Jakarta MRT
Indonesia

Program for Construction Safety Improvement applying OSV monitoring at Jakarta MRT Project in Indonesia

Final Report Summary

March 2016

Japan International Cooperation Agency（JICA）

The General Environmental Technos Co., Ltd.
Toa Elmes Co., Ltd.
Akebono Brake Industry Co., Ltd.

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Chapter 1 Project Background

The Japan International Cooperation Agency (JICA) financially supports the Jakarta MRT System Project by ODA Loan Agreement with the Republic of Indonesia. Since it is the first subway construction project in Indonesia, it is expected to implement an effective project plan including the safety and environmental management. In addition, the underground excavation is carried out through the concentrated Jakarta metropolitan area. The minimization of the construction influence towards the population and buildings is essential.

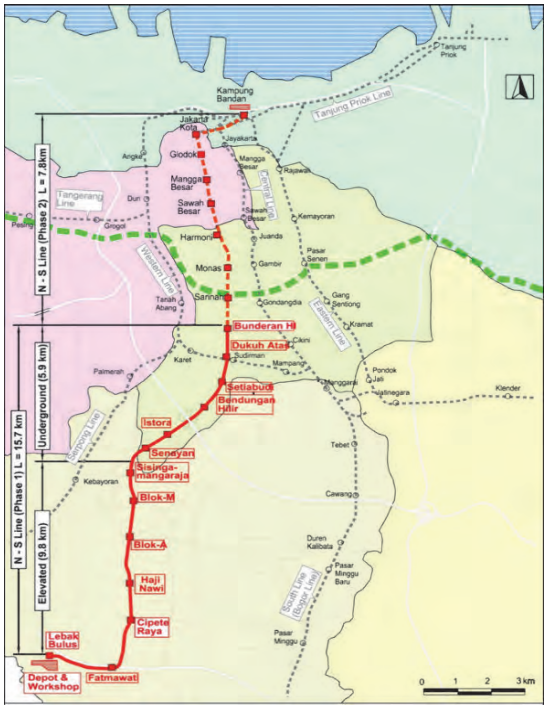


Figure 1.1 Jakarta MRT project map

The Jakarta MRT System Project Phase 1 (15.7km) has been executed already and has expanded to Phase 2, which runs in the city area. The appropriate safety management plan is key for further infrastructure development as well.

It has become a serious issue regarding deficient safety management of construction projects in developing countries. Once a major accident occurs and it brings negative public attention, the project can occasionally be ceased.

Figure 1.2 Jakarta MRT Construction Site

The main advantage of the On Site Visualization system (OSV) is that the safety level is shown in situ visually. It enables the safety information to be open to the public extended from the construction site. In addition, it can be an ideal opportunity to prove that advanced Japanese technologies are able to provide strong safety plans to the construction projects founded by JICA.

Chapter 2 Project Overview

2.1 Project Title

Program for Construction Safety Improvement applying OSV monitoring at Jakarta MRT Project in Indonesia.

2.2 Objectives

JICA has supported subway construction projects in developing countries, however, accidents at construction sites still occur and urgent safety management plan are in demand. This programme is mainly utilizing OSV measurement technology for the improvement of safety at construction projects in developing countries. The main purpose of this programme is to support the improvement of the safety management and to give proof of the usability of the Japanese measurement technology. The OSV measurement system was implemented for subway construction projects in India and the outcome was well recognized. This programme plan includes the implement of the OSV monitoring systems, the prevailing Japanese measurement technique, the establishment of the safety management plan and the improvement of safety awareness of the construction personnel and the residents near the construction area.

2.3 Activities

Success of this programme will bring further opportunities for the implementation of the Japanese safety management techniques and the measurement instruments. After the installation of the OSV measurement system onto the Jakarta MRT project, the sales of the OSV devices will be available at seminars, site visits and exhibition of the OSV devices.

The programme is composed of the following three phases.

