Study on Results of Public Construction Quality Inspection in Taiwan

Study on Results of Public Construction Quality Inspection in Taiwan

Wu-Te Ko[1*], Tai-Yuan Ho[2] and Kuan-Chou Lin[1]

(Received December 1, 2020)

Abstract

The quality of public construction projects signals the degree of a nation's development to the rest of the world. Any nation hoping to advertise its strength and competitiveness on a global scale aims to improve the quality of its public construction, which includes establishing and maintaining an effective public construction quality management system. This article discusses the current results of public construction quality inspections in Taiwan and is expected to improve the quality of Taiwan's public construction, which may help the nation advance in international prestige and compete in international markets.

1. Introduction

Taiwan promoted its Ten Major Construction Projects in the 1970s as a means of driving economic development. Since then, Taiwan's cities have become even larger and more prosperous, such that the construction of additional transportation infrastructure and other critical infrastructure has been inevitable. The number and quality of public construction projects are indicators of economic growth, and only high-quality construction projects are safe and reliable over the long term. Thus, the quality of public construction projects is a matter of significant interest to any country with enough development to support such projects.[1)]

In 1993, Taiwan's Executive Yuan established a three-level "Public Construction Quality Management System" that includes the "Construction Quality Management System", which concerns contractors, the "Construction Quality Assurance System", which concerns the host engineering unit, and the "Project Construction Quality Evaluation System", which concerns the inspection authority.[2)] In 2002, the third level was revised into a construction quality inspection mechanism in accordance with the "Government Procurement Law". Although construction quality has improved a great deal in the last twenty years, common construction inspection defects still persist. It is crucial for Taiwan to develop ways to prevent these defects and improve construction quality.[3)]

2. Purpose of construction inspection in Taiwan

The main purpose of construction inspections is to determine whether the building contractor has used optimal construction management methods and mechanisms (including construction quality, construction progress, labor safety and health, material quality and

1 Department of Civil Engineering and Geomatics, Cheng Shiu University, Kaohsiung, Taiwan
2 Department of Railway Engineering, CECI Engineering Consultants, Inc., Taipei, Taiwan

machine maintenance, and document management) and that there are no omissions in the evaluation of the project's quality. Deductions and fines are applied in cases of failure to ensure vigilance on the part of contractors and supervision units. The maximum fine is NTD 8,000 per point deduction.[4)]

Since the usual duration of a quality inspection is only one day, which is much shorter than the entire on-site quality control process, the inspection cannot effectively evaluate the quality of every aspect of the project. Yet good construction quality should not depend on the construction inspection alone. Instead, the on-site construction personnel should insist on improving the quality of the project from beginning to end, as this is the only way to achieve truly excellent project quality. In fact, the purpose of identifying any defects through a construction inspection is not only to trigger the repair of those specific defects, but also, and more importantly, to require the construction manufacturer to fundamentally change the company's internal quality control mechanisms, to work to identify the ultimate cause of the defect, and to adopt practices that will allow them to avoid similar defects in the future.

3. Anti-epidemic measures introduced at construction sites in response to COVID-19

On January 21, 2020, Taiwan reported its first patient diagnosed with COVID-19. Foreigners who had been to China were prohibited from entering Taiwan from February 19, and all foreigners have been prohibited from entering Taiwan since March 19. On May 5, the Ministry of Transportation and Communications announced the following nine major epidemic prevention measures for the workplace in response to COVID-19.

(1) a. Before entering the work area, personnel must sign in to register or receive a travel history survey, and have their body temperature measured and recorded. b. Anyone with a body temperature of 37.5°C or higher before starting work is forbidden to enter the work area and should be instructed to return home or seek medical treatment.

(2) a. Employees with fever or respiratory symptoms should rest at home. b. Follow cough etiquette and wear masks correctly. c. Keep social distance (indoor 1.5 m, outdoor 1 m). d. Post anti-epidemic posters in public areas. e. Use communication software or email to strengthen advocacy.

(3) a. Areas, utensils or objects at risk of infection in the workplace, such as site entrances and exits, meeting rooms, elevators, toilets, etc., as well as their door handles, switch buttons or desktops, should be disinfected. b. Personal cleaning supplies such as hand-washing supplies, hand towels, and hand sanitizer should be provided in public areas. c. Environmental cleaning of public areas should be included in the construction log.

