MASTER PLAN STUDY ON BRIDG

REPORT AND REHABILITATION GUIDELINE JUI

JAPAN INTERNATIONAL COOPERATION AGENCY ROAD DEVELOPMENT AUTHORITY MINISTRY OF HEALTH, HIGHWAYS AND SOCIAL SERVICES

MASTER PLAN STUDY ON BRIDGE DEVELOPMENT IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FINAL REPORT

BRIDGE INSPECTION, MAINTENANCE AND REHABILITATION GUIDELINE



JULY 1996

JAPAN BRIDGE & STRUCTURE INSTITUTE, INC., TOKYO PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

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Abbreviation

AASHTO : American Association of State Highway and Transportation

Officials

ADB : Asia Development Bank

Admin. : Administration

ADT : Average Daily Traffic

ARCH/BR : Brick Arch Bridge

ARCH/CO : Concrete Arch Bridge

ARCH/S : Steel Arch Bridge

ARCH/ST : Stone Arch Bridge

BAILEY : Bailey Bridge

Br. : Bridge

BS : British Standard

CAUSEWAY : Causeway Bridge

Con. : Concrete

Const. : Construction

Cov : Cover

DD : Detailed Design

Dept. : Department

E.E. : Executive Engineer

F/S : Feasibility Study

JICA : Japan International Cooperation Agency

JIS : Japanese Industrial Standard

MMC : Maintenance Management & Construction Division

N.A. : Not applicable

No. : Number
Nos. : Numbers

ODA : Official Development Assistance

OECF, OECFJ : Overseas Economic Cooperation Fund, Japan

PSC/POS : Prestressed Posttentioned Concrete Beam

PSC/PRE : Prestressed Pretensioned Concrete Beam

RCB: Reinforced Concrete Beam (Bridge)

RCC: Reinforced Concrete

RCDC : Road Construction and Development Corporation

RCS : Reinforced Concrete Slab (Bridge)

Rd. : Road

RDA : Road Development Authority

RECONST : Reconstruction RED, Red : Re-decking

RC/BOX : Reinforced Concrete Box Culvert

Rs. : Rupees

RSJ/BUC : Buckle Plate over Rolled Steel Joist

RSJ/COR : Corrugated Plate over Rolled Steel Joist

RSJ/DEC : Deck Plate over Rolled Steel Joist

RSJ/RCS : Reinforced Concrete Slab over Rolled Steel Joist

RSJ/T : Timber Deck over Rolled Steel Joist

RST/BUC : Buckle Plate over Steel Girder

S/W : Scope of Works

SER. Ser. : Serial

SETT : Settlement

SPT : Standard Penetration Test

ST. TR/D : Steel Deck Truss

ST. TRIT : Steel Through Truss

STONE : Stone Bridge
TIMBER : Timber Bridge

UK : United Kingdom

VOC : VehicleOperation Cost

W: Width

WB : World Bank

CHAPTER 1 PREFACE

1.1 General

Democratic Socialist Republic of Sri Lanka (hereinafter referred to as "Sri Lanka") is a peach-shaped island country of a total land area of 66,400 km² and consists of nine provinces.

Under the British rule from 1796 to 1947 Sri Lanka established the plantation-based economy by exporting traditional products (tea, coconuts and rubber) to European countries and Near and Middle East countries. In the course of establishment of the economy the inland traffic network was developed with growing material transport volume between the inland and coastal areas.

As of 1991 the total road length reached 97,375 km. with 5,262 bridges, and the road density (1.48 km/km²) is equivalent to that of advanced countries. The ratio accounted for by the road traffic in the land traffic is 90% for goods and 82% for passengers. The road network plays an extremely important role in Sri Lanka.

The road section of the road network has been improved all over the country utilizing domestic resources and assistance from other countries. Concerning bridges, however, actual rehabilitation was made only for 20% or less of facilities requiring urgent rehabilitation, with remaining facilities left unattended because of budgetary and technical constraints. These unattended bridges become bottlenecks for the safety and smooth flow of the road traffic, and their rehabilitation is now the urgent tasks for Sri Lanka.

1.2 Background and Purposes of the Guideline

1.2.1 Background

Under such circumstances the Government of Sri Lanka in January 1990 requested Japan to conduct the Study for the Bridge Rehabilitation Project in Sri Lanka.

JICA organized in May, 1995 the Study Team and dispatched the Study Team to Sri Lanka to conduct the Study. The Study Team worked in close cooperation with the RDA counterpart team in accordance with the agreed Scope of Works.

The objectives of the Study are as follows:

(1) To formulate a bridge rehabilitation master plan with the completion date scheduled for 2010, which covers all bridges of the national highways A and bridges of the national highways B whose rehabilitation is deemed to be urgently required in Sri Lanka

(2) To formulate a guideline which Sri Lanka can utilize to establish her own bridge maintenance and rehabilitation manual

This bridge inspection, maintenance and rehabilitation guideline has been prepared to achieve the object (2) described above.

1.2.2 Purpose of Guideline

To maintain bridges in the sound state early detection and rehabilitation of bridges are essential. Overlooking any abnormality or damage in the early stage will allow such damage to grow further to result in accident. Periodical maintenance will minimize the overlooking and contribute to extension of the durable life of bridges and to early detection of damage through inspection.

It is necessary to inspect the bridge's present conditions correctly according to the established inspection procedure and to prepare and assess the inspection result on the basis of thorough recognition of the characteristics and deformation of the structure. Then the rehabilitation is executed according to the schedule and method established on the basis of the assessment result. The bridge maintenance and management must be executed periodically according to the maintenance procedure.

In order to put into effect the bridge rehabilitation master plan for principal roads for the target year 2010, Sri Lanka should establish the bridge maintenance and rehabilitation manual. The purpose of this guideline is therefore to summarize, in such a manner as to help Sri Lanka execute the plan, through a series of bridge maintenance and rehabilitation works, namely the inspection, assessment and maintenance and the rehabilitation.

The bridge maintenance and rehabilitation consists of inspection, maintenance and rehabilitation as shown in Figure 1.1.

