Construction Productivity Awareness and Improvement Programs in Saudi Arabia

by

Muhannad Mahmoud Abu-Asbah

A Thesis Presented to the

FACULTY OF THE COLLEGE OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

CONSTRUCTION ENGINEERING AND MANAGEMENT

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This thesis, written by Muhannad Mahmoud Abu-Asbah, under the direction of his Thesis Committee, and approved by all the members, has been presented to and accepted by the Dean, College of Graduate Studies, in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE IN CONSTRUCTION ENGINEERING AND MANAGEMENT.

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I dedicate this work to my late father.

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THESIS ABSTRACT

FULL NAME OF STUDENT	:	Muhannad Mahmoud Ahmad Abu-Asbah
TITLE OF STUDY	:	Construction Productivity Awareness and Improvement Programs in Saudi Arabia
MAJOR FIELD	:	Construction Engineering and Management
DATE OF DEGREE	:	January, 1994

This study investigates and studies many construction productivity related issues in Saudi Arabia including productivity awareness among construction contractors, applicability of different productivity measurement methods, hindrances of productivity improvement programs, areas and functions which have high potential for productivity improvement, and the possibility of establishing construction productivity improvement programs.

This study reveals the presence of construction productivity problem. The findings of this study further indicate that Cost Reporting and Control System (CRCS)) is the most familiar, popular, and effective productivity measurement method, and that the lack of management support, trained personnel, and awareness are the most important obstacles to Productivity Improvement Programs. Of the Head Office areas, planning and scheduling are found to be of the highest potential to improve productivity regardless of the firm size. Of the site areas, management and equipment areas are of the highest potential to improvement productivity. Productivity Improvement Programs are found to be suited for all projects regardless of their characteristics.

A model, in the form of a flow chart, for establishing Productivity Improvement Programs is developed.

MASTER OF SCIENCE DEGREE

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خلاصة الرسالة

اسم الطالب : مهند محمود أحمد أبوعصبه .
عنوان الرسالة : الوعي بانتاجية التشييد وبرامج تحسينها في المملكة العربية السعودية .
التخصص : هندسة وإدارة التشييد .
تاريخ الشهادة : شعبان ١٤١٤هـ .

هذه الرسالة تبحث في العديد من القضايا المتعلقة بانتاجية التشييد في المملكة العربية السعودية بما في ذلك وعي المقاولين بانتاجية التشييد ، وقابلية تطبيق طرق قياس الانتاجية المختلفة ، وعوائق اقامة برامج لتحسين الانتاجية ، ومدى تاثير الوظائف المرتبطة بكل من المكتب الرئيسي للشركة وموقع العمل في تحسين الانتاجية ، ومدى امكانية اقامة برامج لتحسين الانتاجية .

وجد من خلال البحث أن هناك مشكلة انتاجية حسبما يرى مقاولو التشييد . وقد وجد أيضاً أن نظام تقرير التكلفة والتحكم بها (CRCS) أكثر طرق قياس الانتاجية شيوعاً وأكثرها فاعلية . وتبين أن أهم الأسباب المثبطة لقيام برامج لتحسين الانتاجية هي محدودية دعم الادارة العليا وقلة الكوادر المؤهلة بالاضافة لنقص الوعي بالانتاجية وطرق قياسها . أما بالنسبة للوظائف ذات الامكانية الكامنة لتحسين الانتاجية ، وجد أن التخطيط والجدولة هما الوظيفتان الأكثر أهمية من بين الوظائف المتعلقة بالمكتب الرئيسي ، بينما وظائف الادارة والمعدات هي الأكثر أهمية بالنسبة للوظائف المتعلقة بموقع العمل . وأخيراً فقد تبين أن برامج تحسين الإنتاجية تناسب جميع المشاريع بغض النظر عن اختلاف خصائصها . وفي نهاية الدراسة تم تطوير نموذج (رسم انسيابي) للمساعدة على اقامة برنامج لتحسين انتاجية التشييد.

درجة الماجستير في العلوم
جامعة الملك فهد للبترول والمعادن
الظهران ، المملكة العربية السعودية
يناير١٩٩٤م

CHAPTER 1

INTRODUCTION

Management awareness of performance-related issues and its commitment to improving construction operations are basic prerequisites of productivity improvement (Civil Engg., 1981, Howell, 1981). This research intends to assess the levels of management awareness of and commitment to productivity among Saudi construction contractors. To achieve this, the following major questions are raised in this study:

1. Are Saudi construction contractors satisfied with their existing level of productivity? If not satisfied, what are they doing to improve productivity?
2. How do Saudi contractors measure their construction productivity? How do they evaluate measurement methods?
3. What are the hindrances to Productivity Improvement Programs (PIP)?
4. What are the areas with the highest potential for productivity improvement?

1.1 SIGNIFICANCE OF THE STUDY

Although the construction industry is a major sector of the economy, construction productivity is lagging behind other industries (Civil Engineering, 1981, Lowe, 1987, Strandell, 1978). So, there is high potential for construction productivity improvement and there are high rewards too. If this is the case in the U.S., which is a developed country, then one would expect that construction productivity is not in better shape in Saudi Arabia, which is a developing country.

The Saudi construction industry has experienced a decline in its volume in the last few years. This decline has resulted in a highly competitive atmosphere for contractors (Orakzai, 1984) and since productivity has an inverse relation to cost, contractors can benefit from improving their productivity , by which they can save more money, earn more profit and/or become more competitive. Moreover, a contractor with high productivity can offer a lower bid price to win the contract and still make a good profit, which will secure his share of the market. This makes the study of construction productivity an important issue.

Productivity Improvement Programs have proved to be successful in identifying and eliminating unnecessary costs and in improving job efficiency, which has resulted in a good payoff (ENR, 1980). It is important for contractors to benefit from this experience in the national construction industry. Since management awareness of and commitment to productivity are key factors in the success of such programs, it is important to investigate and evaluate contractors' attitudes toward productivity and their perception of programs for its improvement. Because productivity measurement is an essential part of any productivity improvement programs, the applicability of different measurement methods should be assessed.

1.2 OBJECTIVES OF THE RESEARCH

The main objective of the research is to promote construction productivity in Saudi Arabia by:

(a) Investigating the awareness among construction contractors of the idea of productivity improvement and its application in the construction industry .

(b) Investigating the applicability of different productivity measurement methods.

(c) Identifying the obstacles which hinder the use of productivity improvement programs .

(d) Determining areas which have high potential for productivity improvement .

(e) Assessing the possibility of establishing construction productivity improvement programs.

1.3 SCOPE AND LIMITATIONS

The study will be limited to large building contractors as classified by the Ministry of Public Works and Housing (MPWH). It will be further limited to large building contractors in Jeddah, Riyadh, Dammam and Al-Khobar which are the major cities of Saudi Arabia in which large contractors usually establish their head offices. Building contractors are chosen for several reasons:

1. Building construction in comparison to other types of construction , is unique in that it is labor-intensive and contains many different activities which make it a prime candidate for productivity improvement .

2. In comparison to other types of construction , the number of owners of building projects is large, thus there will be a commensurate number of beneficiaries of the research findings.

Other types of construction are excluded because of the limitation of time and resources. This study, which is an exploratory type of study, is also limited to large contractors who are classified by MPWH in the first three grades for Saudi contractors and in the first five grades for foreign contractors. These contractors are allowed to take on projects of SR 50 million or more per project.

Large contractors are chosen for the following reasons:

1. Large contractors mean larger projects with high potential for productivity improvement . This is because large projects have numerous activities and need huge resources, which makes them complex and in need of careful planning and management.

2. Large contractors taking on larger projects could expect greater savings (even with limited percentage of improvement). Because of the huge resources that are invested in such projects, even a limited percentage of improvement will result in appreciable monetary savings.

3. Large contractors with more qualified management, that appreciate productivity improvement , would have a greater tendency to establish productivity improvement programs.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the literature is reviewed in three parts: productivity in construction , measuring productivity , and improving productivity .

2.1 PRODUCTIVITY IN CONSTRUCTION

Productivity is defined by ***The Business Roundtable*** (1982) as a ratio of output over input:

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

A more general definition is offered by the ASCE Committee on productivity , "delivery of a quality construction product that achieves total cost effectiveness through the optimal use of resources" (Koehn & Caplan, 1987, p. 328). Productivity can also be viewed as "factor" or "total" productivity in which the former is the ratio of output to one type of input (labor, for example), and the latter is the ratio of output to all input factors (labor, capital, land and other investments) (Strandell, 1982).

Construction professionals and owners agree that productivity in the construction industry is a problem that needs to be studied seriously, because of its significant effect on the cost and duration of construction projects (Strandell, 1978). This has increased the attention toward the productivity problem in the last twenty years especially with the arrival of the so-called "super project" and its constant cost overrun (Hohns, 1979).

When attempting to predict the productivity of his resource combination used for performing a construction activity, the contractor typically uses productivity data or relies on his experience. Productivity data may be in the form of records published by contracting services, such as Dodge, or contractor's productivity records. A typical form of an activity productivity record is shown in Table 2.1.

Table 2.1

Productivity of Man Shoveling Loosened Soil Into Truck

Soil	Cu.yd. per labor hr.	Hr. per cu. yd.
Light, from ground	1.20-2.50	0.40-0.85
Medium, from ground	1.00-2.00	0.50-1.00
Hard pan, from ground	0.70-1.25	0.80-1.40
Light, from excavation	1.10-2.30	0.45-0.90
Medium, from excavation	0.90-1.80	0.55-1.10
Hard pan, from excavation	0.60-1.10	0.90-1.65

(Adrian, 1983, p. 270)

Productivity data is usually stated in terms of average productivity. Assuming average weather, an average amount of delays, average job conditions, and so forth, the contractor may use the records to predict his activity productivity . Faced with non-average conditions, the contractor may revert to the use of index numbers to predict activity productivity . These index numbers adjust the average productivity by weighing its value as a function of non-average conditions (Adrian, 1983).

2.2 MEASURING PRODUCTIVITY

Measurement is important in improving productivity in construction. It determines the level of productivity and the response to corrective actions. Appropriate construction-productivity measurement will help owners and contractors to:

1. Determine how effectively their projects are being managed.
2. Detect adverse trends quickly so corrective actions may be taken.
3. Determine the effects of changed methods or conditions.
4. Identify both high and low areas of productivity and reasons for the differences.
5. Compare the performance of different projects (***Business Roundtable***, 1982).

2.2.1 Measurement Difficulties in Construction

The above significance of measurement is unfortunately coupled with difficulties in making measurement. The difficulties are primarily due to the fact that factors influencing productivity are never constant, varying from job to job (Logcher & Collins, 1978).

It is necessary to have an accurate measurement of output in order to get an accurate measure of productivity . This leads to another difficulty, due to the fact that output in construction is a complex product composed of many components, such as walls, roofs, etc.; at varying completion levels and of a multitude of different materials (ENR, 1975).

2.2.2 Measurement Methods

There are various methods used in measuring construction productivity , icluding:

1. Work Sampling (WS)

As defined by Richardson, "work sampling is a productivity measurement technique used for the quantitative analysis, in terms of time, of the activities of men or equipment" (Richardson, 1976, p.123). In Work Sampling, a large number of observations are taken randomly. The activity in which the worker is involved during the observation is classified in predefined work categories. Inferences can then be drawn from the sample representing the total work activity (Thomas & Holland, 1980).

The first step in any Work sampling Study is to have a defined objective. Then work categories are established according to the objective of the study. Broad objectives imply broad categories and sharply focused objectives require more detailed categories. The intervals between studies should be compatible with the program objective. The widely spaced studies are of limited value and will identify only acute problems that have been occurring for an extended period of time. The data can be collected by utilizing a Tour approach where the observer walks around and records the activities of all of the craftsmen in view. In the tour approach, worker absence will not be noted, and worker crossover will result in increased percentages in the travel and carrying tools/materials categories. Another alternative to data collection is a crew approach where the group (the population) is redefined into smaller sizes such that each member of the group can be included in the sample. Work Sampling results are evaluated by assessing the percentages of certain work categories that appear to be unusually high or low. The results of a typical Work Sampling study are shown in Table 2.2 (Thomas & Holland, 1980).

Table 2.2 Work Sampling Results

Category of Activity (1)	Percentage of Observations (2)
Direct work	31.0
Receiving/giving instructions and reading drawings	6.6
Handling tools and materials	3.3
Transporting tools and materials	5.4
Travelling empty-handed	13.9
Waiting and unexplained idle	29.7
Personal and breaks	3.5
Late starts and early quits	6.6

(Thomas & Holland, 1980, p.520)

2. *Craftsman Questionnaire (CQ)*

The Craftsman Questionnaire (CQ) is a technique that identifies the causes and assess the severity of problems that affect craftsmen's productivity and motivation. The craftsman is required to estimate the loss of time associated with each problem, rank the severity of the problems, and suggest possible solutions to these problems (Chang & Borcherding, 1985).

Questionnaires are given to groups of up to 100 craftsmen in self-administered sessions on the site. An administrator gives a brief idea about the questionnaire and clarifies any ambiguity. After the information is collected and the results are obtained, interviews are held with groups of craftsmen and foremen to find out substantial problems and potential solutions. The topics studied in the CQ for estimating the average weekly loss of work hours are determined, based on the characteristics of the construction project (Russell & Chang, 1987).

Typical results of a Craftsman Questionnaire are shown in Table 2.3, and a sample question in a Craftsman Questionnaire is shown in Figure 2.1.

Table 2.3: Typical Results of Craftsman Questionnaire

Problematic Situation	Lost Manhours Per Craftsman Per week	Percent of Work
Reading work	5.70	14.3
Material Availability	6.27	15.7
Tool Availability	3.80	9.5
Cross Interfacing	3.29	8.2
Overcrowded Work Areas	5.00	12.5
Instruction Time	2.12	5.3
Instruction Delays	2.66	6.7
Total Unproductive Time	**28.84**	**72.2**

(Russell & Chang, 1987, P.K.1.4)

Figure 2.1

An Example Question In A Craftsman Questionnaire

Materials and Tools

1. Do you often have to stop work and wait or move to another spot because you don't have the materials to work with?
   ________ Yes ____________ No

2. How many hours per week would you guess are spent waiting for materials, getting materials, or moving to a different area because of no materials?
   _________ Hour(s) per week

3. Do you often have to stop work and wait or move to another spot because you don't have the tools you need?
   ________ Yes ____________ No

4. How many hours per week would you guess are spent waiting for tools, getting tools, or moving to a different area because of no tools?
   _________ Hour(s) per week

5. In your opinion, why is getting materials or tools to your working area a problem?

6. How do you think the material problem could be improved?

(Russell & Chang, 1987, P.K. 1.4)

3. Craftsmen Questionnaire Sampling (CQS)

The idea behind the Craftsmen Questionnaire Sampling is to combine the advantages of both the Work Sampling and the Craftsman

Questionnaire. This is achieved by using the questionnaire as a means of data collection to replace the sampler's observation in work sampling. Thus, it can determine craftsmen's time spent on various activities with a statistical reliability (Chang & Borcherding, 1986).

With the questionnaire in hand, the administrator, like the work sampler, goes into the field to collect data. The administrator walks around the site and randomly selects a foreman. The administrator then explains the purpose of the survey and asks the foreman to gather his crew right at their work location. If the craftsmen in this selected crew are present, they are given a questionnaire to fill out and asked to report what they have just been doing. If any of the craftsmen are absent, the foreman is asked to fill out a different form to complement the information regarding the activities of the absent craftsmen (Russell & Chang, 1987).

A typical questionnaire filled out by craftsmen in CQS is shown in Figure 2.2, and typical results of Craftsmen Questionnaire Sampling is shown in Table 2.4.

Figure 2.2

Questionnaire Filled by Craftsman in Craftsman Questionnaire Sampling

Physically involved in work, other than travelling	Active (Direct) work (using the tools of any 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 of truck Because of over-crowded area Due to other crew interference For design interaction or additional engineering information Other__________ ______________
	Unrelated but necessary	Safety meeting Training session Union Business Personal break Other	
Travelling to get (or to do)	Information Equipment or truck Material Tools Other assigned that Personal/ unrelated Other__________ ______________		

(Russell & Chang, 1987, P.K. 1.7)

Table 2.4

Typical Results of

Craftsman Questionnaire Sampling

(Russell & Chang, 1987)

Categories	Percent	Cumulative Percent
Direct	55.4	55.4
Support/Help	8.0	61.4
Travelling	12.2	75.6
Waiting/Standby	22.5	95.9
Unrelated	4.1	100.0

(Russell & Chang, 1987, P.K.1.8)

4. Foreman Delay Survey (FDS)

Foreman Delay Survey (FDS) is a method of determining the administration related delays which are beyond a foreman's control, but have a direct influence upon his crew's productivity . A questionnaire is filled in by each foreman on site at the end of each working day for a limited period of time (Tucker et al, 1982).

Brief orientation meetings should be scheduled for all foremen, to be included in the program. General foremen and superintendents supervising these foremen should also be included in the orientation meetings (Tucker et al, 1982).

The orientation meeting includes a line-by-line review of the survey form, citing examples of the types of delays which are frequently encountered. The foremen are told how the forms will be distributed, when the forms will be completed (the end of each day or the following morning), and when and how they will be collected. It is generally most successful to collect delay reports as frequently and through the same channels as time cards are collected. The foremen are told that a summary will be prepared from .their responses, and that the summary will be discussed with them at a future date (Tucker et al. 1982).

A typical Delay Report form is shown in Fig. 2.3.

Fig. 2.3: Typical Delay Report Form

Date:____________________ Name:______________________________

Gen. Foreman:______________________

Number in Crew:____________

Foreman Name:______________________

PROBLEMS CAUSING DELAY

MANHOURS LOST

Number of hours % x Number of Men = Manhours

Changes/Redoing work (Design error or change) ________ x ________ = ________

Changes/Redoing work (Prefabrication Error) ________ x ________ = ________

Changes/Redoing work (Field error or damage) ________ x ________ = ________

Waiting for materials (warehouse) ________ x ________ = ________

Waiting for materials (vendor furnished) ________ x ________ = ________

Waiting for tools ________ x ________ = ________

Waiting for construction equipment ________ x ________ = ________

Construction equipment breakdown ________ x ________ = ________

Waiting for information ________ x ________ = ________

Waiting for other crews ________ x ________ = ________

Waiting for fellow crew members ________ x ________ = ________

Unexplained or unnecessary move ________ x ________ = ________

Other________________________ ________ x ________ = ________

____________________________ ________ x ________ = ________

Comments:____

____

(Tucker, et al, 1982, p.580)

5. Cost Reporting & Control System (CRCS)

The Cost Reporting and Control System requires establishment of cost accounts and codes, estimation of production rates, and measurement of cost data and quantities to date. The basic premise of this method is that cost performance is a measure of productivity (Russell & Chang, 1987).

Due to the complexity of construction projects, each project must be broken down into many manageable blocks of work. These blocks are called cost accounts. Each block or cost account is broken down into specific detail by the type of work which is measurable in the field. Then each cost account is assigned a cost code which is part of the company's overall coding structure. For example, activities involving the use of concrete can be broken down into concrete pouring, finishing and curing. As shown in Table 2.5, the corresponding cost codes might be 230.01 - Concrete, Footings, 230.51 - Concrete Trowel Finish and 230.91 - Concrete Curing (Slab) (Russell & Chang, 1987).

Management estimates labor rates for planning, reporting and controlling site productivity . The rate for each account is an essential part of the system because it provides a criterion for progress and performance comparison. The estimate of workhours and/or cost for every account becomes the base line against which actual workhours and cost are measured.

TABLE 2.5

TYPICAL WEEKLY COST REPORT

WEEKLY LABOR COST SUMMARY

Job Civil Engineering Addition -Purdue University

Job No. 500

Week Ending : November 21, 1966

Prepared by: J.S. Russell

Cost Code	Work Description	Unit	Quantity			Total Cost			Unit Cost			To Date		Projected	
			Estimated	This Week	To Date	Estimated	This Week	To Date	Estimated	This Week	To Date	Saving	Loss	Saving	Loss
230.01	Concrete, Footings	c.y.	1.020	200	670	$ 3,060	$ 680	$ 2,162	$ 3.00	$ 3.40	$ 3.23		$154		$ 235
230.05	Concrete, Grade Beams	c.y.	800	195	400	3,360	800	1,680	4.20	4.10	4.20		0		0
230.07	Concrete, Slab	c.y.	2,770	60	600	11,080	300	2,982	4.00	5.00	4.97		582		2,678
230.08	Concrete, Beams	c.y.	500	60	60	2,100	250	250	4.20	4.17	4.17	2		15	
230.51	Concrete, Trowel Finish	s.f.	128,000	3,000	53,460	19,200	400	7,486	0.15	.13	.14	535		1,280	
230.9	Concrete, Curing, (Slab)	s.f.	128,000	3,000	53,460	1,920	43	643	0.015	.014	.012	160		384	

(Russel & Chang, 1987, P.K.1.2)

The measurement of cost to date includes such items as wages paid, fringe benefits, taxes, insurance, etc. This information can be obtained from the payroll system and can be sorted into each cost account. The measurement of cost needs to take into account the economic effect of wage rates, various crew mixes and their input on cost. It is recommended that the measurement of workhours spent to date, be included.

The cost to date information, without concerning the quantities of work produced, by a given number of workhours and/or corresponding cost is useless for determining the actual unit rate for the purpose of comparison with the planned rate (Russell & Chang, 1987).

6. Method Productivity Delay Model (MPDM)

The Method Productivity Delay Model (MPDM) is basically an application of the principles of time and motion analysis on cyclic construction activities. It can be looked at as a combination of Work Sampling, Time Study, and Motion Analysis to measure, predict and improve productivity (Adrian, 1983).

An overview of the MPDM is shown in Figure 2.4. The model is broken into four elements. These consist of collecting data, processing data, structuring the model, and implementing the model (Adrian, 1983, 1981).

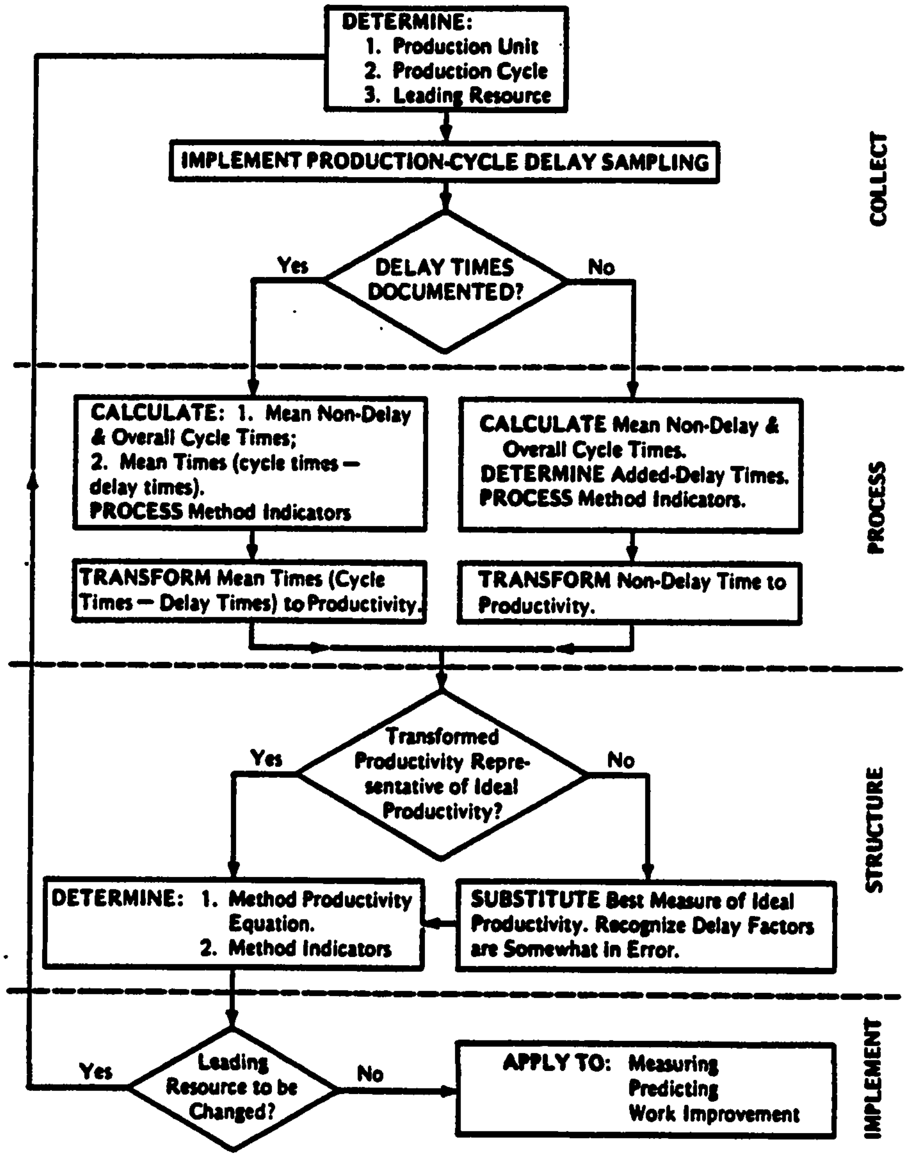

DETERMINE:
1. Production Unit
2. Production Cycle
3. Leading Resource
IMPLEMENT PRODUCTION-CYCLE DELAY SAMPLING
DELAY TIMES DOCUMENTED?
Yes
No
COLLECT
CALCULATE: 1. Mean Non-Delay & Overall Cycle Times;
2. Mean Times (cycle times — delay times).
PROCESS Method Indicators
CALCULATE Mean Non-Delay & Overall Cycle Times.
DETERMINE Added-Delay Times.
PROCESS Method Indicators.
TRANSFORM Mean Times (Cycle Times — Delay Times) to Productivity.
TRANSFORM Non-Delay Time to Productivity.
PROCESS
Transformed Productivity Representative of Ideal Productivity?
Yes
No
DETERMINE: 1. Method Productivity Equation.
2. Method Indicators
SUBSTITUTE Best Measure of Ideal Productivity. Recognize Delay Factors are Somewhat in Error.
STRUCTURE
Leading Resource to be Changed?
Yes
No
APPLY TO: Measuring
Predicting
Work Improvement
IMPLEMENT

Fig. 2.4: Overview of the MPDM

(Adrian, 1983, p. 299)

7. Flow Process Chart (FPC)

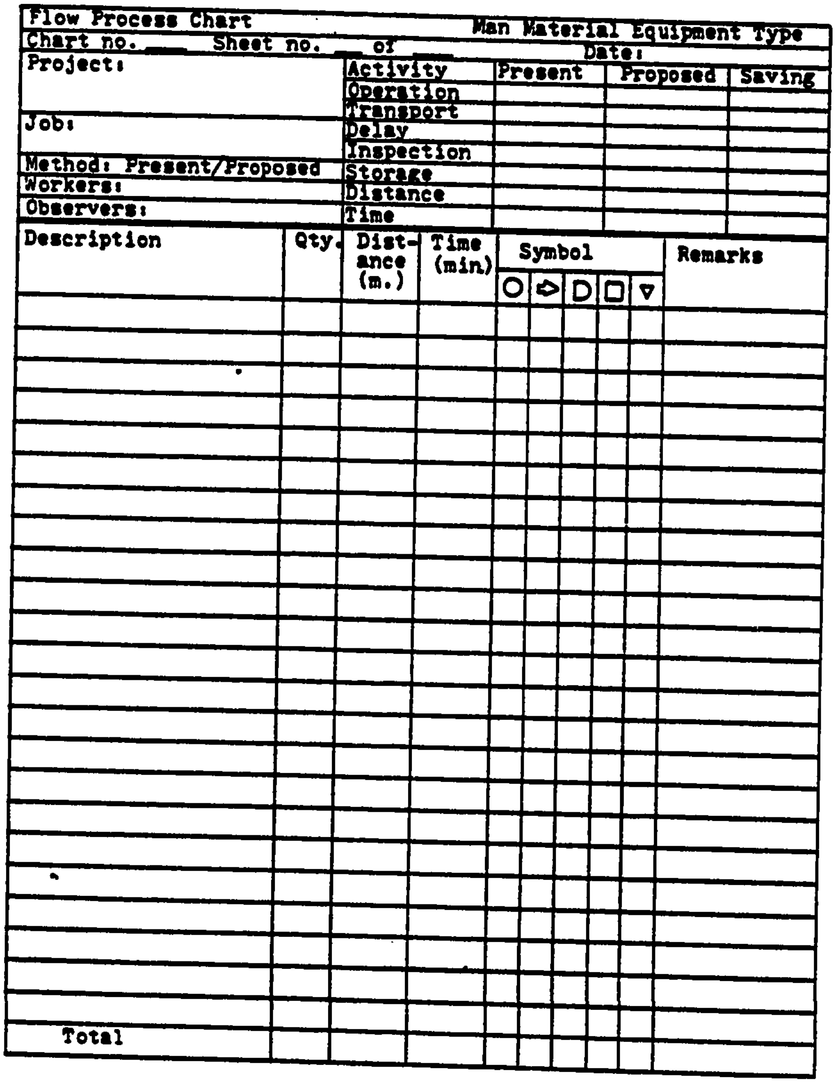
According to the British Standards Institution, a Flow Process Chart sets out the sequence of the flow of a product or a procedure by recording all events under review, using the appropriate process chart symbols. A Flow Process Chart which records what the worker does is called a man-type Flow Process Chart. If the chart records what happens to the material, it is called a material-type Flow Process Chart. Should the main interest be in the flow of the equipment, an equipment-type Flow Process Chart could be used. Flow Process Chart Format is shown in Fig. 2.5 (Drewin, 1982).

