Expansion Joints
Dampers (Pylon, Girder, Cable)
Lighting

Updating of repaired date after carrying out repairs is designed to input automatic by the system from the repair database file to the routine inspection database file, depending on their process in the repair database system. Their design concepts is presented in detail in the later section of repair system.

Routine inspection coding sheets are presented in Appendix-A.025 to Appendix-A.035 for the Land Section and Appendix-A.036 to Appendix-A.044 for the Rama IX Bridge Section.

5.5.3 Routine Inspection Report Forms

Routine inspection database system provides two kinds of output forms, which are routine inspection report forms and member list to be inspected for routine inspection work, for both the Land Section and the Rama IX Bridge Section, exclusively. Their forms and retrieval conditions for output are common to the Land Section and the Rama IX Bridge Section on design concepts shown below.

1) Routine Inspection Report

Land Section

Eleven routine inspection report forms are provided by the system for the Land Section, in terms of the difference of damage items and combination of key identifiers on each structure or facilities as follows:

<Routine Inspection Report Forms for Land Section>

Superstructures and Retaining Wall
Piers
Embankments
Pavement
Guard Wall
Drainage
Expansion Joints
Bearings

Lighting
Traffic Signs
Noise Barrier

Retrieval of outputting routine inspection reports are designed so information can be extracted by any combination of the following conditions:

- damaged member as an indispensable data,
- inspected date in form of from date to date,
- work class in form of from work class to another work class,
- route,
- direction of traffic,
- main road/ramp distinction,
- chainage from start point to end point, and
- unique number which are pier number, pole number, location and code,
- evaluation in form of from rank to another rank,
- work needed in form of work to another work needed,
- date to be done in form of from date to date, and
- repaired date in form of from date to date.

Depending on the combination of the above retrieval conditions, users can readily obtain output forms for the better use of information stored for the maintenance work, in the same manner of that of the daily inspection system, for example:

- routine inspection report:
  to extract designated inspection date in form of from date to date, together with other retrieval conditions if any, users can obtain monthly routine inspection reports,

- repaired list:
  to extract repaired date in the similar procedures to the former section of daily inspection, users can get repaired member list which presents members already repaired due to its damages, and

- member list for repair needed:
  to extract repaired date in the same manner as the above, users can obtain member list of which are needed repair works, for any repairs has not been performed in spite of being serious damage.

Rama IX Bridge Section

Nine routine inspection report forms are provided by the system for the Rama IX Bridge Section, in terms of the difference of damage items on structures or facilities, as follows:

<Routine Inspection Report Forms for Rama IX Bridge>

Steel Plates and Frame Members (Steel General)
(for main girder, pylon, maintenance facilities and guard barriers)
Stay Cable
Pavement
Piers
Drainage
Bearings (Pendel, Neo-Pot, Wind)
Expansion Joints
Dampers (Pylon, Girder, Cable)
Lighting

Retrieval of outputting routine inspection reports are designed so information can be extracted by any combination of the following conditions:

- damaged member as an indispensable data,
- inspected date in form of from date to date,
- work class in form of from work class to another work class,
- unit number of members on the Rama IX Bridge, which are lot number on girder and pylon, pier number, pole number, etc., in form of from number to number,
- evaluation in form of from rank to another rank,
- work needed in form of work to another work needed,
- date to be done in form of from date to date, and
- repaired date in form of from date to date.

Depending on the combination of the above retrieval conditions, users can readily obtain output forms for the better use of information stored for the maintenance work, in the same manner of that of the Land Section as follows:

- routine inspection report,
- repaired list, and
- member list for repair needed.

Routine inspection report forms are presented in Appendix-A.069 to Appendix-A.079 for the Land Section and Appendix-A.080 to Appendix-A.088 for the Rama IX Bridge Section.

2) Member List to be Inspected

In order to assist in routine inspection planning, the system provides member list to be inspected to users, of which members were not been performed routine inspection for a certain duration in the past. These information can be taken out from routine inspection database file, together with road inventory database for the Land Section and member database for the Rama IX Bridge Section.

Land Section

One output form, which is for four major members of superstructures, piers, expansion joints and pavement for routine inspection, are provided describing in the essential key identifiers and the last date of routine inspection conducted, except for work class.

Retrieval of outputting this form is designed to extract information by following conditions:

- route number as an indispensable data,
- member code for routine inspection as an indispensable data, and
- date of the last routine inspection performed.

Rama IX Bridge Section

One output forms, which is for seven major members of main girder, cables, pylons, pavement, piers, bearings and expansion joints for routine inspection for the Rama IX Bridge Section, are provided describing in the essential key identifiers and the last date of routine inspection, except for work class.

Retrieval of outputting this form is designed to extract information by following conditions:

- member code for routine inspection as an indispensable data, and
- date of the last routine inspection performed.

Member list to be inspected forms are presented in Appendix-A.089 for the Land Section and Appendix-A.090 for the Rama IX Bridge Section.

5.5.4 Design Concepts on Processing

The process flow of the routine inspection system is subdivided into four processes: appending, altering, outputting and deleting, which is common to both the Land Section and the Rama IX Bridge Section, as shown in Figure-5.5.1.

The output process is separated into two processes for two output forms, routine inspection report and member list to be inspected. This member list is made from information stored in the routine inspection database file and the road inventory database file for the Land Section. Meanwhile, member list for the Rama IX Bridge Section is extracted from the routine inspection database file and the member database file for the bridge.

The processes on the above four branches are common functions to that of the inventory database system. Their detail process flow is presented in the system users manual.

The screen layouts for their processes are separated in consideration of items of information to be displayed on the screen, for example, eleven appending screens for the Land Section and nine screens for the Rama IX Bridge Section. The screen layout for appending is presented as a sample for superstructures in Figure-5.5.2 for the Land Section.

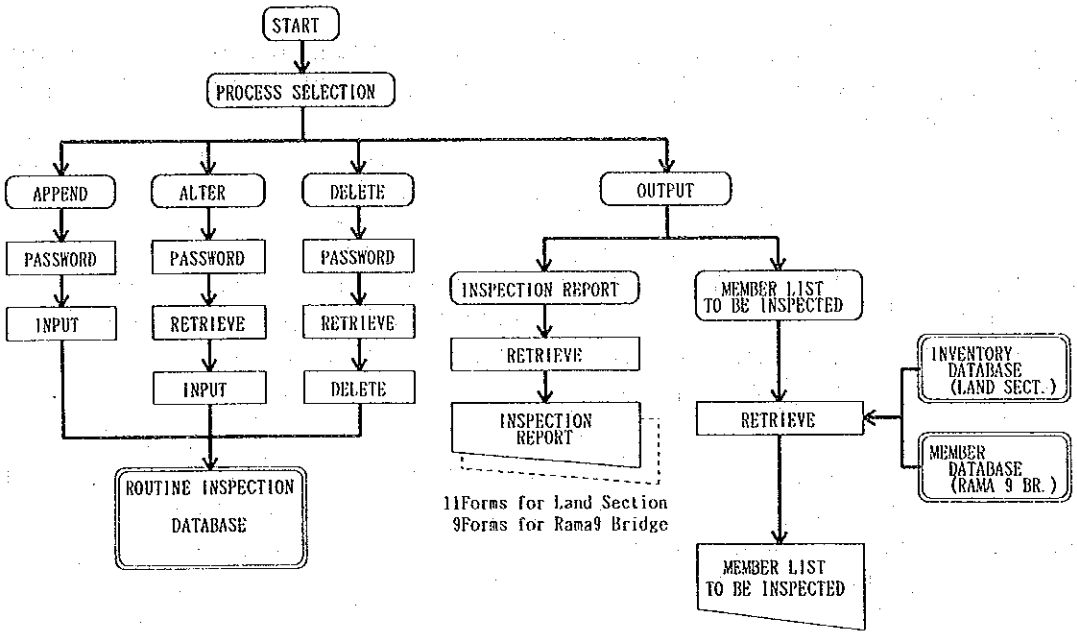


Figure-5.5.1 Process Flow of Routine Inspection System

```
          INSPECTED MEMBER :99 _____________
            INSPECTED DATE :YY/MM/DD
                WORK CLASS :99 ___________________
              ROUTE NUMBER :XX-XX
        DIRECTION OF TRAFFIC :X
            MAIN ROAD / RAMP :9 ________
                  CHAINAGE :START 999999.999 m    END 999999.999 m
                           <DAMAGE CONDITIONS>
                WATER LEAKAGE AND LEACHING OF FREE LIME :X
                                              CRACKING :X
              SPALLING AND CORROSION OF REINFORCING BAR :X
                                              CAVITIES :X
                           DISPLACEMENT OR SETTLEMENT :X
                                      TOTAL EVALUATION :X
                  COMMENTS :XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

               WORKS NEEDED :99 _____________
          DATE TO BE DONE :YY/MM
        NAME OF INSPECTOR :XXXXXXXXXXXXXXXXXXXX
         DOCUMENTS NUMBER :XXXXXXXXXXXXXXXXXXXX

    (1) APPEND AND CONTINUE  (2) APPEND AND END   (3) REENTRY   (4) ESCAPE
                                 Select No ==> 9
    MESSAGE AREA :XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Figure-5.5.2 Screen Layout on Appending of
Routine Inspection for the Land Section

5.6 Repair Database System

5.6.1 Database Files and Data Items

1) Land Section

The repair database files are designed to store information generated by any kinds of repairs except for cleaning works, and system is formulated in the same manner as those of the inspection database system, in form of single database for both the Land Section and the Rama IX Bridge Section.

The data items in single repair database file for the Land Section are determined to be capable of covering all objective members to be stored in this database file. The number of items of this database file consists of thirty-six items in total, with fifteen key identifiers, sixteen attributive data and five control data for information processing in the system. Items of repair database file for the Land Section is presented in Table-5.6.1.

Essential data items to be inputted for each objective member are different each other in terms of the difference of key identifiers of repaired members, and are summarized in Table-5.6.2.

2) Rama IX Bridge Section

The repair database for the Rama IX Bridge Section is also designed to accommodate information in a single database file in the same manner as that of the Land Section as shown in Table-5.6.3.

The number of items in this database file is thirty-two items in total, with seven items for key identifiers, sixteen items for attributive data and five items for information processing. The total number of items of this database file is less than those of the Land Section, since number of key identifiers is less than those of the Land Section.

Essential data items to be inputted for each objective member are different from pavement and other members in term of key identifiers, and are summarized in Table-5.6.4.

Table-5.6.1 Items of Repair Database File for Land Section

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Repaired Member	C	2	◎	○		Cl:27
Repaired Date	N	6	◎	○		yy/mm/dd completion
Repair Work Class	C	2	◎	○		Cl:29
Inspected Date	N	6	◎	○		yy/mm/dd in INS. DB
Inspection Work Class	C	2	◎	○		Cl:28 in INS. DB
Route	X	5	◎	○		character in XX-XX
Direction of Traffic	X	1	◎	○		character in A, B, ··
Main Road/Ramp	C	1	○	○		Cl:1
Chainage(Start)	N	6	○	○		999999 (m)
(End)	N	6	○	○		do.
Pier Number (Start)	X	10	○	○		character
(End)	X	10	○	○		do.
Contract Number	X		○	○		
Location Code 1	X	1	○	○		character in S, E, ··
Location Code 2	C	1	○	○		Cl:14
Lane Number	X	1	○	○		character in E, 1, 2,··
Pole Number	X	10	○	○		character
(Repair Conditions)						
Repair Method	C	5		○		Cl:35
Quantity in Meters (m)	N	10			○	99,999,999.9(m)
Quantity in Sq.m (m^2)	N	10			○	99,999,999.9(m^2)
Quantity in KG (kg)	N	5			○	99,999(kg)
Q'ty in No of Location	N	5			○	99,999
Unit Costs for (m)	N	10				9,999,999,999 Baht
Unit Costs for (m^2)	N	10				do.
Unit Costs for (kg)	N	10				do.
Unit Costs for No. Loc	N	10				do.
Total Costs	N	10			○	do.
Name of Contractor	X	20				character
Contract Number	X	20				do.
Repair Work Duration	N	3				days
New Type Code	N	2				member code by object
Comments	X	40				do.
(Remarks)						
Name of Engineer	X	20				character
Date of Data Inputted	N	6				yy/mm/dd by cpu
Documents Number	X	20				character
(Flags)						
Code Check	N	1				ok=1
Ex. Indispensable Item	N	1				do.
Duplication	N	1				do.
Key CheckK	N	1				do.
Update to Ins. DB	N	1				done=1 on repaired date
	(Total 303)					

Table-5.6.2 Items of Repair Database File for Rama IX Bridge Section

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Repaired Member	C	2	◎	○		Cl:30
Repaired Date	N	6	◎	○		yy/mm/dd completion
Repair Work Class	C	2	◎	○		Cl:29
Inspected Date	N	6	◎	○		yy/mm/dd in INS. DB
Inspection Work Class	C	2	◎	○		Cl:28 in INS. DB
Unit Number	X	6	◎	○		character
Lane Number	X	1	○	○		character in E, 1, 2,··
(Repair Conditions)						
Repair Method	C	5		○		Cl:36
Quantity in Meters (m)	N	10			○	99,999,999.9(m)
Quantity in Sq.m (m^2)	N	10			○	99,999,999.9(m^2)
Quantity in Kg. (kg)	N	5			○	99,999(kg)
Q'ty in No.of Location	N	5			○	99,999
Unit Costs for (m)	N	10				9,999,999,999 Baht
Unit Costs for (m^2)	N	10				do.
Unit Costs for (kg)	N	10				do.
Unit Costs for (no loc	N	10				do.
Total Costs	N	10			○	do.
Name of Contractor	X	20				character
Contract Number	X	20				do.
Repair Work Duration	N	3				days
New Type Code	N	2				member code by object
Comments	X	40				do.
(Remarks)						
Name of Engineer	X	20				character
Date of Data Inputted	N	6				yy/mm/dd by cpu
Documents Number	X	20				character
(Flags)						
Code Check	N	1				ok=1
Ex.Indispensable Item	N	1				do.
Duplication	N	1				do.
Key CheckK	N	1				do.
Update to Ins. DB	N	1				done=1 on repaired date
	(Total 246)					

Table-5.6.3 Essential Items by Repaired Members for Land Section

DATA ITEM \ PARTS		SUPER STRUCTURE / RETAINING WALL	EMBANKMENT / DRAINAGE	PIER	PAVEMENT	GUARD WALL / NOISE BARRIER	HAND RAIL / GUARD RAIL / GUARD FENCE	EXPANSION JOINTS	BEARINGS	LIGHTINGS / TRAFFIC SIGN
KEY IDENTIFIER	REPAIRED MEMBER		◎	◎	◎		◎	◎	◎	◎
	REPAIRED DATE		◎	◎	◎		◎	◎	◎	◎
	REPAIR WORK CLASS		◎	◎	◎		◎	◎	◎	◎
	ROUTE		◎	◎	◎		◎	◎	◎	○
	DIRECTION OF TRAFFIC		◎	◎	◎		◎	◎	◎	○
	MAIN ROAD/RAMP		◎	◎	◎		◎	◎	◎	○
	CHAINAGE(START)		◎	◎	◎		◎	◎	◎	○
	CHAINAGE(END)		◎		◎		◎			
	PIER NUMBER			○						
	LOCATION CODE 1								◎	
	LOCATION CODE 2						◎			○
	LANE NUMBER				◎					
	POLE NUMBER									◎
	INSPECTED DATE		○	○	○		○	○	○	○
	INSPECTION WORK CLASS		○	○	○		○	○	○	○
REPAIR CONDITIONS	REPAIR METHOD		○	○	○		○	○	○	○
	QUANTITY IN METERS (m)		○	○	○		○	○	○	○
	QUANTITY IN SQ.m (m^2)		○	○	○		○	○	○	○
	QUANTITY IN KG (kg)		○	○	○		○	○	○	○
	Q'TY IN NO OF LOCATION		○	○	○		○	○	○	○
	UNIT COSTS FOR (m)		○	○	○		○	○	○	○
	UNIT COSTS FOR (m^2)		○	○	○		○	○	○	○
	UNIT COSTS FOR (kg)		○	○	○		○	○	○	○
	UNIT COSTS FOR NO. LOC		○	○	○		○	○	○	○
	TOTAL COSTS		○	○	○		○	○	○	○
	NAME OF CONTRACTOR		○	○	○		○	○	○	○
	CONTRACT NUMBER		○	○	○		○	○	○	○
	COMMENTS		○	○	○		○	○	○	○
REMARKS	NAME OF ENGINEER		○	○	○		○	○	○	○
	DATE OF DATA INPUTTED		○	○	○		○	○	○	○
	DOCUMENTS NUMBER		○	○	○		○	○	○	○
FLAGS	CODE CHECK		○	○	○		○	○	○	○
	EX. INDISPENSABLE ITEM		○	○	○		○	○	○	○
	DUPLICATION		○	○	○		○	○	○	○
	KEY CHECK		○	○	○		○	○	○	○
	UPDATE TO INS. DB		○	○	○		○	○	○	○
TOTAL NUMBER OF DATA ITEMS		31		31	32	32		30	31	32

NOTE ◎: INDISPENSABLE KEY IDENTIFIERS
○: SUPPLEMENTAL KEY IDENTIFIERS OR ATTRIBUTIVE DATA ITEM

Table-5.6.4 Essential Items by Repaired Members for Rama IX Bridge Section

DATA ITEM \ PARTS		MAIN GIRDER / STAY CABLE / PYLON / PIER / GUARD BARRIER	HAND RAIL / DRAINAGE / PENDEL BEARING / NEO-POT BEARING / WIND BEARING	EXPANSION JOINTS / PYLON DAMPER / GIRDER DAMPER / GIRDER GANTRY / PYLON LIFT	PYLON LADDER / PYLON GONDOLA / CABLE GONDOLA / LIGHTINGS / TRAFFIC SIGN	PAVEMENT
KEY IDENTIFIER	REPAIRED MEMBER			◎		◎
	REPAIRED DATE			◎		◎
	REPAIR WORK CLASS			◎		◎
	UNIT NUMBER			◎		◎
	LANE NUMBER					◎
	INSPECTED DATE			○		○
	INSPECTION WORK CLASS			○		○
REPAIR CONDITIONS	REPAIR METHOD			○		○
	QUANTITY IN METERS (m)			○		○
	QUANTITY IN SQ.m (m^2)			○		○
	QUANTIRY IN KG. (kg)			○		○
	Q'TY IN NO.OF LOCATION			○		○
	UNIT COSTS FOR (m)			○		○
	UNIT COSTS FOR (m^2)			○		○
	UNIT COSTS FOR (kg)			○		○
	UNIT COSTS FOR NO.LOC			○		○
	TOTAL COSTS			○		○
	NAME OF CONTRACTOR			○		○
	CONTRACT NUMBER			○		○
	COMMENTS			○		○
REMARKS	NAME OF ENGINEER			○		○
	DATE OF DATA INPUTTED			○		○
	DOCUMENTS NUMBER			○		○
FLAGS	CODE CHECK			○		○
	EX.INDISPENSABLE ITEM			○		○
	DUPLICATION			○		○
	KEY CHECK			○		○
	UPDATE TO INS. DB			○		○
TOTAL NUMBER OF DATA ITEMS				27		28

NOTE ◎: INDISPENSABLE KEY IDENTIFIERS
○: SUPPLEMENTAL KEY IDENTIFIERS OR ATTRIBUTIVE DATA ITEM

5.6.2 Coding Sheets for Repairs

Coding sheet for inputting repaired data are designed based on the following design concepts in such a way that it is possible to:

- provide separate coding sheets for both the Land Section and the Rama IX Bridge Section,
- write into repaired data easily, together with code table indicated in the coding sheets,
- input repair information into database easily, for layout form of coding sheet is similar to that of the computer screen for inputting, etc.

Eight coding sheets for repair database file, which are separated by the difference of key identifiers of each member, are provided for the Land Section and are as below.

<Repair Coding Sheets for Land Section>

Superstructures, Retaining Wall, Embankment and Drainage,
Piers
Pavement
Guard Wall and Noise Barrier
Expansion Joints
Bearings
Lighting and Traffic Signs
Handrails, Guard Rails and Fence

Two coding sheets for repair database file for the Rama IX Bridge, which are separated by the difference of key identifiers of each member, are provided and are as below.

<Repair Coding Sheets for Rama IX Bridge>

General (except for pavement)
Pavement

Repair coding sheets are presented in Appendix-A.045 to Appendix-A.052 for the Land Section and Appendix-A.053 to Appendix-A.054 for the Rama IX Bridge Section.

5.6.3 Repair Report Forms

The repair database system provides three kinds of output forms to users from databases; repair reports, member list to be repaired and cost evaluation lists.

1) Repair Reports

Land Section

Eight (8) forms of repair report are provided by the system for the Land Section, in form of classified as shown below.

<Repair Reports for Land Section>

Superstructures, Retaining Wall, Embankment and Drainage,
Piers
Pavement
Guard Wall and Noise Barrier
Expansion Joints
Bearings
Lighting and Traffic Signs
Handrails, Guard Rails and Fence

Retrieval of outputting repair reports is designed to extract information by any combination in the following conditions:

- repaired member as an indispensable data,
- repaired date in form of from date to date,
- repair work class in form of from class to another class,
- route,
- direction of traffic,
- main road/ramp distinction,
- chainage from start point to end point,
- unique number such as pier number, pole number, etc.,
- damage inspected date in form of from date to date,
- inspected work class in form of from class to another class, and
- repair methods in form of from method to another method.

Depending on the combination of the above retrieval conditions, users can readily obtain repair reports for the better use of information stored for the maintenance work, in the same manner as that of routine inspection.

Rama IX Bridge Section

Two (2) forms of repair report are provided by the system for the Rama IX Bridge Section, in form of classified as shown in Table-5.6.4 and below.

<Repair Reports for Rama IX Bridge>

General (except for pavement)
Pavement

Retrieval of outputting repair reports is designed to retrieve information by any combination in the following conditions:

- repaired member as an indispensable data,
- repaired date in form of from date to date,
- repair work class in form of from class to another class,
- unit number such as pier number, pole number, etc.,
- damage inspected date in form of from date to date,
- inspected work class in form of from class to another class, and
- repair methods in form of from method to another method.

Users can readily obtain repair reports for the better use of information stored, depending on the combination of the above retrieval conditions, in the same manner of the above mentioned.

Repair report forms are presented in Appendix-A.091 to Appendix-A.098 for the Land Section and Appendix-A.099 to Appendix-A.100 for the Rama IX Bridge Section.

2) Member List to be Repaired

In order to assist maintenance engineers in terms of providing member list automatic by the system, the system provides member list to be repaired members of which have not been performed any repairs in spite of being serious damage to be repaired.

Two output forms are supplied by the system for both the Land Section and the Rama IX Bridge Section. These forms present the essential key identifiers for members, damage evaluation, works needed and date to be done from the routine inspection database

file. Objective members for each section are below.

<Objective Members to be Repaired for Land Section>

Superstructures
Guard Wall
Drainage
Piers
Expansion Joints
Bearings
Embankment
Retaining Wall
Pavement
Lighting
Traffic Signs
Noise Barrier

<Objective Members to be Repaired for Rama IX Bridge Section>

Main Girder
Stay Cable
Pylon
Pavement
Pier
Guard Barrier
Drainage
Pendel Bearings
Neo-Pot Bearings
Wind Bearings
Expansion Joints
Pylon Damper
Girder Damper
Cable Damper
Girder Gantry
Pylon Lift
Pylon Ladder
Pylon Gondola
Cable Gondola
Lighting

Retrieval of outputting this form is designed to extract information by following conditions:

- route number as an indispensable data for land section,

- member code for repairs as an indispensable data,
- works needed in form of from work to another works, and
- date to be done in form of from date to date.

The layout of member list to be repaired are attached in Appendix-A.101 for the Land Section and Appendix-A.102 for the Rama IX Bridge Section.

3) Cost Evaluation List

In order to support repair works in terms of providing rough costs for repairs by the system, the system provides cost evaluation list for pavement for both the Land Section and the Rama IX Bridge Section, in response to the inputted unit costs together with some retrieval conditions for repairs. Further, the system provides cost evaluation list for expansion joints for the Land Section which are apt to be damaged directly by the wheel loads.

Retrieval of outputting cost estimation list is designed to extract information by any combination in the following conditions:

<for Land Section>

- repaired member, which is pavement or expansion joints, as an indispensable data,
- route as an indispensable data,
- direction of traffic as an indispensable data,
- main road/ ramp distinction as an indispensable data,
- chainage in form of from chainage to chainage as an indispensable data,
- damage rating by damage item in form of from rating to rating,
- total damage rating in form of from rating to rating,
- work needed in form of work class to work class, and
- date to be done in form of date to date.

Meanwhile, retrieval to output cost estimation list for pavement of the Rama IX Bridge is designed to extract information by any combination in the following conditions:

<for Rama IX Bridge>

- unit number and lane number in form of from number to number,
- damage rating by damage item in form of from rating to rating,
- rutting depth in form of depth to depth,
- PSI in form of value to value,
- total damage rating in form of from rating to rating,
- work needed in form of work class to work class, and
- date to be done in form of date to date.

The layouts of cost evaluation lists are presented in Appendix-A.103 and A.104 for the Land Section, and Appendix-A.105 for the Rama IX Bridge Section.

5.6.4 Design Concepts on Processing

The process flow of repair database system is subdivided into four branch processes: appending, altering, outputting, and deleting. Appending process facilitates updating repaired date in the repair database file to that of the daily or routine inspection database file. Outputting process provides three

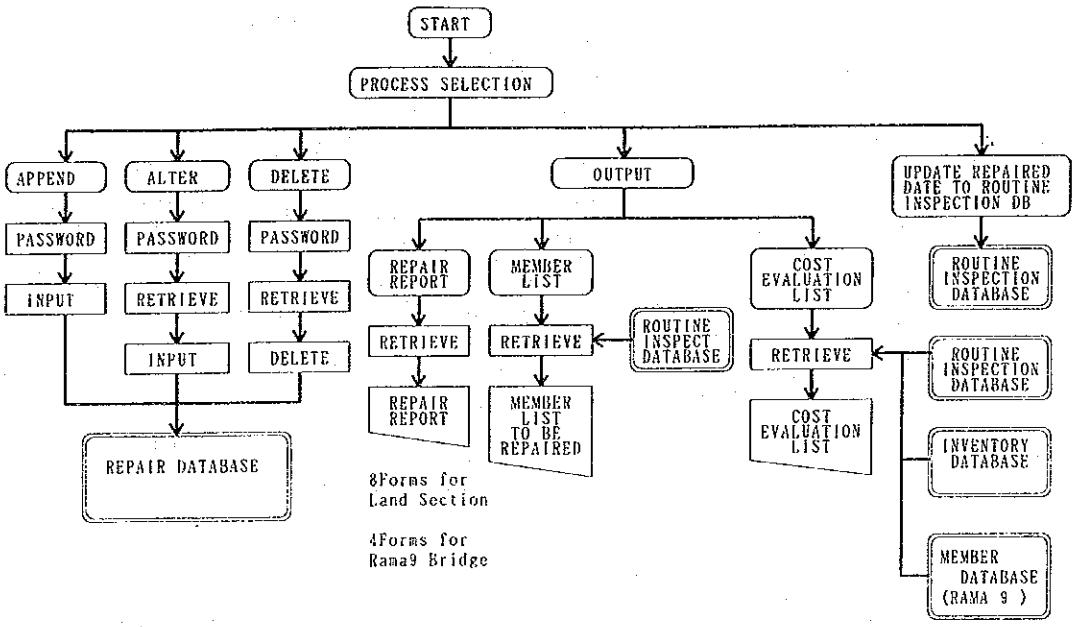


Figure-5.6.1 Process Flow of Repair Database System

output forms, which are repair report, member list to be repaired and cost evaluation lists. These processes are common to both the Land Section and the Rama IX Bridge Section as shown in Figure-5.6.1.

Processes of appending, altering and deleting are similar function to that of the inventory and inspection database system. Outputting process is subdivided into three processes to output three type of output forms as mentioned in the former section.

Updating process of repaired date in the repair database to the corresponding daily or routine inspection database file, which are special process for this system, will provide automatic functions by the system to support users in identifying that repairs were carried out in the daily or routine inspection database file.

Screen layouts on appending repair data for the Land Section is Presented in Figure-5.6.2 as a sample.

