Fundamental Study on Evaluation of Concrete Practices in Thai Public Works

Kochi University of Technology, Member, Associate Professor
Tsunemi Watanabe
Asian Institute of Technology, Non-Member
Kriangsak Chatanantavet

1. Introduction

Despite various kinds of development of concrete technology, maintaining quality of concrete works does not yet look a very easy task. In Bangkok, Thailand, for example, Setkit (1998) studied 48 concrete bridges and found that 19 bridges had deteriorating reinforced concrete structures and five of them were in severe conditions. The presence of cracks and small thickness of the concrete cover are considered causes of deterioration of the surveyed bridges. The small thickness of the concrete cover is an evidence of poor construction.

More than thirty years have passed since McLaughlin (1965) stated, "if half the available knowledge on concrete was put into practice, ninety-five percent of the problems would evaporate." The result of the above study in Bangkok demonstrates how improper practice affects quality of the concrete structure like thirty years ago. It is worthwhile studying how concreting works are conducted on site and why poor works occur if there is any.

In this study an attempt is made to evaluate concrete practices on sites of Thai public building projects, identify problems, and make some recommendations to improve concrete process management.

2. Structure of Study

In this study, five public building projects with its budget higher than one hundred million baht were investigated in Bangkok and surrounding provinces. The four main parts of concrete structure of each building, that is, post-tension slab, RC slab & ramp, column, and beam, were studied, respectively. Field survey period was from Oct. 16, 2001 to Jan. 15, 2002.

The study consists of 1) finding out what attitudes each main party such as owner, consultant, main contractor, subcontractor, and concrete supplier has on concrete practices, 2) observing and evaluating how frequently concrete practices are conducted according to work standards, and 3) finding out how concreting works are being managed and where should be improved. Questionnaire surveys, interviews, and field observations were conducted to complete the study.

3. Evaluation of Concrete Practice on Site

The main objective of this part is to attempt to evaluate overall performance of concrete practice in terms of quality. The evaluation equation is given by:

$$y = \boldsymbol{w}^T A \boldsymbol{x} \qquad (1)$$

where:

- $y \in \boldsymbol{R}^{1\times 1}$: Overall performance score of concrete practices
- $\boldsymbol{w} \in \boldsymbol{R}^{17}$: Weighting vector to represent relative importance degree of each concrete property
- $A \in \boldsymbol{R}^{17\times 14}$: Matrix whose (i, j) component represents how much the j^{th} concrete practice influences the i^{th} concrete property
- $\boldsymbol{x} \in \boldsymbol{R}^{14}$: Concrete practice score vector to represent how frequently each concreting work is conducted according to each work standard

Here the following 17 concrete properties were selected as important properties. Those are 1) workability, 2) segregation, 3) bleeding, 4) durability, 5) watertightness, 6) strength: a) early compressive strength, b) 28-day compressive strength, c) tensile strength, d) flexural strength, and e) bond strength, 7) creep, 8) extensibility and cracking: a) pre-hardening crack and b) after hardening crack, 9) thermal properties: temperature rise in mass concrete, and 10) surface texture: a) honeycomb, b) surface voids, and c) cold joint.

Relative importance of each property in each of the four concrete structures such as post-tension slab, RC slab & ramp, column, and beam was rated by 13 concrete specialists all of who are members of the Subcommittee on Concrete and Materials of the Engineering Institute of Thailand (EIT). Ratings were given with four scales from 0 (not important) to 3 (highly important). The averages of thirteen sets of the ratings were used as the final weighting vector, $\boldsymbol{w}$.

Similarly to weighting vector $\boldsymbol{w}$, all components of Matrix A, were rated by the 13 concrete specialists with seven scales from –3 (very negatively influential) to 3 (very positively influential). If the rating of a certain component is uncertain, the component was left blank. The average of the ratings by the 13 specialists were used as the final value of each component.

Concrete practice score vector $\boldsymbol{x}$ was rated by an author based on his observation of concrete practices for each structure on each site. Since this study focuses on field works, observations were made on 14 activities categorized in five processes described in Table 1. Observation of each activity is made on a certain interval. Its rating is one if that activity conforms to work standard and zero otherwise. The average of rating of all samples was calculated and used for each component of vector $\boldsymbol{x}$.

