MEASURES FOR STRATEGIC PREVENTIVE BRIDGE MANAGEMENT OF TOKYO METROPOLITAN GOVERNMENT

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Abstract

Tokyo Metropolitan Government (TMG), Bureau of Construction has done periodic bridge inspection and has been corrective bridge maintenance. As aging bridge is increase, the possibility that serious accident is high. Finance limitation demand the peak project cost cut and reduce of total cost. Therefore we changed maintenance management strategy from corrective to preventive. We adopted New Public Management type Asset management. We developed some mechanism, which is deterioration model, social benefit, project prioritization method, and computer systems. Finally we planned "Long-Term Bridge Management Plan". This paper reports our measures for strategic preventive bridge management of TMG.

Introduction

TMG, Bureau of Construction, manages approximately 1,250 road bridges. Many bridges constructed in two periods. First period is reconstruction period from Great Kanto earthquake damage on 1923.Second period is high economic growth period from middle 1950s to early 1970s. (figure 1). For number of bridge, 52 percent are Reinforced concrete bridges or Prestressed concrete bridges, and 40 percent are Steel bridges. Whereas for area, only 12 percent is Reinforced concrete or Prestressed concrete and 56 percent is Steel (figure 2).

Bureau of Construction developed periodic bridge inspection every five years from 1987. The method is direct sight inspection as much as possible. Inspection contents are thirty one, which is corrosion, fatigue of steel girder, crack of concrete, and so on. Bridge health index is decided two steps. First, the condition of bridge is graded five ranks from 'a' to 'e' for member unit. Second, total bridge health index is graded five ranks from 'A' to 'E' for span unit and bridge unit, with used two index durability and safety. The deterioration of bridge progressed certainly, by the result of bridge inspection from 1987 to 2002. The rank C and D, which is required to rehabilitation, is increase (figure 3).The cause of steel girder bridge damage and deterioration is below. First is corrosion and deterioration of painting. Second is deformation caused by bearing has not work normally or foundation have moved. Third is fatigue damage by repeated heavy load. The damages of concrete bridge are confirmed fall of filling deck slab, free lime, and crack.

Bridge maintenance was corrective, when damage and deterioration was found, bridge took appropriate measures. TMG constructed many bridges in the 1960s, high economic growth period. We envisage the peak of bridge replacement cost is early 2030s, so that huge budget is need. Supposed from present TMG budget, increase of

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bridge management budget is not much expected. We need to try to decrease peak cost of bridge replacement and total bridge management cost. As bridge is aging, damage and deterioration is rapidly extended, it is difficult to the inspector find damage and deterioration. Thus, in the case of too late finding damage and deterioration to practice corrective measure, serious accident can occur. The I-35W bridge collapse in Minneapolis, Minnesota in the United States, 2007. In Japan, steel truss diagonal member broke on two bridges, Kisogawa Ohashi Bridge on National Road 23 and Honjo-Ohashi Bridge on National Road 7. Existent bridge is lack of usability and safety. It is not satisfy present design standard. Remaining this condition, the possibility of fatigue damage is high. A surrounded environment changed with progress of technique. Asset management methodology developed and tried to introduce on business in many countries. As the result of high level study, the technique of new material and new method of construction developed. Therefore the measure to long-life bridge without block traffic flow, is enable.

On a basis of the change of these situations, TMG change management strategy to preventive maintenance with asset management methodology. We decide try to decrease peak cost of bridge replacement, to reduction total bridge management cost, and to keep safety traffic. For important bridges, replacement of bridge is not executed because the replacement cost of these bridges is much cost needed. To satisfy present design and to make long-life bridges, maintenance cost decrease by performance based design. This paper reports present condition of measures of TMG.

Asset Management

Asset management means generally the businesses which manage property substitute for owner and investor. The term used to use securities firm and real estate agent.

Recently, in the United States and other countries, Asset management methodology was introduced to operation and maintenance of infrastructure. FHWA created an office of Asset management in 1999. Now, Asset management is accepted among many agencies in the United States. In Japan, some local government are working on introduce of Asset management.

Japanese Asset Management method is two types. One type is LCC type, to try minimum life cycle cost and another type is New Public Management (NPM) type, to try maximum difference between value and cost (JSCE(2005)). NPM type is the advanced LCC type, to progressively and for invests. As we know, in Japan, local governments except TMG have introduced LCC type Asset management. Only TMG is introduced NPM type Asset management.

