Craftsman Questionnaire Sampling

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Abstract: Craftsman Questionnaire Sampling (CQS) was recently developed for performance measurement and productivity improvement at construction sites. CQS uses a questionnaire to collect data. It has the virtues of the Craftsman Questionnaire Survey, which provides information regarding the sources of delays, the amount of rework performed, as well as creating a participating atmosphere on site. Meanwhile, CQS imitates the sampling procedure from the Work Sampling method by randomly selecting craftsmen in the field and asking them to determine the activities involved in the immediate past. This procedure empowers the CQS to apply the theory of binominal distribution to estimate ratio delays and to maintain the advantages of relative simplicity and statistical reliability as the Work Sampling method does. CQS was tested at a large nuclear power plant site. The results indicated the feasibility and efficiency of CQS in helping construction management identify delays that could provide a base for productivity improvement.

Introduction

The need to improve productivity in the construction industry is evident. However, the prerequisite to any improvement effort is to establish an efficient system to measure the organization's productivity so that management efforts and productivity trends can be controlled and improved.

There are various ways to measure construction productivity. Craftsman Questionnaire (CQ) and Work Sampling (WS) are two popular methods to measure construction site productivity and supplement the direct productivity measurement of cost reporting system. The CQ efficiently unveils the causes of problems that adversely affect craftsmen's productivity and motivation. WS is not only simple to implement, but also supplies comparatively timely and statistically reliable information regarding craftsmen's time spent on various activities (12). Nevertheless, both CQ and WS methods have some inherent deficiencies. The numerical results of CQ lack validity, which creates a skepticism on the part of the construction industry regarding its use (9). Moreover, the data collection of CQ, which requires the craftsman to go to a preassigned location away from the work area, not only takes time but also interrupts the on-going construction activities (10,16). In the practice of WS, the construction workers may suspect that they are always being spied upon by observers. Also, the classification of their observed activities is often complicated. An inexperienced observer may easily affect the validity of the results. Furthermore, even an experienced and competent work sampler can get a reliable ratio data of the work activities, but further effort is still needed to seek the causes of the problems that are observed (13,14,16).

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Because of these shortcomings, a new method called Craftsman Questionnaire Sampling (CQS) has been developed to maximize the benefit of both CQ and WS methods and minimizes their adverse factors.

The purpose of this paper is to introduce the CQS. The theoretical background of CQS is explained. The step-by-step procedure of performing CQS is summarized. The similarities and differences among CQ, WS, and CQS are compared. The empirical results are presented with a discussion of the advantages and disadvantages of CQS. In addition, better ways to perform the CQS are recommended.

METHODS

Logic.—The main idea of CQS is to use questionnaires as a means of data collection to substitute for samplers' observation in work sampling. In other words, the tally form filled by samplers in WS are now filled by craftsmen. Craftsmen are the ones closest to the work and perform the tasks themselves on a daily basis. They can discern and determine the activities involved much more clearly than the "outsider" involved in work sampling. Meanwhile, because it uses a questionnaire to collect data, CQS has the virtues of the Craftsman Questionnaire Method, which provides information regarding the sources of delay, amount of time on rework, the necessity of the work performed, and also creates a participatory atmosphere on site.

The other procedure of CQS imitate those of WS. The administrator of CQS walks around the field as the WS sampler does. The administrator randomly selects craftsmen to answer the questionnaire. Because of the manner of random selection and the determination of the activities, the craftsmen are involved in the immediate past. CQS is able to apply the statistical theory of Binominal Distribution to make estimates of ratio delays as WS does (1,12). Thus, CQS will possess the same advantages of comparative simplicity and statistical reliability as WS.

Ration Delay Analysis.—Work sampling employs a random sampling theory, which selects a sample at random from the population and then infers the characteristics of the population. Also, the sampling theory provides the means to measure the errors due to sampling. The determination of the percentage of the working day that the craftsman is engaged in direct work, support work, or delay activities is based upon percentage of the number of observations that record the craftsman in direct work, support work, or delay. It is a reliable measure of the percentage of time that the craftsman spent on the observed activities (1,12).

If the craftsman is directly engaged in his work by using his trade tolls, the WS sampler will give him a tally mark under "direct work." If he is waiting, which is one of the delays, he is given a tally mark under "waiting." The percentage of the studied period that the craftsman is waiting is the ration of the number of "waiting" tally marks to the total number of observations made by WS sampler in the studied period.

