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Improvement of Construction Safety Management Checklist for Preventing Construction Accidents in Winter

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Abstract

Background/Objectives: At construction sites, checklists are used for each construction for disaster prevention and safety management. However, there is no seasonal checklist. Occupational accidents include environmental factors. In particular, the disaster rate is high in winter. Therefore, it is necessary to develop the construction safety management checklist in winter.

Methods/Statistical analysis: In this study, the items of the existing checklist were examined for improving the checklist of winter construction safety management. Unnecessary items were removed through interviews with experts, and a questionnaire survey was conducted. Awareness of winter safety management and awareness of how important checklist use is for safety management was investigated. A questionnaire survey was also conducted to improve the items on the existing checklist.

Findings: As a result of the awareness survey, the checklist to prepare for winter is important, but it is not used practically now. In addition, the two-way communication between the worker and the safety manager was not smooth. Items that were above the average of the questionnaire results and response results for the items were selected, and 5 major items and 12 minor items were added. Since then, the checklist creation format has been improved. A double check for workers and safety managers and a date and time when safety management was implemented were added, and improvement was made so that there were no unconfirmed safety management items.

Improvements/Applications: In this study, the scope of application of the checklist was divided into seasons, and items suitable for winter were improved. This study is expected to be the basic study of the seasonal construction safety management checklist. However, since this is the result of selection through a questionnaire survey, additional research is needed to confirm field applicability.

Keywords: Winter season, Construction safety management, Checklist, Construction sites, Construction accident.

1. Introduction

The construction industry is an industry with many disaster victims and a very high probability of serious disasters[1-6]. However, according to the Korea National Statistical Office, the number of occupational accidents in the construction industry in 2018 was 27,686 out of 102,305. This accounts for 27.1%. The number of death from disasters in the construction industry was 570, which is the highest among all industries. In particular, in the case of construction sites in winter, an analysis of the annual number of occupational accidents revealed that 140 people were killed in winter accidents. This figure is 10.2% higher than the average annual number of death from disasters of 127. Winter construction site accidents take place by climatic characteristics such as cold wave, heavy snow, strong wind and freezing. In addition, a fire can occur due to heating, electric heating, and the use of welding equipment. In addition, temporary structures collapse occurs due to heavy snow and strong wind, cracks and collapses occur due to the ground freeze and expansion. The causes of such construction occupational accidents

are inadequate on-site safety inspections and improper management items in winter. At construction sites, safety management is carried out for construction work such as by construction procedure and by process. However, it has not been created for necessary situations such as seasons and environment, and its scope of application is insufficient. In addition, it is not widely used at construction sites and relies heavily on the judgment of safety managers[7-8]. This study conducted an awareness survey of workers regarding the winter checklist. A questionnaire survey was conducted on the necessity, importance, communication, and problems of the winter safety management checklist. As shown in Figure 1, more than 80% of the respondents answered that a winter checklist is very necessary and very important as a safety inspection activity. In addition, 50% of respondents said that the follow-up measure is uncertain due to lack of two-way communication between workers and safety managers and checklist items were not suitable for winter.