(4) a. If the workplace is a confined or enclosed space, the air circulation status of the working environment should be confirmed regularly. b. Air circulation should be maintained during the engineering meeting. The maximum number of people in the work meeting shall be controlled or a more spacious meeting room shall be used.

(5) a. Eating or drinking during meetings should be avoided, and hand cleansing before meals should be enforced. b. A distance of more than 1.5 meters during meals should be maintained. c. Meals should be provided at various time slots for different people. d. Gatherings and other activities after work are to be avoided.

(6) a. A manpower backup plan for fever and respiratory symptoms should be established. b.

Workspace partitions should be installed for large-scale projects. c. Divisional control measures for engineering personnel should be carried out according to the work area.

(7) a. Public social areas should be closed to avoid group gatherings in areas with construction site accommodations or staff dormitories (including migrant workers). b. An isolated space should be set up as a place for home quarantine or isolation of workers with relevant symptoms. c. There should be an administrator in the dormitory to implement access control, measure body temperature, and disinfect hands with alcohol. d. People in non-isolated dormitories should wear masks.

(8) a. The cross-border movement of personnel should be reduced and the introduction of migrant workers should be suspended in reference to the relevant measures of the Ministry of Labor (for example: employers are encouraged to renew employment contracts upon expiration or use domestic employees; migrant workers are asked to temporarily stop returning to their home countries during leave, and the working period for which migrant workers in Taiwan are eligible is extended). b. Employers should implement epidemic prevention practices when hiring migrant workers (e.g., attaching home quarantine plans when applying for migrant workers, and personally arranging or having the intermediary company arrange a quarantine residence along with plans for a 14-day home quarantine in accordance with regulations).

(9) a. Procedures for contacting local government health units and a notification process for severe and special infectious pneumonia have been established. b. Employers should be aware of the locations of nearby medical resources with continuous attention to the epidemic situation as announced by the epidemic command center.

As of September 15, 2020, the number of confirmed cases in Taiwan was 499, and public works were almost completely unaffected by COVID-19. Construction projects were proceeding normally.

4. Discussion of construction inspection results

This study analyzes and discusses the statistics on the numbers of inspections carried out by the construction quality inspection team and published by the Public Construction Commission, Executive Yuan, every quarter (i.e., every three months). We hope that this will allow us to identify the reasons for the observed defects as well as some countermeasures that can be explored to prevent future defects. In the 54-month period from January 2016 to June 2020, a total of 16,199 construction projects were inspected. Table 1 and Figure 1 present statistical data on the first 20 defects discovered during quality control inspections of construction document. Items with the defect number [4.01] are defects for which the competent authority is responsible, those with the defect number [4.02] are defects for which the supervision unit is responsible, and those with the defect number [4.03] are defects for which the contractor is responsible.[5)]

We can see from Table 1 and Figure 1 that the proportions of defects in each of these categories are 84.0%, 73.7%, and 55.2%, respectively. Given that all of these proportions are over 50%, we should think deeply about why they are so high. The most common type of document defect was unquantified data, inappropriate formatting, or insufficient content on one of three important forms: a self-inspection list, a spot-check record or a material and

equipment test/inspection control summary statement, or a construction log. A thorough understanding of how to complete these forms properly is crucial for young engineers as it gives them a good grasp of the construction process and quality conditions. It is recommended that the above forms should be completed by a senior engineer after mastering the construction drawings and specifications so as to meet the needs of the site.

