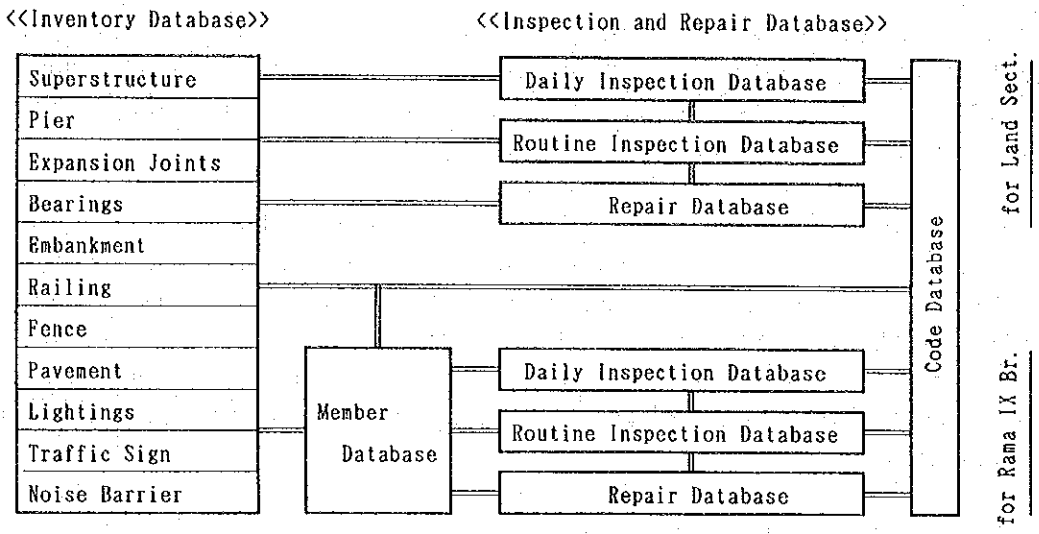

Figure-4.2.4 Database Framework

The road inventory database is composed of the following 11 database files:

- superstructure
  (superstructure, guard walls, drainage and handrails),
- piers,
- expansion joints,
- bearings,
- embankments (embankments, retaining walls),
- railing,
- fences,
- pavement (pavement and lane markings),
- lighting,
- traffic signs, and
- noise barriers.

A member database for the Rama IX Bridge Section is formulated these section's members and their locations defined using unit numbers to facilitate bridge inspection and repair work.

A daily inspection database is formulated to handle information obtained by daily inspection. In consideration of ETA's maintenance system, this information is separated into database files for a land section and a section for the Rama IX Bridge.

The same approach is taken for the routine inspection and repair databases.

The code database compiles code and its associated characters both in English and Thai, and can be accessed from all the database files in changing numerical code to characters for outputting.

Data items are explained in detail for each of the 19 database files in Chapter 5, and the number of items and their size summarized in Table-4.2.1.

Table-4.2.1 Number of Data Items of Database Files

Database Files	Key Identif'r	Attributive Data	Control Data	Total Items	Length (bytes)
<Inventory>					
Superstructures	7	16	3	26	137
Piers	6	8	3	17	96
Expansion Joints	4	7	3	14	79
Bearings	6	6	3	15	71
Embankments	5	19	3	27	129
Railing	6	6	3	15	90
Fence	6	7	3	16	91
Pavement	5	40	3	48	218
Lighting	6	10	3	19	118
Traffic Signs	6	19	3	28	172
Noise Barrier	6	7	3	16	91
<Daily Inspection>					
Land Section	5	18	5	28	165
Rama IX Bridge	4	16	5	25	155
<Routine Inspection>					
Land Section	13	17	4	34	175
Rama IX Bridge	5	21	4	30	136
<Repair>					
Land Section	17	16	7	40	311
Rama IX Bridge	7	16	7	30	246
<Member>	3	1	4	8	24
<Code>	1	3	2	6	70

3) Numbering System

a) Units for Identification

In order to specify and manage each road structure and facility, it is necessary to subdivide road structures and facilities by unique code (number). The subdivision is done so corresponding information is stored in the database for each structure or facility, and the units for maintenance work for the structures and facilities are as follows:

- by span : superstructure,
  pavement on the viaduct,
  guard wall on the viaduct,
  railing and fence on the viaduct,
  drainage on the viaduct,
  noise barrier on the viaduct,

- by installed line : pier,
  expansion joints,
  bearings,

- by one facility with unique number:
  pier in case of being unique number,
  lightings,
  traffic sign,

- by constant distance in chainage:
  embankment,
  pavement on the embankment,
  retaining wall,
  guard wall on the embankment,
  railing and fence on the embankment,
  drainage on the embankment,
  noise barrier on the embankment.

b) Key Identifiers

Inventory Database

Database files are similar to a table that consists of columns and rows. Columns are called a field, which corresponds to data items, and rows are called a record, which corresponds to a collection of data belonging to a common key identifier, such

as one bridge span in a superstructure database. A record is distinguished by key identifiers that specify a given data record from other records in a database file. The whole database for maintenance work possesses several items with key identifiers at the head of each record. Consequently, every record has particular key identifiers to access and extract data from a database.

Key identifiers for the inventory database are defined as indispensable items and supplemental items to identify an object and its location on the expressway. They are composed of seven (7) items and their combinations are as follows:

- route,
- direction of traffic,
- main road or ramp,
- chainage at the start and end of a section,
- pier number (or contract number):
  to identify the location of a designated pier directly,
- pole number:
  to identify the location of a designated pole directly for lighting and traffic signs,
- location code:
  to identify a location at a crossing, such as the left or right.

Items of the key identifiers for the eleven inventory database files are different from each other. The key identifiers of the inventory database files are summarized in Table-4.2.2.

Table-4.2.2 Key Identifiers of Road Inventory Database

	Route	Direction of Traffic	Main Road /Ramp	Chainage (Start)	Chainage (End)	Pier Number (Start)	Pier Number (End)	Contract Number	Pole Number	Location Code 1	Location Code 2
Superstructure	◎	◎	◎	◎	◎	○	○				
Pier	◎	◎	◎	◎		○		○			
Expansion Joints	◎	◎	◎	◎							
Bearings	◎	◎	◎	◎						◎	
Embankment	◎	◎	◎	◎	◎						
Railing	◎	◎	◎	◎	◎						◎
Fence	◎	◎	◎	◎	◎						◎
Pavement	◎	◎	◎	◎	◎						
Lightings	○	○	○	○					◎		○
Traffic Sign	○	○	○	○					◎		○
Noise Barrier	◎	◎	◎	◎	◎						◎

Note ◎: Indispensable items to identify the object.
○: Supplemental items to identify the location of the object.
Location Code 1: To identify the location along roadway.
Location Code 2: To identify the location crossing roadway.

Daily Inspection Database for Land Section

Key identifiers of the daily inspection database for the land section are set up to identify the date, location and damaged member in the database as follows:

- inspected date,
- damaged member in form of a member code,
- route,
- direction of traffic,
- main road/ramp,
- chainage, chainage at end point of the road segment if necessary,
- location code (2),
- lane number for pavement only, and
- pole number for lighting and traffic signs.

Daily Inspection Database for Rama IX Bridge

Key identifiers of the daily inspection database for the Rama IX Bridge are simpler than those of the land section and identify date, location, and damaged member in the database as follows:

- inspected date,
- damaged member in form of a member code,
- unit number which identify the detailed location on the bridge, and
- lane number which is a special item to identify the location of pavement on the bridge.

Routine Inspection Database for Land Section

Key identifiers for the routine inspection database for the land section require a number of items to identify the data record in the routine inspection database in addition to that of the inventory database. Additional items for inspection data are:

- member code:
  to identify inspected member in the inspection database in the form of a single database,

- inspection date:

Table-4.2.3 Key Identifiers of Inspection Database for Land Section

	Member Code	Inspected Date	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
Superstructure	◎	◎	◎	◎	◎	◎	◎	◎					
Pier	◎	◎	◎	◎	◎	◎	◎		○				
Retaining Wall	◎	◎	◎	◎	◎	◎	◎	◎					
Embankment	◎	◎	◎	◎	◎	◎	◎	◎					
Pavement	◎	◎	◎	◎	◎	◎	◎	◎				◎	
Guard Wall	◎	◎	◎	◎	◎	◎	◎	◎			◎		
Drainage	◎	◎	◎	◎	◎	◎	◎	◎					
EX. Joints	◎	◎	◎	◎	◎	◎	◎						
Bearings	◎	◎	◎	◎	◎	◎	◎			◎			
Lightings	◎	◎	◎	○	○	○	○				○		◎
Traffic Sign	◎	◎	◎	○	○	○	○				○		◎
Handrail	routine inspection is not performed												
Guard Rail													
Fence													
Noise Barrier	◎	◎	◎	◎	◎	◎	◎	◎			◎		

Note ◎: Indispensable items to identify the object.
○: Supplemental items to identify the location of the object.
Location Code 1: To identify the location along roadway.
Location Code 2: To identify the location crossing roadway.

to identify the inspection date since inspection data are stored over time,

- work class:
  to identify the inspection work class, since all damage data are stored in terms of routine, special and emergency inspections,

- location code for roadway direction:
  to identify in detail by object's location such as two bearing lines on a pier top,

- lane number:
  to identify inspected results on pavement, since inspection on pavement is carried out and stored by lane.

The items of the key identifiers for the routine inspection database are different from other objective members. The key identifiers of the inspection database by inspected member are summarized in Table-4.2.3.

Routine Inspection Database for Rama IX Bridge

Key identifiers for the routine inspection database for the Rama IX Bridge are simpler than those of the land section, since each segment of the bridge member has an unique unit number by location, such as the lot number for the main girder. Based on this, some additional unit numbers are necessary to review and confirm the identification of all members in addition to existing unit numbers. New unit numbers, including the existing unit numbers, are suggested to identify the following location:

- main girder : lot number of girder,
- stay cable : cable number,
- pylon : lot number of pylon,
- pavement : lot number of girder and lane number,
- pier : pier number,
- guard barrier : lot number of girder and left/right number,
- handrail : ditto.,
- drainage : ditto.,
- pendel bearing : pier number and left/right number,
- neo-pot bearing : unique number by location,
- wind bearing : ditto.,

Table-4.2.4 Key Identifiers of Inspection Database for Rama IX Bridge

	Member Code	Inspected Date	Work Class	Unit Number	Lane Number
Main Girder	◎	◎	◎	◎	
Stay Cable	◎	◎	◎	◎	
Pylon	◎	◎	◎	◎	
Pavement	◎	◎	◎	◎	◎
Pier	◎	◎	◎	◎	
Guard Barrier	◎	◎	◎	◎	
Hand Rail	routine inspection is not performed				
Drainage	◎	◎	◎	◎	
Pendel Bearing	◎	◎	◎	◎	
Neo-Pot Bearing	◎	◎	◎	◎	
Wind Bearing	◎	◎	◎	◎	
Ex. Joints	◎	◎	◎	◎	
Pylon Damper	◎	◎	◎	◎	
Girder Damper	◎	◎	◎	◎	
Girder Gantry	◎	◎	◎	◎	
Pylon Lift	◎	◎	◎	◎	
Pylon Ladder	◎	◎	◎	◎	
Pylon Gondola	◎	◎	◎	◎	
Cable Gondola	◎	◎	◎	◎	
Lightings	◎	◎	◎	◎	
Traffic Sign	routine inspection is not performed				

Note ◎: Indispensable items to identify the object and its locaion in the Rama IX Bridge.

- expansion joints: ditto.,
- pylon damper : pier number,
- girder damper : unique number by location,
- girder gantry : ditto.,
- pylon lift : ditto.,
- pylon ladder : ditto.,
- pylon gondola : ditto.,
- cable gondola : ditto.,
- lighting : ditto.,
- traffic sign : ditto.,

The above unit numbers are presented as basic key identifiers in the bridge inspection manual. Items of the key identifiers for routine inspection database for the Rama IX Bridge are different from each other. Key identifiers by inspected member are summarized in Table-4.2.4.

Repair Database for Land Section

Key identifiers of the repair database for the land section are formulated in the same manner as that of the routine inspection database as shown in Table-4.2.5.

Repair Database for Rama IX Bridge

Key identifiers of the repair database for the Rama IX Bridge are simpler than those of the land section to identify, location and repaired member in the database as shown in Table-4.2.6.

Table-4.2.5 Key Identifiers of Repair Database for Land Section

		Inspection Data		Repair Data		Location Data									
	Member Code	Inspected Date	Work Class	Repaired Date	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
Superstructure	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎					
Pier	◎	◎	◎	◎	◎	◎	◎	◎	◎		○				
Retaining Wall	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎					
Embankment	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎					
Pavement	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎				◎	
Guard Wall	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎			◎		
Drainage	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎					
EX. Joints	◎	◎	◎	◎	◎	◎	◎	◎	◎						
Bearings	◎	◎	◎	◎	◎	◎	◎	◎	◎			◎			
Lightings	◎	◎	◎	◎	◎	○	○	○	○				○		◎
Traffic Sign	◎	◎	◎	◎	◎	○	○	○	○				○		◎
Handrail	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎			◎		
Guard Rail	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎			◎		
Fence	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎			◎		
Noise Barrier	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎			◎		

Note ◎: Indispensable items to identify the object.
○: Supplemental items to identify the location of the object.
Location Code 1: To identify the location along roadway.
Location Code 2: To identify the location crossing roadway.

Table-4.2.6 Key Identifiers of Repair Database for Rama IX Bridge

	Member Code	Inspection Data		Repair Data			
		Inspected Date	Work Class	Repaired Date	Work Class	Unit Number	Lane Number
Main Girder	◎	◎	◎	◎	◎	◎	
Stay Cable	◎	◎	◎	◎	◎	◎	
Pylon	◎	◎	◎	◎	◎	◎	
Pavement	◎	◎	◎	◎	◎	◎	◎
Pier	◎	◎	◎	◎	◎	◎	
Guard Barrier	◎	◎	◎	◎	◎	◎	
Hand Rail	◎	◎	◎	◎	◎	◎	
Drainage	◎	◎	◎	◎	◎	◎	
Pendel Bearing	◎	◎	◎	◎	◎	◎	
Neo-Pot Bearing	◎	◎	◎	◎	◎	◎	
Wind Bearing	◎	◎	◎	◎	◎	◎	
Ex. Joints	◎	◎	◎	◎	◎	◎	
Pylon Damper	◎	◎	◎	◎	◎	◎	
Girder Damper	◎	◎	◎	◎	◎	◎	
Girder Gantry	◎	◎	◎	◎	◎	◎	
Pylon Lift	◎	◎	◎	◎	◎	◎	
Pylon Ladder	◎	◎	◎	◎	◎	◎	
Pylon Gondola	◎	◎	◎	◎	◎	◎	
Cable Gondola	◎	◎	◎	◎	◎	◎	
Lightings	◎	◎	◎	◎	◎	◎	
Traffic Sign	◎	◎	◎	◎	◎	◎	

Note ◎: Indispensable items to identify the object and its locaion in the Rama IX Bridge.

4) Manuals for Inspection and Maintenance

a) Basic Concepts on Manuals

The manuals cover all items essential to maintenance work from fundamental concepts to execution methods. Also, the manuals are user-friendly for ETA staff so they can use it for daily maintenance work. All the manuals were prepared, in addition to the existing manuals in ETA, focusing on the up-grading of maintenance work using the developed system so that it is possible to:

- perform maintenance work effectively with appropriate procedures,
- use stored information effectively in the database,
- establish necessary reports with the system,
- evaluate the ranking or rating of the conditions of road structures and facilities,
- perform further inspection or investigation using suitable methods,
- assist in the selection of maintenance methods for damaged structures or facilities, etc.

b) Contents of Manuals

Outline of each manual is explained below.

Inspection Manual for Land Section

Chapter 1 (Introduction): provides comprehensive knowledge on the formulated inspection and maintenance system for the expressway, concerning such issues as work procedures and application of the database.

Chapter 2 (Inspection-General): provides basic and common information concerning all inspection work, such as categorization of inspection, personal and equipment for work, work safety, basic concepts on the ratings of observations, and reporting.

Chapter 3 (Daily Inspection): explains objects to be inspected and, methods and reporting for daily inspection.

Chapter 4 (Routine Inspection): explains the objects to be

inspected, inspection methods, and damage priorities for structures and facilities in detail, and reporting for routine inspection.

Chapter 5 (Special Inspection): explains the special inspection methods for concrete structures, pavement, expansion joints, etc.

Chapter 6 (Emergency Inspection) presents objectives and methods for emergency inspection necessary in case of serious natural disaster or accident on the expressway.

The appendices provide the coding sheets for inspection, which can be photocopied freely and used directly, report forms for system output, inventory forms to assist in inspection and code tables.

Inspection Manual for the Rama IX Bridge

The contents of this manual are slightly modified from those of the land section in view of the structural characteristics of the bridge.

Chapter 1 (Introduction): is similar to that of the land section.

Chapter 2 (General Description of the Bridge): explains design criteria, superstructure, substructure, attached facilities and equipment.

Chapter 3 (Inspection-General): is similar to that of the land section.

Chapter 4 (Daily Inspection): is similar to that of the land section.

Chapter 5 (Routine Inspection A): is similar to that of the land section, however describes the steel cable-stayed bridge and damage and deterioration to it.

Chapter 6 (Routine Inspection B): explains detail methods to maintain the bridge functioning, such as inclination of pylon, camber of girder, cable tension forces, etc.

Chapter 7 (Special Inspection) explains the special inspection and test methods for concrete structures and pavement, etc..

Chapter 8 (Emergency Inspection) presents objectives and methods for emergency inspection necessary in case of serious natural disaster or accident on the expressway.

The appendices provide coding sheets for inspection which can be photocopied freely and used directly, report forms for system output, and initial measuring results for special inspection.

Maintenance and Repair Manual

This manual explains the methods and procedures for comprehensive maintenance work, including cleaning and repairs common throughout the whole expressway. The contents of this manual are explained below:

Chapter 1 (Introduction): is similar to that of the inspection manual.

Chapter 2 (Repair and Maintenance-General): provides a general description on objectives of maintenance, categorization of maintenance work, work planning, labor and equipment, work safety and reporting.

Chapter 3 (Ordinary Maintenance Operations): provides information on the methods and procedures for cleaning and painting of road structures and facilities.

Chapter 4 (Specialized Maintenance Operations): provides an explanation on repair methods for concrete structures, steel structures, expansion joints and pavement, due to unexpected damage or deterioration, and explains some reinforcing methods for concrete structures.

The appendices provide repair coding sheets for the land section and the Rama IX Bridge, which can be photocopied freely and used directly, and repair report forms as output for the system.

Table of contents of above three manuals and 'Database System Users Manual' are attached in Appendix-A.008 to A.011.