CQS employs the same ratio-delay analysis method as WS. For example, if 350 out of 1,000 participating craftsmen indicate on the questionnaire that they are waiting, the conclusion is that 35% of the craftsmen's time is spent on waiting in this study period and so on.

Procedure.—The following flow chart on Fig. 1 summarizes the pro-

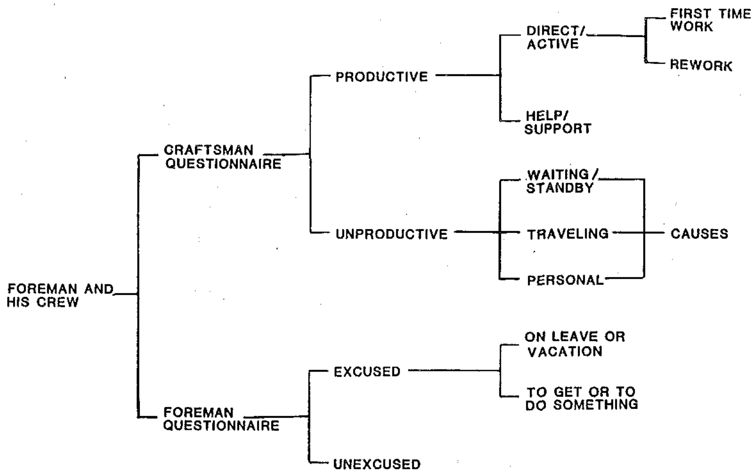

FIG. 1.—Procedure of Craftsman Questionnaire Sampling

cedure for performing CQS. First, the CQS administrator, just like the WS sampler, goes out to the field where craftsmen can be polled instead of moving the craftsmen away from their work area into an office or classroom. The administrator walks around the site and randomly selects a foreman on the site. Herein, "randomly" means random time, place, and crew. Second, the administrator explains the purpose for the survey and asks the foreman to gather his/her crew right at their work spots or areas. If the craftsmen in this selected crew are present, they are given a brief introduction, and a questionnaire is given to each craftsman to fill out. Appendix I shows the questionnaire filled by craftsmen. Once the craftsmen get the questionnaire, they are asked to describe what kind of activities they were engaged in right before their foreman invited them to participate in the survey. There are five investigated activities on the questionnaire, which are categorized as either "productive" or "unproductive." If the workmen felt and indicated that they were physically involved in work by either using their trade tools or supporting (or helping) other craftsmen, their work is categorized as productive and followed by an indication of whether it was initial work or rework. If they were waiting, on standby, traveling, or doing personal business, these activities are categorized as unproductive. Traveling is classified as unproductive in this study since it reflects the fact that the craftsmen are moving unnecessarily from their immediate work to other areas.

If the craftsmen were engaged in unproductive activities right before the foreman stopped their work, the next step on the questionnaire is to ask them to indicate what caused the unproductive activity. The idea is to understand why the craftsmen were waiting or traveling, and this understanding could not be ascertained using the WS method. Third, if any craftsman is absent, the foreman is asked to fill out a different form of questionnaire. Appendix II exhibits the questionnaire filled by foremen.

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The reasons for absence are classified as either excused or unexcused. If it is unexcused, the absent craftsman's activity would be treated as personal. On the other hand, if the foreman assigned the absent craftsman to get or do something, the activities would be categorized as traveling since the craftsman was not in the work area but another.

The fourth step is as follows: after the questionnaires are filled out by both the craftsmen and the foreman, the administrator repeats step one through three, until he/she gets an adequate sample size (4).

Similarities and Differences.—From the preceding description of the logic, contents, and procedure of CQ, it is clear that the approach of CQS is similar to that of Work Sampling. Both are measurement techniques for quantitative analysis in terms of time and activity of craftsman. Both consist of a large number of random observations that are taken at random intervals, and both methods apply the ratio-delay method to analyze the data. The study results of both methods posses the characteristics of known statistical reliability.

