

# **A STUDY OF MAKING A DATABASE FOR THE DETERIORATED CONCRETE BRIDGES**

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## **ABSTRACT**

*There are many reports of deteriorated structures in mega cities of Asia due to imperfections of design standards and inadequacy of construction management and maintenance. In the near future, there are many structures needed for maintenance simultaneously. In this study, we made a concept of a database of deteriorated concrete bridges in metropolitan area of Japan. This database includes some information such as locations of bridges, year of construction and degree of deterioration. Also there are many photos and the results of non-destructive tests such as digital still camera and thermal camera. In order to inspect the deteriorated concrete bridges, we used “the inspection software for deteriorated concrete structures” which is produced by IIS. In this paper, we introduce this software and apply to the deteriorated concrete bridges. As a result, we can recognize the cause and degree of deterioration.*

## **1. INTRODUCTION**

It is a very big problem that the current infrastructures of developing countries in east-Asian and south-east Asian are weakened because of incomplete design standard, inadequate construction managements and maintenances. It is clear that the structures are destroyed by a declination of concrete durability, not by an earthquake. There are many infrastructures that quality of concrete and structures are problems in those countries. Moreover, those structures were built at the same time during the growing economy. That means it is clear that we should be faced with a lot of problems at the same time in near future. Therefore, we have to make a solution for these problems. Otherwise it is clear that we have a big damage for society and economy of Asia.

We need to make a database for regional data about structures, environments and so on to establish a solution for those problems. In this research, we make a database experimentally about concrete bridges, which are 9 bridges located in metropolitan area as an object of this study. At first, we considered the items for a database. Then, we checked a data of maintenance for investigate structures including a visual inspection, digital still camera and thermograph.

## 2. STUDY FOR ITEMS ON DATABASE

We have to clear that how to use the collected information for studying items by database. In this research, we approach investigation of weak points on concrete structures by using database. The aim of this research is to forecast the period of structural dangers in Asian big city in the future. So for making the database of the existing concrete bridges, we decided to collect data about the existing area of structure, the type of structure, information of deterioration and history for maintenance.

Table 1 shows the minimum items for making database on this research. We don't need to use the scaffold for investigating structures in order to get all items in this research.

*Table 1: The necessary items for making database*

Classify	Items
Information of structure	Year of construction
	Type of structure
Location of structure	Existing location
	Surrounding condition
Maintenance	Deterioration
	Cause of deterioration
	Evaluation of deterioration
	History of maintenance
Photos	Surrounding condition
	View of the structure
	Deteriorated spots
	Thermograph

## 3. METHOD FOR COLLECTING DATA FOR DATABASE

### 3.1 Outline

#### 3.1.1 *Information of structure*

We can get the planning book at constructing time. According to this book, there are year of construction and type of structure. Sometimes we can identify used materials and mix proportion. If it is possible to get some cored samples from existing concrete structures, we can do the tests to estimate mix proportion and chemical constituent. Finally, we can include these data in the database.

#### 3.1.2 *Location of structure*

It is important that the location of structure should be added into the map using by GPS and so on. It is good relationship between the location and environmental condition. So, it is useful that we understand the location of structure for determining the deterioration causes. And it is possible to make the hazard map for estimating risky area.

### 3.1.3 Maintenance

It is necessary to get the deteriorations and to estimate the deterioration level on maintenance. However, it is difficult for people who do not have any special knowledge. So, we need many people who are specialists in maintenance of deteriorated concrete structures to investigate many structures. However, we use “the inspection software for deteriorated concrete structures” which is developed by IIS committee in this research. We explain this software later in section 3.2.

### 3.1.4 Photos

We use digital still camera and thermograph for recording the structures. The digital still camera can record the view of the structures, surrounding conditions and deteriorated spots. The thermograph can record the deteriorated spots. We explain these methods in section 3.3.

