Web-based Database System for Bridge Management Systems

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Summary

Careful maintenance is essential to ensure the long-term serviceability of bridges. It is therefore necessary to establish a database which has a large capacity for storage of time-series data including structural properties at construction completion, inspection records, and repair and maintenance records, and which utilizes state-of-the-art information and telecommunication technologies to allow such data to be retrieved anytime and also anywhere [1]. This paper outlines a web-based database system developed in response to this demand. Utilizing data telecommunication technologies such as the Internet and cellular phones which are rapidly becoming prevalent, the system is designed to facilitate bridge maintenance in a cost-effective manner [2].

1. Introduction

In Japan, due to factors such as the increasing volume of traffic, increasing weight of road vehicles, and structural aging, the number of deteriorated bridges is increasing in recently. As a result, the cost of maintaining these bridges is also increasing. Thus, the maintenance of these bridges has become a major social concern. Therefore, it has become necessary to develop a practical Bridge Management System (BMS). The authors have for some time been developing a bridge management system, which is so-called the Japanese Bridge Management System (***J-BMS***) with Yamaguchi-prefectural government, etc. in Japan.

The J-BMS evaluates the performance of the bridge members using the inspection data and technical specifications of the target bridge. This evaluation is performed using a program referred to as the Bridge Rating Expert System (***BREX***) integrated in the J-BMS, which is also currently being developed by the authors. The outputs of this evaluation include soundness scores for load-carrying capability and durability, which are given on a scale of 0-100. Then, based on the results of the BREX, the present degree of deterioration is characterized and the remaining service life of the target bridge is estimated using a deterioration prediction function. If the present remaining service life calculated by the J-BMS does not exceed the expected service life of the target bridge, a maintenance strategy is generated by considering the costs and effects of repairs and strengthening. The strategy includes various maintenance plans based on cost minimization or quality maximization. Furthermore, the J-BMS, as shown in Figure 1 has a database system, which stores data such as technical specifications, traffic volume and inspection results for evaluation and maintenance planning of target bridges. However, J-BMS had only worked on a personal computer located in a limited place, because the system was stand-alone type.

On the other hand, information technology (IT) revolution is currently taking the world by storm. The IT revolution and then apply them to more sophisticated, strategic technology development. Then, the aim of this study is to develop a practical Web-based Database System for the Bridge Management Systems by using Internet. In the Web-based Database System, because it is applied a client server model, Database server and Web server are set up in the prefectural main-offices. As a result, the development of the system enables system users to utilize not only the J-BMS in branch-

office but also the BREX in bridge site. For instance, it is easy for system users to refer data such as inspection results and technical specifications of a target bridge in the branch-offices. In bridge site, after visual inspection of the target bridge, by getting some data such as technical specifications from the Database server located in a main-office, system users are able to evaluate the performance of he target bridge using the BREX.

2. System Description

Figure 2 shows the general structure that all users can easily access the same web-based database system which is designed to allow the viewer to browse various data on existing bridges on-line: such as inventory data, inspection records, photographs, drawings, etc. This system functions on a client-server basis, with the bridge supervisory office on the server and the front-line offices directly in charge of bridge maintenance on the client computers. All data on existing bridges, including inventory data, inspection records, and repair and retrofit records, are centrally maintained and controlled in the database. The data are transmitted to each client's computer via the web server and the Internet. In addition, since the database is connected to the Internet, the all users can retrieve necessary data not only at an office but also at home or on the move. This allows any person carrying a portable information terminal, such as a cellular phone and a notebook-sized personal computer, to access to the database while working outside (e.g. patrol, inspection, and on-site activities). Theoretically, the all users of this system can quickly retrieve necessary data anytime and also anywhere in the world, which will greatly improve the efficiency of bridge maintenance.

