USING QUALITY CIRCLES TO RAISE PRODUCTIVITY AND QUALITY OF WORK LIFE

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ABSTRACT: The participative-creative approach of quality circles, for simultaneous enhancement of productivity and quality of work life, has been introduced in many leading manufacturing and service corporations in the West within the general trend of adopting so-called Japanese managerial approaches. The construction industry, however, by and large has failed to use the potential of this powerful approach, apparently due to the mismatch commonly seen between the participative, long-term, people-building process of quality circles and the "hostile" environment of the construction industry, which features instability, temporary employment, and an ever-changing work setting. This paper presents a counterintuitive hypothesis arguing that construction also features several unique conditions that impart special merit to the quality-circle approach: The combination of low initial efficiency and dynamic, multiphase projects guarantees a continuous flow of significant and challenging problems for treatment by the circles, while the authority of site managers to implement significant modifications without further approval can save the frustration observed in many quality-circle programs. The main part of the paper deals with actual field treatments. Findings are presented in statistical terms as well as in case studies and benefit/cost analyses.

INTRODUCTION

Low productivity has been a problem common to most construction industries in Western countries over the last few decades. At the same period, a successful "Japanese" approach to human resources, the approach known as quality circles—which was introduced in Japan by U.S. consultants after World War II—made major inroads in many manufacturing and service industries in the Western Hemisphere, but somehow failed to take root in the construction industry. There is apparently a marked mismatch between the quality-circle approach, which relies on a long-term, participative, people-building process, and the construction industry, which is characterized by unstable environments and work force. Despite this, a counterintuitive hypothesis led the writers to believe that quality circles may succeed at construction sites, even more than in other work settings.

This paper reports on a study (Rosenfeld et al. 1986) that examined the applicability of the quality-circle approach to construction sites, in a program launched by the Israeli National Building Research Institute, Haifa, Israel, for raising construction productivity and safety. In addition to theoretical analysis and personal interviews, this study relied on actual experiments in the field—each four to 14 months long—designed and closely monitored by the writers, with systematic treatment accompanied by pre- and postintervention measurements. The study resulted in empirical findings, which

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quite reliably indicated that the quality-circle approach can be harnessed to improve both productivity and the quality of work life at construction sites.

Quality Circles—A Brief Background

A "quality circle" is basically a small group of employees from the same working environment that meets regularly to identify and analyze work-related problems or deficiencies, suggest solutions, and implement them. Typical quality circles meet for 1 hour per week, either during working hours or afterwards, on paid time. Participation is voluntary, but regular attendance is essential to the process.

The following is a very brief introductory background on quality circles: their history, philosophy, techniques, and uniqueness. Readers are referred to one of the many guidebooks for further details, e.g., Dewar (1980), Gryna (1981), Gibson (1982), Robson (1982), or Barra (1983).

The origin of participative productivity improvement programs can be traced back to the famous Scanlon plan in the United States during the 1930s (e.g., Lesieur 1958). However, the participative problem-solving concept, known nowadays as quality circles, had been conceived in Japan during the 1950s by two American consultants—J. J. Juran and W. E. Deming. They devised the quality-control-circle concept as one component of a broader integrated quality management campaign to cope with the low-quality reputation of Japanese products in those days. During the 1960s it had been developed, refined, put into practice, and institutionalized nationwide. Since then, the quality-circle approach has been gaining enormous popularity in Japan and elsewhere around the world. Where properly implemented, it has proved not only instrumental in improving quality-related issues but also very effective in solving problems of production, waste reduction, resource use, and safety, as well as problems of social and human nature. Their original name, quality control circles, has been shortened to quality circles, with the term *quality* given a wider interpretation, adding quality of work life to product quality.

The vitality of quality circles stems from their people-oriented and team-building approach. They recognize the ability and potential of each individual to make contributions to a team effort, either by generating ideas or at least by improving ideas offered by other team members. All members are personally involved in setting goals of higher achievement and jointly seek to devise ways of smarter and more efficient work; at the same time, they build their personality and create for themselves—and for their peers—a better physical and social working environment, thereby enhancing the total quality of their work life.

The structured cyclic process in a typical quality circle usually takes several months, and includes the stages presented in Fig. 1.

Each circle has a leader, mostly the foreman or the senior member in the group, who acts as chairman and as a communication link. Basic training

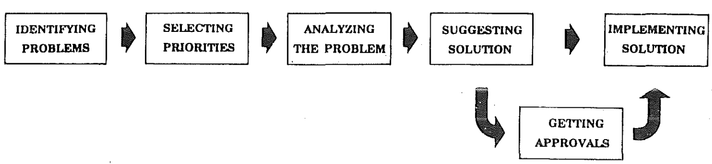

FIG. 1. Typical Quality-Circle Process

for regular members is provided by either the leader at the first few meetings or professional instructors in larger forums. It includes basic techniques for identifying and analyzing problems with the aid, whenever possible, of participative and creative approaches. The most common quality-circle techniques are:

- Brainstorming.
- Cause-and-effect diagrams.
- Data collecting and processing techniques.
- Histogram and Pareto analyses.
- Management presentations.

