Winter Service

Preparing for Extreme Snowfall to Prevent Large-Scale Vehicle Stranding

Services routiers hivernaux

Mesures face aux chutes de neige extrêmes
visant à prévenir les blocages à grande échelle

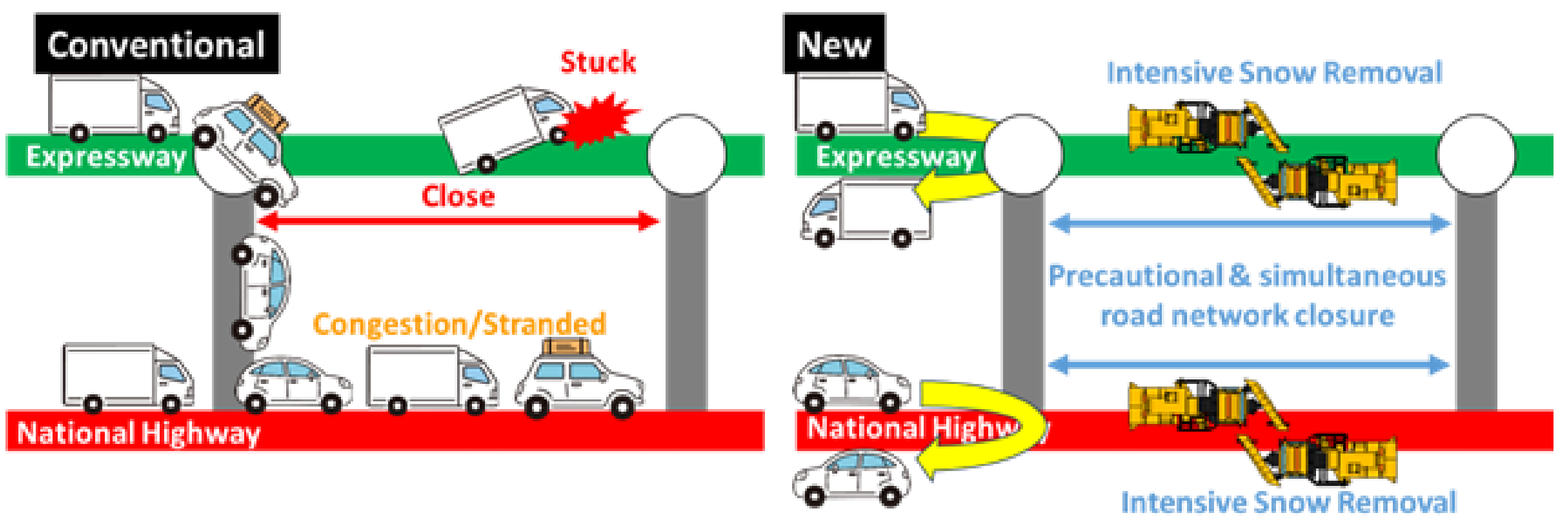
- Due to climate change, intensive snowfall events and the amount of snowfall have been increasing in recent years, and the risk of large-scale vehicle stranding caused by vehicles getting stuck on expressways has been increasing.
- The conventional policy focused on reopening closed road sections as much as possible. However, this has changed in view of the fact that extreme snowfall events involving intermittent intensive snowfall have been occurring every year.
- The new policy is to carry out preventive road closures before the occurrence of vehicle stranding in time zones and road sections in which extreme snowfall is likely to occur, in order to start snow removal operations promptly after snow stops falling so that roads can be opened to traffic as soon as possible. In the Kanazawa area in north-central Japan, which experienced large-scale vehicle stranding, no similar road closure has occurred since the preventive measures were taken, but vehicle stranding problems remain unsolved in other areas. Possible causes include the fact that the roads where such problems occurred are heavy-traffic routes with many large vehicles and many summer-tire-equipped vehicles driven by drivers inexperienced in snow and ice conditions.
- Further efforts are also underway to introduce new equipment in order to improve on-site activities.

