Attachment 4
Standard Repair Cost and Standard Unit Rate of Bridge Member Repair

Table of Contents

List of Tables

List of Figures

1. Basic Concept of Standard Repair Cost

The purpose of using Standard repair cost is to roughly estimate the scale of repair cost for the bridges which the RDA maintain and operate

Standard repair cost is determined by Health Index; however the type of damage varies even though the Heath Index is same. Therefore it is necessary to recognize the existence of the difference between standard and actual repair cost.

Besides, the necessity of repairs is decided not only by the periodic inspection results but also on the total repair cost estimated by SUR which indicates total repair cost for all bridges regardless of Heath Index, and do not indicate planned actual total repair cost.

2. Method to Calculate Standard Repair Cost

Standard Unit Rate is determined by Heath Index, and standard repair cost is calculated based on Standard Unit Rate, Length of bridge (Span length) and width of bridge.

The method of calculation for standard repair cost for each member is shown below.

2.1 Surface

(1) Pavement

Standard repair cost＝

Heath Index／100 × Span Length × Width of bridge × Unit rate of repair work

【Unit rate of repair work】

Health Index	Unit rate（Rs / m^2）	NOTE
0～100	400	Refer Page 63

(2) Expansion Joint

Standard repair cost＝

Heath Index／100 × Width of bridge × Unit rate of repair work

【Unit rate of repair work】

Health Index	Unit rate（Rs / m）	NOTE
0～100	6,500	Refer Page 63

(3) Accessories

Standard repair cost＝

Heath Index／100 × Span Length × Unit rate of repair work

【Unit rate of repair work】

Health Index	Unit rate（Rs / m）	NOTE
0～100	3,500	Refer Page 63

(4) Approaches

Standard repair cost＝

Heath Index／100 × Width of bridge × Unit rate of repair work

【Unit rate of repair work】

Health Index	Unit rate（Rs / m）	NOTE
0～100	6,200	Refer Page 63

2.2 Superstructure

(1) RC-S

1) Deck Slab

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	31,300	Refer Page 11
30	20,800	”
90	900	”
100	0	”

(2) PSC-PRE

1) Main Beam

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	22,800	Refer Page 15
30	15,400	”
70	1,700	”
90	300	”
100	0	”

(3) PSC-POS, RCS-RCB

1) Main Beam

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	24,300	Refer Page 20
30	16,200	”
90	300	”
100	0	”

2) Deck Slab

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	29,000	Refer Page 23
30	20,700	”
90	1,500	”
100	0	”

3) Diaphragm

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	13,100	Refer Page 26
30	9,400	”
90	300	”
100	0	”

(4) Box Bridge

1) Deck Slab

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	23,800	Refer Page 30
30	12,700	”
90	1,100	”
100	0	”

(5) Truss Bridge

1) Main Beam

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	23,800	Refer Page 34
50	1,500	”
100	0	”

2) Deck Slab

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	6,000	Refer Page 35
100	0	”

3) Cross Beam

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	21,600	Refer Page 38
50	1,900	”
100	0	”

(6) Steel Bridge

1) Main Beam

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	20,500	Refer Page 42
50	3,300	”
100	0	”

2) Deck Slab

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	6,000	Refer Page 43
100	0	”

3) Cross Beam

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	15,300	Refer Page 46
50	1,900	”
100	0	”

(7) Arch Bridge

1) Arch Rib

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	14,800	Refer Page 50
1	6,800	”
100	0	”

2) Spandrel

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	12,100	Refer Page 53
1	6,800	”
100	0	”

2.3 Bridge Bearing

Standard repair cost＝

Health Index／100 × Width of bridge × Unit rate of repair work

【Unit rate of repair work】

Health Index	Unit rate (Rs / m)	NOTE
0～100	132,700	Refer Page 60

2.4 Substructure

Standard repair cost＝

Span Length × Width of bridge × Unit rate of repair work corresponding to HI

【Unit rate of repair work】

Health Index	Unit rate (Rs / m^2)	NOTE
0	35,600	Refer Page 57
30	25,700	”
90	1,700	”
100	0	”

3. Basis of Setting Standard Repair Cost

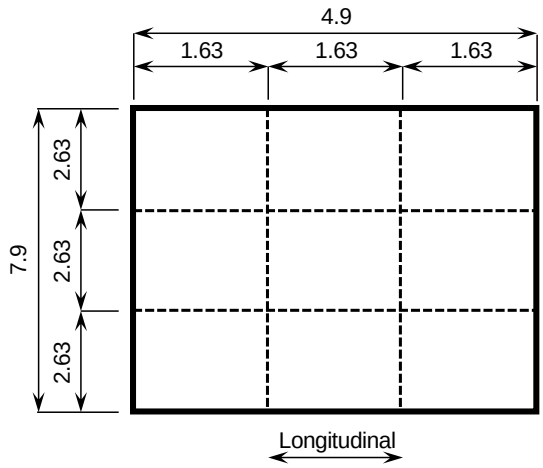
3.1 Super Structure

3.1.1. Structure type: RC-S

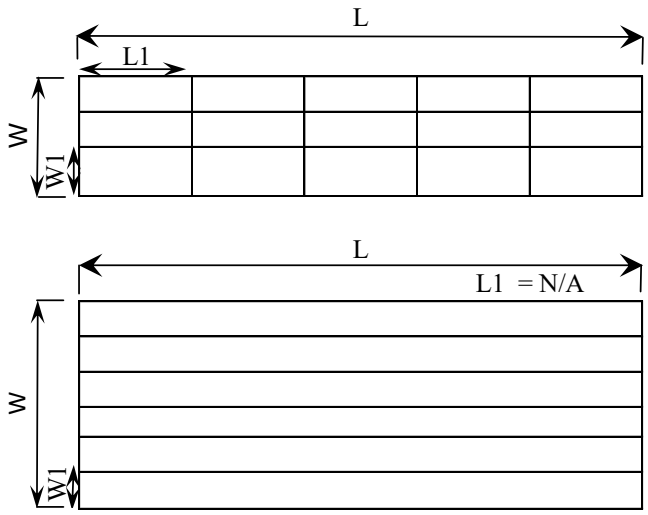
(1) Sample Bridge to be applied for unit rate

Following bridge is used for cost estimation for repair work.

Table 3.1.1.1 Basic information of bridge

Basic Information	Photos
Route No : B324 Bridge No : No.10/4 Length of bridge (L) : 4.9m L1 = 1.63 Width of bridge (W) : 7.9m W1 = 2.63	
Plane view	
 ※ 9 elements in horizontal plane	

These figures are used for all the structure types



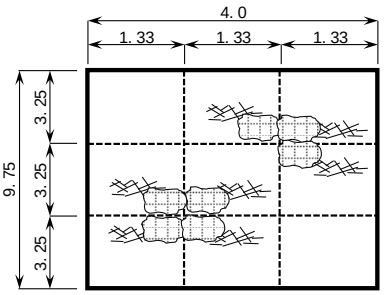
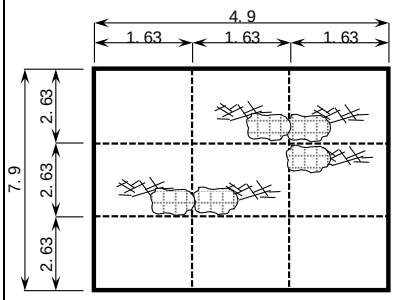
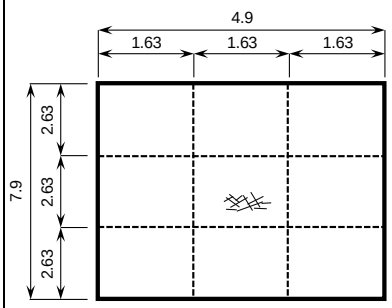
(2) Assumed Health Index and Degree of Damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in following table.

Degree of damage between the border lines shall be calculated by linear interpolation

Table 3.1.1.2 Assumed Degree of Damage at Each HI

HI	Degree of damage	Outline figure
HI=0	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 7 elements. ※Average of Spalling / Delamination / Ex-rebar exist in 30% area of one element and the depth of damage is 80mm based on inspection result. ※Cracks penetrate the element onto transversal direction.	
HI=30	Spalling / Delamination / Ex-rebar (e grade) and cracks (e grade) generate at 5 elements.	
HI=90	Crack (e grade) generates in one element.	

NOTE

 Spalling / Delamination / Ex-rebar

 Crack

(3) Quantity Calculation for Repair Work

Quantities of repair work as at the border line (HI = 0, 30, 90) condition are shown in the following Table.

Table 3.1.1.3 Quantity of Repair Work at Each HI

HI	Type of damage	Quantity of repair work	
HI=0	Spalling / Delamination / Ex-rebar	2.63 (L1) × 1.63 (W1) × 0.08 (Depth) × 30 % × 7 nos	0.7m^3
	Crack	2.63 × 7 nos	18.1m
HI=30	Spalling / Delamination / Ex-rebar	2.63 (L1) × 1.63 (W1) × 0.06 (Depth) × 30 % × 5 nos	0.4m^3
	Crack	2.63(L1)×5 nos	12.9m
HI=90	Crack	2.63(L1)×1 nos	2.6m

(4) Cost Estimation of Repair Work as at Each HI Condition

The repair cost on border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5 using same unit rates

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.1.4 Cost for repair work at border line of HI (=0, 30, 90)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Spalling / Delamination / Ex-rebar	Grouting	347,900	Rs	No.Co-32
	Crack	Crack Injection	162,900	Rs	No.Co-10
	—	CFRS bonding (Strengthening)	677,600		No.Co-50
	Total cost		1,188,400	Rs	
	Unit rate per m^2		31,300	Rs/m^2	
HI=30	Spalling / Delamination / Ex-rebar	Grouting	186,800	Rs	No.Co-33
	Crack	Crack Injection	116,100	Rs	No.Co-9
		CFRS bonding (Strengthening)	485,100		No.Co-51
	Total cost		788,000	Rs	
	Unit rate per m^2		20,800	Rs/m^2	
HI=90	Crack	Crack Injection	33,400	Rs	No.Co-8
	Unit rate per m^2		900	Rs/m^2	

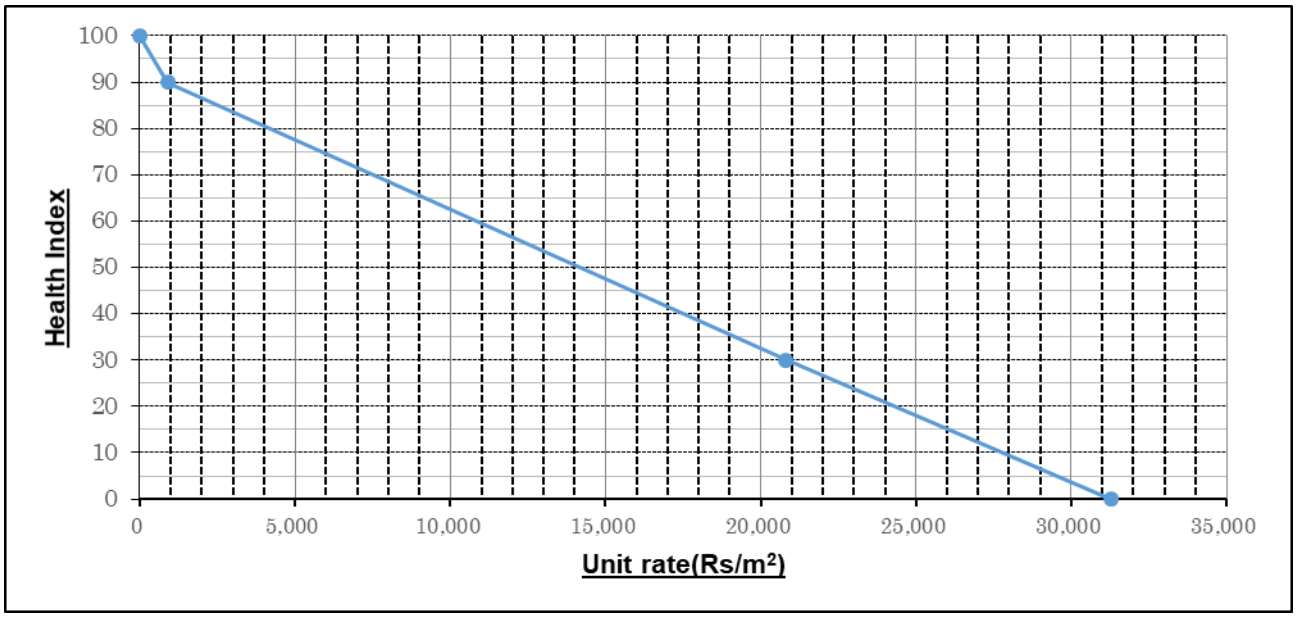


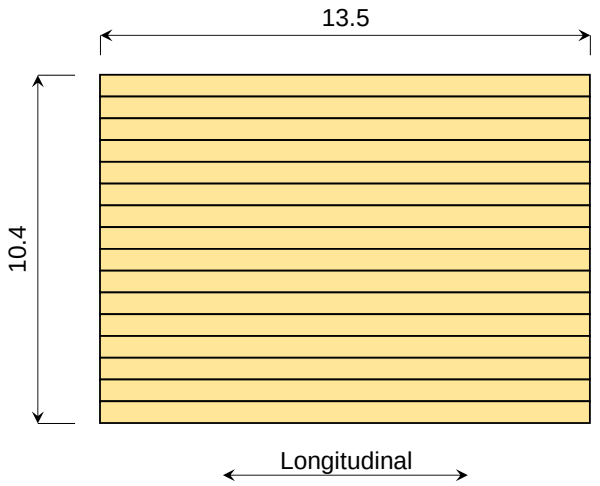
Figure 3.1.1.1 Relation between HI and unit rate

3.1.2 Super Structure type: PSC-PRE

(1) Sample Bridge to be applied for Unit Rate

Following bridge is used for cost estimation for repair work.

Table 3.1.2.1 Basic Information of Bridge

Basic Information	Photos
Route No : A004 Bridge No : No.42/1 Length of bridge (L) : 13.5m L1 = N/A Width of bridge (W) : 10.4m W1 = 0.65	
Plane View	
 ※ 16 elements in horizontal plane	

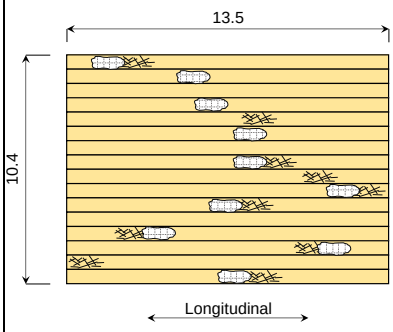
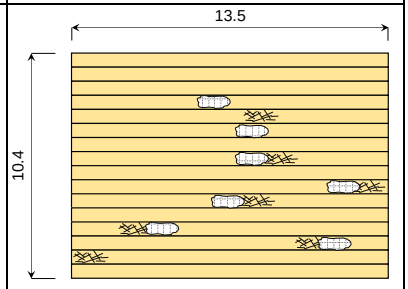
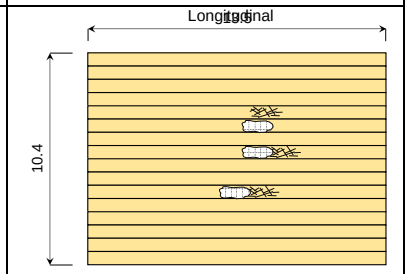
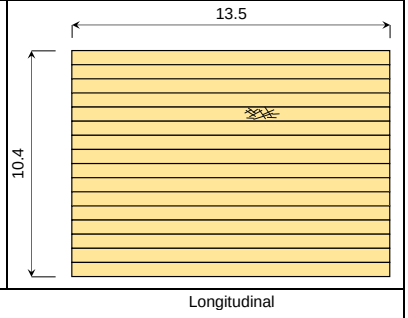
(2) Assumed Health Index and Degree of Damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in the following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.2.2. Assumed Degree of Damage at Each HI

HI	Degree of damage	Outline figure
HI=0	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 60% of total elements. ※PSC-PRE bridges in Sri Lanka do not have serious conditions equivalent to "HI=0". Therefore, it is assumed that degree of damage of PSC-PRE is same as RC-S. ※Cracks penetrate the element to transversal direction.	
HI=30	Spalling / Delamination / Ex-rebar (e grade) and cracks (e grade) generate on 40% of total elements.	
HI=70	Spalling / Delamination / Ex-rebar (e grade) and cracks (e grade) generate on 20% of total elements.	
HI=90	Cracks (e grade) generate in one element.	

NOTE

Spalling / Delamination / Ex-rebar, Crack

(3) Quantity Calculation for Repair Work

Quantities of repair work as at the border line (HI = 0, 30, 70, 90) condition are shown in the following table.

Table 3.1.2.3 Quantity of Repair Work at Each HI

HI	Type of damage	Quantity of repair work	
HI=0	Spalling / Delamination / Ex-rebar	13.5 (L) × 0.65 (W1) × 0.80 (Depth) × 30 % × 10 nos	2.1m^3
	Crack	0.65 × 10 nos	6.5m
HI=30	Spalling / Delamination / Ex-rebar	13.5 (L) × 0.65 (W1) × 0.06 (Depth) × 30 %× 7 nos	1.1m^3
	Crack	0.65×6 nos	3.9m
HI=70	Spalling / Delamination / Ex-rebar	13.5 (L) × 0.65 (W1) × 0.02 (Depth) × 30 %×3 nos	0.2m^3
	Crack	0.65(W1)×3 nos	2.0m
HI=90	Crack	0.65(W1)×1 nos	0.7m

(4) Cost Estimation of Repair Work as at Each HI Condition

The repair cost as at border line of Health Index (HI=0, 30, 70, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5 mentioned which unit rate was used.)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate is applied for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure carried out by internal processing in BMS system.

Table 3.1.2.4 Cost for repair work as at border line of HI (=0, 30, 70, 90)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Spalling / Delamination / Ex-rebar	Grouting	1,110,200	Rs	No.Co-36
	Crack	Crack Injection	58,500	Rs	No.Co-17
		CFRS bonding (Strengthening)	2,025,100	Rs	No.Co-48
	Total cost		3,193,800	Rs	
	Unit rate per m^2		22,800	Rs/m^2	
HI=30	Spalling / Delamination / Ex-rebar	Grouting	705,700	Rs	No.Co-37
	Crack	Crack Injection	35,100	Rs	No.Co-16
		CFRS bonding (Strengthening)	1,416,800	Rs	No.Co-49
	Total cost		2,157,600	Rs	
	Unit rate per m^2		15,400	Rs/m^2	
HI=70	Spalling / Delamination / Ex-rebar	Plastering	217,200	Rs	No.Co-3
	Crack	Crack Injection	18,000	Rs	No.Co-15
	Total cost		235,200	Rs	
	Unit rate per m^2		1,700	Rs/m^2	
HI=90	Crack	Crack Injection	28,800	Rs	No.Co-14
	Unit rate per m^2		300	Rs/m^2	

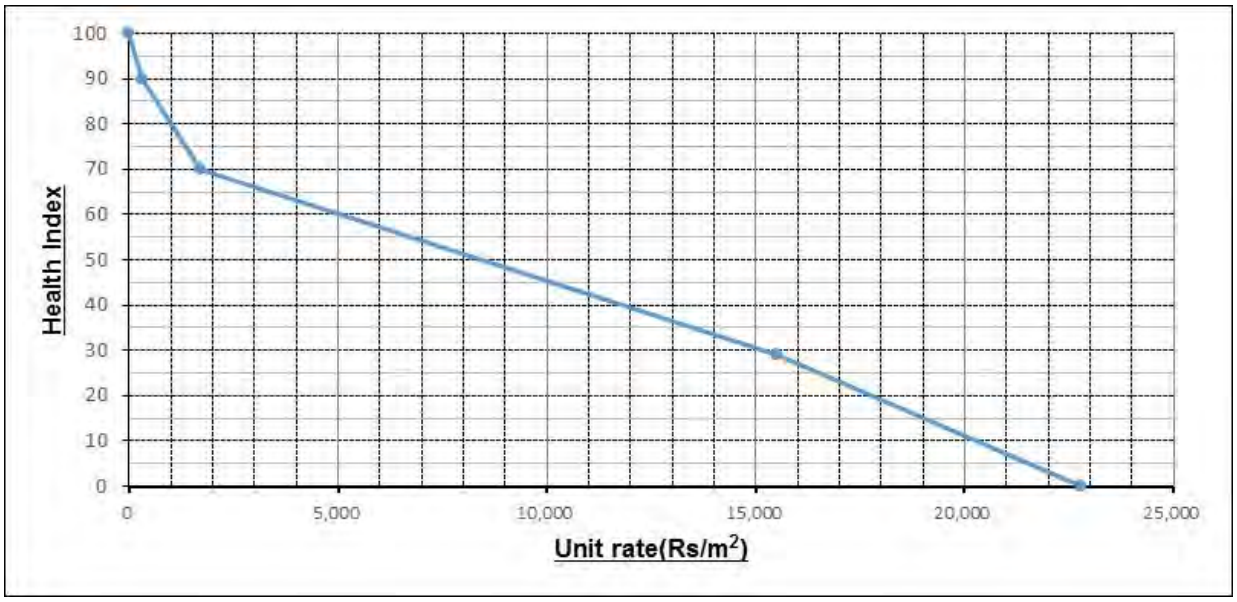


Figure 3.1.2.1 Relation between HI and unit rate

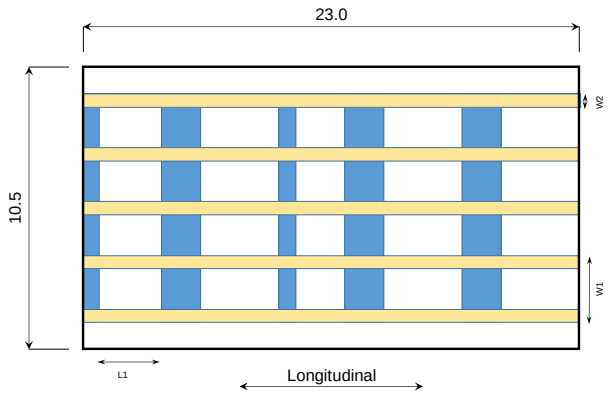
3.1.3 Structure Type –PSC-POS, RCS-RCB,

(1) Main Beam

1) Sample Bridge to be used for Repair Work

Following Bridge is used for Cost Estimation for Repair Work.

Table 3.1.3.1 Basic Information of Bridge

Basic Information				Photos
Route No	:	AA026		
Bridge No	:	No.5/1		
Length of bridge (L)	:	23.0m	L1 = 4.64	
Width of bridge (W)	:	10.5m	W1 = 2.1	
Plane view				
 ※ 25elements in horizontal plane				

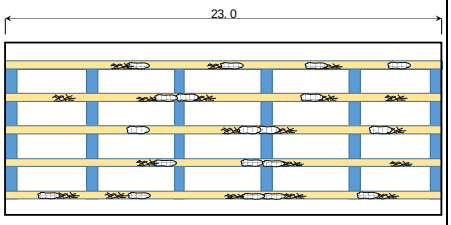
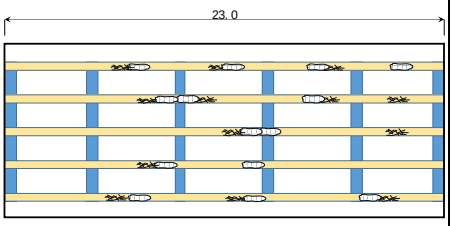
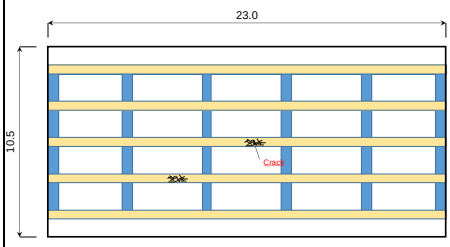
2) Assumed Health Index and Degree of Damage

Repair method shall be selected based on the extent of area damaged and depth of the damage.

Border line of HI at which repair method shall be changed is shown in the following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.3.2 Assumed Degree of Damage at Each HI

HI	Degree of damage	Outline figure
HI=0	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 80% of total elements. ※PSC-POS, RCS-RCB bridges in Sri Lanka do not have serious conditions equivalent to "HI=0". Therefore, it is assumed that degree of damage of PSC-POS, RCS-RCB is same as RC-S. ※Cracks penetrate the element to transversal direction.	
HI=30	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 55% of total element.	
HI=90	Crack (e grade) generates two elements (Ratio: 8%).	
NOTE Spalling / Delamination / Ex-rebar, Crack		

3) Quantity Calculation of Repair Work

Quantities of repair work as at the border line (HI = 0, 30, 90) condition are shown in the following table.

Table 3.1.3.3 Quantity of Repair Work at Each HI

HI	Type of damage	Quantity of repair work	
HI=0	Spalling / Delamination / Ex-rebar	4.64 (L1) × 0.4 (W2) × 0.08 (Depth) × 30 % × 19 nos	0.8m^3
	Crack	0.40 × 19 nos	7.6m
HI=30	Spalling / Delamination / Ex-rebar	4.64 (L1) × 0.4 (W2) × 0.06 (Depth) × 30 %×14 nos	0.5m^3
	Crack	0.40 (W2)×13 nos	5.2m
HI=90	Crack	0.40 (W2)×2 nos	0.8m

4) Cost Estimation of Repair Work as at Each HI Condition

The repair costs as at border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5, using same unit rates.)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.3.4 Cost for repair work at border line of HI (=0, 30, 90)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Spalling / Delamination / Ex-rebar	Grouting	899,600	Rs	No.Co-39
	Crack	Crack Injection	64,800	Rs	No.Co-20
	—	CFRS bonding (Strengthening)	4,889,500	Rs	No.Co-52
	Total cost		5,857,500	Rs	
	Unit rate per m^2		24,300	Rs/m^2	
HI=30	Spalling / Delamination / Ex-rebar	Grouting	241,000	Rs	No.Co-40
	Crack	Crack Injection	46,800	Rs	No.Co-19
		CFRS bonding (Strengthening)	3,603,600		No.Co-53
	Total cost		3,891,400	Rs	
	Unit rate per m^2		16,200	Rs/m^2	
HI=90	Crack	Crack Injection	67,200	Rs	No.Co-18
	Unit rate per m^2		300	Rs/m^2	

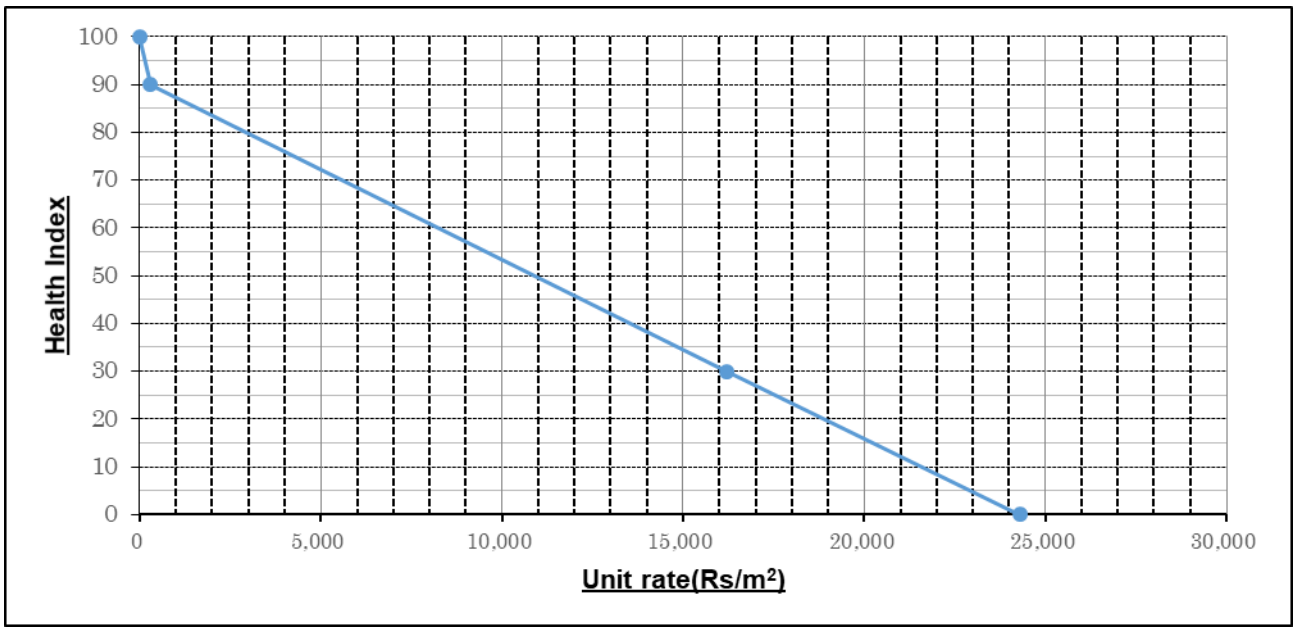


Figure 3.1.3.1 Relation between HI and unit rate

(2) Deck Slab

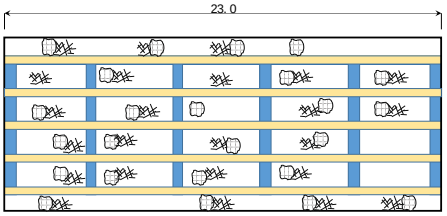
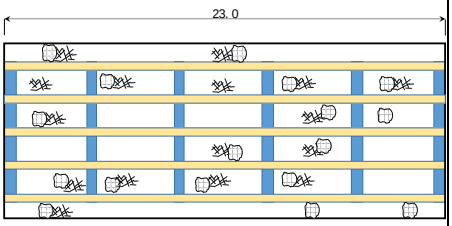
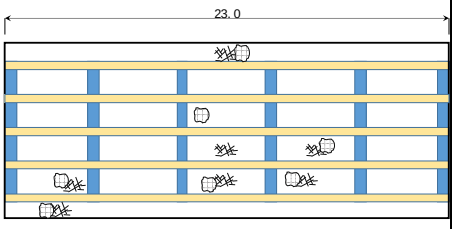
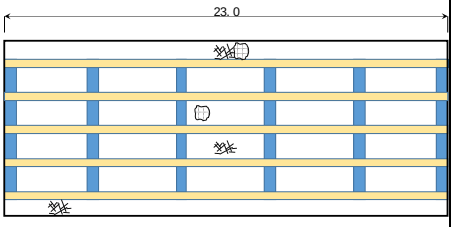
1) Assumed Health Index

Repair method shall be selected based on extent of area damaged and depth of damage.

