STUDY ON FALL PROTECTION FOR ASSEMBLING AND DISMANTLING WORKS OF SYSTEM SCAFFOLDS

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ABSTRACT

Falling accidents are a serious problem in the construction industry in Japan. Approximately 40% of fatal construction accidents are caused by falls. Therefore, Japan has introduced and strictly enforces countermeasures to reduce falls from scaffolds with various safety guidelines, e.g., the Guideline for Preceding Guardrail (Advanced Guardrail) Installation Method for work requiring scaffold assembling and dismantling. These countermeasures have resulted in a reduction in fatalities caused by workers falling from scaffolds. However, the rate of fatal accidental falls is still high in the construction industry. In order to examine further countermeasures to reduce such falls, the Ministry of Health, Labour and Welfare, Japan established a committee at the authors' institute to evaluate various construction methods according to present safety guidelines. From the results and the discussion, the Guideline for Advanced Guardrail Installation Method was amended in 2009. However, it was discovered that this method is not widely used, especially for system scaffolds due to a low working property of the methods. Therefore, in this study, other assembling and dismantling method for system scaffolds were examined for the safety work. From the results, the safety method by using a safety harness was devised, and the safety of the method was confirmed on the stability and the strength of the scaffolds by the fall experiments using a human dummy. Finally, the assembling work of the system scaffolds was performed to examine whether the method was practicable, and it could be confirmed that the proposed method was practicable.

Keywords: System scaffolds, fall accident, advanced guardrail, safety harness, labour accident.

1. INTRODUCTION

The frequency of fall accidents is one of the most serious problems in the construction industry in Japan. Approximately 40% of fatal construction accidents are caused by falls. Therefore, in Japan, countermeasures against falls from scaffolds have been tightened with the institution of guidelines, such as the Guideline for Preceding Guardrail (Advanced Guardrail) Installation Method for scaffold erection work, as shown in Figure 1. These countermeasures have resulted in a reduction in fatalities caused by workers falling from scaffolds. However, the rate of fatal accidental falls is still high in the construction industry. Distribution of information about the method became the main focus of the 11th Labor Accident Prevention Plan in Japan.

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In order to examine further countermeasures to reduce such falls, the Ministry of Health, Labour and Welfare, Japan (MHLW) established a committee at the authors' institute to evaluate various construction methods according to present safety guidelines. From the results and the discussion, the Guideline for Advanced Guardrail Installation Method was amended (Ministry of Health, Labour and Welfare, Japan 2009).

Figure 1: Prefabricated scaffolds assembled by Advanced Guardrail Installation Method.

However, it was discovered that this method is not widely used. The MHLW investigated the use rate of this method on 4,892 construction sites. The result is shown in Figure 2. Only 31% of construction sites used this method, and it was found that the use of the method was not widespread, especially for system scaffolds due to a low working property of the methods. Therefore, in this study, other assembling and dismantling method for system scaffolds were examined for the safety work. Finally, the assembling work of the system scaffolds was performed to examine whether the method was practicable.

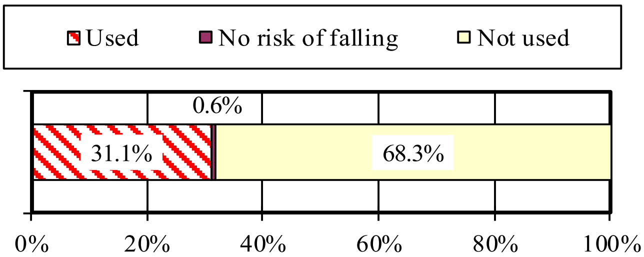


Figure 2: The use rate of Advanced Guardrail Installation Method.

2. EXPERIMENTAL METHOD

In this study, typical system scaffolds by wedge connections in Japan were selected to examine the safety assembling and dismantling method for prevention the fall from the scaffolds. Then, it was decided that wedge pockets were used for connecting the hook of the safety harness to the scaffolds for fall prevention. Three types of the system scaffolds in Japan were selected in this study. Figure 3 show the typical wedge pockets of the selected system scaffolds and the hook of the safety harness connected to the wedge pockets.

