Investigation of Trouble & Risk Prevention Sheet in the Construction of Building Facilities Considering Environment, Safety and Quality

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***Abstract*— To introduce effective safety measures and risk management/analysis/evaluation methods that can be used in future guidelines for safety education / training for building facilities, multifaceted analyses were carried out on the safety and accident conditions of building facilities by referring to official statistics and accident data of a specialized contractor. From the analyses, accident prevention methods are proposed considering environment, safety and quality in this report.**

***Index Terms*—building facilities, trouble & risk avoidance sheet, environment, safety, quality**

I. Introduction

The purpose of this study is to examine safety and quality improvement techniques for construction of building facilities in Japan. The properties and practicability of the "trouble and risk prevention sheet for safety and quality improvement" are examined in details on the basis of results obtained through experimental implementation in actual work sites.

In this paper, the implementation of trouble and risk prevention sheets for safety and quality improvement, which can be utilized in actual building construction sites, will be discussed. First, comments and opinions of users about the sheets are put together. Then, the necessity and aim of the trouble and risk prevention sheet are verified. The form of the sheet is shown with some examples. Finally, it shows about the implementation of the trouble/risk prevention sheet for safety and quality Improvement.

II. Experimental Implementation of "Trouble and Risk Prevention Sheet for Safety and Quality Improvement" for Actual Work Sites

A "trouble and risk prevention sheet for safety and quality improvement" was experimentally implemented in two different types of work sites.

A. Opinions from the Test Sites about Experimental Implementation of the Sheet

Opinions given by workers in the sites after the experimental implementation of the sheet were sorted out and grouped into the following three points:

(1) The format is complicated for the daily use if the sheet is required to be completed every day in the same manner as a daily report and an accident prediction sheet.

(2) It is difficult to identify and evaluate quality risks.

(3) Desired effects of the sheet may be obtained if it is completed at the stage of construction planning.

On the basis of the above three opinions, problems about the experimental implementation of the sheet this time were sorted out with consideration for the properties of the tested sites.

B. Problems of Experimental Implementation

The followings are several problems we have obtained through the experimental implementation

1) Differences between new construction work and repair or renovation work

As for new construction work, post-installation inspection is scheduled, where a main concern is placed on the minimization of complaints from the client. Thus, the cost performance of new construction work would become poor if substantial efforts are devoted to finding out risks for each work and their corresponding countermeasures during the installation works, because these activities would make a big burden on a daily operation despite relatively poor returns.

To the contrary, repair or renovation works and maintenance works are expected to produce more and better effects. In most cases of repair or renovation works to existing facilities, no mistakes are afforded even in a post-installation check test, leakage during a pressure test of piping for example. Thus, it is meaningful to identify risks and draw up their countermeasures beforehand. Characteristics of troubles in the process of construction and complaints after the completion of construction are indicated in Table I.

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TABLE I. CHARACTERISTICS OF TROUBLES DURING INSTALLATION AND COMPLAINTS AFTER COMPLETION FOR NEW CONSTRUCTION AND REPAIR OR RENOVATION WORK

Type of Work	Troubles During Installation of Work	Measure to Prevent Complaints after Completion of Work
New Construction	Because all works in the site are in the process of installation, troubles are hard to become obvious	Construction failures can be redressed as they are detected by post-installation inspection (e.g. a pressure test on pipes)
Repair or Renovation Work	Because the customer's facilities other than an executed area are under operated, troubles in the process of installation, if any, tend to become serious.	Even in post-installation inspection (e.g. a pressure test on pipes), a water leakage will be a serious problem if it occurs.

2) Persons in charge of identifying and evaluating risks

It may be unreasonable to leave the task of evaluating the significance of risks and estimating the amount of damages to a foreman or an ordinary worker. The employee of a sub-contractor or one in higher position must be responsible for the assessment of risk damage. It is also important to incorporate Indexes other than the amount of damage into the evaluation of the significance of risks.

III. DIFFICULTIES IN FORMULATION AND IMPLEMENTATION OF SAFETY OPERATING PROCEDURES

Our trouble and risk prevention sheet is drawn up on the model of safety operating procedures which are generally adopted in construction sites. Such a tendency was noted that some safety operating procedures included key points with the aim of preventing quality accidents in addition to safety issues.