Border line of HI on which repair method shall be changed is shown in the Following Table.

Degree of damage between the border lines shall be calculated by linear interpolation

Table.3.1.3.5 Assumed Degree of Damage at HI=0, 30, 70, 90

HI	Degree of damage	Outline figure
HI=0	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 80% of total elements. ※PSC-POS, RCS-RCB bridges in Sri Lanka do not have serious conditions equivalent to "HI=0". Therefore, it is assumed that degree of damage of PSC-POS, RCS-RCB same as RC-S. ※Crack penetrates the element to transversal direction.	
HI=30	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 55% of total elements.	
HI=70	Spalling / Delamination / Ex-rebar (e grade) spandrel and crack (e grade) generate at 25% of total elements.	
HI=90	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 10% of total elements.	

NOTE

Spalling / Delamination / Ex-rebar, Crack

2) Quantity Calculation for Repair Work

Quantities of repair work on the border line (HI = 0, 70, 90) condition are shown in the following Table.

Table 3.1.3.6 Quantity of Repair Work at HI=0, 30, 70, 90

HI	Type of damage	Quantity of repair work	
HI=0	Spalling / Delamination / Ex-rebar	8.05 (W/6+L/5) × 0.08 (Depth) × 30 % × 24 nos	4.6m^3
	Crack	1.75(W/6) × 24 nos	42.0m
HI=30	Spalling / Delamination / Ex-rebar	8.05 (W/6+L/5) × 0.06 (Depth) × 30 % × 17 nos	2.5m^3
	Crack	1.75(W/6) × 16 nos	28.0m
HI=90	Spalling / Delamination / Ex-rebar	8.05 (W/6+L/5) × 0.01 (Depth) × 30 %×2 nos	0.1m^3
	Crack	1.75(W/6)×3 nos	5.3m

3) Cost Estimation of Repair Work as at Each HI Condition

The repair cost on the border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5 using same unit rates.)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.3.7 Cost for repair work at border line of HI (=0, 30, 70, 90)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Spalling / Delamination / Ex-rebar	Grouting	2,147,700	Rs	No.Co-41
	Crack	Crack Injection	378,000	Rs	No.Co-26
	—	CFRS bonding (Strengthening)	4,466,000	Rs	No.Co-54
	Total cost		6,991,700	Rs	
	Unit rate per m^2		29,000	Rs/m^2	
HI=30	Spalling / Delamination / Ex-rebar	Grouting	1,570,000	Rs	No.Co-43
	Crack	Crack Injection	252,000	Rs	No.Co-25
		CFRS bonding (Strengthening)	3,164,700	Rs	No.Co-55
	Total cost		4,986,700	Rs	
	Unit rate per m^2		20,700	Rs/m^2	
HI=90	Spalling / Delamination / Ex-rebar	Plastering	303,700	Rs	No.Co-5
	Crack	Crack Injection	47,700	Rs	No.Co-24
	Total cost		351,400	Rs	
	Unit rate per m^2		1,500	Rs/m^2	

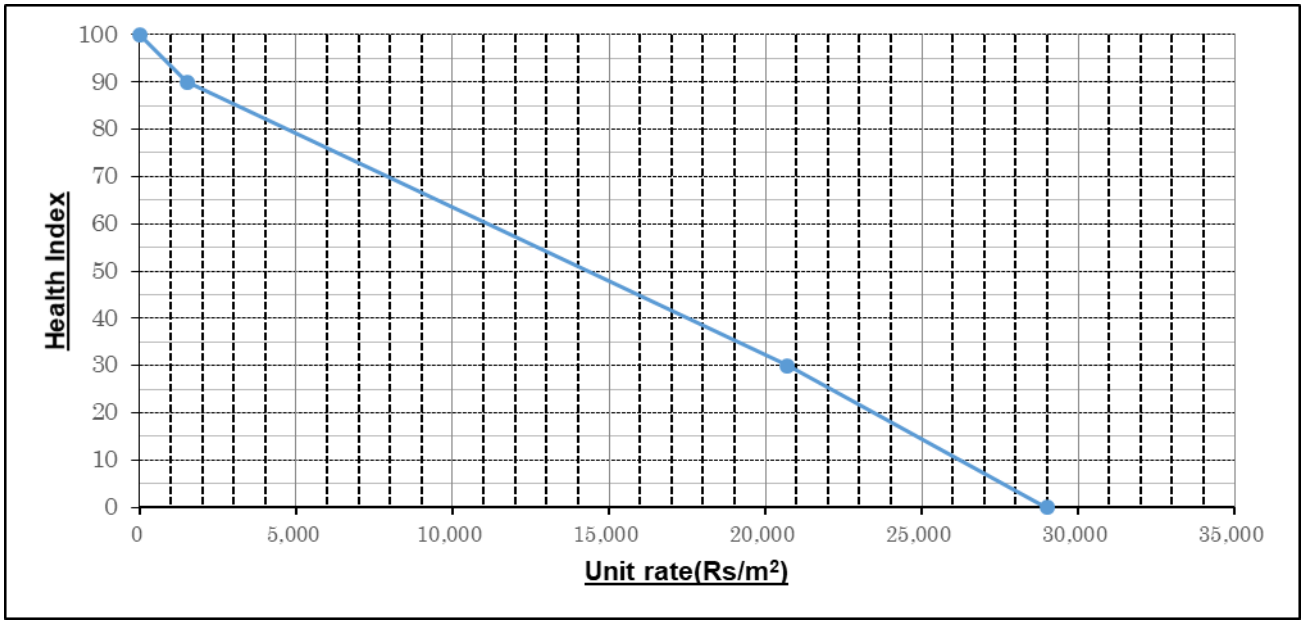


Figure 3.1.3.2 Relation between HI and unit rate

(3) Diaphragm

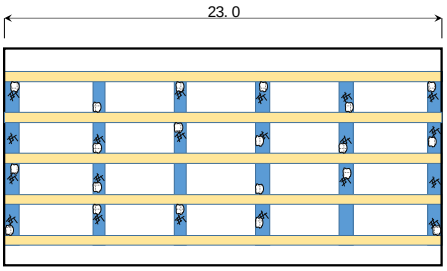
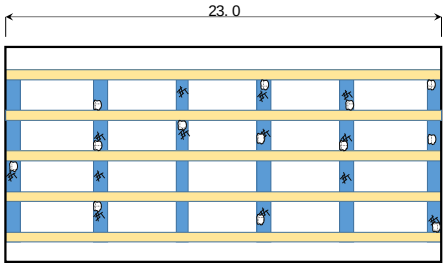
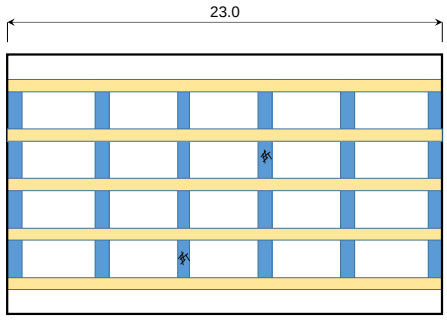
1) Assumed Health Index and Degree of Damage

The repair method shall be selected based on the extent of area damaged and depth of the damage.

Border line of HI on which repair method shall be changed is shown in the following Table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.3.8 Assumed Degree of Damage at HI=0, 30, 90

HI	Degree of damage	Outline figure
HI=0	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 80% of total elements. ※PSC-POS, RCS-RCB bridges in Sri Lanka do not have serious conditions equivalent to "HI=0". Therefore, it is assumed that degree of damage of PSC-POS, RCS-RCB is same as RC-S. ※Crack penetrate the element to transversal direction.	
HI=30	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 55% of total elements.	
HI=90	Crack (e grade) generates 10% of total elements.	

NOTE

Spalling / Delamination / Ex-rebar, Crack

(2) Quantity Calculation for Repair Work

Quantities of repair work as at the border line (HI = 0, 30, 90) condition are shown in following table.

Table 3.1.3.9 Quantity of Repair Work at HI=0, 30, 90

HI	Type of damage	Quantity of repair work	
HI=0	Spalling / Delamination / Ex-rebar	2.1 (W1) × 0.4 (W2) ×0.08 (Depth) × 30 % × 20 nos	0.4m^3
	Crack	0.4 (W2) × 20 nos	8.0m
HI=30	Spalling / Delamination / Ex-rebar	2.1 (W1) × 0.4 (W2) ×0.06 (Depth) × 30 %×13 nos	0.2m^3
	Crack	0.4(W2)×13 nos	5.2m
HI=90	Crack	0.4(W2)×2 nos	0.8m

3) Cost Estimation of Repair Work as at Each HI Condition

The repair cost as at border line of Health Index (HI=0, 30, 90) condition is calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system

Table 3.1.3.10 Cost for repair work at border line of HI (=0, 30, 90)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Spalling / Delamination / Ex-rebar	Grouting	754,800	Rs	No.Co-44
	Crack	Crack Injection	72,000	Rs	No.Co-23
	—	CFRS bonding (Strengthening)	2,325,400	Rs	No.Co-56
	Total cost		3,152,200	Rs	
	Unit rate per m^2		13,100	Rs/m^2	
HI=30	Spalling / Delamination / Ex-rebar	Grouting	682,400	Rs	No.Co-45
	Crack	Crack Injection	46,800	Rs	No.Co-22
		CFRS bonding (Strengthening)	1,516,900	Rs	No.Co-57
	Total cost		2,246,100	Rs	
	Unit rate per m^2		9,400	Rs/m^2	
HI=90	Crack	Crack Injection	67,200	Rs	No.Co-21
	Unit rate per m^2		300	Rs/m^2	

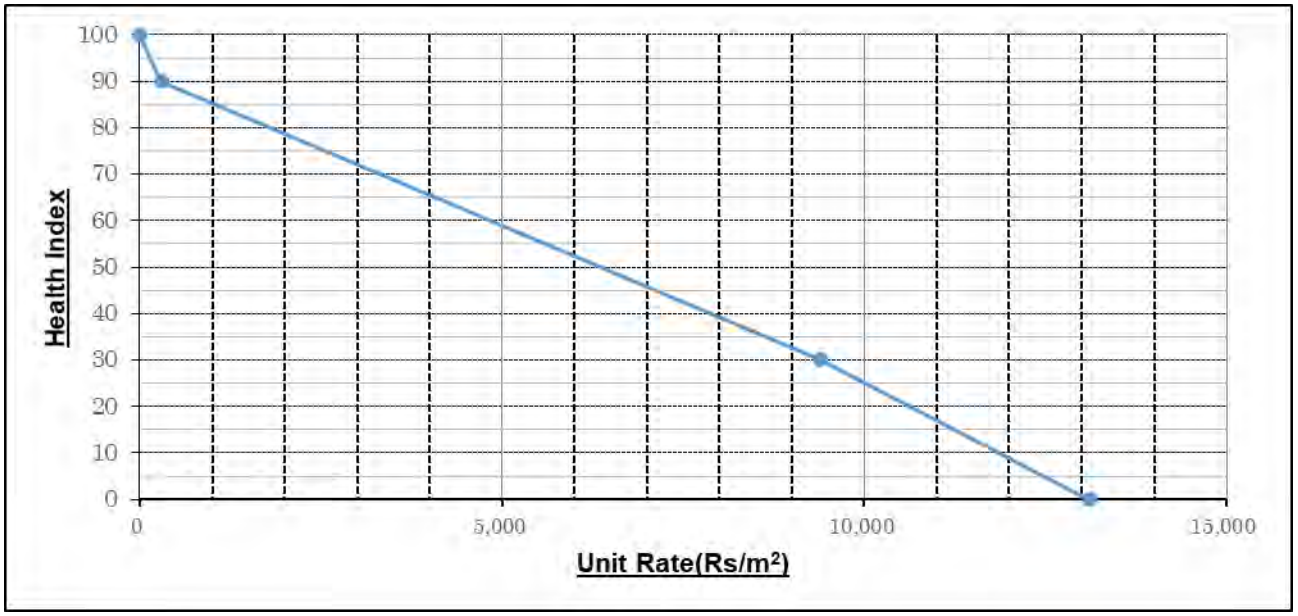


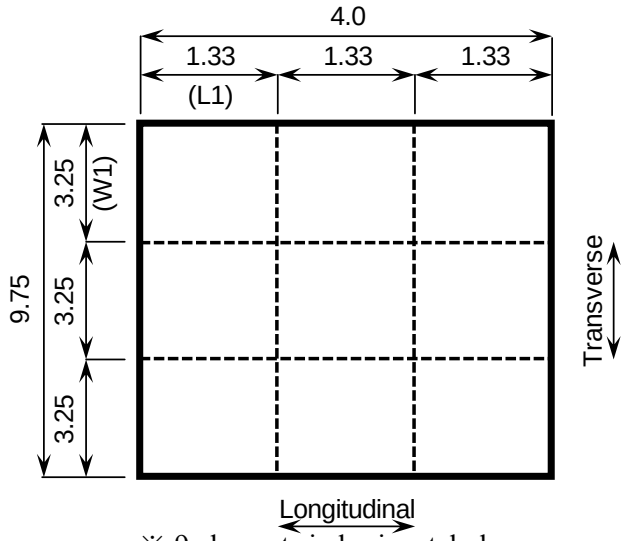
Figure 3.1.3.3 Relation between HI and unit rate

3.1.4 Structure type: Box Bridge

(1) Sample Bridge to be applied for unit rate

Following bridge is used for cost estimation for repair work.

Table 3.1.4.1 Basic information of bridge

Basic Information	Photos
Route No : A158 Bridge No : No.14/3 Length of bridge : 4.0m L1 = 1.33 Width of bridge : 9.75m W1 = 3.25	
Plane view	
 ※ 9 elements in horizontal plane	

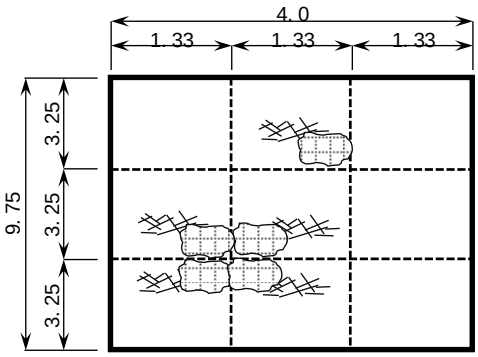
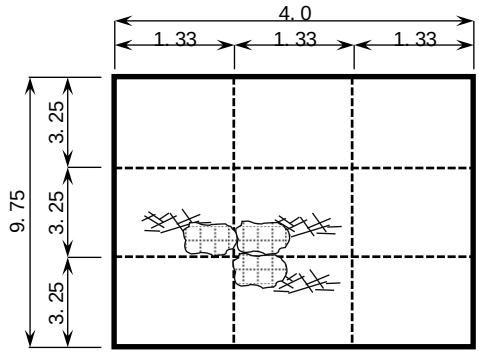
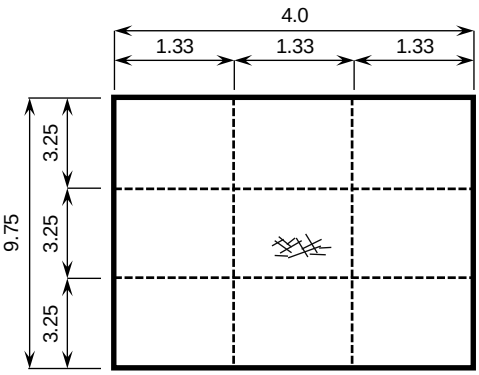
(2) Assumed Health Index and Degree of Damage

Repair method shall be selected based on the extent of area damaged and depth of damage.

Border line of HI on which repair method shall be changed is shown in the following Table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.4.2 Assumed Degree of Damage at Each HI

HI	Degree of damage	Outline figure
HI=0	Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 5 elements. ※Box bridges in Sri Lanka do not have serious conditions equivalent to "HI=0". Therefore, it is assumed that degree of damage of Box bridges is same as RC-S. ※Cracks penetrates the element to transversal direction.	
HI=30	Spalling / Delamination / Ex-rebar (e grade) generates 3 elements and crack (e grade) generates at 3elements.	
HI=90	Crack (e grade) generates in one element.	
NOTE Spalling / Delamination / Ex-rebar, Crack		

Quantities of repair work on the border line (HI = 0, 30, 90) condition are shown in the following Table.

(3) Quantity Calculation for Repair Work

Quantities of repair work as at the border line (HI = 0, 30, 90) condition are shown in the following table.

Table 3.1.4.3 Quantity of repair work at each HI (=0, 30, 90)

HI	Type of damage	Quantity of repair work	
HI=0	Spalling / Delamination / Ex-rebar	3.25 (W1) × 1.33 (L1) × 0.08 (Depth) × 30 % × 5 nos	0.5m^3
	Crack	3.25 (W1) × 5 nos	16.3m
HI=30	Spalling / Delamination / Ex-rebar	3.25 (W1) × 1.33 (L1) × 0.06 (Depth) × 30 % × 3 nos	0.2m^3
	Crack	3.25(W1)×3 nos	9.8m
HI=90	Crack	3.25(W1)×1 nos	3.3m

(4) Cost Estimation of Repair Work as at Each HI Condition

The repair costs on border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5, using same unit rates.)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis (method)

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation of repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.4.4 Cost for repair work at border line of HI (=0, 30, 90)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Spalling / Delamination / Ex-rebar	Grouting	277,800	Rs	No.Co-34
	Crack	Crack Injection	146,700	Rs	No.Co-13
	—	CFRS bonding (Strengthening)	500,500		No.Co-58
	Total cost		925,000	Rs	
	Unit rate per m^2		23,800	Rs/m^2	
HI=30	Spalling / Delamination / Ex-rebar	Grouting	104,700	Rs	No.Co-35
	Crack	Crack Injection	88,200	Rs	No.Co-12
		CFRS bonding (Strengthening)	300,300		No.Co-59
	Total cost		493,200	Rs	
	Unit rate per m^2		12,700	Rs/m^2	
HI=90	Crack	Crack Injection	40,500	Rs	No.Co-11
	Unit rate per m^2		1,100	Rs/m^2	

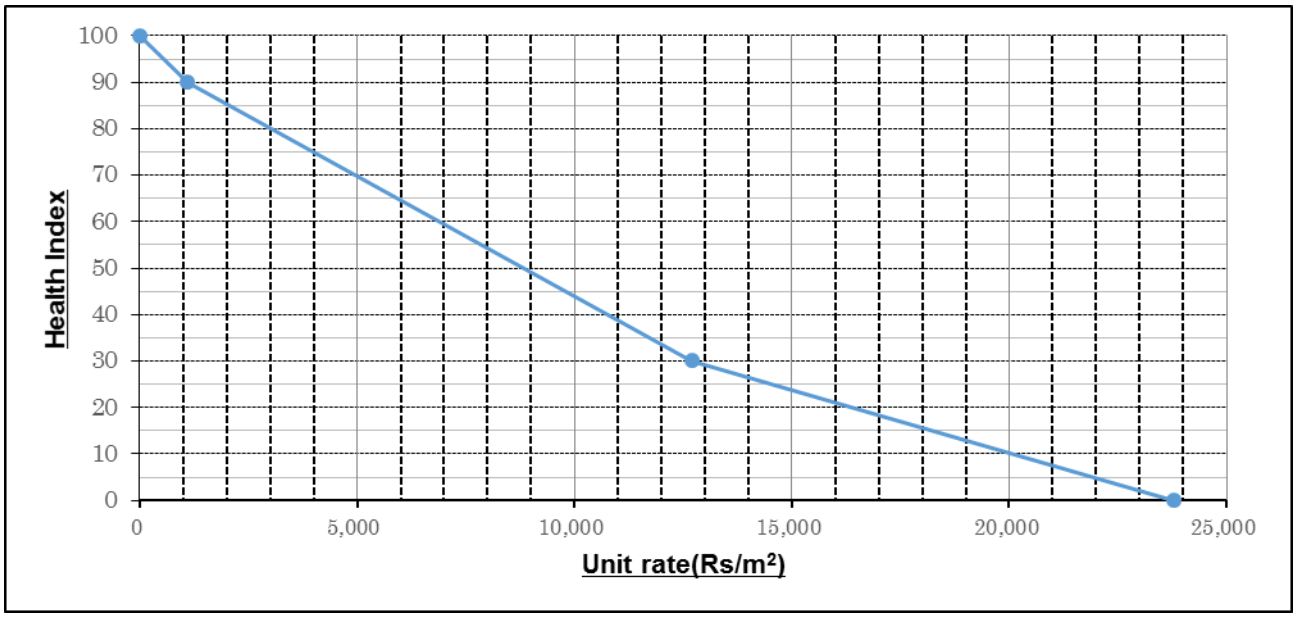


Figure 3.1.4.1 Relation between HI and unit rate

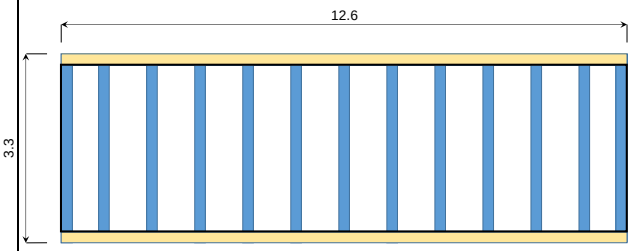
3.1.5 Structure type: Truss Bridge

(1) Main Beam

1). Sample Bridge to be applied for unit rate

Following bridge is used for cost estimation for repair work.

Table 3.1.5.1 Basic information of bridge

Basic Information			Photos
Route No	:	B188	
Bridge No	:	No.5/4	
Length of bridge	:	12.6m (L1)	
Width of bridge	:	3.3m (W1)	
Number of main beam	:	2 nos	
Number of cross beam	:	13nos	
Height of main beam	:	1.5m (H1)	
Height of cross beam	:	0.4m (H2)	
Length of cross beam	:	3.2m (L2)	
Plane view			
 ※ 15elements in horizontal plane			

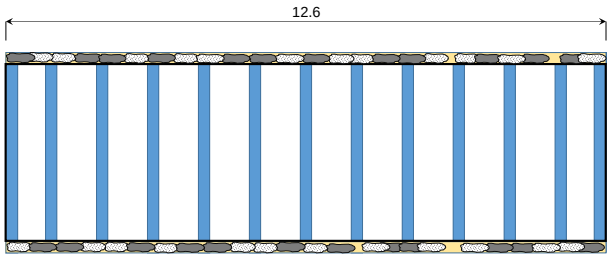
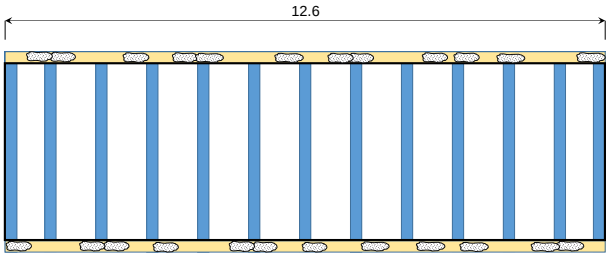
2). Assumed Health Index and Degree of damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.5.2 Assumed degree of damage at each HI (=0, 50)

HI	Degree of damage	Outline figure
HI=0	Paint Degradation (e grade) and Corrosion (e grade) generate at all elements. ※Paint Degradation exists on 50% area in one element. ※Corrosion exists on 50% area in one element.	
HI=50	Paint Degradation (e grade) generate at all elements. ※Paint Degradation exist 50% area in one element.	

NOTE

Paint Degradation

Corrosion

3). Quantity calculation for repair work

Quantities of repair work as at the border line (HI = 0, 50) condition are shown in following table.

Table 3.1.5.3 Quantity of repair work at each HI (=0, 50)

HI	Type of damage	Quantity of repair work	
HI=0	Corrosion	1/2×12.6(L1)×2	12.6m
	Paint Degradation	1.5(H1)×12.6(L1)×2×0.15×2	11.3m^2
HI=50	Paint Degradation	1.5(H1)×12.6(L1)×2×0.15×2	11.3m^2

4). Cost estimation of repair work as at each HI condition

The repair cost as at border line of Health Index (HI=0, 50) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case, the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.5.4 Cost for repair work at border line of HI (=0, 50)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Paint Degradation	Painting	32,800	Rs	No.St-8
	Corrosion	Replacement of member	954,200	Rs	No.St-4
	Total cost		987,000	Rs	
	Unit rate per m^2		23,800	Rs/m^2	
HI=50	Paint Degradation	Painting	59,800	Rs	No.St-7
	Unit rate per m^2		1,500	Rs/m^2	

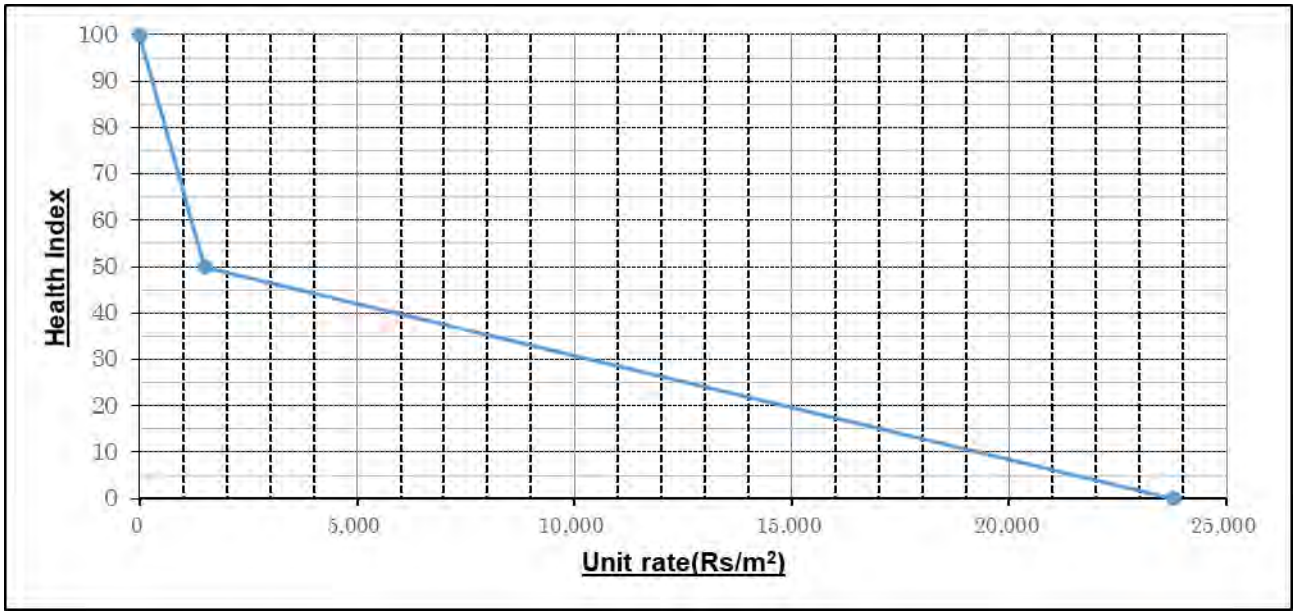


Figure 3.1.5.1 Relation between HI and unit rate

(2) Deck slab

Table 3.1.5.5 Cost for repair work

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement of deck slab		-	Deck slab	-	(NO.De-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Redecking	6,000 Rs/m^2	77.7 m^2	466,200 Rs	Following Maho EE office's cost estimation
Total		*6,000 Rs/m^2*		*466,200 Rs*	

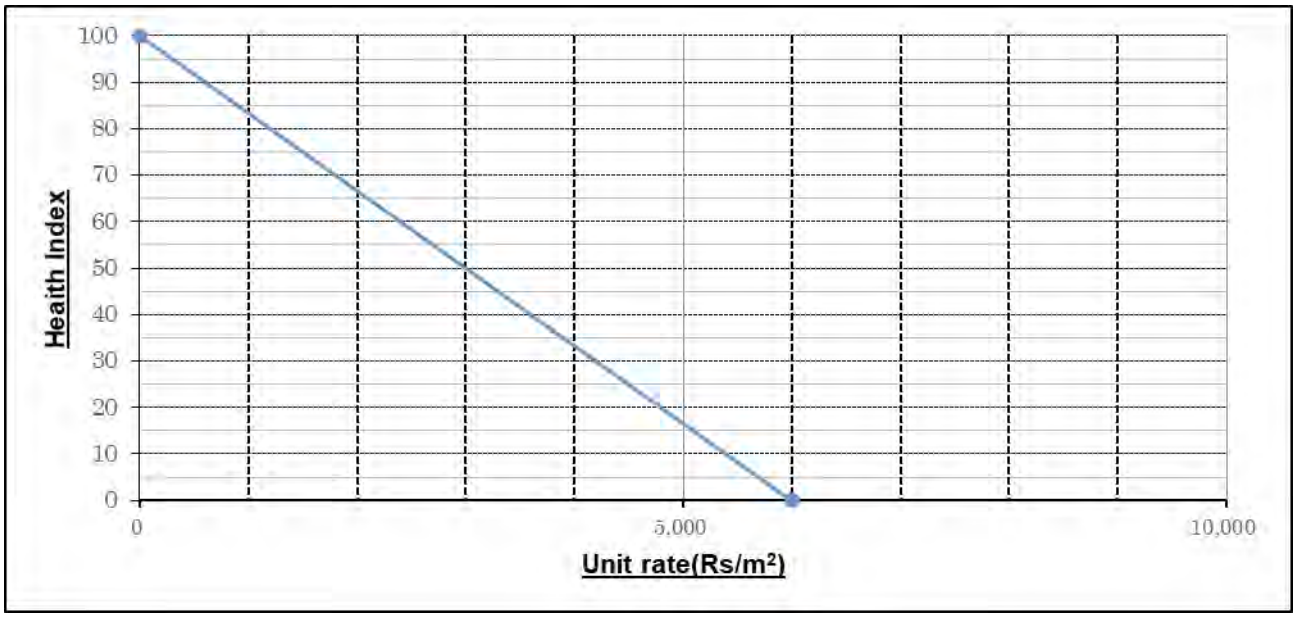


Figure 3.1.5.2 Relation between HI and unit rate

(3) Cross Beam

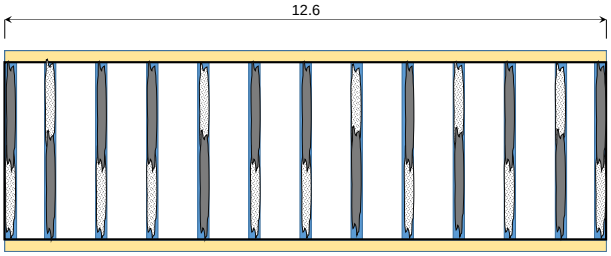
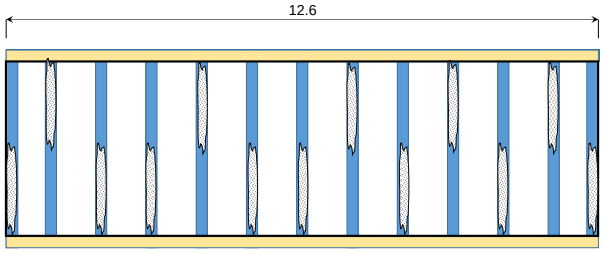
1). Assumed Health Index and Degree of damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.5.6 Assumed degree of damage at each HI

HI	Degree of damage	Outline figure
HI=0	Paint Degradation (e grade) and Corrosion (e grade) generate at all elements. ※Paint Degradation exists on 50% area in one element. ※Corrosion exists on 50% area in one element.	
HI=50	Paint Degradation (e grade) generated at all elements. ※Paint Degradation exists on 50% area in one element.	