4.3 Inspection Concepts

4.3.1 Category of Inspection Work

1) Categorization of Inspection

Inspection work is categorized into the following four types in terms of purpose, frequency, major objects and method. They are classified and presented in Table-4.3.1, and are explained as below.

- Daily Inspection
  Daily visual inspection of damage and/or deterioration to road structures, facilities and traffic conditions, from a running car on the expressway.

- Routine Inspection

  Routine inspection is classified into following two types according to its purpose and object.

  Routine Inspection A:
  Periodic inspection on foot of the damage and deterioration to road structures and facilities, using equipment at close range.

  Routine Inspection B:
  Periodic measurement on the comprehensive bridge behavior of the Rama IX Bridge to confirm the condition as designed and/or to discover unexpected behaviors of the bridge.

- Special Inspection
  Investigation of road structures using more detailed methods to supplement the periodical inspection whenever necessary.

- Emergency Inspection
  Temporary inspection of road structures and facilities due to unexpected occurrences, such as accidents or natural disasters.

Table-4.3.1 Classification of Inspection

Inspection	Major Object	Purpose	Frequency	Methods
Daily	Structures & facilities on road	Confirmation of safety, damage finding	Daily	On road, on running car
Routine A	Structures & facilities under road & bridge	Damage finding	Periodic	On/under road and viaducts
Routine B	Rama IX Br. structures	Confirmation as designed, damage finding	Periodic	Detailed measurement
Special	Structures	Detailed investigation, monitoring	as necce-sitated	Detailed inspection
Emergency	Structures & facilities	Damage finding, confirmation of safety	Accident, disaster	On/under road and viaducts

2) Frequency of Inspection

The frequencies of the above inspection work types depends on the purposes and methods of the inspections and are as follows:

- Daily Inspection
  This inspection is performed daily over the whole length of the expressway in order to grasp both damage/deterioration and daily traffic conditions on the expressway.

- Routine Inspection
  This inspection is performed at regular intervals that are determined based on the importance of the inspected members. Routine inspection for major structural members such as the superstructure, pavement, piers, and expansion joints is performed once a year at least.

- Special Inspection
  This inspection is performed anytime the need arises.

- Emergency Inspection
  This inspection is carried out whenever there is any damage or deterioration caused by an accident or natural disaster.

3) Objective Members by Inspection

The inspection frequencies for every structure and facility are presented in detail in Table-4.3.2 for the Land Section and Table-4.3.3 for the Rama IX Bridge Section.

4.3.2 Damage Categorization

1) Basic Concepts for Damage Ratings

In order to judge the necessity of repair work, observations of damage or deterioration are categorized into four ranks according to the following guidelines.

Rating A
Urgent repairs are necessary to secure the safety of vehicular traffic or to avoid the inconveniencing or injuring of third parties, due to outstanding damage or deterioration or possible damage which may cause in the near future.

Rating B
Repairs are required due to the existence of serious damage or deterioration which effects on the function or durability of the structure.

Rating C
Damage or deterioration is small and no repairs are necessary. However, further study such as monitoring or observation may be necessary.

Rating D
Virtually no repairs and no further study are required due to the existence or non existence of slight damage or deterioration.

The nature of damage and deterioration of functions differs greatly among road structures and facilities, and personal judgment on damage varies from inspector to inspector. Consequently, the definition of ratings for observations is very

Table-4.3.2 Objective Structures and Facilities by Inspection Category for Land Section

Member	Inspection Category		Remarks
Obstacles on Road	D		No inventory defined
Superstructures		R	
Guard Walls	D	R	At viaducts and embank.
Handrails	D		do.
Drainage	D	R	do.
Piers		R	
Expansion Joints	D	R	
Bearings		R	
Embankments	D	R	
Retaining Walls		R	
Railing	D		
Fences	D		
Pavement	D	R	PSI survey every 2 years
Lighting	D	R	
Traffic Signs	D	R	
Noise Barriers	D	R	

Note: D is daily inspection members.
R is routine inspection members.

Table-4.3.3 Objective Structures and Facilities by Inspection Category for Rama IX Bridge Section

Member	Inspection Category		Remarks
Obstacles on Road	D		No inventory defined
Main Girders		RA, RB	
Stay Cables		RA, RB	
Pylons		RA, RB	
Pavement	D	RA	
Piers		RA, RB	
Guard Barriers	D	RA	
Handrails	D		
Drainage	D	RA	
Pendel Bearings		RA	
Neo-Pot Bearings		RA	
Wind Bearings		RA	
Expansion Joints	D	RA	
Pylon Dampers		RA	
Girder Dampers		RA	
Cable Dampers		RA	
Girder Gantries		RA	
Pylon Lifts		RA	
Pylon Ladders		RA	
Pylon Gondolas		RA	
Cable Gondolas		RA	
Lighting	D	RA	
Traffic Signs	D		

Note: D is daily inspection members.
RA is routine inspection (A) members.
RB is routine inspection (B) members.

important to manage and maintain adequately road structures and facilities.

In the case of Rating A, urgent repair or restoration of a damaged road structure or facility is required as soon as possible to avoid hazard to traffic or third parties.

In case of Rating B, repairs are necessary but not urgent. Implementation of repairs depends on many factors, such as the location of damage, the progress of the damage, and whether the damaged member is a primary or secondary member. Further special inspection is necessary in some cases to clarify causes and its effects of the damage.

In case of Rating C, continuous inspections may be necessary by means of daily or routine inspection work.

2) Damage Countermeasures

Damage or deterioration countermeasures for road structures and facilities is categorized in terms of importance and urgency of a need of remedial measures for damaged member as shown below.

a) Emergency Measures

In order to secure vehicles and third persons from the more serious damage or accidents which may cause by an initial damage in case, emergency measures shall be performed immediately in site. Essential measures are, in general, removal of damaged members, spacing of corns, and torches or lights mark barricading and channelization at night, etc.

b) Repair Work

- Urgent repair:
  Immediate remedial work is needed to restore damaged component to a condition for which only routine maintenance is necessary. Work should be scheduled for completion at an early date to prevent further damage to the component or need for complete reconstruction at a later time.

- Special repair:
  Due to the unexpected damage or deterioration by the results of inspection, special remedial work is necessary requiring

special skills, equipment, or materials to restore the functions of a damaged component.

c) Routine Maintenance

- Routine repair:
  Some roadway components such as steel members and pavement, which are deteriorated by vehicular traffic loads, acid gas in the air or ultraviolet rays, require restoration to their initial condition, by means of painting for steel members, overlay or reconstruction works for pavement.

- Cleaning:
  Some parts of the roadway are apt to accumulate debris or dust from rain water, such as the pavement surface, and drainage and bearing beds on piers, and it is necessary to remove and clean them periodically.

d) Special Inspection

- Reinspection:
  Reinspection work is necessary to supplement and perform further study on such things as repair design for damaged structures, which are identified as being defective or in a state of deterioration by routine inspection.

- Special inspection:
  Some major members of structures found damaged or in a state of deterioration by routine inspection, and requiring investigation with methods more detailed than those of routine inspection.

4.3.3 Damage to be Inspected

1) Land Section

Damage and deterioration to road structures and facilities have been classified in many ways by both engineers and scholars involved in structural and maintenance engineering. However, damage or deterioration is basically defined by the materials used and by the structural nature of a road structure or facility.

The inspection system is formulated so as to be user-freiendly in both its theoretical and operational aspects. The types of damage and deterioration as well as obstacles to road traffic that can occur on the above-mentioned 15 road structures and facilities, are determined through a detailed review of maintenance standards in Japan and in other countries.

The types of damage are classified into the following 11 categories, taking into consideration the structural, material and damage characteristics of the above 15 objective members for inspection. The capitalized words are abbreviations used to output damage items on a computer display and in hard copy.

- Obstacles to Road Traffic
  - FALLEN LOADS : Obstacles to vehicular traffic due to fallen objects
  - DUST : Obstacles to vehicular traffic due to the accumulation of dust
  - OIL STAIN : Slippery road surface due to oil stains,
  - STANDING WATER: Obstacles to vehicular traffic due to standing water
  - CRASHED CAR : Obstacles to vehicular traffic due to crashed car
  - DISABLED CAR : Obstacles to vehicular traffic due to disabled car

- Damage to Concrete Members
  (superstructure, guard walls, piers, and retaining walls)
  - LEAKAGE : Water leakage and leaching of free lime
  - CRACKING : Cracking
  - SPALLING : Spalling and corrosion of reinforcing bars
  - CAVITIES : Cavities
  - DISPLACEMENT : Displacement or settlement

- Damage to Expansion Joints
  - DAMAGE-JOINT : Damage to joint elements
  - DAMAGE-PLUG : Damage to plugging and faulting
  - LEAKAGE : Water leakage due to damage or deterioration
  - NOISE : Unusual noise due to damage or unevenness

- Damage to Bearings
  - DAMAGE-BEARING: Damage to rubber or steel bearing elements
  - DAMAGE-BED : Damage to bearing beds
  - DAMAGE-BOLTS : Damage to anchor bolts

DEBRIS : Accumulation of debris around bearings

- Damage to Embankments
  EROSION : Erosion or heaving at bank shoulders
  SUBSIDENCE : Subsidence of bank shoulders
  DAMAGE-MASONRY: Damage to masonry walls
  DISPLACEMENT : Displacement or settlement of masonry walls

- Damage to Drainage
  DAMAGE-INLET : Damage to drain inlets
  DAMAGE-PIPE : Damage to pipes, ditches or connections
  DEBRIS : Accumulation or clogging of debris
  DEFECT-DISCH. : Defects in drain discharge

- Damage to Metal Facilities
  (concerns guardrails, handrails and fences)
  CORROS-COLUMN : Damage to paint and corrosion of support columns
  DEFORM-COLUMN : Deformation of support columns
  DISP.-COLUMN : Displacement or loosening/falling out of bolts of support columns
  CORROS-PANEL : Damage to paint and corrosion of panels or fences
  DEFORM-PANEL : Deformation of panels
  DISP.-PANEL : Displacement or loosening/falling out of bolts

- Damage to Pavement
  CRACKING : Cracking to pavement
  DEFORMATION : Deformation of pavement, rutting, corrugation, depression and faulting
  DISRUPTION : Disruption of pavement, pot holes, exfoliation
  ABRASION : Abrasion of pavement, scaling
  DAMAGE-MARK : Wearing away of lane marking paint

- Damage to Lighting
  CORROS-POLE : Damage to paint and corrosion of poles
  DEFORM-POLE : Deformation of poles
  DISP-POLE : Displacement or loosening/falling out of bolts of poles
  LAMP BREAK : Burning out/decline in luminosity of lamps
  DAMAGE-REFRECT: Damage to reflectors

- Damage to Traffic Signs
  CORROS-POLE : Damage to paint and corrosion of poles
  DEFORM-POLE : Deformation of pole
  DISP-POLE : Displacement or loosening/falling out of bolts
  VISUAL DEFECT : Deterioration in visibility of signboards
  DAMAGE-PANEL : Damage to panels/attachments of signboards
  LAMP BREAK : Burning out/decline in luminosity of lamps
  DAMAGE-REFRECT: Damage to reflector

- Damage to Noise Barriers
  CORROS-COLUMN : Damage to paint and corrosion of support columns
  DEFORM-COLUMN : Deformation of support columns
  DISP-COLUMN : Displacement or loosening/falling out of bolts
  DAMAGE-PANEL : Damage to barrier panels
  DAMAGE-BOLTS : Loosening or falling out of bolts
  CORROS-PANEL : Damage to paint and corrosion

Figure-4.3.1 shows the relationship between objective member and its damage items for the Land Section.

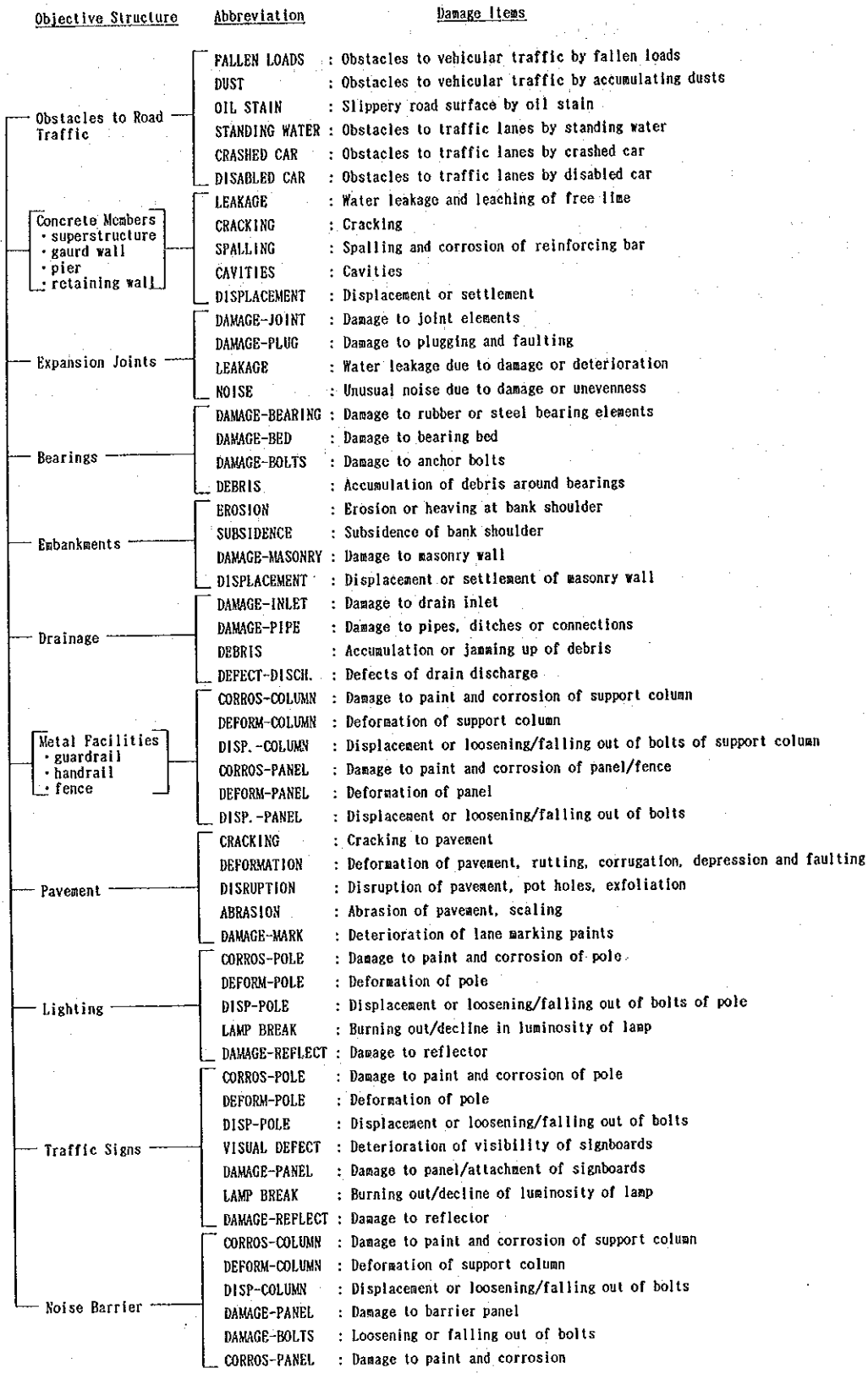

Figure-4.3.1 Objective Members and Damage Items for Land Section

2) Rama IX Bridge Section

The types of damage and deterioration as well as obstacles to road traffic that can occur on the above-mentioned 14 road structures and facilities, are determined through a detailed review of maintenance standards in Japan and in other countries.

These types of damage are classified into the following 11 categories, taking into consideration the structural, material and damage characteristics of the above 14 objective members for inspection. The capitalized words are abbreviations used to output damage items on a computer display and in hard copy.

- Obstacles to Road Traffic
  - FALLEN LOADS : Obstacles to vehicular traffic due to fallen loads
  - DUST : Obstacles to vehicular traffic due to accumulation of dust
  - OIL STAIN : Slippery road surface due to oil stains
  - STANDING WATER: Obstacles to vehicular traffic due to standing water
  - CRASHED CAR : Obstacles to vehicular traffic due to a crashed car
  - DISABLED CAR : Obstacles to vehicular traffic due to a disabled car

- Damage to Steel Plates and Frame
  (main girders, pylons, railing and maintenance facilities)
  - DEFORMATION : Deformation of plates or frame
  - CRACKING : Cracking of plates or frame
  - DAMAGE-BOLTS : Loosening or falling out of bolts
  - DAMAGE-CORROS.: Damage to paint and corrosion
  - DEBRIS/WATER : Accumulation of debris or water
  - DISPLACEMENT : Displacement or settlement

- Damage to Stay Cable
  - CRACK-CABLE : Cracking or corrosion of cable
  - SAG DISPLACE. : Unusual displacement of sag
  - VIBRATION : Unusual vibration of cable
  - CRACK-COVER : Cracking of cable cover
  - DAMAGE-BOLTS : Loosening or falling out of bolts of cover
  - SOCKET SLIP. : Socket slippage of cable anchorage
  - OIL LEAKAGE : Oil leakage from cable anchorage

PAINT-ANCHOR : Damage to paint of cable anchorage

- Damage to Pavement
  CRACKING : Cracking of pavement
  DEFORMATION : Deformation of pavement, rutting, corrugation, depression and faulting
  DISRUPTION : Disruption of pavement, pot holes, exfoliation
  ABRASION : Abrasion of pavement, scaling
  DAMAGE-MARK : Deterioration of lane marking paints

- Damage to Concrete Members (piers)
  LEAKAGE : Water leakage and leaching of free lime
  CRACKING : Cracking
  SPALLING : Spalling and corrosion of reinforcing bar
  CAVITIES : Cavities
  DISPLACEMENT : Displacement or settlement

- Damage to Drainage
  DAMAGE-INLET : Damage to drain inlets
  DAMAGE-PIPE : Damage to pipes, ditches or connections
  DEBRIS : Accumulation or clogging of debris
  DEFECT-DISCH. : Defects in drain discharge

- Damage to Bearings
  (concerns pendel, neo-pot and wind bearings)
  DAMAGE-PAINT : Damage to paint and corrosion
  CRACKING : Cracking or deformation
  DAMAGE-BOLTS : Damage to anchor bolts
  UNUSUAL MOVE. : Unusual movement
  ABRASION : Abrasion or deterioration of attached elements
  NOISE : Unusual noise

- Damage to Expansion Joints
  DAMAGE-PAINT : Damage to paint and corrosion
  ABRASION : Abrasion or deformation
  DAMAGE-BOLTS : Loosening or falling out of bolts
  UNUSUAL MOVE. : Unusual movement
  NOISE : Unusual noise due to damage or unevenness
  DAMAGE-DRAIN : Damage to drainage

- Damage to Dampers
  (concerns pylon, girder and cable damper)
  OIL LEAKAGE : Oil leakage due to damage or deterioration
  DAMAGE-BOLTS : Loosening or falling out of bolts
  DAMAGE-PAINT : Damage to paint and corrosion
  UNUSUAL MOVE. : Unusual movement

- Damage to Lighting
  CORROS-POLE : Damage to paint and corrosion of poles
  DEFORM-POLE : Deformation of poles
  DISP-POLE : Displacement or loosening/falling out of bolts of poles
  LAMP BREAK : Burning out/decline in luminosity of lamps
  DAMAGE-REFRECT: Damage to reflectors

- Damage to Traffic Sign
  CORROS-POLE : Damage to paint and corrosion of poles
  DEFORM-POLE : Deformation of poles
  DISP-POLE : Displacement or loosening/falling out of bolts
  VISUAL DEFECT : Decline in visibility of signboards
  DAMAGE-PANEL : Damage to panel/attachment of signboards
  LAMP BREAK : Burning out/decline in luminosity of lamp
  DAMAGE-REFRECT: Damage to reflectors

Figure-4.3.2 shows the relationship between objective member and its damage items for the Rama IX Bridge Section.

