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STUDY OF THE MEASUREMENT OF LABOR PRODUCTIVITY IN THE PALESTINIAN CONSTRUCTION INDUSTRY: THE GAZA STRIP

Eng. Zeyad Ahmed Abo Mostafa

B.Sc. Civil Engineering

Supervised by

Prof. Dr. Adnan Enshassi

Professor of Construction Engineering and Management

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نتيجة الحكم على أطروحة ماجستير

بناءً على موافقة عمادة الدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث زياد أحمد محمود أبومصطفى المقدمة لكلية الهندسة لنيل درجة الماجستير في كلية الهندسة قسم إدارة التشييد.

دراسة قياس الإنتاجية للعمال في صناعة التشييد في قطاع غزة

وبعد المناقشة العلنية التي تمت اليوم الأحد 4 ذوالقعدة 1424هـ الموافق 2003/12/28م الساعة 10 صباحاً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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وبعد المداولة أوصت اللجنة بمنح الباحث درجة الماجستير في كلية الهندسة قسم إدارة التشييد.

واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

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12/28
أ.د. أحمد يوسف أبوحلبية

ص.ب 108، الرمال، غزة، فلسطين تلكس 23311 هاتف Fax: (+970/8)2863552 Tel:(+970/8)286 3554-2823311
Web Site: www.iugaza.edu e-mail: public@mail.iugaza.edu

بسم الله الرحمن الرحيم

يقول الله تعالى:

" وقل اعملوا فسيرى الله عملكم و

رسوله والمؤمنون"

صدق الله العظيم

Dedication

To my parents and wife

for their unlimited

support

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ABSTRACT

Productivity is an issue of a particular importance to the Gaza Strip projects as it is considered a newly developed area and because of the huge amount of projects planned to be carried out in the near future. The purpose of this research is to study "measurement of labor productivity in the construction industry in the Gaza Strip". The main objectives of this study are to gain understanding of the factors affecting labor productivity in buildings construction and measuring labor productivity of block work operation in the Gaza Strip.

The objectives of this research have been achieved through a study of seventy - six questionnaires and a case study in the Gaza Strip. The results of analysis of 45 factors considered in the questionnaire concluded that the main factors negatively affecting labor productivity in buildings construction are: material shortages, lack of labor experiences, lack of labor surveillance, misunderstanding between labor and superintendents, drawings and specifications alteration during execution, payment delay, labor disloyalty, inspection delay, working for 7 days of the week without holiday, and tool / equipment shortages. The results of site observations of block work operation in the case study demonstrated that average productivity of skilled laborer in laying blocks 20 is 38.40 blocks per hour (3.07 m2/h) while average productivity of skilled laborer in laying blocks 10 is 40.50 blocks per hour (3.24m2/h). The findings also indicate that productive time of skilled labor is 77.01% of working time, contributory time of skilled labor is 9.76 % of working time, and unproductive time of skilled labor is 13.23% of working time.

The results of this study recommended that contracting companies have to conduct labor productivity study in their projects to improve labor productivity. It is important for each contracting company to adopt motivational or personnel management measures to boost workers' morale. Contracting companies are requested to use project scheduling techniques such as computer-aided construction project management in their projects.

ملخص البحث

دراسة قياس الإنتاجية للعمال في صناعة التشييد في قطاع غزة

موضوع الإنتاجية يمثل أهمية خاصة للمشاريع في قطاع غزه وذلك باعتبارها منطقة تطوير جديدة ونظرا للعدد الكبير من المشاريع المتوقع انشائها في المستقبل القريب. تم أجراء هذا البحث بغرض دراسة قياس إنتاجية العمال في صناعة التشييد في قطاع غزة. ان الاهداف الرئيسية لهذا البحث هو معرفة العوامل الاساسية المؤثرة على إنتاجية العمال في مشاريع المباني في قطاع غزة بالإضافة إلى قياس إنتاجية العمال في بناء الحجر في قطاع غزة. استخدم هذا البحث اسلوب الاستبيان لجمع المعلومات الخاصة بالعوامل المؤثرة على إنتاجية العمال بالإضافة الى دراسة حالة عملية لقياس إنتاجية العمال في بناء الحجر.

لقد اوضحت النتائج الخاصة بتحليل خمسة واربعون عاملا تم سردها في الاستبيان أن العوامل الرئيسية التي تؤثر سلبا على إنتاجية العمال في مشاريع البناء هي: النقص في المواد وقلة خبرة العمال وعدم مراقبة ومتابعة العمال أثناء العمل من قبل المهندس المسئول عن العمل و غياب التفاهم بين العمال والمهندس المسئول عن العمل و التغيير في المواصفات والخرائط اثناء التنفيذ والتأخير في دفع رواتب العمال و عدم شعور العامل بالولاء والانتماء للشركة التي يعمل بها وتأخر فحص الاعمال الجاهزة من قبل الاشراف والعمل كل ايام الاسبوع بدون أخذ يوم أجازة والنقص في عدد الالات والمعدات. كما أظهرت نتائج ملاحظة عملية بناء الحجر في الحالة الدراسية أن متوسط إنتاجية العامل الفني في بناء حجر مقاس 20 هو 38.40 حجر في الساعة (3.07 متر مربع في الساعة) ومتوسط إنتاجية العامل الفني في بناء حجر مقاس 10 هو 40.50 حجر في الساعة (3.24 متر مربع في الساعة). أيضا اظهرت النتائج أن العامل الفني يقضي 77.01 % من أوقات العمل في فعاليات منتجة و يقضي 9.76 % من أوقات العمل في فعاليات تساعد على الانتاج و يقضي 13.23 % من أوقات العمل في فعاليات غير منتجة.

ان أهم توصيات هذا البحث هي ضرورة قيام شركات المقاولات بدراسة إنتاجية العمال في جميع مشاريعها لمعرفة سبل تحسين الانتاجية. أيضا يجب أن تقوم شركات المقاولات بتطبيق نظام حوافز مناسب لتحفيز العمال على زيادة الإنتاجية. كما أن هناك حاجة ماسة لأستخدام تقنيات جدولة المشاريع في إدارة المشاريع.

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List of Abbreviations

ASIST	Advisory Support, Information Services, and Training
BS	British Standard
CQ	Craftsman Questionnaire
CQS	Craftsman Questionnaire Sampling
FDS	Foreman Delay Survey
GDP	Gross Domestic Product
GNP	Gross National Product
MAS	Palestinian Economic Policy Research Institute
MOPIC	Ministry of Planning and International Co-operation
PASSIA	Palestinian Academic Society for the Study of International Affairs
PCBS	Palestinian Central Bureau of Statistics
PECDAR	Palestinian Economic Council For Development and Reconstruction
SPSS	Statistical Package for Social Science
UNSCO	United Nations Special Coordinator in the Occupied Territories

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service industries. These characteristics are physical products, cost, and complexity but construction industry like service industry more than manufacturing industry (Barrie et al, 1992). The construction industry includes residential construction, building construction, heavy engineering construction, and industrial construction (Barrie et al, 1992). Construction industry suffered in recent years from rapid decline in the growth of productivity (Abdul-Kadir et al, 1995).

1.2 The Palestinian economy

The Palestinian economy may be characterized by its limited size. In 1999, GDP accounted for approximately US $ 4.15 billion; the total population was approximately 2.8 million; and thus GDP per capita reached approximately $1,500 (World Bank, 2000). The gross national product (GNP) per capita was higher, around $1,800, given the large inflow of remittances from Palestinian workers in Israel and international aid (World Bank, 2000). Using GNP or GDP criteria, the West Bank and Gaza Strip ranks within the group of lower middle-income countries (World Bank, 2000).

Average real monthly expenditures for seven-person households in the West Bank and Gaza Strip in 1997 averaged US$ 750 as compared to US$ 828 in 1996 with a decline of 9.4 percent (UNSCO, 1998). The rate of inflation on consumer prices in the West Bank and Gaza Strip was 6.1 percent in 1997. The consumer price index rose by 4.8 percent in the West Bank, 6.9 percent in the Gaza Strip (UNSCO, 1998).

Poverty in the West Bank and Gaza Strip is estimated at 23.2 percent of the population in 1998, equivalent to about 682,000 persons. The overall poverty figures mask significant differences between the West Bank and Gaza Strip. In 1998, the share of the Gazan population living in poverty was 37 percent, more than twice as high as in the West Bank where it was 15 percent (World Bank, 2001). Private investment in productive activities

remains low, around 14 percent of GDP in 1998, while public investment amounts to 7 percent of GDP, financed almost entirely by external assistance (World Bank, 2000).

