnosis of inspection results flow



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Diagnosis Meeting

Purpose

* **Re-checking results of inspection by ME master and ME one by one.**
* Confirming Judgement of damage level
* Consideration of countermeasure
  (Every defect one by one)

Frequency

* 1 time / month (or week)

Member

* ME master +ME (Chair: Deputy Director)

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Maintenance Operation Meeting (MOM)

Purpose

* Reporting bridge inspection progress
* Reporting defect and damage level
  (Example of typical or peculiar defect)
* Approve of countermeasure

Frequency

* 2 time / year (April. November)

Member

* All members (Chair: Director General)

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Glossaries

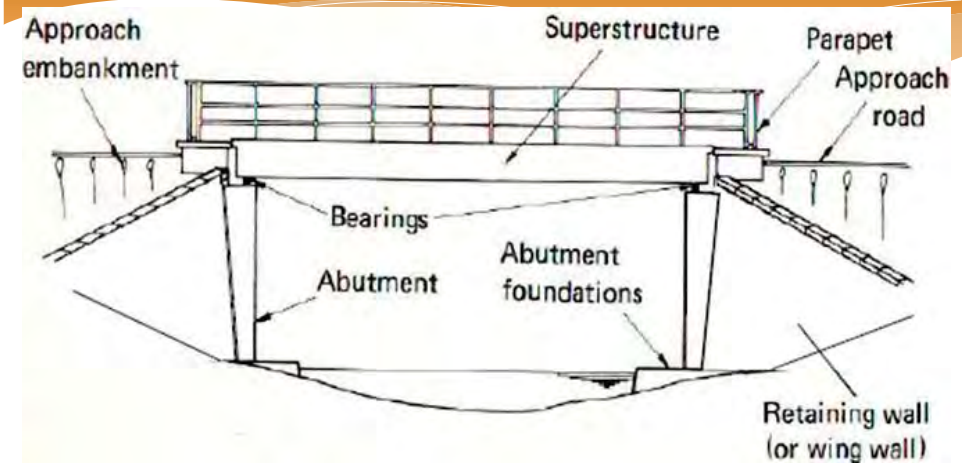

Fig. 1.3.1 Single Span Bridge

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Glossaries

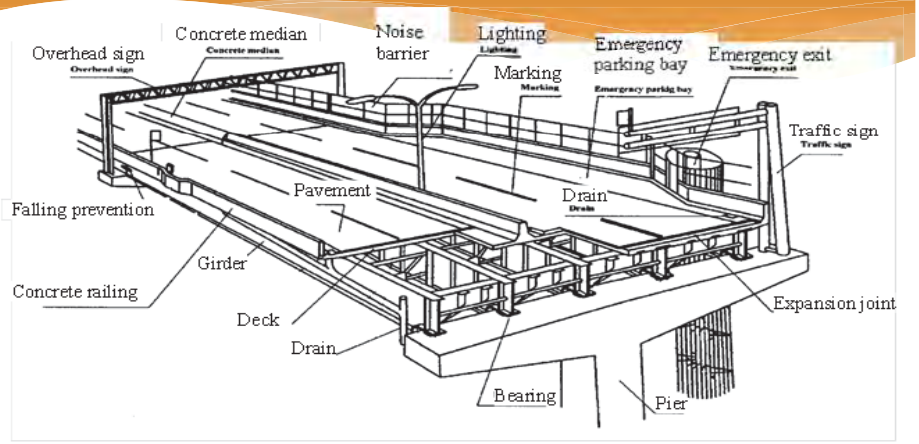

Fig. 1.3.2 Glossary of Bridge Structure

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Glossaries

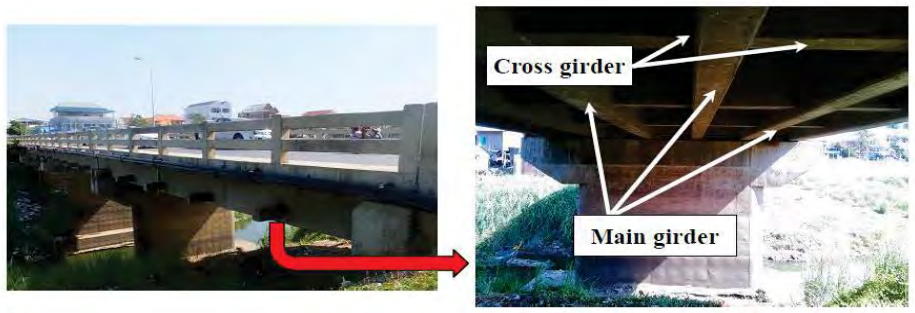

Photo 1.3.1 Glossary of Girder

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Glossaries

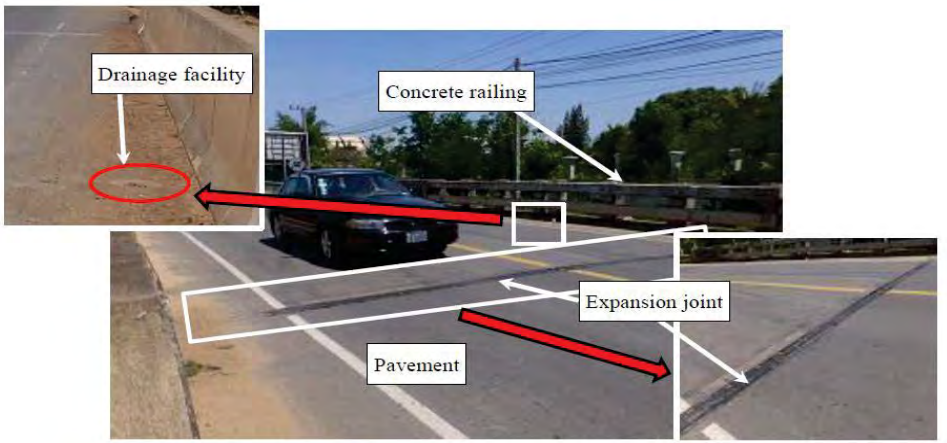

Photo 1.3.2 Glossary of superstructure (On surface)

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Bridge Types

(a) Category by material

1) **Steel bridge**: Bridge mainly made by steel

2) **Reinforced concrete (RC) bridge**:
Bridge mainly made by reinforced concrete

3) **Pre-stressed concrete (PC) bridge** : Bridge mainly made by pre-stressed concrete

25

Bridge Types

(b) Category by structural feature

1) **Girder bridge**

I-shaped steel and H-shaped steel are most commonly used for steel bridge and called as "Plate girder bridge"

26

Bridge Types

(b) Category by structural feature

2) **Concrete deck bridge**

Concrete deck bridge is applied for relatively short-span bridges.

Bridge Types

(b) Category by structural feature

3) **Bailey Bridge**

Bailey bridge is a type of portable, pre-fabricated, truss bridge. A "through" type of steel Deck Girder; the roadway is being carried between the two main girders. The main girders are formed from modular elements 3m long pinned together end to end for quick assembly.

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Bridge Types

(b) Category by structural feature

4) **Cable stayed bridge**

Cable stayed bridge applies pre-stress to continuous girder by cable set up from tower of center pier. Compressive force to the girder and tensile force to the cable are equilibrant on the sides of tower. This type of bridge is economical for bridge span of up to 400m.

29

Bridge Types

(b) Category by structural feature

5) **Truss bridge**

Truss bridge is a frame structure with members set in triangle-geometry and connected each with pins. Truss bridge employs the truss as main structure. Mechanical feature is that truss member considered exerting only compression or tension of axle force.

30

Bridge Types

(b) Category by structural feature

6) **Arch bridge**

Arch structure supports both sides of girder or truss beam with chamber rigidly. Arch rib is principal structural member resists for compressive axle force and bending moment. Bridge structure which mainly resists force horizontally called as "Arch bridge".

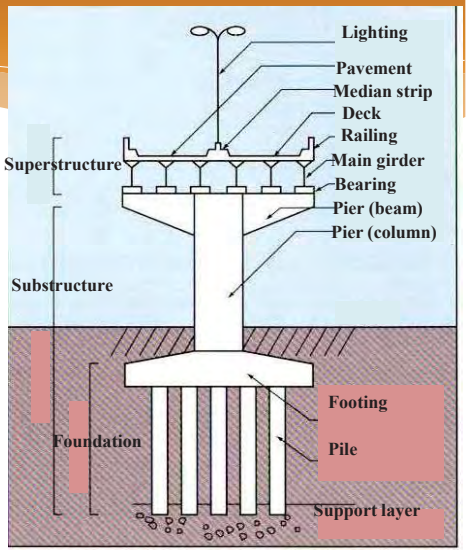
31

Configuration of bridges

(a)Superstructure and substructure

Superstructure is a main part of the bridge comprises deck/floor and girder/beam.

Substructure supports superstructure and transmits its load to the ground. It comprises abutment, pier and foundation.



Configuration of bridges

(b)Bearing

Generally, bearing intermediates connection of bridge girder and pier. Bearings sustain vertical load such as dead load or live load of bridge and lateral load due to wind or earthquake.

33

Configuration of bridges

(c)Deck plate and floor system

Deck plate is one of the component of superstructure which sustains vehicle load directly and transmits it to girder directly or through floor system.

34

Configuration of bridges

(d)Lateral bracing and sway bracing

Each girder is connected with truss structure such as lateral bracing in lateral direction and sway bracing in section. Lateral bracing resists force due to wind or earthquake and sway bracing avoids sectional deformation.

35

Configuration of bridges

(e)Road furniture

Drainage facility

In order to lead rainwater on the bridge to ground drainage pipe, drainage pits are set properly on the surface of bridge. Rainwater is induced from drainage pit to ground along girder and pier with polyvinyl chloride drainage pipe.

36

Configuration of bridges

(e) Road furniture
Expansion joint

Expansion joint allows displacement of girder due to temperature change and keeps flatness of road surface.

In addition, it has a function as drainage of rain water.

Definition of terminology

<Damage level>

SD (Bridge): Serious damaged (bridge)

D (Bridge): Damaged (bridge)

<Method of Inspection>

Visual Inspection: Bridge inspection using binocular from distance

Hands-on Inspection: Bridge inspection by touching and hammering

Definition of terminology

<Type of Inspection>

Routine Inspection: Checking (Pavement, Railing, Drainage system) by car or on foot

Periodic Inspection: Afar inspection by using binocular (As well as 2,000 Bridges Survey)

Detailed Inspection: Closed inspection to get detail information of damage and bridge by considering the result of periodic inspection

Follow-up Inspection: Follow-up inspection for the damage by considering the result of periodic inspection

Emergency Inspection: Bridge inspection after emergency occurrence (Ex. Traffic accident or disaster)

Definition of terminology

<Type of Countermeasure>

Replace: Reconstructing the bridge after removing

Repair works: Repair, Retrofit, Rehabilitate the bridge

Urgent (Emergency) Repair Works:
Repair work to prevent accident for third party

Bridges to be reconstructed

Reconstruction of bridges should be determined in considering to following condition;

1) Damage condition (According to inspection result)

* SD bridge (Necessary to define criteria of SD / D bridge clearly)

2) Function failure

* Inadequate width
* Ineptitude lane
* Problem around river bank or quay

3) Bridge Type (temporary bridges)

* Bailey bridge
* Wooden bridge

41

Detailed Inspection

Inspection method

* Whole parts of bridge should be inspected (Not only damaged part)
* Necessary to inspect by on-hand ex. hammering
* Crack width check > about 0.3mm

Observation (re-inspection in 5 years)

* Bridges which replacement is in plan
* Allowable damage was confirmed by visual inspection
* Hands-on inspection was conducted at periodic inspection (Ex. Low clearance bridge)

42

Objectives of Detailed Inspection

* To get scale or degree of damage situation
* To get information of damage progress
* To judge necessity of repair work
* To select repair method
* To estimate repair work cost for budgeting

43

Check point of Detailed Inspection

* Defect point of the bridge part
* Defect size, degree,
* Checking by touching and hammering
* Comparing present result with past result
* Measuring crack length and width

44

Urgent (Emergency) Repair Works

* Damage influence to safety for third party or soundness of structure (Ex. Hole on slab deck, Broken steel member, etc)

* The damage shall be repaired urgently within 1 month or another countermeasure shall be taken (Ex. Closure of bridge)

45

Sample of SD Bridge

Impossible to pass

46

Sample of SD Bridge

Serious structural defect on concrete slab deck

47

Sample of SD Bridge

Serious structural defect on concrete girder (Shear crack)

48

Sample of SD Bridge

Serious structural defect on steel slab deck
(Fatigue crack)

49

Sample of SD Bridge

Serious structural defect
on main girder or truss girder
(Fatigue crack)

50

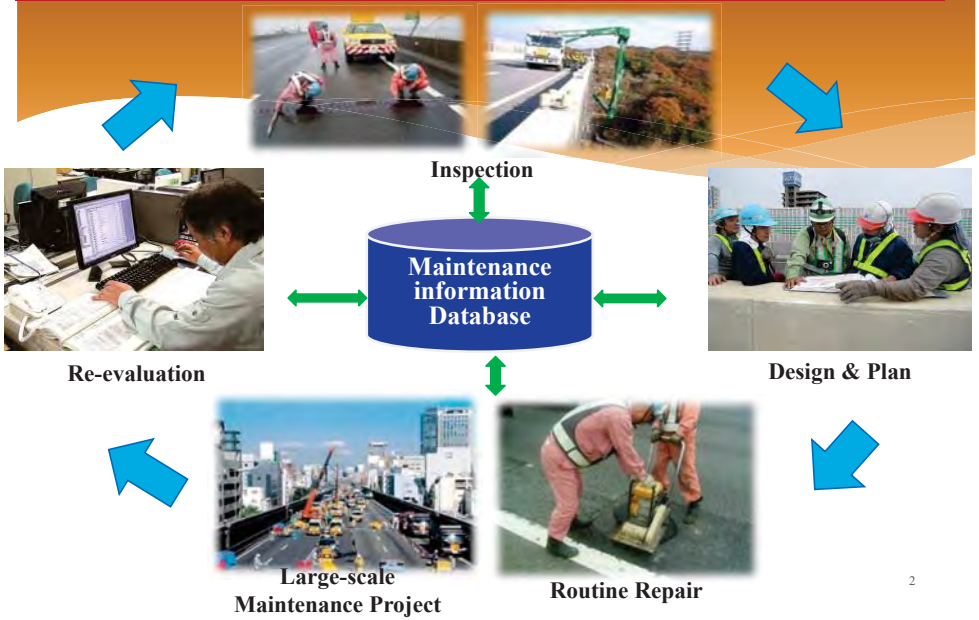
Sample of SD Bridge

Abutment or pier unstable by scouring
(Settled due to back filled soil
washed out by scouring)

51

Chapter 2: ORGANINATION FOR BRIDGE MAINTENANCE

Road Maintenance Cycle



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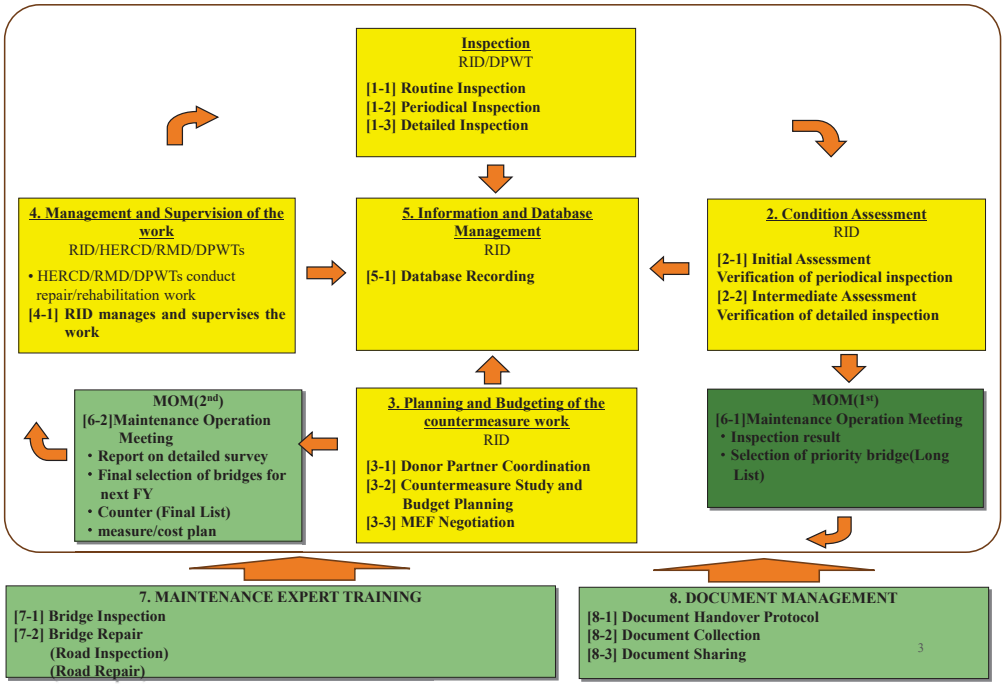

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Action plan

1. Bridge Inspection

Action to take

- **[1-1] Routine Inspection**: Conducting Routine Inspection of bridges along with road inspection.
- **[1-2] Periodic Inspection:** Conducting Periodic Inspection of selected bridges of the year (inspect all bridges through 5 years (= approximately 450 bridges per year)
- **[1-3] Detailed Inspection:** The detailed bridge inspection is to be conducted for the selected bridges from Periodic Inspection result in the 1st MOM. (approximately 5 to 10 bridges)
- Database update: sending data to server

Implementer

- RID Bridge Inspection Team
- Support from DPWT

4

Action plan

2. Condition Assessment

Action to take

* **[2-1] Initial Assessment:** Review and evaluation of the periodic inspection result. The evaluation result will be verified in 1st MOM. Prepare long list.
* **[2-2] Intermediate Assessment:** Assessment of detailed survey result. Select priority bridge to prepare short list.
* Prepare result to 2nd MOM

Implementer

* RID
* ME

5

Action plan

3. Planning and budgeting

Action to take

* **[3-1] Donor Partner Coordination:** Coordination with donor fund project and reflect to short list.
* **[3-2] Counter measure study and budget plan:** Study counter measure based on the detailed survey and prepare budget plan. Prepare the Final List.
* **[3-3] MEF Negotiation :** with MEF for the select target bridges for next fiscal year (FY 2018) using inspection result.

Implementer

* RID
* ME
* DPWT

6

Action plan

4. Management and Supervision

Action to take

* **[4-1] Supervision of Works:** Supervision of the work by DPWT

Implementer

* RID
* ME
* DPWT

7

Action plan

5. Information and Database Management

Action to take

* **[5-1] Record the inspection result into the database**

- Update of database
- Provision of data to DPWTs

Implementer

* RID
* ME

8

Action plan

6. Maintenance Operation Meeting (MOM)

* Draft ordinance is attached in **Appendix 2**

Action to take

* **[6-1] 1st MOM**
* - Inspection result
* - Selection of priority bridge (Long List)
* **[6-2] 2nd MOM**
* - Report on detailed survey
* - Final selection of bridges for next FY(Final List)
* - Counter measure/cost plan

Action plan

* **[6-3] Monitoring Meeting**
* - Verification of intermediate assessment
* - Donor partner coordination
* - Preparation of Short List

Implementer

* RID
* ME
* (DPWT)

Action plan

7. Maintenance Expert Training

* Concept Paper is in **Appendix 3**.

Action to take

* **[7-1] Maintenance Expert Training for Bridge:**
* To conduct training of Maintenance Expert to RID and DPWT officials on the bridge maintenance
* **[7-2] Maintenance Expert Training for Road:**
* To conduct training of Maintenance Expert to RID and DPWT officials on the road maintenance
* Training of Master Trainers

Implementer

* RID
* ME
* DPWT

Action plan

8. Document Management

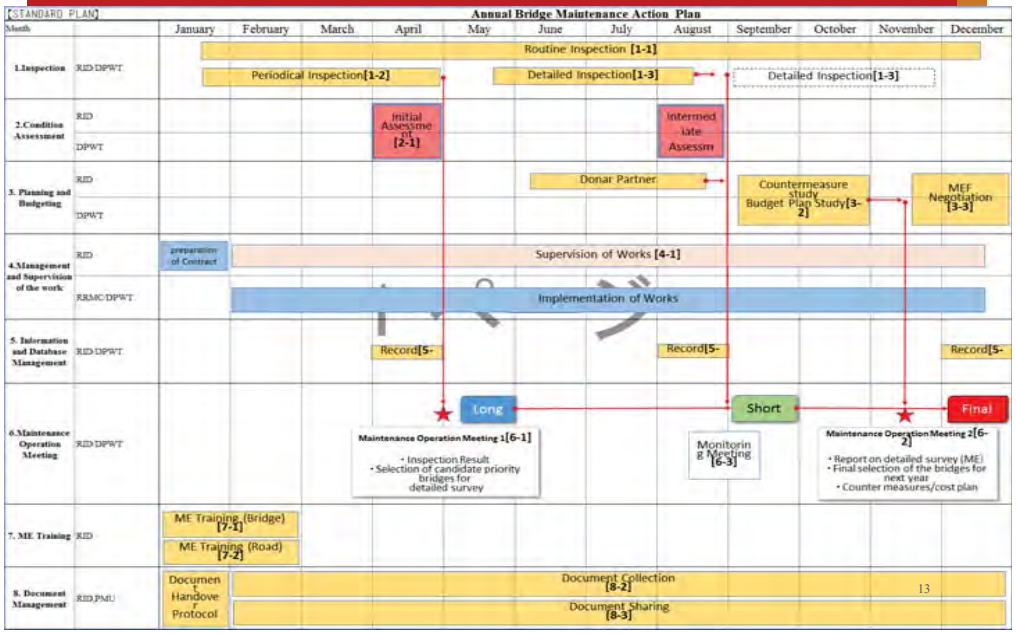
Action to taka

* **[8-1] Document Handover Protocol**
* Creation of the protocol for handover the document at handover of the completed project to RID for maintenance
* **[8-2] Document Collection**
* Rehabilitation of the library database created in 2012
* Collection of the contract documents of past project, especially donor fund projects
* **[8-3] Document Sharing**
* Share the list of collected documents to RID and DPWT etc.,

Implementer

* PMU, other department implemented the construction
* RID

Annual action plan for bridge maintenance



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Required Task	DPWT	HERCD/RMD	RID	Remarks
1. Inspection				
(1) Planning inspection	Discuss the plan with RID		Planning inspection (Type, Area, methodology, Cost, etc.)	(January)
(2) Conduct inspection -Initial inspection -Routine inspection -Periodic inspection -Emergency inspection	Conducts inspection		Conducts inspection and support DPWT	RID/DPWT conduct inspection. From Mar. to Dec.
(3)Record inspection data			-Collect the inspection data (bridge data, location, defects, other info.) -Save data to Database	

Required Task	DPWT	HERCD/RMD	RID	Remarks
2. Condition Assessment				
(1) Preparation			-Collect inspection data from Database	
(2) Primary Assessment	Implement primary assessment supported by RID	Assist RID's support	Implement primary assess with DPWT	DPWT/RID implement primary assessment by using inspection data.
(3) Final Assessment	Discussion with RID for determine counter measure(s)	Discussion with RID for determine counter measure(s)	Maintenance Expert (ME) implement final assessment and draft counter measure(s)	4 times/ year Once/every quarter

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30

Required Task	DPWT	HERCD/RMD	RID	Remarks
3. Planning and Budgeting of the Countermeasure(s)				
(1) Preparation			- Collect inspection data from Database -Select SD, D ranked bridge	
(2) Planning countermeasure(s)		Support RID's study	Study the state of the structure and draft countermeasure(s) to recover the function of the SD, D bridges	
(3) Cost estimation			Estimate the rough cost of the countermeasure(s)	Through MOM Twice a year
(4) Get approval from high class officials in MPWT		Support RID's submission	Submit the draft counter-measure(s) and rough cost to get approval of high class officials through the meeting in MPWT	
(5) Budgeting			Prepare budgeting document to submit MEF and arrange budget meeting with MEF Negotiate with MEF for budgeting	

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Required Task	DPWT	HERCD/RMD	RID	Remarks
4. Management and Supervision of the Work				
(1) Preparation			-Prepare tendering documents	
(2) Repair work etc.	Implement field works	HERCD: Implement rehabilitation works RMD: Implement repair and maintenance works	Supervise the works	(Under discussion for the demarcation among them) (170428 RID) In case of difficult and high tech. work, HERCD/RMD supports DPWT
(3) Collect the data of the works	Submit the data to Bridge G, RID	Submit the data to Bridge G, RID	Bridge G, RID collects the data and check them. (After checking them, the data are submit to Database G, RID	

Required Task	DPWT	HERCD/RMD	RID	Remarks
5. Information and Database Management				
(1) Database management			Database G, RID is in charge of Database management such as collect, check, save(update) of the data	
(2) Public relation			Database G, RID plans the RID's public relation through selecting targets, making the publication material	

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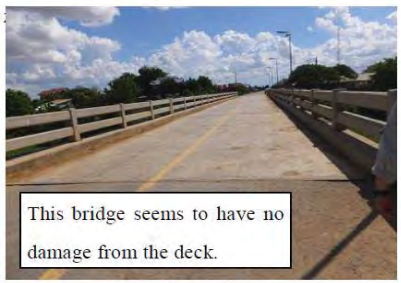
Chapter 3: General Requirement for Bridge Inspections

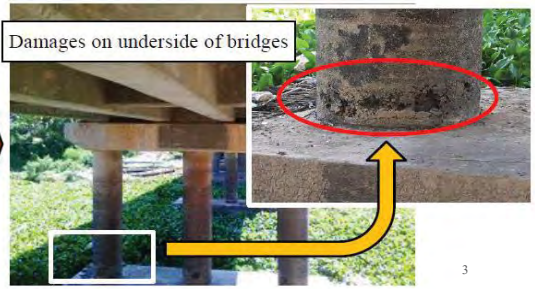
Outline

Hands-on inspection (including close visual inspection and hammering) is the principal method

Outline

In addition, the inspection shall not be limited to bridge's topside but cover also its underside because serious damages are often hidden there.





Scope of Bridge Inspection

* The bridge inspection is a detailed investigation and evaluation of damage and/or material properties of specified elements.
* The damage may be due to environmental impact (climate, saline soil, etc.), wear (insufficient maintenance), design and construction errors and overloading or similar conditions.

Scope of Bridge Inspection

The scope of the bridge inspection will include:

1) Review of any previous inspection reports;

2) Determination and provision of equipment and resources required for the inspection including preparation of a safety plan;

5

Scope of Bridge Inspection

3) Inspection of all relevant bridge attributes including measurements, testing and analysis as necessary to supplement the visual inspection; and

4) Identification of the probable causes and projected rate of deterioration and the effects of continued deterioration on the performance, durability and residual life of the structure.

6

Preparations before Inspection

Prior to the inspection, available information on the type of bridge, its maintenance history and previous inspection reports shall be reviewed by the inspector.

It may be necessary to search further for bridge drawings, maintenance histories, consultant's reports, etc.

7

Preparations before Inspection

Points of preparations before Inspection are as follows:

1) Inspector shall collect the Inspection Report and all available documents (plans, drawing and reports) of the bridge to be inspected;

2) Inspector shall check equipment (including all non-destructive testing apparatus) and/or vehicles required for Engineering Inspection;

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Preparations before Inspection

3) Inspector shall check and confirm that all necessary materials and safety gadgets are prepared and operative;

4) Inspector shall prepare ‘Inspection Result Form’ (Fig. 3.9.1); and

5) Inspector shall make sure that safety measures are in-place prior to inspection.

Consideration for Safety Works

For safety of inspectors, preparation of good surrounding work environment and safety trainings are essential on every work site.

Consideration to health and safety must be the highest priority at all times during field operation.

The following safety aspect shall be applied and must be considered prior to commencement of any inspection works.

Equipment of Inspection

Equipment of Inspection

《Must prepare》

Helmet, safety belt, reflecting jacket, safety shoes, scale, light, writing utensil, inspection hummer

《May need》

Oxygen meter, anemometer, Non-destructive testing device（Eddy current testing, ultrasonic thickness meter, etc.）









Road safety during inspection

Working on roads is extremely dangerous.

The points to keep in mind on the road works are as follows:

1) Before commencement inspection at the site, ensure that:
* All personnel are wearing high visibility vests;
* Inspector must know where to take refuge in case of emergency; and
* Locations of unsafe areas and roads must be identified and shared to all inspector team;

2) Do not walk on or cross the road unless absolutely necessary.

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Road safety during inspection

3) Always walk in the direction so that you are facing the oncoming vehicles (The vehicles should not come from behind you).

4) When inspector crosses roads, they make sure that all the lanes are clear; and

5) Inspector must not step backwards without looking. Under the noise of your machine and traffic you may not hear the sound of approaching vehicles.

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Work Safety

Work safety measures must be planned ahead.

The points of work safety are as follows:

1) Ensure that all tools, equipment and apparatus are available and in good working order;

2) Inspector shall prepare helmets, masks, safety harnesses, footwear, gloves, and any other necessary safety gears.

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Work Safety

3) Plan and arrange road closures and suitable traffic management procedures if necessary;

4) Identify and locate all the utilities existing at site such as electricity, water, sewerage, communications, and gas lines. If any risk is foreseen, inspector shall inform the relevant authorities to stand by for any emergencies;

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Work Safety

5) All inspections should be carried out in well-ventilated and well-lit areas. If necessary make prior arrangements for exhaust fans and artificial lighting; and

6) Do not allow personnel under the influence of alcohol (or any medication which impairs alertness or causes drowsiness) to work at site or to operate any mechanical equipment.

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Definition of Inspection

(a) Initial Inspection
(b) Routine Inspection
(c) Periodic Inspection
(d) Detailed Inspection
(e) Follow-up Inspection
(f) Emergency Inspection

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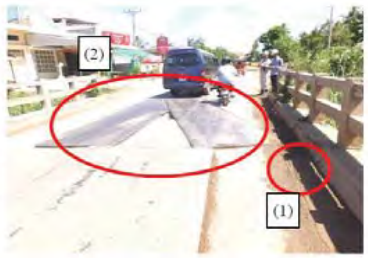
(a) Initial Inspection

Initial inspection determines the primary condition of bridge structures that are newly constructed.

(b) Routine Inspection

Routine inspection confirms the safety condition of the bridge structures. The main methods are the **visual check from such as a running vehicle**.

When an inspector checks clogging of drainage pipes, in a routine inspection, it is necessary to conduct a cleaning as a part of routine repair works.



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(c) Routine Inspection

Also, an inspector checks whether an abnormal condition is shown on there that was repaired in an emergency repair work.

21

(d) Periodic Inspection

'Periodic Inspection' is to be carried out on a regular basis by **visual inspection** or **hammering test** in order to confirm the total condition of the structure.

Visual inspection by using binocular (As well as 2,000 Bridges Survey) (1Time/ Every 5 Years).

22

(e) Detailed Inspection

'Detailed Inspection' is to be carried out by **hammering test or close visual check** in order to confirm whether the **damage that were detected by a former inspection has been in progress.**

Hands-on inspection to get detail information of damage and bridge by considering the result of periodic inspection.

23

(f) Follow-up Inspection

Follow-up inspection for the damage by considering the result of periodic inspection until finishing repair work or placement.
Frequency is depending on situation of defect.
(1 time / 1 month, 1 time / 3 months, 1 time / 1 year)

24

(g) Emergency Inspection

Emergency inspection is to be implemented on demand to supplement routine inspections or to check road structures when abnormal weather conditions occur such as heavy rainfall.

Also, an emergency inspection is to be immediately conducted when the road structures are damaged by any major accidents.

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Frequency of inspection

Classification of inspection	Standard Frequency	Remarks
Initial Inspection	Conducted before in-service	—
Routine Inspection	Once/month	With road inspection
Periodic Inspection	Once/Every 5 year	Afar inspection by using binocular
Detailed Inspection	Once/5 years	Closed inspection
Follow-up Inspection	Once/1 month or 3month or year (Depending on situation)	Until finishing repair work or placement
Emergency Inspection	Whenever necessary	—

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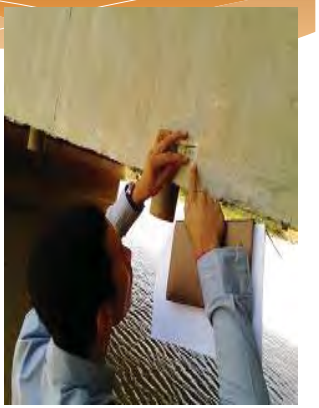
Visual inspection and Hands-on Inspection (hammer testing)

* Even if defects are not found by visual inspection, implement hummer testing on all rough surfaces.
* In case that defect are found, hummer closely.
* Especially in part of followed water or leaked water, have to inspect carefully.

Visual inspection (CHAPTER 3)



Touching structure directly as possible

28

Hammering test

Clear sound

The concrete is considered as healthy

Dull sound

The concrete is considered as having peeling or lifting or cavity.

Having peeling

Visual inspection and Hands-on Inspection (hammer testing)

* If a part of concrete surface may drop, it is necessary to remove remaining part of defect as soon as possible.
* If any cracks on surface found, measure crack widths.

30

Check Points on Concrete Structure

[Overall] Is entire path OK? Are there any swollen places? Pay attention to hitting sound, crack condition, and water leakage. Is there any efflorescence or rust fluid?

Are there any cracks or pot holes on the paved surface?

Are there any problems with floor slab (girder) and flared section?

Is there a drain hole at the hollow section? Is there efflorescence leaching?

Is floor slab (girder) end in good condition? Carefully inspect area around bearing.

Is opening between girder and parapet correct?

31

Check Points on Steel Structure

Are there any abnormal sounds, abnormal vibrations, or low frequency waves?

When cracks or efflorescence are noticeable on the floor slab, check the undersurface of the road (cracks, pot holes) as well.

Are there any defects at bridge collapse preventive mechanism and its fixing section? Is opening between main girder and parapet

Coating Condition (Especially, rust is likely to occur at girder edge, lower flange corner, and along the joint.)

Are there any HT bolts missing?

Are there any cracks at welded part of the main girder and sole plate?

Are there any fatigue cracks? (Pay attention to the second to third cross frame gusset plate welded from supporting point.)

32

Drainage facility

Drainage clogging is desired to be removed by the water jet

33

Scouring or settlement

* Scouring is caused by removing covering concrete or soil under the abutment or pier by fast water follow.
* If it is removed covering widely and deeply, there is a possibility that abutment or pier may settle or tilt.

Scouring or settlement

Scouring and settle pier(RN8)
(This bridge is out of service)

Scouring and broken pile
(RN14)

35

Scouring or settlement

* Of course, we cannot see under the water level, we **have to check at dry season**.
* Scouring occurs in not only riverbank, but also riverbed. So, it is important to protect riverbank and riverbed. Most of the river sections where it was reinforced with gabions (steel baskets filled with stones) still maintain a good condition.

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Scouring or settlement

Protect from scouring
(Left : RN2 Right: RN8)
(Very good)

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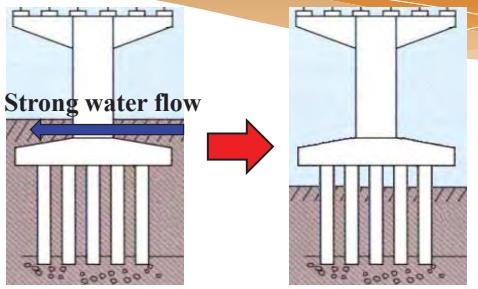
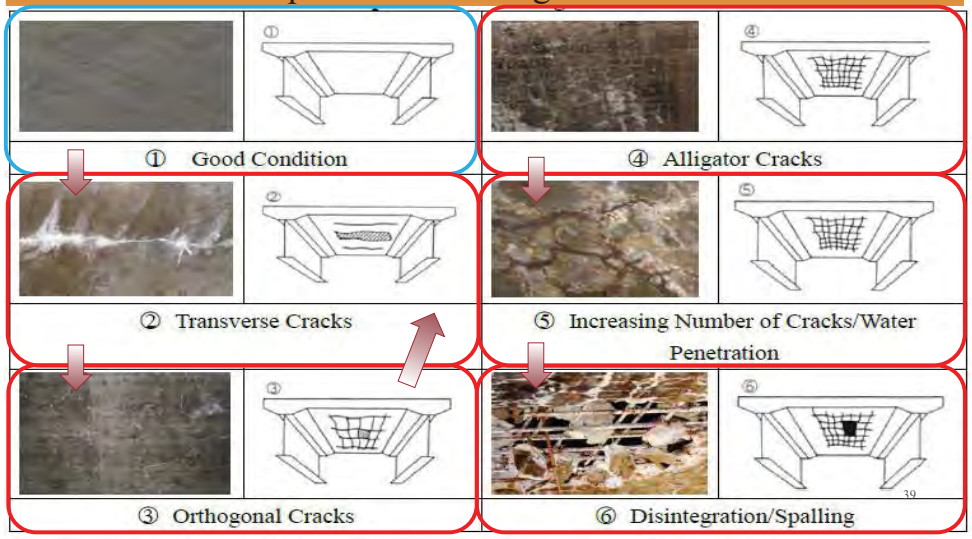
Scouring (Abutment, Pier)



Crack on RC deck

Development of cracking in RC deck slub



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Crack on RC deck

Be careful!
Crack on road surface

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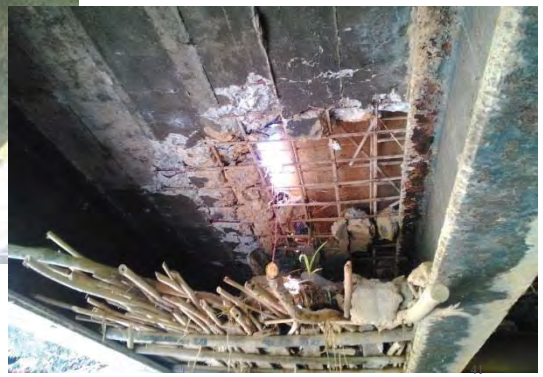
Crack on RC deck

Phase 4 condition
(Alligator crack)

Phase 6 condition
(disintegration)



Concrete Slab

Sedimentation of soil at bearing

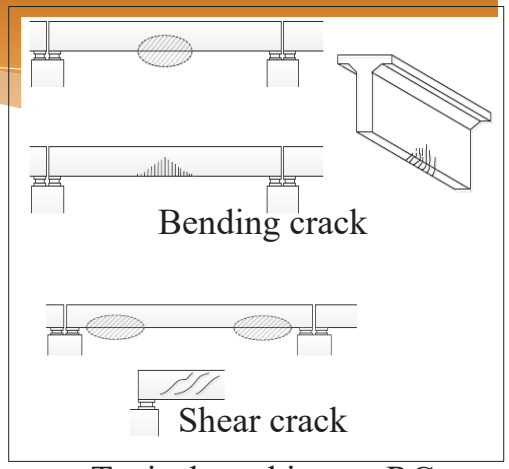
* Around bearing, it is easy to gather soil from expansion joint, it is important to remove soil before inspection. Because defects may not be found without cleaning.

Cracks around bearing

* If girder was put on directly without bearing, it is easy to occur crack under girder without flexibility against external force (foundation of girder).

Crack in girder

* All cracking in concrete members is **caused by tensile stresses** (concrete has a **low tensile strength, but high compressive strength**).



Typical cracking on RC girder

45

Measuring crack width

* In case of RC(PC) structure
  W＞0.3mm (0.2mm) Need to repair
  W＜0.3mm (0.2mm) No need to repair (observation)

Crack scale
(measurement crack width tool)

Attach crack scale to concrete surface on crack

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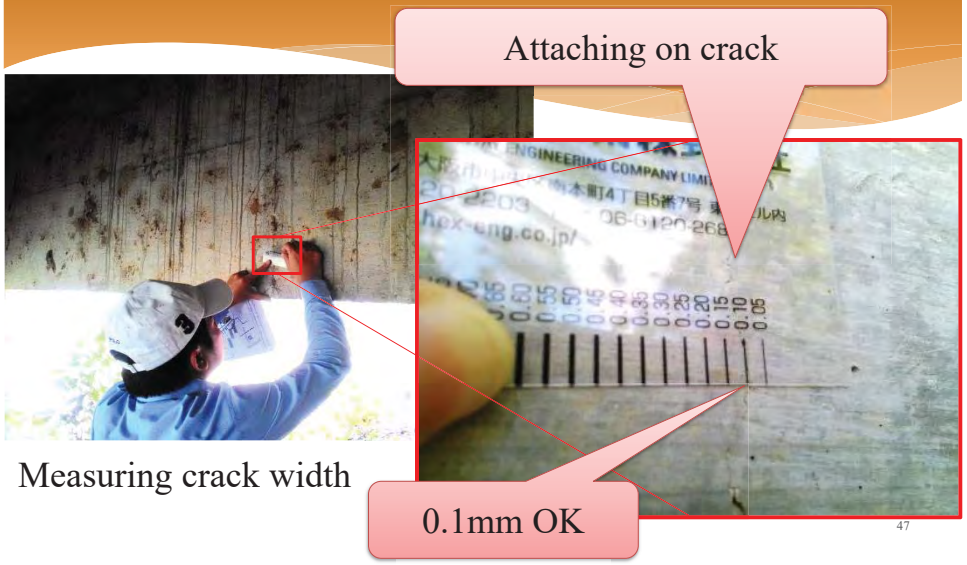
Measuring crack width on RC structure



Measuring crack width

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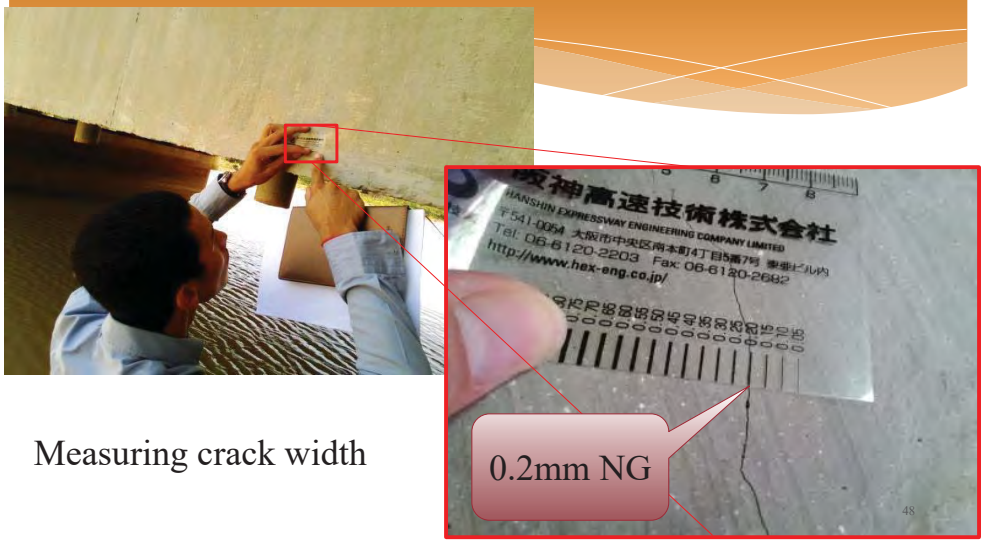
Measuring crack width on PC structure



Measuring crack width

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Crack in girder

* Crack penetration which starts around bearing to girder may lead collapse in worst case.