New Public Management is the movement to achieve public efficiency and progress of quality of work, by widely introduced private enterprise management style. The goal of the NPM type Asset management of TMG is, the government as agent of Tokyo metropolitan citizens, uses their tax efficiency to road infrastructure, and return effective and efficient public service to citizen or user. More specifically, the result of public investment, entrusted use of citizen tax, to maximum the effect tax payer received. Bureau of Construction make investment project plan to difference between benefit occurred from bridge exist and project cost.

Deterioration Model

On preventive maintenance management, evaluate future condition of each bridge by deterioration forecasting and make plan which can execute appropriate measure on best timing is need.

We set original deterioration curve from past twenty decades bridge inspection data collection, calculated last bridge life length. The deterioration curve is calculated life-cycle analysis and non linear regression analysis. In the beginnings, we tried to set standard deterioration curve, with use linear curve as general deterioration curve calculation method. But there are almost no data the most danger health index 'E', we judged this linear curve do not mirror real deterioration and changed our policy to the above method.

The process of deterioration curve set is below. First, we divided bridge inspection data into twenty types by combination of three elements, member, material, and damage. And calculate the time to reach next rank by life-cycle analysis. Second, we made four alternative curve types, exponential convex curve type, linear curve type, second polynomial curve type, and third concave curve type. Each bridge deterioration curve is decided by select the most nearly curve type compared with the result of the life-cycle analysis(figure 4).

Social Benefit

The achievement of NPM type Asset management of TMG is to maximize the difference between benefit Tokyo citizens receive and project cost. The benefit is imaginary profit, and we call social benefit it. Cost benefit analysis, which is used in economic and civil field, supply that the measurement method of some benefit. Setting on each benefit contents, we focused that the variations in traffic flow with project operation. We reasoned that the benefit Tokyo people received is difference benefit of With: the project is operated, and of Without: the project is not operated. We set five benefit contents, drive time shortening, driving cost reduction, comfort driving, environment load reduction, and traffic accident reduction.

Drive time shortening is based on the Cost Benefit Analysis manual (MLIT(2003)) . We suppose drive time is increase because of traffic jam and diversion traffic by road construction. We estimate the difference of drive time with measure construction and without.

Drive cost reduction is also based on the same Cost Benefit Analysis manual. The target contents is except concerned with drive time, of the cost reduction by drive condition is improved. We estimated the cost, gas, grease, tire, maintenance, and depreciation.

Comfort driving is well ride and well handling operation. We can quantitative estimate the effect of improvement of road condition. The method is Willingness To Pay (WTP). WTP is the amount people would be willing to pay for the value. We estimated WTP by Contingent Valuation Method (CVM). We did a paper survey of 10,000 people lives in Tokyo in 2005, and estimated amount for good road condition.

Environment load reduction contents are air pollution, traffic noise, landscape, ecosystem, and energy. Executing our project, roadside environment is improved. We estimated five contents. CO_2, $NO_{x,}$ PM, and traffic tremble was estimated by past

literature and existent data. Traffic noise was estimated by survey.

Traffic accident reduction is estimated three contents. One is human damage cost about driver, people in the car with driver, and pedestrian. Second is object damage cost about vehicle and construction that occurred damage by traffic accident. Third is variation in damages cost by traffic concentration.

Project Prioritization

Project prioritization is decided by evaluation of the best combination of each bridge project. Index of project priority is Net Present Value (NPV). NPV is investment index, private enterprise use of project feasibility research. We define the best investment plan is not only obtain to minimum of project cost, but also achieve NPV>0 and obtain to maximum of the difference between benefit and cost. We developed loop program to decide project prioritization. This program can select the best project combination to maximum of NPV for 30 years. The project combination is calculated to prevent traffic concentration, by construction site with traffic restriction is close to each other.

Asset Management System

We programmed application software which realized our plan, started operation of the asset management system in 2007. The system is consisted of calculation server, database server, web server, and firewall system. Server OS is Windows 2000 server and database soft is oracle engine. The functions of the system are database area and calculation area. By utilize accumulated data, the system can calculate various programs, deterioration prediction, project prioritization, and so on.

Long-Term Bridge Management Plan

We made “Long-Term Bridge Management Plan” in 2009 with our asset management methodology. We predicted deterioration of bridge and decided the adequate timing for measures in every bridge. Each measure, concrete deck exchange to steel deck, steel girder to tied, and so on, set according to health index. The standard costs of each measure refer latest rehabilitation technique. We evaluated Life Cycle Cost (LCC) both corrective maintenance and preventive maintenance, and compared two. Finally, we decided project prioritization and finished this planning.

This plan is all the bridges is divided into three maintenance types; long-life, general and replacement. The measure to existent bridge, for earthquake and over loading, is also included.

