

## Awareness of Legislation for Hand-dug Caisson Work in Highway Construction

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Muhammad Zulfikhri<sup>1</sup>, Samira Albaty Kamaruddin<sup>1,\*</sup>

<sup>1</sup> Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100 Kuala Lumpur, Malaysia

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### ABSTRACT

Hand-dug caisson work is one of the alternative methods of piling for areas that have restrictions on the use of machines. This type of construction work has been used in urban areas in Malaysia. The technique is considered to be a hazardous operation as it involves various high-risk activities, such as lifting and working in confined space. Hand-dug caisson work must comply with various Occupational Safety and Health (OSH) Legislation that covers every aspect of its operation. The aim of this qualitative and quantitative study is to analyze the awareness of highway construction workers concerning legislation that specifically covers hand-dug caisson work. A questionnaire survey was used to determine the awareness of personnel involved in this activity concerning the relevant legislation. Although the results of the survey showed that the personnel were aware of the basic OSH Legislation currently being used in Malaysia, the survey results for specific OSH Legislation related to each process showed that the awareness of the personnel involved was only about 52.44%. The low awareness of OSH Legislation would lead to non-compliance with the Law and impact on the safety, company image, and productivity. Recommendations to improve awareness of the related OSH Legislation are also discussed in this study.

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## 1. Introduction

Hand-dug caissons are a form of sub-structure work that is suitable for a wide range of structures. Caisson work is carried out as an alternative to machine use for sub-structure work whether in confined spaces or hilly construction areas or where there is limited public access. Here, a confined space is defined as a closed area where the people entrance with neither fully or partially body, with restricted access and egress, normal atmospheric pressure, it poses a risk, and is not a regular workplace [1]. Caisson work has been recommended for areas with limited space, where heavy machinery is restricted or not able to access and other relevant factors. It is considered as one of the most dangerous activities in highway construction projects with high-risk activities involving crane work, confined space, and crane-lifted working platforms. Wilson et al. [2] revealed that from 1992 to 2005, there were about 38 fatalities per year because of poisoning and breathing problems in

\* Corresponding author.

E-mail address: [samira.kl@utm.my](mailto:samira.kl@utm.my)

confined space. In general, caisson work that requires manual digging up to 40 m deep pose safety issues in construction industry [3].

Legislation, such as Occupational Safety and Health Act (OSHA) 1994, Factories and Machinery Act (FMA) 1967 and Industry Code of Practice (ICOP) 2010: Working in Confined Space has been used for caisson work compliance. Nurdan [4] claimed that legislation is important to enforce the construction workforce to comply with a healthy and safe environment. This is also supported by Kamarl [5] that awareness on Safety and Health legislation is one of important things to be consider to make sure all of projects can be done successful without any problems such as accidents and injuries at construction site. This activity involves various hazards from commencement until completion. Many hazardous trades are related to hand-dug caisson activity, such as crange operations, and crane-lifted working platforms. Presently, there are no guidelines on the legislation to be complied with from the commencement of the activity until completion of the operation. The government has gazette the relevant legislation for each activity, but there is no specific guidance for compliance with the legislation for hand-dug caisson work.

Hand-dug caisson work is one of the hazardous work processes in the construction industry involving major incidents and serious injuries that occur due to negligence and non-compliance with the pertinent legislation. The operational team has been identified as lacking exposure to, and knowledge about the legislation. Although this work activity is widely used for various projects including highway construction, building work, and railway construction, there are no guidelines concerning the legislation requirements for hand-dug caisson work.

The first phase of this study begins with identifying the relevant legislation for each process involved in hand-dug caisson work. The required information for these activities will be gathered from the Method of Statement (MoS), government legislation, and Hazard Identification, Risk Assessment and Risk Control (HIRARC) that are specific to hand-dug caisson work. The MoS is a compulsory document covering every construction activity and includes information on the resources – manpower and machinery, drawings, work procedures, safety, health and environmental aspects and other relevant information for the commencement of the activity. The MoS has been endorsed by Professional Engineers (PE) to ensure that it is valid as guidance. It has been used to furnish comprehensive information regarding the activity and to determine the relevant legislation for each process. The information in the MoS includes the method of work, the resources required for commencing the activity; for example, manpower and machinery, and the work procedures. The legislation will be reviewed after determining the machinery to be used and the sub-activities for each process. The legislation includes Acts, Orders, Regulations, Guidelines, and Standards that are applicable to the machinery used and the sub-activities. Meanwhile HIRARC is the document that furnishes information on the respective compliance needed for each sub-activity, such as regulatory Competent Person and Certificate of Fitness for machinery, and for determining the current compliance with the legislation for hand-dug caisson work. The integrated information for the commencement of this activity is important for understanding and ensuring compliance with the legislation for the safety of the workers involved in this activity. This is also supported by a research that safety performance can be increased in relation to the understanding of the work tasks and handling the unsafe behavior [6].