NOTE

Paint Degradation

Corrosion

2). Quantity calculation for repair work

Quantities of repair work as at the border line (HI = 0, 50) condition are shown in following table.

Table 3.1.5.7 Quantity of repair work at each HI (=0, 50)

HI	Type of damage	Quantity of repair work	
HI=0	Corrosion	13×3.3(W1)／2	21.5m
	Paint Degradation	(0.4×2)×3.2(L2)×13	34.3m^2
HI=50	Paint Degradation	(0.4(H2)×2)×3.2(L2)×13	34.3m^2

3). Cost estimation of repair work as at each HI condition

The repair cost as at border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.5.8 Cost for repair work at border line of HI (=0, 50)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Paint Degradation	Painting	89,200	Rs	No.St-12
	Corrosion	Steel plate bonding	806,500	Rs	No.St-2
	Total cost		895,700	Rs	
	Unit rate per m^2		21,600	Rs/m^2	
HI=50	Paint Degradation	Painting	74,900	Rs	No.St-11
	Unit rate per m^2		1,900	Rs/m^2	

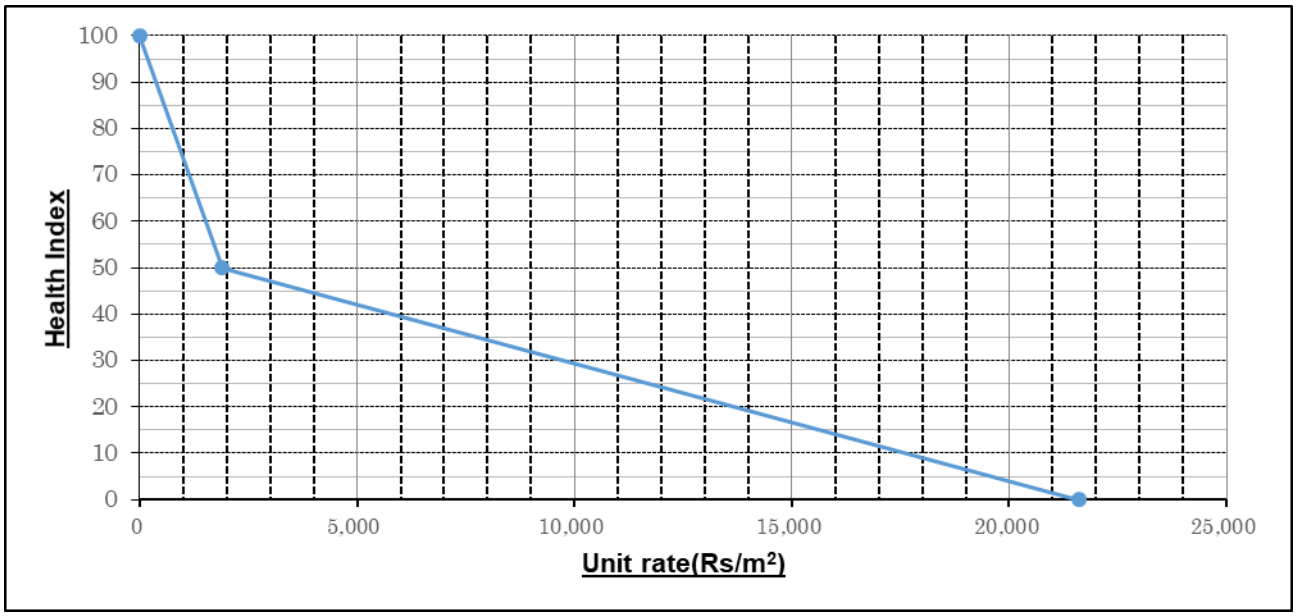


Figure 3.1.5.3 Relation between HI and unit rate

3.1.6 Structure type: Steel Bridge

(4) Main Beam

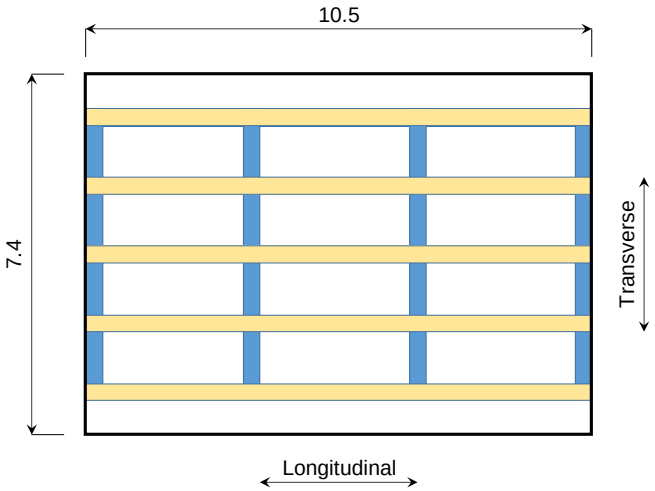
1). Sample Bridge to be applied for unit rate

Following bridge is used for cost estimation for repair work.

Table 3.1.6.1 Basic information of bridge

Basic Information			Photos
Route No	:	A004	
Bridge No	:	No.31/1	
Length of bridge	:	10.5m (L1)	
Width of bridge	:	7.4m (W2)	
Number of main beam	:	5nos	
Number of cross beam	:	4nos	
Height of main beam	:	0.7m (H1)	
Height of cross beam	:	0.7m (H2)	
Length of cross beam	:	7.4m (W3)	
Width of flunge	:	0.3m (W1)	

Plane view



※ 15elements in horizontal plane– Main beam

※ 16elements in horizontal plane – Cross beam

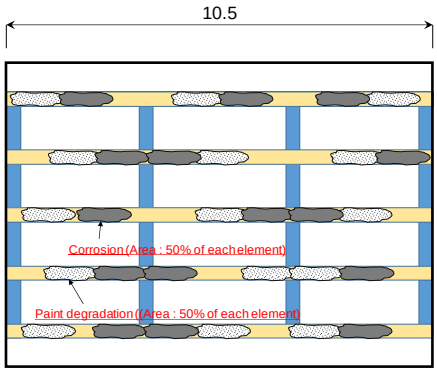
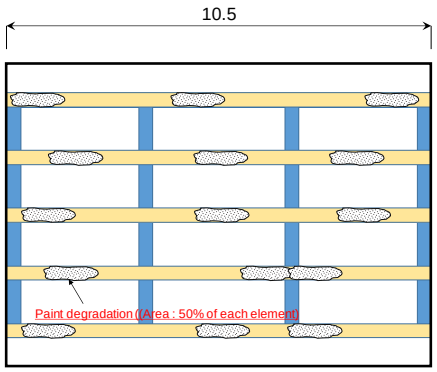
2). Assumed Health Index and Degree of damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.6.2 Assumed degree of damage at HI=0, 50

HI	Degree of damage	Outline figure
HI=0	Paint Degradation (e grade) and Corrosion (e grade) generated at all elements. ※Paint Degradation exists on 50% area in one element. ※Corrosion exists on 50% area in one element.	
HI=50	Paint Degradation (e grade) generated at all elements. ※Paint Degradation exists on 50% area in one element.	

NOTE

Paint Degradation, Corrosion

3). Quantity calculation for repair work

Quantities of repair work as at the border line (HI = 0, 50) condition are shown in following table.

Table 3.1.6.3 Quantity of repair work at HI=0, 50

HI	Type of damage	Quantity of repair work	
HI=0	Corrosion	1/2×10.5(L1)×5	26.3m
	Paint Degradation	(3×0.3(W1)+2×0.7(H1))×10.5(L1)×5	120.8m^2
HI=50	Paint Degradation	(3×0.3(W1)+2×0.7(H1))×10.5(L1)×5	120.8m^2

4). Cost estimation of repair work as at each HI condition

The repair cost as at border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate is applied for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.6.4 Cost for repair work at border line of HI (=0, 50)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Paint Degradation	Painting	15,800	Rs	No.St-6
	Corrosion	Steel plate bonding	1,574,100	Rs	No.St-1
	Total cost		1,589,900	Rs	
	Unit rate per m^2		20,500	Rs/m^2	
HI=50	Paint Degradation	Painting	254,100	Rs	No.St-5
	Unit rate per m^2		3,300	Rs/m^2	

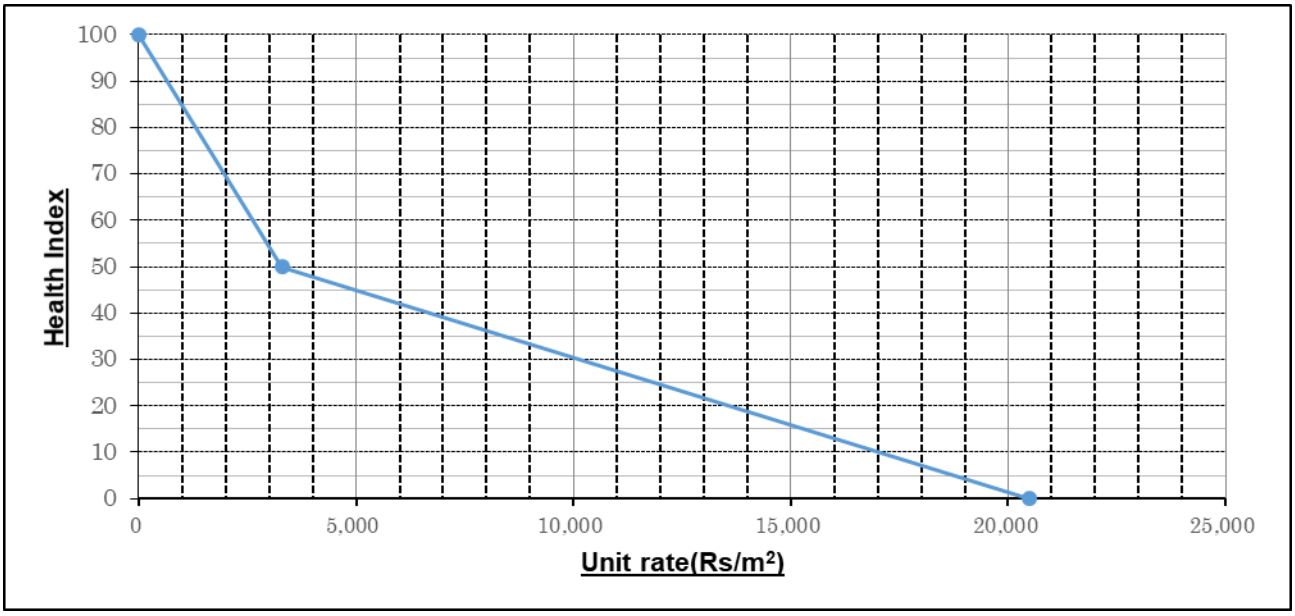


Figure 3.1.6.1 Relation between HI and unit rate

(5) Deck slab

Table 3.1.6.5 Cost for repair work

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement of deck slab		-	Deck slab	-	(NO.De-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Redecking	6,000 Rs/m^2	77.7 m^2	466,200 Rs	Following Maho EE office's cost estimation
Total		*6,000 Rs/m^2*		*466,200 Rs*	

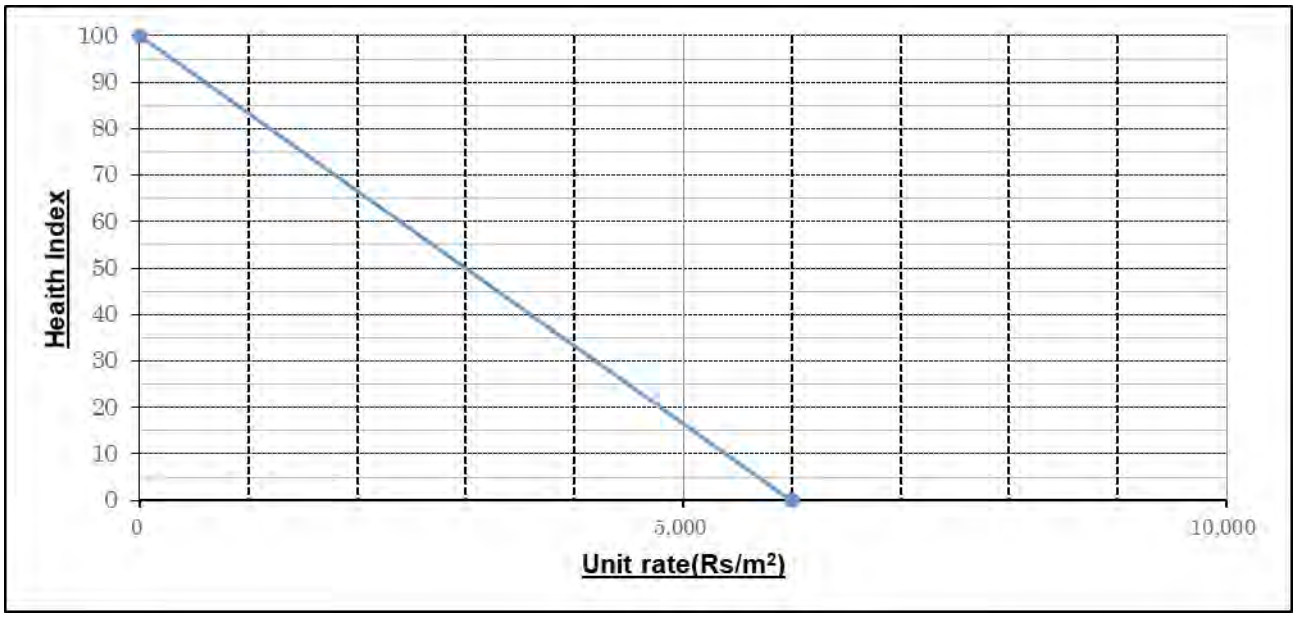


Figure 3.1.6.2 Relation between HI and unit rate

(6) Cross Beam

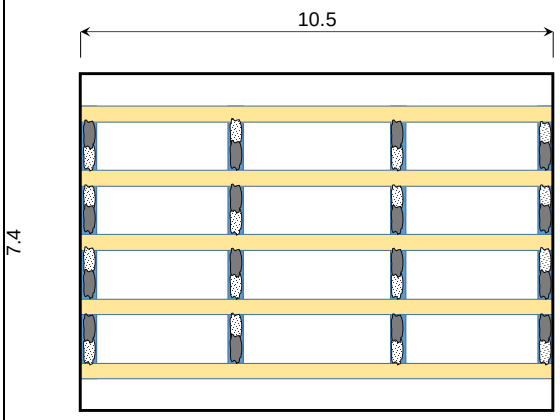
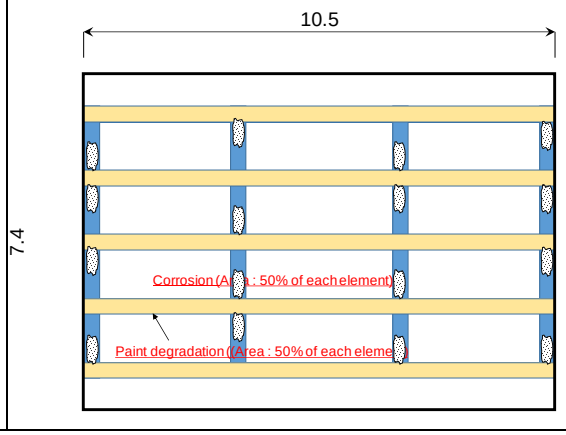
1). Assumed Health Index and Degree of damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.6.6 Assumed degree of damage at each HI

HI	Degree of damage	Outline figure
HI=0	Paint Degradation (e grade) and Corrosion (e grade) generate at all elements. ※Paint Degradation generated on 50% area of one element. ※Corrosion exists on 50% area in one element.	
HI=50	Paint Degradation (e grade) generate at all elements. ※Paint Degradation generated on 50% area in one element.	

NOTE

Paint Degradation, Corrosion

2). Quantity calculation for repair work

Quantities of repair work as at border line (HI = 0, 50) condition are shown in following table.

Table 3.1.6.7 Quantity of repair work at each HI (=0, 50)

HI	Type of damage	Quantity of repair work	
HI=0	Corrosion	1/2×7.4(W2)×4	14.8m
	Paint Degradation	(3×0.3(W1)+2×0.7(H2))×7.4(W3)×4	68.1m^2
HI=50	Paint Degradation	(3×0.3(W1)+2×0.7(H2))×7.4(W3)×4	68.1m^2

3). Cost estimation of repair work as at each HI condition

The repair cost as at border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case, the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate is applied for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.6.8 Cost for repair work at border line of HI (=0, 50)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Paint Degradation	Painting	88,700	Rs	No.St-10
	Corrosion	Replacement of member	1,094,100	Rs	No.St-3
	Total cost		1,182,800	Rs	
	Unit rate per m^2		15,300	Rs/m^2	
HI=50	Paint Degradation	Painting	141,300	Rs	No.St-9
	Unit rate per m^2		1,900	Rs/m^2	

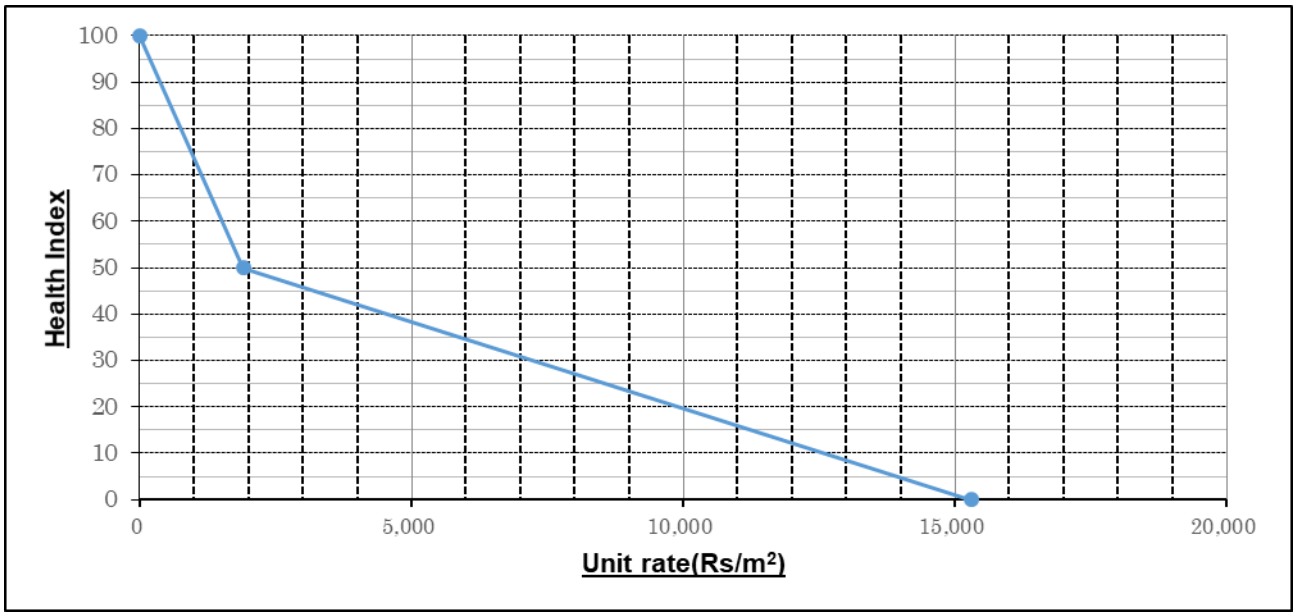


Figure.3.1.6.3 Relation between HI and unit rate

3.1.7 Structure type: Arch Bridge

(1) Arch Rib

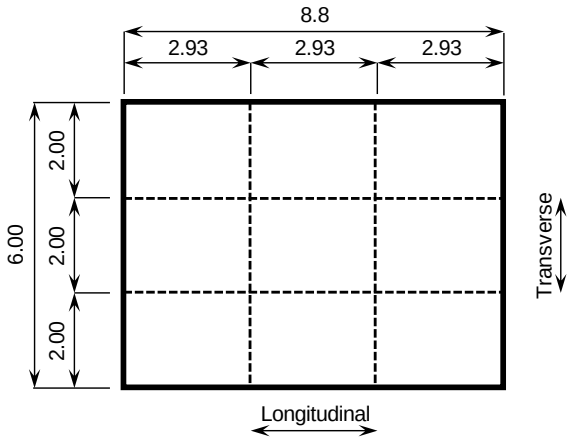
1). Sample Bridge to be applied for unit rate

Following bridge is used for cost estimation for repair work.

Table 3.1.7.1 Basic information of bridge

Basic Information			Photos
Route No	:	B364	
Bridge No	:	No.7/15	
Length of bridge	:	8.6m (L2)	
Width of bridge	:	6.0m (W1)	
Arch rise	:	2.2m (H2)	
Clear span	:	7.1m	
Length of arch	:	8.95m (L1)	
Height of abutment	:	2.0m (H1)	
Height of spandrel	:	2.0m (H3)	

Plane view



※ 9elements in horizontal plane

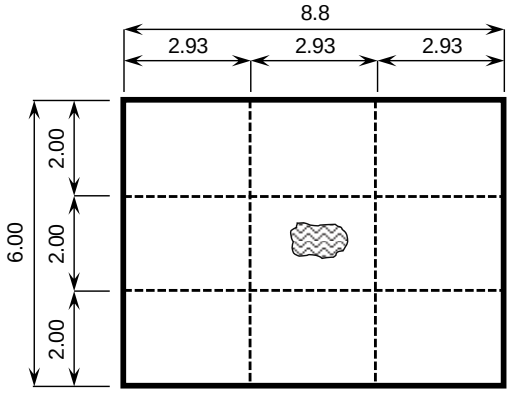
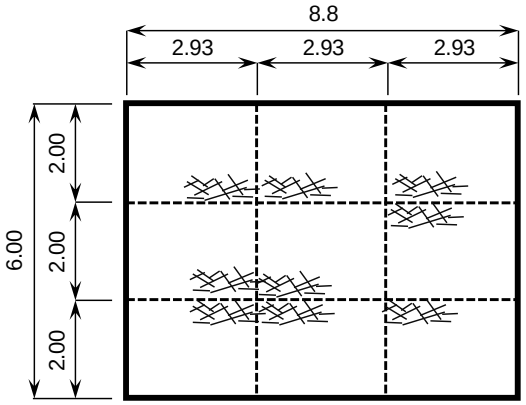
2). Assumed Health Index and Degree of damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.7.2 Assumed degree of damage at each HI

HI	Degree of damage	Outline figure
HI=0	Arch Line (Displacement) generate.	
HI=1	Crack generate at 9 elements	
NOTE Arch Line (Displacement), Crack		

3). Quantity calculation for repair work

Quantities of repair work as at the border line (HI = 0, 30, 90) condition are shown in the following table.

Table 3.1.7.3 Quantity of repair work at each HI

HI	Type of damage	Quantity of repair work	
HI=0	Displacement	(8.95(L1)×6.0(W1)+2.0(H1)×6.0(W1))×0.25	16.4m^3
HI=1	Crack	8.95(L1)×3	26.9m

4). Cost estimation of repair work as at each HI condition

The repair cost as at border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (In basis of repair cost in chapter 5 mentioned which unit rate was used.)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.1.7.4 Cost for repair work at border line of HI (=0, 1)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Arch line (Displacement)	Mortar spraying	763,600	Rs	No.Ar-1
	Total cost		763,600	Rs	
	Unit rate per m^2		14,800	Rs/m^2	
HI=1	Crack	Crack Injection	347,100	Rs	No.Co-30
	Unit rate per m^2		6,800	Rs/m^2	

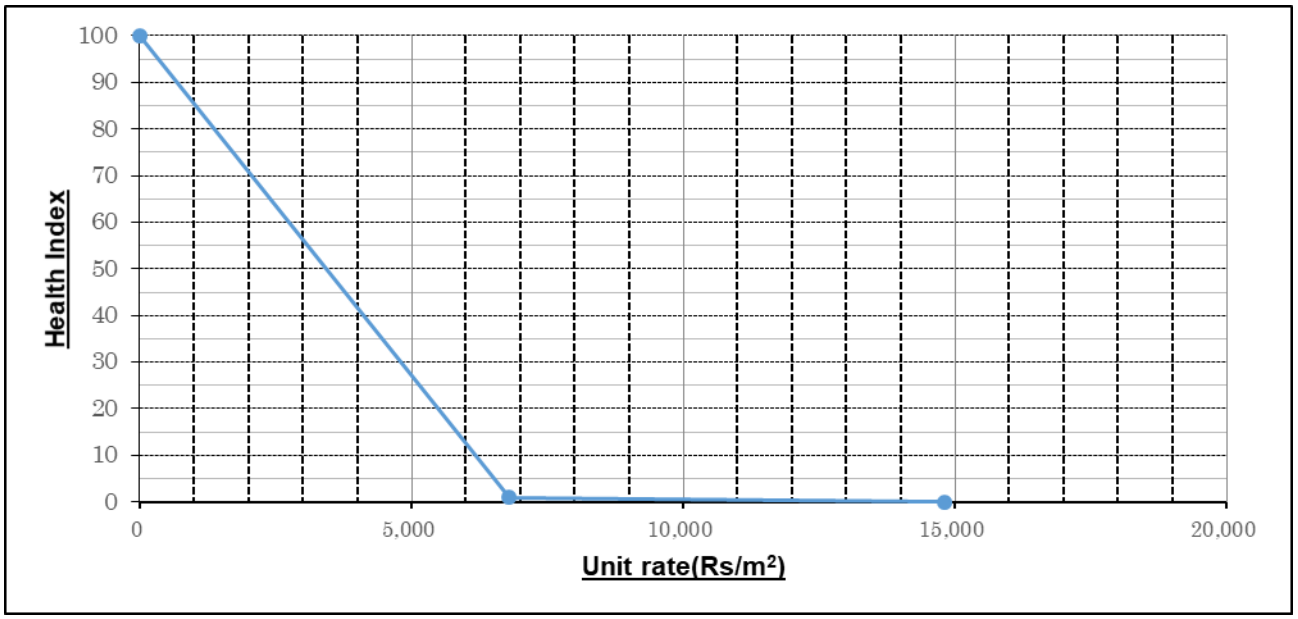


Figure 3.1.7.1 Relation between HI and unit rate

(2) Spandrel

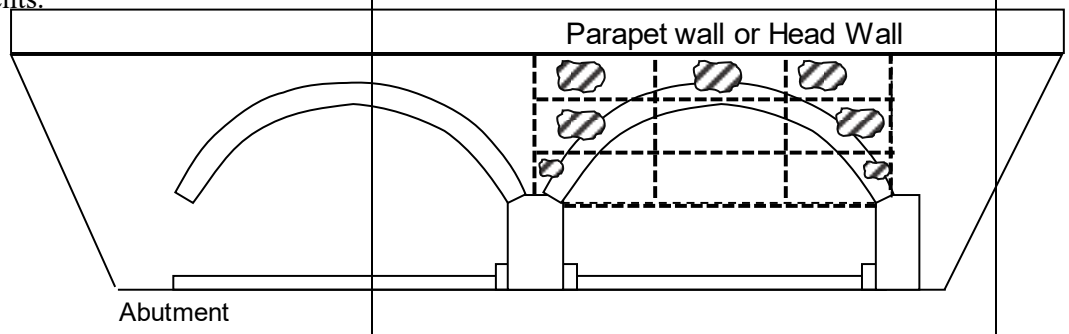
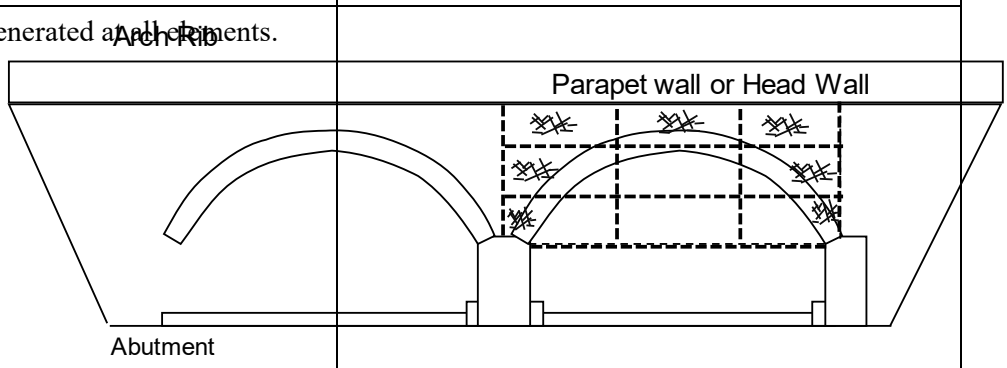
1). Assumed Health Index and Degree of damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.1.7.5 Assumed degree of damage at each HI (=0, 1)

HI	Degree of damage	Outline figure
HI=0	Deteriorated (Loose) generate at all elements.	
HI=1	Crack generated at all elements.	
NOTE Crack、 Deteriorated (Loose)		

2). Quantity calculation for repair work

Quantities of repair work as at the border line (HI = 0, 1) condition are shown in following table.