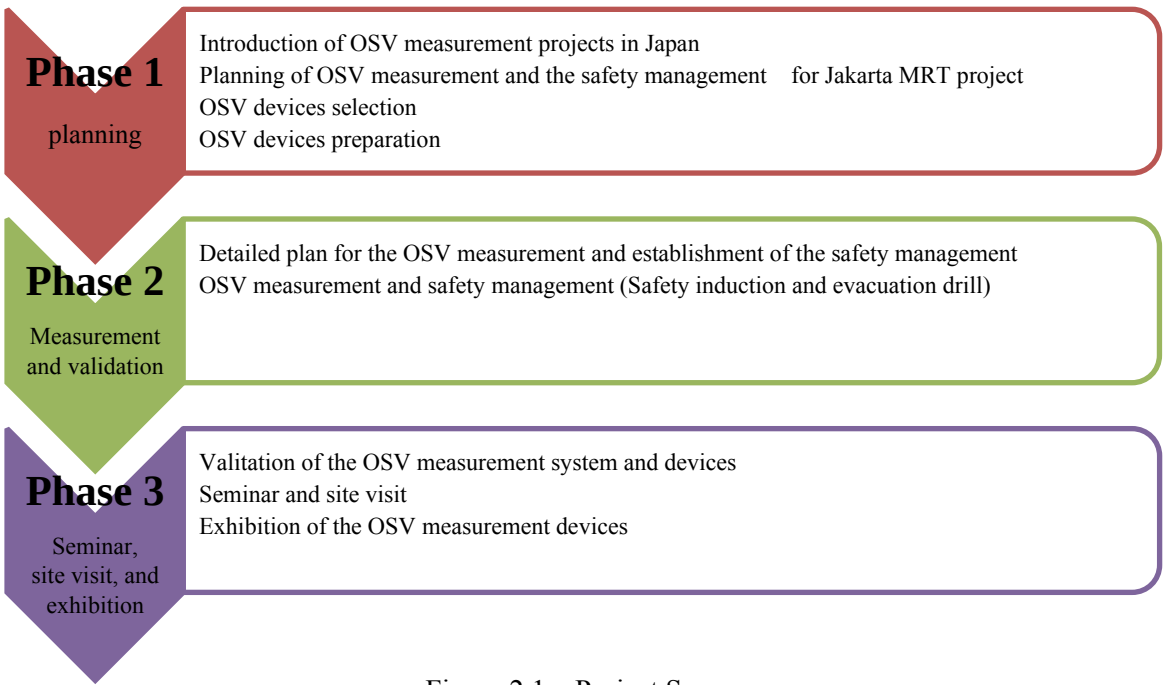


Figure 2.1 Project Summary

2.4 System Specifications

The OSV devices are used for measuring the deformation of the existing buildings including the adjacent buildings and statues and makeshift structures such as retaining walls. The table below summaries the OSV measurement details.

Table 2.1 OSV devices

Devices	Specification	Visual effect	Measurement point
 LEC (Light Emitting Converter)	The LEC is a data logger which is designed for connection to variety sensors for real-time data display as 5 different coloured lights.	Light colour changes for different data level.	Incline of the existing and makeshift structures
 LEIS(Light Emitting Inclination Sensor)-Pocket version	Mobile inclination sensor with the LED light. It has 1/500 degree accuracy and requires short initialization time.	LED light colour changes for 3 levels. At the flashing mode, the battery lasts for approximately 1 week.	Incline of the existing and makeshift structures
 SOP(Single Observation Point)	A LED or other light source is fixed on one side and reflected on a mirror placed on the area to be monitored. With this set up, the light will cease to be reflected should there be any deformation of the area where the mirror is placed.	The observation needs to be from the fixed points. The deformation is able to detect only from the observation points. It is applicable to enclose the information.	Deformation of the makeshift structures

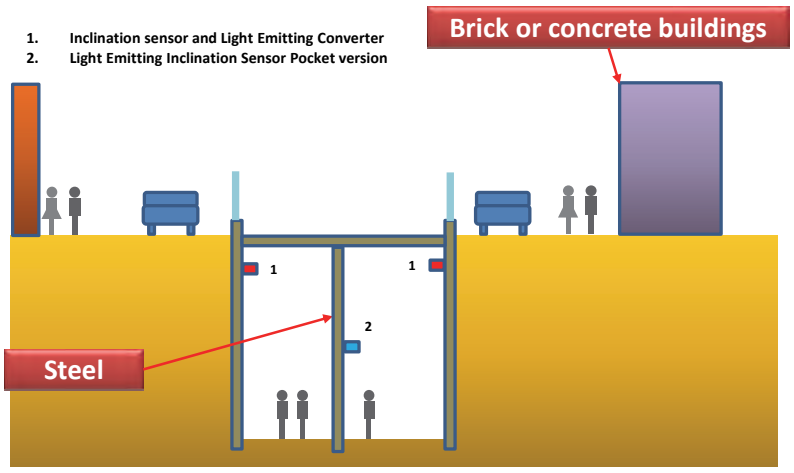


Figure 2.2 Monitoring concept in construction site

2.5 Agency

Applicants:

The General Environmental Technos Co., Ltd.

Toa Elmes Co., Ltd.

Akebono Brake Industry Co., Ltd.
Oriental Consultants Global Co., Ltd.
Oriental Consultants Co., Ltd.
Kobe University

Clients:
Mass Rapid Transit Jakarta, Indonesia

Chapter 3 Project Plan

3.1 Project Summary

3.1.1 Monitoring Location

Figure 3.1 shows OSV monitoring locations (CP106、CP102).

Device installation and monitoring were conducted at CPI06 (Bunderan HI, Dukuh Atas). At CP102, monitoring was conducted by a contractor after device installation.