3. System Applications and Discussion

This section explains the procedure for using the system by referring to the examples of the web pages. Figures 3 to 6 show the examples of images which appear on the browser screen when using the database. What is shown on the left of the browser screen in Figure 3 is the data entry box for retrieving bridge information stored in the database. The system offers three options for searching the information: bridge name search, bridge register number search, and multiple word search. Figure 3 shows the browser screen for multiple word search. Entering necessary information in the box on the left finds all bridges in the database that completely match the information input. A list containing the data for such bridges then appears on the right side of the screen. By clicking the button "***Go!***" in the rightmost "more information" column of the list, the users can browse a page as shown in Figure 4 which contains the detailed inventory information of the bridge selected. The information on the browser screen in Figure 4 includes administrative data; major inventory data; superstructure data; abutment data (including data on the footing and the foundation & soil below); pier data (including data on the footing and the foundation & soil below); hand rail data; expansion joint data; falling prevention restrainers device (earthquake) data; paint data; and data on miscellaneous items such as pavement and secondary structural members. In addition, the users can browse the photographs and drawings, inspection records, and construction work records of the selected bridges by clicking the corresponding button.

Figure 5 is an example of the browser screens showing image data such as photographs and drawings, and Figure 6 that of the browser screens showing inspection records. When clicking the "Inspection Records" button in the screen in the Figure 4, a list showing the dates of inspections for the bridge appears. Selecting one of the dates displays a list showing the number of each span inspected on that day. The user can further browse the data on the type and details of the defect detected during the inspection by selecting one of the spans. The remarks column provides information on the findings during the inspection.

As mentioned above, the web-based database system has many useful functions to facilitate bridge maintenance which is expected to increase in the future. However, there are two major problems to be overcome to better improve the usability of the system:

1) Connected to the Internet, the database system can be accessed by any user carrying a cellular phone or PHS. However, it is difficult at the moment to utilize this system in mountainous areas

where many bridges are constructed, since cellular phones and PHS may not properly work and using other telecommunication means is necessary in such places.
2) Establishing a strict security system is necessary to prevent illegal data conversion and unnecessary data disclosure, since the database is disclosed worldwide on the Internet.

4. Conclusion

This paper briefly described the contents of a web-based database which was develop using information technologies (IT) to store various data necessary for bridge maintenance (e.g. technical knowledge, inspection records, diagnosis results, and information on measures taken after inspections), and to provide engineers in the world with such data for facilitating bridge maintenance. Connected to the Internet, this web-based database will help many bridge maintenance engineers with the search, reference, and retrieval of the data.

References

[1] B. Lassen: Web-based Management Systems, Proceedings of 16th Congress of IABSE, Lucerne, 2000(CD-ROM), pp.1-10, Sept. 2000.9.
[2] S. Kanba et al.: Development of Database System for BMS (Bridge Management System), Journal of Civil Engineering Information Processing System in 1999, Vol.8, The Civil Engineering Information System Committee of Japan Society of Civil Engineers (JSCE), pp.167-174, Oct. 1999 (in Japanese).

