

## “Technical Research and Development for Road Policy Quality Improvement”

## Study Summary

No.	Title	Principal Researcher
No.29 - 9	Research and development on efficient maintenance and management of highway earth structures using remote sensing technology	Univ. of Tokyo Prof. Junichi KOSEKI

Research and development of technology aiming at improving the efficiency of road maintenance and management and reducing geological risks by using remote sensing technology (synthetic aperture radar [SAR]) to obtain changes in the deformation of highway earth structures (slopes, landslides, large cuts and embankments, etc.) over a wide area over time, to evaluate the priority of road inspections and disaster prevention budgets, and to predict disasters in advance.

## 1. Backgrounds and Objects

There are the technical issues in monitoring and maintenance management of the wide area road infrastructure.

The engineers have no information of the deforming areas because of the lack of database for the displacements from at the time of building and the difficulties of measuring quantitatively deformation.

Deformations cannot be easily detected particularly in the unmanaged road site due to the vegetation cover.

The indefinite activity of area which has alarming topographic or geological features causes the uncertain priority of inspection and countermeasures.

In order to solve these issues and to improve efficiency of the road structure maintenance, we have conducted researches for the following three objectives: The determination of applied condition of the Differential Interferometric Synthetic Aperture Radar (DInSAR) processing methods, the examination of DInSAR results from a the point of view the ground engineering, and the manual preparation of SAR technologies for the road maintenance.

## 2. Activities in Research Period

In 2017, in order to verify the applicability of Interferometric SAR to road soil structures, we compared successfully the measured and analyzed values in landslide areas and subsidence areas of embankment on soft ground.

In 2018, we confirmed the validity of the estimated areas of deformation, the reproducibility of precursor of collapse, and the consistency between horizontal/vertical displacement analysis and measured values in any cross section, in Kisa and Takano districts where slope collapse and landslides are in progress along Onomichi-Matsue Expressway.

We also compared the ground deformation measurement value obtained by GNSS and analyzed value at the high embankment by NEXCO ( in Takarazuka district), based on which we studied the validity of the analysis.

In 2019, we focused on Onomichi-Matsue Expressway as a one line in a wide area, and screened for deformation areas to classify the deformation areas by risk. We examined future policy, and made a geotechnical engineering consideration by confirming the deformed part on site.

In 2020, we made a draft manual of utilization by compiling outcomes from the last 3 years studies. This draft manual was checked by road administrators so that edited as easily usable at the side.

## 3. Study Results

(1) Maintenance and management of road structures and utilization of Interferometric SAR

- For slopes, landslides, large cuts, and embankments on soft ground, it was shown that it is possible to grasp the extent and activity of deformation, including uncontrolled ones, to understand the precursor phenomena of slope failure, and to supplement the periodic measurement of settlement.
- For the screening of a wide area of a single railroad line, we showed the possibility of

developing a policy for future actions and quantitative measurements by combining the priorities based on the variation rank classification with the topographical and geological information that should be paid attention to.

- In terms of disaster response, we demonstrated the possibility of minimizing weeding by understanding the extent of deformation, providing geological engineers with information on areas of severe deformation, and minimizing the number of dynamic observation points by using time-series behavior information.

## (2) Optimal Interferometric SAR Analysis Method and Organization for Maintenance of Highway Earth Structures

### (3) Example of analysis

#### 1) Grasp of deformation

A comparison of the results of the Interferometric SAR analysis and field survey in the Kisa area of Onomichi-Matsue Expressway is shown in Figure-1. It can be seen that the extent of the deformation is almost the same.



Fig. 1 Comparison between field survey and Interferometric SAR of slope failure area

#### 2) Understanding precursor phenomena

For the landslide in the Takano area of Onomichi-Matsue Expressway that occurred during the July 2018 heavy rains, the antecedent phenomena before the heavy rains were evaluated and shown in Figure-2. It can be seen that ground deformation occurred in the section where there were no slope anchors before the heavy rain. In addition, the slope was analyzed as having "deformations" in areas other than the target slope, and we confirmed that there were no deformations. This is probably because errors caused by changes in the electron density of the ionosphere, atmospheric effects, and the overall movement of the earth cannot be completely eliminated.