The number of Long-life type maintenance bridge, is 212: high social value bridge, and the bridge that rehabilitation is difficult for the construction is serious affect to traffic. Kachidoki Bashi Bridge, Eitai bashi Bridge, and Kiyosu Bashi Bridge, they are nominated national important heritage, is included. For the Long-life type bridge, measure to obtain the lifetime more than 100 years by utilized new technology is executed.

Effects

Executing this plan produces five effects: cost, benefit, environment, safety, and accountability.

First is the project peak cost cut and reduction of total project cost. The peak cost is cut by long-life measure is executed. The effect of the total project cost reduction is expected 1,100 billion yen (1,200 million dollars, if one dollar is 90yen), the total cost is 1,600 billion yen (1,800 million dollars) on corrective maintenance and the total cost is 500 billion yen (600 million dollars) on preventive maintenance based on this plan (figure 5).

Secondly, the best project combination plan can achieve to maximum of the difference between benefit and cost. We try to minimum of construction cost and device the combination of construction project. We keep road safety and save the benefit Tokyo citizens received.

The third is reduction of the load to environment. CO_2 emission is reduced by the life of bridge become long. Bridge replacement is decrease, quantity of used material becomes less, and the operation time of construction machine is decrease. When the bridge management strategy is change from corrective maintenance to preventive maintenance, CO_2 emission in thirty years is reduced 1,120 thousand ton, from 1,590 thousand ton to 470 thousand ton. For evaluating CO_2 emission, we adopted released unit as much as possible. We evaluated the emission data in each bridge, used the emission data of construction machine. The data is released from Japan Science Committee Engineering and Center for Advanced Engineering Structual Assesment and Research.

The fourth is save the road safety and secure. We can considerably loss the risk by the lack of safety. Because we estimate bridge condition by inspection, predict deterioration and damage, and execute preventive measures. The safety of bridge is secured by the measures for long-life bridge. Because executing the measure for over-load and earthquake can improve durability of bridge.

The Final effect is progress of accountability. We execute the project which based on the plan utilized with the asset management system, we can account about planning process and project assessment for Tokyo citizens.

Conclusion

This paper reported about the TMG measure for bridge management; try to change management strategy from corrective maintenance to preventive maintenance.

"Long-term bridge management plan" have planned with developed Asset management system. The purpose is bridge replacement peak cut, reduction of total project cost, and save road safety. Some issues remain to steadily executing this plan: secure the project organization system, reconfirm project cost, training in-house engineers, and improving bridge inspection.

TMG forward preventive maintenance steadily, realizes effective and efficient bridge management for Tokyo citizens, and keeps road safety and secure.

References

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pp.35-40 (in Japanese）

Ministry of Land, Infrastructure, Transportation, and Tourism (MLIT) (2003), Cost Benefit Analysis manual (in Japanese)