These techniques inherently encourage, and actually necessitate, participation and involvement by all members. The basic philosophy is that the people who do the job daily are best able to spot and correct its deficiencies, given the proper atmosphere and stimulation to induce them to speak up and apply their creative thinking.

Quality circles had been designed to provide such a framework, along with proven problem-solving techniques. They have at least three unique characteristics compared to other participative approaches:

1. The members of each circle are not delegates of different groups, but rather people who know each other well from day-to-day experience.
2. The issues are actual work-related problems familiar to all circle members, so that everyone has something to say about them.
3. At the end of each cycle, participants implement their own ideas and suggestions (either directly or after a management presentation and approval procedure); they thus gain enormous intrinsic satisfaction, recognition, and pride, which in turn reinforce their commitment to seek visible improvements.

These unique features of quality circles combined with the social status and ceremonial symbols provided for participants, plus the backing of a permanent staff of facilitators, coordinators, steering committees, and others, ensured quality circles long-term viability in Japan (Hull and Azumi 1988) and good prospects elsewhere.

A quarter of a century had elapsed before this effective approach showed up back in the United States as a "Japanese" technique. During the late 1970s quality circles were formed by leading corporations in manufacturing and service industries, and experienced phenomenal growth during the 1980s, following the establishment of the International Association of Quality Circles in 1977. Since the mid-1980s about 90% of the *Fortune* 500 companies in the United States have had quality-circle programs. However, a quick-fix mood and poor introduction, often combined with unrealistic expectations, have led many critics to the impression that quality circles may become, in America, merely another managerial fad (e.g., Wood et al. 1983; Lawler and Mohraman 1985).

Are Quality Circles Suitable for Construction?

As discussed, this was a very difficult question to answer in the near-total absence of precedents. Quality circles basically rely on a bottom-up approach; they were originally formed within stable industrial work settings, where their main mission was to create a framework and encourage apparently apathetic and careless line workers to show more interest and involvement in their work and derive more personal satisfaction from it. Even in Japan, quality circles have not been widely tried among construction workers who, due to their unstable workplace and ever-changing work tasks, appear as mostly unsuited to the quality circles' continuous, multiphase process.

From this conservative standpoint, there are indeed strong doubts with regard to quality circles in construction.

Why Do Quality Circles Seem Unsuitable for Construction?

1. Prototypical nature of construction projects: Unlike manufacturing industries, which produce large quantities of similar products, and unlike most service industries, where people perform limited sets of tasks over and over again, the construction industry usually produces one-of-a-kind large units, in which low repetition obviously negates the multiplicative effect of method improvement.
2. Short-term relevancy of problems: The physical environment of construction sites is highly dynamic: The shape of the constructed facility and the pattern of operations change continuously, and so do the production problems related to them. Apparently the thorough, multiple-stage, lengthy procedure of quality circles cannot fit into the fast-paced environment of construction projects.
3. Instability of the work force: The quality-circle process relies on group dynamics and on development of a team spirit through mutual interaction among individuals. Construction, however, features temporary employment and high turnover, which militate against the quality-circle process.
4. Low benefit-to-cost-ratio: Doubts and questions may be raised as to whether construction workers are capable of generating sufficient valuable and implementable suggestions to justify the effort, time, and money needed to establish, run, and maintain quality circles.

These and other considerations point to a priori rejection of the idea of quality circles at construction sites. Yet conversely, some other arguments listed in the following—given some minor departures from the original pattern of quality circles—indicate fairly good prospects in construction.

What Gives Quality Circles Special Merit in Construction?

1. There is low initial efficiency: Unlike manufacturing and service processes that usually are carefully preplanned in great detail, the construction process is usually planned only in general terms, while the details of operations are left to site superintendents and foremen. This common practice makes for low initial efficiency, which in turn creates many opportunities for modifications and improvements on site. Thus, quality circles in construction are almost guaranteed to come up with meaningful results.
2. Every construction project carries new challenges: Even if initial attempts had been made to plan the construction process properly, local conditions often create new problems and new opportunities for modifications and improvements on the spot. This feature of construction likewise indicates that quality circle may come up with fruitful results, even in routine projects.
3. Although construction projects are prototypical, construction operations

are repetitious: In spite of the previous argument that each construction project often produces a singular, one-of-a-kind product, they still comprise many similar components. Method improvement through quality circles in a specific operation may pay off even if applied in one project, while the improved method usually is likely to be adopted, at least partly, at other projects as well, with the attendant long-term effect on productivity.

4. The quality-circle process spots problems early: The time factor is so crucial in most construction operations that a simple but timely solution is preferable to a perfect but late one. Quality circles are instrumental in accommodating this dynamic nature of the construction site, since the whole cycle, from spotting a problem to implementing the selected solution, can be completed within one or several meetings.

5. There already is authority for implementation: In most nonconstruction work settings, quality circles can only make recommendations, which have to be examined and approved elsewhere, so that many good ideas often dissolve or decay in the bureaucratic network. In the construction work setting, however, the site management usually has the power to make independent decisions on most changes in construction method without need for approval. Such unique opportunity of making most ideas a reality almost instantaneously is another argument for implementing quality circles at construction sites.

