DEVELOPMENT OF BRIDGE MANAGEMENT SYSTEM IN THE REPUBLIC OF KOREA

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Abstract

Since the opening of Seoul-Inchon Highway in 1968, ten highways for a total length of 1,551km have been constructed, where 1,046 bridges were included with the total length of about 68km which is 4.4% of the total length of highways. Among the highway bridges, 781 bridges(75%) have been in service for over ten years and particularly 366 bridges (35%) in service for over twenty years.

Increasing of the number of deficient bridges made it difficult to manually monitor and keep maintenance records and special data of bridges and required the computerized management tool whereby all informations were stored and reported following requirements of managers.

The Bridge Management System(BMS) developed here consists of three subsystems;Data Base System(DBS), Rehabilitation & Replacement Priority Decision System(RRPDS), Maintenance & Repair Priority Decision System(MRPDS). In DBS are 110 manual input items and 14 automatic input items and ten kinds of annual report can be issued. RRPDS was developed to decide the priorities on rehabilitation and replacement of deficient bridges and can use twenty-one items from DBS with limiting condition algorithm when determine the priorities. MRPDS can determine the priori-ties on maintenance and repair of them.

The BMS was tested for 17 bridges from three highways. Test results were compared with the results given by the old manual system and it was proved to produce a similiar result. But the new system could prominently save the time and cost to make plans of maintaining deficient bridges.

1. Introduction

Since the opening of 24 km long Seoul-Inchon Highway, ten highways for a total length of 1,551 km have been constructed, which include 1,046 bridges with total length of 68 km (4.4% of total length of the highways), and three highways under construction.

Among ten highways three highways have been in service for twenty years and the others for ten years. With the number of aged highway increasing in Korea, the corresponding increase in deficient bridges have recently appeared to be large. Since the number of bridges to be maintained is increasing due to the expansion of the highway network, it is difficult to manually monitor and keep the maintenance records and specific data of all highway bridges. So the development of Bridge Management System(BMS) was required to carry out bridge maintenance tasks effectively with the limited budget. In 1987 BMS project began and was successfully completed in 1989.

2. In-Won Lee, Myung-Suk Bang, Byung-Suk Kim & Doo-Hyun Cho, "Developement of Bridge Management System in the Republic of Korea", *Proceedings of International Conference on Bridges & Flyovers,*

2. Status of highway bridges

Among the 1,046 highway bridges, 781 bridges (75%) have been in service for ten years. In Table I, the summary of highway bridges in Korea is shown.

Table I. Route and bridge type

Unit : m

Route Name	Steel brdg.	R.C. Brdg.	P.C. Brdg.	Others	Total
Seoul-Pusan HW	(67) 3,358	(172) 6,676	(87) 8,840	(3) 114	(329) 18,818
Seoul-Inchon HW	(1) 28	(14) 249	(22) 824		(37) 1,101
Honam HW	(17) 1,144	(99) 2,927	(54) 5,368		(170) 9,439
Yong-dong HW	(2) 80	(47) 1,060	(30) 3,408		(79) 4,548
Dong-hae HW		(13) 438	(12) 1,260		(25) 1,698
Nam-hae HW	(14) 4,081	(72) 1,580	(39) 4,709		(125) 10,370
Taegu-Masan HW	(4) 931	(22) 1,263	(19) 1,681		(45) 3,875
Ulsan HW		(9) 103	(3) 230		(12) 333
88 Olympic HW	(13) 1,957	(72) 2,259	(30) 4,291		(115) 8,507
Chung boo HW	(11) 1,606	(71) 3,347	(27) 4,819		(109) 9,772
Total Proportion (%)	(129) 13,415 12.5	(591) 19,902 56.2	(323) 35,030 31.0	(3) 114 0.3	(1046)(8,461 100.0

* Note : HW = Highway ( ) = Bridge Number

2.1 Types of Bridges in service

Highway bridges shown in Table I consist of the following three types ;

- Steel Bridge 12.5 %
- Reinforced Concrete(R.C) Bridge 56.2 %
- Prestressed concrete(P.C) Bridge 31.0 %

While over 50% of the bridges are R.C type, P.C type constitutes 51% of the total bridge length. The portion of steel bridge is small in Korea. To investigate the type of superstructure, the bridges on Seoul-Pusan Highway, the main transportation corridor in Korea, are assorted as follows ;

- Steel Bridge 20.3 % (67 bridges, 3,588 m)
- R.C Bridge 52.3 % (172 Bridges, 6,676 m)
- P.C Bridge 26.4 % (87 bridges, 8,440 m)

About 96% of the steel bridges are girder type. Also 85% of R.C bridges and 100% of P.C bridges are girder type. In terms of bridge length, 88.7% of all bridges are less than 100m long and the remainder are longer than 100m. This features are shown in Fig. 1.