Crack at the end of concrete girder
(Chroy Changva bridge)

49

Crack in girder

* Shear Crack on concrete girder also may lead to collapse in the worst case.

Crack at the end of concrete girder
(PN265E bridge)

50

Corrosion

* The end of girder is easy to corrode. Because, **soil and water from expansion joint gathers around** the **end of girder (=around the bearing)** and it is always wet.

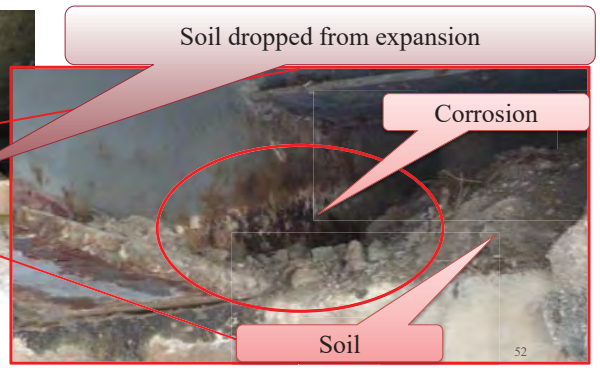
Corrosion of end of girder (In Japan)

51

Corrosion

* When inspect a bridge, **remove soil around the end of girder.**

Corrosion of end
of girder (RN5)



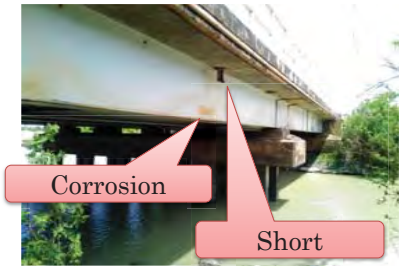
52

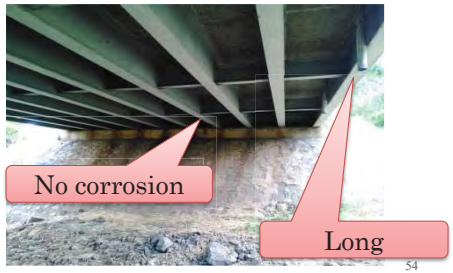
Corrosion

* Metal members around drainage pipe are also easy to corrode. It is very important to prevent water to stay from such area by proper drainage system.

Corrosion

* If drain pipe is shorter than the bottom of girder, the girder around the drain pipe is easy to corrode.(Left)
* On the other hand, if drain pipe is longer than bottom of the girder, it will be no corrosion. (Right)





Fatigue crack

* In steel structure, fatigue usually cause cracks.
* **The fatigue crack occurs on welding.** The time until occurring fatigue crack is influenced by stress in welding , number of load and shape of welding.

* If **the shape of welding is poor (=rough or bumpy)**, it will be easy to occur fatigue crack.
* So, quality of welding is important.

Very poor welding

Hand Railing

Broken due to traffic accident

57

Damage of expansion joints

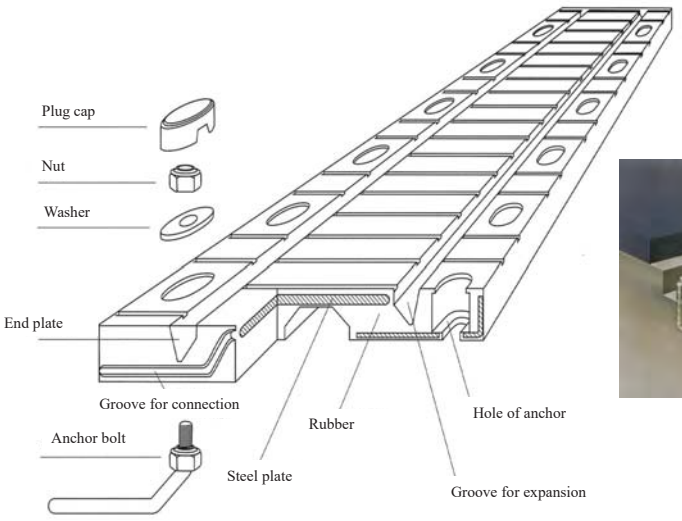
* Damage of expansion joint affects not only **driving safety**, but also **structural soundness**.
* If expansion joint may break, broken parts have risk to be scattered on roads.
* In Japan, scattered piece of expansion joint caused a traffic accident to traveling car.

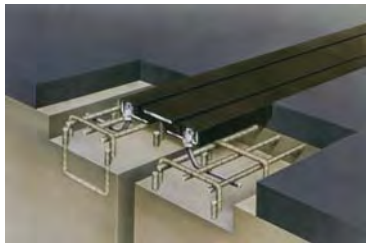
Damage of Expansion Joint (RN7)

Loss of Expansion Joint (RN7)

58

Damage of expansion joints





59

Damage of expansion joints

* There are bumps occurring at expansion joint. It causes **impact force and cracking** on deck slab.
* Examples of disintegration around expansion joint are shown below.

Disintegration around expansion joint

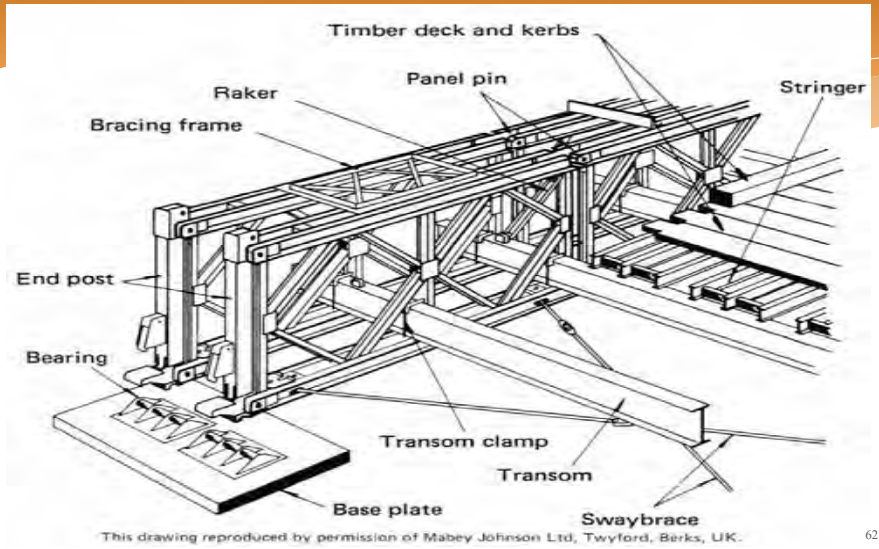
60

Damage of expansion joints

* Mostly, life time of expansion joint is shorter than main structural members. And if expansion joints damage, the damage will develop very quickly. For expansion joint, it is important to check and maintain in close and periodically.
* The checking points are anchors (including concrete beam fixing the joints), and damage of joint body.
* Typical damage of joint body is surface deterioration.

61

Bailey bridge



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62

Bailey bridge

Damage of Bailey bridge
（Left : Broken rib　Right : Loss of a pin）

63

Bailey bridge

Damage of Bailey bridge （Loosing of a pin）

64

Bailey bridge

Damage of Bailey bridge
（Detachment of reinforced steel plate due to loss of bolt connection.）

65

Lighting pole

* Lighting pole is fixed by 4 anchors on railing

* If anchor loosing occurs, lighting pole will fall over. So, when inspect bridge, it is important to check the anchor of lighting pole.

Lighting pole
(Fixed by only 4 anchors)

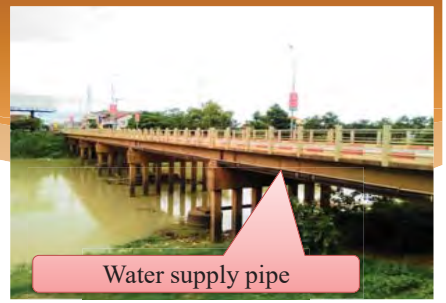
66

Sample of defect on lighting pole base

Water supply pipe

* For some bridges, there is water supply pipe attached.

* If the pipe breaks, it will affect not only water supply, but also deterioration on girders.



68

Defect Assessment Examples【Bridge Type: Concrete Defect Type: Crack on Girder under side 】

Sample Photos:

Comment on the defect assessment:

○Defect Rating Result: SD (Serious Damage)

○Defect Type: Longitudinal Crack on underside of Girder

○Damaged Member: Main Girder(Concrete)

○Focus Points for assessment:

This kind of Crack is caused by rebar expansion with main rebar corrosion. The crack will develop as time goes, and finally This girder may collapse by vehicles' load. Therefore this defect/bridge should be judged as SD.

Bridge Information:

○Name: Phum Ty 8

○Location: Kampong Cham 3KC1, PK 21+400, (11.479052, 104.600518)

Remarks:

Defect Assessment Examples【Bridge Type: Concrete Defect Type: Shearing Crack on Girder 】

Sample Photos:

Comment on the defect assessment:

○Defect Rating Result: SD (Serious Damage)

○Defect Type: Shearing Crack on Girder side

○Damaged Member: Main Girder(Concrete)

○Focus Points for assessment:

This kind of crack, Shearing Crack, is caused by shear force and impact force brought by vehicle load and acts ultimate strength of girder decreasing. When the shearing crack occurred, it will develop quickly, and then this girder will be collapsed soon. Therefore this defect/bridge should be judged as SD.

Bridge Information:

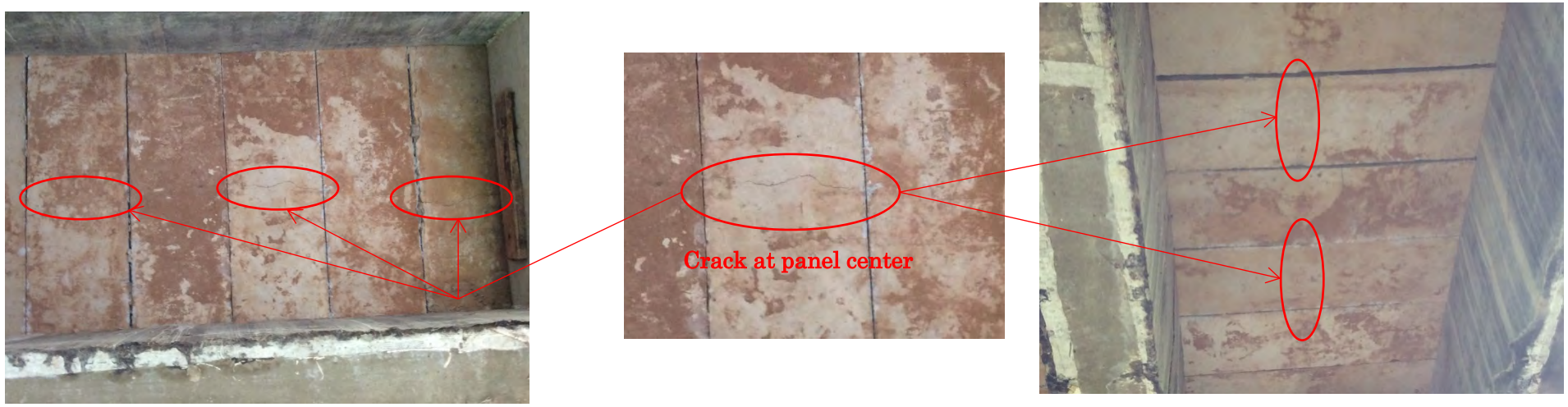
○Name: East Ror Lous

○Location: Siem Reap, PN265E, 0+900, (12.734030,104.786447)

Remarks:

Defect Assessment Examples【Bridge Type: Concrete Defect Type: Crack on Slab under side 】

Sample Photos:



Comment on the defect assessment:

○Defect Rating Result: D (Damage)

○Defect Type: Crack on Slab underside (Longitudinal)

○Damaged Member: Slab(Concrete)

○Focus Points for assessment:

Crack caused by slab bending due to overloading or construction failure. After crack progressed widely, it is possible to collapse concrete slab. Therefore this defect/bridge should be judged as D, because it is necessary to replace only damaged slab panel.

Bridge Information:

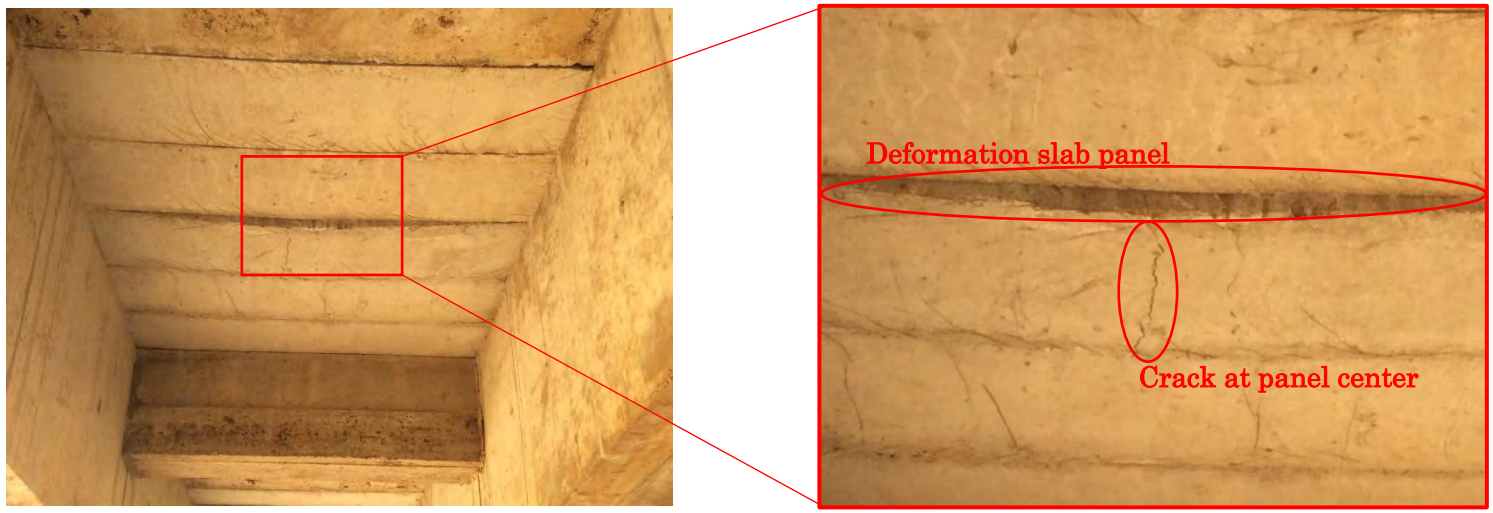
○Name: Spean 2

○Location: Preah Vihea PR2628, PK 3+840, (13.789236, 104.966115)

Remarks:

Defect Assessment Examples【Bridge Type: Concrete Defect Type: Crack on Slab under side 】

Sample Photos:



Comment on the defect assessment:

○Defect Rating Result: D (Damage)

○Defect Type: Crack on Slab underside (Longitudinal)

○Damaged Member: Slab(Concrete)

○Focus Points for assessment:

Crack caused by slab bending due to overloading or construction failure. It is possible to cause concrete slab collapse. Therefore this defect/bridge should be judged as D, it is necessary to replace slab panel early.

Bridge Information:

○Name: Tompeng Vay

○Location: Preah Vihea, Phum Chek, PK 1+815, (13.763263,104.549990)

Remarks:

Defect Assessment Examples【Bridge Type: Concrete Defect Type: Crack on Slab under side and deteriorating girder 】

Sample Photos:

Comment on the defect assessment:

○Defect Rating Result: D (Damage)

○Defect Type: Crack on Slab under side and water leak. Deteriorating girder by water leaking(flaking and rebar corrosion)

○Damaged Member: Slab and Girder(above bearing)

○Focus Points for assessment:

Water is leaking through slab deck. There is a possibility of rebar corrosion in slab deck and girder. Because this water leak position is located above bearing. When the deterioration is progressing, it may cause of bearing malfunction.

Bridge Information:

○Name: Phsar Kompong Speu(Old)

○Location: PR143, PK 0+900, (11.419629,104.649885)

Remarks:

Scoring Inspection Results

Bridge Score

Results of bridge inspection should be evaluated appropriately based on bridge(soundness or damage) score.

Bridge soundness score:

100 : No damage

100 ~ 85 : Good Condition

85 ~ 60 : Damaged

0 ~ 60 : Seriously Damaged

2

Basis of Scoring

Score of each defect	0-15
Soring every parts	0-100
Effect factor in Bridge	
Road Surface	10%
Bridge Girder	30%
Bridge Slab	30%
Bearing	10%
Pier/Abutment	20%

Bridge Score is calculated automatically.

3

Defect and Scoring

Location	Part	Inspection item	Check point	Score	Score total	Part Score	Part Tolal	Effect factor	Damage Score
					a	b	c=b/a	d	c*d
Road Surface	Bridge Railing / Guardrail / Curb	Damage	No Damage	0	27		0	10%	0
			Damage	1					
			Damage (Possiblity of harm third party)	10					
	Expansion Joint	Step	No damage	0					
			Step under 20mm	1					
			Step over 20mm	3					
		Deformation / Damage	No damage	0					
			Abnormal expansion gap (More than 2cm)	2					
			Deformation / Damage	3					
			Abnormal sound	3					
	Drainage System	Clog of drainage pipe	No Damage	0					
			Partial no function (Impossibility flood)	1					
			Almost no function(stuffed, broken, etc)	3					

Defect should be repaired urgently (Urgent Repair)

4

Location	Part	Inspection item	Check point	Score	Score total	Part Score	Part Tolal	Effect factor	Damage Score
					a	b	c=b/a	d	c*d
Bridge Girder	Superstructure (Steel)	Corrosion / Rust	No Damage	0	36		0	30%	0
			Corrosion on steel members	1					
			Hole by corrosion	4					
			Invisible						
		Crack, Deformation, Loss, Break	No Damage	0					
			Steel members deformation	1					
			Crack on steel member	3					
			Steel member loss/broken (Secondary member)	5					
			Steel member loss/broken (Primary member)	10					
			Invisible						
		Missing bolt	No Damage	0					
			Missing less than 10%.	2					
			Missing more than 10%.	10					
			Invisible						
	Superstructure (Concrete)	Honeycomb / Flaking / Exposure of rebar /Crack	No Damage	0	17		0	30%	0
			Free lime/ Honeycomb/ Flaking and/or Lacking concrete	1					
			Exposure of rebar	1					
			Rebar rusting	2					
		(Crack width)	Rust fluid from crack	2					
		RC: >about 0.3mm	Crack on girder	3					
		PC: >about 0.2mm	Crack on girder (above Bearing)	8					
			Invisible						

5

Defect should be repaired urgently (Urgent Repair)

Location	Part	Inspection item	Check point	Score	Score total	Part Score	Part Tolal	Effect factor	Damage Score
					a	b	c=b/a	d	c*d
Bailey Bridge	Superstructure (Bailey Bridge)	Missing pin	No Damage	0	75		0		0
			Loosing pin on bailey bridge	4					
			Missing pin on bailey bridge (Connecting part)	15					
		Truss Girder Corrosion / Rust / Crack / Deformation /Loss /Break	No Damage	0					
			Corrosion on steel member	1					
			Steel member deformation	1					
			Hole by corrosion	3					
			Crack on steel member	5					
			Steel member loss/broken	15					
			Invisible						
		Slab Corrosion / Crack	No Damage	0					
			Corrosion and/or Rust on steel member	1					
			Crack	15					
			Hole	15					
			Invisible						

Defect should be repaired urgently (Urgent Repair)

6

54

Location	Part	Inspection item	Check point	Score	Score total	Part Score	Part Tolal	Effect factor	Damage Score
					a	b	c=b/a	d	c*d
Bridge Slab	Superstructure (Wooden)	Rotting	No Damage	0	8		0	30%	0
			Rot of wood	1					
			Reduction of cross section	2					
			Invisible						
		Crack / Damage	No Damage	0					
			Damage (Crack / Partial loss)	2					
			Big damage (collaspe risk / Impassable)	3					
			Invisible						
	Slab (Concrete)	Honeycomb / Flaking / Exposure of rebar Crack / Hole	No Damage	0	18		0	30%	0
			Free lime/ Honeycomb/ Flaking and/or Lacking concrete	1					
			Exposure of rebar	1					
			Rebar rusting	2					
			Rust fluid from crack	2					
		(Crack width)	Crack on undersurface (Longitudinal)	2					
		RC: >about 0.3mm	Crack on undersurface (Transversal)	3					
		PC: >about 0.2mm	Hole	8					
			Invisible						

Defect should be repaired urgently (Urgent Repair)

7

Location	Part	Inspection item	Check point	Score	Score total	Part Score	Part Tolal	Effect factor	Damage Score
					a	b	c=b/a	d	c*d
Bridge Slab	Slab (Wooden)	Rotting	No Damage	0	14		0	30%	0
			Rot of wood	1					
			Reduction of cross section	2					
			Invisible						
		Crack / Damage	No Damage	0					
			Big damage (collaspe risk) / Impassable	5					
			Hole / Missing slab plate	5					
			Invisible						
		Vibration, Abnormal Sound	No Damage	0					
			Vibration and/or Abnormal sound at travelling	1					
Sub-structure	Bearing	Sedimentation / Damage	No Damage	0	9		0	10%	0
			Partial sedimentation	1					
			Corrosion and/or damage	2					
			Partial sedimentation (Cannot see bearings)	3					
			No function (Include rusting)	3					
			Invisible						

Defect should be repaired urgently (Urgent Repair)

8

Location	Part	Inspection item	Check point	Score	Score total	Part Score	Part Tolal	Effect factor	Damage Score
					a	b	c=b/a	d	c*d
	Pier / Abutment	Scouring / Settlement	No Damage	0	30		0	20%	0
			Scouring around substructure	4					
			Settlement of substructure	10					
			Invisible						
		Honeycomb / Flaking / Exposure of rebar / Crack (Crack width) RC: >about 0.3mm PC: >about 0.2mm	No Damage	0					
			Free lime/ Honeycomb/ Flaking and/or Lacking concrete	1					
			Exposure of rebar	1					
			Rebar rusting	2					
			Rust fluid from crack	2					
			Crack on surface (Horizontal Direction)	5					
			Crack on surface (Vertical Direction)	5					
			Invisible						
		Total Damage Score							0.0
		Total Soundness Score of Bridge							100.0

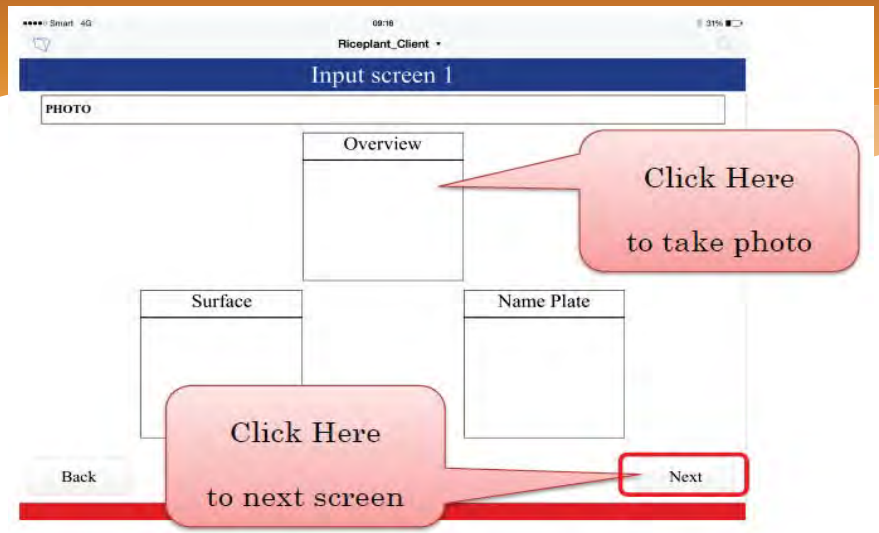
Defect should be repaired urgently (Urgent Repair)

Damage Level	Damage Score	Judgement	
Damage Level III	>40	SD	Defect should be repaired as emergency
Damage Level II	40> >15 or CD	D	Defect should be repaired as periodic
Damage Level I	<15	O	Defect should be observated

Chapter 4:- Bridge Inspection Recording

Bridge Inventory

2



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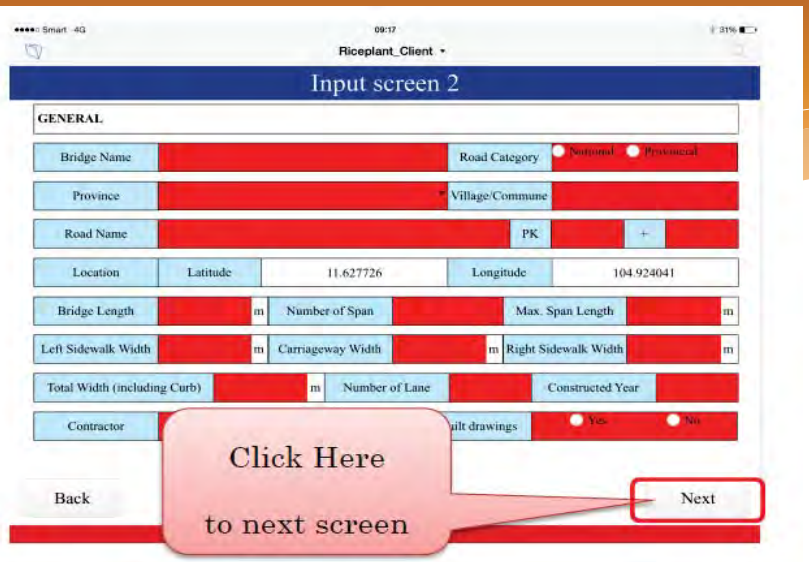

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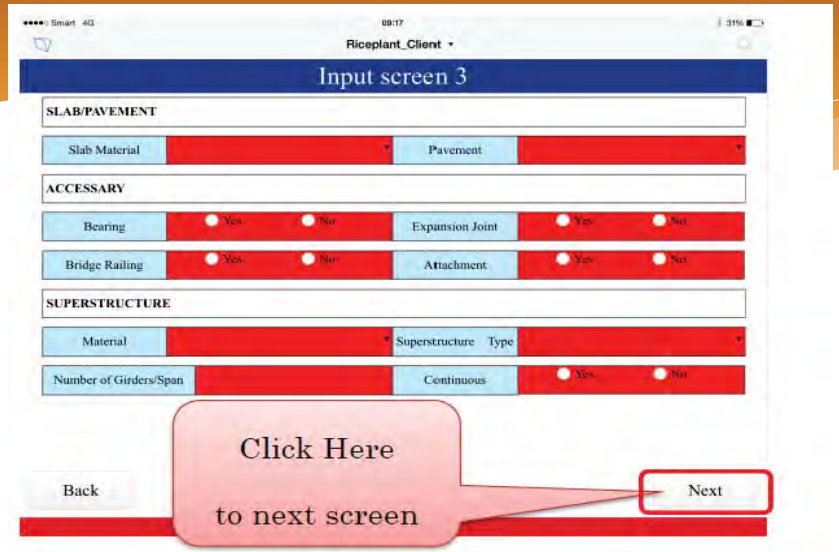

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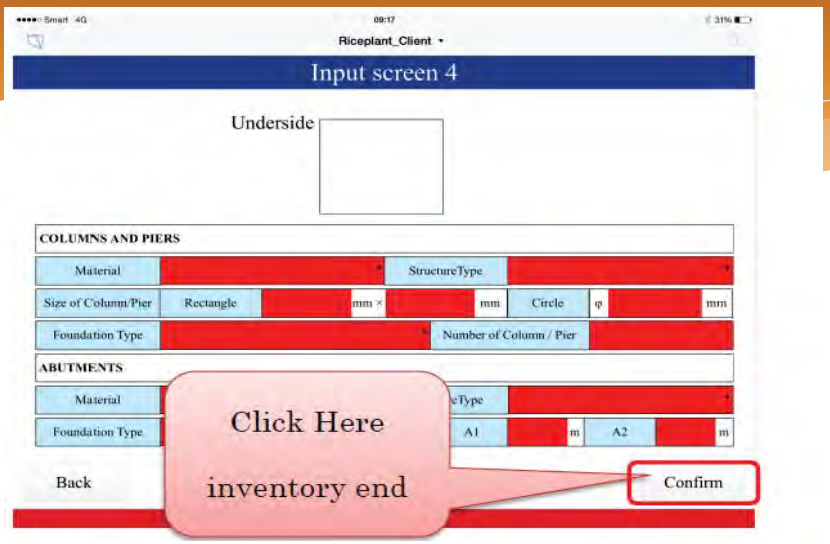

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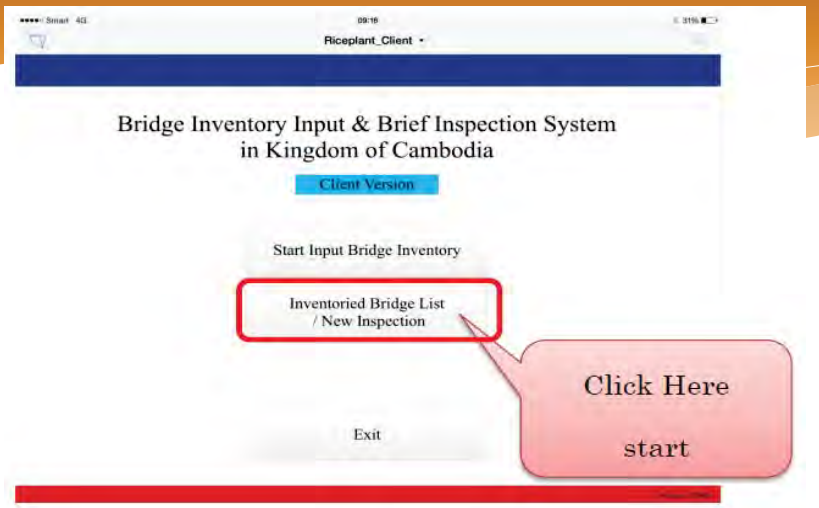
7

Bridge Inspection



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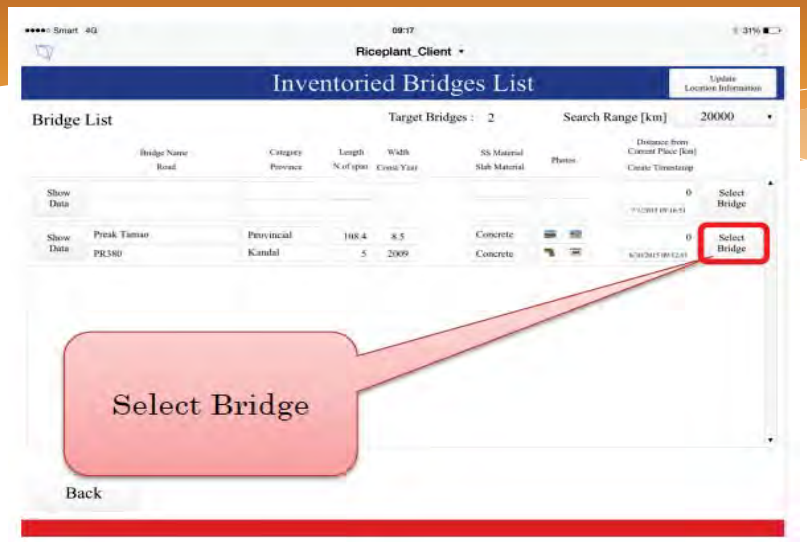
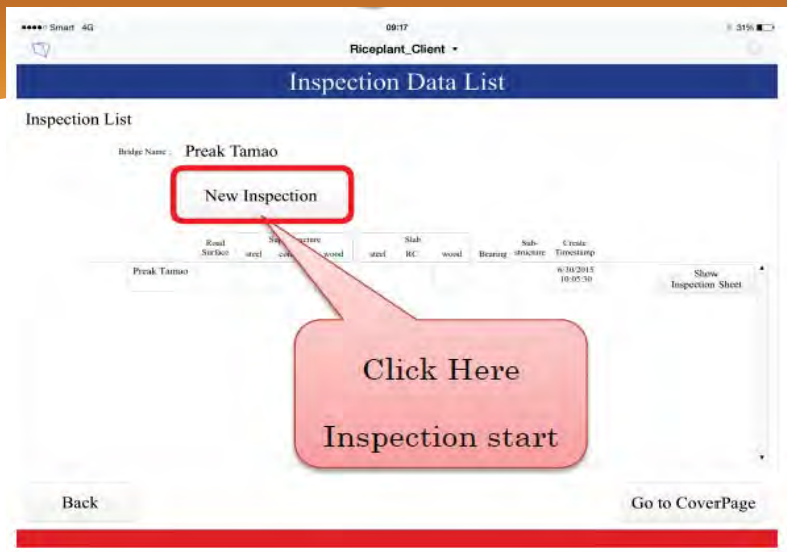
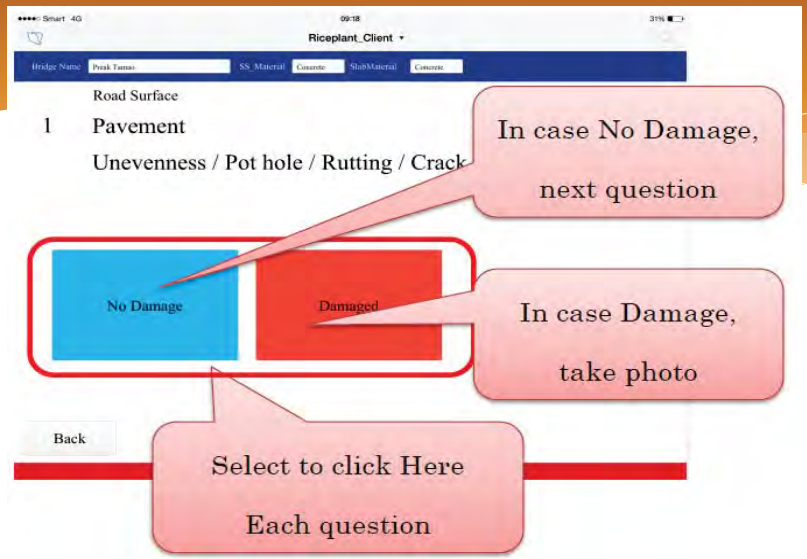

Riceplant_Client
Inventoried Bridges List
Update Location Information
Bridge List
Target Bridges : 2
Search Range [km] 20000
Show Data
Preak Tamao
Provincial
108.4
8.5
Concrete
Select Bridge
PR380
Kandal
5
2009
Concrete
Select Bridge
Select Bridge
Back

9


Riceplant_Client
Inspection Data List
Inspection List
Bridge Name : Preak Tamao
New Inspection
Preak Tamao
Show Inspection Sheet
Click Here
Inspection start
Back
Go to CoverPage

10


Riceplant_Client
Bridge Name Preak Tamao
SS_Material Concrete
SlabMaterial Concrete
Road Surface
1 Pavement
Unevenness / Pot hole / Rutting / Crack
In case No Damage, next question
No Damage
Damaged
In case Damage, take photo
Back
Select to click Here
Each question

11


Riceplant_Client
Commen
Input comments. (Bridge condition, damage situation ,your feeling, etc)
Back
Next
Click Here
inspection end
Previous Next
Done

12

Maintenance Expert Program
Bridge Inspection

Writing Test

NAME:

ORGANIZATION:

Q1: What is purpose of Bridge Inspection?

Select a wrong sentence.

1. To confirm the results of bridge condition inspection.
2. To determine the cause/mechanisms of damage;
3. To assess the rate of deterioration and residual life expectancy
4. To investigate the damage for estimating repair cost.
5. It is unnecessary to inspect new bridge.

2

Q2: What is purpose of Bridge Inspection?

Select a wrong sentence.

1. If defect is not serious, it needs not to repair by defect proceeding seriously.
2. To confirm as built drawings and design documents.
3. To undertake additional investigations necessary for evaluation of defects.
4. To evaluate the need for repair and rehabilitation.
5. To assess the current bridge structural condition, behavior and load capacity.

3

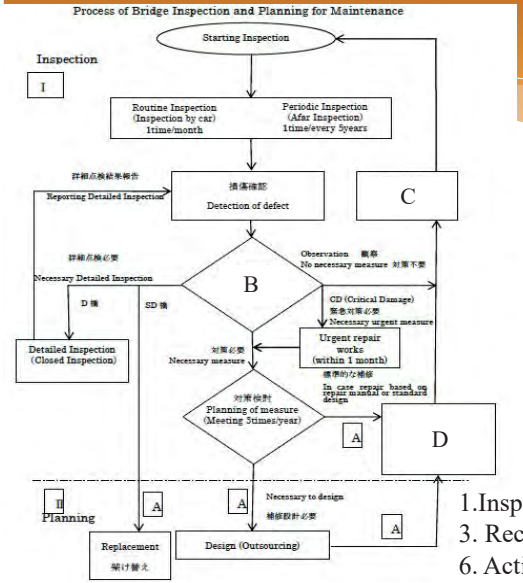
Q3: What is purpose of Bridge Maintenance?

Select a wrong sentence.

1. It is important to repair to early after inspection.
2. After repairing defect, bridge maintenance is completed.
3. Maintenance cycle contain “Inspection”, “Design & Plan”, “Repair works” and “Re-evaluation”
4. Bridges must be maintained appropriately by MPWT and DPWT.
5. The Bridges are part of the road infrastructure that must be very well maintained for Cambodia economy.

4

Q4:Process of Maintenance



A:

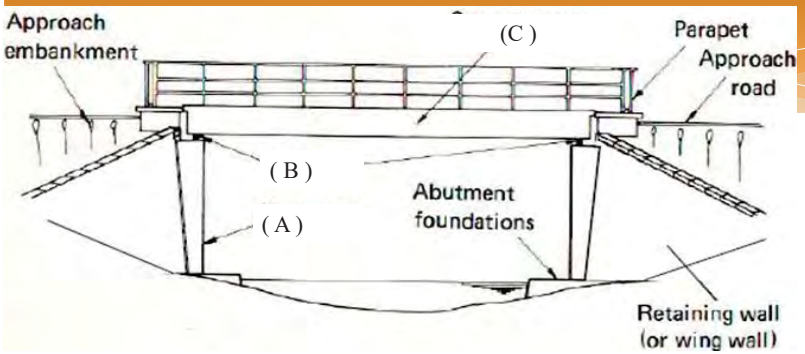
B:

C:

D:

1.Inspection 2. Repair works / Rehabilitation
3. Record 4. Testing 5. Diagnosis
6. Action 7. Follow-up inspection

Q5: Bridge member terms



A:

B:

C:

1. Superstructure 2. Foundation 3. Abutment
4. Pier 5.Main Girder 6. Pavement 7. Bearing

Q6: Bridge member terms

A:

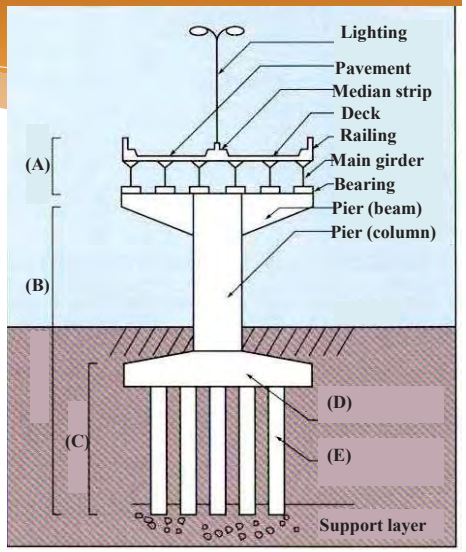
B:

C:

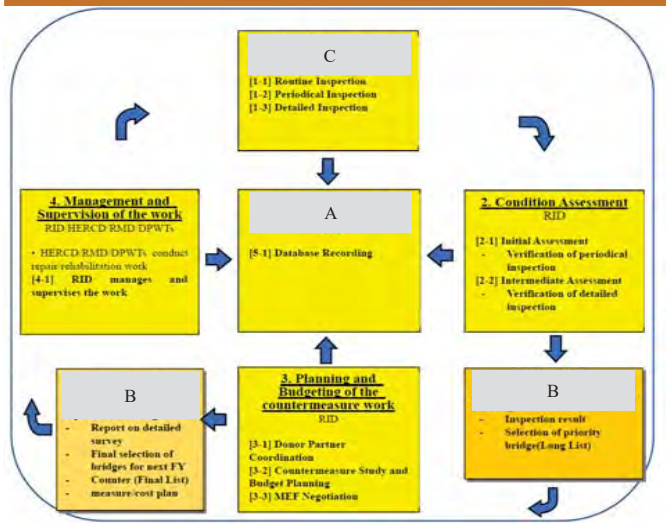
D:

E:

1. Superstructure 2.Pile
3. Substructure 4.Footing
5. Foundation



Q7: Annual Action Plan



A:

B:

C:

1: MOM 2: Information and Database Management 3: Inspection
4: Estimating 5: Diagnosis of inspection results

Q8: Role of Implementation

Required Task	A	B	C	Remarks
1. Inspection				
(1) Planning inspection	Discuss the plan with RID		Planning inspection (Type, Area, methodology, Cost, etc.)	(January)
(2) Conduct inspection -Initial inspection -Routine inspection -Periodic inspection -Emergency inspection	Conducts inspection		Conducts inspection and support DPWT	RID/DPWT conduct inspection. From Mar. to Dec.
(3)Record inspection data			-Collect the inspection data (bridge data, location, defects, other info.) -Save data to Database	

A: B: C:

1: DPWT
2: RID
3: HERCD/RMD
4: MPWT

9

Q9: Role of Implementation

Required Task	DPWT	HERCD/RMD	RID	Remarks
4. Management and Supervision of the Work				
(1) Preparation			-Prepare tendering documents	
(2) Repair work etc.	A	HERCD: Implement rehabilitation works RMD: Implement repair and maintenance works	C	
(3) Collect the data of the works	B	Submit the data to Bridge G, RID	Bridge G, RID collects the data and check them. (After checking them, the data are submit to Database G, RID	

A: B: C:

1: Supervise the works
2: Submit the data to Bridge G,RID
3: Implement field works
4: Input into database

10

Q10: Definition of Inspection

A: To confirm primary condition. ( )

B: To be carried out on a regular basis by visual inspection or hammering test in order to confirm the total condition of the structure. ( )

C: To be immediately conducted when the road structures are damaged by any major accidents. ( )

D: To be carried out by hammering test or close visual check to confirm damage progress. ( )

E: To confirm the safety condition of the bridge structures by visual check from such as a running vehicle. ( )

1. Initial Inspection
2. Routine Inspection
3. Periodic Inspection
4. Detailed Inspection
5. Emergency Inspection

11

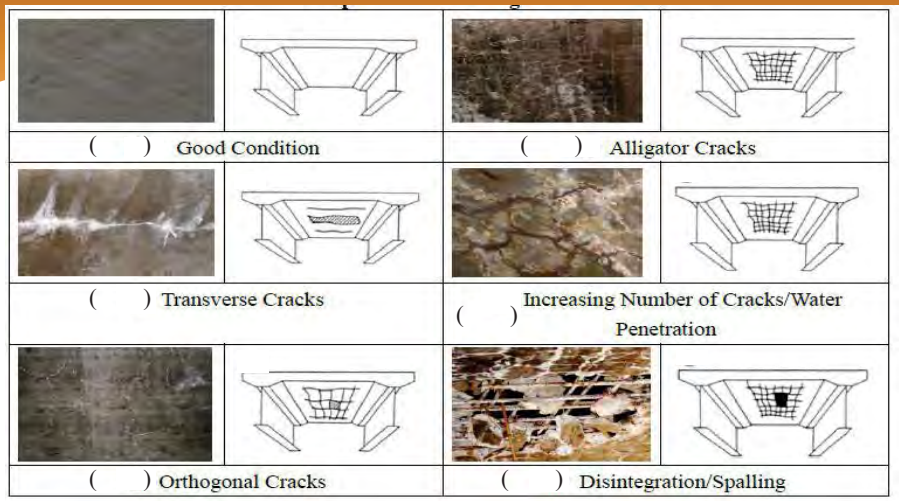
Q11: Type of Damage

Fill in what and where damage occurred in Sample Photo

Damage Photo	Damage (Name/ Position)	Damage Photo	Damage (Name/ Position)
			
			

12

Q12:Development of cracking on RC deck slab



Fill in the development order of deterioration on RC deck.