To sum up, there are at least as many arguments for quality circles in construction as there are against them, each with its own logic. Theoretical analysis and even assessments through questionings and observations have low validity; thus, the only way to obtain a realistic appreciation as to whether, to what extent, and under what conditions quality circles may succeed in construction was through experimental application in real field settings, with pre- and postintervention measurements.

PRE-EXPERIMENT PREPARATIONS

Possible Organizational Levels for Experiment

On the one hand, thorough study of available quality-circle literature yielded a diagnostic insight and understanding of the major factors that make quality circles in general succeed or fail; on the other hand, close familiarity with and practical experience in the construction industry made it possible to recognize the aforementioned features of this industry favorable for quality-circle applications. Combination and synthesis of these two sets of knowledge resulted in a tailor-fit quality-circle program for the construction industry at three hierarchical levels:

1. The work-group level, where workers meet regularly with their immediate superiors (foremen) to discuss and solve work-related problems; they may follow the regular quality-circle scheme presented in Fig. 1, at an accelerated pace.
2. The site-management level, where the construction project manager, site engineer(s), superintendent(s), and foremen of the major trades meet regularly to discuss issues that concern the site as a whole, such as schedule, construction methods, coordination among trades, analyzing and overcoming delays, working conditions, morale problems, quality of work, and safety.
3. The firm level, where midlevel and senior managers from company headquarters periodically meet with project managers to discuss, in a quality-circle–like manner, issues and problems of common interest, such as company policies

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and procedures; supply practices; subcontracting guidelines; manpower and equipment allocation; coordination and negotiation with designers, clients, and owners; and performance evaluation. They can also deal with specific technical and organizational problems of a particular project, for which the cumulative experience of all participants can be applied in the search for working solutions.

Determination of Most Promising Level

This wide range of possibilities was too ambitious for simultaneous investigation. Limitations of time and resources dictated a selection process of the experiment topics through preassessment of their chances of success. It was hypothesized that, in a certain organizational and social climate, and at certain hierarchical levels, quality circles might be more effective than at others. A selected panel of experts—25 experienced senior executives in the construction industry—was highly instrumental in channeling the first experiments in the apparently most promising direction. They were given a short written and oral introduction to quality circles in face-to-face interviews and asked to assess their suitability and effectiveness at the aforementioned three levels.

The main results of this survey are summarized as follows:

1. Ninety-two percent of the experts shared the view that quality circles are feasible in construction and should not be rejected a priori. Contractors, project managers, superintendents, and foremen are generally expected to cooperate in implementing them.
2. Somewhat surprisingly, all 25 interviewees shared the opinion that simple construction line workers are not the right organizational stratum to start with; they perceived the typical line worker to be a person unable and/or unwilling to contribute to quality-circle–like processes. (Further investigation is needed to determine the causes of this common view and what could be done about it.) Most of them predicted far greater success at the site-management and firm levels.
3. Eighty-four percent of the experts shared the view that field managers are key persons for any program aimed at improving productivity and morale at construction sites, and that most efforts be directed at them.
4. All interviewees were positive about considering one or more experimental circles in their own companies.

The generally positive response of the experts and their strong preference of the site level—on top of the initial reasoning regarding the pros and cons in the preceding section—dictated the following course of experimentation.

Experiment Program

The pioneering character of quality circles at construction sites necessitated a careful stepwise approach. It appeared imperative to run a pilot circle first, with a view to gaining some experience and learning preliminary lessons in preparation for the main program. Accordingly, the experiment was planned in two consecutive stages: a pilot circle followed by three more circles (all at the site level).

A basic training program was put together in advance, to be presented—during the first four or five meetings of each circle—by the first writer, who assumed the role of facilitator.

Each circle comprised the following members: construction project manager, site engineer, project superintendent, and two to four foremen of the major trades on site.

An important consideration in selecting sites for the experiments was the desire to cover versatile construction projects, social settings, and personal attitudes of the participants to assess the influence of such variables on the effectiveness and progress of the circles. Project characteristics included type, size, complexity, repetitiveness, and duration, while group characteristics of the participants included task orientation versus people orientation, initial degree of enthusiasm, relationship and communication with higher management, and degree of support provided at the top.

Although there were no illusions about the ability of these experiments to isolate, examine, and control so many variables, it was assumed that they would at least yield some indicative conclusions.

Prior to implementation, a checklist of 43 criteria was prepared for evaluating the influence of quality-circle activity on monetary issues as well as on less tangible human issues. These were grouped within the following categories: labor, materials, equipment, other performance aspects (e.g., schedule, quality, and safety), effects on the organization (e.g., communication, involvement, motivation, climate, and image), effects on job characteristics (e.g., responsibility, enrichment, and importance), and effects on individual participants (e.g., self-growth, recognition, interest, satisfaction, and status).

In addition, two sets of questionnaires were prepared: one for preintervention condition assessment as the candidates themselves evaluated it, and the other for postintervention condition assessment by the same people to evaluate achievements and other results.