This study aims to identify and analyze the relevant legislation required for each process involved in hand-dug caisson work. The study identifies the Act, Order, Regulation or ICOP related to the activity. Three objectives are identified: (1) to identify the related legislation for each respective work process in the hand-dug caisson work in the Klang highway project; (2) to analyze the awareness of the legislation requirements for hand-dug caisson work; and (3) to propose legislation awareness programs and legislation guidelines for hand-dug caisson work. For objective one, the MoS, HIRARC,

and OSH Legislation are the tools used to identify the legislation requirements for each process. The limitations are that the operations are specific to the respective project as the MoS can be different for other projects. This is because the MoS established shall be appropriated with the working conditions. The survey of the awareness of the legislation for each process of the hand-dug caisson work at the supervisory level and above who are involved in the activity is used to achieve the second objective. Lastly, objective three is to propose guidelines on legislation for hand-dug caisson work.

The existing safety and health legislative have been used to identify the relevant legislation that is applicable to hand-dug caisson work. The relevant safety and health legislation should be determined for each process of the hand-dug caisson. For the processes for work and machinery for use in hand-dug caisson work, one should refer to the internal MoS. A previous study by Nurdan [3] showed that 75% of employers were not aware of the legislation but agreed on the need for sufficient established OSH Legislation. The legislation is mentioned as below:

- 1) Occupational Safety and Health Act 1994 and its Order, Regulation, ICOP, and Guideline.
- 2) Factories and Machinery Act 1967 and its Order, Regulation, ICOP, and Guideline.
- 3) MS 2204 : 2008 'Cranes – Equipment for Lifting Persons – Part 1 : Suspended Basket.

Caisson piles are widely used in construction activities, particularly in urban areas where the work areas are congested due to adjacent structures or public areas. Presently, there are no specific requirements for the operations of hand-dug caisson work, just a combination of several requirements for ensuring it is safe to commence the work. Geminiani [7] revealed an inspection summary by the government officials for legislation compliance in France; they appear to issue a large number of verbal and written warnings. More than half the sites visited in Portugal were closed down by their enforcement agency, and Italy seems to issue a large number of on-the-spot fines.

Szana [8] revealed the results of inspections by officers in South Africa in April 2007 during which 1455 notices were issued: 255 improvement (17.5%), 1028 contravention (70.6%), and 172 prohibition (11.8%). This shows the impact on organizations that fail to comply with the legislation. Previous internal records and history show that non-compliance affects the involved party, i.e., the company, as well as the workers. The impact according to the records is that when a company suffers a stop work order from the authorities, it will hinder the construction progress as well as affect the worker's salary as they are being paid for the total of the excavated length.

Referring to the conceptual framework, HIRARC [9] has been chosen as the risk assessment method to identify the hazards involved in each process. This will identify the mitigating action to be taken to minimize the risk of an incident occurring. Throughout this process, a specific legislation awareness program is addressed to ensure the effectiveness of the safety work system for hand-dug caisson work.

As mentioned earlier, one of the limitations of this study was difficulty in obtaining literature that specifically reviewed hand-dug caisson work. Hence, the approach was to find literature that reviewed the specific work processes involved and observe and compare the hazardous activities with others. Another point to be considered in identifying relevant literature was reviewing internal documents regarding any safety and health issue for hand-dug caisson work.

## 2. Methodology

A questionnaire is a preformatted written set of questions that is given to respondents to record their feedback or answers. It can be administered personally or e-mailed to the respondents to collect the data. The questionnaire for this survey used two types of question: 'yes' and 'no' questions and multiple-choice questions based on a Likert scale with five ordinal measures for each statement. The questionnaire was divided into four sections as follows: Part A = Respondent Profile, Part B = General

OSH (Occupational Safety & Health) Legislation, Part C = Specific Legislation for each work process, and Part D = How to improve Legislation Awareness.

