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著者	NAKASHIMA Mari, NAGAI Kohei
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# AN INVESTIGATION OF ROAD BRIDGE MAINTENANCE SYSTEM IN JAPAN IN DEVELOPED SOCIETY

Mari NAKASHIMA, Kohei NAGAI  
The University of Tokyo

**ABSTRACT:** The road assets in Japan have peak of construction in high economic growth period around 1970s. At that time, maintenance was not considered enough. After many bridges in the United States without maintenance were rapidly deteriorated and caused tragic accidents, Japan started to establish a countermeasure to prevent to be "Japan in ruins." Because most municipalities had not even inspected bridges although they are in charge of more than half of bridges in Japan, central government decided to subsidize local governments who inspect bridges and make plans for maintaining them for long term by "preventive maintenance". After this policy, most managers have inspected and made their own manuals. The plans should fit to each government's capacity to manage sustainably. However, some plans are made without considering its own circumstances. This research assess the plans from the perspective of physical conditions, potential of managers, and social conditions using indexes to propose the proper way to manage bridges in municipalities.

**KEYWORDS:** road bridge deterioration, maintenance management, municipality

## 1. INTRODUCTION

Many bridges in the United States constructed in New Deal felled down with loss of lives for inappropriate maintenance. From the accidents, we learned that there is huge economical loss once an accident happens with loss of lives.(Inoue, 2010) Japan has 157 thousands of bridges over 15m span and 700 thousands over 2m span, and number of deficient bridges is increasing every year. This is a problem of developed society which had a construction boom in high economic growth period. Also, those societies have the problem of aging society of people at the same time. Especially in local areas, the problem is serious. Even though local governments are having hard time with shortage of public finance and staffs, they have to manage the bridges they have. The total number of national road bridge is 5 thousands in 2011 and that of prefecture

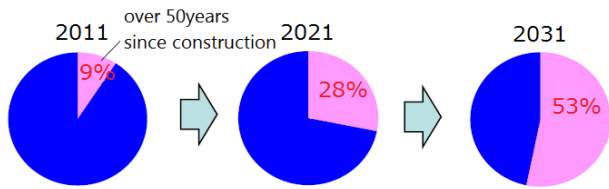
is 100 thousand, and of municipality is 521 thousand, which means 77 percent of bridges are managed by local government (Annual Report of Road Statistics 2011). National government tries to support the local governments which made their own sustainable maintenance plan by grant. However, some of these plans are not suitable for the local governments in terms of budget, the number of staffs, location and so on. This research investigates a current situation of road bridge management system in Japan and propose some indexes that will help local managers in management.

## 2. PRESENT CIRCUMSTANCE

### 2.1 Aging problem of bridges in Japan

In 2031, the number of bridges whose age is more than 50 years will be over 50% of all the bridges. (Figure 1, Road installations present situation

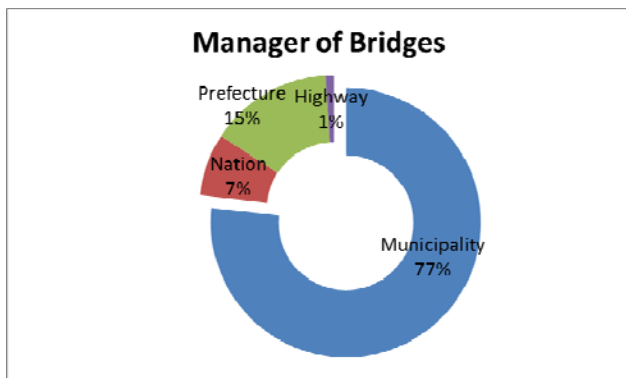
investigation 2010) In Japan, bridges whose age is more than 50 increase rapidly in a few decades although it is impossible to replace them at the same time in this condition of finance. To flatten the cost to the years, preventive maintenance is introduced.