Preventive road closure

Large-scale vehicle stranding

Asking drivers whether they want to evacuate temporarily

Preventive road closure



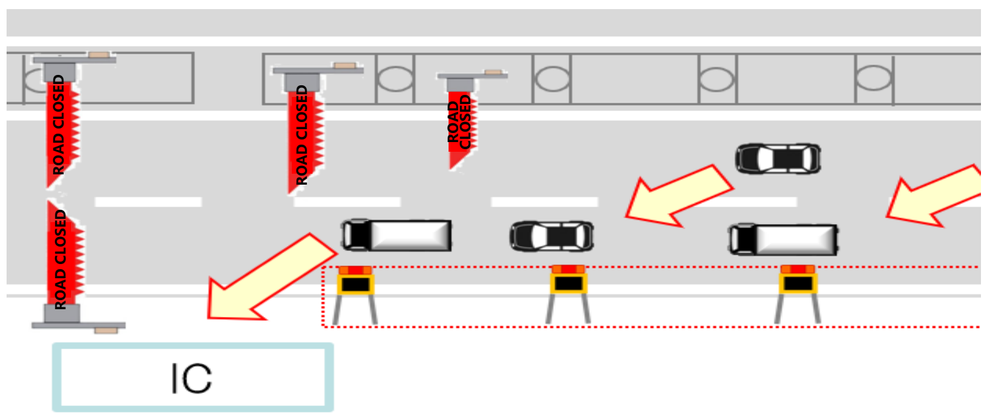
Unexpected Closures by Stranded vehicles
- ✓ Vehicle gets stuck on expressway
- ✓ Expressway closed due to stranded vehicles
- ✓ Traffic detouring to highway leads to congestion
- ✓ In worst case, vehicles stranded on highway

Optimized Operation for Early Re-opening
- ✓ Precautional & simultaneous road network closure
- ✓ Intensive snow removal
- ✓ Early re-opening of road network while ensuring safety

Improvement of on-site activities

Inflatable crossing barriers

The first thing to do when closing a road is to display a road closure message on message boards. However, some vehicles may have already entered the road closure section before the road closure begins, so they may get stuck or stranded. In order to prevent such situations, inflatable crossing barriers have been installed to enable physical closures to be performed in real time while information is displayed on the message boards.



Road closure with inflatable crossing barriers

Inflatable crossing barriers

EV snowmobiles utilized to assist road users

The standard approach for collecting information on stranded vehicles and delivering emergency relief goods to road users was to walk or use sleighs to reach stranded road users, which were labor-intensive and time-consuming. To perform those tasks efficiently, EV snowmobiles and drones have been introduced, and efforts are underway to strengthen emergency response services by conducting drills.

EV snowmobiles

EV bike that can also be used as a snowmobile

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NEXCO CENTRAL

Development of Technology to Automate Snowplow Operation
~ Labor Savings through Autonomous and Multi-Vehicle Convoy Technologies ~

Développement de technologies de conduite autonome pour les engins de déneigement
~ Réduction des effectifs grâce à la conduite autonome de plusieurs véhicules et à la conduite en convoi ~

In view of the shortage of skilled snowplow operators due to the aging of population and a declining workforce, we are working on developing the technology to automate snowplow operation with the aim of reducing or eliminating workforce requirements associated with the convoy operation of snowplows. The goal is to reduce the number of snow-removing equipment operators for the second and third snowplows in a convoy from two to one.

Features of technology development

- Each snowplow moves autonomously on a different path (autonomous driving technology).
- Each trailing vehicle runs on a different path from the vehicle ahead while keeping an appropriate inter-vehicle distance (inter-vehicle distance maintenance technology).

Development phases

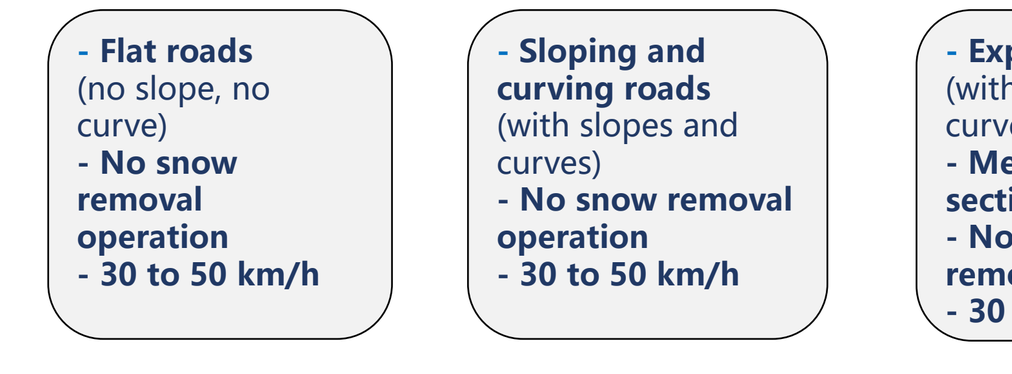
As shown below, the technology for the convoy operation of snowplows has been developed in phases. The ongoing Phase 4 involves field testing under realistic snowfall conditions. The next step is to move onto the validation stage using prototype vehicles for further demonstration.