Since 1994, over $3 billion has been disbursed under various donor programs, making the West Bank and Gaza Strip the third largest per capita recipient of non military foreign aid in the world after Israel and Bosnia-Herzegovina. Most foreign assistance has taken the form of grants, and the public level of external borrowing remains low, representing only 7 percent of GDP in 1999 (World Bank, 2000). The West Bank and Gaza Strip has no currency, and uses mostly the New Israeli Shekel for its domestic transactions (World Bank, 2000).

Elaqsa Intifada caused steep decline in all Palestinian economic indicators. Gross national income (GNI) in 2002 mounted to 40 percent less than in 2000 (World Bank, 2003). Also physical damages resulting from conflict jumped from US$ 305 million at the end of 2001 to US$ 728 million by the end of August 2002 (World Bank, 2003). Between June 2000 and June 2002 Palestinian exports declined by 45 percent in Value (World Bank, 2003). World Bank estimated that 21 percent of the Palestinian population was poor on the eve of the Intifada. a number that increased to about 60 percent by December, 2002. Accounting for population growth, the numbers of poor have tripled from 682,000 to just under 2 million (World Bank, 2003).

1.3 The construction industry in Palestine

The construction sector in Palestine had experienced a considerable growth in the aftermath of 1967. Its share of GDP increased from under 9 % in 1972 to over 17 % in 1985. During that period the contribution of sector had fluctuated in an upward long run trend bounded by 9 % & 19 % from 1970 to 1980 and by 15.2 % & 23 % from 1980 to 1985 (Pedar, 1997). However in 1996 it appears that the contribution of the construction sector to the GDP has been reduced to 9 % (World bank, 1998) and in 1998 become 10.63% (PCBS, 2000). Figure 1.2 illustrates the distribution of GDP among different sectors during the year 1996.

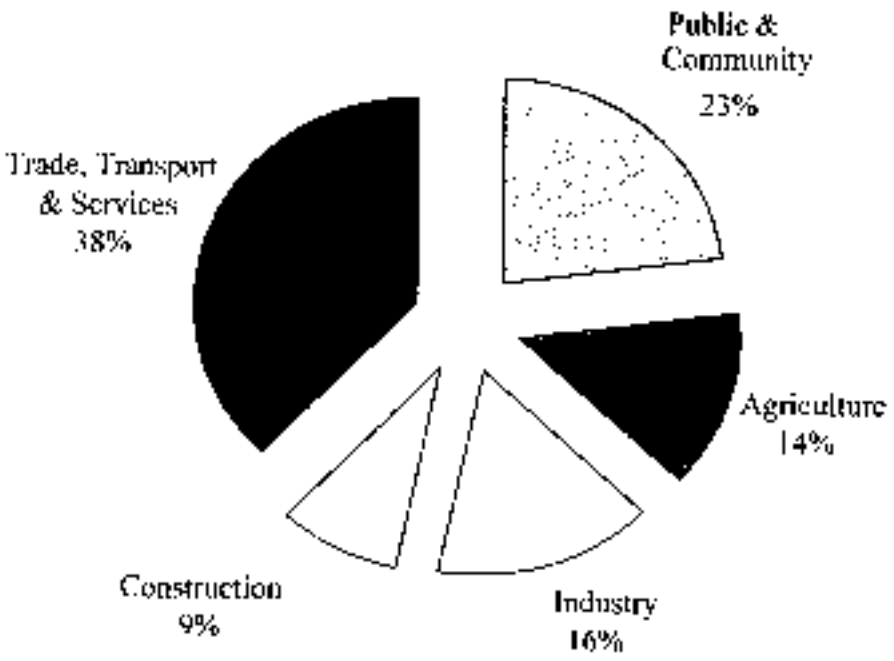

Figure 1.2. Distribution of GDP in Palestine by sector (World bank, 1998)

The construction sector enjoyed a steady increase from 1991, due to pent-up demand from the Intifada, and to accommodate Palestinian returnees from the Gulf after the Gulf War. The peace process accelerated this increase, especially after the return of many Palestinians who came with the Palestinian National Authority (MAS, 1997). Expansion of the construction activity has generated a lot of jobs for skilled, semiskilled, and unskilled labor. Figure 1.3 shows the distribution of labor force in the construction sector from 1997 to 2001 (PASSIA, 2002, cited in (El Sawalhi, 2002).

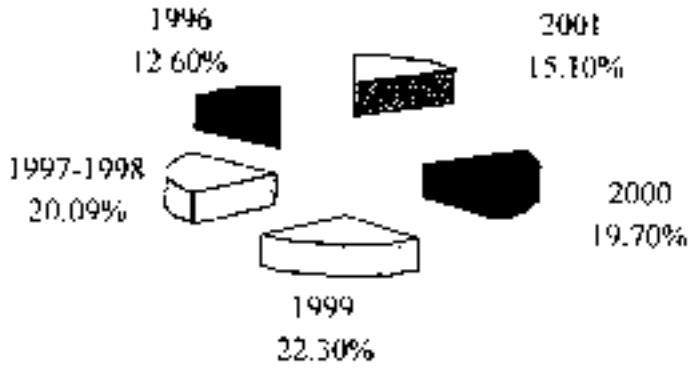

Figure1.3. Labor forces employed in the Palestinian construction industry (PASSIA, 2002, cited in El Sawalhi, 2002).

Building construction is one of the pioneer sectors that achieved high growth rates during last two decades and played a crucial role in absorbing gradual injections into the Palestinian labor force (PCBS, 2000). Table 1.1 and table1.2 show the cost of construction of buildings in Palestinian Territory by cost item and region during the year of 1999 (PCBS, 2000).

Table 1.1. Cost of construction of buildings in Palestine Territory during the year of 1999, (Value in US$ 1000) (PCBS, 2000)

Cost Item	Gaza Strip	West Bank
Excavation by machinery	980.20	12011.60
Workmanship	41794.60	132578.00
Construction materials	117500.20	453381.20
Workmanship + materials	60080.80	93280.50
Contracting companies	23339.40	20647.20
Licensing fees	2242.20	6617.20
Utilities construction fees	2723.10	6174.30
Others	1438.80	2277.90
Total	250099.30	726968.20

Table 1.2. Cost of buildings in Palestine Territory during the year of 1999 (Values in Million US $) (PCBS, 2000)

Item	Value
A. cost of building construction by building type:	
a. Building	211.30
b. Villa / House	463.80
c. Establishment	43.40
d. Others, including marginal buildings and enclosures	281.50
B. Cost of building construction by building status:	
a. Completed	405.30
b. Under construction	445.20
c. Under construction and utilized but not completed	249.50
C. Cost of building construction by building utilization:	
a. Residential only	499.50
b. Work only	49.80
c. Work and residential	104.70
d. Others	346.00

1.4 Research Problem

Contractors construction time and cost estimation at the time of tender is based on personal experience whether good or poor because there are no manuals of productivity rates in the construction industry in the Gaza Strip to estimate the required resources and time for projects. In a number of cases it would seem as though time and cost estimates at the time of tender is still very poor resulting in gross time and cost overrun. Very little has been done in terms of productivity with respect to the building construction industry in the Gaza Strip. In an effort to try and correct this situation it was found necessary to carry out a productivity

rate measurement study to establish productivity rates for one of the main trades in the construction industry and study factors negatively affecting labor productivity in building projects.

Labor Productivity rate measurement could be used in improving labor productivity in construction sites and determines the required resources to execute the activities of the projects and required duration to carry these activities according to specifications and time period of the contract.

1.5 Research importance

Productivity remains an intriguing subject and a dominant issue in construction sector, promising efficient usage of resources and cost savings and ultimately affecting the bottom line of every effort in the construction sector (Olomolaiye et al, 1998). At the bid stage of a project, contractors are interested in site labor productivity index in order to estimate the likely labor cost for particular task (Gilleard, 1992). However if the contract is awarded to the contractors, the company needs to ensure that this estimated level of productivity is achieved or bettered. Hence the more accurate the original data, the more able the construction manager will be to (Gilleard, 1992):

a. Determine how effectively his or her projects are being managed;
b. Detect adverse trends quickly so that corrective action may be taken quickly;
c. Determine the effects of changed methods and conditions;
d. Identify both high and low areas of productivity and reasons for this differences;
e. Compare performance between sites.

Only few studies focused on measuring productivity rate in the construction sector in the Gaza Strip, therefore there are no reference handbooks and manuals of productivity rate in the construction industry in the Gaza Strip to estimate the required resources and time to control projects. In this research due to the importance of labor productivity role in

construction industry development, labor productivity for block work and factors that lead to low productivity in the building construction in the Gaza Strip was be investigated to determine the labor productivity rate in this activity and factors negatively affecting labor productivity in the building construction.