In this study, 42 questionnaires were distributed to the supervisory level and above since the population size of the relevant personnel at the construction site involved in the awareness of safety legislation works was 45 as study by Krejcie and Morgan [10]. The sampling was carried out at a construction site in Klang, Selangor, Malaysia, for the highway construction project. The respondents were construction personnel targeting site construction managers, site engineers, site supervisors, HSE personnel and competent persons. The sample was selected from a construction division of one of Malaysia's leading conglomerates in construction, property, infrastructure, plantation, and industry. The construction division has been involved in many major projects, such as the Mass Rapid Transit (MRT) Project, West Coast Expressway Project, new township development – Seremban 2 and Bandar Rimbayu, and high-rise projects. The West Coast Expressway, Section 4 Project, is one of the current infrastructure projects for the construction division. This project involves the design and construction of an approximately 5.59 km length with approximately 4.5 km of elevated structure between the New North Klang Straits Bypass and the NKVE/Federal Highway Route 2. This project is located in a congested area with interventions with local roads, existing highways, and residential and industrial areas. This project involves major construction activities including the (1) installation and relocation of utilities and services work (water pipe, telco, electricity, gas pipe); (2) sub-structure work (piling work – bore pile, spun pile, caisson pile); (3) superstructure work (bridge work – column, crosshead, beam, etc.); (4) infra work (site clearing, demolition, earthwork, etc.); and (5) finishing work, such as pavement, street lighting, and CCTV.

All the information and data obtained from the questionnaire survey were analyzed using Statistical Packages for Social Sciences (SPSS) software version 16. Frequency analysis and the average index method were used in this analysis. The frequency analysis is represented in the form of tables and charts. The frequency values determine the average index value based on the average index =  $\sum (aX)$ , where  $X = n / N$ ,  $a$  = constant expressing the weight given,  $N$  = total number of respondents, and  $n$  = variable frequency of respondents.

### 3. Results and Discussion

Table 1 shows the summary of the respondents' background. As the construction industry is a male-dominated industry, it was found that about 73.8% of the respondents were male. More than half of the respondents (52.4%) were below 30 years of age, while only 9.5% respondents were aged over 40 years old. In terms of position, the results showed that engineers were the most involved in the survey with 38.1%, while the lowest involvement was from competent persons with 7.1%. Other positions involved were supervisor with 28.6%, HSE personnel with 16.7%, and managers with 9.5%. The data showed that for educational background 52.4% of the respondents were graduates followed by diploma level with 28.6%, 16.7% were SPM level and the lowest percentage involved was for the certificate level with 2.4%. The data for work experience showed that the respondents with experience of less than 5 years and the respondents with 5-10 years of experience were both 40.5%; the percentage of respondents with experience of more than 10 years was 19%.

From the survey results shown in Table 2, 90.5% of the respondents were aware of the OSH Law in Malaysia, but only 2.4% of the respondents had a full understanding of the OSH Law. The highest level of understanding of OSH Law was 52.4% with an average understanding regarding this Law. Other levels of understanding regarding this Law were 38.1% for partly understand while 4.8% had no idea regarding the OSH Law. The results also showed that 73.8% of the respondents were aware that there are two Laws for OSH being enforced in Malaysia but the results were slightly lower at

69.0% for the question concerning the awareness of the availability of the Regulation, Order, and Guideline for each OSH Law. In terms of the requirement to comply with the Law, 88.1% of the respondents were aware that it is compulsory to comply with the OSH Law. The results also showed that the respondents' answers were equal at 50% for the question concerning whether the current OSH Law is sufficient.

The survey concerning how the respondents knew about this OSH Law showed that the majority of the respondents mentioned that the medium for them knowing about the Law was from the Hazard Identification, Risk Assessment and Risk Control (HIRARC) process. The lowest result regarding the medium was from the HQ audit report/inspection and from authorities inspection/notice with only 9.5%. Regarding the awareness on hand-dug caisson work that involved various OSH Laws, 81% of the respondents were aware of this matter, and 88.1% of the respondents mentioned that they had been briefed on the OSH Law related to the activity. Based on the survey results for the general awareness of the OSH Law, the results showed that most of the respondents were aware with more than half achieved for each question asked regarding the general information concerning the OSH Law.