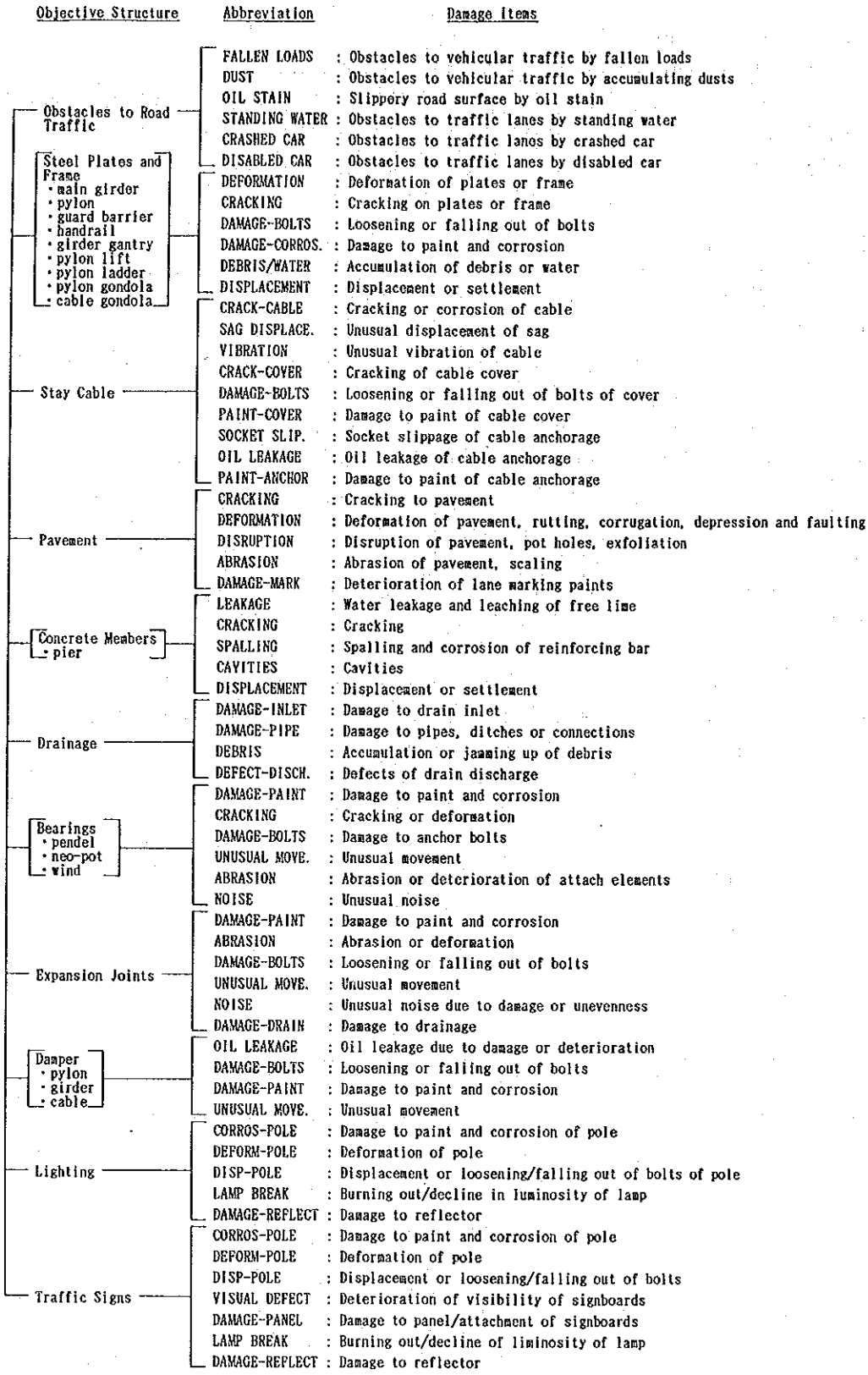

Figure-4.3.2 Objective Members and Damage Items for Rama IX Bridge Section

4.3.4 Inspection Work Procedures

1) General

In order to standardize and systematize maintenance information as well, it is necessary that inspection work procedures be standardized. This enables maintenance work in the field and information in the office to be linked, resulting in a smooth execution of maintenance work.

2) Daily Inspection

Actual work procedures for daily inspections are presented in Figure-4.3.3. Inspection work is performed in cooperation with other maintenance work, such as repairs. Details on daily inspection work items are explained below.

a) Annual Plan
In order to perform daily inspection work efficiently and to disperse work loads evenly throughout the year, engineers in charge of inspection shall first make an annual plan for daily inspections. The following two items shall be considered when planning:

- Selection of an appropriate season for each structure and facility to properly grasp their condition, such as the rainy season for drainage system inspection.

- Manpower and frequency of work.

b) Execution Plan
A monthly or weekly execution plan shall be made for manpower allocation and for organizing inspection teams and routes. In order to perform daily inspections efficiently, it is desirable to prioritize the members to be inspected.

c) Damage ?
Before starting inspection work, inspectors shall prepare coding sheets to record their observations of damage.

d) Emergency Measures Need ?
When an inspector discovers serious obstacles to road traffic due to damage to road structures or facilities, or to an accident on the roadway, the inspector shall determine wheth-

er or not emergency measures are necessary in order to ensure safety and to avoid further accidents or problems.

e) Emergency Measures
Inspectors shall convey information to a section in charge to secure traffic safety and to avoid further accidents with appropriate emergency measures.

f) Rating / Coding by Inspectors
When an inspector discovers damage, the inspector shall describe the condition of the damage and rate it according to the inspection manual. Inspectors shall also take photographs of any serious damage to show the engineers.

The initial coding of damage in the coding sheets shall be done by the inspector himself. A coding sheet is attached in the Appendix and can be photocopied freely and used directly.

g) Urgent Repair ?
Serious damage to major members that support vehicle loads directly, may require urgent remedial measures to secure the safety of vehicular traffic and to avoid the progress of damage. In this case, inspectors shall judge whether or not urgent repairs are necessary as quickly as possible for safety and cost-efficient reasons .

h) Further Inspection ?
When an inspector can not decide the damage rating and/or cause of damage by visual inspection only, the inspector shall decide whether further inspections such as a special inspection, reinspection or monitoring are necessary.

i) Inspection Plan
When further inspections such as monitoring or detail inspection is necessary, an inspection plan shall be drawn up.

j) Special Inspection
Special inspections will be carried out considering inspection methods based on the characteristics of a structure and its damage.

k) Repair Need ?
The final decision for countermeasures for damage members

shall be made by inspectors and maintenance engineers.

l) Input into Database
Coded results on the above issues shall be inputted into the daily inspection database file by an operator in daily basis.

m) Output from Database
The daily inspection report form, which is outputted from database system, shall be in the form of an official report. In addition, shall be made immediately after checks for input errors. When photographs are necessary to supplement the explanation on damage, photographs be attached to the daily inspection report form.

n) Daily Inspection Report
Daily inspection reports shall be kept on file, and referred to or photocopied for any official reason.

o) Repair Plan
A repair plan shall be formulated by maintenance engineers concerning the repair methods and design, the date of completion, persons in charge, and the budget allocation.

In the above work items g), h) and k), maintenance engineers judgment and/or approval is required as below.

- The results of an inspection shall be shown by the inspector himself to engineers back at the office, and the damage rating checked and basic countermeasures. The observation results and basic countermeasures shall be approved by a chief inspection engineer.

- When a decision can not be made by engineers due to lack of information, an engineer shall go to the relevant site and confirm the damage.

- A final decision on countermeasures for damaged members shall be made by maintenance engineers.

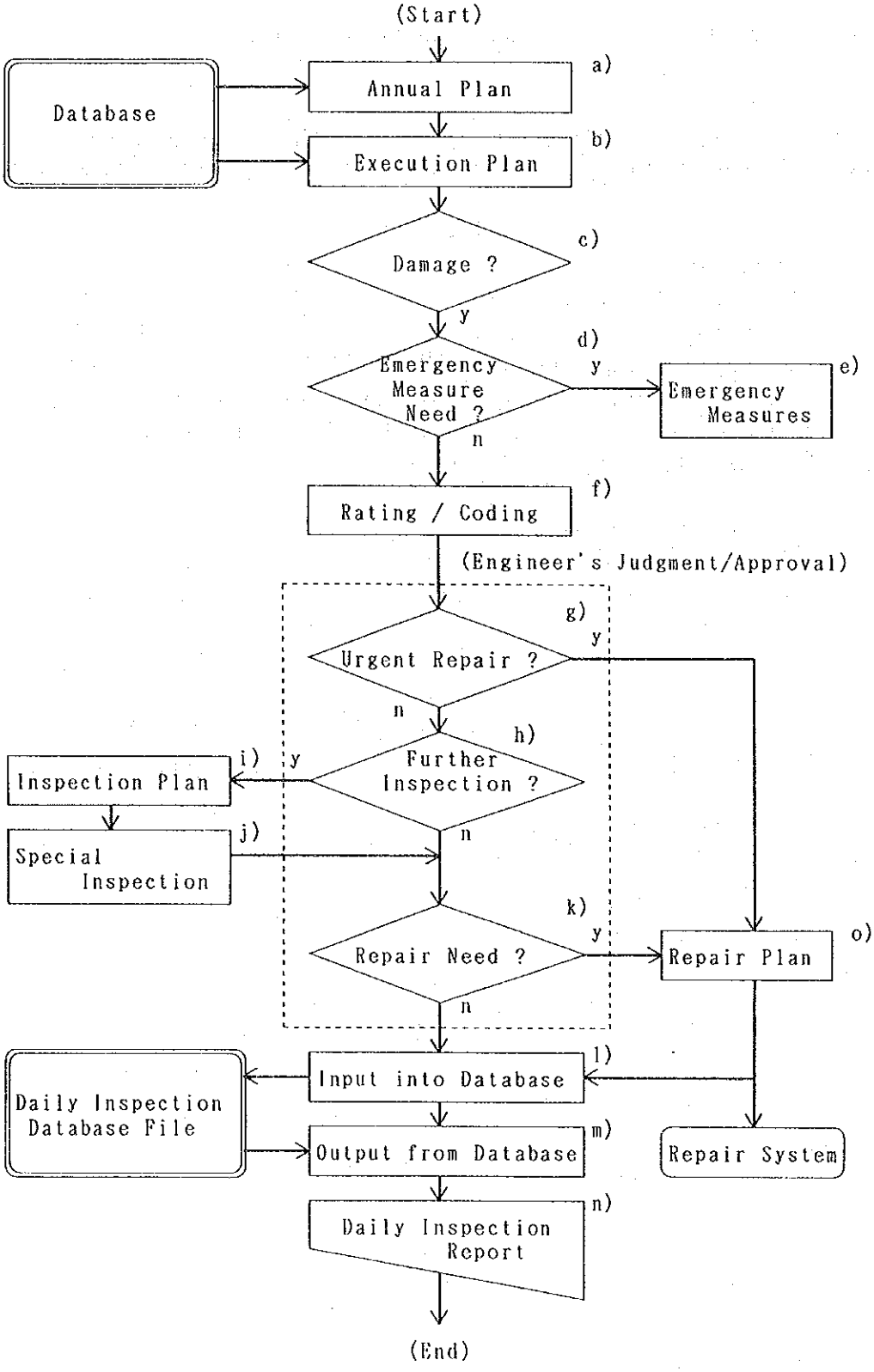

Figure-4.3.3 Daily Inspection Procedures

3) Routine Inspection

Actual routine inspection work procedures are shown in Figure-4.3.4. Inspection work shall be performed in cooperation with other maintenance work, such as repairs. Details of routine inspection work items are explained below.

a) Annual Plan
In order to perform routine inspection work efficiently and disperse work loads evenly throughout the year, engineers in charge of inspection shall first make an annual plan for routine inspections. The following four items shall be considered when planning:

- selection of an appropriate season for each structure and facility to properly grasp their condition, such as the rainy season for drainage system inspection,

- equal distribution of manpower throughout the year to execute work,

- arrangement of inspection equipment,

- drawing up a of time schedule to execute repairs based on inspected results.

b) Execution Plan
A monthly or weekly execution plan shall be made for manpower allocation, and for organizing inspection teams and routes. In order to perform routine inspection work efficiently, the following two items shall be considered:

- detailed allocation of manpower and inspection teams on a daily basis, and

- detailed allocation of equipment on a daily basis.

c) Damage ?
Before starting inspection work, inspectors shall prepare coding sheets to record their observations of damage.

Damage can be discovered by appropriate work execution, as well as by having a correct knowledge concerning damage and road structures.

When an inspector discovers damage to a road structure or facility, the inspector shall determine whether further measures are needed.

d) Rating / Coding by Inspectors
When an inspector discovers damage, the inspector shall describe the condition of the damage and rate it according to the inspection manual. Inspectors shall also take photographs of any serious damage to use in their report.

The initial coding of damage in the coding sheets shall be done by the inspector himself. A coding sheet is attached in the Appendix and can be photocopied freely and used directly.

e) Urgent Repair ?
Serious damage to major members that support vehicle loads directly, such as slabs, may require urgent remedial measures to secure the safety of vehicular traffic and to avoid the progress of damage. In this case, inspectors shall judge whether or not urgent repairs are necessary as quickly as possible for safety and cost-efficient reasons .

f) Further Inspection ?
When an inspector can not decide the damage rating and/or cause of damage by visual inspection only, the inspector shall decide whether further inspections such as a special inspection, reinspection or monitoring are necessary.

g) Inspection Plan
When further inspections is necessary, such as monitoring or a detailed inspection is necessary, inspection plans shall be drawn up.

h) Special Inspection
Special inspections will be carried out considering inspection methods based on the characteristics of a structure and its damage.

i) Repair Need ?
The final decision for countermeasures for damage members shall be made by inspectors and maintenance engineers.

j) Input into Database
Coded results of the above mentioned issues shall be inputted into the routine inspection database file by operators as soon as possible.

k) Output from Database
The routine inspection report form, which is outputted from the database system, shall be in the form of an official report. In addition, checks for input errors shall be made immediately after inputting. When photographs are necessary to supplement the explanation on damage, photographs can be attached to the routine inspection report form.

l) Routine Inspection Report
Routine inspection reports shall be kept on file, and referred to or photocopied to an any official reason.

m) Repair Plan
A repair plan shall be formulated by maintenance engineers concerning the repair methods and design, the date of completion, persons in charge, and the budget allocation.

In the above work items e), f) and i), maintenance engineers judgment and/or approval is required as below.

- The results of an inspection shall be shown by the inspector himself to engineers back at the office, and the damage rating checked and basic countermeasures. The observation results and basic countermeasures shall be approved by a chief inspection engineer.

- When a decision can not be made by engineers due to lack of information, an engineer shall go to the relevant site and confirm the damage.

- A final decision on countermeasures for damaged members shall be made by maintenance engineers.

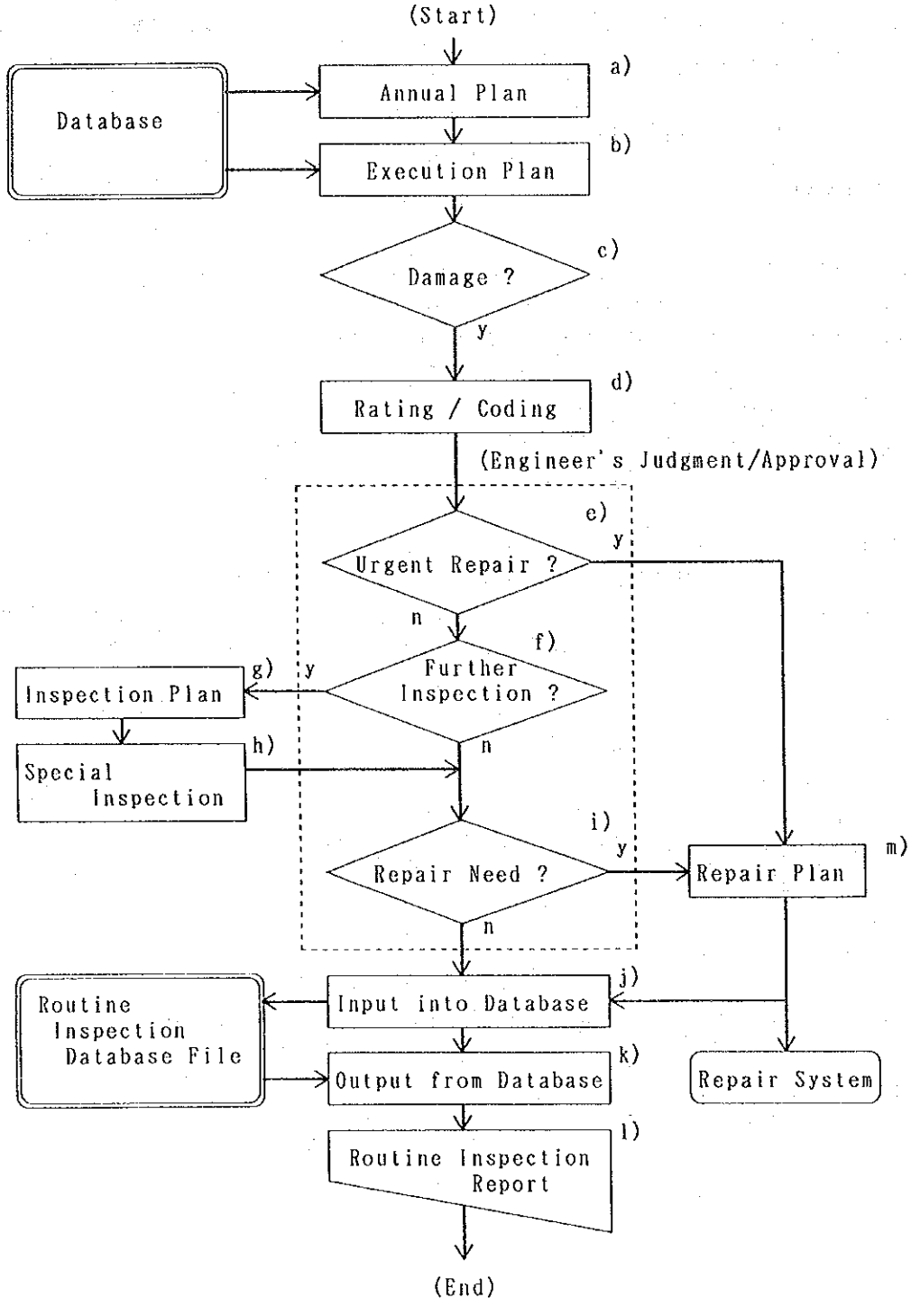

Figure-4.3.4 Routine Inspection Procedures

4) Emergency Inspection

Actual work procedures for emergency inspections are presented in Figure-4.3.5. Emergency inspection work is performed in case of natural disaster or accident related to expressway structures and/or facilities. Details on emergency inspection work items are explained below.

a) Damage ?
Before starting inspection work, inspectors shall prepare coding sheets to record their observations of damage.

b) Emergency Measures Need ?
When an inspector discovers serious obstacles to road traffic due to damage to road structures or facilities, or to an accident on the roadway, the inspector shall determine whether or not emergency measures are necessary in order to ensure safety and to avoid further accidents or problems.

c) Emergency Measures
Inspectors shall convey information to a section in charge to secure traffic safety and to avoid further accidents with appropriate emergency measures.

d) Rating / Coding by Inspectors
When an inspector discovers damage, the inspector shall describe the condition of the damage and rate it according to the inspection manual. Inspectors shall also take photographs of any serious damage to show the engineers.

