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Infrastructure Development Institute—JAPAN

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Mobile Mapping System【IMS3】

Simplify maintaining road facilities by a small-scale 360-degree camera IMS3

1.Introduction

Teikoku INC. is a Japanese survey and civil consulting company, which started as a small survey company in 1954, located in Gifu prefecture. We have been assisting the local government by surveying, measuring and designing infrastructure at the district long term. In 2013 we have entered a new frontier; expanding our business to the capital, Tokyo and overseas. Additionally we have been recently developing a new survey technology called the Mobile Mapping System (MMS). Our new goal is to become a global consulting company recognized both for its excellence of services and social contributions.

2. Outline of Mobile Mapping System (MMS)

(1) Outline of MMS

The MMS automatically acquires 3D coordinate data and image data of various structures such as roads, surrounding buildings, signs and guard rails using mounting cameras, 3D scanners, and a GPS on automobiles. This system is mainly used for the maintenance of road equipment, road facility surveys, and road damage surveys.

(2) The MMS

The MMS is mainly categorized into two types depending on different surveying mechanisms ; the Photographic Surveying system and the Laser Surveying system.

Our company provides a photographic surveying system called the【IMS3】.

IMS3 can carry out the measurement of terrain and objects through a 360 degree video after analyzing and processing photographic data.

The table below compares and evaluates the IMS3 system in comparison with the laser surveying system.

Table-1 Comparing the laser surveying system with ISM3

	Laser Surveying system	IMS3
Appearance	  Laser System Device	  Panorama Camera
Output	 A Collection of the Point Group Data	 Wide and Detailed Photographs
Total Price of the System	**US$ 810,000**	**US$ 243,000** **Rate 123.53yen Sep 2020*
Survey Accuracy	Higher	Average
Image Data	Colored Point Cloud data	High precision image data
Date Amount	Larger (Point Cloud Data +Photographic Data)	Smaller (Photogaraphic Data)
Require ments for PC	Needs higher processing capability	Needs lower processing capability

[Pros of IMS3]

- The IMS3 system is more affordable than its comparative product (only costing about 33% of the price of the laser surveying system)
- A high-precision measurement and image data can be acquired
- It is possible to directly take measurements on the image; this operation can be performed easily.
- Due to its data amount being smaller than the laser system, data will be processed fast, making it easier to manage
- Since the amount of data is small, PC specifications can be supported at the low end.

3. Features of IMS3

(1) Overview of IMS3

This system contains two 360-degree cameras and a GPS receiver placed on the vehicle, simultaneously shooting all the road structures while driving (approximately 50 km / h). The photographed images are subjected to an image analysis, processed using a dedicated software, and the data of road structures are added to the video database. During this process, the images are converted to a three-dimensional video, and its size can be measured instantly.

Moreover, it can be linked with map information allowing a detailed position of the structures to be specified. Additional information of the equipment can be attached to a detailed road management database that contains video and text data.

Figure-1 IMS3 filming its surroundings

(2) Composition of IMS3

IMS3 consists of two Ladybug3 cameras, one accelerometer, one GNSS, one PC, and two hard disks. Each Ladybug 3 camera can photograph 16 frames of the surroundings per second. To compensate the vertical position, acceleration in XYZ-axis can be measured by an accelerometer. The geographic coordinate information of the car can be obtained from the GNSS, and the PC and hard disks are used for recording the video data.

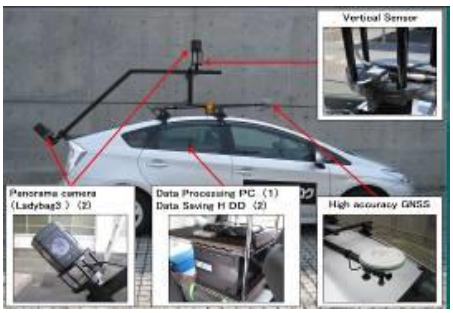

Figure-2 Composition of IMS3

(3) Main features of IMS3

1) IMS3 has a very simple composition and can be equipped to various vehicles.

2) The cameras, sensors, and other parts (of IMS3) can be easily dismantled and assembled. This makes it convenient to protect these parts when the vehicle travels far distance.

3) High precision data can be obtained from the GNSS data. Measurements can be taken while the vehicle is moving, which can save much more time in comparison to traditional surveying work. The moving mapping system (MMS) secures safety during the surveying process.

4) Structures can be identified from any angle using the 360-degree video processed by the software.

Due to the lack of any dead angles, this video can be utilized for 3D measurements.