For the preparation of Flow Process Charts, the following considerations are suggested:

1. Charting is used for recording because it gives a complete picture of what is being done and helps the mind to understand the facts and their relationship to one another.

2. The details which appear on a chart must be obtained from direct observation. Once they have been recorded on the chart, the mind is freed from the task of retaining them, but they remain available for reference and for explaining the situation to others. Charts must not be based on memory but must be prepared as the work is observed (except when a chart is prepared to illustrate a proposed new method).

Fig. 2.5: Flow Process Chart Format



Flow Process Chart Man Material Equipment Type
Chart no. ___ Sheet no. ___ of ___ Date:
Project:
Job:
Method: Present/Proposed
Workers:
Observers:

Activity	Present	Proposed	Saving
Operation			
Transport			
Delay			
Inspection			
Storage			
Distance			
Time			

Description	Qty.	Dist-ance (m.)	Time (min)	Symbol					Remarks
				○	⇨	D	□	▽	
Total									

(Drewin, 1982, p. 78)

3. A high standard of neatness and accuracy should be maintained in preparing fair copies of charts constructed from direct observation. The charts will be used in explaining proposals for standardizing work or improving methods. An untidy chart will always make a bad impression and may lead to errors.

4. To maintain their value for future reference and to provide as complete information as possible, all charts should carry a heading giving the information shown in Fig. 2.5 (Drewin, F.J., 1982)

Each element on the process chart must be critically analyzed in relationship to full cycle for the design of a new, improved method. Improvements are typically made in the transportation activities. Rearranging the operations and the material flow often reduces ineffective transportations. (Drewin, F.J., 1982)

2.2.3 Measurement Methods Attributes

The previously mentioned construction productivity measurement methods have different attributes. Although no concrete definitions of these attributes can be found in the literature, the following will serve as a brief explanation of such attributes:

1. Reliability refers to the use of reliable statistical techniques in collecting and analyzing data.
2. Comprehensiveness is a reflection of the scope of coverage and the level of measurement.
3. Potential of positive reaction of workers is related to these effects

resulting from the co-operation and participation atmosphere created by using certain methods.

4. Effectiveness is the achievement of the goals of measuring and improving productivity.
5. The cost of measurement is all costs including the direct cost of manpower and material as well as the direct cost resulting from the possible interruption of work activities.
6. The time of measurement refers to the time needed to collect data, analyze them, and take actions.
7. The potential of negative reaction of workers is the reaction which may emerge as a result of workers' suspicion that they are being spied on, or as a result of misunderstanding and lack of co-ordination.
8. The level of data processing is the relative sophistication of computation which varies from simple calculated percentages to sophisticated computerized data processing.
9. Potential of communication problems refers to difficulties arising from language barriers, co-ordination pitfalls, or organizational constraints.
10. The demand on trained personnel refers to the technical qualifications of the people performing the measurement and the data analysis (Chang & Borcherding, 1986).

2.3 IMPROVING PRODUCTIVITY

2.3.1 Management Commitment

According to a study conducted by the Business Roundtable, management practices are a significant factor behind declining productivity in the construction industry . Many management-related activities, e.g., better planning and communication, more effective management, better job procedures, etc., need to be implemented to attain high productivity . Also, one of the reasons behind the continuous decline in construction productivity is that management has not paid attention to the productivity problem (Civil Engg., 1981).

Top management support of the philosophy and the requirements of the control system and its procedures, along with data collection and analysis on a timely basis, to develop improvements, produced tangible results (Peltier, 1978). In order for any productivity program to succeed, managers have to be willing to be committed to productivity improvement and to translate that commitment into action. Without this support and commitment, there can be no improvement (Howell, 1981).

However, "while there is concern by those making capital investments, there is evidence that many of these same people, including chief executives, not only fail to appreciate the extent of the effect of productivity on cost, but are in most cases almost powerless to control it" (Strandell, 1978, p. 57).

2.3.2 Areas of Productivity Improvement

To maximize productivity improvement in construction , it is better to concentrate on those areas which have high potential for productivity improvement (Charomokos & McKee, 1981). These areas can be classified into two main groups. The first group is the Head Office related areas such as planning, procurement, scheduling, drafting, estimating, specifications, communications, engineering, and marketing. The second group is the site related areas which are further classified into six main categories. The first category is Management which contains labor relations, cost control, and supervision. The second category is Materials which contains delivery, storage, packaging, prefabrication, standardization, product availability, and new product. The third category is Labor which contains contract agreement, training, quality control, turnover, availability, recruitment, and motivation. The fourth category is Engineering/Design which contains design standards, design improvement, systems engineering, and standard specifications. The fifth category is Equipment which contains capacity, maintainability, and utilization. The sixth category is Construction Techniques which contains precast elements, pre-assemble modulars, and methods (Koehn & Caplan, 1987).

2.3.3 Productivity Improvement Programs

Productivity improvement should be viewed as a system formalized by a Productivity Improvement Program. The basic philosophy of the program is to analyze all major aspects of the project and to derive means for improvement, at less cost, with greater safety, and at a faster rate. The slogan work smarter, not harder, is a concise statement of the results to be expected from an effective program (Parker & Oglesby, 1972, pp. 1-3).

Historically speaking, managerial analysis of basic tasks was started in construction in the early part of the twentieth century by Gilbreth and

Hauer, who later developed some of the industrial engineering techniques (Parker & Oglesby, 1972).

The typical components of a successful productivity improvement programs are:

1. Select an initial target area that has high visibility and probability for success.
2. Gain the support of appropriate management. Improvements in productivity cannot come totally from the employee, but must result from the actions of management which determines policies and specific goals.
3. Involve all levels of personnel, including management, staff, supervisors, and labor in the development and implementation of the plan. Cooperation generates enthusiasm for the desired goals.
4. Detail and install the system for measuring productivity so that the procedures and findings will be clearly understood and monitored. Then analyze results to find improvement opportunity.
5. Management should select an appropriate area for improvement and implement the change (Schillo, 1979).

CHAPTER 3

RESEARCH METHODOLOGY

This study is an exploratory type of research in investigating contractors' attitudes toward and perception of, productivity and its improvement programs. The sample survey method, which is the most appropriate methodology in research aimed at describing population characteristics and attitudes, is used in this research. This chapter presents the stages which were carried out to accomplish the research objectives. The stages cover the following issues: required data, data collection, population and sample, interview sessions, and data analysis.

3.1 Required Data

According to the research objectives stated in Section 1.2, data regarding the following issues was to be collected:

* Contractors' awareness of the idea of productivity and its measurement techniques.
* Applicability and evaluation of different measurement techniques.
* Roadblocks hindering the use of productivity improvement programs.
* Areas which have high potential for productivity improvement, both head office and site related areas.
* Possibility of establishing construction productivity

improvement programs.

3.2 Data Collection

Required data for this study was gathered by personal interviews with a sample of large building contractors in the Kingdom (grades 1, 2 and 3 for Saudi contractors and grades 1-5 for foreign contractors, according to MPWH classification). The interview method was selected because of the following reasons:

1. Rate of response in interviews, compared with mailed questionnaires, is high.
2. Some techniques and ideas can be explained and clarified.
3. The presence of interviewer decreases the number of "don't knows" and "no answers".

A questionnaire was filled out during each interview. This questionnaire is divided into three parts. The first part is related to the respondent and his firm (size, activities, etc.). The second part inquires into the awareness among contractors of productivity, the applicability of different measurement methods, and the roadblocks hindering productivity improvement programs, the third part helps to determine areas of potential productivity improvement and to assess the possibility of establishing a productivity improvement program. Appendix (A) shows a copy of the questionnaire .

3.3 Population and Sample

The population of this study is all building contractors classified by MHPW in the first three grades for Saudi contractors and in the first five grades for foreign contractors. According to MPWH classification, these contractors can bid for projects of SR 50 million or more per project. The total number of these contractors in Saudi Arabia is 258 (MPWH classification, 1409 H.).

A sample size of 54 was selected based on a confidence level of 90% and an error limit of 0.1, using the following equation (Kish, 1965, p. 50):

$$n = \frac{n}{1+n/N}$$

where:

$$n' = \frac{S^2}{V^2} = \frac{(0.5)^2}{(0.0608)^2} = 67.6$$

$$n = \frac{67.6}{1 + \frac{67.6}{258}} = 53.5\text{, say, } 54.$$

Where:

n' = Sample size from an infinite population

n = Sample size from a finite population

N = Total population

V = Standard error of sampling population

$= \frac{0.1}{1.645} = 0.0608$ (for a total error of 0.1 and confidence level of 90%, $t = 1.645$).

S^2 = The variance of the population elements (a maximum value at $P = 0.5$, $S^2 = P(1-P) = 0.5 * 0.5 = 0.25$.

P = The proportion of population elements that belong to the defined class.

The elements of this sample (contractors) were selected using tables of random numbers to assure randomness, independence, and representativeness (Burgess, 1980). When any selected contractor could not be approached for any reason, another contractor was selected using the same tables to substitute for him. Around twenty contractors were replaced for different reasons e.g., the contractor has gone out of business or change his field of business, the contractor was not willing to co-operate, or contractor could not be approached, because his address had changed.

3.4 Interview Sessions

After selecting a sample of 55 contractors, the researcher contacted each contractor to explain to him about the study and to ask him for his cooperation. Cooperative contractors were asked about their addresses and convenient times and dates for visits.

In each company, the researcher sought an interview with the highest possible manager or official (general manager, deputy general manager, technical manager, construction manager, or project manager), usually someone who holds an engineering degree and has a field experience.

Some interviews were as short as two hours and others as long as four hours. The researcher had to break down some interviews into two sessions due to the respondents' time limitation.

Some respondents preferred to go over the questionnaire with the researcher in order to clarify any ambiguity, so that they would be able to fill it out alone in their free time and send it in by mail. Twenty one respondents chose to do so, out of which fourteen sent the filled questionnaire back. The researcher prepared stamped and self-addressed envelopes for this category of respondents.

The researcher had a lot of discussion with the interviewees. At the beginning of the interview, the respondent was given a copy of the questionnaire while the researcher had another one in order to follow each other.

Some respondents read, answered the questions, and wrote (or checked) the answers by themselves. Others, either only answered or only read and answered the questions verbally while the researcher had to do the checking and the writing.

3.5 Data Analysis

Each piece of information - with the exception of open-ended questions - was coded. Coded data was then entered into the computer. SAS - Statistical Analysis System - which is a package in the KFUPM mainframe, was used to get all necessary statistics, such as discriminant analysis, analysis of variance (ANOVA), Spearman's and Pearson's correlations, and other discriptive statistics (means, percentages, and frequencies). Data obtained from open-ended questions was manually grouped and summarized.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter includes the findings of this study regarding various productivity related issues. Interview schedules (questionnaires) were filled out through personal interviews with 55 respondents. All respondents are engineers in construction contracting firms with field experience in building construction . About 39% of the respondents are either general or deputy general managers. The rest of the respondents include 9% technical managers, 13% construction managers, 22% project managers, and 17% other titles. Information regarding contractors characteristics can be found in Appendix (B).

The results of this study are divided into five main issues: productivity awareness, productivity measurement methods, hindrances to productivity improvement programs (PIP), potential areas for productivity improvement, and possibility of establishing productivity improvement programs (PIP). Each of these main issues includes several sections. For each section, the results are presented first and then followed by a discussion.

4.1 Productivity Awareness

The awareness of the productivity problem among construction contractors is a prerequisite for any possible productivity improvement. This awareness is investigated in this part which includes the following sections: meaning of construction productivity , effect of construction productivity on different project attributes, satisfaction with different productivity areas, and productivity records used in estimating.

4.1.1 Meaning of Construction Productivity

The respondents were asked about what "construction productivity" means to them. Nineteen respondents answered this question. Their answers contained the following key concepts: output/input ratio, cost efficiency, profit and economic gains, time efficiency (proceed according to schedule), quality (according to specifications and drawings), reduction of non-essential work, improved construction methods, and optimum utilization of resources. A more detailed breakdown of the responses is as follows:

Four of the respondents approached productivity at a macro level "total productivity", while six of the respondents approached it at a micro level "factor productivity ". The other nine defined productivity in terms that can be considered as a mixture of the two levels.

Ten respondents responded in terms that are more related to site work productivity , while the other nine respondents answered in more general terms which can be related to both site work and head office or to neither of them.

Four respondents mentioned the time element as an input or as a constraint. Two of them considered time schedules as frames of reference.

To eight respondents , construction productivity meant output/input ratio, while to another four respondents , it meant cost efficiency, profit, and economic gains.

Only three respondents made quality a dimension of productivity .

From the observations above, it can be seen that the respondents do not have a unified conceptualization of productivity and actually some respondents gave statements (not definitions) about productivity, e.g., it is the cornerstone of construction , it is more important in construction than in manufacturing. This indicates that the awareness of productivity even among those who are called professionals should be enhanced. There should be a unified definition of productivity to serve as starting point for the improvement process. It is noticed also that 35 respondents did not provide answers. Some of those may have thought that the researcher expected a highly sophisticated and formal "unified" definition which they did not have in mind. Another possible reason is ignorance.

4.1.2 Effect of Construction Productivity on Different Attributes

Question B3 of the questionnaire. inquires about the effects of the resondents level of construction productivity on different project attributes. The definition of productivity, as mentioned in Section 2.1, was explained to the respondents before discussing question B3. The question contained six different attributes which may be affected by construction productivity status. These attributes are project cost, project duration, project quality, employee morale, employee job satisfaction, and overall profitability. The respondents were asked to evaluate these effects on their projects using a range of five levels of negativity/positivity. Fifty-five respondents participated in the evaluation of these effects.

As presented in Table 4.1, the project cost appears to be affected the most with a mean response of (2.11) which is very close to the negative response. Project duration follows with a mean response of (2.36). Then come the overall profitability (2.40), employee morale (2.42), project quality (2.56), and employee job satisfaction (2.60).

Looking at these results, it can be seen that all these mean responses lie somewhere between the "negative" and the "no effect" responses. But they are mostly closer to the "negative" response, which suggests that there is a productivity problem anticipated by the respondents.

The above results may, however, have been clouded by the aggregation involved in calculating the mean response, the picture will be clearer when considering the percentages of the negative responses ("negative" and "extremely negative" responses) and the positive responses ("positive" and "extremely positive" responses) for each attribute (Figure 4.1). For project cost, project duration, and overall profitability, more than 70% of the respondents perceived a negative or extremely negative effect of their level of construction productivity . This indicates that these respondents have a problem with construction productivity . In other words, their construction productivity is low (The reference level of productivity varies according to activities, job conditions, past experience of contractors). The percentages of Fig. 4.1 also indicate that 63% of the respondents (the mean percentage of all attributes) are suffering productivity problems while 14.25% are reaping the benefits of productivity . The other 22.75% perceive a neutral effect of productivity on project attributes.

Table 4.1

Effects of Construction Productivity on Different Project Attributes

Project Attributes	Mean* Response	Standard Deviation	Rank
Project cost	2.11	1.10	1
Project duration	2.36	1.06	2
Overall Profitability of the firm	2.40	0.89	3
Employee morale	2.42	1.05	4
Project quality	2.56	0.92	5
Employee job satisfaction	2.60	0.95	6

(*) Ranges from 1 (extremely negative) to 5 (extremely positive) with 3 as (no effect).

N = 55

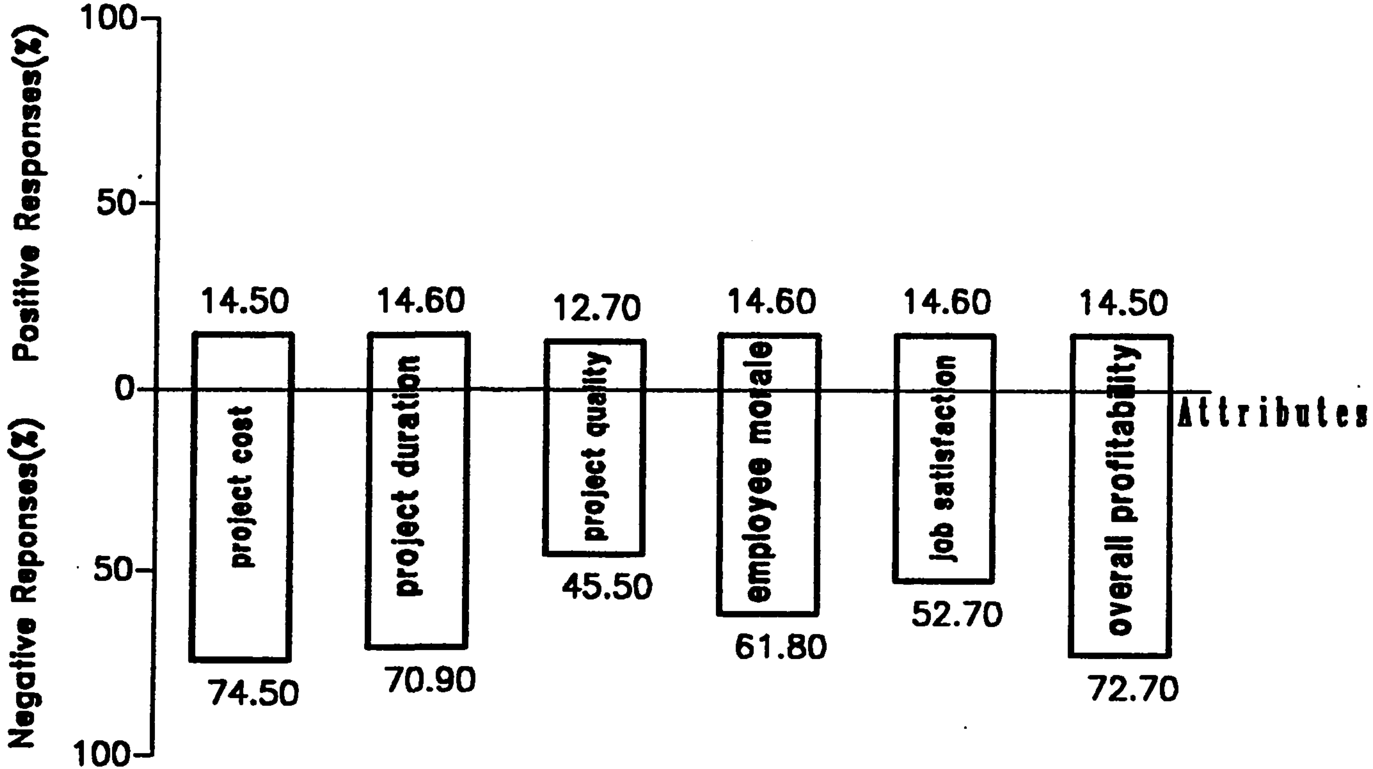


figure 4.1 effect of construction productivity,N=55

Those respondents whose productivity level is high show this uniformly over all the stated attributes, even though the percentage of such respondents is low. Negative effect of low productivity is mostly identifiable with cost, duration and profitability which are more tangible compared with other attributes which are less tangible such as quality, morale, and satisfaction. This should be expected and may help in selling productivity improvement programs to contractors since profitability is their prime objective.

The percentage of respondents who indicated extreme responses (both positive and negative) are shown in Table 4.2.

Table 4.2

Percentages of Extreme Responses

Project Attribute	**% of Extreme Responses (Positive and Negative)**
Project cost	36.3
Project duration	21.8
Project quality	14.5
Employee morale	21.9
Employee job satisfaction	12.8
Overall Profitability (Firm)	9.1

N = 55

The percentages presented in Table 4.2 indicate that productivity is most important on project cost (36.3%) and then on project duration and employee morale (21.9%). The huge difference between project cost (36.3%) and overall profitability (9.1%) which are related attributes may be due to the perception by respondents of the project cost as being one of the factors and not the only one, which affects profitability. Furthermore, the percentage of neutral responses where respondents think there is no effect of productivity on project attributes, is shown in Figure 4.1b. In this figure, it is clear that project quality is perceived to be the least affected by productivity (41.8%). A possible reason behind this is that there is not big margin to deviate project quality from the quality required in specifications. It can also be partially explained by the definition of productivity by respondents, where only three respondents out of nineteen considered quality a dimension of productivity (4.1.1). Project cost is the most affected (11.0% perceived no effect of productivity) and then comes the overall profitability (12.80%). This can be related to the definition of productivity by respondents, where to 12 respondents out of nineteen, productivity meant output/input ratio, cost efficiency, profit and economic gains.

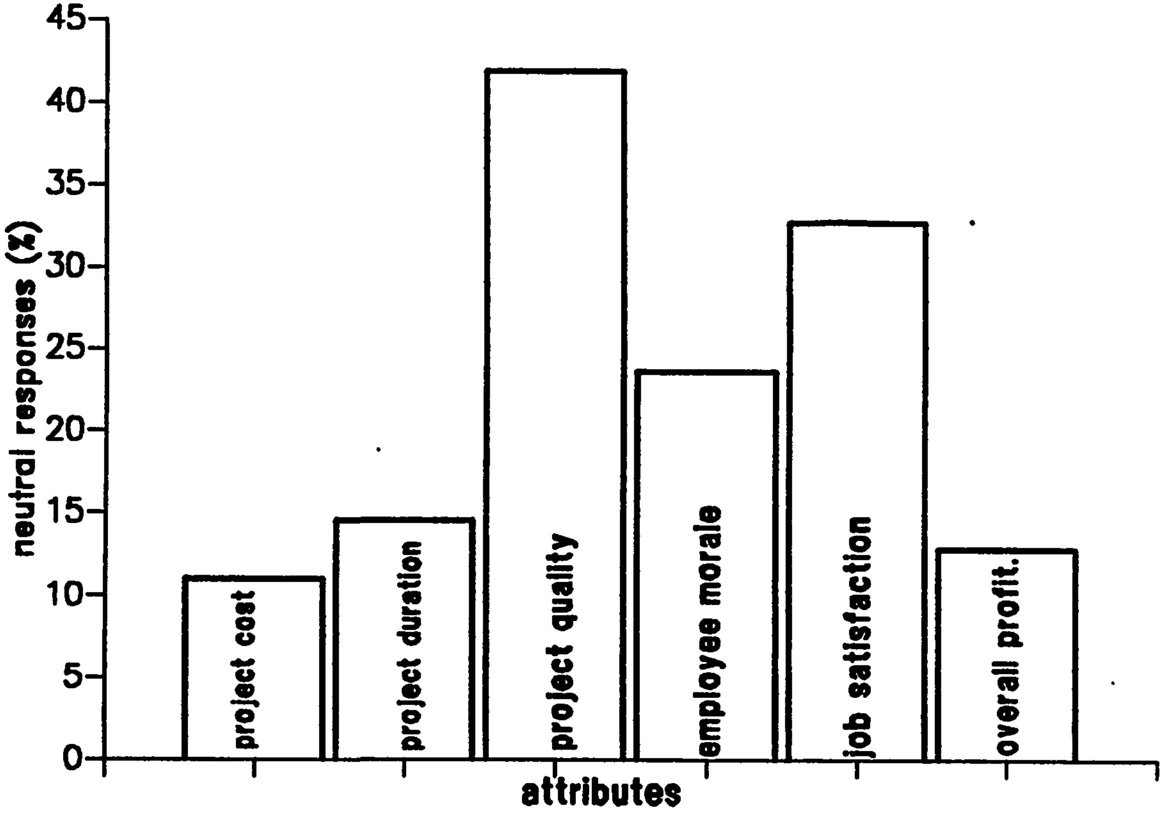


fig. 4.1b neutral effect of productivity,N=55

4.1.3 Satisfaction with Different Productivity Areas

In question B4, the respondents were asked to express their degree of satisfaction with the level of various productivity areas in their firms. Satisfaction ranges from 1 (extremely dissatisfied) to 5 (extremely satisfied). Table 4.3 shows that the mean response for each productivity area to range from 2.24 to 2.65.

Table 4.3

Satisfaction with Different Productivity Areas

Productivity Area	Mean* Response	Standard Deviation	Rank
Construction Workers Productivity	2.24	1.00	1
Equipment Productivity	2.27	0.95	2
Method Productivity	2.36	0.91	3
Site Management Productivity	2.40	0.97	4
Overall Productivity of the firm	2.45	0.96	5
Office Management Productivity	2.65	0.93	6

(*) Ranges from 1 (extremely dissatisfied) to 5 (extremely satisfied).

N = 55

The respondents demonstrated that they are mostly dissatisfied with construction workers' productivity followed by equipment and methods productivity . The least dissatisfaction is reported in the areas of site management, firm, and office management. To gain a better insight of the dissatisfaction differences between these six areas, the responses of dissatisfied (extremely dissatisfied and dissatisfied) and the satisfied (extremely satisfied and satisfied) are presented graphically in Figure 4.2. It can be seen that 65.5% expressed their dissatisfaction with firm's overall productivity and 74.5% expressed their dissatisfaction with construction workers' productivity .

The high dissatisfaction with construction workers' productivity may be due to the following reasons:

The first reason is that people in construction when they talk about productivity , tend to mean workers' productivity . The second reason is that labor productivity is the major determinant of productivity , so if overall productivity is low, the first possible problem is labor. The third reason is that labor productivity is relatively easier to quantify compared with other areas of productivity . The fourth reason may be the general feeling that third world workers are not productive.

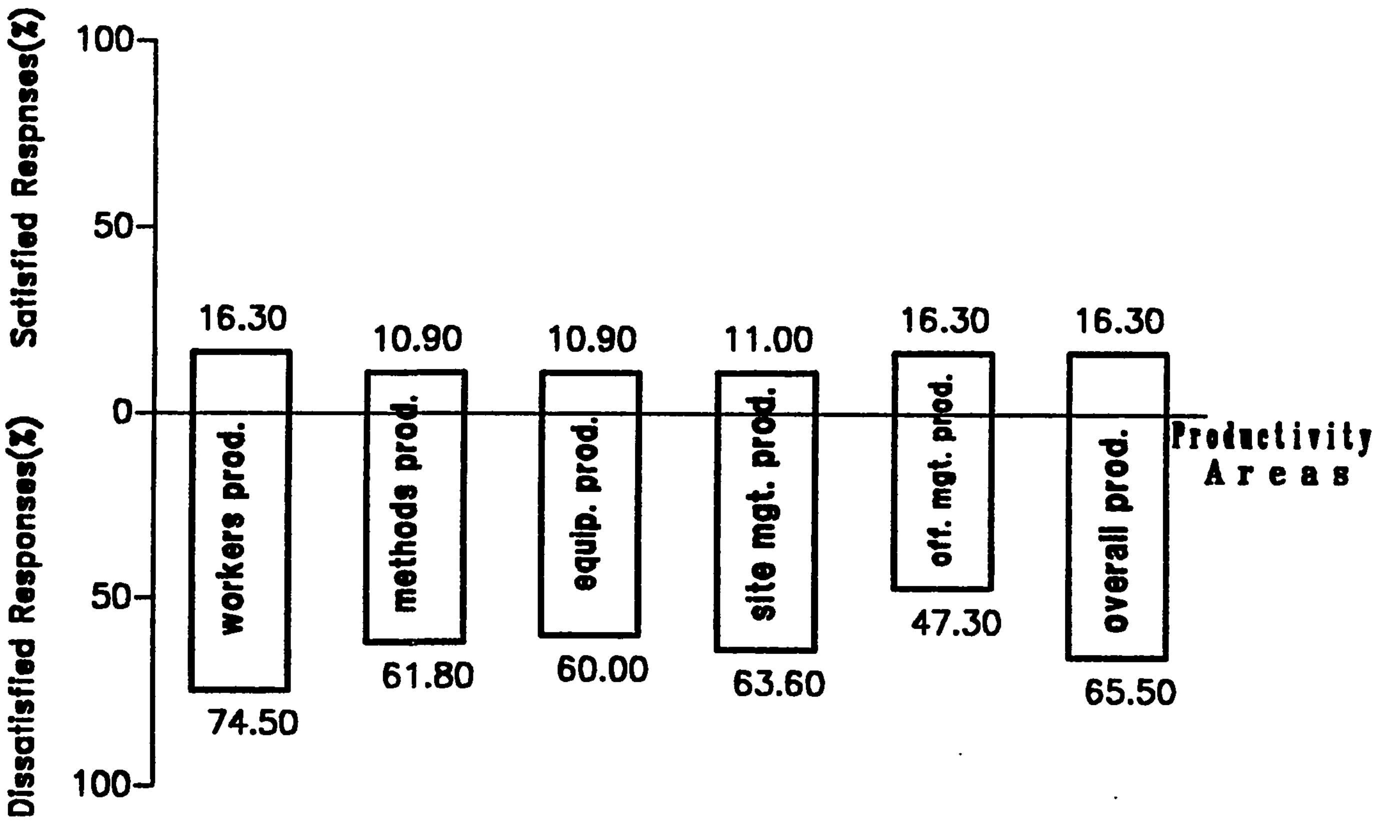


figure 4.2 satisfaction with existing level of productivity, N=55

Methods, site management, and equipment productivity received almost the same dissatisfaction/satisfaction level (60/10%). Sixty percent of the respondents expressed their dissatisfaction with equipment productivity , which is a relatively high percentage for building construction where equipment is not heavily involved. One reason behind this is that almost all large building contractors are also classified in other types of construction which are equipment intensive (road, utility, and industrial) (MPWH classification, 1409 H.). The mean value of equipment owned by contractors interviewed in this research is SR. 27.24 million (see Appendix B). Part of the dissatisfaction with equipment productivity may be associated with the dissatisfaction of workers' productivity .