However, as their practical use has not been served broadly, these safety operating procedures are not effectively utilized and there are some cases where quality accidents actually took place. The following is one example of those quality accidents.

A. One Example of Quality Accidents

The work to replace a two-way type valve for a ceiling-mounted air-conditioner was carried out in accordance with the operating procedures for an air-conditioner that is to be mounted on the floor of machine room. When a worker loosened a flange bolt before exchanging two-way type valves, water began to leak because valves located in front and behind were not closed. As a result, the client's facility was damaged by water

B. Major Causes

(1)The two-way type valve for the floor-mounted air-conditioner was placed above a drain pan inside of the air-conditioner. Because water damage could be prevented by the drain pan even if water leakage occurred in this system, nothing was clearly mentioned about measures for avoiding water damage such as the placement of a water receptor.

In the meantime, the ceiling-mounted air-conditioner had the two-way type valve outside of the device, for which some measures against water leakage should have been taken. As a consequence of conducting the work with the operating procedures for changing two-way type valves of a floor-mounted air-conditioner, measures against possible water leakage were not taken.

(2) The placement of valves equipped in a device differs between the floor-mounted air-conditioner and the ceiling-mounted air-conditioner. So does the location of very valves that must be closed in exchanging two-way type valves.

Lacking in experience, the worker was not quick-witted enough to aptly read the operating procedures concerning valves that must be closed in the ceiling-mounted air-conditioner system. As a consequence, the valves in front and behind the two-way type valve were not rightly closed and water leakage occurred. The worker believed that he was following the procedures faithfully.

(3) In the first place, this work should have been executed by a foreman and the worker in pair. With the manual of operating procedures at hand, they placed too much confidence in the manual. While the foreman went out to make a preliminary inspection of other facilities, the work was left to the inexperienced worker.

Cases of quality accidents which took place even though the manual of operating procedures was prepared are roughly classified as Table II. This particular case falls under Condition (3). Cases classified into Conditions (2) and (3) occur because actual situations in work sites are not taken into consideration at the planning stage of operating procedures. Because working conditions change day by day in a construction site, the manual of operating procedures once completed for one site is not necessarily applicable to other sites.

This example shows the difficulty as well as importance of adapting operating procedures to working conditions on the daily basis.

TABLE II. CASES OF ACCIDENTS WHICH OCCURRED EVEN THOUGH THE MANUAL OF OPERATING PROCEDURES WAS PREPARED

Working Conditions	Observance of Procedures	Contents of Procedures
(1)Works were not carried out in accordance with operating procedures	Not observed	Right or wrong
(2)Works could not be carried out in accordance with operating procedures		Wrong
(3)Works were carried out in accordance with wrong operation procedures	Observed	

IV. Examination as to Reasons for Difficulties in Identifying and Evaluating Quality Risks in Comparison with Safety Risks

The trouble and risk prevention sheet is a modified version in terms of quality following after a method of risk assessment for safety. When the sheet was experimentally implemented in actual work sites, however, many opinions were heard about difficulties in identifying and evaluating quality risks in comparison with safety risks. Examination is given below regarding reasons for difficulties in identifying quality risks and finding measures for them in actual site, in comparison with safety risks.

A. Identification of Safety Risks and Countermeasures

(1) Many common features of safety risks are shared in most work sites regardless of occupational category or type of work (installation of pipes, ducts, insulations, electricities, automatic controls and so on). No matter what type of work is conducted on a scaffold, for example, certain safety measures for the height have already been established and widely known to the public

(2) Identification of safety risks has been practiced for.measures for them in actual site, in comparison with safety risks.

(3) The classification of safety risks is largely based on such factors as work conditions, tools, instruments and materials to be used rather than types of works.

B. Identification of Quality Risks and Countermeasures

(1) Quality risks are hard to be singled out because they have variations for each type of work.

(2) The significance of a quality risk identified is determined mostly on the basis of a purpose and an installation location rather than installation of work foracilities itself. In some cases, quality risks are not smoothly selected.

(3) It is difficult even for the employee of a sub-contractor or one in higher position to estimate the proper amount of damage, which can be considered as an indicator of the significant of a quality risk. Although precedents for damage claims can be referred to, the amount of compensation for damage by insurance is far smaller than actual restoration cost in most cases.