Table 1. Document quality control defects in construction inspection

No.	Defect number	Content of defect	Number of defective cases	Defect rate
1	4.03.04	Quality control self-inspection list is not implemented, or inspection standards are not quantified and errors are allowed, or inspected values are not truthfully recorded.	13,601	84.0%
2	4.02.03.04	No spot-check of construction operation or spot-test of materials and equipment is carried out, or no spot-check (test) record sheet is completed, or no material and equipment inspection (test) control summary statement is prepared, or approved, or implemented.	11,940	73.7%
3	4.03.03	Construction log is not implemented and executed, or its format does not meet the requirements.	8,939	55.2%
4	4.02.01.05	Quality control standards for materials/equipment and construction are not prepared or fail to meet requirements.	7,242	44.7%
5	4.02.03.08	No supervision statement is completed or no record is maintained.	7,161	44.2%
6	4.03.05	Material inspection (test) report is not reviewed, or material and equipment approval control summary statement and material and equipment inspection (test) control summary statement are not prepared or fail to meet requirements.	5,899	36.4%
7	4.01.04	No quality supervision and surveillance is implemented or inspection records or contents are inaccurate.	5,823	35.9%
8	4.02.03.05	Defect is not reported to the unit for improvement within the specified time immediately upon identification and improvement results are not confirmed, or no supervision over the execution of work on on-site safety and health, traffic maintenance, environmental protection, etc. by contractor is implemented.	5,668	35.0%
9	4.02.01.10	Material and equipment approval control summary statement and material and equipment inspection (test) control summary statement, spot-check standards, spot-check records, or supervision statement and other related statements are incomplete or fail to meet requirements.	5,164	31.9%
10	4.03.02.04	No sub-project quality control standard is developed.	5,134	31.7%
11	4.01.06	There is no approved record or no verification for the manufacturing supervision plan.	4,846	29.9%
12	4.03.11.06	Whether to fill in the inspection record form, or whether to implement the record.	4,091	25.3%
13	4.02.01.06	The inspection stop point for each material/equipment and construction is not determined, or the requirements are not met.	3,921	24.2%

14	4.02.03.03	The construction plan, quality plan, scheduled progress, construction drawings, equipment samples and other cases submitted for review are not reviewed, or the qualifications of important subcontractors and equipment manufacturers are not reviewed, the construction quality is not inspected, or the inspection items agreed upon in the contract are not sampled together with the manufacturer for inspection.	3,622	22.4%
15	4.03.02.05	The inspection timing of each material/equipment and construction (including clearly marking the inspection stop points set by the manufacturing supervision unit), or the inspection frequency has not been set.	3,616	22.3%
16	4.03.08.02	There is no internal quality audit, such as an audit of the inspection items on the self-inspection list, or of whether the inspection results are recorded in detail.	3,196	19.7%
17	4.03.06	There are no defect correction and prevention measures for environmental protection, construction safety and health and other performance matters, or defects are not tracked, improved, implemented, or the response to defects otherwise does not meet the requirements.	3,050	18.8%
18	4.03.14.03	Safety and health education and training is not arranged.	3,029	18.7%
19	4.01.05	There is no review, supervision or inspection to track defect improvement record, or the content is inaccurate and incomplete.	2,610	16.1%
20	4.02.01.01	The structure of the manufacturing supervision plan does not include the basic content required by the quality control points, or important project items are missing.	2,595	16.0%

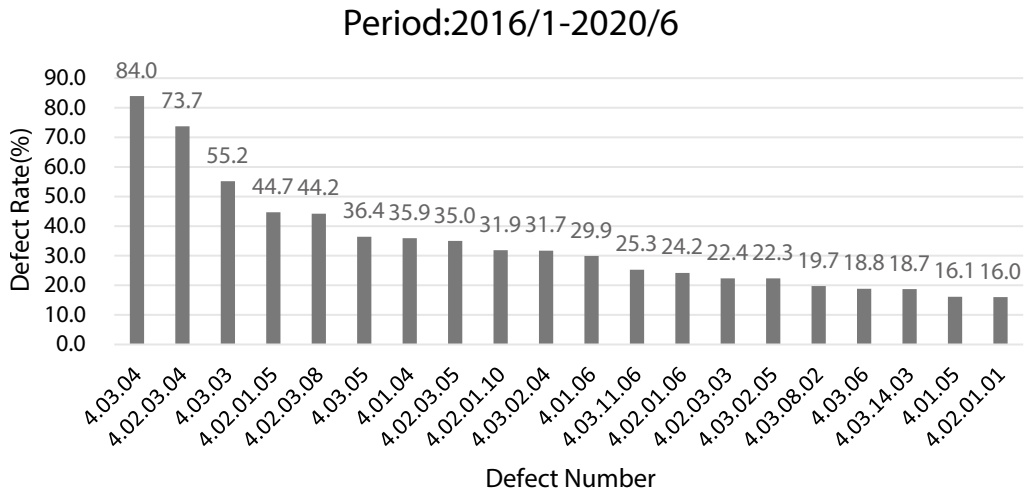

Figure 1. Document quality control defect rate in construction inspections

Figure 2 shows the cumulative number of document quality control defects discovered during construction inspections classified according to unit. Figure 2 shows that the cumulative number of defects for which the contractor is responsible is the highest at greater than 50,000. The cumulative number of defects for which the competent authority is responsible, on the other hand, is the lowest at 13,000; in addition, all of these defects belong to

one of only three types, in stark contrast to the defects for which the other two units are responsible. From this, we can learn that inspections are relatively cautious when it comes to correcting defects for which the competent authority is responsible. In addition, the incidence of each of the first five documented quality control defects identified in construction inspections is as high as 40%, while the incidence of each of the first 10 items is greater than 30%. We can learn from this that the current quality management system is not effective, and that all engineering staff must work together to improve it.