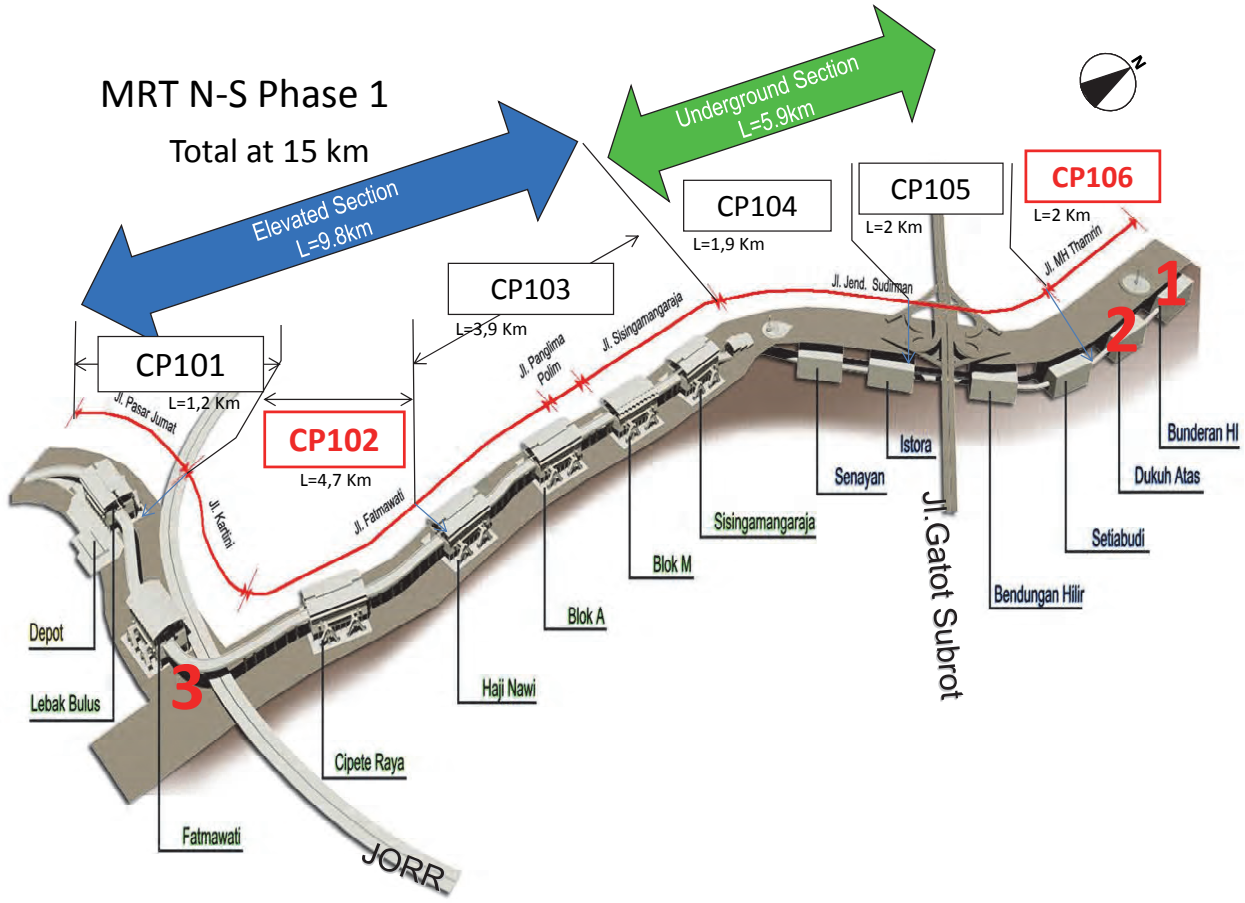


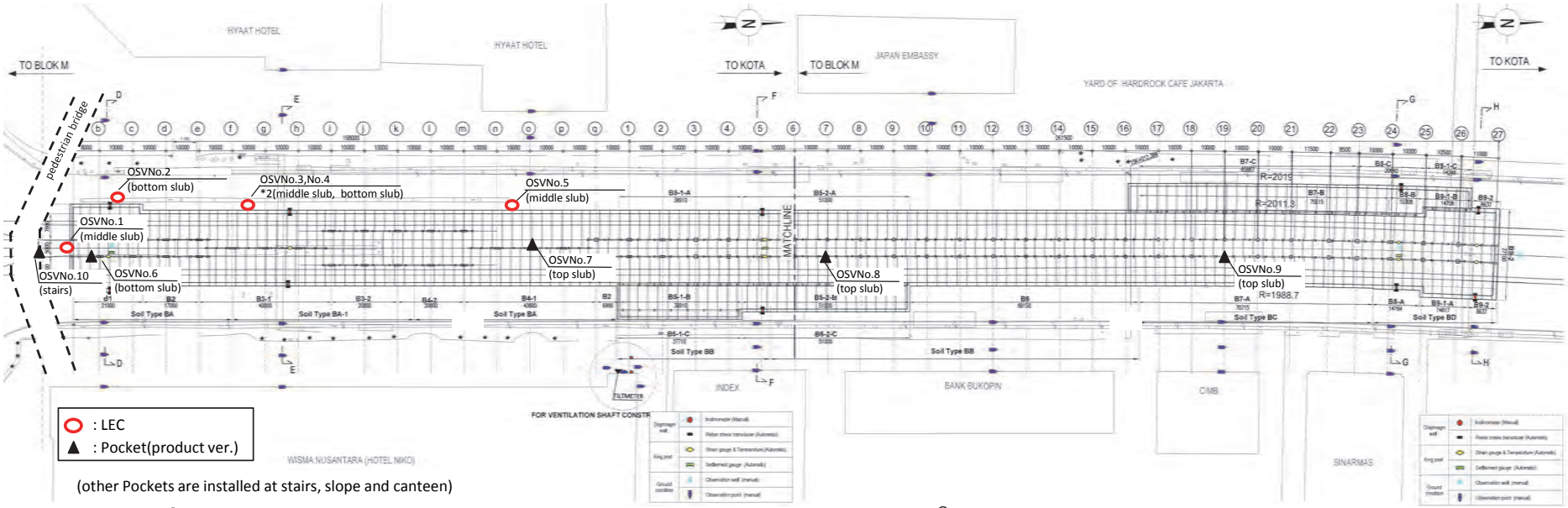
Figure 3.1 Monitoring location

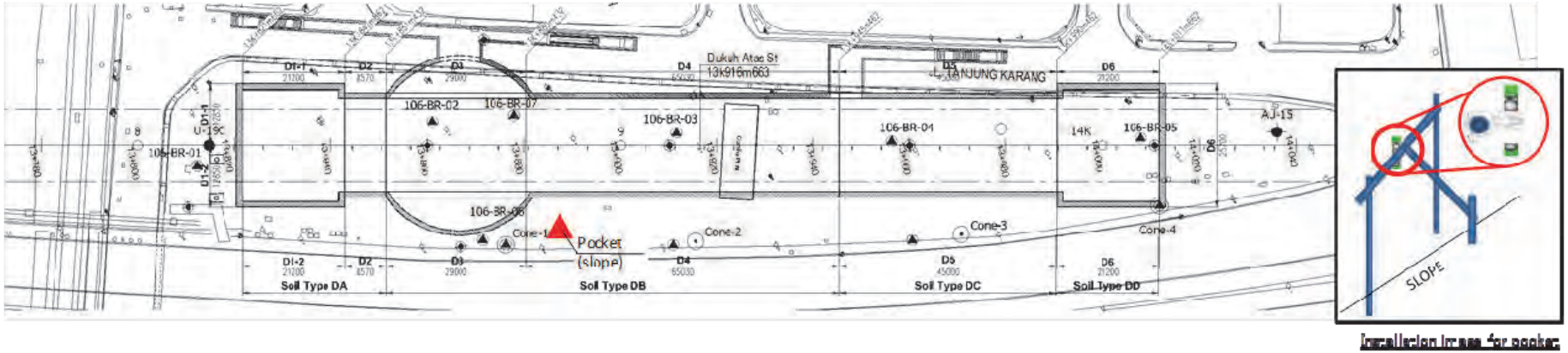
3.1.2 Install Location and Monitoring Settings

Monitoring device installation location and monitoring settings are shown in Figure 3.2. The plan was discussed and decided with the contractor considering the area condition and construction plan.

3.1.3 Monitoring schedule

Monitoring schedule is shown in Figure 3.3.