```
                                                              [RML S.STR AP]
  *REPAIRED DATE :YY/MM/DD       *REPAIR WORK CLASS :XX _____ (R.WALL)
 *INSPECTED DATE :YY/MM/DD    *INSPECTED WORK CLASS :XX _____ (DRAIN )
         *ROUTE :XXXXX        *DIRECTION OF TRAFFIC :X        (BANK  )
 ------------------------------------------------------------------------

        *MAIN ROAD/RAMP :9 _____
             *CHAINAGE :START 999999 m        END 999999 m
           *PIER NUMBER :START XXXXXXXXXX     END XXXXXXXXXX
         REPAIR METHOD :XXXXX _____
QUANTITY :9999999999 m                UNIT COST :9999999999 Baht/m
QUANTITY :9999999999 sq.m             UNIT COST :9999999999 Baht/Sq.m
QUANTITY :99999      kg               UNIT COST :9999999999 Baht/kg
QUANTITY :99999      location         UNIT COST :9999999999 Baht/location
                                   TOTAL COSTS :9999999999 Baht
     NAME OF CONTRACTOR :XXXXXXXXXXXXXXXXXXX
        CONTRACT NUMBER :XXXXXXXXXXXXXXXXXXX
   REPAIR WORK DURATION :999 days
              COMMENTS :XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      NAME OF ENGINEER :XXXXXXXXXXXXXXXXXXX
      DOCUMENTS NUMBER :XXXXXXXXXXXXXXXXXXX

            (1) APPEND AND CONTINUE   (2) REENTRY   (9) EXIT
                              Select No ==> 9
  MESSAGE AREA :XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Figure-5.6.2 Screen Layout on Appending of Repairs for Land Section

5.7 Member Database for Rama IX Bridge

5.7.1 Database File and Data Items

The member database is formulated to define objective members for the maintenance work for the Rama IX Bridge Section. Consequently, all the members which generates inspection and repair information, are registered in this database file, in order to compile these information into the related database.

The data items of this database file is eight, which is sufficient enough to register all members of the bridge, as shown in Table-5.7.1. Items of lane number and start chainage are exclusive items to process for cost estimation for pavement repair.

Table-5.7.1 Items of Member Database File for Rama IX Bridge Section

Data Item	Type	Digits	Remarks
Member Code	N	3	Cl:30
Unit Number	X	6	character
Lane Number	X	1	for Pavement, in E, 1, 2, 3
Start Chainage	N	6	999999 (m)
Date of Data Inputted	N	6	yy/mm/dd by cpu
(Flags)			
Code Check	N	1	1: checked and OK
Indispensable Items	N	1	do.
Duplication Check	N	1	do.
	(Total	25)	

5.7.2 Design Concepts on Processing

There are three branch processes in this system, appending, deleting and outputting, as shown in Figure-5.7.1. No coding sheets is provided to users in inputting, because of being simple items and its maintenance work for this database. Output process supplies to print member list in response to users retrieval conditions on member code.

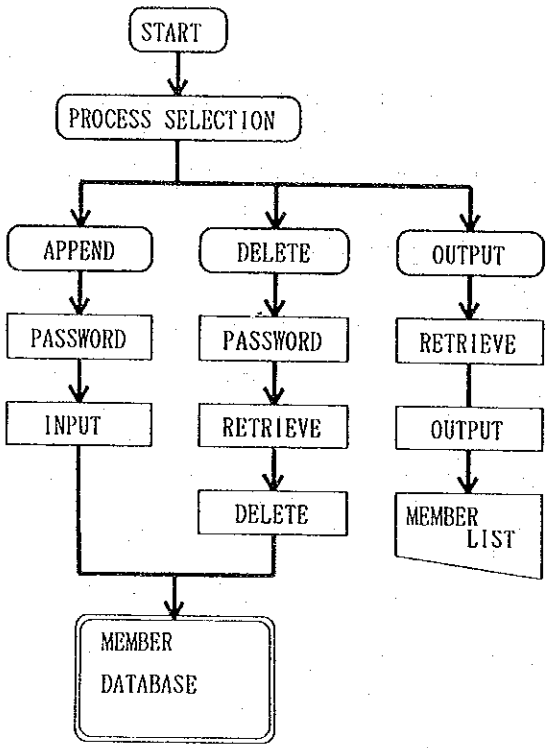


Figure-5.7.1 Process Flow of Member Database System for Rama IX Bridge

5.8 Code Database System

5.8.1 Database File and Data Items

The code database file is established to supply characters corresponding to input of numeric code number such as structural type, material type, etc. On the basis of this database file, all the numeric code is changed to characters in presentation on output forms and on the computer screen. And this database file is accessed commonly from all the database files in changing processes on code into characters.

The data items of this database is eight, with code number comprising of three digits for item number and five digits for code number, characters in English, two items for each twenty characters in Thai, and three items for system processing of this database file. Item of characters in Thai is used to direct output in Thai on both the output forms and screen, when it can treat Thai directly in the system. Items of this database file are presented in Table-5.8.1.

Table-5.8.1 Items of Code Database File

Data Item	Type	Digits	Remarks
Code Index	X	3	
Code	N	5	
English	X	14	character in English
Thai-1	X	20	character in Thai
Thai-2	X	20	character in Thai
Date of Data Inputted	N	6	yy/mm/dd by cpu
(Flags)			
Indispensable Items	N	1	do.
Duplication Check	N	1	do.
	(Total	70)	

Code items, which are accommodated in this database file for the inspection and maintenance database system, are summarized in Table-5.8.2. Details of each code are defined in this database file, and they are presented as an independent code table in the manuals for the system.

Table-5.8.2 Code Items for Inspection and Maintenance System

CODE ITEMS	ITEM NO.	DIGITS	NO. OF RE	REMARKS
MAIN ROAD / RAMP	1	1	3	
TYPE OF CROSS SECTION	2	1	2	OF ROADWAY
TYPE OF MAIN GIRDER	3	2	8	
USE OF UNDER BRIDGE	4	2	6	
TYPE OF GUARD WALL	5	2	8	
TYPE OF DRAIN SYSTEM	6	1	5	
TYPE OF INLET	7	1	2	
TYPE OF PIER	8	2	5	
TYPE OF FOUNDATION	9	1	2	
CONNECTION TYPE	10	1	3	
TYPE OF EX. JOINTS	11	2	7	
TYPE OF BEARINGS	12	2	6	
TYPE OF BANK	13	1	3	
LOCATION	14	1	6	LEFT/RIGHT/THRU.
OBJECT OF INSTALLATION	15	1	3	GUARD FENCE
TYPE OF FENCE	16	1	3	
TYPE OF GUARD RAIL	17	1	4	
TYPE OF ROAD-BED	18	1	3	
TYPE OF PAVEMENT	19	2	3	
TYPE OF LIGHTING POLE	20	1	4	
TYPE OF LAMP	21	1	5	LIGHTING, SIGN
TYPE OF SIGN POLE	22	1	3	
TYPE OF SIGN SYSTEM	23	1	2	
TYPE OF SIGN	24	1	4	
OBJECT OF PROTECTION	25	1	4	NOISE BARRIER
TYPE OF BARRIER PLATE	26	1	3	
MEMBER CODE	27	2	15	FOR LAND SECT.
INSPECTION WORK CLASS	28	2	5	
COUNTERMEASURE CODE	29	2	9	
MEMBER CODE	30	2	22	FOR RAMA9 BR.
DAY OF WEEK	31	1	7	
WEATHER	32	1	9	
DAMAGE ITEM (LS)	33	3	56	FOR LAND SECT.
DAMAGE ITEM (RAMA9)	34	3	67	FOR RAMA9 BR.
REPAIR METHOD	35	5	106	COMMON TO
(Vacant)				ALL EXPRESSWAY
TYPE OF CULVERT	37	1	3	

5.8.2 Design Concepts on Processing

The process flow of the code database system branches into four processes in appending, altering, outputting and deleting as shown in Figure-5.8.1.

Appending and altering processes are similar functions to the above databases. Output process can provide the current code table to users readily in response to the requests. Deleting process is used to delete wrong code number and its characters.

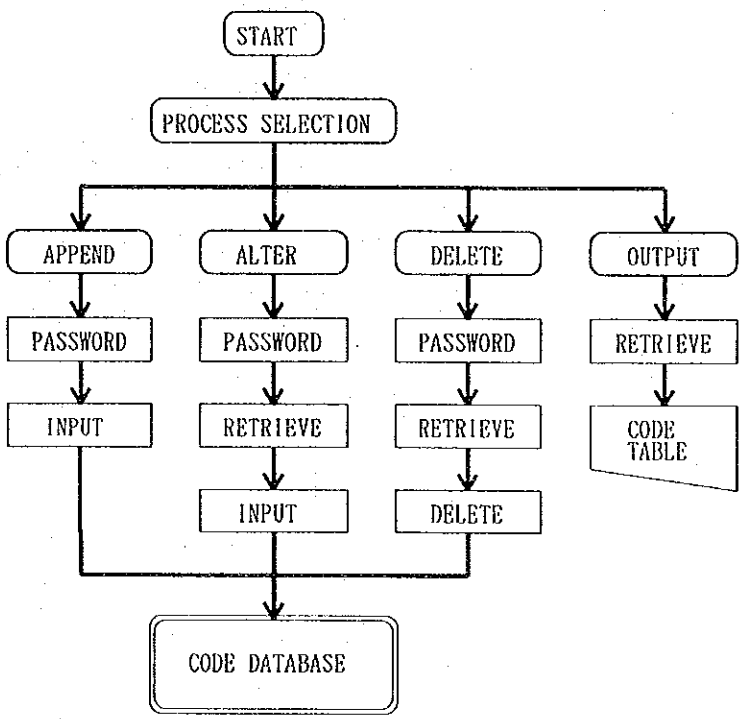


Figure-5.8.1 Process Flow of Code Database System

5.9 Road Facility Database System

5.9.1 Introduction

Although the road facility database system does not include items other than those described in the Scope of Works for this study, ETA requested the Study Team to establish a inventory database system for the maintenance of unincluded facilities as well. In response to this request, the Study Team designed the structure and processes of the database through discussions with ETA counterpart team members, on the condition that the counterparts will create the database themselves.

The objective facilities consist of support structures for emergency telephones, CCTV, and toll plaza facilities on the expressway. The database system is designed and formulated in such a way that it is possible to update, retrieve, and output information stored in the database by using dBASE4 language. However, the structure of the database system is simpler than that of the main structures and facilities.

5.9.2 Database Files and Data Items

Objective Facilities and Database Files

The database system, as shown below, is subdivided into six separate six database files for effective computer usage and to avoid duplication of stored information.

Toll Plaza Facilities: 4 database files on
- toll booths
- toll booth windows
- toll booth doors and
- toll plaza canopies

Emergency Telephone : 1 database file
CCTV : 1 database file

Data Items

In order to manage, operate and utilize the road sections making up the expressway, data in each above database file include information not only on an object's location and structure but also on the damage and repairs on an object has received. The number of items of the road facility database has

been determined in form of simpler contents and less number of items, taking into consideration of data maintenance work in the same kind of database system in Japan.

The number of data items contained in the above six database files are shown in Table-5.9.1. Details on these items are indicated in Table-5.9.2 to Table-5.9.7.

Table-5.9.1 Number of Data Items of Road Facility Database

Database File	Key Identifiers	Attributive Data	Total Items	Length (bytes)
Toll Booth	2	31	33	153
Toll Booth Window	3	6	9	66
Toll Booth Door	3	7	10	39
Toll Plaza Canopy	1	32	33	189
Emergency Telephone	4	12	16	103
CCTV	4	11	15	103

Key identifiers are used to identify a designated data record in a database file. Attributive data are essential maintenance information stored in a database file for that can be accessed by key identifiers. Below, the abbreviations and symbols used in the Table-5.9.2 to Table-5.9.7 are explained:

- Type (type of data)
  X : character data,
  C : code data in numerics,
  N : numerical values.