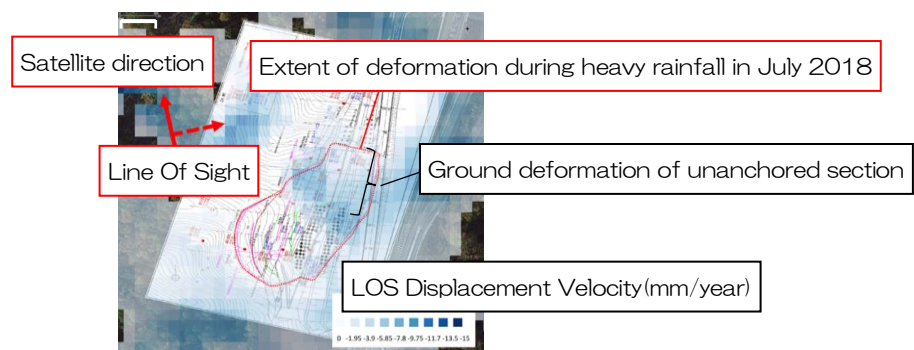


Figure-2 Range of possible precursor phenomena before the July 2018 heavy rains.

#### 3) Example of application on a single route in a wide area

Screening by Interferometric SAR analysis was conducted on Onomichi-Matsue Expressway. As shown in Fig. 3, each location was classified into four categories (Fluctuations A to D) and evaluated together with the topography and geology to be noted.

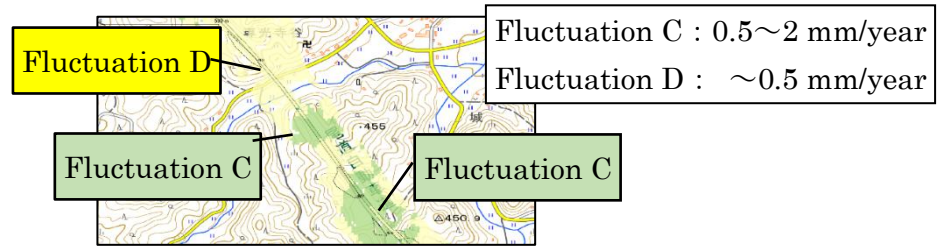


Figure-3 Screening on the Onomichi-Matsue Road

#### 4. Papers for Presentation

- J. Koseki, S. Yokota, W. Takeuchi, T. Yoshikawa, Y. Yagiura, Y. Noguchi: Deformation Evaluation by InSAR for Efficient Maintenance and management of road earth structures, Geotechnical Engineering Magazine, pp. 22-25, 2018
- T. Yoshikawa, J. Koseki, Y. Kamata, T. Kiyota, Y. Yagiura, W. Takeuchi and Y. Noguchi: Efficient Maintenance of Road Structures Using Satellite SAR, 33rd Japan Road Conference, 2019
- T. Yoshikawa, J. Koseki, T. Kiyota, and W. Takeuchi: Understanding slope deformation using interferometric SAR, Foundation Engineering & Equipment, Jan. 2021, pp. 63-65, 2021

#### 5. Study Development and Future Issues

It will be possible to periodically screen the road deformation in a wide area for each route at once, and to focus the inspection on the areas with large deformation. Southeast Asia, like Japan, is covered with forests, and we believe that the results of this research will be useful.

#### 6. Contribution to Road Policy Quality Improvement

It enables periodic screening of road deformation in a wide area, and inspection and detailed investigation can be carried out with emphasis on areas with frequent deformation. This makes it possible to efficiently inspect and maintain highway earth structures, reduce inspection costs, and improve the durability of the entire route in a uniform manner.

#### 7. References, Websites, etc.

[https://www.kiso.co.jp/services/remotesensing/analytic\\_technology.html](https://www.kiso.co.jp/services/remotesensing/analytic_technology.html)