**Table 1**  
 Demographic profile

Profile	Description	Frequency	Percentage, %
Gender	Male	31	73.8
	Female	11	26.2
Age	<30	33	52.4
	30 – 40	16	38.1
	>40	4	9.5
Position	Supervisor	12	28.6
	Engineer	16	38.1
	HSE Personnel	7	16.7
	Manager	4	9.5
	Competent Person	3	7.1
Education	SPM	7	16.7
Background	Certificate	1	2.4
	Diploma	12	28.6
	Graduate	22	52.4
Work Experience	<5	17	40.5
	5 – 10	17	40.5
	>10	8	19

**Table 2**  
 Awareness of the OSH Law in Malaysia

Description	Yes (%)	No (%)
Is there any OSH Law in Malaysia?	90.5	9.5
What is your understanding regarding the OSH Law?		
1. Fully understand	2.4	
2. Partly understand	38.1	
3. Average understanding	52.4	
4. Only heard the name	2.4	
5. No idea	4.8	
Do you know there are two types of Legislation for OSH in Malaysia?	73.8	26.2
Do you know there are Regulations, Order and Guidance for each Law?	69.0	31.0
Do we need to comply with all the OSH Laws?	88.1	11.9
Have you been briefed regarding the OSH Law related to your work?	88.1	11.9

What is the medium that made you aware of OSH Laws?		
1. During HIRARC process	42.9	
2. Internal inspection report/NCR	21.4	
3. Authorities inspection/Notice	9.5	
4. HQ audit report/inspection	7.1	
5. Read document	19.0	
Are you aware that Hand-dug Caisson Work involves various OSH Laws?	81.0	19.0
Is there any specific guidance that states the relevant OSH Law?	61.9	38.1
Do you agree that the current available OSH Law is sufficient?	50.0	50.0

Table 3 shows that most understood the legislation for piloting work, which was 'garis panduan kerja pengorekan 2017' with 78.6% of respondents being aware of this legislation. However, the awareness of FMA 1967, BOWEC Regulations, Part XII 1986 was only 40.5%. The total summary for the legislation for piloting work was only 52.96% although all of the listed legislation related to piloting work. For the results concerning awareness of the required legislation for the installation of frame and lifting appliances work, the most answered was OSHA 1994, Section 15 with 66.7% awareness from respondents. The second understanding was the legislation on Guideline for Public Safety and Health at Construction Sites 2007 with 59.5%; the third was for FMA 1967, Notification, Certification of Fitness and Inspection Regulation 1970 with 47.6%. The total summary for the legislation for the installation of frame and lifting appliances work was poor with only 48.1% even though all the listed legislation related to hand-dug caisson work. The survey results for manual digging work specific to working in a confined space showed positive result for awareness of ICOP for Confined Space 2010 with 78.6%. The awareness of OSHA 1994, Section 15 was 54.9%, while the awareness of FMA 1967, Safety, Health and Welfare Regulation 1970 was only 40.5%. The total summary for the legislation for manual digging work (working in confined space) was only 58% although all of the listed legislation related to hand-dug caisson work.

The Guideline on Control of Occupational Noise 2005 was the highest with 66.7%, while awareness of the Guideline of Occupational Vibration 2003 was slightly lower with 61.7%. The awareness of OSHA 1994, Section 15 showed a positive result with 57.1%, while the last two legislations showed equal awareness with 47.6%. The total summary for the legislation for manual digging work (hacking work) was only 56.18% even though all of the listed legislation related to hand-dug caisson work. Awareness of OSHA 1994, Section 15 for lifting operations for material bucket was the highest with 73.8% while the lowest was Guideline for Public Safety and Health at Construction Site 2007 with 31%. The total summary for the legislation awareness for this activity was 54.77% although all of the listed legislation related to hand-dug caisson work.

Lifting operation for man-riding cage work, which involves seven different types of legislation. Awareness of OSHA 1994, Section 15 was found to be the highest with 73.8% followed by Approval by DOSH for use of crane lifted working platform with 66.7%. The lowest awareness of the legislation for this type of work was for Guideline for Public Safety and Health at Construction Site 2007 with only 21.4%. The third highest was for FMA 1967, Notification, Certification of Fitness and Inspection Regulation 1970 with 57.1%, while less than half of the respondents were aware of the remaining three legislations. The total summary for the awareness of the legislation for this activity was shown to be poor at 48.98% even though all of the listed legislation related to hand-dug caisson work.

