GUIDELINE FOR MAINTENANCE OF RAILWAY CONCRETE STRUCTURES

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Abstract: Since Japanese railway was firstly laid in 1872, railway network has been highly developed and many railway structures have been constructed. Especially, a large amount of railway structures in such as Shinkansen lines, metropolitan railway lines has been put in place in 1970s corresponded to high economic growth period in Japan. To keep the train service functions in the good state, structural performance and durability are required to maintain in a certain level for long years. To realize this, much R&D concerning nondestructive test, diagnosis, repair and strengthening has been conducted, nevertheless the guideline for maintenance of railway structures such as viaducts, bridges, tunnels, embankment and cutting ground has not been published. Based on the above circumstances, Railway Technical Research Institute (RTRI) has proposed the maintenance guideline for railway structures. In this maintenance guideline, the performance-verification system has been adopted. As structural performance, safety performance in addition to serviceability and restorability is verified. In this paper, the gist of the maintenance guideline for concrete structures is described.

Keywords: maintenance guideline for concrete structures, performance-verification system, inspection system

1. INTRODUCTION

There is a wide variety of Japanese railway structures in terms of structural type and material. And the elapsed years of the railway structures after construction are various, too. There are some structures whose ages are over 100 years. Therefore, in maintaining these railway structures, it is important to take above-mentioned structural characteristics into account.

By maintaining the railway structures in an appropriate manner, it would be possible to prolong their service life. On the other hand, structures would fall into ruin under the bad condition of maintenance. Because of trimming public works spending, road structures in US fell into the severe condition in 1970s. It is well known as 'America in ruins'. In Japan, on account of absence of maintaining structures during the Pacific War, railway structures had been heavily devastated.

From the above lessons of history, it has been recognized the importance of maintaining structures. To carry out maintaining structures rationally, the guideline for maintaining railway structures is needed. In this paper, the guideline for maintenance of concrete structures which is under consideration is outlined.

2. PRINCIPLE FOR SYSTEMATIZING MAINTENANCE OF RAILWAY STRUCTURES

The guideline for maintaining railway structures consists of five parts as shown in Fig.1. Concrete structures are dealt in Part 1. Though the each part of the guideline corresponds to each kind of railway structures, the basic concept is common. That is, the policy in drafting the guideline is as follows.

(1) Recently, in the design code of structures, a performance verification type standard has been introduced. To interface with this trend, the guideline adopts the performance verification system.
(2) Though both quality and quantity of railway structures which each railway company has are quite different, the guideline would be applicable to every railway company.
(3) Fundamental frame of the maintenance system which each railway company has adopted would be left unchanged.

3. PERFORMANCE VERIFICATION SYSTEM IN MAINTENANCE OF RAILWAY STRUCTURES

Performance of railway structures gradually declines. Therefore, it is necessary to keep performance of railway structures not below an acceptable level. Though it is very important to detect damage in railway structures by inspection, it is very difficult to evaluate the decreasing degree of structural performance by detected damages. Then, based on the past experience, it is considered that performance verification of structures would be possible by the following maintenance procedures.

(1) With a view to detecting damage or deterioration, periodic visual inspection would be carried out.
(2) Based on the above visual inspection results, rather damaged structures would be selected. And, detailed inspection should be carried out for selected structures.
(3) Based on the above inspection results, it should be evaluated whether the performance of railway structures might comply with the required performance or not.
(4) Based on the above evaluation, necessary remedial measures such as repair, strengthening and so forth should be taken.

Guideline for maintenance of railway structures

PART 1:Concrete structures
PART 2:Steel structures
PART 3:Foundations
PART 4:Earth structures
PART 5:Tunnels