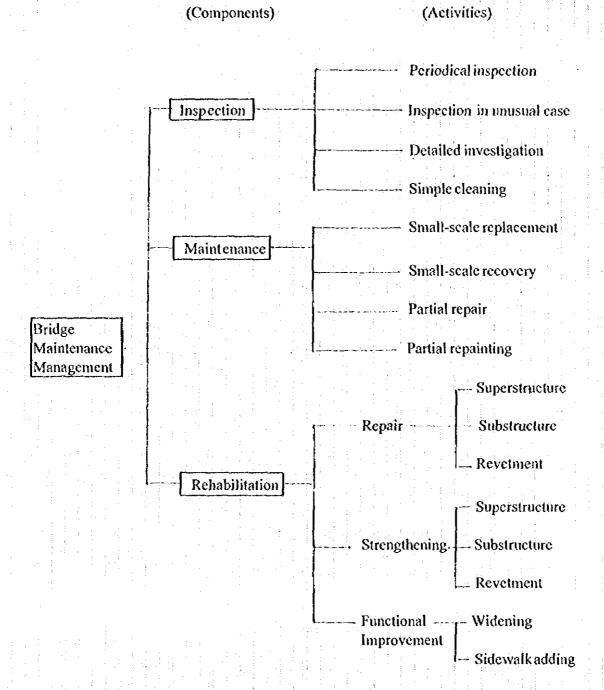


Figure 1.1 Definition and Functions of Maintenance Management

1.3 Composition of Guideline

The Inspection, Maintenance and Rehabilitation Guideline consists of following chapters:

Chapter 1 Preface

Chapter 2 Preparation and Filing of Documents and Inventory

This chapter describes collection, filing, and storage of design documents and related data which are the bases for maintenance and management of bridges. The Sri Lanka RDA has already been using the bridge inventory and inspection forms. But this chapter deals with the bridge inventory and inspection form which have been newly established in this Study for use in the future bridge maintenance and management

Chapter 3 Bridge Inspection Procedure

This chapter describes firstly the purpose of bridge inspection, scope and frequency of inspection and inspection items. Secondly this chapter deals with the materials, equipment and tools used for inspection, including the bridge inspection vehicle, scaffolding, etc.

Chapter 4 Bridge Assessment Procedure

This chapter describes the method to assess the damage to the bridges on the basis of the inspection results. This description includes the damage assessment criteria and assessment method.

Chapter 5 Bridge Maintenance Procedure

This chapter describes the method of maintenance carried out periodically for members of a bridge.

Chapter 6 Bridge Rehabilitation Procedure

This chapter describes the purpose of repair, strengthening and rehabilitation of bridges, criteria for selection of the repair, strengthening and rehabilitation methods and applicable methods.

Chapter 7 Maintenance Management System

This chapter describes the Bridge Maintenance Management system. The description covers organization, work flow and material and equipment.

CHAPTER 2 PREPARATION AND FILING OF DOCUMENTS AND INVENTORY

2.1 Standards and Specifications

The first thing to do in maintenance and rehabilitation of bridges is to collect, file and store the design standards and specifications.

Applicable documents include;

- (1) Standards, manuals, etc.
 Standard Specifications for Construction and Maintenance of Roads and Bridges, RDA
- (2) Road Maintenance Manual, 1989 RDA (attached as an appendix)
- (3) Related BS and AASHTO standards
- (4) Bridge design conditions and material strength standards (for each published year)
- (5) Manuals, guideline, standards and codes related to bridge design
- (6) Standards for the road geometric design and data concerning the road and accessory works

2.2 Design Documents and Construction and Material Records

(1) Design documents.

As a result of preliminary investigation the number of bridges for which the design documents were available was as small as 15 bridges (7%) for the total number of 206 bridges. It is essential that the design documents are filed from now on for bridge maintenance and management works.

The design documents provide data for confirmation of the shape, construction and stress condition of a bridge concerned. These documents can also provide data for identification of the cause of damage because they indicate the steel arrangement or member shape which are clues to find out the cause and they offer the basic data for the load test.

Data to be included in design documents are as follows:

- (i) Design drawings
- (ii) Design calculation sheets

(iii) Geological survey report (data which become necessary when the cause of damage is considered to be deformation of substructure or foundation)

(2) Construction record

The construction record provides data for the construction condition of bridges. Particularly in the case of a concrete bridge, faulty construction often leads to bridge damage. In this context understanding of the construction condition (method, etc.) has significant meaning.

Data to be included in the construction record are as follows:

a) Concrete bridges

- 1. Concrete placement condition and quality control record
- 2. Curing method
- 3. Age of concrete when forms are removed
- 4. Type of falsework, form and spacer
- 5. Girder erection method

b) Steel bridges

- 1. Welding method (plant, site)
- 2. Girder erection method
- 3. Painting record (including repainting)
- 4. Slab construction method

(3) Material records

The material record provides data for materials of a damaged bridge. Particularly in the case of concrete bridges the material is often the cause of damage, such as salt damage and alkali-aggregatoreaction.

Data to be included in the materials record is shown below. If the bridge is old and no record is left, it is necessary to investigate the actual member and estimate the data.

a) Concrete bridges

- 1. Mixing proportion and strength of concrete
- 2. Type and place of production of aggregates.
- 3. Type and manufacturer of cement
- 4. Type of admixtures
- 5. Type and manufacturer of steel
- 6. Various test results

b) Steel bridges

- 1. Welding materials
- 2. Painting materials (including repainting)
- 3. Various test results

2.3 Bridge Inventory and Inspection Form

Up to 1995 Sri Lanka RDA has used its own bridge inventory and inspection forms. After discussions with RDA concerning the forms which can be used for a long time in the future, the bridge inventory, bridge inspection form (concrete), bridge inspection form 2, photographs, and preliminary environmental examination form (Sheets 1, 2, and 3) as described in pages 2-5 to 2-11 were recommended by this Study.

It is recommended to assign the Engineering Services Division of RDA to take charge and to select persons in charge, so that they will be responsible for preparation and filing of documents.

Forms consist of the followings:

- (1) Bridge inventory
- (2) Inspection form
- (3) Natural conditions data (meteorological, hydrological, topographic and geological) of bridges
- (4) Data related to environment of bridges

2.4 Other Information

(1) Repair history and past inspection results

The repair history and past inspection results are important data not only for understanding of the history of repair and investigation, but also for identification of the cause of damage, because another defect may have appeared before occurrence of the damage. The repair itself may be responsible for the damage. Data can be also be used to confirm the effect of repair.

(2) Reference literature

Damages to bridges are similar to those of the past in many cases. Collection and filing of literature containing damage and investigation cases will prove helpful for detailed investigation.

