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## **Activity Report for TC- 28 Application of Monitoring Technology for Infrastructure Maintenance**

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*Date: 2024.2.6*

*Name of Chair: Eiki YAMAGUCHI*

*Responsible Society: JSCE*

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### **1. Outline of TC**

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#### **1.1. Objectives**

Infrastructure is critical for economic prosperity, economic growth, and sustainable development. While many countries invest heavily in infrastructure construction, much less attention has been paid to maintenance work, which could generate a serious bottleneck to economic growth and public services in the long run. Utilizing new technologies for systematic infrastructure management is essential for both preventing accident and minimizing life-cycle-cost.

Civil Infrastructures have been constructed across the Asian region and maintenance has already become a big issue to be addressed. Although many monitoring technologies and products are developed, the administrators are struggling to choose technologies as the practical specifications are not sufficiently standardized. The objective of TC28 is to prepare the guidelines on the scheme for maintenance of infrastructures by demonstrating good use of monitoring technology for making maintenance works more sophisticated and efficient.

#### **1.2. Terms of Reference**

TC28 provides the guidelines and recommendations for utilization of monitoring technologies, which cover wide range of fields: namely, concrete decks, concrete beams, steel beams, salt environment, bridge piers and foundations, embankment and cutting slopes, and handling of monitoring data.

TC28 holds periodical meetings to share and discuss the maintenance and monitoring issues with members from various disciplines and sectors. Integration of knowledge and opinions leads to enhancement for quality of the guideline and practical applications of monitoring technologies in Asian countries.

#### **1.3. Expected Outcomes**

- ACECC guidelines for application of monitoring technology for infrastructure maintenance
- Reports on status and issues of maintenance and monitoring in the member countries
- Reports on introduction to latest technologies of monitoring and application examples
- Suggestions to promote practical applications of monitoring in Asia for the next generations.

#### **1.4. Period of Activity (1) since TC's inception, and (2) for this Report (Month/Year to Month/Year)**

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October 2021 - September 2024 (3 years)

## 1.5. Members

Organization	Name	Affiliation
ASCE	Lian Duan	California Department of Transportation
ASCE	Chungwook Sim	University of Nebraska at Lincoln
CICHE	Tzu-Kang Lin	University of Yanming-Chiaotung
EA	Shane Scriven	Engineers Australia's Asset Management Council
IEB	A.F.M.Saiful Amin	Bangladesh University of Engineering and Technology
IEP	Shamsoon Fareed	University of Engineering & Technology
IEP	Wajahat Nassar	Inventories/Warehousing
KSCE	Chang-Su Shim	Chung-Ang University
KSCE	Robin Eunju Kim	Hanyang University
PICE	Benito M. Pacheco	University of the Philippines Diliman
VFCEA	Pham Hoang Kien	University of Transport and Communication
VFCEA	Le Thanh Binh	Anglia Ruskin University, UK
JSCE (Chair)	Eiki Yamaguchi	Ho Chi Minh city University of Transport, Vietnam
JSCE	Masaaki Nakano	Kyushu Institute of Technology
JSCE	Tetsuro Goda	Nippon Koei

## 1.6. Financial Background

NA

## 2. Recent Activities and Outcomes

We had the 3<sup>rd</sup> meeting of TC28 on 27<sup>th</sup> of September. The agenda is as follows; 1) Opening, 2) Self Introduction by New Members, 3) Brief Explanation on All Chapters of the Guideline, 4) Explanation on Chapter1 of the Guideline, 5) Result of the Questionnaire (VFCEA, KSCE, JSCE), 6) Discussion on the Result of the Questionnaire, 7) Future Work of TC28, 8) Free Discussion, and 9) Closing.

We made a discussion on the result of the questionnaire regarding Chapter1 “General provisions” of the translated JSCE monitoring guidelines and exchanged opinions to establish the ACECC monitoring guidelines.



## 5. Result of the Questionnaire (VFCEA, KSCE, JSCE)



### Result of Questionnaire

#### Differences among countries regarding Chapter 1 General Provisions

No	Question	VFCEA	KSCE	JSCE
3	Please provide any additional information or suggestions for revision regarding the maintenance management cycle in Figures 1.1.1 and 1.1.2 based on the actual situation and issues in your country.	Figure 1.1.1 it should have a starting point which can be inspection Figure 1.1.2. No comment	Definition of the monitoring is needed. As-built information is very important at the beginning of the maintenance. So, it will be better to add the information delivery from project information to maintenance. Recently, digital twin models are actively developed for the life-cycle maintenance. So, we need to focus on KPI(key performance indicator) according to different structural types. Especially, time-dependent performance needs to be monitored to update the analysis model (ref. IBASE TG.5)	"Monitoring to assist in emergency response" in Figure 1.1.1 is not related to the maintenance cycle.
4	Regarding "Positioning of Monitoring" in 1.2, there are types of monitoring in Japan. Please provide any additional information or suggestions for revision based on the actual situation and issues in your country.	No further suggestions.		

