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Risk Assessment of Major Work Type for Prevention of Accident Occurring at Construction Sites in Korea

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Abstract

This study evaluated the risk of the main work types at the construction site and suggested quantitative data that can be used to establish a reasonable safety management plan. Three construction safety experts compared the risk for 21 main work types. It was analyzed that lift work, glass and window work and steel framework were the highest risk. In addition, the degree of risk of 21 main work types evaluated by three construction safety experts was calculated and averaged, and it was analyzed that rebar work was the highest risk. As a result of this study, it is expected to improve the effectiveness of safety management and prevent safety accidents in construction work by enhancing safety management such as the additional arrangement of safety management personnel and strengthening safety education for high risk work types.

Keywords - Construction Work, Construction Accident, Work Type, Matrix analysis, Risk.

I. INTRODUCTION

According to the Ministry of Employment and Labor, the central administrative organization that manages Korea's employment policy and work, industrial injuries in 2018 were down 0.9% from 2017 [1]. However, the number of deaths from industrial accidents in 2018 increased 10.1% compared to 2016. The number of industrial accidents in Korea in 2018 was 1,897 in mining, 25,333 in manufacturing, 25,649 in construction, 87 in electricity and gas water supply, 4,237 in transportation, warehousing and communication service, 1,124 in forestry and 30,595 in other industries. As such, construction is the industry with the highest number of accidents. In 2018, the number of deaths by industry in Korea was 457 in mining, 433 in manufacturing, 579 in construction, 4 in electricity and gas water supply, 121 in transportation, warehousing and communication service, 16 in forestry and 318 in other industries [1]. Construction is the largest number of deaths. Korea's construction industry has reached a world level in technology due to the rapid development of the national economy. However, behind the development of the construction industry, accidents at construction sites frequently occur due to safety insensitivity [2]. The construction industry handles heavy equipment and heavy goods more than other industries. In addition, since the work is performed by subcontracting, and outdoor work and high place work are mainly performed, systematic and continuous management is difficult. There are always various and sudden risk factors at construction sites. Also, construction sites have a higher frequency and intensity of accidents than other industries [3]. Safety management refers to management activities aimed at preventing accidents by anticipating risk factors in all construction processes [4]. Information for safety management includes safety technology level, accident prevention measures and accident cases. Among these, accident cases provide direct information on predicting the risk of work and developing safety management plans [5]. Through analysis of accident cases, it is possible to identify and intensively manage work types that have a high risk of accident in advance during construction. However, construction companies are reluctant to disclose information about accident cases occurring at construction sites. In addition, no risk assessment methodology has been established for work types that are prone to accidents during construction [6]. The purpose of this study is to analyze the work type with high risk of accident at construction stage, using the empirical knowledge of experts in construction safety field. This study suggests the work types that require safety management and enhance the effectiveness of safety management activities.

II. REVIEW OF PREVIOUS STUDY AND METHOD OF STUDY

Study on accidents occurring at construction sites and preventing accidents has been conducted in various aspects. J. B. Lee, S. S. Go and S. R. Chang analyzed the degree of risk of major accident cases in Korea from 1992 to 2004 [2]. K. J. Yi investigated the current state of safety-related regulations at small and medium sized construction sites [3]. E. J. Kim and H. S. Ahn analyzed various factors affecting the occurrence of a fall accident [4]. S. H. Jung. Et. al. analyzed the causes of accidents in 12 sub-contracts where many accidents occur [5]. S. S. Go and H. Song analyzed the accident cases that occurred at the construction site and databased each type of accident [6]. Previous studies have been conducted mainly on death accidents that occurred in Korea or on work types with relatively high accident rates. Major accidents including deaths have greater consequences of accidents, namely degree of accidents than general accidents and near misses. However, major accidents, general accidents and near misses are only differences in outcomes. All major accidents, general accidents and infrequent accidents need preventive and proactive management.

The scope of this study is to assess the risk of accidents by main work type that can occur in the construction phase. This study assessed the risk of main work types in the construction

phase using the following methods and procedures.

(1) Select main work types for risk assessment.