(3) Local conditions

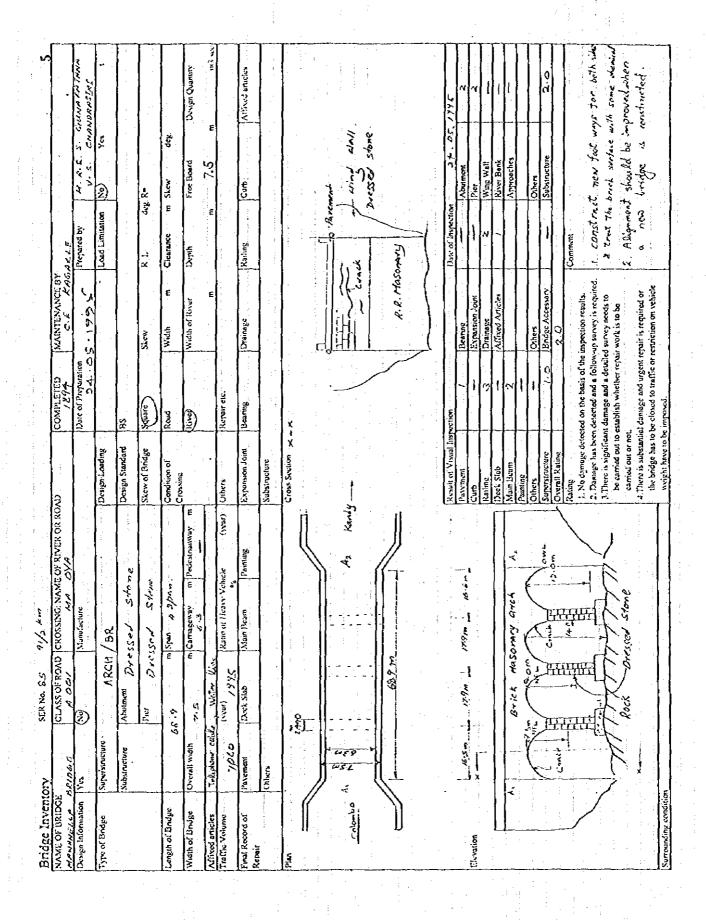
Concerning environmental conditions, including the air temperature, wind, corrosive environment, salt spray and local conditions (ambient state and subsurface conditions) and any useful data must be collected and filed.

(4) Traffic data

Data concerning the traffic volume on bridges concerned and traffic data including ratio of heavy vehicles must be collected from the traffic count files. Data on traffic will become important when dealing with damage caused by increased load and volume.

2.5 Renewal of Design Documents

In the case of revision or modification of above documents the location and date of such modification must be identified clearly. One copy of each old document must be filed instead of being thrown away, because they are necessary for maintenance and rehabilitation in the future.



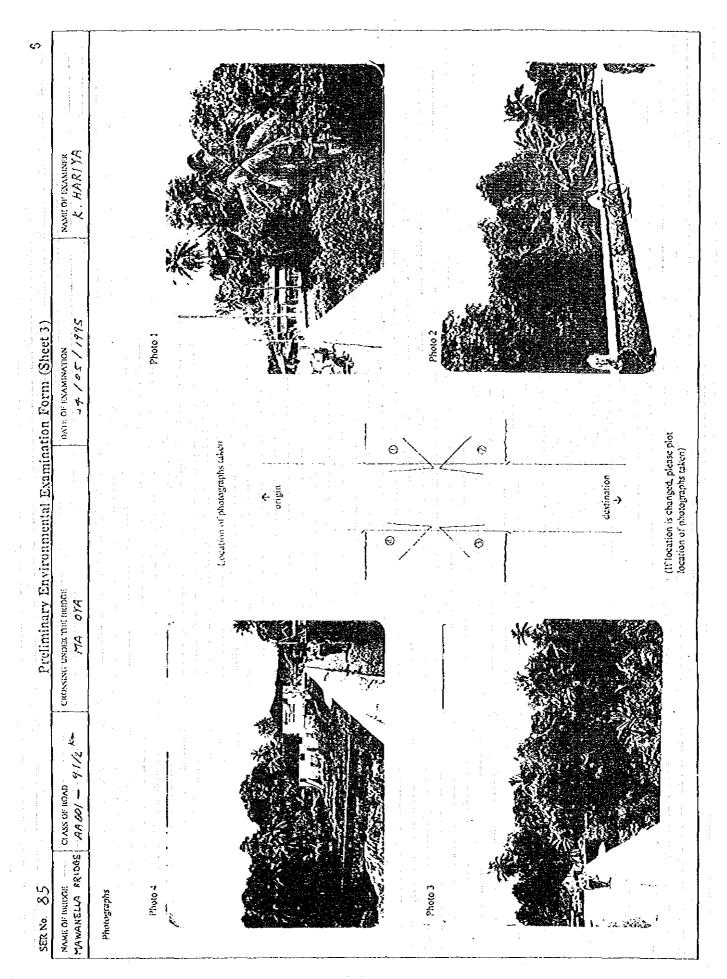
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:	-Kight of common (for lands adjacent to bridge/approach roads)	C Not. clear	☐ Navigation (please attach details)		-Historical (or refroitas) area		
	O Do sof crist		Duse of over water, i.e. water supply, agricultural, industrial (please attach dataits)		D Yes		
·			Collectuse, e.g. washing bathing, ove. (please strach details)		-National park (or any other area restricted for development) — Yes — The second sec	9	
						:	
Land-	-Distribution of scenic places/	-Effect of bridge rehabilitation/conservation			Photographs (landschie of bridey)		
ž	C) Usial (pleases show position and name of state in sketch on sheet 1)	C. Scenic, places in rehabilitation/	O Avuitable (phuses attach map)				
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CHAPTER 3 BRIDGE INSPECTION PROCEDURE

3.1 General

In the course of preparation of Bridge Inspection Procedure "the Bridge Inspection Procedure (draft)" by Public Works Research Institute, Ministry of Construction, Japan, July 1988 was used as a basis, and modified to meet the existing conditions in Sri Lanka.

The inspection services described herein include periodical inspection, inspection in unusual case and detailed investigation, which are stipulated in this procedure. Since this procedure has been prepared principally for periodical inspection, the inspection method and details not stipulated in this procedure must be studied before execution in the case of inspection in unusual case and detailed investigation.

The first purpose is to grasp the present condition of bridges under control to detect early any damage affecting the safety and serviceability of bridges adversely, thereby enabling early and appropriate countermeasures and ensuring safe and smooth traffic.

The second purpose is to continue to understand the degree of damage and abnormality, which is indispensable for efficient maintenance and repair.

3.2 Type, Frequency and Execution System of Inspection

3.2.1 Type and Object of Inspection

The inspection is classified as follows:

(1) Periodical inspection

The periodical inspection is made to identity bridges conditions, visually and with simple inspection machinery and tools.

(2) Inspection in unusual case

This inspection is made mainly to confirm the safety of a specific bridge when disaster such as localized torrential downpour and landslide, etc. has occurred or these unusual cases are expected or when any abnormal defect is found.

(3) Detailed investigation

The detailed investigation is made using inspection machinery and tools to determine the necessity of repair and strengthening.

This investigation covers bridge members whose detailed investigation is judged necessary as a result of periodical inspection and inspection in unusual case. Through the detailed investigation the rehabilitation method is selected and finalized as discussed in Chapter 4.

The inspection will be made in the flow shown in Figure 3.1.