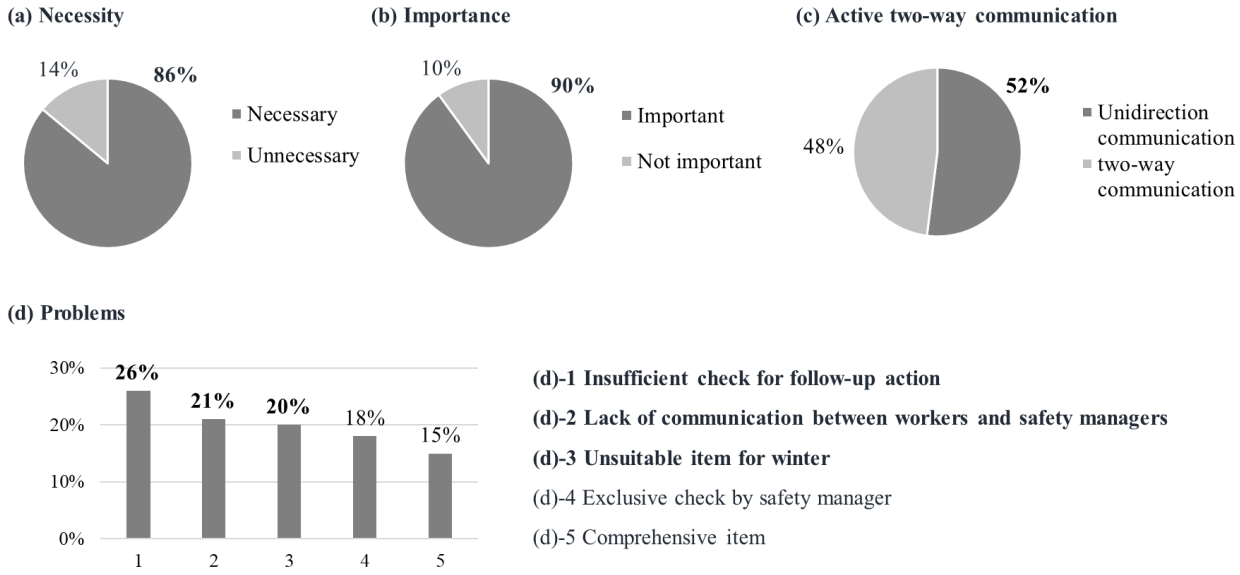

Figure 1. Construction workers' awareness of the winter safety management checklist.

As such, in order to prevent construction disasters that occur in winter, it is necessary to improve the items on the checklist and manage safety through two-way communication. In response to this, this study attempts to improve the safety management checklist suitable for winter. The procedure of this study investigates and classifies the items of the existing safety management checklist as shown in Figure 2. A questionnaire is followed for construction workers in order to select items that are suitable for winter safety management. Finally, this study derives the items of the improved checklist and presents how to utilize the checklist based on it.

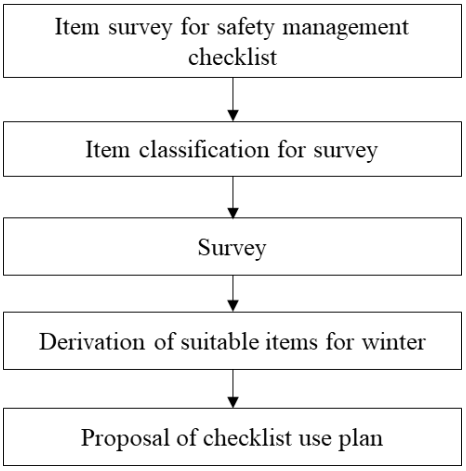

Figure 2. Study flow

2. Literature review

At construction sites, safety inspection activities are carried out to identify and manage risk factors for work using checklists. It is necessary to describe the contents of the checklist in more detail and provide specific contents according to the scope of application for the user to clearly understand the contents[7].

Because of such need, many studies have recently conducted to develop checklists according to detailed work scope such as work type, construction site scale and accident cause for safety management of construction sites. Hong(2004) figured out the cause of the disaster for steel frame construction during construction work in order to develop a safety management checklist for detailed work. He conducted a questionnaire survey and created a disaster cause classification system for each detailed work type. He created a cause-effect diagram to develop a checklist for safety management in the event of a disaster[8]. Sim(2010) argued that although the systematization of construction sites has simplified the construction method, disasters are still increasing in the reinforced concrete construction, which is highly dependent on manpower, and the size of disaster becomes larger. Therefore, he proposed a checklist for efficient safety management, focusing on reinforced concrete construction. He investigated disaster cases and causes and conducted a questionnaire to those involved in the construction site. Depending on the psychological state of the worker, the basic factors related to the disaster at the construction site were derived, the correlation between each factor was analyzed, and a checklist was proposed[9]. Cho(2017) proposed a checklist that can focus on safety management according to the degree of risk in order to reduce possible accidents during mold construction at small construction sites. She extracted the risk factors of work, investigated disaster cases to select inspection items, and extracted inspection items for each disaster type. Then, it was applied to the construction site and clear instructions for safety management were given[5]. In addition, Park(2008) has developed a safety management checklist to deal with accidents caused by the increased use of system foam molds. He analyzed the safety management problems for each process of mold work and derived a safety management checklist suitable for the system form based on it[10]. Guo(2019) proposed an improved safety checklist that uses intelligent video surveillance for efficient safety management throughout the construction process. He proposed to place an intelligent camera inside the construction site to inspect all items on the construction site according to the safety checklist[6]. Choi(2018) has developed a safety checklist for a safety management system that figures out the current situation in real time. The risk factors in the fatal accident case of a shipbuilding company in the past was figured out, the characteristics of the accident was analyzed and the items of the safety checklist was derived. Accident prediction results were evaluated using a learning model to develop a safety management system[11].