Labor Productivity rate measurement data can be used by management for planning, estimating, and controlling the project activities. Also Productivity rate measurement data can be used for following management functions (Guhathakurta et al, 1993):

a. Determine the number of workers to be assigned for a task;
b. Determine the most economic method from alternatives;
c. Determine the unit rate for various operations; and
d. Provide basis for cost control.

1.6 Research aim

The aim of this research is to study measurement of labor productivity in the construction industry in the Gaza Strip. Labor productivity formed the focal area of the study because it is the main value adding function in the construction industry in the Gaza Strip as well as developing countries.

1.7 Research objectives

1. Exploring the factors and their relative importance that negatively affecting labor productivity in building projects;
2. Measuring productivity rate of skilled labor in block work operation;
3. Studying relationship between productivity of skilled labor and working hours and days in block work operation;
4. Measuring productive time, contributory time, and unproductive time of skilled labor and unskilled labor in block work operation;

5. Studying the impact of skilled labor age, skilled labor experience, skilled labor wage, and number of skilled labor in gang on productivity of skilled labor in block work operation;
6. Evaluating and Ranking the factors that negatively affecting labor productivity of block work operation; and
7. Providing practical suggestions and recommendations aiming to upgrade the knowledge and improve the labor productivity in construction projects.

1.8 Research boundaries

1. Due to time limitation, this research was concerned with building construction only and did not take into account the other categories of construction industry like heavy engineering construction (tunnels, bridge, dams), industrial projects (factories and workshops), and utilities construction (sewage and water supply).

2. Research focus on labor productivity without including total factors productivity and financial productivity.

3. Only contractors registered in the Palestinian contractors union and block work labor working in Sheikh Zayed Township project were be involved in this study.

4. This research focus on evaluating the factors affecting labor productivity in construction building projects, and measuring labor productivity in block work activity.

CHAPTER 2

Productivity

2.1 Introduction

Productivity is one of the most important issues in both developed and developing countries. Developed countries aware that productivity is very important for economical growth and social welfare. Developing countries which face unemployment problems, inflation, resource scarcity and growth rate decline try to utilize its resources in such away that achieve economical growth and improve citizens life. Productivity is one of the key measures of utilization of human and financial resources because it is a strong indicator of efficient use of available resources and converts it to noticeable results.

This chapter will deal with different definitions of the term productivity, types of productivity, importance of productivity in construction industry, factors affecting labor productivity, and measurement of labor productivity.

2.2 Productivity – concept, and basic definition

Improving productivity is a major concern of any profit oriented organization as representing the effective and efficient conversion of resources into marketable products and determining business profitability (Wilcox et al, 1993). Consequently considerable effort has been directed to understanding the productivity concept, with the different approaches taken by researchers resulting in a wide variety of definitions of productivity. Some of these definitions are listed in a chronological order in table 2.1.

Table 2.1. Chronology of important definitions of productivity (Alfeld, 1988 - Lema, 1995 - Pilcher, 1997 - Gupta et al, 2000 - Oglesby, 2002)

Century	Author	Year	Definition
19th	Littre	1883	Faculty to produce.
20th	Early	1900s	Relationship between output and means employed to produce this output.
	Davis	1955	Change in product obtained for the resources used.
	Fabricant	1962	Always a ratio of output to input.
	Kendrick et al	1965	Functional definition of partial, total factor and total productivity.
	Siegel	1976	A family of ratios of output to input
	Sumanth	1979	Total productivity - the ratio of tangible output to tangible input.
	Alfeld	1988	The ratio that relates measurements of outputs to measurements of inputs.
	Lema	1995	The ratio of outputs to inputs in a production process.
	Pilcher	1997	The rate of producing i.e output divided by input.
	Gupta et al	2002	The output in any productive work in relation to inputs.
	Oglesby et al	2002	The ability to produce an abundance or richness of output.

Some productivity definitions also originated from special interest groups such as economists, industrialists, trade unions and politicians. Individuals or groups have meanings that fit their situation. For example the Organization for the European Economic Co-operation (cited in lema, 1995) defined productivity as "a quotient obtained by dividing output by one of the factors of production. In this way it is possible to speak of the

productivity of capital, investment, or raw materials according to whether output is being considered in relation to capital, investment or raw materials etc".

Japanese National Productivity Centre (cited in Iema, 1995) described productivity as follows "Productivity is above all else, an attitude of mind. It is a mentality of progress, of constant improvement of that which exists. It is the certainty of being able to do better today than yesterday and less well than tomorrow. It is the will to improve the present situation, no matter how good it may seem, no matter how good it may really be. It is a constant adaptation of economic and social life to changing conditions; it is the continual effort to apply new techniques to new methods; it is faith in human progress."

international Labor Office (1996) described productivity as follows "Productivity is a comparison between how much you have put into the projects in terms of manpower, material, machinery or tools and the result you get out of the project. Productivity has to do with the efficiency of production. Making a site more productive means getting more output for less cost in less time. Productivity covers every activity that goes into completing the construction site works, from the planning stage to the final site clearing. If the contractor can carry out these activities at lower cost in less time with fewer workers, or with less equipment then productivity will be improved" (Andersson et al, 1996) .

From the above definitions it is concluded that productivity is generally defined as the ratio of outputs to inputs.

$$\text{Productivity} = \frac{\text{Outputs}}{\text{Inputs}}$$

It is important to specify the inputs and outputs to be measured when calculating productivity because there are many inputs, such as labor, materials, equipment, tools, capital, and design. The conversion process from inputs to outputs associated with any operation is also complex, influenced by the technology used, by many externalities such as government regulations,

weather, unions, economic conditions, management, and various internal environmental components.

2.3 Differences between Productivity and production

Many people are confused between productivity and production terms. They think that the greater the production, the greater the productivity. This is not necessarily true. Production in any productive work denotes the outputs only without any reference to inputs. But productivity is concerned with the effective and efficient utilization of resources (inputs) in producing goods or services (outputs) (Gupta et al, 2000). If viewed in quantities terms, production is quantity of outputs produced, while productivity is the ratio of the outputs produced to the inputs used (Gupta et al, 2000).

2.4 Types of productivity

There are three types of productivity, namely single factor productivity, total factor productivity and total productivity.

2.4.1 Single factor productivity

Single factor productivity is a ratio of outputs to one type of input (Lema, 1995). For example labor productivity is the ratio of outputs to labor input. Similarly capital productivity is the ratio between outputs and capital input. Single factor productivity is widely used as measures of economic efficiency and have at least the advantages of simplicity but it suffers from a weakness in that it does not include the total productive process and it does not adequately deal with the impact of technological change and factor substitution (Lowe, 1987)

2.4.1.1 Labor productivity

Labor productivity is the most widely used yardstick of operational efficiency. This does not imply that labor is the best input element for productivity measurement but simply reflects the difficulty or impossibility of obtaining numerical values for the other determinants of productivity. Thus many of the essays on productivity seem to assume that labor productivity is the only suitable measure (Lowe, 1987). One common measure of average labor productivity is a ratio of output per labor.

$$\text{Average labor productivity} = \frac{Q}{L} \qquad (1)$$

Where Q = outputs

L = Labor employed

Labor employed (L) has to be quantified and while to take it as the number of operatives has at least the advantages of simplicity and because it utilize statistics which are fairly easily available (Lowe, 1987). Numerous permutations on this theme have been formulated- outputs / operative hours, outputs / operative year, index of labor costs, etc (Lowe, 1987). In this context average labor productivity is a measure of the labor intensity of the productive process and does not necessarily imply anything about the efficiency of use of resources. Labor productivity can thus be increased by substituting another factor – usually capital for labor. This substitution may or may not result in a better use of resources and cheaper unit costs of production. Thus for example if plant is substituted for site labor, this will improve labor productivity. Similarly using off-site fabricated components, which involve substituting off-site labor for on-site labor, will also improve average labor productivity (Lowe, 1987).

2.4.1.2 Capital productivity

Capital productivity is usually defined in terms of a percentage return on capital invested, either using a traditional method such as average rate of return or a discounted cash flow method such as the internal rate of return method (Lowe, 1987).

$$\text{Average capital productivity} = \frac{\text{profit}}{\text{capital invested}} \qquad (2)$$

In order to calculate capital productivity, an estimate will be required of the value of the fixed capital stock. Problems exist since different methods of valuing capital assets exist and since all estimates will be to some extent subjective, in that the managers of a company may have a different view from the shareholders, as may a potential asset stripper. In any event, such information is unlikely to be readily available. Capital productivity is thus less widely used than labor productivity (Lowe, 1987)

Despite these practical difficulties, capital productivity is a far more useful criterion than labor productivity for judging the performance of an enterprise operating within a market economy. Most private firms will seek to ensure an adequate return on capital invested to their shareholders – thus a high return on capital invested is far more relevant than high outputs per operative (Lowe, 1987).