## 3.2 Inspection software for deteriorated concrete structures

This system was developed by the concept that inexperienced engineers can easily diagnose and indicate necessities for the detailed inspections through a visual check. The software should also enable user to refer to many samples of deterioration patterns and to the structure types when clear diagnosis cannot be made. The causes and levels of deterioration are determined by the software, based on the data collected during the visual inspection. In this process, the inspection methods already been listed in the database are deduced automatically related to the causes. Finally, the current condition and the result of diagnosis are stored part-by-part for each inspected structure so the history of inspection can also be traced. The table 2 and 3 show the items for input data and output data.

Table 2: Input data on inspection software

<b>Basic data</b>	A	Environmental conditions	Area for corrosion of steel, Advanced area of carbonation
		Accidental conditions	Fire, earthquakes
		Internal (construction, materials) conditions	Construction site, condition of materials
	B	Structural conditions	PC bridges, RC bridges
<b>Current conditions</b>	C	Deterioration regarding cracks	Crack width, direction of cracks, corrosion of steels
	D	Deteriorations with cracks	Spalling, separation, exposure of steel
	E	Deteriorations other than cracks	Honeycomb, Cold joint, Gel, Scaling

Table 3: Output data on inspection software

Deteriorated causes	Primary defects	Damage
Carbonation Salt supply Use of sea sand Freezing and thawing damage Chemical attack Alkali-aggregate reaction Fatigue	Drying shrinkage Thermal stress Lack of section Improper grouting Loss of pre-stress Lack of concrete cover Improper curing Loading at young age Improper compaction Improper construction joint Defect of mix proportion or material	Over loading Collision Earthquake Uneven settlement Fire

### 3.3 Digital still camera and Thermograph

The digital still camera has been used for recording the inspected results, such as distribution of cracks and honeycombs that can be seen by visual inspection. The photographs taken by the digital still camera can be easily mounted on a computer and as shown in Photo 1, the distorted portion can be modified, especially the corners of photograph. Also, the results of other inspected data can be easily mounted on the photograph.

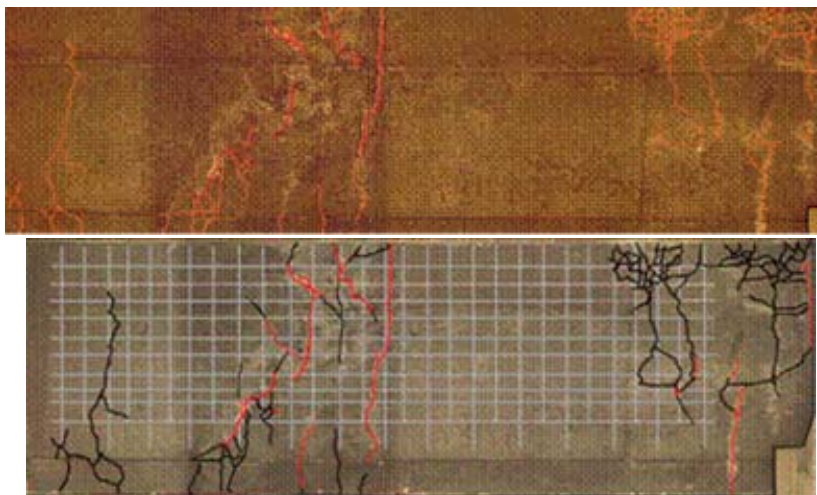


Photo 1: Appearance of concrete bridge slab by digital still camera and mounting other inspected result

Thermograph is another useful tool. When any void exist close to the surface of concrete, they can easily detected by using thermograph. The tool looks the same with digital still camera but the information we can obtain is different. When a void with certain size exists close to the surface, due to sun light, etc., surface temperature of concrete becomes slightly higher than the surroundings. As a result, the voids in concrete can be easily detected.