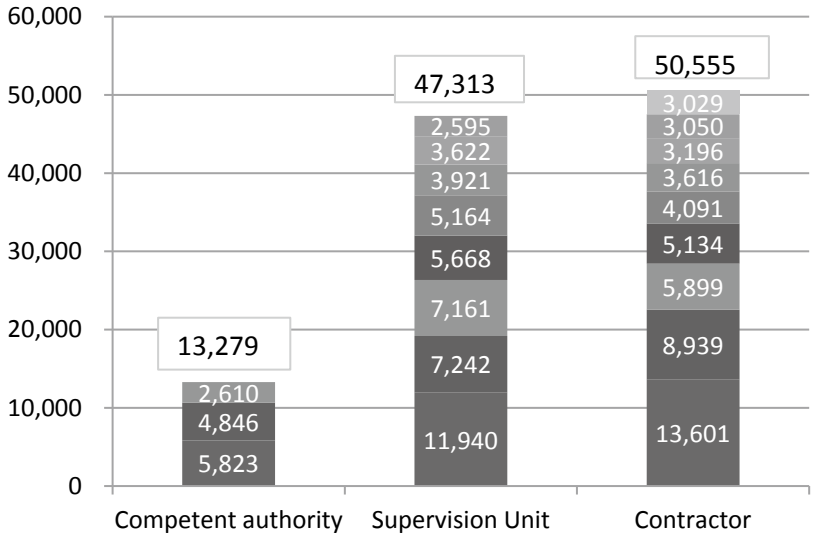

Figure 2. Accumulated number of document quality control defects in construction inspection by unit

Table 2 and Figure 3 show statistical data on the top 20 quality defects discovered during construction inspections. The most common defect is incorrect or missing content of the project sign, occurring at a rate of 39.3%. This defect should be avoided through careful checking of all signage. The second most common defect is "concrete placement and compaction fail to meet specifications with cold joint, honeycomb, or holes". The main types of defects and their respective prevention measures and correction methods are shown in Table 3.

Table 2. Quality defects in construction inspection

No.	Defect number	Content of defect	Number of defective cases	Defect rate
1	5.09.08	There is no project notice board or contents thereon fail to meet the requirements; facilities including fence and external shield of scaffold are insufficient, or are damaged and remain unrepaired; or inaccurate information is provided, or the safety of adjacent buildings is impaired.	6,361	39.3
2	5.01.01	Concrete placement and compaction fail to meet specification with cold joint, honeycomb, or holes	4,747	29.3
3	5.14.01.01	There are no required fall prevention facilities such as fence, protective cover, safety net, or safety harness set along the edge or opening at a workplace with an altitude difference of more than 2 meters or such fall prevention facilities fail to meet the requirements.	4,283	26.4

4	5.01.04	There is residual debris on the surface of concrete (such as iron wire, iron pieces, and formwork).	3,879	23.9
5	5.14.07	Traffic warning facilities for construction on site are insufficient.	3,710	22.9
6	5.14.04	Contractor maintains no labor safety self-inspection records, or such records are untrue.	3,288	20.3
7	5.16.01	There is no disaster prevention self-inspection list on site during flood season, or such list is not implemented.	3,091	19.1
8	5.09.09	Machines and tools and materials are placed on site haphazardly and are not properly protected.	2,991	18.5
9	5.01.02	Concrete curing fails to meet specification, and there are plastic shrinkage cracks.	2,785	17.2
10	5.14.06.01	Exposed reinforcing bar at workplace may puncture or bruise victims, and no protective facilities such as cover or jacket are provided to curved tips.	2,619	16.2
11	5.10.01.02	No chloride ion content test record is maintained, or test frequency is insufficient or contents thereof are inconsistent.	2,361	14.6
12	5.01.03	Perpendicularity and levelness of finished surface of concrete fail to meet specifications, or there are numerous repair traces.	2,328	14.4
13	5.02.05	No spacer and heel block are used, and protective layer fails to meet requirement.	2,288	14.1
14	5.01.05	Setting of construction joint and expansion joint are improper, or construction is improper or no such joint is set.	2,075	12.8
15	5.14.08	Facilities such as fence and external shield are insufficient.	2,053	12.7
16	5.14.01.04	Required equipment for safe access is not set at workplace with an altitude difference of more than 1.5 meters.	2,042	12.6
17	5.10.02.02	No radiation pollution verification record is maintained.	1,783	11.0
18	5.05.09	Garbage and wastes are not removed, leading to environmental pollution.	1,767	10.9
19	5.14.03.01	Electric wires of temporary electric equipment are not protected.	1,695	10.5
20	5.14.02.01	Scaffold fails to be properly and reliably connected to stable structures, or fails to meet requirements.	1,678	10.4