2.4.2 Total factor productivity

To overcome the limitations of the single factor approaches considered above the total factors productivity measurement was developed. Total factor productivity is the ratio of net output to the sum of associated labor and capital input (Lema, 1995)

$$TFPt = \frac{\text{Output}}{(Ht + Ct)} \qquad (3)$$

Where

TFPt = total factor productivity over period t

Ht = human input over period t

Ct = capital input over period t

From the point of view of productive efficiency under conditions of scarcity, an enterprise will have to combine the various inputs in the correct combination for optimal results to either minimize costs for a given level of production or to maximize production from available resources. From the point view of allocative efficiency, the owners of the various factors of production may be assumed to seek to maximize their return from those factors (Lowe, 1987).

2.4.3 Total productivity

Total productivity is the ratio of total outputs to the sum of all input factors. Thus a total productivity measure reflects the joint impact of all the inputs in producing the outputs. In all of the above definitions both the outputs and the inputs are real or physical terms by being reduced to constant dollars of a reference period (Lema, 1995). This reduction to base period is accomplished by dividing the value of outputs and inputs by deflators or inflators depending upon whether the prices of outputs and inputs have gone up or down respectively (Lema, 1995).

$$TPt = \frac{\text{Total Output}}{\text{Total Input}} \qquad (4)$$

Where TPt is total productivity over period t

$$\text{Thus } TPt = \frac{Vt}{(Ht + Ct + Mt + Et + Ot)} \qquad (5)$$

Where

Vt = output value over period t

Ht = human input over period t

Ct = capital input over period t

Mt = material input over period t

Et = energy input over period t

Ot = other expenses over period t.

2.5 Productivity variables

Productivity increases exist because of the management of three variables. These productivity variables are labor, capital, and management. These three factors are critical to productivity improvement. They represent the broad areas in which managers can take action to obtain better productivity (Heizer et al, 1990).

A. Labor

The quality of labor is very important to improve productivity. Three traditional variables for improved labor productivity have been (Heizer et al, 1990).

1- Basic education appropriate for an effective labor force;

2- Diet of the labor force;

3- Social overhead that makes labor available, such as transportation and sanitation.

In developing countries these three variables are very important however, in developed nation; the critical variable is maintaining and enhancing the skill of labor.

B. Capital

Human being is a tool using animals. Capital investment provides those tools. These tools can range from desk computers to complex machinery and new airports (Heizer et al, 1990). Production can often be accomplished with some trade-off between labor and capital. That is, if we want to build a road we can do so with crews of thousands using shovels or we can invest in earth moving equipment. The trade-off between capital and labor is continually in flux (Heizer et al, 1990).

C. Management

Management is a factor of production and an economic resource. It is responsible for insuring that labor and capital are effectively used to increase productivity. The arts and sciences of management include improvements made by technology and knowledge. Such improvement requires training and education as well as dynamic organization (Heizer et al, 1990).

2.6 Productivity cycle

Productivity cycle has four stages: productivity measurement, productivity evolution, productivity planning, and productivity improvement as shown in figure.2.1 [cited in Sisalem et al, 2000].

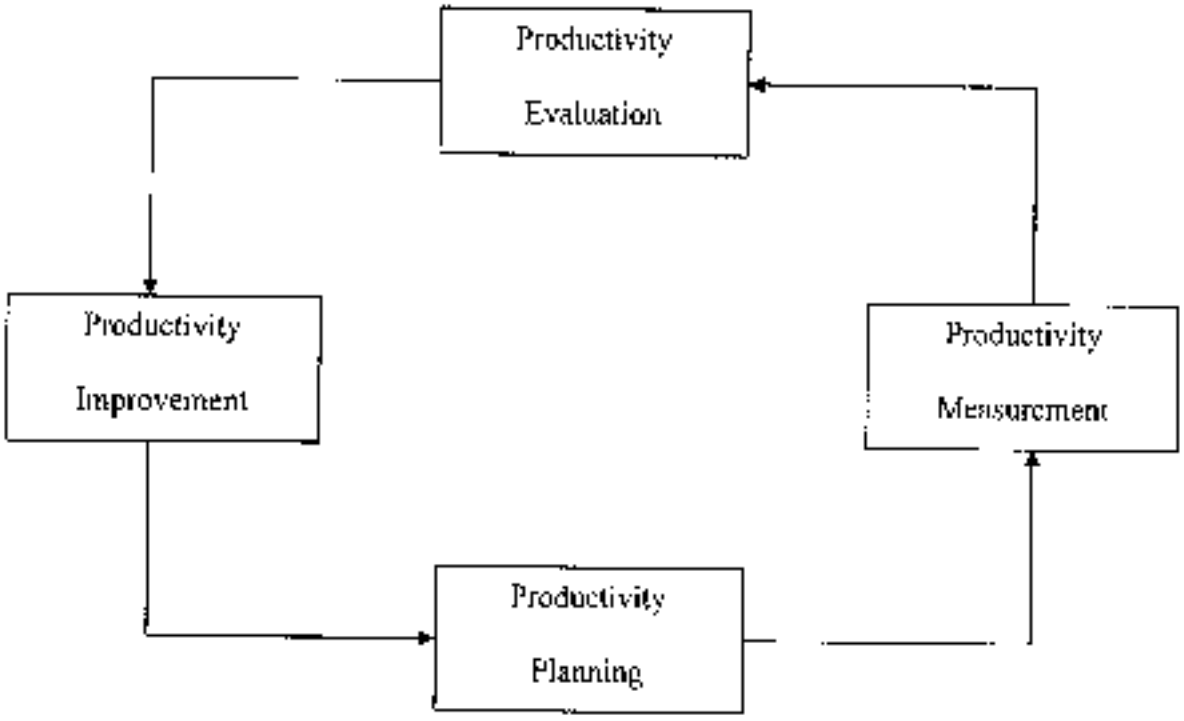

Figure.2.1. Productivity cycle (cited in Sisalem et al, 2000).

An organization that begins a formal productivity program for the first time can begin with productivity measurement. When productivity levels are measured, they have to be evaluated or compared against planned values. Based on this evaluation target, levels of productivity

are planned on short and long terms bases. To achieve the planned targets, productivity improvement will take place next period; productivity level must be measured again. This cycle thus continues for as long as the productivity program operates in the organization (Armstrong, 1988).

The productivity cycle concept shows us that productivity improvement must be preceded by measurement, evolution, and planning. All four phases are important not just productivity measurement or just productivity improvement. Also this cycle emphasizes the process nature of the productivity issue. A productivity program is not one time project but rather a continuous on going process.

2.7 Construction productivity

Construction productivity is central to the value of money obtained by construction client. The knowledge of productivity is essential part of the construction management The most application of accurate productivity measurement in the area of resource management. However productivity rates are related to many other subjects in the construction process such as cost estimating, activities scheduling, cost control, labor resources, and payroll (Herbsman et al, 1990). Therefore accurate determination of productivity is very important but productivity measurement in construction is a complex issue because of the interaction of labor, capital, materials, and equipment and varying effect of various site conditions on productivity rates of most standard construction items.

2.8 Factors affecting construction productivity

The factors that influence construction productivity have been the subject of inquiry by many researchers. In order to improve productivity, a study of the factors that affect it, whether positively or negatively is necessary. Making use of the factors that have a positive effect, and eliminating (or controlling) factors that have a negative effect will improve productivity.

If all factors influencing productivity are known, it would also be possible to forecast productivity (lema, 1995). Several researchers have investigated the factors that influence labor productivity. These include United Nations (1965), Kane et al (1980). Thomas, et al (1991), Yates et al (1993), Lim et al (1995), lema (1995), Olomolaiye et al (1996), Heizer et al (1996) , Olomolaiye et al (1998), Kaming. et al (1998), Teicholz (2001), Thomas et al (2001), Wachira. (2001), Rojas et al (2003). In spite of such intensive investigations, researchers have not agreed on a universal set of factors with significant influence on productivity nor has there been agreement on the classifications of these factors.

2.8.1 Classification of productivity factors

There have been several approaches to the classification of the factors affecting construction productivity can be identified. The following examples illustrate some of approaches to the classification of productivity factors.