13

Q13:Inspection Recording

Select a wrong sentence.

1. Input bridge inventory or inspection data at site.
2. It is necessary to input location data in bridge inventory.
3. If there is no damage, it is unnecessary to input inspection data.
4. It is necessary to input comment that inspector noticed.

14

Maintenance Expert Program
Bridge Inspection

Writing Test
(with Answer)

NAME:

ORGANIZATION:

Q1: What is purpose of Bridge Inspection?

Select a wrong sentence.

1. To confirm the results of bridge condition inspection.
2. To determine the cause/mechanisms of damage;
3. To assess the rate of deterioration and residual life expectancy
4. To investigate the damage for estimating repair cost.
5. It is unnecessary to inspect new bridge.

2

Q2: What is purpose of Bridge Inspection?

Select a wrong sentence.

1. If defect is not serious, it need not to repair by defect proceeding seriously.
2. To confirm as built drawings and design documents.
3. To undertake additional investigations necessary for evaluation of defects.
4. To evaluate the need for repair and rehabilitation.
5. To assess the current bridge structural condition, behavior and load capacity.

3

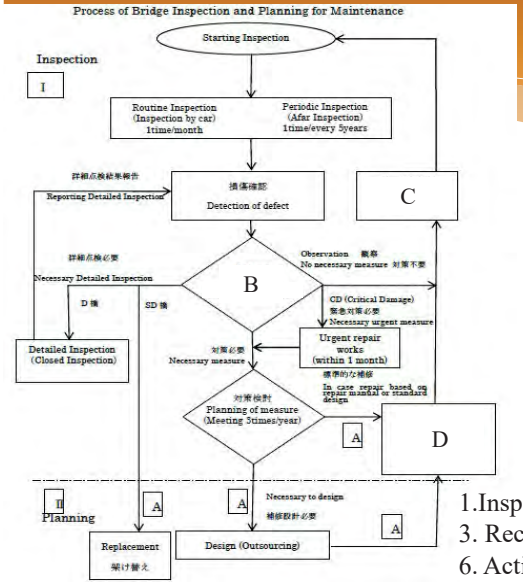
Q3: What is purpose of Bridge Maintenance?

Select a wrong sentence.

1. It is important to repair to early after inspection.
2. After repairing defect, bridge maintenance is completed.
3. Maintenance cycle contain “Inspection”, “Design & Plan”, “Repair works” and “Re-evaluation”
4. Bridges must be maintained appropriately by MPWT and DPWT.
5. The Bridges are part of the road infrastructure that must be very well maintained for Cambodia economy.

4

Q4:Process of Maintenance



A: 7

B: 5

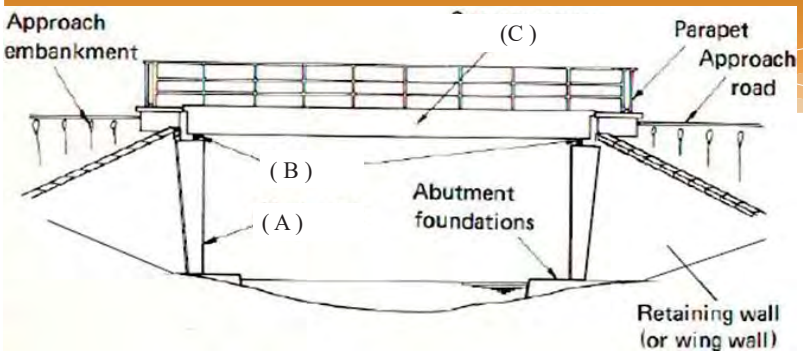
C: 3

D: 2

1.Inspection 2. Repair works / Rehabilitation
3. Record 4. Testing 5. Diagnosis
6. Action 7. Follow-up inspection

5

Q5: Bridge member terms



A: 3

B: 7

C: 1or5

1. Superstructure 2. Foundation 3. Abutment
4. Pier 5.Main Girder 6. Pavement 7. Bearing

6

64

Q6: Bridge member terms

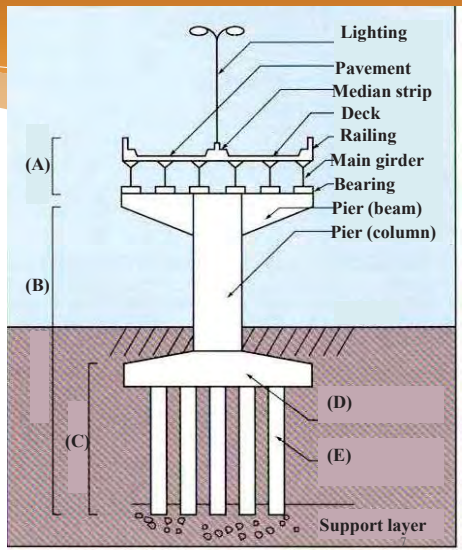
A: 1

B: 3

C: 5

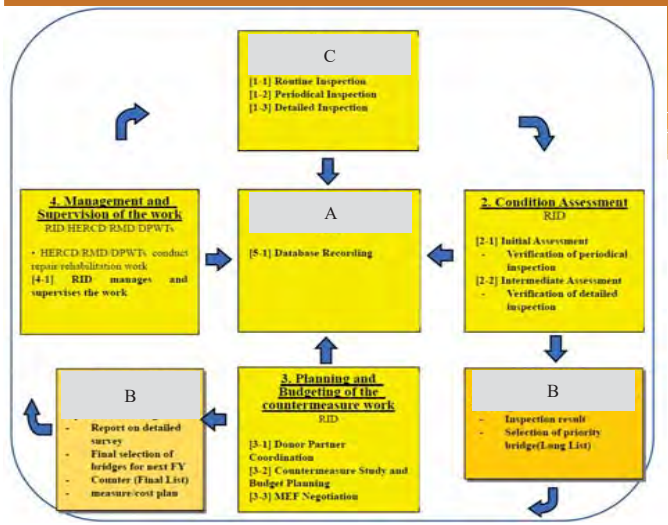
D: 4

E: 2



1. Superstructure 2.Pile
3. Substructure 4.Footing
5. Foundation

Q7: Annual Action Plan



A: 2

B: 1

C: 3

1: MOM 2: Information and Database Management 3: Inspection
4: Estimating 5: Diagnosis of inspection results

8

Q8: Role of Implementation

Required Task	A	B	C	Remarks
1. Inspection				
(1) Planning inspection	Discuss the plan with RID		Planning inspection (Type, Area, methodology, Cost, etc.)	(January)
(2) Conduct inspection -Initial inspection -Routine inspection -Periodic inspection -Emergency inspection	Conducts inspection		Conducts inspection and support DPWT	RID/DPWT conduct inspection. From Mar. to Dec.
(3)Record inspection data			-Collect the inspection data (bridge data, location, defects, other info.) -Save data to Database	

A: 1 B: 3 C: 2

1: DPWT
2: RID
3: HERCD/RMD
4: MPWT

9

Q9: Role of Implementation

Required Task	DPWT	HERCD/RMD	RID	Remarks
4. Management and Supervision of the Work				
(1) Preparation			-Prepare tendering documents	
(2) Repair work etc.	A	HERCD: Implement rehabilitation works RMD: Implement repair and maintenance works	C	
(3) Collect the data of the works	B	Submit the data to Bridge G, RID	Bridge G, RID collects the data and check them. (After checking them, the data are submit to Database G, RID	

A: 3 B: 2 C: 1

1: Supervise the works
2: Submit the data to Bridge G,RID
3: Implement field works
4: Input into database

10

65

Q10: Definition of Inspection

A: To confirm primary condition. (1)

B: To be carried out on a regular basis by visual inspection or hammering test in order to confirm the total condition of the structure. (3)

C: To be immediately conducted when the road structures are damaged by any major accidents. (5)

D: To be carried out by hammering test or close visual check to confirm damage progress. (4)

E: To confirm the safety condition of the bridge structures by visual check from such as a running vehicle. (2)

1. Initial Inspection
2. Routine Inspection
3. Periodic Inspection
4. Detailed Inspection
5. Emergency Inspection

11

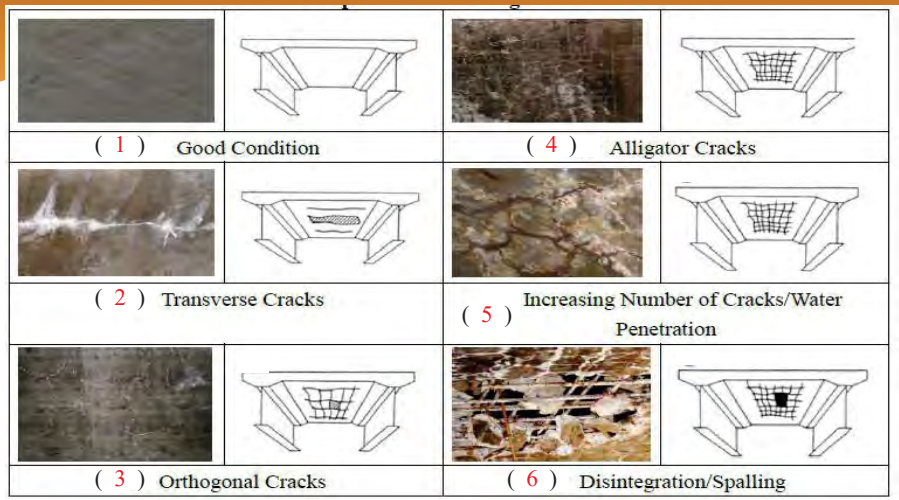
Q11: Type of Damage

Fill in what and where damage occurred in Sample Photo

Damage Photo	Damage (Name/ Position)	Damage Photo	Damage (Name/ Position)
	Abutment (Pier) Souring		Girder Crack
	Slab Hole		Abutment (Pier) Exposure of Rebar (Flaking)

12

Q12:Development of cracking on RC deck slab



Fill in the development order of deterioration on RC deck.

Q13:Inspection Recording

Select a wrong sentence.

1. Input bridge inventory or inspection data at site.
2. It is necessary to input location data in bridge inventory.
3. If there is no damage, it is unnecessary to input inspection data.
4. It is necessary to input comment that inspector noticed.

How to Collect Bridge Data - using iPad system -

The top screen is below.

At first, bridge inventory data collection is started.

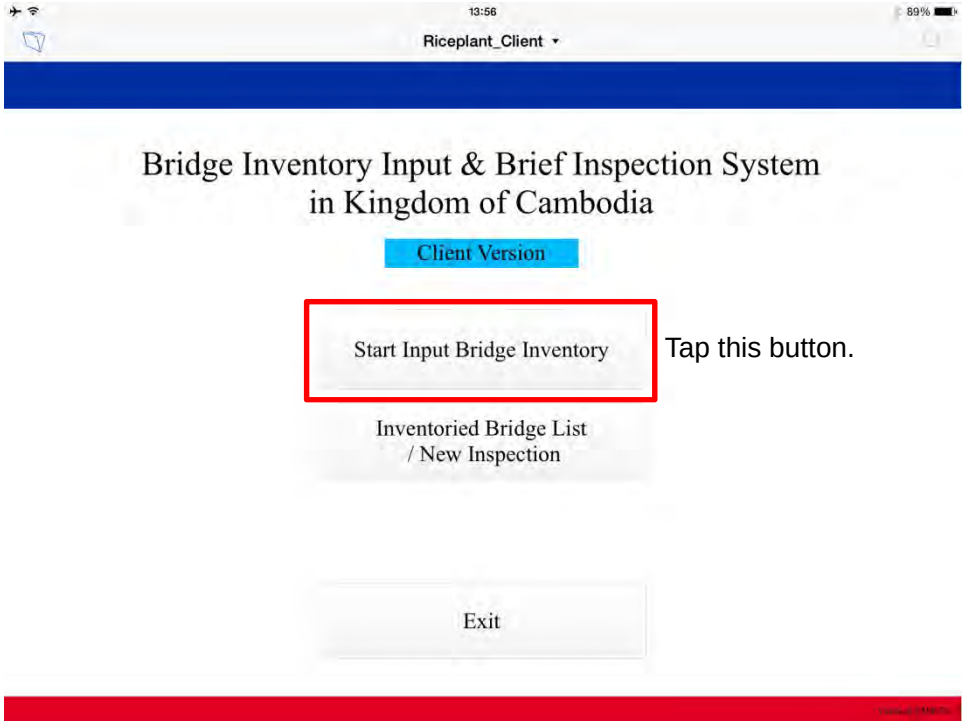


Fig-1 First screen of the iPad system (Front screen)

1. Bridge Photos

Firstly, 3 photos should be taken.

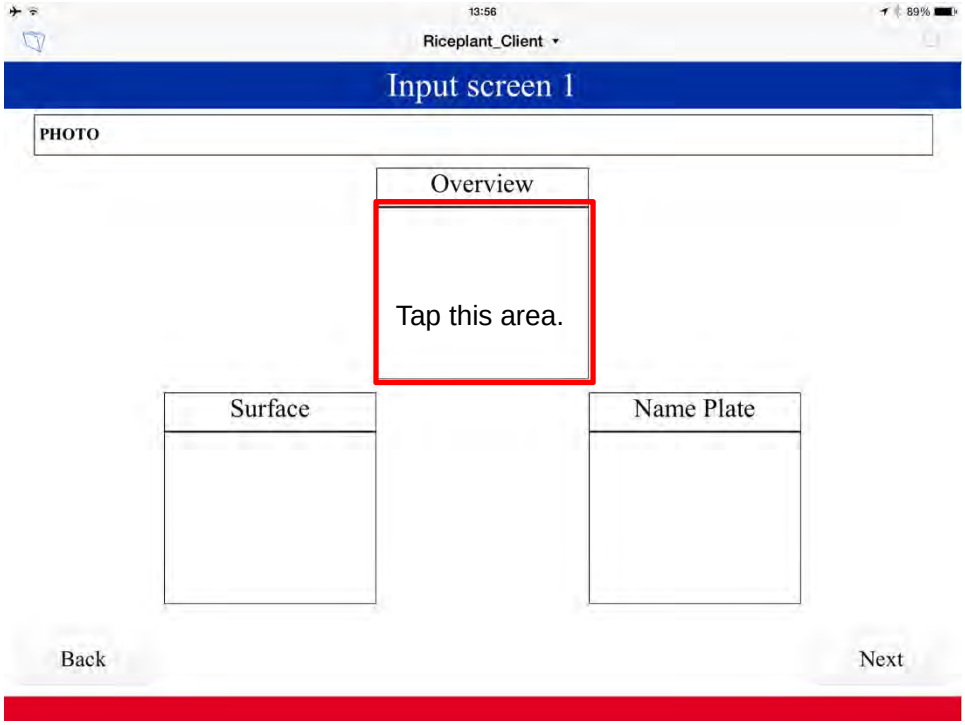


Fig-2 Second screen of the iPad system (Input Screen 1)

Photos should be taken from the directions below.

1) Overview (including abutment to abutment)

Sample picture is below.

2) Road Surface

Sample picture is below.

3) Bridge Nameplate (If present)

Sample picture is below.

2. Bridge Basic Information (1)

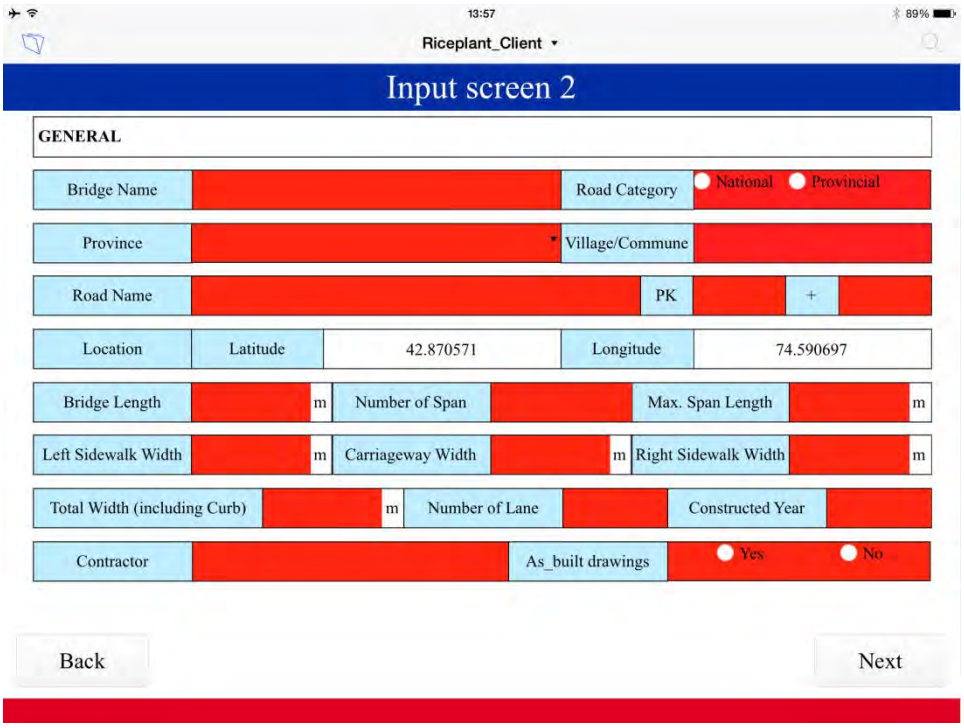


Fig-3 Third screen of the iPad system (Input Screen 2)

Red parts are the information should be filled up. Location is automatically filled up from GPS information by iPad. If impossible to fill up the cell, it is OK to remain red.

Contents of “A. GENERAL” are below.

- Bridge Name (Manually input)
- Road Category (Selection input)
- Province (Selection input, Pull down menu)
- Village/Commune (Manually input)
- Road Name (Road Number), PK (Manually input)
- Location (Latitude, Longitude) (Automatically input)
- Bridge Length (Manually input)
- Number of Span (Manually input)
- Max. Span Length (Manually input)
- Width (Manually input)
  - Left sidewalk
  - Carriageway
  - Right sidewalk
  - Total width
- Number of Lane (Manually input)
- Constructed Year (Manually input)
- Contractor (Manually input)
- As built drawing (Selection input)

3. Bridge Basic Information (2)

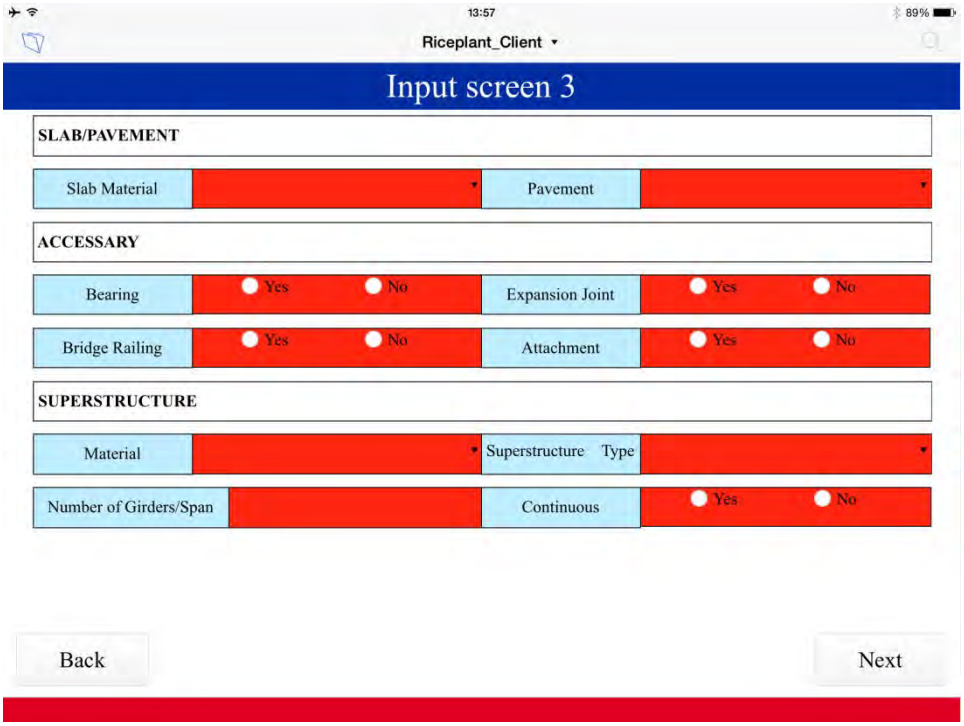


Fig-4 Fourth screen of the iPad system (Input Screen 3)

Red parts are the information should be filled up. If impossible to fill up the cell, it is OK to remain red.

Contents of “SLAB/PAVEMENT” are below.

- Slab Material (Selection input, Pull down menu)
- Pavement (Selection input, Pull down menu)

Contents of “ACCESSARY” are below.

- Bearing (Yes or No) (Selection input)
- Expansion Joint (Yes or No) (Selection input)
- Bridge Railing (Yes or No) (Selection input)
- Attachment (Yes or No) (Selection input)

  Attachment means lifeline (electric cable, communication cable, water supply, etc.).

Contents of “SUPERSTRUCTURE” are below.

- Material (Selection input, Pull down menu)
- Superstructure Type (Selection input, Pull down menu)
- Number of Girder / one span (Manually input)
- Continuous (Yes or No) (Selection input)

4. Bridge Basic Information (3)

Fig-5 Fifth screen of the iPad system (Input Screen 4)

Firstly, tap the area of red square, then take a photo of the bridge from underside.

Sample picture is below. It should be taken care to take a photo including deck slab and substructure.

And, red parts are the information should be filled up. If impossible to fill up the cell, it is OK to remain red.

Contents of “COLUMNS AND PIERS” are below.

- Material (Selection input, Pull down menu)
- Structure Type (Selection input, Pull down menu)
- Size of Column/Pier (Manually input)
- Foundation Type (Selection input, Pull down menu)
- Number of Column/Pier (Manually input)

Contents of “ABUTMENT” are below.

- Material (Selection input, Pull down menu)
- Structure Type (Selection input, Pull down menu)
- Foundation Type (Selection input, Pull down menu)
- Height (Manually input, Abutment 1 and Abutment 2)

5. Inventory Data Sheet

Bridge inventory data sheet with 4 photos is automatically formed like below.

Bridge Inventory Sheet

Back | Delete this bridge data

						Fill in	2015/05/29
						Revised in	2015/05/29
A. GENERAL							
Bridge Name				Road Category			
DPWT				Prov./City			
Road Name				Kp		km +	
Location	Latitude	11.574191		Longitude	104.922699		
Bridge Length	m	Number of Span		Max. Span Length	m		
Left Sidewalk Width	m	Carriageway Width	m	Right Sidewalk Width	m		
Total Width (including Kerb)	m	Number of Lane		Constructed Year			
Contractor		As_built drawings	○ Yes	○ No			
B. SUPERSTRUCTURE							
Material		Superstructure Type					
Number of Girders/Span		Continuous	○ Yes	○ No			
C. SLAB/PAVEMENT							
Slab Material		Pavement					
D. ABUTMENTS							
Material		StructureType					
Foundation Type		Height	A1	m	A2	m	
E. COLUMNS AND PIERS							
Material		StructureType					
Size of Column/Pier	Rectangle	mm ×	mm	Circle	φ	mm	
Foundation Type		Number of Column / Pier					
F. ACCESSARY							
Bearing	○ Yes	○ No	Expansion Joint	○ Yes	○ No		
Bridge Railing	○ Yes	○ No	Attachment	○ Yes	○ No		
G. PHOTO							




Back

6. Definition of each dimension

1) Each Length and Each Width

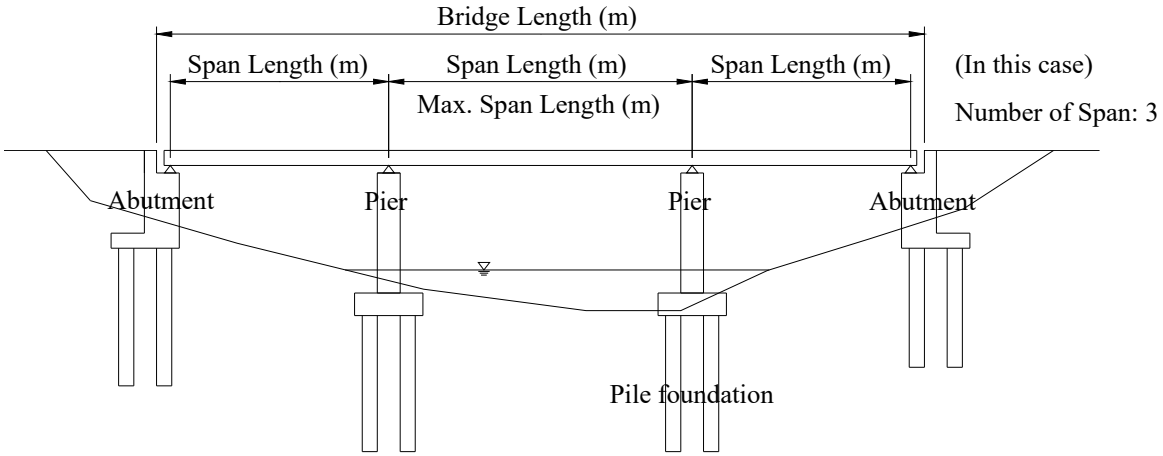
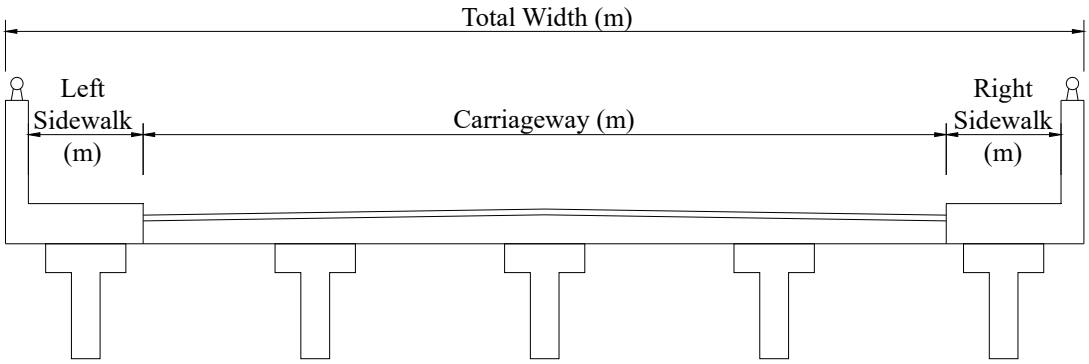


Fig-6 Length



(In this case) Number of Girder: 5

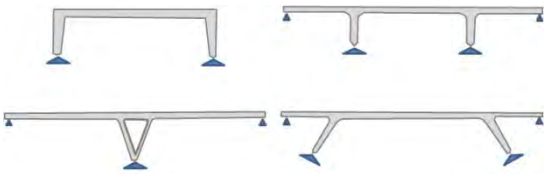
Fig-7 Width

7. Superstructure

Material for superstructure is selected from 5 items below.

<table>
<tr><td>(1) Concrete</td><td>(2) Steel</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>(3) Wooden</td><td>(4) Masonry</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>(5) Others</td><td></td></tr>
<tr><td> 
Above bridge is a bridge for pedestrian which is made from Glass Fiber Reinforced Plastic.</td><td></td></tr>
</table>

As superstructure type in pull down menu is prepared 6 items below.

(1) Girder	(2) Slab girder
	
(3) Truss	**(4) Arch**
	
(5) Frame (Rigid Frame)	
	 Other types of Rigid Frame
(6) Cable-stayed	**(7) Others**
	

8. Slab / Pavement

As slab material in pull down menu is prepared 4 items below.

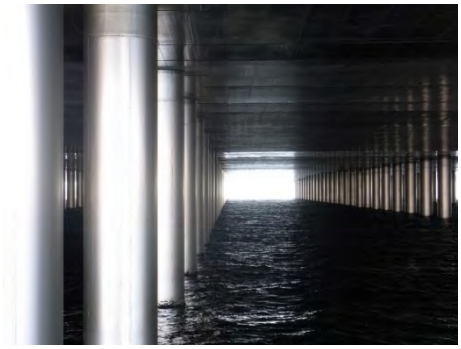
(1) Concrete	(2) Steel
	
(3) Wooden	(4) Others (If present)
	

As pavement type in pull down menu is prepared 4 items below.

(1) Asphalt Concrete	(2) DBST or SBST
	
(3) Concrete	(4) No pavement
	

9. Substructure (Abutment, and Column and Pier)

As abutment material in pull down menu is prepared 5 items below.

(1) Concrete	(2) Steel
	
(3) Wooden	(4) Masonry
	
(5) Others (If present)	
 These piers are made of titanium.	

As structure type of pier in pull down menu is prepared 4 items below.

(1) Wall Type



(2) Single Column



(3) Multi Columns



(4) Others

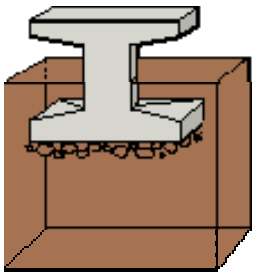
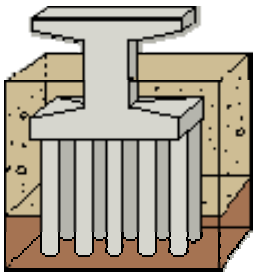
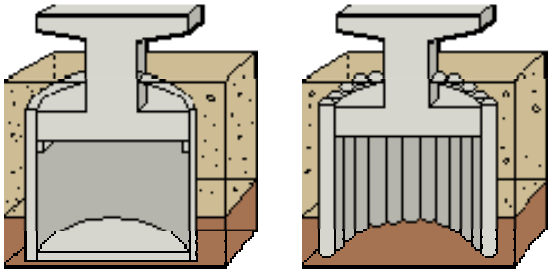


As structure type of abutment in pull down menu is prepared 4 items below.

(1) Full-Retaining (h>5m)	(2) Semi-Retaining (h<5m)
	
(3) Spill Through (Open)	**(4) Others**
	 There is a bridge without abutment mainly in case of wooden bridge and masonry bridge.

10. Foundation

As structure type of foundation of abutment and pier in pull down menu is prepared 4 items below.
But, it is difficult to find bridge foundation after construction. So, when it is difficult to estimate bridge foundation type in consideration around bridge, "(4) unknown" should be selected.

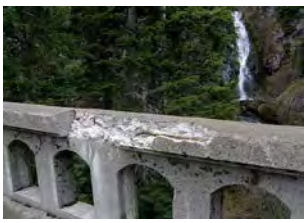
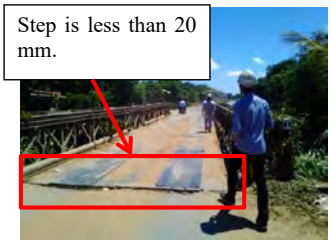
(1) Spread Foundation	(2) Pile Foundation
	
(3) Others	**(4) Unknown**
	

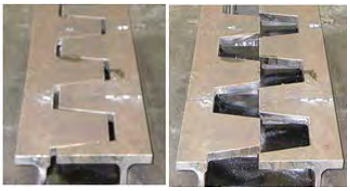
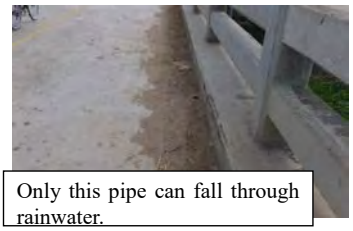
11. Accessories

As bridge accessories, it should be checked that 4 items below is existed or not.

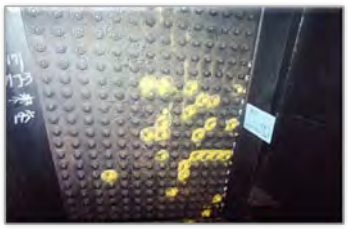
(1) Bearing	(2) Expansion Joint
	
	

(3) Bridge Railing	(4) Attachment
 	  Ex) Electric Cable, Water supply line, Communication Cable, etc.

Sample Photos of each damage					
Location	Part	Inspection item	Check point	Score	Sample of Photo
Road Surface	Bridge Railing / Guardrail / Curb	Damage	No Damage	0	
			Damage	1	
			Damage (Possiblity of harm third party)	10	
Road Surface	Expansion Joint	Step	No damage	0	
			Step under 20mm	1	
			Step over 20mm	3	
Road Surface		Deformation / Damage	No damage	0	

Location	Part	Inspection item	Check point	Score	Sample of Photo
			Abnormal expansion gap (More than 2cm)	2	
			Deformation / Damage	3	
Road Surface			Abnormal sound	3	If hear abnormal sound at vehicle traveling, then record the sound by audio function in iPad.
	Drainage System	Clog of drainage pipe	No Damage	0	
			Partial no function (Impossibility flood)	1	 Only this pipe can fall through rainwater.
Road Surface			Almost no function(stuffed, broken, etc)	3	 Almost of drainage pipes are clogged.
Bridge Girder	Superstructure (Steel)	Corrosion / Rust	No Damage	0	

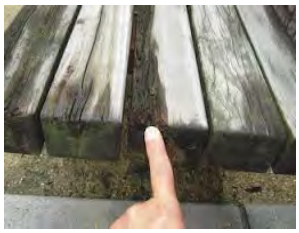
Location	Part	Inspection item	Check point	Score	Sample of Photo
			Corrosion on steel members	1	
Bridge Girder	Superstructure (Steel)		Hole by corrosion	4	
			Invisible		
		Crack, Deformation,	No Damage	0	
Bridge Girder	Superstructure (Steel)	Loss, Break	Steel members deformation	1	
			Crack on steel member	3	
			Steel member loss/broken (Secondary membe	5	

Location	Part	Inspection item	Check point	Score	Sample of Photo
Bridge Girder	Superstructure (Steel)		Steel member loss/broken (Primary member)	10	
			Invisible		
		Missing bolt	No Damage	0	
Bridge Girder	Superstructure (Steel)		Missing less than 10%.	2	
			Missing more than 10%.	10	
			Invisible		
Bridge Girder	Superstructure (Concrete)	Honeycomb / Flaking /	No Damage	0	

Location	Part	Inspection item	Check point	Score	Sample of Photo
		Exposure of rebar /Crack	Free lime/ Honeycomb/ Flaking and/or Lacking concrete	1	
			Exposure of rebar	1	
	Superstructure (Concrete)		Rebar rusting	2	
		(Crack width)	Rust fluid from crack	2	
		RC: >about 0.3mm	Crack on girder	3	
	Superstructure (Concrete)	PC: >about 0.2mm	Crack on girder (above Bearing)	8	
			Invisible		

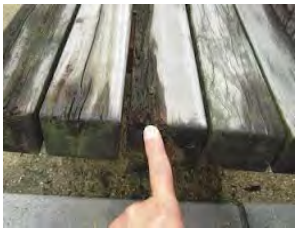
Location	Part	Inspection item	Check point	Score	Sample of Photo
Bailey Bridge	Superstructure (Bailey Bridge)	Missing pin	No Damage	0	
			Loosing pin on bailey bridge	4	
			Missing pin on bailey bridge (Connecting part)	15	
Bailey Bridge	Superstructure (Bailey Bridge)	Truss Girder	No Damage	0	
		Corrosion / Rust / Crack /	Corrosion on steel member	1	
		Deformation /Loss /Break	Steel member deformation	1	
Bailey Bridge	Superstructure (Bailey Bridge)		Hole by corrosion	3	

Location	Part	Inspection item	Check point	Score	Sample of Photo
			Crack on steel member	5	
			Steel member loss/broken	15	
Bailey Bridge	Superstructure (Bailey Bridge)		Invisible		
		Slab	No Damage	0	
		Corrosion / Crack	Corrosion and/or Rust on steel member	1	
Bailey Bridge	Superstructure (Bailey Bridge)		Crack	15	
			Hole	15	

Location	Part	Inspection item	Check point	Score	Sample of Photo
			Invisible		
Bridge Slab	Superstructure (Woodn)	Rotting	No Damage	0	
			Rot of wood	1	
			Reduction of cross section	2	
Bridge Slab	Superstructure (Woodn)		Invisible		
		Crack / Damage	No Damage	0	
			Damage (Crack / Partial loss)	2	

Location	Part	Inspection item	Check point	Score	Sample of Photo
Bridge Slab	Superstructure (Woodn)		Big damage (collaspe risk / Impassable)	3	
			Invisible		
	Slab (Concrete)	Honeycomb / Flaking /	No Damage	0	
Bridge Slab	Slab (Concrete)	Exposure of rebar	Free lime/ Honeycomb/ Flaking and/or Lacking concrete	1	
		Crack / Hole	Exposure of rebar	1	
			Rebar rusting	1	
Bridge Slab	Slab (Concrete)		Rust fluid from crack	2	

Location	Part	Inspection item	Check point	Score	Sample of Photo
Bridge Slab		(Crack width)	Crack on undersurface (Longitudinal)	2	
		RC: >about 0.3mm	Crack on undersurface (Transversal)	3	
	Slab (Concrete)	PC: >about 0.2mm	Hole	8	
			Invisible		

Location	Part	Inspection item	Check point	Score	Sample of Photo
Bridge Slab	Slab (Wooden)	Rotting	No Damage	0	
			Rot of wood	1	
			Reduction of cross section	2	
Bridge Slab	Slab (Wooden)		Invisible		
		Crack / Damage	No Damage	0	
			Big damage (collaspe risk) / Impassable	5	
Bridge Slab	Slab (Wooden)		Hole / Missing slab plate	5	

Location	Part	Inspection item	Check point	Score	Sample of Photo
			Invisible		
		Vibration, Abnormal Sound	No Damage	0	
			Vibration and/or Abnormal sound at travelling	1	If feel vibration and/or abnormal sound at vehicle traveling, then record the sound by audio function in iPad.
Sub-structure	Bearing	Sedimentation / Damage	No Damage	0	
			Partial sedimentation	1	
Sub-structure	Bearing		Corrosion and/or damage	2	
			Partial sedimentation (Cannot see bearings)	3	

Location	Part	Inspection item	Check point	Score	Sample of Photo
Sub-structure			No function (Include rusting)	3	 Steel pad is fall out. Bearing is not supporting to superstructure.
	Bearing		Invisible		
	Pier / Abutment	Scouring / Settlement	No Damage	0	
			Scouring around substructure	4	
Sub-structure	Pier / Abutment		Settlement of substructure	10	
			Invisible		
		Honeycomb / Flaking / (Crack width) RC: >about 0.3mm PC: >about 0.2mm	No Damage	0	

Location	Part	Inspection item	Check point	Score	Sample of Photo
Sub-structure	Pier / Abutment	Exposure of rebar /	Free lime/ Honeycomb/ Flaking and/or Lacking concrete	1	
		Crack	Exposure of rebar	1	
			Rebar rusting	2	
Sub-structure	Pier / Abutment	(Crack width)	Rust fluid from crack	2	
		RC: >about 0.3mm	Crack on surface (Horizontal Direction)	5	
		PC: >about 0.2mm	Crack on surface (Vertical Direction)	5	
			Invisible		

Part 2

Bridge Repair

Maintenance Expert Program

Bridge Repair

ME-BR

Lecture Material

ME Training Program

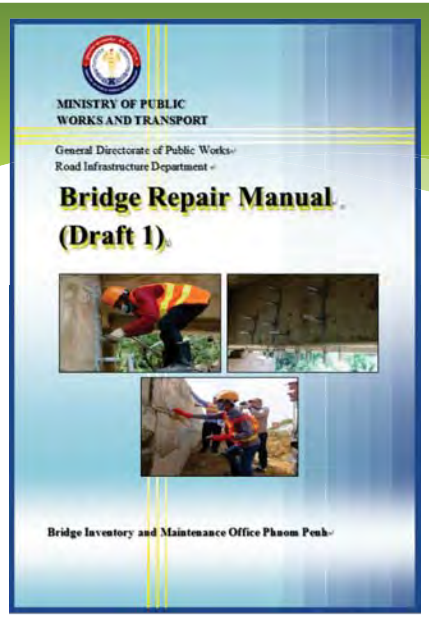
ME	Bridge ME		Road ME	
	ME-BI	ME-BR	ME-RI	MR-RR
Subject of ME	Bridge Inspection	Bridge Repair	Road Inspection	Road Repair
Competences	Bridge inspection Bridge database	Standard bridge repair	DRIMS Visual inspection	Standard road repair
Manual to be used	Bridge Inspection Manual	Bridge Repair Manual	Guidelines for Routine Maintenance Using IRI	Guidelines for Repairing Defects of Roads
Number of days	3 days	1 day	3 days	1 day
Remark	1 day for field training	Lecture only	Theory and field training	Lecture only

Bridge ME: Bridge Repair

Contents	Key Concepts
CHAPTER 1 Introduction	・The importance of maintenance ・Concept of Preventive Maintenance ・Glossary of bridge, damage
CHAPTER 2 Organization for bridge repair	・Bridge repair Schedule ・Jurisdiction of Bridge repair
CHAPTER 3 Safety and maintenance work	・For keeping safety repair work ・Confirmation before repair work ・Confirmation during repair work ・Routine maintenance