Due to the increase in the disasters for each work, a research has been carried out to subdivide the scope of application and develop a checklist for efficient safety management. However, occupational accidents at construction sites can include not only work-specific accident causes but also environmental factors. That is, even if safety management is performed for each work, the causes and types of disasters differ depending on the seasons. Therefore, it is necessary to carry out safety management at construction sites in consideration of the causes of disasters in each season.

3. Improvement of winter construction safety management checklist

3.1. *Outline of the survey*

In this study, in order to present a method for improving the checklist for safety management at construction sites in winter, the items were investigated with reference to the existing safety

management checklist. The surveyed items were selected through interviews with experts regarding winter safety management. The selected items were 5 major items including fire and explosion, closed space work, heavy snow and freezing, strong wind and others, and 27 minor items. A questionnaire was created to conduct a questionnaire survey based on the selected items. The questionnaire was organized for the purpose of obtaining opinions on the appropriateness of the newly added items and whether they are actually applicable. The questionnaire survey was conducted on 16 safety managers and construction supervisors involved in the construction industry, and 5 workers. More than 80% of the respondents had more than 10 years of work experience in management and supervision, and it was judged that the answers to the questionnaire were appropriate. In addition, it was checked if the existing checklist currently used for the purpose of recognition survey was suitable for winter, and a questionnaire survey was conducted to understand problems. The outline of the questionnaire survey is shown in Table 1.

Table 1. Outline of the survey

Outline	Summary
Title	Survey to improve winter construction site safety management checklist
Survey target	16 safety managers and construction supervisors, 5 workers
Survey item	Fire and explosion, Closed space work, Heavy snow and freezing, Strong wind, Others

3.2. *Survey result analysis*

The results of the questionnaire for the selected items are as follows. In order to add the analyzed items to the checklist, items that are above the average of the response results were selected as additional items. As shown in Table 2, in the category of fire and explosion, 4 minor items which are above the average value 14.4% were selected. These include whether a supervisor is placed during fire hazard work (23%), whether heating appliance power and short circuit failure are checked (21%), whether electric heating wire coating is damaged (18%) and whether there is temperature control sensor (16%). Many types of heating appliances are used in winter to withstand the cold, and a fire may occur even after leaving work. Therefore, it is necessary to constantly check the power supply of the heating appliance, check the malfunctions and failures, and the state of the electric heating wire at any time in advance for continuous management. In addition, it is difficult for workers to check and confirm the safety of fire appliances and the surrounding environment during fire hazard. Accordingly, there is a low probability that a fire can be dealt with immediately. Therefore, it is necessary to assign a supervisor so that they can prevent and deal with them.

