Study on Quality Management for Infrastructure in Taiwan

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Abstract

Asian countries face various developmental issues such as natural disasters, water concerns, urbanization, healthcare, and climate change, and there is the need to develop infrastructure to resolve these issues. This paper first introduces the system of Taiwan's infrastructure quality management and then provides a study on the countermeasures to improve quality management. The findings of the discussions will be collected as an infrastructure maintenance and management reference.

1. Introduction

Asia is facing various issues such as natural disasters, urbanization, population increases, aging societies, a declining birthrate, traffic congestion in urban areas, health risks, climate change, and access to safe water. Asian countries need to develop infrastructure to resolve these issues and contribute to achieving sustainable development goals.[1)]

The quality of public construction work may be the indicator of the national development level. Taiwan is one of the world's developed countries and high-quality engineering is also necessary to keep pace with the economic development. Based on the "Public Works Construction Quality Management System" issued by Executive Yuan of Taiwan in 1993, a three-tier quality management framework was established. The "Key Points in Public Works Construction Quality Management" was issued in 1996, and the "Government Procurement Law" was issued in 1999. In 2002, the third tier was modified as the construction quality verification mechanism according to Article 70 of the "Government Procurement Law." In the same year, the "Public Works Implementation Plan under the Whole Nation's Supervision" was formulated. To promote infrastructure development and to increase the public's understanding of the significance of quality infrastructure in those countries, we should consider efficiency, safety, resiliency, social and environmental states, and the contribution to local societies and their economies by transferring technology and building capacity. Currently, the top priority is how to enhance public work quality management, improve construction quality, and establish effective quality management systems. [2)]

2. Infrastructure Construction Quality Management in Taiwan

The three-tier quality management framework is shown in Figure 1.

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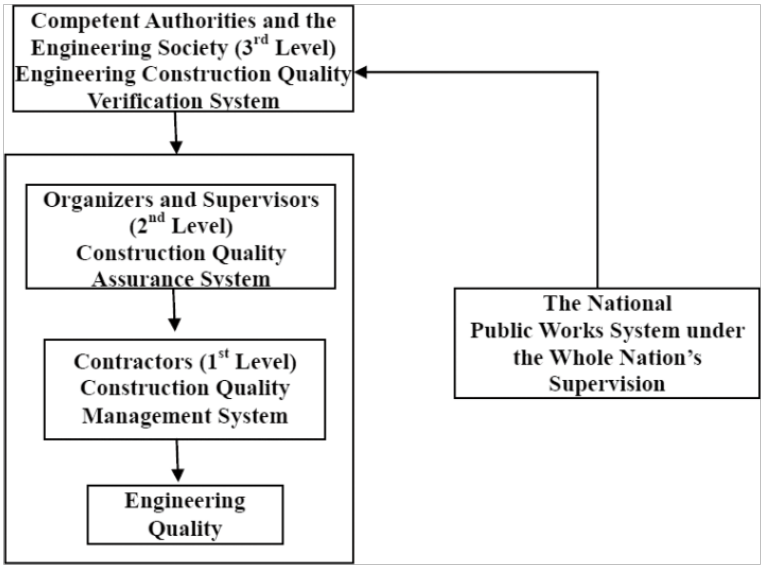

Figure 1. Three-tier Quality Management Framework [3)]

This paper introduces the National Supervision on Public Construction System and the Construction Quality Surveillance System.

2.1 National Supervision on Public Construction System

For the purpose of this system, people can report any construction quality defect found anywhere by using any of the contact information specified below:

Tel: 0800-009-609 or 1999

Fax: (02)8789-7714, (02)8789-7724

Post: Public Construction Commission, Executive Yuan, 9F, No. 3, Songren Rd., Xinyi Dist., Taipei City

Online: Website of Public Construction Commission, Executive Yuan (www.pcc.gov.tw)

The Public Construction Commission, Executive Yuan will forward such information reported to the competent authority, which can, upon on-site confirmation of the required improvement, conduct on-site surveillance in accordance with the Construction Quality Surveillance System, or will directly require the competent authority to implement improvement immediately. Upon the completion of the improvement, the competent authority shall upload the entire treatment process onto the website of the Public Construction Commission, Executive Yuan-National Supervision on Public Construction System and notify the informer. The informer shall be advised to complete a satisfaction survey and the case will be closed upon satisfaction of the informer.[4)]