## 4. Investigation for concrete bridges

### 4.1 Target of investigating concrete bridges

We determined 9 concrete bridges existing in metropolitan area as targets for investigating and making a database in this research. Figure 1 shows the location of target concrete bridges. We collected the structural data from the organization of the maintenance for each bridge. Then the specialist in diagnosis of concrete structures investigated these bridges by visual inspection in order to understand deterioration levels. Table 4 shows the result of the investigation for 9 bridges. At the same time, we took the photos of the deteriorated spots on the concrete bridges by digital still camera and thermograph for considering making the database.



Figure 1: Location of targets for investigating bridges

### 4.2 Results of investigating concrete bridges

#### 4.2.1 Result of inspection software

Result obtained by software is as good as the result obtained by specialist and it can be shorter time to get the result. It is useful for making database from these data.

#### 4.2.2 Result of photos

It is possible that we can identify the deterioration causes and levels by using digital still camera. We can get the photos of crack, spalling, separation and stain of corrosion of steel on concrete surface. We have an analyzing technology for crack width and crack pattern from digital photos.

It is possible that we can investigate the spalling and separation of surface of concrete on below surface of slab. Photo 3 shows the result of thermograph. The principal of thermograph is that it shows the process of the heat distribution and heat radiation from stored sunbeam in structure. That is to say, the more thickness of structures is, the more ability to

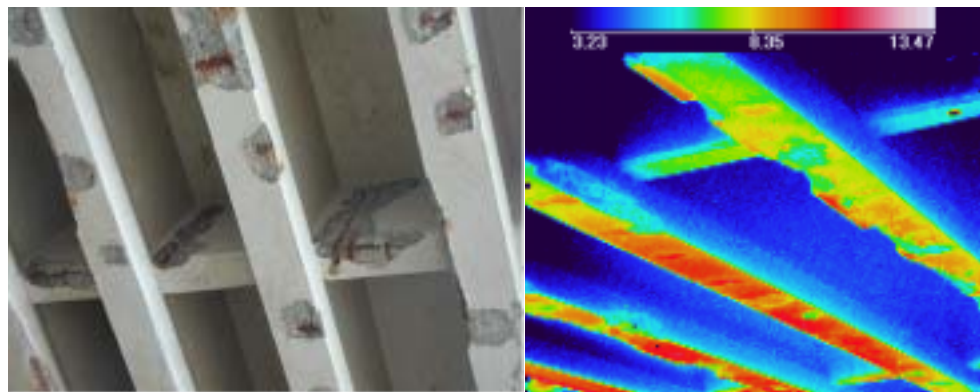
Table 4: Results of investigation for each bridge by specialist

No.	Bridge name	Length(m)	Year of construction	Traffic (/day)	Deteriorated condition (Main beam)	Deteriorated condition(Bearing support)	Deteriorated causes
1	Higashi-Rokugo	150.06	1983	6000	Crack	Corrosion steel bar	Shrinkage, Water leak
2	Shimo-Akatuka	111.5	1971	2747	Crack	Corrosion steel bar	Over loading
3	Shin-Kasai	163	1964	6240		Damage	Over loading, Uneven settlement
4	Yagiri	259.5	1965	5818	Crack	Corrosion steel bar	Over loading
5	Sakai	62.7	1967	11370	Free lime, Exposure steel bar		Salt supply, Improper construction joint
6	Fuki	30	1972	630	Exposure steel bar		Salt supply
7	Koyurugi	1098.9	1966	3010	Crack, Rust	Corrosion steel bar	Salt supply
8	Hatano	160	1962	3170	Crack, Rust, Exposure steel bar, Free lime	Corrosion steel bar	Improper construction joint
9	Imagawa	18.09	1973	17876	Separation, Exposure steel bar		Over loading

accumulate the heat is. Therefore, we can detect the spalling spots of concrete and the separating area of cover material on surface of concrete. We are able to get the useful data for making database using digital still camera and thermograph.