Table 3.1.7.6 Quantity of repair work at each HI (=0, 1)

HI	Type of damage	Quantity of repair work	
HI=0	Deteriorated (Loose)	2×0.25×（(2(H1)+2(H3)）×8.6(L2)-π/4×（2.2(H2)+7.0/2）^{2}-7.0×0.5×7.0/2）×0.25×2	10.6m^3
HI=1	Crack	3×(2+2)×2	24.0m

3). Cost estimation of repair work as at each HI condition

The repair costs as at border line of Health Index (HI=0, 30, 90) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (On the basis of repair cost in chapter 5 mentioned which unit rate was used.)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case, the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate is applied for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure carried out by internal processing in BMS system.

Table 3.1.7.7 Cost for repair work at border line of HI (=0, 1)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Deteriorated(Loose)	Mortar praying	619,900	Rs	No.Ar-2
	Total cost		619,900	Rs	
	Unit rate per m^2		12,100	Rs/m^2	
HI=1	Crack	Crack Injection	346,000	Rs	No.Co-31
	Unit rate per m^2		6,800	Rs/m^2	

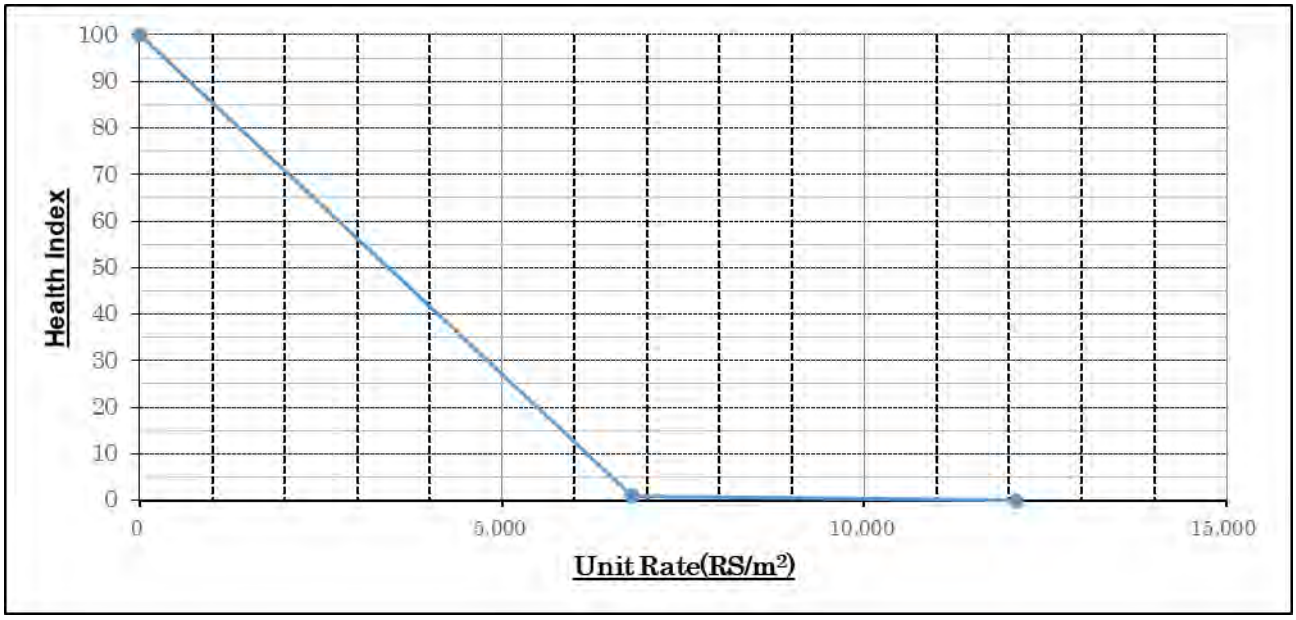


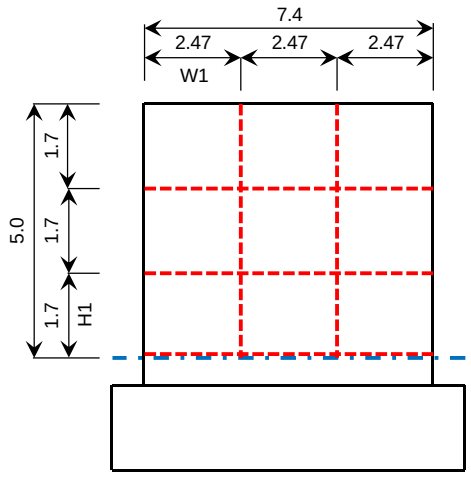
Figure 3.1.7.2 Relation between HI and unit rate

3.2 Substructure

(1) Sample Bridge to be applied for unit rate

Table 3.2.1 Basic information of bridge

Basic Information			Photos
Route No	:	A004	
Bridge No	:	No.31/1	
Length of bridge	:	10.5m	
Width of bridge	:	7.4m	
Height of Pier	:	5.1m	
Width of Pier	:	7.4m (W2)	
Plane view			



※ 9elements in horizontal plane

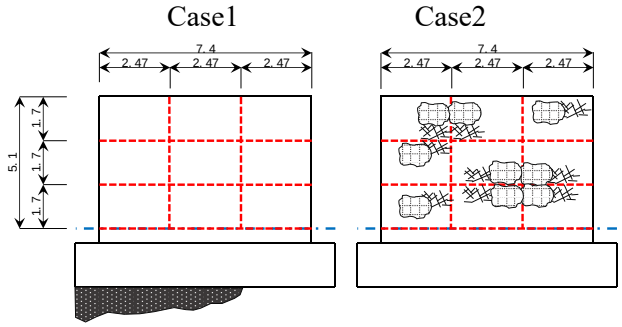
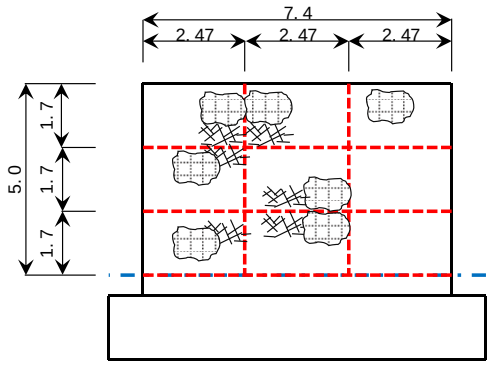
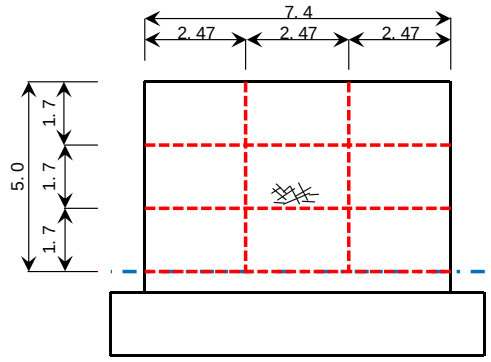
(2) Assumed Health Index and Degree of damage

Repair method shall be selected based on area and depth of damage.

Border line of HI at which repair method shall be changed is shown in following table.

Degree of damage between the border lines shall be calculated by linear interpolation.

Table 3.2.2 Assumed degree of damage at each HI

HI	Degree of damage	Outline figure
HI=0	Case1: Scour generate. Case2: Spalling / Delamination / Ex-rebar (e grade) and crack (e grade) generate at 9 elements (Ratio: 100%).	
HI=30	Spalling / Delamination / Ex-rebar (e grade) generate 7 elements (Ratio: 78%) and crack (e grade) generate at 6 elements (Ratio: 67%).	
HI=90	Crack (e grade) generate at 1 elements (Ratio: 11%).	

NOTE

Scour

Spalling / Delamination / Ex-rebar, Crack

(3) Quantity calculation for repair work

Quantities of repair work as at the border line (HI = 0, 1, 10) condition are shown in following table.

Table 3.2.3 Quantity of repair work at each HI (=0, 1, 10)

HI	Type of damage	Quantity of repair work	
HI=0	Scour	（7.4(W2)+2）×2	18.8m^3
HI=0	Spalling / Delamination / Ex-rebar	1.7(H1)×2.47(W1)×0.08×0.30×9	0.9m^3
	Crack	1.7(H1)×9	15.3m
HI=30	Spalling / Delamination / Ex-rebar	1.7(H1)×2.47(W1)×0.06×0.30×7	0.5m^3
	Crack	1.7(H1)×6	10.2m
HI=90	Crack	1.7(H1)×1	1.7m

(4) Cost estimation of repair work as at each HI condition

The repair cost as at border line of Health Index (HI=0, 1, 10) condition are calculated according to the following procedure.

Procedure.1

Calculate the repair cost using following unit rate. (In basis of repair cost in chapter 5 mentioned which unit rate was used.)

Case.1: Unit rate mentioned in HSR

Case.2: Unit rate from contractor or Japanese basis

(In case, the unit rate is not mentioned in HSR)

Procedure.2

Calculate unit rate per area of bridge.

In BMS system, this unit rate applies for the calculation for repair work.

Between the border lines of Health Index conditions, the unit rate is calculated by linear interpolation.

This procedure is carried out by internal processing in BMS system.

Table 3.2.4 Cost for repair work at border line of HI (=0, 30, 90)

HI	Type of damage	Repair method	Repair cost		Refer No.
HI=0	Scour	Packing rubble and pouring concrete	250,300	Rs	No.Fu-1
	Total cost		250,300	Rs	
	Unit rate per m^2		3,300	Rs/m^2	
HI=0	Spalling / Delamination / Ex-rebar	Grouting	325,800	Rs	No.Co-47
	Crack	Crack Injection	185,200	Rs	No.Co-29
	―	CFRS bonding (Strengthening)	870,100	Rs	No.Co-61
	Total cost		1,381,100	Rs	
	Unit rate per m^2		35,600	Rs/m^2	
HI=30	Spalling / Delamination / Ex-rebar	Plastering	181,000	Rs	No.Co-6
	Crack	Crack Injection	139,300	Rs	No.Co-28
	―	CFRS bonding (Strengthening)	677,600	Rs	No.Co-60
	Total cost		997,900	Rs	
	Unit rate per m^2		25,700	Rs/m^2	
HI=90	Crack	Crack Injection	62,800	Rs	No.Co-27
	Unit rate per m^2		1,700	Rs/m^2	

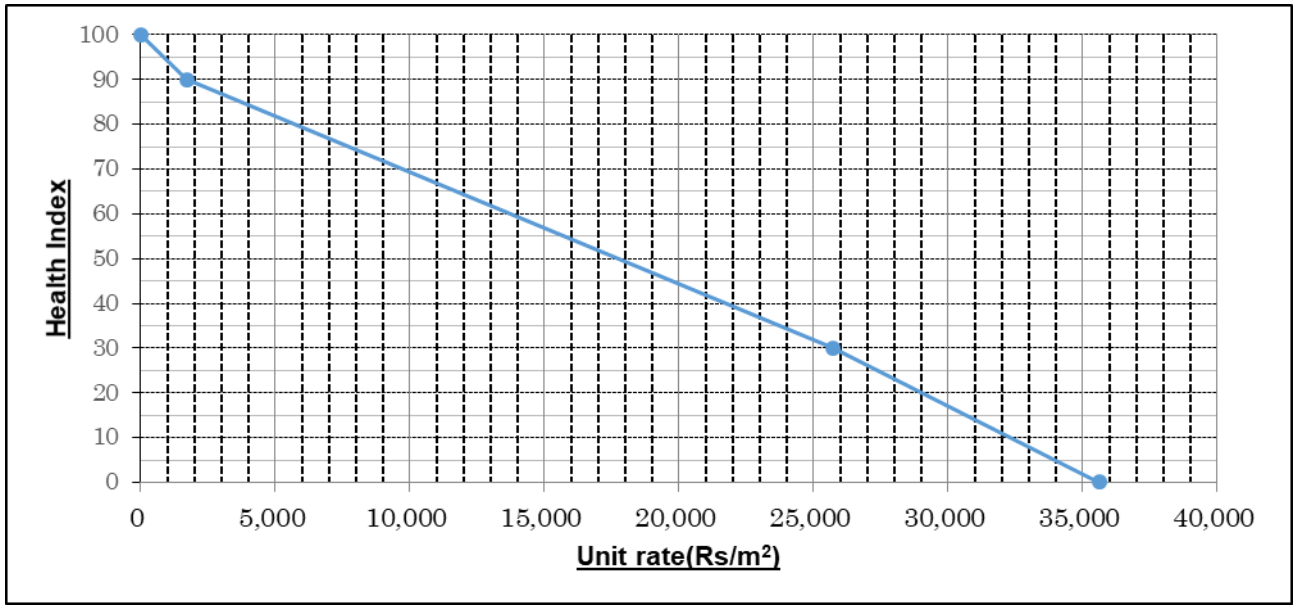


Figure 3.2.1 Relation between HI and unit rate

3.3 Surface

3.3.1 Pavement

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Pavement		-	Pavement	-	(NO.Pa-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Supply, lay and compact asphalt premix concrete- Bridge decks	380 Rs/m^2	58.9 m2	22,400 Rs	Unit rate is extracted from HSR Assumed thickness is 5cm (S1-031)
Total		*400 Rs/m^2*		*22,400 Rs*	

3.3.2 Expansion Joint

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement		-	Expansion joint	-	(NO.Jo-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	M.S. ANGLE IRON AND HARD RUBBER EXPANSION JOINTS AS PER DRAWING NO. T/B/107 REV.1	6,500 Rs/m	10.7 m	69,600 Rs	Unit rate is extracted from HSR (ST1-122)
Total		*6,500 Rs/m*		*69,600 Rs*	

3.3.3 Accessories (Service Duct, Railing)

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement		-	Serviceduct and Railing	-	(NO.Dr-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Fixing pre cast hand railing and uplight	1,100 Rs/m	20 m	22,000 Rs	Unit rate is extracted from HSR ST1-106
	110mm ϕ type 400 PVC service duct	640 Rs/m	20 m	12,800 Rs	Unit rate is extracted from HSR St1-147
Total		*3,500 Rs/m*		*34,800 Rs*	

3.3.4 Approaches

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Approach		-	Approach	-	(NO.Ap-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Flat paving 150mm thick	200 Rs/m^2	85.6 m^2	17,100 Rs	Unit rate is extracted from HSR Assumed thickness is 5cm (S1-031)
	Braking road surface	100 Rs/m^2	85.6 m^2	8,600 Rs	Unit rate is extracted from HSR (M1-002)
	Approved soil spread and compactefd in place behind the abutment	470 Rs/m^2	85.6 m^2	40,200 Rs	Unit rate is extracted from HSR Assumed thickness 1.0m (EW 1-006)
Total		*6,200 Rs/m*		*65,900 Rs*	

3.4 Bearing

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement		-	Bearing	-	(NO.Be-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	SUPPLYING AND LAYING APPROVED HARD RUBBER BEARING PADS 75MM X 12MM OVER CAPPING BEAMS AND UNDER THE APPROACH SLABS	1,500 Rs/m	21.4 m	32,100 Rs	Unit rate is extracted from HSR (ST1-122)
	Hydruulic Jack	1,700 Rs/day/nos	6 nos 14 day	142,800 Rs	Unit rate is extracted from japanese standard
	Temporary support	23,200 Rs/day/nos	2 nos 14 day	649,600 Rs	Unit rate is extracted from japanese standard
	Crane Crawler 25t	36,800 Rs/day	4 day	147,200 Rs	Unit rate is extracted from HSR
	Skilled labor A－20stuff	32,000 Rs/day	14 day	448,000 Rs	Unit rate is extracted from HSR
Total		*132,700 Rs/m*		*1,419,700 Rs*	

4. Basis of unit repair rate

The summary table of unit rate and basis are shown in the following.

Table 4.1 Summary table for unit rate (1/2)

Code number	Type of repair method	Type of bridge	Member	Health Index
(NO.Pa-1)	Pavement	-	Pavement	-
(NO.Ap-1)	Approach	-	Approach	-
(NO.Jo-1)	Replacement	-	Expansion joint	-
(NO.Be-1)	Replacement	-	Bearing	-
(NO.Dr-1)	Replacement	-	Serviceduct andRailing	-
(NO.St-1)	Steel Plate Bonding	Steel	Main Beam	HI=0
(NO.St-2)	Steel Plate Bonding	Truss	Cross Beam	HI=0
(NO.St-3)	Replacement of a steel members	Steel	Cross Beam	HI=0
(NO.St-4)	Replacement of a truss members	Truss	Main Beam	HI=0
(NO.St-5)	Zone Painting	Steel	Main beam	HI=50
(NO.St-6)	Zone Painting	Steel	Main beam	HI=0
(NO.St-7)	Zone Painting	Truss	Main beam	HI=50
(NO.St-8)	Zone Painting	Truss	Main beam	HI=0
(NO.St-9)	Zone Painting	Steel	Cross beam	HI=50
(NO.St-10)	Zone Painting	Steel	Cross beam	HI=0
(NO.St-11)	Zone Painting	Truss	Cross beam	HI=50
(NO.St-12)	Zone Painting	Truss	Cross beam	HI=0
(NO.De-1)	Replacement of deck slab	-	Deck slab	-
(NO.Co-1)	Plastring (Polymer cement mortar)	RCS	Deck Slab	HI=30
(NO.Co-2)	Plastring (Polymer cement mortar)	Box Bridge	Deck Slab	HI=30
(NO.Co-3)	Plastring (Polymer cement mortar)	PSC-PRE	Deck Slab	HI=70
(NO.Co-4)	Plastring (Polymer cement mortar)	PSC-POS,RCS-RCB	Main Beam	HI=30
(NO.Co-5)	Plastring (Polymer cement mortar)	PSC-POS,RCS-RCB	Deck slab	HI=90
(NO.Co-6)	Plastring (Polymer cement mortar)	PSC-POS,RCS-RCB	Diaphragm	HI=30
(NO.Co-7)	Plastring (Polymer cement mortar)	-	Substructure	HI=30
(NO.Co-8)	Crack Injection	RCS	Deck Slab	HI=90
(NO.Co-9)	Crack Injection	RCS	Deck Slab	HI=30
(NO.Co-10)	Crack Injection	RCS	Deck Slab	HI=0
(NO.Co-11)	Crack Injection	Box bridge	-	HI=90
(NO.Co-12)	Crack Injection	Box bridge	-	HI=30
(NO.Co-13)	Crack Injection	Box bridge	-	HI=0
(NO.Co-14)	Crack Injection	PSC-PRE	Deck Slab	HI=90
(NO.Co-15)	Crack Injection	PSC-PRE	Deck Slab	HI=70
(NO.Co-16)	Crack Injection	PSC-PRE	Deck Slab	HI=30
(NO.Co-17)	Crack Injection	PSC-PRE	Deck Slab	HI=0
(NO.Co-18)	Crack Injection	PSC-POS,RCS-RCB	Main Beam	HI=90
(NO.Co-19)	Crack Injection	PSC-POS,RCS-RCB	Main Beam	HI=30
(NO.Co-20)	Crack Injection	PSC-POS,RCS-RCB	Main Beam	HI=0
(NO.Co-21)	Crack Injection	PSC-POS,RCS-RCB	Diaphragm	HI=90
(NO.Co-22)	Crack Injection	PSC-POS,RCS-RCB	Diaphragm	HI=30
(NO.Co-23)	Crack Injection	PSC-POS,RCS-RCB	Diaphragm	HI=0
(NO.Co-24)	Crack Injection	PSC-POS,RCS-RCB	Deck Slab	HI=90
(NO.Co-25)	Crack Injection	PSC-POS,RCS-RCB	Deck Slab	HI=30
(NO.Co-26)	Crack Injection	PSC-POS,RCS-RCB	Deck Slab	HI=0
(NO.Co-27)	Crack Injection	-	Substructure	HI=90
(NO.Co-28)	Crack Injection	-	Substructure	HI=30
(NO.Co-29)	Crack Injection	-	Substructure	HI=0
(NO.Co-30)	Crack Injection	Arch Bridge	Arch Rib	HI=1

Table 4.1 Summary table for unit rate (2/2)

Code number	Type of repair method	Type of bridge	Member	Health Index
(NO.Co-31)	Crack Injection	Arch Bridge	Spandrel	HI=1
(NO.Co-32)	Grouting	RCS	Deck Slab	HI=0
(NO.Co-33)	Grouting	RCS	Deck Slab	HI=29
(NO.Co-34)	Grouting	Box Bridge	Deck Slab	HI=0
(NO.Co-35)	Grouting	Box Bridge	Deck Slab	HI=29
(NO.Co-36)	Grouting	PSC-PRE	Deck Slab	HI=0
(NO.Co-37)	Grouting	PSC-PRE	Deck Slab	HI=30
(NO.Co-38)	Grouting	PSC-PRE	Deck Slab	HI=69
(NO.Co-39)	Grouting	PSC-POS,RCS-RCB	Main Beam	HI=0
(NO.Co-40)	Grouting	PSC-POS,RCS-RCB	Main Beam	HI=29
(NO.Co-41)	Grouting	PSC-POS,RCS-RCB	Deck slab	HI=0
(NO.Co-42)	Grouting	PSC-POS,RCS-RCB	Deck slab	HI=89
(NO.Co-43)	Grouting	PSC-POS,RCS-RCB	Deck slab	HI=30
(NO.Co-44)	Grouting	PSC-POS,RCS-RCB	Diaphragm	HI=0
(NO.Co-45)	Grouting	PSC-POS,RCS-RCB	Diaphragm	HI=29
(NO.Co-46)	Grouting	-	Substructure	HI=29
(NO.Co-47)	Grouting	-	Substructure	HI=0
(NO.Co-48)	Fiber sheet bonding	PSC-PRE	Deck Slab	HI=0
(NO.Co-49)	Fiber sheet bonding	PSC-PRE	Deck Slab	HI=29
(NO.Co-50)	Fiber sheet bonding	RCS	Deck Slab	HI=0
(NO.Co-51)	Fiber sheet bonding	RCS	Deck Slab	HI=29
(NO.Co-52)	Fiber sheet bonding	PSC-POS,RCS-RCB	Main Beam	HI=0
(NO.Co-53)	Fiber sheet bonding	PSC-POS,RCS-RCB	Main Beam	HI=29
(NO.Co-54)	Fiber sheet bonding	PSC-POS,RCS-RCB	Deck slab	HI=0
(NO.Co-55)	Fiber sheet bonding	PSC-POS,RCS-RCB	Deck slab	HI=29
(NO.Co-56)	Fiber sheet bonding	PSC-POS,RCS-RCB	Diaphragm	HI=0
(NO.Co-57)	Fiber sheet bonding	PSC-POS,RCS-RCB	Diaphragm	HI=29
(NO.Co-58)	Fiber sheet bonding	Box bridge	-	HI=0
(NO.Co-59)	Fiber sheet bonding	Box bridge	-	HI=29
(NO.Co-60)	Fiber sheet bonding	Substructure	-	HI=29
(NO.Fu-1)	Repair the Scouring part	-	Substructure	HI=0
(NO.Ar-1)	Mortar spraying	Arch bridge	Arch Rib	HI=0
(NO.Ar-2)	Mortar spraying	Arch bridge	Arch spandrel	HI=0