(2) A risk analysis model for each main work type was designed.

(3) Using the empirical knowledge of experts in the field of construction safety, the risk comparison between the main work types was compared.

(4) The risk was calculated by quantifying the risk by main work type.

III. DESIGN OF RISK ASSESSMENT MODEL

III.I COMPOSITION OF MAIN WORK TYPES FOR RISK ASSESSMENT

The main work types for risk analysis were composed using the accident analysis data of construction work of Korea Occupational Safety & Health Agency. The work types included in both the construction accident analysis data of the Korea Occupational Safety & Health Agency and the standard specifications for construction work of Korea are concrete work, earth work and foundation work, electric work, embellishment and metal work, facilities work, form work, glass and window work, lift work, masonry work, mortar and tile work, paint work, rebar work, steel framework, stone and wall work, temporary installation work and waterproof work. Insulation work, curtain wall work, elevator work, elevator work, break work and movement beyond work which are not included in the construction accident analysis data of Korea Occupational Safety & Health Agency are added. 21 main work types of construction work for risk analysis are shown in Table 1.

Table 1. Work types for risk assessment

Number	Code of work type	Name of work type (Alphabetical order)
1	WT01	Break Work
2	WT02	Concrete Work
3	WT03	Curtain Wall Work
4	WT04	Elevator Work
5	WT05	Earth & Foundation Work
6	WT06	Electric Work
7	WT07	Embellishment and Metal Work
8	WT08	Facilities Work
9	WT09	Form Work
10	WT10	Glass and Window Work
11	WT11	Insulation Work
12	WT12	Lift Work
13	WT13	Masonry Work
14	WT14	Mortar & Tile Work
15	WT15	Movement Beyond Work
16	WT16	Paint Work
17	WT17	Rebar Work
18	WT18	Steel Framework
19	WT19	Stone and Wall Work
20	WT20	Temporary Installation Work
21	WT21	Waterproof Work

III.II RISK ASSESSMENT MODEL

Risk assessment is a method of combining the uncertainty of a risk event and the potential loss of a risk event using probability theory [7]. The risk is the frequency of the accident and the intensity of the accident. This study used matrix analysis to assess the risk of main work types. Matrix analysis is a way of comparing the risks between work types as shown in Fig. 1. The risk assessment method of main work

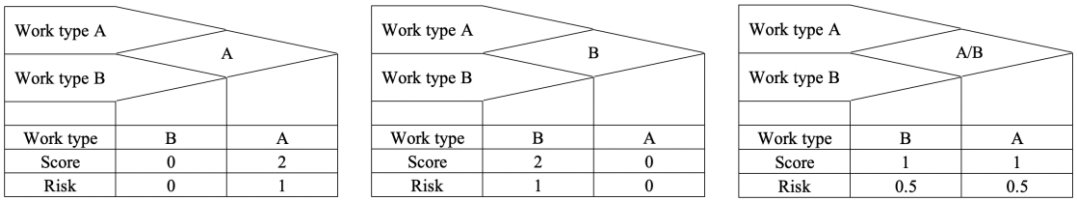
type using matrix analysis is as follows. For example, compare the high and low risks of work type A and work type B.

Case 1. If work type A is at higher risk than work type B: Write the code of work type A on the matrix where work type A and work type B meet and add 2 points to work type A.

Case 2. If work type A is at lower risk than work type B: Write the code of work type B on the matrix where work type A and work type B meet and add 2 points to work type B.

Case 3. If work type A has similar or identical risk compared to work type B: Write both work type A and work type B codes in the matrix where work type A and work type B meet and add 1 point for both work type A and work type B.

Define the sum of the scores of work types as '1' and calculate the risk for each work type by linearly transforming the scores for each work type. A work type with high risk is a work type of priority control target that has high frequency of accident and accident severity.



