

## ACTIVITIES OF GIFU UNIVERSITY SIP IMPLEMENTATION TEAM FOR UTILIZING NEW MAINTENANCE TECHNOLOGIES

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### ABSTRACT

This contribution reports the content of technical seminars and field trials and the results of questionnaire and hearing surveys from the activities of the Gifu University SIP implementation team (GU-SIP team) for promoting the utilization of new maintenance technologies for infrastructure. Technical seminars and field trials held by the GU-SIP team played important roles for exchanging needs and seeds of new technologies among engineers from local governments, construction industry and technology-development companies. It was indicated that new inspection technologies with robots, such as drones, are efficient for screening before regular inspection, periodically monitoring changes at defective portions and measurement of the initial values of structures. The results of hearing surveys regarding obstacles to the application of new maintenance technologies indicated that the major obstacles for engineers from ordering parties are the troublesome task of explaining the necessity of adopting the new technologies and the issue of responsibility when troubles occur.

**Keywords:** Implementation, Infrastructure, Inspection, Maintenance, SIP

### 1. INTRODUCTION

In Japan, many infrastructure components such as roads were constructed during the high economic growth period after World War II. Along with the aging of such infrastructure, the possibility of serious accidents and the increase in the maintenance expenditures have become significant social issues. Introducing new maintenance technologies seems efficient to maintain safe and comfortable infrastructure, to improve the efficiency of the maintenance management, and to keep the work of maintenance engineers worthwhile. However, adoption of new technologies has not progressed much in the field of maintenance concerning infrastructure [1], as compared with the medical field concerning humans.

In 2014, the project titled "Infrastructure Maintenance, Renovation and Management" [2], which is one of the projects under the Cross-ministerial Strategic Innovation Promotion Program (SIP), started in order to accelerate the research and development on maintenance technologies. In 2016, 11 regional implementation teams including the Gifu University SIP implementation team (GU-SIP

team) [3] commenced their activities to promote the use of SIP maintenance technologies for infrastructure managed by the local governments. This contribution introduces the activities of the GU-SIP team.

### 2. ACTIVITIES OF GU-SIP TEAM

The regional implementation teams are expected to play an important role in the following activities in the maintenance field:

- Promotion of the use of new maintenance technologies,
- Collaboration among maintenance engineers of the local governments, industry and academia,
- Education of maintenance engineers.

Gifu University has continued to educate maintenance engineers called Maintenance Experts (ME) since 2008. In the ME education course for civil engineers engaged in maintenance work, they learn about maintenance engineering of infrastructure including steel bridges, concrete bridges and tunnels through lectures and practical training for four weeks at Gifu University. The qualification "ME" is granted to those who passed the final examination. ME-qualified engineers now

number over 350. The collaboration among engineers from the local governments, industry and academia provides strong support for the ME education course.

As shown in Figure 1, the GU-SIP team constructed model structures of a prestressed concrete bridge, an end block of a steel bridge, and a tunnel cross section (horizontally laid for safety) on the campus of Gifu University. They are used as educational tools for maintenance engineers as well as model structures for verification of inspection technologies.

The GU-SIP team held technical seminars and field trials to introduce new SIP technologies to engineers in the Gifu region with support from ME-qualified engineers and related engineers. We conducted questionnaire and hearing surveys on obstacles and measures when adopting new technologies. The following chapters describe the results of these activities.

### 3. TECHNICAL SEMINARS AND FIELD TRIALS FOR INTRODUCING NEW TECHNOLOGIES

For introducing new technologies into the maintenance field, we selected 14 SIP maintenance technologies applicable in the Gifu region and asked the developers to present the details at technical seminars held four times in Gifu. Regarding 8 of the 14 SIP technologies, we had demonstrations conducted at field trials held six times as shown in Figure 2. More than 150 engineers of the local governments, construction companies and consulting companies participated in the field trials. In the technical seminars and field trials, we asked the participants to communicate their ideas and needs to the developers and asked the developers to show the features of their technologies to the participants. The developers of the technologies appreciated the user's opinions and ideas, which contained useful information for their future development. Many of the participants said that the lectures at the technical seminars are easier to understand than explanatory documents and that the demonstrations at the field trials are even easier to understand.