The initial coding of damage in the coding sheets shall be done by the inspector himself. A coding sheet is attached in the Appendix and can be photocopied freely and used directly.

e) Urgent Repair ?
Serious damage to major members that support vehicle loads directly, may require urgent remedial measures to secure the safety of vehicular traffic and to avoid the progress of damage. In this case, inspectors shall judge whether or not urgent repairs are necessary as quickly as possible for safety and cost-efficient reasons .

f) Further Inspection ?
When an inspector can not decide the damage rating and/or cause of damage by visual inspection only, the inspector shall decide whether further inspections such as a special inspection, reinspection or monitoring are necessary.

g) Inspection Plan
When further inspections such as monitoring or detail inspection is necessary, an inspection plan shall be drawn up.

h) Special Inspection
Special inspections will be carried out considering inspection methods based on the characteristics of a structure and its damage.

i) Repair Need ?
The final decision for countermeasures for damage members shall be made by inspectors and maintenance engineers.

j) Input into Database
Coded results on the above issues shall be inputted into the inspection database file by an operator as soon as possible.

k) Output from Database
The emergency inspection report form, which is outputted from database system, shall be in the form of an official report. In addition, shall be made immediately after checks for input errors. When photographs are necessary to supplement the explanation on damage, photographs be attached to the inspection report form.

l) Emergency Inspection Report
Emergency inspection reports shall be kept on file, and referred to or photocopied for any official reason.

m) Repair Plan
A repair plan shall be formulated by maintenance engineers concerning the repair methods and design, the date of completion, persons in charge, and the budget allocation.

In the above work items e), f) and i), maintenance engineers judgment and/or approval is required as below.

- The results of an inspection shall be shown by the inspector

himself to engineers back at the office, and the damage rating checked and basic countermeasures.

- When a decision can not be made by engineers due to lack of information, an engineer shall go to the relevant site and confirm the damage.

- A final decision on countermeasures for damaged members shall be made by maintenance engineers.

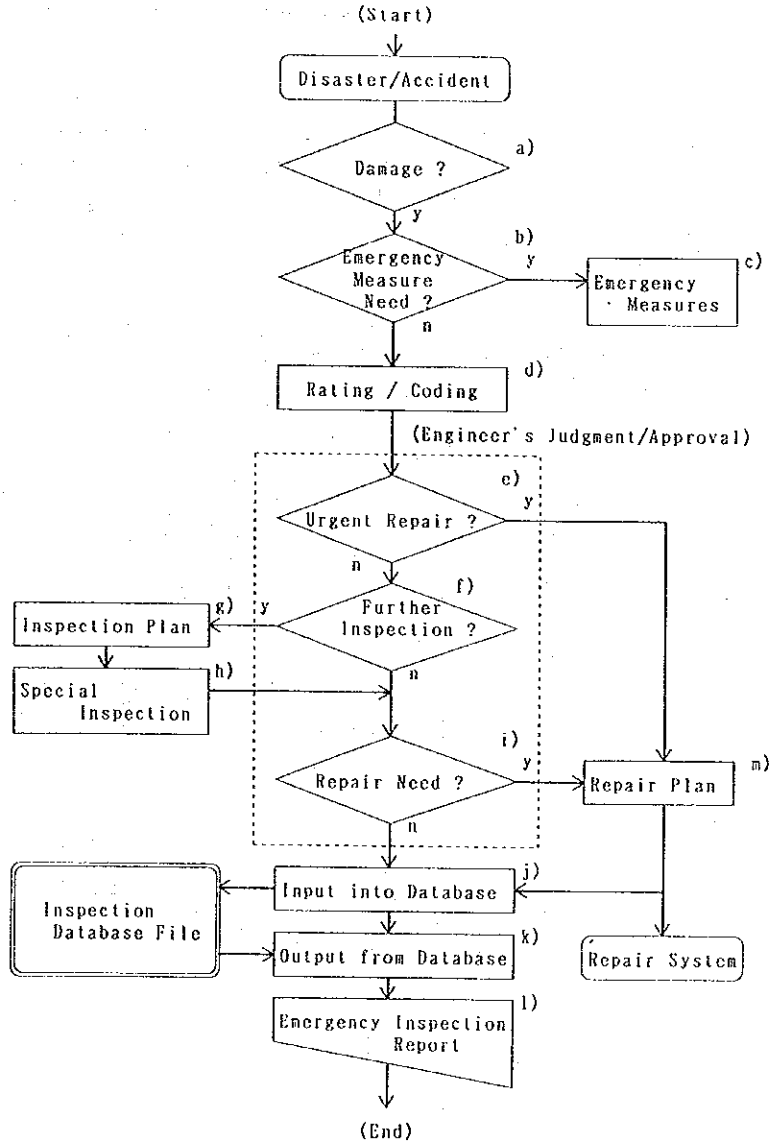

Figure-4.3.5 Emergency Inspection Procedures

4.3.5 Inspection Concepts

1) Land Section

a) General

The main purpose of inspection work is to identify damage and deterioration to structures before they proceed to a more serious stage. In other words, if quick and proper inspection work is followed by quick and proper repair and maintenance work, there will be a reduction in the total maintenance expenditures of the expressway.

Up until now, damage and deterioration that have been identified by inspection work have concerned mostly attached facilities and not main structures such as upper decks and columns.

b) Concrete Structures

Half joints that are made of concrete and located at the ends of girders and cantilever beams are rather vulnerable. However, there has hardly been any reported damage to half joints in the First Stage Expressway System (FES). In addition , although deck slabs are generally said to be damage prone to heavy traffic and overloading, there have been very few reports on deck slab damage in spite of the current heavy traffic.

As mentioned previously, expressway structures look rather sound in relation to external forces, but there has been some displacement due to the settlement of subsoil. Consequently, inspection and monitoring of displacement shall be one of the important inspection items to focus on in the future.

In the inspection system, a damage rating system to cover most of the structures is established to decide repair method systematically. The damage rating system plays an intermediary role between inspection and repair work.

c) Pavement

The need for pavement repairs has been determined based on the visual evaluation of expressway by road engineers. However, this sometimes lacks a quantitative basis. Hence, it is necessary to establish a quantitative method to evaluate the pave-

ment conditions of ETA's expressway.

In Japan, the quantitative evaluation of pavement damage has been carried out for a long time. Therefore, pavement inspection methods are drawn up in accordance with several Japanese pavement inspection manuals.

A comprehensive rating method, which is the Present Serviceability Index (P.S.I.), is introduced to evaluate condition of the pavement quantitatively. The PSI is based on measurements for cracking, rutting, patching, and longitudinal roughness. As longitudinal roughness is the dominant factor in estimating the P.S.I., a reliable method for measuring longitudinal roughness is very important. Therefore, a laser profilometer is applied.

d) Expansion Joints

Expansion joints are generally troublesome, since they are easily damaged by the direct and repeated vehicle axle loads they receive. Suitable expansion joints have proper clearance for freedom of movement and proper alignment, and provide a smooth ride for vehicles crossing the viaducts without receiving or causing undue impact and noise.

Visual inspections, as well as measurements of damage and defects, should be conducted. Areas above and beneath expansion joints, together with pavement adjacent to the joints, should be carefully inspected. In addition, the causes of unusual noises and vehicle riding shock/impact are to be visually checked. Cracking, tearing and settlement of the joints, and uneven surface elevation of plugs are also to be measured.

e) Embankments

Structures on embankments area, such as earth shoulders, masonry walls and pavement, are damaged mainly by differential settlement of the roadbed, which is supported by the Bangkok soft clay ground. Hence, daily inspection is very important, especially when there is heavy rainfall in the rainy season. Inspection should basically be visually performed in nature and on foot, with sketching and photographing.

f) Bearings

Bearings are designed to support the superstructure, and to carry all forces from it to the substructure. They provide for the free movement of the girders. Bearings should be cleared of debris and dust to prevent corrosive "freezing". The movement of the bridge is accommodated by sliding plates or elastomeric pads.

Inspection is carried out by approaching the bearings as close as possible, by means of a lift or scaffolding. Visual inspection and measurements on damage and defect should also be conducted.

g) Drainage

The pooling and overflowing of water can cause damage to the expressway structure and can cause serious traffic hazards. Clogged inlets and pipes are a major problem that results in the overflow of water on to the deck slab. Also, an improper drain outlet will result in the erosion of a fill and embankment or flooding of the roadway under the bridge.

Inspection of drainage facilities should be carried out during or immediately after rainfall to check the drainage system and drainage functions as well as to check for any damage.

h) Safety Barriers, Fences, and Noise Barriers

The physical condition of safety barriers, fences, and noise barriers as well as their ability to function as originally designed, should be inspected. Also, there should be checked deterioration and damage due to collisions.

i) Lighting and Traffic Signs

The physical condition of lighting and traffic signs, as well as their ability to function as originally designed, should be inspected. Steel supports are to be checked for deterioration and damage due to collisions. Failures with lighting should be given special attention to ensure traffic safety at night.

2) Rama IX Bridge Section

a) General

The Rama 9 Bridge, which is a large steel bridge on the ETA expressway system, has seven spans and crosses the Chaophraya River. The Bridge is a uniplanar fan-type cable-stayed bridge with steel decks and box girders.

In general, it always necessary to think about protecting steel bridge members from rust and corrosion. Also, consideration of maintenance measures for the steel deck and asphalt pavement are necessary, since they are always exposed to severe traffic loads. Therefore, special attention should be given to the steel decks, cross frames, welded sections, as well as to leakage due to damaged asphalt pavement.

When executing inspections, it is important to grasp the function of each member and to define the possible points of damage, in order to realize the most effective inspections possible.

Though there are four types of inspection work in terms of purpose, method and frequency, the surface of the Bridge and its upper deck are usually checked by daily inspection. The asphalt pavement, expansion joints, drainage system, pylons, and cables, on the other hand, require more detailed inspection. Other bridge members are checked via routine inspection.

b) Main Bridge Members

The Rama IX Bridge mainly consists of a main box girder, two pylons, and a number of stay cables.

Main Box Girder

The main box girder consists of an upper deck, lower deck, web plates, and cross frames in order to support the weight of the asphalt pavement and severe vehicle loads.

The great part of the loads are transmitted to the pylons through the cross frames and cables. Therefore, it is necessary to maintain the main girder at its original cross and longitudinal positions. The upper deck, cross frames, and anchoring

system of the main girder should especially checked.

The deck system of the bridge is a typical orthotropic steel deck with longitudinal ribs which are supported by lateral floor ribs. The fatigue strength of this type of steel deck is affected by the wheel load position, the longitudinal rib spacing and the deformation of the pavement. Longitudinal ribs, which are beard by lateral floor ribs in elastic, support directly the wheel loading on the steel deck. Priority locations in fatigue cracking on the upper deck are welded connections between deck plate and longitudinal ribs especially adjacent to floor ribs, where are affected with the lager stresses in alternating and secondary stresses. In this reason, due attention should be paid on fatigue cracking in inspection as described in the manual.

Pylons

Pylons consist of four main vertical plates, vertical stiffeners, horizontal diaphragms, anchor bolts for the pylon piers, and anchor frames for the stay cables.

The pylons support the great part of the dead weight and live load on the main girder through the multiple stay cables. These external forces act on the pylons as a normal compressive force and bending moment in a longitudinal direction. Therefore, it is necessary to check deformation of the main vertical plates, connecting anchor bolts at the base of the pylons, and anchor frames inside the pylons.

Stay Cables

A stay cable consists of locked coiled ropes and socket anchors at both ends of the ropes, and functions as a tensile member that transmits the great part of the loads on the main box girder to a pylon through the cable anchor system.

Therefore, it is necessary to check the stay cables and anchor systems especially for damage to corrosion, cracks, slippage of socket anchors, leakage of oil, and unusual cable sag.

c) Special Equipment for the Cable-Stayed Bridge

Dampers, bearings, and special expansion joints serve as special equipment for the Rama IX Bridge, and their functions are as below.

Dampers

Two types of eight pairs of tuned mass damper are installed symmetrically at the central portion of the main span of the Bridge. One of them is a "moment mood damper" to absorb the vertical vibration of the main girder. The other is a "twisting mood damper" to absorb the vibration from rotation due to uneven vehicle loads.

In addition, a tuned mass damper is installed at the top of pylons to absorb lateral vibration due to wind loads. This damper is a cylinder full of viscous fluid in which a plunger is attached to some members of the Bridge or pylon. It is very simple structure, but it needs to be checked for the falling out or loosening of connecting bolts, the breaking of springs, the lack of fluid, etc.

Finally, the last type of damper is an oil damper that is attached near the lower end of cables at the main girder to absorb unusual cable vibrations due to wind. The oil damper should also have to be checked its connecting bolts, paint, and seals checked for damage or deterioration.

Bearings

Pendel Bearings:
Pendel bearings are installed at each pylon pier to transmit vertical reaction, including uplift due to uneven vehicle loads. Checks should be made on damage to connecting bolts, deformation to vertical compression members, and abrasion to connecting pins and paint.

Neo-Pot Bearings:
A neo-pot bearing is installed in a longitudinal direction on the lower part of the pylon on the Thonburi side to resist the longitudinal movement of the main bridge due to vehicle loads, earthquakes, and temperature changes. Other neo-pot bearings are installed at the side in a transverse direction on the

lower portion of pylons on both the Bangkok and Thonburi sides. Finally, a neo-pot bearing is installed at the center of the lower deck at the junction piers to absorb horizontal lateral force due to wind loads. Checks should be made for damage to connection bolts, abrasion of parts, deterioration of rubber seals and unusual movements.

Expansion Joints

In the cable-stayed bridge, horizontal movement at the end of the Bridge is bigger than other bridges in general. Therefore, special expansion joints, which is a rolling-leaf type, is used to absorb this movement. Expansion joints consist of a rocker plate, sliding plates, tongue plate, supporting parts, and connecting pins and bolts. Since expansion joints are always exposed to severe vehicle loads, such damage as the deterioration or abrasion of parts and the loosening or falling out of connection bolts will occur.

d) Routine Inspection (B)

Since the completion of the Bridge, the superstructure and substructure have continuously endured dead weight and severe traffic loads, and stress and fatigue have accumulated in every member of the bridge, including the foundation strata, which may result in displacement occurring on the Bridge. In addition, the ground in Bangkok area tends to subside due to the pumping up of ground water and the consolidation of the clay layer.

Therefore, a routine inspection (B) is performed at regular interval to grasp the comprehensive behavior of the Rama IX Bridge in order to judge its soundness continuously. The objects and frequency of this inspection are recommended in once a every two years at least on the following items.

- Inclination of Pylons
- Camber of Main Girder
- Cable Tension Force
- Movement of Main Girder
- Displacement of Piers

4.3.6 Coding and Reporting

1) General

In order to support engineers via the coding of maintenance information in standardized work procedures, regular coding forms for daily and routine inspections are provided to maintenance engineers for each member and facility. Operators who are in charge of inputting coding data can easily input the contents of the forms into the database system.

The inspection reports for both the daily and routine inspections, which are outputted by the database system, are designed in such a way that they can be used as official reports by ETA.

2) Daily Inspection

a) Coding of Inspection Results

A daily inspection report is produced for both the Land Section and Rama IX Bridge Section by referring to a coding sheet, which contains the recorded observations on objectives. Together with the coding sheet, a summarized code table is also provided to inspectors to assist in the coding of inspection results from on site or from a car.

The way to use a coding sheet is as follows:

- use a new coding sheet when there is a change in date, route and main road/ramp,
- code observation results in the order of their discovery,
- refer to the code table with the designated code index (CI) for code numbers and their characters,
- when photographs are taken to record damage or an accident, write the photograph's number on the coding sheet, and
- operators are refer to coding sheets to input observation results into the database system.

Coding sheets for daily inspection are presented in Appendix-A.023 for the Land Section and Appendix-A.024 for the Rama IX Bridge Section.

b) Reporting and Report Form

After inputting observation results into the database system, a daily inspection report, which can serve as an official report, is outputted. All of the inputted items in the form of code number are converted into the Thai language.

Daily inspection reports are to be kept on file. When it is necessary to modify report contents, make corrections in red and carry out the appropriate alterations of the database.

Daily inspection reports are presented in Appendix-A.067 for Land Section and Appendix-A.068 for the Rama IX Bridge Section.

3) Routine Inspection

a) Coding of Inspection Results

Twenty coding sheets, 11 for the Land Section and 9 for the Rama IX Bridge Section, are provided to inspectors to record observations by inspected member.

Land Section

The 11 coding sheets for the Land Section are distinguished by different key identifiers and damage items, and are as follows:

Superstructure and Retaining Wall Coding Sheet,
Guard Wall Coding Sheet,
Drainage Coding Sheet,
Pier Coding Sheet,
Expansion Joints Coding Sheet,
Bearing Coding Sheet,
Embankment Coding Sheet,
Pavement Coding Sheet,
Lighting Coding Sheet,
Traffic Sign Coding Sheet, and
Noise Barrier Coding Sheet.

Coding sheets for routine inspection are presented in Appendix-A.025 to Appendix-A.035 for the Land Section.