The relatively low dissatisfaction (47.30%) with office management productivity may be due to the fact that management personnel in construction firms are more steady in their jobs so they can learn and get familiar with all job aspects, and it may be due to the fact that respondents are basically management staff which may cause some bias in favor of management. These results, along with the results of the previous section, suggest that there is a common agreement among construction contractors that there is a productivity problem.

4.1.4 Productivity Records

An indication of contractors productivity awareness is the maintenance of productivity records. This issue was investigated indirectly by asking the respondents to indicate the type of productivity records or information used in preparing a cost estimate for new projects. Figure 4.3 shows that 26% of the respondents stated that they depend on experience-based judgement. Twenty-one percent said that they use cost records associated with each element of work. Seventeen percent stated that they use both cost records associated with each element of work and experience-based judgement, fifteen percent said they use productivity records associated with each production factor. Nineteen percent said they use both cost records associated with each element of work and productivity records associated with each production factor.

This suggests that the documentation and keeping of productivity records and their reuse in preparing estimates is not fully utilized. People depend more on experience-based judgement in preparing estimates. In other words, only thirty-four percent use productivity records which indicate low awareness of the importance of productivity records.

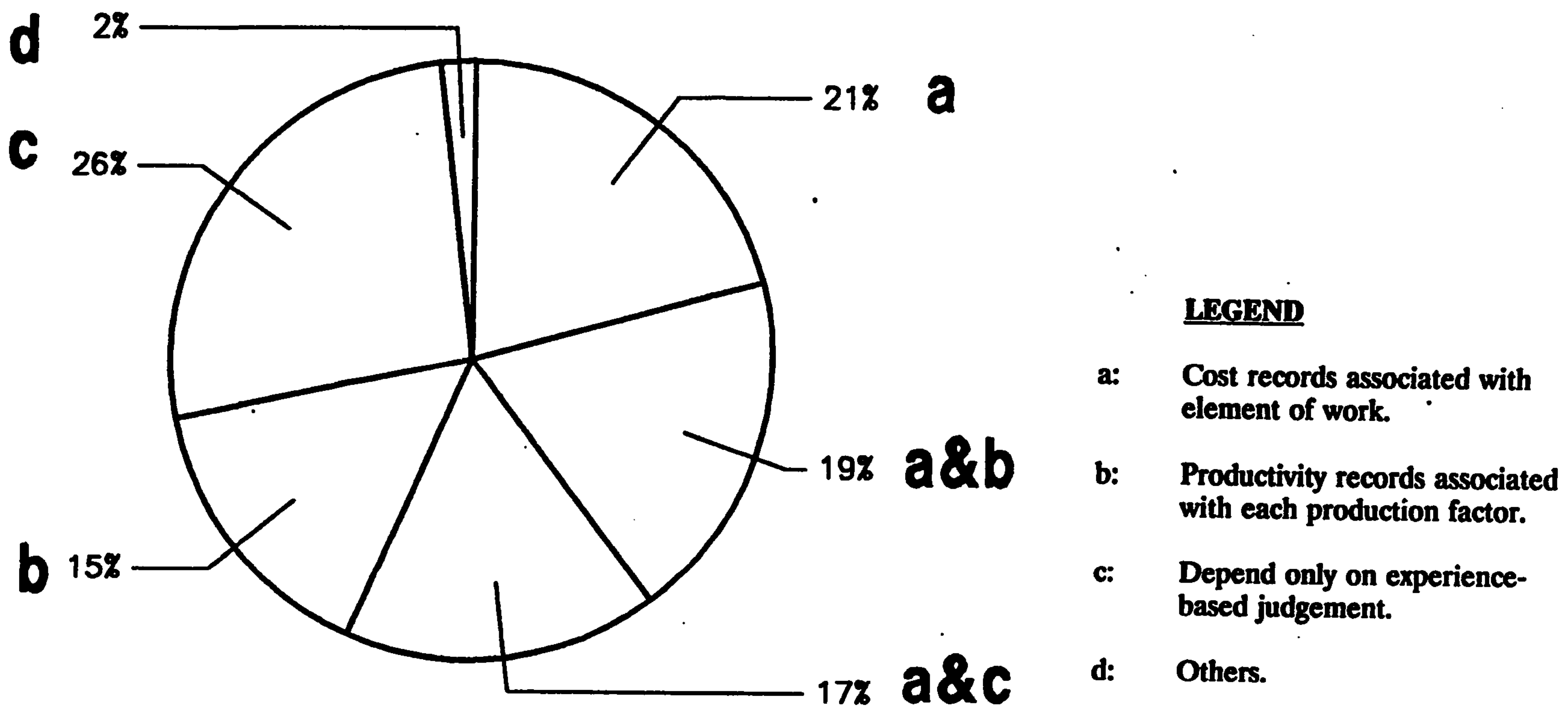


figure 4.3 productivity records used in estimating, N=55

4.2 Productivity Measurement Methods

Productivity measurement is vital to any improvement effort aimed at construction productivity . As described in Chapter 2, there are many productivity measurement methods available to the construction industry. In this part, the familiarity, the popularity, and the evaluation of these methods will be presented.

4.2.1 Familiarity of Methods

In question B8 of the questionnaire , the respondents were asked to indicate their level of familiarity with various productivity measurement methods. The methods were explained to respondents prior to answering the question. Five levels of familiarity were used. Table 4.4 shows various methods and the mean responses indicating the respondents' familiarity with each of them.

The Cost Reporting and Cost Control System (CRCS) was the most familiar measurement method with a mean response of 3.69 which is more than the "familiar" and closer to the "very familiar" response. None of the respondents indicated that he had never heard of CRCS. Respondents' familiarity with the other six measurement methods was around the "somewhat familiar" response ranging from 1.84 to 2.24. This suggests that Cost Reporting and Control System (CRCS) is practically the only method that respondents are familiar with. These results were somewhat expected since the Cost Reporting and Control System (CRCS) is a traditional method which is commonly used by construction companies (Russell & Chang, 1987).

Table 4.4

Respondents' Familiarity with Different Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank
Cost Reporting and Control System (CRCS)	3.69	0.73	1
Work Sampling (WS)	2.24	1.18	2
Foreman Delay Survey (FDS)	2.08	1.1	3
Flow Process Chart (FPC)	2.04	1.13	4
Craftsman Questionnaire (CQ)	1.86	0.98	5
Method Productivity Delay Model (MPDM)	1.85	1.15	6
Craftsman Questionnaire Sampling (CQS)	1.84	0.96	7

* Ranges from 1 (never heard of) to 5 (extremely familiar)

N = 49.

To gain some understanding of the association between the level of familiarity with the measurement techniques and the contractors' characteristics, a correlation analysis using Pearson's correlation coefficient (r) was performed. Among contractors' characteristics investigated are Riyal value of equipment, annual construction volume, and number of employees. The results show that the Riyal value of construction equipment was found to be positively correlated with the familiarity with the following measurement methods: Craftsman Questionnaire (CQ) ($r = 0.54$, $P < 0.001$), Craftsman Questionnaire Sampling (CQS) ($r = 0.52$, $P < 0.001$), Foreman Delay Survey (FDS) ($r = 0.37$, $P < 0.1$), Method Productivity Delay Model (MPDM) ($r = 0.52$, $P < 0.001$), and Flow Process Chart (FPC) ($r = 0.50$, $P < 0.001$). The annual construction volume was found to be positively correlated with Craftsman Questionnaire (CQ) ($r = 0.51$, $P < 0.001$), and Craftsman questionnaire sampling (CQS) ($r = 0.44$, $P < 0.01$). The number of employees was found to be positively correlated with Craftsman Questionnaire (CQ) ($r = 0.38$, $P < 0.01$), and Craftsman Questionnaire Sampling (CQS) ($r = 0.37$, $P < 0.1$). Since the value of equipment, the number of employees, and the annual construction volume are indicators of the size of a company, it can be said that larger companies tend to be more familiar with non-traditional productivity measurement methods. This may be due to the fact that larger firms tend to tackle the productivity problem in a more serious way than smaller firms do. This seriousness includes, among other things, the use of different alternative methods to measure and improve productivity and the tendency to recruit more qualified personnel who have updated knowledge in this field.

4.2.2 Popularity of Methods

Question B9 of the questionnaire requested information about the frequency of usage for each measurement method. The frequency was measured on a scale ranging from 1 (never) to 5 (always). The results are shown in Table 4.5.

Table 4.5

Popularity of Various Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank
Cost Reporting and Control System (CRCS)	3.38	0.93	1
Work Sampling (WS)	2.00	1.20	2
Foreman Delay Survey (FDS)	1.85	1.12	3
Flow Process Chart (FPC)	1.70	0.95	4
Craftsman Questionnaire Sampling (CQS)	1.67	0.97	5
Craftsman Questionnaire (CQ)	1.56	0.90	6
Method Productivity Delay Model (MPDM)	1.5	0.84	7

* Ranges from 1 (never) to 5 (always)

N = 48.

As can be seen from the results, the Cost Reporting and Control System got an average response of (3.38) which is a little more than the "sometimes" response. It ranked first as the most popular and used method. Work sampling came out to be the second most popular method with an average response of 2.0 which is "rarely used". The other five methods got average responses somewhere between 1.5 and 1.85 which are less than the "rarely used" response. These results indicate that there is a lack of utilization of the productivity measurement methods.

The correlation coefficients between the familiarity and the popularity (frequency of usage) of methods are shown in Table 4.6.

Table 4.6

Coefficients of Correlation Between Familiarity and Popularity of Methods

Method	(r)	P <
Work sampling (WS)	0.80	0.001
Craftsman questionnaire (CQ)	0.77	0.001
Craftsman questionnaire sampling (CQS)	0.82	0.001
Foreman-Delay Survey (FDS)	0.85	0.001
Cost Reporting and Control System (CRCS)	0.49	0.001
Method Productivity Delay Model (MPDM)	0.68	0.001
Flow Process Chart (FPC)	0.79	0.001

N = 48.

These high positive values of the correlation coefficient show that the frequency of usage of different methods is strongly related to the familiarity with these methods. Hence, a very plausible reason behind not using these methods is the unfamiliarity. This seems logical because the familiarity (the know-how) is a prerequisite for the usage of any method.

4.2.3 Evaluation of Methods

The respondents were asked in question B10 of the questionnaire to evaluate the presence of different attributes in each measurement method. Each attribute was to be rated on a 1 to 5 scale, where 1 stands for "very low" and 5 stands for "very high". Some of these attributes are positive such as reliability, comprehensiveness, positive participation of workers, and effectiveness in measuring and improving productivity , while the others are negative such as, the demand on trained personnel, demand on data processing, cost of measurement, time of measurement, negative reaction of workers, and communication problems. Only respondents who indicated familiarity with a particular method, even if they did not use it, were used for the evaluation of the method.

The results of all attributes are shown in Tables 4.7 through 4.16 where the negative scores of negative attributes are not reversed. It is noticed in all these tables that N is smaller in the case of responses to methods other than Cost Reporting and Control System. This is due to the fact that respondents are less familiar with these methods. Starting first with the positive attributes, Table 4.7 shows the results of the reliability where the Cost Reporting and Control System (CRCS) got the highest score followed by the foreman delay survey (FDS). The remaining five methods, which are CQS, WS, FPC, MPDM, and CQS, got almost the same scores ranging from 2.63 to 2.84. However, the Flow Process Chart (FPC) and the Method Productivity Delay Model which are quantitative methods got relatively low scores of 2.72 and 2.67 respectively, which was not expected. One possible reason behind this is that the respondent's perception of a method is affected somehow by the familiarity with that method. In other words, a relatively low familiarity with these two methods may have led to this misjudgement and unexpected results. Although the difference is too small between the scores of Craftsman Questionnaire Sampling (2.84) and Craftsman Questionnaire (2.63), this difference may be due to the fact that Craftsman questionnaire sampling involves more statistical reliability (Russell & Chang, 1987). This could be due to less demand on memory.

The second positive attribute is the comprehensiveness, whose results are shown in Table 4.8; where the Cost Reporting and Control System (CRCS) received the highest score, followed by the Foreman Delay Survey (FDS), the Craftsman Questionnaire (CQ), the Craftsman Questionnaire Sampling (CQS), Method Productivity Delay Model (MPDM), and the Flow Process Chart (FPC) which received almost the same scores ranging from 2.83 to 3.16. The Work Sampling (WS) got the lowest score which is somewhat unexpected since Work Sampling can be used for different objectives where the work categories are established according to the objective of the study. Broad objectives imply broad categories and sharply focused objectives require more detailed categories (Thomas & Holland, 1980).

The results of the third positive attribute which is the positive participation of workers are shown in Table 4.9. The Craftsman Questionnaire scored the highest followed by the Foreman Delay Survey and then by Craftsman Questionnaire sampling. This makes sense because these methods require workers' input which creates an open and active atmosphere of participation that may bring job satisfaction and motivation to workers (Chang & Borcherding, 1985). The other four methods which are CRCS, MPDM, WS and FPC had scores ranging from 1.82 to 2.56. These methods do not need workers input.

Table 4.10 shows the results of the fourth positive attribute which is the effectiveness in measuring productivity , the Cost Reporting and Control System (CRCS) scored the highest followed by Method Productivity Delay Model, Foreman Delay Survey, and Craftsman Questionnaire which got scores ranging from 3.26 to 3.45 which are nearly the same.

The first negative attribute is the requirement of trained personnel. Table 4.11 shows the results of this attribute where Cost Reporting and Control System made the most demand on trained personnel followed by method productivity delay model, then came the remaining five methods ordered as follows: FPC, CQS, CQ, FDS and WS. This order generally makes sense except for CQ where there is not much demand on trained personnel.

The second negative attribute is the level of data processing. Table 4.12 shows the results of this attribute where Cost Reporting and Control System scored the highest (3.82) which is too high if the cost records are already used in the organization, but it would be expected if CRCS is exclusively maintained for Productivity Measurement. Following CRCS are CQ, FDS, CQS and MPDM with scores ranging from 3.00 to 3.21 which are nearly the same. The Flow Process Chart scored the lowest (2.14) which is very low and unexpected since FPC is a quantitative method and needs data processing. This may be due to the relatively low familiarity with FPC.

The third negative attribute is the cost of measurement. Table 4.13 shows the results of this attribute where the Cost Reporting and Control System scored the highest (3.65) which is too high if cost records are already used in the firm. The second highest method is the Craftsman Questionnaire, then comes CQS, MPDM, and FDS with scores ranging from 2.68 to 2.84 which are almost the same. The last two methods are FPC and WS. The ordering of methods is generally reasonable.

The fourth negative attribute is the time requirement for measurement. Table 4.14 shows the results of this attribute where the Cost Reporting and Control System scored the highest (3.75) which is too high if cost records are already in the firm. Then came the remaining methods which are CQ, CQS, MPDM, FDS, FPC, and WS. The methods in this table are ordered in the same way as in Table 4.13. A possible explanation for this is that time is a component of cost.

The fifth negative attribute is the potential for negative reaction of workers. Table 4.15 shows the results of this attribute where Work Sampling scored the highest followed by Craftsman Questionnaire, Foreman Delay Survey, and Craftsman Questionnaire Sampling which makes sense because these methods require workers' input. Then come the remaining three methods which are MPDM, CRCS, and FPC. This is reasonable since these methods do not require workers' input.

The sixth negative attribute is the potential communication problems. The communication meant here is that between the different parties, within the organization, who are involved in the application of the method. The communication problem may be due to some language barriers, organizational constraints, or misunderstanding resulting from the application of some methods without full coordination between different interested parties (Thomas & Holland, 1980). Table 4.16 shows the results of this attribute where Craftsman Questionnaire Sampling scored the highest followed by Craftsman Questionnaire which makes sense since the application of both methods involves many parties, i.e., productivity engineer, foreman and workers. CQS, CQ, and CRCS had almost the same scores ranging from 3.02 to 3.21. FDS, MPDM, and FPC had nearly the same scores ranging from 2.59 to 2.79. Work Sampling got a very low score (1.95) which is not expected since WS has a potential for communication problems (Thomas & Holland, 1980).

Another way of looking at the whole picture is by drawing a curve showing the scores of major attributes, with the scores of negative attributes reversed. The major attributes selected are: reliability, comprehensiveness, cost of measurement, time of measurement, and effectiveness. Fig. 4.5 shows the curves for all methods, the higher the curve at each attribute, the better the method.

From Figure 4.5, it can be seen that the Cost Reporting and Control System scored the highest in the three major positive attributes; while it scored the least, after reversing the score, in the two major negative attributes. This is despite the fact that CRCS is the most familiar and popular method (4.2.1, 4.2.2). One possible reason behind this is that respondents give, in general, more weight to the negative attributes than the positive ones. One more thing to be noticed is that the difference between CRCS and the second highest method in positive attributes is relatively big. This suggests that CRCS is, relatively, the best method for use on a continuous basis, since it requires continuous maintenance of cost records. Putting more emphasis on the effectiveness score, MPDM is the second method advised for use and FDS is the third method recommended for use.

Table 4.7: Reliability of Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank	N
Cost Reporting and Control System (CRCS)	4.19	0.76	1	48
Foreman Delay Survey (FDS)	3.26	0.56	2	19
Craftsman Questionnaire Sampling (CQS)	2.84	0.76	3	19
Work Sampling (WS)	2.77	0.75	4	22
Flow Process Chart (FPC)	2.72	0.67	5	18
Method Productivity Delay Model (MPDM)	2.67	1.07	6	12
Craftsman Questionnaire (CQ)	2.63	0.50	7	19

* Ranges from 1 (very low) to 5 (very high).

Table 4.8: Comprehensiveness of Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank	N
Cost Reporting and Control System (CRCS)	3.94	0.73	1	48
Foreman Delay Survey (FDS)	3.32	0.67	2	19
Craftsman Questionnaire (CQ)	3.16	0.76	3	19
Craftsman Questionnaire Sampling (CQS)	3.05	0.62	4	19
Method Productivity Delay Model (MPDM)	2.92	1.16	5	12
Flow Process Chart (FPC)	2.83	0.99	6	18
Work Sampling (WS)	2.36	0.90	7	22

* Ranges from 1 (very low) to 5 (very high).

Table 4.9

Potential of Positive Participation of Workers

Method	Mean* Response	Standard Deviation	Rank	N
Craftsman Questionnaire (CQ)	3.84	0.96	1	19
Foreman Delay Survey (FDS)	3.68	0.48	2	19
Craftsman Questionnaire Sampling (CQS)	3.53	0.61	3	19
Cost Reporting and Control System (CRCS)	2.56	1.03	4	48
Method Productivity Delay Model (MPDM)	2.33	1.44	5	12
Work Sampling (WS)	2.23	1.15	6	22
Flow Process Chart (FPC)	1.82	1.19	7	17

* Ranges from 1 (very low) to 5 (very high).

Table 4.10

Methods Effectiveness in Measuring Productivity

Method	Mean* Response	Standard Deviation	Rank	N
Cost Reporting and Control System (CRCS)	4.27	0.54	1	48
Method Productivity Delay Model (MPDM)	3.45	0.93	2	11
Foreman Delay Survey (FDS)	3.42	0.51	3	19
Craftsman Questionnaire Sampling (CQS)	3.26	0.56	4	19
Craftsman Questionnaire (CQ)	3.11	0.46	5	19
Flow Process Chart (FPC)	3.00	0.79	6	17
Work Sampling (WS)	2.77	0.81	7	22

* Ranges from 1 (very low) to 5 (very high).

Table 4.11

Requirement of Trained Personnel for Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank	N
Cost Reporting and Control System (CRCS)	3.72	0.68	1	47
Method Productivity Delay Model (MPDM)	3.58	0.67	2	12
Flow Process Chart (FPC)	3.17	0.86	3	18
Craftsman Questionnaire Sampling(CQS)	3.00	0.91	4	18
Craftsman Questionnaire (CQ)	2.94	0.94	5	18
Foreman Delay Survey (FDS)	2.72	0.75	6	18
Work Sampling (WS)	2.14	0.79	7	21

* Ranges from 1 (very low) to 5 (very high).

Table 4.12

Level of Data Processing for Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank	N
Cost Reporting and Control System (CRCS)	3.82	0.76	1	44
Craftsman Questionnaire (CQ)	3.21	0.71	2	19
Foreman Delay Survey (FDS)	3.20	0.56	3	15
Craftsman Questionnaire Sampling (CQS)	3.05	0.62	4	19
Method Productivity Delay Model (MPDM)	3.00	0.76	5	8
Work Sampling (WS)	2.73	0.70	6	22
Flow Process Chart (FPC)	2.14	1.17	7	14

* Ranges from 1 (very low) to 5 (very high).

Table 4.13

Cost of Measurement in Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank	N
Cost Reporting and Control System (CRCS)	3.65	0.70	1	48
Craftsman Questionnaire (CQ)	3.32	0.75	2	19
Craftsman Questionnaire Sampling (CQS)	2.84	0.76	3	19
Method Productivity Delay Model (MPDM)	2.83	1.11	4	12
Foreman Delay Survey (FDS)	2.68	0.82	5	19
Flow Process Chart (FPC)	2.39	1.24	6	18
Work Sampling (WS)	2.14	0.94	7	22

* Ranges from 1 (very low) to 5 (very high).

Table 4.14

Time Requirement for Measurement in Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank	N
Cost Reporting and Control System (CRCS)	3.75	0.76	1	48
Craftsman Questionnaire (CQ)	3.26	0.87	2	19
Craftsman Questionnaire Sampling (CQS)	2.89	0.94	3	19
Method Productivity Delay Model (MPDM)	2.83	0.94	4	12
Foreman Delay Survey (FDS)	2.79	0.79	5	19
Flow Process Chart (FPC)	2.67	0.91	6	18
Work Sampling (WS)	2.27	0.7	7	22

* Ranges from 1 (very low) to 5 (very high).

Table 4.15

Potential of Negative Reaction of Workers

Method	Mean* Response	Standard Deviation	Rank	N
Work Sampling (WS)	3.59	0.80	1	22
Craftsman Questionnaire (CQ)	3.47	0.84	2	19
Foreman Delay Survey (FDS)	3.32	0.67	3	19
Craftsman Questionnaire Sampling (CQS)	3.26	0.73	4	19
Method Productivity Delay Model (MPDM)	2.50	1.24	5	12
Cost Reporting and Control System (CRCS)	2.38	1.12	6	48
Flow Process Chart (FPC)	1.76	1.03	7	17

* Ranges from 1 (very low) to 5 (very high).

Table 4.16

Potential Communication Problems in Productivity Measurement Methods

Method	Mean* Response	Standard Deviation	Rank	N
Craftsman Questionnaire Sampling (CQS)	3.21	0.63	1	19
Craftsman Questionnaire (CQ)	3.16	0.69	2	19
Cost Reporting and Control System (CRCS)	3.02	0.91	3	48
Foreman Delay Survey (FDS)	2.79	1.13	4	19
Method Productivity Delay Model (MPDM)	2.67	1.30	5	12
Flow Process Chart (FPC)	2.59	1.33	6	17
Work Sampling (WS)	1.95	1.17	7	22

* Ranges from 1 (very low) to 5 (very high).

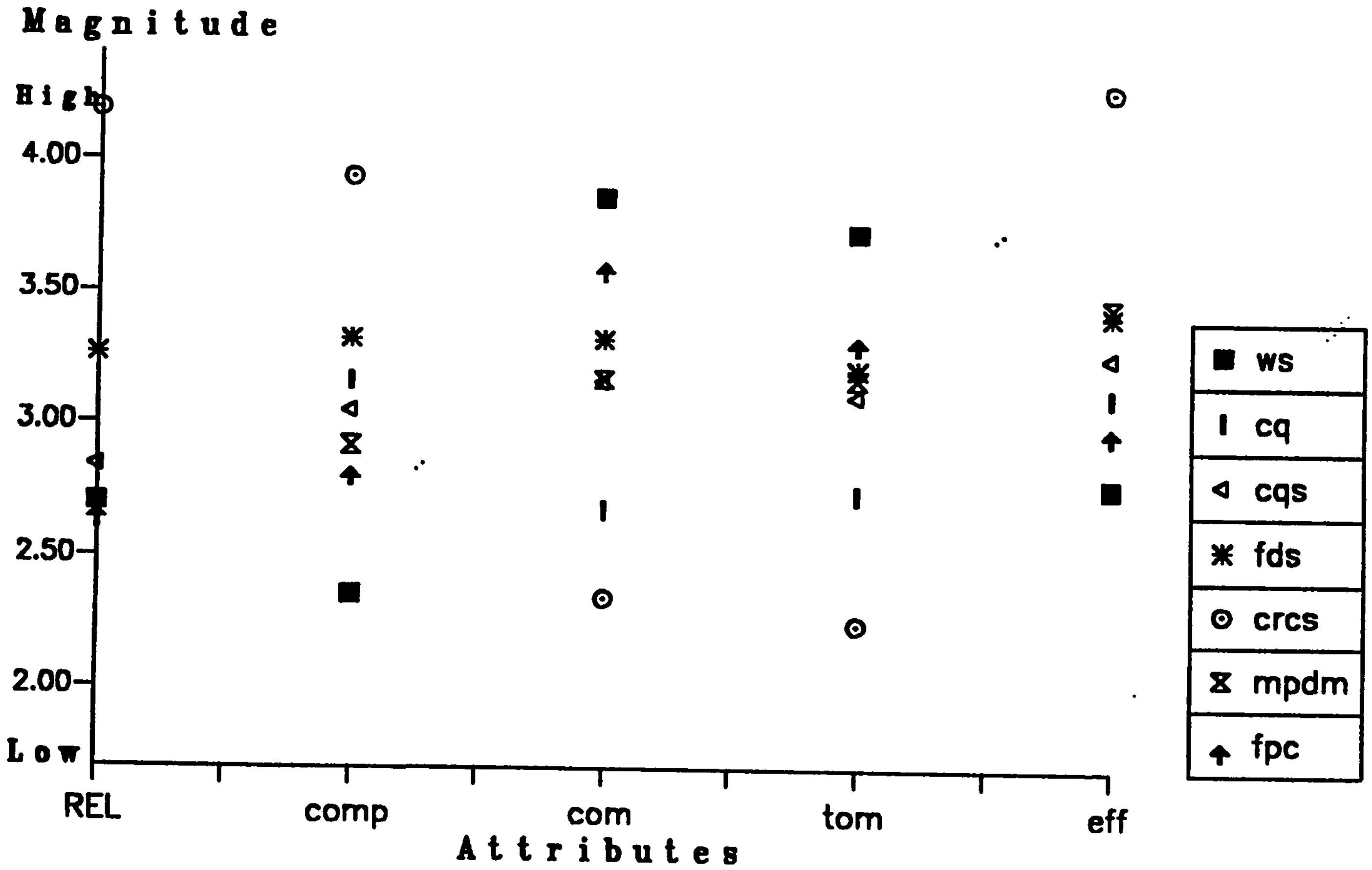


figure 4.5 evaluation of methods major attributes

4.3 Hindrances to Productivity Improvement Programs (PIP)

There are many factors which can be perceived as hindrances to Productivity Improvement Programs (PIP). Fourteen such factors are investigated. These factors are: The concept of productivity improvement programs is not well known to us, measurement of productivity is too difficult, measurement of benefit/cost of productivity is too difficult, lack of incentives from project owners to implement productivity improvement programs, lack of qualified personnel to apply them, it is just "good engineering" which we do anyway, the concept of productivity is too complicated and theoretical, it is too difficult to get started (we are too busy), the culture of the organization is not productivity conscious, projects are too short to implement productivity programs, it costs too much, lack of awareness among contractors, lack of management support, and lack of trained personnel. The respondents were asked to indicate their level of agreement with various factors as being hindrances to PIP in their own firms. Table 4.17 shows the results of question B6 of the questionnaire .