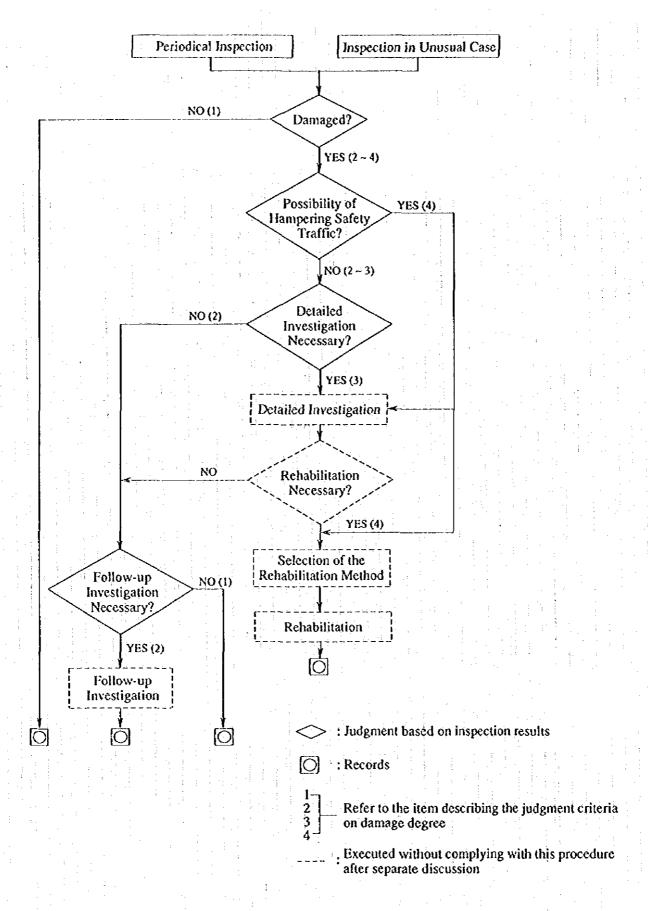


Figure 3.1 Inspection Flow

3.2.2 Inspection Frequency and Method

The standard inspection frequency and method are shown in Table 3.1.

Table 3.1 Inspection Frequency and Method

_	-				
:		Periodicali	nspection	Inspection in	Detailed
		Remote visual	Proximity	unusual case	investigation
		inspection	visual inspection		
	Inspection method	As a rule, this inspection will be made on foot or on boat if necessary.	As a rule, this inspection will be inade on an inspection vehicle or work scaffolding or on boat if necessary.	Depending on the purpose	Depending on the purpose
	Frequency	About once every two years	About once every ten years	As required	As required
	Superstructure	0	0		
	Substructure	O	0		
М	Bearing	0	0		
e	Railings	Ο	0		
m	Protection fence	0	0		
b	Curbs	0	0		
e	Curb stone	Ο	Ο	Depending on	Depending on the
r				the purpose	purpose
S	Median	0	0		4
	Pavement	Ο	0		
	Expansion joint	0	0		
	Drainage facilities	0	0		·
	Bridge falling preventive unit	0	0		
	Inspection facilities	0	0		
	Noise barrier		. 0		
	Lightingfacilities		0		
	Traffic sign	-			
	Wing wall	0	0		
	Affixed articles	<u>.</u>	0		

Note) Symbols in the table have the following meanings:

O: Inspection to be made without fail

-: Inspection to be made if possible

Though inspection must be made on all members to understand their present state in detail, it takes substantial time and cost to carry out detailed investigation into all bridge members. With the existing inspection system and actual damage condition such detailed inspection is not appropriate. It is therefore necessary to inspect efficiently in order to determine the method and frequency.

The periodical inspection will be a combination of two kinds of inspections; remote and proximate visual inspections.

As a rule remote visual inspection will be made once every two years to detect early any damage possibly affecting the load carrying capacity, durability and serviceability to the substantial degree. This inspection will be made as a rule on foot, without using an inspection vehicle, by visually inspecting a bridge from a relatively long distance. If possible it is recommended to go as near as possible to the bridge for visual inspection at close range.

Proximity visual inspection will be made as a rule once every ten years to detect any damage, which may affect the load carrying capacity, durability, and serviceability adversely, in the early stage. Proximity visual inspection will be made while approaching the members by using the bridge inspection vehicle or scaffolding. In this case the inspection machinery and tools must be used if necessary. All members are included in the scope of proximity visual inspection. Affixed articles are originally considered not included in the scope of control of bridge administrator, but included in the scope of proximity visual inspection because their damagemay affect the bridge adversely.

3.2 3 Periodical Inspection System

Name and Duties of Inspection Personnel

(1) Inspector

The inspector will control the inspection team, with due attention paid on the safety control, and understands the activities of each personnel while keeping close contact with the assistant inspector during inspection and investigation.

(2) Assistant inspector

The assistant inspector will assist the inspection work under instruction of the inspector. On detecting any defect or abnormality he will take record of the measurement result and practical defect/abnormality state using tools in compliance with the bridge inspection procedure. He will also take photographs.

(3) Inspection vehicle operator

The inspection vehicle operator will operate the inspection vehicle under instruction of the inspector.

(4) Traffic controller

The traffic controller will prevent traffic disturbance and ensure the safety of the inspection personnel during inspection. A driver for transportation of a inspector and others shall take this assignment.

Members of the Inspection Team

The members of the inspection team per bridge inspection vehicle will be determined as shown in Table 3.2.

Table 3.2 Members of the Inspection Team

	Inspection vehicle	Other facilities
Inspector	1 Note1)	1 Note 2)
Assistant inspector	2 Note 1)	2 Note 2)
Inspection vehicle operator	Note 1)	
Traffic controller		

- Note 1) Bridge inspection vehicle: The members will be determined with due consideration of the required scope of inspection work and traffic condition for each bridge and equipment used.
- Note 2) Other facilities: These facilities include an inspection passage, ladder, boat, and scaffolding for coating and the members will be determined with due consideration of the local conditions and inspection method (inspection items and tools).

3.3 Inspection Equipment and Tools

The inspectors must carry the necessary inspection machinery and tools appropriate to the type and content of the inspection work when the inspection is made.

To ensure effective inspection the equipment appropriate to the purpose must always be carried. The equipment used for inspection is shown below:

- (1) Inspection instrument
 - Telescope, binoculars, test hammers (large and small), steel tape, vernier calipers, wire brush, string, crack gauge, pole, etc.
- (2) Recording instrument

Camera (a whole set), chalk, white board, marking pen, scale, recording paper, etc.

(3) Ancillary inspection instrument

Ladder, traffic control tools, projector, rope, sticky tape, wire, pliers, flash light, inspection vehicles, cloth, cars, boat, etc.