2.2 Change in Design Load

Before the year 1978, design load for the first class bridge was DB-18 ton(HS-20 in U.S.A.). However, trucks have been larger and heavier owing to the rapid industrialization. To accommodate this situation, design load for the first class bridge was changed to DB-24 ton (HS-26 in U.S.A.) and was specified in the

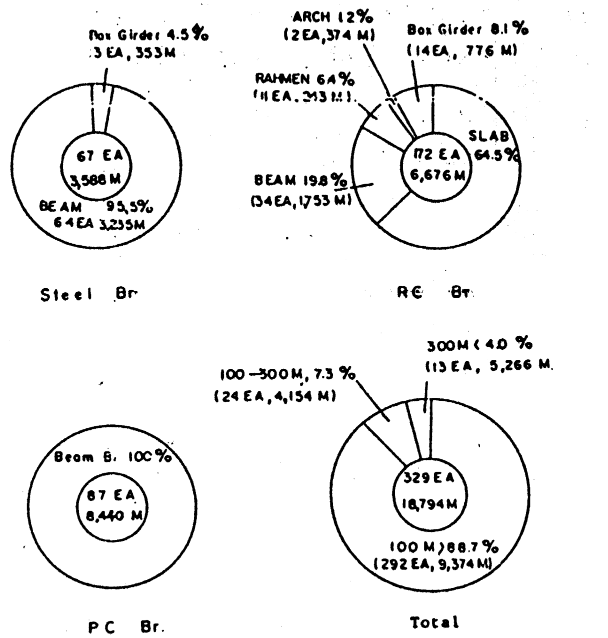


Fig 1. Proportion, number, and length of bridge by type of superstructure

Standard Design Specification for Highway Bridges. Table II shows bridge construction during last 20 years.

Table II. Bridge construction by period of construction

Period (Year)	'68	'69-'73	'74-'78	'79-'83	'84-'88	Total
Length of the HW (Km)	24.0	870.6	317.3	20.6	319.0	1,551.5
No. of Brdgs	37	612	132	74	241	1,046
Bridge length (m)	1,101	35,532	8,958	3,381	19,489	68,461
Proportion (%)	4.59	4.08	2.82	16.41	6.11	4.41
Design load	DB 18	DB 18	DB 18	DB 18	DB 24	

* Note : DB 18 equal to HS-20, DB24 equal to HS-26

Except for the bridges replaced in recent years on Seoul - Pusan highway, most of original bridges need the restriction of heavy-weight traffic since they were designed according to the DB-18 ton which now becomes design load for second class bridges.

2.3 Traffic Volume

Figure 2 shows the highway map and traffic volume in Korea. Average increases of the traffic volume per year were 20% for cars, 12.5% for buses, and 9% for trucks.

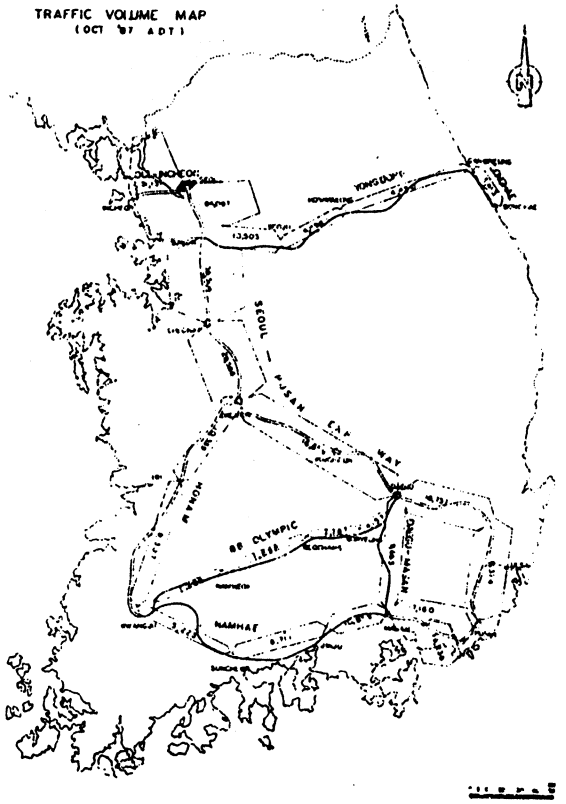


Figure 2. Highway and traffic volume map

2.4 Bridge Inspection

Bridge inspection should be carried out 4 times a year. Table III describes contents of bridge inspection and Figure 3 shows the flow chart of inspection procedure.