2.2 Construction Quality Surveillance System

The Central Government and county and municipal governments shall form a "Construction Quality Surveillance Unit" to conduct periodic surveillance and shall not issue prior notice before on-site surveillance. Surveillance frequency shall not fall below 20% of the construction contracts executed in the current year. Surveillance commissioners shall be appointed from the list of surveillance commissioners and experts of the Construction Quality

Surveillance Unit. More than three surveillance commissioners shall be appointed for each surveillance operation. The surveillance operation will last for 1 day. Upon arrival of the surveillance commissioners on site, the construction quality surveillance process shown in Figure 2 shall be executed. At the close of the meeting, the number and content of the defects and relevant deduction points shall be disclosed in accordance with the "Quality Defect and Deduction Point Record Sheet in Surveillance." Where there is a deduction point, fines shall be imposed on the contractor and supervision unit. When the defect is identified by the Surveillance Unit during their observations, the authority shall urge the supervision unit and the contractor to make improvements within a specified period of time and take pictures before, during, and after improvement for future reference. Fines for quality defects in construction surveillance are as listed in Table 1. Finalized surveillance scores of 90 points and above shall be categorized as Top Grade, above 80 points but below 90 points as Grade A, above 70 points but below 80 points as Grade B, and below 70 points as Grade C. For Grade C, in addition to the treatment as agreed to in the contract, the authority shall take disposition measures upon a review of the accountability of personnel based on the circumstances of the defect(s) in each case. [5)]

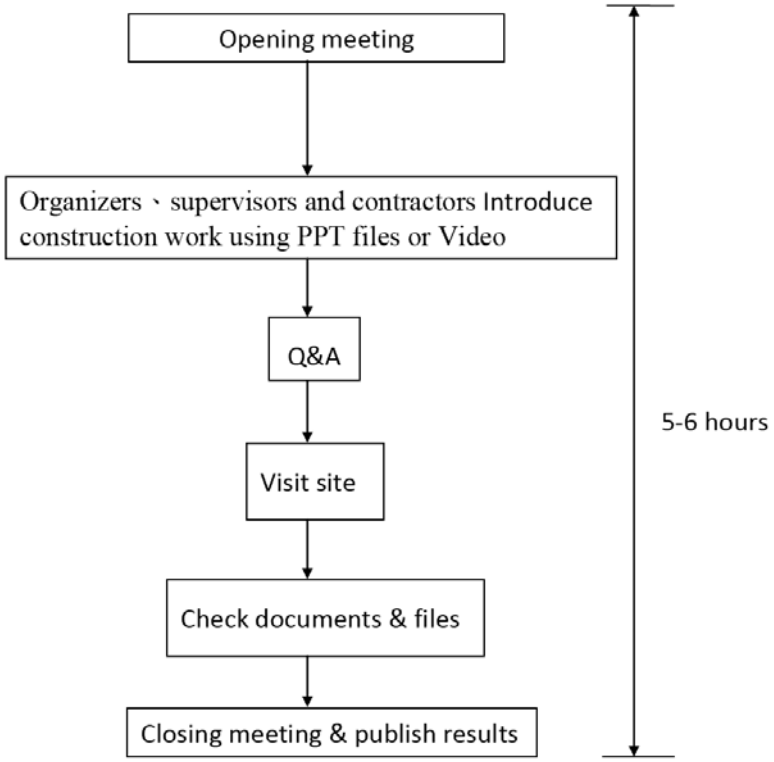

Figure 2. Construction Quality Surveillance Process [3)]

Table 1. List of fines on quality defects in construction surveillance [3)]

	Fines per point	
Contract amount	Contractor	Supervision unit
Contract amount >200,000,000	8,000	2,000
50,000,000～199,999,999	4,000	1,000
10,000,000～49,999,999	2,000	500
Contract amount＜10,000,000	1,000	250