*Photo 2: View of the No.7 Bridge (Koyurugi)*



*Photo 3: Deteriorated condition  
(Left: Digital still camera, Right: Thermograph)*

## 5. DEVELOPPING DATABASE

Figure 2 shows the image of database in this research. When we clicked the bridges number or name on the digital map, we can see this image including collected data. It is not only the location of structures, but also deterioration causes and levels as different color on digital map. It is possible that the data can be renewed after re-inspection linking to inspection software.

It is desirable that there are many results of inspection for structures on database. We really need the diagnosis of deteriorated structures for the whole country in order to evaluate the dangerous level and make the hazardous map for each area. On the other hand, we also have to investigate the deteriorated structure in small area, and it is important to understand deteriorated causes and levels in that small area.



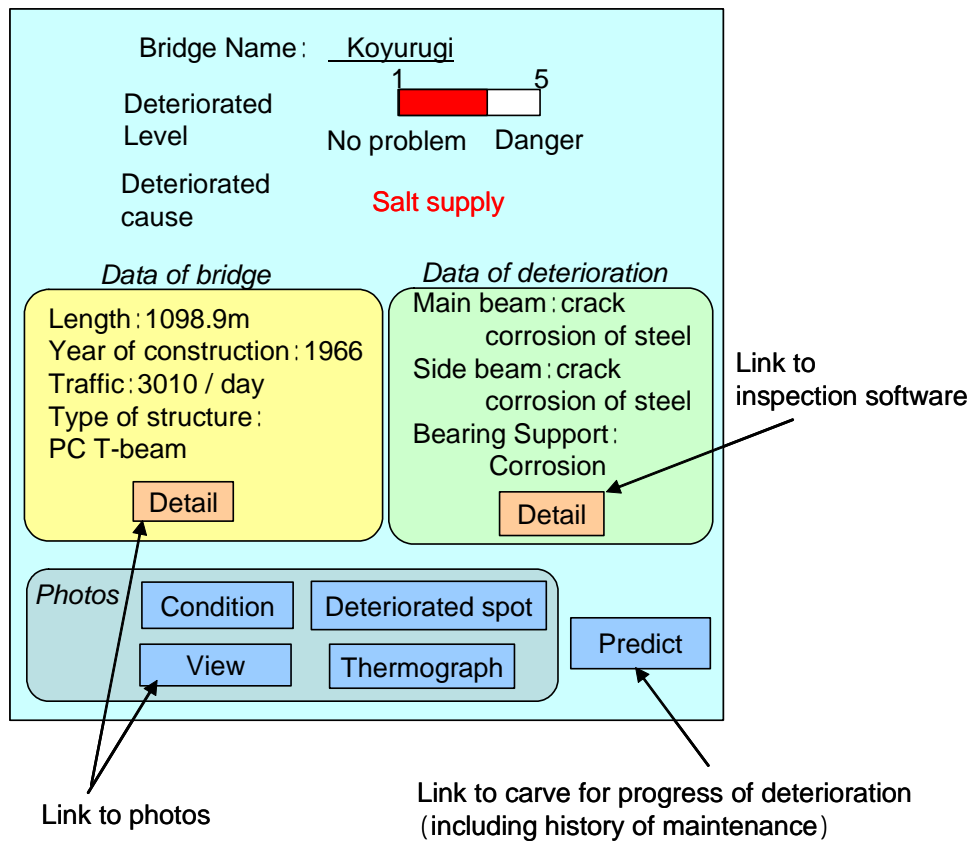


Figure 2: Image of suggested database

## 6. CONCLUSION

- (1) There will be a lot of maintenance for deteriorated concrete bridges near the future. In this paper, we suggest the database for collecting information of bridges and we showed one of the information management methods.
- (2) The suggested database includes information and location of structure, their maintenance and photos. The collection method for the data of maintenance is the inspection software and in case of photos are digital still camera and thermograph.
- (3) It is possible to evaluate dangerous levels and the hazardous map by using suggested database. And it is possible for the concentrated management to search the structure which needs the inspection and maintenance in many targets of structures.

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