**Figure 1** Change of the ratio of bridges over 50 years since construction

### 2.2 Circumstances of Municipalities

As mentioned above, 77 percent of bridges are managed by municipalities but the local government have problem of shortage of staffs and budget. (Figure 2) The ratio of inspected bridges of municipalities was only 16% in 2007.



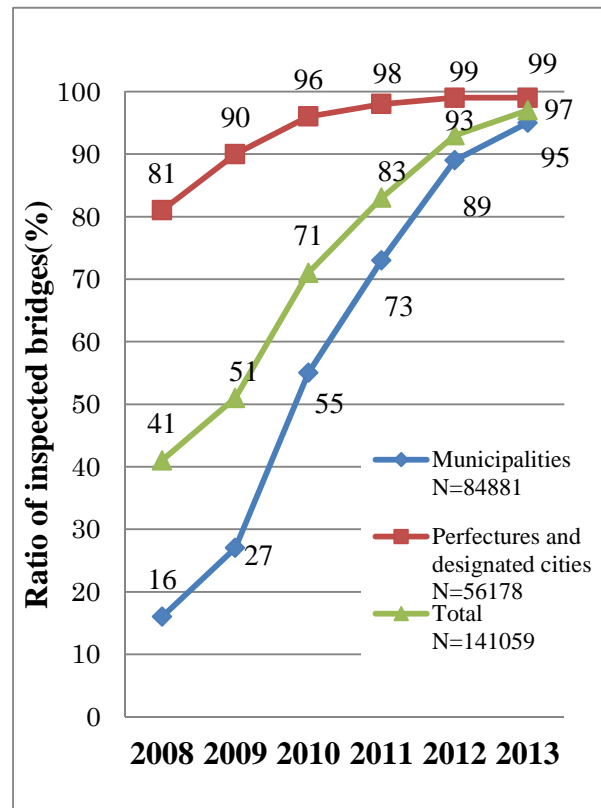
**Figure 2** Manager of bridges

### 2.3 Sustainable Maintenance Plan

National Government decided to deliver grant for the municipalities that made their own plans by 2013. The aim of the policy is to let municipalities inspect their bridges, and successfully the ratio increased as shown in Figure 3.

The work of planning is usually outsourced to consultants or institutions of prefecture. The process is following: inspection, collecting data, adjusting simulation, simulation to output plan, modification, and publishing. It includes deterioration prediction

but it is a rough estimation to prioritize, not an actual estimation of repair cost. Calculation of cost should be done for each bridge and it depends on skill of staff in this process.

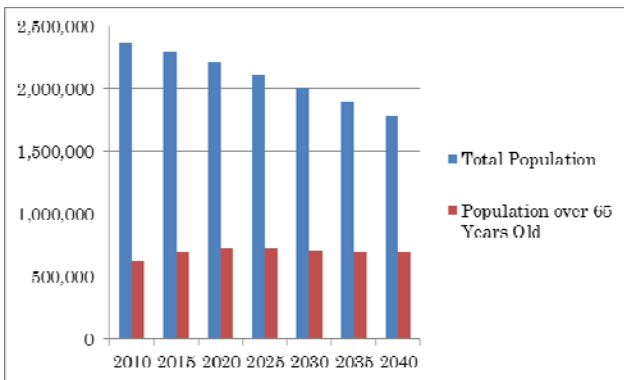


**Figure 3** Change of the Ratio of Inspected Bridges

### 2.3 Problems

To manage bridges sustainably, it is necessary to have appropriate plan of maintenance management which fit to each municipality. Whether the management is appropriate or not is decided by worth of investment. In the situation of decreasing population and aging society as shown in Figure 4 of the data in Niigata prefecture, the user and income decrease and it may be inappropriate to take preventive maintenance to keep high quality. It is possible that there is a gap between social life span and that of bridges. This is only one perspective of population, but there should be more to consider making difference of management level and means to manage sustainably. Following chapter shows

