Technological verification to realize the observation of the overall movement of civil engineering structures during an earthquake

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1. Challenges that the National Institute for Land and Infrastructure Management is facing in strong-motion observation

The National Institute for Land and Infrastructure Management (NILIM) has been conducting strong-motion observations since 1958 to rationalize and advance earthquake resistant design standards for civil engineering structures and to clarify their movement during earthquakes. The findings of the study have been reflected in earthquake resistant design standards for civil engineering structures, such as roads, rivers, and lifeline facilities, in addition to the Specifications for Highway Bridges V Earthquake Resistant Design Edition.

The strong-motion observations targeted civil engineering structures and are being conducted by carefully selecting structures at about three locations because of the issue of cost. Still, the record of earthquakes at three locations was not enough to represent earthquake movements to clarify the complicated movement of structures during earthquakes, such as the movement of bridges with a horizontal force distribution structure.

In addition, the current strong-motion observations by the NILIM require the collection of earthquake records from actual sites rather than real-time observations using networks. The collection of records is delayed in the case of the onset of a major earthquake, and costs, such as labor costs, are required.

Based on the above, to ensure instant record collection and to identify the movement of structures during an earthquake at high precision, it is necessary to construct an observation system that can simultaneously conduct observations at multiple locations of a structure as shown in figure 1.

2. Experimental installation of MEMS accelerometer

Small and low-cost measuring instruments, such as MEMS accelerometers, have been developed in recent years. These instruments are expected to realize observation systems that could not be easily constructed when the strong-motion observation started. Still, MEMS accelerometers have not been sufficiently tested in regard to maintenance and management, such as testing outdoor communication technologies and securing outdoor power supplies. Therefore, MEMS accelerometers were installed as experiments to verify the measurement precision and on-site technologies to establish observation systems to clarify the complicated movement of civil engineering structures during earthquakes using recent technological renovations.

Accelerometers were installed as experiments on viaducts where the NILIM has been conducting strong-motion observations (figure 2). Specifically, new wireless systems and two types of MEMS accelerometers were installed in areas where earthquake meters had already been installed at Nos. 1 to 5 to perform simultaneous observations.

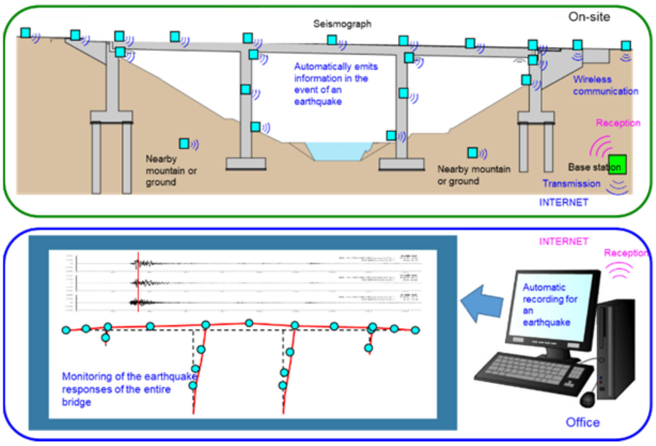

Figure 1: Schematic diagram of earthquake movement observation system

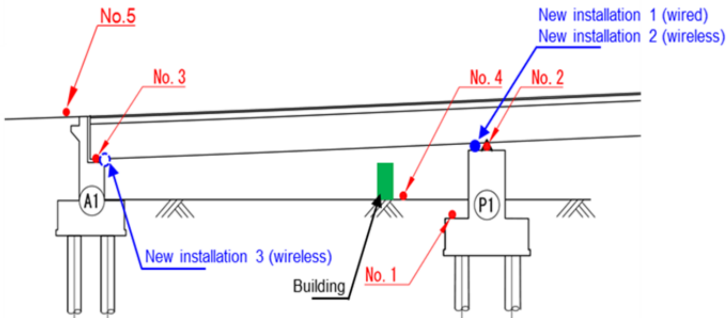

Figure 2: Experimental installation on a viaduct

3. Future activities

The NILIM is going to verify the effectiveness of the observation system using MEMS accelerometers from the perspectives of the precision of observation records obtained from individual devices, installation cost, and maintenance and management cost. The NILIM is then going to construct the observation system shown in figure 1 for the viaducts shown in figure 2. The outcome of these activities will be used as a model case to establish technologies to further improve the strong-motion observation of the NILIM to gather earthquake records that would further contribute to the rationalization and advancement of earthquake resistant design standards for civil engineering structures.