On the other hand, the similarities between CQS and CQ are that both of them are self-administered questionnaires. They attempt first to determine the administrative problems which adversely affect craftsmen's productivity and second to create an open and active participatory at-

TABLE 1.—Differences among Work Sampling, Craftsman Questionnaire Sampling, and Craftsman Questionnaire

Area concerned (1)	Work sampling (2)	Craftsman questionnaire sampling (3)	Craftsman questionnaire (4)
Means for collecting data information	By sight	By self-administered questionnaire	By self-administered questionnaire
Who provides the information	WS Sampler	Craftsmen and foremen	Craftsmen
How long it takes for each observation	Few seconds	2–5 min. Foreman may take up to 45 min to gather the crew together	1–1-1/2 hrs
Interruption	No	Yes	Yes
Where observation is made	Field	Field	Office or classroom
Sampling method	Random	Random	Deterministic
Contents of survey	Percentages of craftsman's time spent on direct work, support work, and delays	Identification of administrative delays, cause of delays, estimate of craftsmen's spent on direct work, support work, and delays	Identification of administrative delays, and their corresponding time losses

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TABLE 2.—Differences among Work Sampling, Craftsman Questionnaire Sampling and Craftsman Questionnaire

Area concerned (1)	Work sampling (2)	Craftsman questionniare sampling (3)	Craftsman questionnaire (4)
Any motivational effect	Obtrusive feeling may occur	Yes, positive effect on foremen and craftsmen	Yes, positive effect on craftsmen
Rework information	No	Yes	Yes
Absenteeism information	No	Yes	No. It lists the adverse factors causing people to be absent
Approach style	Top-down	Bottom-up	Bottom-up
Type of time losses estimates	Ratio-delay estimate	Ratio-delay estimate	Parameter estimate of manhours lost
Personal time estimate	Yes	Yes	No
Does it estimate the equipment utilization	Yes	No	No
Reliability of time losses estimate	Statistically reliable due to instantaneous glance	Statistically reliable. Craftsmen recall their activity for the immediate past	Some studies evidenced the estimate, but industry still suspect
Any willingness or cooperation	No	Yes, craftsman's and foreman's cooperation	Yes, craftsman's cooperation
Difficulties for defining the activities	Yes	Yes	No

mosphere which may enhance motivation and job satisfaction for craftsmen. Both are productivity measurement instruments used to measure craftsmen's time spent on various activities. The differences between WS, CQS, and CQ are compared item by item in Table 1 and Table 2.

Research Strategies.—CQS is theoretically implementable but still needs to be empirically verified. To verify the feasibility and efficiency of CQS empirically, a nuclear power plant construction site that has a regular WS program was selected and accessed. The site had a work force of about 4,000 people with 62% project completion. The strategy is to run both CQS and WS at the same time and on the same tradesmen so that a comparison of both results could be made. The hypothesis is that if the results of CQS are equal to those of WS and the time necessary to conduct CQS is much less than that for CQ, the new system may be an efficient one since it has the same reliability as WS, is more informative than WS, and produces less interruption than CQ. Less interruption

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means less cost. Furthermore, CQS allowed a participatory relationship rather than an adverse relationship with the craftsmen, which occurs with WS.

Definition of Work Activities.—There are five categories of work activities defined in the WS program of the selected site. They are direct work, set-up, support, standby, and personal.

In order to enable comparisons between CQS and WS, to keep the contents that CQ intended to investigate, and to avoid disturbing the existing WS program, five compatible activities are listed or categorized on the questionnaire filled out by craftsmen in CQS. Appendix I describes the questionnaires and the five categories. They are direct work, support work, traveling, waiting, and unrelated work. Direct work refers to "hands-on" activities, which craftsmen are physically involved in by using their trade tools and which can add to the plant being constructed. Examples of direct work are a carpenter driving a nail, a welder welding a pipe, or an electrician pulling a cable. Support work refers to work that does not directly add to the permanent plant but which is essential to advance the physical completion of the plant, e.g., necessary carrying of parts or tools, supporting other craftsmen by holding the material being handled, performing general clean-up, or holding a ladder for another. Traveling is defined as activities in which craftsmen are moving from their immediate work area to or from another area in order to accomplish or get something. This category does not reflect whether the craftsman is empty handed or not. Examples of traveling include getting material at a location away from the immediate work area, traveling to an engineer's office to get information, or traveling to a foreman's office to get approval for requesting tools. The emphasis in this study is on unnecessary moving that can be prevented if work is well-planned prior to job assignment. Waiting is the situation in which craftsmen are available for and ready to work but are not working because they are waiting for an inspection, instructions, materials, tools, equipment, a drawing interpretation and other engineering information, or because of the delays from congested work areas, other crews' interference, or any unexplained waiting. Unrelated but necessary activities include safety meetings, training sessions, union business, personal breaks, unexcused breaks, or doing personal business.