Characteristics and Functioning of Experimental Circles

The following is a narrative description of the experimental circles, followed by a more formal quantitative assessment of their characteristics and functioning, as presented in Tables 1 and 2. Initial candidate projects for the experiment were offered by members of the expert panel. In view of the excess of nominees for the four planned circles, there was considerable freedom in selecting the experiment subjects. Basic terms included a requirement to remain at least three months on the project, initial management support for the program, and voluntary participation of all circle members. Within these basic terms, the sequence of the circles reflected gradual deterioration of the opening conditions.

Circle 1 started with a feeling of success due to strong and direct management support and encouragement; a complex project with vast opportunities for improvements; and a highly motivated, goal-driven team, with good interpersonal relationships.

Indeed, circle 1 smoothly absorbed the quality-circle concepts and techniques, and achieved significant results. This pilot circle proved that quality circles are feasible and can function at construction sites.

Circle 2 took place in a totally different organizational climate, namely that of a publicly owned, large, unionized construction firm afflicted with productivity problems. While top management supported the formation of an experimental quality circle for this particular "flag project," the regional branch manager merely accepted the initiative but did not support it actively. The project manager on site, however, got excited by the quality-circle participative problem-solving concepts, which fit into the people-oriented

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TABLE 1. Project Characteristics

Characteristics (1)	Circle Number (2)	(3)	(4)	(5)
Type of project	Industrial	Commercial	Office	High Tech research & development
Average number of employees directly supervised by the circle team	60	80	60	50
Duration of team's stay on site (months)	6	36	12	4
Project uniqueness (1 = very routine, 5 = very unique)	4	3	2	5
Project complexity (1 = very simple, 5 = very complex)	4	3	2	3
Quality of preconstruction planning (1 = improvizations on site, 5 = detailed preplanning)	4	3	3	5
Flexibility of work methods (1 = fixed, unchangeable, 5 = flexible, open)	5	3	2	2
Repetitiveness of operations (1 = very low, 5 = very high)	4	5	2	4

TABLE 2. Circle Characteristics

Characteristics (1)	Circle Number (2)	(3)	(4)	(5)
Number of participants	6–7	6–7	5	4–5
Length of controlled experiment (months)	6	>12	4	4
Task orientation of circle members (1 = very low, 5 = very high)	5	3	3	4
People orientation of circle members (1 = very low, 5 = very high)	4	5	3	2
Circle's enthusiasm (1 = very poor, 5 = very good)	5	4	3	3
Management's support for circle (1 = very weak, 5 = very strong)	5	2	4	4
Communication between home office and site (1 = very poor, 5 = very good)	5	2	3	3
Management's performance concern (1 = very low, 5 = very high)	5	3	4	4
Management's people concern (1 = very low, 5 = very high)	4	2	3	3

atmosphere of his superintendent and foremen. As a team they showed only moderate concern for productivity and efficiency, since they could not expect from their superiors in this organization any special recognition, appreciation, or rewards for special achievements. Project characteristics were not encouraging, either; construction methods were quite conservative, leaving little scope for dramatic improvements.

In these circumstances the achievements of this circle were really surprising, since the main impetus that kept it going was the members' enjoyment of the teamwork process and the personal satisfaction they derived from the results. In fact, their intrinsic motivation and group dynamics sufficed to continue the circle's activity on their own for over six months after termination of the experiment.

Circle 3 began with even worse opening conditions: It enjoyed neither the strong task orientation and favorable project characteristics of circle 1 nor the group cohesiveness of circle 2. The project was routine and simple with few challenges. Prior to establishment of the circle, its members used to perform their jobs individually with minimal interaction. Management support here was stronger than in the case of circle 2, but weaker than in that of 1. In almost all respects, it was a typical mediocre case. In the preintervention interviews, the intended circle members did not express enthusiasm for the quality-circle process at their site, and did not expect any significant consequences. They agreed, however, to give it a chance—just to please their boss, who advocated the experiment—on the consideration that they did not stand to lose anything by trying it.

Nevertheless, even this mediocre circle produced important achievements. However, due to the long periods of routine operations, their excitement showed signs of waning as the significance of the problems declined.

Circle 4 involved the same firm and the same regional branch as 3, but the characteristics of this project were quite different. It was a unique, high-tech, light-industry facility with a fast-track schedule, using innovative, nonconventional, and thoroughly planned construction methods. In these circumstances nobody in the preintervention interviews expected that a quality circle (or any other technique) could substantially contribute to its productivity and efficiency. Although the team agreed to the experiment (for the same reasons as in the case of circle 3), everybody was sure that it would run out of problems after a few meetings.

This circle demonstrated that there is almost no limit to creative improvements, once motivation for them exists—as in this case, where the team was offered bonuses for earlier completion of the project. This common goal was perhaps the key to the success, since it helped the members overcome deeply rooted personal differences and frequent disagreements, thus becoming a creative and productive task-oriented team. The participative decisionmaking introduced through the quality circle created a totally new atmosphere among the members, who recognized the advantages of true teamwork versus the authoritative management style that had prevailed earlier. Instead of endless recriminations and counterproductive arguments about work-related problems, they spotted them, discussed them, and solved them in a friendly and efficient manner. Although the circle did not immediately erase the aggravations accumulated over many years, it did initiate a total change in attitude. According to the testimonies of the members in the postintervention interviews after four months of operation, they felt that this was the circle's most important contribution, apart from notable cost and time savings.