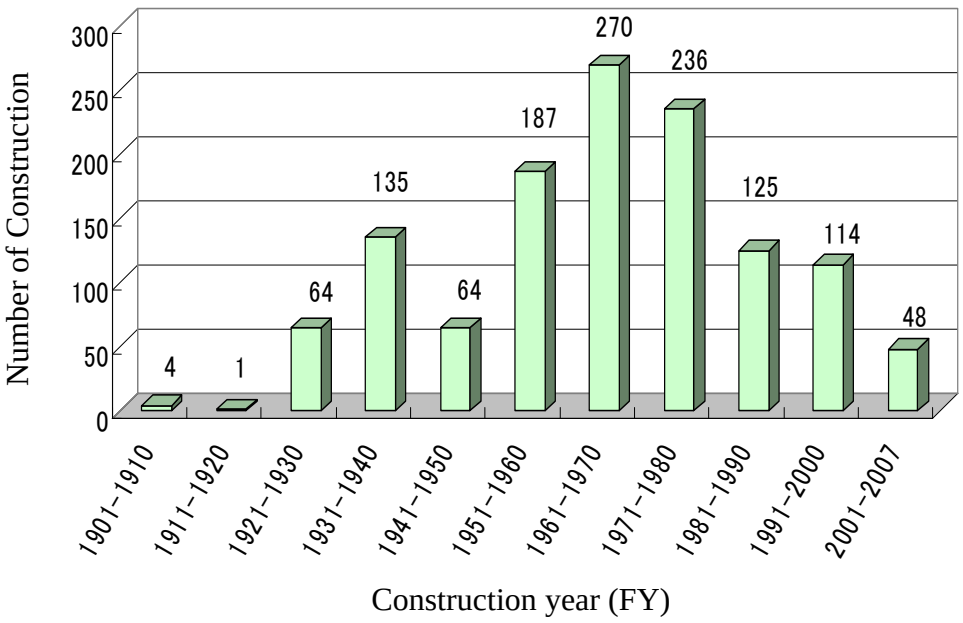


Figure 1: Distribution bridge construction year of TMG

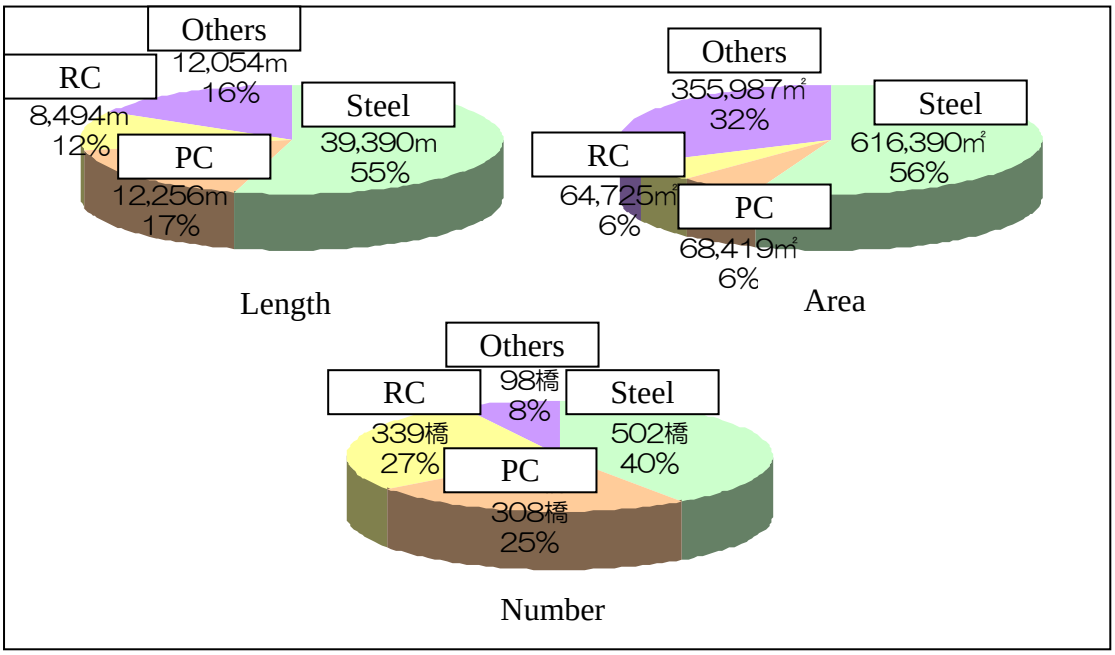


Figure 2: classification by material of TMG bridge

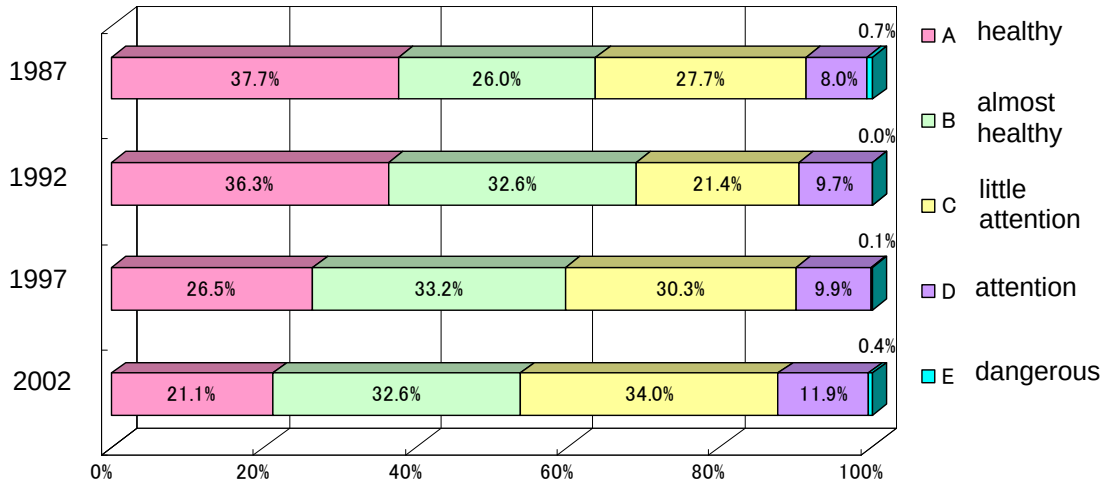
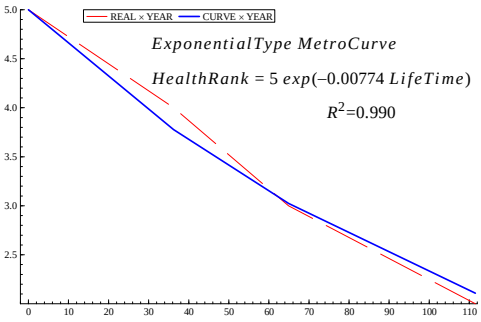
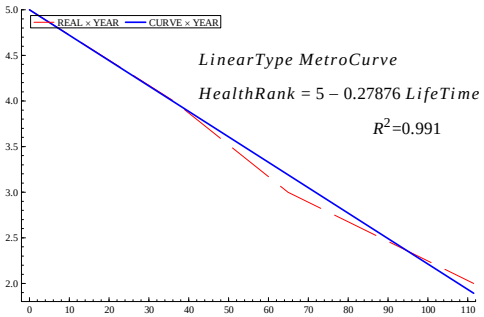