Table 2. Fire and explosion

Fire and explosion	Result
1. Whether a supervisor is placed during fire hazard work	23%
2. Whether heating appliance power and short circuit failure are checked Survey item	21%
3. Whether electric heating wire coating is damaged	18%

4. Whether there is electric heating wire overheat blocking device and whether there is temperature control sensor	16%
5. Whether there is sufficient rest for workers related to welding and fusing work, and whether there is prior confirmation of sensitive group	11%
6. Whether the temporary wire is finished	7%
7. Whether to provide sufficient cold weather equipment for workers	2%

As shown in Table 3, the closed space work has two minor items which have beyond average value of 23.7%: Whether the type and concentration of harmful gas is grasped before the closed space work (32%), and whether the number of personnel is grasped when entering and exiting the closed space (24%). When working in a closed space, it is important to notify of danger in advance and to understand the surrounding environment such as the type and concentration of harmful gas. In addition, although it is important to take early measures in an emergency, it is difficult to request help such as report and evacuation in the event of accidents. Accordingly, it is necessary to grasp the presence of harmful gas and the number of workers in advance, and to proceed with the work in pairs.

Table 3. Closed space work

Closed space work	Result
1. Whether the type and concentration of harmful gas is grasped before the closed space work before working in a closed space	32%
2. Whether the number of personnel is grasped when entering and exiting the closed space	24%
3. Whether there is a closed space evacuation equipment	20%
4. Whether the closed space is checked and hazard is marked	17%
5. Whether health abnormalities are checked after working in a closed space	7%

As shown in Table 4, heavy snow and freezing have two minor items which have beyond average value of 28.1%: Whether there is a countermeasure for worker movement passage freezing (45%) and whether heavy snow standard is confirmed before work start (30%). In winter, it is obligatory to check the weather conditions on the day of work before the start of work. In addition, drop and fall accidents are the most common accidents on work roads and worker movement passages due to heavy snow and freezing. Therefore, it must be sure to confirm the weather conditions on the day before the work start, to clearly recognize the heavy snow warning and heavy snow warning standards and to change the work depending on the situation. Also, the preventive and countermeasure manual for freezing of roads and worker movement passages must be instructed in advanced to workers so that they may be familiar with them.

Table 4. Heavy snow and freezing

Heavy snow and freezing	Result
1. Whether there is a countermeasure for worker movement passage freezing	45%

2. Whether materials are deployed in advance due to weather changes	30%
3. Whether materials are deployed in advance due to weather changes	15%
4. Whether the stability of the facility is reviewed due to snow load	10%
5. Whether the heater and electric heater are operating	0%

As shown in Table 5, strong wind has three minor items which have beyond average value of 21.2%: Whether there is support reinforcement for heavy equipment cranes (33%), whether there is stability of temporary structures (27%) and whether there is defect in scaffolding and joints of temporary structures. Strong wind often occurs unexpectedly, and when a disaster occurs, the scale of the accident is large and it is very likely that it would lead to a serious disaster. In addition, it is necessary to confirm whether the structure under construction is carried out based on the structural calculation. Therefore, it is necessary to add new selected items to be aware of strong wind and to prepare for it.

Table 5. Strong wind

Strong wind	Result
1. Whether there is support reinforcement for heavy equipment cranes	33%
2. Whether there is stability of temporary structures	27%
3. Whether there is defect in scaffolding and joints of temporary structures.	27%
4. Whether windbreak wall is installed according to the installation standards	10%
5. Whether the vehicle can be operated according to the dangerous wind speed by vehicle type	3%

As shown in Table 6, other items have three minor items which have beyond average value of 25.8%: Whether the worker's health condition is grasped (30%), whether the MSDS is indicated on the anti-freezing subdivision container (26%) and whether the edible drinking water is displayed. Cases of ingestion accidents due to non-marking of anti-freezing agents frequently occur, and it is necessary to indicate harmful materials and store them separately. In addition, worker safety and protection are the most important parts of the field. Therefore, it is necessary to indicate for harmful solutions and the edible drinking water. The basic health of the worker should be checked on a regular basis.

Table 6. Others

Others	Result
1. Whether the worker's health condition is grasped	30%
2. Whether the MSDS is indicated on the anti-freezing subdivision container	26%
3. Whether edible drinking water is indicated	26%
4. Whether there is an emergency contact network in case of deterioration of worker's health	13%
5. Whether there is indication of the workplace handling anti-freezing agents	4%

Table 7 shows the winter construction safety management checklist derived from the results of the survey. Twelve minor items have been added to the existing checklist, consisting of five major items and 56 minor items.