Direct personal contact between the staffs of ordering parties and private companies, such as exchanging information and opinions, is prohibited in Japan to prevent collusion problems. From the viewpoint of fairness, the engineers of ordering parties, such as local governments, cannot arrange technical seminars and field trials to introduce technologies developed by a specific company. The engineers of ordering parties cannot attend these kinds of events arranged by

private companies. However, engineers from ordering parties, developers and contractors can freely join the technical seminars and field trials arranged by regional universities, such as the GU-SIP team, and exchange meaningful opinions in these events. Universities have not been so active in providing these opportunities in Japan.

The participants of the technical seminars and field trials pointed out that the following applications are effective in the case of new bridge inspection technologies involving robots, such as drones:



(a) Prestressed concrete bridge



(b) End block of steel bridge



(c) Tunnel cross section

Fig. 1 Infrastructure models indicating construction process.

- Use them for screening to pick out parts to be subject to human inspection during regular inspections,
- Use them for periodically monitoring changes at marked defective portions,
- Use them to take initial values of structures upon completion of construction or repair work,
- Use them to find damaged portions of structures immediately after disasters such as earthquakes,
- Use them to gather data of the structure for a consultant service to formulate design documents/drawings after receiving an order for its repair.

#### 4. SURVEYS ON OBSTACLES AND MEASURES WHEN ADOPTING NEW TECHNOLOGIES

We conducted questionnaire and hearing surveys of the following engineers in order to clarify what are obstacles to the application of new technologies to infrastructure managed by local

governments and what measures are effective in overcoming such obstacles:

- Ordering parties: 16 civil engineers of local governments on the ordering side,
- Developers: 8 engineers developing new technologies in the maintenance field,
- Contractors: 7 civil engineers of construction companies and construction consulting companies on the contractor side.

#### 4.1 Results of Questionnaire Survey

The questionnaire consists of description-type questions No. 1, 2 and 6 and selection-type questions No. 3-5 as shown in Table 1. In the selection-type questions, options were prepared beforehand, and the respondents made a plurality of selections and the most fitting one. This questionnaire on the application of new technologies covers not only maintenance but also all processes including survey, design, construction, and maintenance of civil engineering projects. “Conventional technologies” are defined as those described in



(a) Tunnel inspection system using non-contacting radar



(b) Robotic camera indicating crack scale for bridge inspection



(c) Pavement inspection system using surface-wave and electric-resistivity



(d) Two-wheeled drone with camera for bridge inspection



(e) Drone with hammering test equipment for bridge inspection



(f) Weeding machine with inspection system for river embankment



(g) Drone with rotatable spherical shell for bridge inspection



(h) Drone with wheel for visual observation and hammering tests

Fig. 2 SIP maintenance technologies demonstrated at field trials.

the current technical standards and manuals in addition to data for the cost calculation. Technologies other than these are defined as “new technologies”.

#### 4.1.1 Obstacles

Figure 3 shows the results of question No. 3 regarding the obstacles to the promotion of new technologies for each position. “Fairness is not

guaranteed” and “Burden over explanation for account audit” were the main obstacles for the engineers from the ordering parties. The obstacles for the engineers from the developers and contractors were “Insufficient ascertainment of needs” and “Performance and precision are not assured,” respectively. About 40% of the engineers from the developers and contractors chose “Standards or manuals are not satisfied”, but only 20% of the engineers from the ordering

Table 1 Contents of questionnaires.

No.	Questions	Contents
1	Image of new technologies	- How do you feel about utilizing new technologies for your work? - When you hear “new technologies”, what comes to mind?
2	Experience in utilizing new technologies	- Have you ever adopted new technologies in your past work? - What kind of new technologies did you adopt? - Was the adoption a success or failure? - What do you think was the reason for the success or failure?
3	Obstacles to the utilization of new technologies	- What are the reasons why you cannot or are averse to using new technologies? (Selection-type question)
4	Measures to promote utilization of new technologies	- What are effective measures to make it easier to utilize new technologies? (Selection-type question)
5	Key points in utilizing new technologies	- What are the key points when utilizing new technologies? (Selection-type question)
6	Others	- Free description.