For reference, tools used generally to each damage type are listed in Table 3.3.

During detailed investigation the inspection using nondestructive test equipment may be employed to understand the degree of damage into more detail. Examples of nondestructive test methods for detailed investigation are shown in Table 3.4. Note that features of each method are described only briefly and thus application of individual methods require further study.

When these nondestructive test methods are used, it is necessary to study their applicability. It is also necessary to confirm the performance of the equipment before application of a method, because the performance and application scope vary depending on the equipment.

Table 3.3 Type of Damage and Applicable Equipment

Material	No	Type of damage	Remote visual inspection	Proximity visual inspection
Materiai	110.		Visual	
٠	.1	Corrosion	Visuai	Visual, (thickness gauge), vernier calipers
S	2	Crack	Visual	Visual, (flaw examination
t i	:			unit), test hammer
e	3	Looseness		Visual, (torque wrench)
e .	4	Dislodgement	Visual	Visual
1	5	Breakage	Visual	Visual
	6	Degraded coating	Visual	Visual, (test of adhesion)
	7	Crack	Visual, (photos)	Visual, crack gauge, photos, (video tape)
C	8	Separation, exposure of reinforcing bar	Visual, (photos)	Visual, photos, (video tape)
n	9	Free lime	Visual, (photos)	Visual, photos, (video tape)
c	10	Honeycomb, cavity	Visual	Visual, test hammer, photos,
r				(video tape)
e	11	Wear, erosion	Visual	Visual, convex tape, pole
t	12	Punching out	Visual	Visual
[⊟e	13	Damagé to steel plate weld	Visual (test hammer)	Visual, test hammer
	14	Crack in deck slab	Visual	Visual, crack gauge
	15	Abnormal expansion spacing	Visual	Visual, convex tape
0	16	Diff. settlement, corrugation	Visual (convex tape, pole)	Visual, rules, convex tape, pole
h	17	Pot hole	Visual (convex tape, pole)	Visual, rules, convex tape, pole
e r	18	Crack in pavement	Visual (convex tape, pole)	Visual, rules, convex tape, pole
S	19	Rutting	Visual (convex tape, pole)	Visual, rules, convex tape, pole
	20	Others		
: 1	21	Discoloration, degradation	Visual	Visual (Schmidt hammer), (neutralization test)
l c	22	Water leakage, flow	Visual	Visual
	23	Abnormal sound	Hearing	Hearing
n	24	Abnormal vibration	Visual	Visual
m	25	Abnormal deflection	Visual	Visual
0	26		Visual	Visual, string bob, convex
n	20	Detoundon	* 130di	tape
["	27	Filling with sand	Visual	Visual
	28	Settlement	Visual	Visual (level)
	29	Moving	Visual	Visual, (survey)
	30	Inclination	Visual	Visual, string, convex tape
	31	Scour	Visual	Visual, string, pole
	32	Sectional reduction	Visual	Visual
Ļ		Sectional rediction	1.1340	Line

^() in the above table shows required tools.

Table 3.4 Typical Nondestructive Inspection Method

(1) Steel members

Method	Available data	Scope	Procedure	Advantages	Drawbacks
Ultra- sonic testing	- Applicable to detect member defects, particularly crack. Easy to identify defect locations	- Metallic, non- metallic, plastic and other materials which allow trans- mission of ultra- sonic wave Applicability not so restricted in terms of the shape of members	Ordinary method, pulse reflection method	- Difficult to detect small defects, but applicability not restricted in terms of materials thickness - Easy to carry around - Abundant successful results - Economical	 Difficult to store the record Skill necessary for measurement Difficult to understand the damage shape Low in sensitivity when the coating is thick
Magnetic particle exami- nation	- Applicable to detect crack in or around the member surface	- Magnetic materials (iron and steel)	- Ordinary method, Yoke methods		- Applicable only to magnetic materials such as iron and steel Impossible to detect internal damage - Impossible to measure the crack depth
Ulfrasonic method	Measurement of the thickness	- Metaltic, non- metallic, and other materials which allow transmission of ultrasonic wave	Measurement of the thickness by causing resonance with ultrasonic wave	- Easy to measure - Abundant successful results	 Difficult to store the record Low accuracy when the coating film is thick

(2) Concrete members

Method	Available data	Scope	Procedure	Advantages	Drawbacks
Schmidt hammer method	Measurement of the concrete surface hardness - Estimation of concrete compressive strength	- Concrete Models Type N Type NR Type L Type P Type M		- Easy to measure - Applicable without regard to the shape and dimensions of objects - Easy to measure objects	Measurement possible only for the surface area Relatively large variance in accuracy Period in service must be taken into account
Ultra- sonic method	- Estimation of concrete compressive strength	- Applicable without much restriction in terms of concrete shape		- Easy to measure	 Not satisfactory in accuracy Application restricted in terms of member thickness
Ultra- sonic method	- Crack, cavity and honey comb	- Concrete mortar, etc.	Measurement frequency is several 10 kHz, which is lower than that for measurement of steel members	Easy to measure No restriction in terms of the shape of object	 Skillnecessary for judgment to a certain degree Difficult to store the record Size of defect can not be determined
Ultra- sonic method	- Estimation of concrete thickness	Members in general		- Easy to measure	

3.3.1 Non Destructive Inspection Equipment

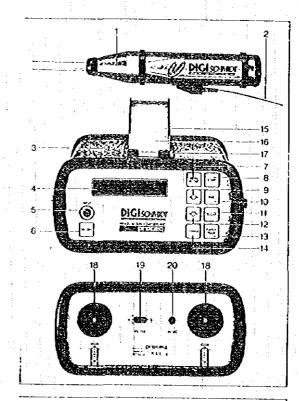
(1) Schmidt Hammer

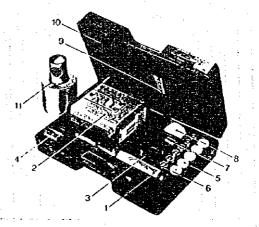
The compressive strength of concrete can be estimated without breaking with a Schmidt hammer. This method was introduced by Mr. Schmidt in 1948 and are used now in worldwide. However the test result depends on shape and dimension of structures, point to be tested, wet/dry condition of structure surface and smoothness of surface. Therefore results show reference only not exact figure.