CONTENTS

Fig. 1 Organization of guideline

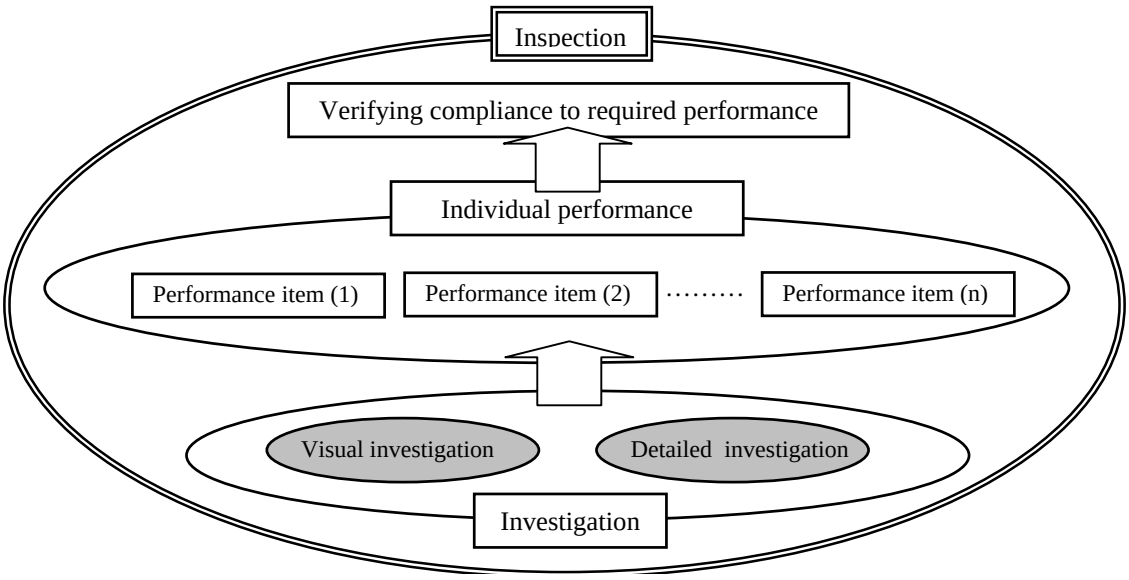


Fig. 2 Flow of Inspection

In the guideline, the phrase 'performance' implies safety. Safety is one of the most important performance, safety means that the train can safely run on the structures and human life in and around the structure is ensured. And according to the circumstances, serviceability and restorability may be adopted as a major performance of railway structures.

4. INSPECTION SYSTEM

In the guideline, the phrase 'inspection' includes investigation such as visual or detailed one and verification of performance of railway structures as shown in Fig.2. And the inspection system shown in Fig.3 is adopted. Inspection is classified into four categories such as initial one, general one, detailed one and extraordinary one. Moreover, general inspection is classified into periodic and nonperiodic inspection. The gist of the each inspection is described below.

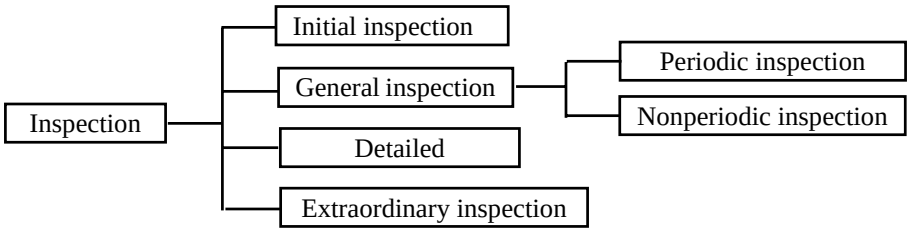
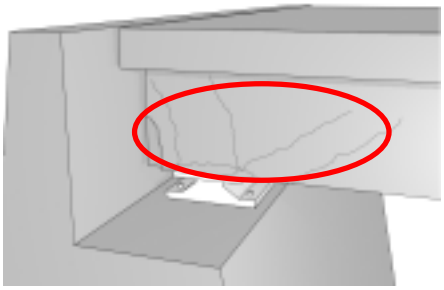


Fig. 3 Inspection system

Structural region to be noticed	Appearance	Judgement
Crashing condition of concrete near the support Cracking condition in the end of the girder 	Diagonal cracking proceed to support. And crack width is very broad. Diagonal crack width is over 0.2mm. Perpendicular cracking from the support Rust exudation from crack.	AA A A A

AA: Emergent measures need to be taken. A: Detailed inspection needs to be taken

Fig. 4 An example of criteria for judgement

Fig. 5 Portable inspection tool utilizing IT skill

5. INITIAL INSPECTION

The object of the initial inspection are railway structures newly constructed or upgraded in large. The aim of the initial inspection consists in grasping the initial condition of the railway structures before placing in service.