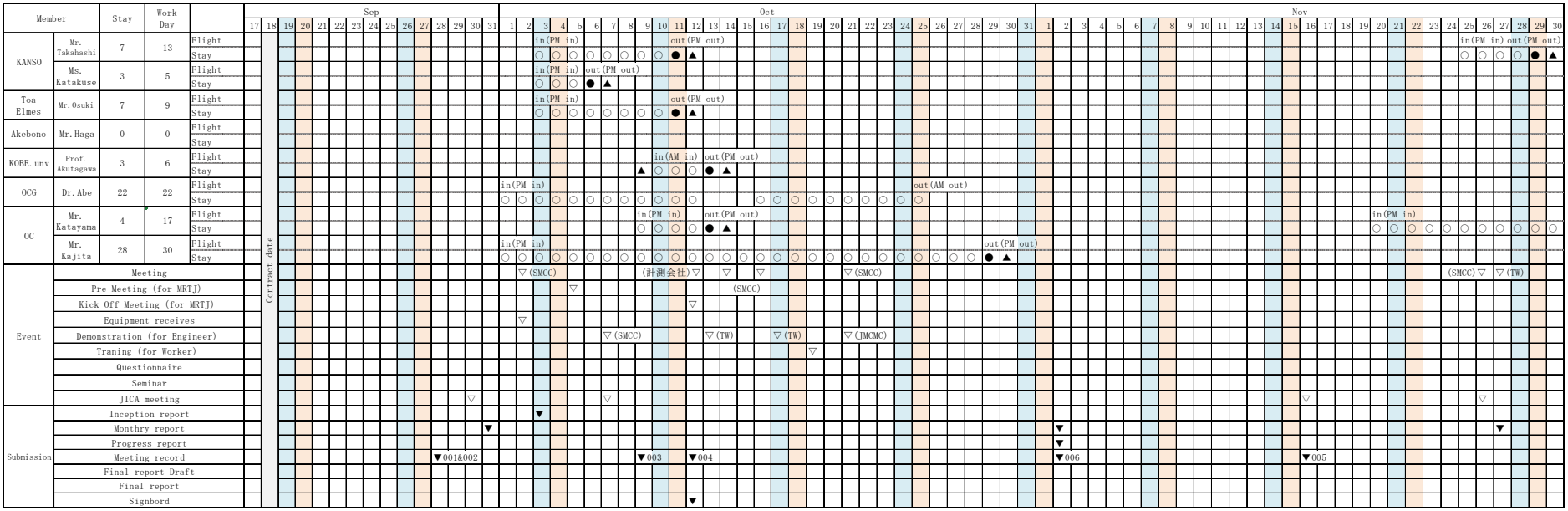


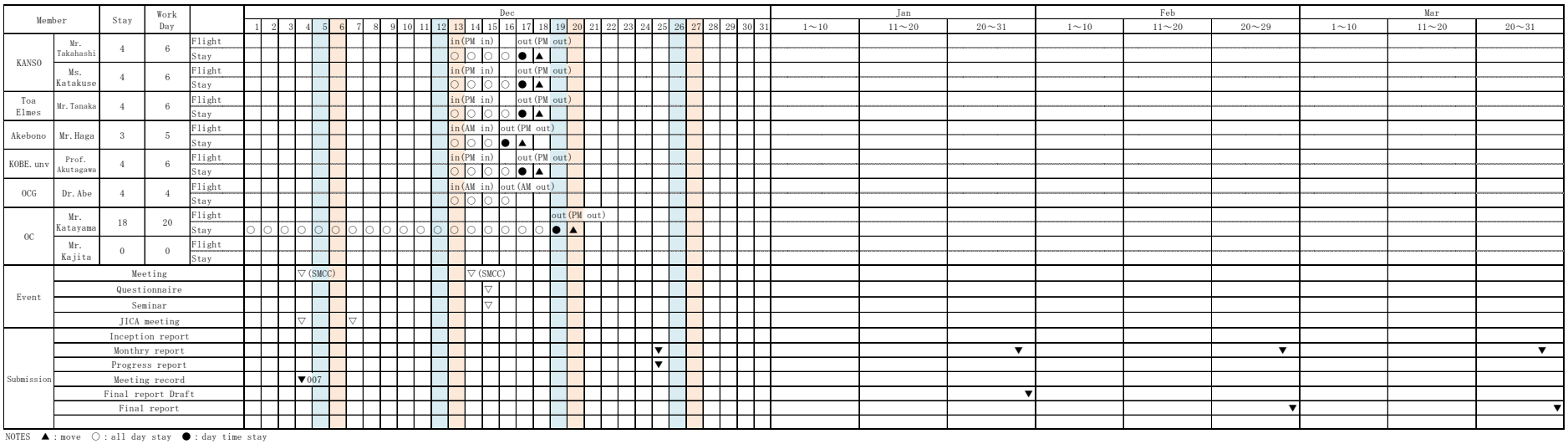


OSV No.	LOCATION	INSTALLATION	CONTROL STANDARD VALUE			
		LEC or Pocket	Allowable Level (A.V)	Alert Level*1 BLUE LIGHT	Action Level*2 YELLOW LIGHT	Alarm Level*3 RED LIGHT
1～5	diaphragm	LEC	Design Value	less than 0.057(deg) [1/1000]	0.057(deg) [1/1000] or more less than 0.191(deg) [1/300]	0.191(deg) [1/300] or more

OSV No.	LOCATION	INSTALLATION	CONTROL STANDARD VALUE			
		LEC or Pocket	Allowable Level (A.V)	Alert Level*1 GREEN LIGHT	Action Level*2 YELLOW LIGHT	Alarm Level*3 RED LIGHT
6～9	kingpost	Pocket	Design Value	less than 0.1(deg)	0.1(deg) or more less than 0.2(deg)	0.2(deg) or more

Figure 3.2 Device installation plan view and monitoring settings (CP106 above: BUNDERAN HI station, below: DUKUH ATAS station)





NOTES ▲ : move ○ : all day stay ● : day time stay

Figure 3.3 Monitoring schedule

3.2 Measurement Results

3.2.1 Light Emitting Converter

(1) Objectives

Slabs were monitored on-time by inclination sensors and Light Emitting Converter II (LEC-II) showed monitoring value by different colours.

(2) Measurement Results

Monitoring data confirmed that there was no problem in the monitoring devices operations and installation locations. Although No.4 and No.5 showed some variations, the data were stable in overall. It is also confirmed that monitoring techniques were transferred to local workers;

- Monitoring devices were installed by a local engineer at No.5 and the data showed a similar value compared with other monitoring locations where both Japanese and local engineers were involved in device installation.
- LEC-II was installed at No.2 on 2015/12/16 by a local engineer and there was no problem seen in the obtained data.