Looking at the results shown in Table 4.17, it can be seen that only factor 4 (lack of incentives from project owners to implement productivity improvement programs) out of the first 11 factors received a relatively high level of agreement. This may be due to the fact that factor 4 shifts the responsibility to owners. In the remaining ten of the first eleven factors, the clear majority of respondents disagree with these factors as being hindrances to PIP. Such disagreement is inconsistent with the results of section 4.1.1, which indicated that respondents do not have a unified conceptualization of productivity and a majority of respondents did not provide answers to what productivity means to them which suggests that there is a lack of awareness. It is also inconsistent with the results of section 4.2.1, which suggest that CRCS is practically the only method that respondents are familiar with, and with those of section 4.5.1.1 which show limited organizational commitment to the area of productivity . This discrepancy may be due to the lack of productivity awareness. It may also be due to some bias caused by the fact that respondents tend to defend themselves against looking like being not fully aware of productivity concepts or not having qualified people to implement PIP. Another possible reason behind this discrepancy is that respondents lost the link between the first eleven factors and the beginning of the question. On the other hand, the last three factors which are the lack of awareness among contractors, lack of management support, and lack of trained personnel received a high level of agreement as being hindrances to PIP. Item 13 which asked to identify other hindrances received no answer. This may be due to the comprehensiveness of the factors which are listed in the questionnaire or due to misunderstanding of the question.

Assuming limited impact of the above biases, the above results suggest that sources of hindrances are limited and that in order to initiate a PIP, management support should be gained by addressing the economical feasibility of PIPs. The awareness should be enhanced at both the individual and the organizational levels. The staff who are supposed to handle the PIP should be well trained. Furthermore, the owners should put some incentives for the contractors to encourage them to initiate and implement PIP. Some incentives may be in the form of sharing the profit accrued by cost saving due to PIP usage in cost reimbursable contracts. The government may enforce the implementation of PIP in government projects which will result in more productivity and less project costs at the national level.

Table 4.17: Hindrances of Productivity Improvement Programs

SI No.	REASONS	RESPONSES *					
		STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE	MEAN**
1	The Concept of productivity improvement programs is not well known to us.	3 5.90	3 5.90	9 17.60	21 41.20	15 29.4	3.82
2	Measurement of productivity is too difficult	2. 3.8	11 21.2	7 13.5	23 44.2	9 17.3	3.50
3	Measurement of benefit/cost of productivity is too difficult	0 0	11 21.2	13 25	16 30.8	12 23.1	3.56
4	We have never been asked by owners to implement productivity improvement program for additional incentives	10 19.2	12 23.1	15 28.8	7 13.5	8 15.4	2.83
5	We do not have qualified personnel to apply it	3 5.8	8 15.4	13 25	20 38.5	8 15.4	3.42
6	It is just "good engineering" which we do any way	5 9.8	9 17.6	13 25.5	20 39.2	4 7.8	3.18
7	Productivity concept is too complicated and theoretical	0 0	2 3.8	12 23.1	18 34.6	20 38.5	4.08
8	It is too difficult to get started (we are too busy)	0 0	5 9.6	12 23.1	25 48.1	10 19.2	3.77
9	The organization culture is not productivity conscious	0 0	2 3.9	9 17.6	28 54.9	12 23.5	3.98
10	Projects are too short to implement productivity programs	0 0	2 3.8	17 32.3	30 57.7	11 21.2	3.96
11	It costs too much	1 1.9	4 7.7	17 32.7	23 44.2	7 13.5	3.60
12	Productivity Improvement Programs will not succeed in Saudi Arabia because of:						
	(a) Lack of awareness among contractors	10 20	17 34	8 16	9 18	6 12	2.68
	(b) Lack of management support	9 18	22 44	7 14	6 12	6 12	2.56
	(c) Lack of trained personnel: mgt./workers	6 11.8	17 33.4	16 31.4	6 11.8	6 11.8	2.78

* The top figure is the frequency and the lower figure is the percentage
** Ranges from 1 (strongly agree) to 5 (strongly disagree)
N = 51

4.4 Potential Areas for Productivity Improvement

In order to improve construction productivity, it is important not only to remove hindrance, but also to focus on specific areas or functions with high potential to improve productivity . There are two types of such areas. Head Office-Related Areas, and Site-Related Areas.

4.4.1 Head Office-Related Areas

Question C12 of the questionnaire lists nine head office-related areas. As mentioned in Section 2.3.2, these are the areas which are taken care of by the head office of the company and may have an impact on construction productivity . Respondents were asked to rate these areas for their potential to improve construction productivity . Table 4.18 shows these areas ranked in accordance with their potential to improve construction productivity . The mean response was used to rank the functions where 5 = very high potential and 1 = very low potential. All these functions can be considered as having a potential for productivity improvement. The lowest function is the drafting with a mean response of 3.08, and the highest function is the planning with a mean response of 4.51. Fig. 4.6 shows this result too. However, the level of potential to improve productivity may be affected by the size of the construction firm. Contractors were classified into three classes based on their annual construction volume: small (less than SR. 50 million), medium (larger than SR. 50 million but less than SR. 200 million), and large (more than SR. 200 million). This criteria was used because the construction volumes of many contractors were found to be incompatible with their grades, e.g., a contractor who is classified in second grade has a construction volume of SR 6 million.

Table 4.18

"Headquarters-Type" Functions Potential to Improve Productivity [All Firms]

Functions	Mean* Response	Standard Deviation	Rank
Planning	4.51	0.63	1
Scheduling	4.4	0.76	2
Procurement	4.07	0.88	3
Engineering	3.78	0.84	4
Communication	3.55	0.89	5
Marketing	3.48	0.93	6
Specification	3.43	0.85	7
Estimating	3.40	0.93	8
Drafting	3.08	1.02	9

* (5 = very high, 1 = very low).

N = 55.

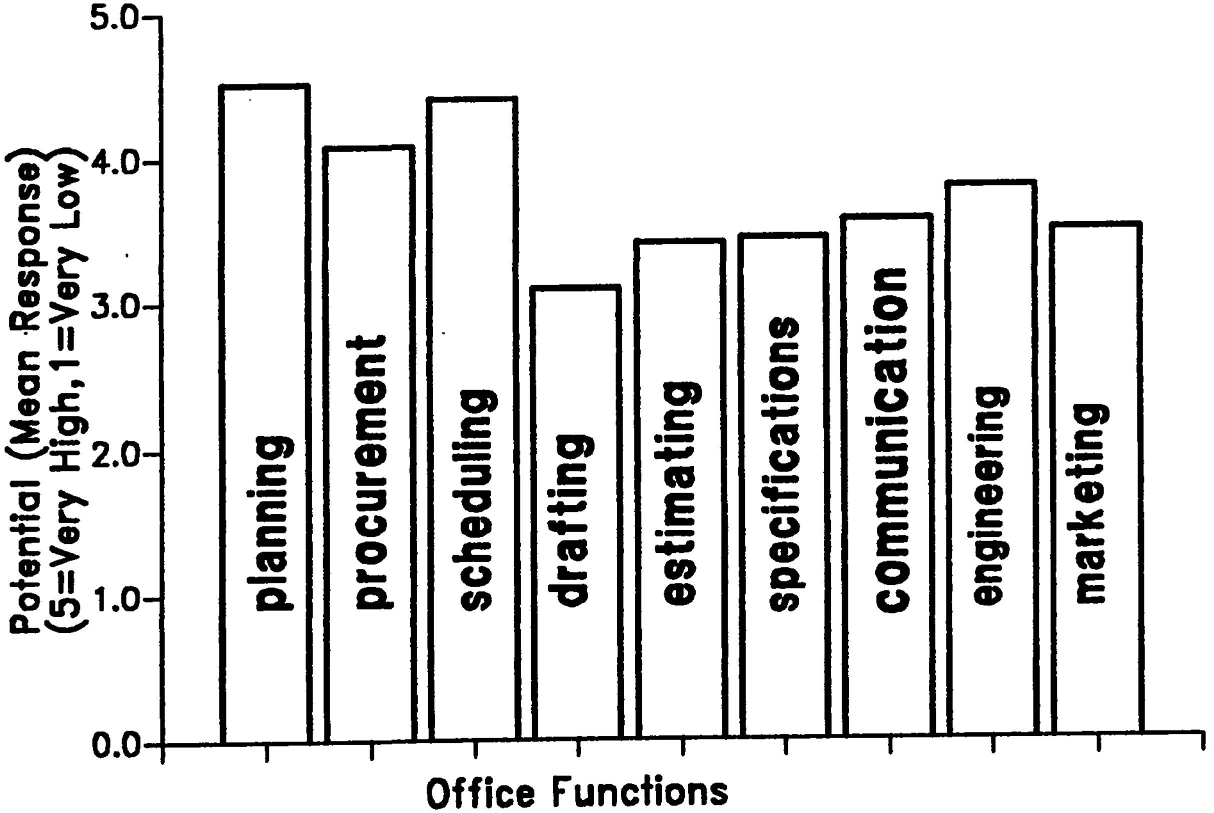


Figure 4.6 Office-related Functions Potential to Improve Productivity (All Firms), N=55

Tables 4.19, 4.20 and 4.21 and Figures 4.7, 4.8 and 4.9 show that scheduling is the area with the highest potential for productivity improvement for both medium and large size contractors while planning is the second highest (with a slight difference) for the same two sizes. For small size contractors, planning is the area with the highest potential for productivity improvement, whereas scheduling is the area with the second highest potential (with a slight difference).

Table 4.19

"Headquarters-Type" Functions Potential to Improve Productivity [Small Firms]

Functions	Mean* Response	Rank
Planning	4.38	1
Scheduling	4.04	2
Procurement	3.88	3
Marketing	3.76	4
Engineering	3.71	5
Communication	3.54	6
Specification	3.25	7
Estimating	3.13	8
Drafting	2.79	9

* (5 = very high, 1 = very low).

N = 24

Table 4.20

"Headquarters-Type" Functions Potential to Improve Productivity [Medium Firms]

Functions	Mean* Response	Rank
Scheduling	4.75	1
Planning	4.70	2
Procurement	4.30	3
Specification	3.94	4
Engineering	3.82	5
Estimating	3.67	6
Communication	3.67	6
Drafting	3.50	8
Marketing	3.46	9

* (5 = very high, 1 = very low).

N = 23

Table 4.21

"Headquarters-Type" Functions Potential to Improve Productivity [Large Firms]

Functions	Mean* Response	Rank
Scheduling	4.55	1
Planning	4.45	2
Procurement	4.09	3
Engineering	3.89	4
Estimating	3.55	5
Communication	3.36	6
Drafting	3.00	7
Specification	3.00	7
Marketing	2.90	9

* (5 = very high, 1 = very low).

N = 8

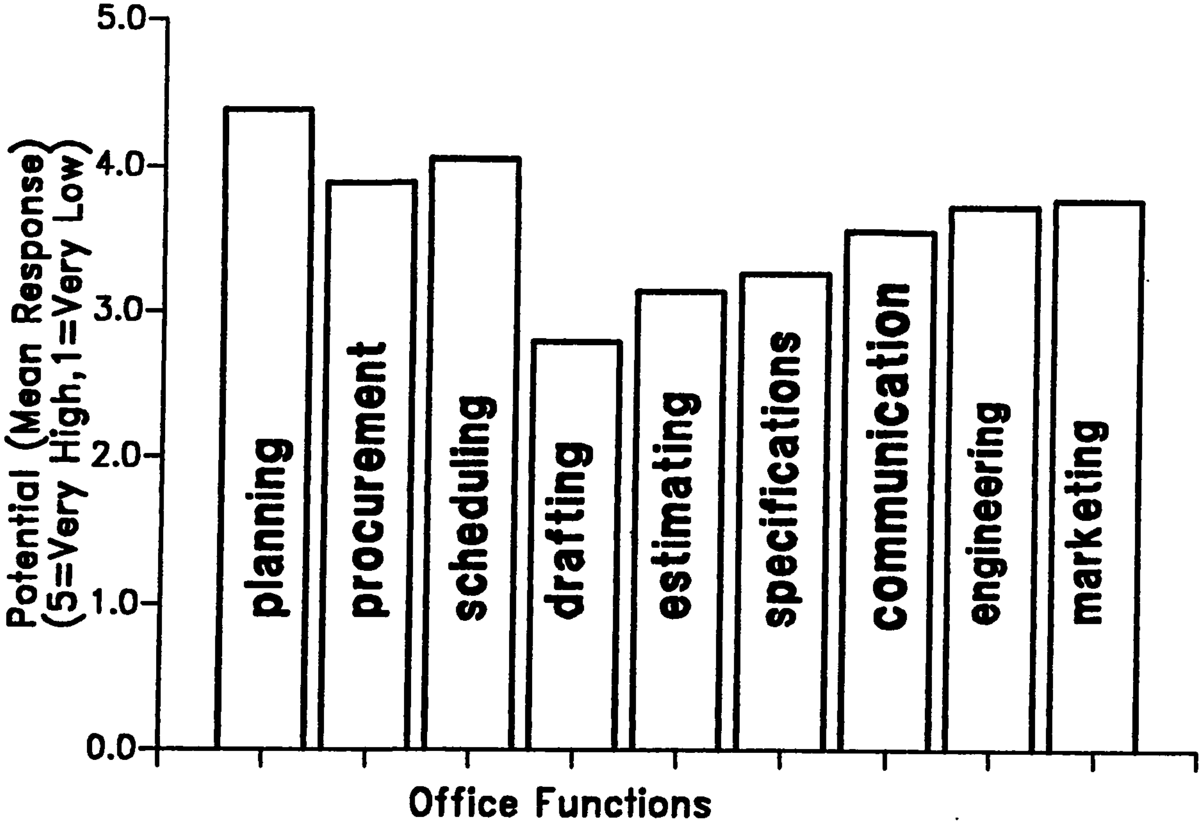


Figure 4.7 Office-related Functions Potential To Improve Productivity (Small Firms), N=24

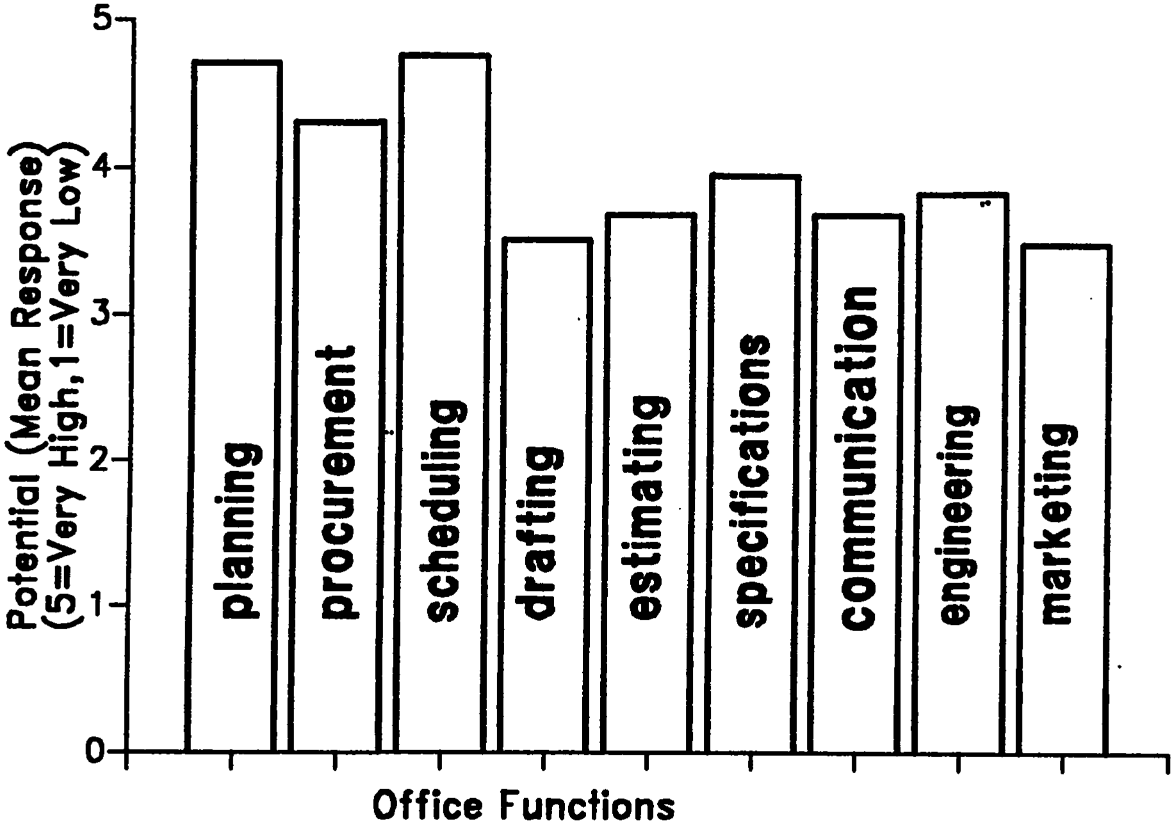


Figure 4.8 Office-related Functions Potential To Improve Productivity (Medium Firms),N=23

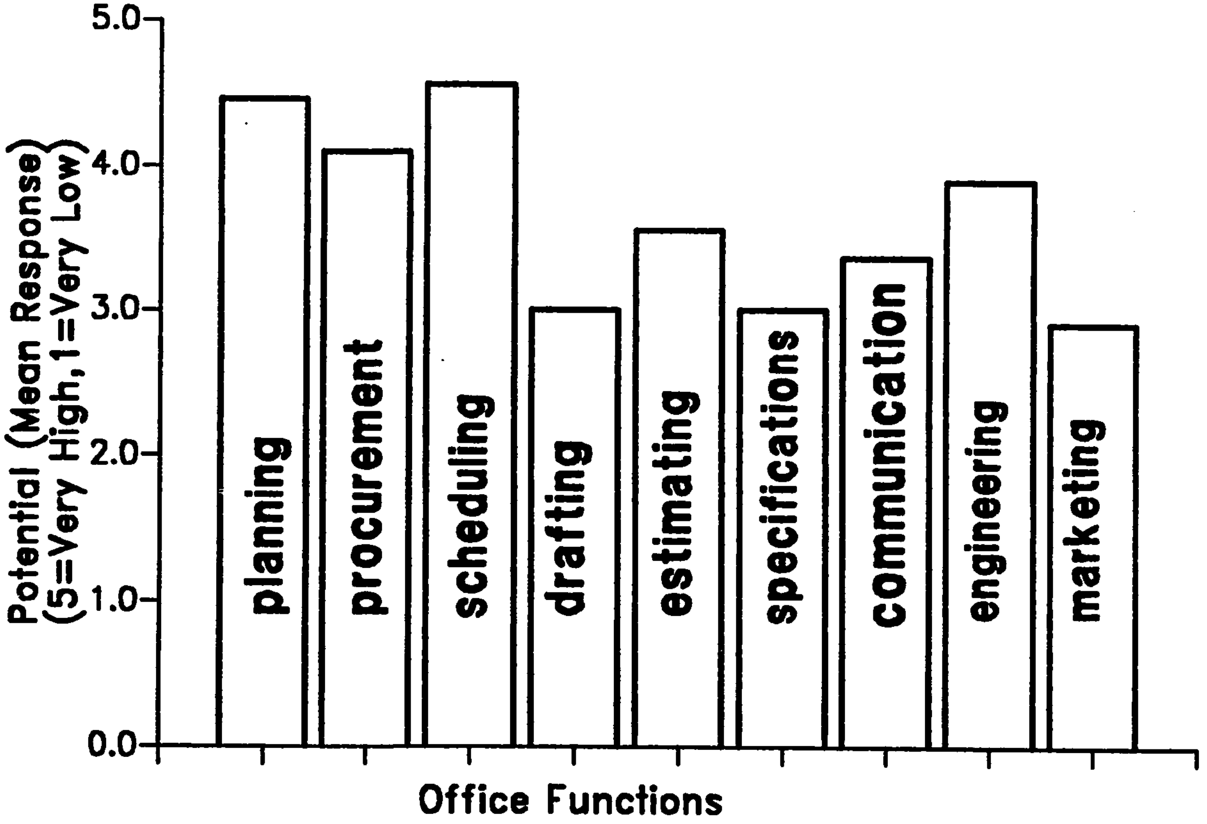


Figure 4.9 Office-related Functions Potential To Improve Productivity (Large Firms),N=8

Areas with the lowest potential for productivity improvement are marketing for large and medium size contractors, and drafting for small size contractors.

From the above results, planning and scheduling can be considered as the two most important areas with potential to improve productivity , regardless of the size of the firm. This is not unexpected because planning and scheduling are basically the heart of construction management. Procurement is also important for all.

Marketing scored the lowest for large and medium size firms. This may be due to the fact that bigger firms are well known in the market, so there is not much potential for productivity improvement in marketing, while in the case of small firms, marketing ranked fourth. This is because small firms need to be known in the market in order to get more projects. Another possible reason is the weak link between marketing and construction productivity .

In order to test and identify differences between different sizes, DISCRIMINANT ANALYSIS was used.

The Discriminant Function Analysis (DFA) is a multivarite technique which helps to explain how groups differ. The basic mechanism of this technique is to linearly combine a set of discriminant variables to create functions which will produce maximally different group scores (SAS USER GUIDE, 1982). In the setting of this research, the groups are the three sizes of contractors and the discriminant variables are the areas (functions) of productivity improvement.

There are two stages of analyzing the output of the discriminant analysis. The first stage is the selection of the discriminant functions. This can be done by reviewing the results shown in Table 4.22, where the following parameters can be observed.

1. Canonical correlation for function 1 = 0.650

2. Canonical correlation for function 2 = 0.454

This means that the degree of association between the three sizes and (Can1 and Can2) is relatively high which implies the sizes are different.

Examining the Eigen Values:

- Eigen Value for function 1 = 0.732
- Eigen Value for function 2 = 0.260

Seventy four percent of the variance of the discriminating variables is explained by function 1 while 26% of this variance is explained by function 2.

3. Square canonical correlation for function 1 = 0.422.
4. Square canonical correlation for function 2 = 0.206.

This indicates that the proportion of variation in the discriminant functions is explained by the groups (Klecka, 1980).

```
HEADQUARTERS-TYPE FUNCTIONS

Canonical Discriminant Analysis

45 Observations          44 DF Total
 9 Variables             42 DF Within Classes
 3 Classes                2 DF Between Classes


                    Adjusted       Approx        Squared                   Eigenvalues of INV(E)*H
      Canonical     Canonical      Standard      Canonical                    = CanRsq/(1-CanRsq)
      Correlation   Correlation    Error         Correlation    Eigenvalue  Difference   Proportion   Cumulative

   1   0.650146      0.552468      0.087033      0.422690        0.7322      0.4719       0.7378       0.7378
   2   0.454421      0.341502      0.119625      0.206499        0.2602       .            0.2622       1.0000

              Test of HO: The canonical correlations in the
                current row and all that follow are zero

      Likelihood
        Ratio        Approx F       Num DF       Den DF     Pr > F

   1   0.45809605     1.8038          18           68      0.0426
   2   0.79350124     1.1385           8           35      0.3629

Multivariate Statistics and F Approximations

S=2    M=3    N=16

Statistic                       Value          F       Num DF     Den DF  Pr > F

Wilks' Lambda                0.45809605     1.8038       18          68  0.0426
Pillai's Trace               0.62918896     1.7850       18          70  0.0448
Hotelling-Lawley Trace       0.99240968     1.8194       18          66  0.0411
Roy's Greatest Root          0.73217220     2.8473        9          35  0.0126

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
NOTE: F Statistic for Wilks' Lambda is exact.
```

Table 4.22: Canonical Discriminant Analysis, Headquarter-Type Functions

Wilk's Lamda = 0.458. This indicates a moderate level of discrimination between the groups with no effect of sampling process (Klecka, 1980). The value of Lamda before any discriminant function is derived, provides a measure for the discriminating power originally existing in the discriminant variables. The smaller the value of Wilk's Lamda, the more the discriminating power (Klecka, 1980).

5. Percentage of Correct Classification:

A set of classification functions which predicts the classification (size) of every subject is computed. This prediction is consequently compared with actual membership in the form of percentage of correct classification; the higher this percentage, the more successful is the discrimination between the groups (Klecka, 1980). The classification results shown in Table 4.23 indicate a reasonable correct classification rate since 61.64% of the contractors utilized in this analysis were correctly classified in their respective sizes.

Table 4.23: Classification Results by Size

(Head Office-Related Areas)

	Predicted Size*			
Actual Size	N	Large	Medium	Small
Large	6	3 (50.00)a	0 0.00	3 50.00
Medium	18	3 16.67	14 (77.78)a	1 5.56
Small	21	7 33.33	2 9.52	12 (57.14)a
Percent of grouped cases correctly classified - 61.64%				

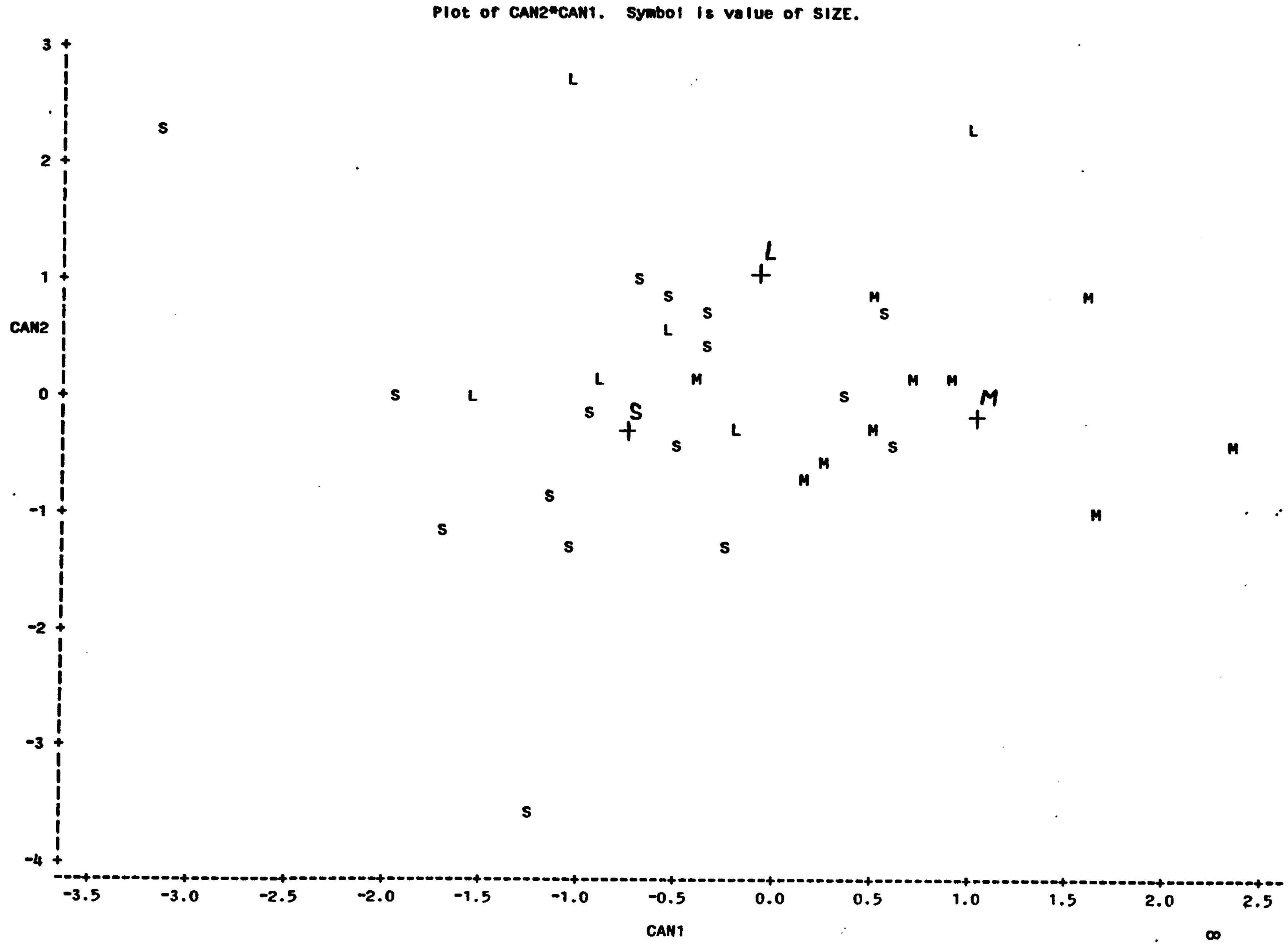
* Extracted from SAS Output.

a: Percent of subjects correctly classified.