Bridge ME: Bridge Repair

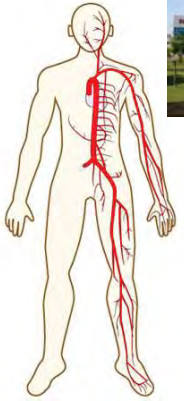
Contents	Key Concepts
CHAPTER 4 Maintenance room and Basic knowledge of concrete	・Maintenance Room ・Knowledge of Concrete Material ・Damages due to construction failures (Concrete) ・Concrete Work ・Concrete quality verification test
CHAPTER 5 Repair of concrete structure	・Planning of Concrete structure repair ・Introduction of Concrete structure repair
CHAPTER 6 Repair of steel structure	・Planning of Steel structure repair ・Introduction of Steel structure repair
CHAPTER 7 Repair of foundation or other structure	・Introduction of foundation or other structure repair

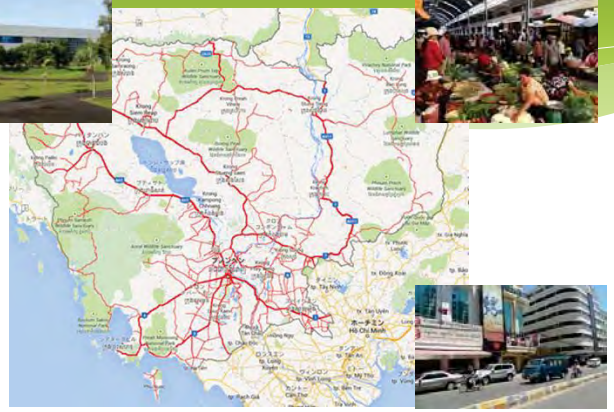


Bridge Repair Manual

Chapter 1 Introduction

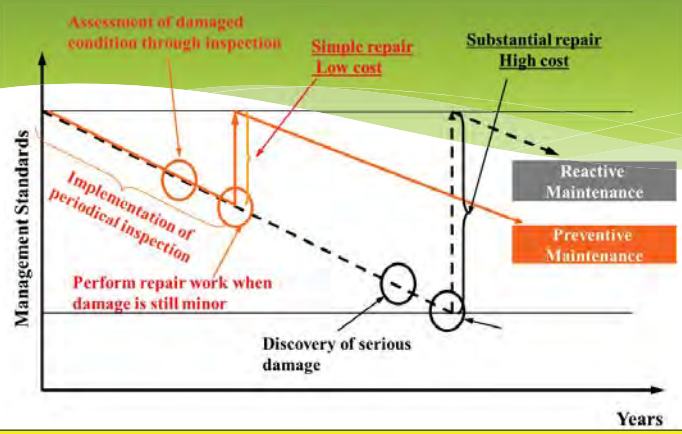
Road Network (Equivalent to Blood Vessels)





The road infrastructure is essential for Cambodia economy

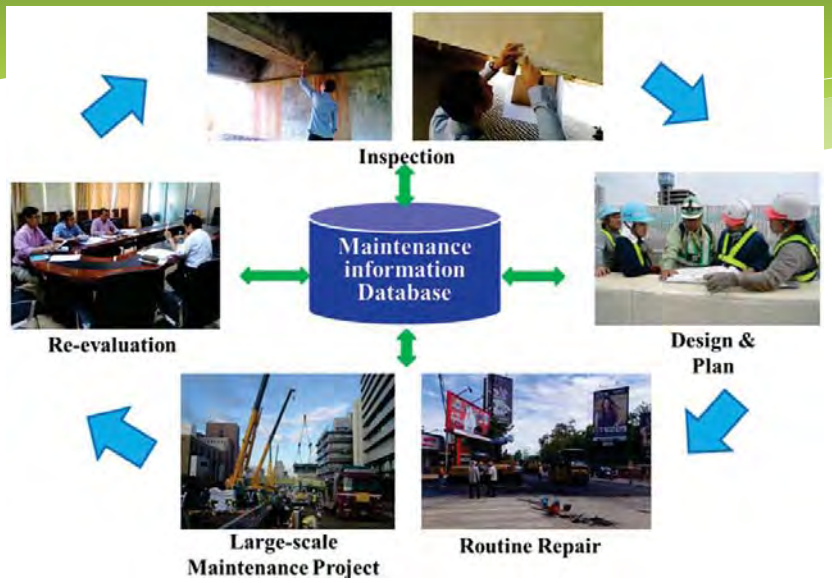
Concept of Preventive Maintenance



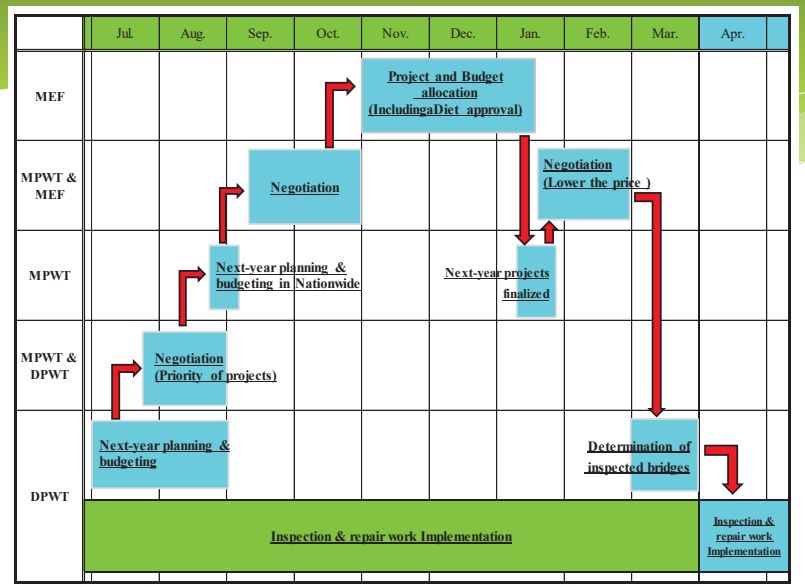
In order to reduce the burden of future maintenance to minimize the life cycle cost consequently, **constant and timely inspection and repair work are essential.**

Chapter 2
Organization for Bridge Repair

Routine Bridge Maintenance Cycle



Maintenance Budgeting Schedule

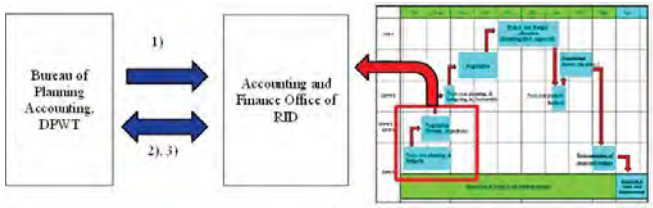


Annual Implementation Plan

Content	The unit in charge	Relevant division
1) To Prepare the annual implementation plan	Bureau of Public Work, DPWT	Road Inventory & Routine Maintenance Office of RID
2) To quest and to receives answer about the plan	Road Inventory & Routine Maintenance Office of RID	Bureau of Public Work, DPWT
3) The collected information and edited	Road Inventory & Routine Maintenance Office of RID	Bureau of Public Work, DPWT

Cost Estimation

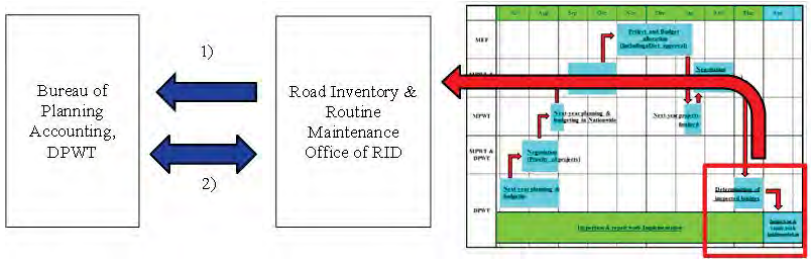
Content	The unit in charge	Relevant division
1) To estimate the cost	Bureau of Public Work, DPWT	Road Inventory & Routine Maintenance Office of RID
2) To quest and to receives answer about the Cost Estimation	Road Inventory & Routine Maintenance Office of RID	Bureau of Public Work, DPWT
3) To summarize and to edit the estimation	Road Inventory & Routine Maintenance Office of RID	Bureau of Public Work, DPWT



12

Budget Management

Content	The unit in charge	Relevant division
1) Management of overall national budget	Road Inventory & Routine Maintenance Office of RID	Bureau of Public Work, DPWT
2) To checks and to confirm the balance between budget and actual spending	Road Inventory & Routine Maintenance Office of RID	Bureau of Public Work, DPWT

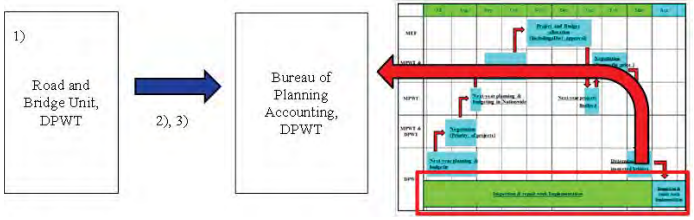


13

100

Implementation of repair work

Content	The unit in charge	Relevant division
1) To conduct bridge repair	Road and Bridge Unit, DPWT	—
2) To report the actual repair cost	Road and Bridge Unit, DPWT	Bureau of Planning Accounting, DPWT
3) The report repair cost (In case of excessive spending)	Road and Bridge Unit, DPWT	Bureau of Planning Accounting, DPWT



14

Data Input of Repair Results

Data Input of Repair Results

Content	The unit in charge	Relevant division
1) Inputting the repair result data in the Bridge Inspection Database System	Repair workers (Road and Bridge Unit, DPWT)	—

Confirmation of the Data Input

Content	The unit in charge	Relevant division
1) Input confirmation	The chief of repair team	—

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Chapter3
Safety and Maintenance work

16

For keeping safety : Repair Schedule

Repair Schedule

Before repair work

① Site Cleaning

② Site check

③ Meeting for repair

Repair work

(a) Meeting on site

(b) Site Cleaning

(c) Setting to Scaffolding

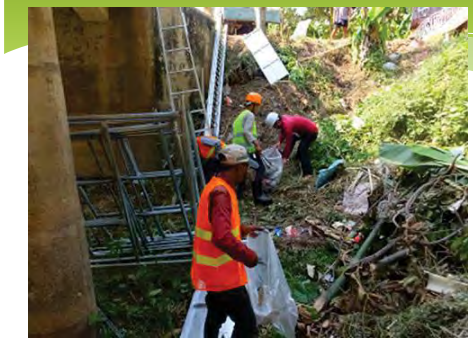
(d) Repair work

17

For keeping safety : ① Site Cleaning (1)

18

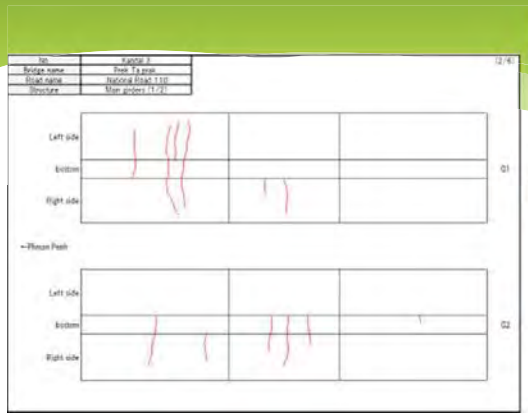
For keeping safety : ② Site Cleaning (2)

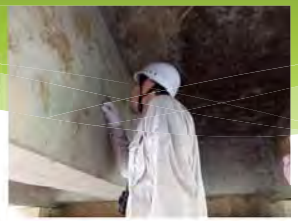


All members carry out site cleaning at first

19

For keeping safety : ② Site check





It is necessary to check the site
in order to confirm target damages to be repaired

20

For keeping safety : ③ Meeting for repair

In this meeting, detail work procedure, schedule, safety measures, number of workers dispatched, material, tools, and assignment of each worker are discussed and confirmed based on newly-obtained knowledge from site check and inspection sheet.

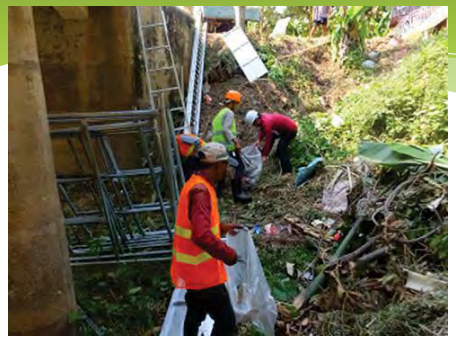
21

For keeping safety : (a) Meeting on site

Before the repair work, the supervisor has to gather the all workers and have a meeting
in order to confirm the procedure of the day's work and caution for safety

22

For keeping safety : (b) Site Cleaning (1)



After the site meeting,
All members carry out site cleaning at first

23

For keeping safety : (b) Site Cleaning (2)

It is difficult for him to fine the hole because the grass is overgrown

Cutting grass

24

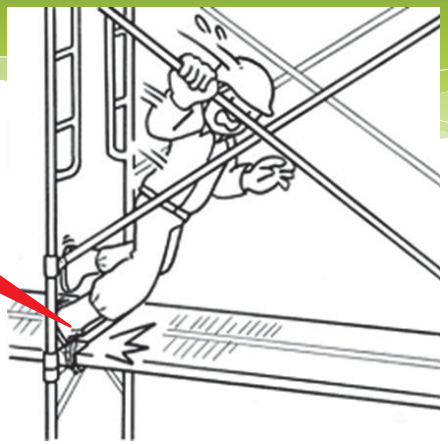
For keeping safety : (c) Scaffolding (1)

Work floor opening is very danger !!

25

For keeping safety : (c) Scaffolding (2)

× Difference in level



Accident by difference in level

26

For keeping safety : (c) Scaffolding (3)

Fixed with the frame

Fixed on the ground

Fixed scaffolding

27

For keeping safety : (d) Repair work (1)

- All people entering the work site must wear the protection helmet, working shoes or leather shoes.
- **Sandals are not allowed in the site**.

28

For keeping safety : (d) Repair work (2)

- **Rubber protection gloves should be worn** in case of using harmful material harmful to skin.

29

Chapter 4 (1/3)
Routine maintenance

30

Routine maintenance : Bridge Deck Cleaning

Drainage facilities and expansion joints on the deck should also be carefully cleaned

31

Routine maintenance : Drainage Cleaning

Drainage facilities and expansion joints on the deck should also be carefully cleaned

32

Routine maintenance : Cleaning of Substructure

All foreign materials such as dirt, dust, sand, rain water, and moss on surfaces of abutment and pier bearing seats and coping shall also be completely removed manually and then washed using a high pressure water bluster.

33

Chapter 4 (2/3)
Maintenance room

34

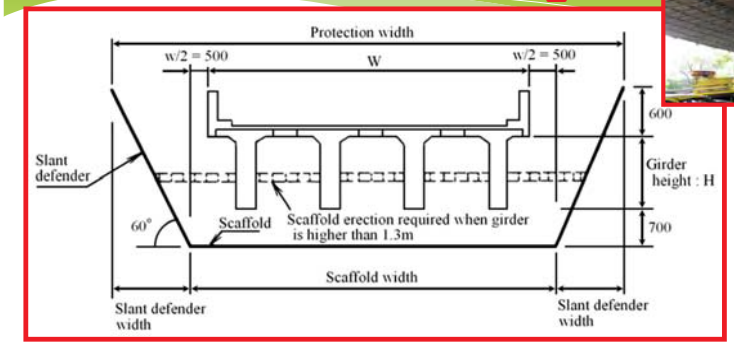
Maintenance room (1)

Enough maintenance room should be secured for the following structures
(a) Bridge structure over river and waterways
(b) Bridge structure over crossing road
(c) Bridge structure adjacent to immovable structures

35

Maintenance room (2)

Example



Scaffolding also needs enough spaces for suspension devices, worker's passage and staircase and protection panel

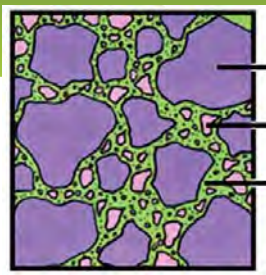
Maintenance room (3)

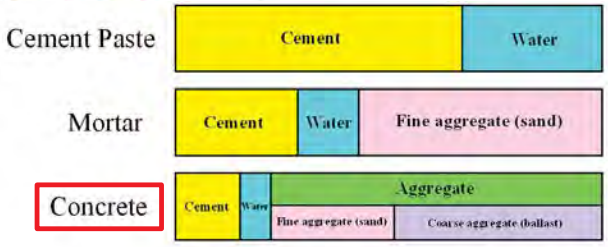
Keep safety !!

Scaffolding also needs enough spaces for suspension devices, worker's passage and staircase and protection panel

Chapter 4 (3/3)
Basic knowledge of concrete

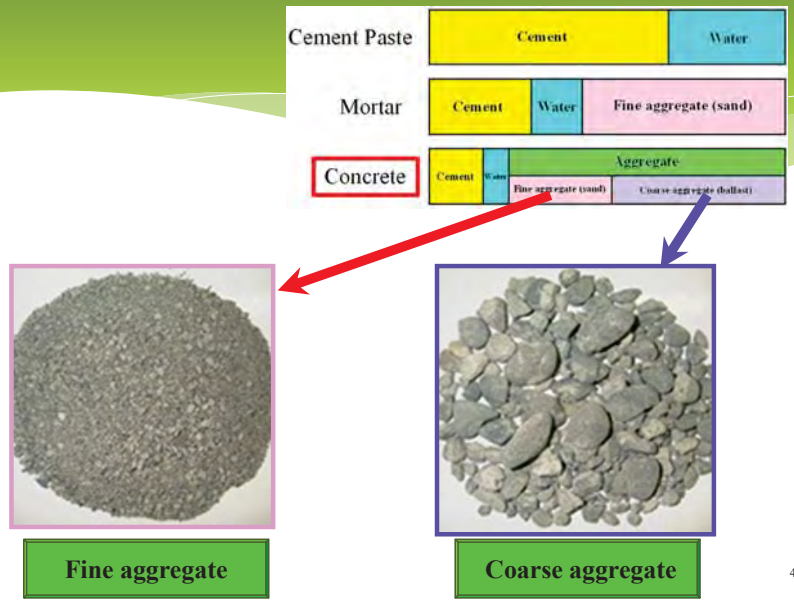
Concrete Material: Composition of Concrete





*Calculated by the mass ratio
*In addition, Admixture and air are mixed.

Concrete Material: Aggregate



40

Construction failures: Honeycombing(1)

Causes

(1) Concrete mix design
(2) Insufficient concrete compaction
(3) High concrete casting position

41

Construction failures: Honeycombing(2)

Preventive measures

(1) The execution of right mix design based on standard specification
→ Workability should be chosen by considering the size and shape of cross-section and reinforcement arrangement.
(2) When formwork is high, casting hole in the intermediate height and supplementary casting devices, pump or concrete hopper should be provided.
(3) Enough lateral space between reinforcements should be secured so that vibrator can be inserted easily.

42

Construction failures: Cold Joint (1)

Causes

The dominant causes of cold joint are concrete solidification time and casting interval between layers.

Allowable Maximum Casting Interval

Ambient Temperature	Allowable Maximum Casting Interval
Over 25 ℃	2.0 hours
Less than 25 ℃	2.5 hours

43

Construction failures: Cold Joint (2)

Preventive measures

- The best way is to make a well-examined casting plan before hand and execute casting accordingly.
- The cold joint forming can be avoided by using admixture for setting retarding.

Storage

Storage of steel

- Reinforcing bars and structural steel shall be stored in storage facilities
- If they are stored outdoors, under appropriate cover instead of being placed directly on the ground surface.

Storage of cement

- If bags of cement are stacked while in storage, the cement in the lower bags might consolidate.
- A recommended limit to the number of layers of stacked bags of cement, therefore about 13.

Concrete work (1)

- Concrete placement shall not generally be performed in rain or strong wind.

- The time from the completion of mixing to the completion of placement
  2 hours or less
  ← The outdoor air temperature is lower than 25 degree Celsius.
  1 .5 hours or less
  ← The outdoor air temperature is higher than 25 degree Celsius.

Concrete work (2) : Internal vibrators

- In principle, internal vibrators should be used for compacting concrete.

- Internal vibrators must not be used for lateral movement, which may cause segregation.

Concrete work (3) : Curing

■The curing method shall generally be wet curing.

Portland cement

: For at least 5 days after placement,

High-early-strength Portland cement

: For at least 3 days after placement.

■Seawater shall not be used for the curing water.

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Concrete work (4) : Construction joint

■At the construction joint, the concrete surface shall be cleared of laitance, loose aggregate.

Laitance

49

Concrete work (5) : Reinforcement

■Reinforcement shall be bended at normal temperature and the bending work shall be performed using a bending machine in a manner.

Bending machine

■At assembling reinforcement, loose rust or other matter that may impair the bond with concrete shall be removed.

Be removed!!

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Concrete quality test : Slump test (1)

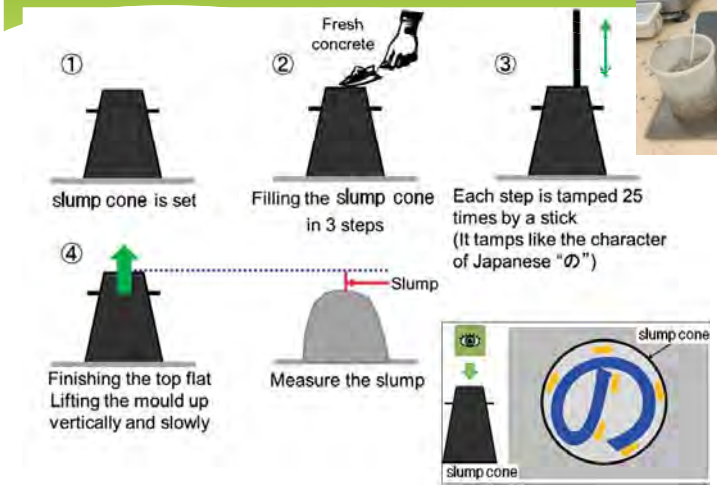
Slump test is used to know the workability, and to know the concrete properties.

The big slump

High workability. But it is not so good for concrete durability.

It is important to **minimize the slump water content within the limits of workability for casting**.

Concrete quality test : Slump test (2)

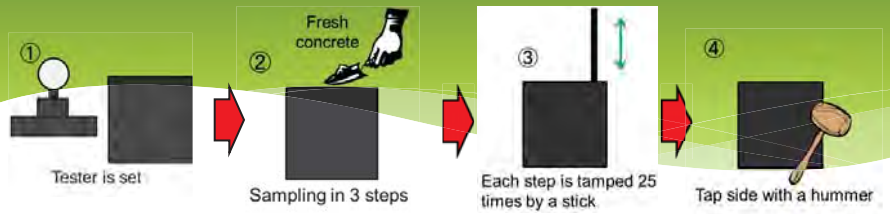


Concrete quality test : Air content test (1)

Air content test is to measure air content contained in concrete.

The more amount of air is large, workability of concrete is good.
However, **if air is put in too much, compressive strength is reduced**.

Concrete quality test : Air content test (2)



⑧ Unit water content take air content and weight into consideration

Chapter 5
Repair of concrete structure

Concrete crack Repair (1)

Progress of concrete crack

56

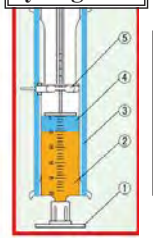
Concrete crack Repair (2)

Outline of repairs

Concrete cracks are filled with epoxy resin injection

Repair material

Syringes set



①Washer
②Syringes
③Rubber Band
④Pressure Ring
⑤Stopper

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Concrete crack Repair (3)

Execution Procedures

①1st day


Removing the dirt


Sealing

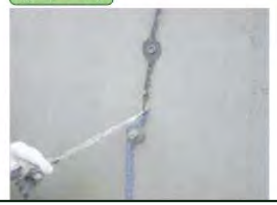
After sealing become hardened (24 hours after)

②2nd day


Injection into cracks with epoxy resin

After Injection material becomes hardened (24 hours after)

③3rd day


Remove syringes, washers and sealing

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Concrete crack Repair (4)

Repair work in Kandal, Phnom Penh (Feb.2016)

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Concrete crack Repair (5)


Ministry of Public Works Transport, Cambodia

BRIDGE REPAIR WORK JOB SHEET

Code : 1 - 00001 | Item : Concrete Crack Repair

Standard
* Concrete cracks are filled with epoxy resin injection
* This method for concrete crack repairing is relatively less expensive than other methodologies

Work Method
* This repair work is carried out by dividing these days

Material: *Epoxy resin *Sealant (Sealing) *Syringes set *Thinner *Chalk *Clay

Tool (Main): *Platform scale *Trowel *Wire brush *Air blower *Stopwatch *Plastic cup *Plastic plate

Safety Signs and Devices: *Scaffolding *Glove *Site Cleaning tool

Expected
*Repair material (Epoxy resin, Sealant, Syringes set Thinner etc.)
*Labor cost *Site inspection cost *Transport workers and material cost
*Equipment hire *Safety cost

Remarks
* This method for concrete crack repairing is relatively less expensive than other methodologies

This method is shown in Code of "Bridge Repair Manual"

Code Number : 1-0001

Concrete Reinforcement method by CFRP(1)

Current bridge damage situation in Cambodia

Case1 Insufficient strength capacity due to **non-conforming** work or design deficiency

Case2 **Overloading**

Concrete Reinforcement method by CFRP(2)

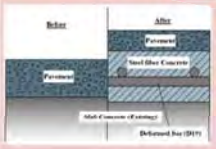
Case1 **Structural reinforcement bridge members** in order to recover the losing strength

Case2 **Strengthening law enforcement of overloading vehicles** and **structural reinforcement of bridge members** in order to increase the strength capacity

'Structural reinforcement of bridge members' is performed.

Concrete Reinforcement method by CFRP(3)

The selection of reinforcement method

	Concrete overlaying	Steel plate bonding	CFRP bonding
Repair Method			
Merits	*Scaffolding not needed	*No traffic regulation needed * Many applications for busy bridges in Japan	*No traffic regulation needed *Incremental weight is very small *Easier construction procedure
Demerits	*Big incremental weight *Heavy equipment needed *Chipping of existing concrete is necessary for firm fixing *Road closure is needed during construction	*Big incremental weight *Scaffolding is needed *Anchor's holding capacity is not guaranteed if the existing concrete is poor *Shaping reinforcing steel plate exactly is necessary and difficult	*Scaffolding is needed *Risk of energization
Judgment	Medium	Not good	Good

Concrete Reinforcement method by CFRP(4)

About CFRP (carbon fiber reinforced plastics)

* *Excellent material properties.
* - Lightweight
* - High strength, high elasticity （Tensile strength:3,400N/mm2 ,10 times more compared with iron）
* - High durability against ultraviolet ray
* *Since CFRP is lighter and stronger than aluminum or iron, recently it is increasing a d vehi
* *Ex ty

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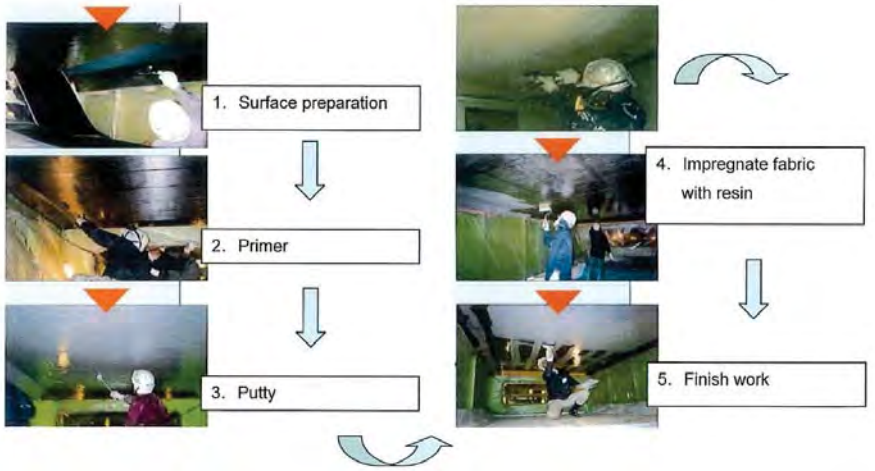
Concrete Reinforcement method by CFRP(5)

Execution Procedures



Concrete Reinforcement method by CFRP(2)

Ministry of Public Works Transport, Cambodia

BRIDGE REPAIR WORK JOB SHEET

Code : 1 - 00003 | Item : Concrete Surface Reinforcement

Standard

Work Method

Material | Tool (Main) | Safety Signs and Devices

Expensed

Remarks

This method is shown in Code of "Bridge Repair Manual"

Code Number : 1-0003

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Repair of steel structure

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Reinforcement by Steel Plate (1)

Outline of repairs

*This method is applied to reinforce the loss part by corrosion.

*This method is applied to reinforce of insufficient structure such as design defect, strength lack due to overloaded vehicles.

*The rust part is removed the by disc sander.

*The deficit part is reinforced by spliced plate. It is designed to determine the size or spliced method of the spliced plate.

*If the existing spliced plate needs to be removed, it is necessary to carefully consider the removal method.

Reinforcement by Steel Plate(2)

Execution Procedures

Reinforcement by Steel Plate(2)

Ministry of Public Works Transport, Cambodia

BRIDGE REPAIR WORK JOB SHEET

Code : 2 - 00002 | Item : Reinforcement by Steel Plate

Standard

* This method is applied to reinforce the loss part by corrosion.
* This method is applied to reinforce of insufficient structure such as design defect, strength lack due to overloaded vehicles.

Work Method

*The rust part is removed the by disc sander.
*The deficit part is reinforced by spliced plate. It is designed to determine the size or spliced method of the spliced plate. For this reason, it is necessary to prepare the design document of the repair bridge.
* If the existing spliced plate need to be removed, it is necessary to carefully consider the removal method.

Material	Tool (Main)	Safety Signs and Devices
*Steel Plate * High strength bolt *Painting * Thinner	*Generator *Impact wrench *Drilling machine *Electric hoist *Disc sander * Brush *Roller	*Scaffolding *Glove *Site Cleaning tool

Expensed

*Repair material (Steel plate, High strength bolt etc.) *Rental Fee
*Labor cost *Site inspection cost *Design cost
*Transport worker and material cost *Equipment hire *Safety cost

Remarks

*This method must be designed to determine the size or spliced method of the spliced plate.
* If the existing spliced plate need to be removed, it is necessary to carefully consider the removal method.

This method is shown in Code of "Bridge Repair Manual"

Code Number : 2-0002

Thank you for your attention

Part 2

Road Inspection

Maintenance Expert Program

Road Inspection

ME-RI

Lecture Material

Road ME: Road Inspection

Day	Activities	Reference*
Day1	[Lecture]	
	1.1 Routine road maintenance system using IRI	Guide-2: P.1-23
	1.2 Outline of DRIMS* operation (instructions for checklist)	Guide-1: P.1-5,45-46
	1.3 Basic operation of DRIMS	Guide-1: P.15-21
	1.4 Hump Calibration	Guide-1: P.24-28
	[DRIMS operation (with trainer's instructions)]	
	1.4 Instruction for checklist application (for 1-5, 1-6)	Guide-1: P. 46
	1.5 Installation of DRIMS equipment into vehicles	Guide-1: P.2, 12-14
	1.6 Hump calibration at site	Guide-1: P.24-28
Day2	[DRIMS operation (with trainer's instructions)]	
	2.1 Instruction for checklist application (for 2-2, 2-3)	Guide-1: P.46
	2.2 Installation of DRIMS equipment into vehicles	Guide-1: P.2, 12-14
	2.3 IRI measurement	Guide-1: P.30-32
	[Lecture]	
	2.4 Analysis for IRI estimation & data storage in database	Guide-1: P.33-40
	[DRIMS operation (with trainer's instructions)]	
	2.5 Analysis for IRI estimation	Guide-1: P.33-40
	2.6 Preparation of inspection outputs & data storage in database	Guide-1: P.41-44
Day3	[DRIMS operation (without trainer's instructions)]	
	3.1 Installation of DRIMS equipment into vehicles	Guide-1: P.2, 12-14
	3.2 IRI measurement	Guide-1: P.30-32
	3.3 Analysis for IRI estimation	Guide-1: P.33-40
	3-4 Preparation of inspection outputs & data storage in database	Guide-1: P.41-44
	[Lecture]	
	3.5 Instructions for reviewing inspection results	Guide-2: P.23-37
	3.6 Recommendation & trouble shooting	Guide-1: 16, 20, 29, 31,32

List of Presentations (Lectures)

Day1

1.1 Routine Road Maintenance System Using IRI

1.2 Outline of DRIMS Operation

1.3 Basic Operation of DRIMS

1.4 Hump Calibration

Day2

2.4 Analysis for IRI Estimation & Data Storage in Database

Day3

3.5 Instructions for Reviewing Inspection Results

3.6 Trouble Shooting & Recommendation

1.1 Routine Road Maintenance System Using IRI

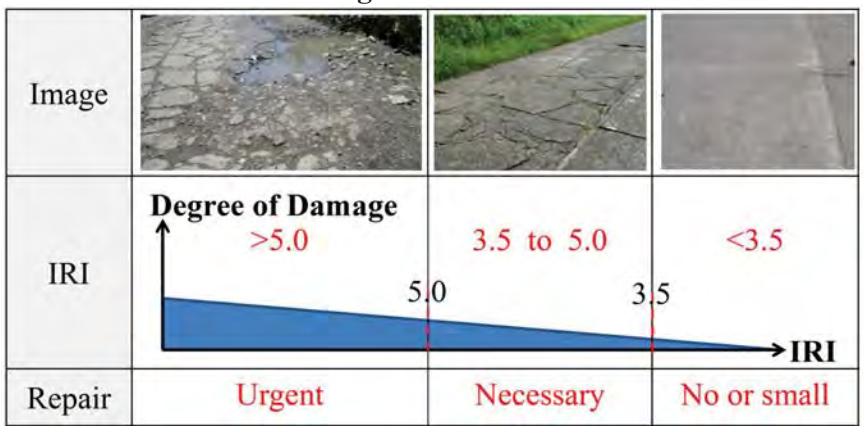
Outline

1. Application of IRI to Road Maintenance

(Guideline-2: P.1)

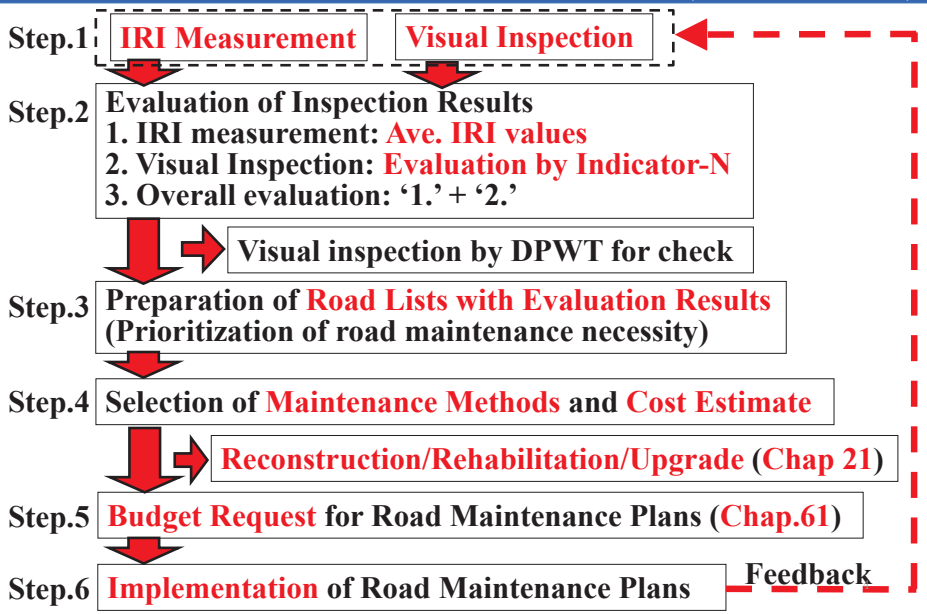
- International Roughness Index (IRI)
- Application of IRI to quantitative evaluation of road surface condition
- Effective for efficient planning of road repair works

100m-ave. IRI for Road Roughness Evaluation



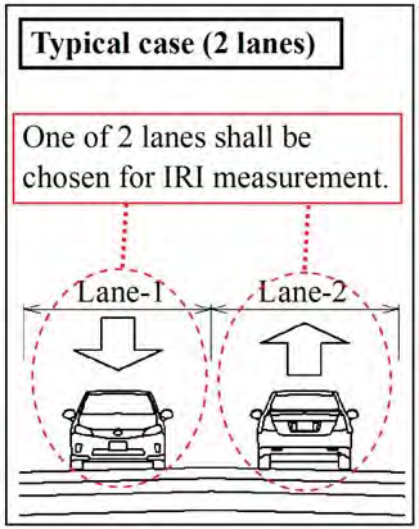
2. Road Maintenance Cycle Using IRI

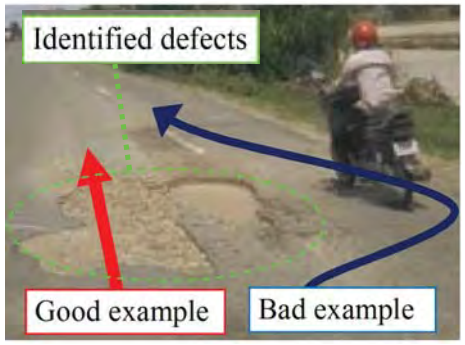
(Guideline-2: P.2)



3. Step-1: IRI Measurement & Visual Inspection
(Guideline-2: P.9)

[IRI Measurement] - Inspection Course -





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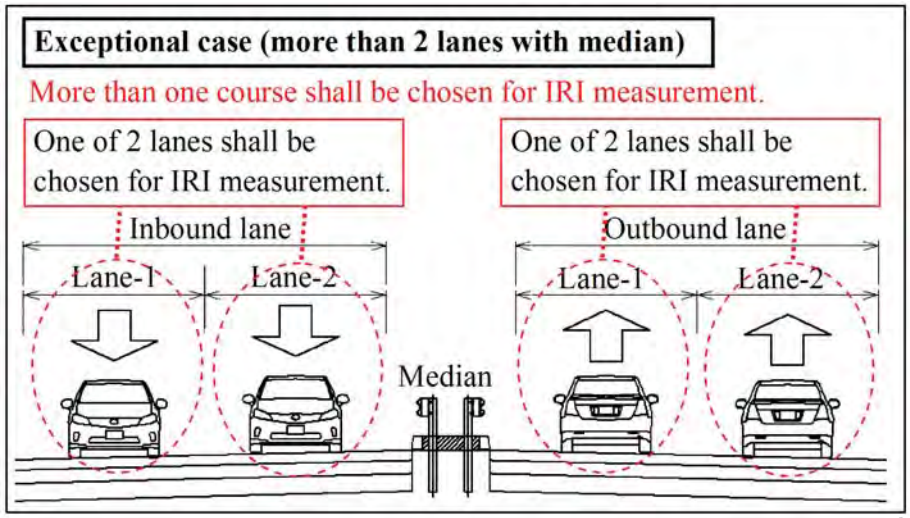
3. Step-1: IRI Measurement & Visual Inspection
(Guideline-2: P.9)

[IRI Measurement] - Inspection Course -



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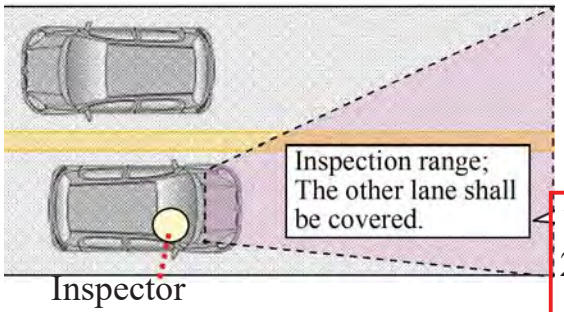
3. Step-1: IRI Measurement & Visual Inspection
(Guideline-2: P.10, 13)

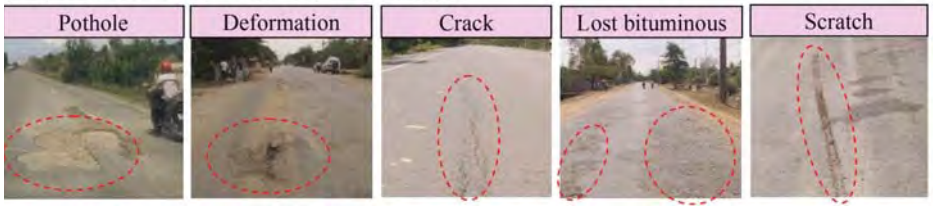
[Visual Inspection by Car]



Take notes

1. Counting of Defects
2. Recording of major findings

[Major Defects to be Considered for Counting]



4. Step-2: Evaluation of Inspection Results
(Guideline-2: P.12)

[Evaluation of Visual Inspection Result]

N= (Number of defects) / (Inspected road length)

Where,

N: Indicator for evaluation of visual inspection

(Number of defects): Number of defects within 5km

(Inspected road length): at the interval of 5km

Indicator N	Evaluation
$0 \leq N < 0.2$	Very good
$0.2 \leq N < 0.4$	Good
$0.4 \leq N < 0.6$	Fairy good
$0.6 \leq N < 1.15$	Fair
$1.15 < N$	Poor

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4. Step-2: Evaluation of Inspection Results
(Guideline-2: P.14)

[Overall Evaluation of Inspection Results]

(IRI) + (Visual Inspection Result)

IRI (5km-ave.) \ Visual Rating	Very good	Good	Fairy Good	Fair	Poor
IRI<3.5	Rank-5: Good (No or small repair)			Rank-4: Fair (Small repair)	Rank-3: Poor (Repair)
3.5≤IRI<5.0	Rank-3: Poor (Repair)			Rank-2: Very Poor (Severe Repair)	
5.0≤IRI	Rank-1: Bad (Reconstruction/Rehabilitation/Upgrade)				

Note: Calculation interval of ave. IRI-value is 5.0km.