5) It can connect to GIS; the 360-degree video can be applied widely to various systems or applications.

Main Features of IMS3

- Extremely simple composition
- Easily equipped on the vehicle
- Efficiently proceeds surveying
- Detects objects from various angles
- Direct measurement of road facilities on the PC Screen
- 360-degree video connecting to GIS

4. Anticipated Results

The image data of road facilities captured by the IMS3 system simplifies the process of maintaining and managing them. This is because the system eliminates the need to carry out a careful inspection and measurement of the road structures on site. This data can be utilized by many users through its combination with various applications, such as GIS.

Examples of how to use this image data is provided below.

(1) Road maintenance and management

IMS3 can be utilized for road maintenance, management, and inspection.

For example, by using the software, the video data of the roads can be used to measure the size of roads and structures and to inspect the pavement condition of roads.

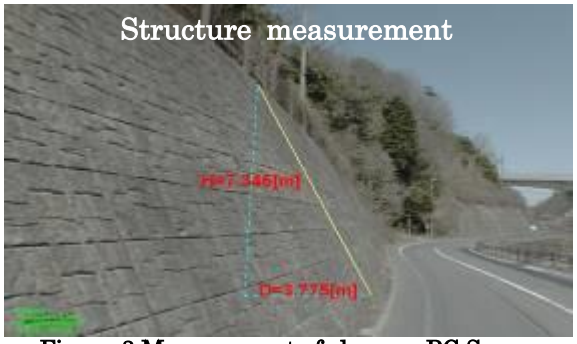

Figure-3 Measurement of slope on PC Screen

Figure-4 Measurement of Road width on PC Screen

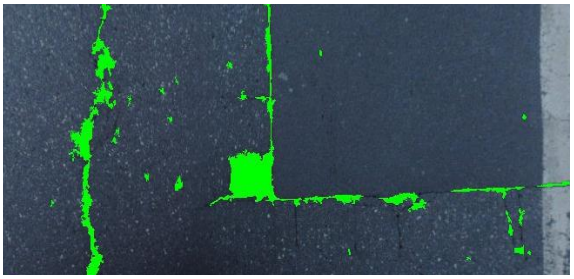

Figure-4 Pavement Cracks on PC Screen

(2) Road Disaster Prevention system

This system can capture the surroundings of the road in detail. Topographical features can be extracted from the captured image. For example, the dimensions of the slope protection work and its deterioration status can be obtained. Furthermore, if the photograph indicates that there is a possibility of a landslide, it is possible to predict its scale. Using this feature, IMS3 can also be applied to disaster prevention inspections.

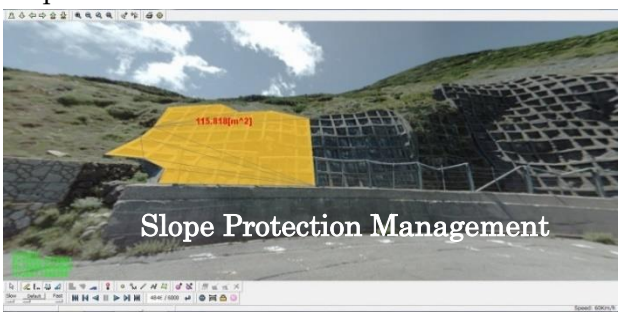

Figure-5 Measurement of Slope Protection

Figure-6 Grasping the size of Possible Landslide

(3) Connecting with GIS

IMS3 can be linked to a GIS (Geographic Information System). When selecting any object in the system, the GIS will reflect its location. If the user makes marks on the screen within the system, the mark will be reflected in the GIS as well.

Figure-7 Connecting with GIS

(4)Landscape Simulation

ISM3 also has a feature that provides a landscape simulation after repair, which can contribute to the development a detailed road repair plan. This feature enables adding 3D CG models to the captured screen, making it useful to present the anticipated results to clients.

Figure-8 Landscape Simulation

(5) Further applications

It is possible to attach IMS3 to any moving vehicle. For example, it can be mounted on a boat. This way, river bulkheads, bridge piers and other objects, which are difficult to identify from land, can be filmed easily. It can also film videos by being mounted on a cart, or moved by a personnel. This will allow to film places where vehicles are prohibited inside; such as theme parks.

Figure-9 IMS3 attached on a boat and cart

5. Conclusion

We believe that Teikoku's IMS3 system can be extremely useful for collecting and organizing data for the maintenance of road facilities. This system can be utilized without going to the site by saving the photographs of all road facilities, structures, and trees along the road in a PC. In addition, if the road manager identifies damage on the road facilities during usage, the location information of the road facility can be shared immediately.