- Digits
  Number of digits of the item

- Key
  Indispensable items to identify a object

- Extract
  Items to extract information for reporting.

Table-5.9.2 Items of Toll Booth Database File

Data Item		Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifiers)							
Ramp Name	RAMP	X	5	○			DD010, DD021, ····
Booth Number	BTHNO	N	2	○			1, 2, 3, ·····
(Toll Booth Data)							
Type of Booth	TPBTH	C	5				CI=1
Number of Window	NOWDW	N	2				
<Outside Wall>							
Type of Wall	TPWL-O	C	5				CI=2
Paint Area	PA-O	N	6				999.99 (m^2)
Type of Paint	TPP-O	C	5				CI=3
Paint Condition	PCND-O	C	1		○		CI=4
Checked Date	CHDT-O	N	4		○		yy/mm
Last Painted Date	LPD-O	N	4		○		yy/mm
Company Name	CN-O	X	10				
<Inside Wall>							
Type of Wall	TPWL-I	C	5				CI=2
Paint Area	PA-I	N	6				999.99 (m^2)
Type of Paint	TPP-I	C	5				CI=3
Paint Condition	PCND-I	C	1		○		CI=4
Checked Date	CHDT-I	N	4		○		yy/mm
Last Painted Date	LPD-I	N	4		○		yy/mm
Company Name	CN-I	X	10				
<Desk>							
Condition	CND-D	C	1		○		CI=4
Checked Date	CHDT-D	N	4		○		yy/mm
Replaced Date	RPDT-D	N	4		○		yy/mm
(Steel Barrier)							
Type of Barrier	TP-SBR	C	5				CI=5
Size	SZ-SBR	X	10				
Paint Area	PA-SBR	N	6				999.99 (m^2)
Barrier Condition	CNDSBR	C	1		○		CI=4
Checked Date	CHDSBR	N	4		○		yy/mm
Last Paint Date	LPDSBR	N	4		○		yy/mm
Replaced Date	PRDSBR	N	4		○		yy/mm
(Concrete Barrier)							
Size	SZ-CBR	X	10				
Paint Area	PA-CBR	N	6				999.99 (m^2)
Barrier Condition	CNDCBR	C	1		○		CI=4
Checked Date	CHDCBR	N	4		○		yy/mm
Last Paint Date	LPDCBR	N	4		○		yy/mm
(total)			153				

Table-5.9.3 Items of Toll Booth Window Database File

Data Item		Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifiers)							
Ramp Name	RAMP	X	5	○			DD010, DD021, ····
Booth Number	BTHNO	N	2	○			1, 2, 3, ·····
Door Number	DRNO	N	2	○			
Window Number	WNDNO	N	2	○			
<Window Data>							
Location	LCT	C	5				
Type of Window	TP	C	5				
Size	SZ	X	10				
Type of Glass	TPGL	C	5				
Colour of Glass	CLGL	C	5				
(total)			41				

Table-5.9.4 Items of Toll Booth Door Database File

Data Item		Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifiers)							
Ramp Name	RAMP	X	5	○			DD010, DD021, ····
Booth Number	BTHNO	N	2	○			1, 2, 3, ·····
Door Number	DNO	N	1	○			
<Door Data>							
Location	LCTN	C	5				CI=6
Type of Door	TPD	C	5				CI=7
Size	SZ	X	10				
Number of Window	NOWDW	N	1				
Door Condition	DCND	C	1		○		CI=4
Checked Date	CHDT	N	4		○		yy/mm
Last Repaied Date	LRDT	N	4		○		yy/mm
(total)			39				

Table-5.9.5 Items of Toll Plaza Canopy Database File

Data Item		Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)							
Ramp Name	RAMP	X	5	○			
(Roof)							
Type of Material	TPMTRF	C	5				CI=8
Area	AR-RF	N	6				999.99 (m^2)
Size	SZ-RF	X	12				
Condition	CND-RF	C	1		○		CI=4
Checked Date	CHD-RF	N	4		○		yy/mm
Last Repaired Date	LRD-RF	N	4		○		yy/mm
(Ceiling)							
Type of Material	TPMTCL	C	5				CI=8
Area	AR-CL	N	6				999.99 (m^2)
Paint Area	PA-CL	N	6				999.99 (m^2)
Condition	CND-CL	C	1		○		CI=4
Checked Date	CHD-CL	N	4		○		yy/mm
Last Painted Date	LPD-CL	N	4		○		yy/mm
(Drainage)							
Total Paint Area	TPA-DR	N	6				999.99 (m^2)
Drainage Condition	CND-DR	C	1		○		CI=4
Checked Date	CHD-DR	N	4		○		yy/mm
Last Painted Date	LPD-DR	N	4		○		yy/mm
Painted Company Name	PCN-DR	X	10				
Last Cleaning Date	LCD-DR	N	4		○		yy/mm
Replaced Date	RD-DR	N	4		○		yy/mm
Company Name	CN-DR	X	10				
<Drainage-1>							
Size	SZ-DR1	X	10				
Paint Area	PA-DR1	N	6				999.99 (m^2)
<Drainage-2>							
Size	SZ-DR2	X	10				
Paint Area	PA-DR2	N	6				999.99 (m^2)
<Drainage-3>							
Size	SZ-DR3	X	10				
Paint Area	PA-DR3	N	6				999.99 (m^2)
<Drainage-4>							
Size	SZ-DR4	X	10				
Paint Area	PA-DR4	N	6				999.99 (m^2)
(Truss)							
Type of Truss	TP-TR	C	5				CI=9
Type of Paint	TPP-TR	C	5				CI=3
Paint Area	PA-TR	N	6				999.99 (m^2)
Last Painted Date	LPD-TR	N	4		○		yy/mm
(total)			191				

Table-5.9.6 Items of Emergency Telephone Database File

Data Item		Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifiers)							
Route	RT	C	5	○			DD, DD010, DD021, ····
Direction of Traffic	DRCT	C	1	○			CI=21
Main Road/Ramp	MRR	C	1	○			CI=22
Chainage	CH	N	10	○			999999.999 (m)
Telephone Number	TELNO	X	10				character
(Telephone Data)							
Location of Telephone	LCTN	C	5				CI=23
Type of Telephone	TPTEL	C	5				CI=24
Type of Paint	TPPA	C	5				CI=25
Paint Area	PAAR	N	7				9999.99 (m^2)
Paint Condition	PACND	C	1		○		CI=26
Checked Date	PADT	N	4		○		yy/mm
Last Painted Date	LPADT	N	4		○		yy/mm
Operation Condition	OPCND	C	1		○		CI=26
Checked Date	OPDT	N	4		○		yy/mm
Name of Constructor	CONS	X	20				character
Document Number	DCMNT	X	20				character
(total)			103				

Table-5.9.7 Items of CCTV Database File

Data Item		Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifiers)							
Route	RT	C	5	○			DD, DD010, DD021, ····
Direction of Traffic	DRCT	C	1	○			CI=21
Main Road/Ramp	MRR	C	1	○			CI=22
Chainage	CH	N	10	○			999999.999 (m)
CCTV Number	TVNO	X	10				character
(CCTV Data)							
Location of CCTV	LCTN	C	5				CI=23
Type of CCTV	TPTV	C	5				CI≧27
Type of Pole	TPPL	C	5				CI=28
Type of Paint	TPPA	C	5				CI=25
Paint Area	PAAR	N	7				9999.99 (m^2)
Paint Condition	PACND	C	1		○		CI=26
Checked Date	PADT	N	4		○		yy/mm
Last Painted Date	LPADT	N	4		○		yy/mm
Name of Constructor	CONS	X	20				character
Document Number	DCMNT	X	20				character
(total)			103				

5.9.3 Coding Sheets

Coding sheets for road facility database files are used to input information in the same manner as those for the main road structures. Separate coding sheets for the six database files are shown in Appendix-A.106 to Appendix-A.111.

5.9.4 Output Forms

Output forms, as shown below, are provided for each database file with separate forms for different items.

- Toll Booths (2 forms)
  Toll Booth List (1/2) on all toll booths and wall data,
  Toll Booth List (2/2) on desk, steel and concrete barriers.

- Toll Booth Windows (1 form)
  Toll Booth Window List

- Toll Booth Doors (1 form)
  Tool Booth Door List

- Toll Plaza Canopies (2 forms)
  Toll Plaza Canopy List (1/2) for roof, ceiling and truss,
  Toll Plaza Canopy List (2/2) for drainage data.

- Emergency Telephone (1 form)
  List of Emergency Telephone Columns

- CCTV (1 form)
  List of CCTV Columns

The above eight forms are shown in Appendix-A.112 to Appendix-A.119.

Also, users can easily extract information and output list by combination of items in 'condition', and 'date' for inspection as well as repairs.

5.9.5 Design Concepts on Processing

The program for operating the above database system is separated into two systems, with one for emergency telephone and CCTV, and toll plaza facilities. However, the processing flow for

each system is the same, and is explained below.

The processing flow of a system begins after selecting a database file on the opening screen of the system. The next process is the selection of a designated process on updating and outputting as shown in Figure-5.9.1.

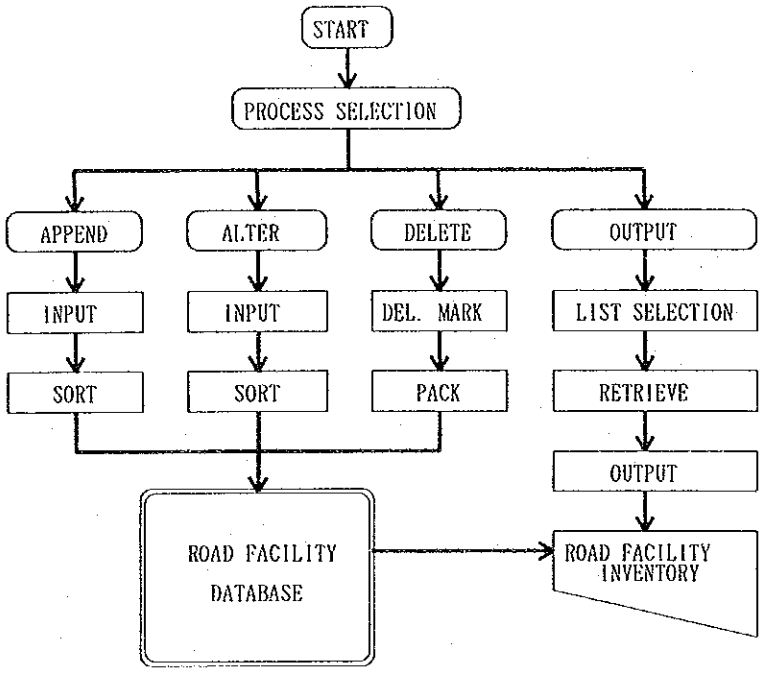


Figure-5.9.1 Process Flow of Road Facility Database System

To update of information, the database system provides for the appending, altering, and deleting of information stored in database files to users. After appending and altering information, sorting using key identifiers is automatically carried out by the system. In the case of deleting information, instead of sorting, packing is executed automatically by the system.

The outputting process begins with the selection of a list to be outputted. After selecting a list, retrieval conditions both on inspection and repairs are displayed on the computer screen by the system. A designated list will be outputted after processing the retrieval command.

CHAPTER 6

DATABASE AND ITS MAINTENANCE

Chapter 6 Database and Its Maintenance

6.1 Road Inventory

6.1.1 Survey Method

1) Survey Items

In order to create an inventory database and demonstrate its applications, road inventory data were collected on the existing 27.1-kilometer ETA expressway. The items of the road inventory are exactly the same as those of the inventory database presented previously.

2) Survey Method

An inventory survey was carried out in the same way that ETA staff will finally operate and maintain the database system when the current work on system development is completed. Accordingly, eleven coding sheets for road inventory which are shown in Appendix-A.012 to Appendix-A.022 were used as survey sheets to code collected data.

Data for the eleven inventory database files were determined basically with the existing drawings that ETA possesses. The materials are listed in the Appendix-A.002.

Data collection and coding work were ordered to the local consultant firm, however, some data were collected by the Study Team in cooperation with their counterparts in case of being insufficient information for the work. Collected data were inputted into inventory database by ETA's operators as a course of technology transfer of the system.

6.1.2 Data Collected

The number of records collected for each database file are listed in Table-6.1.1. All of the collected and compiled data have been reviewed and checked applying the functions of the developed database system.

6.1.3 Major Expressway Indices

Utilizing the collected road inventory database, major indices for the existing ETA expressway are as listed below:

Table-6.1.1 Number of Data Records Collected

Database Files	Number of Records	Volume(KB)
Superstructure	1,637	227
Piers	1,601	154
Expansion Joints	2,715	218
Bearings	3,264	265
Embankments	431	61
Railing	197	16
Fence	822	75
Pavement	2,197	456
Lighting	1,267	150
Traffic Signs	335	58
Noise Barrier	7	1
Total		1,681

- Road Length

Main road	Viaducts	:	18,371.4 m
	Rama IX Bridge	:	782.9 m
	Embankments	:	8,107.7 m
	Total	:	27,262.1 m
Ramps		:	13,072.5 m
Grand Total		:	40,334.6 m

The total expressway length of the ETA expressway is 27,262 meters while present nominal length is 27.1 kilometers. The length of 27,262 meters is obtained in dividing by two for total length for both directions. The length of viaduct and bridge sections accounts for approximately 70 % of the expressway.

- Superstructure Composition

<Number of Viaducts by length>

l < 20 m	:	580 spans
20 m < l < 25 m	:	468 do.
25 m < l < 30 m	:	385 do.

30 m < l < 40 m	:	124 do.
40 m < l	:	73 do.
Total	:	1,630 spans

An average span length of viaduct on the land section is 23.60 meters, however span length here means the length between piers along the expressway.

- Pavement Composition

<Length by Number of Lanes: main road>

5 or more lanes	:	1,353.5 m
4 lanes	:	26,589.7 m
3 lanes	:	15,384.7 m
2 or less lanes	:	11,196.3 m
Total	:	54,524.2 m

In this inventory database, the number of lanes was inputted on the basis of some near future plan in increase it between Bang Na and Din Daeng to all four lanes.

<Pavement Area by Materials>

Asphalt	:	771,400 sqm
(Rama IX Bridge	:	20,311 do.)
Concrete	:	87,148 do.
Total	:	858,547 do.

<Pavement Area by Road-bed: for 2 directions>

Main road	Viaducts/Bridge	:	485,384 sqm
	Embankment	:	231,201 do.
Ramp	Viaducts	:	60,972 do.
	Embankment	:	101,301 do.
Total		:	858,547 do.

The type of pavement accounts for 90 % by asphalt concrete and pavement on the Rama IX Bridge accounts for 2.4 % of the total area of the expressway.

6.2 Database Maintenance and Management

6.2.1 Data Volume

Data Volume of Road Inventory Database

The volume of data for the inventory database for the existing 27.3-kilometer expressway has already reached in 1,681 kilobytes. In addition, if the 18.7-kilometer Ramindra-Atnarong Expressway is eventually included, which has been under construction since the last December and will be operated by the ETA, the volume of data of the inventory database will reach 2,900 kilobytes.

Data Volume of Daily Inspection Database

The estimated data volume of the daily inspection database is approximately 5 kilobytes a day and 1.0 megabyte per year, based on the assumption of fifteen records per day for both the Land Section and Rama IX Bridge Section. After completion of the Ramindra-Atnarong Expressway, it may reach 1.7 megabytes per year.

Data Volume of Routine Inspection

The data volume of routine inspection databases is estimated as being less than 2.0 megabytes a year for the existing expressway, including the Rama IX Bridge Section, based on the assumption that ten records are generated annually for twenty five meters intervals through the expressway. After completion of the Ramindra-Atnarong Expressway, it may reach 2.7 megabytes per year.

Data Volume of Repairs

The data volume of the repair database is estimated at approximately 1.5 megabytes a year, which includes the Rama IX Bridge Section, based on the assumption that twenty-five records at 1-kilometer intervals will be generated a day through the expressway. After completion of the Ramindra-Atnarong Expressway, it may reach 2.0 megabytes per year.

Total Data Volume

Total data volume is summarized below in Table-6.2.1. The microcomputer 'NEC Powermate 466i' with a 240 MB hard disk has sufficient capacity to accommodate and operate the developed database system for more than twenty years.

Table-6.2.1 Data Volume of Database

Database	for Existing Exp'wy (27.3 km)	after Completion of Ramindra Exp'wy (46.0 km)
Road Inventory	1.7 MB	2.9 MB
Daily Inspection	1.0 MB/year	1.7 MB/year
Routine Inspection	2.0 do.	2.7 do.
Repairs	1.5 do.	2.0 do.
Subtotal	4.5 MB/year	6.4 MB/year

Note: MB means megabyte

6.2.2 Database Maintenance

1) General

To make full use of the database system, effective system management is important. System management is comprised of data and system maintenance/management. In order to achieve an efficient database system for actual maintenance work, the following issues are of major importance:

- incorporation of actual maintenance work methods and procedures into the inspection and maintenance database system,

- execution of information management in terms of coding, inputting, and outputting by means described in the manuals,

- appointing maintenance engineers, who have both a knowledge of database systems and expressway maintenance work, to carry out comprehensive database maintenance and management, and

- appointing full-time operators to operate the database system in terms of inputting, retrieving, outputting and maintaining information for maintenance work.

Old data should be updated both on a systematic and periodic basis to maintain the reliability and effectiveness of the database system, otherwise, the system will become useless.

2) Procedures to Create Databases

All databases should be surely created and maintained in a procedure described in the manuals. The procedures to create database are shown in Figure-6.2.1 in the form of a flowchart.

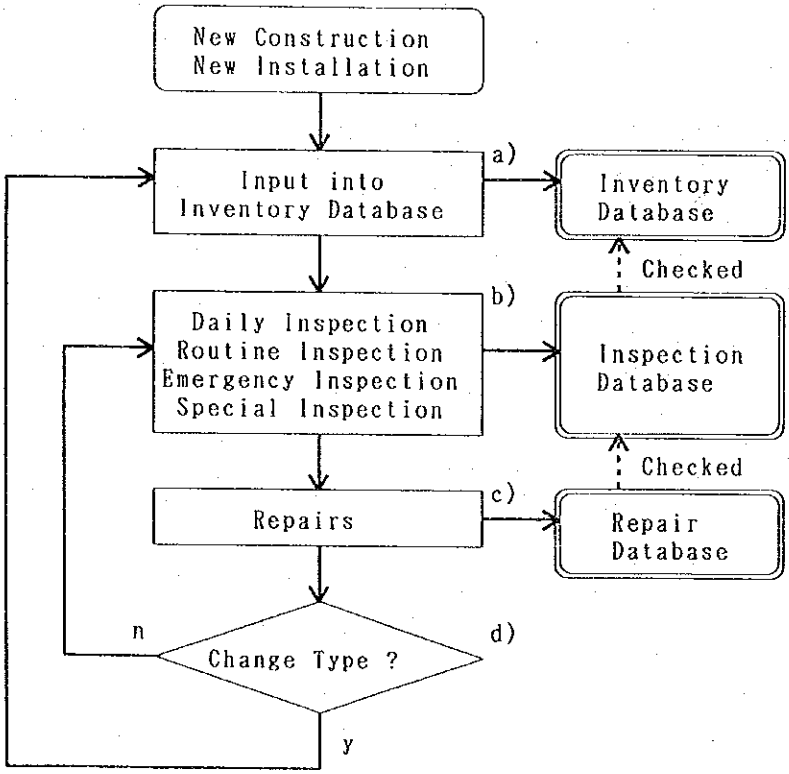


Figure-6.2.1 Procedures to Create Databases

In Figure-6.2.1, procedures to create databases (files) are explained below.

a) Input into Inventory Database

- After the completion and before the opening to the public of a roads, all the road's inventory data should be collected and inputted into a database.

- The installation of new facilities after completion, such as lighting or traffic signs, should also be appended in the same manner.

b) Daily/Routine/Emergency/Special Inspection

- Inspection results shall be inputted into the inspection database as soon as possible in the time frame described in the manuals.