Table 7. Checklist items for winter construction safety management

Major item	Minor item	Major item	Minor item
Fire and explosion	Check oil and combustible materials around heater	Closed space work	Supplying respirator and air supplied respirator if ventilation is not possible
	Extinguishing devices around the entrances		Placement of external watchman in enclosed space and establishment of communication system
	Appropriateness of installation of fault interrupters in an electric machine and tool		Installation of rescue and evacuation equipment for workers in case of emergency
	Check the temporary electrical panel board		Check the location of the enclosed space
	Installing the fault interrupters		Check oxygen concentration in workings
	Appropriate use of electrical appliances such as electrical couplers, wire		**Harmful gas concentration, type before work in enclosed space***
	Installation of fire extinguishers on site		**The number of people in enclosed space***
	Installation of fire extinguishers in places where fire extinguishers are used such as smoking areas, etc.	Heavy snow and freezing	Removing freezing from the worker's driving path and preventing slipping
	Installation of fire extinguishers within 20m of walk distance		Sandboxes and calcium chloride at the site
	Emergency escape route designation		Division of passageways of vehicles and workers at the site
	Installation of distinguishable escape signs and lighting in blackout		Check the roofs and temporary structures that are at risk from heavy snow
	Installation of fire alarming equipment		**Freezing countermeasures roads and workers' passageways***
	Emergency evacuation training for workers		**Check the heavy snow standards before construction begins***
	Isolation of inflammables, combustible materials around	Strong wind	The wind velocity of moment exceeds 10 m/s: stop installation,

	welding work		disassembly, repair, and check
	Installation of fire extinguishers to prevent scattering of sparks and flames		The wind velocity of moment exceeds 15 m/s: stop operation
	Installation of shatter resistance cover, welding firearm		The wind velocity of moment exceeds 30 m/s: check after wind passing
	Training and prevention of welding work around insulation		Prevent effects of wind with gangforms and vertical protective nets
	Welding after checking for explosion, fire hazard materials		Strong binding of structures, signs, materials, etc.
	Check the gas outflow prior to welding		**Support and reinforcement of heavy equipment crane***
	Hose cracking, gas outflow at the connection		**Stability of temporary structure***
	Sticking reverse fire protection device		**Check for defective bond of scaffold and temporary structure***
	Operation of reverse fire protection in acetylene, LPG gas welding device	Others	Performing Tool Box Meeting (T.B.M)
	Place surveillant in fire risk works*		Wearing heat reserving equipment when working outdoors for a long time
	Check heating equipment power, short circuit, trouble*		Wearing moist gloves and safety shoes
	Electric heat wire sheath damage*		Wearing moist gloves and safety shoes is prohibited
	Check electrical heating over temperature breaker, climate control senso*		Prevention for the health care of workers
Closed space work	Sufficient ventilation		Check the health of workers
	Check the location of the use of brown coal and charcoal		Marking MSDS on a small container of the non-freezing compound
			Marking edible water

3.3. *Proposal of checklist utilizing plan*

While work instructions at construction sites go in one direction, two-way communication is important for safety management. However, as a result of the questionnaire survey, it was found that the two-way communication between the worker and the safety manager was insufficient at the construction site. For this reason, in this study, the checklist was created by a double check of the worker and the safety manager by active two-way communication. For worker safety management, two-way

communication with workers is essential, not one-way management by the manager. The existing checklist could not figure out the date and time when the problem occurred for each item, and immediate measures were somewhat impossible. In addition, it is necessary to add the implementation date and time. Accordingly, a date and time entry field was added to the checklist to accumulate accident data that occurs for each date and time, and to prevent accidents from occurring in the future. For reliable safety management, not only the confirmation column, but also the confirmation column of follow-up action was added. In consideration of the afore-mentioned improvements, the checklist creation format has been improved as shown in Figure 3 in order to effectively manage the construction site in winter.