Tables 1 and 2 summarize the different characteristics and observations associated with the circles, graded on a scale of 1–5. Although these are not objective measurements, they are still the best available evaluation by a fairly objective observer.

Special forms were prepared for detailed minutes at the meetings, and other standardized forms were used for documentation, photograph cap-

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tions, and economic evaluation of the cases treated by the circles. This material later permitted systematic analyses and statistical processing. Two representative examples are presented in the following sections, which is aimed at providing the reader with the flavor of real-life problems.

A selected set of diverse case studies will be the subject of a separate paper.

Two Representative Examples

Example 1

This example concerns an achievement of circle 2. At a routine brainstorming session of the circle, the ironworkers' foreman hesitatingly brought up the issue of repeated complaints by his men of fatigue due to hard physical work, as well as of their failure to earn bonuses in this project: They were barely meeting the company's quota of 30 man-hours per ton of reinforcement steel placed, while their earlier performances used to be around 20–25 man-hours per ton only. The circle applied a cause-and-effect analysis to this problem, and soon discovered that the most likely cause of both undesirable effects (fatigue and no bonuses) lay in the particular arrangement of the reinforcing steel in the typical reinforced concrete waffle slabs of the project. Fig. 2 illustrates the problem in a series of photographs: Fig. 2(*a*) is the bottom view of a typical waffle-slab section, which repeats itself at over 20,000-m^2 (250,000-sq-ft) floor area of the 22-story building [Fig. 2(*b*)]. Fig. 2(*c*) shows the forms for these waffle slabs, made in standardized plastic units, with the reinforcement in place. Heavy steel bars, 25 mm (1 in.) in diameter, have to be placed in the channels over stirrups at 20–25-cm (8–10-in.) spacing. There was no problem laying these bars in one direction of the crosswise channels, but in the other direction the bars had to be threaded one by one through the blocked intersections, with all the inconvenience this entailed.

Once the circle spotted the problem, it concentrated on finding a solution that would dispense with the threading. After several rounds of suggestion, trial, evaluation, and modification jointly concerted by the site engineer and the ironworkers' foreman, it arrived at the simple solution presented in Figs. 2(*d*) and 2(*e*). A special shape was devised for modular steel "cages" that were preassembled on site at the weather-sheltered garage level of the building, then hauled in piles by crane directly to the current floor and spread over the forms. These cages replaced the multiple rims and served as the lower reinforcement for the ribs of the waffle slabs, while leaving the channels open in both directions for the heavy longitudinal steel bars.

The consequences of this improvement reached far beyond the original intentions, resulting in a whole array of direct and indirect benefits:

- Instead of spending a whole week placing, tying, and threading the steel bars, the same crew accomplished the same work in less than one day. Thus, about 16,000 man-hours were saved on reinforcement at this project alone (not to mention future projects with waffle slabs).
- The ironworkers were able to earn substantial bonuses by working smarter rather than harder.
- The cage alternative also saved 13 tons of reinforcement steel in this project, compared with the original design.
- The cages could be prepared under any weather conditions, whenever there was no other work to do.