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Pavement		-	Pavement	-	(NO.Pa-0)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Pacthing pot holes of medium depth of 20-75mm	800 Rs/m^2	29.4 m^2	23,500 Rs	Unit rate is extracted from HSR (MS-1)
Total				*23,500 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Pavement		-	Pavement	-	(NO.Pa-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Supply, lay and compact asphalt premix concrete- Bridge decks	380 Rs/m^2	58.9 m2	22,400 Rs	Unit rate is extracted from HSR Assumed thickness is 5cm (S1-031)
Total		*400 Rs/m^2*		*22,400 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement		-	Expansion joint	-	(NO.Jo-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	M.S. ANGLE IRON AND HARD RUBBER EXPANSION JOINTS AS PER DRAWING NO. T/B/107 REV.1	6,500 Rs/m	10.7 m	69,600 Rs	Unit rate is extracted from HSR (ST1-122)
Total		*6,500 Rs/m*		*69,600 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Approach		-	Approach	-	(NO.Ap-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Flat paving 150mm thick	200 Rs/m^2	85.6 m^2	17,100 Rs	Unit rate is extracted from HSR Assumed thickness is 5cm (S1-031)
	Braking road surface	100 Rs/m^2	85.6 m^2	8,600 Rs	Unit rate is extracted from HSR (M1-002)
	Approved soil spread and compactefd in place behind the abutment	470 Rs/m^2	85.6 m^2	40,200 Rs	Unit rate is extracted from HSR Assumed thickness 1.0m (EW 1-006)
Total		*6,200 Rs/m*		*65,900 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement		-	Bearing	-	(NO.Be-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	SUPPLYING AND LAYING APPROVED HARD RUBBER BEARING PADS 75MM X 12MM OVER CAPPING BEAMS AND UNDER THE APPROACH SLABS	1,500 Rs/m	21.4 m	32,100 Rs	Unit rate is extracted from HSR (ST1-122)
	Hydruulic Jack	1,700 Rs/day/nos	6 nos 14 day	142,800 Rs	Unit rate is extracted from japanese standard
	Temporary support	23,200 Rs/day/nos	2 nos 14 day	649,600 Rs	Unit rate is extracted from japanese standard
	Crane Crawler 25t	36,800 Rs/day	4 day	147,200 Rs	Unit rate is extracted from HSR
	Skilled labor A－20stuff	32,000 Rs/day	14 day	448,000 Rs	Unit rate is extracted from HSR
Total		*132,700 Rs/m*		*1,419,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement		-	Serviceduct and Railing	-	(NO.Dr-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Fixing pre cast hand railing and uplight	1,100 Rs/m	20 m	22,000 Rs	Unit rate is extracted from HSR ST1-106
	110mm ϕ type 400 PVC service duct	640 Rs/m	20 m	12,800 Rs	Unit rate is extracted from HSR St1-147
Total		*3,500 Rs/m*		*34,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Steel Plate Bonding		Steel	Main Beam	HI=0	(NO.St-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment and Labor	Welding plant	13,000 Rs/day	5 day	65,000 Rs	Unit rate is extracted from HSR(B0-105)
	Generater Electric 7-10KVA	7,200 Rs/day	20 day	144,000 Rs	Unit rate is extracted from HSR(B0-130A)
	Crane Crawler 25t	36,800 Rs/day	5 day	184,000 Rs	Unit rate is extracted from HSR
	Grinder	450 Rs/day	5 day	2,200 Rs	Unit rate is extracted from HSR(B0-105)
	Fabricating steel	1,400 Rs/day	4 day	5,600 Rs	Unit rate is extracted from HSR(ST1-131)
	Skilled labor A－5stuff	12,800 Rs/day	20 day	256,000 Rs	Unit rate is extracted from HSR
	Surface treatment (Power tools)	2,000 Rs/m^2	60.4 m^2	120,800 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	60.4 m^2	36,200 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	77.7 m^2	194,300 Rs	Unit rate is based on trial construction
	Sub Total			*1,008,100 Rs*	
Material	Mild Steel (h=0.5,L=10.5m,n=5nos)			566,000 Rs	Unit rate is extracted from HSR(B0-411)
Total				*1,574,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Steel Plate Bonding		Truss	Cross Beam	HI=0	(NO.St-2)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment and Labor	Welding plant	13,000 Rs/day	5 day	65,000 Rs	Unit rate is extracted from HSR(B0-105)
	Generater Electric 7-10KVA	7,200 Rs/day	20 day	144,000 Rs	Unit rate is extracted from HSR(B0-130A)
	Crane Crawler 25t	36,800 Rs/day	5 day	184,000 Rs	Unit rate is extracted from HSR
	Grinder	450 Rs/day	5 day	2,200 Rs	Unit rate is extracted from HSR(B0-105)
	Fabricating steel	1,400 Rs/day	4 day	5,600 Rs	Unit rate is extracted from HSR(ST1-131)
	Skilled labor A－5stuff	12,800 Rs/day	20 day	256,000 Rs	Unit rate is extracted from HSR
	Surface treatment (Power tools)	2,000 Rs/m^2	17.2 m^2	34,400 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	17.2 m^2	10,300 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	42 m^2	105,000 Rs	Unit rate is based on trial construction
	Sub Total			*806,500 Rs*	
Material	Mild Steel (h=0.5,L=10.5m,n=5nos)			0 Rs	Unit rate is extracted from HSR(B0-411)
Total				*806,500 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement of a steel members		Steel	Cross Beam	HI=0	(NO.St-3)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Welding plant	13,000 Rs/day	4 day	52,000 Rs	Unit rate is extracted from HSR(B0-105)
	Generater Electric 7-10KVA	7,200 Rs/day	20 day	144,000 Rs	Unit rate is extracted from HSR(B0-130A)
	Crane Crawler 25t	36,800 Rs/day	4 day	147,200 Rs	Unit rate is extracted from HSR
	Grinder	450 Rs/day	4 day	1,800 Rs	Unit rate is extracted from HSR(B0-105)
	Fabricating steel	1,400 Rs/day	4 day	5,600 Rs	Unit rate is extracted from HSR(ST1-131)
	Skilled labor A－5stuff	12,800 Rs/day	20 day	256,000 Rs	Unit rate is extracted from HSR
	Surface treatment (Power tools)	2,000 Rs/m^2	14.8 m^2	29,600 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	14.8 m^2	8,900 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	30 m^2	75,000 Rs	Unit rate is based on trial construction
	Hydruulic Jack	1,700 Rs/day/nos	5 nos 10 day	8,500 Rs	Unit rate is extractied from japanese standard
	Temporary support	23,200 Rs/day/nos	2 nos 10 day	46,400 Rs	Unit rate is extracted from japanese standard Bearing capacity : 50t
	Sub Total			*775,000 Rs*	
Material	Mild Steel			319,100 Rs	Unit rate is extracted from HSR(B0-411)
Total				*1,094,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement of a truss members		Truss	Main Beam	HI=0	(NO.St-4)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Welding plant	13,000 Rs/day	4 day	52,000 Rs	Unit rate is extracted from HSR(B0-105)
	Generater Electric 7-10KVA	7,200 Rs/day	20 day	144,000 Rs	Unit rate is extracted from HSR(B0-130A)
	Crane Crawler 25t	36,800 Rs/day	4 day	147,200 Rs	Unit rate is extracted from HSR
	Grinder	450 Rs/day	4 day	1,800 Rs	Unit rate is extracted from HSR(B0-105)
	Fabricating steel	1,400 Rs/day	4 day	5,600 Rs	Unit rate is extracted from HSR(ST1-131)
	Skilled labor A—5stuff	12,800 Rs/day	20 day	256,000 Rs	Unit rate is extracted from HSR
	Surface treatment (Power tools)	2,000 Rs/m^2	5.7 m^2	11,400 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	5.7 m^2	3,400 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	42 m^2	105,000 Rs	Unit rate is based on trial construction
	Hydruulic Jack	1,700 Rs/day/nos	4 nos 10 day	6,800 Rs	Unit rate is extractied from japanese standard
	Temporary support	23,200 Rs/day/nos	2 nos 10 day	46,400 Rs	Unit rate is extracted from japanese standard Bearing capacity : 50t
	Sub Total			***779,600 Rs***	
Material	Mild Steel			174,600 Rs	Unit rate is extracted from HSR(B0-411)
Total				***954,200 Rs***	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Zone Painting		Steel	Main beam	HI=50	(NO.St-5)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Surface treatment (Power tool	2,000 Rs/m^2	60.4 m^2	120,800 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	60.4 m^2	36,200 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	38.85 m^2	97,100 Rs	Unit rate is based on trial construction
Total		***5,100 Rs/m^2***		***254,100 Rs***	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Zone Painting		Steel	Main beam	HI=0	(NO.St-6)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Surface treatment (Power tool	2,000 Rs/m^2	0 m^2	0 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	26.3 m^2	15,800 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total		*5,100 Rs/m^2*		*15,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Zone Painting		Truss	Main beam	HI=50	(NO.St-7)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Surface treatment (Power tool	2,000 Rs/m^2	2.8 m^2	5,600 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	2.8 m^2	1,700 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	21 m^2	52,500 Rs	Unit rate is based on trial construction
Total		*5,100 Rs/m^2*		*59,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Zone Painting		Truss	Main beam	HI=0	(NO.St-8)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Surface treatment (Power tool	2,000 Rs/m^2	12.6 m^2	25,200 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	12.6 m^2	7,600 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total		*5,100 Rs/m^2*		*32,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Zone Painting		Steel	Cross beam	HI=50	(NO.St-9)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Surface treatment (Power tool	2,000 Rs/m^2	17 m^2	34,000 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	17 m^2	10,200 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	38.85 m^2	97,100 Rs	Unit rate is based on trial construction
Total		*5,100 Rs/m^2*		*141,300 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Zone Painting		Steel	Cross beam	HI=0	(NO.St-10)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Surface treatment (Power tool	2,000 Rs/m^2	34.1 m^2	68,200 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	34.1 m^2	20,500 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total		*5,100 Rs/m^2*		*88,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Zone Painting		Truss	Cross beam	HI=50	(NO.St-11)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Surface treatment (Power tool	2,000 Rs/m^2	8.6 m^2	17,200 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	8.6 m^2	5,200 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	21 m^2	52,500 Rs	Unit rate is based on trial construction
Total		*5,100 Rs/m^2*		*74,900 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Zone Painting		Truss	Cross beam	HI=0	(NO.St-12)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Surface treatment (Power tool	2,000 Rs/m^2	34.32 m^2	68,600 Rs	Unit rate is estimated by contractor
	PAINTING WITH TWO COATS OF ENAMEL PAINT AFTER CLEANING,DERUSTING&APPLICATION OF ONE COAT ANTICORROSIVE PAINT	600 Rs/m^2	34.32 m^2	20,600 Rs	Unit rate is extracted from HSR(ST1-092)
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total		*5,100 Rs/m^2*		*89,200 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Replacement of deck slab		-	Deck slab	-	(NO.De-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Redecking	6,000 Rs/m^2	77.7 m^2	466,200 Rs	Following Maho EE office's cost estimation
Total		*6,000 Rs/m^2*		*466,200 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Plastring (Polymer cement mortar)		RCS	Deck Slab	HI=30	(NO.Co-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Plastering	423,400 Rs/m^3	0.4 m^3	169,400 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	16.8 m^2	42,000 Rs	Unit rate is based on trial construction
Total				*211,400 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Plastring (Polymer cement mortar)		Box Bridge	Deck Slab	HI=30	(NO.Co-2)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Plastering	423,400 Rs/m^3	0.2 m^3	84,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	12.9 m^2	32,300 Rs	Unit rate is based on trial construction
Total				*117,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Plastring (Polymer cement mortar)		PSC-PRE	Deck Slab	HI=70	(NO.Co-3)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Plastering	423,400 Rs/m^3	0.2 m^3	84,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	53 m^2	132,500 Rs	Unit rate is based on trial construction
Total				*217,200 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Plastring (Polymer cement mortar)		PSC-POS,RCS-RCB	Main Beam	HI=30	(NO.Co-4)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Plastering	423,400 Rs/m^3	0.5 m^3	211,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	24 m^2	60,000 Rs	Unit rate is based on trial construction
Total				*271,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Plastring (Polymer cement mortar)		PSC-POS,RCS-RCB	Deck slab	HI=90	(NO.Co-5)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Plastering	423,400 Rs/m^3	0.05 m^3	21,200 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	113 m^2	282,500 Rs	Unit rate is based on trial construction
Total				*303,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Plastring (Polymer cement mortar)		PSC-POS,RCS-RCB	Diaphragm	HI=30	(NO.Co-6)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Plastering	423,400 Rs/m^3	0.2 m^3	84,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	244 m^2	610,000 Rs	Unit rate is based on trial construction
Total				*694,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Plastring (Polymer cement mortar)		-	Substructure	HI=30	(NO.Co-7)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Plastering	423,400 Rs/m^3	0.5 m^3	211,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*211,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		RCS	Deck Slab	HI=90	(NO.Co-8)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	2.6 m	23,400 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	4 m^2	10,000 Rs	Unit rate is based on trial construction
Total				*33,400 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		RCS	Deck Slab	HI=30	(NO.Co-9)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	12.9 m	116,100 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*116,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		RCS	Deck Slab	HI=0	(NO.Co-10)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	18.1 m	162,900 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*162,900 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		Box bridge	-	HI=90	(NO.Co-11)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	3.3 m	29,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	4.3 m^2	10,800 Rs	Unit rate is based on trial construction
Total				*40,500 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		Box bridge	-	HI=30	(NO.Co-12)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	9.8 m	88,200 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*88,200 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		Box bridge	–	HI=0	(NO.Co-13)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	16.3 m	146,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*146,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-PRE	Deck Slab	HI=90	(NO.Co-14)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	0.7 m	6,300 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	9 m^2	22,500 Rs	Unit rate is based on trial construction
Total				*28,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-PRE	Deck Slab	HI=70	(NO.Co-15)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	2 m	18,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*18,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-PRE	Deck Slab	HI=30	(NO.Co-16)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	3.9 m	35,100 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*35,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-PRE	Deck Slab	HI=0	(NO.Co-17)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	6.5 m	58,500 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*58,500 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Main Beam	HI=90	(NO.Co-18)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	0.8 m	7,200 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	24 m^2	60,000 Rs	Unit rate is based on trial construction
Total				*67,200 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Main Beam	HI=30	(NO.Co-19)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	5.2 m	46,800 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*46,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Main Beam	HI=0	(NO.Co-20)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	7.6 m	68,400 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*68,400 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Diaphragm	HI=90	(NO.Co-21)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	0.8 m	7,200 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	24 m^2	60,000 Rs	Unit rate is based on trial construction
Total				*67,200 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Diaphragm	HI=30	(NO.Co-22)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	5.2 m	46,800 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*46,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Diaphragm	HI=0	(NO.Co-23)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	8 m	72,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*72,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Deck Slab	HI=90	(NO.Co-24)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	5.3 m	47,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*47,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Deck Slab	HI=30	(NO.Co-25)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	28 m	252,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*252,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		PSC-POS,RCS-RCB	Deck Slab	HI=0	(NO.Co-26)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	42 m	378,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*378,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		-	Substructure	HI=90	(NO.Co-27)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	1.7 m	15,300 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	19 m^2	47,500 Rs	Unit rate is based on trial construction
Total				*62,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		-	Substructure	HI=30	(NO.Co-28)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	10.2 m	91,800 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	19 m^2	47,500 Rs	Unit rate is based on trial construction
Total				*139,300 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		-	Substructure	HI=0	(NO.Co-29)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	15.3 m	137,700 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	19 m^2	47,500 Rs	Unit rate is based on trial construction
Total				*185,200 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		Arch Bridge	Arch Rib	HI=1	(NO.Co-30)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	26.9 m	242,100 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	42 m^2	105,000 Rs	Unit rate is based on trial construction
Total				*347,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Crack Injection		Arch Bridge	Spandrel	HI=1	(NO.Co-31)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Injection	9,000 Rs/m	24 m	216,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	52 m^2	130,000 Rs	Unit rate is based on trial construction
Total				*346,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		RCS	Deck Slab	HI=0	(NO.Co-32)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.7 m^3	253,400 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	37.8 m^2	94,500 Rs	Unit rate is based on trial construction
Total				*347,900 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		RCS	Deck Slab	HI=29	(NO.Co-33)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.4 m^3	144,800 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	16.8 m^2	42,000 Rs	Unit rate is based on trial construction
Total				*186,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		Box Bridge	Deck Slab	HI=0	(NO.Co-34)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.5 m^3	181,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	38.7 m^2	96,800 Rs	Unit rate is based on trial construction
Total				*277,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		Box Bridge	Deck Slab	HI=29	(NO.Co-35)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.2 m^3	72,400 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	12.9 m^2	32,300 Rs	Unit rate is based on trial construction
Total				*104,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-PRE	Deck Slab	HI=0	(NO.Co-36)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	2.1 m^3	760,200 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	140 m^2	350,000 Rs	Unit rate is based on trial construction
Total				*1,110,200 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-PRE	Deck Slab	HI=30	(NO.Co-37)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	1.1 m^3	398,200 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	123 m^2	307,500 Rs	Unit rate is based on trial construction
Total				*705,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-PRE	Deck Slab	HI=69	(NO.Co-38)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.2 m^3	72,400 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	53 m^2	132,500 Rs	Unit rate is based on trial construction
Total				*204,900 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-POS,RCS-RCB	Main Beam	HI=0	(NO.Co-39)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.8 m^3	289,600 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	244 m^2	610,000 Rs	Unit rate is based on trial construction
Total				*899,600 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-POS,RCS-RCB	Main Beam	HI=29	(NO.Co-40)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.5 m^3	181,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	24 m^2	60,000 Rs	Unit rate is based on trial construction
Total				*241,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-POS,RCS-RCB	Deck slab	HI=0	(NO.Co-41)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	4.6 m^3	1,665,200 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	193 m^2	482,500 Rs	Unit rate is based on trial construction
Total				*2,147,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-POS,RCS-RCB	Deck slab	HI=89	(NO.Co-42)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.05 m^3	18,100 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	113 m^2	282,500 Rs	Unit rate is based on trial construction
Total				*300,600 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-POS,RCS-RCB	Deck slab	HI=30	(NO.Co-43)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	2.5 m^3	905,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	266 m^2	665,000 Rs	Unit rate is based on trial construction
Total				*1,570,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-POS,RCS-RCB	Diaphragm	HI=0	(NO.Co-44)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.4 m^3	144,800 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	244 m^2	610,000 Rs	Unit rate is based on trial construction
Total				*754,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		PSC-POS,RCS-RCB	Diaphragm	HI=29	(NO.Co-45)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.2 m^3	72,400 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	244 m^2	610,000 Rs	Unit rate is based on trial construction
Total				*682,400 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		-	Substructure	HI=29	(NO.Co-46)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.5 m^3	181,000 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*181,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Grouting		-	Substructure	HI=0	(NO.Co-47)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Grouting	362,000 Rs/m^3	0.9 m^3	325,800 Rs	Unit rate is estimated by contractor
	Scaffolding	2,500 Rs/m^2	0 m^2	0 Rs	Unit rate is based on trial construction
Total				*325,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		PSC-PRE	Deck Slab	HI=0	(NO.Co-48)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	26.3 m^2	2,025,100 Rs	Unit rate is estimated by contractor 2Layer
Total				*2,025,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		PSC-PRE	Deck Slab	HI=29	(NO.Co-49)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	18.4 m^2	1,416,800 Rs	Unit rate is estimated by contractor 2Layer
Total				*1,416,800 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		RCS	Deck Slab	HI=0	(NO.Co-50)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	8.8 m^2	677,600 Rs	Unit rate is estimated by contractor 2Layer
Total				*677,600 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		RCS	Deck Slab	HI=29	(NO.Co-51)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	6.3 m^2	485,100 Rs	Unit rate is estimated by contractor 2Layer
Total				*485,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		PSC-POS,RCS-RCB	Main Beam	HI=0	(NO.Co-52)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	63.5 m^2	4,889,500 Rs	Unit rate is estimated by contractor 2Layer
Total				*4,889,500 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		PSC-POS,RCS-RCB	Main Beam	HI=29	(NO.Co-53)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	46.8 m^2	3,603,600 Rs	Unit rate is estimated by contractor 2Layer
Total				*3,603,600 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		PSC-POS,RCS-RCB	Deck slab	HI=0	(NO.Co-54)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	58 m^2	4,466,000 Rs	Unit rate is estimated by contractor 2Layer
Total				*4,466,000 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		PSC-POS,RCS-RCB	Deck slab	HI=29	(NO.Co-55)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	41.1 m^2	3,164,700 Rs	Unit rate is estimated by contractor 2Layer
Total				*3,164,700 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		PSC-POS,RCS-RCB	Diaphragm	HI=0	(NO.Co-56)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	30.2 m^2	2,325,400 Rs	Unit rate is estimated by contractor 2Layer
Total				*2,325,400 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		PSC-POS,RCS-RCB	Diaphragm	HI=29	(NO.Co-57)
Items		Unit Rate	Quantity	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	19.7 m^2	1,516,900 Rs	Unit rate is estimated by contractor 2Layer
Total				*1,516,900 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		Box bridge	-	HI=0	(NO.Co-58)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	6.5 m^2	500,500 Rs	Unit rate is estimated by contractor 2Layer
Total				*500,500 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		Box bridge	-	HI=29	(NO.Co-59)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	3.9 m^2	300,300 Rs	Unit rate is estimated by contractor 2Layer
Total				*300,300 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		Substructure	-	HI=29	(NO.Co-60)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	8.8 m^2	677,600 Rs	Unit rate is estimated by contractor 2Layer
Total				*677,600 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Fiber sheet bonding		Substructure	-	HI=0	(NO.Co-61)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor, Material	Fiber sheet bonding	77,000 Rs/m^2	11.3 m^2	870,100 Rs	Unit rate is estimated by contractor 2Layer
Total				*870,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Repair the Scouring part		-	Substructure	HI=0	(NO.Fu-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Packing available rubble and aggregate filter layers behind m ansory walls	880 Rs/m^3	0.9 m^3	800 Rs	Unit rate is extracted from HSR(ST1-011)
	Random rubble masonry,150-225MM	930 Rs/m^3	0.9 m^3	900 Rs	Unit rate is extracted from HSR(B0-301)
	MIXING & LAYING ,CONCRETE MIXER	11,500 Rs/m^3	0.9 m^3	10,400 Rs	Unit rate is extracted from HSR(ST1-045)
Total				*12,100 Rs*	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Mortar spraying		Arch bridge	Arch Rib	HI=0	(NO.Ar-1)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Mortar spraying	21,000 Rs/m^3	16.4 m^3	344,400 Rs	Unit rate is extracted from HSR(ST1-011)
	Reinforcing steel	104,200 Rs/t	1.2 t	125,100 Rs	Unit rate is extracted from HSR(B0-301)
	CUTTING & LAYING REINFORCEMENT	165 Rs/m^2	65.7 m^2	10,900 Rs	Unit rate is extracted from HSR(ST1-056)
	Anchor	2,200 Rs/nos	81 nos	178,200 Rs	Unit rate is extracted from Japanese standard
	Scaffolding	2,500 Rs/m^2	42 m^2	105,000 Rs	Unit rate is based on trial construction
Total				763,600 Rs	

Repair / Strengthening method		*Type of bridge*	*Member*	*Health Index*	*Code number*
Mortar spraying		Arch bridge	Arch spandrel	HI=0	(NO.Ar-2)
Items		Unit Rate	Quantity (Duration)	Total Cost	NOTE
Equipment, Labor and Material	Mortar spraying	21,000 Rs/m^3	10.6 m^3	222,600 Rs	Unit rate is extracted from HSR(ST1-011)
	Reinforcing steel	104,200 Rs/t	1.4 t	145,900 Rs	Unit rate is extracted from HSR(B0-301)
	CUTTING & LAYING REINFORCEMENT	165 Rs/m^2	42.2 m^2	7,000 Rs	Unit rate is extracted from HSR(ST1-056)
	Anchor	2,200 Rs/nos	52 nos	114,400 Rs	Unit rate is extracted from Japanese standard
	Scaffolding	2,500 Rs/m^2	52 m^2	130,000 Rs	Unit rate is based on trial construction
Total				619,900 Rs	

Attachment 5 - Standard Unit Rate for Bridge Reconstruction

Table of Contents

List of Tables

1. General

Standard unit rate for bridge reconstruction set based on RDA's previous reconstruction record.

In this unit rate includes Preliminaries, General, and Removal of existing structures, Superstructure, Substructure, Foundation and Miscellaneous structure cost.

Overhead, Profit, Contingencies for physical and price, Tax are not included.

2. Standard unit rate for reconstruction

Standard unit rate for reconstruction set 2 types. The bridges whose length is less than 10m and more than 10m.

The standard unit rate for bridge reconstruction are shown in following table.

Table 1 Standard unit rate for reconstruction

Length of bridge	Type of bridge	Unit rate (Rs / m^2)	Referenced previous reconstruction record
L < 10m	Cast in place	169,000	A101C–BOQ–3/30, A169–BOQ – 2/5, A138–BOQ–26/11, G03F–BOQ–11/5
L ≧ 10m	Precast	338,000	A244A–BOQ–12/6, A241C–BOQ–7/1, E042B-BOQ

Table 2 Basis of standard unit rate for bridge reconstruction (L<10m)

Number of BOQ	Type of Bridge	Dimensions of bridge			Summary of Bill						
		Length	Width	Area	Removal of Existing Structure	Foundation & Substructure	Super Structure	Miscellaneous Structure	Preliminaries & General	Total	Unit Rate (Rs/m^2)
A101CB0Q (3-3)	Box	10.4	10.4	108.2	500,000	8,463,095	3,118,717	500,000	1,640,000	14,221,812	131,500
A169CB0Q (2-5)	Box	8.9	10.4	92.6	500,000	8,911,091	2,841,045	500,000	1,640,000	14,392,136	155,500
A183CB0Q (26-11)	Box	6.0	10.4	62.4	800,000	10,167,547	2,987,349	1,000,000	3,690,000	18,644,896	298,800
G-03FBOQ (11-5)	Box	8.0	10.4	83.2	200,000	5,020,000	2,131,252	0		7,351,252	88,400
Average											169,000

Table 3 Basis of standard unit rate for bridge reconstruction (L≧10m)

Number of BOQ	Type of Bridge	Dimensions of bridge			Summary of Bill						
		Length	Width	Area	Removal of Existing Structure	Foundation & Substructure	Super Structure	Miscellaneous Structure	Preliminaries & General	Total	Unit Rate (Rs/m^2)
A244AB0Q-B363-12/6	PC	22.8	9.4	214.3	1,300,000	63,341,466	6,033,945	0	5,540,000	76,215,411	355,600
A241CBOQ - (7-1)	PC	7.1	13.7	97.4	1,000,000	32,938,102	3,709,599	0	5,615,000	43,262,701	444,200
E042BBOQ	PC	50.4	9.8	493.9	2,000,000	68,012,457	31,339,297	500,000	4,390,000	106,241,754	215,100
Average											338,000

*The rates are from RDA cost estimation / HSR 2016

Attachment 6 - Description and Examples in need of Emergency Actions

Table of Contents

List of Figures

When the damage in need of "Emergency Action" is detected during the bridge inspection, bridge inspection shall be interrupted and emergency actions must be implemented immediately. Then, for the damage implemented under "Emergency Action", the plan for the maintenance and repair should be developed.
This attachment describes the examples of damage in need of emergency action and the measures to be taken. "Emergency Action" is needed in view of "Impairing the Safety of Bridge Structures" and "Third-party Effect".

1. Impairing the Safety of Bridge Structures

Bridge structures might have collapsed or fallen down due to damage, which results in the decrease of load carrying capacity. Given below are examples of damage and recommended measures to be taken as an emergency action.

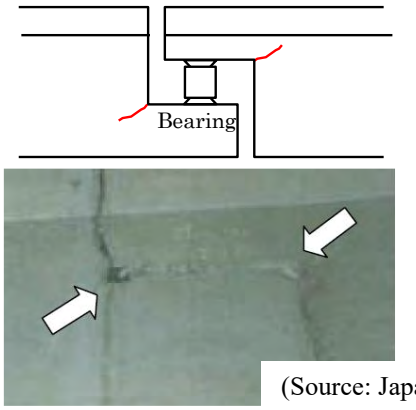
Shear Crack on Concrete

- Example of damage

Shear cracks (Main girder)

Shear crack (Gerber girder)

- Crack width is 0.3mm or more
- Penetrating



(Source: Japan)

Remarkable crack at pier or beam of substructure

Shear cracks on concrete would cause sudden failure of bridge structure without any signs in advance.

- Emergency action

Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed.

Other Damage on Concrete

- Example of damage

Bearing failure (remarkable crack) near support
(remarkable decreasing of function as bearing)

- Crack width is 0.3mm or more
- Impairing the bearing function

(Source: Japan)

Delamination in wide area of the deck slab / main beam with remarkable corrosion or break of rebar / PC cable.
(corrosion of rebar / PC cable will develop more quickly in coastal areas.)

- Ex-rebar with remarkable corrosion or broken re-bar, or delamination
- Damage on about 60% of its all area

The above damage might cause collapse of the bridge structure.

- Emergency action

Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed.

Corrosion and Break on Steel Member

- Example of damage

  Remarkable loss of structural steel (web in the photo) due to corrosion

  - Loss of web steel on its entire depth
  - Loss of lower flange steel by 50% or more
  - Near support

  Break of the diagonal member

  The damage such as those given above as well as remarkable corrosion of prestressing cables, panel points of truss / arch bridge and break of Gerber girder may cause the decrease of load carrying capacity.
  Remarkable loss of structural steel and break of the diagonal member might cause sudden collapse of the bridge structure.

- Emergency action

  Traffic restriction (lane regulation, bridge closure) should be implemented. Then, the temporary support with bents or saddles should be implemented as needed.

Rivet / HSFG on Steel Member

- Example of damage

  Damaged bolts, such as the serious corrosion and the missing of bolts, are about more than 25% of one bolt group and more in number

  It is difficult to transmit force between members due to the above damage.

- Emergency action

  Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed.

Bridge Bearing

- Example of damage

Remarkable loss of structural steel

(Source: Japan)

Falling down of a girder from roller bearing

(Source: Japan)

Remarkable damage of bearing seat mortar

(Source: Japan)

Bridge bearing has the function of supporting the vertical load. The damage above may decrease the vertical load carrying capacity as well as result in difference in levels on bridge surface.

- Emergency action

Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed.

Bridge Piers / Abutments in Water

- Example of damage

  Exposed foundation due to riverbed degradation and/or local scour

  ・ Scoured under footing of pier/abutment

There is a possibility of the unusual deflection and the collapse of a bridge due to riverbed degradation and local scour. Settlement / movement / tilting of substructures might occur at the same time.

- Emergency action

  Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed, and emergency foundation protection work with gabion box should be implemented.

Arch Line

- Example of damage

  Large deformation of the arch line at its crown

For the stone arch, it is quite important to retain the arch line as designed. Deformation of arch line will result in the entire collapse of the arch structure.

- Emergency action

  Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed.

Fatigue Crack on Steel Member
● Example of damage Fatigue cracks occur at Gerber support    (Source: Japan)
Fatigue crack at panel points of truss / arch bridge, stress concentration points such as Gerber support, as well as web of a main beam might cause sudden collapse of the bridge structure. In order to prevent such sudden collapse, emergency action is needed.
● Emergency action Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed.

Deflection, Settlement / Movement / Tilting of Substructure, Unusual Sound / Vibration
● Example of damage Unusual deflection   
Pier movement and settlement      Unusual deflection, sound and vibration may be the sign of settlement, movement or tilting of bridge piers and abutments, and others. When the settlement, movement or tilting of bridge piers and abutments are detected, emergency action shall be taken to prevent the collapse of bridge structure or to secure the safe passage of vehicles and pedestrian in case passage thereof is allowed.
● Emergency action Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed. Emergency action according to other damage should be implemented.

2. Third- Party Effect

When it is suspected that vehicles, trains and/or pedestrians under the bridge are adversely affected by the damage thereof, emergency actions shall be taken immediately. Examples of such damage as well as recommended measures are given below.

Figure 2.1 gives the range of the bridge, affecting the vehicles, trains and/or pedestrians thereunder and along thereof due to its damage.

In case that roads / railways under or along a bridge are not managed by RDA, it is imperative to report to the administrators thereof. Then, preventive measures such as traffic restriction (lane regulation, closure of road / railway) of roads under / along a bridge and installation of caution signs should be implemented as needed after the permission is given.

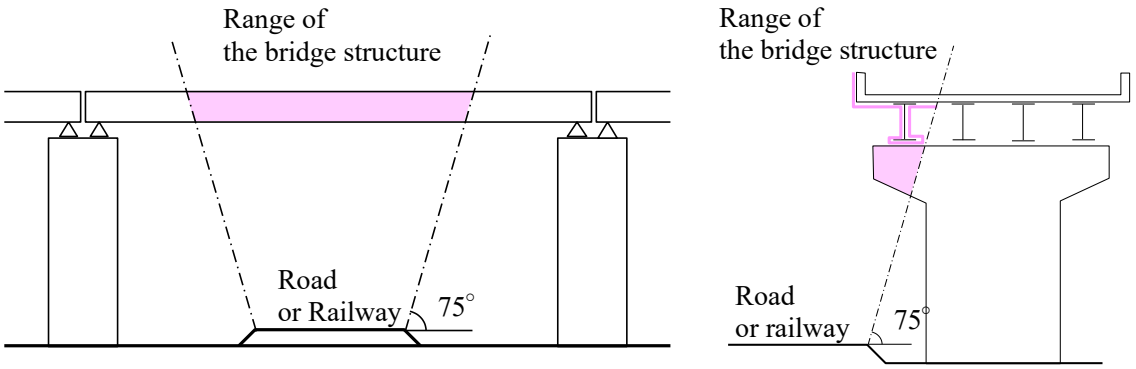


Figure 2.1 Range of Bridge Structure Affecting to Third-Party

Pavement

- Example of damage

Deep and large pothole

- Depth is 50mm or more
- Size is diameter o0.2m or more

Deep and large rutting

- Difference level is 30mm or more

(Source: Japan)

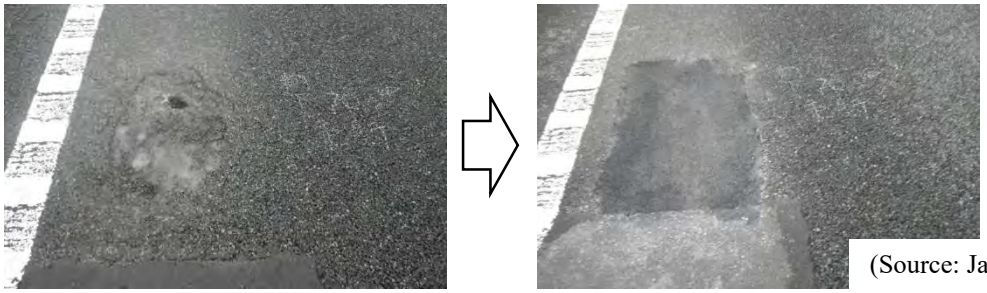
Deep and large waving

- Difference level is 30mm or more

Drivers of motor cycles could lose the steering control due to deep and large potholes / rutting / waving, and fall down. The wheels could get flat. These events might cause serious accidents causing serious injuries or even death.

- Emergency action

- Vehicles should be allowed to travel under traffic restriction (speed control).
- Filling with pavement mixture or partial replacement repairs should be implemented under traffic restriction (lane regulation).



(Source: Japan)

Filling of pavement mixture

Expansion Joint

- Example of damage

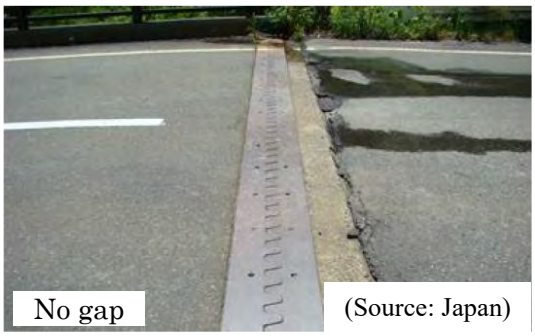
Loss of face plate of the steel finger expansion joint

Depression of pavement on buried joint

- Depth is 50mm or more

Unusual gap between girder end and ballast wall of abutment (i.e., no gap or very wide gap of finger joint)

- Unusual gap is 0.2m or more

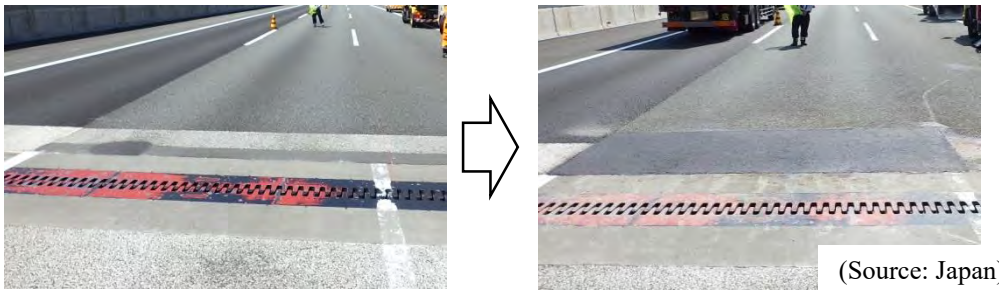


(Source: Japan)

The unusual gap could be caused due to settlement, movement and tilting of substructures.
Drivers of motor cycles could lose the steering control due to the above damage and fall down. The wheels could get flat. These events might cause serious accidents resulting in serious injuries or even death.