The work sampling program used by the selected site categorizes direct, set-up, and support as productive activities, and standby and personal as unproductive. In contrast, CQS classifies direct work and support work as productive activities. Waiting, traveling, and unrelated necessary activities are grouped as unproductive activities.

There is little difference of definition in productive work between the two methods, except that moving materials and tools from yards to work locations is tallied into the productive category of support work in WS, while this type of movement is treated as unproductive traveling in CQS. Nevertheless, the definitions of productive activities for both CQS and WS are comparable.

In addition, the category of delay is nominally included in the category of personal in the WS program of the site selected. However, delays usually are tallied into the category of standby in the WS practice at the selected site because it is difficult to differentiate delay from standby.

The category of standby in CQS is treated as supporting activities if the craftsmen's standby consists of waiting for their partners to finish work so that they can proceed to the next step. However, if the craftsmen indicate that they were on standby for a rest after doing hard work (e.g., welders taking a break to cool off after a long welding session), this standby would be counted as unrelated but necessary and would be comparable to the results of WS. Therefore, the category of standby in WS has the same definition as the category of waiting/standby in CQS.

The personal category in WS covers the same activities as the category of unrelated but necessary in CQS.

Error Sources.—Randomness is critical to the success of statistical inference. To ensure randomness, every craftsman must have an equal opportunity to be included in the sample. The procedure of WS stipulates that the sampler, while walking around the construction site, must observe the craftsmen at random times.

To ensure that there is maximum randomness, a computer program was employed to generate random times and walking routes for WS samplers in the selected site. Similarly, this portion of WS procedure was adopted in the CQS study.

While walking around the construction site, the CQS administrator randomly selects a foreman at a random time and then asks the chosen foreman to gather all the craftsmen of his crew to participate in the questionnaire survey. The random selection of a foreman implies that each foreman's crew has an equal opportunity to be selected to represent the whole work force of the project at any random moment. Consequently, the basic unit of sampling in CQS is a crew instead of a craftsman, as in WS.

According to the theory of probability, every craftsman in the selected crew can be considered to have an equal chance to be selected if every crew in the project has equal size (6,11). This can be interpreted to mean that every craftsman has an equal chance to represent the whole workforce if the size of crew under every selected foreman is equal. In other words, the basic unit of sampling is still a craftsman, not a crew. However, the assumption to have equal crew size is hardly met in reality since crew size varies with different trades, assigned tasks, and projects. The project selected for implementing CQS in this study had crew sizes ranging from 4–12. Although this may cause some variation in the final results, these variations are minor and can be ignored in a practical sense.

The major defects of the Work Sampling method are the difficulties in clearly discerning various predefined work activities by the sampler who is an outsider. To overcome these defects, CQS is designed to ask the craftsman to discern the activities he was just involved in himself. Since the craftsman is closest to the work and manually performs his assigned tasks, he should be able to discern the work activities better than the sampler does. However, there are various work activities in the CQS questionnaire. The CQS administrator may have difficulty describing clearly the definitions of these various work activities in the short introduction when he explains to the participants how to proceed through the questionnaire. Every craftsman may have different perceptions regarding the definitions of work activities, which may affect the creditability of the data.

Data Collection.—The CQS was continuously conducted from February 6–11, while Work Sampling was run on February 8 and 11, respectively. Thirty-five crews, accounting for 279 craftsmen, were randomly selected to participate in the CQS survey. And 3,990 craftsmen were observed in the survey of Work Sampling. Three trades were selected for participation in both CQS survey and WS. They are carpenters, electricians, and pipefitters.

RESULTS

Comparison of Percent Losses.—Table 3 shows the results of CQS from February 7–11. Since these results differ from the results of work sampling shown in Table 4, it is difficult to make any conclusions.