Table III. Contents of bridge inspection

Item	Frequency	Apparatus	Inspector	Methodology
Regular Inspection	2 times/yr	. Binocular . Inspection vehicle . Crack gauge . Shmidt hammer . Camera	Structure inspector	. Inspection note & bridge inspection manual . Review of regular maintenance plan
Inspection of the bridges with potential problems	2 times/yr			. Classification of the bridges with significant defect as the structure with potential problems to be observed . Examination of repair & rehebilitation plan

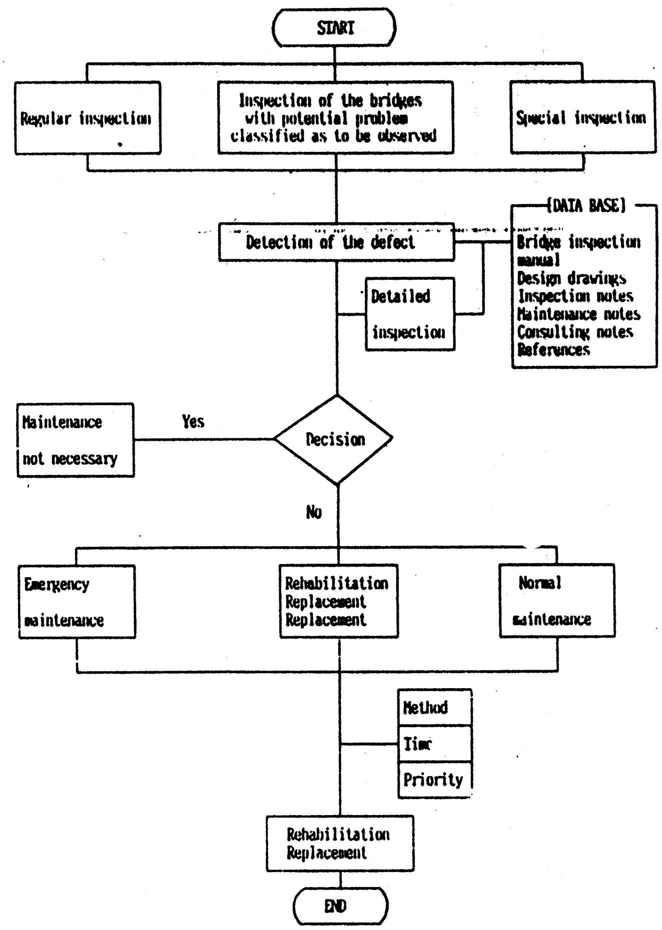
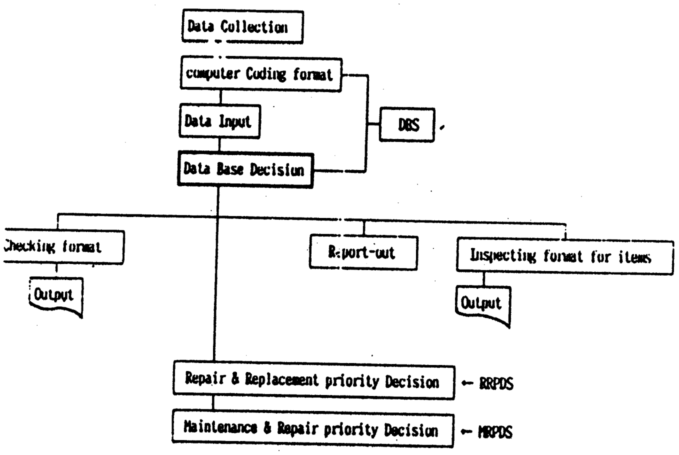


Figure 3. Flow chart of bridge inspection

3. Bridge Management System (BMS)

The Bridge Management System (BMS) developed here consists of three subsystems ; Data Base System(DBS), Rehabilitation & Replacement Priority Decision System (RRPDS), Maintenance & Repair Priority Decision System(MRPDS). The following flow chart shows the bridge management procedure under BMS(Fig. 4).