4. Step-2: Evaluation of Inspection Results

[Evaluation of Inspection Results]

Summarization of Road Conditions

Location		5km-Ave. IRI	Visual rating		Raod condition		Pavement Type
From	To		N	Evaluation	Condition	Discription	
0 km	5 km	2.2	3.00	Poor	Poor	Repair	AC
5 km	10 km	2.3	0.80	Fair	Fair	Repair (small)	AC
10 km	15 km	2.4	0.40	Fairy good	Good	Regular inspection	AC
15 km	20 km	2.7	1.00	Fair	Fair	Repair (small)	AC
20 km	25 km	2.5	2.20	Poor	Poor	Repair	AC
25 km	30 km	3.3	0.60	Fair	Fair	Repair (small)	AC
30 km	35 km	3.7	2.20	Poor	Very poor	Repair/ Resurfacing	AC
35 km	40 km	3.1	1.20	Poor	Poor	Repair	AC
40 km	44 km	2.5	2.20	Poor	Poor	Repair	AC

Identification of deteriorated sections

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5. Site Survey by DPWT for Check

[Visual Inspection by DPWT]

Example of Checking for Paved Roads

- Counting of defects identifying defect categories

(8) Location (PK)		(9) Visual Inspection (Per 1.0km)							(10) Visual Rating (Per 5.0km)		
		Carriage way				Off-Carriage way					
From	To	Pothole	Crack	Defor-mation	Other	Defor-mation	Dragon hole	Other	No.of Defects	Defect Indicator-N	Evalu-ation
0 km + 200	5 km + 0	1			1				2	0.4	Fairy good
5 km + 0	10 km + 0							1	1	0.2	Very good
10 km + 0	15 km + 0	1		1					2	0.4	Very good
15 km + 0	20 km + 0	1	1						2	0.4	Very good
20 km + 0	25 km + 0	3			1				4	0.8	Very good

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6. Step-3: Preparation of Road Lists with Evaluation Results
(Guideline-2: P.19)

[Prioritization of Roads for Maintenance Plans]

Prioritization Criteria

		Criteria-A: Road Classification	Criteria-B: Road Importance &Traffic Volume	Criteria-C: Road condition
Evaluation Index		Digit class of roads	- Road importance - AADT (Annual Average Daily Traffic)	Classification of road conditions by combination of IRI and visual rating (5 ranks)
Evaluation	High	1-digit roads 2-digit roads 3-digit roads 4-digit roads	Large traffic volume	Bad Very poor poor
	Low		Small traffic volume	Fair Good

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6. Step-3: Preparation of Road Lists with Evaluation Results (Guideline-2: P.21)

[Prioritization of Roads for Maintenance Work (2)]

A Table for Prioritization Criteria (Extraction)

Project Priority			Road Name	Reason for Road Importance
Criteria-A: Digit-class	Criteria-B: Road Importance/ Traffic Volume	Criteria-C: Road Condition		
1	1		1	Asian Highway 1, International Corridor
			4	Connecting international port Sihanouk and PP
			5	Asian Highway 1, International Corridor
	2		2	Connecting Vietnam border and PP
			6	Connecting PP and Siem Reap (the biggest tourism city)
			7	Connecting Laos border and PP
	3		3	Detour PP to Sihanouk
			8	1-digit road
			9	1-digit road

To be determined according to inspection results

6. Step-3: Preparation of Road Lists with Evaluation Results (Guideline-2: P.22)

Project Priority			Road Name	Pavement Type	Inspected Length (km)	Ave. IRI	Indicator-N (visual evaluation)	Repair Ratio *1 (%)	Urgency Ratio *2 (%)	Ratio of Investment (Chap.21) *3 (%)
A*	B*	C*								
1	1	1	NR1	A/C	44.00	2.8	1.51 (Poor)	54.5	11.4	0.0
		2	NR5	DBST	8.90	2.7	0.30 (Good)	0.0	0.0	0.0
		3	NR4	A/C, DBST	11.60	2.1	0.00 (Very good)	0.0	0.0	0.0
	2	-	NR2	MCD, DBST	19.60	2.7	1.15 (Poor)	25.0	0.0	0.0
	3	1	NR3	DBST	11.85	2.6	0.80 (Fair)	41.7	0.0	0.0
		2	NR8	A/C	22.20	2.6	1.15 (Poor)	25.0	0.0	0.0
2		3	NR21A	A/C, DBST	20.0	2.8	1.10 (Fair)	50.0	0.0	0.0
	5	-	NR14	DBST	42.4	4.5	10.87 (Poor)	100.0	76.7	34.9
3	6	1	PR110	DBST	78.2	3.9	19.98 (Poor)	50.6	44.3	25.3
		2	PR151A	DBST	6.9	3.6	0.30 (Good)	28.6	0.0	0.0
		3	PR120	DBST	6.7	2.3	0.30 (Good)	0.0	0.0	0.0
		4	PR261	DBST	22.0	1.9	0.04 (Very good)	0.0	0.0	0.0
		5	PR383	Laterite	10.8	3.4	-	9.1	-	0.0

A*: Road classification by "digit class"
B*: Road importance based on traffic volume
C*: Road conditions

6. Step-3: Preparation of Road Lists with Evaluation Results (Guideline-2: P.22)

Project Priority			Road Name	Pavement Type	Inspected Length (km)	Ave. IRI	Indicator-N (visual evaluation)	Repair Ratio *1 (%)	Urgency Ratio *2 (%)	Ratio of Investment (Chap.21) *3 (%)
A*	B*	C*								
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		3	NR4	A/C, DBST	11.60	2.1	0.00 (Very good)	0.0	0.0	0.0
	2	-	NR2	MCD, DBST	19.60	2.7	1.15 (Poor)	25.0	0.0	0.0
	3	1	NR3	DBST	11.85	2.6	0.80 (Fair)	41.7	0.0	0.0
		2	NR8	A/C	22.20	2.6	1.15 (Poor)	25.0	0.0	0.0
2		3	NR21A	A/C, DBST	20.0	2.8	1.10 (Fair)	50.0	0.0	0.0
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		4	PR261	DBST	22.0	1.9	0.04 (Very good)	0.0	0.0	0.0
		5	PR383	Laterite	10.8	3.4	-	9.1	-	0.0

1*: Repair ratio consists of "Very poor"+"Poor"+"Fair".
2*: Urgency ratio consists of "Bad"+"Very poor".
3*: Ratio of Investment (Chap.21) is the ratio of "Bad".

7. Step-4: Selection of Maintenance Methods & Cost Estimate

[Planning of Road Maintenance Work]

Preparation of maintenance plans with cost estimates

National Road No.1
Veal Sbov-Phum Thom
PK 009+000 to PK 016+500 = 7.50km
Price/1km = 2,515.10$

Code	Work Type	Unit	Quanity	Unit Price (US$)	Total Price (US$)
1100-E3	Pothole Repair by Asphalt Concrete (AC)-Hot,Cold	m	360.00	31.47	11,329.07
1131-E	Asphalt watered, stone crush on the cracked road of 1st layers	m	450.00	3.88	1,745.16
1150-E	Shap Correction,prepare the stone for asphalt watered	m	180.00	8.91	1,604.06
1163-E	Pothole repair and foundation joint, Asphalt,Concrete,DBST	m	90.00	24.84	2,235.43
1201-3	Adding of Gravel	m3	140.00	8.55	1,196.69
2100	Cleaning channels of the both sides of road by hand	m	1500.00	0.50	752.84
			Total amount :		**18,863.26**

8. Step-5: Budget Request for Road MaintenancePlans
(Guideline-2: P.35)

[Schedule of Road Maintenance Work]

In Charge	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
MEF					Approval for the plans and budget allocation					
MPWT & MEF			Negotiation				Negotiation for further cost reduction			
MPWT		Approximate maintenance planning & cost estimate					Determination of maintenance work for implementation			
MPWT & DPWT	Prioritization of roads for maintenance work									
DPWT	Approximate maintenance planning & cost estimate								Scheduling of projects	Implementation
	Implementation of maintenance work approved previous year									

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9. Step-6: Implementation of Road Maintenance Plans
(Guideline-2: P.36)

Step.1 IRI Measurement, Visual Inspection

Step.2 Evaluation of Inspection Results
1. IRI measurement: Ave. IRI values
2. Visual Inspection: Evaluation by Indicator-N
3. Overall evaluation: '1.' + '2.'

Visual inspection by DPWT for check

Step.3 Preparation of Road Lists with Evaluation Results (Prioritization of road maintenance necessity)

Step.4 Selection of Maintenance Methods and Cost Estimate

Reconstruction/Rehabilitation/Upgrade (Chap 21)

Step.5 Budget Request for Road Maintenance Plans (Chap.61)

Step.6 Implementation of Road Maintenance Plans

Feedback

10. Feedback of Maintenance Works
(Guideline-2: P.36)

[Update of the Road Lists]

Comparison of IRI between Before & After repair work

[Before Repair Work]
(IRI = 7.0 to 10.0)

[After Repair Work]
(IRI < 5.0)

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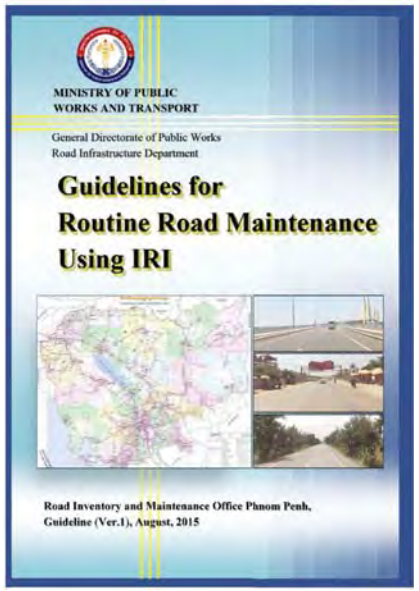
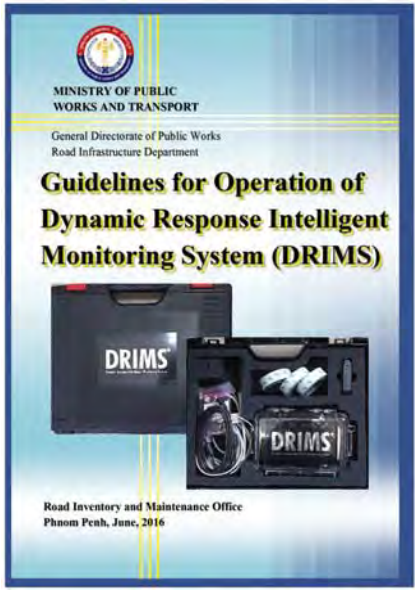
11. Guidelines for Road Maintenance





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1.2 Outline of DRIMS Operation

Outline

1. Main Features of DRIMS
2. Mechanism of IRI Measurement by DRIMS
3. Image of DRIMS Installation into Vehicles
4. List of DRIMS Equipment
5. Outline of IRI Estimation Using DRIMS
6. DRIMS Operation Procedure
7. Instructions for Checklist Application

2

1. Main Features of DRIMS

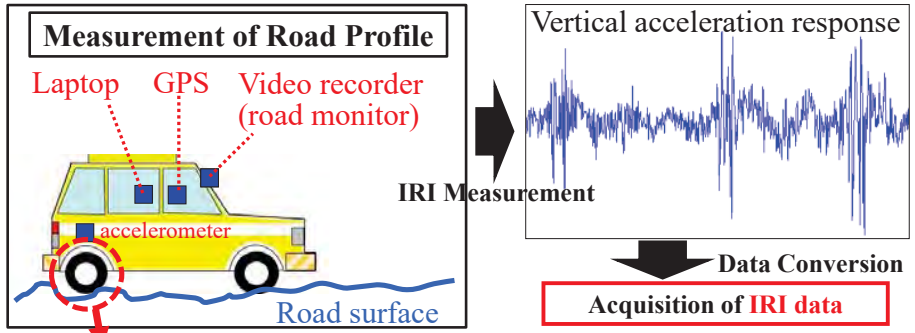
Recommendation for IRI measurement by DRIMS*

*DRIMS: Dynamic Response Intelligent Monitoring System

[Main Features of DRIMS]
- Compact & easy installation
- Inexpensive
- Needs of small amount of energy (car-battery-operated)
- Available for any types of vehicles
  (Adjustment of spring properties by calibrations)
- Accurate IRI estimation regardless of driving speed
  (Range of driving speed : 30-110km/h)

3

2. Mechanism of IRI Measurement by DRIMS
(Guideline-1: P.1)



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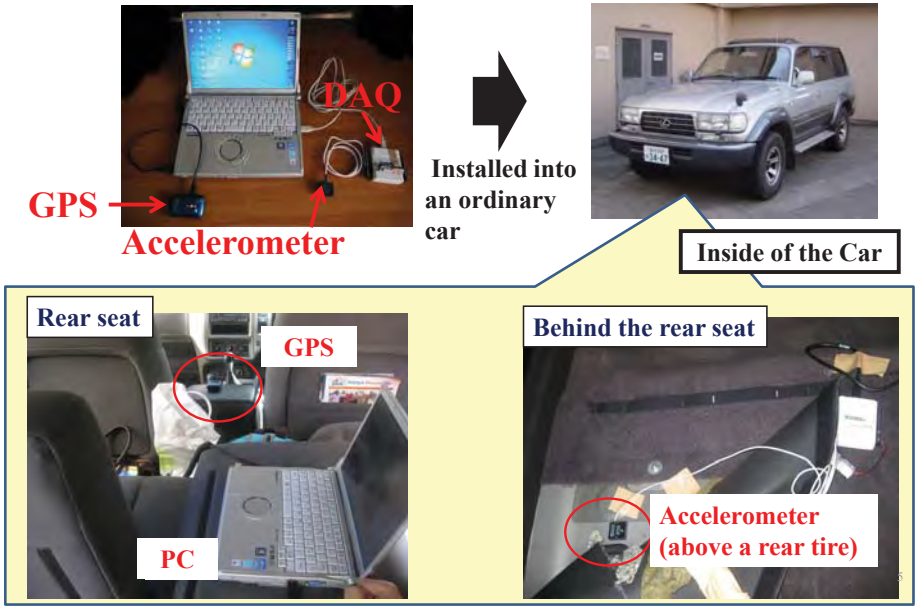
3. Image of DRIMS Installation into Vehicles (1)
(Guideline-1: P.1)



3. Image of DRIMS Installation into Vehicles (2)
(Guideline-1: P.1)

[Installation Image of Movie Recorder into Vehicles]

To be Installed on front window shield near rear view mirror

4. List of DRIMS Equipment (1)
(Guideline-1: P.2)

1. Laptop PC
2. GPS
3. Accelerometer
4. DAQ (Data Acquisition Module)
5. Tape
6. Humps
7. Color cone

[Additional Device]

*A: Road condition recorder

*B: DC-AC inverter

4. List of DRIMS Equipment (2)
(Guideline-1: P.2)

1	Laptop PC	
2	GPS	
3	Accelerometer	
4	DAQ (Data Acquisition Module)	

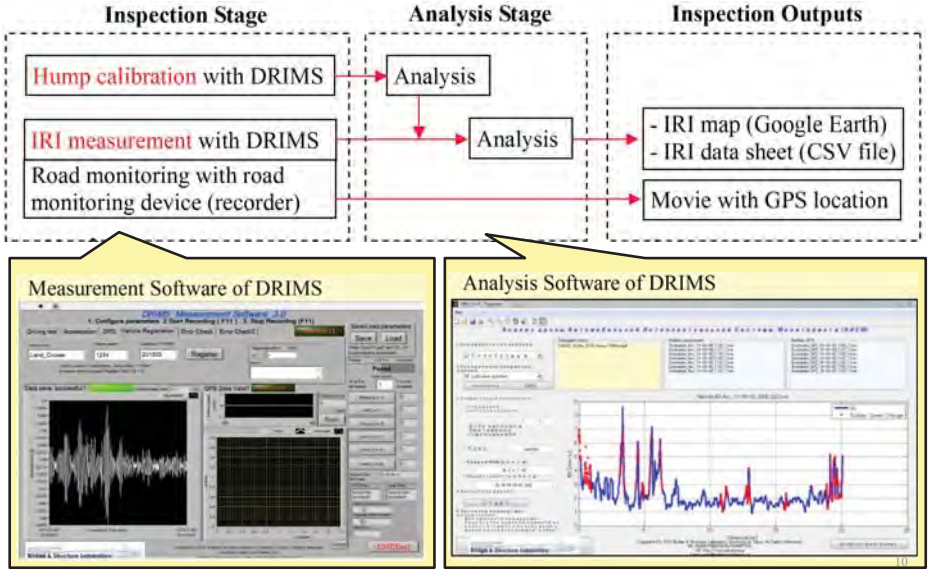
4. List of DRIMS Equipment (3)

(Guideline-1: P.2)

5	Tape	
6	Humps	
7	Color cone	
*A	Road monitoring device (Road condition recorder)	
*B	DC-AC Inverter	

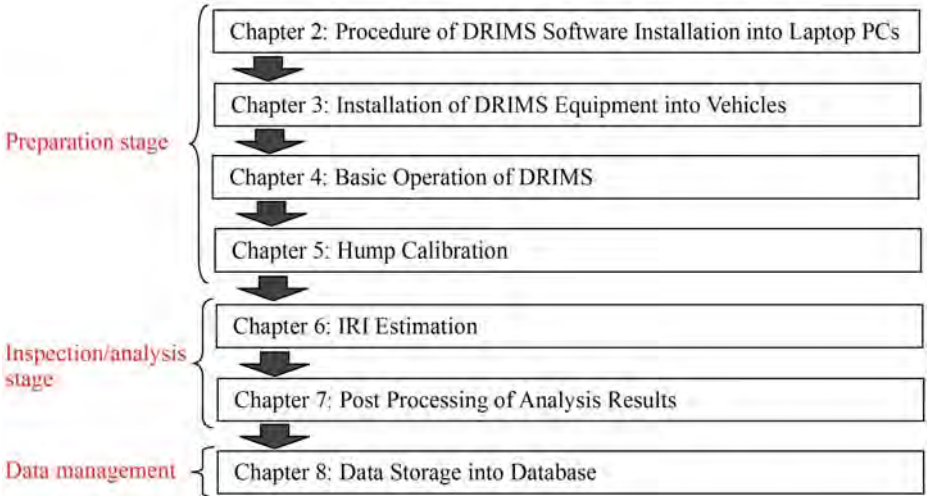
5. Outline of IRI Estimation Using DRIMS

(Guideline-1: P.3)



6. DRIMS Operation Procedure

(Guideline-1: P.4)



7. Instructions for Checklist Application (1)

(Guideline-1: P.45)

Step-1: Check which "Operation Stage" you are in, and in what chapter instructions are given.

Step-2: Read checklist descriptions and find instructions in the Guideline-1, referring to page number indicated next to each checklist description.

Step-3: Carry out activities specified in the checklist descriptions, following the Guideline-1 instructions.

Step-4: Fill in checkboxes, upon completion of checklist descriptions.

7. Instructions for Checklist Application (2)

(Guideline-1: P.46)

[Checklist for 8 DRIMS-operation stages]

(To be used for evaluation of training activities)

*1. Installation of software into laptop PCs
2. Installation of DRIMS equipment into vehicles
3. Basic operation of DRIMS
4. Hump calibration
5. IRI measurement
6. Analysis for IRI estimation
7. Preparation of road inventory
8. Data storage in database

*Note: not part of the training program

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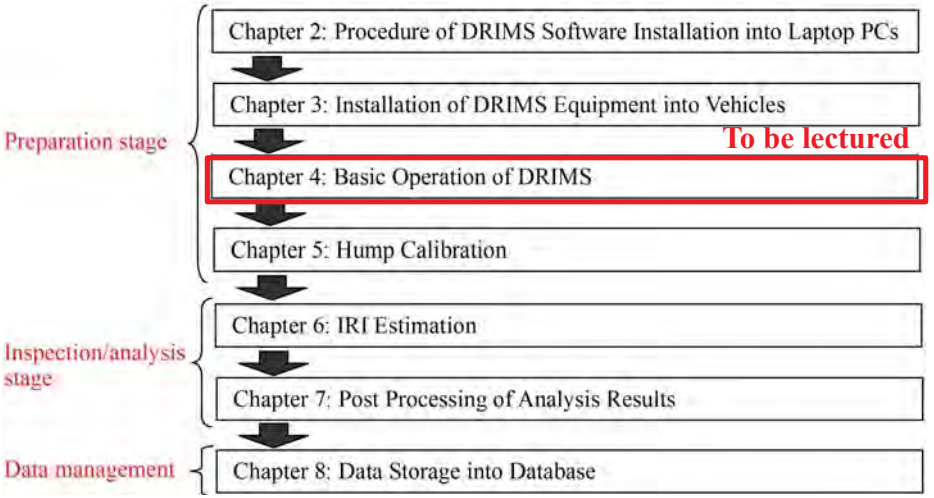
1.3 Basic Operation of DRIMS

DRIMS Operation Stage
(Guideline-1: P.4)



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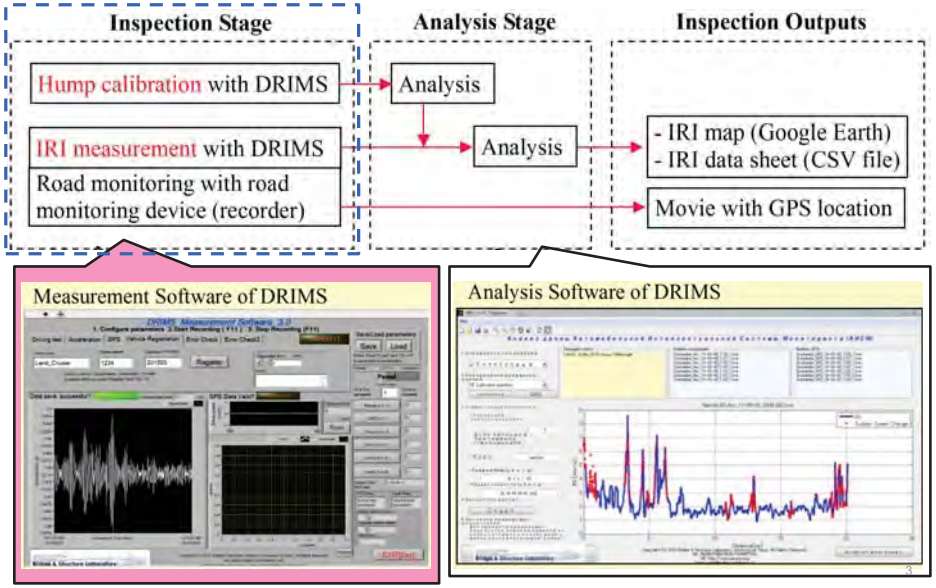
Outline of IRI Estimation Using DRIMS
(Guideline-1: P.3)



Outline

1. Configuration & Operation Check of DRIMS
2. Operation Test Before Actual Inspections
3. Screen Structure of DRIMS Measurement Software
4. Counting Function
5. Basic Rules for DRIMS Operation
6. Folder Structure of DRIMS Measurement Software
7. Hump Calibration
8. Outline of IRI Estimation Using DRIMS

4

1. Configuration & Operation Check of DRIMS (1)
(Guideline-1: P.15)

Step-1: Preparation of GPS

1) Connect USB cable to computer.
2) Turn on GPS by moving the switch from "OFF" to "Smart".
3) Move the switch from "Smart" to "Car".
4) Wait for about 30 seconds.
5) Confirm twice peep sound and blinking the center light. (It means connecting to satellite.)

[Initially, power is off.] [Move the switch to "Smart"] [Move the switch to "Car"]

1. Configuration & Operation Check of DRIMS (2)
(Guideline-1: P.15)

Step-2: Start DRIMS measurement software

1) Click and turn on DRIMS measurement software.

DRIMS_Measurement_3_1_6.exe ····· Click

2) Enter a DRIMS activation code (registration for license) if requested

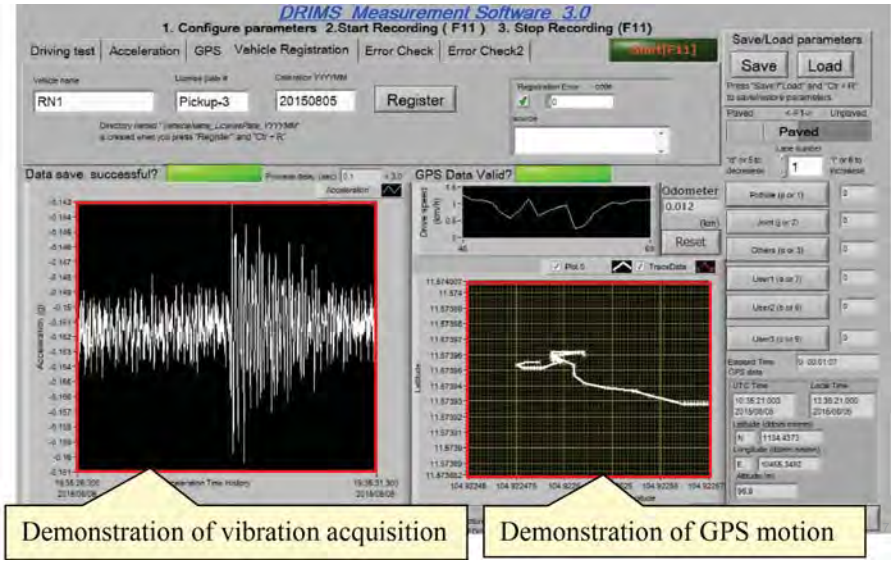
A DRIMS activation code is to be requested if computers are not licensed. The activation codes are defined according to DRIMS serial numbers (S/N); Ex. S/N: 1A349B0, license code: 3469360

If there's no problem with initial preparation explained so far, the following window is to be displayed and software gets activated.

These 2 items shall be checked as "OK".
If not, close the software and restart it after checking if all the equipment is set properly.

1. Configuration & Operation Check of DRIMS (3)
(Guideline-1: P.16)

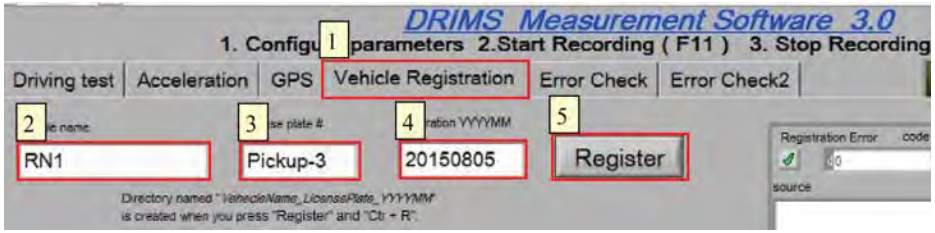
Properly functioning image of the software



1. Configuration & Operation Check of DRIMS (4)
(Guideline-1: P.17)

Step-3: Data entry for "Vehicle Registration"

1) Select "Vehicle Registration".
2) Enter road name (Ex. RN1).
3) Enter 1) a type of inspection vehicles and 2) number of passengers (Ex. Pickup-3).
4) Inspection date.
5) Click "Register".



6) Check a folder for outputs generated in the folder where Measurement Software is saved.

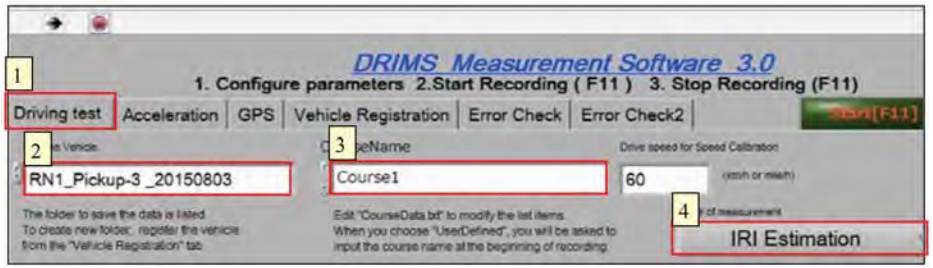
RN1_Pickup-3_20150805
RN2_Pickup-3_20150731

The generated folder (Outputs of inspections are to be saved in here.)

1. Configuration & Operation Check of DRIMS (5)
(Guideline-1: P.18)

Step-4: Data entry for "Driving Test"

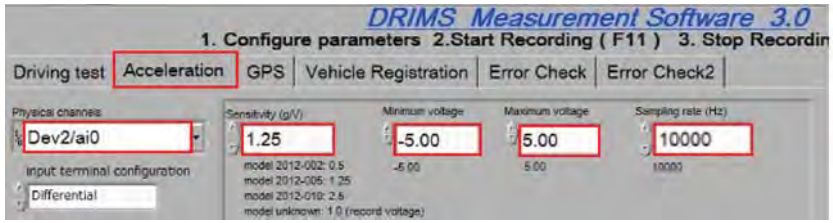
1) Select "Driving test".
2) Check if the folder generated in Step-3 is selected.
3) Define course name. (Ex. Couse1, Course2, Course3 etc.)
4) Chose either "IRI Estimation" or "Hump Calibration".



1. Configuration & Operation Check of DRIMS (6)
(Guideline-1: P.18)

Step-5: Data check of "Acceleration"

Select "Acceleration" and check if necessary data entry is the same as the example shown below.

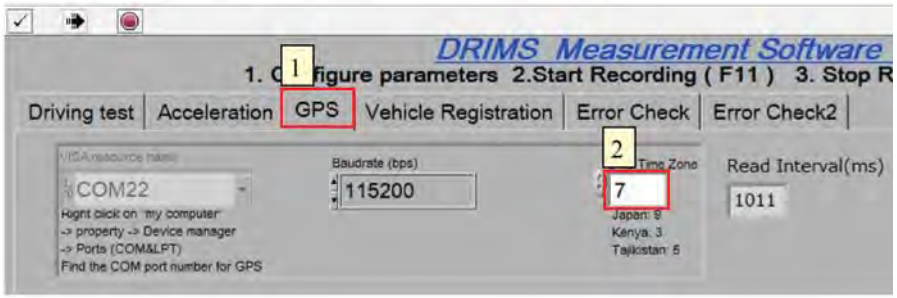


1. Configuration & Operation Check of DRIMS (7)
(Guideline-1: P.18)

Step-6: Data check of "GPS"

1) Select "GPS".
2) Enter "7" in UTC Time Zone.

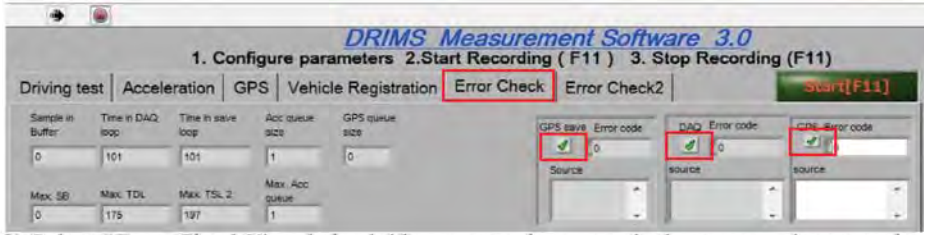
Note: Universal Time, Coordinated (UTC) in Cambodia is "+7".



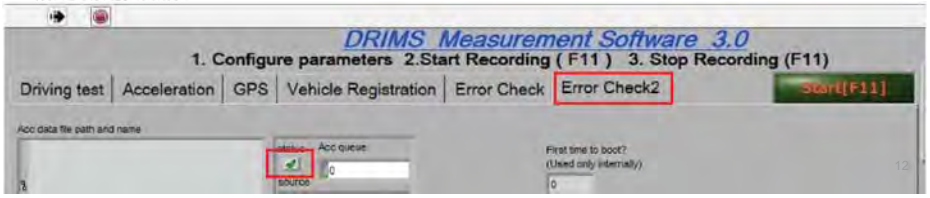
1. Configuration & Operation Check of DRIMS (8)
(Guideline-1: P.19)

Step-7:Error check

1) Select "Error Check" and check if necessary data entry is the same as the example shown below.



2) Select "Error Check2" and check if necessary data entry is the same as the example shown below.

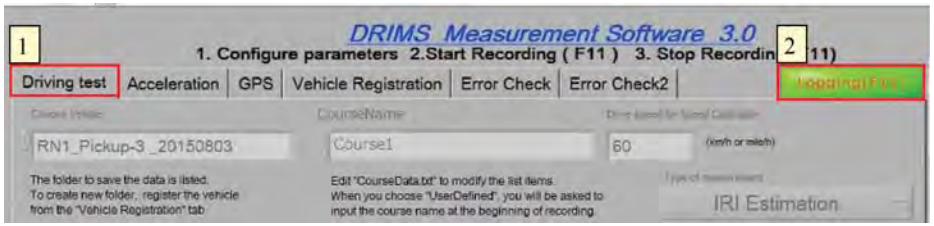


1. Configuration & Operation Check of DRIMS (9)
(Guideline-1: P.19)

Step-8: Run the measurement software

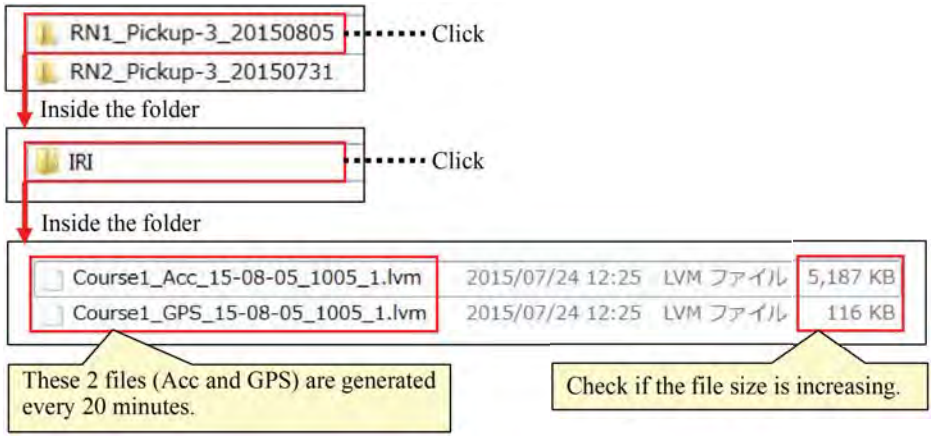
1) Select "Driving test".

2) Click "Start[F11]" to run the software. (The icon turns into "Logging[F11]".)



1. Configuration & Operation Check of DRIMS (10)
(Guideline-1: P.19)

Step-9: Check if output files are generated in the folder explained in Step-3.



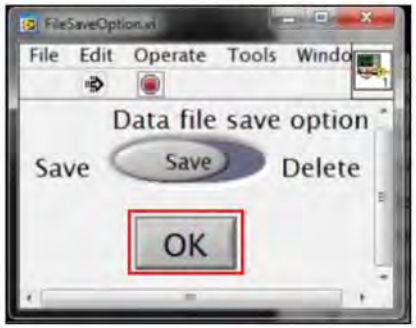
1. Configuration & Operation Check of DRIMS (11)
(Guideline-1: P.20)

Step-10: Stop the software

1) Click "Logging[F11]" to stop the software.

Click

2) Choose "OK" to save the generated data files.



Step-11: Check the generated data files in the folder.

2. Operation Test Before Actual Inspections
(Guideline-1: P.20)

Process of Step-8 through Step-10 should be carried out as operation test

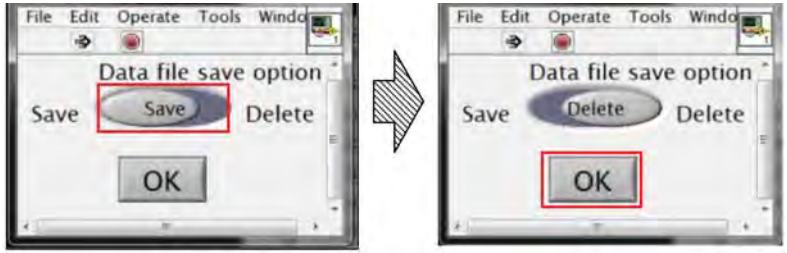
1) Click "Start[F11]" to run the software.

Click

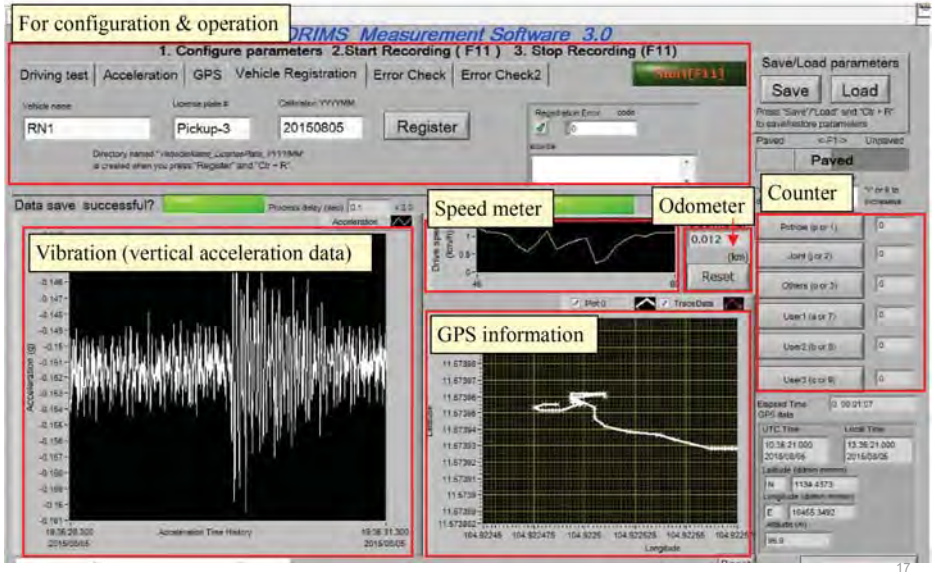
2) Click "Logging[F11]" to stop the software.

Click

3) Click "Save" first. Then, click "OK" after confirming that "Save" has turned into "Delete".