A United Nations (1965) (cited in Lema, 1995) report stated that, in ordinary situations, there are two major factors affecting site labor-productivity requirements: organizational continuity and executional continuity. Organizational continuity encompasses physical components of work, specification requirements, design details, and so forth. Executional continuity relates to work environment and how well a job is organized and managed. Management aspects include weather, material and equipment availability, congestion, and out-of-sequence work. A conceptual representation of the findings of the UN report is shown in Figure 2.2.

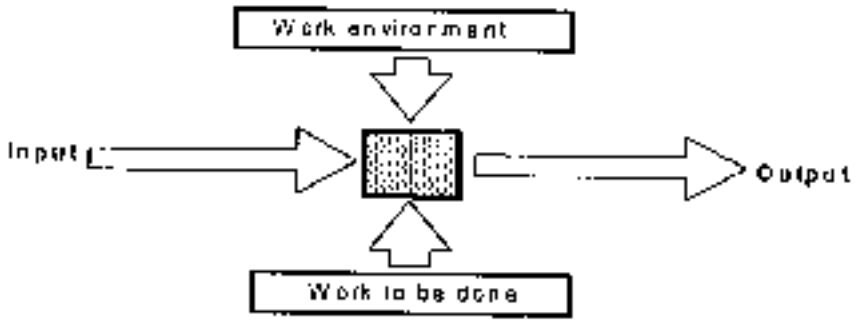

Figure 2.2. Conceptual representation of the findings of the UN report (cited in Lema, 1995).

The flow of inputs and outputs is comparable to a pipeline. The work to be done and work environment categories is analogous to catalysts in the form of resources and conditions needed to efficiently convert inputs (work-hours) to outputs (quantities). The model classifies factors into those related to work environment and those related to the work to be done. The model has been adopted and extended by Thomas et al, 1993 (cited in Thomas et al, 1995). The model has been referred to as the factor model and is shown in Figure 2.3.

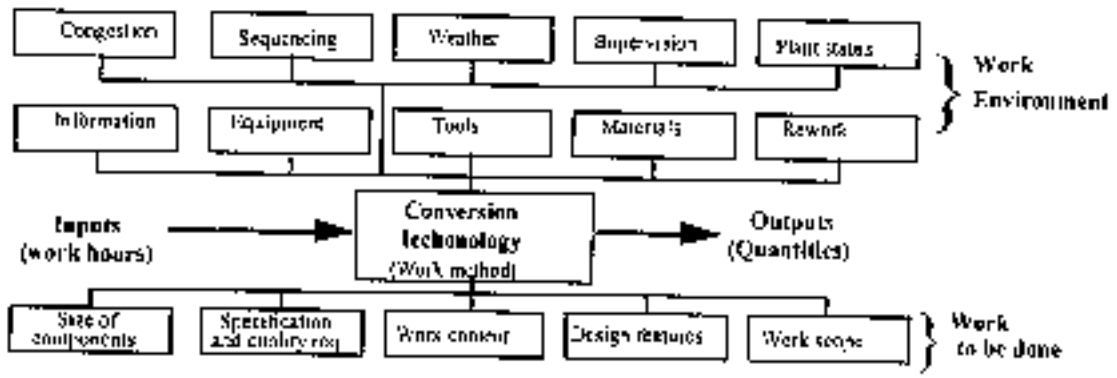

Figure 2.3. Factors model (Thomas et al, 1993, cited in Thomas et al, 1995)

There have been several approaches to the classifications of productivity. Kane et al (1980) (cited in Herbsman et al, 1990) classified factors affecting construction productivity into two main groups: technological factors and administrative factors. The technological factors encompassed those related mostly to the design of the project. The administrative factors are related to the management and to the construction of the project. The distinction between two groups explained from a different perspective. If the influence factors can be determined in the preconstruction stage it is likely that it will be from the first group (Technological factors). However if the value of the influence factors can not be determined in the preconstruction stage it is likely that it will be from the second group (Administrative factors). Technological factors have subgroups such as design factors, materials factors, and location factors. Administrative factors group have subgroups such as construction methods and procedures factors, equipment factors, labor factors, and social factors

On the other hand, Heizer et al (1996) classified factors influence site productivity into three groups: labor characteristics factors, project work conditions factors and non productive activities.

a) Labor characteristics divided into two factors (Heizer et al, 1996):

- Age and experience of workforce; and
- Leadership and motivation of workforce.

b) Project work conditions included among other factors (Heizer et al, 1996):

- Job size and complexity;
- Job site accessibility;
- Labor availability;
- Equipment utilization;
- Contractual agreements; and
- Local climate;
- Local cultural characteristics, particularly to foreign operations.

c) Non productive activities included (Heizer et al, 1996):

- Rework for correcting unsatisfactory work;
- Temporary work stoppage due to inclement weather or material shortage;
- Absentee time, including late start and early quits; and
- Strikes.

Olomolaiye et al (1998) stated that factors affecting construction productivity are rarely constant and may vary from country to country, from project to project, and even on the same project depending on the circumstances. Olomolaiye et al (1998) classified factors influencing construction productivity into two categories external and internal representing those outside the control of the firm's management and those originating within the firm respectively. External factors included Nature of the industry; Construction client knowledge

of construction procedure, weather, and level of economic development. Internal factors included management, technology, labor, and labor unions.

2.8.2 Factors affecting construction productivity

The diversity of methodologies of quantification or evaluation of the factors makes it difficult to compare findings. The following examples illustrate the diversity of factors.

Thomas et al (1990) (cited in Lema, 1995) studied masonry productivity similarities in seven countries. Their study utilized the following productivity disruptive factors that were considered to be significant:

- Materials delay or suspension of work;
- Size and organization of materials storage area;
- Materials handling and distribution;
- Materials availability;
- Tools availability;
- Interference with other crews or congestion;
- Out of sequence work or prerequisite work;
- Rework or fabrication errors;
- Accidents;
- Equipment availability; and
- Supervision and staffing.

Productivity factors have been identified by Thomas et al (1991) in their study of masonry labor productivity comparison for various projects in seven countries. These included:

- Manpower and labor pool;
- Total quantity of a task;
- Design features;

- Environmental conditions and weather;
- Construction methods;
- Project organization;
- Project features;
- Management practices and control; and
- Daily diary.

Guhathakurta et al (1993) found that there is a 100 percent agreement on the five most delay causing factors between the US and Nigeria. The factors affecting productivity was

a) Lack of material

The reasons given for this problem in US were (Borcherding et al, 1980, cited in Guhathakurta et al, 1993):

- Lack of crane or trucks or both in transport materials;
- Too few laborers to retrieve orders from the warehouse;
- Excessive paper work necessary for requesting;
- Nonexistence of certain items at the site;
- Receival of improper materials upon delivery to the work area, and
- Lack of proper planning by supervisors.

The reasons given for this problem in Nigeria were (Olomolaiye et al, 1987, cited in Guhathakurta et al, 1993):

- Cash flow problems experienced by contractors;
- Lack of proper planning; and
- Site transporting difficulties.

b) Lack of proper tools

The major's causes for this problem in both US and Nigeria were (Borcherding et al, 1980, Olomolaiye et al, 1987, cited in Guhathakurta et al, 1993):

- Poor quality tools;
- Improper maintenance; and
- Insufficient tools.

c) Repeat work

The major's causes for this problem in both US and Nigeria were (Yates et al, 1993):

- Change orders;
- Poor quality of engineering drawings; and
- Poor instructions as results of misinterpretation of drawings and instructions.

d) Inspection delays

A considerable number of artisans both in the US and Nigeria blamed supervisors incompetence and inspection delay as contributing to low productivity.

Lim et al (1995) conducted a survey of top civil engineering and building contractors in Singapore to identify the problems that could affect construction productivity. They found that the most important issues affecting productivity are:

- Difficulty in the recruitment of supervisors;
- Difficulty in the recruitment of workers;
- A high rate of labor turn over;
- Absenteeism at work site; and
- Communication problems with foreign workers.

Lema (1995) studied factors affecting labor productivity in Tanzanian building construction. The investigation demonstrated that Key productivity factors affecting productivity are:

- Financial incentives;
- Wages;
- Other non-financial incentives;
- Level of skill;

- Level of mechanization; and
- Quality of leadership on site.