- When inspection data are inputted, the system will check for the existence of the relevant members in the inventory database file by means of matching key identifiers. Inputted data will not be accepted in the database in the case of mismatching key identifiers between inputted one and stored in the inventory.

c) Repairs

- After a repair, all the repair data shall be recorded on the appropriate code sheets and inputted into the repair database in the time frame described in the repair manual.

- When repair data are inputted, the system will check for the existence of relevant members and damage in the inspection database file by means of matching key identifiers. Inputted data will not be accepted in the repair database in the case of mismatching key identifiers between inputted one and stored in the inspection database.

d) Change Type ?

- When the structure or material of an object is changed due to repairs, the inventory data should be modified manually by users.

Special Caution for a Change in the Number of Lanes

All pavement components are defined and compiled in the inventory database by subdividing by segment length and lane width. Segment length is the length between piers on viaduct sections. An embankments a constant length of 100 meters is used, and a special length by lot length is used for the Rama IX Bridge Section. Lane width was fixed initially by the relationship

between surface width and the number of lanes.

However, the number of lanes on some road sections changed due to the operating principles of the ETA expressway. In this case, appropriate changes in information of the pavement inventory shall be made concerning the number of lanes and pavement area by lane number. In addition all data stored in the databases for inspections and repairs shall be deleted at the same time. Otherwise, the coordination of key identifiers among the database files will be lost and will become illogical in key identifiers.

3) Periodical Backing-up of Databases

An unexpected failure of the database system can possibly occur due to an electrical or mechanical failure or because of human error. In order to secure and restore a database whenever necessary, it is required that information stored on said database be backed up on floppy disks periodically. It is recommended that a database be backed up once a month in the initial stages, and every three months after the system's users are well acquainted with the system.

4) Storage of Information and Materials

After inputting information from coding sheets into the database system, the coding sheets will be useless. However, the output forms, which serve as official maintenance work reports, and other related materials such as photographs, shall be kept in custody for five years. This period was determined based on past experience and the actual utilization of original materials.

On the other hand, information stored in the database system will be kept without a time limitation in order to use information whenever necessary.

6.2.3 System Management

To obtain the best results from the database system, there are four things that should be considered. They are database management, database restoration (after system failure), daily user services and user training, as explained below.

- Database Management
  This will mainly consist of checking and confirming the inputting and updating of information.

- Database Restoration
  Restoration work will mainly consist of rectifying problems with the information or programs of the database system and making floppy disks to restore a database in the case of system failure.

- User Services and Training
  In order to have the system widely utilized for maintenance work, it is essential to provide suggestions and advice to users and to train users periodically.

CHAPTER 7

SYSTEM APPLICATION

Chapter 7 System Application

7.1 Tentative Application Plan

Tentative application of the developed inspection and maintenance system to the actual expressway maintenance work of ETA staff was carried out in Work Step 5 and Work Step 6 from May to September 1994. In order to conduct the tentative application smoothly, the following preparatory work was done:

- Selection of Pilot Road Segments
  The application basically focused on the entire existing expressway. However, pilot road segments were selected in order to perform a tentative application smoothly, and cover all the items described in the manuals given a limited amount of time. Through the discussions with the Study Team and counterpart team, pilot road segments on the section between Petchburi Road and Rama IV Road were taken up which includes viaducts and embankments for a length of 3,075 meters as shown in Figure-7.1.1 in addition to the Rama IX Bridge Section.

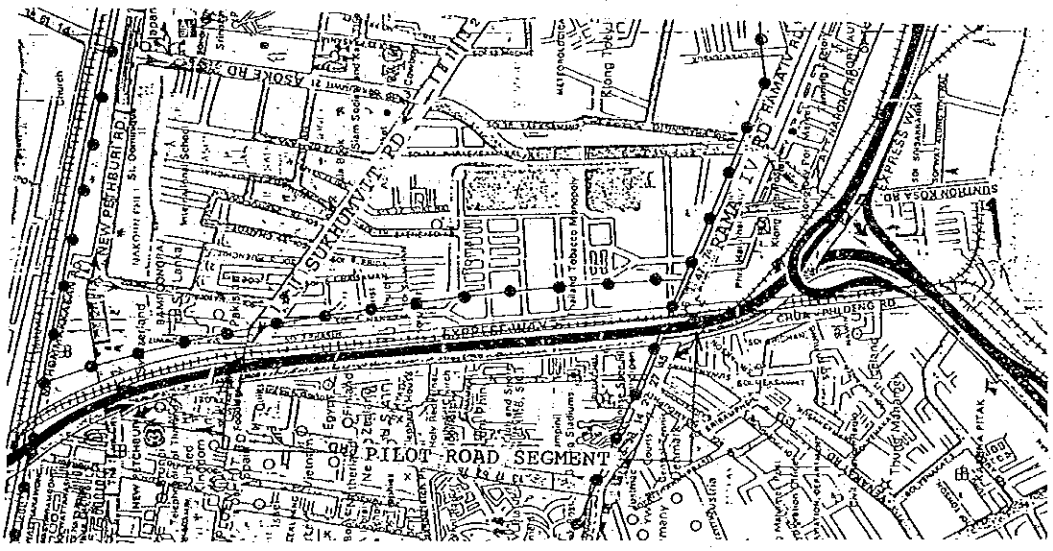


Figure-7.1.1 Pilot Road Segments for Tentative Application

- Preparatory Work
  The developed system standardizes maintenance information using a numbering system, etc. In order to identify each member of the expressway, a member should be identified by a key identifier and numbered as described in the manuals, in

the form of chainage, pole numbers, and unit numbers (especially on the Rama IX Bridge Section), prior to the practical application of the system.

For this purpose, the following materials were drawn up to execute application work smoothly, in addition to the prepared materials such as coding sheets.

Code Table	
Materials for Land Section	: List of Key Identifiers
	Drawings for Pilot Segment
Materials for Rama IX Bridge	: Member List of Bridge
	Drawings of Bridge

- Training
  It is necessary to apply the developed system smoothly so that ETA staff can understand the basic composition of the system, coding methods for inspection and repair, and what each person shall do with system. For this reason, the training of persons in charge of maintenance was carried out prior to the practical application of the system.

7.2 Application Works

In order to detect any problems with the applicability and serviceability of the developed inspection and maintenance system, tentative application to actual inspection and repair work was carried out on the ETA expressway together with Study Team members and counterpart team members in May 1994.

A tentative application was executed with the following goals:

- to have ETA carry out application work itself for more than one month starting in June 1994, in order to confirm the applicability of the system for the ETA expressway,

- to grasp technical problems and to eliminate them through system improvement,

- to obtain information on the problems encountered with practical use and to study works to improve application procedures through actual work, and

- to grasp the effects of systematization on the inspection

and maintenance work of the ETA expressway.

In addition to the above tentative application work, a supplemental application of the system was carried out so that ETA's inspection and maintenance system could switch over smoothly to the developed system after completion of the study.

7.3 Summary Comments

Based on the results of the application work, the following should be done to apply more effectively the developed system to the ETA expressway.

- Maintenance Work Documents
  Some documents are essential to conduct inspection and maintenance work efficiently. One is the as-built drawings of the expressway, and the other is drawings on plan and side view of expressway structures and attached facilities in 1/1,000, in order to identify the location and existence of expressway facilities.

  Some data for the road inventory could not be collected due to a shortage of original drawings in contract stage. The minimum necessary information for maintenance work should be surely kept at hand in maintenance sections.

- System Operation
  Operators that were not engineers inputted maintenance work information into the database in the tentative application stage. However, it is desirable that maintenance engineers themselves can also input and output information into/from the database, in order to realize the better utilization and management of the database for the maintenance work.

- System Training
  In order to execute inspection work smoothly, all personnel who are in charge of inspection and maintenance work for the expressway should comprehend the inspection and maintenance system up to a certain level concerning its methods and procedures. It seems that only a few engineer can understand the systems composition, work and operation for the maintenance work. It is desirable that all the engineer in charge of maintenance shall be familiar to operate and utilize the system up to a certain level.

CHAPTER 8

SYSTEM EVALUATION

Chapter 8 System Evaluation

8.1 Introduction

The role of the expressway inspection and maintenance system is to systematize information and work procedures, and the database system is to handle and manage information for maintenance work.

System evaluation means, in general, to measure and objectively the output of a system. The effective use of information, which is a product of the database system, can not be easily evaluated like a typical industrial product. In other words, information is of great value to those that utilize it effectively; however, information itself has no intrinsic value to many and unspecific persons.

However, the effectiveness of the system can be measured and evaluated quantitatively and economically as well. Here, the effectiveness of systematization is subdivided into quantitative and qualitative effects. The former one can be measured and evaluated economically; however, it is difficult to do that for the latter one. This means, the system should be evaluated in view of the comprehensive effects on the engineering, administration, and operation of maintenance work for the expressway.

Figure-8.1.1 shows the major effects of systematization on maintenance work, with an explanation on these effects following afterwards.

- Rise in Work Efficiency
  Reductions in costs and time are directly evaluated quantitatively in maintenance work, while increases in the accuracy of information due to the database system are evaluated as a qualitatively.

- Dispersion of Information
  This effect, which results in a involve qualitative improvement in maintenance work, occurs because of the easier accessibility to maintenance information and real-time utilization whenever necessary.

- Rise in Creativity
  This new effect occurs because the information stored in the database system provides the opportunity for analyses, planning and technical studies to be carried out on maintenance works.

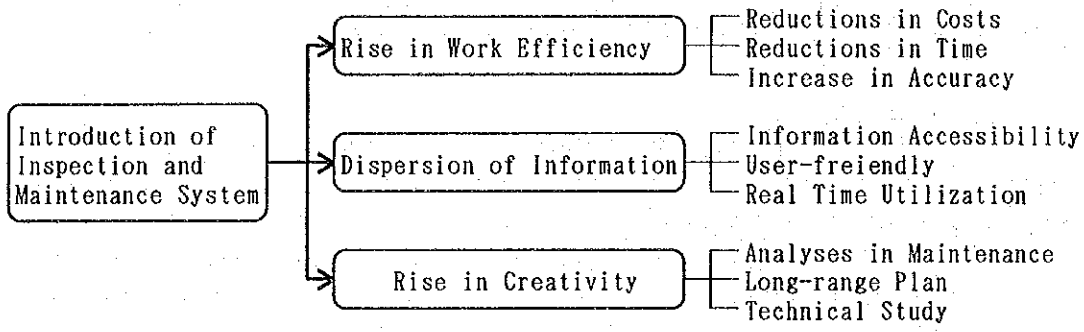


Figure-8.1.1 Effect of Systematization on Maintenance Work

8.2 System Evaluation

8.2.1 Quantitative Evaluation

Quantitative effects due to systematization are also called direct effects, because they can be economically evaluated. Below, the quantitative effects of manpower, costs, and time reduction are explained below.

- Reduction in Manpower
  A reduction in manpower occurs due to the rise in work efficiency attained from coding information for inspection and repair work, inputting and outputting information quickly and accurately managing information in the form of a database.

- Reduction in Costs
  Reductions in costs are possible due to the lower manpower, material, management, and storage requirements of the database system as composed to the present system.

- Reduction in Time
  On the installation and utilization of a database system, there will be a systematization and standardization of information and work procedures on site as well as at the office, reducing the time required to access and apply information.

To measure the direct effects, the difference in manpower, costs and time should be compared before and after systematization of maintenance work. However, since there is an insufficient answer of data on current manpower and costs, this is not possible. For this reason, a 'scoring model' as shown in Table-8.2.1, is applied to quantify direct effects using ranking system that measures reduction in said effects.

Table-8.2.1 Ranking Table of Direct Effects

Rank	Criteria
5	90% reduction by systematization
4	70% do.
3	50% do.
2	30% do.
1	10% do.

As shown in Table-8.2.2, the average scores are 3 for a reduction in manpower, 2 for costs, and 3 for time. The total quantitative effects may be considered to be approximately an overall reduction of 30 to 50 %.

Table-8.2.2 Change in Direct Effects After Systematization

Items of Direct Effects		Rank	Remarks
Manpower	Inspection/Repair	1	On site/office work
	Coding	2	
	Reporting	4	
	Info. Management	4	
	(Average)	3	
Costs	Inspection/Repair	1	On site/office work
	Manpower	1	
	Material	1	
	Information Storage	4	by database system
	(Average)	2	
Time	Inspection/Repair	1	On site/office work
	Coding	2	
	Reporting	4	
	Access to Information	4	by database system
	(Average)	3	

To grasp the effects of systematization of information on manpower for regular maintenance work, the following assumptions are made and the subsequent results summarized in Table-8.2.3.

- Daily inspection is carried out twice a week over the entire expressway and 15 records are generated a day.
- Routine inspection is carried out once a year for each of 12 members (see Table-4.2.3), and 10 records are generated annually at 25-meter intervals.
- The amount of repair data generated is one-third of that for routine inspection.
- Unexpected maintenance such as maintenance in the case of emergencies, is not included when measuring the effects of systematization.
- Field and office work that is common to Pre-and-Post systematization are not included when comparing the effects of systematization.

Table-8.2.3 Effects of Information Systematization

Work Item	Current	Systematized	Remarks
<Daily Ins.>			
Input/Report	2 x 52 = 104	1 x 52 = 52	52 weeks/year
Info. Management	1 x 52 = 52	0	
(sub total)	(156)	(55)	67% reduction
<Routine Ins.>			
Ins. Plan	5 x 12 = 60	2	12 components
Input/Report	3 x 104 = 312	1 x 104 = 104	104 days/year
Info. Management	2 x 52 = 104	0	52 weeks/year
(sub total)	(476)	(106)	78% reduction
<Repair>			
Repair Plan	3 x 15 = 45	3	15 components
Input/Report	3 x 70 = 210	0.5 x 70 = 35	70 days/year
Info. Management	1 x 52 = 52	0	52 weeks/year
(sub total)	(307)	(38)	88% reduction
Total	939	196	79% reduction

Note Unit is the number of persons a day,

Although the above comparison is based on rough assumptions, there shall be approximately a 79% reduction in manpower due to the effects of information systematization of regular maintenance work. If all other site and office work, such as inspection and design, is considered together with maintenance information management, there would be a decrease in manpower of approximately 30 to 50 % (which confirms the results of the above scoring model).

8.2.2 Qualitative Evaluation

The qualitative effects of higher information accuracy, better information management, better administration and rising creativity due to work systematization, which are considered as indirect effects, are explained below.

- Higher Information Accuracy
  The accuracy of maintenance work information will be improved due to the standardization and storage of information in the database, as well as to the regular coding sheets used for maintenance work.

- Improvement in Information Management
  Almost all information necessary for maintenance work will be compiled and managed by the database system, together with regular work procedures and methods for maintenance information.

- Improvement in Administration
  When the developed database system is able to be operated smoothly and utilized as a tool for maintenance work, the system will improve the potential and quality of ETA's organization and manpower.

- Rise in Creativity
  Information stored in the database can be readily utilized for any kind of maintenance work whenever necessary, and can also be used for creative work such as the analyses and planning of expressway maintenance.

A scoring model, similar to that used for measuring quantitative effects, is used to evaluate the qualitative effects of maintenance work systematization as shown in Table-8.2.4. Each item is explained as a accomplished level depending upon the

systematization.

Table-8.2.4 Ranking of Indirect Effect

Items of Indirect Effect	Rank	Criteria
Higher Info. Accuracy	5	An organization is established for speciality to check information and manage
	4	Interpretations of information are provided
	3	Information is provided accurately and efficiently
	2	Higher information accuracy
	1	Same as before
Improvement in Info. Management	5	An organization is established speciality to manage information
	4	All information is managed intensively and systematically
	3	All information is integrated
	2	Information is cross-referenced
	1	Same as before
Improvement in Administration	5	Remarkable rise attained in organizational potential
	4	Organization and work systems are improved
	3	Overall improvement in organizational constitution
	2	Partial improvement in management
	1	Same as before
Rise in Creativity	5	System is efficiently utilized for operational strategy
	4	Long-range information available for operational purpose
	3	Short-range information available day-to-day for work
	2	Systematization is improved
	1	Same as before

The qualitative effects will depend on the way the database system is utilized and managed by ETA. Here, supposing that almost all system utilization and management are performed as described in the manuals and report of the Study, the qualitative effects attained may correspond to those shown in Table-8.2.5. The average score for qualitative effects is approximately 4, which is a rather higher satisfactory score than that of quantitative effects.

Table-8.2.5 Change in Indirect Effects After Systematization

Items of Indirect Effects	Rank	Remarks
Increase in Info. Accuracy	4	Database for inventory, inspection and repairs improves accuracy of maintenance work information
Improvement in Info. Management	4	System rises management level due to systematization and standardization
Improvement in Administration	3	Level of organizational potential rises
Rise in Creativity	4	Rise in creative ability due to better and more accessible information

8.3 Summary Comments

The developed inspection and maintenance system for the ETA expressway aims to reduce manpower, costs and information processing time, as well as improve the overall quality of maintenance work. However, it is not clear yet how to evaluate the effects of the inspection and maintenance system for actual expressway maintenance work, due to insufficient information both for current work and the system's work.

An introduction of a new system requires, in general, a temporary increase in manpower to digest the new technics and tasks. This means maintenance engineers in ETA are required to upgrade their ability concerning maintenance work so as not to increase manpower. Total manpower can be reduced from automating and rationalizing maintenance work, as a long-term benefit, after mastering the new technics and tasks.

As mentioned in the previous sections, the quantitative effects will not be so large, while the qualitative effects will be larger than the quantitative ones, as shown in Figure-8.3.1.

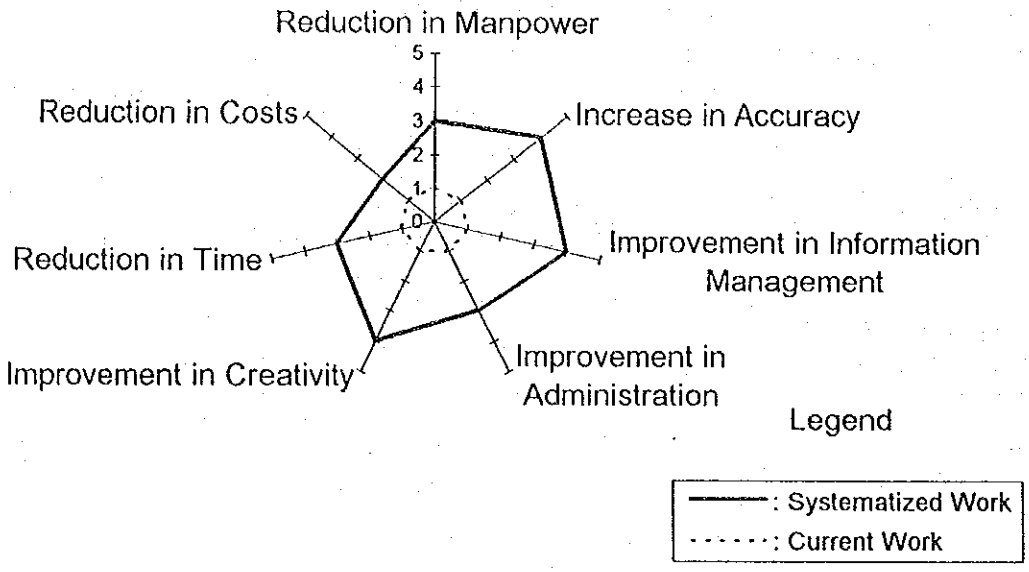


Figure-8.3.1 Diagram of System Evaluation

The size of the qualitative effects due to systematization will depend on how ETA utilizes and manages the developed system by ETA maintenance engineers themselves. Currently, no serious damage can be found on the ETA expressway. However, it is expected that damage and repairs will increase within the near few years due to heavy vehicular traffic and structural aging. It should be noted that it will be too late to start systematizing work with a database system when damage is at a serious stage and timely countermeasures are impossible.