Rama IX Bridge Section

The 9 coding sheets for the Rama IX Bridge, which are used in routine inspections, are as follows:

Steel Plate and Frame Member Coding Sheet,
covers main girders, pylons, guard barriers, girder gantries, pylon lifts, pylon ladders, pylon gondolas and cables,
Stay-Cable Coding Sheet,
Pavement Coding Sheet,
Pier Coding Sheet,
Drainage Coding Sheet,
Bearings Coding Sheet,
covers pendel, neo-pot and wind bearings,
Expansion-Joints Coding Sheet,
Dampers Coding Sheet,
covers girder damper, pylon damper and cable dampers, and
Lighting Coding Sheet.

Coding sheets for routine inspection are presented in Appendix-A.036 to Appendix-A.044 for the Rama IX Bridge Section.

b) Reporting and Report Form

After inputting observation results into the database system, a routine inspection report, which can serve as an official report, is outputted. The system provides types of reports corresponding to types of coding sheets mentioned above. All items inputted in the form of code are converted in the Thai language.

Routine inspection reports are to be kept on file. When it is necessary to modify report contents, make corrections in red and carry out the appropriate alteration of the database system.

Layout of routine inspection reports are attached 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.

4.4 Maintenance and Repair Concepts

4.4.1 General

1) Objectives of Maintenance and Repair

The existing expressway system is playing an important role as a main artery for vehicular traffic in the Bangkok metropolitan area, and it is also expected that this role will become higher and higher in the future, together with economic growth in the country.

The maintenance and repairs to the expressway structures and appurtenances shall be carried out to keep its service level, to protect persons from a accident and to maintain its functions as follows:

- To provide the better and safer service to users
  In order to provide the better and safer traffic to users without accidents and hindrance on the expressway, it is necessary to keep expressway surface and appurtenances in a good condition together with the enough loading capacity of the structure.

- To protect the third persons from an unexpected accident
  The existing expressway locates in the high density population area in Bangkok. In this reason, it is necessary to protect the third persons surrounding the expressway from a possible accident and hazard due to defect or deterioration to the expressway structures and facilities.

- To maintain function and durability of expressway itself
  In case of leaving a damaged structure as it is without any remedial measures, damage or deterioration to them become more serious quickly with the time. Damages and deteriorations to structures, which exceeds an allowable range, make shorten the durability of roadway structures.

- To provide the better environmental conditions
  It is necessary to keep the environmental states within a certain level to both within and surroundings of the expressway, in terms of noise, exhaust gas and vibration due to traffic. And aesthetic view of the expressway influences the urban landscape, due to a smudge or a fading of color on the

structure and facility.

It will be possible to minimize the maintenance costs and obtain the higher benefits to both users and ETA itself over an extended period of time with attaining the above object.

Maintenance and repair works, which aims at the above effects, are classified into the following three categories based on the executed work objectives as follows:

- Rehabilitation
  To restore functions of a damaged or deteriorated structure and facility to its initial conditions in order to achieve original loading capacity, durability and aesthetics, etc.

- Reinforcing
  To strengthen the functions of capacity of a damaged or deteriorated structure and facility to the stronger conditions, in order to cope with initial inferior functions or capacity.

- Improvement
  To provide a damaged or deteriorated structure and facility with the better functions or the higher capacity than it originally possessed, in order to cope with an increase in needs.

2) Maintenance and Repair Work Framework

Maintenance and repair work is categorized into routine maintenance operations and specialized maintenance operations as shown in Figure-4.4.1.

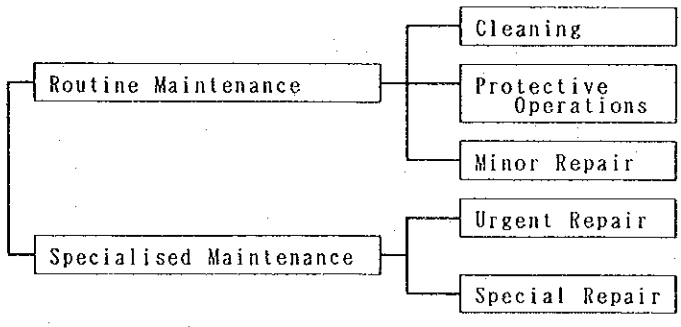

Figure-4.4.1 Maintenance and Repair Framework

Routine maintenance work is composed of cleaning and minor repairs and are as follows:

- Cleaning
  In order to keep function of structures and facilities on roadway in the better condition, it is required cleaning and removal of dirt, debris, and vegetation from pier caps, abutment seats, around bearings, expansion joints, drainage inlets, etc.

- Protective Operations
  Besides cleaning works for structures and facilities, protective operations to secure functions, durability and aesthetics, is essential for structures or facilities such as periodic repainting for deteriorated paint on steel structures.

- Minor Repairs
  Spot painting or protective coating as required of bearings and exposed portions of steel members; also small-scale repair work for washouts and embankment erosion, and replacement or correcting for loose or missing anchor nuts and bolts, etc.

Specialized maintenance works comprises urgent repair and special repair for a damaged or deteriorated structure and facility as follows:

- Urgent Repair
  Immediate remedial work is needed to restore damaged component to a condition for which only routine maintenance is necessary. Work should be scheduled for completion at an early date to prevent further damage to the component or need for complete reconstruction at a later time.

- Special Repair
  Due to the unexpected damage or deterioration by the results of inspection, special remedial work is necessary requiring special skills, equipment, or materials to restore the functions of a damaged component.

In addition to the above, emergency measures especially in daily inspection shall be performed immediately to secure vehicles and third persons from the more serious damage or

accidents which may cause by an initial damage in case. Essential measures are, in general, removal of damaged members, spacing of corns, and torches or light mark barricading and channelization at night, etc.

3) Repair Work Procedures

Maintenance and repair work is comprised of three categories, i.e., daily maintenance work such as cleaning, unexpected remedial work that should be done immediately, and repair work that is conducted on scheduled. In order to execute this work smoothly, standard work procedures should be stipulated for information management reasons.

Recommended repair work procedures are presented in Figure-4.4.2. Maintenance and repair work is performed based on the above maintenance work categorization. Detail on each step are explained bellow.

a) Members to be Repaired
The members to be repaired are compiled in the inspection database. The database system then outputs members requiring remedial work in the form of a repair report, in response to users retrieval conditions. This operation is explained in detail in the System Users Manual.

b) Cost Evaluation
After selecting objective members requiring repair, a cost evaluation shall be carried out to select members actually to be repaired and their repair method.

The database system can provide cost-evaluation lists on pavement rehabilitation both for the Land Section and the Rama IX Bridge Section, and a cost-evaluation list on expansion joints for the Land Section only, in response to inputted unit costs for repairs.

c) Budget Plan
Based on the above repair cost evaluation, a repair budget plan is formulated considering other maintenance and repair work, such as cleaning and urgent repairs.

d) Annual Plan
In order to perform repair work efficiently and maintain

even work load throughout the year, engineers in charge of maintenance shall first make an annual repair plan. When drawing up an annual repair plan, an appropriate season for each damaged structure and facility to execute repair work, such as the dry season for pavement repairs, will be taken into consideration.

e) Execution Plan
A monthly or weekly execution plan shall be made for manpower allocation, the organizing of repair teams, equipment allocation, material supply, and work locations.

f) Unexpected Damage
Based on the results of a daily or routine inspection, unexpected damage requiring urgent repairs may be necessary in addition to the above scheduled repairs. These urgent repairs are given top priority to avoid further problems from the initial damage.

g) Further Surveys Needs ?
In order to decide on the final execution of repairs or to perform repair design, engineers shall determine whether or not further inspections, such as monitoring or a detail inspection, are needed together with their methodology.

h) Further Surveys
Further surveys shall be carried out on the basis of a survey plan.

i) Repair Design
Detailed repair designs shall be carried out to draw up repair drawings, determine materials, etc.

j) Contract Work ?
It is necessary to decide whether repair work is to be executed by ETA staff or by a private construction company.

k) Contract
When repairs are to be made by a private company, it is necessary to make a contract with the private company for work in question.

l) Repairs by ETA
Repairs are conducted by ETA.

m) Repair Work
A private company carries out repairs under the supervision of ETA.

n) Coding/Approval of Engineer
Repair results shall be coded by persons in charge of maintenance, and they shall obtain the approval of an engineer before inputting them into the database system.

o) Input into Database
The coded results of repairs shall be inputted into their relevant repair database files by an operator.

p) Output from Database
Repair reports, which are outputted from the database system shall be in the form of an official ETA report. In addition, outputted reports can be used to confirm the accuracy of the inputting of repair data.

q) Repair Report
Repair reports will be kept on file, and may be referred to or photocopied for any official purpose.

4.4.2 Maintenance and Repair Concepts

1) Land Section

a) Concrete Structures

Most of the major structures on the Land Section consist of concrete structures, except for some attached facilities such as lighting poles, traffic signs, and guard fence. Consequently, the Maintenance and Repair Manual are focuses on concrete structures.

The Maintenance and Repair Manual deals with most common types of damage and deterioration, the causes of damage and deterioration, and appropriate remedial measures. Although some types of damage and deterioration have not yet been reported for FES, the Manual prescribes repair methods in case such damage should occur in the future.

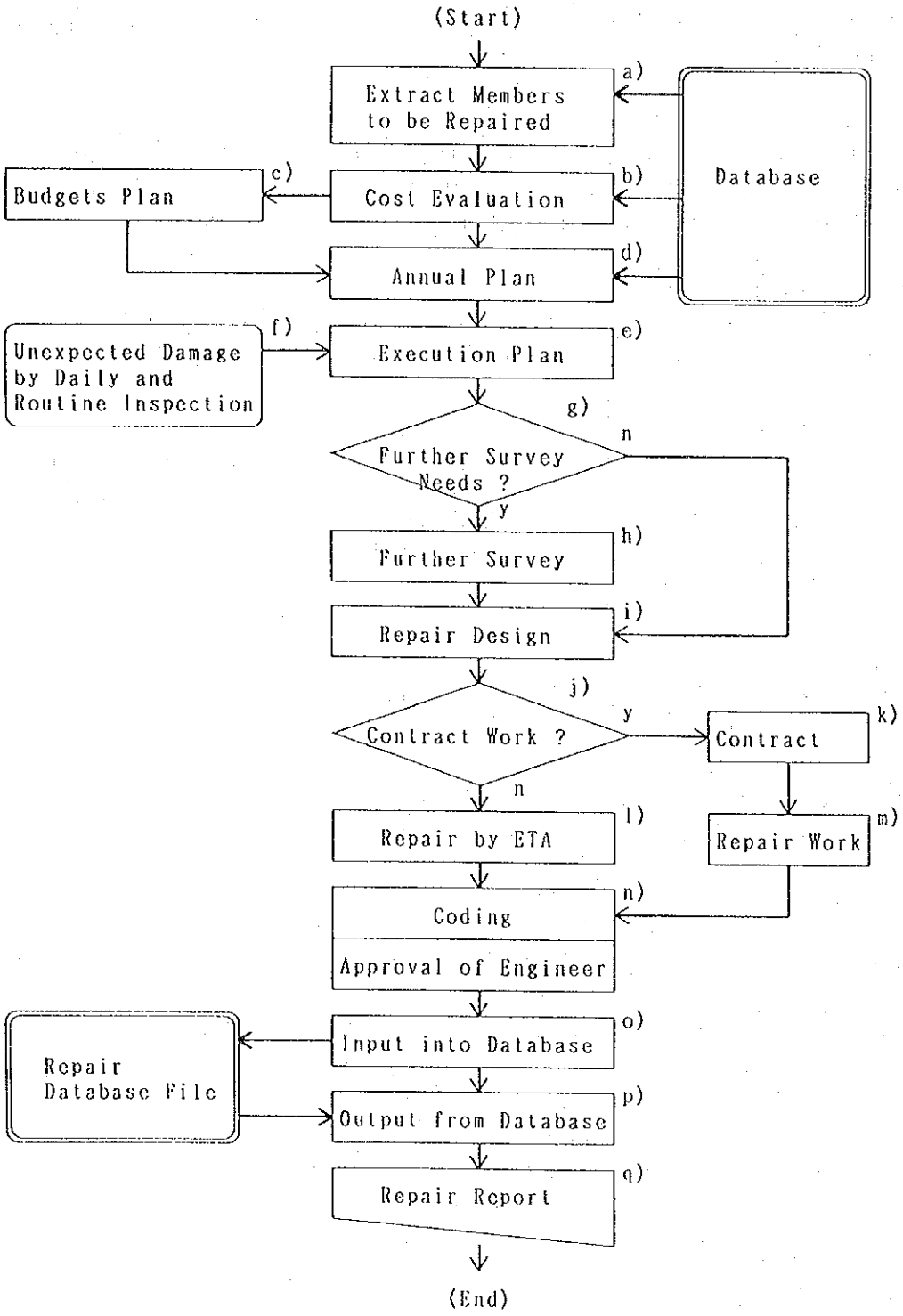

Figure-4.4.2 Repair Work Procedures

In prescribing repair methods and materials, local techniques and materials shall be considered first as a matter of course. From this standpoint, repair methods and repair materials are selected.

Since the opening of the first section of the FES to traffic around 10 years ago, there has not been any serious damage to the expressway structure. This fact is hard evidence that the structure has been kept sound and, even in the future, may be kept sound if no extraordinary hazards are encountered.

b) Pavement

Asphalt pavement is always exposed to external forces such as traffic loads and weather conditions, with the pavement itself being incessantly weathered. If left alone, its serviceability deteriorates before long and obstacles to the smooth and safe flow of traffic occur.

To prevent such a situation, it is indispensable that the condition of pavement be grasped at all times, and appropriate maintenance and repairs be carried out.

In this study, in order to analyze pavement damage such as rutting and cracking, as well as to forecast the progress of damage and establish repair plans, the activities and results of inspections, defect and damage detection, clarification of the causes of defects and damage, repair method selection and repair work execution are inputted into the database and the information outputted as the need arises.

Starting with daily patrols to inspect pavement defects and damage, a series of operations that clarify the causes of damage, evaluate the condition of pavement, select the most suitable maintenance/repair methods, and implement the selected methods on site are all able to be processed systematically with the computer database at ETA's Expressway Maintenance Center. This is quite different than the manual processing applied at present.

c) Expansion Joints

Expansion joints repair is categorized into two groups, urgent repair and ordinary repair.

An urgent repair is executed immediately to eliminate damage that threatens the smooth flow of traffic on the expressway.

An ordinary repair is executed periodically in accordance with a schedule in order to keep the functions of the expressway operating property. There are two types of ordinary repair and they are:

- Partial Repair
  This consists of repairs for fittings or accessories, not to the main body of joints, such as tightening a loosened nut, replacing damaged/deteriorated rubber, and replacing concrete plug.

- Replacement
  This work consists of complete replacing damaged/deteriorated joints with the original type or another type and completely replacing slab concrete and anchors.

d) Other Facilities

In order to keep the road functioning smoothly, it is necessary to properly maintain related road structures and facilities such as bearings, drainage, and traffic safety facilities.
Major maintenance work for these facilities consists mainly of routine work such as cleaning and preventive maintenance measures such as repainting and minor repairs. Cleaning drainage facilities and bearings is an important maintenance operation.

2) Rama IX Bridge

Maintenance and repair work for the Rama IX Bridge Section consists of daily maintenance work, urgent repair work and scheduled repair work, or the same as that for the Land Section. Faults in steel structures are usually induced by stress concentration, overloading, fatigue, sudden temperature changes due to welding, etc. The cause of faults are so complicated that countermeasures can not be drawn up without further detailed investigations and analyses. Therefore, countermeasures for major faults are not handled in the Maintenance and Repair Manual.

Fortunately, no major faults have been found in the Rama IX

Bridge during its five-year life span. This proof that the bridge was successfully designed and constructed, and it suggest no major faults will occur in the future without any huge external force or extraordinary change in bearing layer. However, it will be possible to accumulate fatigue stress concentration by repeating live load by vehicle wheels on the deck system, and to lead cracking at welded connections on the steel deck.

Regardless of faults, paint will deteriorate as the years pass. Consequently, maintenance operations for the Rama IX Bridge focus on preventive and remedial maintenance for painting. However, the time intervals for preventive repainting could not be concluded due to a lack of information and data. Conclusions on repainting intervals will be drawn after further study.

4.4.3 Repair Planning

1) Work Items

The items of some types of repair work, in comparison with ordinary maintenance work such as cleaning, are not so easy to determine beforehand, since some repairs can not be planned for in advance. In this respect, repair work can be divided into two categories: unexpected repair work that should be carried out immediately, and repairs that can be conducted on schedule, such as routine repairs.

Routine repairs consist of the following preventive care and minor repairs:

- repainting of steel structures and facilities,
- small-scale repairs for washouts and embankment erosion,
- replacement or tightening of missing or loose anchor nuts and bolts, and
- small-scale repairs for pavement, drainage, lighting, and traffic signs, etc.

In addition to the above repairs, there are the unpredictable urgent and special repairs. Urgent repairs require immediate restoration of damaged components to prevent further damage to said component or further accidents. On the other hand, special repairs need, in general, a further inspection to decide their repair method, a cost evaluation and a budget plan.

The inspection and maintenance system can assist repair engineers in formulating repair plans as described below.

2) Annual Planning

The selection of members and locations shall first be determined via the procedures below.

- Selection of members and locations to be repaired
  The database system provides a list of the members and location requiring remedial measures, and is in the form of a repair report issued via user retrieval conditions.

- Cost evaluation and reselection of members
  A cost evaluation is carried out to narrow the selection of members and locations requiring repairs. The database system can provide cost-evaluation lists on pavement repair for the entire expressway, and on expansion joints for the Land Section only, in response to the unit costs inputted by users.

- Budget plan
  The budget for repairs, which can be determined on the basis of the annual plan, shall consider other maintenance costs.

After determining the members to be repaired and their locations, an annual repair plan, which is in the form of a table and includes routine repair work, shall be established considering the following:

- seasonal characteristics, such as the rainy and dry seasons, to determine the most appropriate season for cleaning,
- the even distribution of manpower to execute work throughout the year,
- the appropriate allocation of work equipment,
- work conditions and worker safety, and
- traffic conditions and roadside conditions.

3) Execution Planning

A monthly or weekly execution plan, which is in the form of a table, shall be established considering the following:

- detailed manpower planning on a daily basis, and
- detailed allocation planning for equipment on a daily basis.

4.4.4 Coding and Reporting

1) Coding of Repair Results

Coding sheets are provided to maintenance engineers to efficiently record repair results. There is a single coding sheet for the Land Section and a single coding sheet for the Rama IX Bridge Section, with both used to code repair work for all of their respective structures and facilities.

Repair coding sheets for the Land Section and for the Rama IX Bridge Section are attached in the appendices of their respective inspection manuals. Any engineer can photocopy them freely for their own use.

After filling in a repair coding sheet, maintenance engineers or operators must input the results into the database system. However, it should be noted that repair data can only be appended for members having data previously stored in the inspection database.