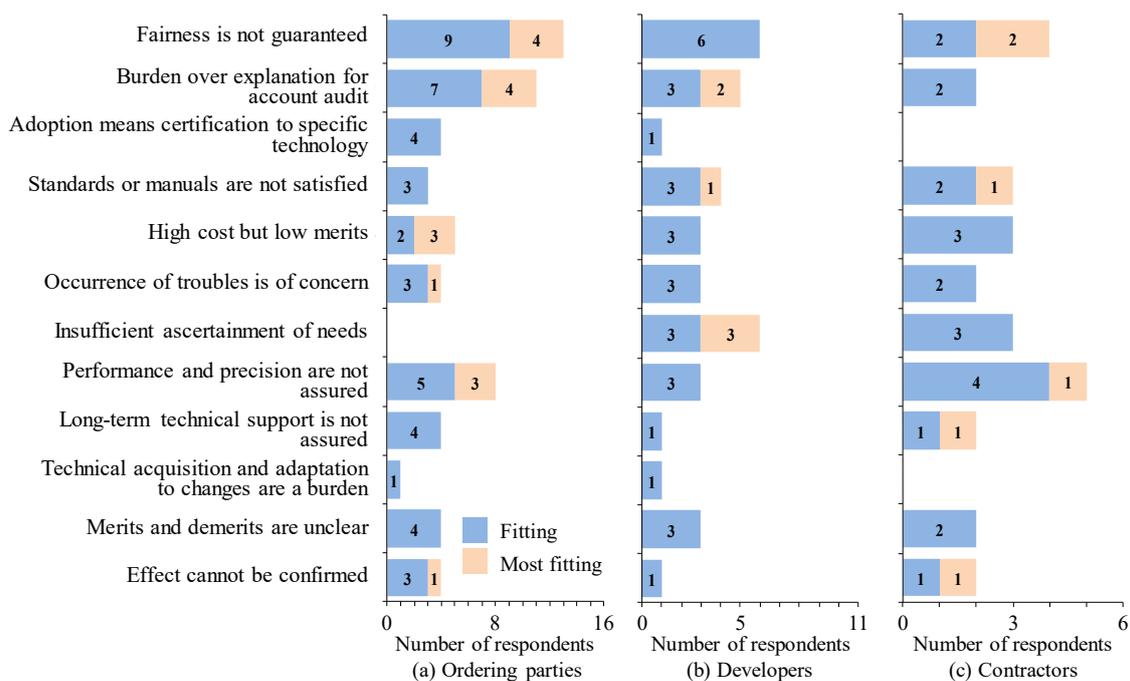


Fig. 3 Results of questionnaire survey regarding obstacles.

parties made that choice. Therefore, we can say that the new technologies that do not satisfy the standards or manuals can be accepted by the ordering parties, provided the main obstacles, “Fairness is not guaranteed” and “Burden over explanation for account audit,” are removed. Japan’s account audit system that rigorously checks appropriate use of tax revenue at local governments may form the background of these answers.

#### 4.1.2 Measures

Figure 4 shows the results of question No.4 regarding measures for the promotion of new technologies. Many engineers of all positions chose “Describe adoption of new technologies in manuals.” Engineers from the developers and contractors chose “Provide application examples of new technology” and “Create neutral evaluation systems for new technologies.”

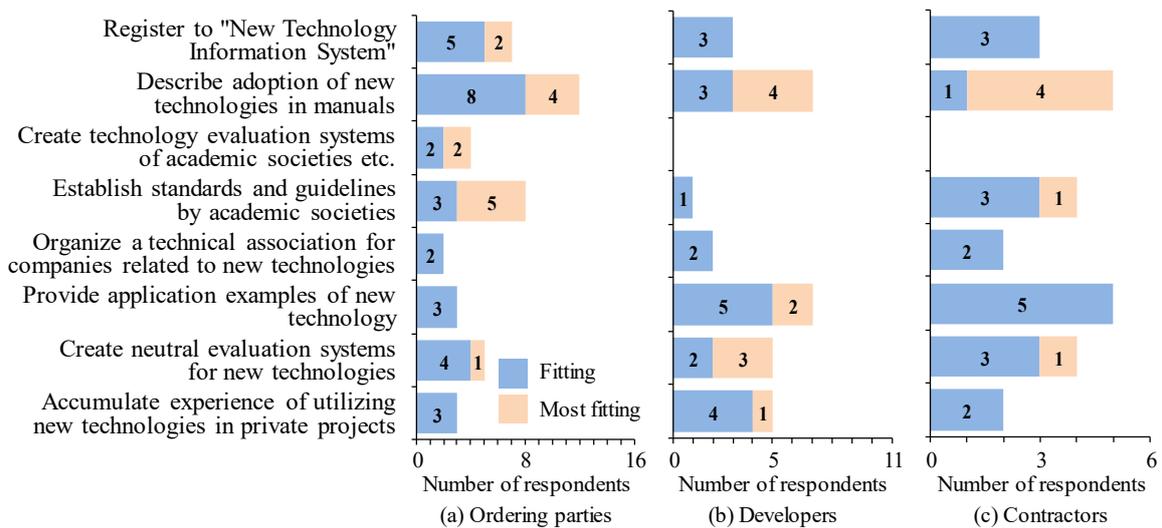


Fig. 4 Results of questionnaire survey regarding measures.