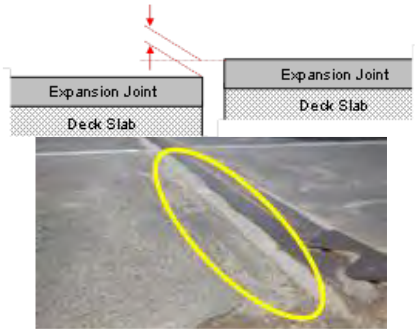
- Emergency action

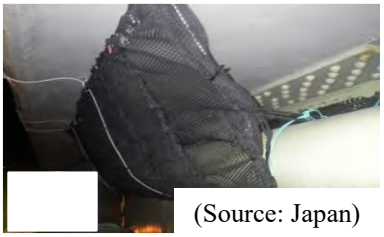
- Vehicles should be allowed to travel under traffic restriction (speed control).
- Filling with pavement mixture or partial replacement repairs should be implemented under traffic restriction (lane regulation).



(Source: Japan)

Partial replacement work

Difference in Levels
● Example of damage Difference in levels is large due to embankment settlement, repeated loads, or damage on expansion joint. ・ Difference level is 20mm or more      Drivers of motor cycles could lose the steering control due to large difference in levels, and fall down. The wheel could get flat. These events might cause serious accidents resulting in serious injuries or even death.
● Emergency action - Vehicles should be allowed to travel under traffic restriction (speed control). - Temporary slope with pavement mixture or iron plats should be implemented under traffic restriction (lane regulation)

Drainage
● Example of damage Holes of drain pipe      In Bridge Inspection and Diagnosis Manual, “Damage on Drainage” is evaluated whether there is sediment of soil at catch basin or drainage pipe. However, other damage on drainage could cause the following obstacles; - The splash of water from holes of drain pipe could damage bridge structures / vehicles / trains, or harm pedestrians. - Falling of pipe / bolts due to damage of installation bolts could damage vehicles / trains or harm pedestrians. When the drainage facilities do not function properly due to sediment of soil at catch basin or drainage pipe, ponding could occur on bridge surface. Drivers of motor cycles could lose the steering control due to ponding and fall down. This event might cause serious accidents resulting in serious injuries or even death.
● Emergency action When the “Third-Party Effect” is suspected, this situation should be reported to the administrators who manage the roads / railways under a bridge. Then, preventive measures, such as traffic restriction (lane regulation, closure of road / railway) of roads / railways under a bridge and installation of caution signs, should be implemented as needed after the permission is given. In addition, repair works of drainage pipe and temporary fixing of drainage pipe should be implemented.    (Source: Japan)

Railing / Parapet
● Emergency action Missing, break, and large deformation of railing / parapet         There is a possibility that vehicles and pedestrians will fall from the bridge due to missing or break of railing / parapet.
● Emergency action Installation of caution signs and traffic restriction (lane regulation) shall be conducted so that the vehicles and pedestrians are restricted in approaching. Then, temporary railing should be installed.

Approach Road / River Bank
● Example of damage Large collapse of approach road / riverbank that causes the depression and crack of road surface      Drivers of motor cycles could lose the steering control due to depression of road surface and fall down. Vehicles and pedestrians could fall from approach road. These events might cause serious accidents resulting in serious injuries or even death.
● Emergency action Installation of caution signs and traffic restriction (lane regulation) shall be conducted so that the vehicles and pedestrians are restricted in approaching. Then, repair with sandbags and/or gabion boxes should be implemented.

Fallen Objects

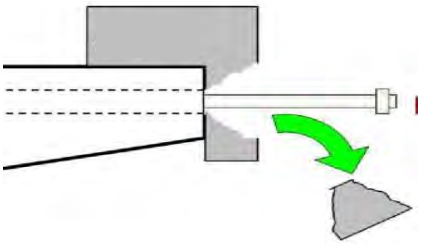
- Example of damage

  Delamination

  (Delamination might have resulted from the development of concrete crack.)

  Falling down of a concrete block from the deck slab

  Falling of anchorage cover concrete due to ruptured tendon



- Emergency action

  Inspectors should knock off the damage section to prevent “Third-Party Effect” if they detect delamination. In addition, rust prevention treatment should be implemented if Ex-rebar is detected exposed.
  When the “Third-Party Effect” is supposed, this situation should be reported to the administrators who manage the roads / railways under a bridge. Then, preventive measures, such as traffic restriction (lane regulation, closure of road / railway) of roads / railways under a bridge and installation of caution signs, should be implemented as needed after the permission is given.

  In case of ruptured tendon, there is a possibility of the loss of a structural integration as a deck slab. Traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed.

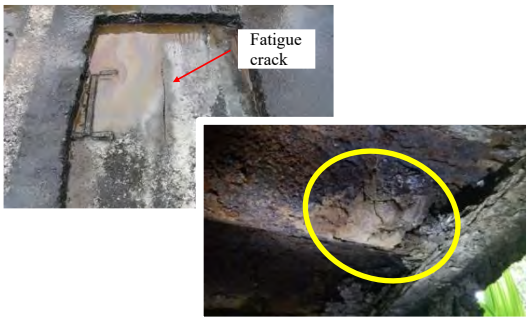
Damage on Deck Slab

- Example of damage

Large cracks

Falling down of a concrete block from the deck slab

Severe damage of steel deck slab, such as large crack and large loss of structural steel



This damage would cause the depression of road surface. Drivers of motor cycles could lose the steering control due to depression of road surface and fall down. The wheel could get flat. These events might cause serious accidents resulting in serious injuries or even death.
It could damage vehicles or harm pedestrians under / near a bridge due to the fall of a concrete block from the deck slab.

When the serious damage is detected on one or more of the main beams, excess load might be distributed to other main beams / members. This could result in the collapse of the bridge.

- Emergency action

Traffic restriction (lane regulation, bridge closure) should be implemented, or iron plates should be set on road surface and vehicles should be allowed to travel under traffic restriction (speed control) as needed.

Furthermore, in case there is a possibility of collapse of a bridge, traffic restriction (lane regulation, bridge closure) should be implemented. Then, a bridge should be supported temporarily with bents or saddles as needed.

Attachment 7 - Examples of Bridge Diagnosis

Table of Contents

List of Tables

List of Figures

List of Photographs

Bridge inspection is implemented to collect the necessary data and information for efficient and effective bridge management within the limited human and financial resources. Data and information to be collected are condition of the bridges, which should be the quantified value for comparison among the bridges (not an absolute value).

In this Manual, quantified value of Health Index (HI) is introduced to express the soundness of bridge member, a span and an entire bridge based on the objective evaluation of damage obtained from the inspection.

Health Index (HI) is calculated for each member first, followed by for a span based on the HIs of bridge members and degree of importance of each bridge member to a span (weighting factor / correlation factor), and for an entire bridge for bridges with several spans. Details shall refer to Appendix (Guideline of Calculation of Health Index).

Health Index (HI) is used to prevent variations of the soundness among the inspectors / evaluators and to calculate the repair and maintenance costs for developing the bridge repair and maintenance plan.

Thereafter, soundness of the bridge member, a span and an entire bridge are categorized into four (4) classifications in order that the road administrator can generally understand the condition of bridges under its management and utilize it as a convenient indicator for releasing the bridge conditions to the public.

It is noted, however, that Health Index (HI) does neither consider all types of damage on each bridge member and rate of progress of damage, nor include the influence of location of damage to the soundness of the bridge member, a span and an entire bridge.

Therefore, highly experienced experts within RDA shall review and change the bridge soundness classification of a span (not of a bridge member) determined by Health Index from the viewpoints of shortcomings of HI mentioned above (hereinafter called “Bridge Diagnosis”) at the end of bridge periodic inspection. The value of Health Index shall not be changed.

This Appendix provides the examples for the RDA experts to carry out the Bridge Diagnosis.

1. Concrete

1.1 Classification C

This section provides the types and degree of damage that might impair the structural safety of an entire bridge and need to be repaired before the next periodic inspection (within 5 years).

If the types of damage with the degree thereof given below are detected at the periodic inspection, soundness of an entire bridge should be classified as “C”, regardless of the bridge soundness classification determined by Health Index (HI).

Spall / Dela / Ex-rebar(No,12), Concrete Crack (No.13)	
	● Delamination on main concrete beam / slab to a large extent When the main concrete members have the delamination relatively to a large extent with the reinforcing steels exposed, it is suspected that steels in concrete may be seriously corroded. Such damage may impair the structural safety of an entire bridge shortly.
	● Large crack on main concrete beam / slab When the main concrete members have cracks with large surface width, it is suspected that steels in concrete are extensively corroded, resulted in the decrease of load carrying capacity.
 (Source: Japan)	● Crack with water leakage on concrete structure When the concrete structures have cracks with water leakage widespread, it is supposed that concrete will deteriorate earlier near such cracks than other areas. Such damage will impair the structural safety of an entire bridge.

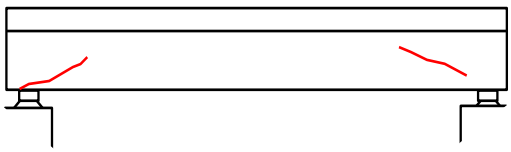
Damage on Deck Slab (RC) (No.22-1)	
	● Pattern cracking on bridge deck slab Deck slab has a function of distributing the loads among the main beams. When the serious pattern cracking / map cracking (in both longitudinal and transversal directions) is observed on deck slab, it is suspected that excess load is delivered to a main beam due to the degradation of such load distribution function and damages the said beam. It will impair the structural safety of an entire bridge.
	● Penetrating crack on concrete main beam / slab When the penetrating crack(s) are detected on main concrete beams / slabs, load carrying capacity thereof will be decreased. It is suspected that excess load is delivered to other main beams / parts causing damages to the said beams / parts. It will impair the structural safety of an entire bridge.

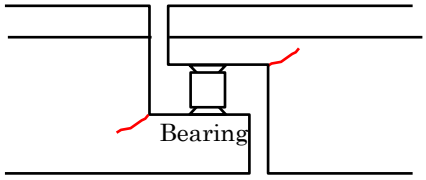
1.2 Classification D

This section provides the type and degree of damage that might impair the structural safety of an entire bridge and need to be repaired immediately (within one year).

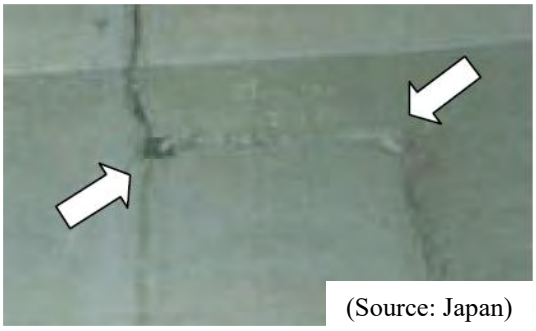
If the types of damage with the degree thereof given below are detected at the periodic inspection, soundness of an entire bridge should be classified as “D”, regardless of the bridge soundness classification determined by Health Index (HI).

Spall / Dela / Ex-Rebar (No. 12)	
	● Delamination on main beam / slab When the main concrete members have the delamination extensively with the reinforcing steels exposed, the break of the steels is suspected, which might have resulted in the decrease of load carrying capacity.

Concrete Crack (No.13) – Superstructure -	
 (Source: Japan)	● Bearing failure at support of main beam Concrete beams near the support have remarkable cracks due to the bearing failure, which may result in the decrease of bearing capacity. Such damage will impair the structural safety of an entire bridge and lead to a bridge collapse.
 Shear cracks diagonally developed near supports.	● Shear cracks on main beam In general, concrete structures are designed to ensure that flexural failure will occur before the shear failure. Shear cracks will result in shear failure which can occur suddenly without warning and is more dangerous than flexural failure.



Shear cracks diagonally developed locally by concentration of stress.



(Source: Japan)

- Shear crack on Gerber beam

  In general, concrete structures are designed to ensure that flexural failure will occur before the shear failure.

  Shear cracks will result in shear failure which can occur suddenly without warning and is more dangerous than flexural failure.

Concrete Crack (No.13) – Substructure -

- Shear cracks on substructure

  Shear cracks are detected on the body wall / column or beam of the pier and abutment.

  Shear cracks will result in shear failure which can occur suddenly without warning and is more dangerous than flexural failure.

1.3 Other points to consider

(1) Features of the rate of progress of steel corrosion caused by salt damage and carbonation

It is the reference to judge the rate of corrosion progress caused by the salt damage and carbonation.

Table 1.1: Rate of Corrosion Progress caused by Salt Damage and Carbonation

	Salt Damage	Carbonation of Concrete
Region	Coastal areas	All regions
Factor	Chloride ion	Carbon dioxide
Time corrosion occurs	After 20 - 40 years	After 50 years or more
Rate of corrosion	Rapid	Slow
Example Photo		

(2) Unsupported RC deck slab by additional new beam

There are some strengthening works with additional new beam(s) in Sri Lanka.

It was identified that some such bridges have additional new beams which do not support / integrate with deck slab. Unsupported deck slab might be damaged easily.

Photo 1.2 Unsupported RC Deck Slab

(3) Substructure on soft ground

Crack and displacement of the abutment wing on soft ground is frequently found due to settlement of the abutment foundation. This damage is found in lagoons and other places in soft ground.

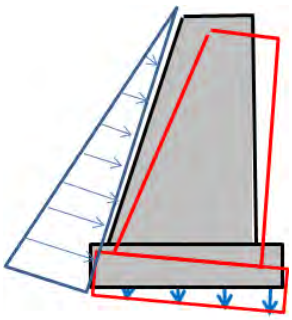


Figure 1 Example of Damage of Wing Wall

2. Steel

2.1 Classification C

This section provides the types and degree of damage that might impair the structural safety of an entire bridge and need to be repaired before the next periodic inspection (within 5 years).

If the types of damage with the degree thereof given below are detected at the periodic inspection, soundness of an entire bridge should be classified as “C”, regardless of the bridge soundness classification determined by Health Index (HI).

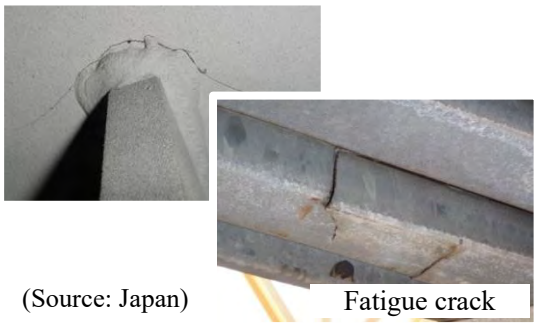
<table>
<tr><th colspan="2">Corrosion (No.20)</th></tr>
<tr><td>


Damage on lower flange

Hole
on the web

Damage on Truss
</td><td>
● Serious extensive corrosion and local loss of structural steel
● 30% or more of the lower flange steel has been lost.
● Steel web has been lost on one-third or more of its depth.
● For the truss bridge, 20% or more of steel of its diagonal / vertical member or chord has been lost.
With the loss of structural steels above, load carrying capacity will be decreased. It will impair the structural safety of an entire bridge.
</td></tr>
<tr><td>

</td><td>
● Unusual corrosion on galvanized coating with local loss of structural steel
It is suspected that load carrying capacity might be decreased, It will impair the structural safety of an entire bridge.
</td></tr>
</table>

Damage on Deck Slab (Steel) (No.22-2)	
 (Source: Japan) Fatigue crack  Fatigue crack	● Crack on deck slab steel Deck slab has a function of distributing the loads among the main beams. When the cracks are detected on deck slab steel, it is suspected that excess load is delivered to a main beam due to the degradation of such load distribution function that damages the said beam. It will impair the structural safety of an entire bridge.
 Large loss of structural steel	● Damage on steel deck slab When the loss of steel of deck slab is detected to a large extent, it is suspected that excess load is delivered to a main beam due to the degradation of load distribution function that damages the said beam. It will impair the structural safety of an entire bridge.

Crack	
 (Source: Japan)	● Crack on Steel Member with little influence on load carrying capacity When the crack is detected on main steel member, it is suspected load carrying capacity might be decreased.

2.2 Classification D

This section provides the type and degree of damage that might impair the structural safety of an entire bridge and need to be repaired immediately (within one year).

If the types of damage with the degree thereof given below are detected at the periodic inspection, soundness of an entire bridge should be classified as “D”, regardless of the bridge soundness classification determined by Health Index (HI).

Corrosion (No.20)	
	● Loss of web steel on its entire depth ● Loss of lower flange steel by 50% or more. Remarkable loss of structural steel might cause sudden collapse of the bridge structure.
	● Break of diagonal members of truss ● For the truss bridge, 40% or more of steel of its diagonal / vertical member or chord has been lost. Break of the diagonal member might cause sudden collapse of the bridge structure.

Damage (Rivet / HSFG) (No.21)	
	● 25% or more of the bolts in number in one group are seriously corroded or missed It is difficult to transmit the force between members due to the above damage. As the result, this damage might cause sudden collapse of the bridge structure.

Fatigue Crack	
 (Source: Japan)	● Fatigue crack at Gerber support Fatigue crack at panel points of truss / arch bridge, stress concentration points such as Gerber support, as well as web of a main beam might cause sudden collapse of the bridge structure.

2.3 Other points to consider

(1) Fatigue crack on steel deck slab

In order to draw your attention at the bridge inspection, the below provides the locations where fatigue cracks may occur on steel deck slab as in Figure 2.1.

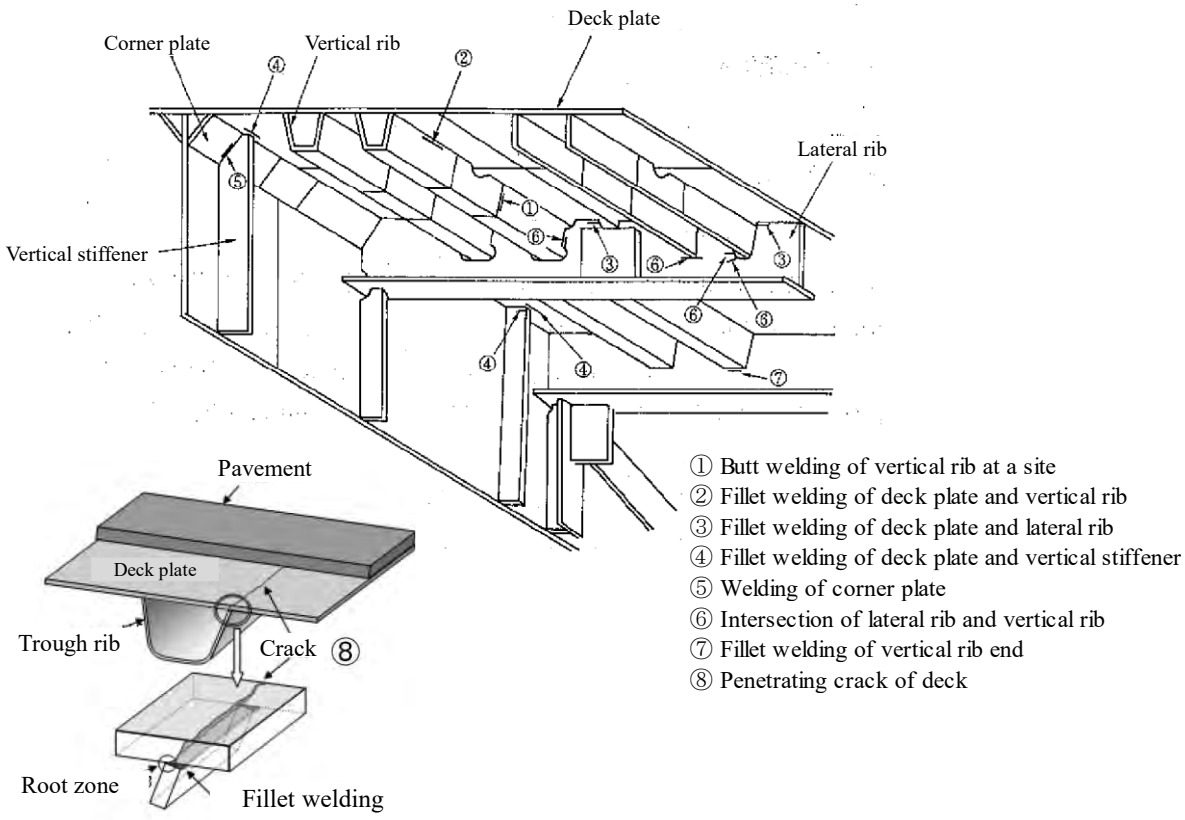


Figure 2.1 Crack in deck slab (Steel)

(2) Fatigue crack at sole plates

Bridge bearing has the functions to provide the rotation of a beam by live load, transfer of the horizontal load to the substructure, smooth movement of a beam by expansion and contraction arising from the variation in temperature.

When these functions do not exhibit efficiency due to the corrosion of steel bearings, fatigue cracks could occur at the welding part of sole plates. These cracks will develop rapidly from the lower flange to the web.

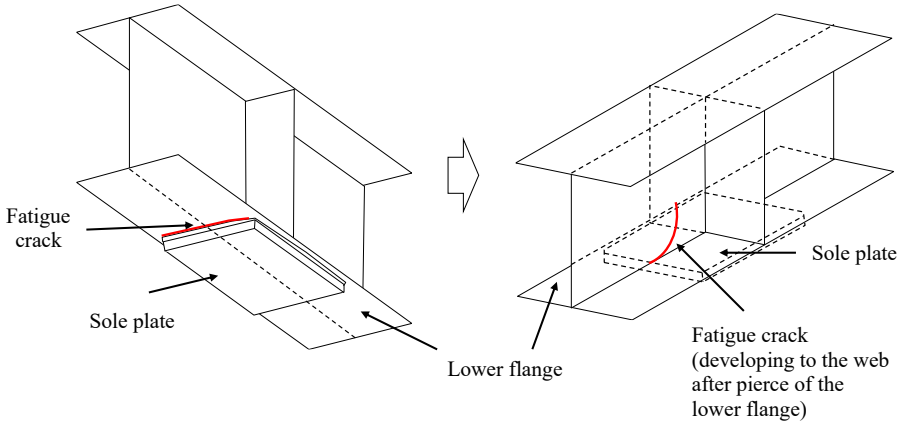


Figure 2.2 Fatigue Crack at the Welding Part of Sole Plates

(3) Half-through bridge

In Sri Lanka, most of the steel truss bridges are “half-through bridge” type. The part above the deck slab is properly maintained in general, such as cleaning or repainting. Engineers should pay attention to the conditions of truss members below the deck slab

Photo 2.1 Half –through Bridge

(4) Truss members buried in concrete

When such steel truss members as diagonal / vertical members are embedded in concrete (concrete deck slab, for example), steels in concrete will be rapidly damaged with the following reasons:

- Corrosion by repetitive wet and dry conditions
- Local force due to restriction of deformation of such member by concrete

The damage above will impair the structural safety of an entire bridge.

(5) Galvanized coating

On the surface of the steel material, the galvanized coating forms a zinc layer that functions as a zinc passive film to prevent the corrosion. It has a long-term durability in ordinary environments.

There are many galvanized steel bridges along the coast in the eastern and northern areas of Sri Lanka. In the coastal areas, chloride ions that adhere to the surface of galvanized coating corroded the zinc, and this corrosion develops rapidly from the surface layer to the base layer. Photo 2.1. Shows the example of a steel bridge galvanized in Sri Lanka after approximately 10 years from its completion. The zinc layer has decreased and the bare steel substrate is exposed in this photo. The painting over the galvanized coating is the effective measure in order to reduce the progress of the corrosion.

Photo 2.2 Example of Corrosion of Galvanized Coating in Sri Lanka

(6) Weather conditions in Sri Lanka

Figure 2.3 shows that corrosion of steel material occurs in the atmosphere which humidity exceeds 65%, and data shows that the amount of corrosion advances according to the humidity. The humidity in Colombo is shown in Figure 2.4. Due to the high humidity and temperature in the area around Colombo, it is believed that this represents a harsh environment for steel corrosion. It is also known that the speed of corrosion advances with repeated wet-dry cycles and the effects of dirt.

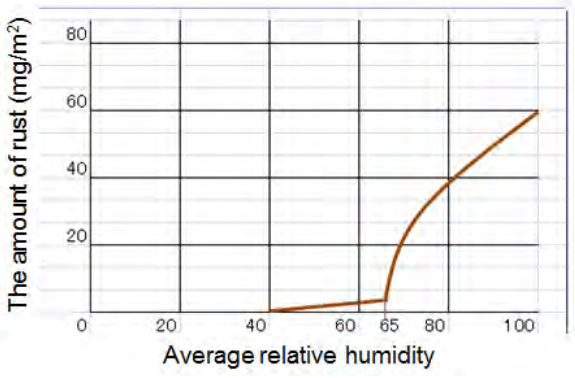


Figure 2.3 Relationship between steel corrosion and humidity

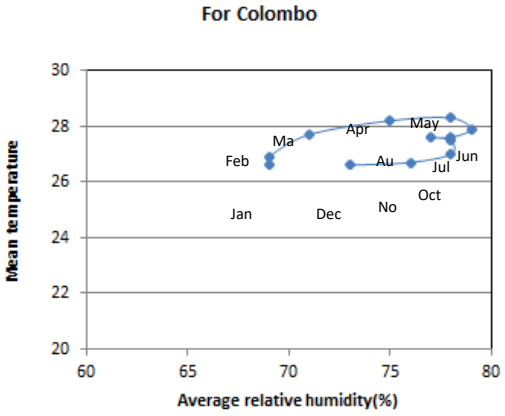


Figure 2.4 Colombo average monthly temp and humidity

3. Others

3.1 Classification C

This section provides the types and degree of damage that might impair the structural safety of an entire bridge and need to be repaired before the next periodic inspection (within 5 years).

If the types of damage with the degree thereof given below are detected at the periodic inspection, soundness of an entire bridge should be classified as “C”, regardless of the bridge soundness classification determined by Health Index (HI).

<table>
<tr><td colspan="2">Damage on Bridge Bearing (No.16)</td></tr>
<tr><td> 
(Source: Japan)</td><td>● Remarkable loss of structural steel on bridge bearing and main beam

Bridge bearing has the function of supporting the vertical load. The damage above may decrease the vertical load carrying capacity as well as result in difference in levels on bridge surface.</td></tr>
<tr><td> 
(Source: Japan)</td><td>● Fallen down of a beam from roller bearing

Bridge bearing has the function of supporting the vertical load. The damage above may decrease the vertical load carrying capacity as well as result in difference in levels on bridge surface.</td></tr>
<tr><td> 
(Source: Japan)</td><td>● Remarkable damage on bridge bearing seat mortar

Bridge bearing has the function of supporting the vertical load. The damage above may decrease the vertical load carrying capacity as well as result in difference in levels on bridge surface.</td></tr>
</table>

3.2 Classification D

This section provides the type and degree of damage that might impair the structural safety of an entire bridge which would need to be repaired immediately (within one year).

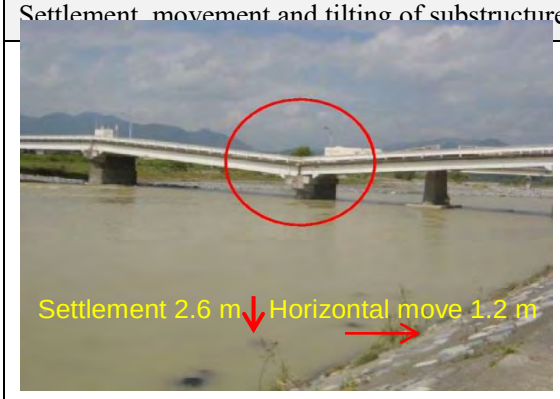
If the types of damage with the degree thereof given below are detected at the periodic inspection, soundness of an entire bridge should be classified as “D”, regardless of the bridge soundness classification determined by Health Index (HI).

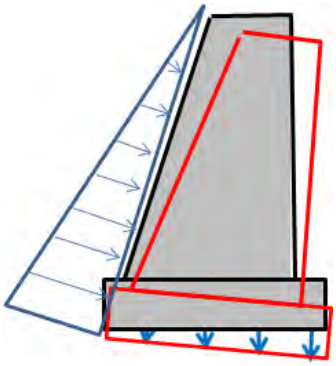
Scour (No.17)	
	● Exposed foundation due to riverbed degradation and/or local scour Unusual deflection and the collapse of a bridge might occur due to riverbed degradation and local scour. Settlement / movement / tilting of substructures might occur at the same time.

Arch Line (Displacement) (No.23), Deteriorated (Loose) ‘No.24)	
	● Large deformation of arch line at its crown For the stone arch, it is quite important to retain the arch line as designed. Deformation of arch line will result in the entire collapse of the arch structure.

Deflection	
	● Unusual deflection on an entire bridge Unusual deflection may be the sign of settlement, movement or tilting of bridge piers and abutments, and others.

Settlement, movement and tilting of substructures





Tilting of abutment on soft ground

- Settlement, movement or tilting of piers / abutments

  When the settlement, movement or tilting of bridge piers and abutments are detected, emergency action shall be taken to prevent the collapse of bridge structure.

  Thereafter, immediate permanent action shall be taken.

Unusual gap of expansion joint (No gap)

Shifted to the bridge-axis rectangular direction

3.3 Other points to consider

(1) Unusual sound and vibration

When the unusual sound and vibration occur due to passage of vehicles, it is suspected that bridges might have the following unusual conditions:

Unusual gap of expansion joint (No. 5), Large difference in levels (No.6), Break or lack of Railing / Parapet (N0.9), Large cracks on substructure or near supports (No. 13), Break of diagonal members of truss (No.20), Falling down of many bolts at a connection part (No.21), Cracks in deck slab (steel) (No.22-2), Unusual deflection

Attachment 8 - Method of Bridge Inspection by Bridge Inspection Vehicle

Table of Contents

List of Tables

List of Figures

List of Photographs

1. Purpose

Purpose of the bridge inspection methods described in this appendix is to collect necessary information for bridge management. It is for the same reason that the inspection methods were described in the bridge inspection and diagnosis manual. This appendix is a summary only of the important matters related to bridge inspection conducted by BIV.