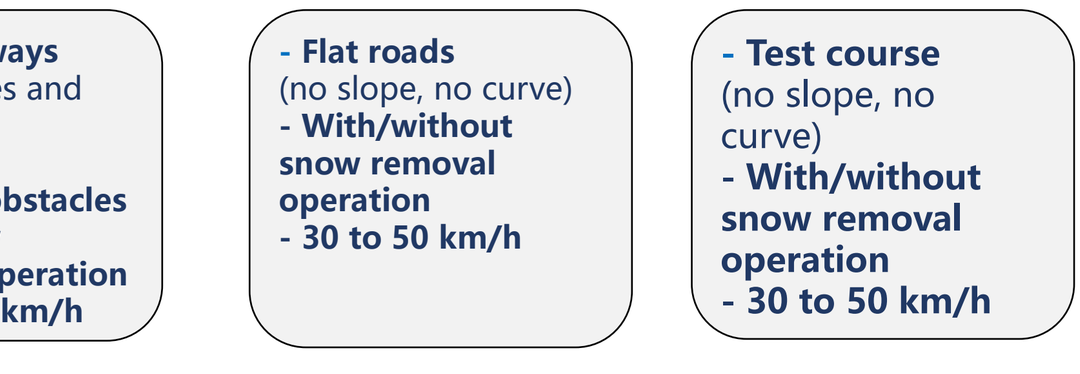
Phase 1 2023	Phase 2 2023	Phase 3 2024	Phase 4 2025	Phase 5 (Prototype vehicle) 2026
- Flat roads (no slope, no curve) **- No snow removal operation** **- 30 to 50 km/h**	**- Sloping and curving roads** (with slopes and curves) **- No snow removal operation** **- 30 to 50 km/h**	**- Expressways** (with slopes and curves) **- Merging sections/obstacles** **- No snow removal operation** **- 30 to 50 km/h**	**- Flat roads** (no slope, no curve) **- With/without snow removal operation** **- 30 to 50 km/h**	**- Test course** (no slope, no curve) **- With/without snow removal operation** **- 30 to 50 km/h**

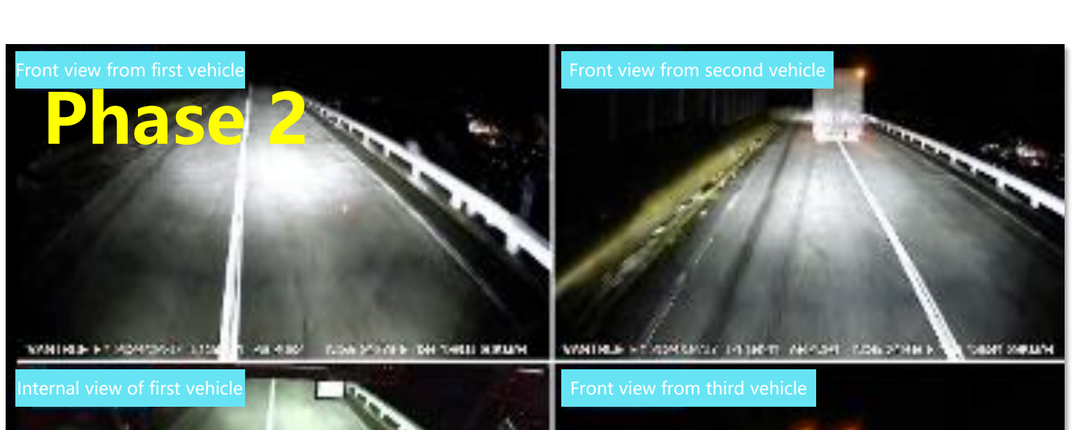
Establishment of convoy technology for practical operation

Establishment of technology to transition from single-row operation to convoy operation

Phased development process







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NEXCO CENTRAL

Efficient Training of Personnel for Snow and Ice Operations
Vehicle Operation Simulator for Snowplow Operator Training

Formation efficace du personnel chargé des opérations de neige et de verglas
« Simulateur de conduite »
pour la formation des opérateurs d’ engins de déneigement

NEXCO CENTRAL has developed a vehicle operation simulator to train expressway snowplow operators jointly with Central Nippon Highway Maintenance Nagoya Company Limited (a NEXCO CENTRAL group company) and other companies.