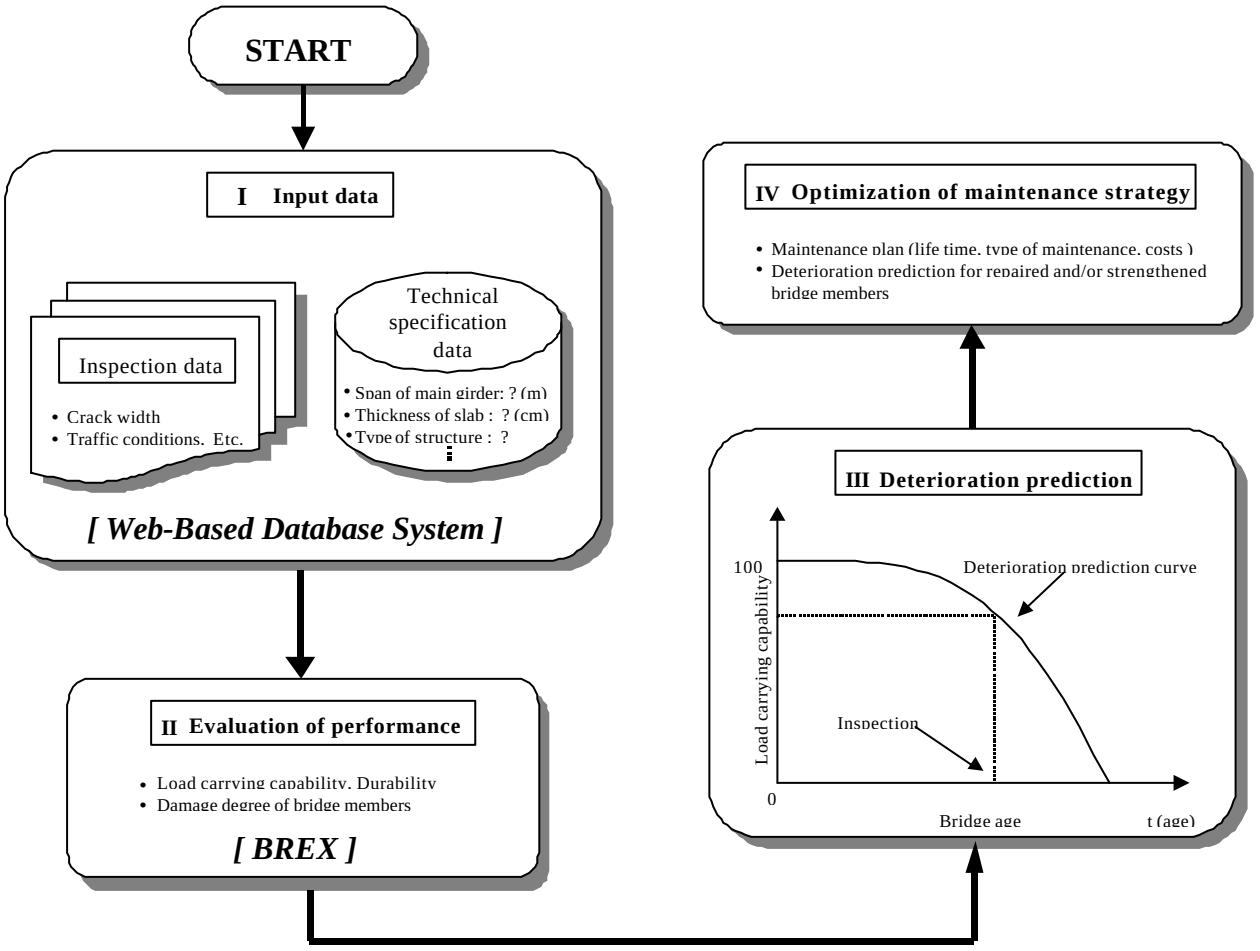


*Fig. 1 Flowchart of **J-BMS***

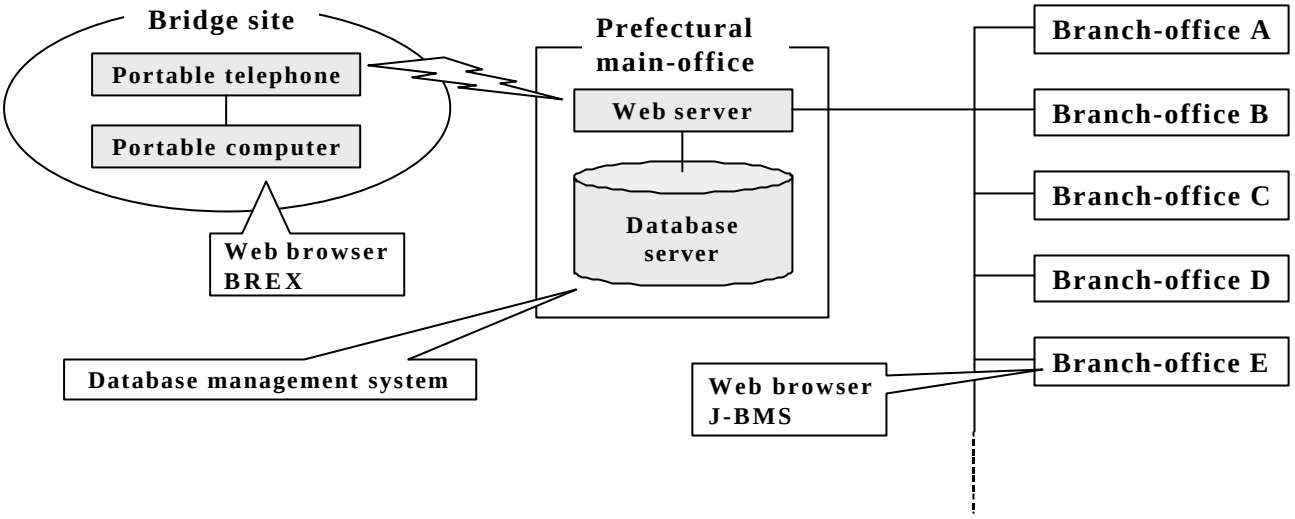


Fig. 2 Conception of Web-based