This manual is an appendix to the “Bridge Inspection and Diagnosis Manual”.

For an inspection by BIV, it is important to conduct a preliminary investigation, to decide the need for the usage of BIV, and to collect necessary information for development of a plan for the inspection. It is also important to ensure safety management procedures during the inspection.

2. Planning of Inspection by BIV

2.1 Leader

Inspection by BIV must be carried out according to the instructions given by the leader of the inspection team. A leader should be appointed prior to the inspection.

It is necessary to appoint a leader of the inspection team for an inspection by BIV, because the inspection requires more management practices, than the inspection without the inspection vehicle. These practices include planning and implementation of traffic control and operation of BIV. The leader is going to conduct the following tasks:

1) Develop an inspection plan.
2) Inform the inspection plan to the staff, who will assist him/her, in order to conduct the inspection according to the prepared plan
3) Provide necessary instructions to the staff and supervise all matters during the inspection.

2.2 Development of Inspection Plan

The leader needs to develop an inspection plan after conducting a preliminary survey. The inspection plan is developed according to the format shown in Table 2.1.

The preliminary investigation is conducted mainly to study if the bridge could be inspected by BIV, and to develop an idea about the traffic control.

The following are the conditions of bridges that can be inspected by BIV:

1) The width of the carriageway is 3 meters or more（Note: A traffic closure will be required if it is one lane, however.）

2) The height from the girder to the ground is around 1.7 meters or more（Note: An inspection of outside beam can be conducted even where the height is less than 1.7m）
3) There are no overhead electric wires in the working range of BIV. (Note: There should be a distance of more than 1 meter, in case voltage of the electric wires is less than 600V)

The inspection plan includes the following contents:

1) General description of the bridge
2) Description of the surrounding environment
3) Inspection plan including the following:
    - Scheduled date of inspection, an optional extra day, time duration for the inspection.
    - Area range of the inspection
    - Steps taken for the inspection
    - Method of traffic control

Table 2.1 Format of Inspection Plan

Classification	Contents				
General description of the bridge	Province			Route No.	
	Bridge Length (m)			Overall Width(m)	
	Width of carriageway(m)			Width of Sidewalk(m)	
	Type of Superstructure			No. of Spans	
	No. of Main Beam			No. of Cross Beam	
	Distance from the bottom of the beam/deck to the ground		a.>1.7m, b. <1.7m ( ), Record measured values in ( )		
Surrounding environment	Electric wires	LHS		Starting and ending positions	–
		RHS		Starting and ending positions	–
	Telecommunication Cables	LHS		Starting and ending positions	–
		RHS		Starting and ending positions	–
	Existence of an intersection nearby				
	Others				
Inspection plan	Scheduled date of inspection			Date of preliminary inspection	
	Expected time to start and end the inspection				
	Starting and ending positions of the inspection	LHS	–		
		RHS	–		
	Steps for the inspection		⇒		
	Method of traffic control		a. Traffic control of 2-lanes (Alternate traffic control) b. Traffic control of 2-wide lanes (use of shoulder width) c. Traffic control of 4-lanes or more (1 lane closure) d. Road is closed e. Others		
	Sections and orders of traffic control, in case the traffic control area is divided		1st : – 2nd : – 3rd : – 4th : –		
	Discussion with traffic divisions of the relevant police stations				

2.3 Coordination with the Stakeholders

The leader will discuss with other departments of RDA, and consult with traffic divisions of the relevant police stations to arrange a suitable traffic control plan.

Coordination with EE offices is needed for effective coordination with the RDA.

It is recommended to consult the police for traffic control in the following instances

(a) When the road is closed.

(b) When traffic volume is large and traffic congestion is expected.

(c) When there is a cross-point near the traffic control area and traffic congestion is expected.

3. Safety Management

3.1 Introduction

An inspection by BIV needs the following safety measures adopted , in addition to the matters needed for normal inspection:

1) Conduct a safety meeting before commencing the work, and make sure tasks of each staff in traffic control and safety management are explained to them; and ensure inter personnel communication among the staff is properly laid down.
2) The staff members on the platform should always wear safety belts while at work**.**
3) The inspection must be suspended in case of bad weather conditions, especially during strong winds.

The safety meeting must make sure the roles of each staff member and communication method pertaining to the traffic control and inspection. It also needs to discuss about possible accidents, which might happen during the inspection. See the examples of possible accidents shown in the Reference.

3.2 Communication during the Inspection

The leader decides the method of communication during the inspection. He/she is going to provide instructions about commencement, suspension and completion of the inspection, and movement of BIV to each staff member. The leader also should ensure the method of communication to be followed by the inspection team and how signals should be given by the security staff to be assigned at the start- and end-points of the traffic control area.

Communication during the inspection by BIV will be conducted by using audio equipment installed in the vehicle. It is recommended that security staff assigned at the traffic control area use walkie-talkies to make sure smooth communication. In case if walkie-talkies are not available, discuss and decide an appropriate communication method, by using hand-held sign boards and other communication methods.

3.3 Monitoring of Traffic Controls during the Inspection

The leader needs to monitor movement of the security staff and, status of traffic control equipment, and take suitable measures if there are any improvements needed.

Improvement needed, for example, in case traffic cones are turned over, signals given by the security staff during stopping and then allowing vehicles to proceed along the bridge are not clear, and pedestrians will not be properly guided**.**

3.4 Securing Safety of Pedestrians

In the traffic control section, pedestrians need to bypass the traffic control area by walking on the sidewalk in opposite side or on a carriageway prepared at the side of the traffic control area. However, if the traffic volume is large and it is dangerous for them to cross the road, they are guided to walk on the sidewalk of the lane, in which the bridge inspection is carried out. When pedestrians travel under the boom of the BIV, it is necessary to stop moving the boom or platform of the vehicle or to ask them to wait until the work is over. Instruction for these arrangements need to be given by the leader of the inspection group.

4. Traffic control

4.1 Traffic Control Plan

The leader needs to prepare a traffic control plan by conducting a preliminary investigation of the bridge to be inspected and its surrounding environment. The length of traffic control area is determined according to the scope of bridge inspection (Figure 4.1). If the length of the bridge and that of traffic control area is long, communication between the security staff becomes difficult. In an instance, it is recommended to divide the range of inspection in to sections ranging from 20 to 30 meters, to shorten the length of traffic control area (Figure 4.2).

The method of traffic control varies depending on the inspection ranges and width configuration of the bridge. There are three types of traffic controls as follows: (1) 2-lane road, (2) 2-lane road with wide width, and (3) 4-lanes road (Fig.4.3 (1) - 4.3 (3).

Each figure shows the standard arrangement of traffic control equipment. The standard arrangement of equipment is shown in Table 4.1.

Table 4.1 Standard arrangement of traffic control equipment

Locations		Number of traffic control equipment
Locations of the security staff（Start and end points）		01 traffic cone
Taper	Start point	03 traffic cones
	End point	03 traffic cones
Boundary of the traffic control area and the carriageway		Traffic cones of 4 -5 meter-interval
On the sidewalk in-front and behind the BIV		02 traffic cones

Figure 4.1 shows typical relationship between the inspection range by BIV and the length of the traffic control.

Situation of completion for the traffic control

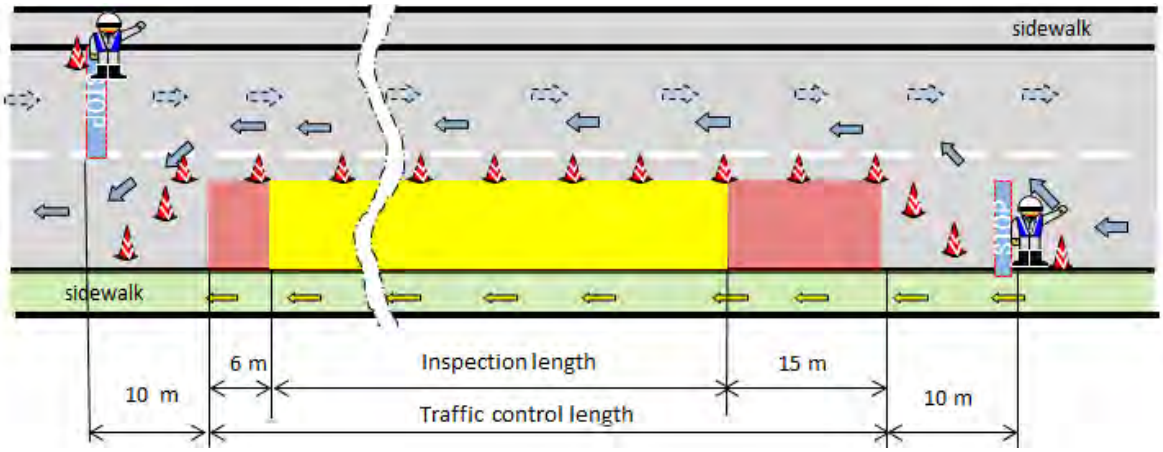
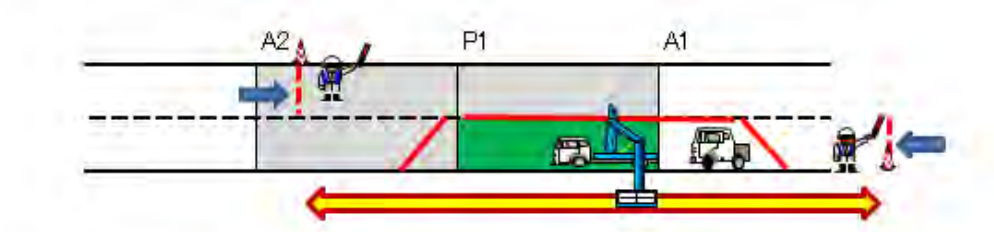


Figure 4.1 Relationship between traffic control and bridge inspection areas

1st (A1-P1 Inspection area)



2nd (P1-A2 Inspection area)

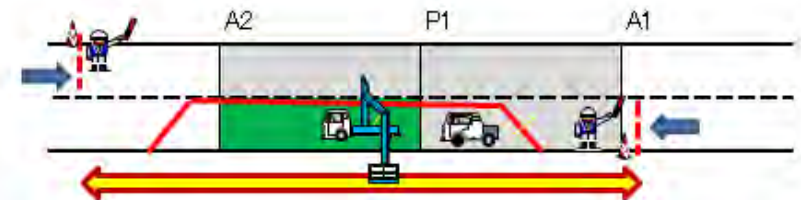


Figure 4.2 Example to divide and shorten the range of inspection, and make the length of traffic control shorter

Three patterns of traffic control are shown in the following figure 4.3

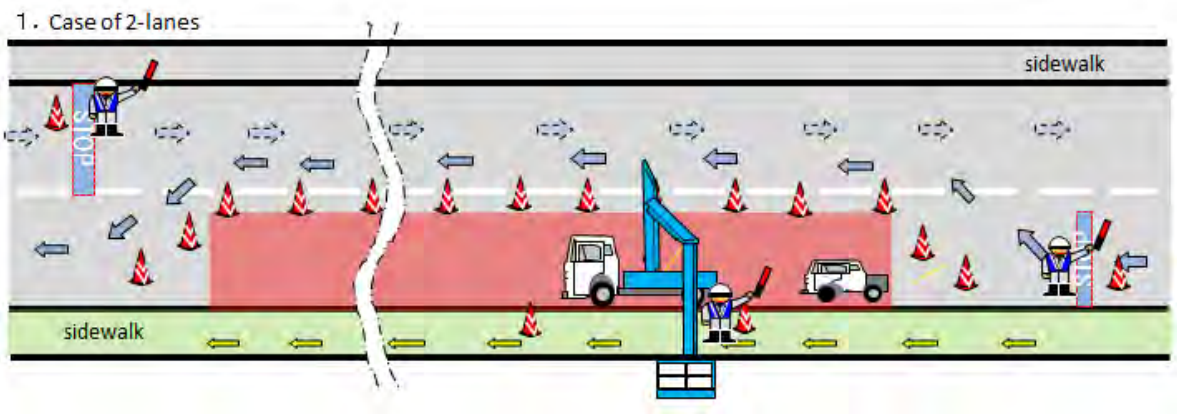


Figure 4.3(1) Traffic control of 2-lanes (Alternate Traffic Control)

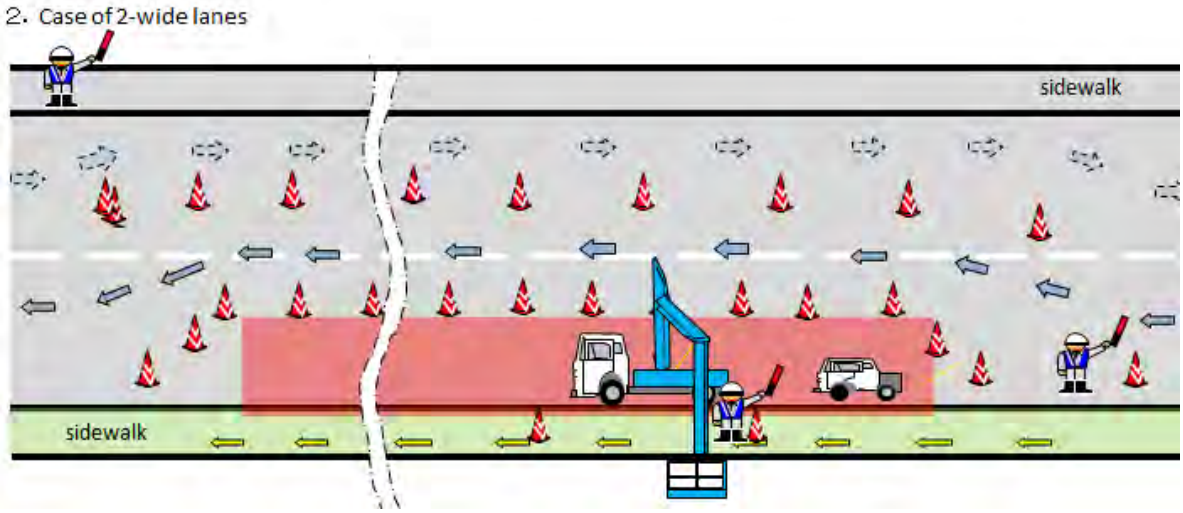


Figure 4.3(2) Traffic control of 2-wide lanes (Use shoulder width)

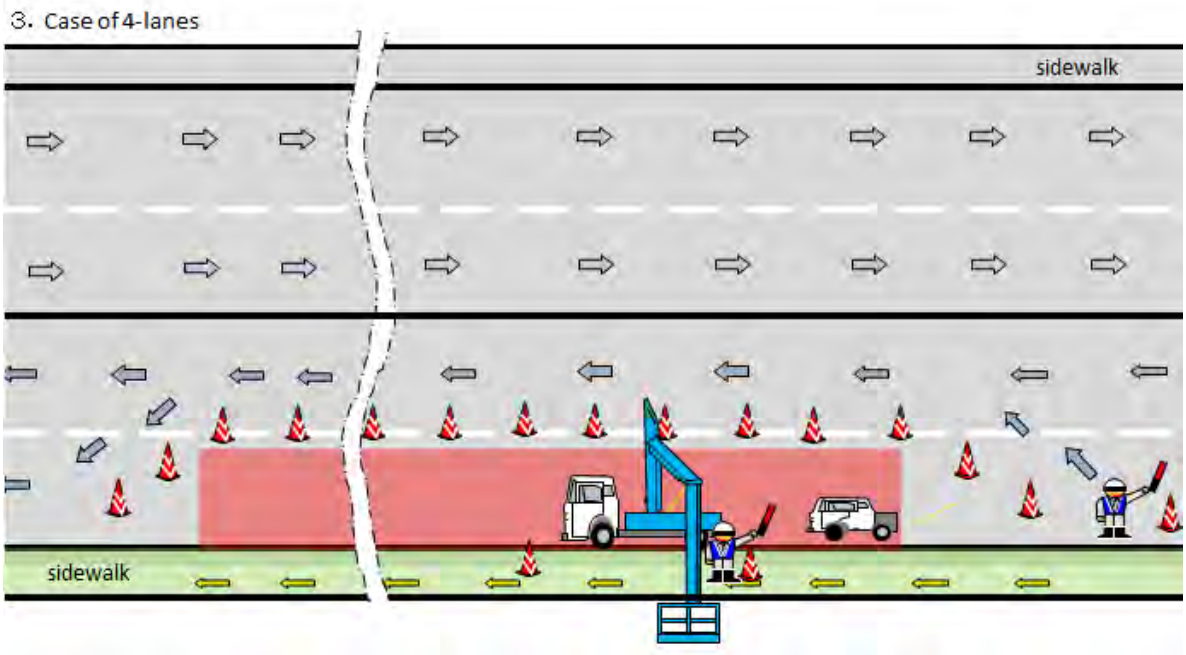
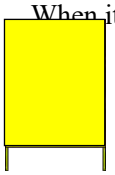


Figure 4.3(3) Traffic control of 4-lanes (1 lane closure)

4.2 Traffic Control Equipment

The traffic control equipment to be used is shown in the following Table 4.2. If regulated equipment is insufficient, it should be added to.

Table 4.2 Equipment or traffic control

Equipment	Quantity	Application
Signboards	2	 When it is judged necessary (Such as when the road is closed, or traffic congestion is expected.)
Traffic cones	25	
hand-held sign board and whistle, or flags & whistle	2	

4.3 Implementation of Traffic Control

1. Traffic control is conducted by controlling road vehicles, for ensuring safety of the vehicles and technicians working for the bridge inspection by BIV, and to ensure safety of the moving vehicles and pedestrians.
2. Organizational structure of the inspection team is described in the bridge inspection and diagnosis manual. Traffic control should be implemented promptly according to the instructions provided by the leader of the inspection team.

   The roles of each Member during the traffic control are shown in Table 4.3.

Table 4.3 The Roles of Each Staff Member During the Traffic Control

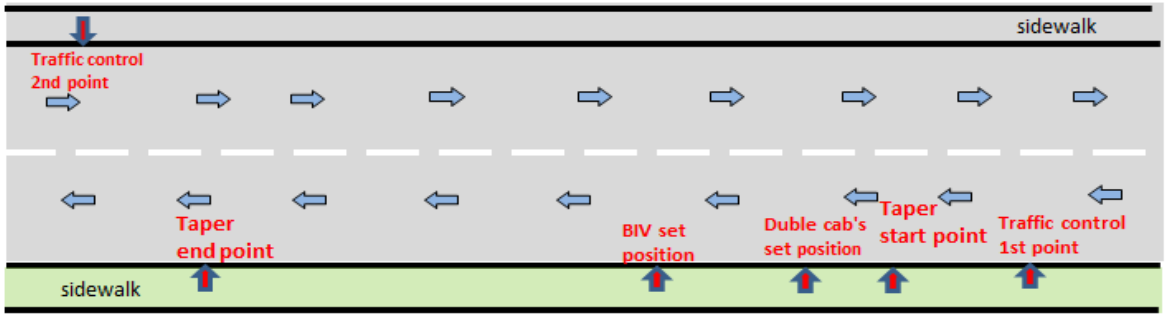
Category of staff	Necessary numbers	Roles and Responsibilities
Leader	01	i. The leader decides locations of the traffic control equipment and instructs placement and removal of them. ii. The leader instructs the BIV to enter the traffic control area. iii.The leader monitors status of the traffic control and instructs improvement when necessary.
Inspection staff	02	Before starting the traffic control, the inspection staff instructs security staff on the method of giving signals and communication among the staff, including method of stopping vehicles and allowing to travel on the road.
BIV (operator & driver)	02	i. The operator assists placement of the traffic control equipment. ii. The driver brings in the BIV into the traffic control area after completion of the traffic control arrangement.
Double cab(driver)	01	The driver transports the traffic control equipment. During the inspection, the driver watches tail of the BIV.
Traffic control security staff (Including vehicle)	04	i. Two security staff members undertake traffic control. One places traffic control equipment and gives safety guidance to the pedestrians once the traffic control arrangement is completed. ii. One of them assists the traffic control and work as a replacement member.

3. Table 4.4 shows the standard procedure for traffic control on a two-lane road. The procedure of traffic control and roles of staff members during the traffic control are shown in Figure 4.4 The procedure for removal of the equipment will be conducted in an opposite manner.

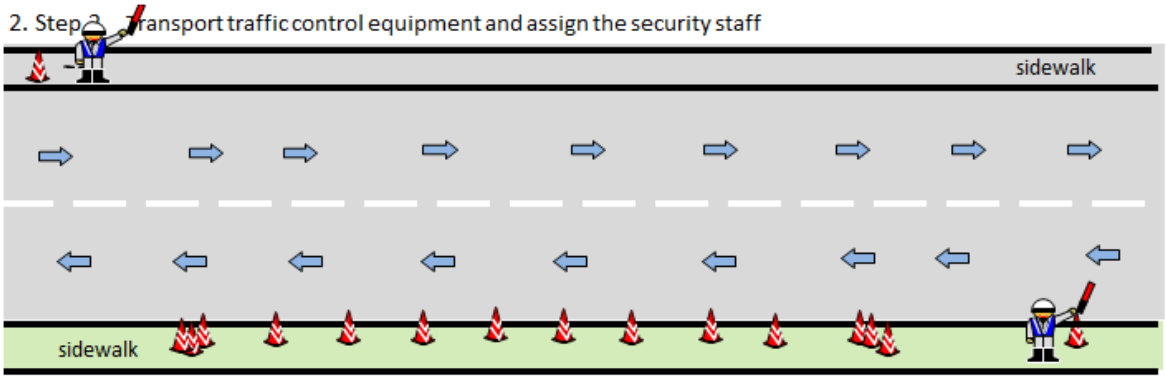
Table 4.4 Standard Procedure for Traffic Control

Steps	Work Items
1. Make sure traffic control area and locations of the vehicles	At the site of the traffic control, the leader firstly makes sure locations of the security staff in the traffic control area, location of the tapers, and initial locations of the BIV and the double cab. The double cab is placed around 7-meters behind the BIV.
2. Transport traffic control equipment and assign the security staff	Transport the traffic control equipment to the sidewalk, where they are supposed to be placed. Assign the engineer and a security staff at the start- and end-points, where road vehicles are stopped.
3. Entry of the vehicles into the designated location and commencement of traffic control	Bring the BIV and the double cab to the designated location according to the instructions of the leader. Once the vehicles begin moving, the engineer and the security staff place one of the traffic cones, which were already transported to the designated locations, stop the vehicles at the start-point and commence traffic control. The engineer gives necessary instructions to the security staff for the control of traffic. Park the double cab, in a way that its front wheels turned to left, and the rear wheels are chocked.
4.Place the safety tapers and commence the one-side traffic control	One of the security staff and operators quickly place tapers with traffic cones. Commence one-side traffic control after the placement of the tapers.
5. Placement of traffic cones at the boundary of the traffic control area and the carriageway	One of the security staff and the operator place traffic cones at 4 – 5 meter intervals commencing from the start-point. (Place traffic cones on the sidewalk in-front and behind the BIV)
6. Completion of the placement of the traffic control equipment	Complete the placement of the traffic control equipment by placing the safety taper at the end-point.
7. Commencement of bridge inspection	Commence the inspection. The leader provides necessary instructions and undertakes safety management. The security staff assigned at both ends of the traffic control area undertakes traffic control. The security staff assigned at the middle of the area undertakes giving guidance to the pedestrians.

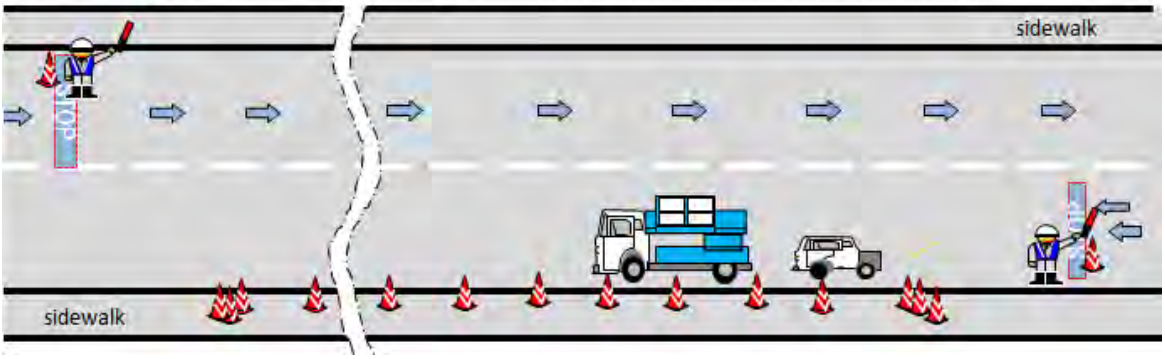
1.Step1 Make sure traffic control area and locations of the vehicles



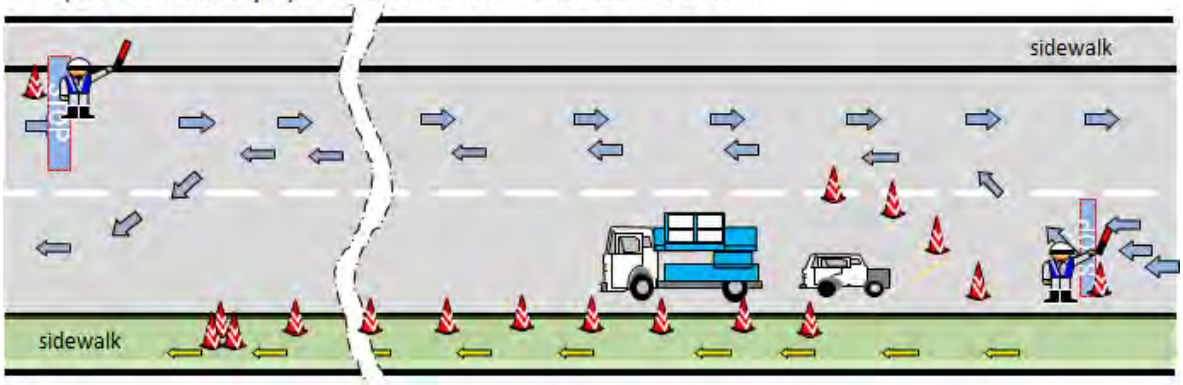
2. Step 2 Transport traffic control equipment and assign the security staff



3.Step 3 Entry of the vehicles into the designated location and commencement of traffic control



4..Step 4 Place the safety tapers and commence the one-side traffic control



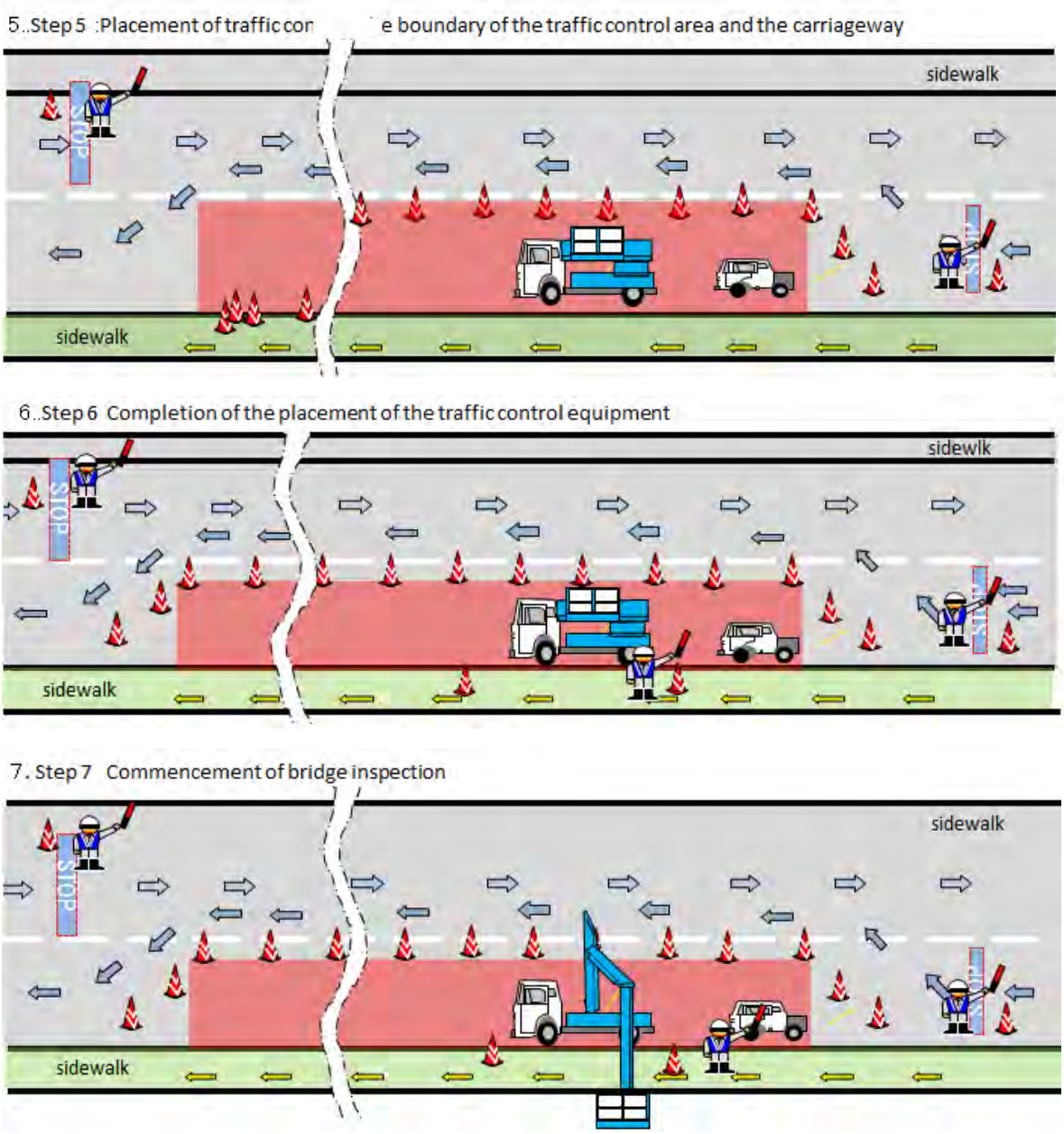


Figure 4.4 Procedures and roles of traffic control

5. Operation of the BIV

5.1 Introduction

The leader confirms result of the startup inspection, result of the BIV, provides instructions of locations, commencement of work, movements in the traffic control area, suspension and end of the inspection work.