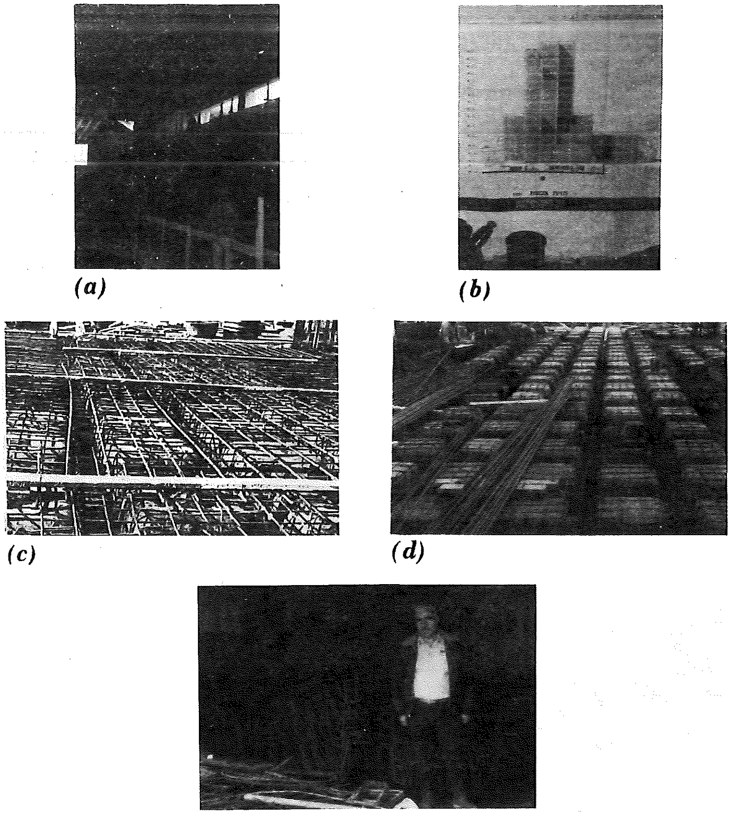


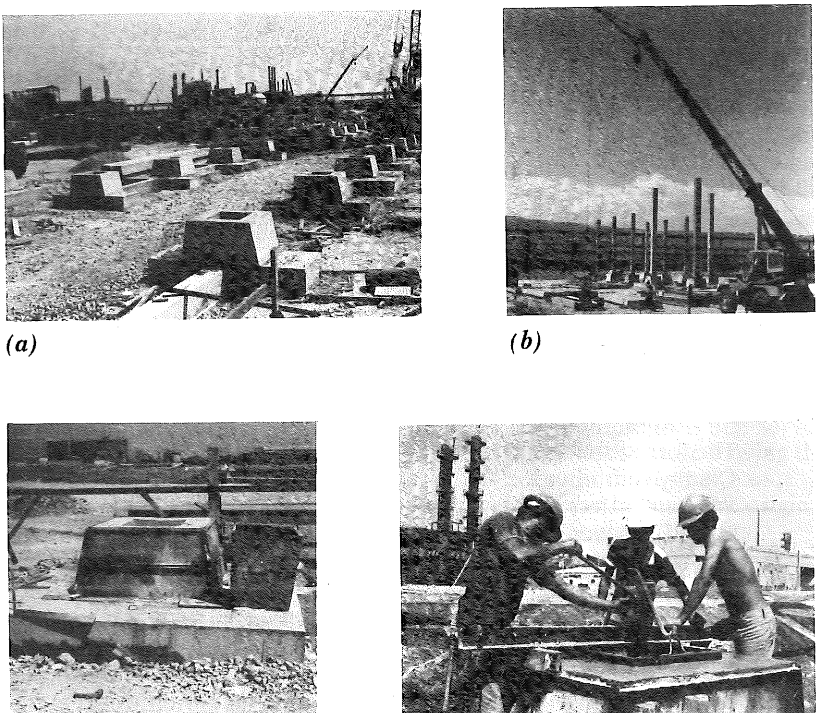
FIG. 2. Example 1: (*a*) Bottom View of Typical Waffle-Slab Section; (*b*) 22-Story Complex; (c) Original Reinforcement Pattern; (*d*) Improved Method, Leaving Channels Open in Both Directions; and (e) Piles of Modular "Cages" Beside Assembling Area

- The forms could be recycled at a much faster pace.
- Quality control of the reinforcement was much better and easier.
- Workers' safety and health were improved (no more back pains and fatigue), as were their morale and income.
- The new method speeded up the construction process and saved at least two months on the critical path of the project schedule.

It must be emphasized that under normal circumstances, the workers' complaints would not have received much attention. At best, the project manager would have recognized the fact that there is more threading here than in the normal reinforced concrete elements, and would have approved some special compensation for the ironworkers. In the case in point, they had already completed nearly half of the waffle slabs, and the only response to their "routine" complaints had been assignment of several unskilled workers to help them from time to time. Everyone involved in this case shared the opinion that only the quality-circle framework, techniques, and atmosphere stimulated and made this great improvement possible.

Example 2

This case, drawn from the accomplishments of circle 1, also demonstrates the multiaspect feature of quality-circle achievements. The project concerned the concrete and steel skeleton of a facility at an oil refinery. The first phase included about 2,000 cast-in-place footings for prefabricated concrete columns [Fig. 3(*a*) and 3(*b*)]. These footings—truncated pyramids—had been cast in specially ordered steel forms [Fig. 3(*c*)]. The inner parts of the forms had to be released within 2–3 hours after casting so as not to be stuck in the concrete. The mobile crane shown in the figure had been called for about 1.5 hours every day, to release five of these inner forms, holding up other operations and crews who also needed the crane. Such interruptions were viewed as unavoidable shortcomings of the construction process, and nearly 500 out of the 2,000 footings had already been done with the aid of the crane. Without the circle at this site, nobody would have thought of modifying the existing practice. However, as the quality circle began to look for potential improvements, the issue of the overoccupied crane received attention. The circle members analyzed its typical daily as-



(*a*) (*b*) (*c*) (*d*)

FIG. 3. Example 2: (*a*) Typical View of About 2,000 Similar Footings for an Oil Refinery; (*b*) Prefabricated Beams and Columns; (*c*) Release of Inner Part of Form; and (*d*) Release of Forms Following Improvement, Done by Simple Jack

signments, and soon arrived at the idea presented in Figs. 3(*d*) and 3(*e*). A simple car jack was adapted to release the inner forms quickly and gently, as it also freed a total of 400 hours of the busy crane for other tasks.

While the original motive of this improvement was only better equipment use, it also contributed to product quality (no more broken edges), worker safety (less close interaction with the cumbersome crane), worker morale (less interruptions to other crews), and obvious savings in man-hours and in the overall schedule of the project.