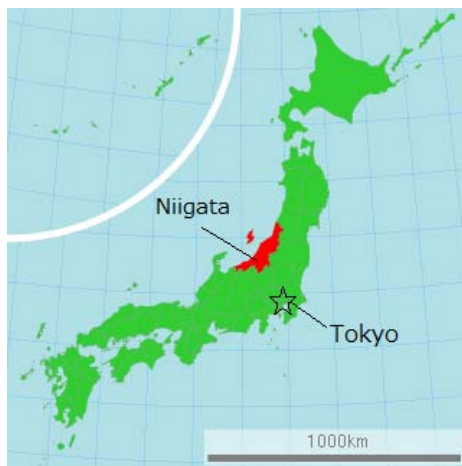
indexes that should be considered when governments make maintenance plan.



**Figure 4 Estimation of Population Change in Niigata Prefecture**

### 3. INVESTIGATION IN NIIGATA

Niigata prefecture is located 300 km North West of Tokyo (Figure 5), faced to the Sea of Japan and has a heavy snow fall in winter.



**Figure 5 Location of Niigata Prefecture**

This investigation focused on municipalities in Niigata prefecture. There used to be more than 100 municipalities but there are 30 after merger. The location and name of municipalities are shown in Figure 6.

In perspective of bridge management, management classification is introduced basically based on the rank of road, length of the bridge, whether or not it is prestressed concrete bridge nearby sea and if there is the third person's damage. Following chapters

visualizes those component using graphs and suggests indexes that should be considered when managers make diagnosis.

Figure7 to 10 shows basic data of municipalities. Bridge density is calculated by number of bridges divided by total area to see how far each bridge is. Using those data, further investigation follows.

#### 3.1 Physical conditions

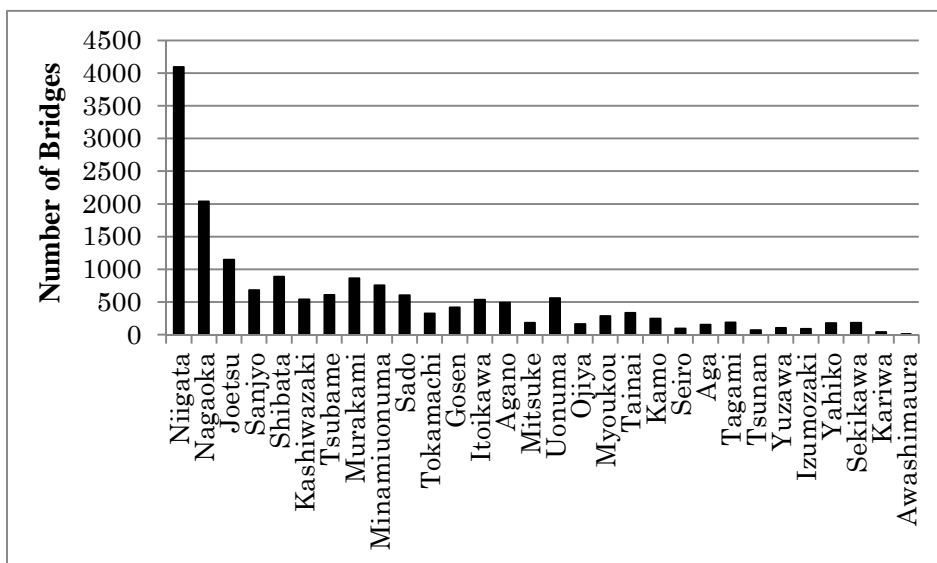
The number of bridges and distance from sea can be indexes for physical conditions. Furthermore, the number of bridges plotted versus bridge density can be one of the perspectives to see the hardness of management. (Figure 11) The bridge density is calculated by number of bridges divided by area. A municipality that has not just a large number of bridges but those that are apart, need more time consumed for inspection. For example, the left upper group, include Murakami and Joetsu, are expected to need more time than the right lower group include Tsubame, Tagami and Yahiko.