- 1. Hammer
- 2. Cable
- 3. Indicator unit
- 4. Display
- 5. Cable plug
- 6. On/off switch
- 7. Switch for menu open/finish
- 8. Start switch
- 9. Selection of menu
- 16. Record paper
- 18. Battery box
- 20. Adapter plug

[Standard Set]

- 1. Hammer
- 2. Indicator unit
- 3. Belt to carry
- 4. Paper winding
- 5. Paper
- 6. Battery
- 7. Anti dust ring
- 8. Carbo random stone
- 11. Test anvil

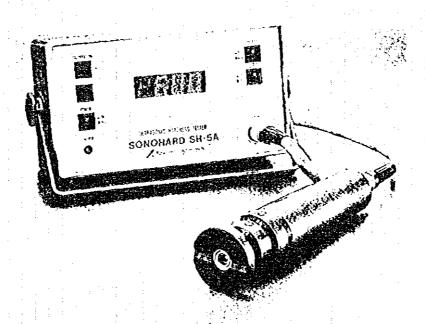




(2) Ultrasonic Hardness Meter

This meter is used to measure rapidly to pick hardness or Rockwell hardness with ultrasonic vibration.

SONOHARD' COLLADA



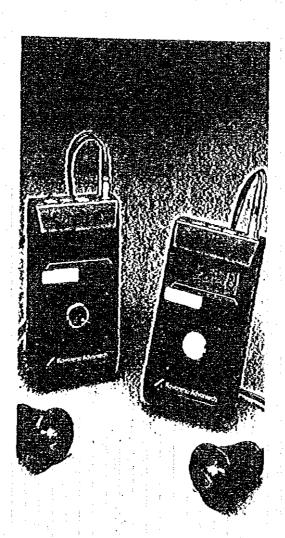
(3) Ultrasonic Thickness Meter

This meter is used to measure the thickness of steel tank, steel pipe and structures. It will be used also to measure degree of collosion.

Materials to be tested: steel, cast steel, aluminum, copper, titan, grass, ceramic, plastic, etc.

Range of thickness 0.8 mm to 80 mm

Unit of measure 0.1 mm



(4) Concrete Neutralization Tester (CONKIT)

Concrete during easting contains strong alkali. However when time passes, concrete touches carbon dioxide (CO2) in the air and alkali of concrete will decrease.

The pH of concrete is below 9, then reinforcement steel has a environment to start rust.

Procedure of test

- 1) Spray test liquid to the point of concrete
- 2) Red color- to alkali No change-to Neutral
- 3) In order to test the depth of neutralization, chip concrete with electric hammer drill then spray test liquid.



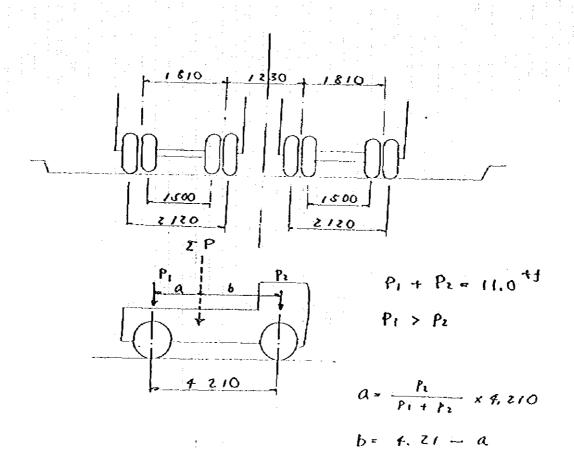
Full Scale Loading Test

To obtain the actual carrying capacity of dominant type of bridges in Sri Lanka and determine the appropriate design load on rehabilitation planning and design. Full scale loading test was carried out on some bridges.

Prior to the loading test all dimensions were surveyed in order to obtain calculated deflection to be compared with surveyed actual deflection.

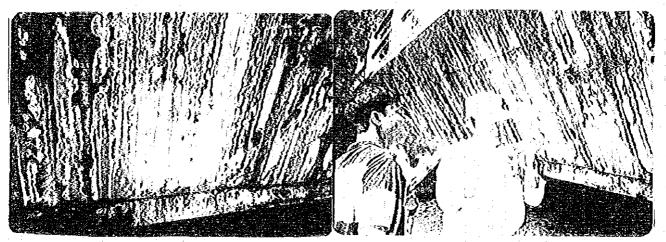
As to test method and result, please see relevant chapter of main text.

Loading on BR. Ser. No. 212



Schmidt Hammer Test

Ser. No. 212 AA002 138/1 km

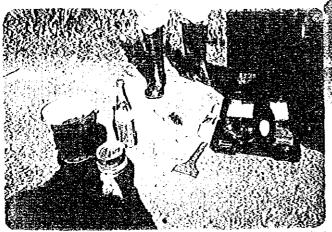


A1 - P1 Curb end

Schmidt hammer test

Steel Beam Thickness Measurement

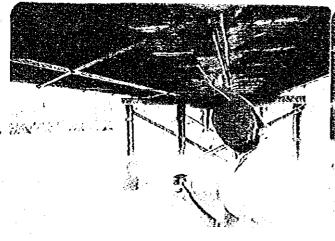
Ser No. 59 B157 43/4 km



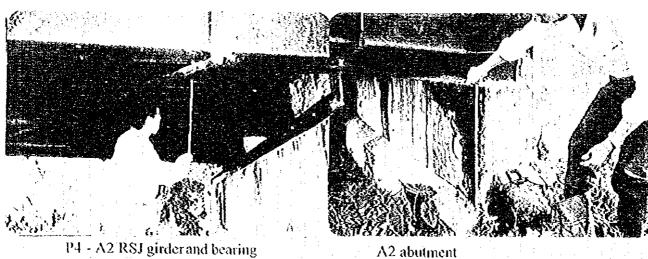
Thickness measuring tools, a whole set



Thickness measurement







A2 abutment

Loading Test

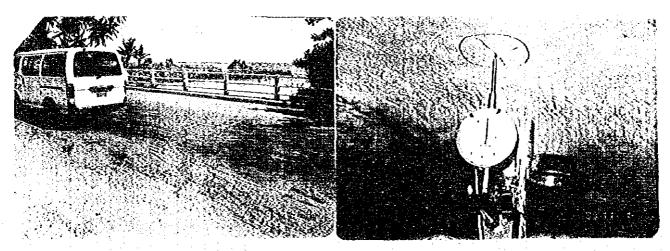


Axle Load Test

Same as Left



Ser No. 59



Ser No. 212

3.4 Inspection Machineries and Access Facilities

3.4.1 Bridge inspection vehicle

The use of a bridge inspection vehicle, rapid to install and superior in safety, will prove convenience to the inspection.

The Sri Lanka RDA obtains one German-made sky lift, which however can not be set to existing single-lane bridge, as its outrigger is larger than the bridge width and thus not used in the bridge inspection.

For the bridge maintenance and management in Sri Lanka from now on, it is recommended to purchase and utilize a midium bridge inspection vehicle as shown in page 3-19.