In the initial inspection, cracking, peeling or spalling of concrete and excessive deformation are mainly investigated by visual observation. But, as is often the case with peeling of concrete, it cannot be detected by the visual inspection. It may be necessary to use visual observation and tapping with a hammer. Moreover, it may be favorable to investigate the mix proportion of concrete, concrete strength and cover depth.

6. GENERAL INSPECTION

6.1 Periodic Inspection

The periodic inspection has been mainly carried out by visual observation as well as the initial inspection. The frequency of the periodic inspection is once every two years. The first aim of the periodic inspection is to find out damaged railway structures. The second one is to evaluate the degree of the damages in structures. The above evaluation considerably depends on the each engineer's judgement. To make the individual variation smaller, a certain criteria for judgement has been adopted in

Fig. 6 Investigation of chloride content and carbonation depth by drilling method

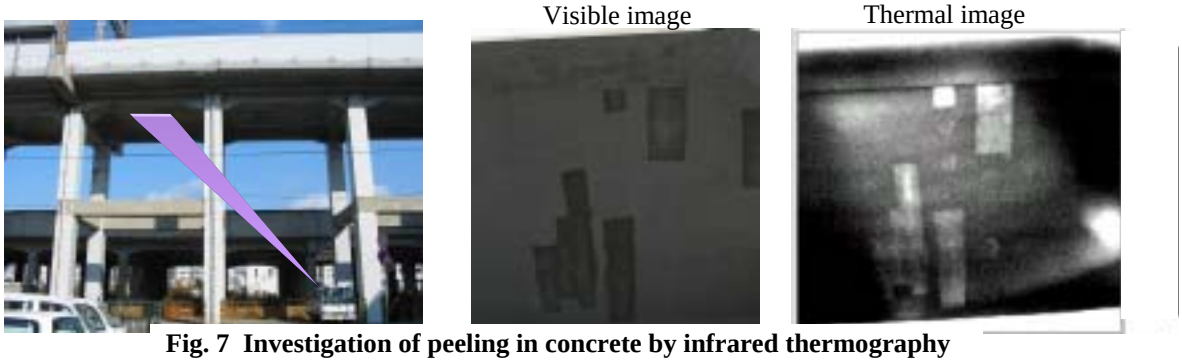


Fig. 7 Investigation of peeling in concrete by infrared thermography

the guideline. An example of the above criteria is shown in Fig.4.

Lately, it has been desired to efficiently inspect the enormous amount of railway structures. Then, various visual inspection tools utilized IT skill have been developed as shown in Fig.5.

6.2 Nonperiodic Inspection

Nonperiodic inspection would be carried out to enhance accuracy of judgement for degree of concrete structures. Generally, the detailed investigation such as carbonation depth, chloride content, steel corrosion and so forth.

Though corrective maintenance in which remedy measures would be taken after manifestation of deterioration is adopted as shown in Fig.3, the above investigation results may be effectively utilized for preventive maintenance. Preventive maintenance is an approach for maintaining a structure by carrying out detailed inspection before deterioration becomes manifest and taking appropriate measures to maintain it latent. In case where a structure is evaluated to be durable from the above investigation results, it may be possible to prolong the interval of periodic inspection.

7. DETAILED INSPECTION

In detailed inspection, the object is a rather damaged structure. At first, it is desired for expert inspectors to estimate the cause of damages and judge the necessity of detailed investigation by visual observation.

In case where the detailed investigation is needed, investigation items such as carbonation depth, chloride content and material strength would be selected. As shown in Fig.6, drilling method is recommended as the efficient one method in the guideline.

Besides the drilling method, there are many methods to investigate damages in concrete structures. As an applicable way to detect peeling/spalling of concrete, infrared thermography has gotten a lot of attention lately. Infrared thermography seems to be suitable for high-rise viaducts and bridges as shown in Fig.7..

Then, based on the results of detailed investigation, deterioration procedure would be predicted. As the corrosion rate of reinforcing steel may be proposed in the guideline, it will be possible to calculate the bearing capacity of a structure taking into account of reinforcing steel corrosion. From the above results, it may be possible to verify not only the current performance of a structure but also the future one. Remedy measures would be taken in consideration of the current damage condition and the above deterioration process.

8. CONCLUSION

The gist of the guideline for maintenance of railway concrete structures has been outlined. Though the above guideline seems to be improved in adopting performance verification type standard, there is much room to be examined in maintenance technology. It is greatly hoped that further technology development will vigorously advance.