Coding sheets for repairs are attached 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.

2) Reporting and Report Forms

Repair reports are provided to users by the database system after inputting the coded results for repair works. These reports are in the form of an official ETA report.

In addition to the above reports, the database system provides a "Members List to be Repaired" to users after they input retrieval conditions. Also, a "Cost-Estimation List" is provided on pavement for the entire expressway and on expansion joints for the Land Section only.

Repair reports are attached 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.

CHAPTER 5

DATABASE SYSTEM DESIGN

Chapter 5 Database System Design

5.1 Database Design Concepts

5.1.1 Processing Concepts

1) Basic Process Flow

In order to utilize the developed database system effectively for the maintenance and management of the expressway, the basic processing flow of the system is designed in such a way that it is possible to:

- access directly the designated process for daily use, such as the reporting of daily inspection,
- access separately the databases for both the land section and the Rama IX Bridge, and
- access readily the dBASE4 language for database management, such making backup database files and the deletion of information stored in the database.

Figure-5.1.1 presents the basic process flow of the database system, and Figure-5.1.2 shows the opening computer screen of the database system. "ETAMS" is a name for the system, which means "ETA Maintenance System".

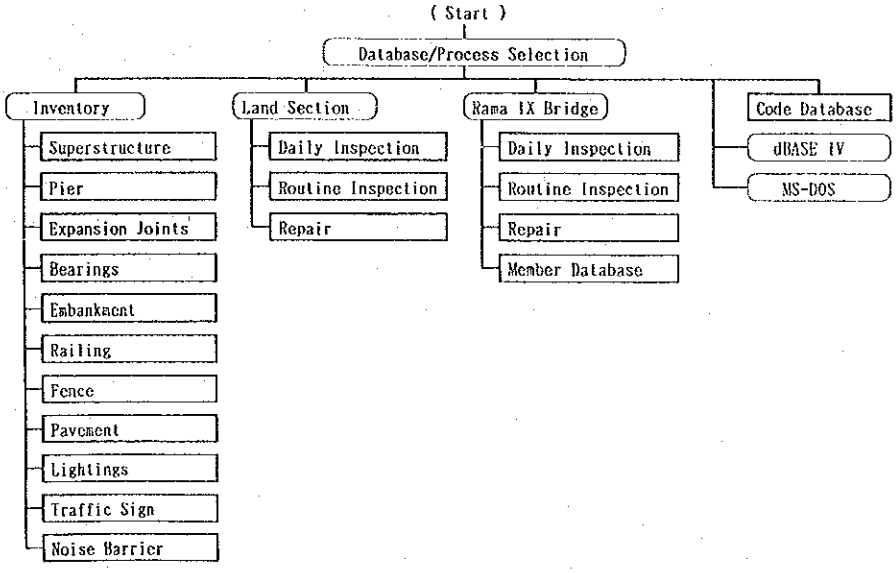

Figure-5.1.1 Basic Process Flow of Database System

2) Updating of Databases

The basic design concepts for updating databases, which consists of appending, altering and deleting, are to protect database from erroneous inputting and mishandling, with only a correct password triggering the beginning of a designated process as shown below.

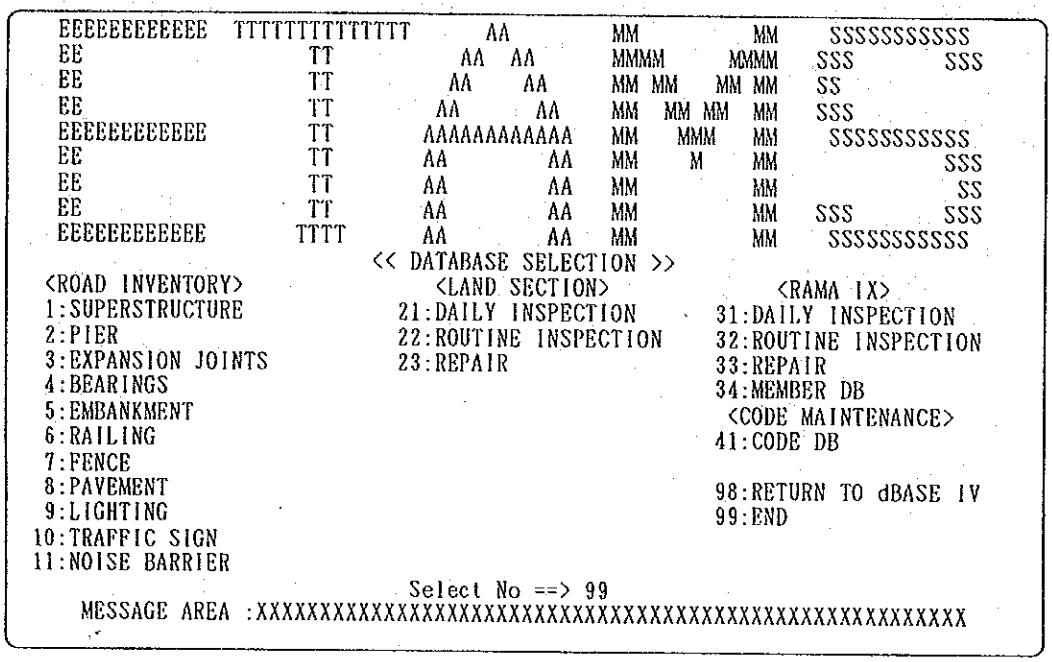

Figure-5.1.2 Opening Screen of Database System

- Append:
  adds new data to the database, and is used when new facilities are installed or a new section of the expressway system is opened.

- Alter:
  alters information stored in the database system based on changes in information, and is used in such cases as when a facility is renovated.

- Delete:
  deletes data records stored in the database due to the removal of a roadway facility.

The three ways listed below for checking inputted information is carried out in the above updating process, with the purpose of protecting and managing databases from erroneous data by displaying error messages on the computer screen.

- Code matching:
  matches inputted code and the defined code of the code database file.

- Key matching:
  matches inputted key identifiers and the key identifiers stored in the road inventory database.

- Record duplication check:
  checks for the same key identifiers in database files.

Figure-5.1.3 shows the basic updating flow of the database files, as well as interrelations between database files.

5.1.2 Retrieval and Outputs

1) The Form of Output

The output interface program enables prompt retrieval of designated data records stored in the database files, and displays extracted information on the screen and outputs said information in a predetermined form. There are 52 forms for the outputting of information and they are as follows:

- Land Section and Rama IX Bridge Section

Road Inventory (by facility)	: 11 Forms
Code	: 1 do.

- Land Section

Daily Inspection Report	: 1 Forms
Routine Inspection Report	: 11 do.
Members List to be Inspected	: 1 do.
Repair Report	: 8 do.
Members List to be Repaired	: 1 do.
Cost Evaluation List	: 2 do.

- Rama IX Bridge Section

Daily Inspection Report	: 1 Forms
Routine Inspection Report	: 9 do.

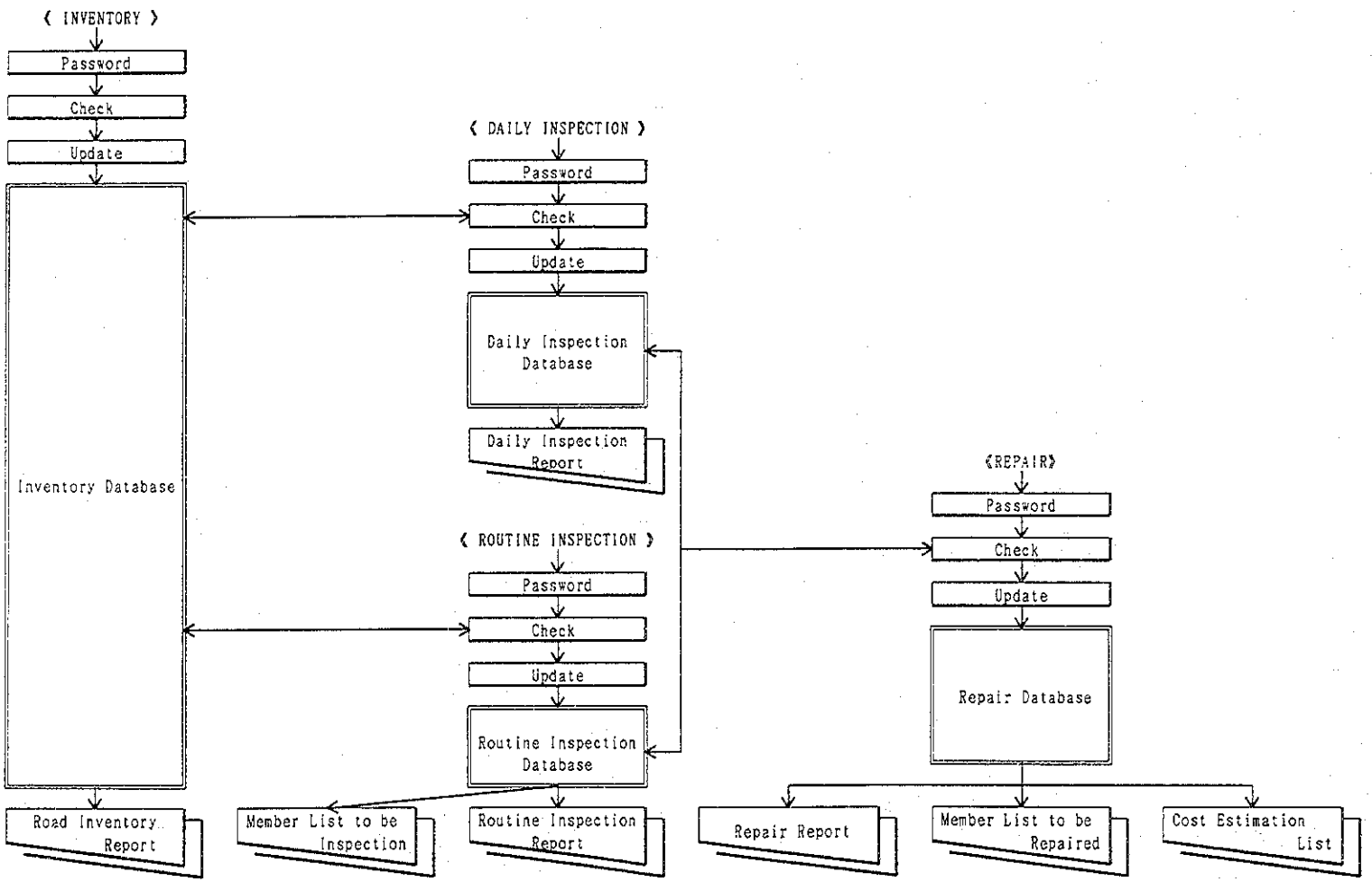

Figure-5.1.3 Basic Updating Process Flow of Database Files

Members List to be Inspected	:	1 do.
Repair Report	:	2 do.
Members List to be Repaired	:	1 do.
Cost Evaluation List	:	1 do.
Member List	:	1 do.

2) Retrieval Conditions for Output

Basic retrieval concepts allow for the extraction of information from database files by any combination of retrieval conditions, for the effective use of compiled data for a wide scope of maintenance work. Retrieval conditions for each of the above forms are summarized in Table-5.1.1 to Table-5.1.4.

Table-5.1.1 Inventory Forms and Retrieval Conditions

Output Forms	Retrieval Conditions
	: Common for all inventories in route, direction, main road/ramp, chainage
Superstructures	: pier no., girder type, use of under bridge guard wall type, drain type
Piers	: pier no., contract no., pier type
Expansion Joints	: ex.joint type
Bearings	: location, bearing type
Embankments	: bank type, guard wall type, drain type cross-section type
Railing	: location, railing type
Fence	: location, object of fence, fence type
Pavement	: road-bed type, pavement type
Lighting	: pole no., location, pole type, lamp type
Traffic Signs	: pole no., pole type, sign type, lamp type
Noise Barrier	: location, object of barrier, barrier type

Table-5.1.2 Daily Inspection Report and Retrieval Conditions

Output Forms	Retrieval Conditions
<Land Section>	: route, direction, main road/ramp, chainage inspection date, location, lane no. pole no., damaged member, damage type damage rating, work needed date to be done, repair date
<Rama IX Bridge>	: inspection date, damage member, unit no. lane no., damage type, damage rating work needed, date to be done, repair date

Table-5.1.3 Routine Inspection Report and Retrieval Conditions

Output Forms	Retrieval Conditions
<Land Section>	
Inspection Report	route, direction, main road/ramp, chainage Inspected member, Inspection date work class, damage rating by items work needed, date to be done repair date
Member List to be Inspected	route, direction, main road/ramp, chainage member, last inspection date
<Rama IX Bridge>	
Inspection Report	member, inspection date, work class, unit no., damage rating by items, work needed date to be done, repaired date
Member List to be Inspected	member, last inspection date

Table-5.1.4 Retrieval Conditions for Repair Database

Output Forms	Retrieval Conditions
<Land Section>	
Repair Report	repair member, repair date, repair class inspection date, inspection work class route, direction, main road/ramp, chainage pier no., repair method
Member List to be Repaired	member, route, chainage, work needed date to be done,
Cost Estimation List	member, route, direction, main road/ramp chainage, damage rating by items work needed, date to be done
<Rama IX Bridge>	
Repair Report	repair date, repair work class inspection date, inspection work class unit no., lane no., repair method
Member List to be Repaired	member, work needed, date to be done
Cost Estimation List (pavement)	unit no., lane no. damage rating by items, rutting depth PSI, work needed, date to be done

5.1.3 Operational Concepts

1) Operational Framework

The operational framework of the database system is presented in Figure-5.1.4. Users can select a designated process from among 21 branches over 11 inventory items, with there being three processes for inspection and repair for the Land Section and four processes for the Rama IX Bridge Section. In addition, it is possible to either operate in a dBASE or MS-DOS environment.

The road inventory system provides road inventory tasks to users for eleven kinds of road members, which make up the roadway in terms of its structures and facilities.

The inspection and repair system is divided into two parts, i.e., the Land Section and the Rama IX Bridge Section.

After selecting "Daily Inspection" on the main menu, the screen turns to "Process Selection", which contains "Append", 'Alter" and "Output". The "Append" process permits the inputting of collected data into the database. The "Alter" process changes stored data in the database, and the "Output" process prints out information in the form of a daily inspection report.

The processes for routine inspection have the same functions as those of the daily inspection. However, the "Output" process supplies two kinds of forms, i.e., a routine inspection report and a members list to be inspected.

The processes for repair can append, alter and delete repair data for each database file, and output repair reports, members list to be repaired, and cost-evaluation lists for pavement and expansion joints.

The member database contains the unit numbers of members on the Rama IX Bridge to identify their location.

The code database compiles code and its associated characters both in English and Thai, and supplies the newest code table to users whenever they desire it.

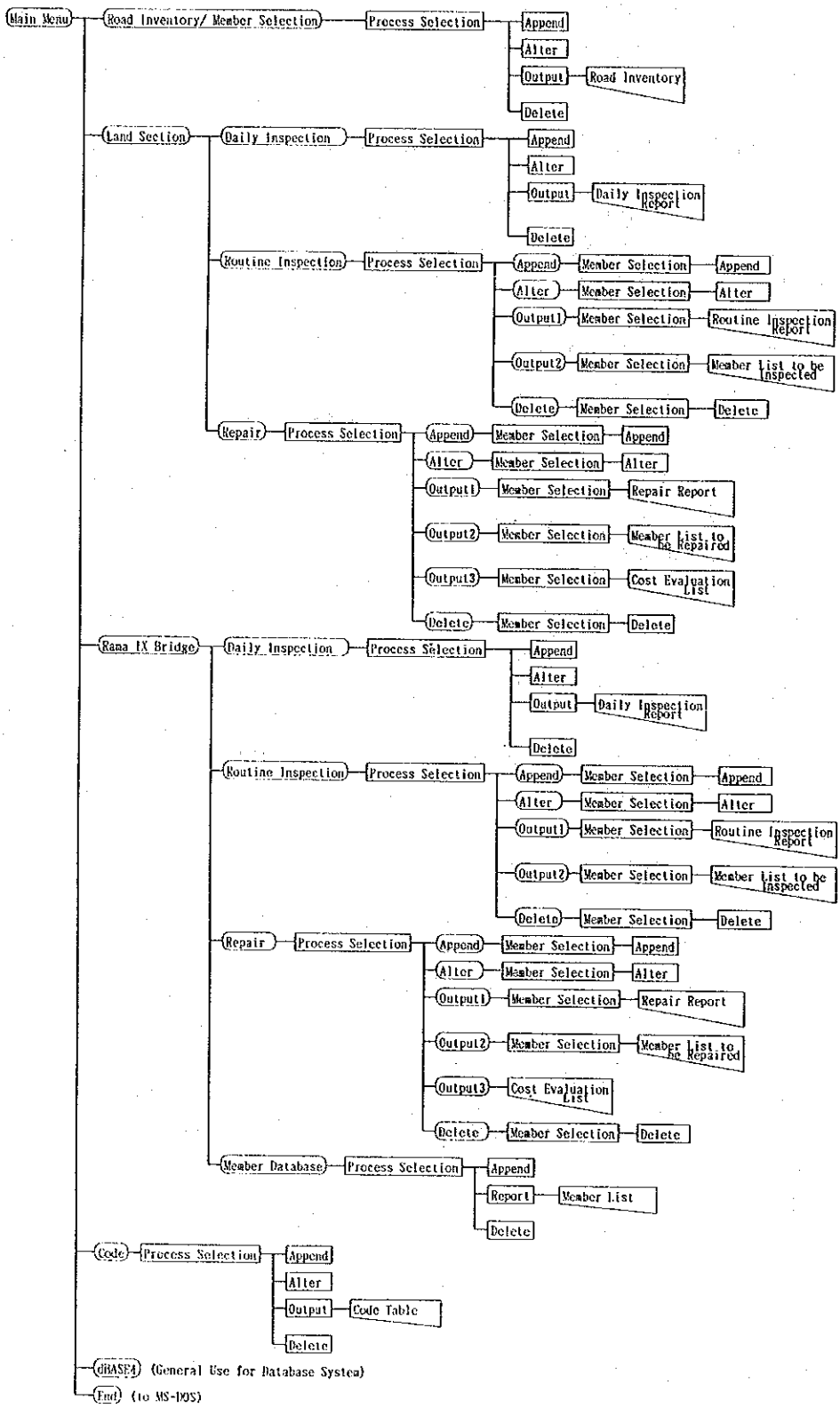

Figure-5.1.4 Operational Framework of the Database System

dBASE4 is for operating the database system directly. The operational methods are presented in detail in the System Users Manual.

MS-DOS is for the general management of all computer files.

2) Screen Layouts

Screen layouts in appending information are designed in the same inputting order as those of the coding sheets for user convenience and to avoid erroneous inputting. All appending is arranged to be done on a single screen in the same manner.

When users make an error inputting key identifiers or a code item, the system immediately display an error message on the screen.