CHAPTER 9

RECOMMENDATIONS ON MAINTENANCE OF ETA EXPRESSWAY

Chapter 9 Recommendations on Maintenance of ETA Expressway

9.1 Introduction

The present status of ETA's organization and the existing problems related to maintenance work are reviewed in Chapter 3 of this report. The present maintenance organization of ETA is considered to be functioning without much of a problem in executing its current maintenance work. However, ETA still has to expand its functions and maintain the expressway under its direct management and operation. In consideration of the future organization and its work, it is desirable to strengthen ETA's organization and to improve its work system in responsible for the expressway maintenance.

The new 18.7-kilometer Ramindra-Atnarong Expressway is now being built by ETA. After its completion in a few year, the total length of expressway to be managed will be approximately 46 kilometers. In addition, it is expected that damage to road structures and facilities will escalate with the increases in traffic volume, the ratio of heavy vehicles, and the number of aged structures and facilities.

The inspection and maintenance system for ETA's expressway network has been formulated to cope with the above problems and to improve maintenance methods as well. In this section, taking the existing and future status of ETA's expressway network into account, recommendations are made for the purpose of effectively utilizing the ETA's expressway, concerning equipment, organization, work systems and future expansion of the maintenance work system.

9.2 Documents and Equipment for Maintenance Work

9.2.1 Route Maps for Maintenance Work

It is necessary for inspectors to be able to identify readily a damaged location on the expressway, in terms of chainage or unit number of a damaged facility. In this way, work can be easily carried out at the relevant site and the surrounding conditions of the expressway taken into consideration.

Road administrators in Japan, in general, possess and maintain periodically route maps along the roads at a scale of 1/1,000 or 1/1,500 for the above mentioned purpose. These are essential for inspection work, especially for daily inspections that require identifying the location on the roadway on the running car. In the tentative application of the system, the same kinds of drawings were made and used for the pilot road segments and their efficiency confirmed in the work.

It is recommended that ETA make route maps for the Land Section's maintenance work as shown in Figure-9.2.1, and in the form described below.

Scale : 1/1,000
Form : A4 paper folded continuously along a 5-kilometer alignment (drawing is about 5 meters long),
Contents:- plans of expressway and buildings within 100 meters from both edges of roadway,
- side view of major structures,
- front view of major structures,
- chainage for a fixed length (every 100 meters),
- chainage at major structures such as piers and expansion joints,
- location and chainage of all facilities,
- unit number, if any, for lighting poles and traffic signs,

Revision: once a year, or when there are improvements.

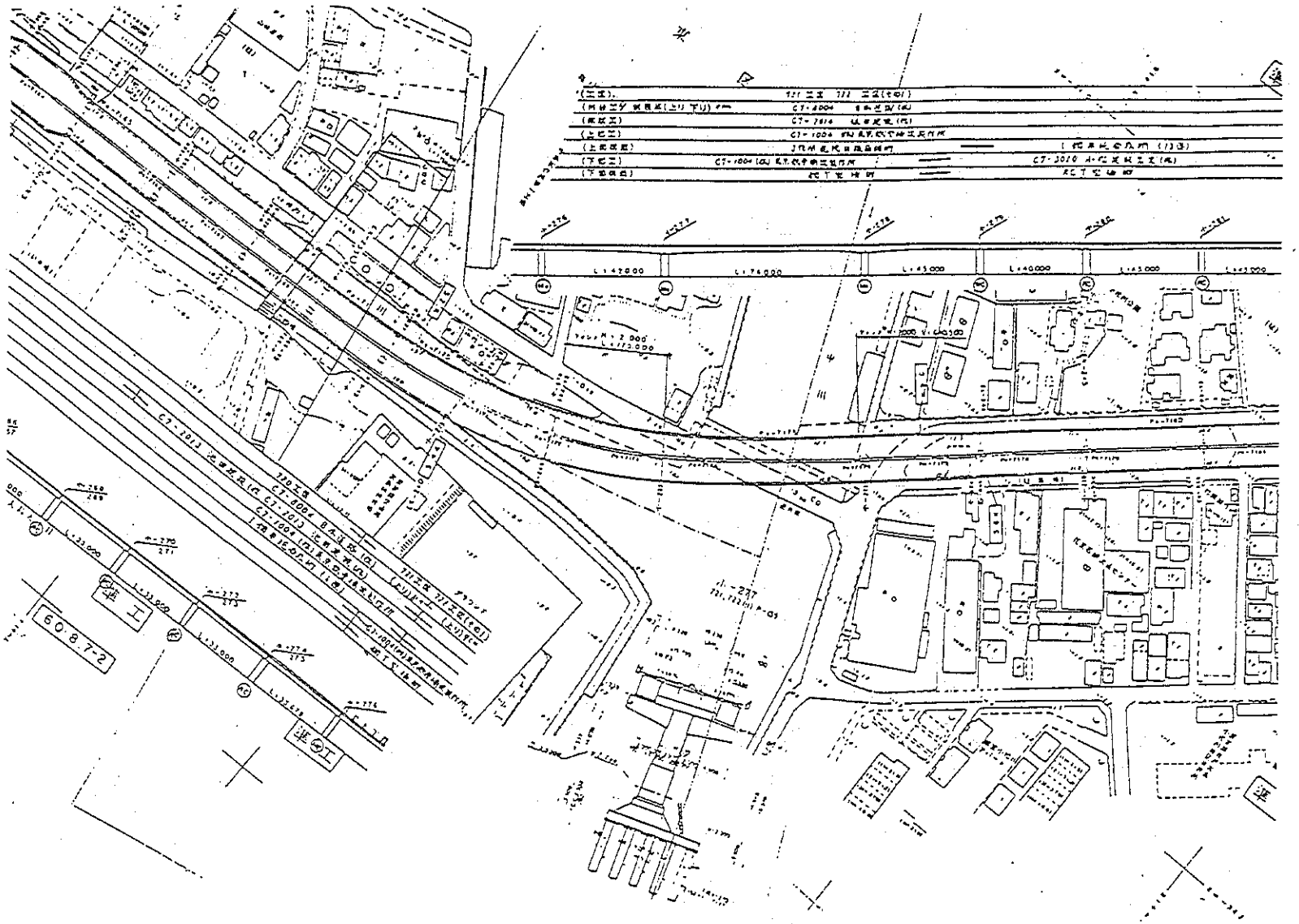


Figure-9.2.1 A Sample Route Map of the Expressway

For the Rama IX Bridge, the following drawings are recommended.

Scale : 1/2,500 for side view,
Form : A3 paper,
Contents:- plan, side view and cross section of bridge,
- chainage for a fixed length (every 100 meters),
- chainage at major structures such as piers and expansion joints,
- location and unit number for all structures and facilities,
Revision: once a year, or when there are improvements.

9.2.2 Numbering System

Some numbering systems have been introduced by ETA, such as chainage, pole numbers and unit numbers for the Rama IX Bridge Section. However, as almost all of these are based on the conditions of the construction-completion stage, they do not function well enough for maintenance work. Discussions were held by the study team in order to improve the numbering systems for ETA's expressway, and the results are summarized below.

- Chainage
  A chainage system seems to function normally for major road sections. However, some slight modifications are recommended below to identify more easily road segments for maintenance work.

  Chainage along ramp sections shall be the same as those of the main road and will branch at the nose of an alignment, since a chainage of ramp is used as built stage for each ramp in a different value from those of the main road.

  Chainage at a Port interchange requires breaking points because of the complicated alignment. Present breaking points are set in the middle of main road segments. If breaking points are changed to be at the point of an alignment nose, all the road segments will be continuous and will be easy to identify location for maintenance purpose.

- Pier Number
  Existing pier numbers are used in chainage, and there is no way to identify the direction of the expressway. In order to

identify readily a pier's location along the expressway, a simple unique pier number for each pier is more effective than the current chainage by pier.

The pier number system recommended is as follows:

DD-I-0016: sixteenth pier in direction of In-bound at Din Daeng section,
DD-DK-009: ninths pier on Din Daeng-Dao Khanong section at port interchange.

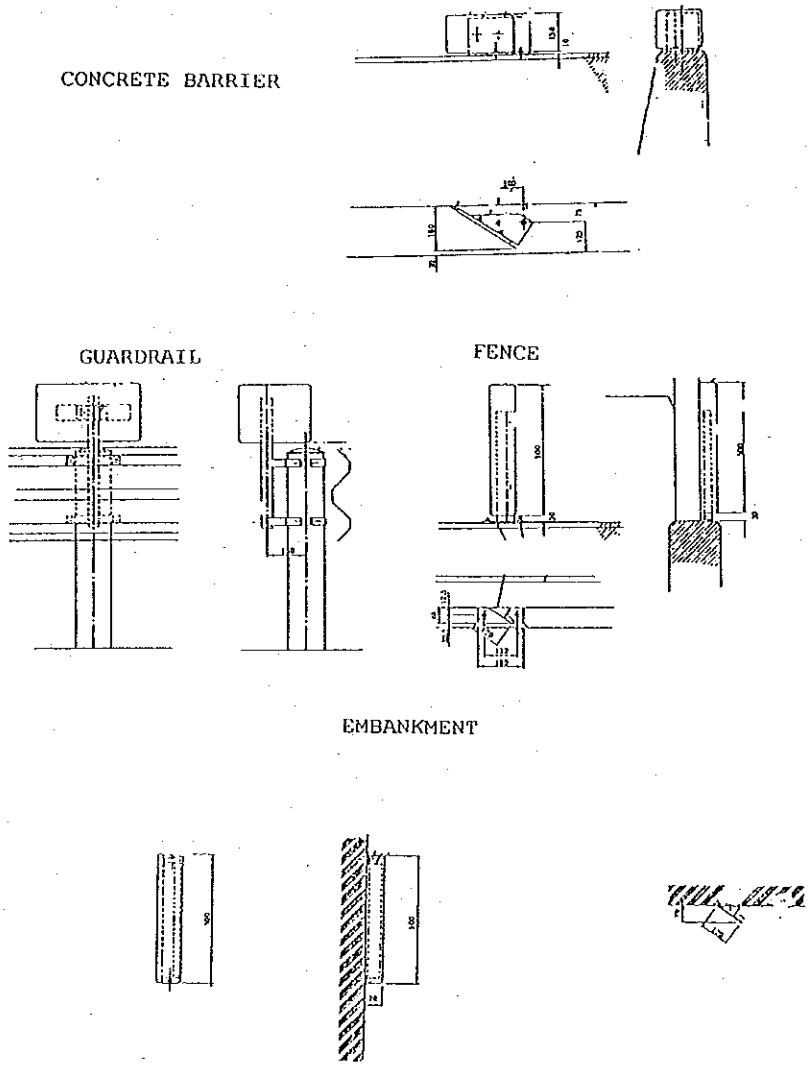


Figure-9.2.2 Recommended Kiloposts

- Kilopost
  Kiloposts which indicate the chainage along a route, are located on the left-hand barrier wall at 100-meter interval. Those are not easy to identify the location from a running car used for daily inspection. Therefore, it is recommended that a separate panel for chainage be attached to the left-hand barrier wall stating the route, direction and chainage in every 100 meters, as shown in Figure-9.2.2.

- Inscription of Unit Numbers
  As in the case of kiloposts, unit numbers for each component of the expressway shall be clearly written for easy identification. As the unit numbers for the Rama IX Bridge section will be modified, the new unit numbers shall be inscribed at the designated locations on each bridge component.

- Pole Numbers of Lighting
  Lighting pole numbers, because of their position in a higher place, are convenient for a running car to grasp its location, since those numbers are at a position higher than a large cars such as bus and truck.

  Therefore, installation of easy-to-understand large pole numbers at a height of more than 5 meters from the road surface throughout the expressway are recommended for maintenance work use.

9.2.3 Preservation of As-Built Drawings and Documents

As-built drawings per contract are kept and utilized in the form of A3 paper. However, some problems in ETA's document management system concerning storage, equipment, and management were detected in the course of the study, especially concerning data collection for road inventory. Problems and recommendations on document management are presented below.

- Lack of Originals
  Some information for road inventory could not been obtained due to the lack of original drawings, especially concerning those facilities designed by ETA itself. This indicates that are improvements and the formulation of rules on document management are essential issues in ETA.

- Formulation of Rules on Document Management
  In order to keep and utilize engineering documents for maintenance work in better condition, the formulation of rules on document management concerning the following is recommended.

  Organization and responsibility,
  Procedures for document management, and
  Document numbering system.

- Introduction of Microfilm System
  Original drawings written on paper are apt to fade with time, and the storage of originals requires much space. In order to keep originals in good condition for the lifetime of road system, it is recommended that ETA introduce a reliable method for document management using more advanced equipment.

  Therefore, a microfilm system is recommended to manage document from the viewpoints of storage, durability, and economy in making and reprinting and serviceability, taking into consideration the present data volume and expected future needs. The following items shall be considered for the system's introduction.

  - Microfilm production shall be done by a private company that can handle microfilm processing in order to guarantee the quality of the microfilms.

  - Based on the experience of the Metropolitan Expressway Public Corporation, the microfilm should take the following form:

    A1-size Drawings or larger : 35 mm Aperture Card,
    A3-size Documents or smaller : 16 mm Cartridge.

  - Detailed investigations on data volume and the quality of originals is essential to begin the new document management system.

  - The production of microfilms shall be included in a contract between ETA and a contractor on the basis of the above rules and specifications.

9.2.4 Maintenance Work Equipment

Maintenance work executed by ETA staff consists of inspection and repair work, according to the current work system in ETA. All inspections are conducted by ETA staff, while large-scale repairs such as pavement and expansion joints are farmed out and conducted by the private companies.

It is expected that the operational length of ETA's expressway will increase rapidly to cope with the traffic demands in Bangkok. For this reason, the maintenance work system in ETA may change with the increase in maintenance work. However, supposing that the current work system continues as it is, the following equipment are recommended to be introduced to improve the level of maintenance work.

- Traffic-sign Cars
  Maintenance workers that conducts inspection, routine maintenance and repair works, are always confronted with the possibility of a traffic accident due to the high vehicle speeds on the expressway. For this reason, careful attention should be paid to the safety of workers and all efforts made to avoid a traffic accident from occurring.

  Therefore, traffic-sign car, which calls the attention of drivers with a large warning signboards having an arrow plate and revolving lights to the location of maintenance workers, should be used. Traffic-sign cars also have shock absorbers to deal with reckless drivers that might hit them from the rear.

- Patrol Cars with Higher Revolving Lights
  Currently, ETA patrol cars have revolving lights on the roof. However, it is difficult to recognize them from a distance during a traffic jam.

  Therefore, it is recommended that patrol cars be equipped with revolving lights whose height can be varied in case of necessary, together with traffic signboards.

- Vacuum Car
  A vacuum car would be useful for cleaning work for both inlets and culverts on the expressway.

- Sweeper
  Sweeper for cleaning medians and side barriers to conduct efficient work on the expressway.

- Lift Car
  ETA has a lift car, however, it seems to be used quite frequently for inspection and maintenance work on lighting poles, traffic signs, closed circuit TV (CCTV), superstructures, and other road facilities located in a high position. Therefore, it is proposed that ETA introduce the more number of lift cars in order to execute the site work quickly and efficiently.

- Truck Crane
  Maintenance work requires loading/unloading materials or equipment for work frequently. ETA possesses a truck crane, however, it is proposed to introduce the more number of truck cranes in the same reason as above mentioned.

- Command Vehicle for Maintenance Work
  Nowadays, ETA uses light truck or microbus to transport workers to site. However, it is desirable that command vehicle be used equipped with revolving lights, loud speakers and a radio apparatus. Therefore, it is recommend that ETA introduce (or improve) command vehicles to transport workers, to use a commanding on site, and to ensure maintenance work and safety.

- Microfilm Reader/Printer
  Introduction of a microfilm system is recommended in the former section to manage ETA's drawings and documents for maintenance work. However, microfilm production is recommended to be done by a private company. Introduction of microfilm reader/printer is recommended in order to extract necessary documents or drawings readily.

9.3 Maintenance Organization

9.3.1 Organization for System Management

1) Work Components of Database System

A important task for making full use of the developed database system is system maintenance/management. Maintenance/management work for the database system is as shown in Figure-9.3.1.

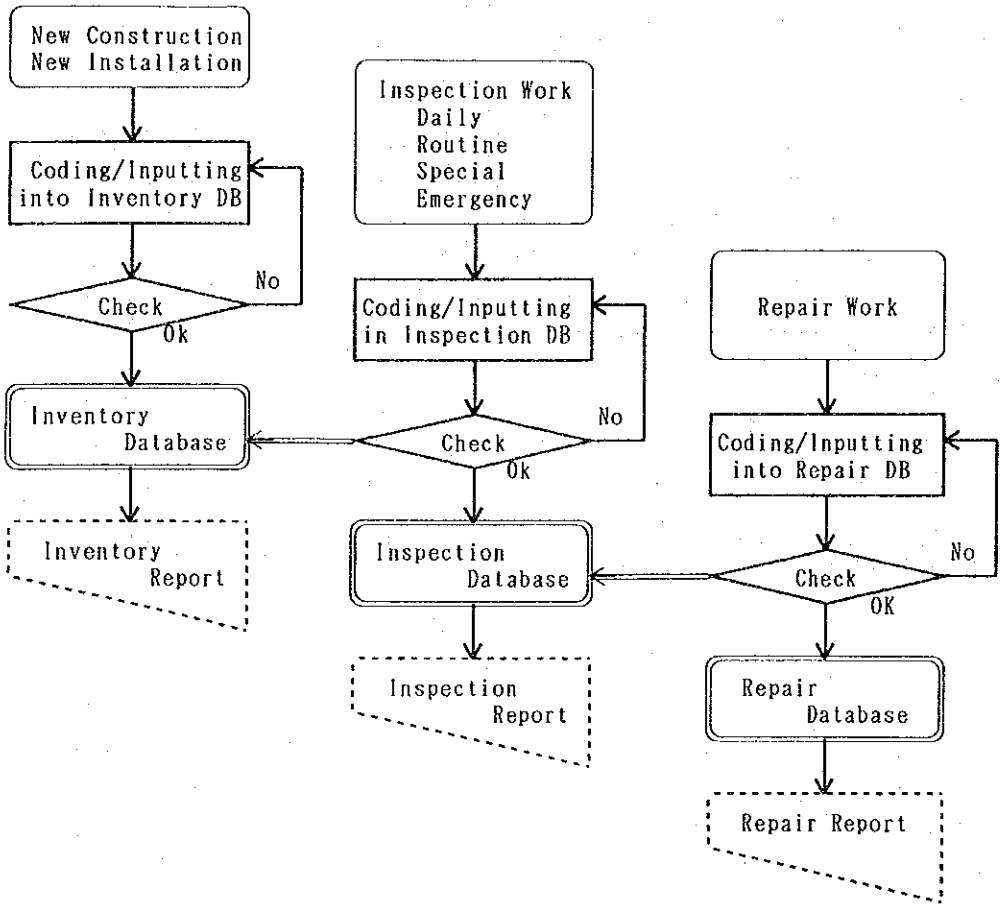


Figure-9.3.1 Simplified Work Flow of ETA's Maintenance System

Database System Operation

Database system operation, which involves actual worker-computer interaction, consists of the following work:

- the inputting, updating, altering, and deleting of data in

the database system;
- the outputting of data upon request from the database system;
- the backing up of database system information on floppy disks periodically; and
- the execution of any other work as indicated by the engineering staff, such as the updating of the code file in the database system.

Operation of the computer system has to be performed on daily basis together with maintenance work. Skillful operators are necessary to operate the computers on efficient and timely basis.

System Management

System management, which has the duty of ensuring system operation efficiency, consists of the following work:

- the management of work concerning the inputting, updating, altering, and deleting of information in the database;
- the management of the flow of inspection and maintenance information;
- database guidance to users;
- the resolution of database system problems (such as database recovery);
- the training of maintenance personnel and other database system users;
- the formulation of system improvement plans based on current opinions and problems concerning the database system and inspection/maintenance work; and
- the execution of any other management work that will result in the more effective utilization of the database system and effective performance of inspection/maintenance work.