3. Discussion

The first author has served as a surveillance commissioner for more than 10 years. The analysis and discussion in this paper were based on the statistical table of surveillance cases by the Construction Quality Surveillance Unit released by the Public Construction Commission, Executive Yuan quarterly (every 3 months) in an effort to identify causes and devise measures for providing a reference for improvement. The surveillance period lasted for a total of 30 months from January 2017 to June 2019 during which a total of 8,852 construction projects were surveilled. Table 2 sets forth the statistical table of document quality control defects in construction surveillance, where a defect number of 4.01 represents a defect of the competent authority, a defect number of 4.02 represents a defect of the supervision unit, and a defect number of 4.03 represents a defect of the contractor. Figure 3 shows document quality control defects in construction surveillance by the unit, and Figure 4 sets forth the quarterly defect rates of 4.03.04, 4.02.34.04, 4.03.03, and 4.01.04.

Table 2. Document quality control defects in construction surveillance

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.	7,453	84.20%
2	4.02.03.04	No spot check of construction operation and spot test of materials and equipment are carried out, and no spot check (test) record sheet is completed, and no material and equipment inspection (test) control summary statement is prepared, or approved, or implemented.	6,501	73.44%
3	4.03.03	Construction log is not implemented and executed, or its format does not meet the requirements.	4,812	54.36%
4	4.02.01.05	Quality control standards for materials/equipment and construction are not prepared or fail to meet requirements.	3,926	44.35%
5	4.02.03.08	No supervision statement is completed or no record is maintained.	3,874	43.76%
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.	3,307	37.36%
7	4.01.04	No quality supervision and surveillance is implemented or inspection records or contents are inaccurate.	3,230	36.49%

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.	3,150	35.59%
9	4.02.01.10	Material and equipment approval control summary statement and material and equipment inspection (test) control summary statement, spot check standards, sport check records, or supervision statement and other related statements are incomplete or fail to meet requirements.	2,937	33.18%
10	4.03.02.04	No sub-project quality control standard is developed.	2,829	31.96%

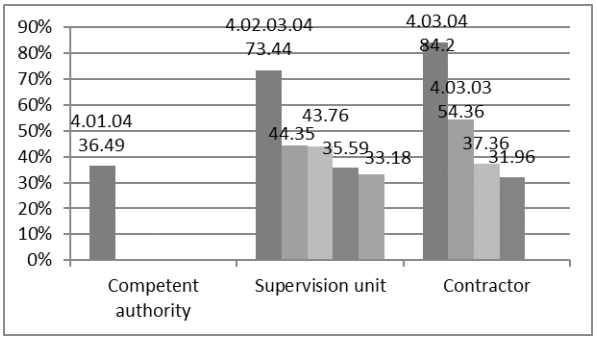

Figure 3. Document quality control defects in construction surveillance by unit

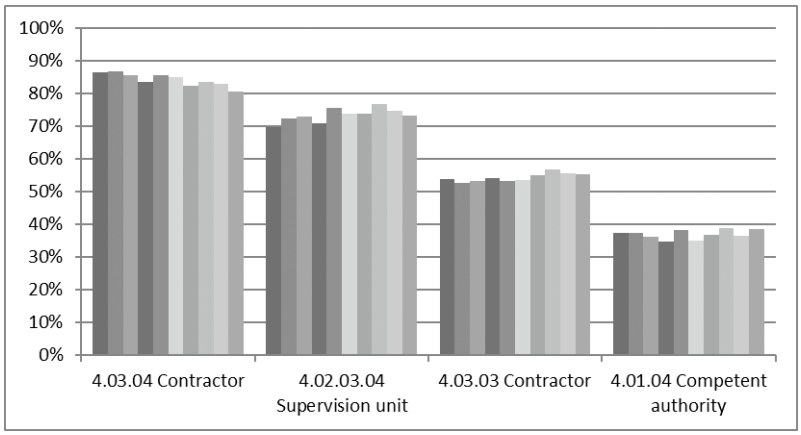

Figure 4. Quarterly defect rates of 4.03.04, 4.02.03.04, 4.03.03, and 4.01.04

In terms of document quality control in construction surveillance, the following four conclusions can be drawn from Table 2 and Figure 3:

1) The defect rate of the self-inspection list reached up to 84.2%, and, according to Figure 4, the defect rate of the self-inspection list substantially remained above 80% in each quarter of the the two and a half years of the study.