Two research teams conducted the CQS survey from February 7–11, 1983. The first team covered February 7 and 8, while the second team finished the rest of survey. A brief oral introduction was made before processing the CQS in order to motivate the participation and cooperation of craftsmen and foremen. During the introduction, the first research team emphasized that the respondents needed to circle the activities that they engaged in right before they participated in the survey. If there were any activities such as waiting/standby, traveling or unrelated, these needed to be honestly indicated. However, the second team shifted the focus to encourage the respondents to comment on their work freely. Consequently, the data obtained for these two teams are obviously different. Table 5 shows that the first team has higher percent-

TABLE 3.—Results of Craftsman Questionnaire Sampling from February 7–11, 1983

Categories (1)	Frequency on each Date 2/7 (2)	2/8 (3)	2/9 (4)	2/10 (5)	2/11 (6)	Total frequency (7)	Cumulative (8)	Percentage (9)	Cumulative percentage (10)
Active/direct work	48	31	42	24	20	165	165	59.1	59.1
Support/help	7	5	4	5	5	26	191	9.3	68.4
Traveling	13	5	2	4	4	28	219	10.0	78.4
Waiting/ tand-by	16	17	11	6	2	52	271	18.7	97.1
Unrelated	4	2	1	1	0	8	279	2.9	100.0

TABLE 4.—Results of Work Sampling on February 8 and 11, 1983

Categories (1)	Percentage (2)	Cumulative percentage (3)	Frequency (4)	Cumulative frequency (5)
Direct work	28.3	28.3	1,129	1,129
Set-up	16.5	44.8	658	1,787
Support	17.8	62.6	709	2,496
Stand-by	24.5	87.1	979	3,475
Personal	12.9	100.0	515	3,990

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TABLE 5.—Results of Craftsman Questionnaire Sampling on February 7 and 8, 1983

Categories (1)	Percentage (2)	Cumulative percentage (3)	Frequency (4)	Cumulative frequency (5)
Direct/active	53.4	53.4	79	79
Support/help	8.0	61.4	12	91
Traveling	12.2	73.6	18	109
Waiting/stand-by	22.3	95.9	33	142
Unrelated	4.1	100.0	6	148

TABLE 6.—Results of Craftsman Questionnaire Sampling on February 9–11, 1983

Categories (1)	Percentage (2)	Cumulative percentage (3)	Frequency (4)	Cumulative frequency (5)
Direct/active	65.7	65.7	86	86
Support/help	10.7	76.4	14	100
Traveling	7.6	84.0	19	119
Waiting/stand-by	14.5	98.5	2	121
Unrelated	1.5	100.0	10	131

ages of waiting/standby, traveling, and unrelated activities than the second team's (Table 6). The second team's data have more comments about the respondents' work. These data have extremely low percentages of waiting/standby, traveling, and unrelated activities in comparison with that of WS at the site selected. These different data gathered by the two research teams demonstrates that the administrators' introductions have an impact on the data provided by the respondents. Therefore, if one compares the first two days' results of CQS in Table 5 with those of WS (Table 4), two significant points can be addressed as follows:

1. The standby category is counted as 24.54%. According to the t-test, this result is equal to the 22.3% results in WS at Alpha = 0.05 level.
2. The work sampling method categorizes direct work, set-up, and support as productive activities. In other words, the results represented in three categories in WS are represented in two categories in CQS. The percentage of productive activities is 62.56 in WS and 61.4 in CQS.

Although the WS method defines "moving materials and tools from yard to work locations" as a productive activity while the CQS method counts this as an unproductive activity, it can be argued that these two figures (62.56% versus 61.4%) are equal in a practical sense.

Estimates of Percent Losses in Rework.—Rework refers to redoing the same work twice or more. It includes the activities of a craftsman who removes or requires work-in-place because of either a change order or noncompliance with the plans and specifications. Since craftsmen's previous efforts and time are wasted, rework is thus considered to be an unproductive activity and indicates a need for attention. Also, it has an adverse effect on morale and productivity. In CQS, after the craftsman's determination of his involvement in productive activities, he is asked to indicate whether his work is rework or initial work. Thirty-two out of 279 craftsmen responded that they were engaged in rework in the CQS study, which is 11.47%. This result is almost equal to the 10.11% losses obtained from parallel experiment, in which a regular Craftsmen Questionnaire survey was conducted to examine the validity of CQ (5). Meanwhile, a *t*-test showed that there is no difference between 10.11% and 11.47% at Alpha = 0.05 level.