For awareness of the legislation for rebar work, the highest awareness by the respondents was for OSHA 1994, Section 15 with 78.6%. The second was for FMA 1967, Safety, Health and Welfare Regulation 1970 with 54.8%, followed by 23.8% for Guideline for Public Safety and Health at Construction Site 2007. The total summary for legislation awareness for this activity was only 52.4% even though all the listed legislation were related to hand-dug caisson work. The final process in hand-dug caisson work is the installation of the rebar cage and concrete for which the results of the

legislation survey are also shown in Table 3. The legislation that most of the respondents were aware of was OSHA 1994, Section 15 with 76.2%, followed by FMA 1967, BOWEC Regulation, Part III 1986 with 52.4%. The remaining three legislations showed poor awareness with less than half of the respondents being aware. The total summary for legislation awareness for this activity was poor with only 48.12% even though all of the listed legislation related to hand-dug caisson work.

**Table 3**  
Specific legislation for hand-dug caisson work process

Work Process	Description	Yes (%)	No (%)
Piloting Work	<i>Garis Panduan Kerja Pengorekan 2017</i>	78.6	24.1
	FMA 1967, BOWEC Regulation, Part XII 1986	40.5	59.5
	FMA 1967, Safety, Health and Welfare Regulation 1970	35.7	64.3
	OSHA 1994, Section 15	57.1	42.9
Installation of Frame and Lifting Appliances	Guideline for Public Safety and Health at Construction Site 2007	59.5	40.5
	FMA 1967, Safety, Health and Welfare Regulation 1970	58.6	71.4
	FMA 196, Notification, Certification of Fitness and Inspection Regulation 1970	47.6	52.4
	Guideline of Prevention of Falls 2007	38.1	61.9
Manual Digging Work (Working in Confined Space)	OSHA 1994, Section 15	66.7	33.3
	ICOP for Sale Work in Confined Space 2010	78.6	21.4
	FMA 1967, Safety, Health and Welfare Regulation 1970	40.5	59.5
Manual Digging Work (Hacking Work)	OSHA 1994, Section 15	54.9	45.2
	FMA 1967, Notification, Certification of Fitness and inspection Regulation 1970	47.6	52.4
	OSHA 1994, Section 15	57.1	42.9
	Guideline on Control of Occupational Noise 2005	66.7	33.3
	Guideline of Occupational Vibration 2003	61.9	38.1
Lifting Operation for Material Bucket	FMA 1967, BOWEC Regulation, Part XVI 1986	47.6	52.4
	FMA 1967, Notification, Certification of Fitness and inspection Regulation 1970	59.5	40.5
	OSHA 1994, Section 15	73.8	26.2
	Guideline for Public Safety and Health at Construction Site 2007	31	69
Lifting Operation for Man-Riding Cage	FMA 1967, Notification, Certification of Fitness and Inspection Regulation 1970	57.1	42.9
	OSHA 1994, Section 15	73.8	26.2
	Approval by DOSH for use of crane lifted working platform	66.7	33.3
	MS 2204: Suspended Basket	42.9	57.1
	FMA 1967, Safety, Health and Welfare Regulation 1970	42.9	57.1
	Guideline of Prevention of Falls 2007	38.1	61.9
Rebar Work	Guideline for Public Safety and Health at Construction Site 2007	21.4	78.6
	OSHA 1994, Section 15	78.6	21.4
	FMA 1967, Safety, Health and Welfare Regulation 1970	54.8	45.2
Installation of Rebar Cage and Concrete	Guideline for Public Safety and Health at Construction Site 2007	23.8	76.2
	FMA 1967, Notification, Certification of Fitness and Inspection Regulation 1970	42.9	57.1
	OSHA 1994, Section 15	76.2	23.8
	FMA 1967, BOWEC Regulation, Part III 1986	52.4	47.8
	FMA 1967, Safety, Health, and Welfare Regulation 1970	31.0	69.0
	Guideline for Public, Safety and Health at Construction Site 2007	38.1	61.9

The summary in Table 4 shows awareness of the legislation for activity involved in hand-dug caisson work. It could be concluded that the average awareness for legislation for each process is poor with 52.44% for all eight processes involved in hand-dug caisson work. The deviation between each process shows a slight increase or decrease to each other.