Cautions for inspection with a bridge inspection vehicle are as follows:

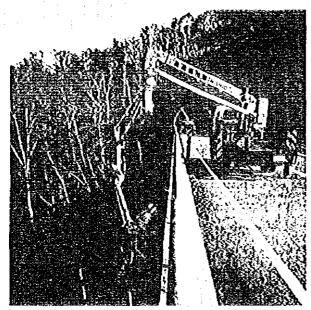
- (1) A trained operator must operate the bucket/platform and keep contact with an inspector on the bucket/platform.
- (2) Bridges in Sri Lanka are mostly of a single-lane and the use of the bridge inspection vehicle may cause closing of the road to traffic. Accordingly it is necessary to submit the work plan beforehand to a local police authority for approval.

3.4.2 Access facilities

The problem during inspection of bridges is how to make access to check particularly the damaged slabs, main girders and piers.

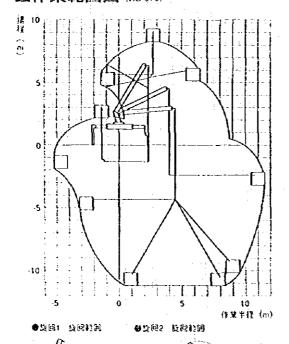
For bridges with narrow under clearance, scaffolding is a general practice to take for inspection. A bridge inspection vehicle is used when the bridge piers are tall or for an arch bridge crossing over a valley.

The safety as well as the cost and required time must be taken into account when selecting which means to take scaffolding or a bridge inspection vehicle

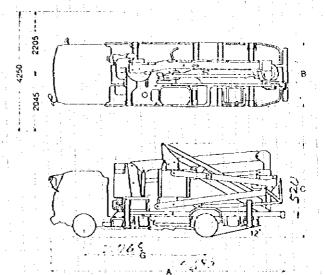


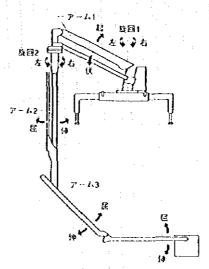
●写真はアンダーブリッジです。

图作業範囲図 (KU 070)



111 03 (1) 作業範囲図は、アウトリガーを撃士上に水平に設置したときのものであり、ブームのたわみを含んでいません。(2) 作業高さ3mまでの衝撃超え可能。





- Deck/platform

Weight	250 kg
Depth	5.8 m
Height	6.4 m
Working radius	5.4 m

- Boom

Angle	-15° ~ 60°
Length	$3.06 \text{ m} \sim 5.11 \text{ m}$

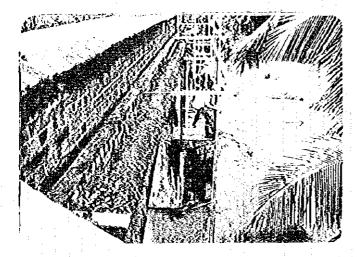
- Post

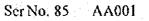
	1.		- 1				
1	.eng	gth	٠.	2.94	m ~	9.44	11

- Outrigger

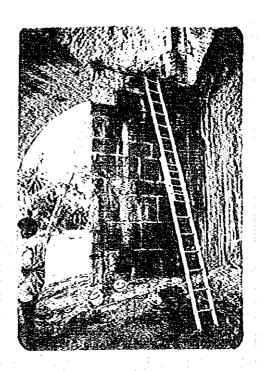
Front		3.35	m
Rear		3.17	m

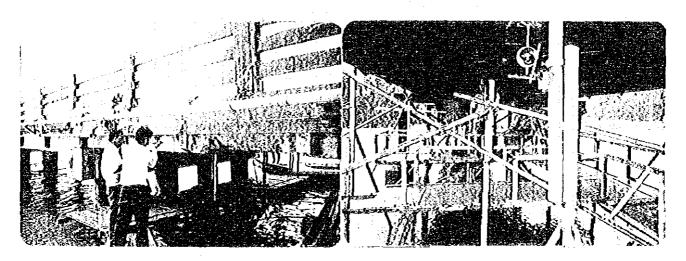
Scaffolding for Investigation





91/2 km





Ser No. 7

B425

20/4 km

Scaffolding for loading test Ser No. 59

3.5 Inspection Forms

A set of forms listed below was agreed to use from now on by RDA in the course of bridge maintenance and management, as shown in pages 3-22 to 3-28.

- * Bridge inventory form
- * Bridge inspection form (steel bridge)
- * Bridge inspection form (concrete bridge)
- * Bridge inspection form 2
- * Photographs
- * Bridge rehabilitation record form (steel bridge)
- * Bridge rehabilitation record form (concrete bridge)

Bridge Inventory	ory	SER No.					A Company of Accounts			
NAME OF BRIDGE		CLASS OF ROAD	CLASS OF ROAD CROSSING, NAME OF RIVER OR ROAD	OF RIVER OR ROA		COMPLETED	WAINTENANCE BY	· · · · · · · · · · · · · · · · · · ·		
Design Information	Yes	No No	Manufacture			Date of Preparation		Prepared by		
Type of Bridge	Superstructure				Design Loading			Load Limitation	No Yes	•
	Substructure	Abutment			Design Standard	BS				
		Pier			Skew of Bridge	Square	Skew	R L deg	deg. R-	
Length of Bridge		E	m Span		Condition of	Road	Width	Clearance m	m Skew deg.	
Width of Bridge	Overall width	ε.	m Camayeway m P	m Pedestnanway m	. ,	River	Width of River	Depth	Free Board	Design Quantity
Affixed articles							E	E	E	n m3/sec
Traffic Volume	- 10 mm - 10 mm	(vear)	Ratio of Heavy Vehicle	(Aear)	Others	Repair etc.		2		
Final Record of	Pavement	Deck Stab	Main Beam P	Painting	Expansion Joint	Bearing	Drainage	Railing	Curb	Affined articles
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Photographs

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Bridge Inspection Form (Steel Bridge)

SER No.

Topic Condition of Damps Rating Creation of Damps Rating Condition Rating Co	Code Warring Strange Critical Code Conditions of James Code Co	N.V.	NAME OF BRIDGE	CLASS OF ROAD	CROSSING: NAME OF RIVER OR ROAD	COMPLETED DATE OF	DATE OF INSPECTION MAINTENANCE BY	ANCEBY
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e imposed 4 Deck slab (Underface) 9 Elevation 14 Pier	posodui o			loant damage and a detailed survey needs to be can	thed out to establish whether repair work is to be carried out or not.	3 Expansion joint		
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Bridge Inspection Form (Concrete Bridge)

SER No.