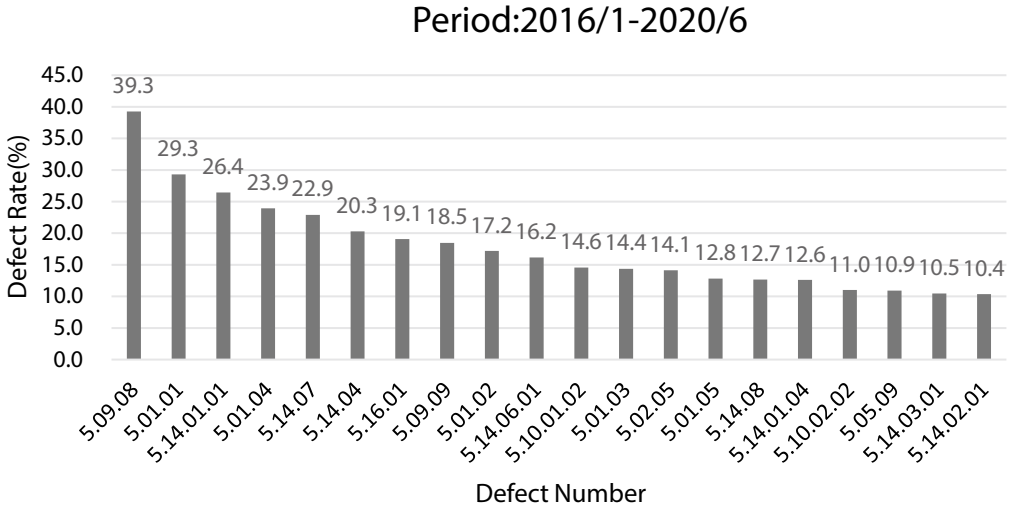

Figure 3. Quality defect rate in construction inspection

Table 3. Main types of concrete defects, prevention measures and correction methods

No	Major types of defects	Defect prevention measures	Defect correction method
1	The corners are not tamped, causing uneven distribution of coarse and fine particles at the edge of the concrete, resulting in honeycombs.	Have layer-by-layer pouring and tamping, strengthen supervision of work shifts with more frequent defects, and ensure that the vibration depth, interval, and range are correct.	Repair method of honeycombs: 1. Chiseling out the honeycomb: The chiseling thickness should not be too thin, and the root area of the honeycomb is slightly enlarged. 2. Cement mortar bonding: Apply 1:1 (cement: fine sand through 30 screens) cement mortar as a bonding layer. 3. Filling up: Use the cement mortar that should not exceed 1:2.5 (cement: fine sand through 16 screens, roughly the same as the original ratio) to repair and flush. # When the repair depth is greater than 3cm, use the concrete of the original ratio to repair. # Start to repair when the bonding layer loses moisture, fully compact and scrape the surface.
2	The arrangement of reinforcing bars is too dense, which affects the distribution of granules and produces honeycombs.	Check that the spacing of the reinforcing bars is not too dense and the protective layer is correct.	
3	The concrete ratio is not appropriate, resulting in poor workability, or insufficient fine materials, resulting in honeycombs.	Review the concrete ratio, and if necessary, change the slump of the concrete ratio with the approval of the relevant unit to improve workability.	
4	The pouring distance is too long, and the discharge height is too high, causing particle separation.	When unloading, try to be as close to the pouring surface as possible, and use baffles, chutes or plastic hoses to avoid particle separation.	

As shown in Figure 4, the first 20 defects can be divided into three categories: those pertaining to safety and health, those pertaining to concrete, and those pertaining to reinforcing bars. There are 12 items pertaining to safety and health, totaling 35,578 incidents (61.5%). There are six items pertaining to concrete, totaling 18,175 incidents (31.4%). There are two items pertaining to reinforcing bars, totaling 4,071 incidents (7.1%). Clearly, the most common category of defect is safety and health.