(a) Case 1 (b) Case 2 (c) Case 3

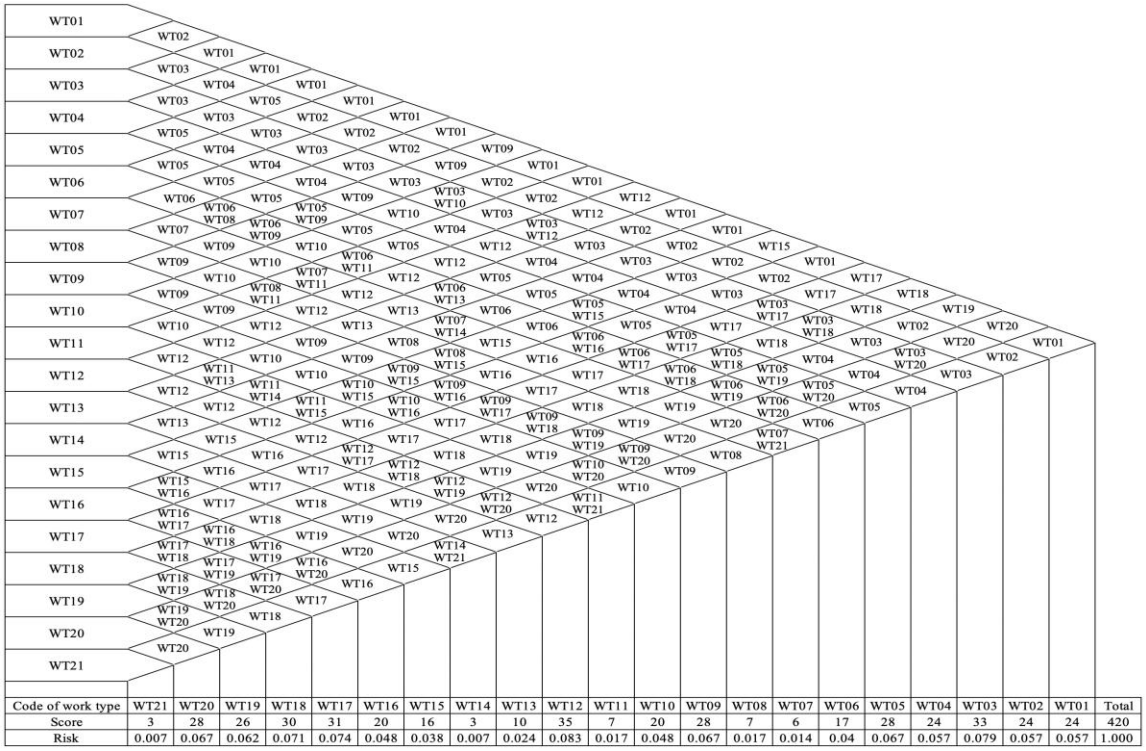
Fig. 1. Matrix Analysis (Example)

IV. Risk ASSESSMENT

Three experts in the field of construction safety were asked to evaluate the risks of 21 work types. Depending on the expert, the results of the risk assessment may differ for each main work type. Therefore, the final risk by work type was calculated using the average value of risk by work type analyzed by the experts. The risks for 21 work types analyzed by the experts are as follows.

IV.I EXPERT A'S RISK ANALYSIS RESULT

Table 2 shows the result of expert A's risk assessment for 21 work types. Expert A analyzed WT12 as the highest risk work type. The risk of WT12 is 0.083. Next, the risks were WT03, WT17, WT18, WT05, WT09, WT20, WT19, WT01, WT02, WT04, WT10, WT16, WT06, WT15, WT13, WT08, WT11 and WT07. The lowest risk work types are WT14 and WT21. The risk of WT14 and WT21 is 0.007. Fig. 2 shows Expert A's risk assessment matrix.