Figure 4.10 shows a plot of Can1 and Can2. By designating the centroid for each group, the discrimination can be observed. Can2 differentiates between large firms and both small and medium firms, while Can1 differentiates between large, small, and medium firms.

From the above, it can be said that Can1 is significant (Pr > F = 0.04). Thus, it is selected.

HEADQUARTERS-TYPE FUNCTIONS



NOTE: 10 obs had missing values. 13 obs hidden.

Fig. 4.10: Plot of CAN1 and CAN2 for Headquarter Type Functions

The second stage in analyzing the output of the discriminant analysis is to select the variables which contribute most to the discrimination between the three sizes of firms. One approach is utilized for this purpose, as follows:

Total Canonical Structure

In this approach, any variable with a coefficient of 0.3 or more (regardless of the sign) is considered significant (Tabachnick and Fidell, 1983). Table 4.25 shows the total canonical structure. Can1 is significantly related to six variables (Productivity Areas). These areas are: Planning, Procurement, Scheduling, Drafting, Estimating and Specifications.

The above mentioned variables are explained as follows:

Drafting

Shop drawings that are related to the job site works are required in all projects. This makes drafting an important productivity area. Medium firms, as shown in Table 4.20, tend to give drafting more importance.

Specifications

Clear specifications make the job easier which make it an area of potential to improve productivity . Medium firms, as shown in Table 4.20, give specifications more importance.

Planning and Scheduling

Planning and scheduling are very essential for any job to be successful and productive. Medium firms, as shown in Table 4.20, give planning and scheduling more importance.

Procurement

Procurement of resources, in a timely manner, is important for the success of a project. Medium firms, as shown in Table 4.20, tend to give more importance to procurement.

Estimating

Large contractors bid in large projects with many items and variables which make the estimating more difficult and more important to productivity. The more accurate the estimate, the better the chance of having satisfactory productivity. Medium and large firms, as shown in Tables 4.20 and 4.21, give estimating more importance.

```
HEADQUARTERS-TYPE FUNCTIONS

Canonical Discriminant Analysis

Total Canonical Structure

                        CAN1

C12_1               0.528376                          PLANNING
C12_2               0.454615                          PROCUREMENT
C12_3               0.636329                          SCHEDULING
C12_4               0.696995                          DRAFTING
C12_5               0.622640                          ESTIMATING
C12_6               0.580077                          SPECIFICATION
C12_7               0.049979                          COMMUNICATION
C12_8               0.069736                          ENGINEERING
C12_9              -0.279350                          MARKETING
```

Table 4.25: Total Canonical Structure (Headquarter Type Functions)

4.4.2 Site-Related Areas

Question C13 of the questionnaire lists the areas which are related to the construction site and may have an effect on productivity . These areas are listed in Section 2.3.2. They were extracted from a questionnaire prepared by Chromokos and McKee (1981) with some modifications to suit Saudi construction , e.g., areas related to regulations such as EPA, OSHA, and EEO were omitted. Respondents were asked to rate these areas for their potential to improve construction productivity . Table 4.26 shows these areas ranked in accordance with their potential to improve construction productivity . The mean response was used to rank the areas, where 5 = very high potential and 1 = very low potential. Figure 4.11 shows the same areas.

From Table 4.26 and Figure 4.11, it can be seen that all areas (functions) have the potential to improve productivity . However, by dividing the areas, (functions) of Figure 4.11, into groups according to the mean response received by each function, four groups can be recognized. The first ranking group (mean response > 4.0) contains cost control, supervision, materials delivery, labor motivation, equipment maintainability, and equipment utilization. These functions are spread into different categories, i.e., management, materials, labor, and equipment. In other words, there is no commonality between them. The second ranking group (mean response 3.5 - 4.0) contains labor relations, materials product availability, labor training, labor quality control, labor availability, design improvement, equipment capacity, precast elements and methods. There is no commonality between these functions. The third ranking group (mean response: 3.0-3.5) contains materials prefabrication, materials standardization, labor contract agreement, labor turnover, labor recruitment, design standard, systems engineering, standard specification and pre-assemble modulars. These functions belong mainly to labor and engineering/design categories. The fourth ranking group (mean response < 3.0) contains materials storage, materials packaging, and materials new product which all belong to the materials category.

As shown in Figure 4.12, by taking the average of each category, an overall assessment of the main categories of the site related areas, for all sizes of contractors can be made. It can be seen that equipment-related and management-related areas have the highest potential for productivity improvement.

Taking the size of contractors into consideration, Tables 4.27 to 4.29 list all site-related areas ranked according to their potential to improve productivity . The mean response was used to rank the areas, where 5 = very high potential and 1 = very low potential. Figures 4.13 to 4.15 show the same information graphically.

Table 4.26

Site-related Areas Potential to Improve Productivity (All Firms)

Functions	Mean* Response	Standard Deviation	Rank
Management			
Labor Relations	3.71	0.67	12
Cost Control	4.31	0.70	5
Supervision	4.54	0.61	3
Materials			
Delivery	4.58	0.60	1
Storage	2.93	1.08	25
Packaging	2.50	1.05	27
Prefabrication	3.39	0.95	17
Standardization	3.18	0.91	20
Product availability	3.60	1.00	14
New product	2.82	0.85	26
Labor			
Contract agreement	3.48	0.72	16
Training	3.75	0.83	11
Quality control	3.90	0.85	9
Turnover	3.30	0.91	18
Availability	3.62	1.08	13
Recruitment	3.18	0.91	20
Motivation	4.51	0.57	4
Engineering & Design			
Design Standards	3.18	1.13	20
Design Improvement	3.59	1.12	15
Systems Engineering	3.04	1.09	24
Standard Specification	3.27	0.96	19
Equipment			
Capacity	3.98	0.59	7
Maintainability	4.11	0.74	6
Utilization	4.56	0.74	2
Construction Techniques			
Precast elements	3.78	0.46	10
Pre-Assemble Modulars	3.10	1.09	23
Methods	3.98	0.76	7

* (5 = very high, 1 = very low).

N = 55.

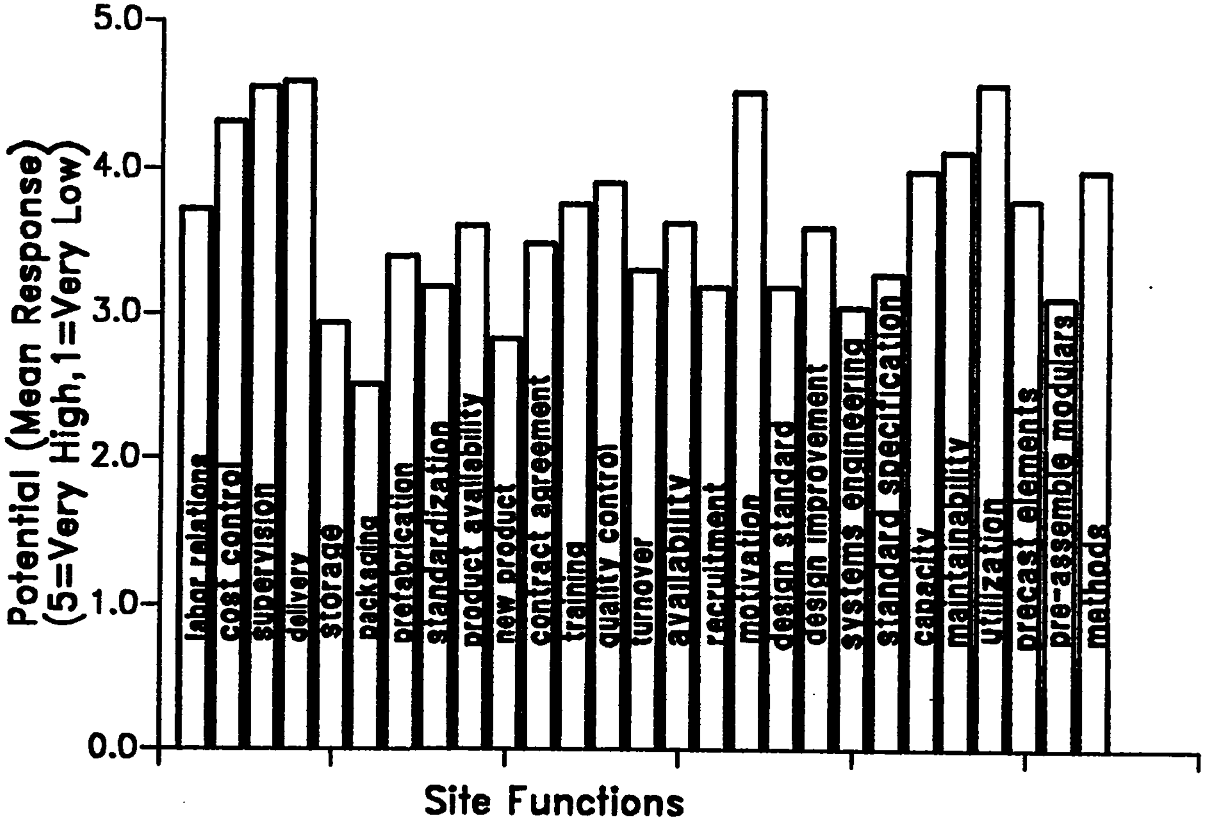


Figure 4.11 Site-related Functions Potential to Improve Productivity (All Firms), N=55

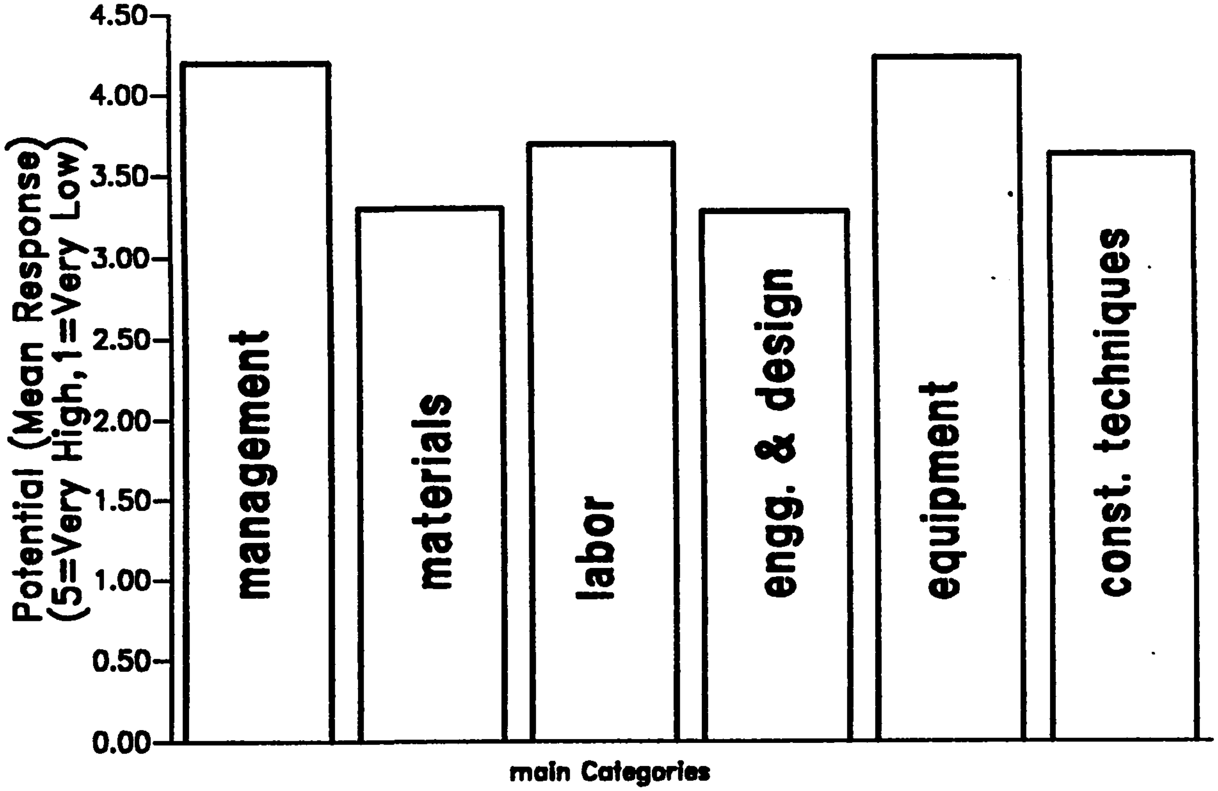


Figure 4.12 Site-related Functions Potential to Improve Productivity (All Firms),N=55

Table 4.27

Site-related Areas Potential to Improve Productivity (Small Firms)

Functions	Mean* Response	Rank
Management		
Labor Relations	3.70	10
Cost Control	4.17	5
Supervision	4.74	1
Materials		
Delivery	4.42	3
Storage	2.71	25
Packaging	2.41	27
Prefabrication	3.24	19
Standardization	3.14	20
Product availability	3.65	11
New product	2.62	13
Labor		
Contract agreement	3.30	18
Training	3.59	14
Quality control	3.87	7
Turnover	3.32	17
Availability	3.46	15
Recruitment	3.08	21
Motivation	4.42	3
Engineering & Design		
Design Standards	3.00	23
Design Improvement	3.45	16
Systems Engineering	2.90	24
Standard Specification	3.05	22
Equipment		
Capacity	3.92	6
Maintainability	3.79	8
Utilization	4.46	2
Construction Techniques		
Precast elements	3.65	11
Pre-Assemble Modulars	2.65	26
Methods	3.76	9

* (5 = very high, 1 = very low).

N = 24.

Table 4.28

Site-related Areas Potential to Improve Productivity (Medium Firms)

Functions	Mean* Response	Rank
Management		
Labor Relations	3.78	13
Cost Control	4.50	4
Supervision	4.35	6
Materials		
Delivery	4.80	1
Storage	3.21	23
Packaging	2.88	27
Prefabrication	3.65	17
Standardization	3.17	24
Product availability	3.83	11
New product	3.11	26
Labor		
Contract agreement	3.70	16
Training	3.75	14
Quality control	4.11	8
Turnover	3.60	18
Availability	3.90	9
Recruitment	3.41	22
Motivation	4.60	2
Engineering & Design		
Design Standards	3.56	19
Design Improvement	3.72	15
Systems Engineering	3.13	25
Standard Specification	3.44	21
Equipment		
Capacity	3.90	9
Maintainability	4.50	4
Utilization	4.60	2
Construction Techniques		
Precast elements	3.79	12
Pre-Assemble Modulars	3.47	20
Methods	4.21	7

* (5 = very high, 1 = very low).

N = 23.

Table 4.29

Site-related Areas Potential to Improve Productivity (Large Firms)

Functions	Mean* Response	Rank
Management		
Labor Relations	3.64	12
Cost Control	4.27	5
Supervision	4.45	4
Materials		
Delivery	4.55	2
Storage	2.91	23
Packaging	2.09	27
Prefabrication	3.27	17
Standardization	3.27	17
Product availability	3.09	21
New product	2.73	25
Labor		
Contract agreement	3.45	14
Training	4.09	7
Quality control	3.64	12
Turnover	2.73	25
Availability	3.45	14
Recruitment	3.00	22
Motivation	4.55	2
Engineering & Design		
Design Standards	2.89	24
Design Improvement	3.67	11
Systems Engineering	3.22	20
Standard Specification	3.44	16
Equipment		
Capacity	4.27	5
Maintainability	4.09	7
Utilization	4.73	1
Construction Techniques		
Precast elements	4.00	9
Pre-Assemble Modulars	3.27	17
Methods	4.00	9

* (5 = very high, 1 = very low).

N = 8.

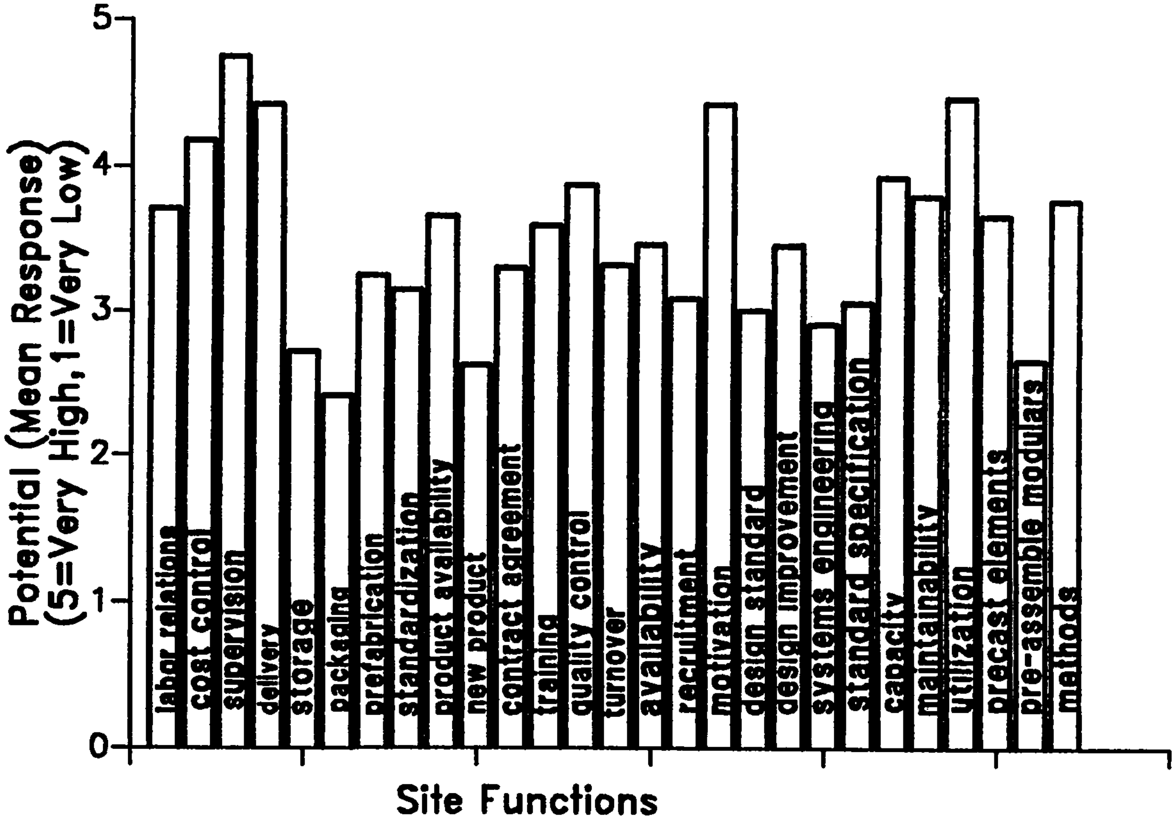


Figure 4.13 Site-related Functions Potential To Improve Productivity (Small Firms), N=24

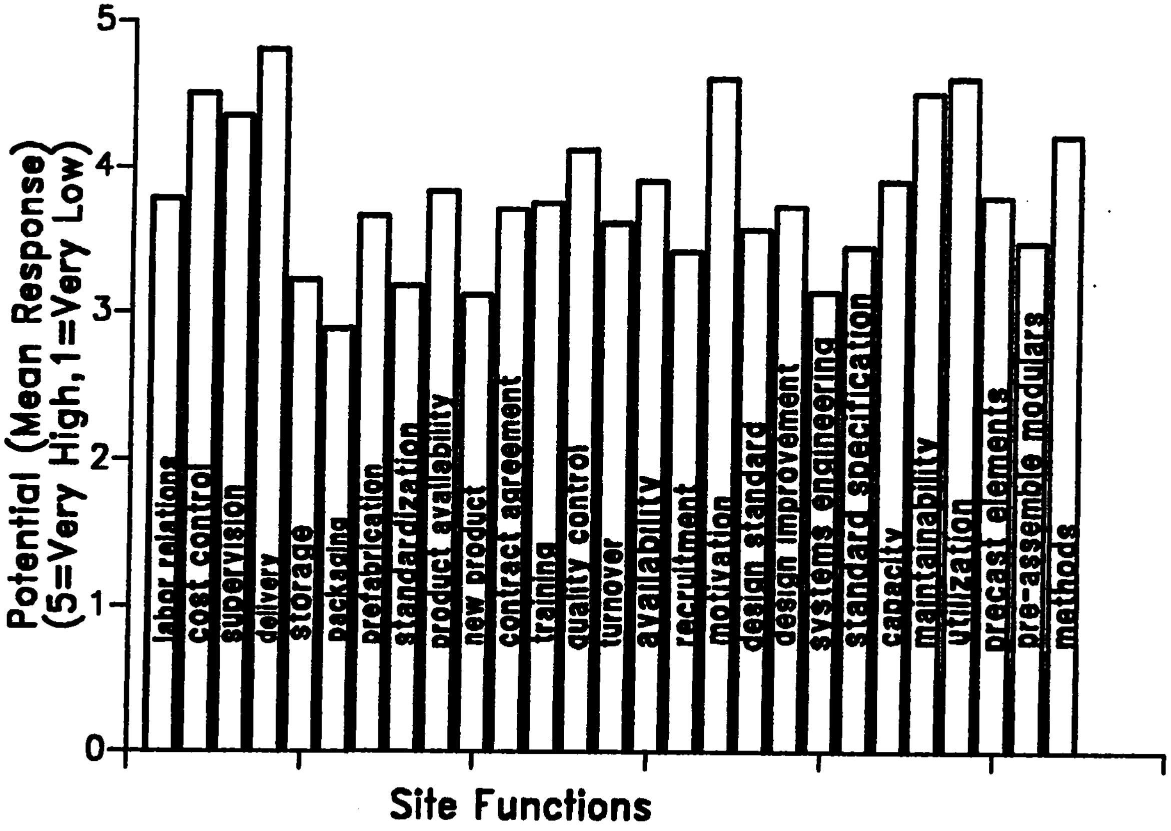


Figure 4.14 Site-related Functions Potential To Improve Productivity (Medium Firms), N=23

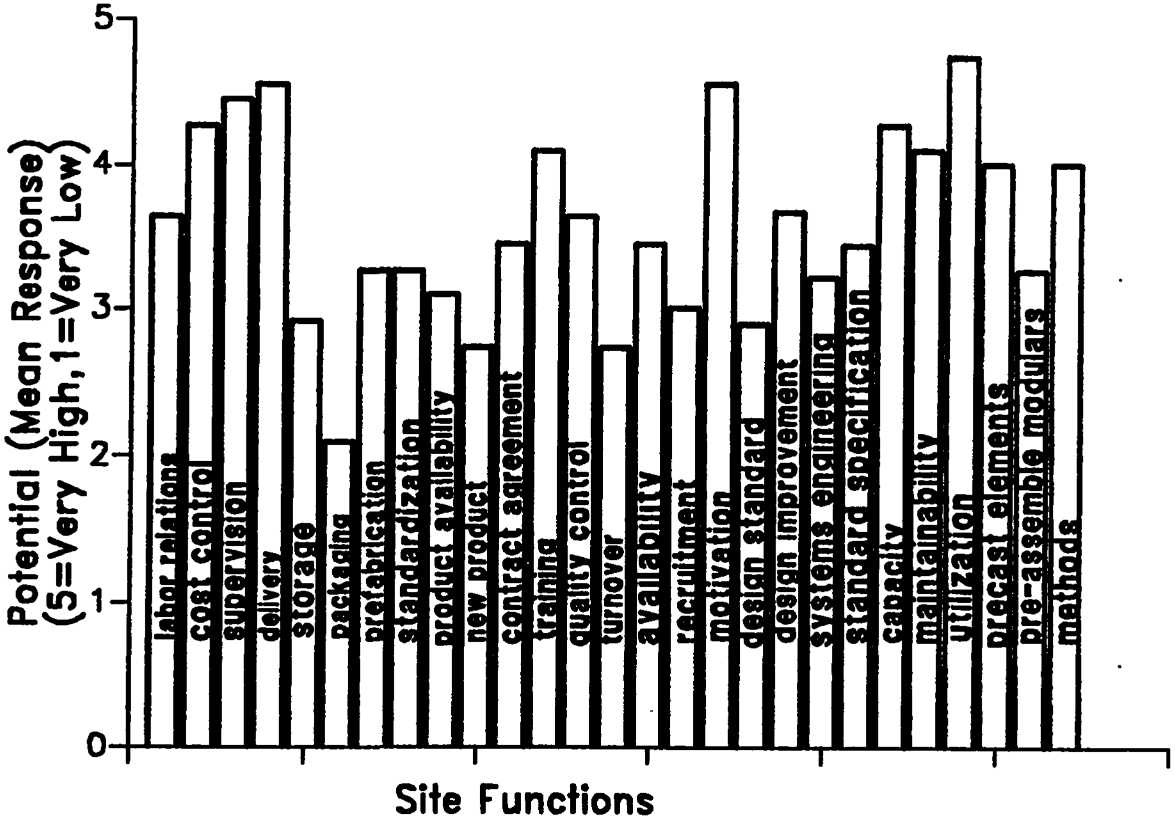


Figure 4.15 Site-related Functions Potential To Improve Productivity (Large Firms),N=8

By dividing the areas (functions) of Figure 4.13 (small firms) into groups according to the mean response received by each function, four groups can be recognized. The first ranking group (mean response > 4.0) contains cost control, supervision, material delivery, labor motivation, and equipment utilization. These functions are spread over different categories, i.e., management, materials, labor and equipment. In other words, there is no commonality between them. The second ranking group (mean response: 3.5-4.0) contains labor relations, product availability, labor training, labor quality control, equipment capacity, equipment maintainability, precast elements, and methods. These functions belong to different categories and have nothing in common. The third ranking group (mean response: 3.0-3.5) contains materials prefabrication, materials standardization, labor contract agreement, labor turnover, labor availability, labor recruitment, design improvement, and standard specification. These functions mainly belong to the labor category. The fourth ranking group (mean response < 3.0) contains materials storage, materials packaging, materials new product, design standard, systems engineering, and pre-assemble modulars. These functions mainly belong to materials category.

The same grouping can be made with areas (functions) of Figure 4.14 (medium firms), where the first ranking group (mean response > 4.0) contains cost control, supervision, materials delivery, labor quality control, labor motivation, equipment maintability, equipment utilization, and methods. These functions belong to different categories. The second ranking group (mean response: 3.5-4.0) contains labor relations, materials prefabrication, product availability, design standard, design improvement, equipment capacity, and precast elements. These functions belong to different categories. The third ranking group (mean response: 3.0-3.5) contains materials storage, standardization, new products, labor recruitment, systems engineering, standard specification, and pre-assemble modulars. These functions mainly belong to materials and engineering/design categories. The fourth group (mean response < 3.0) contains one function which is materials packaging.

Functions of Figure 4.15 (large firms) can be grouped in the same manner, where the first group contains cost control, supervision, materials delivery, labor training, motivation, equipment capacity, maintainability, and utilization. All equipment related functions are contained in this group which stresses the importance of equipment for large contractors, the second group (mean response: 3.5 - 4.0) contains labor relations, labor quality control, design improvement, precast elements, and methods. These functions belong to different categories. The third group (mean response 3.0-3.5) contains materials prefabrication, standardization, product availability, labor contract agreement, labor availability, systems engineering, standard specification, and pre-assemble modulars. These functions belong to different categories. The fourth group (mean response < 3.0) contains materials storage, packaging, new products, labor turnover, labor recruitment, and design standards. These functions mainly belong to material and labor categories.

Figures 4.16 to 4.18 show the ranking of the main categories of the site related areas according to contractor size. All the three graphs ranked the six main categories almost similarly. All graphs rank Management and Equipment as top (ranked either 1 or 2), Labor and Construction Techniques as middle (ranked 3 or 4), and Material and Engineering/Design as lowest (ranked 5 or 6).