From the descriptive summary in Table 5, the highest mean at 4.50 for the most effective method to increase the awareness of the legislation was the requirement for specific training on the legislation for hand-dug caisson work. The second method, with a mean of 4.29, was establish a handbook for specific OSH legislation. The lowest result was increase display of signage as a method to increase the awareness of legislation while the results for the remaining six methods were almost the same.

From Table 6, the basic awareness of the relevant OSH Legislation was quite satisfactory with 80.35% for the four basic criteria. The result for each criterion also showed a positive result in terms of the level of awareness of the respondents. However, in terms of the specific legislation for each hand-dug caisson work process, the summary for all eight processes involved indicated that only 52.44% level of awareness for the respective legislation required for each process. The eight processes involved are piloting work, installation of frame and lifting appliances, manual digging work (working in confined space), manual digging work (hacking work), lifting operation for material bucket, lifting operation for man-riding cage, rebar work, and installation of rebar cage and concrete. From this analysis, the respondents should be more knowledgeable in terms of the required OSH legislation as non-compliance will impact the safety, productivity, and company image.

**Table 4**

**Awareness of the legislation for activity involved in hand-dug caisson work**

Summary	Yes (%)	No (%)
Piloting Work	52.96	47.04
Installation of Frame and Lifting Appliances	48.1	51.9
Manual Digging Work (Working in Confined Space)	58	42
Manual Digging Work (Hacking Work)	56.18	43.82
Lifting Operation for Material Bucket	54.77	45.23
Lifting Operation for Man-Riding Cage	48.98	51.02
Rebar Work	52.4	47.6
Installation of Rebar Cage and Concrete	48.12	51.88
Average	52.44	47.56

**Table 5**

**Proposed legislation awareness programs and legislation guideline for hand-dug caisson work**

Item	N	Min	Max	Mean	SD
Specific training on legislation requirement for hand-dug caisson work	42	3.00	5.00	4.5000	0.6344
Establish hand book for specific OSH legislation	42	1.00	5.00	4.2857	0.8913
Specific process checklist of applicable legislation for each work process	42	1.00	5.00	3.9524	0.9615
Increase instruction and advice on legislation requirements	42	2.00	5.00	3.9286	0.8083
The enforcement on personnel should be more stringent	42	1.00	5.00	3.8095	1.0647
Quiz and reward session	42	3.00	5.00	3.7143	0.6730
Increase inspection of legislation compliance	42	2.00	5.00	3.7143	0.8635
Briefing on relevant OSH legislation in Malaysia	42	1.00	5.00	3.5476	1.0407
Increase display of signage in the workplace	42	1.00	5.00	3.3571	0.8211



**Table 6**

Awareness of relative legislation

Awareness of relative Legislation	Yes (%)	No (%)
Is there any OSH Law in Malaysia?	90.5	9.5
Do you know there are two Legislations for OSH in Malaysia?	73.8	26.2
Do you know there are Regulations, Orders and Guidelines for each Law?	69.0	31.0
Do we need to comply with all these OSH Laws?	88.1	11.9
Total	80.35	19.65
Summary of improving legislation awareness	52.44	47.56

#### 4. Conclusion

This paper investigated the subject of how to improve the awareness of legislation for hand-dug caisson work since it is related to various OSH Legislation in Malaysia. The respondents' awareness of the OSH Legislation was examined through a questionnaire survey concerning the general OSH Legislation and the specific OSH Legislation for each process involved in the activities. From the survey results, it was found that awareness of the general OSH Legislation was quite good compared to the results for the specific legislation for each process involved. Implementing sufficient and effective methods to increase awareness should be the first step to ensure that these hand-dug caisson operations comply with all the related legislation. Based on the highest mean from the descriptive summary shown in Table 5, organize specific training on legislation requirement for hand-dug caisson work, establish hand book for specific OSH legislation, specific process checklist of applicable legislation for each work process and increase instruction and advice on legislation requirements are recommended to improve awareness of legislation for hand-dug caisson work.

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