Inputted code items are immediately displayed in Thai characters next to the inputted code.

3) Input/Output in Thai

Use of the Thai language supports a variety of utilizations of the database system. For this reason, the system is designed to use Thai to do the followings:

- convert inputted code (number) and display it on the screen and output it on sheets in Thai, and
- allow users to input and output in Thai comments such as name, document number, etc.

5.2 Hardware and Software

5.2.1 Computer and Software

1) Microcomputer

The microcomputer 'NEC PowerMate 466i' is used to load the database system. This microcomputer has enough capacity to accommodate the road inventory, inspection and repair results for the expressway. Details on its hardware are as listed below.

- CPU: Intel i486DX2-66 (runs at a speed of 66 MHz)
- External Memory: 20 MB
- Internal Cache Memory: 8 KB
- Flash Memory: 128 KB
- Floppy Disk Drive: 3.5"(1.44 MB) and 5.24"(1.2 MB),
- Hard Disk (AT Bus): 240 MB

2) Software

In order to manage information for maintenance work, the database management system (DBMS) named 'dBASE4' is used for the following reasons:

- it is capable of developing a database system for workstations in ETA,
- it is commercially available in Bangkok with the possibility of after-care service,
- it has enough functions and can formulate a database system for maintenance work,
- it is capable of inputting and outputting in the Thai language, and
- it is easy for ETA staff maintain and to make improvements in the system.

MS-DOS is used to load the above database management system 'dBASE4' into the microcomputer, and their versions are as follows:

- MS-DOS : Version 6
- dBASE4 : Version 1.0

5.2.2 Programs

Interface programs, which enable the efficient appending, altering, deleting, and outputting of database information, are written in the English-like dBASE language. The programs are composed of more than hundred subroutines, and the total size of all the programs reaches approximately 2,000 kilobytes as shown in Table-5.2.1.

All the efforts of system development focused on easy access by users. As a result, users can operate the system by answering query statements that appear on the computer display.

Table-5.2.1 Developed Programs and Size

Programs		Size
<Inventory>	Superstructures	46
	Piers	28
	Expansion Joints	27
	Bearings	26
	Embankments	39
	Railing	27
	Fence	28
	Pavement	62
	Lighting	30
	Traffic Signs	38
	Noise Barrier	28
	(total)	379
<Daily Inspection>	Land Section	113
	Rama IX Bridge Section	82
	(total)	195
<Routine Inspection>	Land Section	553
	Rama IX Bridge Section	297
	(total)	850
<Repair System>	Land Section	415
	Rama IX Bridge Section	173
	(total)	588
Bridge Member System		53
Code System		35
grand total		2,100

Note: Units are in kilobytes.

5.3 Road Inventory System

5.3.1 Database Files and Data Items

The data items of the inventory database for road structures and facilities on the ETA expressway are determined in consideration of:

- characteristics of existing structures and facilities on the expressway,
- appropriate data volume to be managed by micro-computer basis,
- effective usage of maintenance work, and
- appropriate data volume to be maintained by ETA the staff itself, etc.

The details of the items for each database are presented in Table-5.3.1 to Table-5.3.11.

Key identifiers are set up to identify designated data records in the database. Attributive data are information essential to store into a database for maintenance work belonging to a collection of key identifiers. Control data are necessary information to process the database system effectively, such as data confirmation.

In Table-5.3.1 to Table-5.3.11, abbreviation and marks shows the following:

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

- Digits: number of digits of the item

- Key: Double Circle: Common indispensable items to all members to identify a object,
  Single Circle: Indispensable items for a designated member. It depends on member and its corresponding inventory file.

- Extract: Items to extract information for reporting.

- Sum: Summing up items for reporting.

Table-5.3.1 Items of Superstructure Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ····
Main Road / Ramp	C	1	◎	○		Cl:1
Chainage (Start)	N	10	◎	○		999999.999(m)
(End)	N	10	◎	○		do.
Pier Number (Start)	X	10	○	○		
(End)	X	10	○	○		
(Bridge Items)						
Type of Cross Section	C	1				Cl:2, twin/double dir'tn
Type of Girder	C	2		○		Cl:3, main girder
Bridge Length	N	7			○	999.999(m)
Bridge Width (Start)	N	7				do. total width
(End)	N	7				do.
Number of Girders	N	2				
Depth of Girder	N	7				999.999 (m) incl. slab
Use of Under-Bridge	C	2		○		Cl:4
(Attached Facility)						
Type of Guard Wall(L)	C	2		○		Cl:5, left side
Type of Guard Wall(R)	C	2		○		Cl:5, incl. median
Type of Drain System	C	1		○		Cl:6
Type of Inlet	C	1				Cl:7
Number of Inlet	N	2				
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total 137)					

Table-5.3.2 Items of Pier Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ···
Main Road / Ramp	C	1	◎	○		Cl:1
Chainage	N	10	◎	○		999999.999(m)
Pier Number	X	10	○	○		
Contract Number	X	10	○	○		
(Pier Data)						
Type of Cross Section	C	1				Cl:2
Type of Pier	C	2		○		Cl:8
Type of Foundation	C	1				Cl:9
Number of Column	N	1				
Hight of Column	N	7				999.999(m)
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total 96)					

Table-5.3.3 Items of Expansion Joints Inventory Database File

Data Item		Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)							
Route		X	5	◎	◎		XX-XX
Direction of Traffic		X	1	◎	◎		A, B, ···
Main Road / Ramp		C	1	◎	○		C1:1
Chainage		N	10	◎	○		999999.999 (m)
(Ex. Joint Data)							
Exj-Type	Original	C	2		○		C1:11, as built
	Current	C	2		○		C1:11, latest type
	Changed Date	N	4		○		yy/mm
Length		N	7			○	999.999 (m)
(Remarks)							
Name of Constructor		X	20				
Date of Completion		N	4				yy/mm
Documents Number		X	20				
(Flags)							
Code Check		N	1				
Ex. Indispensable Item		N	1				
Duplication		N	1				
		(Total 79)					

Table-5.3.4 Items of Bearings Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ···
Main Road / Ramp	C	1	◎	○		CI:1
Chainage	N	10	◎	○		999999.999 (m)
Connection Type	C	1				CI:10
Location Code	X	1	◎			S, J, E in character
(Bearing Data)						
Type of Bearing	C	2		○		CI:12, start side
Number of Bearing	N	2			○	
F/M Distinction	X	1				F/M/H···
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total 71					

Table-5.3.5 Items of Embankment Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ····
Main Road / Ramp	C	1	◎	○		Cl:1
Chainage (Start)	N	10	◎	○		999999.999 (m)
(End)	N	10	◎	○		do.
(Embankment)						
Hight of Bank	N	7				999.999 (m)
Type of Bank	C	1		○		Cl:13
Hight of Retaining Wal	N	7				999.999 (m)
(Attached Facility)						
Type of Guard Wall(L)	C	2		○		Cl:5, left side
Type of Guard Wall(R)	C	2		○		Cl:5, incl. median
Type of Drain System	C	1		○		Cl:6
Type of Inlet	C	1				Cl:7
Number of Inlet	N	2				
(Culvert)						
1: Cross Section Type	C	1		○		Cl:37
Width	N	5				999.9(m)
Height	N	5				999.9(m)
Length	N	5			○	999.9(m)
2: Cross Section Type	C	1		○		Cl:37
Width	N	5				999.9(m)
Height	N	5				999.9(m)
Length	N	5			○	999.9(m)
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total 97)					

Table-5.3.6 Items of Railing Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ····
Main Road / Ramp	C	1	◎	○		CI:1
Chainage (Start)	N	10	◎	○		999999.999 (m)
(End)	N	10	◎	○		do.
Location of Railing	C	1	◎	○		CI:14, left/right
(Railing Data)						
Type of Guard Rail	C	1		○		CI:17
Hight of Guard Rail	N	7				999.999 (m)
Length of Guard Rail	N	7			○	999.999 (m)
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total 90)					

Table-5.3.7 Items of Fence Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ····
Main Road / Ramp	C	1	◎	○		Cl:1
Chainage (Start)	N	10	◎	○		999999.999 (m)
(End)	N	10	◎	○		do.
Location of Fence	C	1	◎	○		Cl:14, left/right
(Guard Fence Data)						
Object of Installation	C	1		○		Cl:15
Type of Fence	C	1		○		Cl:16
Hight of Fence	N	7				999.999 (m)
Length of Fence	N	7			○	999.999 (m)
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total 91)					

Table-5.3.8 Items of Pavement Inventory Database File

Data Item		Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)							
Route		X	5	◎	◎		XX-XX
Direction of Traffic		X	1	◎	◎		A, B, ····
Main Road / Ramp		C	1	◎	○		Cl:1
Chainage (Start)		N	10	◎	○		999999.999 (m)
(End)		N	10	◎	○		do.
(Common Dimensions)							
Type of Cross Section		C	1				Cl:2
Type of Road-bed		C	1		○		Cl:18
Number of Lanes		N	1				
Length of Road Segment		N	7			○	999.999 (m)
Width of R.O.W.		N	7				999.999 (m)
(Pavement Data)							
Pavement Width (Start)		N	7				999.999 (m)
(End)		N	7				do.
Total Pavement Area		N	7			○	9999.99 (m^2)
(Type, Area by Lane)							
Shoulder	Area	N	7			○	9999.99 (m^2)
	Origin. Type	C	2				Cl:19
	Current Type	C	2				do.
	Changed Date	N	4				yy/mm
Lane 1	Area	N	7			○	9999.99 (m^2)
	Origin. Type	C	2				Cl:19
	Current Type	C	2				do.
	Changed Date	N	4				yy/mm
Lane 2	Area	N	7			○	9999.99 (m^2)
	Origin. Type	C	2				Cl:19
	Current Type	C	2				do.
	Changed Date	N	4				yy/mm
Lane 3	Area	N	7			○	9999.99 (m^2)
	Origin. Type	C	2				Cl:19
	Current Type	C	2				do.
	Changed Date	N	4				yy/mm
Lane 4	Area	N	7			○	9999.99 (m^2)
	Origin. Type	C	2				Cl:19
	Current Type	C	2				do.
	Changed Date	N	4				yy/mm
Lane 5	Area	N	7			○	9999.99 (m^2)
	Origin. Type	C	2				Cl:19
	Current Type	C	2				do.
	Changed Date	N	4				yy/mm
Lane 6	Area	N	7			○	9999.99 (m^2)
	Origin. Type	C	2				Cl:19
	Current Type	C	2				do.
	Changed Date	N	4				yy/mm
No. of Lane Mark Lines		N	1				
(Remarks)							
Name of Constructor		X	20				
Date of Completion		N	4				yy/mm
Documents Number		X	20				
(Flags)							
Code Check		N	1				
Ex. Indispensable Item		N	1				
Duplication		N	1				
		(Total 218)					

Table-5.3.9 Items of Lighting Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ・・・
Main Road / Ramp	C	1	○	○		Cl:1
Chainage	N	10	○	○		999999.999 (m)
Pole Number	X	10	◎	○		
(Pole Data)						
Location of Pole	C	1	○	○		Cl:14
Type of Pole	C	1		○		Cl:20
Name of Maker	X	20				
(Lamp Data)						
Type of Lamp	C	1		○		Cl:21
Number of Lamps	N	1			○	
Elec. Consumption	N	5			○	watt/hour
Average Luminus Int'ty	N	5				lux
Switch Group	X	10				
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total 118)					

Table-5.3.10 Items of Traffic Sign Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ····
Main Road / Ramp	C	1	○	○		Cl:1
Chainage	N	10	○	○		999999.999 (m)
Pole Number	X	10	◎	○		
(Pole Data)						
Location of Pole	C	1				Cl:14
Type of Pole	C	1		○		Cl:22
(Sign Data)						
Type of Sign System	C	1		○		Cl:23, fix/variable
Number of Signs	N	2				
Sign (A) :Type of Sign	C	1				Cl:24
:contents	X	20				for guide sign
(B) :Type of Sign	C	1				Cl:24
:contents	X	20				for guide sign
(C) :Type of Sign	C	1				Cl:24
:contents	X	20				for guide sign
(D) :Type of Sign	C	1				Cl:24
:contents	X	20				for guide sign
(Lights)						
Type of Lamp	C	1		○		Cl:21
No. of Lamps (A)	N	2			○	
(B)	N	2			○	
(C)	N	2			○	
(D)	N	2			○	
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total169)					

Table-5.3.11 Items of Noise Barrier Inventory Database File

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Route	X	5	◎	◎		XX-XX
Direction of Traffic	X	1	◎	◎		A, B, ···
Main Road / Ramp	C	1	◎	○		Cl:1
Chainage (Start)	N	10	◎	○		999999.999 (m)
(End)	N	10	◎	○		do.
Location of Barrier	C	1	◎	○		Cl:14, left/right
(Noise Barrier)						
Object of Protection	C	1		○		Cl:25
Hight of Barrier	N	7				999.999 (m)
Length of Barrier	N	7			○	999.999 (m)
Type of Barrier Panel	C	1		○		Cl:26
(Remarks)						
Name of Constructor	X	20				
Date of Completion	N	4				yy/mm
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
	(Total 91)					

5.3.2 Coding Sheets for Inventory

Coding sheets for inventory, which are also used for road inventory survey in the study, are determined in consideration of:

- items on coding sheet are arranged in the same order as that of screen layout for data inputting,
- suitable layout for data collection work by documents, and
- attaching related code table on the coding sheet for easy coding by users, etc.

Separate coding sheets for each eleven (11) databases are presented in detail in Appendix-A.012 to Appendix-A.022.

5.3.3 Road Inventory Forms

Eleven road inventory forms will be provided by each road inventory database for maintenance work as shown below.

- superstructure inventory,
- pier inventory,
- embankment inventory,
- pavement inventory,
- expansion joint inventory,
- bearing inventory,
- lighting inventory,
- traffic sign inventory,
- guardrail inventory,
- fence inventory,
- noise barrier inventory.

Inventory forms are presented on all structures and facilities in Appendix-A.055 to Appendix-A.065.

Users of this system in ETA can readily extract road inventory information by any combination of key identifiers such as route, location, chainage and objective member for maintenance work as follows:

- objective structure as an indispensable data,
- route as an indispensable data,
- direction of traffic as an indispensable data,
- main road/ramp distinction,

- chainage from start point to end point, and unique number which are pier number, pole number for lighting and location code on left and right.

5.3.4 Design Concepts on Processing

The Process flow of the road inventory begins after selecting an inventory database and objective structure or facility on the opening screen of the system. The next process is selection of a designated process on appending, altering and outputting data, as shown in Figure-5.3.1.

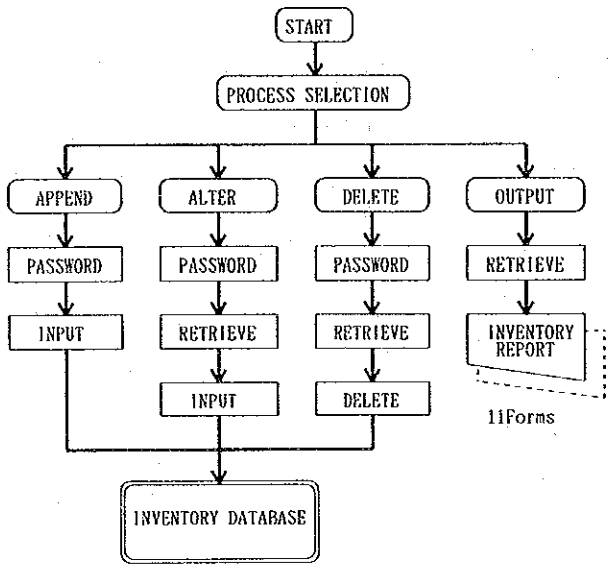

Figure-5.3.1 Process Flow of Inventory Database System

Appending and altering data stored in the database are guarded by a password to prevent inputting of erroneous data and mis-handling. When type or material was changed by repair work, modification of information stored in the inventory database shall be performed by using "altering" process by manually.

However, the output of inventory and checks on stored data are available to any user without limitation. The detailed process flow is presented in the system users manual.

In order to understand easily the practical operation of the road inventory system, some sample screen in the process are shown in Figure-5.3.2 for appending and altering, Figure-5.3.3

is for the outputting of inventory for the superstructure.

```
          ROUTE NUMBER :XX-XX
     DIRECTION OF TRAFFIC :X
        MAIN ROAD / RAMP :9 _________
      NAME OF CONSTRUCTOR :XXXXXXXXXXXXXXXXXXX
       DATE OF COMPLETION :YY/MM

              CHAINAGE :START 999999.999 m    END 999999.999 m
            PIER NUMBER :START XXXXXXXXXX      END XXXXXXXXXX

   TYPE OF CROSS SECTION :9  ____________
         TYPE OF GIRDER :99 ____________
          BRIDGE LENGTH :999.999 m
          BRIDGE WIDTH :START 999.999 m    END 999.999 m
      NUMBER OF GIRDERS :99
        DEPTH OF GIRDER :999.999 m
     USE OF UNDER BRIDGE :99 _________
      TYPE OF GUARD WALL :LEFT 99 _____________  RIGHT 99 _____________
    TYPE OF DRAIN SYSTEM :9  _________
          TYPE OF INLET :9  ____________
        NUMBER OF INLET :99
       DOCUMENTS NUMBER :XXXXXXXXXXXXXXXXXXX
(1) APPEND AND CONTINUE  (2) APPEND AND END   (3) REENTRY   (4) ESCAPE
                         Select No ==> 9
MESSAGE AREA :XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Figure-5.3.2 Screen Layout on Appending for Superstructure

```
                    << RETRIEVAL CONDITIONS >>

                          ROUTE :XX-XX

                DIRECTION OF TRAFFIC :FROM X  TO X

                    MAIN ROAD / RAMP :FROM 9  TO 9

                        CHAINAGE :FROM 999999.999 m   TO 999999.999 m

                      PIER NUMBER :FROM XXXXXXXXXX     TO XXXXXXXXXX




                   (1) PRINT    (2) REENTRY   (3) ESCAPE
                                Select No ==> 9
MESSAGE AREA :XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Figure-5.3.3 Screen Layout on Outputting
of Inventory for Superstructure

5.4 Daily Inspection Database System

5.4.1 Database Files and Data Items

1) Land Section

The daily inspection database is designed to accommodate information obtained by daily inspection work on the expressway, in the form of single database common to all objective members for daily inspection.

The total number of data items of the daily inspection database for the land section is twenty eight (28) items, which there are five items for key identifiers, eighteen items for attributive data, and five items for system control.

The data items are determined taking into consideration of ETA's current daily inspection as shown in Table-5.4.1.

A number of data records to be inputted into database in a day is not limited in this database, for one damage data on a certain member at one location is compiled in one record in the database file.

2) Rama IX Bridge

The daily inspection database for the Rama IX Bridge is formulated as a single database as the same manner as the land section, as shown in Table-5.4.2.