(4) All relevant people ranging from employees of a sub-contractor to foremen and workers are deeply aware of the scope of repercussion effects of major facilities and structures. When actual occurrences of quality accidents are looked into, however, the results reveal the lack of understanding among workers what harmful repercussion effect a mistake made by an individual worker brings about. Or it is suggested in some cases that there were situations where a worker was not able to associate his mistake with harmful repercussion effects. Unless the association between operational errors and grave repercussion effects is clearly defined, appropriate risk evaluation cannot be carried out although it is very hard to grasp such relevance precisely.

As stated above, many factors are mutually related to each other, making the identification and evaluation of quality risks difficult.

V. Examination of Methods for Facilitating Identification and Evaluation of Quality Risks

As a result of above examinations, it has been realized that some methods for facilitating the identification and evaluation of quality risks are necessary in order to utilize the trouble and risk prevention sheet effectively and develop it as guidelines for safety and quality improvement. Such methods are examined as follows.

(1) A list of typical works and their relating quality risks may be useful. At present, both foremen and workers are not so sensitive to quality risks as they are to safety risks as they are to safety risks that they cannot identify quality risks immediately after they look at contents of works.

(2) The evaluation of quality risks and particularly their significance differs depending on types of structures and purposes (server room and outdoors, for example) as well as times of risk occurrence (phases of only skeleton or near completion). Thus, a list which is compiled taking such circumstances into account may be useful in order to facilitate the risk evaluation.

(3) It is necessary to provide steady trainings for foremen and workers.

(4) To put above mentioned items into practice, more data regarding quality accidents should be collected.

To facilitate the identification and evaluation of quality risks, the preparation of a well-organized list on the nature of risks and their evaluation methods is effective.

VI. Risk Avoidance Measures for Building Construction Management in Japan

It is essential for any organizations in any country to avoid risks. In this section, risk avoidance measures for building construction management in Japan are introduced.

Building construction management brings with it many risks to environment and safety. Fig. 1 shows risk response. As the figure indicates, there are roughly four ways to manage risk: reduction, retention, avoidance, and transfer.

(1) Risk avoidance: This means the action of removing any factors which may create a risk. It is also called risk elimination.

(2) Risk reduction: Measures are taken to diminish the likelihood of risk occurrence or to minimize the effect of risk if it occurs, or to achieve the both. For example, seismic retrofit methods are considered as appropriate measures to reduce the likelihood of such a risk that an earthquake brings down a manufacturing plant and cripples its operation for several months. To minimize the effect of the same risk, it is suggested to increase the operation capacity of another plant and produce substitutes.

(3) Risk transfer: Literally, risk is shifted to another party. It is also called risk sharing, and one of the most

typical measures is the purchase of an insurance policy. The use of outsourcing of professional services is one of means as well.

(4) Risk retention: It involves accepting risk without taking any measures. This act is chosen when the degree of a given risk is considered acceptable, or when it is determined that the risk has to be accepted because there is no plausible measures.