Code of work type	WT21	WT20	WT19	WT18	WT17	WT16	WT15	WT14	WT13	WT12	WT11	WT10	WT09	WT08	WT07	WT06	WT05	WT04	WT03	WT02	WT01	Total
Score	3	28	26	30	31	20	16	3	10	35	7	20	28	7	6	17	28	24	33	24	24	420
Risk	0.007	0.067	0.062	0.071	0.074	0.048	0.038	0.007	0.024	0.083	0.017	0.048	0.067	0.017	0.014	0.04	0.067	0.057	0.079	0.057	0.057	1.000

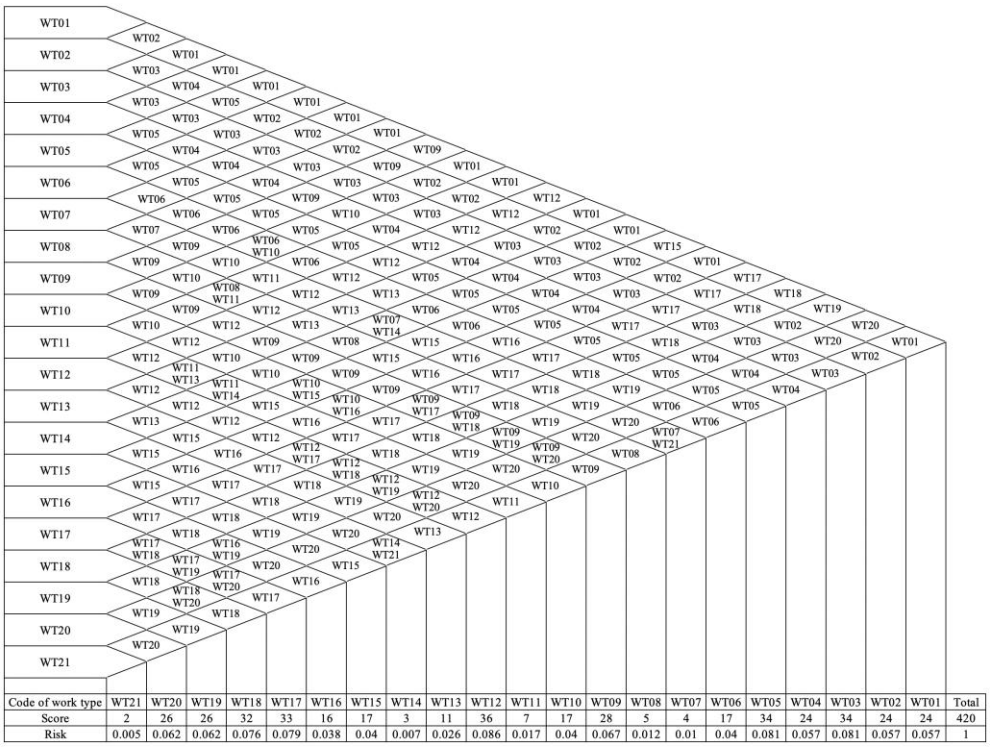
Fig. 2. Expert A's risk assessment matrix data

Table 2. Expert A's risk analysis result

Code of work type	Name of work type	Score	Risk
WT12	Lift Work	35	0.083
WT03	Curtain Wall Work	33	0.079
WT17	Rebar Work	31	0.074
WT18	Steel Framework	30	0.071
WT05	Earth & Foundation Work	28	0.067
WT09	Form Work	28	0.067
WT20	Temporary Installation Work	28	0.067
WT19	Stone and Wall Work	26	0.062
WT01	Break Work	24	0.057
WT02	Concrete Work	24	0.057
WT04	Elevator Work	24	0.057
WT10	Glass and Window Work	20	0.048
WT16	Paint Work	20	0.048
WT06	Electric Work	17	0.04
WT15	Movement Beyond Work	16	0.038
WT13	Masonry Work	10	0.024
WT08	Facilities Work	7	0.017
WT11	Insulation Work	7	0.017
WT07	Embellishment and Metal Work	6	0.014
WT14	Mortar & tile Work	3	0.007
WT21	Waterproof Work	3	0.007
Total		420	1.000

IV.II EXPERT B'S RISK ANALYSIS RESULT

Table 3 shows the result of expert B's risk assessment for 21 work types. Expert B evaluated WT10 as the highest risk work type. The risk of WT10 is 0.086. Next, the risks were WT17, WT20, WT08, WT11, WT01, WT07, WT21, WT03, WT12, WT18, WT02, WT05, WT15, WT13, WT16, WT04, WT19, WT09 and WT06. The lowest risk work type is WT14. The risk of WT14 is 0.005. Fig. 3 shows Expert B's risk assessment matrix.