Since all of information maintenance/management are linked among those of each other work item, which involved almost all works conducted in-house, on site and their information. In order to make effective utilization by means of this developed system, all of above mentioned work procedures on maintenance shall be performed in the better circulation without choking.

2) Maintenance Personnel Capabilities

In order to achieve the required level for the above work, it is necessary to operate and manage the database system, and to manage the whole maintenance work system by linking on-site work with the database. The necessary personnel and abilities needed to achieve this, which will improve ETA's maintenance work via systematization using the developed inspection and maintenance system, are explained below.

Operation of Database System

- Keying in data into a microcomputer based on the system manual and system engineer's guidance,
- Reading and understanding the system manual.

Since the database system is structured to show messages on the computer display to prevent the inputting of erroneous data, unskillful operators can operate the system. For this reason, operators who have experience with word processing, or engineering staff who have the ability to operate a microcomputer, are sufficient enough qualifications.

Idealistically, it is desirable that a maintenance engineer or technician operate the database system himself. This is because they understand the inspection information, and it would be more efficient accurate if they handled their own work. If this is possible, and it will lead to a reduction in time and more effective utilization of the system.

Management of Database System

This work as shown below, consists of both database management and user service, such as system restoration and training, and leading the system utilization.

- Basic ability on the database, information and microcomputer system,
- To understand processing methods of this system,
- Instructing operators and users so that they can input and output information to and from the database easily,
- Managing and checking the operational condition of the database system as per designed, and keeping back-up floppy disks as described in the system manual.

Management of Comprehensive Maintenance Work

Understanding and grasping comprehensively maintenance work required both on the actual engineering work in inspection and repairs with experience, and the framework of the database system. Therefore, it is required to understand the relationship between actual maintenance works and the information generated by such work.

3) Maintenance Organization and Manpower Allocation

In order to introduce smoothly the new inspection and maintenance system to ETA, it is necessary to make the assumption that ETA's current maintenance organization remains the same. That is, it is managed and maintained into two separate sections: one for the Land Section and the other for the Rama IX Bridge Section.

In addition to the above, the following personnel are recommended to minimize an increase in new manpower, as well as with the shortage of ETA engineers:

- A manager who comprehensively manages both engineering work and the database system, for both the Land Section and the Rama IX Bridge Section.

- A maintenance engineer who is directly in charge of managing the database system, and who coordinates engineering work for both the Land Section and the Rama IX Bridge Section.

- Engineers who are respectively in charge of the database system for the Land Section and the Rama IX Bridge Section.

- Operators who are respectively in charge of database operation for the Land Section and the Rama IX Bridge Section. However, as mentioned before, it is desirable that maintenance engineers or technicians operate the database system themselves.

The above issues lead to the following recommendations on manpower allocation for the smooth introduction of the developed system, as shown in Figure-9.3.2, and are explained below.

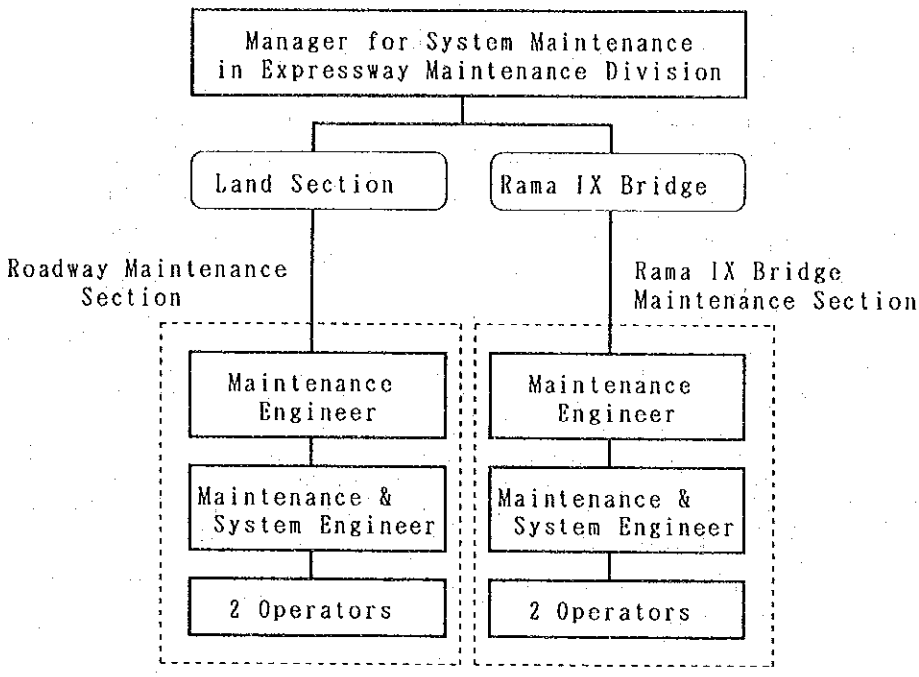


Figure-9.3.2 Organization and Allocation of Personnel

- One managing engineer for the maintenance of the ETA expressway in the Expressway Maintenance Division,

- Two maintenance engineers each for both the Land Section and the Rama IX Bridge Section,

- Two maintenance/system engineers each for both the Land Section and the Rama IX Bridge Section, and

- Four operators each for the daily data maintenance of both the Land Section and the Rama IX Bridge Section.

9.3.2 Organization for Maintenance

1) General

ETA's present maintenance organization looks functioning well. However, ETA still has to expand its functions and maintain on expressway network in Bangkok and rural regions, in order to cope with the ever-increasing economic growth and social demands. In addition to this, a mass transit system in the Bangkok metropolitan area will possibly be undertaken by ETA itself. This suggests that the role of ETA will increase in the operation and maintenance of traffic facilities.

In addition to the above, it is expected that damage to road structures and facilities will escalate with increases in traffic volume, the ratio of heavy vehicles, and the number of age-worn structures and facilities. To cope with these problems, ETA's maintenance organization may have to improve its engineering capacity concerning maintenance.

2) ETA's Maintenance Organization

ETA's present organizational hierarchy concerning maintenance is explained below.

The Expressway Maintenance Division (hereinafter EMD) , which is one of the five engineering divisions in Maintenance Department under the Deputy Governor for Operations, consists of two sections as shown in Figure-3.6.2 to Figure-3.6.3: 1) the Roadway Maintenance Section, 2) the Bridge Maintenance Section. The present manpower of this division is as shown in Table-9.3.1.

Strengthening Maintenance Staffing

The total number of staff at EMD is 111 persons. However, there are 2 vacancies at the important posts of maintenance engineer. In order to perform the assigned responsibilities and enlarged functions of EMD, a shortage of staff will affect ability to carry out the necessary expressway maintenance work.

Table-9.3.1 Manpower of Expressway Maintenance Division

Job Category	Central Administration	Roadway Maintenance Section	Bridge Maintenance Section	Total
(Engineering Staff)				
Director	1			1
Head		1	1	2
Engineer			(2)	(2)
Technicians		11	4	15
Labors		44	22	66
Drivers		3	4	7
Operators		2		2
Administrators		2		2
Clerks	3	2	2	7
Janitors	1			
Total	7	70	34+(2)	111+(2)

Note 1) () number of openings,
2) number of technicians, laborers and drivers, (includes temporary employees)
3) data as of August, 1994.

EMD shall be mainly responsible properly introducing and implementing the developed inspection and maintenance system to ETA's expressway, but shall need close and active cooperation from other divisions under the Deputy Governor for Operations.

In addition to the above, the engineering capacity of EMD seems not to be sufficient enough to carry out the required maintenance work at present. Therefore, it is proposed to increase the number of engineers for maintenance work for ETA's expressway.

Establishment of Maintenance Branch Office

After completing the new 18.7-kilometer Ramindra-Atnarong Expressway, ETA's expressway network will reach 46 kilometers within a few years. However, the location of the present maintenance center seems to be inconvenient to cope with the maintenance work of the new expressway effectively. Therefore, a branch office between Ekamai and Lad Phrao Road may be necessary for the new expressway.

Strengthening Research Engineering Capabilities

ETA has a plenty of plans on the construction and operation of its future expressway and mass transit system. In addition to the appropriate execution of these business, as well as to their upkeep, it is recommended to strengthen the following capabilities from viewpoint of engineering and operation of the expressway.

- Material Testing

It is necessary to conduct material testing, soil testing, pavement testing and research work related to new materials to cope with increasing and progressing maintenance technology for the expressway.

EMD seems to be the most suitable division to realize improvements in material testing in terms of space and work implementation at an early stage.

- Traffic Operation

In addition, the progress of research work on transport economics, traffic flow, safety, information, etc., has also been rapidly progressing. In order to apply these new technologies to ETA's expressway, it is necessary to carry out these research works individually.

However, it may be difficult to execute by ETA staff at an early stage because of a shortage of engineering staff. In this case, it is recommended that ETA farms out to a private engineering consultants, in order to solve the problem and utilize progressed technology, such as on traffic control, operation in case of channeling change, and efficient flow on the expressway.

3) Sub-Governmental Organization

In order to cope with ETA's increasing important role as a toll expressway organization in the country, it seems that it is necessary to strengthen its engineering capabilities in order to carry out its mission.

Therefore, it is proposed that the number of ETA's maintenance

staff be increased. Where this is difficult to do, work such as inspection and routine maintenance can be farmed out to outside organizations. This will permit the engineering staff in ETA to engage in more important maintenance engineering tasks concerning the expressway.

However, it seems that it will be difficult to have a private company perform expressway maintenance work at present in Bangkok, since it is not so exciting and its commercial aspects are uncertain.

To cope with this problem, it is proposed that a sub-governmental organization be established under the jurisdiction of ETA. This organization would perform routine maintenance work and other related work exclusively for the ETA expressway, and could put the maintenance engineering knowledge of retired engineers from ETA to practical use, as well as develop maintenance technology of the expressway.

Possible work to be performed by this sub-governmental organization for ETA's expressway, after referring to such an organization in Japan, are maintenance and related to operation of the expressway as below.

- Daily inspection work
- Routine inspection work
- Cleaning of roadway surfaces and drainage
- Sales of coupon tickets, if any
- Other service related work for expressway users, such as providing route maps and the operation of service facilities, if any, and
- Operation and development of under-viaducts, and ETA's compound, and their management work.

9.4 Maintenance Work System

9.4.1 Regulations for Maintenance Work Safety

Traffic volume on ETA's expressway will continue to increase in the future due to the rapid economic growth and increase in the number of vehicles in the Bangkok metropolitan area. In addition, the operating length of the expressway will also be extended to cope with the traffic demand. This will result in the need to execute expressway maintenance and repair work on a frequent basis.

Major maintenance and repair work are carried out in the night time to avoid traffic congestion on the expressway. On the other hand, regulations concerning speed limit and drunk driving are not strictly enforced. In addition, periodic automobile inspections are not carried out frequently enough to ensure its safety. Given these conditions, it is recommended that maintenance and repair work safety be strengthened on the expressway for both workers and drivers, which will also result in a smoother traffic flow on the expressway.

Recommendations to increase traffic safety on the expressway when maintenance work is being carried out are shown below.

- Driver Information
  Information on expressway maintenance work shall be provided in advance to drivers by means of fixed or variable traffic signs (character information boards), or via the mass media when traffic congestion is expected to be heavy due to the maintenance work itself. This will allow drivers to select an appropriate route, or to be ready for traffic regulations on the expressway.

- Introduction of Traffic-Sign Cars
  In order to let drivers know the location of maintenance work from a distance, bright and clear rotating lights on a traffic-sign car would be suitable. This car is also useful for going to sites with other construction vehicles and arranging the spacing needed for maintenance work.

  A traffic-sign car, in Japan in general, is usually a heavy track equipped with rotating lights and having arrow marks with lights and shock absorbers at the rear for vehicle

collision. The layout of a traffic-sign car is shown in Figure-9.4.1.

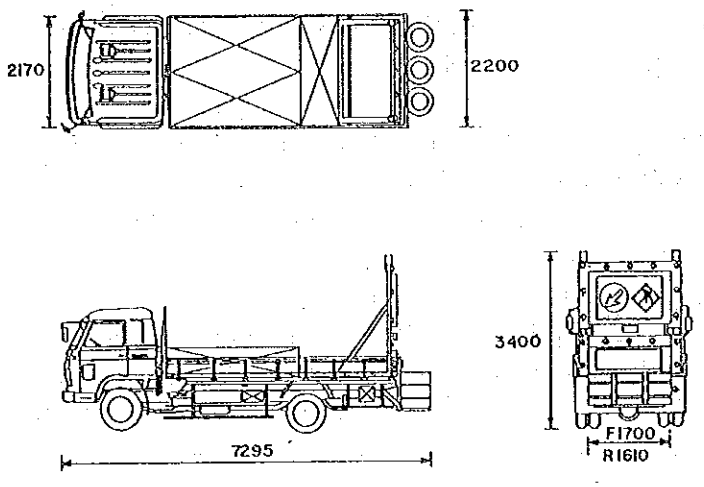


Figure-9.4.1 Traffic-Sign Car

- Traffic Regulations

When it is necessary to control traffic on the expressway for long-term maintenance work, it is required for traffic lane space to be taken over. Detailed spacing of safety devices, such as color cones, arrow marks, revolving lights and traffic-sign car are shown in Figure-9.4.2 to Figure-9.4.3. Regulation length is 250 meters from the beginning to the end of a work area, based on Japanese expressway standards in the urban expressway.

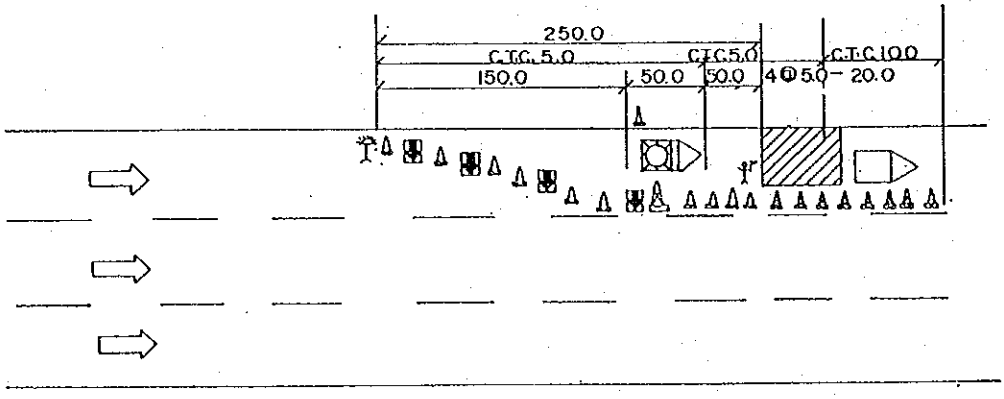


Figure-9.4.2 One Lane Traffic Regulation

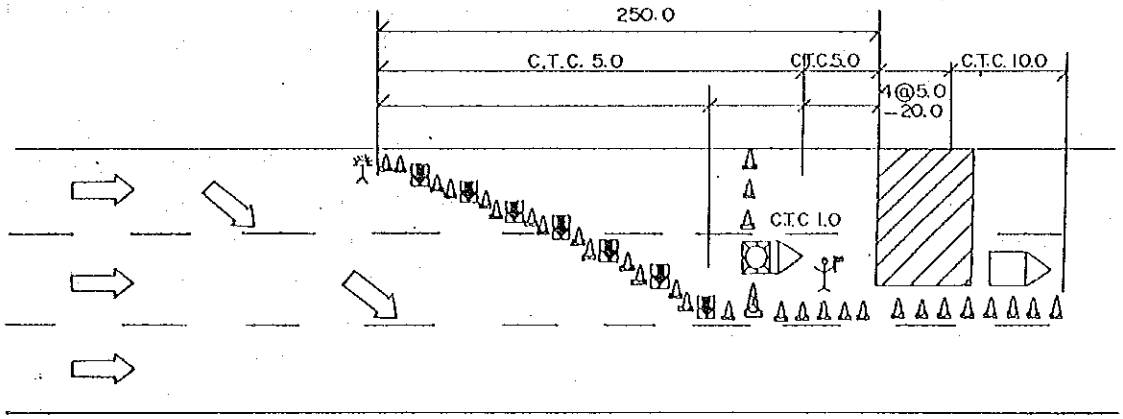


Figure-9.4.3 Two Lane Traffic Regulation

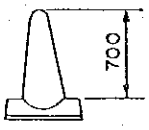
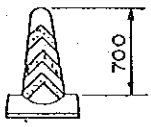
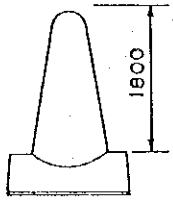
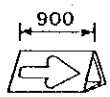
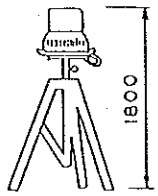
	Color corn			Arrow plate	Red revolving light
	Red	Reflection	Jumbo		
Type					
Rough sketch					

Figure-9.4.4 Traffic Safety Devices

9.4.2 Unit Price Contract System

Repairs for deteriorated structures and facilities on the expressway consists of various kinds of work regarding timing, methodology, work scale, materials, costs, etc. Currently, repairs are not so frequent on the ETA expressway, due to the small amount of damage and short operation length. This means the current ETA work system, is composed of force-account repairs and contract repairs, functions effectively given the present condition of the expressway.

As for force-account repairs, ETA itself performs small-scale repairs, such as the restoration of handrails and traffic signs. In the case of contract repairs, major repair work, such

as pavement and expansion joint repairs, are carried out by contractors based on a job-by job basis. This may be result in the delay of work due to the selection of a company and cost negotiations.

The present work system seems to function effectively given current conditions; however, a more appropriate work system may be necessary for the future when frequent and prompt maintenance work is required. In addition, it is expected that future repair work will require the special technics, materials and equipment.

In order to carry out promptly small-and-medium-scale repairs by contractors, the unit cost contract system is recommended to be applied as below.

- Objective Repair and Maintenance Work
  Objective repair or maintenance work consists of stereotyped work in terms of method, materials used and costs, such as partial concrete patching, restoration of railings, repairing expansion joints, partial pavement repairs, and the replacement of lighting and poles.

- Contracts
  ETA will make a contract with a company in terms of unit costs for each type of repair in the beginning of a fiscal year. Of course, it is necessary to select a company and negotiate unit costs prior to drawing up of a contract.

- Execution of Repairs
  When an ETA inspector discovers damage or deterioration to a structure or facility requiring repair, the maintenance section draws up an execution of repairs for the location and the damage. Both engineers of the ETA and private company confirm the damage and repairs on site, and a company can start repairs immediately.

9.4.3 Initial Data Collection by Contractors

Data collection has been carried out by the Study Team to make the road inventory database for the current ETA expressway in this Study, based on documents stored in ETA and some field surveys with counterpart team. However, some data could not be collected due to the lack of original data. These shortage of

information is caused by the insufficient description on drawings in contract basis, where were no enough detailed information for the actual construction work, and insufficient documents managements in ETA.

The new Ramindra-Atnarong Expressway will be completed and opened to public traffic in 1997. At the same time, inventory data for this new expressway shall be collected and compiled into the inventory database, in order to execute maintenance work by means of the developed inspection and maintenance system. Also, it is easiest in terms of data collection for the inventory to perform right after the completion of the expressway.

The necessary coding sheets and documents have been determined and provided to code readily this inventory information, and any engineer can code the information based on the coding sheets and code table. In order not to increase ETA's work, it is recommended that initial data collection and coding for the road inventory be performed by contractors for future expressway expansion.

9.5 System Expansion

9.5.1 Extension of Expressway

In order to carry out effectively the maintenance work corresponding to the extension of the ETA expressway network in the future, recommendations are presented in this section.

Given the new 18.7-kilometer Ramindra-Atnarong Expressway, the operational length will reach 46-kilometer within a few years. The third stage of the expressway networks extension plans to construct two routes for a total of 29.5-kilometer that will surround the Bangkok metropolitan area on a concession basis. The fourth stage will cover central regions in the country for a total expressway length of 871-kilometer, and an environmental impact study and feasibility study has already been completed. Thus, given the amount of expressway planned, it is obvious that the maintenance system will be of great importance in assisting expressway administrators. Some comments are made below on the extension of the expressway by stage.