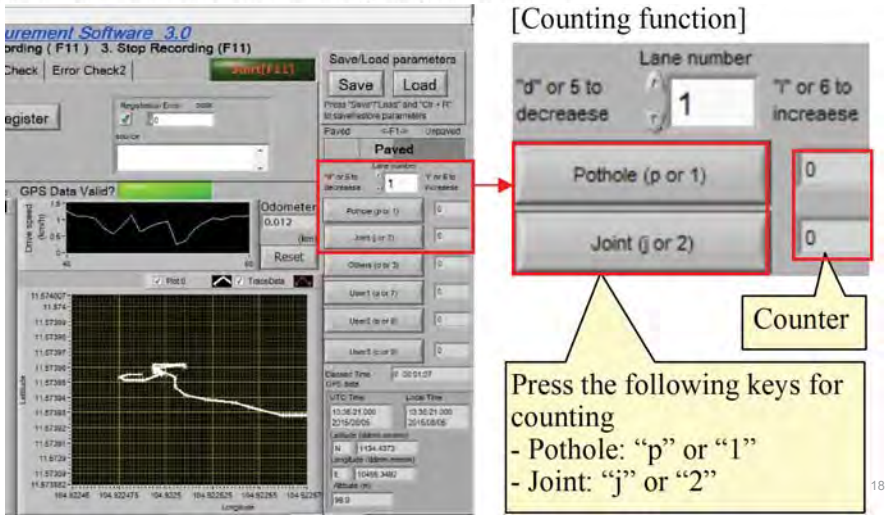


3. Screen Structure of DRIMS Measurement Software
(Guideline-1: P.21)



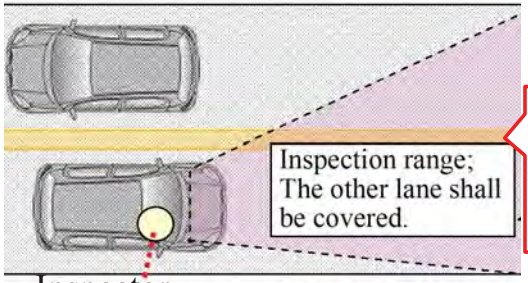
4. Counting Function (1)
(Guideline-1: P.21)

1) Number and locations of potholes
2) Number and locations of bridge expansion joints



4. Counting Function (2)

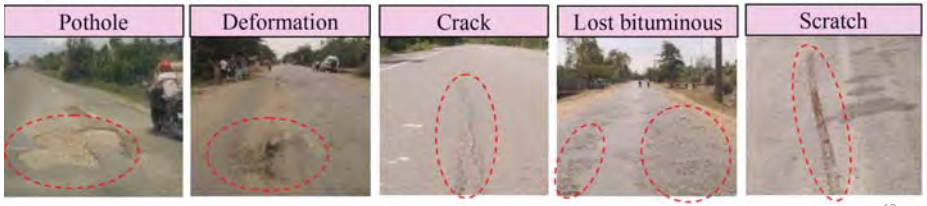
[Visual Inspection together with IRI Measurement]



Visual Inspection

1. Counting of defects using laptop computer
2. Recording of major findings by handwriting

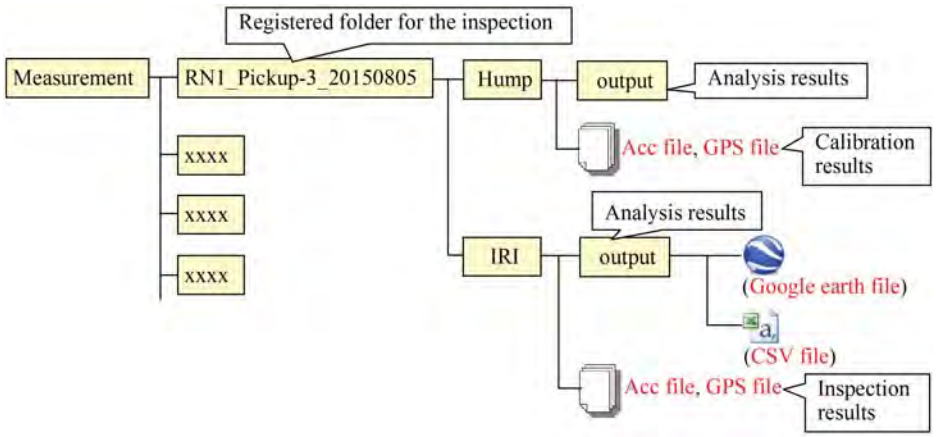
[Major Defects to be Considered for Counting]



5. Basic Rules for DRIMS Operation
(Guideline-1: P.22)

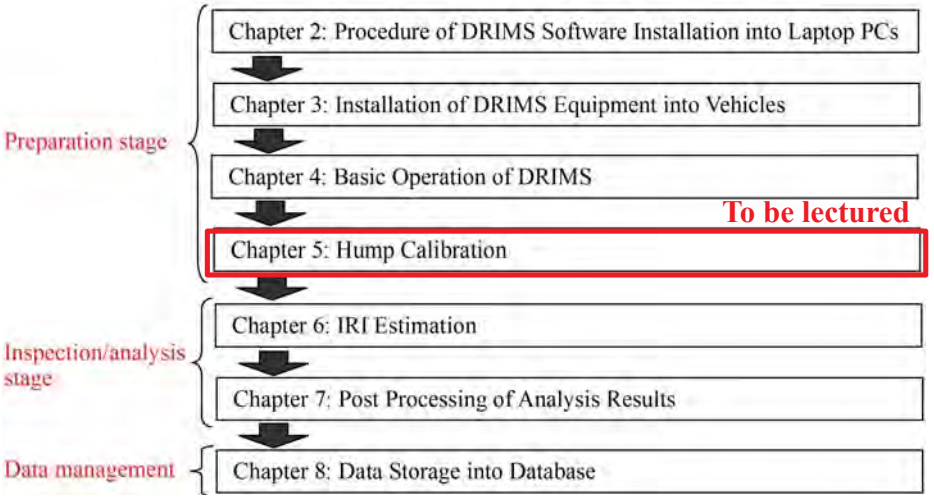
1) Do not start IRI measurement without "Operation Check" of Step-1 through Step-11.
2) During IRI measurement, constantly check if generated data files are properly stored in certain folders.
3) Once IRI measurement is completed, save the obtained data files in properly-named folders of designated file server, PC, etc.; proper data storage in road database

6. Folder Structure of DRIMS Measurement Software
(Guideline-1: P.22)



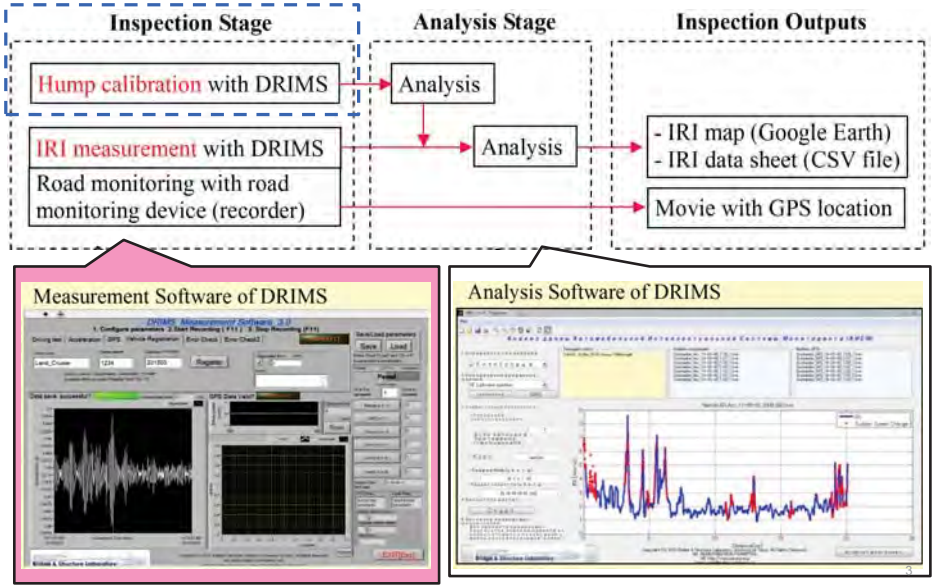
1.4 Hump Calibration

DRIMS Operation Stage
(Guideline-1: P.4)



2

Outline of IRI Estimation Using DRIMS
(Guideline-1: P.3)



3

Outline

1. Objective of Hump Calibration
2. Outline of Hump Calibration
3. Hump Calibration Procedure
4. Analysis for Hump Calibration

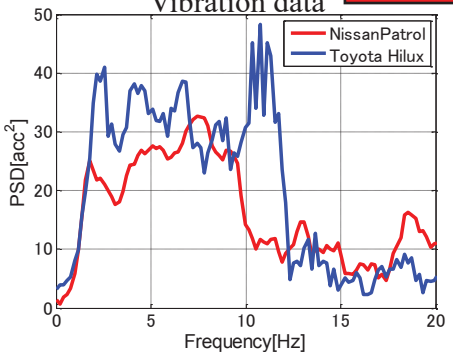
4

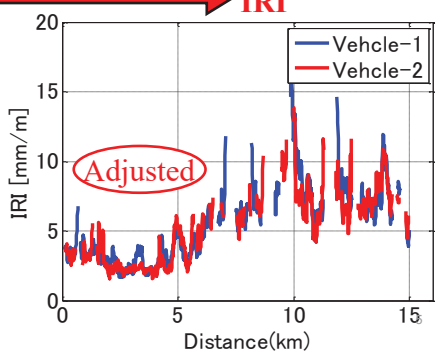
1. Objective of Hump Calibration

(Guideline-1: P.23)

To adjust different vibration characteristics of vehicles

Vibration data → Hump Calibration+Analysis → IRI

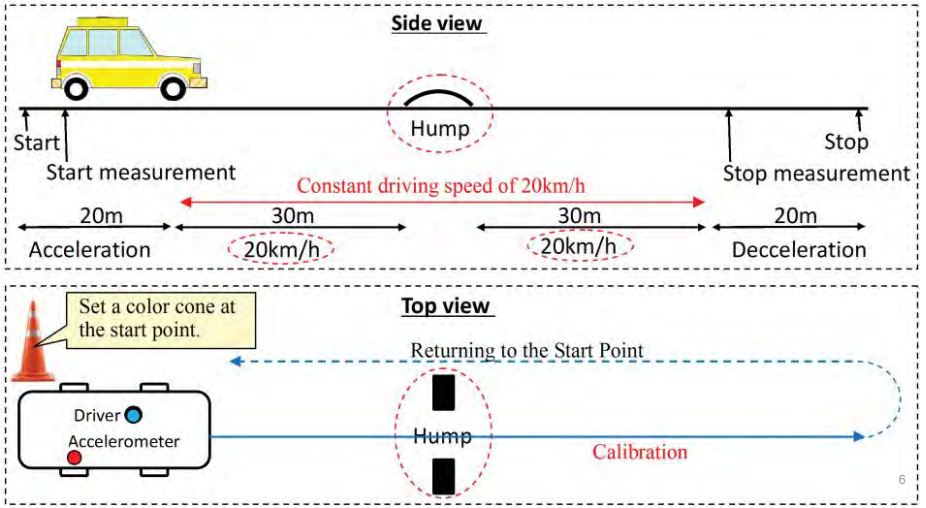




2. Outline of Hump Calibration

(Guideline-1: P.24)

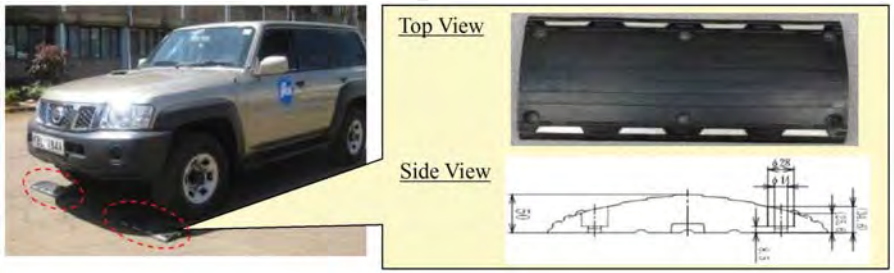
- Speed: 20km/h
- Calibration of 5 times repeatedly in short distance



3. Hump Calibration Procedure (1)

(Guideline-1: P.24)

Step-1: Install humps in the calibration course and a color cone at the start point.



Step-2: Open DRIMS Measurement Software.

DRIMS_Measurement_3_1_6.exe ..... Click

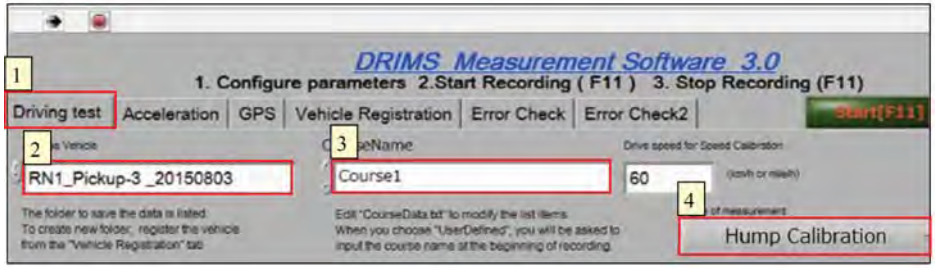
7

3. Hump Calibration Procedure (2)

(Guideline-1: P.25)

Step-3: Data Entry for "Driving test"

1) Select "Driving test".
2) Select the folder for Inspection
3) Define course name. (Ex. Course1)
4) Chose "Hump Calibration".



8

3. Hump Calibration Procedure (3)

(Guideline-1: P.25)

Step-4: Start calibration

1) Set the vehicle at the start point.

2) Click "Start[F11]" to run the software.

Click

3) Speed up and maintain 20km/h.

4) After getting on humps, keep driving at 20km/h for 5 seconds.

5) Click "Logging[F11]" to stop the software.

Click

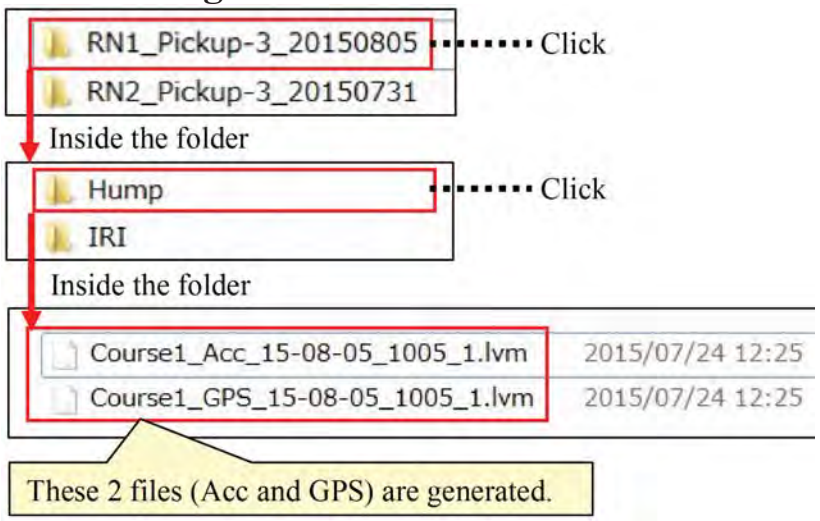
6) Click "OK" and save the data.

9

3. Hump Calibration Procedure (4)

(Guideline-1: P.26)

Step-5: Check if the obtained data is properly saved in the following folder.



10

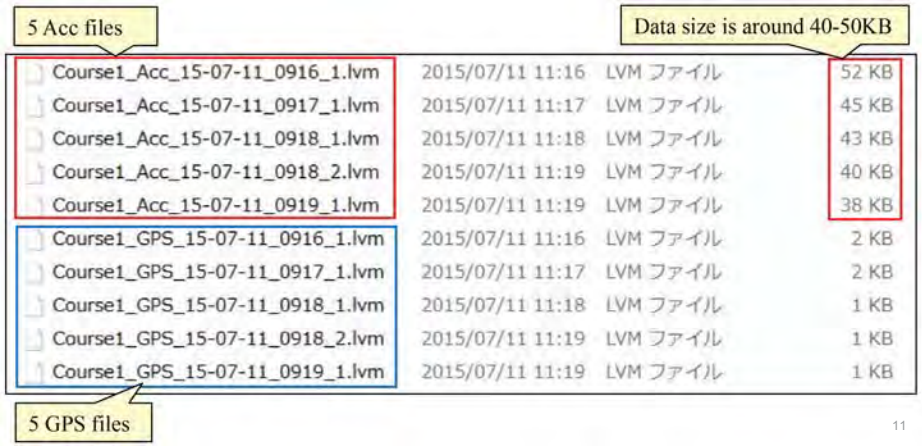
133

3. Hump Calibration Procedure (5)

(Guideline-1: P.26)

Step-6: Repeat the same process 5 times.

Step-7: Check the generated ACC files and GPS files (totally 5 sets).

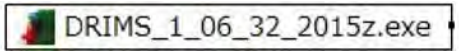


11

4. Analysis for Hump Calibration (1)

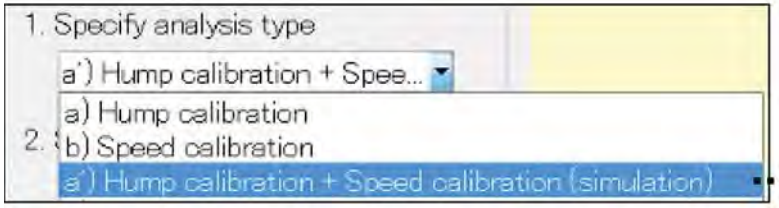
(Guideline-1: P.26)

Step-1: Turn on DRIMS Analysis Software



Click

Step-2: Select "Hump calibration +Speed calibration (simulation)" in "1. Specify analysis type".



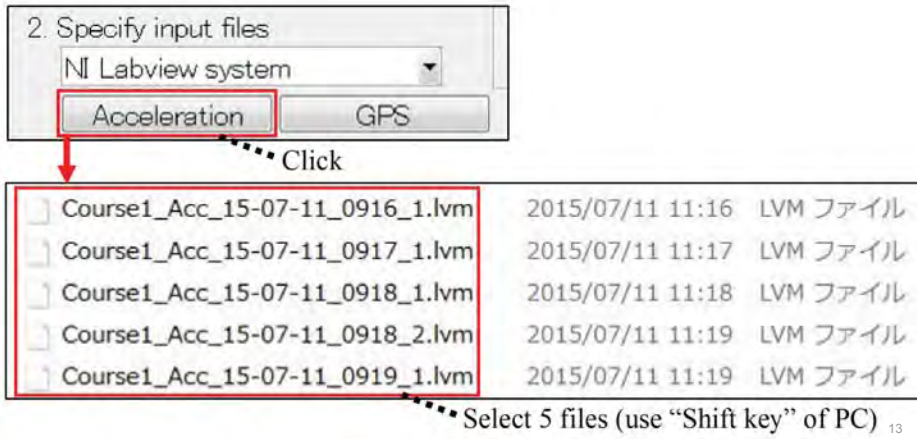
Click

12

4. Analysis for Hump Calibration (2)

(Guideline-1: P.27)

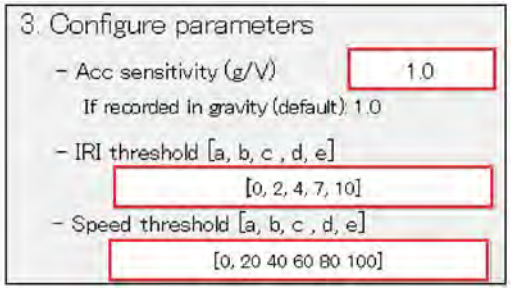
Step-3: Click "Acceleration" in "2. Specify input files" and select 5 Acc files obtained from hump calibration.



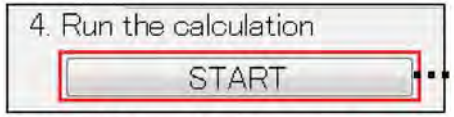
4. Analysis for Hump Calibration (3)

(Guideline-1: P.27)

Step-4: Check if configuration of "3. Configure parameters" is set as follows.



Step-5: Run the calculation.



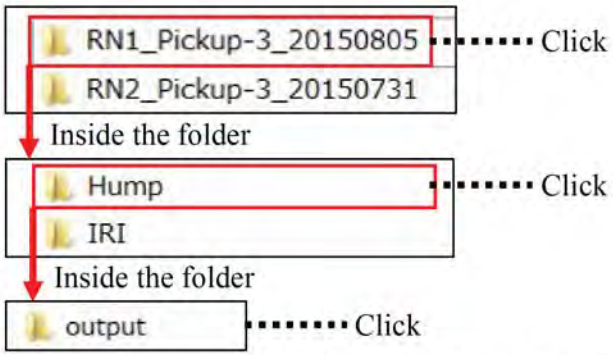
Note: 1) New window pops up when the calculation starts.

2) The calculation is to be finished in 5-10 minutes.

4. Analysis for Hump Calibration (4)

(Guideline-1: P.27)

Step-6: Check if analysis result is properly saved in the following folder.

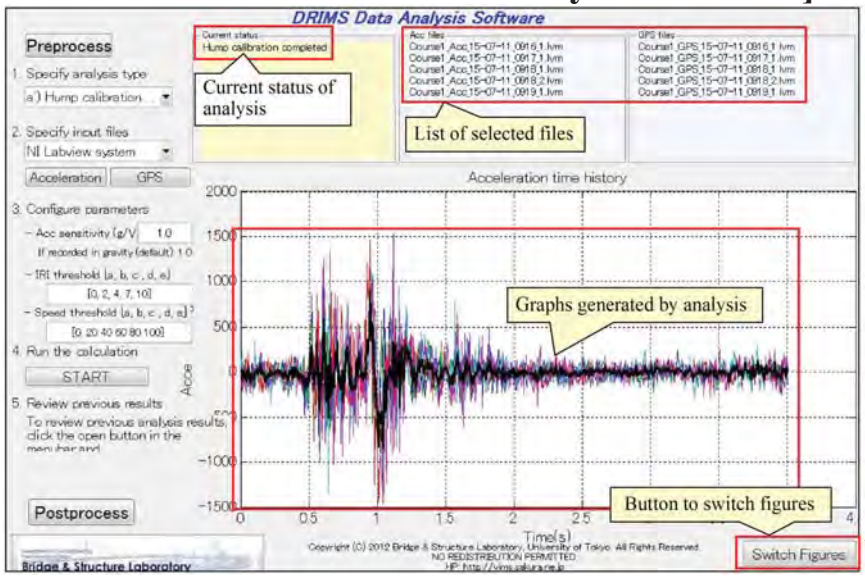


Note: The generated data files are to be used in analysis for IRI estimation.

4. Analysis for Hump Calibration (5)

(Guideline-1: P.28)

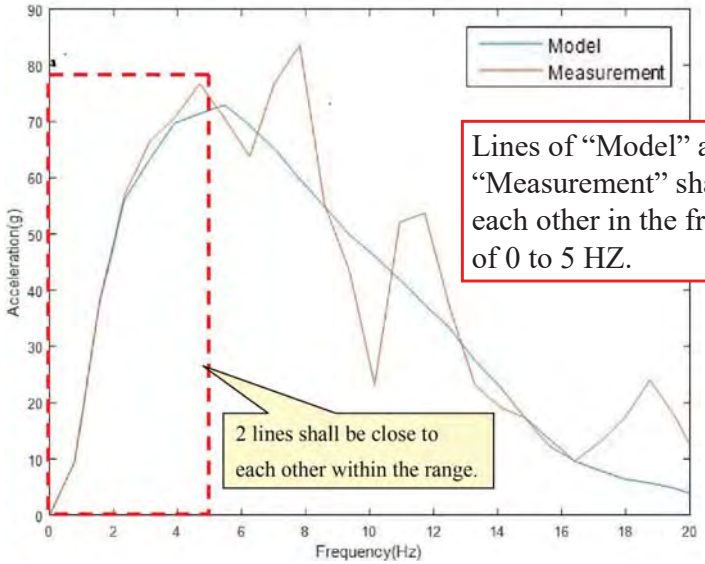
[Screen Structure of DRIMS Analysis Software]



4. Analysis for Hump Calibration (6)

(Guideline-1: P.28)

Step-7: Check the analysis result.



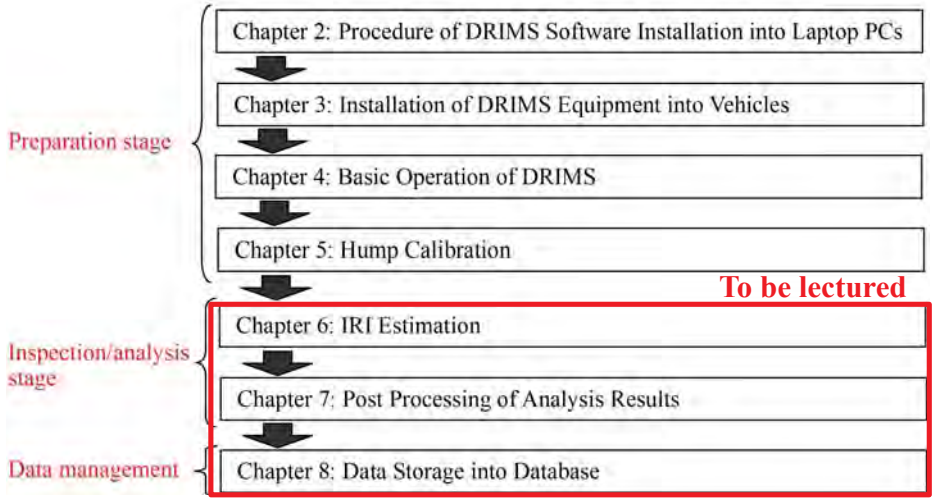
Lines of “Model” and “Measurement” shall be close to each other in the frequency range of 0 to 5 HZ.

2 lines shall be close to each other within the range.

17

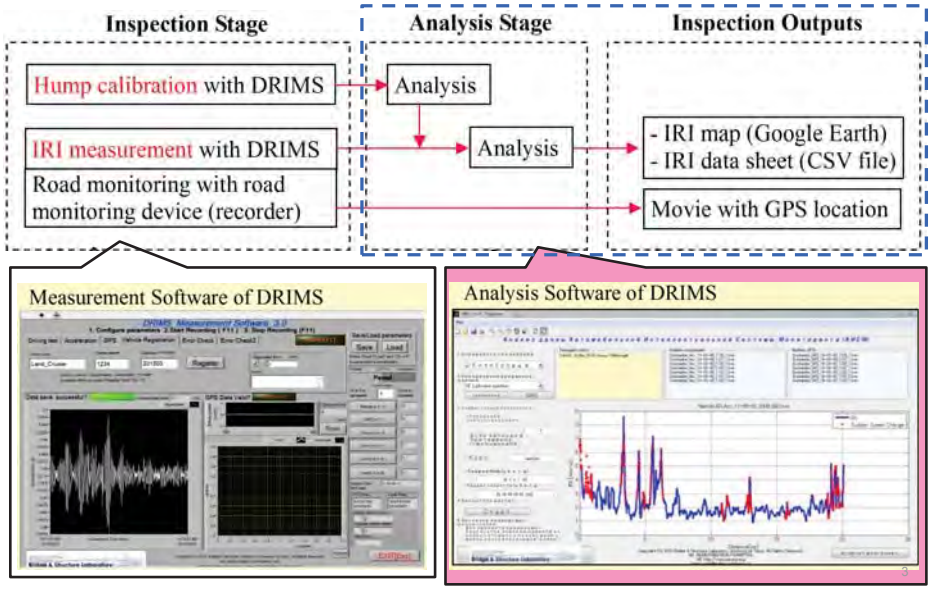
2.4 Analysis for IRI Estimation & Data Storage in Database

DRIMS Operation Stage
(Guideline-1: P.4)



2

Outline of IRI Estimation Using DRIMS
(Guideline-1: P.3)



Outline

1. Analysis for IRI Estimation
2. Post Processing of Analysis Results
3. Integration of DRIMS Outputs into One File
4. Calculation of Average IRI Values
5. Integration of IRI Values into Road Monitoring System
6. Data Storage in Database

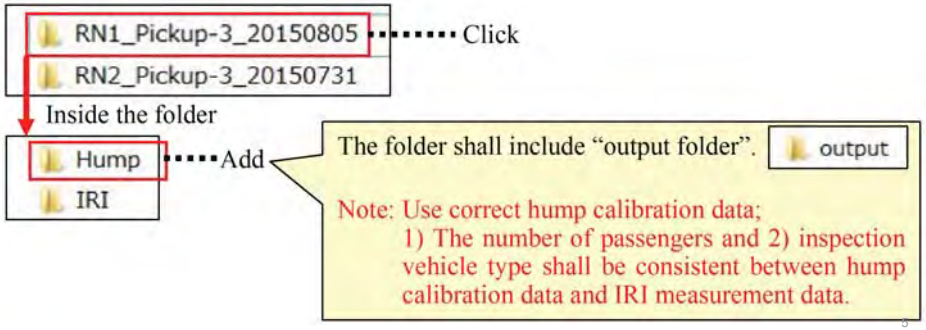
4

1. Analysis for IRI Estimation (1)

(Guideline-1: P.33)

Step-1:Add hump calibration folder (including output) in the folder where IRI measurement results are saved.

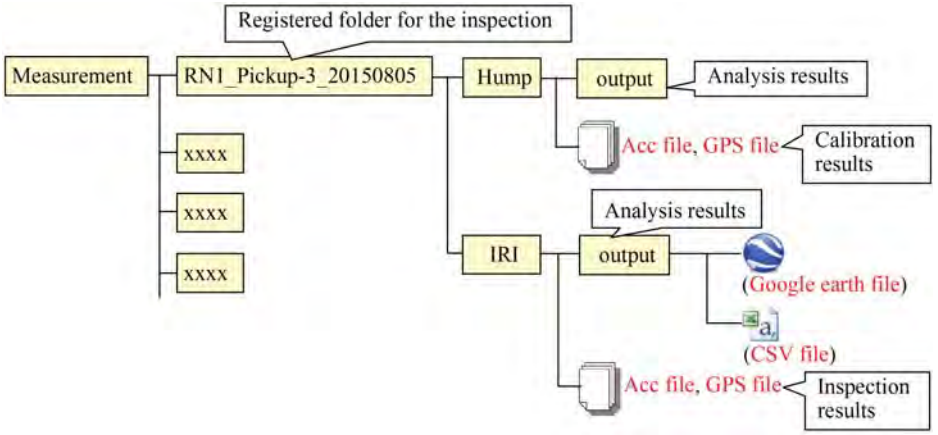
Note: The number of passengers and vehicle type shall be consistent between hump calibration and IRI measurement.



5

Folder Structure of DRIMS Measurement Software

(Guideline-1: P.22)

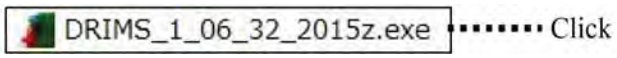


6

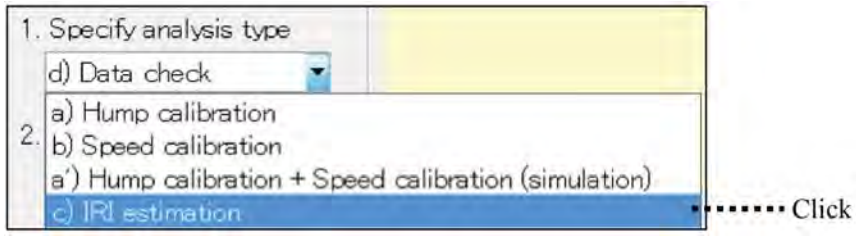
1. Analysis for IRI Estimation (2)

(Guideline-1: P.33)

Step-2: Turn on DRIMS Analysis Software



Step-3: Select 'IRI estimation' in '1. Specify analysis type'.

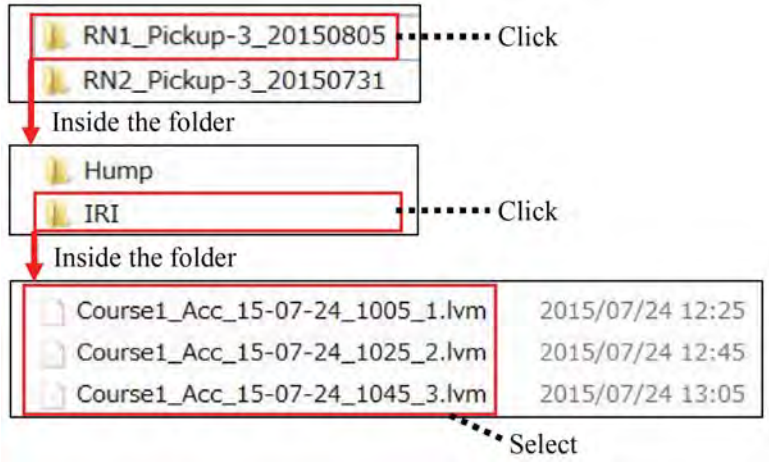


7

1. Analysis for IRI Estimation (3)

(Guideline-1: P.33)

Step-4: Click "Acceleration" in "2. Specify input files" and select all the Acc files obtained from IRI measurement.

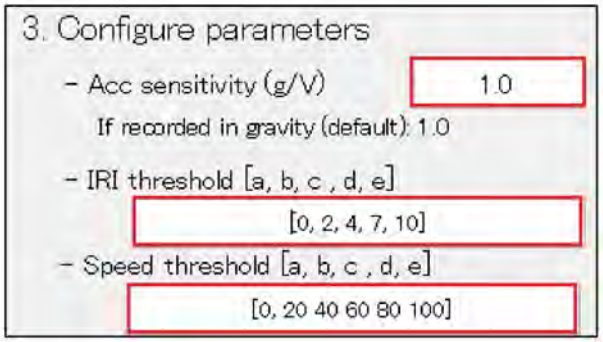


8

1. Analysis for IRI Estimation (4)

(Guideline-1: P.34)

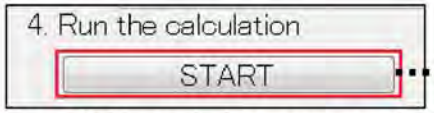
Step-5: Check if configuration of "3. Configure parameters" is set as follows.



1. Analysis for IRI Estimation (5)

(Guideline-1: P.34)

Step-6: Run the calculation



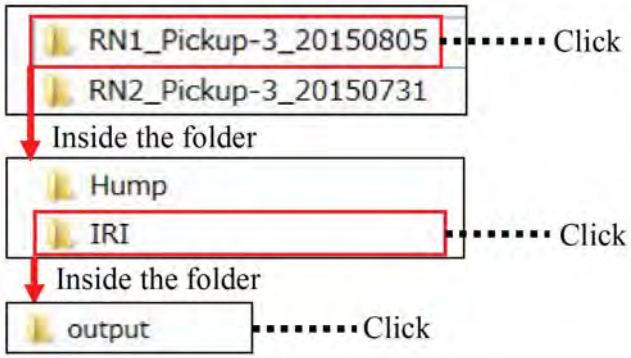
Note: 1) New window pops up when the calculation starts.

2) The calculation time changes, depending on the number of files.

1. Analysis for IRI Estimation (6)

(Guideline-1: P.33)

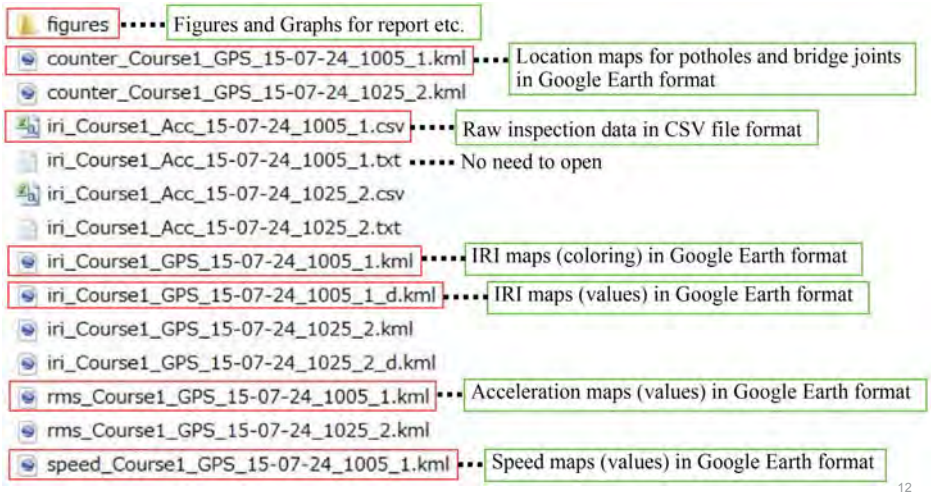
Step-7: Check if analysis result is properly saved in the following folder.



1. Analysis for IRI Estimation (7)

(Guideline-1: P.34)

[Output of Analysis]



2. Post Processing of Analysis Results
(Guideline-1: P.35)

Post Processing

DRIMS analysis result (raw data) → **DRIMS outputs in more sophisticated format**

[3 Post Processing Works]

1) Integration of DRIMS outputs (CSV files and Google Earth files) into one file
2) Calculation of average IRI values at 100m interval
   Note: Originally, calculation interval of average IRI values is 10m.
3) Integration of IRI values into road monitoring system (output of the recorder)

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3. Integration of DRIMS Outputs into One File (1)
(Guideline-1: P.35)

Integration of DRIMS output files into one file
- Row data: More than one file
- After integration: Only one file (integrated)

[Raw data]

iri_Course1_Acc_15-07-24_1005_1....
iri_Course1_Acc_15-07-24_1025_2....
iri_Course1_Acc_15-07-24_1045_3....
iri_Course1_Acc_15-07-24_1105_4....
iri_Course1_Acc_15-07-24_1125_5....
iri_Course1_Acc_15-07-24_1145_6....

Post Processing → **One file**

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3. Integration of DRIMS Outputs into One File (2)
(Guideline-1: P.35)

Step-1: Turn on DRIMS Analysis Software

DRIMS_1_06_32_2015z.exe ····· Click

Step-2: Click "Postprocess" in "5. Review previous results".

5. Review previous results
To review previous analysis results, click the open button in the menubar and open corresponding ".fig" files.
Postprocess ····· Click

15

3. Integration of DRIMS Outputs into One File (3)
(Guideline-1: P.35)

Step-3:Specify the start point and the end point of the inspection course.

Latitude of start points
Longitude of start points
Start point: N 354251.61 E 1394536.46
End point: N 354249.12 E 1394544.34
latitude/longitude format: ddmmss.sss
dd.dddddd (degree)
ddmm.mmmm (degree & minute)
ddmmss.sss(degree, minute, & second)
Select "ddmmss.sss".
Note: dd (2 digit for degree), mm (2 digit for minute) etc.

[Example of data entry]

Google Earth data
Latitude: 11° 31'53.85" N
Longitude: 104° 56'4.01" E

Data entry for DRIMS Analysis Software
Start point: N 113153.85 E 1045604.01

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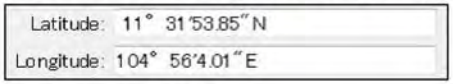
3. Integration of DRIMS Outputs into One File (4)
(Guideline-1: P.36)

iri_Course1_GPS_15-07-24_1005_1.kml Open google earth files

b) Click "Add Placemark" icon in tool bar.

c) Move the icon blinking on the display.

d) Read latitude and longitude of the point (to be entered into DRIMS Analysis Software).



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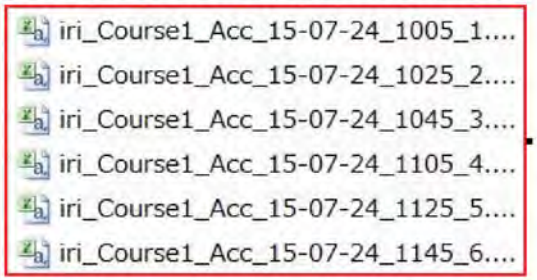
3. Integration of DRIMS Outputs into One File (5)
(Guideline-1: P.36)

Step-4: Select "IRI CSV files".

1) Click "IRI CSV files".

2) Enter the file path of "measurement output folder" in the address bar.

3) Select all the CSV files in the folder and click "OK".



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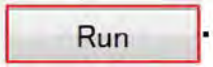
3. Integration of DRIMS Outputs into One File (6)
(Guideline-1: P.37)

Step-5:Click "Run".



Step-6:Check the generated data files

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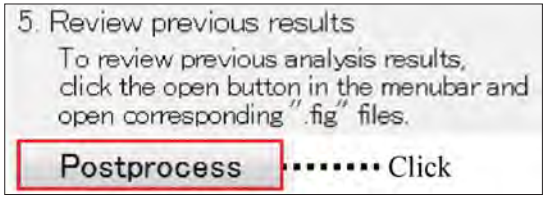
4. Calculation of Average IRI Values (1)
(Guideline-1: P.37)

Conversion for calculation interval of IRI values
- Row data: 10m
- After calculation: 100m

Step-1: Click "Postprocess" in "5. Review previous results".



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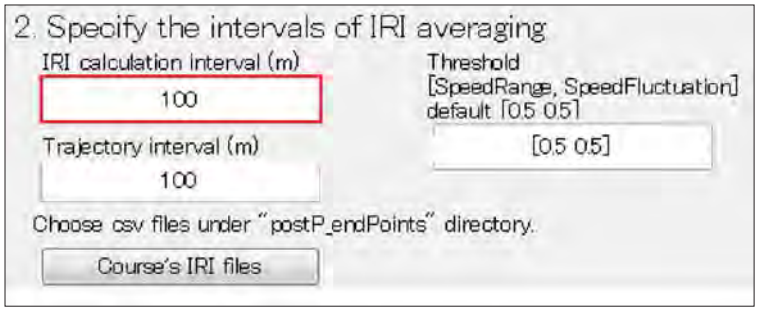
4. Calculation of Average IRI Values (2)
(Guideline-1: P.38)

Step-2: Enter “100” in “IRI calculation interval”.



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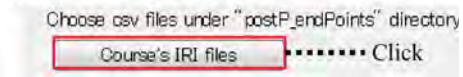
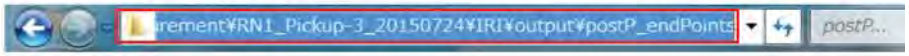
4. Calculation of Average IRI Values (3)
(Guideline-1: P.38)

Step-3: Select “Course’s IRI files”.

1) Click “Course’s IRI files”.

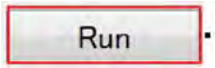


2) Enter the file path of “postP_endPoints” folder (generated in “Section 8.2”) in the address bar.



3) Select the CSV file in the folder and click “OK”.

Step-4:Click “Run”.



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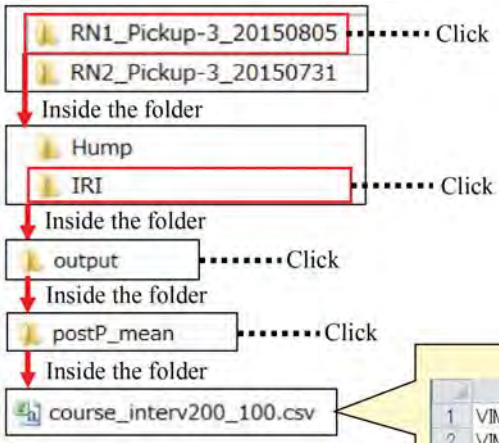
4. Calculation of Average IRI Values (4)
(Guideline-1: P.38)

Step-5: Check the Generated Data File.



100m interval

	A	B	C	D
1	VIMS	distance	IRI	Start(latit
2	VIMS	0	1.6557	11.53151
3	VIMS	100	1.6557	11.53176
4	VIMS	200	1.7042	11.53186
5	VIMS	300	1.7042	11.53182
6	VIMS	400	2.0384	11.53171

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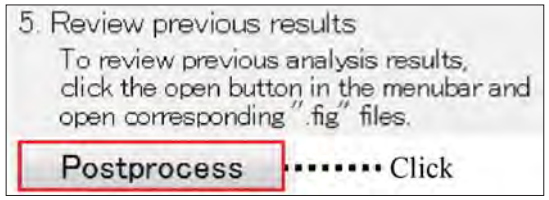
5. Integration of IRI Values into Road Monitoring System (1)
(Guideline-1: P.39)

Integration of IRI values into the monitor

Step-1: Click “Postprocess” in “5. Review previous results”.



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5. Integration of IRI Values into Road Monitoring System (1)

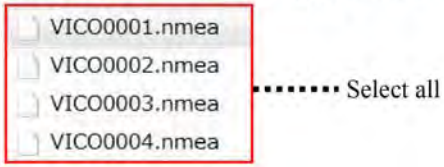
(Guideline-1: P.39)

Step-2:Click “Run” for “Match the Drive Recorder files and DRIMS files”.

Step-3: Select “nmea files”.

1) Enter the file path of “recorder output folder” in the address bar.

2) Select all the “nmea files” (GPS information obtained by the recorder) and click “OK”.



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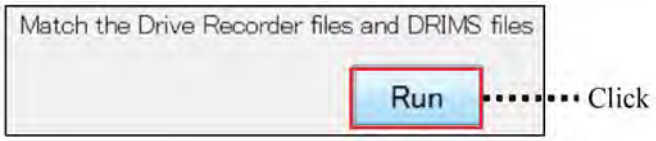
5. Integration of IRI Values into Road Monitoring System (2)

(Guideline-1: P.39)

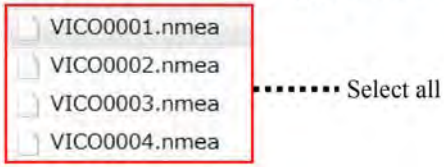
Step-2:Click “Run” for “Match the Drive Recorder files and DRIMS files”.



Step-3: Select “nmea files”.

1) Enter the file path of “recorder output folder” in the address bar.

2) Select all the “nmea files” (GPS information obtained by the recorder) and click “OK”.



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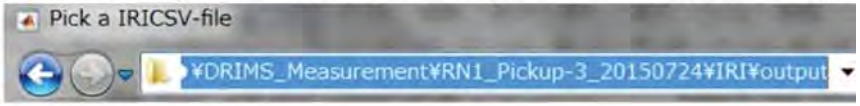
5. Integration of IRI Values into Road Monitoring System (3)

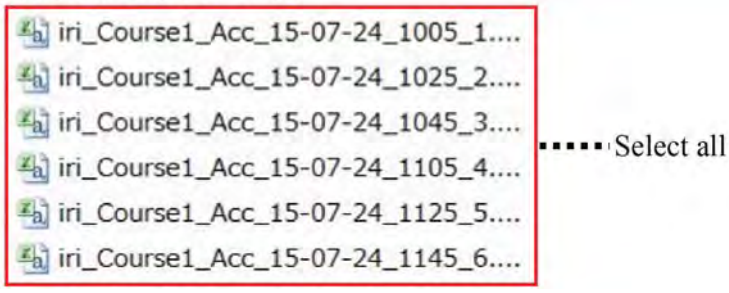
(Guideline-1: P.39)

Step-4: Select CSV files.

1) Enter the file path of “measurement output folder” in the address bar.



2) Select all the CSV files.



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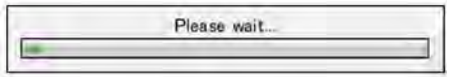
5. Integration of IRI Values into Road Monitoring System (4)

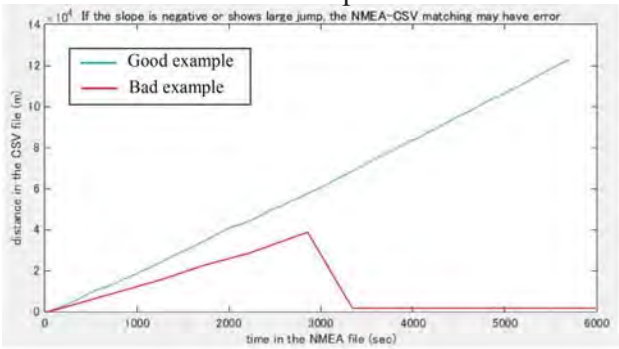
(Guideline-1: P.39)

Note:

1) After selecting CSV files, data integration starts with the following pop-up window.



2) If the integration is successfully done, a linear graph will be given. In case that the graph is not linear, check if correct “nmea files” and CSV files are selected and redo the process.



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5. Integration of IRI Values into Road Monitoring System (5)

(Guideline-1: P.40)

Step-5: Check the Result of Data Integration

1) Open "RegistratorViewer" (road monitoring system software).

RegistratorViewer.exe ····· Click

2) Check if the altitude graph has been replaced with the IRI graph.

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6. Data Storage in Database (1)

(Guideline-1: P.41)

[Overall Structure of Road Inspection Database]

- The database consists of 4 folders.
- All the data is to be manually stored into the database after inspection and subsequent analyses.