Code of work type	WT21	WT20	WT19	WT18	WT17	WT16	WT15	WT14	WT13	WT12	WT11	WT10	WT09	WT08	WT07	WT06	WT05	WT04	WT03	WT02	WT01	Total
Score	2	26	26	32	33	16	17	3	11	36	7	17	28	5	4	17	34	24	34	24	24	420
Risk	0.005	0.062	0.062	0.076	0.079	0.038	0.04	0.007	0.026	0.086	0.017	0.04	0.067	0.012	0.01	0.04	0.081	0.057	0.081	0.057	0.057	1

Fig. 3. Expert B's risk assessment matrix data

Table 3. Expert B's risk analysis result

Code of work type	Name of work type	Score	Risk
WT10	Glass and Window Work	36	0.086
WT17	Rebar Work	34	0.081
WT20	Temporary Installation Work	34	0.081
WT08	Facilities Work	33	0.079
WT11	Insulation Work	32	0.076
WT01	Break Work	28	0.067
WT07	Embellishment and Metal Work	26	0.062
WT21	Waterproof Work	26	0.062
WT03	Curtain wall Work	24	0.057
WT12	Lift Work	24	0.057
WT18	Steel Framework	24	0.057
WT02	Concrete Work	17	0.040
WT05	Earth & Foundation Work	17	0.040
WT15	Movement Beyond Work	17	0.040
WT13	Masonry Work	16	0.038
WT16	Paint Work	11	0.026
WT04	Elevator Work	7	0.017
WT19	Stone and Wall Work	5	0.012
WT09	Form Work	4	0.010
WT06	Electric Work	3	0.007
WT14	Mortar & Tile Work	2	0.005
Total		420	1.000

IV.III EXPERT C'S RISK ANALYSIS RESULT

Table 4 shows the result of expert C's risk assessment for 21 work types. Expert C analyzed WT18 as the highest risk work type. The risk of WT18 is 0.086. Next, the risks were WT12, WT17, WT03, WT20, WT05, WT01, WT04, WT19, WT09, WT02, WT06, WT10, WT15, WT06, WT13, WT08, WT11, WT07 and WT14. The lowest risk work type is WT21. The lowest risk of WT21 is 0.005. Fig. 4 shows Expert C's risk assessment matrix.