Andersson et al (1996) reported that the common reasons for low productivity in construction sites are:

- Supervisors looking after too many;
- Dissatisfied workers with a perceived grievance (for example low pay);
- Very heavy work on a hot day;
- Waiting for materials;
- Waiting for tools;
- Waiting for instruction;
- Machine breakdown;
- Waiting for another worker to finish so they can follow on (poor site layout);
- Working in a confined space and getting in each others way; and
- Working gangs are out of balance (e.g. too many laborers to one mason);

Olomolaiye et al (1996) investigated the problems influencing craftsmen's productivity on 27 large construction sites in Indonesia. Findings showed that problems affecting craftsmen productivity in Indonesia are:

a) Lack of material

The causes of this problem were (Olomolaiye et al, 1996):

- On site transportation difficulties;
- Excessive paper works for request ;
- Improper material shortage; and
- Inadequate planning.

b) Rework

The causes of this problem were (Olomolaiye et al, 1996):

- Design change; and
- Poor instruction.

c) Absenteeism

The causes for quitting the job were (Olomolaiye et al, 1996):

- No enough work site;
- Better pay from other projects; and
- Better working environment on other site.

d) Interference

Interference between gangs and workers was caused by (Olomolaiye et al, 1996):

- Mismanagement of the work sequence; and
- Unbalanced gang sizes.

Olomolaiye et al (1996) also compared productivity problems in Indonesia with other countries obtained from literature. The comparison is presented in table 2.2

Table 2.2. Productivity problems rank (Olomolaiye et al. 1996)

Productivity problems	Indonesia Rank	Nigeria Rank	UK Rank	USA Rank
Lack of material	1st	1st	1st	1st
Lack of tools	5th	3rd	5th	2nd
Interference	3rd	6th	2nd	5th
Absenteeism	4th	5th	6th	6th
Supervision delays	6th	4th	4th	4th
Rework	2nd	2nd	3rd	3rd

From existing literature on the construction industries of developing countries Kaming et al (1998) identified eleven productivity influencing factors. These factors were:

- Lack of materials;
- Lack of proper tools;
- Equipment break down;
- Rework;

- Change crew members;
- Workers interference;
- Workers absenteeism;
- Supervision delay;
- Overcrowding;
- Changing Forman; and
- Working overtime.

ASIST information services (1998) reported that labor productivity might be affected by many factors which are fortunately under the control of the project management. These factors were:

- Experience of the workforce;
- Motivation;
- Organization of the work;
- Type and condition of tools and equipment, and
- Continual monitoring of performance.

Enchassi et al (2000) studied the relationship between the effectiveness of construction manager style and workforce productivity in Palestine and United State of America. The results of study showed that there is a significant positive relation between the effectiveness of construction managers and the level of workforce productivity.

Teicholz (2001) mentioned that possible causes of declining of labor productivity in US construction sector from 1970 to 1998 include:

- Inadequate training of workers;
- Fewer younger workers entering the workforce;
- Increased complexity of projects;
- More safety procedure;
- Greater time pressure on project completion; and

- Greater fragmentation of the work process.

Thomas et al (2001) studied the effect of workforce management quality on labor productivity of concrete formwork in four highway bridge construction projects. The results of study indicated that inefficient workforce management accounts for an average of almost 65% of the total inefficient work hours in these projects. The workforce errors observed in these projects were:

- Overstaffing;
- Interference with other crews; and
- No alternative work assigned.

Wachira (2001) listed the following factors that influence labor productivity of construction sector in Kenya:

- Unfair wages;
- Recruitment of unskilled personnel;
- Poor communication;
- Late deliveries of materials and equipment;
- Poor welfare facilities,
- Lack of motivation;
- Lack of training; and
- Lack of investment in research and development.

Rojas et al (2003) studied many factors which affects labor productivity in construction sector in United State of America. The results of study indicated that management systems and strategies and manpower issues were the two areas with greatest potential to affect labor productivity.

a) Important management systems and strategies issues were (Rojas et al, 2003):

- Management skills;
- Work scheduling; and

- Materials & Equipment management.

c) Important manpower issues were (Rojas et al, 2003):

- Labor experience;
- Activity training;
- Education; and
- Motivation.

2.8.3 Summary of factors affecting labor productivity

It is clear from the above that factors affecting construction productivity are both numerous and diverse. It is nevertheless not exhaustive. It would be unreasonable to assume that it is possible to quantify the effect of each on productivity in a predictable manner since what may be significant in one environment, may be insignificant in another situation. Nevertheless, the literature provides a pool of factors that may be considered for productivity studies. The following is a summary of factors that have been identified in literature

- Lack of materials in local market;
- Worker absenteeism at work site;
- Using motivation system;
- Lack of tools;
- Delays in materials deliveries to working site;
- Labor skill;
- Area of work site;
- Gang size;
- Disruption of power/ water supplies;
- Rework;
- Interference;

- Supervisors absenteeism;
- Climate conditions;
- Accidents;
- Management practices;
- Labor age;
- Safety; and
- Job size and complexity.

2.9 Productivity measurement

Productivity measurement at project and crew levels has both immediate and long-term objectives. Schedule control, cost control, target setting, and motivating the workforce are some of the short term objectives. Employees need productivity data as a feedback on their performance and may be used for pay bargaining. The same actions will lead to the provision of a performance database for planning and evaluating performance at this level. Performance at this level provides management with information that can influence their strategic actions (Iema, 1995).

There are two different techniques of generating labor productivity standards, accountancy-based and engineering-based method. Accountancy based standards rely on the analysis of historical accounting data to establish work hour requirements for specific type of work whilst Engineering-based standards involve breaking down complex work processes into small manageable parts and analyzing these parts for the length of time required to complete these processes (Gilleard, 1992). There are four productivity measurement methods often used for measuring labor productivity in construction projects. These methods are time study, activity sampling, craftsman questionnaire, and forman delay survey.

2.9.1 Time study

Time study was the fundamental approach to productivity improvement introduced by Taylor and Gilbreth in the late 19th and early 20th centuries, and it is the principle technique of work measurement even today (Olomolaiye et al, 1998) . Time study is used to determine the time required by a qualified and well-trained persons working at normal pace to do a specified task (Barnes, 1980). Time study therefore involves (Pilcher, 1997 ; Olomolaiye et al, 1998):

- Familiarization with the work to be studied;
- Timing to discover how long various operations are taking;
- Rating to assess the worker being observed against a norm;
- Building up of time standards by allowing for appropriate relaxation and contingency allowances.

Time study provides an analytical basis for budgeting and controlling human resource costs. It can be an important aid to increase productivity by providing standards against which performance can be planned, monitored and improved ((Armstrong, 1990).

2.9.1.1 Time study equipment

The equipment required to measure and record output information consists of a stop watch, study board and pre-prepared time study sheets, supplemented by a hand calculator, tape measure, micrometer, etc. depending upon the type of work (Harris et al, 1995). The stop watch may take several forms. The simplest type, with one hand is not recommended since it can accumulate an appreciable error if the watch is stopped and read at the end of each cycle element (Olomolaiye et al, 1998). The popular type has a large hand which completes one minute per revolution and is graduated in hundredths of a minute while the small hand records cumulative time up to 30 minutes in one minute graduations. A fly back mechanism on the large hand allows the timing of elements to start at zero for each element without affecting the elapsed time shown on the small hand (Harris et al, 1995).

2.9.1.2 Rating

Because the objective of the time study is to obtain a realistic time for the element, the time study observer must additionally make a judgment on the effective rate of working of the subject under observation since the elapsed time observed for one worker my be different from another doing an identical task (Harris et al, 1995). British Standard (BS) 3138 defines rating (cited in Olomolaiye et al, 1998) as "to assess the workers rate of working relative to the observer's concept of the rate corresponding to standard rating". Thus in addition to timing the observer should also assess the rate of working for each time element. To do this accurately the time study practitioner must have correct concept of standard rating, which comes only from practical experience and training in judging different speeds of movement, effort, consistency, and dexterity (Olomolaiye et al, 1998). The B.S. divided rating scale in 4 point graduations (Cited in Harris et al, 1995) as follows;

125: Very quick; high skill; highly motivated

100: Brisk; qualified skill; motivated.

75: Not fast; average skill; disinterested.

50: Very slow; unskilled; unmotivated.

There are different Factors affecting the rating. These factors can be summarized as follows (Olomolaiye et al, 1998):

- Effectiveness. This implies application of correct and effective methods, the good signs being correct choice of tools, shortest path of movement, adherence to the best method, avoidance of unnecessary activities, tidiness and systematic arrangement of tools and materials;
- Skill. Sureness of touch or sequence, intelligent application of movements and events, effective use of both hands and so on; and

- Speed. This implies diligence, steadiness and continuity; the good signs being rhythm, speed of movement, steady effort, making the job look easy.