Background of development

- In view of the aging of snowplow operators essential for snow and ice operations and a declining workforce, there is a growing need to increase and train operators to prepare for a shortage of snow and ice operation personnel.
- In practice, snow removal on expressways is performed in a convoy operation involving two or more snowplows. Snowplow operators are required to perform complex operations, such as controlling the snowplow blade located in front of the vehicle while driving. However, the company had difficulty providing operators with opportunities to acquire the necessary skills using real snowplow vehicles.
- To solve this problem, we have developed a vehicle operation simulator that can be used for snowplow operation training in a simulated environment.

Snowplow convoy operation

Vehicle driving and plow operation study

Features

- The operator's cabin is equipped with a real snowplow equipment (e.g., snowplow attachment) control system.
- Different weather conditions can be simulated by varying the snowfall intensity and snow cover depth.
- A VR simulation of the alignments and road structures, such as bridges, tunnels and tollgates, of expressways is provided.
- Team operation training can be conducted with up to three simulators.
- The replay function allows operational performance to be reviewed and training results to be evaluated on a five-point scale.

Simulated snow removal operation in a VR environment

View from inside the operator's cabin

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VIBRES System
Technology for Measuring Ground Anchor Tension Using Vibrations
2023 PIARC Prize - Best Innovation Prize Winner

Système VIBRES
Technologie de mesure par vibrations de la tension des ancrages au solLauréat du
« Prix PIARC 2023 – Meilleure innovation »

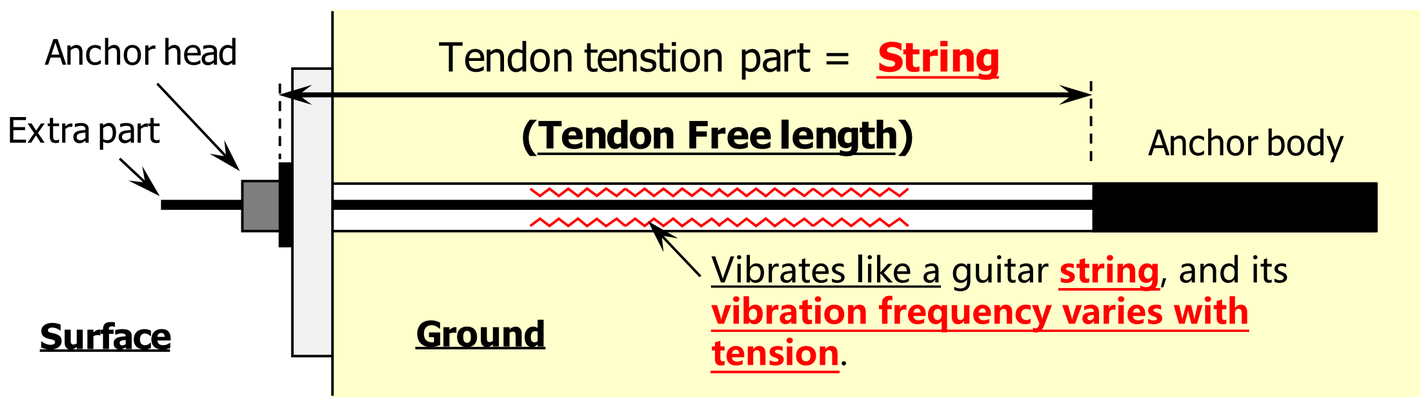
- A ground anchor (hereafter referred to simply as "anchor") is a tendon with one end anchored in stable ground and the opposite (free) end tensioned so as to stabilize a structure such as a slope. Anchors, therefore, need to be inspected.
- During a tension inspection, it is common to conduct a lift-off test using a center-hole jack. However, this test may require heavy equipment and, in some cases, temporary scaffolding.
- The VIBRES system is a new technology to measure anchor tension efficiently using vibrations.