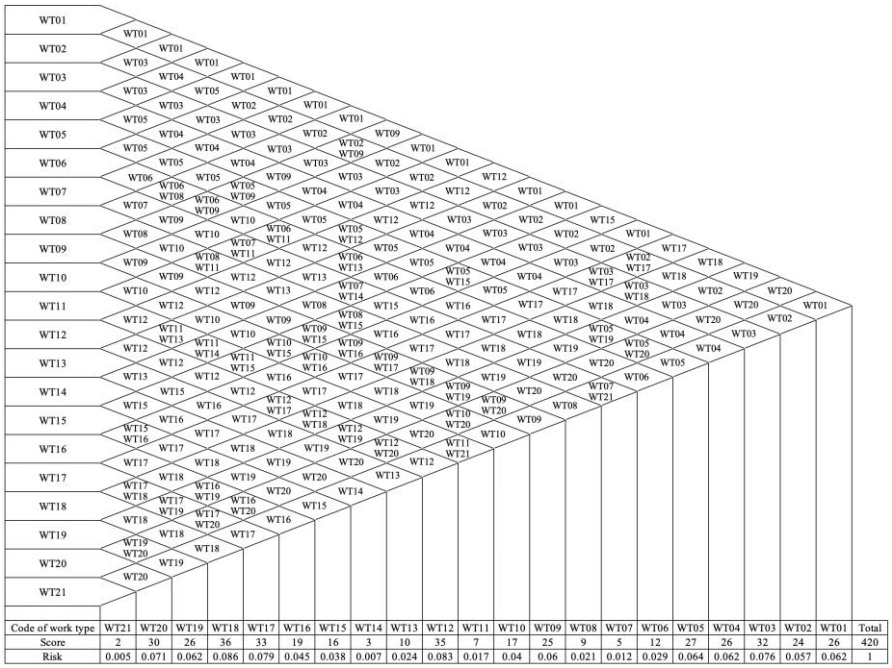


Fig. 4. Expert C's risk assessment matrix data

Table 4. Expert C's risk analysis result

Code of work type	Name of work type	Score	Risk
WT18	Steel Framework	36	0.086
WT12	Lift Work	35	0.083
WT17	Rebar Work	33	0.079
WT03	Curtain Wall Work	32	0.076
WT20	Temporary Installation Work	30	0.071
WT05	Earth & Foundation Work	27	0.064
WT01	Break Work	26	0.062
WT04	Elevator Work	26	0.062
WT19	Stone and wall Work	26	0.062
WT09	Form Work	25	0.06
WT02	Concrete Work	24	0.057
WT16	Paint work	19	0.045
WT10	Glass and Window Work	17	0.04
WT15	Movement Beyond Work	16	0.038
WT06	Electric Work	12	0.029
WT13	Masonry Work	10	0.024
WT08	Facilities Work	9	0.021
WT11	Insulation Work	7	0.017
WT07	Embellishment and Metal Work	5	0.012
WT14	Mortar & Tile Work	3	0.007
WT21	Waterproof Work	2	0.005
Total		420	1.000

IV.IV RESULT OF COMPREHENSIVE RISK ANALYSIS

Expert A evaluated WT12 (Lift Work) as the highest risk work type. Expert B evaluated WT10 (Glass and Window Work) as the highest risk work type. Expert C evaluated WT18 (Steel Framework) as the highest risk work type. For work types with the lowest risk. Experts A and C evaluated WT21 (Waterproof Work) as the lowest risk work type. Expert B, on the other hand, evaluated WT12 (Mortar & Tile Work) as the lowest risk work type. In this way, the evaluation results were different for each expert. Table 5 shows the evaluation data of the highest risk work type and the lowest risk work type evaluated by three experts.

Table 5. Differences in risk analysis results by experts

Expert	The highest risk work type		The lowest risk work type	
	Code of work type (Name of work type)	Risk	Code of work type (Name of work type)	Risk
A	WT12 (Lift Work)	0.083	WT21 (Waterproof Work)	0.007
B	WT10 (Glass and Window Work)	0.086	WT12 (Mortar & Tile Work)	0.005
C	WT18 (Steel Framework)	0.086	WT21 (Waterproof Work)	0.005

Three experts calculated the average risk of main work types. The highest risk work type is WT17 (Rebar Work). The risk of WT17 (Rebar Work) is 0.079. The next highest risk work types are WT12 (Lift Work) and WT20 (Temporary Installation Work). The risk of WT12 (Lift Work) and WT20 (Temporary Installation Work) is equal to 0.074. The lowest risk work type is WT14 (Mortar & Tile Work). The risk of Mortar & Tile Work (WT14) is 0.007. Table 6 and Fig. 5 show the average values of the risks of the main work types analyzed by three experts and the data in order of high average values of the risks.

Table 6. Average risk analysis data by main work types

Code of work type	Name of work type	Average score	Average value of the risk
WT17	Rebar Work	33	0.079
WT12	Lift Work	31	0.074
WT20	Temporary Installation Work	31	0.074
WT03	Curtain wall Work	30	0.071
WT18	Steel Framework	30	0.071
WT01	Break Work	26	0.062
WT05	Earth & Foundation Work	24	0.057
WT10	Glass and window Work	24	0.057
WT02	Concrete Work	22	0.052
WT04	Elevator Work	19	0.045
WT09	Form Work	19	0.045
WT19	Stone and wall Work	19	0.045
WT16	Paint Work	17	0.040
WT08	Facilities Work	16	0.038
WT15	Movement Beyond Work	16	0.038
WT11	Insulation work	15	0.036