FINDINGS

Table 3 presents a statistical analysis of 47 major cases treated by the four circles. All shared a common feature of having simultaneous effects in numerous improvement categories, although each was motivated by only one category. The top and bottom entries in columns 2–6, show that saving in labor input, for instance, had been achieved in 10 out of 10 cases treated by circle 1, 11 out of 19 cases treated by circle 2, nine out of 10 cases treated by circle 3, and seven out of eight cases treated by circle 4. Altogether, 37 cases (79%) out of the total 47 cases achieved saving in labor input with or without direct intention.

The win-win nature of quality-circle activities is clearly highlighted by comparing, side by side, the percentage of cases motivated by each improvement category (column 7) to the percentage of cases contributed to the same category (column 6). In the first category, as already noted, although only five cases (11%) had been motivated by the labor-input saving consideration, 37 cases (79%) resulted in such saving. Similarly, only 11 cases (23%) concerned complaints of hard work, but in the end a total of 35 (75%) showed work load relief. The ratios between columns 6 and 7

TABLE 3. Statistical Analysis of 47 Major Cases Treated by Circles

	NUMBER OF CASES CONTRIBUTED TO EACH CATEGORY OF IMPROVEMENT					
	In Individual Circles					
Category of improvement (1)	1 (2)	2 (3)	3 (4)	4 (5)	Total in all circles (6)	Number of cases motivated by each (7)
Short-term monetary savings	—	—	—	—	—	24 (51%)
Labor input	10	11	9	7	37 (79%)	5 (11%)
Waiting times	4	14	7	5	30 (64%)	3 (6%)
Equipment use	4	5	5	4	18 (38%)	3 (6%)
Materials/waste	4	8	3	1	16 (34%)	2 (4%)
Project duration	8	8	3	5	24 (51%)	11 (23%)
Nontangible and quality-of-work-life outcomes	—	—	—	—	—	23 (49%)
Quality of work	2	5	2	0	9 (19%)	3 (6%)
Workers' safety	6	3	0	1	10 (21%)	2 (4%)
Communication	2	3	1	0	6 (13%)	1 (2%)
Workers' morale	5	6	4	1	16 (34%)	6 (13%)
Easing hard work	7	14	10	4	35 (75%)	11 (23%)
Total	10	19	10	8	—	47 (100%)

indicate that every single category gained significantly more than it was originally meant to (threefold to tenfold as measured by the number of cases). Column 8 shows that the motives of all 47 major cases treated by the circles are almost equally split among the categories of short-term monetary saving and those of nontangible and quality-of-work-life outcomes.

Benefit/Cost Analysis

Many opinions and discussions can be found in management literature regarding the crucial need for continuous evaluation and reinforcement of quality-circle programs to justify their existence and keep them alive (e.g., Wood et al. 1983; Lawler and Mohrman 1985; Dale and Barlow 1987; Clark and McGee 1988). Yet they generally agree that quality circles should be judged not on their short-term monetary contribution, but rather on their long-term positive effects, which cannot be quantified in dollars and cents. In other words, quality circles must be viewed as a management philosophy, aimed at creating a different work climate that will pay off only in a long-term perspective. Thus, the very legitimacy of short-term benefit/cost analyses is questionable, although they do appear from time to time in quality-circle publications. It is interesting to note that quality-circle consultants and advocates (e.g., Dewar 1980; Gryna 1981) tend to quote high benefit/cost ratios of quality circles averaging in the range of 2:1 to 5:1, while others, mainly academics and critics (e.g., Turban and Kamin 1984; Wood et al. 1985) tend to emphasize the indirect and overhead costs of quality-circles operation, which may reduce such short-term benefit/cost ratios well below 1.0 in many cases.

Nevertheless, evidence from the construction-site experiments justifies the circles by any criterion—even the most rigorous benefit/cost analysis of shortsighted materialist managers, and even with achievements significantly lower than those of the experimental circles. The monetary value of the improvements had been assessed for each of the 47 major cases analyzed above. These assessments were highly restricted, only taking into account direct, tangible, short-term, unquestionable savings, such as labor, materials, and equipment. Even these very conservative estimates, when summed up for each circles, led to an average dollar saving per circle meeting of $5,000–$11,000 in these four experimental circles, while the gross cost of a meeting (including facilitator's time and other overhead items) may vary between $200 and $500 only.

The experiments reported here imply that only major and visible achievements could be properly documented and reported in a reliable manner through reasonable efforts, while many additional contributions of the circles were not included in the statistics, simply because of difficulties in proving how much they saved, especially in cases of potential problems identified and solved before they actually arose. Furthermore, even the cases included in the benefit/cost analysis could be quantitatively credited for their direct first-wave contributions only, although they usually had no less important second- and third-wave effects by spreading ideas both geographically to other projects and timewise to future projects.

Results

There are strong indications that quality circles at construction sites are more vital and less vulnerable to various failure causes that were broadly

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treated after the fad phase of quality circles in the West (Dale and Hayward 1984; King and Tan 1986; White and Bednar 1985; Lawler and Mohrman 1985; Ruffner and Etkin 1987).

Although the four experimental circles differed in many characteristics, all arrived at substantial achievements. It had been observed that both the task orientation and people orientation of the members, as graded in Table 2, contributed to the success of the circle in an additive manner, i.e., they strengthened each other, yet either one sufficed to keep a satisfactory level of performance in the circle. (Motivation and ability, by contrast, have a multiplicative effect on performance; if one is missing, the result is zero.)