3.1 Data Base System (DBS)



igure 4. Flow chart of bridge management procedure

The DBS consists of 110 manual input items and 14 automatic input items. These items are assorted into next groups and duplicately used in several groups (Fig 5.) ;

- Basic Date (36 items)
- Intersection Condition Data (20 items)
- Structural Data (20 items)
- Investigation & Evaluation Data (16 items)
- Investigation Opinion Data (3 items)
- Maintenance Method (9 items)
- Maintenance Record (12 items)
- Maintenance & Repair Priority Data (11 items)
- Rehabilitation & Replacement Priority Data (21 items)

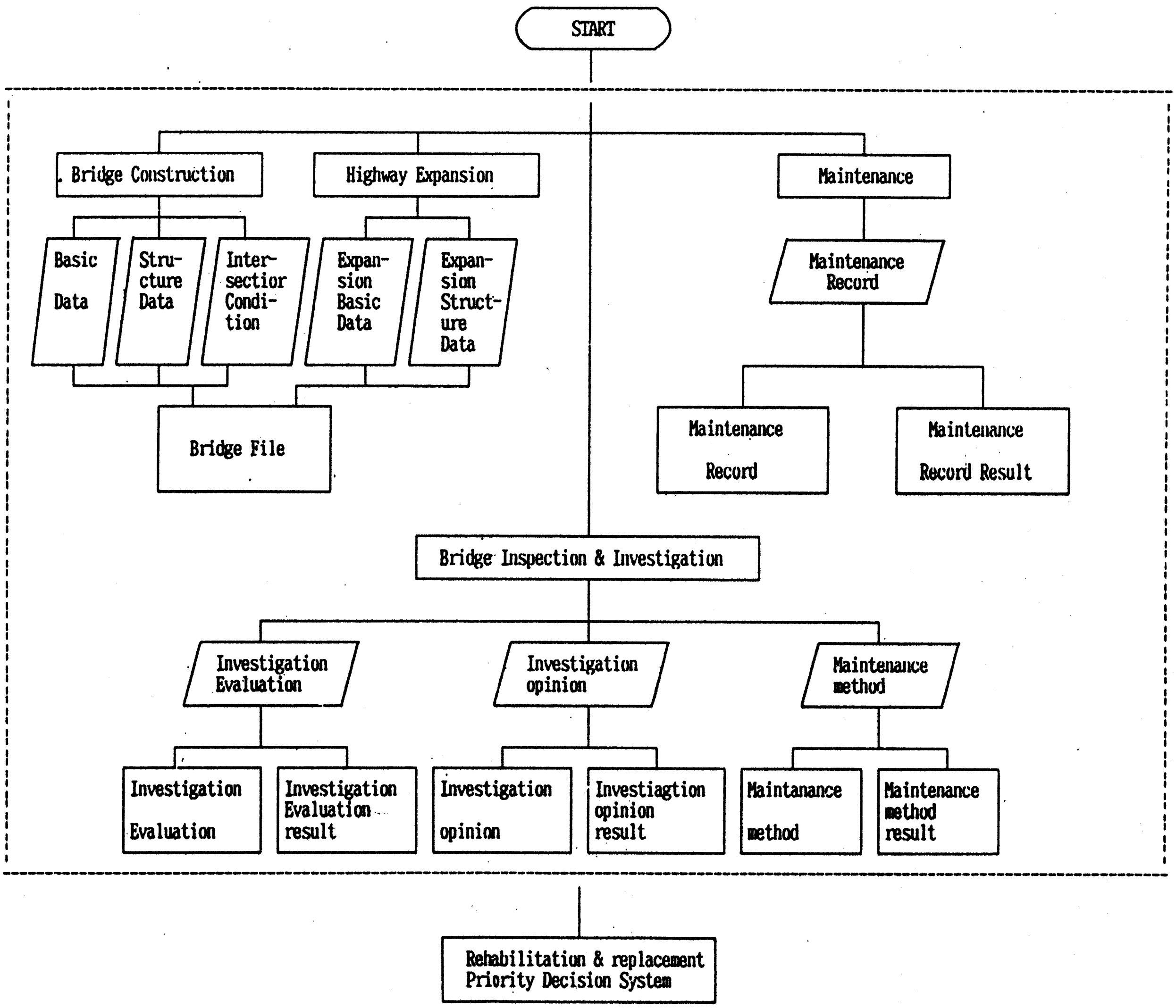


Figure 5. Data group of DBS

3.2 Rehabilitation & Replacement Priority Decision System (RRPDS).

The RRPDS is a kind of decision-making system and its aim is to rationally decide the rehabilitation and replacement priority of deficient bridges. Table IV shows deficient points of items considered in deciding the rehabilitation and replacement priority.