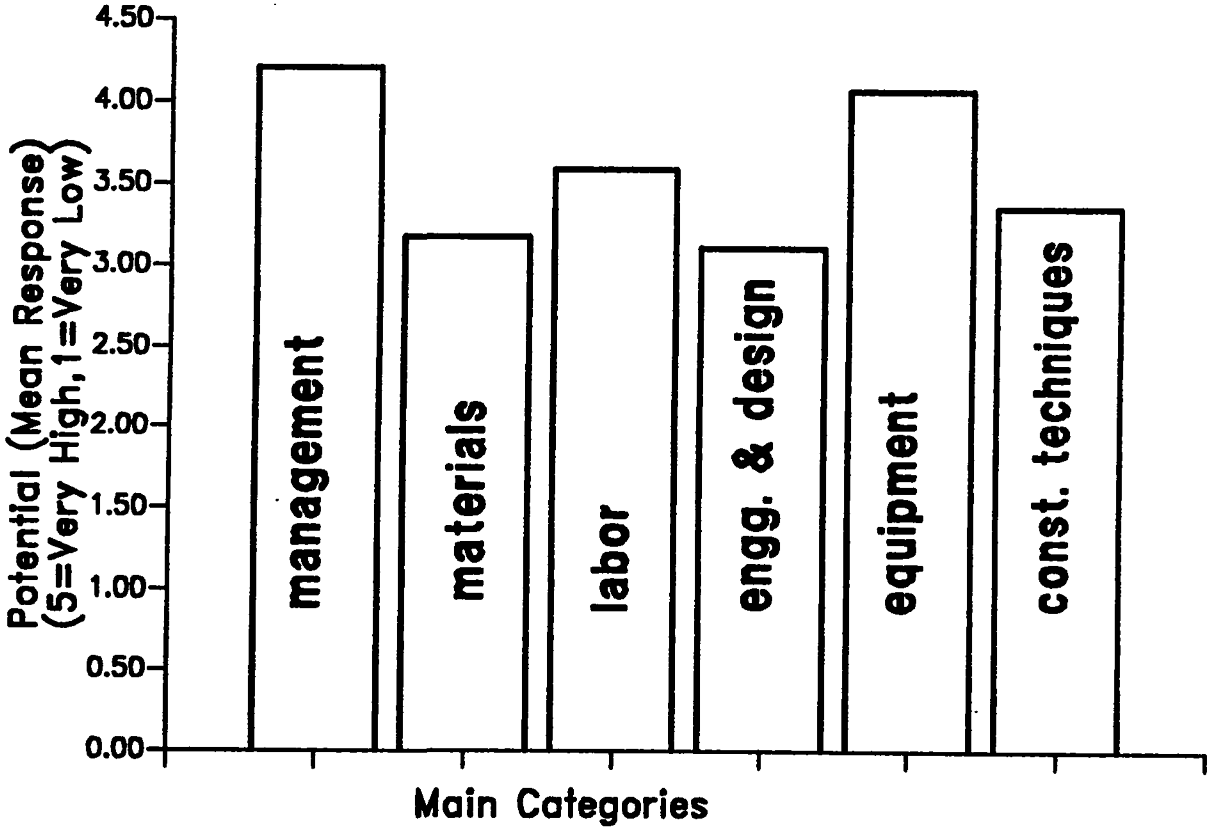


Figure 4.16 Site-related Functions Potentials To Improve Productivity (Small Firms), N=24

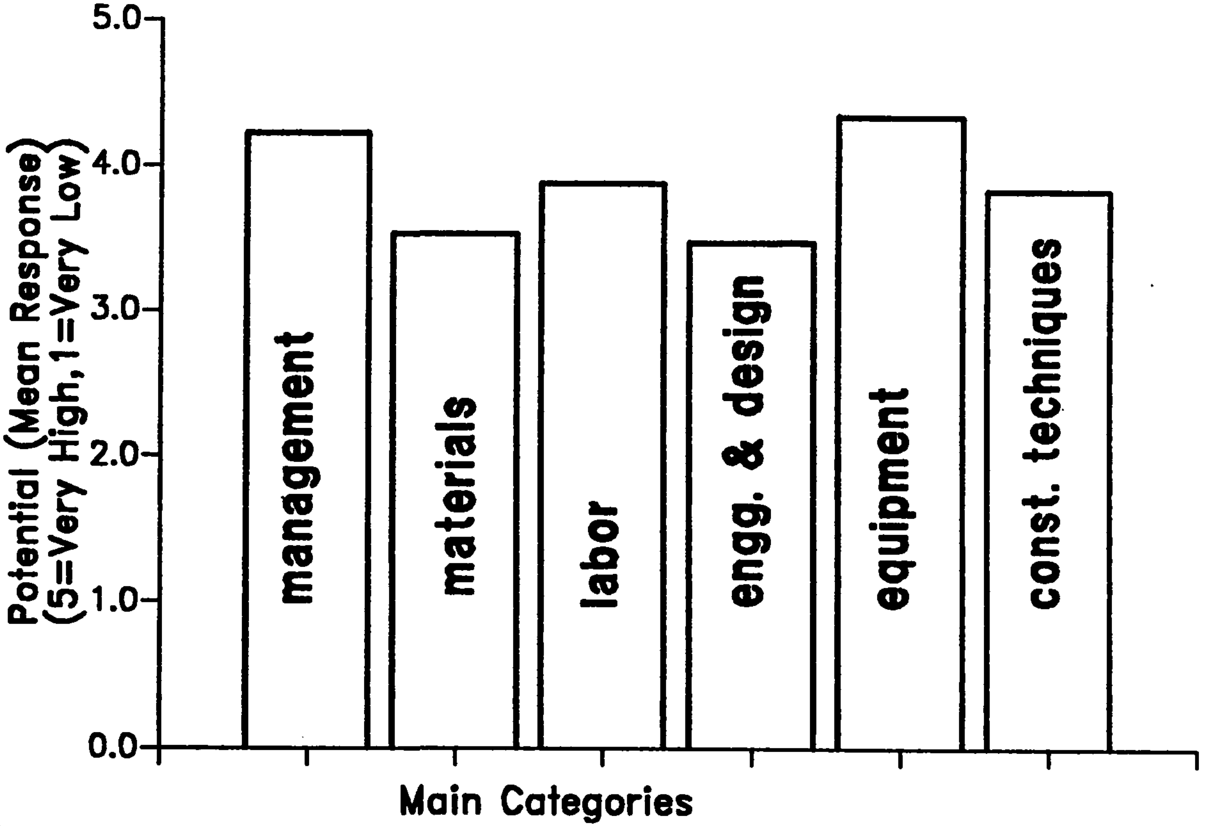


Figure 4.17 Site-related Functions Potential To Improve Productivity (Medium Firms), N=23

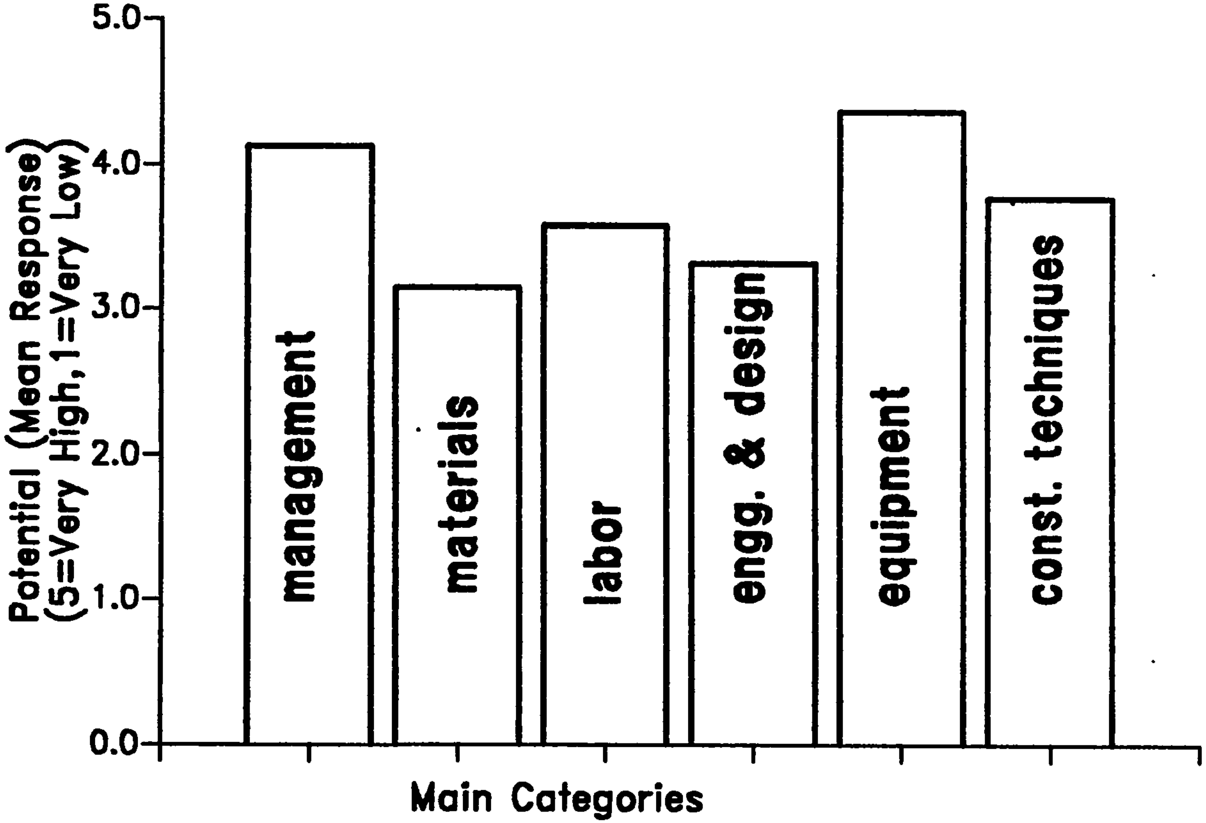


Figure 4.1B Site-related Functions Potential To Improve Productivity (Large Firms), N=8

To investigate the differences between the groups by a more detailed method, DISCRIMINANT ANALYSIS was utilized. Table 4.30 summarizes the results of the Discriminant Analysis for site-related functions. The first stage in analyzing these results is to select the discriminant functions. The following parameters can be observed from Table 4.30:

1. Canonical correlation for function 1 = 0.958.

2. Canonical correlation for function 2 = 0.856.

This means that the degree of association between the three sizes and (Can1 and Can2) is very high, which implies the three sizes are different.

Examining Eigen Values:

- Eigen Value for function 1 = 11.336.
- Eigen Value for function 2 = 2.747.

Eighty percent of the variance of the discriminating variables is explained by Function 1 while 20% of this variance is explained by Function 2.

3. Square Canonical Correlation for Function 1 = 0.918.

4. Square Canonical Correlation for Function 2 = 0.733.

This indicates that the proportion of variance in the discriminant functions is explained by the groups (Klecka, 1980).

```
SITE-RELATED FUNCTIONS

Canonical Discriminant Analysis

40 Observations          39 DF Total
27 Variables             37 DF Within Classes
 3 Classes                2 DF Between Classes

                                                                                    Eigenvalues of INV(E)*H
                          Adjusted       Approx                                       = CanRsq/(1-CanRsq)
          Canonical      Canonical      Standard      Squared
         Correlation    Correlation      Error       Canonical
                                                    Correlation    Eigenvalue    Difference    Proportion    Cumulative

    1     0.958613       0.929644       0.012980     0.918939       11.3363        8.5891        0.8049        0.8049
    2     0.856234       0.761826       0.042732     0.733137        2.7472         .            0.1951        1.0000

              Test of H0: The canonical correlations in the
               current row and all that follow are zero

       Likelihood
         Ratio        Approx F      Num DF      Den DF     Pr > F

    1   0.02163227     2.3626         54          22       0.0147
    2   0.26686278     1.2680         26          12       0.3424

Multivariate Statistics and F Approximations

S=2    M=12    N=4.5

Statistic                        Value           F       Num DF     Den DF   Pr > F

Wilks' Lambda                 0.02163227      2.3626       54         22     0.0147
Pillai's Trace                1.65207582      2.1104       54         24     0.0239
Hotelling-Lawley Trace       14.08357133      2.6081       54         20     0.0105
Roy's Greatest Root          11.33632713      5.0384       27         12     0.0026

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
NOTE: F Statistic for Wilks' Lambda is exact.
```

Table 4.30: Canonical Discriminant Analysis, Site Related Functions

Wilk's Lamda = 0.021. This small value indicates a high level of discrimination between the groups with no effect of sampling process (Klecka, 1980). The value of Lamda before any discriminant function is derived, provides a measure for the discriminating power originally existing in the discriminant variables. The smaller the value of Wilk's Lamda, the more the discriminating power (Klecka, 1980).

5. Percentage of Correct Classification:

Similar to that of Section 4.4.1, the classification results shown in Table 4.31 indicate a very high correct classification rate: 93.06% of the contractors utilized in this analysis were correctly classified in their respective sizes. This means that the discrimination between the groups is highly successful (Klecka, 1980).

Table 4.31: Classification Results by Size*

(Site-Related Areas)

	Predicted Size			
Actual Size	N	Large	Medium	Small
Large	8	7 (87.50)a	0 0.00	1 12.50
Medium	23	0 0.00	23 (100.00)a	0 0.00
Small	24	0 0.00	2 8.33	22 (91.67)a
Percent of grouped cases correctly classified - 93.06%				

a: Percent of subjects correctly classified.

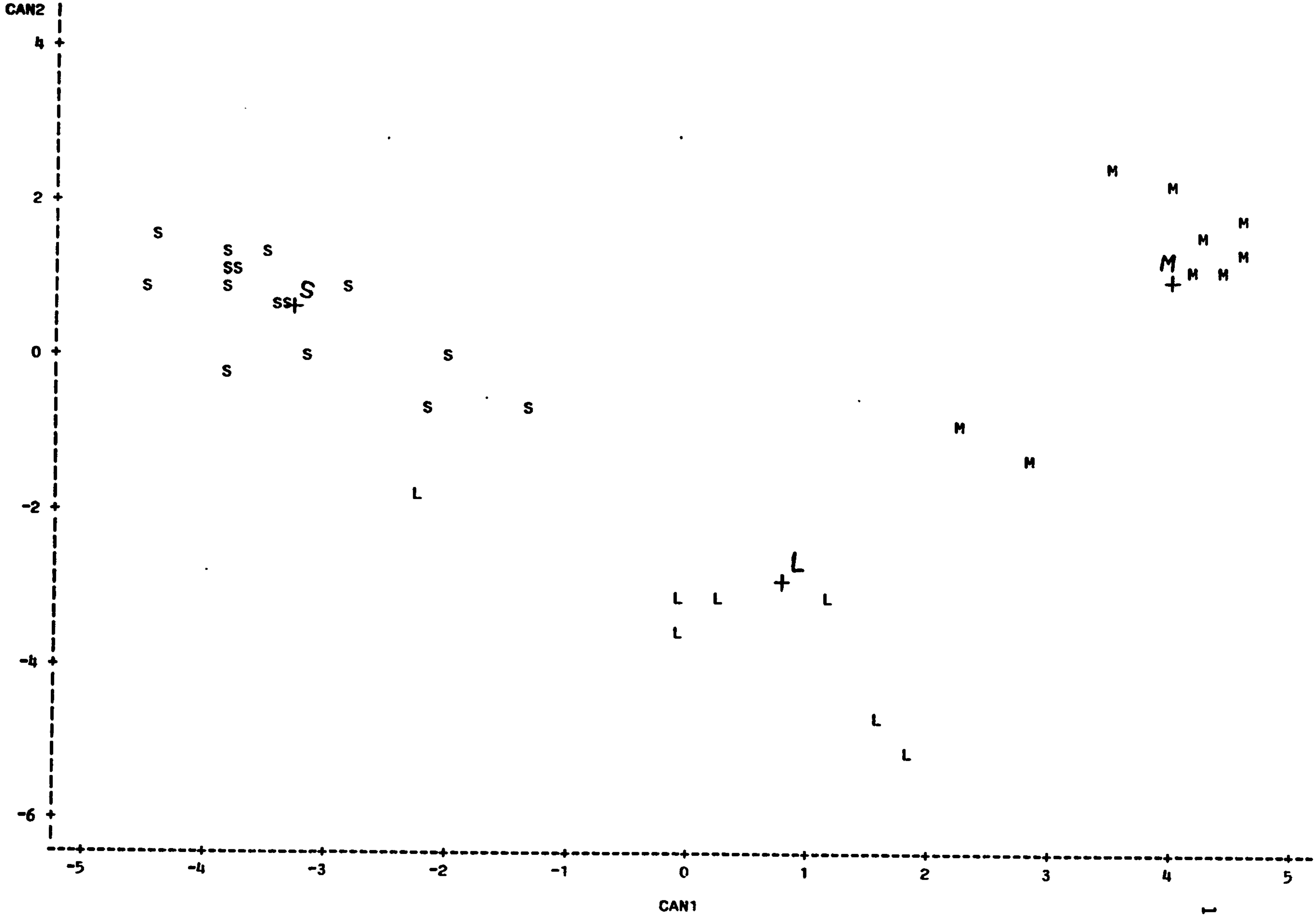
* Extracted from SAS Output.

Figure 4.19 shows a plot of Can1 and Can2. By designating the centroid for each group, the discrimination can be observed. Can2 differentiates between large firms and both small and medium firms, while Can1 differentiates between large, small, and medium firms.

From the above, it can be said that Can1 is significant (Pr > F = 0.01). Thus, it is selected.

SITE-RELATED FUNCTIONS

Plot of CAN2*CAN1. Symbol is value of SIZE.



NOTE: 15 obs had missing values. 9 obs hidden.

Fig. 4.19: Plot of CAN1 and CAN2 for Site-Related Functions

The second stage in analyzing the output of the discriminant analysis is to select the variables which contribute most to the discrimination between the three sizes of firms. As mentioned in Sec. 4.4.1, one approach is utilized for this purpose, as follows:

Total Canonical Structure

In this approach, any variable with a coefficient of 0.3 or more (regardless of the sign) is considered significant (Tabachnick and Fidell, 1983). Table 4.33 shows the total canonical structure. . Can1 is significantly related to six variables (productivity areas). These areas are: supervision, materials delivery, materials new product, labor availability, pre-assemble modulars and equipment maintainability. The above mentioned variables are explained as follows:

Supervision

Supervision is a management-related area which has a potential for productivity improvement. Small firms, as seen from Table 4.27, tend to give supervision more importance.

Materials Delivery

The delivery of materials to the job site in a timely manner is essential to keep things going and maintain high productivity level. This necessity becomes more crucial in large projects where so many types of materials in huge quantity are needed. Medium firms, as shown in Table 4.28, give materials delivery more importance.

Materials New Products

Large projects are more likely to include new products or materials which may not be available in the local market and have to be imported from outside the Kingdom. If these new products are not brought at the right time, this will cause delays and cost incrases which means lower productivity. Medium firms, as shown in Table 4.28, give materials new products more importance.

```
1SITE-RELATED FUNCTIONS

 Canonical Discriminant Analysis

 Total Canonical Structure

                    CAN1

 C13_1          -0.023581                   LABOR RELATIONS (MANAGEMENT)
 C13_2           0.141671                   COST CONTROL
 C13_3          -0.362641                   SUPERVISION
 C13_4           0.303390                   DELIVERY (MATERIALS)
 C13_5           0.254745                   STORAGE
 C13_6           0.226932                   PACKAGING
 C13_7           0.134472                   PREFABRICATION
 C13_8          -0.160565                   STANDARDIZATION
 C13_9           0.100124                   PRODUCT AVAILABILITY
 C13_10          0.347098                   NEW PRODUCT
 C13_11          0.265297                   CONTRACT AGREEMENT (LABOR)
 C13_12          0.172986                   TRAINING
 C13_13          0.086161                   QUALITY CONTROL
 C13_14          0.084144                   TURNOVER
 C13_15          0.312582                   AVAILABILITY
 C13_16          0.264550                   RECRUITMENT
 C13_17          0.034650                   MOTIVATION
 C13_18          0.140457                   DESIGN STANDARDS (ENGG.& DESIGN)
 C13_19          0.023982                   DESIGN IMPROVEMENT
 C13_20          0.065364                   SYSTEMS ENGINEERING
 C13_21          0.108293                   STANDARD SPECIFICATIONS
 C13_22          0.175496                   CAPACITY   (EQUIPMENT)
 C13_23          0.499759                   MAINTAINABILITY
 C13_24          0.279167                   UTILIZATION
 C13_25          0.294132                   PRECAST ELEMENTS (CONST. TECHNIQUES)
 C13_26          0.385214                   PRE-ASSEMBLE MODULARS
 C13_27          0.166508                   METHODS
```

Table 4.33: Total Canonical Structure (Site Related Functions)

Equipment Maintainability

Larger contractors make use of equipment more than small contractors do. This gives equipment maintainability more potential for productivity improvement for larger contractors.

Labor Availability

Labor availability may be a problem for small size contractors, since small contractors tend to keep small numbers of workers. On the other hand, large contractors tend to keep large numbers of workers. Their resources are so huge and the duration of their projects is so long that they can manage to get labor from outside the Kingdom. They usually keep spare visas, to be used when needed, without going throughthe time consuming process of securing visas.

Pre-assembled Modulars

This productivity area is given more importance by medium firms.

4.5 Possibility of Establishing Productivity Improvement Programs (PIP)

In this part, the possibility of establishing Productivity Improvement Programs is assessed and many organizational as well as project considerations are discussed. This is done for those contractors who have PIP's and those who do not have PIP's.

4.5.1 Companies That Have PIP's

Full scale productivity departments are practically non-existent in construction firms in Saudi Arabia and the majority of contractors do not give any significant attention to productivity . Therefore, in order to distinguish contractors who do pay some attention to productivity related issues, from those who do not, the use of various productivity measurement methods which is a major part of any productivity improvement program. That is, any company which implements one or more of the productivity measurement methods, other than cost reporting and control system, is considered to have a productivity program. The exclusion of cost reporting and control system is made because of its wider use for purposes not related to productivity improvement. This liberal definition was necessary in order to make the differentiation among the contractors who in general do not have a PIP in the strict meaning of PIP.

4.5.1.1 Size of Productivity Staff

The productivity staff are the people within the company whose time is devoted fully or partially to productivity related matters. In this study, the number of full time staff ranged between 0 and 30, and part time staff between 0 and 25. A total of 17 respondents answered the question regarding the size of productivity staff, out of which 14 answered the question regarding both full time and part-time staff; two respondents answered only regarding full time staff, and one answered regarding part-time staff. A summary of results is shown in Tables 4.34 and 4.35. One respondent reported that his full-time productivity staff is 30 employees while 4 respondents reported that their part-time productivity staff is 25 employees; which is obviously too high, possibly caused by a too liberal definition, on the respondents side, of productivity staff.

Seventeen respondents (30% of all the fifty-five respondents) said that they have some kind of productivity staff. This may indicate that there is a lack of adoption and implementation of Productivity Improvement Programs. It shows limited organizational commitment to the area of productivity .

Table 4.34 : Full Time Productivity Staff

Number of Employees	Frequency	Percent
0	2	12.5
1	2	12.5
2	1	6.3
3	2	12:5
4	5	31.5
5	3	18.8
30	1	6.3

Table 4.35 : Part Time Productivity Staff

Number of Employees	Frequency	Percent
0	4	26.7
4	1	6.7
5	2	13.3
6	4	26.7
25	4	26.7

4.5.1.2 Responsible Part of the Organization

In question C2 of the questionnaire , the part of organization which takes care of productivity is investigated. The results are shown in Table 4.36.

Table 4.36: Part of Organization Responsible for Productivity

Part of Organization	Frequency	Percent
Studies & Planning Department	15	83.3
Productivity Department	0	0
Site Management	3	16.7
Technical Department	0	0
Other	0	0

As can be seen from the Table above, out of 18 respondents who answered this question, 15 indicated that the Studies and Planning Department takes care of productivity . The other 3 indicated that the site management is the part of organization responsible for productivity . None of the respondents indicated that they have a separate department solely devoted to productivity related matters which suggests that, even among contractors who have PIP, management commitment to and awareness of productivity needs to be enhanced so that Productivity Improvement Departments can be created.

4.5.1.3 Who Conducts PIP

Question C7 of the questionnaire , acquires information regarding who conducts productivity programs in companies which already have them. Out of 20 respondents who answered this question, 16 (80%) of them said that it is handled by in-house staff. None of them sought the help of a consultant to handle productivity related issues alone. This indicates that consultants who are supposed to have more qualified staff with updated knowledge, are not involved in productivity related activities which consequently raises the need for the consultant's role in productivity improvement efforts especially in the case of contractors who want to initiate PIP.

4.5.1.4 Pay-Off

Questions C4 and C3 aimed at investigating the minimum acceptable pay-off ratio (Benefit/Cost ratio), for the money spent on improvement programs and the average pay-off ratio actually realized by applying PIP's in companies which have them. Table 4.39 shows minimum and achieved pay-off ratios for all respondents (with PIP). Both the lowest minimum acceptable pay-off ratio and the lowest pay-off ratio actually achieved by companies who have PIP's are 2:1. Forty one percent of those who have PIP's achieved a 2:1 ratio and 23.5% achieved a 9:1 ratio, which is quite high and encouraging. However, there may be some bias because of the trend that those who have PIP are the ones who had previous financial success in these programs (achieving payoff > minimum acceptable), while contractors with less successful experience (payoff < minimum acceptable) are not included in the data. Four respondents (24%) achieved less than their minimum acceptable ratio. A possible interpretation of this is that the reliability of respondents' data is not high. Another possible interpretation is that anticipated (expected) payoff is different from actual, i.e. the contractor starts PIP based on the initial estimate of payoff greater than minimum acceptable, but after the program is completed actual payoff is less than minimum. None of the respondents said that he had lost by applying a PIP. These results indicate the financial feasibility of applying PIPs.

Table 4.39: Minimum Acceptable And Achieved Pay-off Ratio for Each Respondent (With PIP)

Minimum Acceptable Ratio	Frequency	Achieved Ratio
-	1	2:1
2:1	2	2:1
2:1	2	4:1
2:1	2	9:1
2:1	1	4:1
2:1	1	5:1
3:1	1	8:1
3:1	2	2:1
3:1	1	5:1
4:1	2	2:1
8:1	2	9:1

N = 17.

4.5.1.5 Project Considerations

In question C6, project parameters were investigated as to their relative importance to the suitability of PIP for different projects. Investigated parameters were: project size, type, complexity, duration, and ownership. Each parameter was further subdivided into various categories. The respondents were asked to state their level of agreement with each category as being a feature of the project for which PIP would be most suited. The results are summarized in Table 4.40. These results show that the overwhelming majority of respondents agreed/strongly agreed that construction projects, regardless of their attributes (parameters) are suitable for PIP. However, the relative importance of these attributes differ as follows:

Size: All respondents strongly agreed that large size projects (above SR 200 million) are most suited for PIP. Medium size projects (between SR 50 and 200 million) received 66.7% "Strongly Agree" and 33.3% "Agree", while small size projects (below SR 50 million) received 38.1% "Strongly Agree", 42.9% "Agree" and 19% "Neutral". The mean responses for the three sizes (large, medium, and small) are 1.00, 1.33, and 1.81 respectively, the lower the score the higher the level of agreement.

The size is found to be positively and moderately correlated with the level of agreement ($r = 0.55$, $P < 0.001$), which means the larger the size of a project, the higher the level of agreement.

Table 4.40: Significance of Project Parameters in Using PIP As Viewed by Contractors Who Have PIP *

	PARAMETERS	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE	MEAN RESPONSE	RANK
SIZE	Large (Above SR.200 million)	21 100	0 0	0 0	0 0	0 0	1	1
	Medium (Between SR.50-200 million)	14 66.7	7 33.3	0 0	0 0	0 0	1.33	2
	Small (Below SR.50 million)	8 38.1	9 42.9	4 19	0 0	0 0	1.81	3
TYPE	Building	10 50	10 50	0 0	0 0	0 0	1.5	2
	Engineering	10 55.6	6 33.3	2 11.1	0 0	0 0	1.56	3
	Industrial	14 77.8	2 11.1	2 11	0 0	0 0	1.33	1
COMPLEXITY	High	17 85	1 5	2 10	0 0	0 0	1.25	1
	Medium	8 38	12 57	1 5	0 0	0 0	1.6	2
	Low	8 40	8 40	4 20	0 0	0 0	1.8	3
DURATION	Long	20 100	0 0	0 0	0 0	0 0	1	1
	Medium	13 65	5 25	2 10	0 0	0 0	1.45	2
	Short	7 35	5 25	6 30	0 0	2 10	2.25	3
OWNERSHIP	Government	17 85	2 10	1 5	0 0	0 0	1.2	1
	Private	11 52	9 43	0 0	1 5	0 0	1.45	2

* The top figure is the frequency and the lower figure is the percentage

** Ranges from 1 (strongly agree) to 5 (strongly disagree)

N = 21

From the above results, it can be deduced that the larger the size of a project the more suitable PIP is to that project. This may be due to the great potential for saving in larger projects and also due to the fact that larger projects involve bigger amounts of capital investment which makes the cost of PIP relatively lower.

Type: 77.8% of the respondents strongly agreed that industrial type projects are most suited for PIP, while 11.1% agreed and 11.1% were neutral. Building type of projects received 50% "Strongly Agree" and another 50% "Agree" answers. Finally, engineering type of projects got 55.6% "Strongly Agree", 33.3% "Agree", and 11.1% "Neutral" responses. The mean responses of the industrial, building, and engineering types of project are 1.33, 1.50, and 1.56 respectively. (The lower the mean score the higher the level of agreement).

Although the previous results show that the industrial projects are the most suited for PIP (based on the mean response), the results of ANOVA, as shown in Appendix C, indicate that the variation of the level of agreement is found to be unaffected by different project types (R^2 = 0.02, NS) All types are in the agreement zone (mean response less than 1.56). This indicates that PIP is suitable for all projects regardless of the type.