Management support (or nonsupport) is considered by most writers as the most crucial factor in a quality-circle program. In this respect, quality circles in construction are not an exception. Members explicitly expected management appreciation and encouragement. Members of circle 1, which received strong management support and recognition, never lost their enthusiasm, while those of the others (especially circle 3, which was mediocre in other respects) experienced ups and downs.

In their postintervention questionnaires, all participants found management presentations either very important (75%) or important (25%). They generally praised the program for its effectiveness in both productivity improvements and quality-of-work-life improvements. Members enjoyed both the process itself and the outcomes. Based on their experience, they advocated similar quality circles at site level as a widespread practice in the construction industry. Not surprisingly, most participants shared the opinion that lower-level circles—line workers and their foremen—would not produce satisfactory results in construction, and were quite reluctant even to try them. The independent opinions of these first-line and midlevel managers agreed with those of top managers in the expert survey. Construction managers, at all levels, apparently neither appreciate the capabilities of simple construction workers nor believe in their willingness to contribute to quality-circle–like processes. Managers, in general, have many additional reasons to feel threatened by quality circles in lower levels, as pointed out by Dale and Barlow (1987).

Physical characteristics of the project (e.g., size, complexity, duration, and pace of work) affected the dynamics of the meetings: Challenging, nonroutine projects proved to be far better subjects for quality circles than those based on conservative, traditional methods. Circles 1 and 4 never ran out of significant subjects for quality-circle discussions, while circle 3 did show a visible decline in its enthusiasm after producing a number of good suggestions, and remained only with insignificant and low-priority items on their problems identification list.

An important theoretical finding is schematically presented in Fig. 4. It illustrates an observation that most likely makes construction projects especially receptive to quality-circle techniques. Typical quality circles at industrial or service work settings usually run out of significant subjects after an initial enthusiastic period of one to two years of operation. Then, in many cases, they fall into a stagnation phase, and sometime later into a decay phase, as Lawler and Mohrman (1987) describe it. In construction, however, changes in activities and in the nature and location of work are so dynamic, that the supply of fresh and significant problems almost never ends. This unique characteristic of construction makes for continued excitement and enthusiasm in the circle. When the team, or part of it, moves

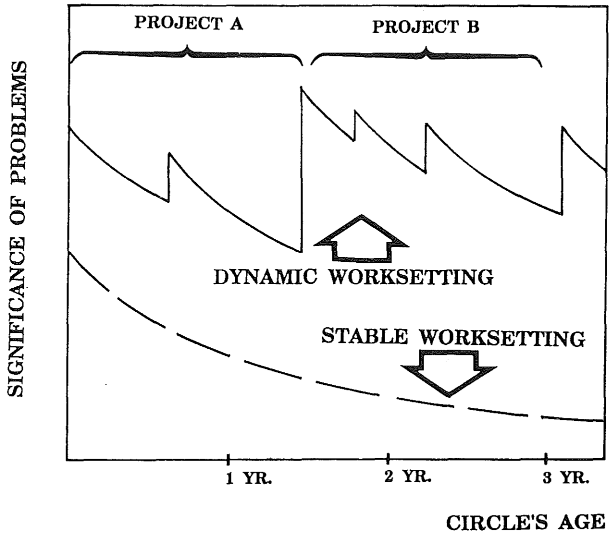

FIG. 4. Decline in Significance of Problems Treated by Quality Circles

to a new project, or when a project moves to a new phase, the life cycle of the circle starts again, and rarely has a chance to reach the decay phase.

Concluding Remarks

Although a limited set of four experiments cannot support definitive conclusions, it suffices for several significant indications about quality circles in construction.

This study focused on the construction-site level, and dealt neither with the lower work-group level nor with the higher firm level. Both deserve thorough investigation. The site level, however, had been identified by the expert panel as the best stratum to start with, and indeed responded very well to the quality-circle treatment in the field experiments.

The most important practical indication of this study is that the quality-circle approach and techniques are highly instrumental in improving both productivity and quality-of-work-life at construction sites. The concept is easily adopted and absorbed by construction managers and foremen, since they are not total strangers to teamwork and participative decision making in their day-to-day work.

We do not advocate blind implementation of full-scale Japanese-style quality-circle programs at Western construction sites. However, we agree completely with Van Buskirk and Adams (1989), who say, "Even if easy adoption of Japanese-style techniques should prove difficult or even inappropriate, understanding and appreciation of our excellent Japanese colleagues can only enrich our management practice."

The inherent dynamic nature of construction projects seems to keep such circles busy with significant and interesting problems most of the time, thus drastically reducing the prospect of their gradual decay and fadeout, as often happens in stable manufacturing and service worksettings.

Methodologywise, this study demonstrates that research methods in con-

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struction should not be limited to theoretical analyses, questioning techniques, and passive field observations or laboratory simulations—all of which used to be justified by limited resources. To reinforce a complex hypothesis with sound evidence, it is also necessary to apply interventive, active treatments in the real field settings. Limited field experiments, with careful preplanning, can be successfully accomplished with moderate research resources.

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