Table IV. Items and deficient points in RRPDS.

Items				Points for defects					Total points
		Pavement		4		30	40	60	100
		Drainage		2					
		Railing, Curb		2					
		Slab	Crack	12	20				
			Deterioration	12					
		Exp. Joint	Damage to joint Body	6	8				
			Damage to joint mortar	4					
		GIRDER Conc.	Crack at supports	10	20	30			
			Crack at midspan	10					
		GIRDER Steel	Deflection	5	20				
			Relaxation of bolt	5					
			Surface condition & corrosion	10					
		Shoe			8				
		Pier & Abutment	Crack		12	24			
			Scour, settlement		12				
	Safety	Load carrying capatity				25	30		
		Stability				10			
Functional Fitness	Accessness & alignment					10	20	40	
	Clearance					15			
Maintainability							10		
Importance of traffic							10		

Figure 6 shows the decision procedure, issued reports, and output file using RRPDS.

3.3 Maintenance & Repair Priority Decision System (MRPDS)

The MRPDS can decide the priority on elements and components of bridges which need the daily maintenance and low-cost repair. Table V shows considered items and their deficient points in deciding the priority.

Table V. Items and points in MRPDS.

Maximum Points		Items		Class	Points
25		Maintenance Activity Ranking		E D C B A	25 20 15 10 5
40		Maintenance Activity Urgency		E D C B A	40 30 20 10 5
25	10	Bridge Adequacy	Current Condition Class	*	*
	15		Load Carrying Capcity	*	*
10	4	Bridge Criticality	Traffic Control	C B A	4 2 0
	6		Effectiveness of Repair	C B A	6 3 0

* Data converted from RRPDS

The evaluating criterions and ratings of each item are explained in detail.

- Maintenance Activity Ranking - The bridge maintenance activities themselves vary in their importance to and effect on the structural integrity of the bridge. The activities have been devided into groups based on their generalized relative importance to the structural stability of the bridge.
- Maintenance Acivity Urgency - The severity of a deficiency can be a reason to increase its priority for repair. It yields an informed, humanized assessment of how soon the work needs to be completed.
- Bridge Adequacy - The capability of the bridge to safely carry the loads that traverse the route and to continue to do so, weight in a manager's decision of whether or not repairs should be implemented. The current condition rating of the most critical component can be used to generally assess the degree of degradation. The load capacity rating indicates the current strength of the bridge.
- Bridge criticality - The importance of a bridge to the road network as well as the impaction of the loss of bridge service to traffic are considered in deciding the priorty in which bridges are to be repaired. The assessment of the importance of the bridge is based on the classification of the highway, its Average Daily Traffic(ADT), and the detour length. Maintenance effect means the degree of upgrading the capability of deteriorated bridges.