Teikoku hopes that many road managers will use this system as its key characteristic lies on its simplicity and usability. We plan to actively work together with road managers overseas to contribute to an efficient management and maintenance of road facilities. In conclusion of this article, we would like to express our deepest gratitude for this opportunity.

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22nd Infrastructure Technology Development Award 2020

Japan Institute of Country-ology and Engineering (JICE) was established as a public interest corporation to promote construction engineering in Japan by conducting cutting-edge research and development activities.

As more incentives should be provided for construction technology researchers and research institutes to enhance the level of construction engineering more effectively, JICE commenced Infrastructure Technology Development Award with Coastal Development Institute of Technology (CDIT) under the auspices of the Ministry of Land, Infrastructure, Transport and Tourism(MLIT).

forty technologies competed for the 22nd Infrastructure Technology Development Award.

In principle, the applicants' technologies should have been developed within the past five years and applied to the real sites already.

As a result of examination, institutes and researchers with the following technologies were awarded 22nd prizes.

The grand prize is " Liquefaction Countermeasure for Existing Residential Areas".

And the two excellence prizes are " Steel timbering erecting robot" ,and "EDUCATIONAL SYSTEM FOR CLOSE VISUAL INSPECTION OF FATIGUE FAILURE IN STEEL BRIDGES".

The grand prize is introduced below.

Any inquiries/ comments please contact to JICE :
Homepage: http://www.jice.or.jp/
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Liquefaction Countermeasure for Existing Residential Areas

Liquefaction Countermeasure by surrounding the Housing Plot with Improved-Soil-Walls, allowing continued daily living

1. Background Information

In 2011 the Great TOHOKU Earthquake caused serious liquefaction disasters in many residential areas, including URAYASU city. (Photo-1) The liquefaction disasters triggered the need for implementing permanent ground stabilization, which can be applied to built-up residential areas. Since large machines are used, conventional liquefaction countermeasures can only be applicable to wide open areas with no existing houses. If the conventional method was to be used for built-up residential areas, houses had to be demolished/moved to provide space for improving the soil underneath. There are other soil improvement methods, however they cannot be used if the ground contains clay. To tackle this problem, our target became to create a new liquefaction countermeasure solution that is compatible with the "clay and built-up area". This new solution is to surround housing plots with Improved-Soil-Walls, as shown in Fig.1.

Photo-1: Residential Area Liquefaction caused by the Great East Japan Earthquake

Fig.1 Surround Housing Plot with Improved Soil Wall

2. Outline of Technology

As the world's first solution, our liquefaction countermeasure allows clay improvement while the residents continue to live in their own houses. Only the ground of the housing plot border is improved, diminishing the need for the houses to be removed. To create these improved-soil walls, different methods for result-evaluation and construction in congested narrow spaces were developed. These Liquefaction Countermeasure technologies are as follows:

1) A New design method using a new analysis method, called the "Pseudo 3-Dimensional F.E.M." It enables analyzing the 3D heavier of the improved-soil-walls as well as the untouched soil confined by the soil-walls. (Fig.2)
2) The "ECOTITE" method, which stabilizes the soil column using a high-pressure cement mixing machine. (Fig.3) Since the machine is very small, this method can easily be adapted to narrow spaces. This method also enables Box-shaped soil improvement.
3) The "SMART-COLUMN", a small machine that mixes cement/soil mechanically inside the roads effectively. (Fig.4) This mixing machine is more affordable compared to the high-pressure cement mixing machine mentioned above.