Inspection Database

Folder-1:	Measurement	DRIMS data (for back-up)
Folder-2:	Movie	Recorded movies
Folder-3:	IRI Map	Google Earth format maps
Folder-4:	Inventory	Excel file format inventories

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6. Data Storage in Database (2) (Folder-2: Movie)

(Guideline-1: P.41)

[Folder Structure]

Main folder	Subfolder-1	Subfolder-2
Movie	2015	RN1 150724
	2016	RN2 150731
	2017	RN3 150804

Maximum of 3 years for data storage

And so on…

Folder name:
Road name
plus
Inspection date

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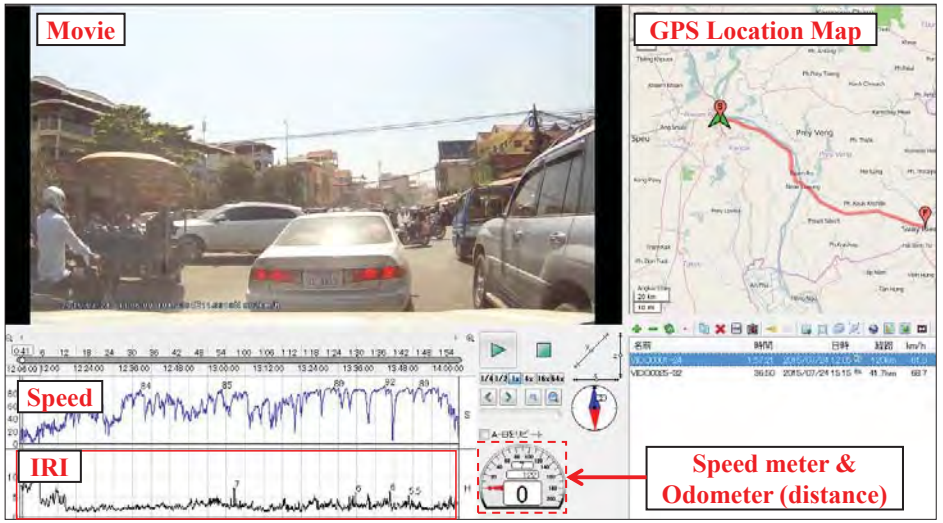
6. Data Storage in Database (3) (Folder-2: Movie)

(Guideline-1: P.42)

[Operation Image of Recorded Movies]



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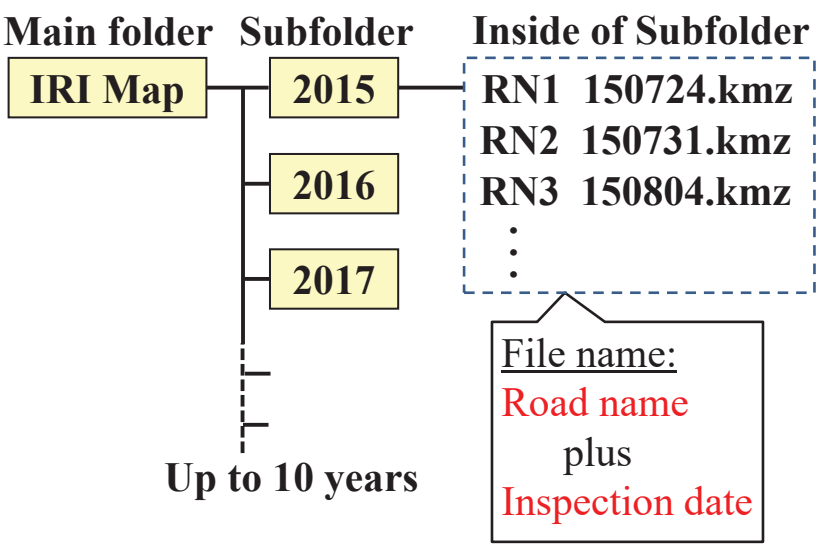
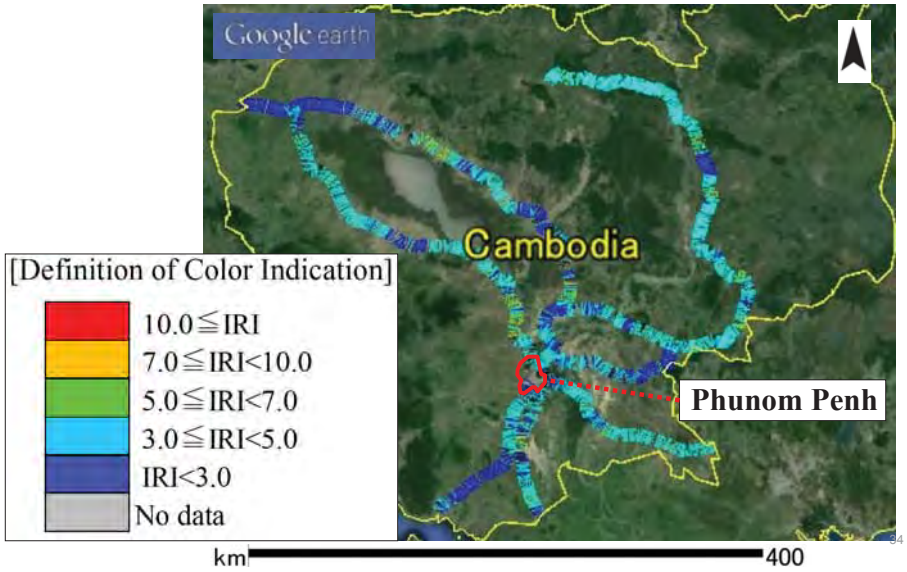
6. Data Storage in Database (4) (Folder-3:IRI Map) (Guideline-1: P.42)

[Folder Structure]



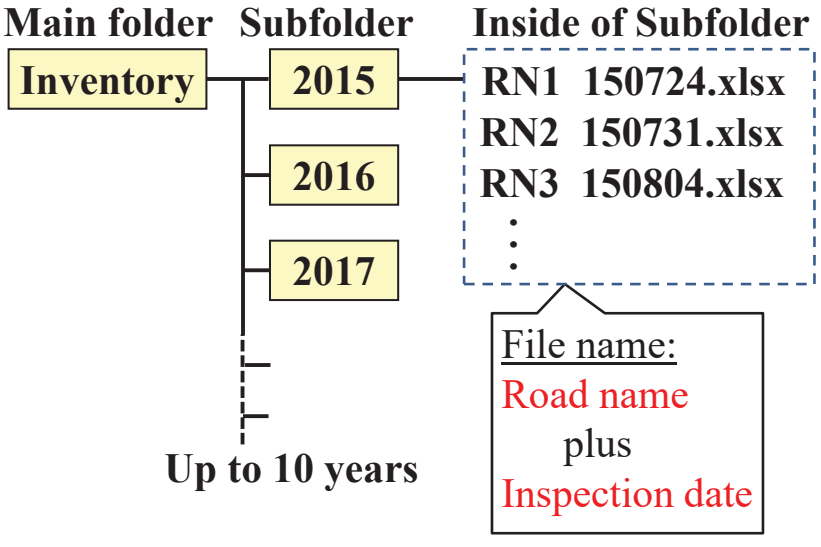
6. Data Storage in Database (5) (Folder-3: IRI Map) (Guideline-1: P.42)

[IRI Map for 1-digit Roads]



6. Data Storage in Database (5) (Folder-4: Inventory) (Guideline-1: P.43)

[Folder Structure]



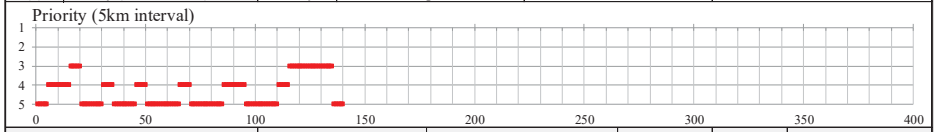
6. Data Storage in Database (6) (Folder-4: Inventory) (Guideline-1: P.44)

[Road Inventory Format (Excel File)]

(1)	Road Name	RN3			
(2)	Road Length (km)	135.4			
(3)	Pavement Type	AC			
(4)	Date of IRI measurement	6/Aug/2015			
(5)	Start Point & End Point	Start	PK0+000	End	PK135+400
(6)	Average IRI (Total Section)	2.1			
(7)	Visual Rating (Total Section)	Indicator N	1.49	Evaluation	Poor
(8)	Priority (Total Section)	Priority-3	Repair		

Breakdown of Road Condition: 0% 0% 18% 29% 53% — Priority-1, Priority-2, Priority-3, Priority-4, Priority-5

Priority (5km interval)



(9) Location		(10) Average IRI			(11) Visual Rating (Per 5.0km)			(12) Priority (Per 5.0km)	(13) Pavement Type	(14) Remarks	
From	To	Per 100m	Per 1.0km	Per 5.0km	No.of Defects Per 100m	No.of Defects Per 5.0km	N	Evaluation			No. of Bridge Joints	Major Findings
4 km + 0	4 km + 100	1.9	2.1	2.0	0	0	0.00	Very good	Priority-5 No or small repair	To be defined	0	
4 km + 100	4 km + 200	1.9			0						0	
4 km + 200	4 km + 300	1.9			0						0	
4 km + 300	4 km + 400	1.9			0						0	
4 km + 400	4 km + 500	NaN			0						0	
4 km + 500	4 km + 600	NaN			0						0	
4 km + 600	4 km + 700	2.7			0						0	
4 km + 700	4 km + 800	2.7			0						0	
4 km + 800	4 km + 900	2.0			0						0	
4 km + 900	5 km + 0	2.0			0						0	

3.5 Instructions for Reviewing Inspection Results

Outline

1. Evaluation Criteria for Road Condition
2. Study on IRI Measurement Results
3. Study on Road Conditions with the Inventory

1. Evaluation Criteria for Road Condition (1)

(Guideline-2: P.1)

(1) IRI for Road Roughness Evaluation

Image			
IRI	Degree of Damage >5.0	3.5 to 5.0	<3.5
Repair	Urgent	Necessary	No or small

1. Evaluation Criteria for Road Condition (2)

(Guideline-2: P.12)

(2) Evaluation Criteria for Visual Inspection

N= (Number of defects) / (Inspected road length)

Where,

N: Indicator for evaluation of visual inspection

(Number of defects): Number of defects within 5km

(Inspected road length): at the interval of 5km

Indicator N	Evaluation
$0 \le N < 0.2$	Very good
$0.2 \le N < 0.4$	Good
$0.4 \le N < 0.6$	Fairy good
$0.6 \le N < 1.15$	Fair
$1.15 < N$	Poor

1. Evaluation Criteria for Road Condition (3)

(Guideline-2: P.14)

(3) Overall Evaluation of Inspection Results

Combination of IRI & Visual Inspection

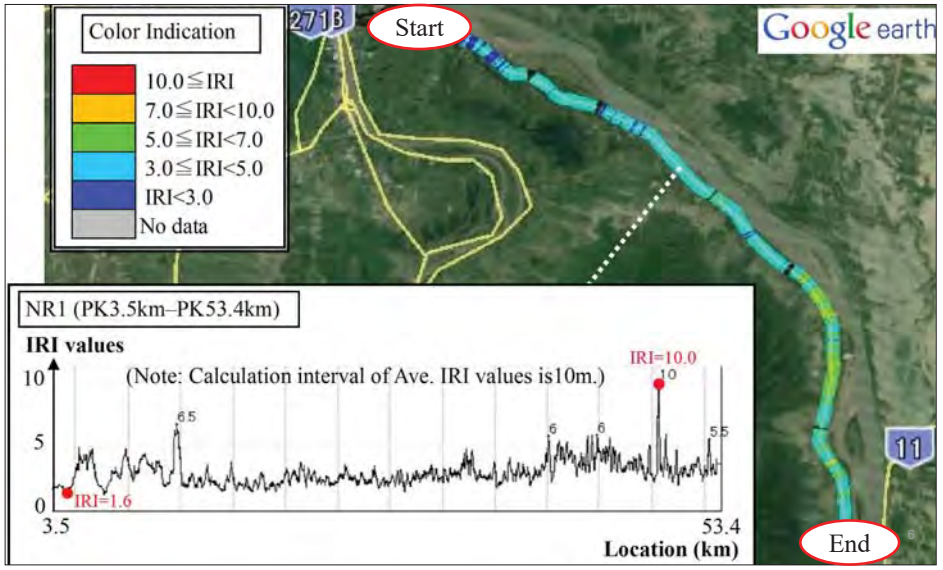
IRI (5km-ave.) \ Visual Rating	Very good	Good	Fairy Good	Fair	Poor
IRI<3.5	Rank-5: Good (No or small repair)			Rank-4: Fair (Small repair)	Rank-3: Poor (Repair)
3.5≦IRI<5.0	Rank-3: Poor (Repair)			Rank-2: Very Poor (Severe Repair)	
5.0≦IRI	Rank-1: Bad (Reconstruction/Rehabilitation/Upgrade)				

Note: Calculation interval of ave. IRI-value is 5.0km.

2. Study on IRI Measurement Results (1)

(Guideline-2: P.38)

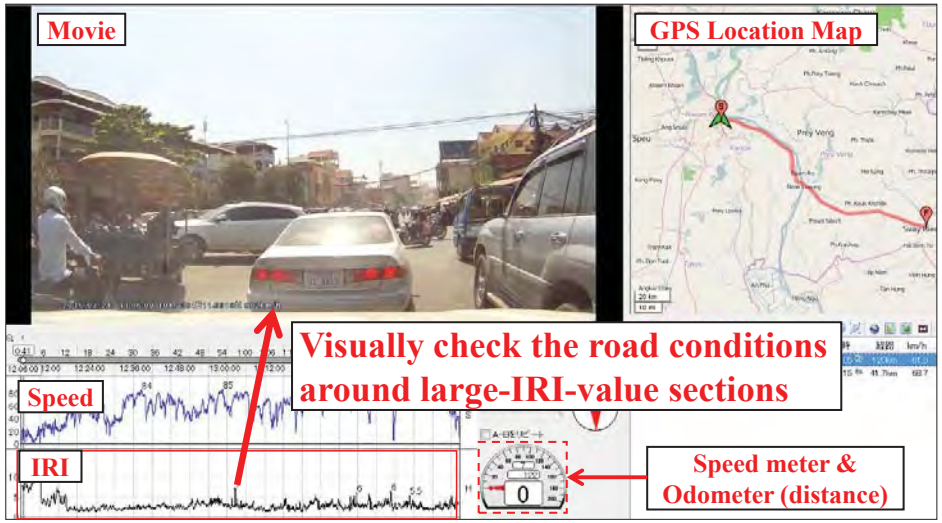
[Examination of IRI Maps & IRI Graphs]



2. Study on IRI Measurement Results (2)

(Guideline-2: P.39)

[Visual Inspection with Recorded Movies]



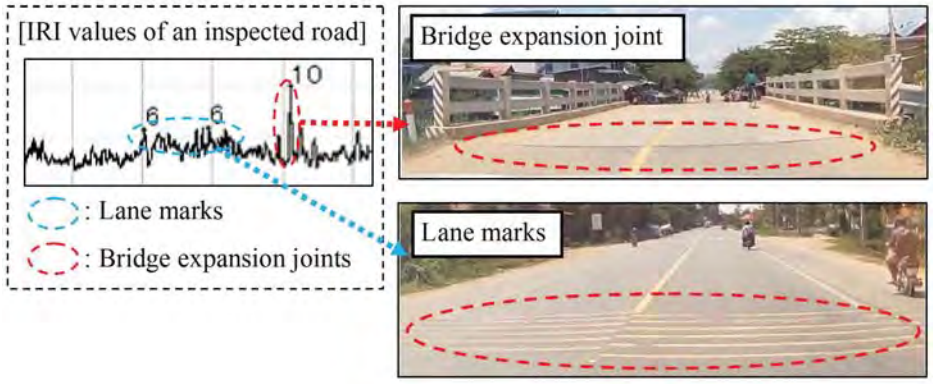
2. Study on IRI Measurement Results (3)

(Guideline-2: P.9)

[Visual Inspection with Recorded Movies]

Reasoning of high IRI values is important;

IRI values become large due to road/bridge facilities.



3. Study on Road Conditions with the Inventory (1)
(Guideline-2: P.15)

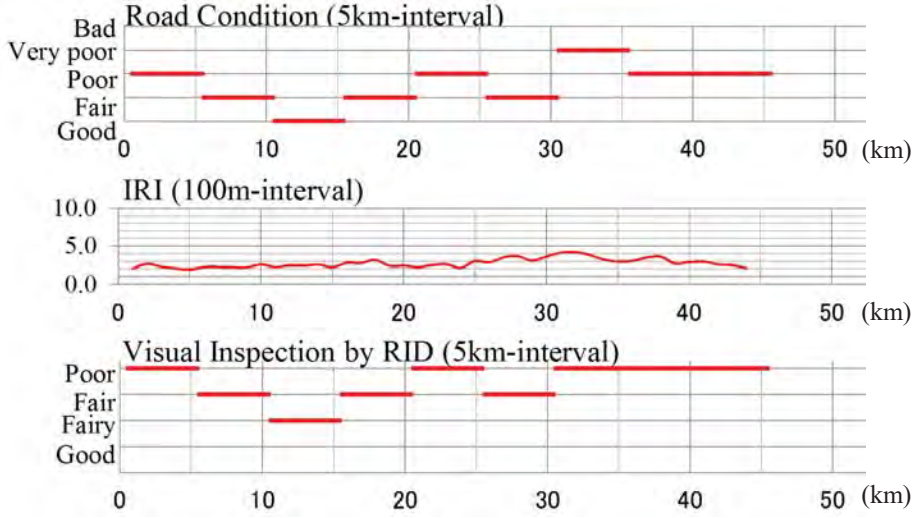
[Road Condition by Pie Chart (for overall check)]

Repair Ratio (%) = Ratio (Bad + Very poor + Poor)

Urgency Ratio (%) = Ratio (Bad + Very poor)

3. Study on Road Conditions with the Inventory (2)
(Guideline-2: P.15)

[Road Condition by Line Chart (to find damaged sections)]



3. Study on Road Conditions with the Inventory (3)
(Guideline-2: P.12)

[Road Conditions by Table (to examine damaged sections)]

(10) Location		(11) Average IRI			(12) Visual Rating (Per 5.0km)				(13) Road Condition (Per 5.0km)	(14) Pavement Type	(15) Remarks	
From	To	Per 100m	Per 1.0km	Per 5.0km	No.of Defects Per 100m	No.of Defects Per 5.0km	N	Evalu-ation			No. of Bridge Joints	Major Findings
3 km + 0	3 km + 100	2.4	2.1	-	0	-	-	-	-	-	0	
3 km + 100	3 km + 200	2.8			3						0	
3 km + 200	3 km + 300	2.5			2						0	
3 km + 300	3 km + 400	2.0			0						0	
3 km + 400	3 km + 500	1.8			0						0	
3 km + 500	3 km + 600	2.0			0						0	
3 km + 600	3 km + 700	1.9			0						0	
3 km + 700	3 km + 800	1.7			0						0	
3 km + 800	3 km + 900	1.8			0						0	
3 km + 900	4 km + 0	1.9			0						0	
4 km + 0	4 km + 100	1.8	1.9	2.2	0	15	3.00	Poor	Poor / Repair	AC	0	
4 km + 100	4 km + 200	2.0			0						0	
4 km + 200	4 km + 300	2.0			1						0	
4 km + 300	4 km + 400	1.9			1						0	
4 km + 400	4 km + 500	1.8			0						0	
4 km + 500	4 km + 600	1.7			0						0	
4 km + 600	4 km + 700	1.8			0						0	
4 km + 700	4 km + 800	1.8			0						1	
4 km + 800	4 km + 900	2.1			0						0	
4 km + 900	5 km + 0	2.1			0						0	

3. Study on Road Conditions with the Inventory (4)
(Guideline-2: P.15)

[Summary of Road Condition (for overall check)]

Location		IRI-based inspection by RID			
		Ave. IRI	Visual rating	Road condition	
From	To			Rank	Discription
0 km	5 km	2.19	Poor	**Poor**	Repair
5 km	10 km	2.30	Fair	**Fair**	Repair (small)
10 km	15 km	2.38	Fairy good	**Good**	Regular inspection
15 km	20 km	2.70	Fair	**Fair**	Repair (small)
20 km	25 km	2.50	Poor	**Poor**	Repair
25 km	30 km	3.33	Fair	**Fair**	Repair (small)
30 km	35 km	3.65	Poor	**Very poor**	Repair/ Resurfacing
35 km	40 km	3.13	Poor	**Poor**	Repair
40 km	45 km	2.52	Poor	**Poor**	Repair

3.6 Trouble Shooting & Recommendation

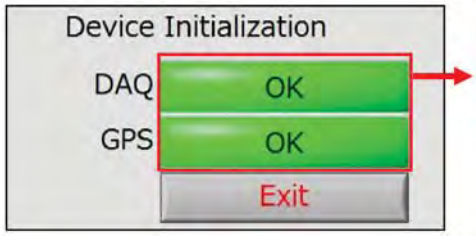
Outline

1. Activation of DRIMS Measurement Software
2. Malfunction of "Data File Save Option"
3. Malfunction of Hump Calibration Analysis
4. Recommendation for Survey Course Selection
5. Malfunction of DRIMS Measurement Software
6. Recommendation for Data Check at End Points

1. Activation of DRIMS Measurement Software (1)
(DRIMS Measurement Software) (Guideline-1: P.16)

(1) Error for Device Initialization

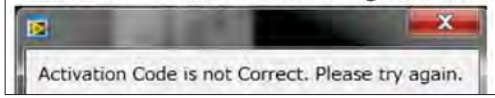
Trouble	Measures to be Taken
"OK" is not shown for DAQ.	Change the USB port for DAQ.
	Remove USB cable and restart software.
"OK" is not shown for GPS.	1) Remove USB and close the software window. 2) Restart GPS before connecting to PC, and confirm beep sound. 3) After that, connect to PC and start the software
	Change the USB port for GPS.



These 2 items indicate "NG" if it's not activated properly.

1. Activation of DRIMS Measurement Software (2)
(DRIMS Measurement Software) (Guideline-1: P.16)

(2) Error for Licensing of PC for DRIMS Activation

Trouble
DRIMS measurement software doesn't get activated with the following error massage. 
Measures to be Taken
1) Delete the old license file named "license.bin" in the DRIMS measurement folder. lisence.bin ····· Select and delete 2) Click and turn on DRIMS Measurement Software. DRIMS_Measurement_3_1_6.exe ····· Click 3) Enter a new activation code (registration for license). DRIMS measurement software gets activated after the new activation code is entered. Once computers are licensed to the unregistered DRIMS equipment, the license file, "license.bin", is to be generated in the DRIMS measurement folder again.

2. Malfunction of "Data File Save Option"
(DRIMS Measurement Software) (Guideline-1: P.20)

Error for Saving Data Files after IRI Measurement

Trouble	Measure
The window shown below doesn't appear when "Logging[F11]" is clicked to stop the software. 	1) Remove all the connected cables. 2) Close the software. 3) Start the procedure all over again from Step-1.

3. Malfunction of Hump Calibration Analysis
(DRIMS Analysis Software) (Guideline-1: P.29)

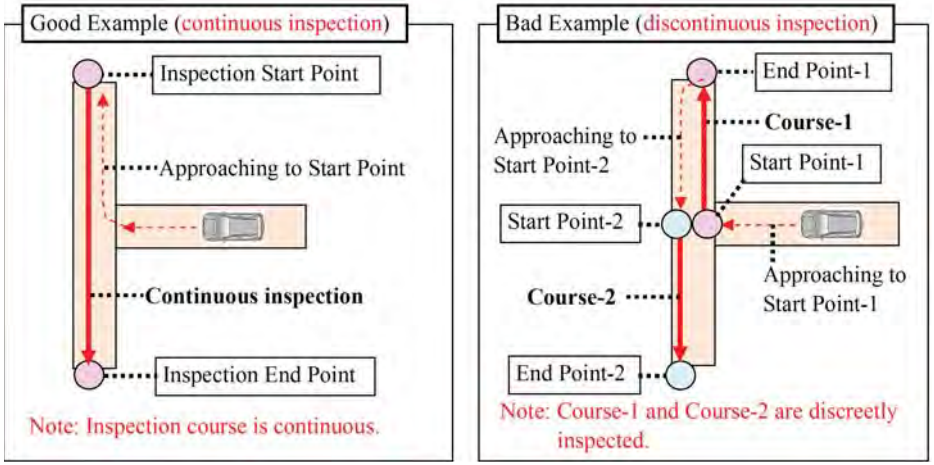
Calculation Stop during Analysis

Trouble	Measures to be Taken
Calculation stop during its process	This error occurs due to inadequacy of some of the selected 5 Acc files. To solve this problem, follow the procedure below. 1) Conduct the analysis again file by file in order to identify which file is defective. 2) Delete the defective files. 3) Carry out hump calibration again in order to obtain Acc files that replace the defective files. Note: Refer to "Section 5.3" and check the procedure closely before redoing the hump calibration.

4. Recommendation for Survey Course Selection
(IRI Measurement) (Guideline-1: P.31)

Recommendation for Continuous Inspection Course

Selection of continuous course makes post-processing of acquired data much more efficient.

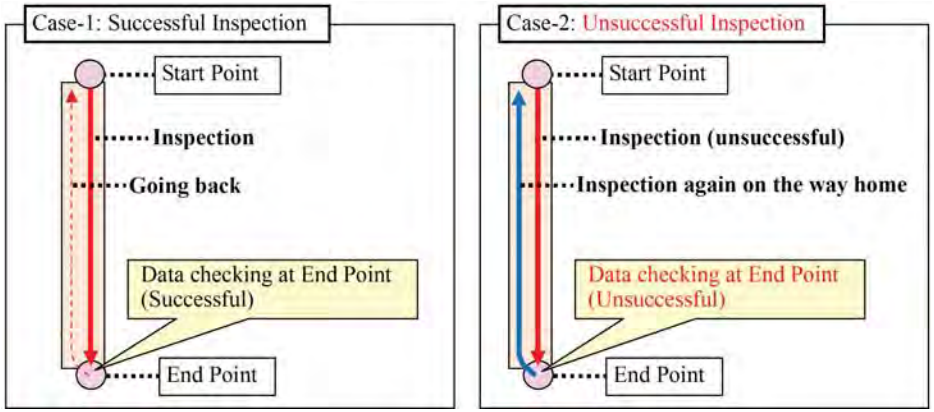


5. Malfunction of DRIMS Measurement Software
(DRIMS Measurement Software) (Guideline-1: P.32)

Trouble	Measures to be Taken
1. Acc/GPS files are not generated. 2. Size of Acc/GPS files are not increasing.	To solve this problem, follow the procedure below. **[Measure-1]** 1) Stop IRI measurement and the inspection vehicle. 2) Check connection between DRIMS equipment and the laptop PC. 3) Conduct "Operation Test" explained in Page-20. 4) If it's working fine, get back to IRI measurement again. If Measure-1 doesn't work, proceed to Measure-2. **[Measure-2]** 1) Restart the laptop PC. 2) Redo "Basic Operation of DRIMS" explained in Page-16 through 20 all over again. 3) If it's working fine, get back to IRI measurement again. If Measure-2 doesn't work, the laptop PC might have some problems. In this case, it's better to stop the inspection and carry out the inspection with other laptop PCs on another day.

6. Recommendation for Data Check at End Points
(DRIMS Measurement Software) (Guideline-1: P.32)

If there's anything wrong with the obtained data, inspectors have one more chance to carry out IRI measurement again on their way home.



Checklist for DRIMS Operation

Operation Stage	Page	Checklist	Checkbox	
Installation of Software into Laptop PCs (Chapter 2)	5-8, 15	DRIMS Measurement Software is installed in laptop PCs, and the laptop PCs are licensed by DRIMS activation codes.		
	9-11	DRIMS Analysis Software is installed in laptop PCs.		
Installation of DRIMS Equipment into Vehicles (Chapter 3)	2	All the equipment shown in Table-1 (Page-2) is ready to be installed.		
	13	Accelerometer is installed in a proper way above one of rear tires on opposite side of driver seats; in case of left hand drive vehicles, the accelerometer is to be installed above the right-side rear tire. The accelerometer is attached to solid part of vehicle body such as steel material.		
	13	No obstacles are put around the fixed accelerometer.		
	13	Cables have sufficient free margins (not stretched).		
	13	DAQ is fixed to vehicles in rear seats.		
	13	The USB cable of DAQ is connected to USB 3.0 port.		
	14	Power of the laptop PC is secured by DC-AC inverter.		
	14	The time of the laptop PC is adjusted. The time of the recorder is synchronized with that of the laptop PC.		
	14	GPS is set near side window to capture a satellite signal.		
Basic Operation of DRIMS (Chapter 4)	These items shall be checked before both hump calibration and IRI measurement.		Hump	IRI
	16	DRIMS measurement software is activated normally.		
	17	Data Entry for “Vehicle Registration” is properly done.		
	18	Data Entry for “Driving test” is properly done.		
	18	Data Entry for “GPS” is properly done.		
	19	Error check is done properly.		
	19, 20	Operation test is carried out before actual inspections. Generation of Acc/GPS files is confirmed during the operation test.		
Hump Calibration (Chapter 5)	24	Appropriate site for hump calibration is selected (enough space & flat surface).		
	24	The number of passengers and vehicle type are the same as those for IRI measurement.		
	16-20	Checking for Basic Operation of DRIMS is complete.		
	24	A color cone is set at the start point. Humps are set about 50m from the start point.		
	24, 25	Constant driving speed of 20km/h is maintained about 5 seconds before and after vehicles get on the humps. If you fail to drive at constant speed of 20km/h, don’t save the data and carry out the calibration again.		
	24	Hump calibration is conducted at least 5 times.		
	26-28	Analysis for 5 calibration results is carried out at the site right after the calibration. Desirable analysis result shown in Figure-10 (P.28) is confirmed.		
IRI Measurement (Chapter 6)	30	Inspection start points and end points are clarified.		
	24	The number of passengers and vehicle type are the same as those for hump calibration.		
	16-20	Checking for Basic Operation of DRIMS is complete.		
	31-32	Generation of Acc/GPS files is constantly checked. Also, increment of the file size is constantly checked during inspections. (If there’s anything wrong with the data acquisition, refer to Page-32.)		
Analysis for IRI Estimation (Chapter 6 & 7)	33	Appropriate calibration data is used for analysis (consistency in the number of passengers & inspection vehicle types)		
	33, 34	IRI Estimation is conducted in accordance with “Section 6.2”.		
	35-37	CSV files/Google Earth files are integrated by post processing.		
	37, 38	Average IRI values (at 100m interval) are calculated by post processing.		
	39, 40	IRI values are integrated into recorded movies.		
Preparation of Road Inventory	-	Road inventory is prepared in accordance with “Guideline for Routine Maintenance Using IRI”.		
Data Storage in Database (Chapter 8)	41-44	The following inspection outputs are saved in “Road Inspection Database”. 1) DRIMS measurement/analysis data 2) Recorded movies 3) IRI map (Goodle Earth format) 4) Road inventory (Excel format)		

Part 2

Road Repair

Maintenance Expert Program

Road Repair

ME-RR

Lecture Material

ME Training Program

ME	Bridge ME		Road ME	
	ME-BI	ME-BR	ME-RI	MR-RR
Subject of ME	Bridge Inspection	Bridge Repair	Road Inspection	Road Repair
Competences	Bridge inspection Bridge database	Standard bridge repair	DRIMS Visual inspection	Standard road repair
Manual to be used	Bridge Inspection Manual	Bridge Repair Manual	Guidelines for Routine Maintenance Using IRI	Guidelines for Repairing Defects of Roads
Number of days	3 days	1 day	3 days	1 day
Remark	1 day for field training	Lecture only	Theory and field training	Lecture only

2

Road ME: Road Repair

Contents	Key Concepts
CHAPTER 1 Introduction and Outline of Guideline	• Importance of Maintenance • Effect of Road Roughness on Vehicle Operation Cost • Purpose of Guideline for Repair of Road Defect
CHAPTER 2 Presentation of Job Codes	• Explanation of major job codes
Examination	• Writing test

3

TRAINING CULLICULUM: ME of ROAD MAINTENANCE

Guideline for Repairing Defects of Road

* Topic 1: Outline of Guideline
* Topic 2: Presentation of Some Job Codes

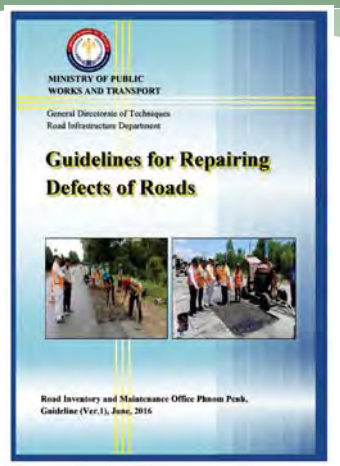
Construction Supervision

* Topic 3: Points of construction supervision

* Topic 4: Writing Test

4

New Proposed Guideline



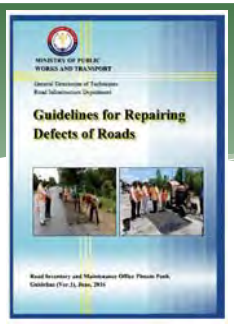
29.7cm

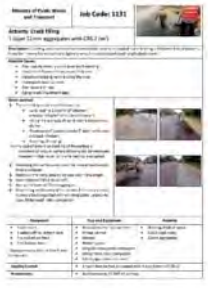
21cm

Convenient in locating each job code

6

153





7

Job code

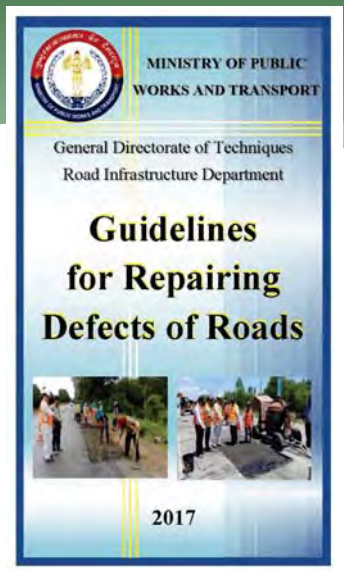
What are the potential risks that could cause this damage?

Step by step explanation of work method

Required materials and equipment

Number of manpower needed for the job

8



16.2cm

10cm

Job Code 1131

Crack filling
1-layer 12mm aggregates with CRS 2 (m2)

Description: Cracking are a series of interconnected cracks in an asphalt layer forming a different kind of patterns. It can be in many forms such as alligator cracks, transverse cracks and longitudinal cracks.

Possible Cause:
- Poor quality materials and poor workmanship
- Insufficient Pavement structure thickness
- Illegal overloading vehicle using the road
- Inadequate base support
- Poor base drainage
- Aging roads (Pavement age)

Work method:
1. There are 4 types of remedies such as:
   - Local sealing 1.5kg/m² of bitumen emulsion+1kg/m² of cut back bitumen)
   - Filling in the cracks (filled in with a bituminous slurry)
   - Treatment of isolated cracks (filled in with a hot cut back bitumen)
   - Patching (Dressing)
2. In the case of extensive cracking of the surface or pavement structure, surface dressing will be necessary, however in this repair, only one method is adopted
3. Sweeping the surface area clean by broom/mechanical broom sweeper
4. Mark out the crack area to be repaired in box shape
5. Application of CRS-2 (0.5L/m²)
6. Apply thin layer of 12mm aggregate
7. Depending on the area of the cracks. If the area is small, it should be compacted with vibrating plate. Large area uses 200kg hand roller compactor

Manpower
- 1 operators
- 2 safety officers at both end
- 4 unskilled workers

5

9

Topic 1: Outline of Guideline

- Introduction
- Purpose of this New Guideline for Repairing Defects of Road
- Contents of Job Code of Guideline Compared to Guideline of 2008 Version
- Current Guideline
- Method of Utilization of Guideline

10

Introduction
1. Road Maintenance Budget in Cambodia

2.3.4 Road Maintenance
a) Road Maintenance Budget

Road maintenance in Cambodia is divided into three main categories:
- Periodic maintenance: Focus on large scale maintenance (newly built or rehabilitation), where budget exceed 200 million riel ($50,000). The budget is taken from National Budget package 61 and 21
- Routine maintenance: Focus on small scale maintenance (repair cracks or potholes). Budget to be used in this category is varied and is taken from National Budget package 61
- Emergency maintenance: Focus on section or portion of road/bridge where it is affected by accident/flood. The budget to be used in this category must be under 200 million Riel ($50,000)[7].

Figure 2-14 shows the recent trend in the major road maintenance budget (Routine and Emergency) increases since 2011 because of rapid deterioration of roads due to severe flooding.

Figure 2-14. Trends of Major Road Maintenance Budget

Currently, road maintenance is implemented by the Department of Public Works and Transport (DPWT) in the provinces, and by private enterprises and construction units from police and armed force. MPWT and Ministry of Economy and Finance (MoEF) play a role in technical supervision and budget auditing of works.

[7] Exchange rate is $1=4,000 Riel

11

Introduction
2.Analysis of DPWT Maintenance Budget

2015 Maintenance Fee in each Province

Unit: 1000 US $

JOB CODE

No.	Province	RN	1100	1131	1132	1140	1150	1161	1162	1163	1164	1160-3	1160-C3	1170	1180	1200	1201	1250	1260	2100	2110	2150	4800	3100	3110	3141	3142	3150	3200	4150	4200	4400	4500	4610	4620	4630	4700	5100	5200	5230	5250	6100	6150	7100	7130	7150	7200	total	
1	Banteay Meanchey	5	71	19			16	33		38						3	6			3				1	1				2	4														0.4				333.8	5.1%
		6	75	17						30							3			1				1					5	4														0.4					
2	Battambang	5		22			25	94		37					128	2	5			5				1					2	5								10			6		4				15	361.0	5.5%
3	Kampong Cham	7	52	9			6			21						2	5			2				1					3	1														0.6				102.6	1.6%
4	Kampong Chhnang	5		149		36	18	112		26						4	9			4				1	1	203			2	3								9			17		6				15	615.0	9.4%
5	Kampong Speu	3		8			13	41		20						1	2			2				0.5					0.5	0.7														0.6				89.3	1.4%
6	Kampot	3		444			22	101		41						4	7			6				0.4					4	3										4	3			0.5				639.9	9.8%
7	Kandal	1	63	6						20							6			1				0.05	1				1	1							31							0.2					
8		2		55			3	7		5				4		0.6	1			1				0.08	1				2	0.4																			
9		3		2			5	16		7						0.5	1			0.6				0.1					0.3	0.2														0.5				415.9	6.4%
10		5		2			3	12		4						0.4	1			0.5				0.08	0.4				1	0.6																			
		8	43	5						16							2			0.6				0.2					3	0.6			76											1					
11	Kratie	7		278	16		16	180		34		129				3	6				15			2					7	3														1				690.0	10.5%
12	Phnom Penh	1	12	2			2			2							1			0.7																													
		2	9	2																					2																							78.0	1.2%
		3	19	3			2			6						0.5	1			1				0.05					1	0.3																			
		6	5	1			1			4										0.4																													
13	Prey Veng	1		6			5	29		11							1			1				0.2	0.3				1	0.7			34											1				302.0	4.6%
14		8	85	6						27							1			2				0.8					2	1			86											1					
15	Pursat	5		581		207	11	129		23						2	4			3				1	0.4	24			6	2								4			11		8	1			10	1027.4	15.7%
16	Seim Reap	6	75	10						14							1			1				0.8	0.4				1	0.7								13			1							117.9	1.8%
17	Stung Treng	7		5			4	36		8										1				0.6					4	2														1				61.6	0.9%
18	Svay Rieng	1		493			30	150		51						3	6			2				0.6					1	2								17						1				756.6	11.6%
19	Takeo	2	25	5	227		8	27		15						4	9			2				1	0.3				2	4								15						1				430.3	6.6%
		3		12			8	41		11						2	4			1				0.4					1	1										3				0.6					
20	Tboung Khmom	7	75	30			25	171		42						3	7			5				1					6	8														5				459.7	7.0%
		8	33	5						18							1			1				0.1						0.6							22							1					
21	Preh Sihanouk	3		6			6		34	12						1	2			1				0.3					0.2	0.7																		63.2	1.0%
	Total		642	2183	243	243	229	1179	34	543	0	129	0	4	128	36	92	0	0	48.8	15	0	0	15.3	7.8	227	0	0	58	49.5	0	0	196	0	0	0	53	68	0	7	38	0	18	17.8	0	0	40	6544.2	100%
	Total (%)		9.8%	33.4%	3.7%	3.7%	3.5%	18.0%	0.5%	8.3%	0%	2.0%	0%	0.1%	2.0%	0.6%	1.4%	0%	0%	0.7%	0.2%	0%	0%	0.2%	0.1%	3.5%	0%	0%	0.9%	0.8%	0%	0%	3.0%	0%	0%	0%	0.8%	1.0%	0%	0.1%	0.6%	0%	0.3%	0.3%	0%	0%	0.6%	100%	
	DIVISION		86.9% ON CARRIAGE WAY																	13.1% OFF CARRIAGE WAY																												100%	

12

Introduction
3. Why is Maintenance important ? (1/6)

1) The purpose of maintenance is to ensure that the road remains serviceable during its lifetime. Maintenance is important because it :

* Prolongs the life of a road by countering the effects of deterioration and thus preserves the value of the previous investments and the road asset.
* Reduces Vehicle Operating Costs (VOC) by providing a smooth running surface.
* Preserves the benefits provided by the original roads by providing reliable access and travel times for people to access healthcare, employment and educational opportunities.

Governments should be interested in preserving the value of their road assets. However, in practice, the responsible agencies have little incentive to undertake preventive maintenance activities.

Introduction
3. Why is Maintenance important ? (2/6)

2) Reduction in the value of road assets

* Postponing road maintenance results in high direct and indirect costs. If road defects are repaired promptly, the cost is usually modest. If defects are neglected, an entire road section may fail completely, requiring full reconstruction at three times or more the cost, on average, of the costs of preventive maintenance.
* The South African National Road Agency Ltd. (SANRAL) estimates that repair costs rise to six times maintenance costs after three years of neglect and to 18 times after five years of neglect.

* So the role of the RID is very important as leading management for maintenance.

Introduction
3. Why is Maintenance important ? (3/6)

3) Higher vehicle operating and transport costs

* Delayed maintenance has indirect costs as well. Neglected roads steadily become more difficult to use, resulting in increased vehicle operating costs (more frequent repairs, more fuel use) and a reluctance by transport operators to use the roads. This imposes a heavy burden on the economy: as passenger and freight services are curtailed, there is a consequent loss of economic and social development opportunities.