Below are recommended measures:

a) Education and training of quality control personnel shall be improved.

b) Quality control personnel shall prepare a self-inspection list upon reading the construction documents and specifications.

c) The competent authority shall issue checklists by project type for reference.

2) The defect rate of material and equipment inspection (test) control summary statement reached up to 73.44%, and, according to Figure 4, the defect rate of material and equipment inspection (test) control summary statement substantially remained above 70% in each quarter of the two and a half years of the study.

Below are recommended measures:

a) Education and training of the supervisor shall be improved.

b) The supervisor shall prepare a material and equipment surveillance (test) control summary statement upon reading the construction documents and specification.

3) The defect rate of the construction log reached up to 54.36%, and, according to Figure 4, the defect rate of construction remained above 50% in each quarter of the two and a half years of the study.

Below are recommended measures:

a) Personnel shall be designated to be responsible for developing the habit of daily completion of various statements and sheets.

b) Education and training of site engineers shall be improved.

c) Initiative on required important items shall be improved.

4) The defect rate of supervision and surveillance by personnel of the competent authority reached up to 36.49%, and, according to Figure 4, the defect rate of supervision and surveillance by personnel of the competent authority remained above 35% in each quarter of the two and a half years of the study.

Below are recommended measures:

a) Personnel of the competent authority shall reside on site during construction.

b) Supervision matters shall be listed in the supervision record sheet.

As listed in Table 2 and shown in Figures 3 and 4, the defect rates remained similar and unimproved in each quarter of the two and a half years of the study. The first two defect rates reached up to 70%, the first five defect rates reached up to 40%, and all of the first ten rates exceeded 30%. It can be seen that the current quality control system is ineffective and the joints effort of all construction personnel is required.

Table 3 sets forth quality defects in construction surveillance. The first 20 defect rates listed in the table can be classified into concrete quality, reinforcing bar quality, construction safety, and labor safety and health, as shown in Figure 5.

Table 3. Quality defects in construction surveillance

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 requirement; 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.	3,385	38.24
2	5.01.01	Concrete placement and compaction fail to meet specification with cold joint, honeycomb, or holes.	2,594	29.30
3	5.14.01.01	There is no required fall prevention facilities such as fence, protective cover, safety net, or safety harness set along the edge or opening at workplace with an altitude difference of more than 2 meters or such fall prevention facilities fail to meet the requirements.	2,346	26.50
4	5.01.04	There is residual debris on the surface of concrete (such as iron wire, iron pieces, and formwork).	2,183	24.66
5	5.14.07	Traffic warning facilities for construction on site are insufficient.	2,088	23.59
6	5.14.04	Contractor maintains no labor safety self-inspection records, or such records are untrue.	1,797	20.30
7	5.16.01	There is no disaster prevention self-inspection list on site during flood season, or such list is not implemented.	1,702	19.23
8	5.09.09	Machines and tools and materials are placed on site haphazardly and are not properly protected.	1,614	18.23
9	5.01.02	Concrete curing fails to meet specification, and there are plastic shrinkage cracks.	1,584	17.89
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.	1,423	16.08
11	5.01.03	Perpendicularity and levelness of finished surface of concrete fail to meet specification, or there are numerous repair traces.	1,308	14.78
12	5.02.05	No spacer and heel block are used, and protective layer fails to meet requirement.	1,271	14.36
13	5.10.01.02	No chloride ion content test record is maintained, or test frequency is insufficient or contents thereof are inconsistent.	1,225	13.84
14	5.01.05	Setting of construction joint and expansion joint are improper, or construction is improper or no such joint is set.	1,178	13.31
15	5.14.08	Facilities such as fence and external shield are insufficient.	1,122	12.68
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.	1,099	12.42
17	5.05.09	Garbage and wastes are not removed, and environment pollution is caused thereby.	957	10.81
18	5.10.02.02	No radiation pollution verification record is maintained.	939	10.61
19	5.14.02.01	Scaffold fails to be properly and reliably connected to stable structures, or fails to meet requirement.	923	10.43
20	5.14.03.01	Electric wires of temporary electric equipment are not protected.	919	10.38