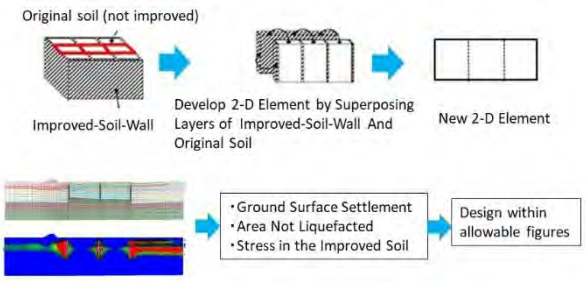
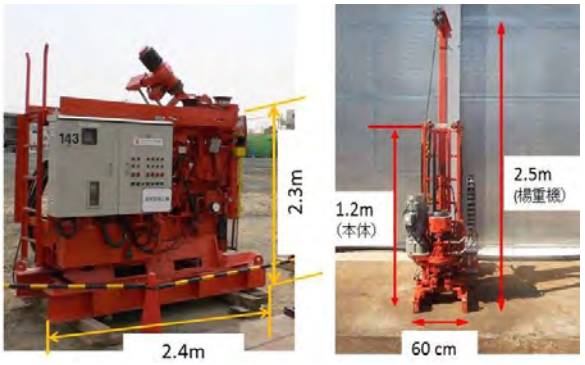
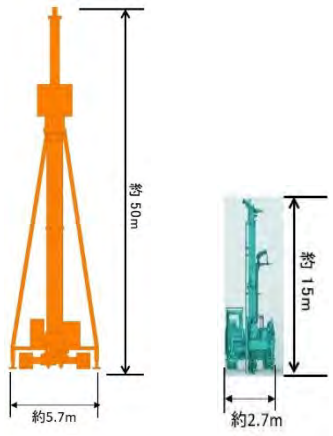


Fig.2 "Pseudo 3-D F.E.M." can analyze the behavior of the improved-soil-wall and vicinity ground



(a) Conventional machine (b) New "ECOTITE"

Fig.3 High-pressure Injection and Mixing machine



(a) Conventional machine (b) New "SMART-COLUMN"
Fig.4 Mechanical Mixing machine "SMART-COLUMN"

3. Dimensional Requirements

Our method can be executed under the following conditions.

- The length of boundary between housing plots must be less than 16 m
- The exterior house wall-to-wall clearance must be wider than 80 cm
- There should be no unremovable underground obstruction wider than 1 m.

4. Effect of Technology

There are direct and indirect effects of the Liquefaction Countermeasure technologies. Direct effects are as follows.

1) Liquefaction countermeasures can be executed while the residents keep on living in their own houses during the operation,
2) The cost for ground improvement and sludge removal is reduced by 28%, compared to the price if the high-pressure-jet-mixing machine was used for the whole road. This is enabled by combining the "SMART-COLUMN" mechanical mixing method with the "Box-shaped" high pressure jet mixing method.
3) The operation period for road improvement is shortened by 22%, using the same comparison as above. Since traffic closure is reduced, this helps maintaining the quality of daily life for residents living nearby.

Indirect effects are as follows.

1) The land asset value increases. Because both housing plots and roads are improved, the infrastructure reliability against earthquakes increases.
2) The vibration caused by traffic is reduced because the housing grounds are surrounded by the improved soil walls.

5. The Social Meaning and Future Development of Technology

This technology has proved that it will contribute to the betterment of future society by protecting peoples' lives and assets against any liquefaction disasters. There are many opportunities and possibilities to apply this technology to foreign countries that are prone to earthquakes. As this technology allows continuous usage of existing facilities during operation, it can be used for upgrading existing industrial plant yards, container yard at ports, etc.

6. Application Record

This liquefaction countermeasure technology has been applied to four places in URAYASU, Chiba prefecture, Japan from December 2016 to March 2019.

Table-1 Conventional Liquefaction Countermeasures and Application Restrictions

Base	Category		Name of Method	Machine Size	Exist. Building to Remain	Clay
Improve Characteristic of Soil	Soil Compaction		Sand Compaction Pile	Large	No	OK
	Ground Hardening	In-situ Soil Mixing	Mechanical Mixing	Large	No	OK
			High-Pressure Jet Mixing	Small	No	OK
		Chemical Injection	Permeation Grouting	Medium	OK	No
	Soil Replacement		Replacement	Large	No.	OK
	Lowering Ground Water Level		Deep Well	Small	OK	No
Improve External Conditions such as Stress, Deformation, Pore Water Pressure	Drainage		Gravel Drain	Large	No	OK
	Restriction		Grid-pattern Ground Improvement	Large	No	OK

Applicant:
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(2) Chemical Grouting Co., Ltd. (CGC)
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Infrastructure Development Institute-Japan (IDI) is a general incorporated association operating under the guidance of Ministry of Land, Infrastructure, Transport and Tourism of Japanese Government.
IDI provides consulting services to facilitate International Assistance to developing countries, to promote international exchange of information and human resources, and to support globalization of project implementation systems targeting both developed and developing countries in the field of infrastructure.

IDI has been publishing the free quarterly journal called “IDI Quarterly” since1996 to introduce information related to public works and construction technologies developed in Japan to foreign countries. We have distributed the journal to administration officials in more than 90 countries around the world by e-mail.

It is highly appreciated if you would send us your opinions, impressions, etc. on the articles.
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