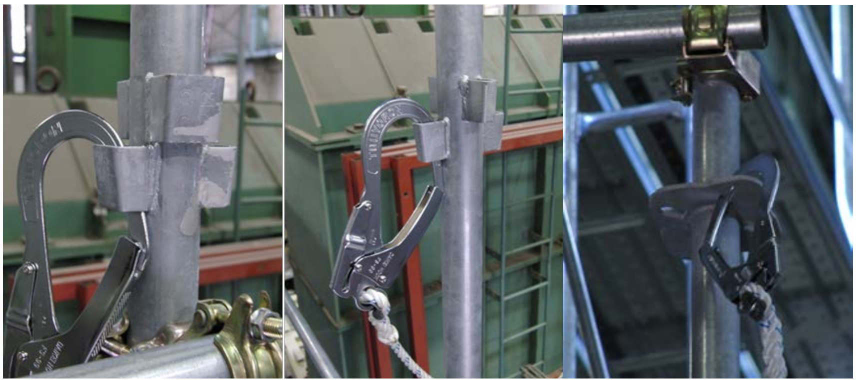


Figure 3: Typical wedge pockets and the hook of the safety harness (Left: Type A, Center: Type B , Right: Type C).

When workers use the safety harness on the scaffolds, the horizontal stability of the scaffolds must be confirmed. In Japan, the ties, which connect the scaffolds to the building wall, shall be installed within 5m (vertical) × 5.5m (horizontal) to keep the horizontal stability of the scaffolds by Occupational Safety and Health Regulation (Ministry of Health, Labour and Welfare, Japan 1972). For the case of typical system scaffolds selected in this study, the height of 1 story is 1.8m or 1.9m, and the width of 1 bay is 1.8m. From these reasons, the ties are assumed to be installed within 2 stories (3.6m or 3.8m) × 3 bays (5.4m) for the selected scaffolds. Therefore, the height and width of the scaffolds were decided to be this maximum tie spacing, as shown in Figure 4.

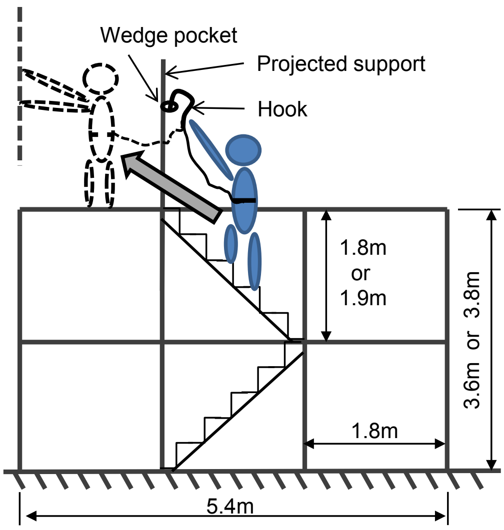


Figure 4: 2 stories and 3 bays scaffolds.

In the experiment, the safety of the fall protection by the safety harness during the assembling or dismantling works above the 2nd story of the scaffolds was examined. A support with wedge pockets was projected above the 2nd story as shown in Figure 4, because it is recommended that the hook should be connected above the ring of lanyard to reduce the damage of falling workers (National Institute of Industrial Safety 2004). Then, the strength of the wedge pocket projected above the 2nd story of the scaffolds must be also confirmed.

The horizontal stability of the scaffolds and the strength of the wedge pocket were confirmed by fall experiments using a human dummy. Figures 5-6 show the structure of the scaffolds in the experiments, and Table 1 shows the experimental cases. Configurations of ties were changed to confirm the stability of the scaffolds and the strength of the wedge pocket in various conditions, as shown in Figures 5-6 and Table 1. The experiment in Figure 6 was performed for confirming the strength of the guardrail.