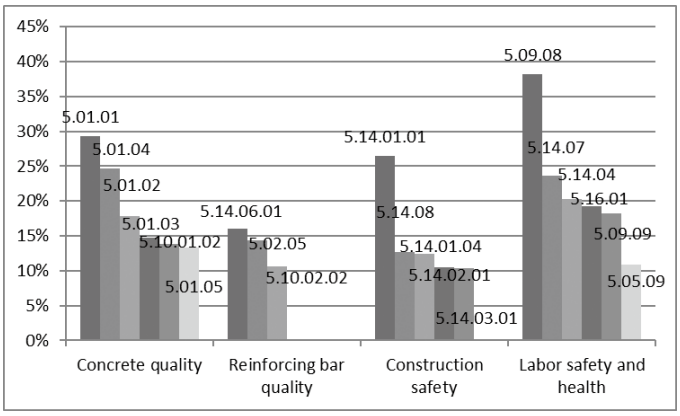

Figure 5. Distribution of quality defect rates in construction surveillance

In terms of quality defects in construction surveillance, the following three conclusions can be drawn from Table 2 and Figure 5:

1) The highest defect rate is observed in the project notice board, fence for isolating the site from the outside environment, and external shield of scaffold, which represents a weak awareness of site engineers to maintain isolation from third parties during construction.

Below are recommended measures:

a) Education and training of the supervisor on labor safety shall be improved.

b) The contractor shall develop a standard facility model.

2) Concrete is the most commonly used material in construction projects. However, "concrete placement and compaction fail to meet specification with cold joint, honeycomb or holes" reached a defect rate of up to 30%. In addition, [reinforcing bar] and [concrete] account for 8 quality defects from among the top 20 quality defects. Therefore, construction quality needs to be further improved.

Below are recommended measures:

a) Formwork quality and vibrating compaction operation shall be improved.

b) Submission of concrete proportioning design for approval shall be implemented.

c) Concrete placement plan shall be developed and a placement sequence board shall be set on site.

3) [Construction safety] and [labor safety and health] account for 11 quality defects from among the top 20 quality defects. [Fall] represents the most frequently occurring labor safety accident over the years; in particular, the fall prevention facility defect rate is ranked third overall. Therefore, construction safety and health need to be further improved.

Below are recommended measures:

a) A person in charge of labor safety shall be designated for daily periodic patrol surveillance.

b) Efforts shall be made to improve the labor safety awareness of all staff members on site, and related education and training programs shall be organized periodically.

c) Warning banners and related pictures shall be provided on site.[6)]

4. Conclusion

This paper analyzed and discussed the "Three-Tier Quality Control System" of the Construction Quality Control System of Taiwan, and the following conclusions have been drawn therefrom:

(1) In terms of document quality control in construction surveillance, defect rates remained similar and were unimproved in each quarter for the two and a half years of the study. The first two defect rates reached up to 70%, the first five defect rates reached up to 40%, and all of the first ten rates exceeded 30%. It can be seen that the current quality control system needs to be improved.

(2) In terms of quality defects in construction surveillance, [reinforcing bar] and [concrete] account for 8 quality defects from among the top 20 quality defects. Therefore, construction quality must be further improved. The fall prevention facility defect rate is ranked third as it accounts for 11 defect rates from among the top 20 defect rates. Therefore, construction safety and health need to be further improved.

(3) Good public construction quality can be obtained only through the implementation of the "Three-Tier Quality Control System." Despite the financial penalty mechanism in the current system, due to its small amount, the deterrence effect is limited and common defects continue to be seen, such as "concrete placement and compaction fail to meet specification with cold joint and honeycomb," which could have a material adverse impact on construction quality. It is recommended that in addition to required improvement and fines based on surveillance results, the business registration certificate of a contractor upon reaching a certain quantity of defects that have a material adverse impact on construction quality (such as honeycomb in concrete) shall be revoked. We believe that this is the only way by which public construction quality can be improved.

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