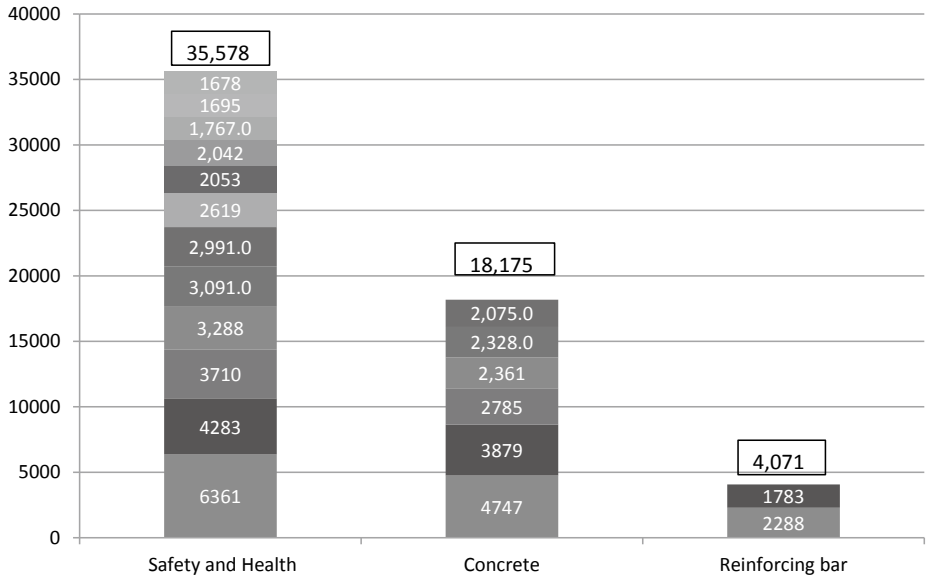

Figure 4. Total number of quality defects discovered during construction inspections by type of work

5. Conclusions

(1) Due to the COVID-19 pandemic, Taiwan has quickly isolated all foreigners entering Taiwan and has conducted epidemic prevention investigations and isolation of contacts of confirmed cases. As a result of all these precautions, the progress of public construction projects has not been affected.

(2) Quality control inspections of document mainly assess three major forms: the self-inspection list, the spot-check record or material and equipment inspection (test) control summary statement, and the construction log. In all three of these form types, the defect rates are too high, suggesting that the current quality management system is not effective. It is necessary to think carefully about whether the education and training of engineering personnel and technical standards need to be improved.

(3) As for quality defects discovered during construction inspections, the incidence of defects and the number of safety- and health-related defects are both too high. General awareness of construction safety and health needs to be improved. The frequency of defects whereby "concrete placement and compaction fail to meet specifications with cold joint, honeycomb, or holes", a problem that seriously affects the quality of a project, is also too high. The suggestions listed in Table 3 of this article are expected to help various sectors identify steps they can take to reduce the incidence of these defects.

(4) From conclusions (2) and (3) above, we know that the current construction inspection system needs to be improved. To achieve this, the relevant departments of the Taiwan government will need to develop improvement measures, and the technical prowess of engineering staffs needs to be improved as well.

References

1) Wu-Te Ko, Tai-Yuan Ho. Status and challenges of quality management for infrastructure in Taiwan: The 8th Civil Engineering Conference in the Asian Region, S4-6, 1-4 (2019).

2) Wu-Te Ko. Study on assessing the quality of infrastructure in Taiwan, presented at the 14th International Symposium in Science and Technology, Bangkok, 2019.

3) Construction and Planning Agency, MOI, Job training course material from "Ministry of the Interior Assigned 220-hour Job Training Course Lecture Program for Site Directors in the Construction Industry", Unit 6 Engineering Construction Management; Chapter 4 Quality Management, 1-25 (2009) (in Chinese).

4) Wu-Te Ko, Tai-Yuan Ho, Yu-Ming Wu, Shan-Mei Chen. Study on quality management for infrastructure in Taiwan. Science and Technology Report of Kansai University, **62**, 75-83(2020).

5) Public Construction Commission, Executive Yuan, https://www.pcc.gov.tw/Content_List.aspx?n=35A7AE4FD0E89AD0(in Chinese)