Code of work type	Name of work type	Average score	Average value of the risk
WT07	Embellishment and Metal Work	12	0.029
WT13	Masonry Work	12	0.029
WT06	Electric Work	11	0.026
WT21	Waterproof Work	10	0.024
WT14	Mortar & Tile Work	3	0.007
Total		420	1.000

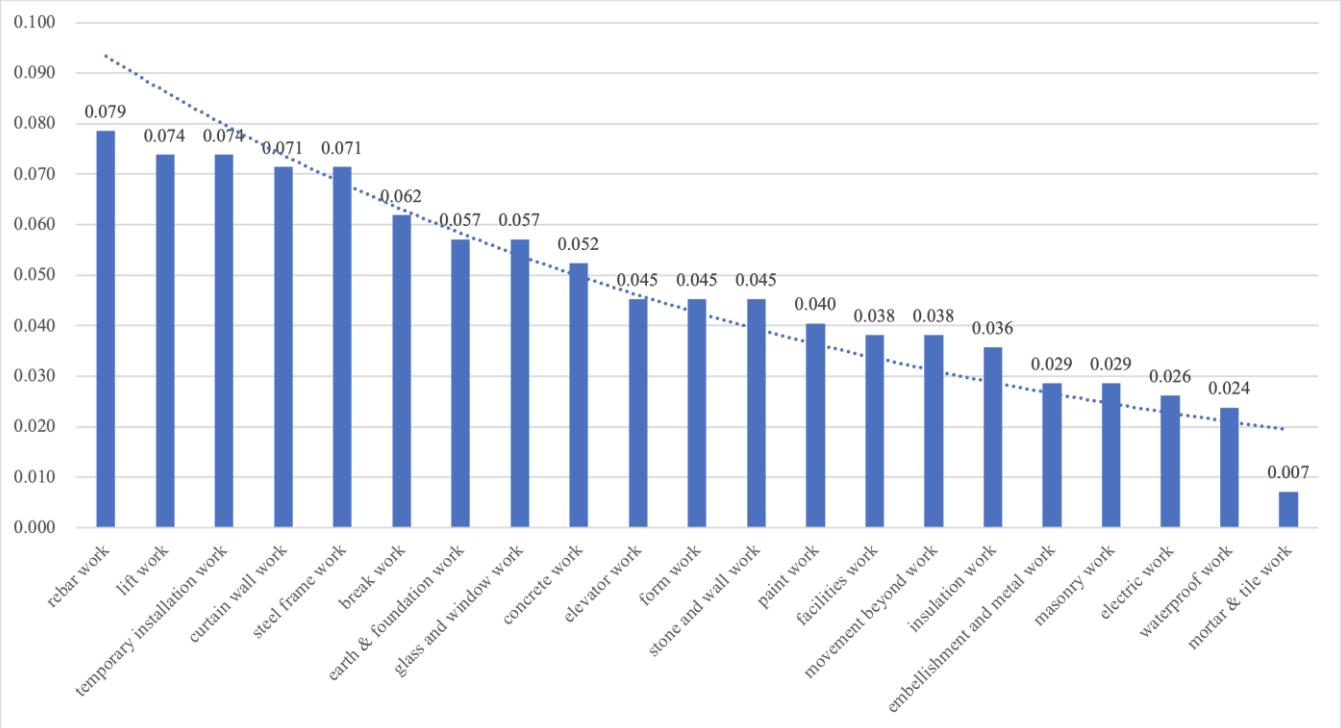


Fig. 5. Average value of the risk

V. CONCLUSION

This study quantitatively presents the risks of the main work types in construction work. The results of the study are summarized as follows. According to the evaluation of three construction safety experts, it was analyzed that lift work, glass and window work and steel framework were the highest risk. Using the risks calculated by three construction safety experts, the average value of the risk for each main work type was calculated. Rebar work was the highest risk. Using this study method, it is possible to grasp the risk by work type of construction work. Risk by main work type can also be used as useful data in establishing preventive safety management plans. However, this study did not reflect the characteristics of various construction works. Therefore, future studies require risk assessment by construction type and construction size.

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