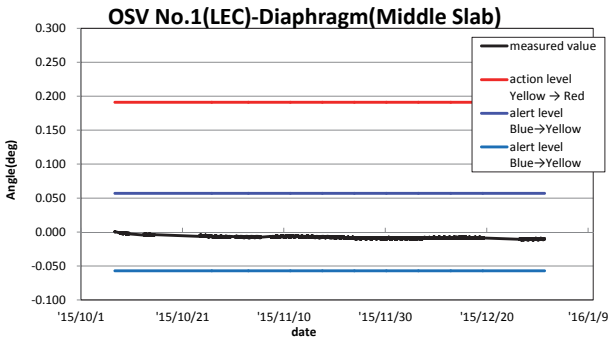
No.1 (Middle Slab)	Data
	

Figure 3.4 An example of monitoring location and obtained data (OSV No.1).

(3) Future Tasks

1) Installation

- Simplify the inclination sensor installation process by improving connector types

2) LEC-IIsettings

- Enable LEC settings by tablet type device rather than laptop
- Installation software multilingualisation

3) Monitoring management

- Prepare the backup power supply for power outage
- Improve the method for obtaining data by using a wireless network / Adopt sound warning system

4） Questionnaire

- Install additional light displays for workers in other construction areas
- Improve awareness regarding OSV monitoring by locating information panels near the monitoring devices

5） Others

- Reduce the total installation cost

3.2.2 Light Emitting Inclination Sensor/Pocket

(1) Objectives

As a part of the safety management plan on the site, Light Emitting Inclination Sensor/Pocket (LEIS / Pocket) was used to monitor selective points in short term and visualize the information using coloured lights.

(2) Measurement Results

Collected data showed that there was no issue for the operation and installing locations. Output was changed when the workers touched the devices, however it was not the actual deformation.

- Data collection and summary were conducted by local engineers
- The simple installation method was fully understood by the local engineers and further device installation was discussed.

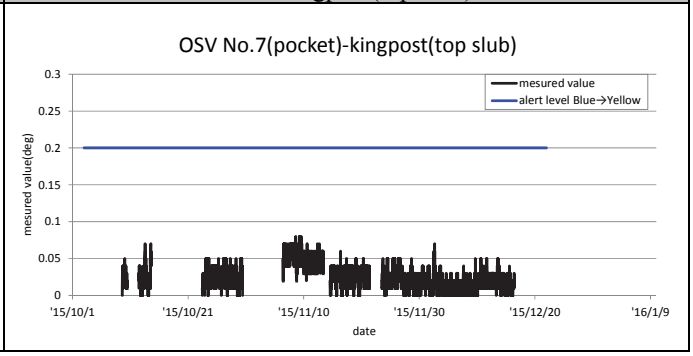
No.6 kingpost(bottom slub)	No.7 kingpost(top slub)
	

Figure 3.5 An example of device installation and collected data (OSV No.7).