Complexity: Projects of high complexity received the highest level of agreement (mean response = 1.25). Eighty five percent of the respondents strongly agreed, while 5% agreed and 10% were neutral. Projects of medium complexity received the second highest level of agreement (mean response = 1.60). Forty percent of the respondents strongly agreed while 60% agreed. Projects of low complexity got the lowest level of agreement (mean response = 1.8). Forty percent of the respondents strongly agreed whereas 40% agreed and 20% were neutral.

It was found that complexity is slightly positively correlated with the level of agreement ($r = 0.35, P < 0.01$).

The aforementioned results show, to some extent, that the higher the complexity of a project the more suitable it is for PIP. This is because a more complex project has more productivity related problems and more potential for improvement.

Duration: Long projects had the highest level of agreement (mean response = 1). All the respondents strongly agreed. Projects of medium duration secured the second highest level of agreement (mean response = 1.45). Sixty five percent of the respondents strongly agreed while 25% agreed and 10% were neutral. Projects of short duration got the lowest level of agreement (mean response = 2.25). Thirty-five percent of the respondents strongly agreed while 25% agreed whereas 30% were neutral and 10% strongly disagreed.

The duration is found to be positively and moderately correlated with the level of agreement ($r = 0.57, P < 0.001$).

These results suggest that long projects are more appropriate for PIP than short projects. This may be due to the fact that long projects have enough time for PIP to be developed and implemented.

Ownership: Government owned projects got higher level of agreement (mean response = 1.2). Eighty five percent of the respondents strongly agreed while 10% agreed and 5% declared neutrality. Privately owned projects came second (mean response = 1.45). Fifty five percent strongly agreed and 45% agreed. However, as shown in Appendix C, the results of ANOVA indicate that the variation of the level of agreement is found to be unaffected by different project owners ($R^2 = 0.05$, NS).

Although the aforementioned project parameters received different levels of agreement, they are still in the agreement zone (mean response less than 2.50). This may imply that all projects; of all sizes, types, complexities, durations, and owners are eligible for PIP.

4.5.1.6 Plans for Future PIP

Question C5 sought information regarding the contractors' plans for future PIPs. Of the seventeen contractors having PIP, only one respondent said he would stay at the current level of PIP in the future. The remaining 16 respondents mentioned that they will increase their use of PIP. This is expected since the payoff ratios are encouraging as mentioned in Section 4.5.1.4.

4.5.2 Companies that do not have PIP

The issues concerning the establishment of PIP as perceived by those respondents whose firms do not have PIP are presented in the following sections.

4.5.2.1 Possibility of Establishing PIP

Seventy percent of those who do not have PIP stated that they are planning to introduce PIP in their companies' construction projects in the future, while 30% of them said they are not planning to do so. Eighty percent of those who are planning to make use of PIP said that they would do so within the next one or two years or in their next project.

The above results indicate that quite a large percentage of those who do not have PIP are willing to introduce such programs in their projects in the near future. This is a good sign, however, some of those (25%) told this researcher that the interview had either initiated or increased their awareness of PIP and that they would consider such programs in the future. This suggests that the awareness of PIP can play an instrumental role in adopting PIPs.

4.5.2.2 Pay-Off

Question C9 sought to collect information regarding the minimum acceptable pay-off ratio (benefit/cost ratio) desired by contractors who do not have PIP if they are to introduce it. The results of the answers to this question are displayed in Table 4.41.

Table 4.41: Minimum Acceptable Pay-Off Ratio for Contractors who do not have PIP

Pay-off Ratio	Frequency	Percent
2:1	5	26.3
3:1	11	57.9
5:1	2	10.5
7:1	1	5.3

As can be observed from the above mentioned Table, no one is ready to accept a pay-off ratio less than 2:1, which is the same as in Table 4.39. The average paypoff from Table 4.41 is 3.16:1 while that from Table 4.39 is 3.38:1 which are approximately similar. There is also quite a large percentage (84.2%) of the respondents who accept payoff less than 3:1 while in Tablè 4.39, it is 75%. This suggests that those who have experienced the use of PIP ask for relatively more payoff which means that they have realized a higher payoff in the past. It also means that the clear majority of contractors view 3:1 as a very attractive return.

4.5.2.3 Who is to Conduct PIP

Question C11 asked contractors who do not have PIP's about who is to conduct PIP's in their projects if they introduce them. Out of the 27 respondents who answered this question, 16 (59.3%) said it is to be handled by in-house staff, while 9 (33.3%) said it is to be conducted by both consultants and in-house staff. Only 2 (7.4%) said that they would hire a consultant to do it for them. This indicates, as in Section 4.5.1.3, the consulants, who are supposed to have more qualified staff with updated knowledge, need to be involved in productivity improvement efforts, especially in the case of contractors who want to initiate PIP.

4.5.2.4 Project Considerations

Project parameters are investigated in this section in the same way as was done in Section 4.5.1.5. Each respondent was requested to indicate his level of agreement with each category as being a feature of the project for which PIP would be most suited. The results are summarized in Table 4.42. These results show that the overwhelming majority of respondents agreed/strongly agreed that construction projects, regardless of their attributes (parameters), are suitable for PIP. However, the relative importance of these attributes differs as follows:

Size: Large sized projects (above SR 200 million) received 82.4% "strongly agree" and 17.6% "agree" with a mean response of 1.18. Medium size projects (between SR 50 and 200 million) received 60.6% "strongly agree" and 39.4% "agree" with a mean response of 1.39. Small size projects (less than SR 50 million) got 21.2% "strongly agree", 51.5% "agree", and 27.3% "neutral" with a mean response of 2.06.

Table 4.42: Significance of Project Parameters in Using PIP As Viewed by Contractors Who Don't Have PIP*

	PARAMETERS	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE	MEAN RESPONSES **
SIZE	Large (Above SR.200 million)	28 82.4	6 17.6	0 0	0 0	0 0	1.18
	Medium (Between SR.50-200 million)	20 60.6	13 39.4	0 0	0 0	0 0	1.39
	Small (Below SR.50 million)	7 21.2	17 51.5	9 27.3	0 0	0 0	2.06
TYPE	Building	20 58.8	11 32.4	3 8.8	0 0	0 0	1.5
	Engineering	16 55.2	13 44.8	0 0	0 0	0 0	1.45
	Industrial	15 45.5	15 45.5	3 9.1	0 0	0 0	1.64
COMPLEXITY	High	19 59.4	8 25	1 3.1	4 12.5	0 0	1.69
	Medium	14 42.4	13 39.4	6 18.2	0 0	0 0	1.76
	Low	9 30	13 43.3	7 23.3	1 3.3	0 0	2
DURATION	Long	23 67.6	7 20.6	4 22.8	0 0	0 0	1.44
	Medium	- 20.6	24 70.6	3 8.8	0 0	0 0	1.88
	Short	3 6.4	11 34.4	15 46.9	3 9.4	0 0	2.56
OWNERSHIP	Government	23 67.6	9 26.5	2 5.9	0 0	0 0	1.38
	Private	13 38.2	14 41.2	5 14.7	2 5.9	0 0	1.88

* The top figure is the frequency and the lower figure is the percentage

** Ranges from 1 (strongly agree) to 5 (strongly disagree)

N = 34

The size is found to be positively and moderately correlated with the level of agreement ($r = 0.54$, $P = 0.0001$), which means the larger the size of a project, the higher the level of agreement is. These results are similar to those of Section 4.5.1.5. This reconfirms the conclusion that larger projects are more suited to PIP application.

Type: The engineering type of projects secured 55.2% "strongly agree" and 44.8% "agree" with a mean response of 1.45. The building type of projects got 58.8% "strongly agree", 32.4% "agree", and 8.8% "neutral" with a mean response of 1.5. The industrial type of projects received 45.5% "strongly agree", 45.5% "agree", and 9.1% "neutral" with a mean response of 1.64.

These results show that the engineering type of projects secured the highest level of agreement, while the building type got the second highest level of agreement, and the industrial type of projects received the lowest level of agreement. However, as in the case of contractors who have PIP, the variation of the level of agreement, as the results of ANOVA which are presented in Appendix C indicate, is found to be unaffected by different project types ($R^2 = 0.016$, NS). In general, all types of projects are in the agreement zone (mean response < 2.5). This indicates, as in the case of those who have PIP, that PIP's are suitable for all types of projects.

Complexity: Projects with high complexity received 59.4% "strongly agree", 25% "agree", 3.1% "neutral", and 12.5% "disagree" with a mean response of 1.69. Projects with medium complexity secured 42.4%

"strongly agree", 39.4% "agree", and 18.2% "neutral" with a mean response of 1.76. Low complexity projects got 30% "strongly agree", 43.3% "agree", 23.3% "neutral", and 3.3% "disagree" with a mean response of 2.00.

It was found that complexity is weakly correlated with the level of agreement (r = 0.20, P = 0.05). This is somewhat different from the case of those who have PIP. This difference may be due to the fact that those who have PIP had some previous experience with PIP to build their views on, while this is not the case with those who do not have PIP.

Duration: Projects of long duration received 67.6% "strongly agree", 20.6% "agree", and 11.8% "neutral" with a mean response of 1.44. Projects of medium duration got 20.6% "strongly agree", 70.6% "agree", and 8.8% "neutral" with a mean response of 1.88. Projects of short duration got 9.4% "strongly agree", 34.4% "agree", 46.9% "neutral", and 9.4% "disagree" with a mean response of 2.56.

The duration is found to be positively and moderately correlated with the level of agreement (r = 0.56, P < 0.001). This suggests, as in the case of those who have PIP (r = 0.57, P < 0.001) that the longer the duration of a project the more suited PIP is for that project.

Ownership: Government owned projects received 67.6% "strongly agree", 26.5% "agree", and 5.9% "neutral" with a mean response of 1.38. Privately owned projects had 38.2% "strongly agree" 41.2% "agree", 14.7% "neutral", and 5.9% "disagree" with a mean response of 1.88.

As presented in Appendix C, the results of ANOVA indicate that ten percent ($R^2 = 0.10$, $P < 0.01$) of the variation in the level of agreement is explained by the prsence of different project owners, while in the case of contractors who have PIP there was no relationship. Although the relationship anticipated by those who do not have PIP is weak ($R^2 = 0.1$), the difference may be due to their perception of government owned projects as being larger in size and number which makes them better candidates for improvement and savings on the national scale.

A correlation between the mean responses of those who have PIP (Table 4.40) and those who do not have PIP (Table 4.42) was run to see the level of agreement between the two groups. The responses of the two groups were found to be highly correlated ($r = 0.88$, $P < 0.001$) which indicates a high level of agreement between these two groups.

From the results of both sections 4.5.1.5 and 4.5.2.4, it can be concluded that productivity improvement programs are suited to all kinds of projects. However, PIP's are most suited to projects which are large, and of long duration. It is also concluded that PIPs are more suited - to a lesser degree - to projects which are of high complexity, and government owned.

4.6 Modeling Productivity Improvement Environment

Based on results and findings of this research, guidelines can be set to help contractors in establishing productivity improvement programs. These guidelines can be stated as 4 stages of implementing Productivity

Improvement Programs:

Stage 1: Commitment and Awareness

A. Gain management support by addressing economic feasibility, and enhance productivity awareness by learning about measurement methods.

B. Management commitment should lead to recruiting qualified personnel needed to run PIP.

Stage 2: Measuring Productivity

A. Determine areas of productivity improvement. These areas are either site related or head office related. The areas are further determined according to the firm size.

B. Measure productivity using different measurement methods.

Stage 3: Evaluate Measurement Results Using Productivity Records Data

A. Determine problem areas.

B. Determine causes of problems.

Stage 4: Take Corrective Actions.

The above guidelines are presented in Figure 4.20 as a flow chart. Numbers mentioned at the bottom of each box are section numbers of the thesis where detailed discussions can be found.

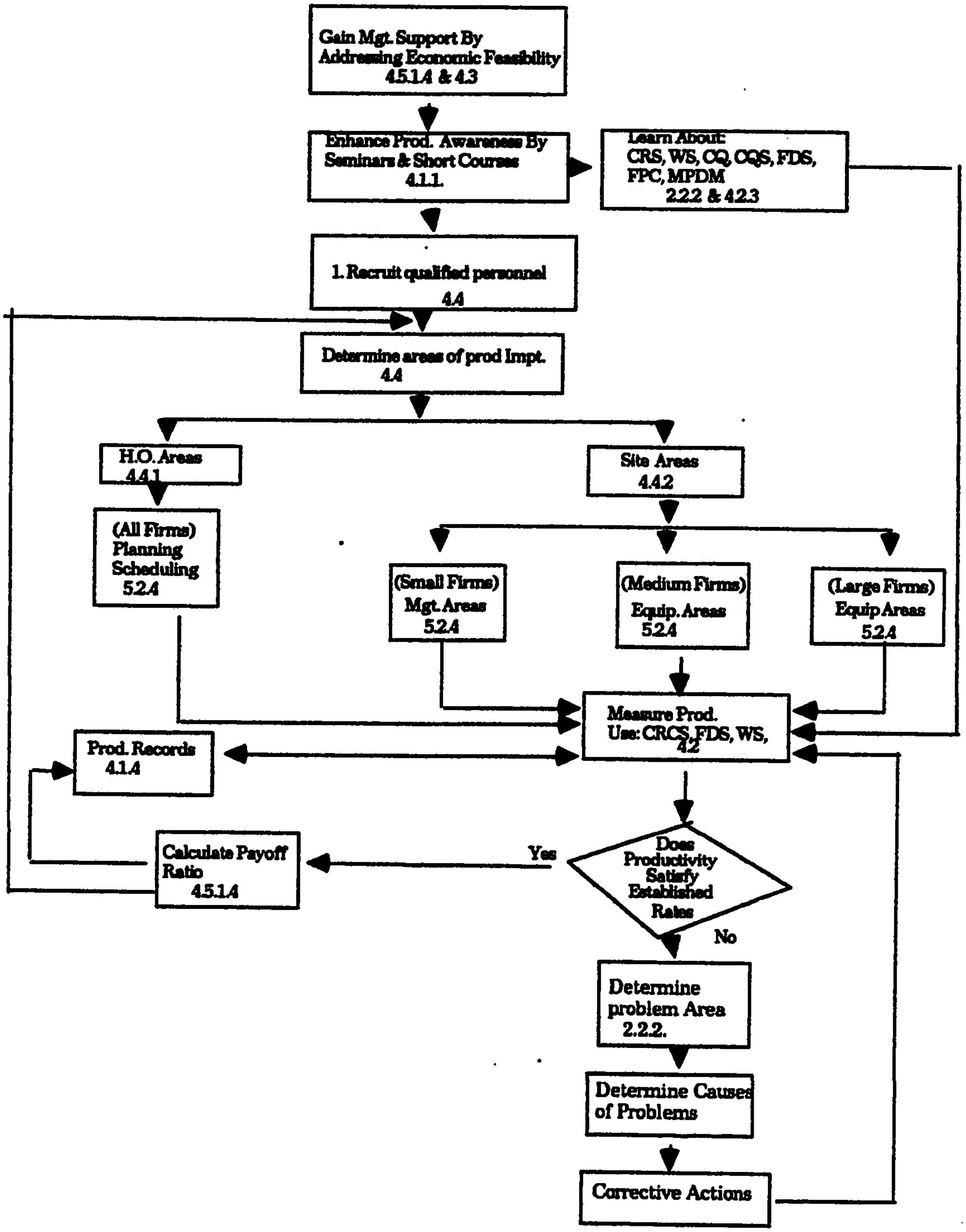

Gain Mgt. Support By Addressing Economic Feasibility 4.5.1.4 & 4.3
Enhance Prod. Awareness By Seminars & Short Courses 4.1.1.
Learn About: CRS, WS, CQ, CQS, FDS, FPC, MPDM 2.2.2 & 4.2.3
1. Recruit qualified personnel 4.4
Determine areas of prod Impt. 4.4
H.O. Areas 4.4.1
Site Areas 4.4.2
(All Firms) Planning Scheduling 5.2.4
(Small Firms) Mgt. Areas 5.2.4
(Medium Firms) Equip. Areas 5.2.4
(Large Firms) Equip Areas 5.2.4
Measure Prod. Use: CRCS, FDS, WS, 4.2
Prod. Records 4.1.4
Calculate Payoff Ratio 4.5.1.4
Yes
Does Productivity Satisfy Established Rates
No
Determine problem Area 2.2.2.
Determine Causes of Problems
Corrective Actions

Fig. 4.20 Guidelines To Establish PIP

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

Productivity in construction is a problem that needs to be investigated and studied seriously. This study investigated and studied many construction productivity related issues in Saudi Arabia, i.e., productivity awareness among construction contractors, the applicability of different productivity measurement methods, the obstacles which hinder the use of Productivity Improvement Programs, areas and functions which have high potential for productivity improvement , and the possibility of establishing construction productivity improvement programs .

This study was limited to large building contractors in Saudi Arabia. Personal interviews were conducted with 55 randomly selected contractors. Productivity questionnaires concerning the issues mentioned above were filled out during these interviews. The data extracted from these questionnaires was analyzed using the SAS Package.

5.2 Findings and Conclusions

Findings and conclusions of the study are presented as follows:

5.2.1 Productivity Awareness

1. Respondents do not have a unified conceptualization of productivity.

2. There is a common agreement among building construction contractors that there is a productivity problem manifested by low productivity .

3. Project cost and project duration are found to be the most negatively affected attributes by low productivity , while project quality is the least affected attribute.

4. Construction workers' productivity is perceived by respondents to be the most unsatisfactory area of productivity while office management productivity is perceived to be the least unsatisfactory area.

5. Documentation and keeping of productivity records and their reuse in preparing estimates is not fully utilized. Contractors depend on experience-based judgement in preparing estimates.

5.2.2 Productivity Measurement Methods

1. The Cost Reporting and Control System (CRCS) is practically the

only productivity measurement and improvement method that respondents are familiar with. Larger companies tend to be more familiar with non-traditional productivity measurement and improvement methods.

2. The Cost Reporting and Control System (CRCS) is the most popular and utilized method of measuring and improving productivity . The popularity of all methods was found to be correlated with their familiarity.

3. The Cost Reporting and Control System is rated by respondents to be the most reliable, effective, and comprehensive productivity measurement method. It is also rated as the most demanding on trained personnel and data processing, the most time consuming, and the most costly method.

5.2.3 Hindrances to Productivity Improvement Programs (PIP)

1. The four most important factors perceived as hindrances to Productivity Improvement Programs (PIP) are: the lack of management support, the lack of awareness among contractors, the lack of trained personnel, and the fact that contractors have never been asked by owners to implement PIP's for additional incentives.

5.2.4 Potential Areas for Productivity Improvement

1. Planning and scheduling are found to be the most important Head Office-related areas with potential to improve productivity ,

regardless of the size of firm.

2. Marketing is rated by large and medium size contractors as the least important Head Office-related area with potential to improve productivity , while it is rated by small size firms to be the fourth most important area.

3. When rating the Head Office-related areas for their potential to improve productivity , the areas that have been found to be the most important discriminators between the three sizes of contractors are drafting, specification, planning, scheduling, procurement and estimating.

4. In site-related areas, materials delivery has the highest potential to improve productivity , then come equipment utilization, supervision, and labor motivation in the second, third, and fourth ranks respectively. From a main group's prospective, management-related and equipment-related areas have the highest potential for productivity improvement.

5. Supervision has the highest potential to improve productivity for small contractors, while materials delivery showed the highest potential for medium contractors, whereas equipment utilization turned out to be the area with the highest potential for large contractors. Packaging of materials is the area with the lowest potential for productivity improvement for all sizes of contractors.

6. Management-related areas have the highest potential for

productivity improvement for small size contractors, while equipment-related areas have the highest potential for productivity improvement for medium and large contractors.

7. When rating the site-related areas for their potential to improve productivity, the areas that have been found to be the most important discriminators between the three sizes are supervision, materials delivery, materials new products, labor availability, equipment maintainability and pre-assemble modulars.

5.2.5 Possibility of Establishing Productivity Improvement Programs

1. Only 21 out of 55 respondents declared that they have some kind of Productivity Improvement Programs. This may indicate that there is a lack of adoption and implementation of Productivity Improvement Programs.

2. The Studies and Planning Department is the part of the organization which takes care of productivity in most of the companies which have PIP. None of the respondents indicated that they have a separate department solely devoted to productivity related matters.

3. Most of the companies that have PIP stated that productivity is handled by in-house staff.

4. Almost half of those who have PIP's achieved 2:1 pay-off ratio and another quarter of them achieved 9:1 pay-off ratio, which is

encouragingly high.

5. Around one quarter of those who have PIP's achieved less than their minimum acceptable pay-off ratio. But, none of them said that he had lost by applying a PIP. This indicates the economic feasibility of applying PIP's.

6. None of the respondents, both those who have and those who do not have PIP, is willing to accept a pay-off ratio less than 2:1.

7. The overwhelming majority of the contractors who have PIP mentioned that they would expand their use of PIP.

8. The majority of the respondents who do not have PIP stated that they are planning to introduce PIP in their companies' construction projects in the future. Some of those, as this researcher was told, had their awareness of PIP either initiated or increased by the interviews conducted in this study.

9. Productivity Improvement Programs are found to be suited to all types of projects. Productivity Improvement Programs are most suited for projects which are large, and of long duration. PIPs are more suited - to a lesser degree - to projects which are of high complexity, and government owned.

5.3 RECOMMENDATIONS

1. Research institutions in the Kingdom should carry out in-depth studies aimed at improving construction productivity . Contractors should contribute to these studies by both providing funding and releasing the necessary information.

2. Contractors should be made aware of the importance of construction productivity records, not only for PIP but also for cost estimates.

3. In building construction , which is labor-intensive, the productivity of construction workers needs to be given special attention.

4. When trying to improve construction productivity , attention must be focused on various areas. Of the Head Office-related areas, planning and scheduling should receive the most attention. Of the site related areas; management and equipment-related areas should receive the most attention.

5. In order to initiate PIPs, productivity awareness must be publicized and promoted at both the individual and organizational levels. Publications, seminars, and other possible means may be utilized for this purpose. Universities can play a key role in this regard.

6. Project owners should offer some incentives to contractors to

encourage them to initiate and implement PIP. An incentive may be in the form of sharing the profit gained by cost savings, due to PIP utilization in cost reimbursable contracts.

7. Consultants who offer construction management services should get more involved in productivity improvement activities especially in helping to establish new PIP's.

8. The model presented in Fig. 4.20, is recommended to be used in establishing productivity improvement programs .

5.4 RECOMMENDATIONS FOR FUTURE STUDIES

1. This study investigated construction productivity from the large building contractors' point of view. The first three grades of the MPWH classification - contractors of other grades and of other types, e.g., roads, utilities, industrial, could be involved in similar future studies. It is also possible to investigate other parties' points of view, e.g., project owners, and consultants.

2. This study approached and investigated the subject at a macro level, relatively speaking. More specific and detailed studies may be undertaken such as studying each productivity measurement method in more detail.

3. The PIP model presented in Fig. 4.20 could be tested to validate its applicability.

APPENDIX - A

INTERVIEW SCHEDULE

(ENGLISH AND ARABIC)

بسم الله الرحمن الرحيم

Ministry of Higher Education
King Fahd University of Petroleum & Minerals
College of Environmental Design
DEAN'S OFFICE

148
وزارة التعليم العالي
جامعة الملك فهد للبترول والمعادن
كلية تصاميم البيئة
مكتب العميد

7 August 1991

TO WHOM IT MAY CONCERN

Mr. Muhannad Abu-Asbah, a graduate student at KFUPM, is presently conducting a study for his master thesis on Construction Productivity in Saudi Arabia for the degree of Master of Science in Construction Engineering and Management. To obtain the required information for the study, interviews have to be made with executive managers of large contractors in Saudi Arabia. We shall, therefore, highly appreciate your kindness towards him in rendering the information as per his needs. Your contribution in this regard is highly appreciated.

We promise that all data of individual firms will be held in strict confidence and will be used for research purposes only.

Thank you for your cooperation.

Dr. Ibrahim M. Shukri
Dean
College of Env. Design

الظهران ٣١٢٦١ ، المملكة العربية السعودية ● تلفون : ٨٦٠٢٥٨٠ (٠٣) ● تلكس : ٨٠١٠٦٠ جافهد ● برقيا : الجامعة
DHAHRAN 31261, SAUDI ARABIA ● TELEPHONE : (03) 860-2580 ● TELEX : 801060 KFUPM SJ ● CABLE : AL-JAM

INTERVIEW SCHEDULE

(Questionnaire)

PREPARED BY :

MUHANNAD ABU-ASBAH

Note : *We will provide you with a summary of this study.*

PART "A"

1. *The Type of Registration*

Saudi Company ( )
Foreign Company ( ) (Specify)
Joint Venture ( )

2. *Respondent's Title or Position:*____________________

Name of the Company:____________________
Location of Main Office:____________________
No. of Branches:____________________
Phone and Fax No.:____________________

3. *Annual Construction Volume (Million SR):*________________

4. *Number of Permanent Employees:*____________________
(including Tradesmen & Foremen)

5. *Nationality of Construction Workers:*

________ ________%
________ ________%
________ ________%
________ ________%

6. **Riyal value of Construction Equipment (Millions of Riyals):____**

7. **Percentage of Construction Equipment Leased or Rented:_______%**

8. **Percentage of Work subcontracted in average job:____________%**

9. **Geographic Location of Projects in the last 5 years:**

Central Region _____ %
Eastern Region _____ %
Western Region _____ %
Southern Region _____ %
Northern Region _____ %
Out of Saudi Arabia _____ %

PART "B"

1. What does "construction productivity" mean to you?

____

____

2. What are the factors that influence construction productivity?

____

____

3. What is the effect of construction productivity on your:

	Extremely Negative	Negative	No effect	Positive	Extremely positive
Project cost	( )	( )	( )	( )	( )
Project duration	( )	( )	( )	( )	( )
Project quality	( )	( )	( )	( )	( )
Employee Morale	( )	( )	( )	( )	( )
Employee job satisfaction	( )	( )	( )	( )	( )
Overall profitability (of the firm)	( )	( )	( )	( )	( )

4. How satisfied are you with the existing level of the following productivity areas in your firm?

	Extremely Dissatisfied	Dissatisfied	Neither	Satisfied	Extremely Satisfied
Construction Workers Productivity	( )	( )	( )	( )	( )
Methods Productivity	( )	( )	( )	( )	( )
Equipment Productivity	( )	( )	( )	( )	( )
Site Mgt. Personnel Productivity	( )	( )	( )	( )	( )
Office Mgt. Personnel Productivity	( )	( )	( )	( )	( )
Overall Productivity	( )	( )	( )	( )	( )

5. What are your organization policies/procedures aimed at improving productivity in the following areas:

a. Construction methods (work methods)·

____

____

____

b. Workers' Recruitment:

____

c. **Workers' Training:**

d. **Workers' Motivation (Rewards/Punishments):**

e. **Equipment Selection:**

f. **Equipment Utilization:**

g. **Site Engineering/Management Personnel:**

h. **Office Engineering/Management Personnel:**

6. The following represents reasons and roadblocks why this firm does not utilize productivity improvement as a formal program (policies and procedures aimed at improving construction productivity). Please state your level of agreement.

REASONS	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. The concept of productivity improvement programs is not well known to us.					
2. Measurement of productivity is too difficult.					
3. Measurement of benefit/cost of productivity is too difficult.					
4. We have never been asked by owners to implement productivity improvement program for additional incentives.					
5. We do not have qualified personnel to apply it.					
6. It is just "good engineering" which we do any way.					
7. Productivity concept is too complicated and theoretical.					
8. It is too difficult to get started (we are too busy).					
9. The organization culture is not productivity conscious.					
10. Projects are too short to implement productivity programs.					
11. It costs too much.					
12. Productivity Improvement Programs will not succeed in Saudi Arabia because of: (a) Lack of awareness among contractors (b) Lack of management support (c) Lack of trained personnel: mgt. / workers.					
13. Others.					