Introduction
3. Why is Maintenance important ? (4/6)

Effect of Road Roughness on Vehicle Operating Costs (Index of VOC: Good=100, at IRI=2.3

	Road condition	
Vehicle class	Fair (4.6 IRI)	Poor (6.9 –9.2 IRI)
Small car	106	114-26
Buses	104	109-16
Light diesel truck	111	123-38
Heavy truck	114	129-46
Articulated truck	112	127-44

Source: World Bank (1988); (IRI-International Roughness Index)

Introduction
3. Why is Maintenance important ? (5/6)

4) The results of longer travel times and reduced access

* Farmers are reluctant to grow a marketable surplus crop because of the difficulties and costs of transporting the crop to markets.
* School enrolment is lower and absenteeism is higher (both for teachers and students).
* Health care standards are poor because of the difficulty in reaching doctors, health care workers and facilities to get timely and appropriate health care.
* Women's working days are longer and harder, because of the time that it takes to reach water and fuel sources; two essential elements for daily life.

17

Purpose of this New Guideline for Repairing Defects of Road

The purpose of this guideline is to present standard practical methods for paved and unpaved road repair to the Provincial Department of Public Works (DPWT) of Cambodia. From past experiences, various methods and materials had been adopted by DPWT which lead to diverse result that has different effect on lifetime of road, quality of the ride for the commuters and the cost of repairing.

This guideline for road repair will provide road engineers with an easy and clear instruction on repairing various job code. With the pocket format will allow engineers to be able to carry around and consult on site. It is a quick reference should there be necessary.

Current Guideline

* MPWT has 4 guidelines
  - Guideline for Repairing Defects of Road
  - Guideline for Regular Inspection
  - Guideline for Supervision of Routine Maintenance
  - Guideline for Supervision of Periodic Maintenance
* Established in 2008
* Arranged in paragraph type, not specifics
* Manual only for cracks and potholes
* Procedure in repairing not specific enough
* Guideline is not handy to be carried around

19

Method of Utilization of Guideline

* This guideline handbook includes minimum requirement of study methods, inspections, material sources and technical specifications. It is also important to remind the engineers to keep records in regards to materials, equipment, number of workers needed and the productivity of work expected daily for update of the guideline.

20

Topic 2:- Presentation of Some Important Job Codes

* 1131 Join and Crack filling 1 layer 12mm aggregate with CRS-2
* 1150 Shape Correction (Ruts / Settlement)
* 1161 Pothole Repair-Mixed stone based DBST
* 1164 Pothole Repair-EXCEL Patch
* 1250 Grading Laterite
* 4700 Dragon Hole Filling

1131 Join and Crack filling 1 layer 12mm aggregate with CRS-2

Ministry of Public Works and Transports	Job Code: 1131

Activity: Join and crack filling

1 layer 12mm aggregates with CRS 2 (m^2)

Description: Cracking are a series of interconnected cracks in an asphalt layer forming a different kind of patterns. It can be in many forms such as alligator cracks, transverse cracks and longitudinal cracks.

Possible Cause:
- Poor quality materials and poor workmanship
- Insufficient Pavement structure thickness
- Illegal overloading vehicle using the road
- Inadequate base support
- Poor base drainage
- Aging roads (Pavement age)

Work method:
1. There are 4 types of remedies such as:
   - Local sealing 1.5kg/m^2 of bitumen emulsion+1kg/m^2 of cut back bitumen)
   - Filling in the cracks (filled in with a bituminous slurry)
   - Treatment of isolated cracks (filled in with a hot cut back bitumen)
   - Patching (Dressing)

   In the case of extensive cracking of the surface or pavement structure, surface dressing will be necessary, however in this repair, only one method is adopted
2. Sweeping the surface area clean by broom/mechanical broom sweeper
3. Mark out the crack area to be repaired in box shape
4. Application of CRS-2 (0.5L/m^2)
5. Apply thin layer of 12mm aggregate
6. Depending on the area of the cracks. If the area is small, it should be compacted with vibrating plate. Large area uses 200kg hand roller compactor


Crack Sealing

Crack sealing



Applying 12mm agr.

Manpower	Tool and Equipment	Material
• 1 operators • 2 safety officer at both end • 4 unskilled workers • 2 skilled workers	• Broom/ mechanical sweeper • Wheel barrow • Shovels • Watering can • 60kg Vibrating plate compactor • 200kg hand roller compactor • Safety sign, cones and vest	• Marking chalk or spray • CRS-2 (tack coat) • 12mm aggregates
Quality Control	• Ensure that surface is cleaned before application of CRS-2	
Productivity	• Approximately 100 m^2 per day	

1150 Shape Correction (Ruts / Settlement)

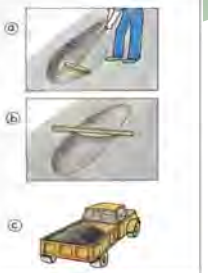
Ministry of Public Works and Transports	Job Code: 1150

Activity: Shape correction (Ruts/Settlement) (m^2)

Description:
Ruts is a depression in the wheel paths. Pavement surface uplift may occur along the side of rut, however in many instances, ruts are noticeable only after a rainfall, when the wheel paths are filled with water.

Possible Cause:
- Insufficient foundation or pavement strength for the traffic being carried
- Inadequate stability of the bituminous surfacing material
- Settlement of the foundation soil.

Work method:
1. Marking out the area to be repaired by string line to flat level.
2. Clean area to be repaired by using mechanical broom or hand broom.
3. Spreading aggregate 4cm x 6cm on the area
4. Compaction using rammer or vibrating plate compactor
5. After spraying CRS-2 (1L/m^2) and spread aggregate 19mm.
6. Compaction using rammer or vibrating plate compactor.
7. Resealing binder-CRS2 (0.4L/m^2) over the surface using a spray lance or a watering can
8. Distribution of aggregate 12mm scattered by shovel from the truck or trailer
9. Compaction using rammer or vibrating plate compactor



Manpower	Tool and Equipment	Material
• 1 operator of rammer or vibrating plate compactor • 2 safety officers at both end of work site • Approximately total of 12 men on the site	• Concrete cutting machine • Wheel barrow • Mechanical broom or hand broom • Shovels • Rammer(60 Kg) or vibrating plate compactor(60kg) • Safety sign, cones, vest	• Aggregate 4cm x 6cm • Aggregate 19mm • CRS-2 • Aggregate 12mm
Quality Control	• Surface of ruts should be 10 mm maximum higher than the original road level.	
Productivity	• Approximately 50m^2/day	

1161 Pothole Repair-Mixed stone based DBST

Ministry of Public Works and Transports	Job Code: 1161

Activity: Pothole repair-mixed stone based-DBST(m^2)

Description:
Potholes are bowl shaped holes in the pavement surface. The bowl has broken into small piece of the lumps without prompt repairs. Average pothole depth is around 5-10 cm. Average pothole size is around 10 – 100 cm.

Possible Cause:
- Poor quality DBST surfacing mix
- Incorrect compaction of the mix during construction
- Infiltration of water
- Break away of material under the action of traffic
- Final stage in the development of depression

Work method:
1. Mark out the pothole area in a rectangular shape
2. Use cutter machine and manual excavation
3. Excavate to remove all bad materials until firm material is found
4. Backfill the hole with aggregate (M30)
5. Compaction using rammer or vibrating plate compactor.
6. Reseal binder-CSS1 (1L/m^2) over the surface and spreading sand
7. Spay CRS-2
8. Spreading aggregate 19mm on the area(t = 2-3 cm)
9. Compaction using rammer or vibrating plate compactor.
10. Spray CRS2 (0.4L/m^2) over the surface
11. Spreading aggregate 12mm on the area(t = 1-2 cm)
12. Compaction using rammer or vibrating plate compactor

Manpower	Tool and Equipment	Material
• 1 operator of rammer or vibrating plate compactor • 2 safety officers at both end of work site • Approximately total of 12 men on the site	• Concrete cutting machine • Pickaxes • Wheel barrow • Mechanical broom or hand broom • Shovels • 60 Kg rammer or vibrating plate compactor (60kg) • Safety sign, cones, vest	• Aggregate M30 • CSS-1 • Sand • CRS-2 • Aggregate 19mm • Aggregate 12mm
Quality Control	• Surface of pothole should be 1 cm maximum higher than the original road level. • Check that all loose/poor material is removed before filling the potholes	
Productivity	• Approximately 25m^2/day (Average pothole size: 50 × 50 cm ~ 100 potholes/day if these are nearby)	

1164 Pothole Repair- EXCEL Patch

Ministry of Public Works and Transports	Job Code: 1164	

Activity: Pothole repair – Excel Patch (m²)

Description:
Urgent patching Application to pothole (maximum diameter 1.0 m, depth 50 mm - 100 m)

Possible Cause:
- Poor quality DBST surfacing mix
- Incorrect composition of the mix during construction
- Infiltration of water
- Break away of material under the action of traffic
- Final stage in the development of depression

Work method:
1. Sweep the pothole.
   Clear and remove sands and soil from edge of the pothole by brushing
2. If pothole more than 5 cm depth, coarse material should be fill prior EXCEL patch
3. Loosen EXCEL
   Before open the bag, loosen EXCEL in the bag.
4. EXCEL in the pothole.
   Put Excel into the pothole. 40% surplus is recommended for even compaction. (see Figure) (1-2cm)
5. Level surface.
   Level surface of the Excel patching with trowel and shovel
6. Spread Sand on an EXCEL.
   Spread sand even on the surface of Excel
7. Compaction by foot or car tires/ vibrating plate compactor/ compacting steel plate="elephant leg"
   Compact surface by foot or tire of vehicle
8. Spread sand onto the EXCEL to reduce friction of EXCEL and car tires

Manpower	Tool and Equipment	Material
• 1-2 unskilled worker	• Square Shovel, Broom, Water (+1 pickup for mobilization) • Pickaxe	• EXCEL base coarse material, sand (for spread)
Quality Control	• To confirm the Excel surface after compaction is smooth and higher than existing road surface. (no water allowed stay)	
Productivity	• 10 minutes per location/ team	

25

1250 Grading Laterite

Ministry of Public Works and Transports	Job Code: 1250	

Activity: Grading laterite (km)

Description: The first objective of maintenance is to keep the road in such a condition that it sheds water quickly. If the road does not shed water, the surface will become soft, and ruts and potholes will quickly appear. Earth roads soon become impassable. Maintenance is needed to restore a good camber on the road to enable water to drain off quickly. This is best achieved by regular grading. Grading and reshaping laterite roads to eliminate edge ruts, ridges, corrugation, high shoulders and to restore good drainage characteristics.

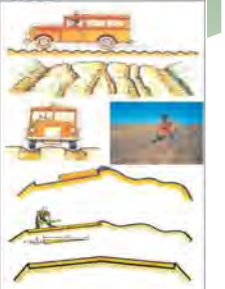
Possible Cause:
- Loss of shape (Cambere at Transersal)
- Ruts
- Pot-hole
- Corrugations
- Erosion gullies
- Blocks ditches

Work method:

Preparation
1. Before work starts, warning signs must be placed at each end of the work area to ensure safety.
2. Filling of large potholes should be carried out in advance of the grading.
3. Areas of standing water should be drained. This penetration will ease the work and make the resulting surface last longer.

Grading
1. Set out shoulder carriageway line using pegs and strings at 10 or 20m intervals.
2. Blade the material toward the centre of the road starting from both edges to specified camber.
3. Check gradient with camber board.
4. Well graded and shaped road without ruts, ridges, corrugations and are flush with road surface with slope 4 to 5 percent.

The grader works on one side of the road at a time and works in passes of about 200m long to convenient and safe turning points. It will normally require 4 passes to reshape the road.



Manpower	Tool and Equipment	Material
• 1 motor grader driver • 2 unskilled workers	• Motor Grader • Light towed grader with trattor • Shovels and Pickaxes • Wheel barrows	
Quality Control	• The width of the carriageway including the shoulders to be checked using tape measure at every 100m with maximum tolerance +50mm or -20mm • The camber to be checked using a camber board at every 50m with and to have a minimum tolerance of +/- 1%	
Productivity	• 2km/day	

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4700 Dragon Hole Filling

Ministry of Public Works and Transports	Job Code: 4700	

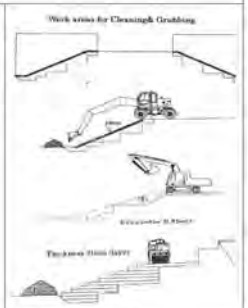
Activity: Dragon hole filling (m³)

Description:
Road sub base is very important in determining the life of road. Without proper base and underground water way, this could lead the erosion of the base and sub base which caused dragon hole.

Possible caused:
- Due to dispersive soil
- Road side drainage is not functioning well
- Sub base compaction of road were not compacted to standard
- Incorrect use Sub base material
- Natural disaster
- Embankment of roadside is not done properly

Work method:
1. Determine the dragon hole and outlet points (if presented)
2. Cleaning &Grubbing
   Remove all spoil material such as root of trees, rubbish etc. above the ground surface.
3. Removal of Topsoil (thickness approx. 10cm).
   Keep on the end of the slope to reused as the Soildy material after slope filling
4. Excavation & Hauling
5. Mixing soil and additives*
6. Slope filling
7. Covering of Topsoil
8. Final Inspection

* Cement and Fly ash are available as additives
Portion of additives are as follows
Cement : 1-3 % of soil in weight
Fly ash : >7 % of soil in weight



Manpower	Tool and Equipment	Material
• 1 vibrating compaction plate operator • 4 unskilled workers	• shovels • Wheel barrow • Vibrating compactor • Safety sign, cones, vest • Backhoe	• Mixed soil • Laterite • Sand • Cement of fly ash as additives
Quality Control	• To confirm material use is good quality	
Productivity	• 100 meters per daily	

27

Examination:- Writing Test

- Job Code Question
- Maintenance Cost
- Reason of Importance for Maintenance
- Existing Guidelines of Road Maintenance
- Definition of Road Maintenance
- Method of Utilization of Guideline

28

Maintenance Expert Program
Road Maintenance

Construction Supervision

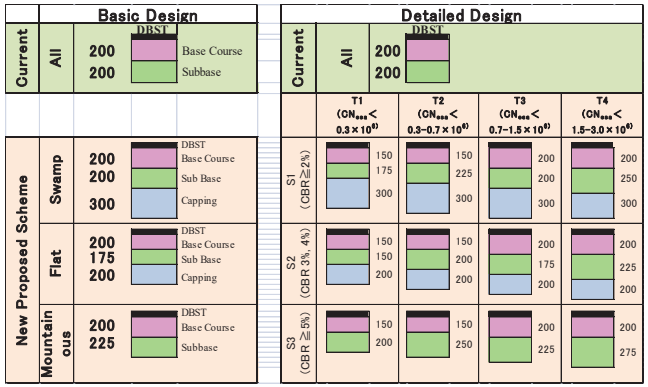
Establishment of Standard Guideline & Regulation for QC

Standard Guideline:
To Specify Technical Matters

Regulation:
To Specify Roles & Responsibilities of Parties

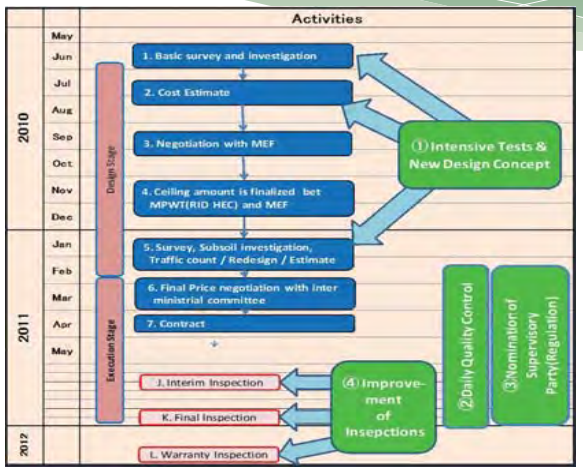
1. Intensive Tests & New Design Concept

* Soil sampling and tests will be conducted with nominated supervisor
* Design concept will be changed as follows.

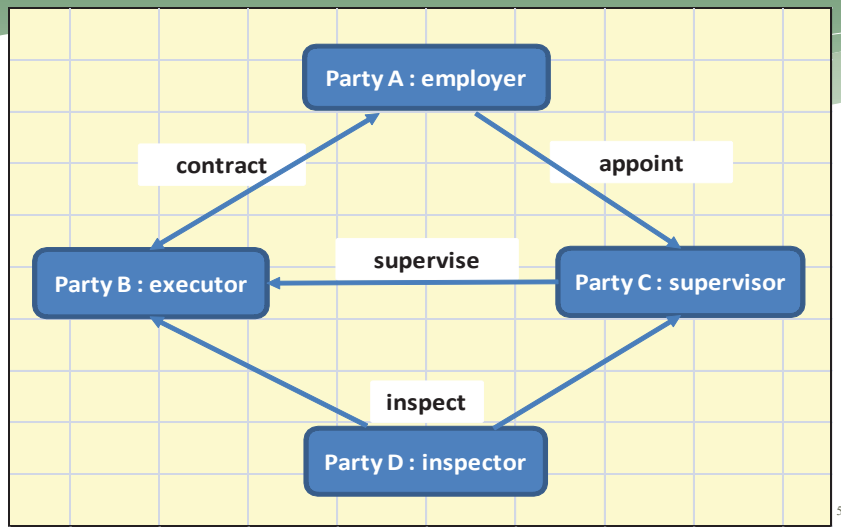


Standard Guideline

Flow of Activities on FA Project



Regulation



5

Party A:
Employer, Director General of Public Works

1. To Give Party B Permission to Work on Site
2. To Appoint Supervisor as Party C
3. To Request MEF Pay Amount to Party B / C

* Party B:
* Executor, DPWT / HEC / RID (Road_Bridge unit)

1. To Carry out Works with Contract Documents
2. To Carry out Quality Tests & Keep Records
3. To Submit Monthly Progress Report
4. To Inform Unforeseen Conditions, if Encountered
5. To Submit Contract Documents & As Build after Completion for Database

6

Party C:
Supervisor, RID (Planning & Technical Bureau) / PWRC

1. To Supervise the Works Carried out by Party B
2. To Witness Quality Tests and Check Records
3. To Call Monthly Progress Meeting
4. To Review Unforeseen Conditions Reported
5. To Issue Instructions & Variations, as Require

* Party D:
* Inspector, PEAC / General Department of Inspection

1. To Check Contract prior to Signing by Party A/B
2. To Inspect Works time to time

7

Regulation contract

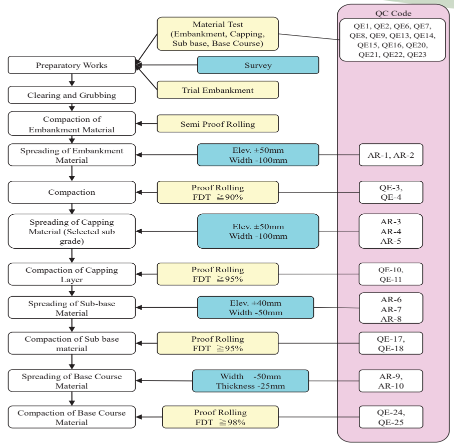
1. **The Contract Agreement**
2. **The Regulation**
3. **The Standard Guideline**
4. **The Detailed Design Documents and Project Costs**

8

2. Daily Quality Control

STANDARD GUIDELINE

Flowchart of Earth Work /Embankment



Q-1 Quality Control Chart for Earth Works

Description		Specs	No	Test Method	Standard	Tolerance	Frequency	Record method	Custody of Records	Witness
Embankment	Mat'l	CCMS Appendix 1	QE-1	Compaction Test	AASHTO T180	MDD, OWC	Per source, whenever any irregularity is observed	Std Form	Party B & C	Party C
			QE-2	Modified CBR	AASHTO T193	≧ 2.0%		Std Form	Party B & C	Party C
	Execution	CS 2.6.3.3	QE-3	Field Density Test	AASHTO T180	Dry Density ≧ 90% of MDD	5 locations/ 2,000m2	Std Form	Party B & C	Party C
		CS 2.6.3.1	QE-4	Proof Rolling		By observation	Entire area on the embankment surface	Check Sheet	Party B & C	Party C
		CS 2.6.3.2	QE-5	Compaction thickness		≦ 20cm	All embankment works	Check Sheet	Party B & C	Party C
Capping Layer (Selected sub-grade)	Material	CCMS Appendix 1	QE-6	Compaction Test	AASHTO T180	MDD, OWC	Per source, whenever any irregularity is observed	Std Form	Party B & C	Party C
			QE-7	Modified CBR	AASHTO T193	≧ 15%		Std Form	Party B & C	Party C
			QE-8	Sieve Analysis	AASHTO T27	74μMass Percent Passing : 10%-30%		Std Form	Party B & C	Party C
			QE-9	LL-PL-PI	AASHTO T89, 90	LL ≦ 40% PI ≦ 20%		Std Form	Party B & C	Party C
	Execution	CCMS Appendix 1	QE-10	Field Density Test	AASHTO T180	Dry Density ≧ 95% of MDD	5 locations / 2,000m2	Std Form	Party B & C	Party C
		CS 3.1.3.5	QE-11	Proof Rolling		Observation	Entire area on the capping layer surface	Check Sheet	Party B & C	Party C
		CCMS Appendix 1	QE-12	Compaction thickness		≦ 20cm	All embankment works	Check Sheet	Party B & C	Party C
Sub Base	Material	CCMS Appendix 1	QE-13	Compaction Test			Per source, whenever any irregularity is observed	Std Form	Party B & C	Party C
			QE-14	Modified CBR	AASHTO T193	≧ 30%		Std Form	Party B & C	Party C
			QE-15	Sieve Analysis	AASHTO T27	Within the ranges specified in the table		Std Form	Party B & C	Party C
			QE-16	LL-PL-PI	AASHTO T89, 90	LL ≦ 35% PI ≦ 20%		Std Form	Party B & C	Party C
	Execution	CCMS Appendix 1	QE-17	Field Density Test	AASHTO T180	Dry Density ≧ 95% of MDD	5 locations / 2,000m2	Std Form	Party B & C	Party C
		CS 3.1.3.5	QE-18	Proof Rolling		Observation	Entire area on the sub base surface	Check Sheet	Party B & C	Party C
		CCMS Appendix 1	QE-19	Compaction thickness		≦ 20cm	All embankment works	Check Sheet	Party B & C	Party C
Base Course	Material	CCMS Appendix 1	QE-20	Compaction Test			Per source, whenever any irregularity is observed	Std Form	Party B & C	Party C
			QE-21	Modified CBR	AASHTO T193	≧ 80%		Std Form	Party B & C	Party C
			QE-22	Sieve Analysis	AASHTO T27	Within the ranges specified in the table		Std Form	Party B & C	Party C
			QE-23	LL-PL-PI	AASHTO T89, 90	LL ≦ 25% PI ≦ 6%		Std Form	Party B & C	Party C
	Execution	CCMS Appendix 1	QE-24	Field Density Test	AASHTO T180	Dry Density ≧ 98% of MDD	5 locations/ 2,000m2	Std Form	Party B & C	Party C
		CS 1.1.17	QE-25	Proof Rolling		Observation	Entire area on the base course surface	Check Sheet	Party B & C	Party C
		CCMS Appendix 1	QE-26	Compaction thickness		≦ 20cm	All embankment works	Check Sheet	Party B & C	Party C

Note : CCMS (Compact Construction Materials Specification)

(Q3) Check Sheet

Check Sheet for Proof Rolling

Budget Year	Province	Name of Part B
Chapter	Road Number	Name of Part C

P : Pass
F: Fail

Date	Work Items[1]	Section	Length(m)	L/R/ L&R	Load[2] (P/F)	Tire[3] (P/F)	Result of Test (P/F)	In charge(Party B) Name	In charge(Party B) Sign	In charge(Party C) Name	In charge(Party C) Sign
		Sta. ~Sta.									
		Sta. ~Sta.									
		Sta. ~Sta.									
		Sta. ~Sta.									
		Sta. ~Sta.									
		Sta. ~Sta.									
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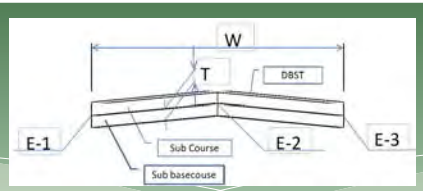
		Sta. ~Sta.									

A-1 Asbuilt Control Chart for Road for Road Works

Description	Specs	No.	Measured Items	Method	Tolerance	Frequency	Record method	Custody of Records	Witness
Embankment / Sub-grade	Civil Works Handbook/Japan	AR-1	Elevation	Level Instrument	± 5.0cm	every 40 m	St'd Form	Party B & C	Party C
	Civil Works Handbook/Japan	AR-2	Width	Measuring Tape	-10.0 cm	every 40 m	St'd Form	Party B & C	Party C
Capping Layer (Selected sub-grade)	Civil Works Handbook/Japan	AR-3	Elevation	Level Instrument	± 5.0cm	every 40 m	St'd Form	Party B & C	Party C
	Civil Works Handbook/Japan	AR-4	Thickness	Measuring Tape	-4.5 cm	every 200 m	St'd Form	Party B & C	Party C
	Civil Works Handbook/Japan	AR-5	Width	Measuring Tape	-5.0 cm	every 80 m	St'd Form	Party B & C	Party C
Sub Base	Civil Works Handbook/Japan	AR-6	Elevation	Level Instrument	± 4.0cm	every 40 m	St'd Form	Party B & C	Party C
	Civil Works Handbook/Japan	AR-7	Thickness	Measuring Tape	-4.5 cm	every 200 m	St'd Form	Party B & C	Party C
	Civil Works Handbook/Japan	AR-8	Width	Measuring Tape	-5.0 cm	every 80 m	St'd Form	Party B & C	Party C
Base Course	Civil Works Handbook/Japan	AR-9	Thickness	Measuring Tape	-2.5 cm	every 200 m	St'd Form	Party B & C	Party C
	Civil Works Handbook/Japan	AR-10	Width	Measuring Tape	-5.0 cm	every 80 m	St'd Form	Party B & C	Party C
Asphalt Concrete	Civil Works Handbook/Japan	AR-11	Thickness	Measuring Tape	-0.7 cm	every 1000 m2	St'd Form	Party B & C	Party C
	Civil Works Handbook/Japan	AR-12	Width	Measuring Tape	-2.5 cm	every 80 m	St'd Form	Party B & C	Party C



Sta	W(±50mm)			T(-45mm)			E-1(±50mm)			E-2(±50mm)			E-3(±50mm)		
	Design	Actual	Error	Design	Actual	Error	Design	Actual	Error	Design	Actual	Error	Design	Actual	Error
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	EL	EL	(mm)	EL	EL	(mm)	EL	EL	(mm)
Sta 0+000	6000	6010	10	200	210	10	15.121	15.131	10	75.121	75.110	-11	15.121	15.141	20
Sta 0+040	6000	-	-	200	-	-	15.621	15.609	-12	75.621	75.609	-12	15.621	15.601	-20
Sta 0+080	6000	6020	20	200	-	-	16.121	16.133	12	76.121	76.133	12	16.121	16.176	55
Sta 0+120	6000	-	-	200	-	-	16.621	16.631	10	76.621	76.644	23	16.621	16.567	-54
Sta 0+160	6000	6020	20	200	-	-	17.121	17.112	-9	77.121	77.155	34	17.121	17.091	-30
Sta 0+200	6000	-	-	200	150	-50	17.621	17.651	30	77.621	77.655	34	17.621	17.581	-40
Sta 0+240	6000	6060	60	200	-	-	18.121	18.151	30	78.121	78.164	43	18.121	18.081	-40
Sta 0+280	6000	-	-	200	-	-	18.621	18.631	10	78.621	78.664	43	18.621	18.655	34
Sta 0+320	6000	6010	10	200	-	-	19.121	19.061	-60	79.121	79.164	43	19.121	19.165	44
Sta 0+360	6000	-	-	200	-	-	19.621	19.576	-45	79.621	79.664	43	19.621	19.664	43
Sta 0+400	6000	5990	-10	200	230	30	20.121	20.071	-50	80.121	80.144	23	20.121	20.165	44
Sta 0+440	6000	-	-	200	-	-	20.621	20.644	23	80.621	80.587	-34	20.621	20.571	-50
Sta 0+480	6000	5980	-20	200	-	-	21.121	21.077	-44	81.121	81.088	-33	21.121	21.154	33
Sta 0+520	6000	-	-	200	-	-	21.621	21.671	50	81.621	81.587	-34	21.621	21.581	-40
Sta 0+560	6000	5950	-50	200	-	-	22.121	22.087	-34	82.121	82.155	34	22.121	22.181	60
Sta 0+600	6000	-	-	200	190	-10	22.621	22.655	34	82.621	82.655	34	22.621	22.581	-40
Sta 0+640	6000	5960	-40	200	-	-	23.121	23.076	-45	83.121	83.164	43	23.121	23.071	-50
Sta 0+680	6000	-	-	200	-	-	23.621	23.655	34	83.621	83.655	34	23.621	23.591	-30
Sta 0+720	6000	5990	-10	200	-	-	24.121	24.166	45	84.121	84.165	44	24.121	24.161	40
Sta 0+760	6000	-	-	200	-	-	24.621	24.664	43	84.621	84.664	43	24.621	24.589	-32
Sta 0+800	6000	6010	10	200	220	20	25.121	25.166	45	85.121	85.155	34	25.121	25.165	44

Maintenance Expert Program
Road Maintenance

Writing Test

NAME:

ORGANIZATION:

Q1: Why is Road Maintenance important?
Mark ○ on the number of the correct answer

1. To prolong the life of a road by countering the effects of deterioration
2. To preserves the value of the previous investments and the road asset
3. To Reduce Vehicle Operating Costs (VOC) by providing a smooth running surface.
4. To Preserve the benefits provided by the original roads by providing reliable access and travel times for people to access healthcare, employment and educational opportunities.

Q2: What is the purpose of New Guideline for Repairing Defects of Road ?

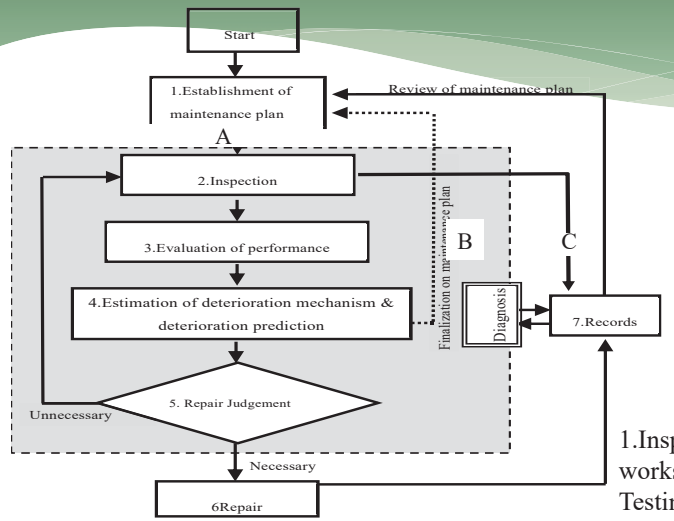
* The purpose of this guideline is to present standard practical methods for paved and unpaved road repair to the (A) of Cambodia. From past experiences, various methods and materials had been adopted by (A) which lead to diverse result that has different effect on (B) of road, quality of the ride for the commuters and the (C) of repairing.

* This guideline for road repair will provide road engineers with an (D) instruction on repairing various job code. With the pocket format will allow engineers to be able to carry around and refer on site. It is a (E) reference for the inspectors.

A: B: C: D: E :

1.JICA 2. cost 3. easy and clear 4. thing 5. DPWT 6. lifetime 7. size 8.person 9. slow and unclear 10.complicated 11. quick

Q3:Process of Maintenance



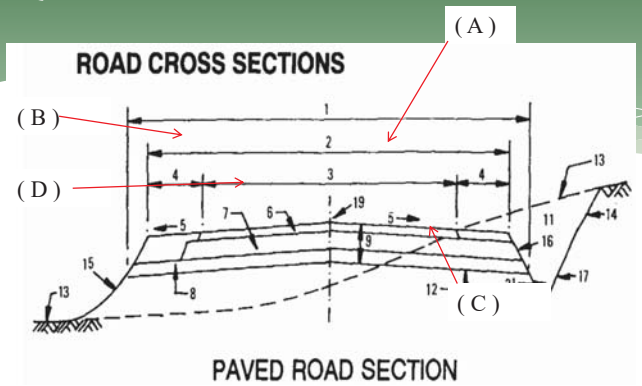
A:

B:

C:

1.Inspection 2. Repair works 3. Record 4. Testing 5. Diagnosis 6. Action

Q4: Road member terms



A:

B:

C:

D:

1. Subgrade 2. Roadway 3. Carriageway 4. Shoulder 5.Camber/Crossfall
6. Surfacing 7. Roadbase 8.Sub-Base 9. Pavement 10.Embankment
11.Cutting 12.Subgrade Surface 13.Original Ground Level
14.Cutting Slope 15.Embankment Slope 16.Ditch Inside Slope
17.Ditch out side Slope 18.V-Ditch 19.Road Centerline

5

Q5: Road Maintenance Cost

* 1) Road Maintenance Cost on Carriage Way in 2015 occupy around (A) % of all cost.
  1.50 2. 75 3. 85
  2) Most highest cost is Job code number (B) in 2015. 1. 1100 2.1131 3.1161
  3) What province did have the biggest budget for road maintenance ? (C)
  1. Kandal 2. Pursat 3. Kampong Cham

A: B:

C:

6

Q6: Existing Guideline of Road Maintenance

* MPWT has 4 guidelines
  - Guideline for Repairing (A) of Road
  - Guideline for Regular Inspection
  - Guideline for Supervision of Routine Maintenance
  - Guideline for Supervision of Periodic Maintenance
* Established in (B)
* Arranged in paragraph type, not (C)
* Manual only for cracks and potholes
* Procedure in repairing not (C) enough
* Guideline is not handy to be carried around

A : B: C :

1. Routine 2. Defects 3. 2000 4. 2008 5. 2010
6. easy 7. outline 8. specific 9.difficult

7

Q7 : Definition of Maintenance

A : To comprise small-scale works conducted regularly, aims "to ensure the daily passability and safety of existing roads in the short-run and to prevent premature deterioration of the roads". ( )

B : To be immediately undertaken for repairs that cannot be foreseen but require immediate attention, such as collapsed culverts or landslides that block a road. ( )

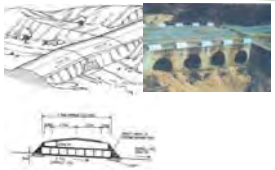
C : To cover activities on a section of road at regular and relatively long intervals, aim "to preserve the structural integrity of the road". These operations tend to be large scale, requiring specialized equipment and skilled personnel. ( )

1. Routine Maintenance 2. Periodic Maintenance
3. Emergency Maintenance

8

Q8: Type of Job Code

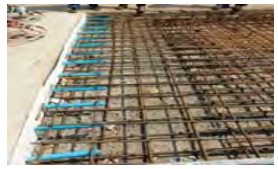
Which number of Job Code is according to Sample Photo of Damage?

Damage Photo	Job Code	Damage Photo	Job Code
			
			

9

Q8: Type of Job Code

Which number of Job Code is according to Sample Photo of Damage?

Damage Photo	Job Code	Damage Photo	Job Code
			
			

10

Q8: Type of Job Code

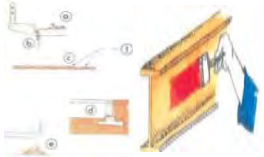
Which number of Job Code is according to Sample Photo of Damage?

Damage Photo	Job Code	Damage Photo	Job Code
			
 			

11

Q8: Type of Damage

Which number of Job Code is according to Sample Photo of Damage?

Damage Photo	Job Code	Damage Photo	Job Code
			
			

12

Q9 : Method of Utilization of Guideline

This guideline handbook includes minimum requirement of study (A), inspections, material sources and technical specifications. It is also important to remind the engineers to keep records in regards to materials, (B), number of workers needed and the (C) of work expected daily for update of the guideline.

A: B: C:

1.materials 2. equipment 3.manpower 4. methods

5.quality 6.productivity 7. engineers 8.cost

Maintenance Expert Program
Road Maintenance

Writing Test
(with Answer)

NAME:

ORGANIZATION:

Q1: Why is Road Maintenance important?

Mark ○ on the number of the correct answer

1. To prolong the life of a road by countering the effects of deterioration
2. To preserve the value of the previous investments and the road asset
3. To Reduce Vehicle Operating Costs (VOC) by providing a smooth running surface.
4. To Preserve the benefits provided by the original roads by providing reliable access and travel times for people to access healthcare, employment and educational opportunities.

Q2: What is the purpose of New Guideline for Repairing Defects of Road ?

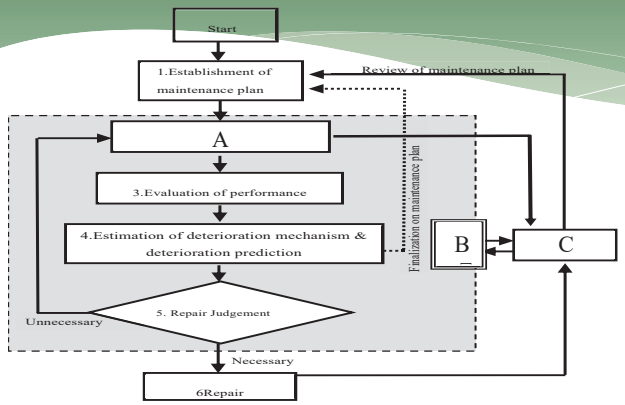
* The purpose of this guideline is to present standard practical methods for paved and unpaved road repair to the (A) of Cambodia. From past experiences, various methods and materials had been adopted by (A) which lead to diverse result that has different effect on (B) of road, quality of the ride for the commuters and the (C) of repairing.

* This guideline for road repair will provide road engineers with an (D) instruction on repairing various job code. With the pocket format will allow engineers to be able to carry around and consult on site. It is a (E) reference should there be necessary.

A: 5 B: 6 C: 2 D: 3 E : 11

1.JICA 2. cost 3. easy and clear 4. thing 5. DPWT 6. lifetime 7. size 8.person 9. slow and unclear 10.complicated 11. quick

Q3:Process of Maintenance



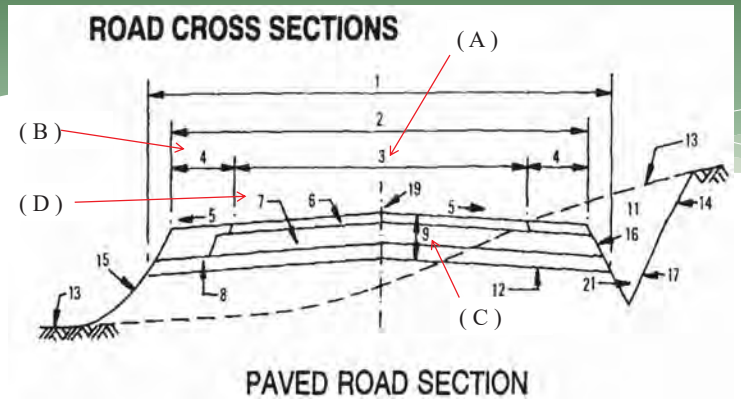
A: 1

B: 5

C: 3

1.Inspection 2. Repair works 3. Record
4. Testing 5. Diagnosis 6. Action

Q4: Road member terms



A: 3

B: 4

C: 9

D: 7

1. Subgrade 2. Roadway 3. Carriageway 4. Shoulder 5.Camber/Crossfall
6. Surfacing 7. Road base 8.Sub-Base 9. Pavement 10.Embankment
11.Cutting 12.Subgrade Surface 13.Original Ground Level
14.Cutting Slope 15.Embankment Slope 16.Ditch Inside Slope
17.Ditch out side Slope 18.V-Ditch 19.Road Centerline

Q5: Road Maintenance Cost

* 1) Road Maintenance Cost on Carriage Way in 2015 occupy around (A) % of all cost.
  1.50 2. 75 3. 85
  2) Most highest cost is Job Code number (B) in 2015. 1. 1100 2.1131 3.1161
  3) What province did have the biggest budget for road maintenance ? (C)
  1. Kandal 2. Pursat 3. Kampong Cham

A : 3 B : 2 C : 2

Q6: Existing Guideline of Road Maintenance

* MPWT has 4 guidelines
  - Guideline for Repairing (A) of Road
  - Guideline for Regular Inspection
  - Guideline for Supervision of Routine Maintenance
  - Guideline for Supervision of Periodic Maintenance
* Established in (B)
* Arranged in paragraph type, not (C)
* Manual only for cracks and potholes
* Procedure in repairing not (C) enough
* Guideline is not handy to be carried around

A : 2 B: 4 C : 8

1. Routine 2. Defects 3. 2000 4. 2008 5. 2010
6. easy 7. outline 8. specific 9.difficult

Q7 : Definition of Maintenance

A : To comprise small-scale works conducted regularly, aims "to ensure the daily passability and safety of existing roads in the short-run and to prevent premature deterioration of the roads". (1)

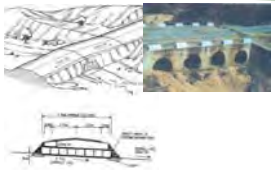
B : To be immediately undertaken for repairs that cannot be foreseen but require immediate attention, such as collapsed culverts or landslides that block a road. (3)

C : To cover activities on a section of road at regular and relatively long intervals, aim "to preserve the structural integrity of the road". These operations tend to be large scale, requiring specialized equipment and skilled personnel. (2)

1. Routine Maintenance 2. Periodic Maintenance
3. Emergency Maintenance

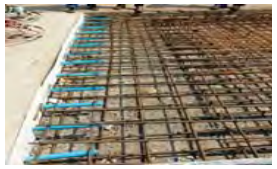
Q8: Type of Job Code

Which number of Job Code is according to Sample Photo of Damage?

Damage Photo	Job Code	Damage Photo	Job Code
	4200		3100
	1100 1101 1161 1162 1163 1164		1150

Q8: Type of Job Code

Which number of Job Code is according to Sample Photo of Damage?

Damage Photo	Job Code	Damage Photo	Job Code
	1140		1180
	4700		1131 1132

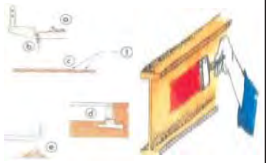
Q8: Type of Job Code

Which number of Job Code is according to Sample Photo of Damage?

Damage Photo	Job Code	Damage Photo	Job Code
	7200		5230 5250
 	4150		5100

Q8: Type of Damage

Which number of Job Code is according to Sample Photo of Damage?

Damage Photo	Job Code	Damage Photo	Job Code
	4800		3200
	2100		1200 1201 1250 1260

Q9 : Method of Utilization of Guideline

This guideline handbook includes minimum requirement of study (A), inspections, material sources and technical specifications. It is also important to remind the engineers to keep records in regards to materials, (B), number of workers needed and the (C) of work expected daily for update of the guideline.

A: 4 B: 2 C: 6

1.materials 2. equipment 3.manpower 4. methods

5.quality 6.productivity 7. engineers 8.cost