(3) Future Tasks

1） Device installation

- Device has to be fixed tightly to avoid malfunction

2） Settings

- Enable LEC settings by tablet type device rather than laptop
- Dedicated software is required to simplify the operation process

3） Monitoring management

- Enable settings to turn on/off the operation check function to avoid confusion.
- Considering the battery cost, the monitoring device has to be selected depending on the monitoring purpose
- Enable the time settings to adjust to the local time
- Add the sound warning system to LEIS / Pocket

4） Questionnaire

- Improve awareness regarding to OSV monitoring by locating the information panels near the monitoring devices

5） Others

- Simplify the operation process and use procurable items for further use

3.2.3 Other OSV Monitoring

The Single Observation Point (SOP) method which measures the inclination using mirrors was implemented as an experiment at the same monitoring point as OSV No.7. Figure 3.6 shows the SOP monitoring concept.

A mirror (size: 3 cm x 8 cm) was attached onto the top slab and the reflected image on the middle slab in the opposite side can be seen through the mirror. If the middle slab is inclined, the reflected image is lost from the mirror.

The SOP was installed and monitored from October to November in 2015. The reflected image was observed during the period, which means that the middle slab did not move. Although the measurement area is limited, SOP can be said to be a cost effective and simple monitoring method.

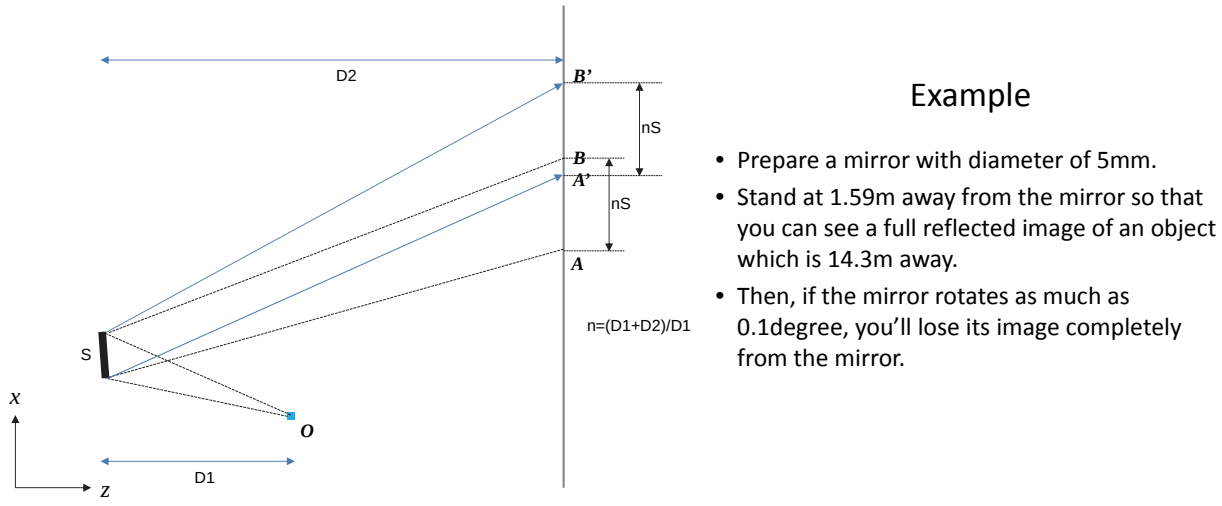


Figure 3.6 SOP monitoring overview

Mirror on the slab

Color image on the middle slab

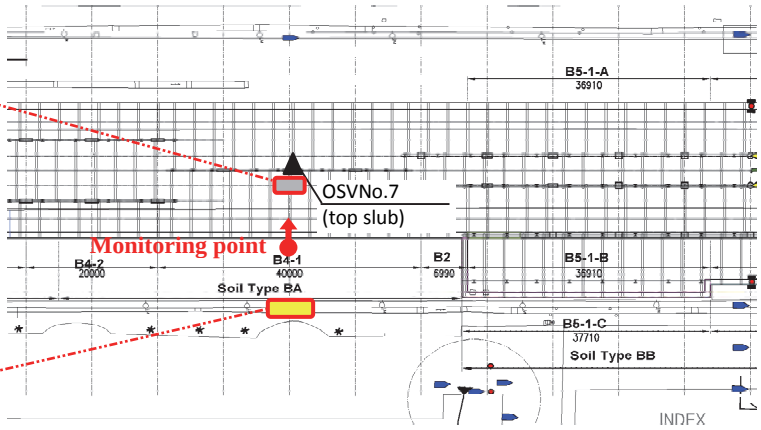


Figure 3.7 SOP monitoring location

3.3 Safety Management using OSV

3.3.1 Safety Meeting

Safety meetings were held for different positions. Figure 3.8 shows the meeting for managers and engineers of Jakarta MRT and Jakarta MRT Construction Management Consultants. For the contractors, the concept of OSV monitoring and the safety management system was explained to management engineers. The details of the safety monitoring system and monitoring plan was explained to local engineers. All the safety meetings were conducted by the JICA Team staff.

Figure 3.8 Safety meeting for MRTJ

Figure 3.9 Safety meeting for local workers

Additionally, the safety managers of the local contractors were educated on how to conduct safety meetings in order to organize the safety meetings for local workers. This safety meeting was held once a week in the morning (see Figure 3.9).