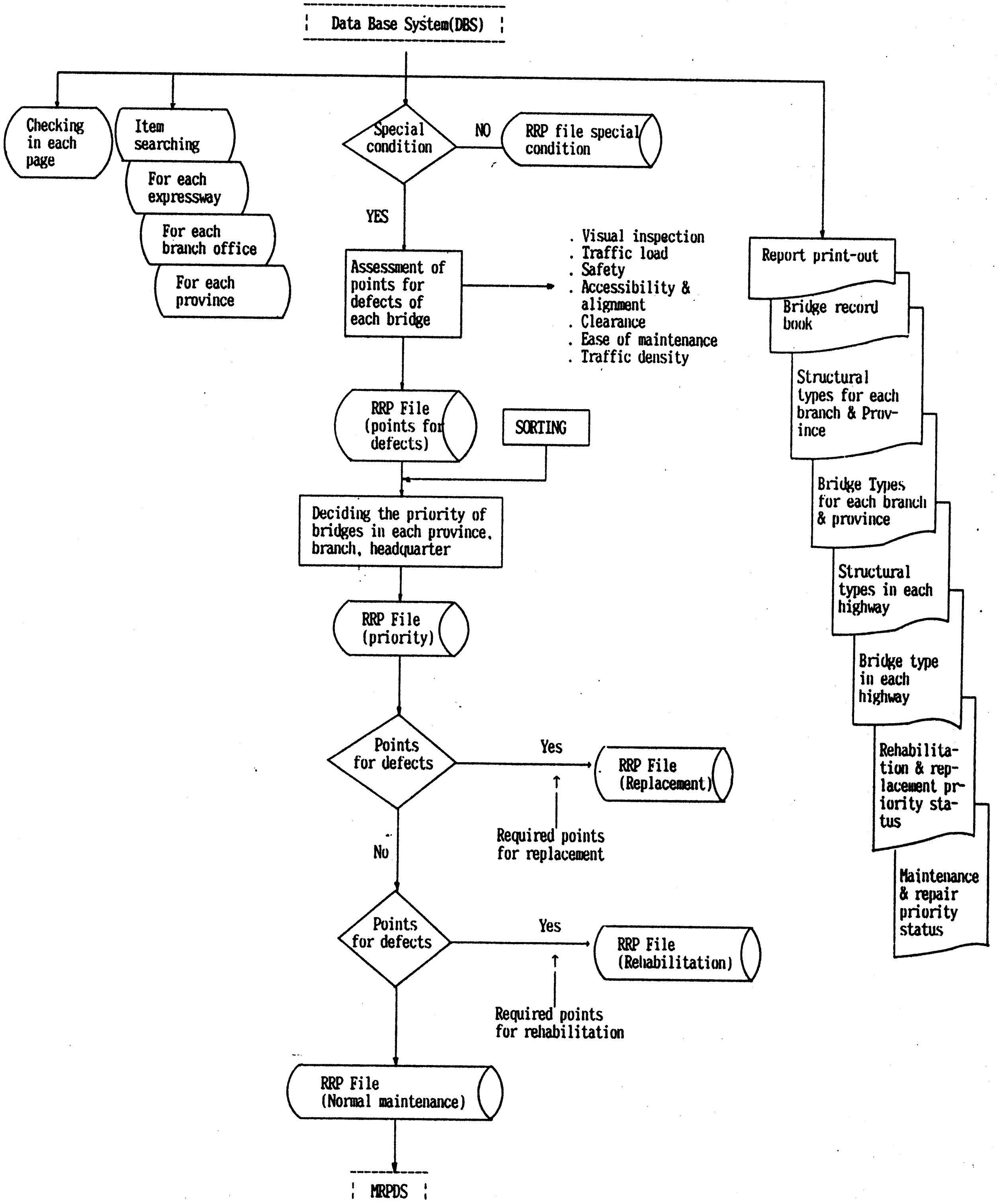


Figure 6. Flow chart of RRPDS.

4. Test Operation

The BMS has been tested for 17 bridges from three highways to check its performance. Table VI shows the details and resolved priorities of tested bridges.

Table VI. Data of tested bridges

Name	Length (m)	type	Height (m)	No. of span	D.P.	Priority
1	54	I - Beam	4.0	4	19.73	15
2	15	I - Beam	3.8	1	32.30	12
3	26	R.C.Rahmen	5.82	2	16.65	16
4	276.47	Plate Girder	17.0	6	45.35	6
5	75	Slab	3.8	6	27.31	13
6	25	P.C. Beam	4.2	1	61.90	1
7	120	T - Beam	4.0	6	49.23	5
8	39	Slab	5.2	3	51.30	4
9	330	P.C. Beam	11.9	9	37.96	10
10	52	T - Beam	6.0	3	38.90	8
11	46	R.C.Rahmen	5.1	3	23.05	14
12	60	I - Beam	4.4	4	34.11	11
13	100	P.C. Beam	4.65	5	44.06	7
14	39	Slab	4.4	3	58.10	3
15	62	P.C. Beam	8.9	3	38.70	9
16	30	T - Beam	6.0	1	60.80	2
17	64	Box Girder	6.4	3	0.0	17

D.P. = Deficient Points

The maintenance priority given by BMS corresponds to the results given by the old manual system. The time savings produced by this system are prominent compared with that of the former system.

5. Conclusion

A computerized Bridge Management System has been successfully implemented in Korea. The system's ability to estimate the future bridge maintenance and to prepare the repair schedule will enhance the country's long range and strategic managing capabilities.

Acknowledgements

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