#### 3.2 Potential of managers

Potential of managers includes the number and skill of staffs and budgets for road bridge maintenance. A survey taken in Niigata shows that number of staffs in charge of bridge maintenance is under 5 in most municipalities and in many cases, they are not experts of bridge (Figures 12 and 13, Maruyama 2013). Their work is usually not only bridge maintenance but management of infrastructure in general so that to see more actual capacity, number of staffs should be multiplied by time ratio spending on road bridges. In anyway, most municipalities have problem of shortage of staffs but they do not have the solution that they increase the number of staffs. To assess the capacity of managers, it is necessary to consider the skill that is required to the managers in further study.



**Figure 6 Municipalities in Niigata**



**Figure 7 Number of Bridges Managed by Municipalities in Niigata**

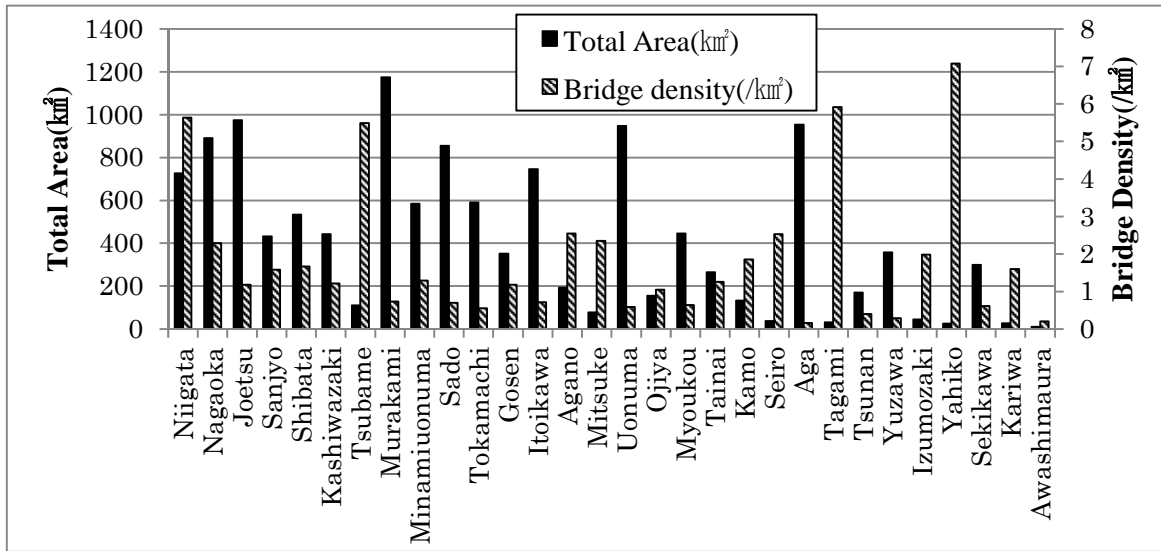


Figure 8 Total area and Bridge Density in Municipalities in Niigata

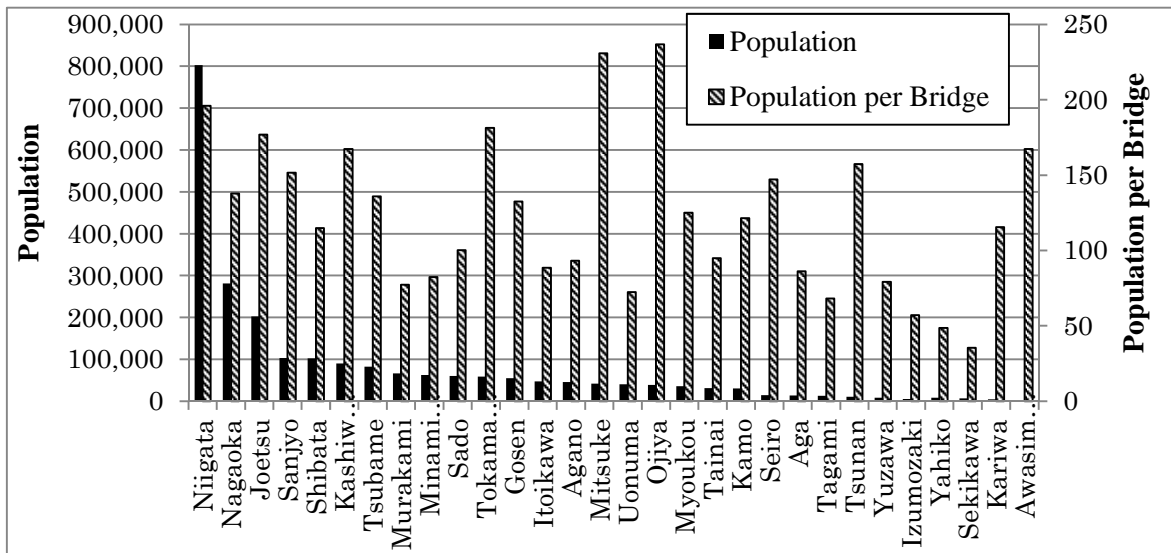


Figure 9 Population and Population per Bridge

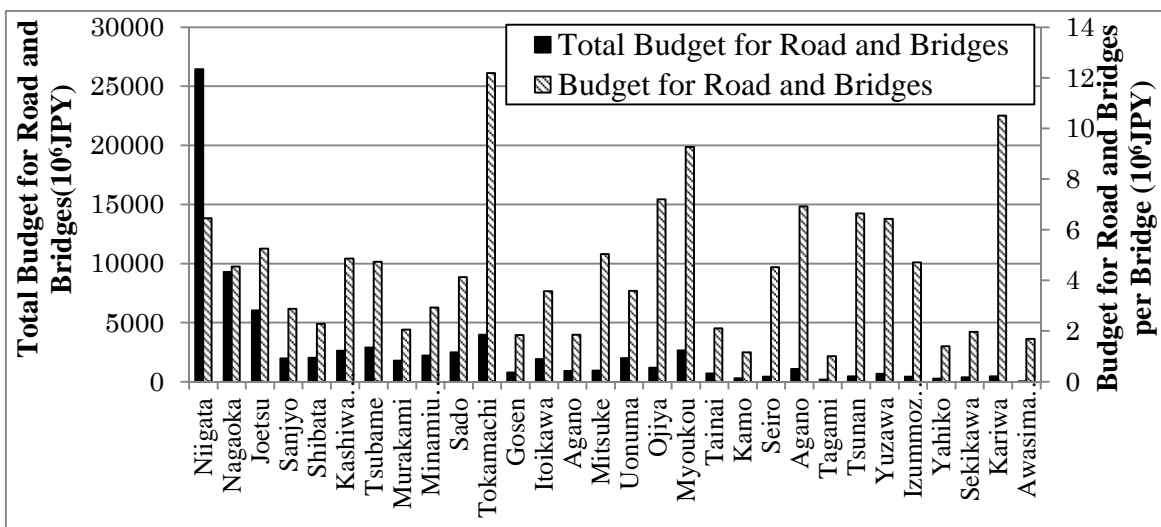
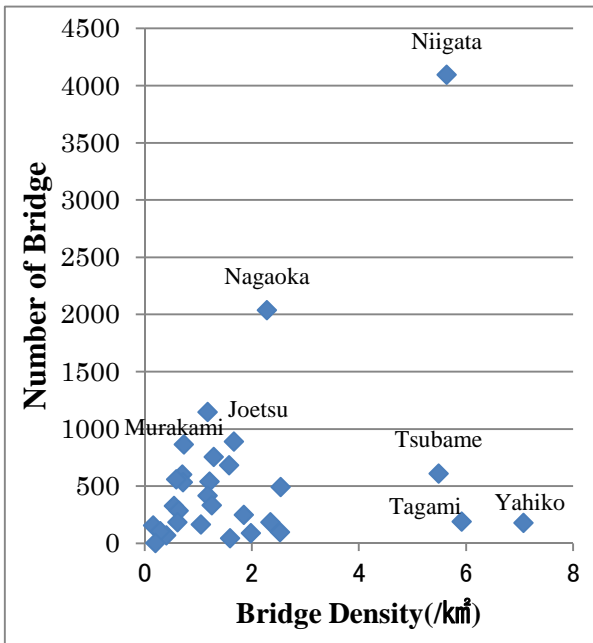
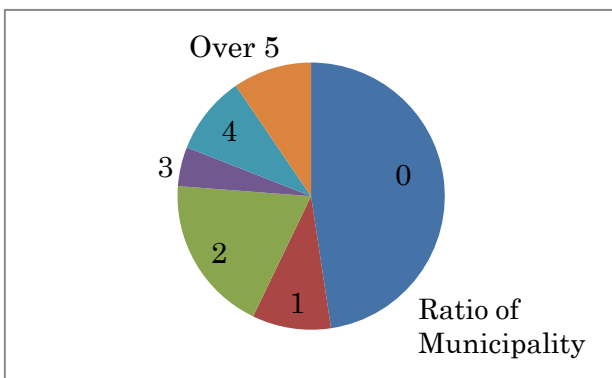