**Definition of Monitoring**  
The monitoring is the act of periodically acquiring data and composing them to understand the occurrence and progression of abnormalities over time.



### Result of Questionnaire

#### Differences among countries regarding Chapter 1 General Provisions

No	Question	VFCEA	KSCE	JSCE
6	In 1.3(2), monitoring systems are mainly classified into acquisition, storage/utilization of structural monitoring data. Please provide any additional information or suggestions for revision based on the actual situation and issues in your country.	No further suggestions.	For common bridges, it is not easy to install the monitoring system for long period. Recently, wireless and detachable sensor systems are utilized in several bridges. Vision-based sensing system is useful for the monitoring of deformation of bridges.	
7	In 1.3(3), control criteria are established to estimate the condition of structures based on measurements obtained from monitoring and to move to the next action according to changes in condition. Please provide any additional information or suggestions for revision based on the actual situation and issues in your country.	This section is important but in practice, it is difficult to determine such control criteria due to the uncertainty regarding the current health of the structures. For example, before installation of the monitoring instrumentation, the structures could have deformed which may not be known and any control criteria can't consider those prior deformations.	We need to define indicators for the control criteria. The indicators need to be derived from the baseline model. For cable-supported bridges, it is common to define upper and lower bound of the sensing data considering design conditions and environmental conditions.	



### Result of Questionnaire

#### Questions regarding current state, challenges, and objectives of monitoring in each country

No	Question	VFCEA	KSCE	JSCE
10	What is the biggest challenge in your country in the maintenance cycle of inspection, diagnosis, action and record? (Multiple answers are acceptable.) Please also indicate the reasons for your answer.	The current practice is highly laborious, the quality of the data can be questionable.	- Insurable damage detection - Decision-making of severely deteriorated bridges - Reliability of data from inspection reports for existing bridges (for ML training)	Damage of structures are recorded well. However, evaluation of soundness is not sufficiently done based on structural analysis. It should be done from the structural point of view.
11	Regarding the position of monitoring, there are mainly monitoring to assist inspection, to aid diagnosis, to confirm effectiveness of repair/reinforcement, and to assist in emergency response. What do you consider the most important in your country? (Multiple answers are acceptable.) Please also indicate the reasons for your answer.	Aid diagnosis and continuous monitoring for structure health. That helps ensure the structures safe for operation.	For common bridges, monitoring can be done for bridges with serious problems or critical decision issues. There are regular maintenance process and regulations. So, the monitoring should be defined as special tasks with additional budget.	Amount of budget and the number of engineers especially in rural areas are not enough to manage all degraded bridges. So, monitoring to assist inspection and to aid diagnosis are important to easily know defects of structure.

### Result of Questionnaire

#### Questions regarding current state, challenges, and objectives of monitoring in each country

No	Question	VFCEA	KSCE	JSCE
14	Small bridges located in rural areas do not tend to be well-maintained using monitoring technology in any country. Is there a strong need to actively promote monitoring for such objects? Please also indicate the reasons for your answer.	Accidents/collapses occasionally happen to small bridges and monitoring can help reduce the consequences. With the advance in IoT BIM Digital Twin, the monitoring can be done with a reasonable cost.	Some bridges already passed the design life. So, bridge owners should decide the new policy to manage the old and deteriorated bridges. Budget limit is a critical issue for the government or local government due to fast increase of demand.	Due to insufficient budgets and shortage of engineers, there is a strong need to set labor-saving systems for maintaining structures in rural areas.
15	What are the obstacles for applying various monitoring techniques to manage road structures in your country? For example, lack of budget, lack of engineers, etc. Please share your thoughts on what is needed to remove these obstacles.	Lack of budget, approval procedure can be long and complicated. Workshops to raise the awareness of the authority on the importance of the monitoring scheme.	No regulations of monitoring systems for common bridges. We need to define when the monitoring system should be installed. If the owner want to expand the service life, the monitoring system is essential to guarantee the safety.	Additional cost need to be paid to install monitoring technologies, but B/C is not calculated well. Monitoring technologies would be adopted more if we know the B/C correctly.