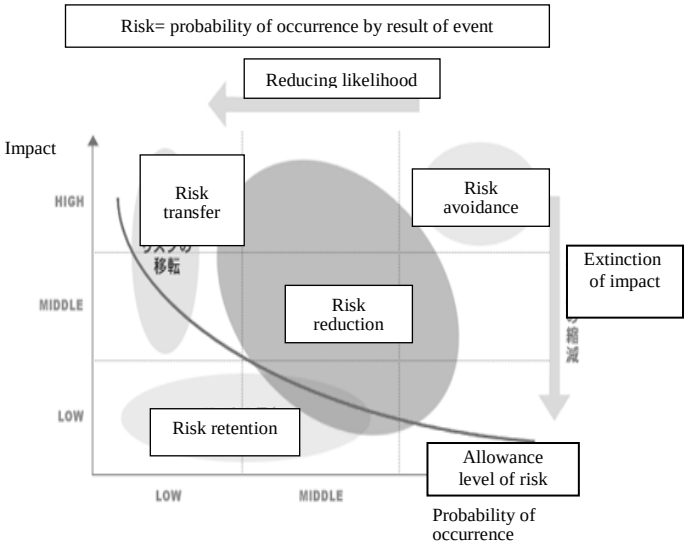

Figure 1. Risk response

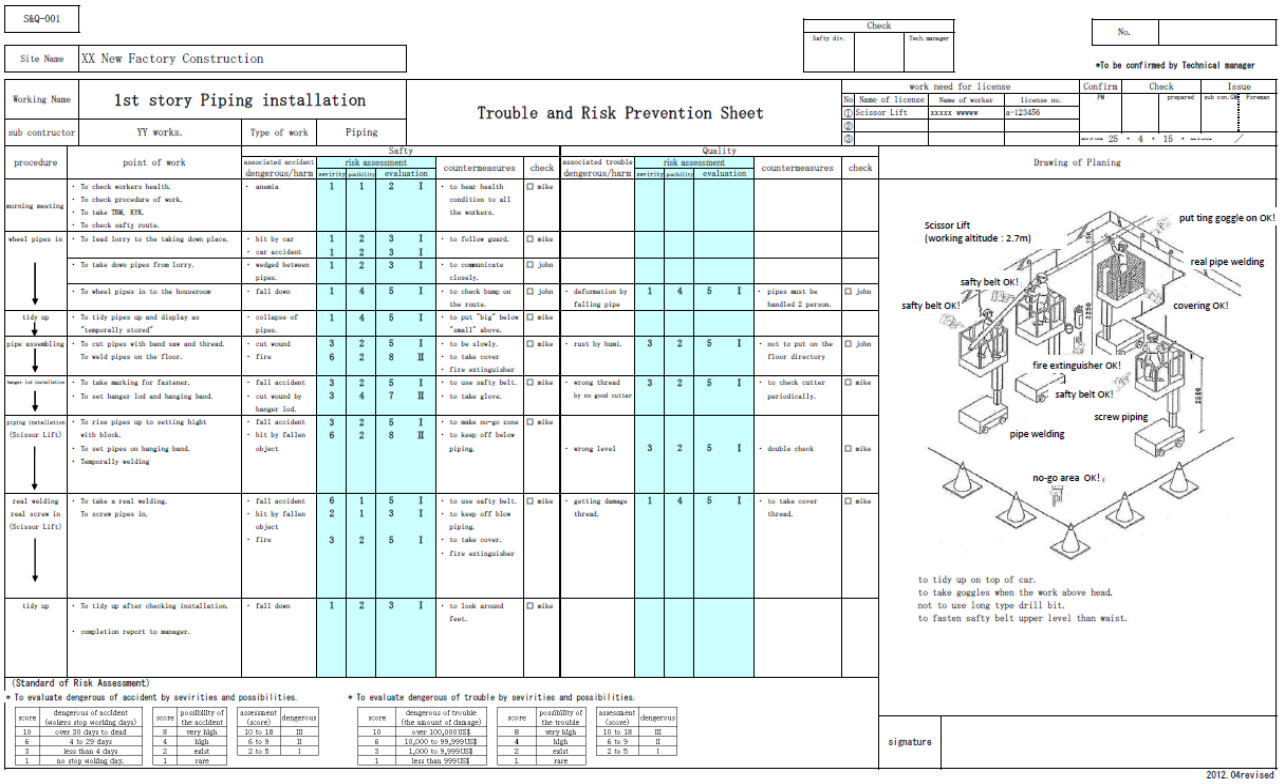

Figure 2. The sample of trouble and risk prevention sheet

VII. SUMMARY

The main conclusions are summarized as follows.

(1)There are some opinions from the test sites about experimental implementation of the sheet.

(2)We find.difficulties in formulation and implementation of safety operating procedures.

(3)We have examination as to reasons for difficulties in identifying and evaluating quality risks in comparison with safety risks.

(4) We have examination of methods for facilitating identification and evaluation of quality risks.

VIII. Futures Issues

ISO45001 was newly issued on March 12, 2018 as the international standard of occupational health and safety management systems, Japan has been striving to efficiently avoid risks by promptly introducing ISOs related to environment and safety. So we will take the way of this new ISO45001 in this Trouble &Risk Prevention Sheet.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

All authors wrote this paper under the direction of Professor Takehiro Tanaka.

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