Figure 10 Total Budget for Road and Bridges and the Budget per Bridge

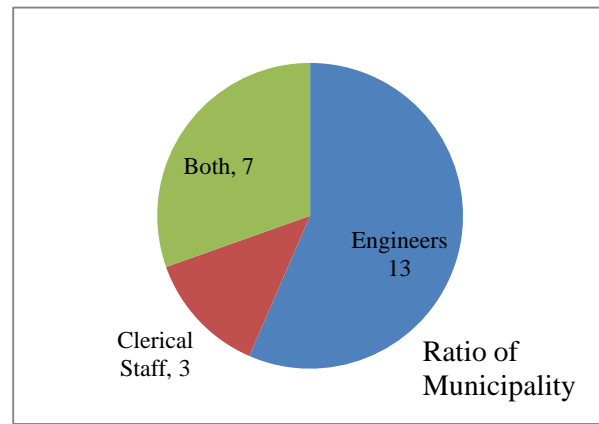


**Figure 11 Number of Bridge versus Bridge Density**

Budget for roads and bridges maintenance is also one index to decide the level of management. (Figure 10) The budget for road and bridges is not only for maintenance but also for newly construction. Budgets that are spending for maintenance in recent years is mostly grant from National Government. What makes it difficult is not only shortage of budget but also restriction of spending and uncertainty for the future grant. Further study is needed to discuss the finance.



**Figure 12 Number of Staffs in Charge of Bridge Maintenance in Niigata**



**Figure 13 Staffs Conducting Technical Works in Bridge Maintenance in Niigata**

### 3.3 Social Conditions

Component of social conditions includes whether or not there are damage to the third person, isolation by disaster, and how population change.

First two components are easy to classify because it is not shown in continuous data but alternative choice of yes or no. If a bridge is over road or other structure, not river, small piece fell off from it may cause accident so that those bridges are categorized as those that may have damage to the third person and should be taken major of falling prevention. Secondly, the bridges that may cause isolation by disaster should be kept in high level.

The difficult component is population change. There are some settlements where nobody is going to live in near future. It is difficult to say appropriate management to make maintenance plans for those bridges but removing them from those villages gives the impression of abundant so that as long as a bridge exists and as people live, governments have to manage. It is a difficult matter to consider quantitatively and the judge depends on the managers. If there is any index that gives numerical support for judgment that will help introducing appropriate management.

#### 4. CONCLUSION

The level and means of bridge management should be different considering the municipalities' physical condition, potential of manager, and social condition. This research showed possible indexes that will help local managers in diagnosis. Further study investigates relativity of those indexes and gives flow chart that may suggest appropriate way of maintenance.

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