An OSV monitoring information board was placed on the construction site. It was installed mainly for engineers and workers at the site, however the board was also designed and located to show the OSV monitoring information to the public (see Figure 3.10). Posters were also put around the site to distribute the information.

Figure 3.10 The OSV information board near the local office

A brochure was printed and distributed to the people involved to provide the safety measurement procedure using the OSV system. It can be used for further projects as an explanatory material.

3.3.2 Evacuation Drills

Based on experiences in India, it is very effective to conduct evacuation drills to prevail the OSV safety

management system. However, it has to be conducted by the local safety managers, not by the JICA Team. Therefore, the JICA Team made a suggestion and the details were organized with the local safety managers.

The evacuation drill was conducted at 3 pm on October 17th. The OSV light at Bunderan HI Station was purposely turned to red and all workers and engineers were evacuated from the construction site (Figure 3.11). To avoid the confusion, JICA team members were located on the exit and stairs to instruct the workers. The evacuation point was decided at the front of the local container and the workers' safety was confirmed. The safety meeting was conducted after the drill to familiarize themselves with the OSV monitoring system.

Figure 3.11 Evacuation drill on the site

The evacuation drill was successful and it was confirmed that the safety management using the OSV system would be continued after the JICA Project.

3.3.3 Future Tasks

Portable OSV devices can easily be installed and placed in any location, however, the light source is weak and difficult to recognize under strong sunlight. Careful attention is required when selecting the monitoring location and OSV devices.

At the evacuation drill, the JICA Team made a suggestion and the details were organized with the local safety managers. Even after the JICA Project, safety management using the OSV system would be continued by local contractors. It was suggested by the local contractor to install a sound warning system onto OSV devices. It is under consideration and the manufactures agree with the suggestion.

The OSV devices used in this project would be continuously used at the Jakarta MRT project. It has been suggested to improve the devices and increase the number of the monitoring locations to the local contractors.

After the OSV project by JICA at the Delhi Metro Project in 2011, the OSV installation became mandatory in further construction plans. The value of the OSV system has been shown clearly to the client, Jakarta MRT. It is expected that the OSV system will become mandatory in the Jakarta MRT construction project in Phase I to improve safety in the construction site.

3.4 Questionnaire

A questionnaire was conducted to the 35 local workers on the site to confirm the improvement in safety awareness by the OSV systems (Figure 3.12 and 3.13).

Figure 3.12 Questionnaire

These eighteen items were confirmed from the questionnaire results:

- Although the name of the OSV system was not dispersed well on the site, the workers had an understanding of the safety management system utilizing the light emission sensor.
- The workers understood the proper actions when the OSV lights turn to blue and red, however, the required action towards yellow light was not recognized well.
- Over 90 % of the local workers answered that 'the OSV system was effective for safety management' and 'recommend for further use'. The effectiveness of the OSV system was recognized at the Jakarta MRT construction site as well.
- An installation of a sound warning system and additional light display at the construction surface area were recommended.

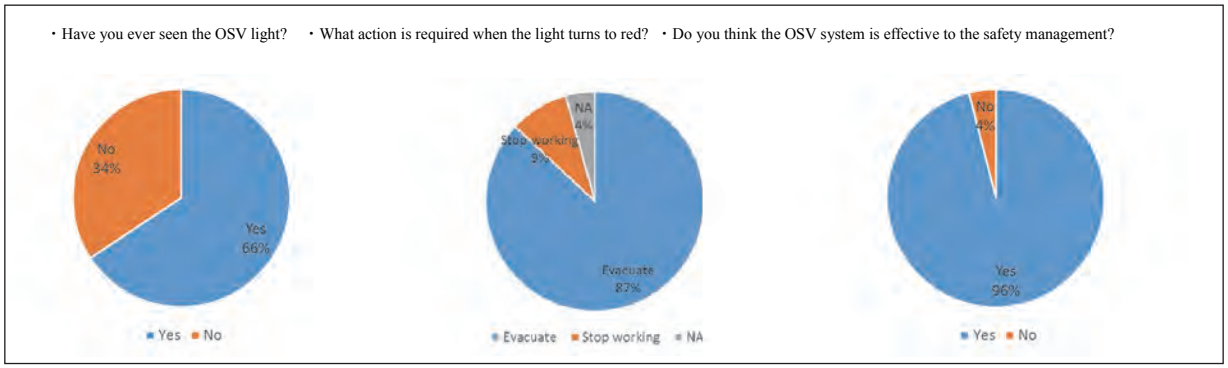


Figure 3.13 An example of the questionnaire result

3.5 Seminar and Exhibition

At the final seminar, the OSV devices were displaced and in addition to the Jakarta MRT project and other case examples, Japanese monitoring devices were introduced and explained. A total of 40 people attended at the final seminar including Muraoka Deputy Director of JICA Indonesia, Allan Project Manager at Jakarta MRT, Indonesian government officials, Transport Ministry officials and Jakarta MRT officials on December 15th in 2015. Unfortunately Indian metro project agency could not attend the seminar due to budget limitations. An additional presentation will be held later. Active discussions between participants were conducted during the break.

Muraoka Deputy Director from JICA Indonesia:

'In addition to sponsor the project, the improvement regarding to the safety management at the construction site has become essential. I expect that the OSV system will improve safety awareness in the construction site and be widely used for further projects.'