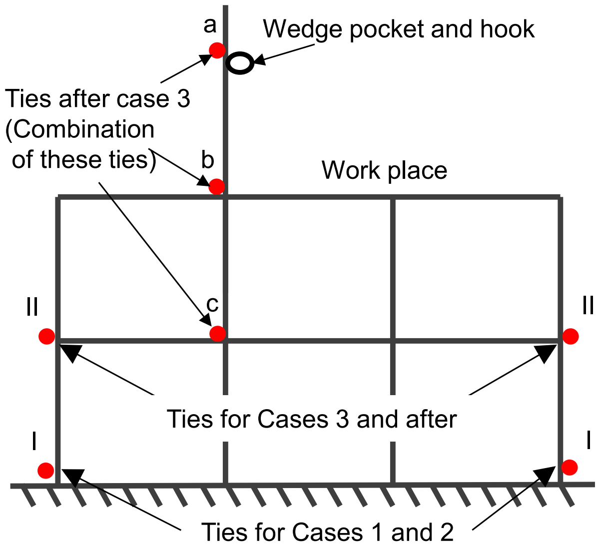


Figure 5: Configurations of ties.

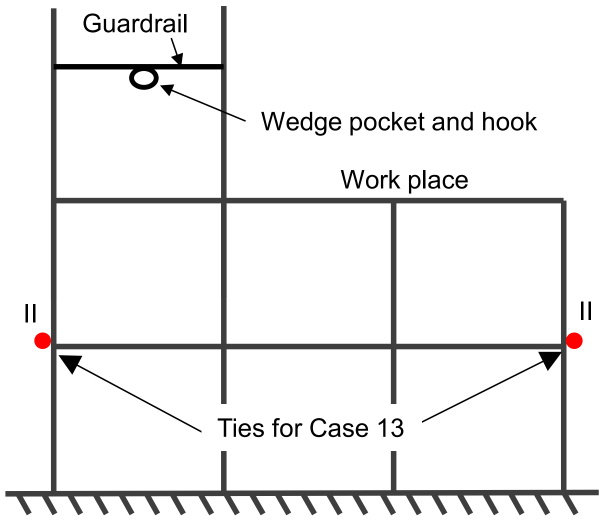
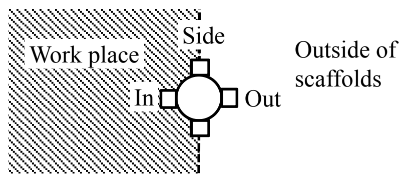


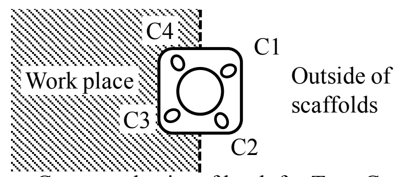
Figure 6: Configurations of ties (Case 13).

Table 1: Experimental cases.

Case	Type of wedge pocket	Connected point of hook	Configurations of ties
1	A	Out	I
2	A	Out	I
3	A	Out	II
4	A	IN	II, a,b
5	A	Side	II, a,b
6	A	Out	II, a,b
7	B	IN	II, a,b
8	B	Side	II, a,b
9	B	Out	II, a,b
10	C	C1	II, a,b
11	C	C2	II, a,b
12	C	C3	II, a,b
13	A	Guardrail	II
14	A	Out	II, c



Connected point of hook for Type A and B



Connected point of hook for Type C

In the experiment, the human dummy, of which weight was 980N was dropped from the same height of the hook of the harness, and the distance between the hook and the human dummy was set to be 800mm as shown in Figure 7. This experimental method was the same way as the fall test by Advanced and Secured Handrail (Japanese Industrial Standards 2006). After the experiments, it was observed the horizontal displacement of the scaffolds and the damage of the wedge pocket, support, guardrail and the hook.

Figure 7: Experimental method for drop of human dummy.

3. RESULTS OF EXPERIMENT

Table 2 shows the results of the experiment. In the cases 1 and 2, the ties were installed at the points of I in Figure 5, which is 2 stories down from the work place. The horizontal displacement of the scaffolds exceeded 300mm, when the human dummy was dropped in these cases. Then, it seemed that the scaffolds were unstable by the video observation of the experiments.

Table 2: Results of experiment.