Table-5.4.1 Items of Daily Inspection Database for Land Section

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Inspected Date	N	6	◎	○		yy/mm/dd
Damage Member	C	2	◎	○		Cl:27
Route	X	5	◎	○		XX-XX in character
Direction	X	1	◎	○		A, B, ·· in character
Main Road/Ramp	C	1	○	○		Cl:1
Chainage (Start)	N	6	○	○		999999 (m)
Chainage (End)	N	6	○	○		999999 (m)
Location Code 2	C	1	○	○		Cl:14
Lane Number	X	1	○	○		character in E, 1, 2 ···
Pole Number	X	10	○	○		character
(Damage-Item)						for one location
Priority Member	C	2				Cl:27, in inspection
Damage	C	3		○		Cl:33
Rating	X	1		○		A, B, C in character
Comments on Damage	X	20				in character
Photo. Number	X	5				do.
Works Needed	C	2		○		Cl:29
Date to be Done	N	6		○		yy/mm/dd
Comments on Repair	X	20				in character
Person in Charge	X	10				of repair
Repaired Date	N	6		○		yy/mm/dd
(Remarks)						
Day of Week	C	1				Cl:31
Name of Inspector	X	10				or team
Weather	C	1				Cl:32
Date of Data Inputted	N	6				yy/mm/dd by cpu
(Flags)						
Code Check	N	1				1: checked and OK
Exis. of Indisp. Items	N	1				do.
Duplication	N	1				do.
Key Check	N	1				do.
	(Total 136)					

Table-5.4.2 Items of Daily Inspection Database for Rama IX Bridge

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Inspected Date	N	6	◎	○		yy/mm/dd
Damage Member	C	2	◎	○		Cl:30
Unit Number	X	6	◎	○		in character
Lane Number	X	1	○	○		E, 1, 2, ·· for pavement
(Damage-Item)						for one location
Priority Member	C	2				Cl:30, in inspection
Damage	C	3		○		Cl:34
Rating	X	1		○		A, B, C in character
Comments on Damage	X	40				in character
Photo. Number	X	5				do.
Works Needed	C	2		○		Cl:29
Date to be Done	N	6		○		yy/mm/dd
Comments on Repair	X	40				in character
Person in Charge	X	10				of repair
Repaired Date	N	6		○		yy/mm/dd
(Remarks)						
Day of Week	C	1				Cl:31
Name of Inspecter	X	10				or team
Weather	C	1				Cl:32
Date of Data Inputted	N	6				yy/mm/dd by cpu
(Flags)						
Code Check	N	1				1: checked and OK
Exis. of Indisp. Items	N	1				do.
Duplication	N	1				do.
Key Check	N	1				do.
	(Total 151)					

5.4.2 Coding Sheets for Daily Inspection

Design concepts on layout forms of coding for daily inspection are presented below. Coding sheets for daily inspection are designed in such a way that it is possible to:

- use separate inspection sheets for the Land Section and the Rama IX Bridge Section with two coding sheets,
- write inspection results on-site without an inspection manual, so major damage items together with a code can be indicated on coding sheets,
- input inspected results into database file easily, for layout form of coding sheet is similar to layout of computer screen.
- provide separate daily inspection report forms for the Land Section and the Rama IX Bridge Section.

Coding sheets for daily inspection, which will be also used in writing inspection results on-site on a car, are presented as a sample in Appendix-A.023 and A.024 for the Land Section and the Rama IX Bridge Section, respectively.

5.4.3 Daily Inspection Report Forms

Daily inspection database files provide two daily inspection reports for the Land Section and the Rama IX Bridge Section exclusively, and their forms are commonly used to output damages for all members.

Retrieval of output daily inspection report from the database file is designed so information can be extracted by any combination of the following conditions:

- inspected date in form of from date to date,
- damage member in form of from member code to member code,
- unit number and/or lane number for pavement,
- evaluation on damage in form of rank to rank,
- work needed in form of from work code to work code,
- 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, system users can make the better use of output forms for the maintenance work, for example:

- daily inspection report:
  to extract a designated date, together with other retrieval conditions if any, user can get a daily inspection report,

- repaired list:
  to extract repaired date, in form of a designated date or from date to date together with other retrieval conditions, user can obtain repaired member lists which presents members already repaired for its damages, and

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

Daily inspection report form are presented in Appendix-A.067 for the Land Section and A.068 for the Rama IX Bridge Section.

5.4.4 Design Concepts on Processing

The Process flow of the daily inspection system is separated into four branches: appending, altering, deleting and outputting, which is common to both the Land Section and the Rama IX Bridge Section, as shown in Figure-5.4.1.

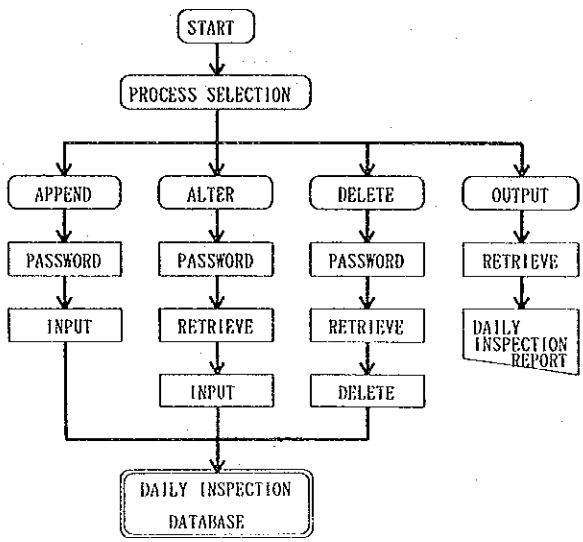

Figure-5.4.1 Process Flow of Daily Inspection System

Process on appending is similar function to that of the inventory and its screen layout is presented in Figure-5.4.2. In the appending process, the existence of designated member is always checked between inputted key identifiers of the daily inspection and that of stored inventory database file. When inputted key identifiers of the daily inspection do not correspond to that of the inventory stored, users can not input any daily inspection data.

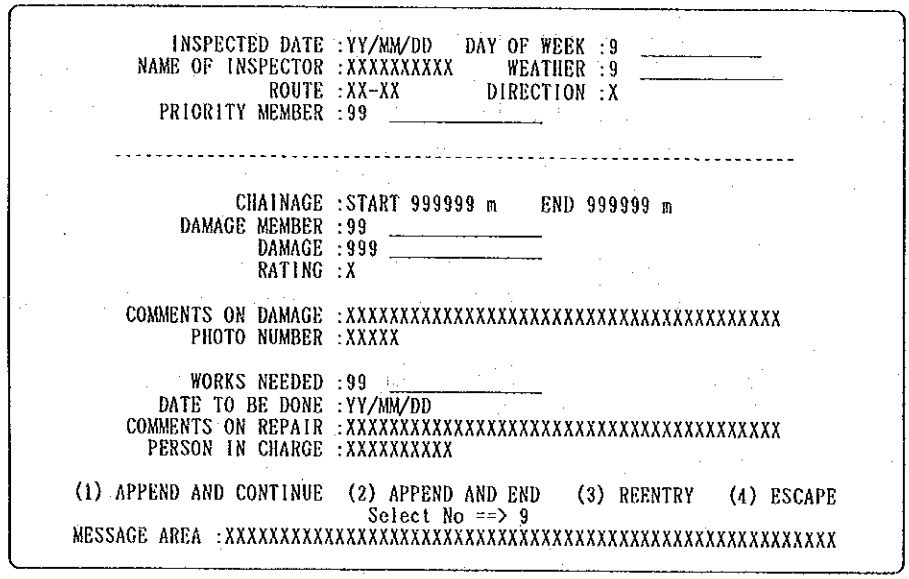

Figure-5.4.2 Screen Layout on Appending of Daily Inspection for the Land Section

5.5 Routine Inspection Database System

5.5.1 Database Files and Data Items

1) Land Section

The routine inspection database is designed to store information obtained by routine or temporary inspection work into a single database for the Land Section, in the same manner as that of the daily inspection database system. Therefore, data items of the routine inspection database are formulated to be capable of covering all objective members to be inspected by this inspection. Based on this, items of routine inspection database are determined as presented in Table-5.5.1.

In order to accommodate routine inspection data for all members, the number of items of this database file consists of thirty-four items in total, with thirteen key identifiers, sixteen attributive data and five control data for information processing. Essential data items to be inputted for each objective members are summarized in Table-5.5.2.

2) Rama IX Bridge Section

The routine inspection 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-5.5.3.

In this database file, the number of items is thirty-five in total: five items for key identifiers, twenty five for attributive data and five items for system control. The number of attributive data items is larger than that of the Land Section, for damage items of stay cables reaches sixteen items. Essential data items to be inputted for each objective members are summarized as shown in Table-5.5.4.

Table-5.5.1 Items of Routine Inspection Database File for Land Section

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Inspected Member	C	2	◎	○		CI:27
Inspected Date	N	6	◎	○		yy/mm/dd
Work Class	C	2	◎	○		CI:28
Route	X	5	◎	○		character in XX-XX
Direction of Traffic	X	1	◎	○		character in A, B, ··
Main Road/Ramp	C	1	○	○		CI:1
Chainage(Start)	N	6	○	○		999999 (m)
(End)	N	6	○	○		do.
Pier Number (Start)	X	10	○	○		character
(End)	X	10	○	○		do.
Contract Number	X	10	○	○		do.
Location Code 1	X	1	○	○		character in S, E, ··
Location Code 2	C	1	○	○		CI:14
Lane Number	X	1	○	○		character in E, 1, 2, ··
Pole Number	X	10	○	○		character
(Damage Conditions)						by judge table
Damage Item-1	X	1		○		character in A, B, C, D
-2	X	1		○		do.
-3	X	1		○		do.
-4	X	1		○		do.
-5	X	1		○		do.
-6	X	1		○		do.
-7	X	1		○		do.
Rutting Depth	N	2		○		99 (mm)
PSI	N	3		○		9.9
Total Evaluation	X	1		○		character in A, B, C, D
Comments	X	40				free comments
(Countermeasures)						
Works Needed	C	2		○		CI:29
Date to be Done	N	4		○		yy/mm
Repaired Date	N	6		○		yy/mm/dd by Repair DB
(Remarks)						
Name of Inspector	X	20				
Date of Data Inputted	N	6				yy/mm/dd by cpu
Documents Number	X	20				
(Flags)						
Code Check	N	1				
Ex. Indispensable Item	N	1				
Duplication	N	1				
Key CheckK	N	1				
	(Total 187)					

Table-5.5.2 Essential Items by Inspected Members in Routine Inspection for Land Section

DATA ITEM \ PARTS		SUPER STRUCTURE / RETAINING WALL	PIER	EMBANKMENT	PAVEMENT	GUARD WALL	DRAINAGE	EXPANSION JOINTS	BEARINGS	LIGHTINGS	TRAFFIC SIGN	NOISE BARRIER
KEY IDENTIFIER	INSPECTED MEMBER	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
	INSPECTED DATE	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
	WORK CLASS	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
	ROUTE NUMBER	◎	◎	◎	◎	◎	◎	◎	◎	○	○	◎
	DIRECTION OF TRAFFIC	◎	◎	◎	◎	◎	◎	◎	◎	○	○	◎
	MAIN ROAD/RAMP	◎	◎	◎	◎	◎	◎	◎	◎	○	○	◎
	CHAINAGE(START)	◎	◎	◎	◎	◎	◎	◎	◎	○	○	◎
	CHAINAGE(END)	◎		◎	◎	◎	◎					◎
	PIER NUMBER		○									
	LOCATION CODE 1								◎			
	LOCATION CODE 2					◎				○	○	◎
	LANE NUMBER				◎							
	POLE NUMBER									◎	◎	
DAMAGE CONDITIONS	DAMAGE ITEM-1	○	○	○	○	○	○	○	○	○	○	○
	DAMAGE ITEM-2	○	○	○	○	○	○	○	○	○	○	○
	DAMAGE ITEM-3	○	○	○	○	○	○	○	○	○	○	○
	DAMAGE ITEM-4	○	○	○	○	○	○	○	○	○	○	○
	DAMAGE ITEM-5	○	○		○	○				○	○	○
	DAMAGE ITEM-6										○	○
	DAMAGE ITEM-7										○	
	RUTTING DEPTH				○							
	PSI				○							
	TOTAL EVALUATION	○	○	○	○	○	○	○	○	○	○	○
	COMMENTS	○	○	○	○	○	○	○	○	○	○	○
COUNTER MEASURES	WORKS NEEDED	○	○	○	○	○	○	○	○	○	○	○
	DATE TO BE DONE	○	○	○	○	○	○	○	○	○	○	○
	REPAIRED DATE	○	○	○	○	○	○	○	○	○	○	○
REMARKS	NAME OF INSPECTOR	○	○	○	○	○	○	○	○	○	○	○
	DATE OF DATA INPUTTED	○	○	○	○	○	○	○	○	○	○	○
	DOCUMENTS NUMBER	○	○	○	○	○	○	○	○	○	○	○
FLAGS	CODE CHECK	○	○	○	○	○	○	○	○	○	○	○
	EX. INDISPENSABLE ITEM	○	○	○	○	○	○	○	○	○	○	○
	DUPLICATION	○	○	○	○	○	○	○	○	○	○	○
	KEY CHECK	○	○	○	○	○	○	○	○	○	○	○
TOTAL NUMBER OF DATA ITEMS		25	25	24	28	26	24	23	24	26	28	27

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

Table-5.5.3 Items of Routine Inspection Database File for Rama IX Bridge Section

Data Item	Type	Digits	Key	Extrct	Sum	Remarks
(Key Identifier)						
Inspected Member	C	2	◎	○		Cl:30
Inspected Date	N	6	◎	○		yy/mm/dd
Work Class	C	2	◎	○		Cl:28
Unit Number	X	6	◎	○		character
Lane Number	X	1	○	○		character in E, 1, 2, 3
(Damage Conditions)						
Damage Item- 1	X	1		○		character in A, B, C, D
- 2	X	1		○		do.
- 3	X	1		○		do.
- 4	X	1		○		do.
- 5	X	1		○		do.
- 6	X	1		○		do.
- 7	X	1		○		do.
- 8	X	1		○		do.
- 9	X	1		○		do.
-10	X	1		○		do.
-11	X	1		○		do.
-12	X	1		○		do.
Rutting Depth	N	2		○		99 (mm) for pavement
PSI	N	3		○		9.9 for pavement
Total Evaluation	X	1		○		character in A, B, C, D
Comments	X	40				free comments
(Countermeasures)						
Works Needed	C	2		○		Cl:29
Date to be Done	N	4		○		yy/mm
Repaired Date	N	6		○		yy/mm/dd by Repair DB
(Remarks)						
Name of Inspector	X	20				
Date of Data Inputted	N	6				yy/mm/dd by cpu
Documents Number	X	20				
(Flags)						
Code check	N	1				1: checked and OK
Exis. of Indisp. Items	N	1				do.
Duplication	N	1				do.
Key Check	N	1				do.
	(Total 141)					

Table-5.5.4 Essential Items by Inspected Members in Routine Inspection for Rama IX Bridge Section

DATA ITEM \ PARTS		MAIN GIRDER / PYLON / GUARD BARRIER / GIRDER GANTRY	PYLON LIFT / PYLON LADDER / PYLON GONDOLA / CABLE GONDOLA	STAY CABLE	PAVEMENT	PIER	DRAINAGE	PENDEL BEARING / NEO-POT BEARING / WIND BEARING	EXPANSION JOINTS	PYLON DAMPER / GIRDER DAMPER	LIGHTINGS
KEY IDENTIFIER	INSPECTED MEMBER	◎		◎	◎	◎	◎	◎	◎	◎	◎
	INSPECTED DATE	◎		◎	◎	◎	◎	◎	◎	◎	◎
	WORK CLASS	◎		◎	◎	◎	◎	◎	◎	◎	◎
	UNIT NUMBER	◎		◎	◎	◎	◎	◎	◎	◎	◎
	LANE NUMBER				◎						
DAMAGE CONDITIONS	DAMAGE ITEM- 1	○		○	○	○	○	○	○	○	○
	DAMAGE ITEM- 2	○		○	○	○	○	○	○	○	○
	DAMAGE ITEM- 3	○		○	○	○	○	○	○	○	○
	DAMAGE ITEM- 4	○		○	○	○	○	○	○	○	○
	DAMAGE ITEM- 5	○		○	○	○		○	○		○
	DAMAGE ITEM- 6	○		○				○	○		
	DAMAGE ITEM- 7			○							
	DAMAGE ITEM- 8			○							
	DAMAGE ITEM- 9			○							
	DAMAGE ITEM-10			○							
	DAMAGE ITEM-11			○							
	DAMAGE ITEM-12			○							
	DAMAGE ITEM-13			○							
	DAMAGE ITEM-14			○							
	DAMAGE ITEM-15			○							
	DAMAGE ITEM-16			○							
	RUTTING DEPTH				○						
	PSI				○						
	TOTAL EVALUATION	○		○	○	○	○	○	○	○	○
	COMMENTS	○		○	○	○	○	○	○	○	○
COUNTER MEASURES	WORKS NEEDED	○		○	○	○	○	○	○	○	○
	DATE TO BE DONE	○		○	○	○	○	○	○	○	○
	REPAIRED DATE	○		○	○	○	○	○	○	○	○
REMARKS	NAME OF INSPECTOR	○		○	○	○	○	○	○	○	○
	DATE DATA INPUTTED	○		○	○	○	○	○	○	○	○
	DOCUMENTS NUMBER	○		○	○	○	○	○	○	○	○
FLAGS	CODE CHECK	○		○	○	○	○	○	○	○	○
	EX.OF.INDIS.ITEM	○		○	○	○	○	○	○	○	○
	DUPLICATION	○		○	○	○	○	○	○	○	○
	KEY CHECK	○		○	○	○	○	○	○	○	○
TOTAL NUMBER OF DATA ITEMS		22		32	24	21	20	22	22	20	21

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

5.5.2 Coding Sheets for Routine Inspection

Design concepts on a layout form for coding sheets and report forms are presented below, and designed in such a way that it is possible to:

- provide separate coding sheets by inspected member for both the Land Section and the Rama IX Bridge Section,
- write inspected results on-site without inspection manuals, and to rate damages together with a code indicated on the coding sheet,
- input inspected results into database easily, for layout form of coding sheet is similar order to layout of computer screen,
- provide separate routine inspection reports by inspected member for both the Land Section and the Rama IX Bridge Section.

Eleven coding sheets for the Land Section and nine coding sheets for the Rama IX Bridge Section, which are used in writing inspection results on-site as below.

<Routine Inspection Coding Forms for Land Section>

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

<Routine Inspection Coding Forms for Rama IX Bridge>

Steel Plates and Frame Members (Steel General)
Stay Cable
Pavement
Piers
Drainage
Bearings (Pendel, Neo-Pot, Wind)