It is recommended that during the operation of the BIV, the operator of the BIV always double checks and confirms the safety clearly and loudly by pointing out the results of each operation.

The leader and operator needs to understand the “Operation Manual" of the manufacturer of the vehicle which is being used for the BIV.

5.2 Roles of the Members of the Bridge Inspection Staff

Table 5.1 shows the roles of staff during the bridge inspection by BIV.

Table 5.1 Roles of staff during the bridge inspection by BIV

Staff	Numbers	Roles and responsibilities
Leader	01	Responsible for overall management of the inspection by BIV.
Inspection staff	02	Conduct bridge inspection and record the results.
Driver and operator of the BIV	02	Driver: Drive the inspection vehicle to the designated location. Operator: Operate the platform of the BIV

5.3 Inspection of the BIV Prior to the Operation

According to the instructions of the leader, the operator of the BIV carries out an inspection prior to the operation, reports the result to the leader and conducts a sampling inspection, if needed.

Items for the initial inspection are shown in Table 5.2.

Table 5.2 Items for the Inspection of BIV- Prior to the Operation

Item	Inspection Items	Inspection Contents	Inspection Method
Engine	Radiator	Quantity water,	Visual inspection
	Battery	Volume of electrolysis solution	Visual inspection
	Hydraulic oil tank	Volume of oil, leakage of oil	Visual inspection
Undercarriage	Tires	Damages, wear, pneumatic pressure	Visual inspection, palpation
	Wheel mounting bottle	Loose, drop out	Visual inspection, palpation
	Outrigger foot step	Outrigger condition	Operation check, visual inspection
	Mission gear	Operating condition	Operation check of the clutch (by operating gears)
	Traveling platform	Damages, dent	Visual inspection
Operating device	Operating lever	Operating condition	Operation check (looseness of the lever)
	Operating switch	Rattling	Operation check (Bounce back of buttons)
	Operating valve	Leakage of oil	Visual inspection
Boom device	Boom, arm	Crack, deformation	Visual inspection
	Boom undulation, stretch cylinder	Malfunction, leakage of oil	Abnormal sound Visual inspection
Work floor device	Work floor handrail	Damages,	Visual inspection
Safety device	Emergency stop	Operating condition	Operation check
	Instruments	Operating condition	Visual inspection
	Alarm device	Operating condition	Operation check, alarm sound, function of lamps

5.4 Operation of the BIV (Main Procedure)

The main operation procedure of the BIV is shown below.

STEP1 Installation of outrigger

Watch outriggers you operate and jack-up one by one at a time (You have to make sure there is no one at the direction of stretching the outriggers and around the jack.

- Set up the front and rear jacks properly.
- Make sure that all tires and jacks are properly fixed.
- If there is the service duct , roller jacks need to load on the end of the service duct(Photo 5.1).

Photo 5.1 Example to position of the roller jacks on the service duct.

STEP2 Get on the platform

- Total weight is up to 200 kg（2 or 3 persons）
- One engineer and one operator; or one engineer and one operator-cum-engineer.

STEP3 Installation of safety belt

- Hang a safety belt on a hook.

STEP4 Boom operation

- Extend the boom.

STEP5 Arm operation

- Slide the platform completely.

STEP6 Arm operation

- Make the arm parallel to the side of the bridge.

STEP7 Platform operation (lateral direction)

- Expand and move the arm, up and down, turn over the bridge,
- Take care not to get too close to electric wires and other objects.

STEP8 Platform operation(vertical direction)

- Lower the platform vertically downward to the bridge.

STEP9 Platform operation (up to the under surface of the bridge)

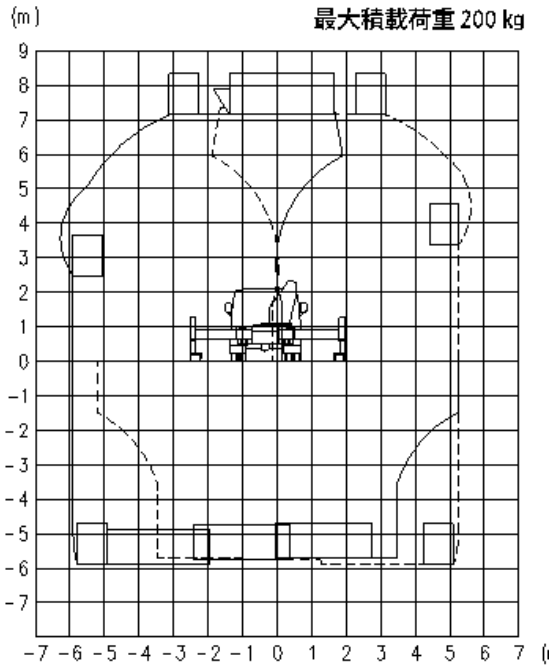
- Be careful the platform will not hit the main girder and others.
- Be careful the staff on the platform will not be caught by the main girder and others.

STEP10　Vehicle movement

- Go ahead taking　care of street lights and objects nearby.
- Go ahead taking care of bridge surface drains, uneven road surface and others.
- Confirm the signal of the staff on the platform and the driver when the vehicle moves.

Working range diagram with maximum outrigger extension of the BIV is given in Figure 5.1

Figure 5.1 Working Range Diagram (Maximum Outrigger Extension) Rated working load:200kg



5.5 Important Remarks for Operation of the BIV

(1) Precautions to be taken when driving

- Make sure all the devices are stored when driving.
- If gravity of the vehicle is high, there is a risk that the vehicle might fall especially when it negotiates corners**...**
- Do not drive the vehicle where the permitted weight is less than the weight of the vehicle.
- Be careful when the vehicle travels on place**s** with height restriction. The platform is located higher than the eye line.
- Do not drive the vehicle when someone is on the platform.

(2) Stop operations when weather condition is not favorable(adverse)

Stop operation during following weather condition**s:**

- High winds: Average wind speed is 10m/s or continuous wind of more than 10 minutes
- Heavy rain: Continuous rainfall of 50mm or more
- Thunder: At the time of lightning

(3) Parking the vehicle on slope

- The maximum permissible incline on which the vehicle can be parked is 5 degrees. It is 3 degrees for roller travelling.
- Choke all wheels of the vehicle when the vehicle is parked on a slope.

(4) Safety before operating the platform

- Make sure that all vehicle tires and jacks are properly fixed.
- Always use safety harness when working on the platform.

(5) Safety while operating equipment of the vehicle

- Make sure no one stands beneath the platform and others.
- Do not drop items from the platform.
- Do not operate the machine roughly.
- Do not walk on the platform while working.
- Do not stretch yourself out from the platform.

6. Implementation of Bridge Inspection

6.1 Introduction

Purpose of the bridge inspection by BIV is to collect necessary information for bridge management, by approaching a part of the bridge, where no one can get close without the aid of an inspection vehicle. Since the inspection is conducted by approaching very close to the part of the bridge, in addition to the information described in the bridge inspection and diagnosis manual, information that is required for designing of repair works and for the preparation of bill of quantities can also be collected.

In case of damages by delamination or loss of structural concrete/ steel were found at the time of inspection by BIV, it is necessary to measure cracks, identify area of delamination by hammering inspection, measure area of defective steel portion as a result of corrosion, and record the results.

In a hammering inspection, you need to identify extent of float caused by rebar corrosion, which cannot be identified by visual inspection. For steel bridges, dimension of cross-sectional defect portion of the steel material, which affects safety of the bridge, and thickness of the steel material must be measured. Damage diagram provides necessary information for designing of repairs and for preparing bill of quantities.

6.2 Tools for the Inspection

The equipment used for the inspection is same as that is used for ordinary inspections. In addition. Crack gauge and choke need to be used. For steel bridges, wire brush, caliper and cello-tapes are also needed for inspection.

6.3 Inspection of Concrete Bridges

Inspection of concrete bridges include visual and hammering inspections. You need to measure and record size of the damages found by the hammering inspection.

(1) For hammering inspection, a 230-gram hammer (approximately 0.5 pounds) should be used in consideration of work efficiency, lesser impact to structures and easiness in recognizing rebound sound. The results of hammering inspection should be evaluated as described in Table 6.1.

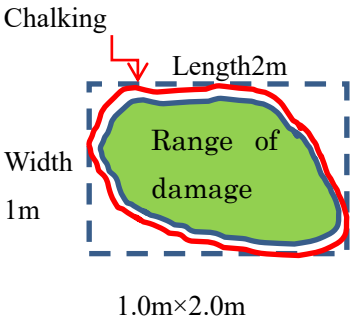
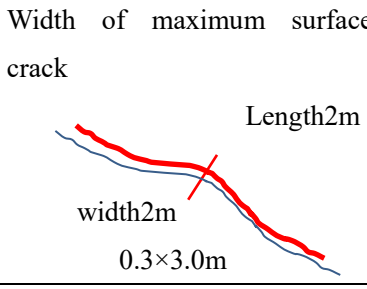
Table 6.1 Guideline for Evaluation of Structure Conditions by Hammering Inspection

Results of Hammering Inspection	Expected Structure Conditions
High metallic clear sounds “king-king” “kong-kong” and strong rebound (Clear Sounds)	Sound
Heavy dull sounds “dong” “dos-dos” (Dull Sounds)	Deteriorated, voids near the surface
Light dull sounds “bocco” “pecco-pecco” (Dull Sounds)	Delamination

A hammering inspection shall be carried out more precisely for the parts where damages were recognized by near visual observation, and for the joints of concrete.

(2) Mark (line) the location and range of the damages using a chalk. Measure the dimensions (length &width) of the damaged areas already marked by chalk; and write the dimensions on the location with chalk just like the figure in Table 6.2. It is desirable to use a chalk with appropriate ink, so that the mark remains until the next inspection.

Table 6.2 Example of Marking a Concrete Bridge by Chalk

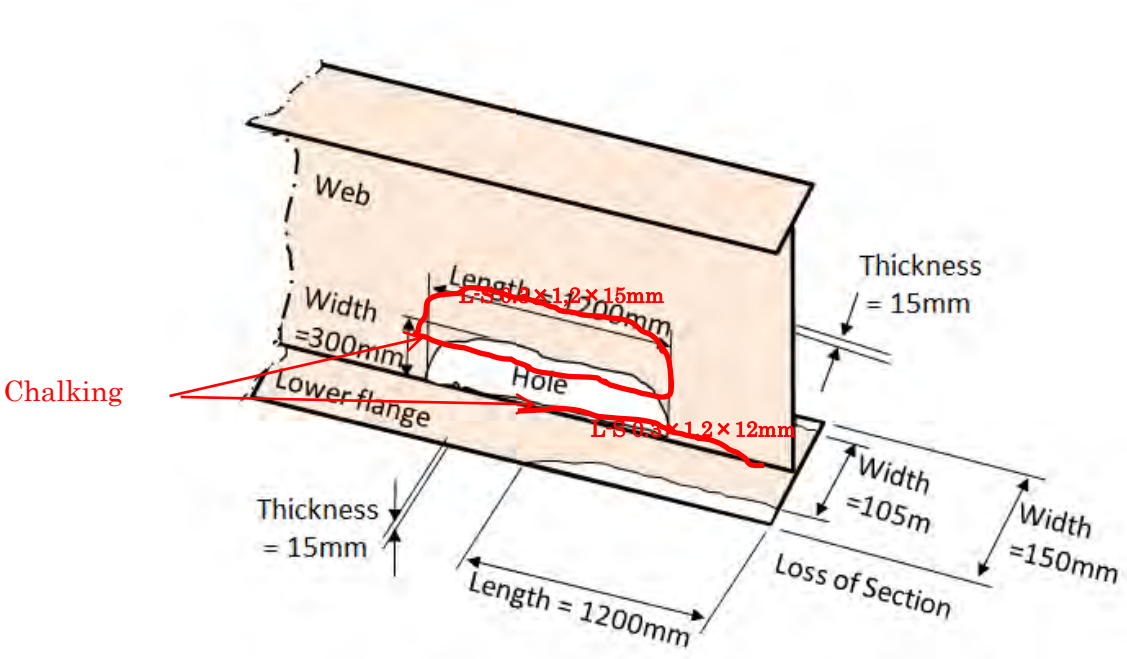
Damage	Example of marking	Method of marking
Spalling/delamination /,expose-rebar		Mark the damage by circling the damaged area. Write types of damage (abbreviation), width and length of the damage range by using chalk on the location.
Cracks		Mark a line along the crack. Write the maximum width and length of the damage on the location.

6.4 Inspection of Steel Bridges

Inspection of steel bridges includes visual inspection and measurement of dimensions and depth of corrosion for the parts where corrosion is in progress and section defects are occurring. Likewise inspect damage conditions of bolt nuts and floor slabs.

Figure 6.1 shows an example of marking with chalk and dimensional recording of a cross-section defect of a steel bridge. After estimating the volume of the corrosion loss, clean the rust thoroughly with a wire brush or a similar device, and measure the residual plate thickness with a caliper. Dimension of the corroded area of a truss member needs to be measured so that the ratio of the area of section defect caused by corrosion against the original section area can be calculated.

Figure 6.1: An example of chalking and dimensional recording of a cross-section defect



The difference between rust and corrosion of steel surface can be identified by cello-tape test as shown in Photo 6.1. Rust adheres to the cello-tape in case it is corroded

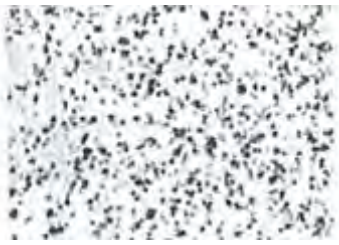


Photo 6.1 Cellophane tape test

6.5 Record of Damages

Enter the major damages onto the diagram showing damages. Major damages are, cracks, flaking / floating, rebar exposure, corrosion, cross section defects, Scouring, and other damages which may create safety issues. Diagrams indicating the damaged areas of the structures must be scanned and filed in a proper manner**.**

Record the position and dimensions of the damaged area, which were marked by a chalk, on the diagram. The method of recording damages on the diagram is shown below.

(1) Care should be taken to ensure the correct location and orientation of the damaged areas on the diagram (up and down of the diagram indicating the damages**).**

(2) Record the size and orientation of the damages according to the scale of the figure.

(3) Record the types and dimensions of the damage. Use the abbreviations shown in Table 6.3 for the types of damages. Table 6.4 shows the method of writing dimensions of the damages.

Table 6.3 Damage List and Abbreviations

List	Abbreviation	Damage	List	Abbreviation	Damage
	Co	Corrosion		Ex-Rba	Expose-Rebar
	L-S	Loss of Section		Spa	Spalling
	C	Crack		Sca	Scour
	Dela	Delamination		Ot	Other

Table 6.4 Recording Method of the Major Damage Size on Damage Schematic Diagram

Structural Member	Classified Type	Damage Type	Unit	Dimensions
Superstructure	Concrete Arch	Crack	m	Crack width(mm)*Length
		Spall, Delamination, Expose-Rebar	m	Width * Length
		Loose / Missing Stone	m	Width * Length
	Steel	Corrosion	m	Width * Length
		Loss of section	m	Width * Length * Thickness(mm)
Substructure	Concrete Steel Arch	Crack	m	Length
		Spall, Delamination, Expose-Rebar	m	Width * Length
		Loose / Missing Stone	m	Width * Length
		Scour	m	Width * Length

Figure 6.2 shows an example of on-site situation of damage and a record of damages on the diagram.

Figure 6.2 Example of on-site situation of damage and a record of damages on the diagram

On-site situation

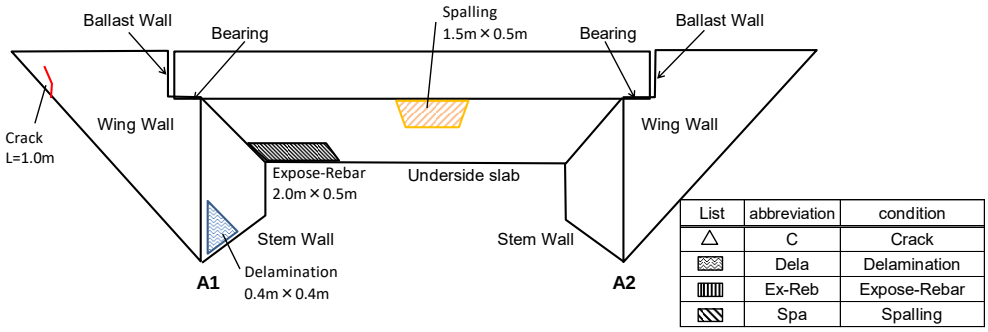
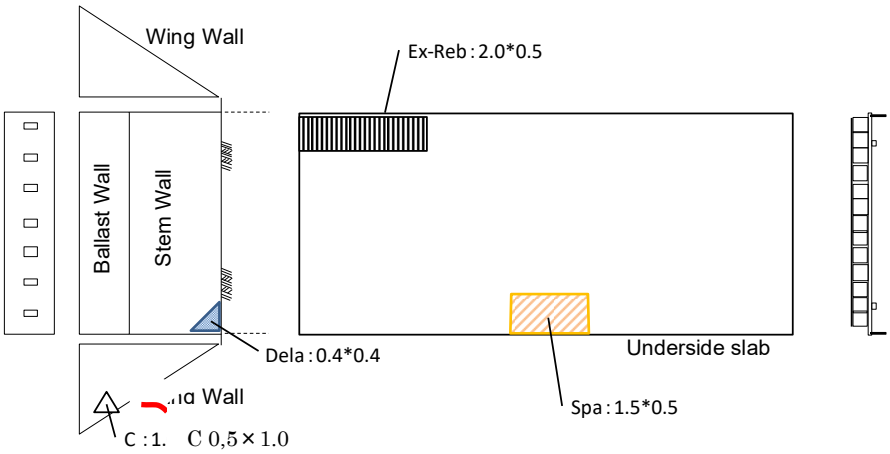


Figure 6.3 Examples of description of damages at site and diagrams showing damages

An example of writing a damage diagram



There are several forms of diagrams showing damages, according to the types of bridges. Figure 6.4 and Figure 6.5 shows examples of diagrams of damaged concrete girder bridge and a steel bridge respectively. This diagram to show damages, was made, in order to describe the degree of damage of each element.

■Example of damage diagram (a concrete girder bridge)

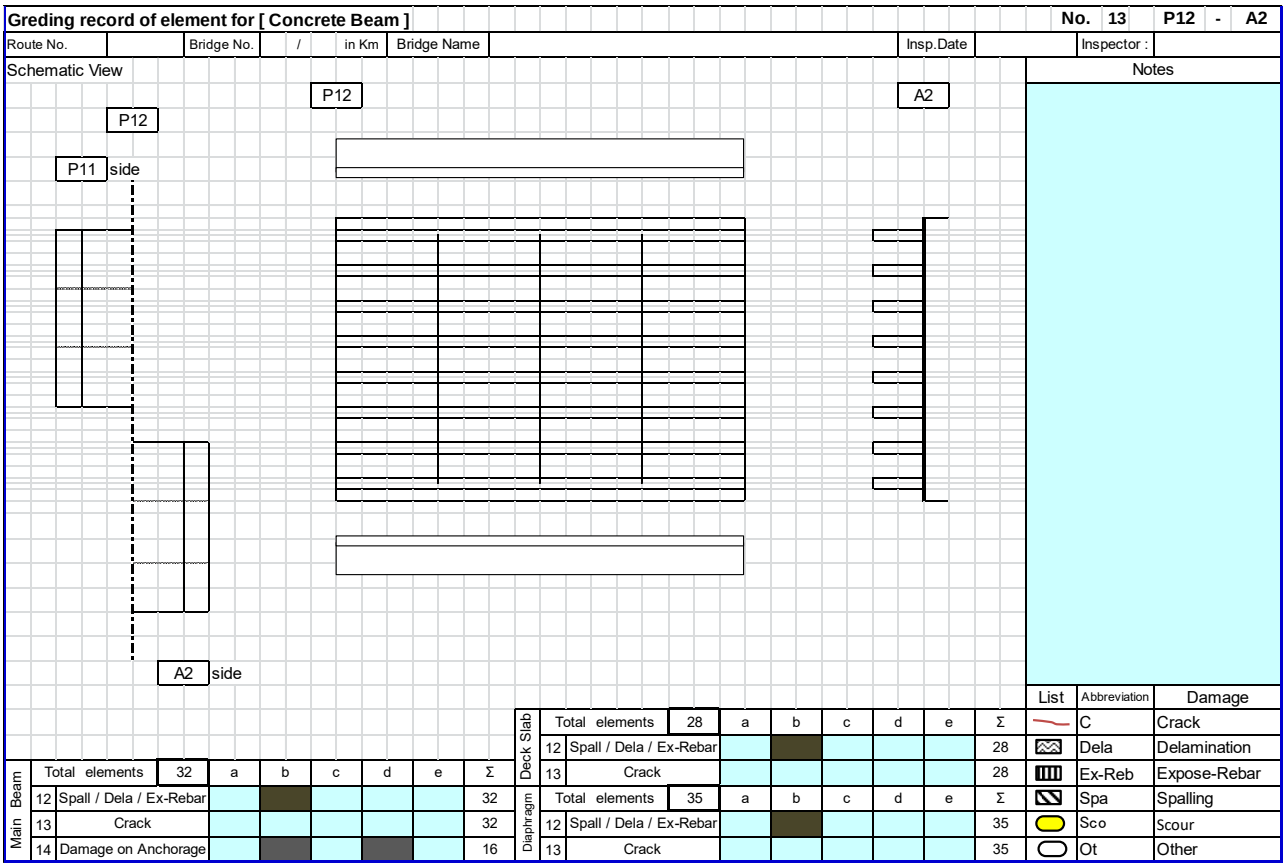


Figure. 6.4 Damage diagram of concrete girder bridge

■Example of damage diagram (a steel bridge)

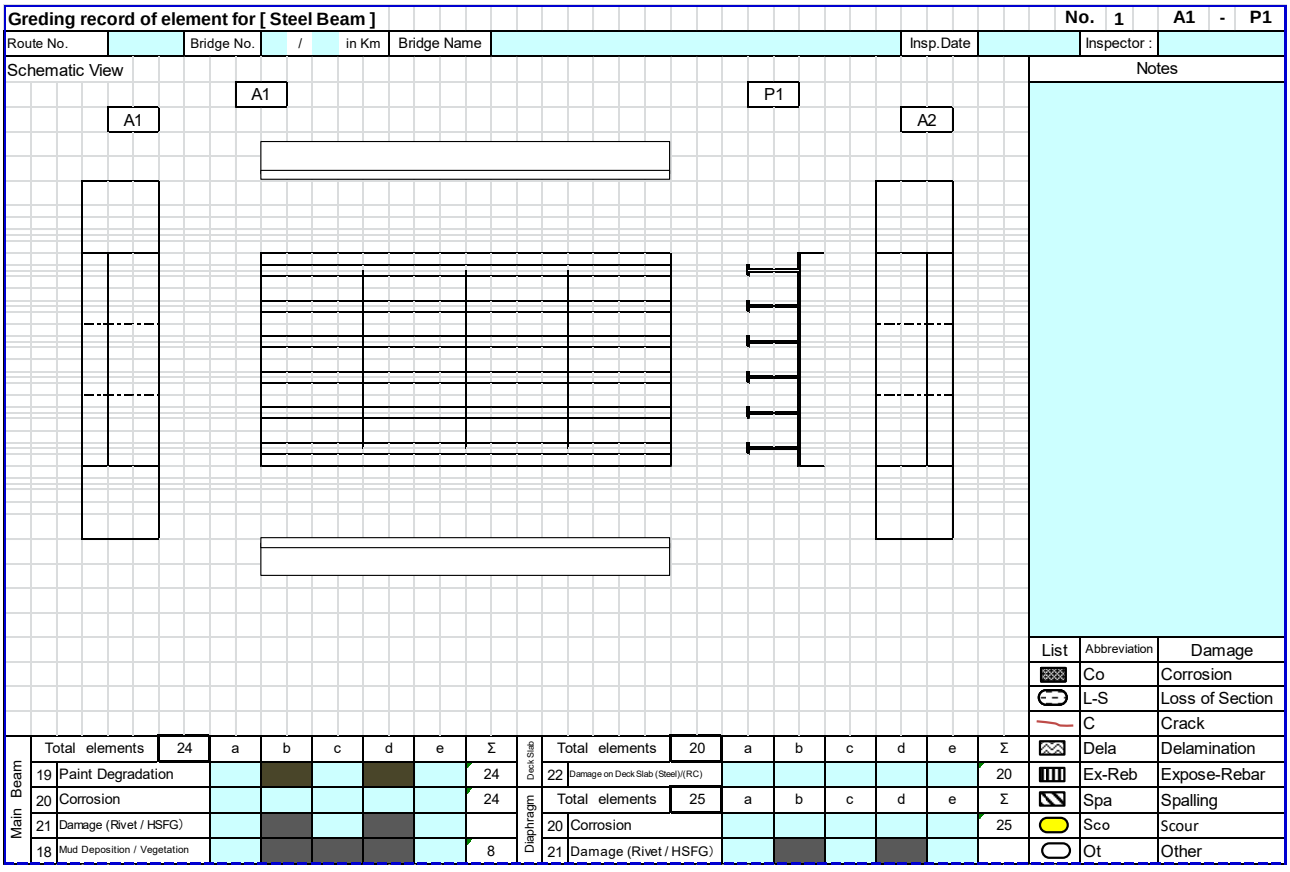


Figure. 6.5 Damage diagram of a steel bridge

【Reference】Examples of the matters to be discussed at the preparatory meeting for bridge inspection by BIV

1. Examples of possible accidents during the inspection (Ref: Attachment 3.1)

1) Injuries by the outrigger during the process of setting

Ensure that people are not present close to the outrigger. When the setting is done You must instruct staff/people to keep a distance from the outrigger during the settings.

2) Vehicles enter the controlled area and hit BIV.

Make sure to use the safety belt when you are at the platform.

The leader and the traffic control security staff in-charge sound the whistle when there would be a risk.

3) A vehicle crashes onto another vehicle coming from opposite lane, when it tries to overtake at the starting point of the traffic control area.

Give clear instruction and stop the vehicle, which is trying to overtake. Stop the vehicle coming from the opposite lane, too. (use flags and whistles)

4) Falling over of safety cones

The traffic control security staff in the middle of the control area need to raise the safety cones.

5) People travelling between the area of BIV and the road when they stay out from the traffic controlled area and if hit by a road vehicle.

Instruct the people to use foot pavement at opposite side or traffic control security staff at the middle, to guide the people to use the pathway between BIV and safety cones.

2. Examples of signals (Ref: attachment 3.2)

(1) Signal by the leader during the operation

Blow a whistle 3 times to stop the operation. Then, the driver has to stop driving the BIV. The operator needs to stop movement of the arm.

(2) Communication between the Driver and the Operator

Communication between the driver of the BIV and operator on the platform needs to be conducted through the leader. The driver of the BIV has to go forward or stop the BIV following the hand signals of the leader at the time of moving the machine using the roller jacks.

(3) Communication among the traffic control security staff during the traffic control

Communication among the traffic control security staff during the traffic control needs to be conducted according to the following guide lines:

i) Stop the vehicles.

ii) Give signals to the traffic control security staff at the opposite side and mutually confirm that the vehicles were stopped.

iii) After the confirmation, let the vehicle at the opposite side to proceed.

iv) Communicate with each other by giving signals, and conduct alternate traffic control smoothly.

【Stop the next vehicle when there is an interruption of traffic flow, and let the vehicles on the other side travel】

Alert the traffic control security staff at the opposite side, by blowing a whistle, using flags and hand signals if there is a vehicle travelling without following the instruction to stop. The traffic control security staff at the other side, should immediately stop the vehicle.

Communication between the traffic control security staff can be conducted by using flags and by hand-held sign board as follows. It is recommended to use a whistle together with flags and plates.

Table 6.5: Communication between traffic control security staff

Work items	Hand-held sign board	Flags
Stop vehicles	Raise "Stop" sign board (blow whistles once)	Hold the flag horizontally (blow whistle once)
Let the vehicles go	"Go" sign board (blow whistle once)	Wave the flag back and forth at horizontal position (blow whistle once)
Acknowledge signs between the staff	Put left hand up	Put left hand up
Alert the danger	Raise and wave the sign board (blow whistle)	Raise and wave the paddles (blow whistle)

3. Procedure for traffic control

Confirm roles of each staff

(1) Confirm locations of traffic control

i) Locations to stop vehicles

ii) Locations to start and end the traffic control

iii) Locations to stop the double cab (DC) and the BIV firstly.

(2) Locations for placing the Traffic Cones（RC）

i) Place the traffic cones along the pavement in the traffic control area【everybody to do this work】

ii) Engineer and traffic control security staff stand at the location where ordinary vehicles will be stopped.

(3) Start bringing in BIV and DC. Commence traffic control.

i) The leader gives instructions to bring BIV and DC and stop at the above-mentioned locations.

ii) Immediately stop the road vehicles at the 1st point (Engineer gives instructions to the traffic control security staff)

【Stop DC 10 m ahead of BIV. Turn the wheels to the left after it is stopped.】

(4) Location of Taper

i) Transport the traffic cones and place the Tapers

【Traffic control security staff at the middle and the operator of the BIV to do this work】

ii) When setting of the Tapers is completed, start alternate traffic control by stopping the road vehicles at the 2nd point and then let the vehicles stopped at the 1st point to proceed

(5) Placement of RC

Place RC in 4 - 5m interval.

【Traffic control security staff at the middle and the operator of the BIV to do this work】

(6) Completion of placement of traffic control equipment

Placement of the traffic control equipment is completed, after the Taper is placed at the end of the traffic control area. Place RC on front and back of the BIV.

(7) Start Bridge Inspection

Figure 6.6: Locations of the 1st and the 2nd Points