Allan Project Manager at Jakarta MRT:

'I appreciate the OSV system installation. I attended the seminar at Kobe University this past February and am glad this system was successfully installed at Jakarta MRT. '

Figure 3.14 Participants and the OSV device exhibition

Based on the success of this project, safety management using the OSV system is expected to be a part of the Jakarta MRT Phase 2 project. A short video was created based on this project and it will be used for promotion such as for the Ahmedabad Metro project in India.

More than 5,000 inquiries were received on the OSV website after the seminar and further projects have been discussed. The Safety Division of the Railway Bureau in Jakarta has been requested for the presentation regarding the safety management using the OSV system. It was planned on January 15th, however, it was postponed due to the terror attack.

Chapter 4　Future Tasks and Recommendations

It is vital to improve the safety at construction sites and establish the new safety management system utilizing the On-Site Visualization which involves all the personnel such as workers, consultants, managers and clients.

In this first project in Indonesia, safety management with the OSV system was successful due to the well-organized management by the skilled engineers. However, several tasks regarding to the device installation and safety management plan remain which are shown below.

‘Simple use’

<Tasks>

Each OSV device has its own procedure for the installation and settings on the site and it has to be correct to conduct the monitoring properly. It is desirable that these devices can be handled in a simple and easy method using data interface with a WiFi network and mobile phones.

<Prospect>

Create a simple user manual for the workers on the site. It is important to communicate well with the local contractors to bring down the cost and to establish a quick support system for the further use. The main part of the OSV devices is manufactured in Japan, however, the other parts can be obtained at local markets.

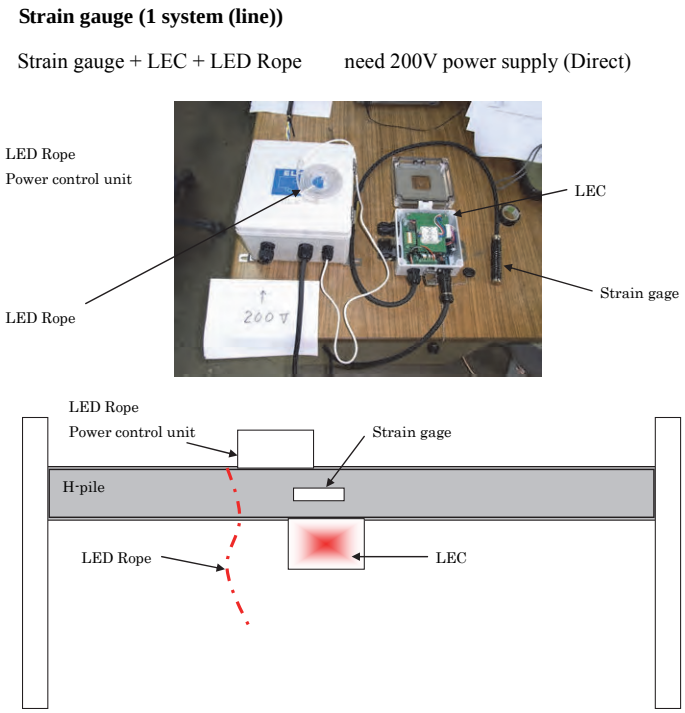


Figure 4.1　An example of the user manual

‘Improvement in function’

<Tasks>

It was suggested to add a sound warning system with the OSV devices. The same suggestion was made after the Delhi Metro Project and it is considered as a part of the further improvement process.

<Prospect>

Some of the OSV devices have had a sound warning system added (Figure 4.2). It is desirable to give clients the opportunity to choose suitable OSV devices depending on their demand and budget.

Figure 4.2 A prototype of OSV device with a sound warning system

Having an additional monitoring display was also suggested in case the monitoring site is far away from the monitoring site. It can be also an ideal option depending on their demand and budget. In addition to hardware improvements such as battery, installation and data collection method and multilingual display, improvement in the operation support system and user manual are required.

For the further use, it is expected to be able to show not only the real time data but also the time rate of change.

‘Low cost’

<Tasks>

A number of points are needed to be monitored to maintain safety on construction sites. The OSV devices are required to have required function with low manufacturing cost to maximize the number of the monitoring points (Figure 4.3).

Figure 4.3 A prospect view of maximized OSV monitoring

<Prospect>

The further development in low cost OSV devices has been promote by the OSV committee.

‘Dissemination’

<Tasks>

The improvement in operation and cost will encourage the spread of the OSV monitoring system in both domestic and international projects.

<Prospect>

In developing countries, a reliable safety management system has not been established in many cases. However, it has become a serious issue and urgent measurement is required. In this project, the new safety management with the OSV system was conducted by the private sector and shown to the public. It was an effective method to present the outcome and to show the understanding of the importance of safety management at the construction site.

Figure 4.4 An example of the OSV application at Delhi Metro Project

This project reveals the effectiveness and further development in the new safety management with the OSV system. The OSV monitoring plan can be modified depending on the construction demand. The cost for the OSV devices can be brought down if the OSV devices can be manufactured by local manufacturers.

It is also required to create comprehensive visual presentation to promote the system for the clients such as the government and public corporations. In this project, the information board and brochures explaining the safety management with the OSV system were spread to the public in order to open the information. A short video was created to show the concept of this project utilizing the visual effect of the OSV devices. These tools can be used for the promotion of OSV and for further projects.

The further use of the OSV devises at MRT construction sites are expected to demonstrate the OSV monitoring systems.

This project clearly shows an ideal stream of infusion of Japanese techniques into overseas projects and it is expected to encourage further use at other construction projects in Indonesia, Vietnam, India and Bangladesh, supported by JICA, to reduce incidents and accidents at construction sites.