Estimation of Absenteeism.—While implementing CQS, if any craftsman is absent, the foreman is asked to indicate the number of the absent craftsmen who are on vacation and leave with any excuses which cannot be counted as the craftsman's work hours on his pay check. Fourteen out of 279 craftsmen were reported absent in CQS survey, which is 5.02%. This result is comparable to the 4.4–10% absenteeism rate provided by the management at the site selected. The absenteeism rate were 4.4, 5.3, and 10%, respectively, for electricians, pipefitters, Civil, and labor in February 1982. The absenteeism rates, provided by management, were derived from the computation with the paid manhours divided by total employed manhours.

Advantages and Disadvantages

Advantages of CQS.—Comparing CQS with CQ, the first advantage of CQS is that it saves a great deal of time. In CQS, the questionnaire is filled out at the craftsman's work spot instead of calling him into a main office or a classroom. Approximately one-half hour traveling time is saved. Meanwhile, the checklist style of questionnaires takes only about 2–5 min for each craftsman to fill out.

The second merit is that CQS is more reliable. The craftsman is asked in CQS to recall the activity he was involved in for the past few seconds instead of for the past weeks, months, or years, as in CQ. The reader should be aware that the craftsman may not necessarily recall an activity from the immediate past, but may instead recall work done immediately prior to the time that the foreman assembled the crew and the administrator introduced the survey.

Third, CQS takes advantage of foreman's knowledge. The foreman is invited to join the survey in CQS. The survey does not separate the foreman from his crew, which CQ may require. The foreman's participation may motivate his awareness of the latest problem that his crew has, which would benefit the project.

Fourth, CQS may be a more useful monitoring tool. Just like WS, CQS can be implemented on a daily basis as a diagnostic tool and can provide chronological information e.g., "to date" or "this period," to help construction management to control the site construction. In contrast, the CQ cannot provide that type of information.

In contrast to WS, CQS has two favorable points. First, CQS is more comprehensive and provides information regarding the administrative causes behind waiting, traveling, and regarding the distinction of rework. WS only gives an overall picture of how the craftsman's time is being utilized in these activities. Second, CQS invites the craftsmen to share their experience and knowledge. CQS is a "bottom-up" method,

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which provides an opportunity for the craftsmen to discuss their jobs in writing. CQS creates a participatory atmosphere, which may bring job satisfaction and motivation to the craftsmen. On the other hand, WS is a "top-down" method, which is usually suspected as a tool for management spying. This problem is illustrated by the fact that the CQS study was resisted by the work force at the beginning of the present study, although many foremen and craftsmen expressed their support after the CQS study.

Disadvantages of CQS.—The CQS was developed to minimize the interruption of on-going activities while performing the CQ. Based on the site selected, it took about two minutes to introduce the purpose and procedure of the CQS to the craftsmen, two minutes for a craftsman to fill out the questionnaire, and 2–45 min for a foreman to gather his whole crew. Although this time is much less than that needed to process CQ, CQS still creates considerable interruption if gathering the whole crew takes 45 min. Second, another concern is that CQS does not provide as much information as the CQ. The craftsman is only asked in CQS to pinpoint what type of administrative problems make him wait, travel, or perform rework at the site (e.g., due to material delays), etc. However, the craftsman can supply further information regarding the causes behind those problems in the CQ. For example, one craftsman indicated that he was waiting for material delivery in CQS. If the CQ were given to the craftsman, he might indicate that he was waiting for material since its delivery was not arranged prior to the job assignment. Moreover, he might suggest some ideas to solve this problem. Obviously, the CQ isolates the problem more specifically than CQS does.

Third, in CQS, as previously mentioned, the information provided by craftsmen can be influenced by the administrators' introductions.

Fourth, the practice of CQS still causes more interruption of on-going construction compared to the WS method. However, it is a trade-off between "more further information" and "a little interruption." If the managers need further information with the same reliable data provided by the WS, it is highly possible that he will implement CQS even with the added cost of interruption.