Databases system for bridge management systems

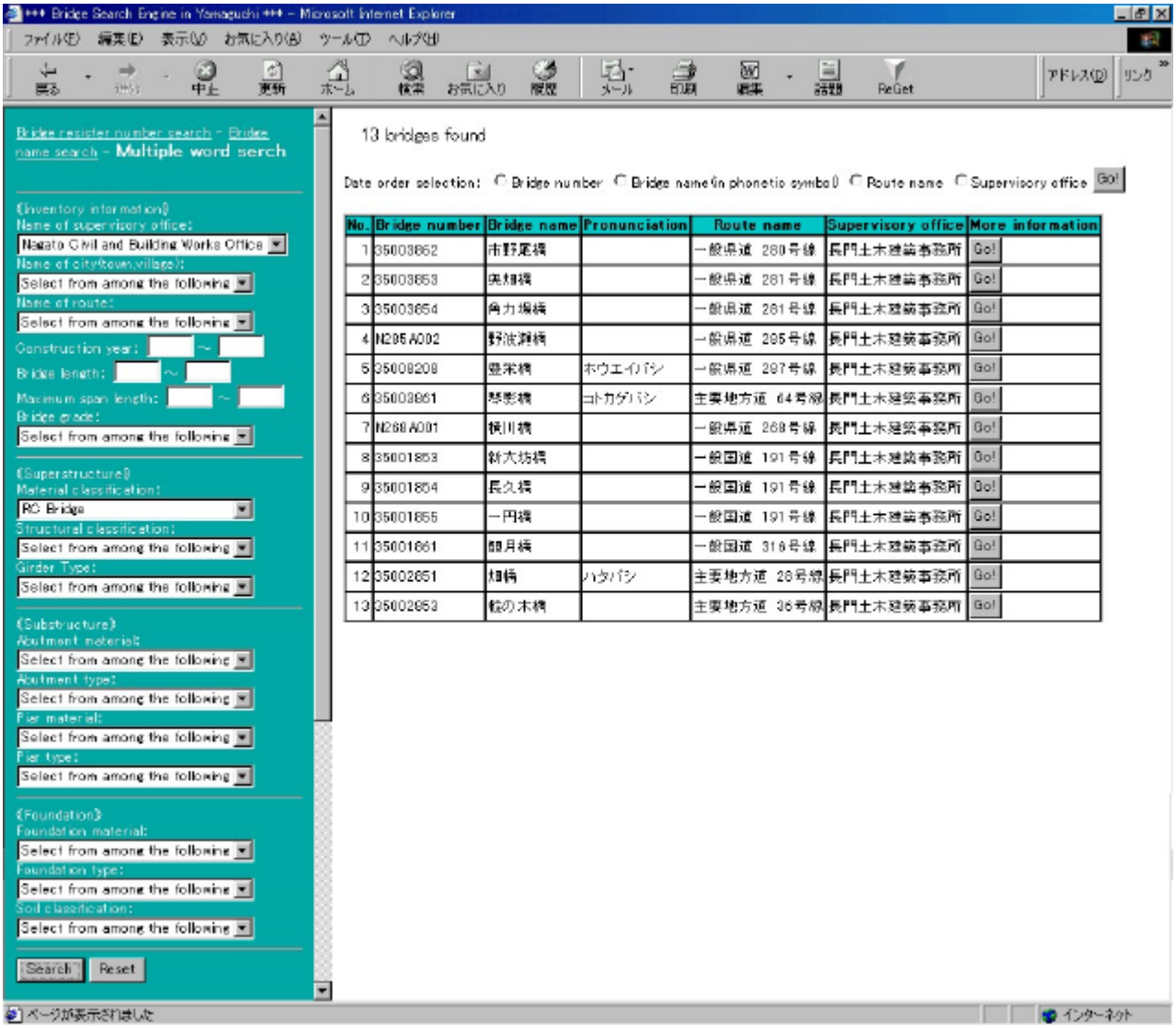


Fig. 3 Data entry box (left) and search result list (right)

