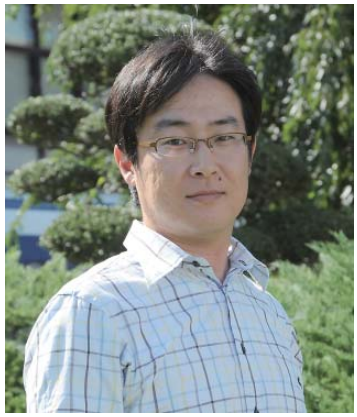
Development of a Damage Detection System for Structural Members in the Ground



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Viaducts with a rigid-frame structure are common on railways. Their foundations, underground beams and pier substructures are normally built in the ground, but for bridge piers in running water, their substructures are submerged below the surface. It is difficult to visually check the conditions of structures existing in the ground or in water.

To facilitate the inspection and diagnosis of hidden pier sections and other bridge substructures for which visual observation is difficult, the Railway Technical Research Institute (RTRI) developed a damage detection system with an RF-ID tag that can transmit attribute information on an object using a non-contact method.

This system uses a sensor unit composed of stainless-steel strain gauges that are attached on the reinforcement of the pier members of rigid-frame viaducts. When the system is applied to a bridge under construction, it detects the load increase by degrees during the construction work and contingent loads after it has been put into service in terms of the strain generated in the primary reinforcement. The detected strain values are stored in the RF-ID tag and sent wirelessly to an outside monitoring system. The developed RF-ID tag sensor system, which does not have a battery power source, is constructed as a contactless passive system capable of receiving power from outside by electromagnetic induction (Figs. 1 and 2). With this system, inspectors can acquire information on the object structure contactlessly from an RF-ID tag buried at eye level. Strain is detected as resistance by the strain gauges, read by a portable reader/writer (R/W) held aloft from outside, displayed and stored on a PC (Figs. 1 and 3).

The damage detection system thus developed was subjected to a monitoring test after installation on the pier foundation of a viaduct construction project (near Musashi-sakai station on the Seibu Tamagawa line and Musashikoganei station on the Chuo line of the East Japan Railway Company) and checked for its applicability to construction work. The RF-ID tag is sheathed with high-strength mortar to enable installation in covering concrete. The procedure for installation is to treat (grind) the surface of a reinforcing bar, weld strain gauges to paste on it, adjust the wiring of leads and affix the RF-ID tag. It takes approximately one hour to install a set of system components during the processes from reinforcing bar fabrication to form assembly without disturbing the bridge construction work (Figs. 4 and 5).

After installation on the viaducts listed above, the system components were loaded with viaduct beams, slabs and tracks in succession for half a year. The RTRI confirmed the applicability and validity of the damage detection system by obtaining stable measurement values, including those for changes in the load from all sensors during this period. By applying this system, therefore, it is now possible to check whether structural members in the ground are damaged and to evaluate the degree of damage if they are subjected to an earthquake or contingent force. This does not require excavation of the surrounding ground.

This system was developed jointly by the RTRI and Toshiba Plant System Co. using a subsidy from the Ministry of Land, Infrastructure and Transport.

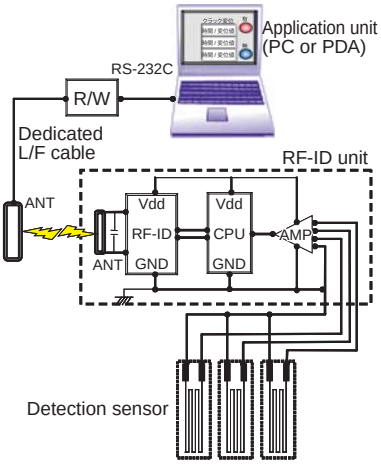

Fig. 1 Basic system composition

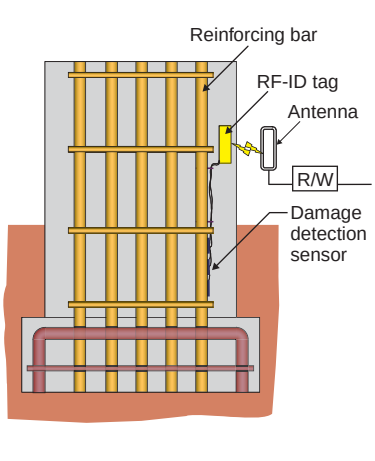

Fig. 2 Data collection

Fig. 4 Installation of detection sensors (to collect data from a rigid-frame viaduct)

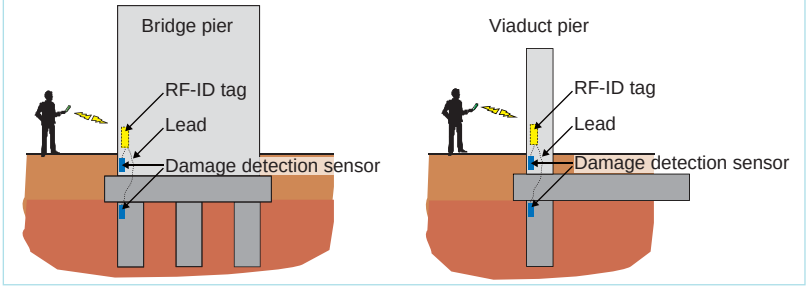

Fig. 3 Installation of damage detection sensors

Fig. 5 Installation of sensors