Principle of the VIBRES system

An anchor consists of an anchor body, a tendon, and an anchor head. Since the tendon of an anchor is a relatively slim member whose thickness is significantly smaller than its length, the free length of the tendon may be regarded as a ‘string’ fixed by the anchorage zone and the anchor head. The vibration frequency (f) of the string is determined by the linear density (μ) of the string, string length (L), and tension (T), and their relationship can be expressed as shown below. The VIBRES system measures the vibration frequency of the tendon free length.

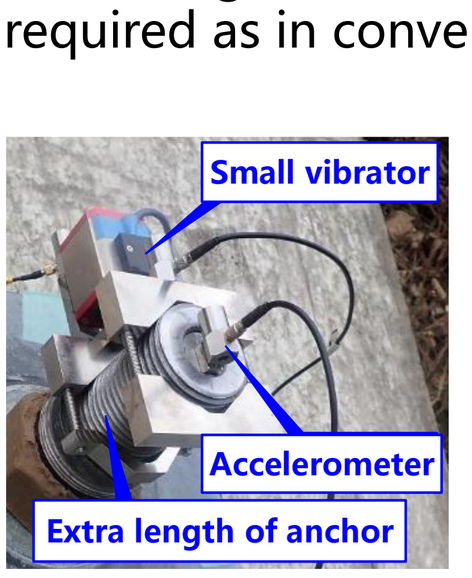
$$T = 4 \times L^2 \times f^2 \times \mu$$

T: Tension (N)
L: Tension Free length (m)
f: Resonance frequency (Hz)
μ: Line density (kg/m)



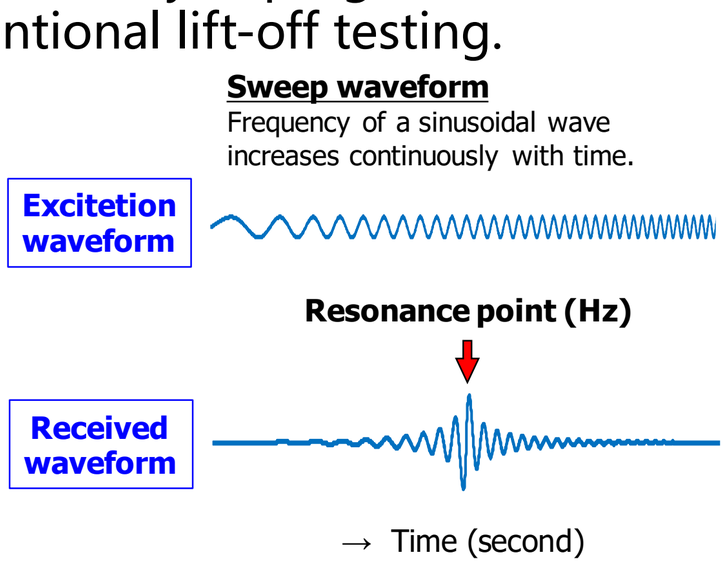
Measuring method of the VIBRES system

Since the free length of the anchor tendon is underground, its vibration frequency cannot be measured directly. The VIBRES system uses a small vibrator installed on the extra-length portion and applies sweep vibrations whose frequency increases over time. When the frequency of the vibrations and the frequency of the free length coincide, resonance occurs. The frequency of this resonance is measured with the accelerometer installed on the extra-length portion to determine the tension of the anchor. One measuring session takes 60 to 120 seconds.
In addition to the small vibrator and the accelerometer, the measurement uses a compact measuring unit and an analysis program installed in a computer. No large equipment is required as in conventional lift-off testing.



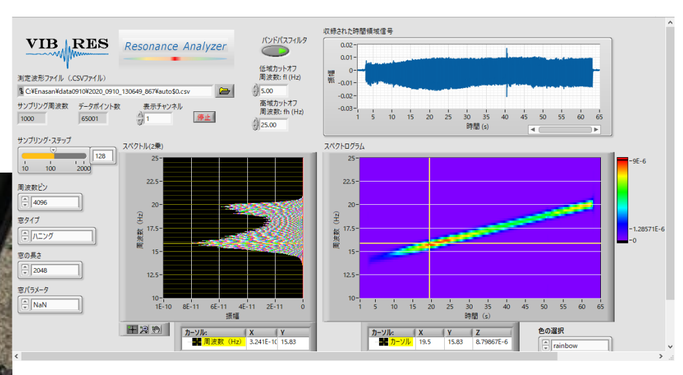
● VIBRES installation

Sweep waveform
Frequency of a sinusoidal wave increases continuously with time.