2.9.1.3 Basic time

Basic time is the time in which an element would be completed if it had been undertaken at a standard rating. It can be calculated as follow (Pilcher, 1997):

$$\text{The basic or normal time for a job} = \frac{\text{Observed time} * \text{Observed rating}}{\text{Standard rating}}$$

2.9.1.4 Relaxation allowances

During a time study it is usual to exclude any elements of relaxation so that the basic time is not affected by the degree of relaxation enjoyed by any individual worker. Relaxation allowance consists of two components (Pilcher, 1997). One is an allowance for the personal needs of worker such as an occasional stretch, a visit to the toilet, and having a drink of water; the other is an allowance for fatigue. Both allowances are normally made by adding a percentage to the basic time. Allowance for the personal needs of worker can be assessed with a reasonable degree of accuracy but allowance for fatigue is very difficult to assess but many companies and industries make their own recommendations (Olomolaiye et al, 1998).

2.9.1.5 Contingency allowance

In addition to relaxation allowances a further amount is added to the basic time to cover contingencies. The following contingencies are typical and can either be added as a percentage to the basic time or as absolute time itself (Harris et al, 1995):

1. Adjustment and maintenance of tools;
2. Waiting time caused by subcontractors, machine breakdowns, lack of materials, etc;
3. Unexpected site conditions, e.g. bad ground, high winds, and bad weather;
4. Learning time;

5. One-off tasks; and

6. Design changes.

2.9.1.6 Standard time

Standard time is the proper time required for a qualified worker working at standard rating to complete a task. If this is achieved then the worker is considered to have achieved standard performance (Olomolaiye et al, 1998). BS 3138 defines standard performance as follows (Olomolaiye, 1998 - Harris, 1995): "The rate of output which qualified workers will naturally achieve without over exertion as an average over the working day or shift provided they are motivated to apply themselves to their work".

Thus standard time = basic time + relaxation allowances + contingency allowance

Because construction work is so variable the difference between standard time and basic time for a job can be quite large and as a consequence, most records or data banks of out times are kept as basic times, with the user applying suitable contingencies as necessary (Harris et al, 1995).

2.9.1.7 Number of observations

The correct sample size is difficult to determine accurately but the simplest method is to plot the cumulative average basic time, preferably for a short cycle element against the number of observations. When the line begins to stabilize, sufficient number of observations has probably been taken (Olomolaiye et al, 1998).

2.9.1.8 Time study procedure

Time study procedure can be summarized as follows (Barnes, 1980):

1. Determine the objective of the study and select the operation to be observed;

2. Divide the operation into elements;

3. Select the time study method and equipment to be used;

4. Make a sketch of the piece and of the work place;
5. Secure the cooperation of the workers to be observed and their Forman; and
6. Record as much detail about work as possible.

When the study is completed. check to make certain that sufficient number of observations have been taken.

2.9.1.9 Limitation of time studies

The main difficulty in using time study techniques for labor productivity studies in developing countries is the lack of work-study experiences not only in construction but also in manufacturing (Lema, 1995). Other difficulties in using time study techniques can be summarized as follows (Olomolaiye et al, 1998):

- The number of workers studied by one observer is limited which requires employment of several observers making manual study prohibitively expensive;
- The information obtained by time studies is limited to the times recorded and facts that can be interpreted from the observers notes which may not cover sufficient details such as interdependencies among components, exact reasons for taking longer or shorter elemental times. These will increase the variability and reduce accuracy; and
- The data cannot be assembled quickly especially in civil engineering where the variables on site complicate the interpretation of information as the relaxation and contingency allowances needed often considerably exceed the required basic time.

2.9.2. Activity sampling

Activity sampling is a technique through which information can be obtained not only quickly and economically but also to predetermine levels of accuracy (Olomolaiye et al, 1998). It is a method that measures the time labor spent in various categories of activities (Thomas et al, 1991). Activity sampling is also known as (Lema, 1995):

- Ratio survey;
- Observation ratio;
- Snap reading method;
- Random observation method; and
- Work sampling.

Activity sampling can be defined as a technique in which a large number of instantaneous observations are made over a period of time of workers, machines, or processes. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity or delay is a measure of the percentage of time during which that activity or delay occurs (Thomas et al, 1986). Activity sampling study provides the necessary information to help determine how time is being employed by the workforce, identify the problem area that cause the work delay, and set up a base line measure for productivity improvement (Thomas et al, 1986) The main advantage of using activity sampling is that it allows a larger number of machines or men to be studied at one time that can be managed using a continuous time study. This leads to a broader picture of the efficiency of a particular operation than that obtained from a more concentrated but continuous study on a smaller group (Pilcher, 1997).

There are general rules for activity sampling should be observed in sampling construction such as (Oglesby et al, 2002):

a) The observer must be able quickly to identify the individuals to be included in and excluded from the sampling;
b) There should be an equal likelihood of observing every worker;
c) Observation must have no sequential relationship;
d) The basic characteristics of the work situation must remain the same while the observations are being made.

2.9.2.1 Activity sampling theory

Activity sampling concepts based on two facts, first fact is a working day can be subdivided into three major parts: productive, contributory, and unproductive time (Oglesby et al, 2002);

Productive time: time spent in elements directly involved in the actual process of putting together or adding to a unit being constructed;

Contributory time: time spent in elements not directly added to but essential to finish the unit;

Unproductive time: idle time or time spent in not useful or all other elements.

Second fact on which activity sampling based is small number of chance occurrences tends to form the same distribution pattern as the whole operation. Thus it is a mathematical technique closely associated with statistics and the theory of probability (Olomolaiye et al. 1998). Activity sampling being based on a sample of observations must adhere to certain statistical principles and rules to obtain a proper representation of the studied operation. Any sampling carried out should be large enough to be statistically valid – can be used to predict the characteristics of studied operation with a desirable degree of accuracy.

The following formula can be used to calculate the required sample size and achieve the specified confidence level and accuracy criteria (Currie, 1987 - Harris et al, 1995 – Lema, 1995 - Pilcher, 1997 - Olomolaiye et al, 1998).

$$N = \frac{Z^2 \times P \times (1 - P)}{L^2} \qquad (6)$$

Where:

N = number of observations required;

P = proportion of the total operation being observed;

L = limit (in percentage) of accuracy required; and

Z = standard normal variable depending on the level of confidence.

In construction work, it is generally accepted that 95 percent confidence limits with limit of error of 15 percent give satisfactory results that can assist in making a real contribution to increase effectiveness (Lema, 1995 - Pilcher, 1997 - Olomolaiye et al, 1998). Also The value of proportion of the total operation being observed, for construction work usually falls within the limits of 0.40 to 0.6 (Lema, 1995 - Pilcher, 1997 - Olomolaiye et al). For construction work, 384 observations are normally accepted as a minimum satisfactory number of observations which allow statistically significant results to be obtained (Pilcher, 1997 - Oglesby et al, 2002).

In practice, other time classifications may be of interest in an activity sampling study. An example of how the construction working day could be broken down along with illustrating some of the classifications is shown in Figure 2.4 (Olomolaiye, 1988, cited in Lema, 1995).

