Overview of Recent Structure Technology R&D at RTRI

Osamu MURATA, Dr.
General Manager, Structures Technology Div.

This paper briefly introduces the new railway structures technology currently being developed at RTRI. This includes design standards, maintenance and cost-saving construction technology, and that aimed at making station environments pleasanter.

Keywords: design standard, maintenance technology, cost-saving technology, station environments

1. Introduction

The new railway structure technology studies we at RTRI have been undertaking have covered, for example,: design standards, maintenance and cost-saving construction technology, and the creation of comfortable station environments.

We have frequently offered fruitful study results on these new technologies to railway companies, as briefly explained below.

An outline of these new technological developments follows.

2. Design standards for railway structures

We have been establishing a number of design standards for railway structures and are in the process of setting them for reinforced concrete structures, soil structure, maintenance technology, and allowable structure deformation.

For reinforced concrete structures, a performance-based design method has been newly adapted together with design methods for checking structure durability and using high strength materials.

In soil structure design standards a performance-based design method will also soon be adopted. New bridge abutment technology using geosynthetics and cement stabilized crushed stones in reinforced earth constructions is also under study and will be adopted in a relevant standard.

In the field of maintenance technology design standards, many new methods for testing how sound structures are will be described.

The design standard for allowable deformation of structures will set out methods of analyzing and calculating the deformation of structures caused by running trains and earthquakes and establish allowable deformation levels, in order to guarantee the safety of trains services.

3. Structure maintenance technology

In Japan, there are a number of old railway structures remaining from those constructed since 1872. It is very important, therefore, for railway companies to conduct effective and reasonable maintenance of existing structures.

Under these circumstances, we emphasize the importance of research into and development of new maintenance technologies.

A total maintenance system, for example, has been developed for existing concrete structures. The deterioration of concrete structures constructed during the high economic growth period in the 1960s has become a social problem in recent years. An easy-to-operate total integrity evaluation system has been developed to provide efficient and reliable in-situ inspections and diagnoses. Figure 1 shows a schematic diagram of the overall system. This is made up of three units: a measuring unit that consists of various nondestructive inspection devices and support programs, another containing various evaluation and verification programs, and a database unit that manages and stores measured and evaluated data.

We have also been researching the strength and fatigue characteristics of aged and corroded reinforced concrete or steel bridges. Many static loading and dynamic loading tests (fatigue tests) have been implemented from the results of which have been found correlations between strength (or fatigue characteristics) and degree of corrosion. By using these relationships, we can estimate the remaining life of structures.

Fundamental studies have been carried out on so-called intelligent materials that have properties enabling them to easily check for damage automatically. A paint that can be electrified has been researched and deve...
oped, for example, in order to assess the appearance of any cracks on structures surfaces. This paint is applied on the surface of tunnels, bridges and other structures. and when a crack forms the electrical circuit is broken. Therefore, we can easily find if a crack exists or not.

4. Cost saving construction technology

New Shinkansen lines and viaducts which can dispense with railway crossings are under construction at a number of sites in urban areas. Therefore, cost saving construction technology is very important.

Described below are three typical technological advances developed by RTRI to save structures construction costs.

Geosynthetic-reinforced soil retaining walls using short planar geosynthetic reinforcements and a continuous rigid facing have been researched and developed.

RTRI performed static loading tests with small models, long-term observation and static loading tests of full scale test embankments, and shaking table tests. The results of these tests showed that facing rigidity remarkably increased the stability of the wall. Based on these results, RTRI proposed the Reinforced Railroad with Rigid Facing (RRR) method that involves constructing an earth retaining wall with a relatively short geosynthetic and a rigid facing (Fig.2). The RRR method has been used for important railway and road embankments and the total length of wall is about 70 km. During the 1995 Hyogoken-Nanbu earthquake, RRR method with a total length of 2 km performed very well, though many conventional masonry, unreinforced gravity-type retaining walls and modern cantilever reinforced concrete retaining walls were seriously damaged. The RRR method normally costs about 20% less to construct than cantilever reinforced concrete retaining walls.

To improve the RRR method, a new abutment system, which is very resistant to strong earthquakes, has been researched and developed (see Fig.3). A part of the backfill is constructed using stabilized crushed stones with planar geosynthetics and an abutment is connected with geosynthetics. Shaking table tests were repeated and the results of these tests showed that this system was very stable during strong tremors so a design method for this new system was established. The construction cost of this new abutment system is about 20-30% less than that of conventional abutments and it has now been adopted at an actual Shinkansen construction site.

Using the caisson foundation design concept, we have proposed a sheet pile foundation. The main motivations behind this are to develop a new foundation system for railway structures on sand and to enhance the performance of existing foundations. The sheet pile foundation is a shallow footing that is skirted by sheet piles around its periphery, as shown in Fig.4. During construction, sheet piles are driven vertically to a sufficient depth and connected to the shallow foundation by shear keys. The skirt of the sheet pile foundation may lead to a higher moment and horizontal capacity than conventional shallow foundation. but the primary load is transferred to the subsoil by the shallow foundation and the sheet pile system is mainly an auxiliary to reduce settlements and tilting. The combination of sheet pile and shallow foundation results in economic advantages, if the former is designed properly. In order to establish a design method for sheet pile foundation, small scale model tests under 1G to be loaded statically and shaking table tests under 1G have been performed as have centrifugal model tests.

5. Technology to create comfortable station environments.

We have also been directing R&D efforts into creating comfortable station environments. A universal design for railway users has also been studied.

For example, a control system to smoothly guide pas-

Fig. 2 An outlook of the proposed method

Fig. 3 Proposed new abutment system

Fig. 4 Sheet pile foundation
Passengers at busy stations has been researched and developed. This informs passengers of less overcrowded routes, steps, and escalators by signs, so that passengers can make their way more easily.

R&D work has also gone into a system to evaluate station environments based on temperature, humidity, noise, vibration, and other factors. For temperature and humidity, the ISO standard, Predicted Mean Vote (PMV) indicating sense of temperature is used and the relationship between PMV and Predicted Percentage Dissatisfied (PPD) evaluated from field tests involving stations users. The test results show that PPD levels at stations are lower than in offices at the same PMV (Fig. 5).

We, the members of the Structure Technology Division, will continue to study and produce effective technologies for railway companies.