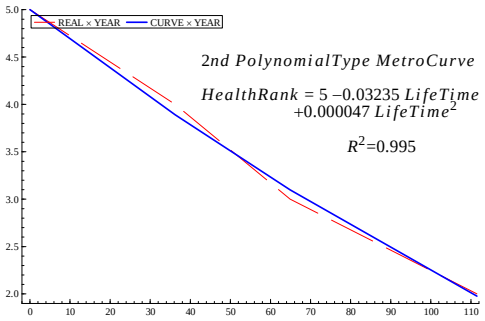
Figure 3: Progress of Bridge Health Index



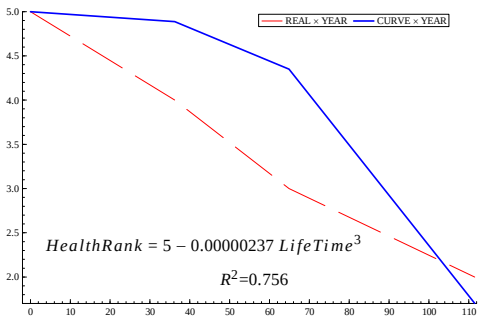
type 1:Exponential convex curve



type 2: Linear type



type 3: Second polynomial curve



type 4: Third concave curve

Figure 4: four alternative deterioration curve types

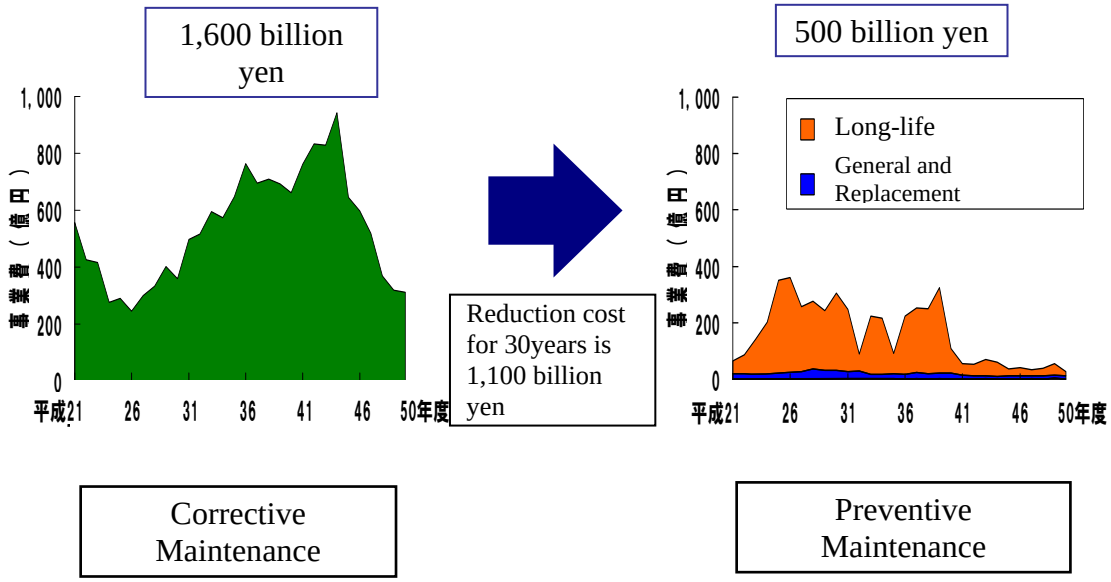


Figure 5: Project cost compared preventive and corrective

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