## Result of Questionnaire

### Questions regarding the state of maintenance and monitoring in each country

No	Question	VFCEA	KSCE	JSCE
1	Are there any technical standards or regulations regarding "maintenance and management" of road and bridges in your country?	Yes In Vietnam <a href="https://urban.chinhphu.vn/default.aspx?pageid=27168&amp;docid=194253">https://urban.chinhphu.vn/default.aspx?pageid=27168&amp;docid=194253</a>	Yes	Yes
2	Are there any technical standards or regulations on "infrastructure monitoring" for road and bridges in your country?	Yes In Vietnam <a href="https://urban.chinhphu.vn/default.aspx?pageid=27168&amp;docid=187774">https://urban.chinhphu.vn/default.aspx?pageid=27168&amp;docid=187774</a>	Yes	Yes

### Result of Questionnaire

#### Differences among countries regarding Chapter 1 General Provisions

No	Question	VFCEA	KSCE	JSCE
5	As stated in 1.2(2), there are 4 cases where monitoring is implemented. Please provide any additional information or suggestions for revision based on the actual situation and issues in your country.	No further suggestions.		Fatigue and Corrosion are critical issues and difficult to monitor. For assessment to judge the service life of existing bridges, it is necessary to monitor the response for some period.

### Result of Questionnaire

#### Differences among countries regarding Chapter 1 General Provisions

No	Question	VFCEA	KSCE	JSCE
8	Please provide any other examples of standards you have applied regarding the examples of setting control standard values in Table 1.3.1.	Restriction on the tunnel lining displacements due to nearby construction activities Code of Practice for RAILWAY PROTECTION (October2004 Edition) (Singapore LTA)		
9	Please provide any other questions or comments regarding Chapter 1 General Provisions.	No questions	Is the guideline for all the common bridges? Or for the special cases such as severe deterioration or natural hazards?	

Table 1.3.1 Examples of setting control standard values

Monitoring Indicator	Control Standard	Remarks
Longitudinal displacement	Less than 10mm	Check with visual check
Transverse displacement	Less than 10mm	Check with visual check
Vertical displacement	Less than 10mm	Check with visual check
Angular displacement	Less than 0.1 degree	Check with visual check
Crack width	Less than 0.1mm	Check with visual check
Corrosion rate	Less than 0.1mm/year	Check with visual check
Temperature	Less than 50 degree C	Check with visual check
Humidity	Less than 80%	Check with visual check
Wind speed	Less than 10m/s	Check with visual check
Seismicity	Less than 0.1g	Check with visual check

### Result of Questionnaire

#### Questions regarding current state, challenges, and objectives of monitoring in each country

No	Question	VFCEA	KSCE	JSCE
12	Are there any road and bridge structures in your country that you are focusing on for monitoring? For example, urban highways or long-span bridges. Please also tell us why you are focusing on them.	Personally, I am not focusing on bridge.	For psc bridges with corrosion issues For steel bridges with fatigue cracks or possibility of cracks due to their long service life.	Monitoring is usually carried out for important expressway and special bridges.
13	Please provide any good examples of monitoring that has been done in your country. We are interested in any road and bridge structures including a special bridge or a small bridge.	Personally, I am not focusing on bridge.	In Korea, we have a leading test for all bridges every 5 years. Sensors are installed during the test. HSM is only for special bridges such as cable-supported bridges. Recently, Government started to support for the development of digital twin models using HSM data.	Expressway companies adopted many types of monitoring including digital technology for managing their assets.

### Result of Questionnaire

#### Table of contents of the guideline

No	Question	VFCEA	KSCE	JSCE
16	This guideline is composed Chapters in the table of contents. Please let us know if you have any suggestions regarding the items to be added or focused.	We should push for IoT digital twin and BIM in monitoring and maintenance purposes.	Data on public infrastructures have security issue. So, the collection of data and accumulation needs de-identification process. In Korea, we are trying to persuade the government to build a data pipeline for the data accumulation. When the maintenance tasks are submitted to the system, automatic data transfer can be done through the pipeline without identification of the structure, only with meta data.	Good examples of installation of monitoring technologies in AECCE countries as an appendix

## Result of Questionnaire

### • Expectations of this TC

No	Question	VFCEA 	KSCE 	JSCE 
17	What are your expectations for TC28 regarding infrastructure monitoring? For example, there are the introduction of advanced technologies, technical guidance, multilateralization of guidelines, and sharing of how to handle big data collected from sensors, etc.	To be discussed in the meeting	Collaboration of data for the development of prediction models such as deterioration, damage progress and structural capacity	To clarify and summarize the common issues and current state on maintenance and monitoring in ACECC countries. Establishment of the guideline which can be adopted in ACECC countries including some good examples of installation of monitoring technologies.

## 3. Activity Plan towards Incoming CECAR

### 3.1. Session Title

Application of Monitoring Technology for Infrastructure Maintenance (Tentative)

### 3.2. List of Presentations

We will have a presentation on the established monitoring guidelines for ACECC. We will decide the content of other presentations after discussion in TC meetings in future.

## 4. Other upcoming activities

TC28 will host a seminar during the ACECC-ECM (Executive Committee Meeting) in Manila from 29 Feb to 2 March 2024. We will also continue to make the ACECC version of monitoring guidelines.

## 5. Any requested Action Items for TCC and /or EC

NA