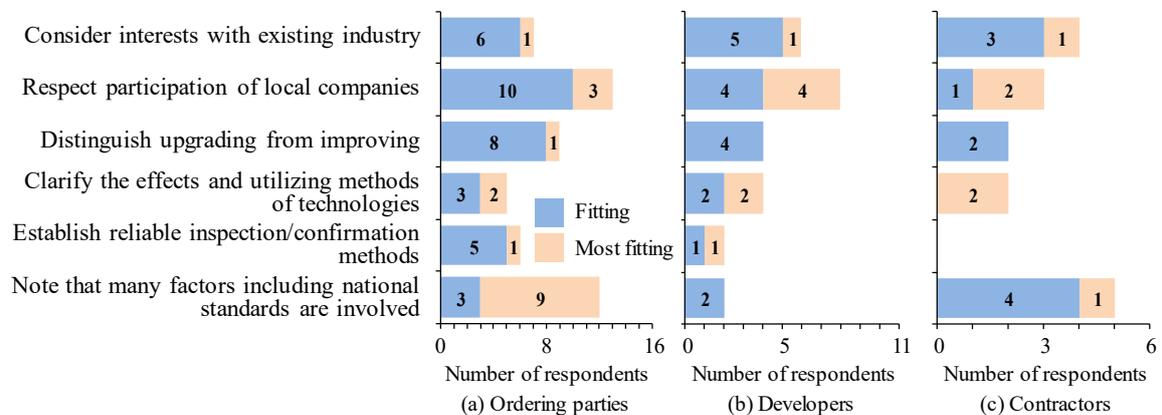


Fig. 5 Results of questionnaire survey regarding key points.

#### 4.1.3 Key points

Figure 5 illustrates the results of question No.5 regarding key points to be considered when utilizing new technologies. Many engineers from the ordering parties and developers chose “Respect participation of local companies.” Many engineers from the ordering parties and contractors chose “Note that many factors including national standards are involved”.

#### 4.2 Results of Interview Survey Following the Questionnaire Survey

Table 2 shows the main obstacles for each position to the application of new technologies obtained from hearing and questionnaire surveys. Half of the obstacles in Table 2 were not listed in the questionnaire survey sheet but obtained from the hearing surveys. Table 3 indicates examples of effective measures for each position.

Table 2 Obstacles viewed from different positions.

Positions	Major obstacles	Major causes
Ordering parties	Attitudes of people in charge widely vary	<ul style="list-style-type: none"> <li>- The organizational mission is unclear.</li> <li>- Enthusiasm gap between head and local offices.</li> <li>- Resistance to changes.</li> </ul>
	Significant energy and effort are required for introduction	<ul style="list-style-type: none"> <li>- Fairness should be ensured.</li> <li>- Basis for external explanation (account audit) is necessary.</li> <li>- Basis for internal explanation (organizational consensus) is necessary.</li> </ul>
	Great risk in the event of trouble	<ul style="list-style-type: none"> <li>- Who takes responsibility is unclear.</li> <li>- Constant and continuing support is not assured.</li> </ul>
Developers	Investment decision for development is difficult	<ul style="list-style-type: none"> <li>- First-mover advantage from development is not assured.</li> <li>- Investment recovery in a short time is difficult.</li> <li>- It is difficult to grasp the market (scale, continuity).</li> </ul>
	Required specifications are unclear	<ul style="list-style-type: none"> <li>- Needs for new technologies (required performance/precision) are unclear.</li> <li>- Appropriate cost for ordering parties is unknown.</li> <li>- Content and period of technical support required are unknown.</li> </ul>
	Government's situation is unknown	<ul style="list-style-type: none"> <li>- Each organization and local government is in a different situation.</li> <li>- Method of order placing and introduction conditions are difficult to understand.</li> <li>- Attention to industry officials is required.</li> </ul>
Contractors	No direct benefit	<ul style="list-style-type: none"> <li>- Technical proposals do not lead to increase in orders received.</li> </ul>
	Great risk in the event of defects	<ul style="list-style-type: none"> <li>- Who takes responsibility is unclear.</li> </ul>
	Cost of technical proposal is high	<ul style="list-style-type: none"> <li>- Needs should be grasped and seeds should be collected.</li> <li>- Documents supporting the validity of introduction should be formulated.</li> </ul>

Table 3 Examples of preferred actions.