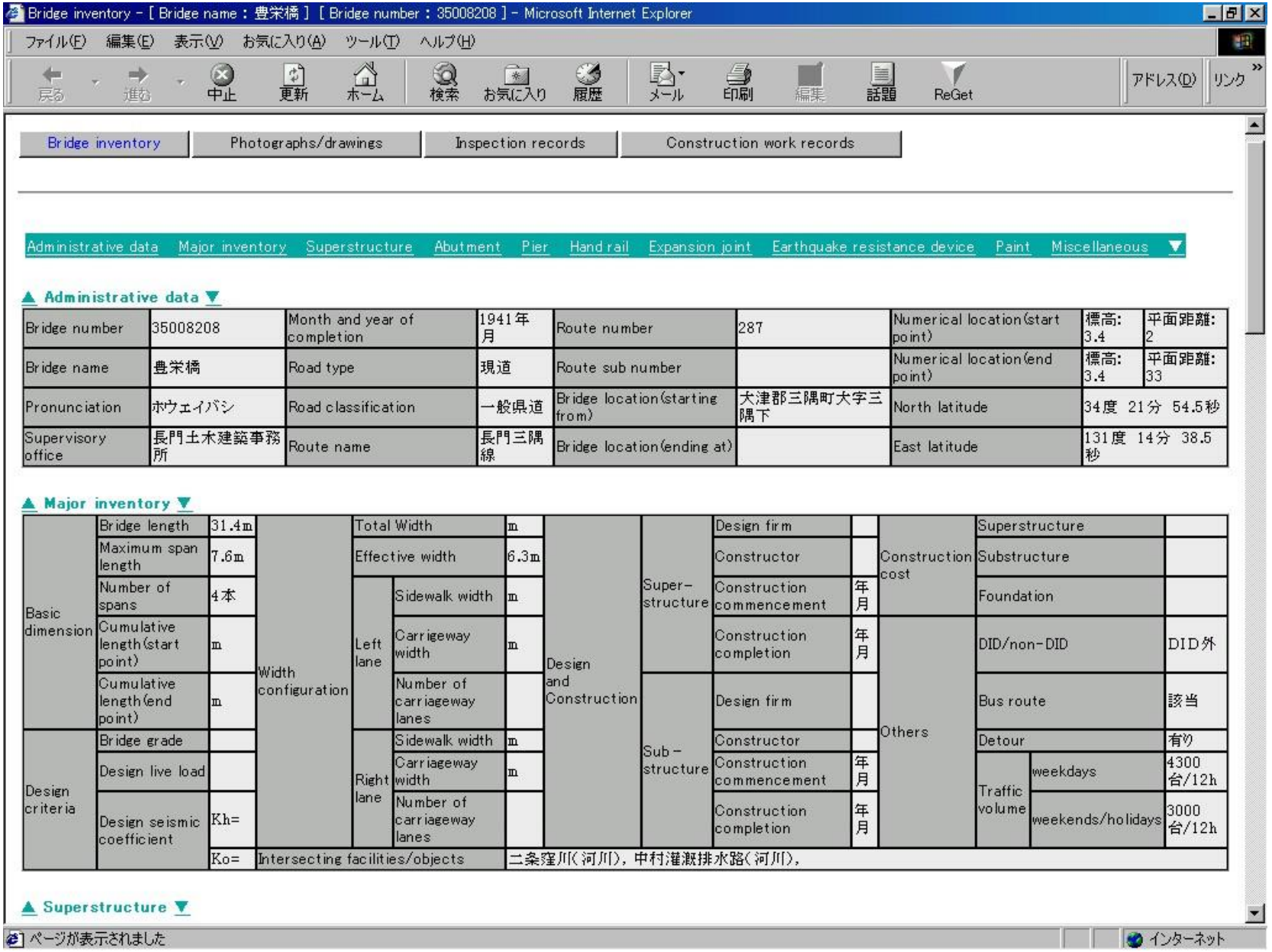


Fig. 4 Browser screen for bridge inventory data

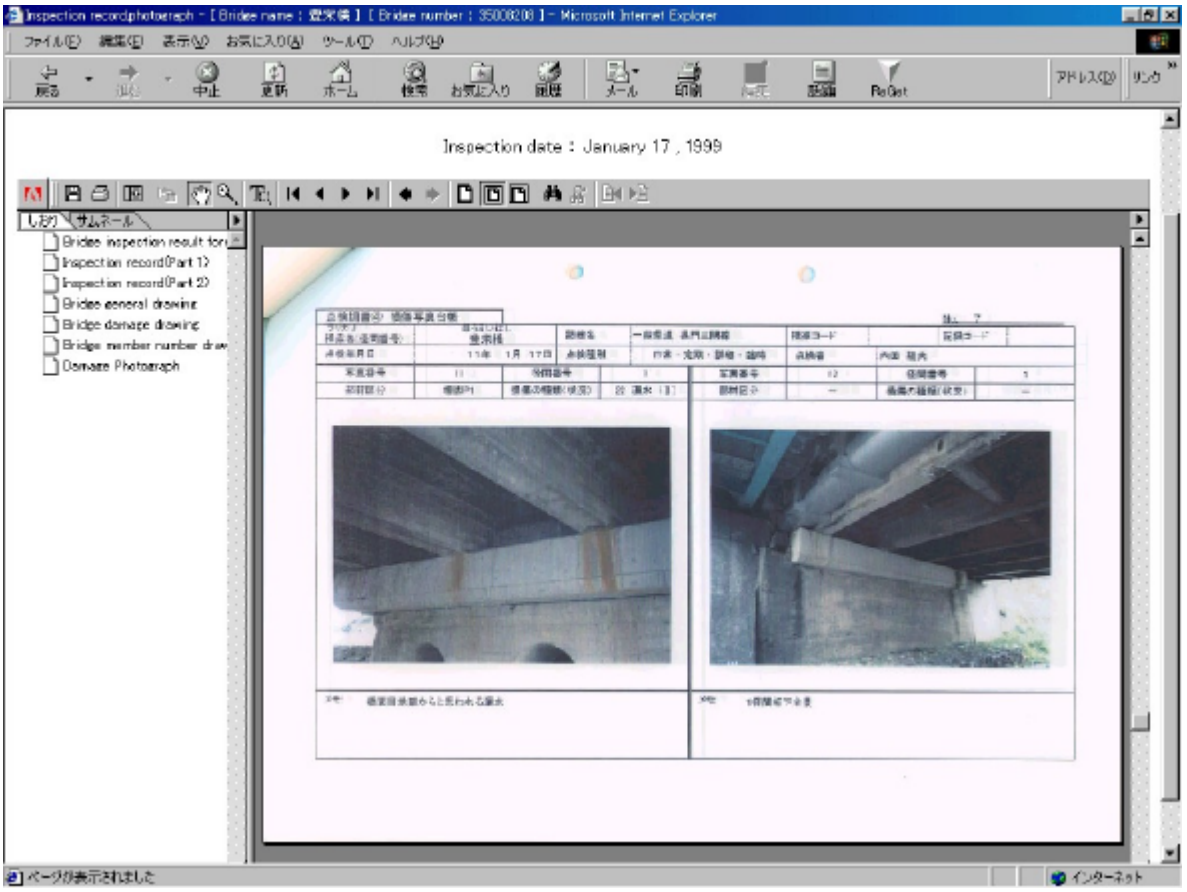
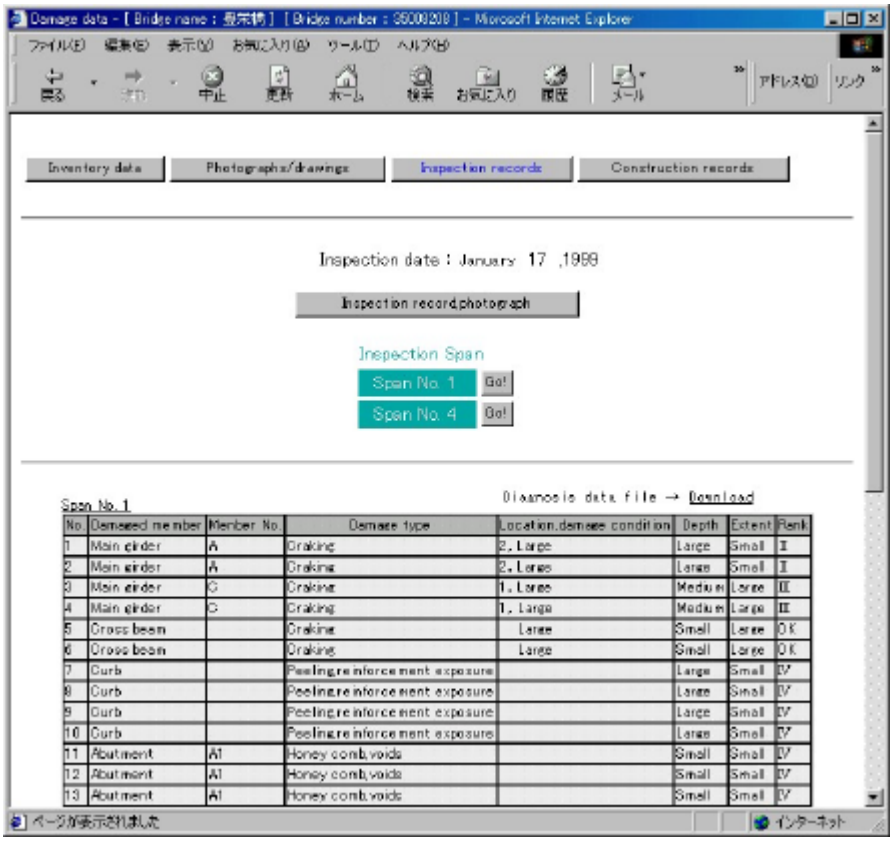


Fig. 5　Screen for browsing photographic images



No	Damaged member	Member No.	Damage type	Location,damage condition	Depth	Extent	Rank
1	Main girder	A	Craking	2, Large	Large	Small	I
2	Main girder	A	Craking	2, Large	Large	Small	I
3	Main girder	C	Craking	1, Large	Medium	Large	III
4	Main girder	C	Craking	1, Large	Medium	Large	III
5	Cross beam		Craking	Large	Small	Large	OK
6	Cross beam		Craking	Large	Small	Large	OK
7	Curb		Peeling,reinforcement exposure		Large	Small	IV
8	Curb		Peeling,reinforcement exposure		Large	Small	IV
9	Curb		Peeling,reinforcement exposure		Large	Small	IV
10	Curb		Peeling,reinforcement exposure		Large	Small	IV
11	Abutment	A1	Honey comb,voids		Small	Small	IV
12	Abutment	A1	Honey comb,voids		Small	Small	IV
13	Abutment	A1	Honey comb,voids		Small	Small	IV

Fig. 6　Inspection data screen