7. What type of productivity records or information do you use in preparing estimates?
   - a. Cost records associated with each element of work.
   - b. Productivity records associated with each production factor (labor, equipment,.....)
   - c. We depend only on experience-based judgement.
   - d. Others:________________________________

8. For each of the following productivity measurement methods, please indicate your level of familiarity with:

		Never heard of	somewhat familiar	Familiar	Very familiar	Extremely Familiar
a.	Work Sampling (WS)	( )	( )	( )	( )	( )
b.	Craftsman Questionnaire(CQ)	( )	( )	( )	( )	( )
c.	Craftsman Questionnaire Sampling (CQS)	( )	( )	( )	( )	( )
d.	Foreman-Delay Survey (FDS)	( )	( )	( )	( )	( )
e.	Cost Reporting and Control System (CRCS)	( )	( )	( )	( )	( )
f.	Method Productivity Delay Model (MPDM)	( )	( )	( )	( )	
g.	Flow Process Chart (FPC)	( )	( )	( )	( )	( )
h.	Other______________________	( )	( )	( )	( )	( )

9. How frequent does your firm use the following productivity measurement methods:

		Never	Rarely	Sometimes	Most of the time	Always
a.	Work Sampling (WS)	( )	( )	( )	( )	( )
b.	Craftsman Questionnaire(CQ)	( )	( )	( )	( )	( )
c.	Craftsman Questionnaire Sampling (CQS)	( )	( )	( )	( )	( )
d.	Foreman-Delay Survey (FDS)	( )	( )	( )	( )	( )
e.	Cost Reporting and Control System (CRCS)	( )	( )	( )	( )	( )
f.	Method Productivity Delay Model (MPDM)	( )	( )	( )	( )	
g.	Flow Process Chart (FPC)	( )	( )	( )	( )	( )
h.	Other________________________	( )	( )	( )	( )	( )

10. Please rate the following methods attributes:

Methods Attributes	WS	CQ	CQS	FDS	CRCS	MPDM	FPC	OTHER
Reliability	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Comprehensiveness (Scope of coverage)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Demand on trained Personnel	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Demand on Data Processing	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Cost of Measurement	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Time of Measurement	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Reaction of the Workers	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Participation of the Workers	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Communication Problems	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Effectiveness	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

5 = Very high. 1 = Very low.

PART "C"

"For Companies who have Productivity Improvement Programs"

1. *The size of productivity staff in this company is:*

   a. Number of Full time:__________

   b. Number of Part time:__________

2. *What part of the organization do above staff work in?*

   ____

3. This company's average benefit (pay off ratio) resulting from the application of productivity improvement program is ____:1.

4. This company considers a minimum acceptable pay off ratio for the money spent on productivity improvement programs to be: ____:1.

5. What are your plans for future productivity improvement programs?

   a. Stay at current level.

   b. Expand. Explain:______________________________

   ____

   c. Shrink. Explain: ______________________________

   ____

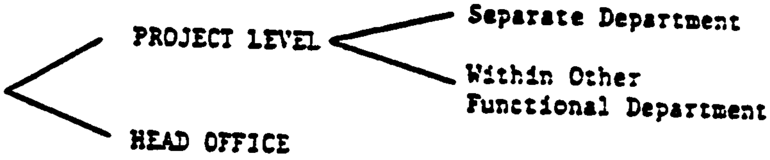
6. Improvement Programs are most suited for:

	PARAMETERS	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
SIZE	Large (Above SR.200 million)						
	Medium (Bet. SR.50-200 million)						
	Small (Below SR.50 million)						
TYPE	Building						
	Engineering						
	Industrial						
COMPLEXITY	Complexity - High						
	- Medium						
	- Low						
DURATION	Duration - Long						
	- Medium						
	- Short						
OWNER	Government						
	Private						

7. For our construction projects, we would like to have productivity "improvement programs" conducted by:

   a. Consultants

   b. In-house staff


PROJECT LEVEL
Separate Department
Within Other Functional Department
HEAD OFFICE

   c. Both consultants and in-house staff

"For Companies Who Don't Have Productivity Improvement Programs"

8. Improvement programs are most suited for:

PARAMETERS			Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
SIZE	Large (Above SR: 200 million)							
	Medium (Bet. SR:50-200 million)							
	Small (Below SR.50 million)							
TYPE	Building							
	Engineering							
	Industrial							
COMPLEXITY	Complexity	- High						
		- Medium						
		- Low						
DURATION	Duration	- Long						
		- Medium						
		- Short						
OWNER	Government							
	Private							

9. This company considers a minimum acceptable pay off ratio for the money spent on productivity improvement programs to be: ____:1.

10. Are you planning to introduce productivity improvement programs in your company's construction projects in the future?

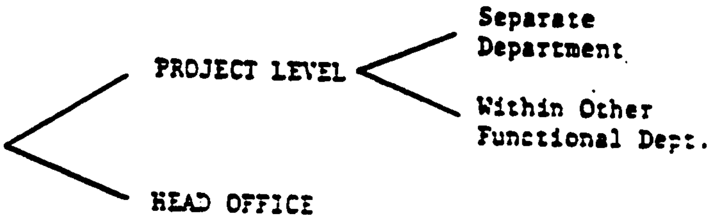
Yes ( ) No ( )

If yes, when? __________

11. For our construction projects, we would like to have productivity improvement programs conducted by:

a. Consultants

b. In-house staff


PROJECT LEVEL
Separate Department
Within Other Functional Dept.
HEAD OFFICE

c. Both consultants and in-house staff

"FOR ALL COMPANIES"

12. Rate the following "headquarters-type" functions for their potential to improve construction productivity in your firm (5 = very high, 1 = very low).

Planning	1	2	3	4	5
Procurement	1	2	3	4	5
Scheduling	1	2	3	4	5
Drafting	1	2	3	4	5
Estimating	1	2	3	4	5
Specifications	1	2	3	4	5
Communications	1	2	3	4	5
Engineering	1	2	3	4	5
Marketing	1	2	3	4	5

13. Please rate the following site-related functions and aspects for their potential to improve construction productivity in your firm (5 = very high, 1 = very low).

Management

Labor Relations	1	2	3	4	5
Cost Control	1	2	3	4	5
Supervision	1	2	3	4	5

Materials:

Delivery	1 2 3 4 5
Storage	1 2 3 4 5
Packaging	1 2 3 4 5
Prefabrication	1 2 3 4 5
Standardization	1 2 3 4 5
Product availability	1 2 3 4 5
New Product	1 2 3 4 5

Labor:

Contract agreement	1 2 3 4 5
Training	1 2 3 4 5
Quality control	1 2 3 4 5
Turnover	1 2 3 4 5
Availability	1 2 3 4 5
Recruitment	1 2 3 4 5
Motivation	1 2 3 4 5

Engineering & Design:

Design Standards	1 2 3 4 5
Design Improvement	1 2 3 4 5
Systems Engineering	1 2 3 4 5
Standard Specifications	1 2 3 4 5

Equipment:

Capacity	1 2 3 4 5
Maintainability	1 2 3 4 5

Utilization	1 2 3 4 5

Construction Techniques:

Precast elements	1 2 3 4 5
Pre-assemble modulars	1 2 3 4 5
Methods	1 2 3 4 5

Others (Specify):________________

14. **Please give any comment that you think is related to this study:**

____

____

Ministry of Higher Education
King Fahd University of Petroleum & Minerals
College of Environmental Design
DEAN'S OFFICE

وزارة التعليم العالي
جامعة الملك فهد للبترول والمعادن
كلية تصاميم البيئة
مكتب العميد

التاريخ : ٣٠ محرم ١٤١٢هـ

الى من يهمه الامر

السلام عليكم ورحمة الله وبركاته .

نفيدكم بان السيد / مهنّد محمود ابو عصبه يقوم بدراسة لإتمام متطلبات الحصول على درجة الماجستير في هندسة وإدارة التشييد من جامعة الملك فهد للبترول والمعادن تتعلق بإنتاجية التشييد في المملكة العربية السعودية .

يتطلب إتمام هذه الدراسة إجراء العديد من المقابلات الشخصية مع المدراء التنفيذيين لشركات المقاولات الكبرى بالمملكة للحصول على المعلومات اللازمة ، والتي نعدكم بأنها ستكون موضع السرية التامة وستستخدم فقط لأغراض البحث .

إن تجاوبكم سوف يساهم في إتمام هذه الدراسة والإنتفاع بنتائجها في المستقبل القريب ، وتعاونكم بتزويده بالمعلومات ذات العلاقة لإتمام الدراسة سيكون موضع تقديرنا وإحترامنا .

وتقبلوا سلفاً فائق التحيات .

الدكتور ابراهيم محمد شكري
عميد كلية تصاميم البيئة

الظهران ٣١٢٦١، المملكة العربية السعودية ● تلفون : ٨٦٠٢٥٨٠ (٠٣) ● تلكس : ٨١٩٥٠ جافهد ● برقيا : الجامعة
DHAHRAN 31261, SAUDI ARABIA ● TELEPHONE: (03) 860-2580 ● TELEX: 801060 KFUPM SJ ● CABLE: AL-JAMAAH

جدول مقابلة

(استبيان)

إعداد

مهند أبو عصبة

ملاحظة : سنزودكم بملخص هذه الدراسة بعد إتمامها.

الجزء الأول

١ ـ نوع التسجيل :

شركة سعودية ( )

شركة أجنبية ( ) (حدد)

متعددة الجنسية ( ) (حدد)

٢ ـ وظيفة المجيب : ....

اسم الشركة :...

موقع المكتب الرئيسي : ....

عدد الفروع : ....

رقم الهاتف والفاكس : ....

٣ ـ حجم التشييد السنوي (ملايين الريالات) : ....

٤ ـ عدد الموظفين الدائمين : ....

(بما في ذلك أصحاب المهن والمراقبين)

٥ ـ جنسيات عمال التشييد :

الجنسية	النسبة المئوية
....	.... ٪
....	.... ٪
....	.... ٪
....	.... ٪

٦ - قيمة معدات التشييد (ملايين الريالات) : .... ٪

٧ - نسبة معدات التشييد المستأجرة : .... ٪

٨ - النسبة المئوية للعمل المعطى للمقاولين من الباطن في متوسط الأعمال : .... ٪

٩ - الموقع الجغرافي للمشاريع خلال الخمس سنوات الأخيرة :

المنطقة الوسطى .... ٪

المنطقة الشرقية .... ٪

المنطقة الغربية .... ٪

المنطقة الجنوبية .... ٪

المنطقة الشمالية .... ٪

الجزء الثاني

١ ـ ماذا تعني « إنتاجية التشييد » لك ؟

....

....

٢ ـ ما هي العوامل التي تؤثر على إنتاجية التشييد ؟

....

....

٣ ـ ما اثر إنتاجية التشييد لديكم على :

	سلبي جدا	سلبي	لا أثر	إيجابي	إيجابي جدا
تكلفة المشروع	( )	( )	( )	( )	( )
مدة تنفيذ المشروع	( )	( )	( )	( )	( )
جودة ونوعية المشروع	( )	( )	( )	( )	( )
معنويات الموظفين	( )	( )	( )	( )	( )
رضى الموظفين بالعمل	( )	( )	( )	( )	( )
الفائدة الكلية للشركة	( )	( )	( )	( )	( )

٤ ـ ما مدى رضاك عن المستوى الحالي لمجالات الإنتاجية التالية لدى شركتكم :

	غير راض على الإطلاق	غير راض	لا هذا ولا ذاك	راض	راض جدا
إنتاجية عمال التشييد	( )	( )	( )	( )	( )
إنتاجية طرق التشييد	( )	( )	( )	( )	( )
إنتاجية معدات التشييد	( )	( )	( )	( )	( )
إنتاجية أفراد إدارة الموقع	( )	( )	( )	( )	( )
إنتاجية أفراد إدارة المكتب	( )	( )	( )	( )	( )
الإنتاجية العامة للشركة	( )	( )	( )	( )	( )

٥ ـ ما هي سياسات وطرق شركتكم التي ترمي إلى تحسين الإنتاجية في المجالات الآتية :

أ ـ طرق التشييد (طرق العمل) :

....

....

....

ب ـ توظيف العمالة :

....

....

....

جـ ـ تدريب العمالة :

....

....

....

د - تشجيع العمالة (الثواب والعقاب) :

....

....

....

هـ - اختيار المعدات :

....

....

....

و - استغلال المعدات :

....

....

....

ز - موظفو الموقع المهندسين والإداريين :

....

....

....

ح - موظفو المكتب المهندسين والإداريين :

....

....

....

٦ـ ما يلي يمثل العقبات والأسباب وراء عدم استغلال شركتنا لبرامج تحسين الإنتاجية (سياسات وطرق تهدف إلى تحسين إنتاجية التشييد) نرجو منكم توضيح مدى موافقتكم عليها :

م	الأسباب والعقبات	أوافق تماما	أوافق	معتدل	غير موافق	غير موافق بالمرة
١ـ	فكرة برامج تحسين الإنتاجية غير معروفة لدينا					
٢ـ	قياس الإنتاجية صعب جدا					
٣ـ	قياس معدل الفائدة بالنسبة للتكلفة الخاصة بالإنتاجية صعب جدا					
٤ـ	لم يطلب منا أصحاب المشاريع تطبيق برامج تحسين الإنتاجية مقابل حوافز إضافية					
٥ـ	ليس لدينا أشخاص مؤهلين لتطبيق برامج تحسين الإنتاجية					
٦ـ	إنها مجرد « هندسة جيدة » وهو ما نعمله أصلا					
٧ـ	فكرة الإنتاجية معقدة جدا ونظرية					
٨ـ	إنه من الصعب أن نبدأ (مشغولون جدا)					
٩ـ	ثقافة الشركة غير منتبهة لموضوع الإنتاجية					
١٠ـ	المشاريع قصيرة جدا بحيث لا يسمح ذلك بتنفيذ برامج تحسين الإنتاجية					
١١ـ	تكلفة برامج تحسين الإنتاجية عالية جدا					
١٢ـ	برامج تحسين إنتاجية التشييد لن تنجح في المملكة بسبب :					
	(أ) نقص الوعي بين المقاولين					
	(ب) نقص الدعم من الإدارة					
	(جـ) نقص في الأشخاص المؤهلين لتطبيق برامج تحسين الإنتاجية : إداريين / عمالة					
١٣ـ	أسباب أخرى :					

٧ـ أي نوع من المعلومات أو السجلات الخاصة بالإنتاجية تستخدمون في إعداد تقدير تكلفة المشاريع ؟

أ ـ السجلات الخاصة بتكلفة كل عنصر أو بند عمل .

ب ـ سجلات الإنتاجية الخاصة بكل عامل إنتاج (العمالة ، المعدات ، .....)

جـ ـ نعتمد فقط على التقدير المبني على الخبرة .

د ـ أنواع أخرى...

٨ ـ لكل من طرق قياس الإنتاجية التالية ، من فضلك حدد مدى إلمامك بها :

		لم أسمع بها	ملم بعض الشيء	ملم	ملم جدا	غاية الإلمام
a.	Work Sampling (WS)	( )	( )	( )	( )	( )
b.	Craftsman Questionnaire (CQ)	( )	( )	( )	( )	( )
c.	Craftsman Questionnaire Sampling (CQS)	( )	( )	( )	( )	( )
d.	Forman-Delay Survey (FDS)	( )	( )	( )	( )	( )
e.	Cost Reporting and Control System (CRCS)	( )	( )	( )	( )	( )
f.	Method Productivity Dely Model (MPDM)	( )	( )	( )	( )	( )
g.	Flow Process Chart (FPC)	( )	( )	( )	( )	( )
h.	Others:	( )	( )	( )	( )	( )

٩ـ ما مدى استخدام شركتكم لطرق قياس الإنتاجية التالية :

		لم تستخدمها أبدا	نادرا	بعض الأحيان	معظم الوقت	دائما
a.	Work Sampling (WS)	( )	( )	( )	( )	( )
b.	Craftsman Questionnaire (CQ)	( )	( )	( )	( )	( )

c.	**Craftsman Questionnaire Sampling (CQS)**	( )	( )	( )	( )	( )
d.	**Forman-Delay Survey (FDS)**	( )	( )	( )	( )	( )
e.	**Cost Reporting and Control System (CRCS)**	( )	( )	( )	( )	( )
f.	**Method Productivity Dely Model (MPDM)**	( )	( )	( )	( )	( )
g.	**Flow Process Chart (FPC)**	( )	( )	( )	( )	( )
h.	**Others:**	( )	( )	( )	( )	( )

١٠ ـ من فضلك ضع دائرة على الرقم المناسب لكل طريقة وخاصية :

الطريقة الخاصية	W.S	CQ	CQS	FDS	CRCS	MPDM	FPC	طرق أخرى
الإعتمادية	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
الشمول (الغرض الذي تغطيه)	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
الإحتياج لأشخاص مؤهلين	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
الإحتياج لمعالجة المعلومات	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
تكلفة القياس	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
وقت القياس	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
رد فعل العمال	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
مشاركة العمال	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
مشاكل التواصل	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥
الفاعلية	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥	١ ٢ ٣ ٤ ٥

٥ : عالي جدا

١ : منخفض جدا

الجزء الثالث

« للشركات التي لديها برامج لتحسين إنتاجية التشييد »

١ ـ عدد موظفي الإنتاجية في شركتكم :

أ ـ عدد المتفرغين كليا:..

ب ـ عدد المتفرغين جزئيا:..

٢ ـ في أي جزء أو إدارة في شركتكم يعمل موظفو الإنتاجية ؟

....

٣ ـ متوسط الفائدة (معدل العائد) الناتجة من تطبيق برامج تحسين الإنتاجية لدى هذه الشركة هو :.................................... : ١

٤ ـ هذه الشركة تعتبر الحد الأدنى المقبول لمعدل العائد من الأموال المصروفة في برامج تحسن الإنتاجية هو :.................................... : ١

٥ ـ ما هي خططكم المستقبلية لبرامج تحسن الإنتاجية ؟

أ ـ تبقى على المستوى الحالي .

ب ـ نتوسع . اشرح:..

....

جـ ـ نقلّص . اشرح:..

....

٦ ـ برامج تحسين الإنتاجية تكون أكثر مناسبة لـ :

		أوافق تماما	أوافق	معتدل	غير موافق	غير موافق إطلاقا
حجم المشروع	كبير (أكثر من ٢٠٠ مليون ريال)					
	متوسط (بين ٥٠ ـ ٢٠٠ مليون ريال)					
	صغير (تحت ٥٠ مليون ريال)					
نوع المشروع	مباني					
	هندسي					
	صناعي					
درجة التعقيد	معقد					
	متوسط التعقيد					
	بسيط					
مدة المشروع	طويلة					
	متوسطة					
	قصيرة					
مالك المشروع	قطاع حكومي					
	قطاع خاص					

٧ ـ بالنسبة لمشاريعنا ، نرغب أن تُنفّذ « برامج التحسين » بواسطة :

أ ـ استشاري .

ب ـ موظفين من الشركة :

- على مستوى المشروع :
  - ١ ـ إدارة مستقلة .
  - ٢ ـ من خلال إدارة وظيفية .
- من المكتب الرئيسي .

جـ ـ موظفون بالشركة بالتعاون مع استشاري .

« للشركات التي ليس لديها برامج لتحسين إنتاجية التشييد »

٨ ـ برامج تحسين الإنتاجية تكون أكثر مناسبة لـ :

		أوافق تماما	أوافق	معتدل	غير موافق	غير موافق إطلاقا
حجم المشروع	كبير (أكثر من ٢٠٠ مليون ريال)					
	متوسط (بين ٥٠ ـ ٢٠٠ مليون ريال)					
	صغير (تحت ٥٠ مليون ريال)					
نوع المشروع	مباني					
	هندسي					
	صناعي					
درجة التعقيد	معقد					
	متوسط التعقيد					
	بسيط					
مدة المشروع	طويلة					
	متوسطة					
	قصيرة					
مالك المشروع	قطاع حكومي					
	قطاع خاص					

٩ - هذه الشركة تعتبر الحد الأدني المقبول لمعدل العائد من الأموال المصروفة على برامج تحسين الإنتاجية :................................ : ١

١٠ - هل تخططون لإدخال برامج تحسين الإنتاجية في مشاريع التشييد التي تنفذها شركتكم في المستقبل ؟

نعم (   )   لا (   )

إذا كانت الإجابة بنعم ، فمتى؟..

١١ - بالنسبة لمشاريع التشييد التي تُنَفّذُها ، نرغب أن تُنفّذ « برامج التحسين » بواسطة :

أ- استشاري

ب- موظفي الشركة

- مستوى المشروع
  - ١- إدارة منفصلة
  - ٢- ضمن إدارة أخرى
- من المكتب الرئيسي

جـ- موظفي الشركة والإستشاري معا .

« لجميع الشركات »

١٢ ـ ضع علامة على الرقم المناسب أمام الوظائف التالية والمرتبطة بالمكتب الرئيسي للشركة للدلالة على الإمكانية الكامنة في كل وظيفة لتحسين إنتاجية التشييد في شركتكم (٥ : عالي جدا ، ١ : منخفض جدا) .

التخطيط	١	٢	٣	٤	٥
المشتريات	١	٢	٣	٤	٥
الجدولة	١	٢	٣	٤	٥
اعداد الرسومات	١	٢	٣	٤	٥
التقدير	١	٢	٣	٤	٥
المواصفات	١	٢	٣	٤	٥
الإتصال	١	٢	٣	٤	٥
النواحي الهندسية	١	٢	٣	٤	٥
التسويق	١	٢	٣	٤	٥

١٣ ـ من فضلك ضع علامة على الرقم المناسب أمام الوظائف والأمور التالية والمرتبطة بالموقع للدلالة على الإمكانية الكامنة في كل وظيفة لتحسين إنتاجية التشييد في شركتكم (٥ : عالي جدا ، ١ : منخفض جدا) .

الإدارة :

علاقات العمال	١	٢	٣	٤	٥
التحكم بالتكلفة	١	٢	٣	٤	٥
الإشراف	١	٢	٣	٤	٥

المواد :

التوصيل	١	٢	٣	٤	٥
التخزين	١	٢	٣	٤	٥
التعبئة	١	٢	٣	٤	٥
الصنع المسبق	١	٢	٣	٤	٥
التقييس	١	٢	٣	٤	٥
توفر المنتجات	١	٢	٣	٤	٥
المنتجات الجديدة	١	٢	٣	٤	٥

العمالة :

اتفاقية العقد	١	٢	٣	٤	٥
التدريب	١	٢	٣	٤	٥
التحكم في الجودة	١	٢	٣	٤	٥
استبدال العمالة	١	٢	٣	٤	٥
توفر العمالة	١	٢	٣	٤	٥
التوظيف	١	٢	٣	٤	٥
التشجيع	١	٢	٣	٤	٥

الهندسة والتصميم :

مقاييس التصميم	١	٢	٣	٤	٥
تحسين التصميم	١	٢	٣	٤	٥
هندسة النظم	١	٢	٣	٤	٥
المواصفات القياسية	١	٢	٣	٤	٥

المعدات :

امكانية المعدات	١	٢	٣	٤	٥
صيانة المعدات	١	٢	٣	٤	٥
استغلال المعدات	١	٢	٣	٤	٥

طرق التشييد :

العناصر المسبقة الصنع	١	٢	٣	٤	٥
النماذج المسبقة التركيب	١	٢	٣	٤	٥
أخرى (حدد)	١	٢	٣	٤	٥

١٤ ـ من فضلك أعط أي تعليق أو ملاحظة تعتقد أنها ذات علاقة بموضوع الدراسة :

....

....

....

APPENDIX - B

CONTRACTORS' CHARACTERISTICS

Table 1: The Type of Registration

Registration	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Saudi Company	49	92.5	49	92.5
Foreign Company	1	1.9	50	94.3
Joint Venture	3	5.7	53	100.0

N = 53.

Table 2: Respondent's Title or Position

Title	Frequency	Percent	Cumulative Frequency	Cumulative Percent
General Manager	10	21.7	10	21.7
Deputy General Manager	8	17.4	18	39.1
Technical Manager	4	8.7	22	47.8
Construction Manager	6	13.0	28	60.9
Project Manager	10	21.7	38	82.6
Others	8	17.4	46	100.0

N = 46.

Table 3: Number of Branches

Number of Branches	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	4.3	1	4.3
1	7	30.4	8	34.8
2	4	17.4	12	52.2
3	8	34.8	20	87.0
4	2	8.7	22	95.7
9	1	4.3	23	100.0

N = 53.

Table 4: Annual Construction Volume

Annual Construction Volume (Millions of SR)	Size	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Less than 50	Small	24	43.6	24	43.6
More than 50 but less than 200	Medium	23	41.8	47	85.4
More than 200	Large	8	14.6	55	100.0

N = 55

Table 5: Number of Permanent Employees

Number	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Under 100	10	18.9	10	18.9
100 - 300	15	28.3	25	47.2
301 - 500	8	15.1	33	62.3
501 -1000	8	15.1	41	77.4
Over 1000	12	22.6	53	100.0

N = 53.

Table 6: Nationality of Construction Workers

Nationality	Mean Response (Percentage)
Thais	8.54
Filipinos	35.79
Indians	19.42
Pakistanis	15.41
Egyptians	14.35
Saudis	0.26
Others	6.23

N = 48.

Table 7: Riyal Value of Construction Equipment
(Millions of Riyals)

Equipment Value	Fre-quency	Percent	Cumulative Frequency	Cumulative Percent
0 - 1	3	5.9	3	5.9
2 - 10	28	54.9	31	60.8
11 - 20	4	7.8	35	68.6
21 - 50	8	15.7	43	84.3
51 and above	8	15.7	51	100.0

N = 51.

Table 8: Percentage of Equipment Leased or Rented

Percentage	Fre-quency	Percent	Cumulative Frequency	Cumulative Percent
0%	12	24	12	24
1% - 5%	12	24	24	48
6% - 30%	18	36	42	84
31% - 70%	5	10	47	94
71% - 100%	3	6	50	100

N = 50.

Table 9: Percentage of Work Subcontracted In Average Job

Percentage	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0%	3	5.8	3	5.8
1% - 10%	12	23.0	15	28.8
11% - 20%	24	46.2	39	75.0
21% - 30%	11	21.2	50	96.2
31% - 50%	2	3.8	52	100.0

N = 52.

Table 10: Geographical Locations of Projects

In the Last 5 Years.

Geographical Location	Mean Response (Percentage)
Central Region	40.28
Eastern Region	27.06
Western Region	22.76
Southern Region	5.00
Northern Region	3.98
Out of Saudi Arabia	0.92

N = 50.

APPENDIX - C

RESULTS OF ANOVA

```
GROUP=PIP

Analysis of Variance Procedure
Class Level Information

Class     Levels    Values

TYPE           3    BUILDING ENGINEERING INDUSTRIAL

Number of observations in by group = 56


GROUP=PIP

Analysis of Variance Procedure

Dependent Variable: RESPONSE

Source                  DF          Sum of Squares          Mean Square      F Value        Pr > F

Model                    2              0.48412698           0.24206349         0.60        0.5534

Error                   53             21.44444444           0.40461216

Corrected Total         55             21.92857143

                  R-Square                    C.V.             Root MSE                RESPONSE Mean

                  0.022077                43.44038           0.63609131                   1.46428571

Source                  DF                Anova SS          Mean Square      F Value        Pr > F

TYPE                     2              0.48412698           0.24206349         0.60        0.5534
```

```
GROUP=PIP

Analysis of Variance Procedure
Class Level Information

Class     Levels    Values

OWN            2    GOVERNMENT PRIVATE

Number of observations in by group = 40


GROUP=PIP

Analysis of Variance Procedure

Dependent Variable: RESPONSE

Source                  DF          Sum of Squares          Mean Square        F Value         Pr > F

Model                    1              0.62500000           0.62500000           2.34         0.1344

Error                   38             10.15000000           0.26710526

Corrected Total         39             10.77500000

                  R-Square                    C.V.             Root MSE                 RESPONSE Mean

                  0.058005                39.00545           0.51682227                    1.32500000

Source                  DF                Anova SS          Mean Square        F Value         Pr > F

OWN                      1              0.62500000           0.62500000           2.34         0.1344
```

```
GROUP=NPIP

Analysis of Variance Procedure
Class Level Information

Class      Levels    Values

TYPE            3    BUILDING ENGINEERING INDUSTRIAL

Number of observations in by group = 96


GROUP=NPIP

Analysis of Variance Procedure

Dependent Variable: RESPONSE

Source                DF          Sum of Squares          Mean Square      F Value           Pr > F

Model                  2              0.59747257           0.29873629         0.79           0.4583

Error                 93             35.30877743           0.37966427

Corrected Total       95             35.90625000

                R-Square                    C.V.             Root MSE                 RESPONSE Mean

                0.016640                40.23961           0.61616903                    1.53125000

Source                DF                Anova SS          Mean Square      F Value           Pr > F

TYPE                   2              0.59747257           0.29873629         0.79           0.4583
```

```
GROUP=NPIP

Analysis of Variance Procedure
Class Level Information

Class     Levels    Values

OWN            2    GOVERNMENT PRIVATE

Number of observations in by group = 68


GROUP=NPIP

Analysis of Variance Procedure

Dependent Variable: RESPONSE

Source                  DF           Sum of Squares          Mean Square        F Value          Pr > F

Model                    1               4.25000000           4.25000000           7.47          0.0081

Error                   66              37.55882353           0.56907308

Corrected Total         67              41.80882353

                  R-Square                     C.V.             Root MSE                  RESPONSE Mean

                  0.101653                 46.21362           0.75436933                     1.63235294

Source                  DF                 Anova SS          Mean Square        F Value          Pr > F

OWN                      1               4.25000000           4.25000000           7.47          0.0081
```

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