Positions	Examples of preferred actions
Government	<ul style="list-style-type: none"> <li>- Improve the descriptions concerning new technologies in standards and manuals.</li> <li>- Support the development of new technologies with a budget.</li> <li>- Support the development of new technologies by indicating clear targets.</li> </ul>
Ordering parties	<ul style="list-style-type: none"> <li>- Clarify the organizational mission to use new technologies.</li> <li>- Place performance-based orders to adopt new technologies.</li> <li>- Utilize the vitality of private companies to adopt new technologies.</li> <li>- Incentivize the adoption of new technologies.</li> </ul>
Developers	<ul style="list-style-type: none"> <li>- Grasp the needs for new technologies to be developed.</li> <li>- Develop attractive new technologies.</li> <li>- Prepare documents to reduce the burden on engineers of ordering parties.</li> </ul>
Contractors	<ul style="list-style-type: none"> <li>- Provide information to developers and ordering parties.</li> <li>- Utilize new technologies within the contracted work.</li> </ul>
Universities	<ul style="list-style-type: none"> <li>- Educate maintenance engineers.</li> <li>- Offer advices on using new technologies to assist the decision making of ordering parties.</li> <li>- Promote collaboration among local governments, industry and academia.</li> <li>- Give lectures and seminars on the applications of new technologies.</li> </ul>

Obstacles and measures for the application of new technologies characterize this study.

As seen from Table 2, the obstacles to the introduction of new technologies comprise those related to the technology itself; those related to the work process; and those related to people's feelings. For the developers of technologies, the obstacles are primarily related to technical problems, such as the lack of knowledge of the needs, appropriate cost, and technical support needed; as well as the difficulty of ascertaining the market and securing a profit.

The ordering party is acutely aware of obstacles related to the work process, such as the large amount of documents to prepare for the accounting audit, explaining the new technologies; and the fear that placing an order with a specific company having a new technology may be perceived unfair. The ordering party also feels psychological stress, such as resistance to changes and anxiety over troubles due to the introduction of new technologies. When developing and utilizing new technologies, it is therefore important to understand the job-related and psychological obstacles felt by the ordering party. Obstacles for the contractors include the fear that proposing a new technology does not lead to an increase in orders received; and the significant risk arising when troubles occur.

As shown in Table 3, as measures for promoting the application of new technologies, all parties pointed out that it is effective to document the promotion of new technologies in such regulations as the manuals for bridge inspection. They pointed out that specifying the precision and performance required for the technologies is effective to accelerate the development. For the developers, it is desirable to prepare well-described documents to reduce the burden on engineers of the ordering parties by describing application examples, examples of specifications, etc. For the ordering parties, clarifying the policy to promote new maintenance technologies is efficient.

## 5. AFTERWORD

The GU-SIP team held technical seminars and field trials of new SIP maintenance technologies to promote their use for infrastructure managed by the local governments. These events played important roles for exchanging needs and seeds

of new technologies among engineers from the local governments, construction industry and technology-development companies. It was indicated that the new inspection technologies with robots, such as drones, are efficient for screening before regular inspection, periodically monitoring changes at defective portions and measuring of the initial values of structures.

The results of hearing surveys are reported regarding obstacles to the application of new maintenance technologies to infrastructure. Major obstacles for the developers include the difficulty of grasping the needs of the ordering party regarding the technologies, cost, and support. Major obstacles for the ordering party include the troublesome task of explaining the necessity of adopting the new technologies and the question of responsibility when troubles occur. Major obstacles for the contractors include the fact that new technologies do not always lead to profits and the fact that the risk of troubles occurring is great.

Sharing the differences of opinions among engineers of different positions will accelerate the applications of new maintenance technologies to civil infrastructure. The number of targeted engineers was small in the interview surveys. Increasing the number of targeted engineers and finely segmenting their positions are needed to improve the reliability of the results.

## 6. ACKNOWLEDGMENTS

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