- Completion of Ramindra-Atnarong Expressway
  The developed database system has sufficient capacity to compile inventory and maintenance data for this new expressway as mentioned before.

  However, the location of the present maintenance center seems to be inconvenient to cope with the maintenance needs of the new section effectively. Therefore, a new maintenance office or branch office may be necessary on the new expressway section between Ekamai and Lad Phrao Road.

- Completion of the Fourth-Stage Expressway
  Some parts of the fourth-stage expressway are recommended to be opened to public traffic by 2001. However, the detailed plans to undertake the project are not clear yet.

  Information processing technology is making rapid progress in terms of both hardware and software. In addition, it is expected that ETA's role will become more important with the increasing traffic demand, which is a result of the country's economic growth and social needs. These circumstances may change the function of ETA itself, but this is not the place to consider such an uncertain possibility in the future.

9.5.2 On-line Utilization of Database

The developed database can be effectively used in not only maintenance work but in various kinds of other work such as administration, budgeting, and planning, as well as for the following management tasks.

- Planning Work
  Planning and scheduling of inspections and repairs, formulation of maintenance plans, identification of damaged structures and facilities, provision of access to road conditions, structural and facility data, and budget planning.

- Information Presentation
  Compilation of road information to grasp the existing status of the expressway.

- Administration Works
  Property management and official reports, etc.

From these viewpoints, the developed database can be widely utilized within the ETA organization, and provides a way to execute maintenance and management work of the expressway in a rational and efficient manner.

A RISC/6000 (MODEL-530H) workstation was introduced for the database task in ETA in 1993. This machine is accessible for both engineering and administrative work in ETA in four offices; i.e., the Main Office, the Rama IX Bridge Maintenance Section, Klongtoey Office and the Maintenance Center in Yannawa district, with the communications network as shown in Figure-9.5.1. The developed database system and stored information in the form of an inventory can be widely utilized for maintenance work as above mentioned through the network.

dBASE4, which is the database management system (DBMS) to control the database in terms of updating, storing and retrieving information into/from the database, is selected to formulate the database for the inspection and maintenance work for the ETA expressway. The selected dBASE4 is capable of managing information for both microcomputers and the RISC/6000 workstation, in terms of converting the developed system for this workstation.

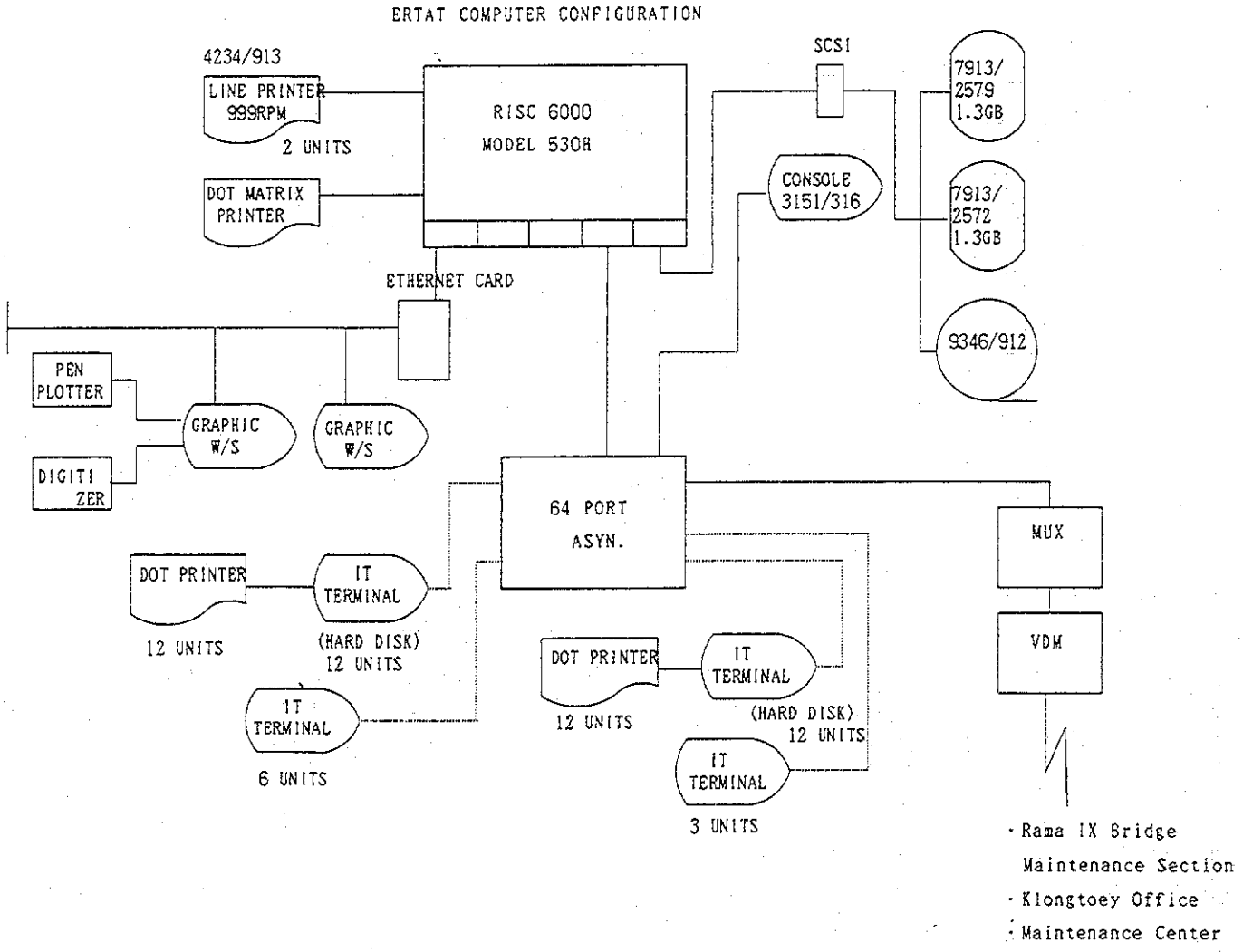


Figure-9.5.1 RISC/6000 Workstation and Network

In addition to this, the characteristics of dBASE4 are as below.

- Introduced approximately 15 years ago as an application software for database management by microcomputer,
- the market share of this DBMS in this country exceeds more than 90 % if microcomputer use is included,
- programming service is commercially available at an appropriate price,
- it seems possible for ETA staff to easily maintain the developed system themselves,
- databases established with this DBMS are common use in mainframe and workstation with this SQL database structure, and
- the installation cost of this DBMS is cheaper than any other.

A RISC/6000 workstation is loaded with AIX as the operating system in the UNIX language. dBASE4 for workstations can be applied with AIX version 3.2.5 or a higher version when loading the developed database system. Accordingly, the following procedure is recommended to convert the developed database system for wider utilization with a RISC/6000 workstation.

- Confirm to see whether the AIX version in the workstation is a version 3.2.5 or higher; if not, introduce the appropriate version,
- Introduce dBASE4 for workstations in the UNIX language,
- Load the developed database system into the RISC/6000 workstation, and
- Copy microcomputer database files and reload them into workstation.

According to the above procedure to convert the system and database, any user in ETA can use the developed database for both engineering and administrative work using the network of the RISC/6000 workstation. However, intensive and systematic information management will be more important to manage the database in updating information stored within the ETA organization.

9.5.3 Improvement of System Functions

Improvement and/or expansion of system functions will certainly be necessary to cope with the increasing and upgrading maintenance work depending upon systematization of information, when the developed database system will be sufficiently utilized in a practical maintenance work on the expressway.

ETA has some concepts for introducing and upgrading information systems in terms of hardware, software and a communications network called the local area network (LAN) for ETA offices, as mentioned in Section 3.8.

Recommendations or comments on the expansion of system functions is rather difficult due to the uncertain future conditions. The most important point is positive utilization of the developed system for maintenance and any other work applicable to the system, and then it will become clear what expansion and improvements in system functions will be needed. The following items can be expected with an expansion of system functions.

- Presentation in Thai
  Information of code are presented in Thai both on computer display and output forms in this system in response to ETA's request in the study, despite the Scope of Work stating that entire system would be developed in English.

  ETA technicians in charge of maintenance work seem not to be familiar with English. Since operation of the database system by technicians is highly desirable for more effective utilization and management of the system, all output and display message should be changed into Thai, if necessary.

- Graphic Displays
  Displays of figures are becoming familiar even in microcomputers, depending on the progress of information technology. Some information for maintenance work may be effectively utilized by users by providing graphic displays automatically, such as location maps for the expressway network or graphs on numerical values necessary for maintenance work.

- Improvement/Addition of Output Forms
  The developed database system provides the necessary output forms for maintenance work, but it only covers the necessary

minimum in terms of system operation. When ETA engineers become familiar with the developed system in their maintenance work, they will want other improved or additional output forms for their own way of work. However, a new study shall be necessary to design new output forms to avoid the duplication of items and to present confusion in the operation of the system.

- Automation of Inventory Updating
  Inventory data can not be automatically changed when new materials or new structural type is introduced. However, it will be necessary in the future, due to the increase in repairs and availability of materials for maintenance and repairs. This situation will change and such a function will be necessary. Here, the maintenance of code in an orderly fashion will become important in order to handle the database efficiently.

- Introduction of Analytical Software
  In order to broaden the usage of information systems for such things as engineering analysis, long-range planning, manpower management, personnel administration and supply administration, an introduction of analytical software will be necessary to use more efficiently the information stored in the database.

Expansion of system functions will depend on the usage of the developed system by ETA maintenance engineers. If the system frequently and adequately utilized, a higher-level system will be necessary as mentioned above.

In Japan, inspection and maintenance systems together with databases have been developed and been used for road maintenance and management work since the mid 1970's. However, some systems require an unexpected amount of manpower and cost to update the database due to too much detailed information compiled in the database. For this reason, an appropriate balance must be kept for information necessary for maintenance work, taking into consideration of system maintenance and database maintenance in terms of manpower, time and costs.

9.6 Summary Comments

In order to manage expressway systems adequately and carry out timely remedial measures, availability of information on road conditions is of great importance to road administrators. The inspection and maintenance system for ETA's expressway is formulated to cope with maintenance and other related problems and to improve maintenance methods as well.

The present maintenance organization of ETA is considered to be functioning without much problem in executing its current maintenance work. However, ETA still has to expand its functions and maintain an expressway network in Bangkok and the rural regions, to cope with the ever-increasing economic growth and social demands. This suggests that the role of ETA will become more important in operating and maintaining the expressway system in this country.

In addition to the above, it is expected that damage to road structures and facilities will escalate with the increases in traffic volume, the ratio of heavy vehicles and the number of age-worn structures and facilities. To cope with these problems, ETA's maintenance organization may have to improve its maintenance engineering capabilities and effectiveness in performing maintenance work.

The developed inspection and maintenance system aims to reduce total maintenance costs and manpower, and upgrade the quality of comprehensive maintenance work. However, an introduction of new system requires, in general, that ETA must raise its maintenance work capabilities in terms of personnel and organization concerned.

An important task for making full use of the new computerized database system is system maintenance to ensure effective utilization for practical rather than technical purposes. Therefore, updating of data on road inventory and inspection/repair should be both systematically and periodically implemented. This will lead to the better circulation of information and improve the maintenance work capability of ETA staff.

APPENDIX

A.001 Workshop Program

THE STUDY ON
INSPECTION AND MAINTENANCE SYSTEM FOR THE EXPRESSWAY

WORKSHOP PROGRAM

on March 24, 1994
at Expressway Control Center of the ETA

1)	9:00- 9:30	(30)	Opening Address Mr. Siva Charoenpong (Deputy Governor of ETA) Mr. Kazuro Yanagida (Leader of Study Team) Mr. Sukavich Rangsitpol (Governor of ETA)
2)	9:30-10:10	(40)	Inspection and Maintenance Work and Damage Examples in the Tokyo Metropolitan Expressway System Mr. Hiroshi Kojima (JICA Expert to ETA)
3)	10:10-10:50	(40)	Ensuring Traffic Safety via Maintenance Work Mr. Fukashi Kogure (JICA Advisory Committee Member)
*	10:50-11:05	(15)	Tea Break
4)	11:05-11:35	(30)	Inspection and Maintenance System Concepts and Framework Mr. Koji Wada (Study Team Member)
	11:35-12:00	(25)	Demonstration of Database System Question and Answer
*	12:00-13:00	(60)	Luncheon Break
5)	13:00-13:30	(30)	Video: PASCO Road Survey System (Automatic Inspection on Pavement Deterioration)
6)	13:30-14:30	(60)	A Database System for Inspection and Maintenance Work Mr. Kunawut Atthasis (Study Team Member)
*	14:30-14:45	(15)	Tea Break
7)	14:45-15:15	(30)	Practical Application Program in ETA Mr. Somsak Mungkarak (ETA Counterpart Team Member)
8)	15:15-15:25	(10)	Question and Answer by Project Principals and Study Team
9)	15:25-15:55	(30)	Video: Tokyo's TRTA Subways (An Example of a Mass Transit System in Tokyo)
10)	15:55-16:00	(5)	Closing Address Mr. Hiroaki Yanagi (Chairman of JICA Advisory Committee)

A.002 List of Data and Information Collected

LIST OF DATA AND INFORMATION COLLECTED

(A) DRAWINGS GENERAL

A-1 Dao-Kanong - Port Section Contract No.1
Nang Linchi - Sathupradit Contract Drawings (As Built)

A-2 Dao-Kanong - Port Section Contract No.2
Sathupradit - Bangkok Approach Bridge
contract Drawings (As Built)

A-3 Dao-Kanong - Port Section Contract No.3
Suksawat Interchange - Dao Kanong
Contract Drawings (As Built)

A-4 Dao-Kanong - port Section Contract No.4A
Dao Kanong Interchange Addendum
Contract Drawings (As Built)

A-5 Dao-Kanong - Port Section Contract No.4
Dao Kanong Interchange
Contract Drawings (As Built)

A-6 Din Daeng - Port Section Contract No.1
Din Daeng - Makason As Built Drawings

A-7 Din Daeng - Port Section Contract No.2
Makason - Rama IV As Built Drawings

A-8 Din Daeng - Port Section Contract No.3
Port As Built Drawing

A-9 Bang-na - Port Section Contract No. 1
Kasemraj Road - Sukhumvit Soi 50 As Built Drawings

A-10 Bang-na - Port Section Contract No.2
Sukhumvit Soi 50 - Bangk-na As Built Drawings

A-11 Bang-na - Port Section contract No.3
Bang-na Interchange As Built Drawings

A-12 Chainage System for Column, Expansion-
Joint and Drainage

A-13 Lighting Polr No. and Detail Drawing

A-14 Ekamai - RaminDra Conceptual Drawings Plan and Profile, By A Sian Engineering Co.,Ltd.

A-15 RaminDra - Artnarong Expressway System
And BMA's Project Contract No.7 & 7B

A-16 Traffic sign Layout

(B) DRAWINGS FOR RAMA 9 BRIDGE

B-1 Contract No.1 Cable-Stayed Bridge Fabrication Drawings Volume I Main Girder

B-2 Contract No.1 Cable-Stayed Bridge Fabrication Draw-

	ings Volume II Pylon
B-3	Contract No.1 Cable-Styled Bridge Fabrication Drawings Volume III Reinforcement & Accessory
B-4	Contract No.1 Cable-Stayed Bridge Contract Drawings
B-5	Contract No.2 Thonbuti Approach Bridge Contract Drawings
B-6	Contract No.3 Bangkok Approach Bridge Contract Drawings
B-7	Contract No.1 Cable-Stayed Bridge (Partially copyed Contract Drawings 18 pages)
B-8	Contract No.1 Cable-Stayed Bridge (Inregard to Pylon 14 pages)
B-9	Inspection report for bolt welded inside Rama IX
B-10	Internal Inspection on Rama 9 Bridge (in Thai & copy only) Pylon
B-11	Pavement inspection on Rama IV Bridge (1 sheet)
B-12	Inspection Report for Cable Tension Force (by Cable Tension Meter Vibration Method) 2 sheets
B-13	Inspection report and repairing schedule of Asphalt pavement
B-14	The inspection of Joint on Rama 9 Bridge (Weekly Inspection Report)
B-15	Rama 9 Bridge, facilitated instrument for making metrological
B-16	Inspection Manual for Rama 4 Bridge (PCI)
B-17	Final report on An Approach to the database of maintenance work for urban expressway

(C) ETA REPORTS AND DOCUMENTS

C-1	Annual Report 1989 The Expressway and Rapid Transit Authority of Thailand
C-2	Annual Report 1990 The Expressway and Rapid Transit Authority of Thailand (English & Thai Edition)
C-3	Role & Function and Projects concerned The Expressway and Rapid Transit Authority of Thailand Technical and Planning Division June 1993
C-4	Saphan Phra-Rama 9 (Thai Edition)
C-5	The Bangkok Cable-Stayed Bridge
C-6	Inspection and Maintenance System of the Expressway System under ETA September 1989 By PADECO
C-7	Inspection and Maintenance System of the Expressway System under ETA September 1991 By PADECO

C-8 Thonburi Approach Bridge Specification Contract No.2 (Dao Kanong - Port Section)
C-9 The Inspection of Joint on Rama 9 Bridge (9 sht) in Thai Edition
C-10 Estimate Cost Year 1991 (19 sht)
C-11 Roadway Maintenance Section Equipment (3 sht)
C-12 Organization chart of ETA Year 1989 (7 sht)
C-13 Repair cost of Rama 9 Bridge pavement (7 sht) (1992)
C-14 Yearly Maintenance Schedule on Rama IX Bridge (Work Ended 1993)
C-15 Material for Construction (Thai Edition)
C-16 Pavement Request letter to Bangken Heae Office for repairing pavement
C-17 Inspection for Exp Joints Repairing record for EXP Joints
C-18 Inspection report for Exp. Joint by ETA Staff (Joint inspection form)
C-19 Statistical Report 1990
C-20 Statistical Report 1991
C-21 Statistical Report 1992

(D) DOCUMENTS BY OTHERS

D-1 Manual for Maintenance Inspection of Bridges 1983 BY Highway Subcommittee on Bridges and Structures
D-2 PUBLISHED by American Association of State Highway and Transportation Official
Manual for Inspection of The Rama IX Bridge March 1990 ETA PREPARED BY Mitsuo Hara JICA
D-3 Inspection Manual for Expressways March 1990 ETA PREPARED BY Mitsuo Hara JICA
D-4 Preliminary Study Report for The Study on Inspection and Maintenance System for The Expressway November 1991 BY Ministry of Construction International Engineering Consultants Association Tokyo JAPAN
D-5 Explanation for Using The Cable Tension Meter Japanese Edition From Mr. Kojima
D-6 Inspection Report for Pavement (except Rama 9 Bridge) By ETA inspector)
D-7 Repairing Report From Contractor for Exp. Joints
D-8 Photograph for the Typical Damage & Repairing works except Asphaslt Pavement on The Rama 9 Bridge

A.003 Roadway Inspection

ROADWAY INSPECTION

ITEM	METHODS	EQUIPMENTS	PERSONNEL	FREQUENCY	REMARKS
1 General condition (as following item 1.2 - 1.1	Observed by moving car and record type, size, location of damage and Photo	*	2	every day	* General Instrument 1) Camera 2) Binoculars 3) Cracking measurement 4) Furrow measurement
2 Shoulder and Drainage system	Observed by eye and record type, size, location of damage and Photo		5	every month	5) Leveling and Staft 6) Calculator 7) Brush 8) Paint 9) Field book 10) Ruler, scale, Tape
3 Control system building and toll building	Observed by eye and record type, size, location of damage and Photo		5	every year	11) Cable carne 12) Electrical instrument 13) Etc. (necessary)
4 Sanitary and sanitaryware of all building	Observed by eye and test the operation		3	every 3 month	
.5 Metal work and Welded - Hand Rail - Pedestrian Crossing - Guard rail and Fence - Traffic Sign			6	every 3 month	
6 Painting (building and expressway) - Hand Rail - Pedestrian Crossing - Guard rail and Fence - Traffic Sign - Building	Observed by eye		3	every 3 month	
.7 Toll booth	Observed by eye and record feature of damage and Photo		4	every 3 month	
8 Pavement Joint - Buried - Exposed - Nitta - Sho bond - Thorma	Observed by eye and record feature of damage and Photo		7	every 3 month	* total Joint 2,492 Joints
9 Pavement - Asphalt - Concrete	Observed by eye and record type, size, location of damage and Photo		4	ever 3 month	Structure Inspection - Girder - Slab - Diaphram - Centilver deck - Column - Bearing
10 Road marking - Thermoplastic	Observed by eye and record feature of damage and Photo				- Parapet
11 Structure of expressway	Recommend by specialist	Recommend by specialist	-	n.a	
12 Report & Statistical Analysis	Computer Input	Computer Diskette	1		