Keywords: Evaluation of concrete practice, quality of concrete works, building project, quality management, Thailand
Tosayamada-cho, Kochi, 782-8502, TEL: 0887-57-2408, FAX: 0887-57-2420, EMAIL:watanabe.tsunemi@kochi-tech.ac.jp

At present, Thailand has not yet established its own standard code for practice of concrete works. Most of guidelines are adopted from foreign standards such as ACI, ASHTO, and BS. Table 1 also shows work standards for each activity used in this study.

The scale of y was adjusted so that its maximum score becomes 100 points.

y is basically a measure of quality of concrete practice process. However, it also includes how much each practice influences each concrete property and how relatively important each concrete property is. Significance of y is to indirectly but concisely measure an index related to quality of concrete structures.

Table 1: Five Processes and 14 activities and concrete practice
(Adapted from Tumwattana (1976), Eugene (1988) and Sertabudth (1993))

Concrete Practice Processes	Concrete Practice Activities and Standards
A. Inspection of freshly mixed concrete	1. Visual observation of consistency of concrete and proper responds to the results 2. ‘Slump Test’ and proper responds to the results
B. Transportation	1. Cleaning transportation equipment 2. No separation due to handling (transportation)
C. Placing	1. Sufficient placing capacity (continuous placing) 2. Using concrete within time limit 3. No separation due to placing 4. Cleaning placing equipment and placing area 5. No added water
D. Consolidation	1. Correct consolidation method (individual layer) 2. Correct consolidation method (between layers) 3. Sufficient vibration
E. Curing	1. Adequate duration of curing 2. No delay in curing

4. Results of Evaluation

Table 2 shows results of evaluation. If all activities conform to work standards, the overall performance score becomes 100. The results do not seem “disastrous.”

It should be noted here, however, that since these projects are relatively large projects in Thailand. Thus, their quality management is likely to be more effective and efficient than many of other projects.

Table 2: Results of Evaluation

Concrete structure \ Project No.	1	2	3	4	5	Average
Post-Tension Slab	76	70	62	73	NA	73
RC Slab & Ramp	73	54	NA	NA	86	72
Column	89	63	89	83	80	80
Beam	79	63	61	NA	84	70
Average	79	63	71	78	83	74

The variance of the overall score with respect to the project is larger than that with respect to the type of structure. This hints that even among large projects concreting works may be much poorly done in some site.

For the Post-tension slab, RC-slab & ramp, and beam, typical problems found in the all projects were inadequate duration and delay of curing. According to the ACI concrete practice standard, exposed surfaces have to be cured with good curing material and proper curing method as soon as possible. In the five projects, however, curing works started on the next day after pouring concrete. Many practitioners even have a view that pouring concrete in the evening and curing on the next day is acceptable because cold weather at nighttime significantly reduces a problem caused by the delay of curing. For the small RC slab & ramp, practitioners are not concerned much about these sections. Some RC slabs were not cured during the observation.

For the column, the standard of “no separation due to placing” was not much satisfied in all projects. The ACI code specifies to use wetter concrete at bottom of the narrow form and use the concrete with reduced slump near the top. It was difficult for practitioners in these projects to follow this standard. Another problem observed in two sites was to provide no flexible drop chute attached to bucket’s collector cone.

5. Problems in Concrete Process Management and Recommendations

Questionnaire surveys and interviews were conducted to identify problems in the four management functions in concrete process: planning, organizing, leading, and controlling.

Regarding the curing, the main contractor and the subcontractor recognize that weak controlling functions are the most serious problems. They are loose inspection and supervision, lack of measuring the actual performance and comparing it with the plan or the standard, and taking no corrective action when problems occur. With results of field observation, it is not an overstatement to say that the controlling functions did hardly work in any of the five construction sites. This weak controlling function is presumably caused by insufficient leading functions, which were identified to be most serious problems by the consultant. Their examples are insufficient external coordination among different parties and lack of motivation of each party. Weak controlling and leading functions are partly caused by improper organizing and planning functions such as unclear role and responsibility of each practitioner, wide span of control, and lack of clear concrete practice standard.

Fundamental reasons for these weak management functions are mainly practitioners’ ignorance of proper concrete techniques and value to prioritize cost and time. Results of the attitude survey towards 46 practitioners including the consultant, main contractor, subcontractor, and concrete supplier, show that 19 of them have never received any concrete practice training. 80% (12 out of 15) of foreman and headman in the main and sub contractors were never trained. This result implies a danger that foreman or headman who have not experienced correct procedures will never practice them. As a middle and long-term solution, to provide sufficient training to the foreman and headman is essential to maintain quality of concreting works.

6. Acknowledgements

The authors sincerely thank those who provided us kind cooperation and valuable advice.