Case	Damage
1	Horizontal displacement > 300mm (unstable)
2	Horizontal displacement > 300mm (unstable)
3	Horizontal displacement < 300mm (stable)
4	Hook (slight damage)
5	No damage
6	No damage
7	Hook and wedge pocket (slight damage)
8	No damage
9	No damage
10	Wedge pocket (slight damage)
11	No damage
12	Hook (slight damage)
13	Support (slight damage)
14	Support (slight damage)

In the case 3, the ties were installed at the points of II in Figure 5, which is 1 story down from the work place, and the horizontal displacement of the scaffolds was also observed after the experiment. From the result of the experiment, it was found that the horizontal displacement did not exceeded 300mm, and it seemed that the scaffolds were stable by the video observation. Therefore, in the experiments after the case 3, the ties were installed at the points of II, as shown in Figure 5.

In the cases that the ties were installed at the points of a and b in Figure 5, it was assumed that the impact load concentrated on the wedge pocket by the fall of the human dummy. In the cases that the ties were installed at the point of c in Figure 5, it was assumed that the moment concentrated on the bottom of the projected support by the fall of the human dummy. The experiments were carried out in consideration of these configurations of ties to confirm the strength of the scaffolds' members.

In a series of these experiments, there were no damage or only a slight damage in the wedge pocket, support, guardrail or the hook, as shown in Table 2 and Figure 8. Therefore, in the case when the ties were installed within 1 story from the work place, it was confirmed that the assembling and dismantling works of the system scaffolds could be performed safe, concerning the stability of the scaffolds and the strength of the scaffolds' members.

Figure 8: Slight curved hook by the fall experiment.

4. EXAMINATION OF PRACTICABILITY OF PROPOSED METHOD

From the results of these experiments, the safety of the proposed method was confirmed on the stability and the strength of the system scaffolds. However, it had not been confirmed yet whether the proposed methods was practicable or not in the actual works. Therefore, the assembling works by the proposed method was performed, to examine whether the method was practicable in each work stage.

First, the worker tried climbing the stairs to the next platform. Then, the hook of the harness could be hung to the wedge pocket with previously projected support, as shown in Figure 9, because it is recommended that the hook should be hung above the ring of lanyard (above the waist) to reduce the damage of falling workers by the Recommendations for Use of Safety Belts (National Institute of Industrial Safety 2004). After climbing to the next platform, the worker tried setting other supports, as shown in Figure 10. Then, the worker could be performed with using the harness.

Next, the worker tried setting the guardrail between the supports, and then the worker could hang the hook of the harness to the guardrail, as shown in Figure 11. After this work stage, the worker could assemble the scaffolds on the next platform with hanging the hook of the harness to the guardrails at all times, as shown in Figure 12. The dismantling work of the scaffolds could be also performed in the reverse order of the assembling work.

Figure 9: The worker who tried climbing the stairs to the next platform.

Figure 10: The worker who tried setting other supports.

Figure 11: The worker who tried setting the guardrail between the supports.

Figure 12: The worker who tried setting other members with hanging the hook of the harness to the guardrail.

From these results, it was found that the worker could hang the hook of the harness above him waist in all work stage, as the provision of the Recommendations for Use of Safety Belts. Therefore, it could be concluded that the proposed method was practicable safely in the assembling and dismantling work of the system scaffolds.

5. CONCLUDING REMARKS

In this study, the safety of the fall protection by the safety harness during the assembling or dismantling works of the system scaffolds was examined experimentally using the human dummy. Finally, the assembling work of the system scaffolds was performed to examine whether the method was practicable. The results are summarized as follows.

(1) In the case when the ties were installed within 1 story from the work place, the system scaffolds were stable against the fall of the human dummy.

(2) There was no damage or only a slight damage in the wedge pocket, support, guardrail or the hook against the fall of the human dummy.

(3) From these results, it was confirmed that the assembling and dismantling works of the system scaffolds could be performed safe, concerning the stability of the scaffolds and the strength of the scaffolds' members.

(4) From the results of the examination to confirm the practicability of the proposed method, it was found that the worker could hang the hook of the harness above him waist in all work stage, as the provision of the Recommendations for Use of Safety Belts by the National Institute of Industrial Safety in 2004.

(5) Therefore, it could be concluded that the proposed method was practicable safely in the assembling and dismantling work of the system scaffolds.

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