A.004 Rama IX Bridge Inspection

RAMA IX BRIDGE INSPECTION

INSPECTION ITEMS	INSPECTION METHODS	EQUIPMENTS	PERSONNEL	FREQUENCY	REMARKS
1. Bridge (Inside)					
1.1 Routine Inspection		*			* General Equipment
- Bolt connected section	Observed by eyes and	Test Hammer and	4	every month	- Field note
- hardness	record the location,	High tention			- Camera
- tensile strength	feature of damage	bolt check meter			- Convex rule
- breaking point					- Black board
- torque					- Tape measure
- Welded section	Observed by eyes and	Crack width	4	every month	- Walky-talky
- cracking	record the location,	measuring device			- Binoculars
- undercut	feature of damage				- Dusting things
- porosity					- Etc.(necessary)
- General feature	Observed by eyes and	-	2	every month	
- strength	record the location,				** Recommend by
- torgue	feature of damage				Specialist
- colour					
- etc.					At Present no
					Cable Tention Meter
1.2 Period Inspection		*			
- Bolt connected section	Random check and	High tention	4	every 3 years	
- hardness	test some property	bolt check meter			
- tensile strength	of bolts				
- elongation					
- breaking point					
- torque					
- Welded section	**	Ultra Sonic test	4	every 3 years	
- air void					
- slag inclusion					
- inadequate joint penetration					
- Shrinkage-Elongation and camber of all member	**	**	-	**	
- Painting	Observed by eyes	-	4	every year	7 years warranty
1.3 Special Inspection	**	**	-	**	
- Critical deflection					
2. Bridge (outside)					
2.1 Routine Inspection					
- General Feature (ie. painting, guard rail, - manhole, etc.)	Observed by eyes and record the location, feature of damage	*	1	every day	
2.2 Period Inspection	Observed by eyes and	*	4	every year	
- General painting	record the location,				
- Main span and Back span Colour	feature of damage				

INSPECTION ITEMS	INSPECTION METHODS	EQUIPMENTS	PERSONNEL	FREQUENCY	REMARKS
2.3 Special Inspection					
- Alignment & Elevation	**	**	-	every year	
- Horizontal Displacement (Longitudinal by seismic load and Traverse by wind load for back and center span)					* General Equipment - Field note - Camera - Convex rule - Black board - Tape measure - Walky-talky - Binoculars - Dusting things - Etc.(necessary)
- Vertical displacement (for back and center span)	**	**	-	every year	
3. Pylong (inside)					
3.1 Routine Inspection		*			** Recommend by Specialist
- Bolt connected section	Observed by eyes and	Test Hammer a	4	every month	
- hardness	record the location,	High tention			
- tensile strength	feature of damage	bolt check me			At Present no
- breaking point					Cable Tention Meter
- torque					
- Welded section	Observed by eyes and	Crack width	4	every month	
- cracking	record the location,	measuring dev			
- undercut	feature of damage				
- porosity					
- General feature	Observed by eyes and	*	2	every month	
- strength	record the location,				
- torgue	feature of damage				
- colour					
- etc.					
3.2 Period Inspection	**	*			
- Bolt connected section	Random check and	High tention	4	every 3 yea	
- hardness	test some property	bolt check me			
- tensile strength	of bolts				
- elongation					
- breaking point					
- torque					
- Welded section	**	Ultra Sonic t	4	every 3 yea	
- air void					
- slag inclusion					
- inadequate joint penetration					
- Pylon colour (inside)	Observed by eyes		4	every year	7 years warranty
- Tensile stress at pylon anchorage	**	Cable tention meter	-	every 2 yea	
4. Pylon (outside)					
4.1 Routine Inspection	Observed by eyes and	*	4	every month	
- General feature (ie. colour, rust, etc.)	record the location, feature of damage				

RAMA IX BRIDGE INSPECTION

INSPECTION ITEMS	INSPECTION METHODS	EQUIPMENTS	PERSONNEL	FREQUENCY	REMARKS
4.2 Periodic Inspection - General Feature (ie. colour, rust, etc.)	Observed by eyes and record the location, feature of damage	*	4	every 2 years	* General Equipment - Field note - Camera - Convex rule - Black board - Tape mensure - Walky-talky - Binoculars - Dusting things - Etc. (necessary)
4.3 Special Inspection - Alignment, Settlement of pylon, Displacement of Tower Top	**	**	-	**	** Recommend by Specialist
5. Cables					
5.1 Routine Inspection - Sagging - Forming - Rust - Lubricant in a socket - Sealing at anchorage	Observed by eyes and record the location, feature of damage	*	2	every 2 weeks	At present no Cable Tention Meter
5.2 Period Inspection - Poping Deflect - Extrustion of Lubricant - Colour	Observed by eyes and record the location, feature of damage	*	6	every 2 years	
- Tensile force & Tensile stress	**	Cable Tention meter	3	every year	
- Slip of cable around cable socket including Lubricant in a socket	Measure the horizont and vertical between surface of cable cov and cable hammer and leakage of Lubricant	Vernier calipers Gab guage	4	every 3 years	
- Slip of Shim & Anchor Plate and other deflect (ie.colour,rust,sealing, , cracking)	Measure slip of shim and anchor plate, record the location and Photo	Vernier calipers Gab guage	4	every 3 years	
- General feature of Cable Cover and Coaming	Observed by eyes and record the location, feature of damage	* cable crane	1	every year	
5.3 Special Inspection - Corrected Cable Tention (in order to feasible with Profile of Bridge)	**	**	-	**	

INSPECTION ITEMS	INSPECTION METHODS	EQUIPMENTS	PERSONNEL	FREQUENCY	REMARKS
6. Pendel Cable					
6.1 Periodic Inspection - Tensile force & Tensile stress	**	* Cable Tention meter	3	every 3 years	* General Equipment - Field note - Camera - Convex rule - Block board - Tape measure - Walky-talky - Binoculars - Dusting things - Etc. (necessary)
- Slip of cable around cable socket including Lubricant in a socket	Measure the horizontal and vertical between surface of cable cover and cable hammer and leakage of Lubricant	Vernier calipers Gab guage	2	every 3 years	
- General feature of Anchorage (ie.colour, rust,cracking,Sealing, Ram-Chair, Top & down Backing Plate)	Observed by eyes and record the location, feature of damage	* cable crane	2	every 3 years	** Recommend by Specialist At present no Cable Tention Meter
7. Bearing, Pendel, Wind Shoe (Approach)					
7.1 Routine Inspection - Pendel - Wind Shoe	- Observed rust and shape of structure - Observed contract surface between Wind Shoe and concrete	*	4	every year	
7.2 Periodic Inspection - Bearing (Behavior, Cracking)	**	**	4	every year	
- Neo-Pot	**	**	4	every year	
8. Drainage System					
8.1 Routine Inspection - Blockage of Drainage - Leakage - Rust, Sealing - Cover Plate - Hanging-Support - Grating	Observed by eyes and record the location, feature of damage	*	2	every year	
8.2 Periodic Inspection - Drainage System	Water Pressure	-	5	every year	

INSPECTION ITEMS	INSPECTION METHODS	EQUIPMENTS	PERSONNEL	FREQUENCY	REMARKS
9. Expansion Joint					
9.1 Routine Inspection					* General Equipment
- Reinforces Elastomeric Type	Observed general feature and cracking of concrete	* Crack Width measuring	4	every week	- Field note - Camera - Convex rule - Black board
- Roller Shutter type	Observed Surface of Joint, Bolts are fitted or not and blockage of drainage Sealing	*	4	every week	- Tape measure - Walky-talky - Binocutars - Dusting things - Etc. (necessary)
9.2 Periodic Inspection		*			
- Reinforces Elastomeric Type	Measure movement of Joint and Sealing	Gab guage Scale	4	every year	** Recommend by Specialist
- Roller Shutter type	Measure Height difference of surface between plate, Movable Length	Gab guage Scale	4	every year	At present no Cable Tention Meter
10. Damper					
10.1 Routine Inspection					
- General condition of Cable Damper -Holding between plate and Cable -Condition of sealing -Leakage inside Damper around plug and welded -Simulation distance of Damper	**	* **	2	every year	
- General condition of Pylon Damper -Movable -Vibration absorb -Setting condition between vertical bar and Joint -Strength, Torque, rust Inside Pylon Damper	**	* **	2	every year	
- General condition of Deck Damper -Leakage of Lubricant -Level of oil -Rust	**	* **	2	every year	

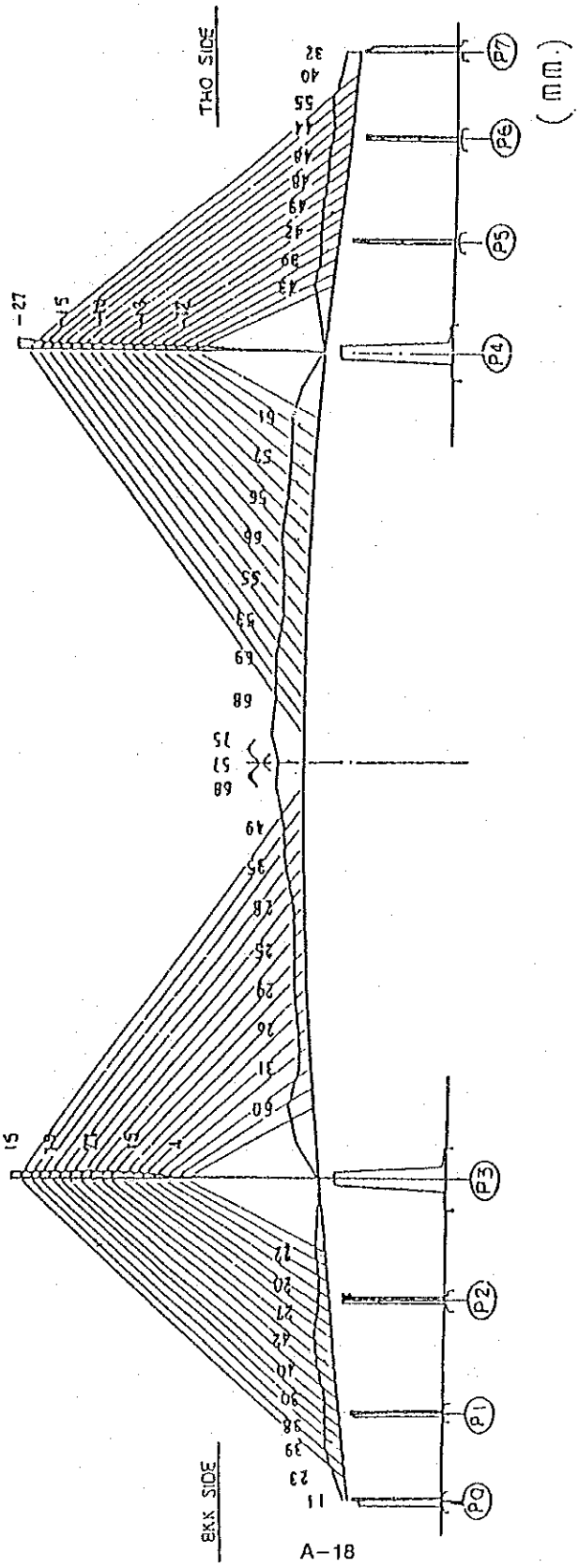
INSPECTION ITEMS	INSPECTION METHODS	EQUIPMENTS	PERSONNEL	FREQUENCY	REMARKS
10.2 Periodic Inspection - Cable Damper - Pylon Damper - Bridge Damper (ie.Property and Level of Lubricant inside Damper, simulation distance of Damper).	**	**	-	every 2 years	* General Equipment - Field note - Camera - Convex rule - Black board - Tape measure - Walky-talky - Binoculars - Dusting things - Etc. (necessary) ** Recommend by Specialist At present no Cable Tention Meter
11. Maintenance Gantry 11.1 Periodic Inspection - Deflection of Frame (Shape, Welded of Joint and Rust) - Deflection of Wheels (Bearing, Holding between Frame and Wheels at Welded) - Drive Units (Engine, Hydraulic system) - Deflection of Rail Welded between Rail and Bridge) - Deflection of Bracket (Hydraulic and Break System)	**	*	2	every year	
12. Craddle 12.1 Periodic Inspection - Structure of Craddle - Rust - Cantiliver Beam suppor Pylon Craddle - Generation Motor	**	**	-	every year	
13. Lift 13.1 Periodic Inspection - Motor and Governer - Car and Counter Weight - Sling Deflection - Rail Deflection	Testing the operation of system and record the deflection, Photo	-	3	every year	Routine Inspection every month
14. Permanent Instrument 14.1 Periodic Inspection - Temperature Measurement - Vibrator Measurement - Wind Measurement	Testing the operation of instrument and record the deflection Photo	-	4	every year	Routine Inspection every day

RAHA IX BRIDGE INSPECTION

INSPECTION ITEMS	INSPECITON METHODS	EQUIPMENTS	PERSONNEL	FREQUENCY	REMARKS
15. Pier and Abutment					
15.1 Periodic Inspection - Cracking (inside and outside) - Size of cracking	Observed by eyes and record the location, feature of damage	* Cable crane	4	every year	* General Equipment - Field note - Camera - Convex rule - Black board - Tape measure - Walky-talky - Binoculars - Dusting things - Etc. (necessary)
16. Concrete Deck					
16.1 Periodic Inspection - Cracking (inside and outside) - Size of cracking	Observed by eyes and record the location, feature of damage, Photo	* Cable crane	4	every day	** Recommend by Specialist
17. Pavement					At present no Cable Tention Meter
17.1 Routine Inspection - Roughness - Cracking	Observed by eyes and record the location, feature of damage, Photo	*	4	every day	

Note: At present there is no repair because there is no damage except the asphaltic pavement

A.005 Deviation of Bridge Profile



A.006 Pavement Maintenance Record

Pavement Maintenance Record (Asphaltic Concrete)

Chainage	Direction	Lane No.	Repair Area (sq.m.)	Repair Date
Roadway				
1+559-1+639	DD-P	1	243.6	02/01/89
1+559-1+734	P-DD	1	612.5	"
2+550	P-DD	1	4.80	"
5+100	P-DD	1	29.4	"
5+550	P-DD	3	38.15	"
6+250-5+920	P-DD	1	1436.05	"
"	P-DD	2	1436.05	"
"	P-DD	3	1436.05	"
-	-	-	1683	"
-	-	-	52.2	"
10+420	P-BN	2	53.9	"
10+450	BN-P	3	237.3	"
-	-	-	3493.4	"
20+403-8+720	DK-P	1	2100	"
-	DK-P	-	2667	"
8+504	DK-P	1	41.65	"
-	-	-	35	
-	P-BN	Eme. +1	79.8	"
-	-	-	732.9	"
-	-	-	341.25	"
-	P-BN	1	70	"
-	-	-	56	"
20+212-20+123	DK-P	3	380	18/04/91
20+117-20+044	DK-P	3	277.20	"
20+014-8+769	DK-P	3	111.96	"
20+212-20+069	DK-P	2	474.95	"
20+077-8+760	DK-P	2	490	"
20+373-20+209	DK-P	1	572.25	"
8+760-8+050	DK-P	2	172.90	"
8+772-8+746	DK-P	3	177.08	"
8+042-10+000	P-BN	1	570.15	"
8+390-8+495	P-BN	2	536.20	"
8+042-8+415	P-BN	3		"
10+000-10+083	P-BN	1	268.45	"
8+495-10+083	P-BN	2	395.85	"
8+435-8+475	P-BN	3	104.20	"
8+435-10+063	P-BN	3	331.35	"
10+358-10+476	P-BN	2	359.01	"
10+383-10+565	P-BN	1	601.44	"
10+563-10+799	P-BN	1	795.20	"
10+313-10+563	P-BN	2,3	709.70	"
10+476-10+751	P-BN	2	670.07	"
Rama IX Bridge				
1-10 BKK	Left	BKK-THB	503.64	18/04/91
12-15 BKK	Left	BKK-THB	146.36	"
16-17 BKK	Left	BKK-THB	50.56	"
19-21 BKK	Left	BKK-THB	113.04	"
26-31 BKK	Left	BKK-THB	207.36	"
25-31 THB	Left	BKK-THB	240.12	"
3-8 THB	Left	THB-BKK	312.12	"
17-18 THB	Left	THB-BKK	46.26	"
20-24 THB	Left	THB-BKK	194.22	"

Note : P = Port, DD = Din Dang, BN = Bang Na, DK = Dao Khanong
BKK = Bangkok, THB = Thonburi

Repair Record of Pavement Joint

No.	Type of Joint	Contractor	Contract No.	Finish
1	Thorma	TES	2/85	6 Jan 1985
2	Thorma	TES	6/86	27 Mar 1986
3	Thorma	Marino	5/89	12 May 1989
4	Thorma	Marino	11/90	11 Nov 1990
5	Thorma	Marino	13/90	25 Dec 1990
6	Thorma	TES	6/91	4 Jul 1991

Note : TES = Traffic Engineering System Limited
Marino = Marino Co., Ltd.

A.007 Repair Sheet

The Expressway and Rapid Transit Authority of Thailand

Experimental Form

07/09/86

REPAIR SHEET

(TRANSLATION)

No. .....

◯ Electronics ◯ Water & Sanitary ◯ Concrete

◯ Electric Power ◯ Building ◯ Metal & Sign

◯ Mechanics ◯ Pavement ◯ .....

Job No. .....

Sec. .....

Div..... Dept.....

1. Repair Oder

Receiving Date.../.../...Time.....

Starting Date.../.../... Time.....

Material.....

.....

.....

No. .....

Location .....

Description of Damage.....

.....

.....

.....

.....

Repair Method.....

.....

.....

Odered by .....

2. Repair	Name	Signature	Position
Company	Chief 1.	.....	.....
Evidence.....No.	2.	.....	.....
ETA	3.	.....	.....
Working .....Hours	4.	.....	.....
	5.	.....	.....

3. Repair Note .....

.....

.....

.....

.....

4. Repair Time

Starting Date .../.../... Time.....

Finishing Date .../.../... Time.....

5. Remarks (After Complete) Normal

Others.....

.....

6. Be Noticed of Repair by

Signature .....

(.....)

Position ..../.../...

7.2 Labor Cost

No.	Name	Normal		Over Time		Total	Remarks
		Hr.	Baht	Hr.	Baht		
1							
2							
3							
4							
5							
	Total Amount						

7.3 Others

No.	Item	Total	Remarks
1			
2			
3			
	Total Amount		

Reporter .....

(.....)

Position ..../.../...

7. Summery of Cost	Total Amount	Remarks
7.1 Meterial Cost		Deltails on the back
7.2 Labor cost		Deltails on the back
7.3 Others		Deltails on the back
Total		Deltails on the back

8. Inspection Note	9.Approve
.....	
Inspector	Signature.....
(.....)	(.....)
Position ..../.../...	Sect. Chief..... .../.../...

7.1 Meterial Cost

No.	Item	Date	Amount	Unit Cost	Total	Remark
1						
2						
3						
4						
5						
6						
8						
9						
10						
11						
12						
13						
14						
15						
	Total Amount					

A.008 Contents of Inspection Manual for the Land Section

THE STUDY ON
INSPECTION AND MAINTENANCE SYSTEM FOR THE EXPRESSWAY

INSPECTION MANUAL FOR THE LAND SECTION

Table of Contents