Category	Items	Date and time	Check		
			Worker	Manager	Follow-up action
Fire and explosion					
	• Check oil and combustible materials around heater				
	• Extinguishing devices around the entrances				
	• Appropriateness of installation of fault interrupters in an electric machine and tool				
	• Check the temporary electrical panel board				

Figure 3. Checklist form for winter construction safety management

Figure 4 shows the procedure and method for using the checklist. The confirmation column of the checklist is filled by the worker representative. The manager confirmation column and the measure completion confirmation column must be filled by the safety manager. The checklist implementation date and time and the worker confirmation column were filled by the worker. If there is no problem in those items, it is simply checked without any separate marking. On the contrary, if there is a problem, it will be described separately in the worker confirmation column. When the worker finishes checking all the items, the checklist is handed over to the manager so that the manager can recheck all the items. After promptly taking measures for problematic items based on the worker confirmation column, whether the follow-up measure is complete nor not is marked in the confirmation completion column. Additionally, by filling the completion time of measure on the implementation date and time, the checklist creation is complete.

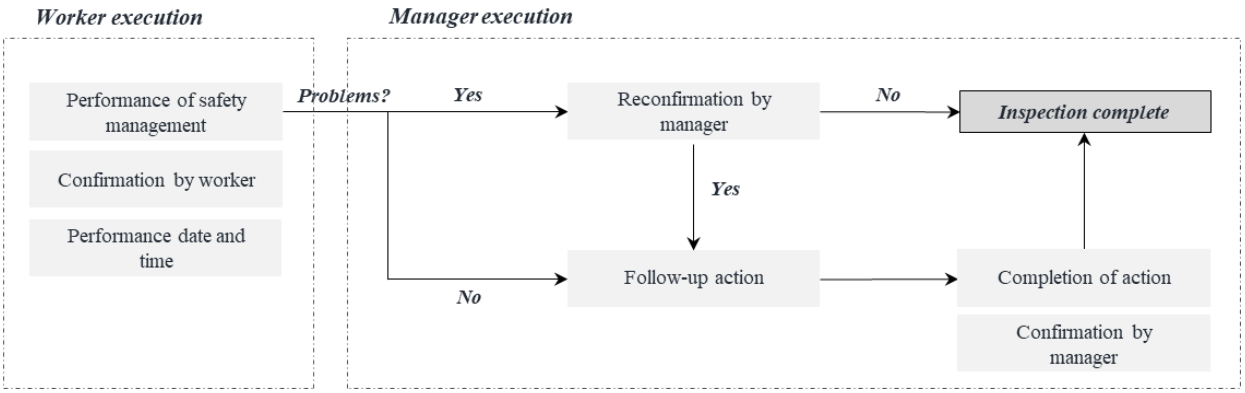

Figure 4. Procedure and method for using checklist

4. Conclusion

Unlike the general manufacturing industry, the construction work has a very high risk of work itself and a high probability of disaster. At the construction site, the risk factors of work are figured out and managed by using the checklist. In order to reduce disasters that occur in each construction work, the scope of application of the checklist was subdivided and developed. However, occupational accidents at construction sites also include environmental factors. Since the causes and types of disasters that occur in each season may differ, it is necessary to carry out safety management in consideration of the causes of disasters that occur in each season. In this study, the checklist for winter construction safety management was improved. For this purpose, an awareness on the winter safety management and the use of the checklist for construction workers was surveyed and a questionnaire survey was conducted to improve the items of existing checklists. As a result of the awareness survey, although the checklist is even more important in winter, it is not practically used at present, and the two-way communication between the worker and the safety manager was not smooth. Items that were above the average of the questionnaire results and response results for the items were selected, and 12 minor items were added. The checklist creation format was improved to effectively manage winter construction sites using the selected items. Double check of workers and safety managers and safety management implementation date and time have been added so that there are no unconfirmed safety management items. In this study, the scope of application of the checklist is divided into seasons to improve the items suitable for winter and this is expected to be a basic study of the seasonal construction safety management checklist. However, since this is the result of selection through a questionnaire survey, a further research is needed to confirm field applicability.

5. Acknowledgment

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