Component	Condition of Damage.	Rating Sketch and comments on major damage	s on major damage		
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	Washing Oracle Der hole Orbers				
and C	Contino	Ţ			
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EXPansion Joint	- 1'			:	
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Bearing					
	Invisible, Existed, Cood, broken, Anchor bolt Abnormal displacement	Comments on rehabilitation method	litation method		
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SER No Bridge Inspection Form 2 NAME OF BRIDGE LOCATION Photo album No

Bridge Rehabilitation Record Form (Steel Bridge)

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ıs O	Curb															
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Bridge Rehabilitation Record Form (Concrete Bridge)

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3.6 Bridge Visual Inspection (Preliminary Bridge Inspection)

Bridge visual inspection carried out in May, 1995 was shown in photos of subsequent pages.

As the number of bridges to be inspected was as large as 100 and they are located widely scattered all over the country, three teams were formed. Each team includes three to four members, including one or two Study Team members and two released engineers of RDA. These teams covered the following areas respectively:

Team 1: Area around Colombo and western province, with Colombo as a base point

Team 2: Southern province, with Galle as a base point

Team 3: Central province, with Kandy as a base point

Each team carried following investigation tools:

- Measuring equipment: Convex tape (3m, 5m), folding measure, 50 m tape, clinometer, crack scale, plumb bob, slide calipers, test hammer, etc.

- Recording tools: Camera, white board, marker pen, ribbon rod, flashlight, chalk, drawing board, etc.

- Access equipment: Ladder, rope, binoculars, etc.

- Safety tools: Color cones, leather gloves, working gloves, boots, etc.

The inspection schedule is shown in Table 3.5.

A total of 39 days were necessary to inspect all of 104 bridges, which means that one team carried out the inspection of 3.7 bridges a day in the average. The number of bridges inspected per day was small because the bridges are scattered all over the country, taking a time for traveling.

Table 3.5 Schedule of Preliminary Bridge Inspection

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					•		18(STTR/T)			202(BAILEY)	(/anc)		30(KSJ/COK)			41(RCS)		74(RSJ/BUC)								86(PSC/PRE)							
(FURUKAWA	(TYPE)	o Tras	o Team		m Team	76(STTR/T)	67(KSJ/RCS)		138(RS1/BUC)		21(STTR/T. RSJ/DUC)	58(RSJ/RCS)	18(%51/%CS)			25(KSJ/KCS)	72(STTR/T)	27(ARCII/ST)								42(STTR/T)		The second second			The second decrease of		
GALLE TEAM (FURUKAWA)	SER. NO (TY	Same as Colombo Team	Same as Colombo Team	·	Same as Colombo Team	7S(STTR/T).	33(STTK/T)		173(RSJ/BWC) 138(RSJ/BWC)	21(STTR/T. RSJ/BUC)	40(RS1/3UC)	S9(RS1/BUC)	31(RSJ/RCS) 18(RSJ/RCS)			35(RS1/RCS)	24(RSJ/T)	\$2(R\$1/COK)							1(800)	87(PSC/PRE)		man of the second of the second			Access to a second	212(150/1785)	:
)	HOTEL,					Anuradapula	Kandy		ditto		ditto		Badulla	Clarenchical		כסרסאסס		ditto	ditto .	ditto	ditto	Nuvara Eliya	Youdy		COLOXBO	ditto	ditto						
HARIYA)							63(CAUSÉTAY: 73(RCS)		(T/X172) (XI				0	(3/10/134)// (0.		33		(X	C) S6(XS1/BUC)		W 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	135(RSJ/BUC)	כספנפיורבג)		D 85(ARCII/BR)	3.)	(%)	S)	1.00				
TEAM (NAMBA.	(TYPE)	Saac as Colombo Tenn	Same as Colombo Team		Shac as Colombo Tene	68(RNJ/BUC, PSC/PRE)		SETAY)	139(CAUSETAY: 119(AKCH/BK)				106(RSJ(RCS) 128(STTR/T)	(02/11/201/10)		DOX) 89(RSJ/COR)		R/T) 133(RSJ/BUC)	/COR> SSCRSI/BUC)			II/ST) 46(ARCII/ST)	LEY) 93(STTK/T)	/BUC)	R/D) = 84(ARCII/S)	/COR) 70(KS)/RCS)	209(ARCII/DR)Ydn. (RS)/RCS)	210(RS1/RCS) 211(RS1/RCS)					
KANDY	SER. NO	Same as	Same as		Shac as		65(KSJ/KCS)	62(CAUSEYAY)	139(CAU		: .: 			(43/48611/08)	(«/XTTR(STT	91(RC/DOX)		(T/XTTX/E)	127(RSJ/COR)			47(ARCII/ST)	22(UAILEY)	57(RSJ/BUC	99(STTR/b)	175(RSJ/COR)	209(ARC)	210(KS1,	-	:	: :		:
(HOTEL	COLOKIO	ditto		ditto	Απικοφορικα	01.1 ip		כסרסאסס		ditto		ditto	9117		ditto		ditto	ditto	ditto	ditto	Kandy	ditto	t was a section of	CO1.0X00	ditto	0)110						2
I. KATAOKA)	:		197(STTX/T)		32(RS1/COK)		(44(RS1/RCS)		ÇÇ.					(AUC)				131 (RS1/COR)	154(KS1/BUC)				60(CAUSEYAY		08(RSJ/BUC)	3							
TEAK (KASUGA,	TYPE)	(11)	195(RSJ/COR) 197(STTR/T)		17(RS1/BUC) 32(RS1/COR)		CHOLULEY)		71CISC/PRE)rec.				Z(RSJ/BUC) 123(PSC/PRE)	COMPLETE		SJ/RCS)	Red. RCS	- 1	151(RS1/BUC) 154(RS1/BUC)			34(STTR/T)	36(RS1/COK)		78(RS)/BBC) 150(RSI/COR) 108(RSI/BBC)		In. (RSJ/RCS)	211(RS1/RCS)					
COLONBO TE		7(PSC/PRE, RCIL)	66(8778/T)	201(ARCII/CO)	79(NTTR/T)	39(RS1/COR)	193(collapset	103(RCS)	122(STTX/T)	80(STTR/T)			Z(RSJ/BUC)	CHRISTIAN CHRIST		77(STTR/T, RSJ/RCS)	120(RN1/COR), Red, RCS	8 Tilli 1294ARCII/BR) 1304STTR/T)	\$3(STTR/T)			20(KS1/COK)	102(KS1/CCR) 36(KS1/COR)			38(RS1/T)	209(ARCH/BR) Tdn. (RSJ/RCS)	210(RSJ/RCS) 211(RSJ/RCS)				1	
		MAY. 8 MON			10 860	UIIT II	12 FR1		13 SAT		NOS 51.		15 20%	16 1116		03x /1		18 [11]	19 FR1	20 SAT	21 SUN	22 XON	23 TUE		24 NED	25 Tittl	26 FR!		27 SAT	28 SUN	29 NON	30 TUE	311860