● Acceleration waveform and received waveform

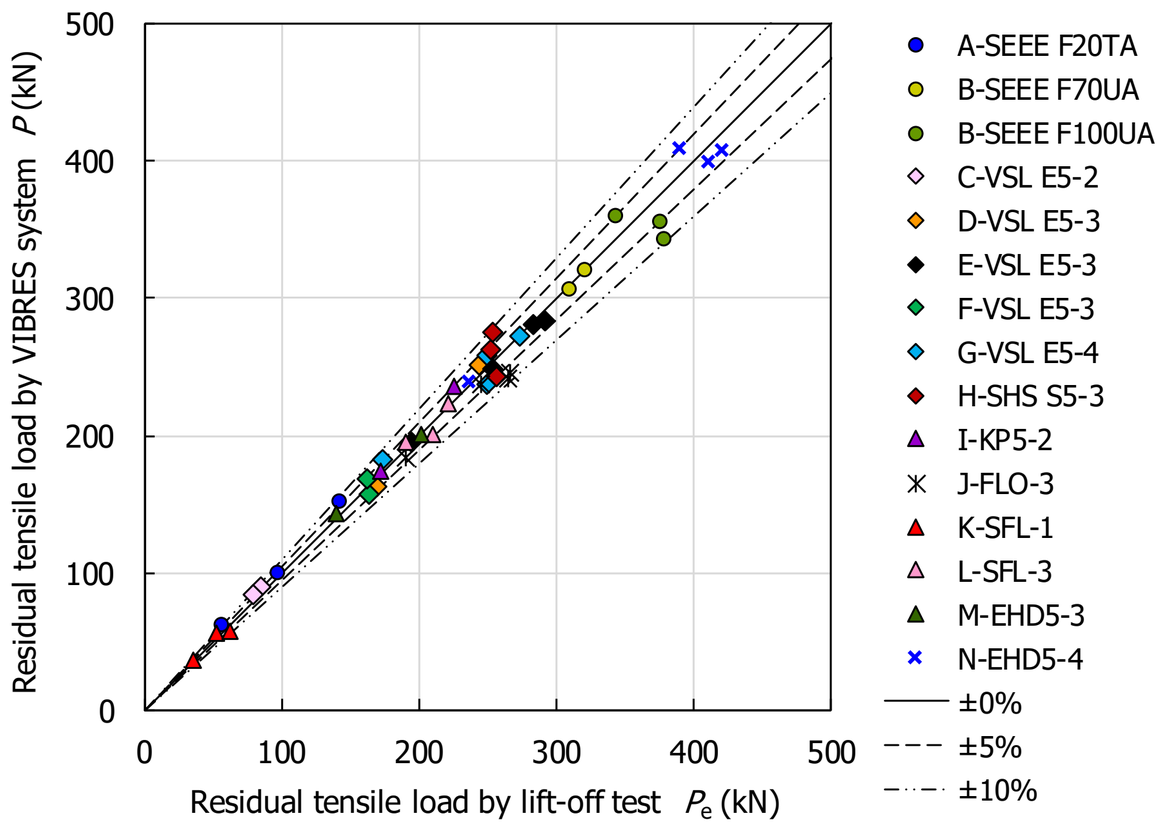
● Measuring unit



● Example of analysis (on the computer screen)

Accuracy of VIBRES system

Comparison of tension measurement results obtained from the VIBRES system and a conventional lift-off test showed that the tension measurements obtained from the VIBRES system were largely within ±10% of the lift-off test results. The VIBRES system is a breakthrough and unique technology that enables efficient inspection and safety enhancement by using vibrations to measure anchor tension.



Comparison of tension measurements:
Lift-off test vs. VIBRES system

* The VIBRES system was developed jointly by Central Nippon Highway Engineering Nagoya Co., Ltd., Oyo Corporation, and Gifu University.

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