Recommendations for Future Studies

The CQS still causes a considerable interruption by the necessary gathering of the whole crew to process the questionnaire. Nevertheless, alleviating this problem is still feasible. Based on the experimental studies of CQS at the selected site, if the CQS sampler met the same randomly selected crew twice, introduction of the survey's purpose and procedure would not be necessary. The time needed to fill out the questionnaire would be approximately 30 sec. Meanwhile, the craftsman in this randomly selected crew would not need to wait until the foreman gathered all of the crew before filling out the questionnaire. The time to gather the whole crew would be eliminated. Therefore, in the future, if the purpose and procedure can be fully understood by the craftsmen in advance, the interruption would be minimized.

Second, for obtaining in-depth information, the follow-up questions, which ask craftsmen to identify the root causes behind administrative

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delays in CQ, can be added to the back page of questionnaires that are filled out both by craftsmen and foremen in the CQS. One may argue that this practice would increase the amount of time needed to fill out the questionnaire. In other words, it may interrupt the on-going construction more. However, it is purely a trade-off between more information and more time. If the management needs more information, they should add follow-up questions on the questionnaire. The range and depth of the investigation in CQS may be modified to fit the specific needs of each construction management.

Third, since the respondents' data are vulnerable to the CQS administrator's introductions, a uniform introduction should be given in all applications of CQS. The CQS administrator should ask the respondents to provide honest information so that these data may help both the management and work force to remove any obstacles that impede tradesmen's performance.

Conclusions

Both the Craftsman Questionnaire and Work Sampling have provided a valuable service to the construction industry. However, both methods have drawbacks that demand further improvement. Therefore, a new system called Craftsman Questionnaire Sampling has been developed and tested empirically to synthesize the merits of both WS and CQ and to reduce their drawbacks. CQS combines the essence of simplicity and statistical reliability from WS by sending administrators out to the field and randomly selecting craftsmen to fill out questionnaires. Meanwhile, CQS enjoys the use of the condensed Craftsman Questionnaire as a means of data collection, which supplies information regarding hidden administrative problems causing delays on site. To test the new system, CQS was implemented at a large nuclear power plant construction site. The results of this test were compared to those of WS and CQ, which were performed simultaneously. Although a definitive conclusion of the value of CQS may not be made at this stage, the results of this test were encouraging. Further exploration of CQS is necessary, and CQS may be improved as a formal system in order to help construction managers to monitor and improve site productivity.

Appendix I.—Questionnaire Filled by Craftsman

Directions:

Work from left to right as the lines lead you. Circle the description that best defines what you have been doing for the last 1 minute before you were invited to come here.

- Physically involved in work, other than traveling
  - Active (Direct) work (using the tools of my trade)
    - First time work
    - Rework or repair
  - Support/Help
    - Support other craftsmen
    - Carry tools, materials, etc.
    - Stand-by

- Not physically involved in work
  - Waiting
    - For inspection
    - For instruction
    - For materials
    - For tools
    - For equipment or truck
    - Because of overcrowded area
    - Due to other crew interference
    - For design interpretation or additional engineering information
    - Other ________ ________
  - Unrelated but necessary
    - Safety meeting
    - Training session
    - Union business
    - Personal break
    - Other ________ ________
- Traveling to get (or to do)
  - Information
  - Equipment or truck
  - Material
  - Tools
  - Other assigned task
  - Personal/unrelated
  - Other ________ ________

Appendix II.—Questionnaire Filled by Foreman in Foreman Questionnaire Sampling

1. How many craftsmen belong to the crew?
   __1 __2 __3 __4 __5 __6 __7 __8 __9 __10 __11 __12
2. How many craftsmen are now answering the Questionnaire in the crew's work area?
   __1 __2 __3 __4 __5 __6 __7 __8 __9 __10 __11 __12
3. For the craftsmen not in the work area unable to answer the questionnaire, please answer the following:
   _____ How many on leave, vacation, or excused absent?
   _____ How many absent, unexcused?
   _____ How many away from work area due to?
      _____ Union business
      _____ Attendance at safety meeting
      _____ Performing necessary personal activities
      _____ Attendance at a training session
      _____ Other, please specify ________________
   _____ How many on assignment to get?
      _____ Material
      _____ Tools
      _____ Equipment
      _____ Additional engineering information
      _____ To other work area because another crew was still working in the area the craftsmen were assigned to

____ Other (Please specify and explain why) ______________

____

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