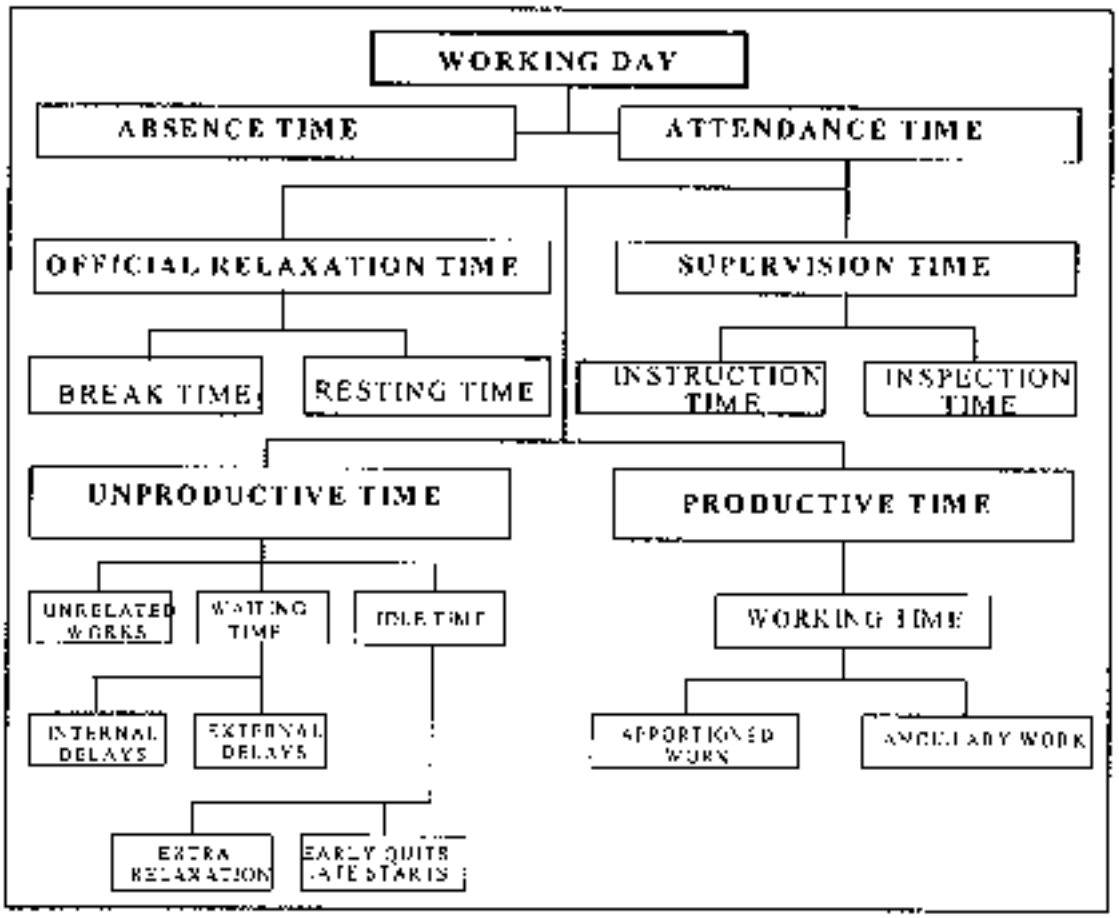

Figure 2.4. Classification of construction working day (Olomolaiye, 1988, cited in Lema, 1995)

2.9.2.2 Activity sampling procedure

Activity sampling procedure can be summarized as follows (Lema, 1995 – Harris et al, 1995):

1) Determine the objective of the study and select the activity to be observed;
2) In terms of chosen confidence level and accuracy range, determine N (the number of observations needed);
3) Identify the workers by name and list the operations and tasks to be studied;
4) Prepare a suitable observation sheet for recording the information;
5) Prepare a planned time table of observation times;
6) Choose a suitable position for taking the observations;
7) Record each activity that is in operation at the instant it is observed together with the worker involved; and
8) Summarize and analyze the results.

2.9.2.3 Activity sampling as a work measurement tool - the dilemma

Strictly, activity sampling is not a labor productivity measurement technique, but a labor activity measurement technique as suggested in the definition. Oglesby et al (2002) stated that activity sampling is a technique for quantifying the time spent by construction or maintenance labor in certain predetermined categories and provides valuable information on areas of low activity and the objective of establishing the level of activity is to enable identification of opportunities for increasing productivity through better utilization of time but activity rate is not synonymous with productivity and a person who looks busy may not necessarily be productive. When activity sampling is used to quantify output, it is a productivity measurement tool.

Several studies have been performed on the basic assumption that a decrease in unproductive time in the construction process has an influence on productivity (Thomas et al, 1982;

Thomas et al, 1984 - Liou et al, 1986 - Price 1986). Some models suggested that by using labor activity rate, labor productivity predictions could be made through work sampling (Handa et al 1989 - Liou, 1984 and Liou et al 1986). This relationship seems logical although arguments against it have been pointed out in recent studies (Thomas 1991). Thomas (1991) examined data from 159 work-sampling studies from more than 30 nuclear power plants constructed between 1973 and 1985 in USA. These studies were conducted in the form of general site wide tours. Direct work was established on the basis of these tours. The study concluded that there was a very weak correlation between direct work and labor productivity. This can be taken to imply that:

1. Productivity cannot be predicted by activity rate; and
2. Improved labor utilization, through better productive time, would not necessarily result in increased productivity.

These two arguments, first advanced by Thomas (1991) and later adopted by various other researchers have probably diminished the value of activity sampling as a work measurement tool in construction. A careful examination of work done by Thomas (1991) revealed that methodology used in this work is illogical because the productivity definitions adopted were unconventional. Productivity was expressed in form of a performance factor (PF) defined as the ratio between the estimated and the actual unit rate (work hours per unit). In other words, estimated output in work hours per unit was divided by achieved output to obtain productivity. Firstly, uniformity in the estimated output across all the thirty projects has to be ensured because two similar outputs from different projects could result in two different performance factors depending on the estimate. For example, an actual output of say one hour per unit will result in a performance factor of 120 percent and 80 percent for an estimated output of 1.2 hours per unit and 0.8 hour per unit respectively. It is unlikely that all

the thirty projects had the same estimate given that they were constructed over a period of 13 years and most likely by different contractors.

Horner (1992) (cited in Lema, 1995) argued that because activity sampling represents a snapshot of the work process, it fails to distinguish between unproductive time arising out of long and short delays. He asserted that productivity was adversely affected by interruptions longer than 15 minutes, while interruptions shorter than 15 minutes have no such effect. He concluded that the percentage of time spent at work determined from activity sampling studies couldn't therefore be used as a surrogate for productivity. Despite the dilemma, activity sampling is still a powerful tool in establishing labor utilization on sites when the scope of work is narrowly defined.

2.9.3 Craftsman questionnaire

Craftsman questionnaire (CQ) used to investigate the problems that adversely affect workers productivity and motivation. The questionnaire usually requires craftsmen to estimate loss of time due to various causes, ranking the severity of the problems and provide potential solutions to productivity problems (Olomolaiye et al, 1998). The questions that are usually asked in this questionnaire are specific for each job site and each craft. The areas that might be covered in this questionnaire are (Oglesby et al, 2002):

- Craft area, type of work;
- Materials: availability, suitability, and conditions;
- Tool: availability, and conditions;
- Equipment: availability, and conditions;
- Rework: amount, and why necessary;
- Crew interferences: with what craft and reason;
- Causes of Overcrowded work areas;
- Availability of instructions and other information; what is missing and why;

- Inspection: reasonableness and whether or not done at proper time; and
- Hours per week lost from each of the above causes, by category

The questionnaire can be simple requiring only 15 minutes of an employee's time or longer and in depth, which takes 45 minutes or more (Oglesby et al, 2002). Careful planning, organizing, and implementation of questionnaire are required. Furthermore information gathered should be effectively analyzed (Olomolaiye et al, 1998).

Another approach to CQ has been called craftsman questionnaire sampling (CQS) whereby a sample of workers selected and interviewers question them about an activity in which they were engaged. These questions will cover the same topics as those of the CQ just described (Oglesby et al, 2002). The procedure of CQS is very similar to activity sampling; the CQS administrator tours the site and randomly selects workers and supervisors by sight. The selected workers are then asked whether they were engaged in productive or unproductive work at that time when they were chosen and the detailed causes of unproductive work by completing a simple questionnaire (Olomolaiye et al, 1998).

More accurate and revealing information about production problems gathered by CQ and CQS since information collected directly from the workers and not through the normal channels of communications, where information can be lost or manipulated for the benefit of either the sender or the receiver but CQ and CQS have disadvantages such as (Olomolaiye et al, 1998):

1. Delay time estimate in the CQ and CQS are usually requested as number of hours lost per week and hence are subject to under or over estimating, casting doubt on the validity of the estimates; and

2. It does not provide information about the efficiency of construction methods or the competence of the workforce.

2.9.4 Foreman delay surveys

Foreman delay survey (FDS) is one such method whereby production problems are exposed by foreman's through the identification of causes and quantification of delays in the daily routine of their workforce (Olomolaiye et al, 1998). The primary purpose of this technique is to highlight problems that are outside the responsibility and control of individual foreman (Oglesby et al, 2002). Figure 2.5 shows a typical FDS form for a single crew (Alfeld, 1988 - Oglesby et al, 2002).

Date: ---------- General Foreman: ----------

Number in crew: ---------- Foreman's name: ----------

Problems causing delay

Problems causing delay	Man hours lost				
	Numbers of hours	*	Numbers of workers	=	Labor hours
Changes / redo (design error or change)	-------	*	-------	=	-------
Changes / redo (prefabrication error)	-------	*	-------	=	-------
Changes / redo (field error or damage)	-------	*	-------	=	-------
Waiting for materials	-------	*	-------	=	-------
Waiting for tools	-------	*	-------	=	-------
Waiting for construction equipment	-------	*	-------	=	-------
construction equipment breakdown	-------	*	-------	=	-------
Waiting for information	-------	*	-------	=	-------
Waiting for other crews	-------	*	-------	=	-------
Waiting for fellow crew members	-------	*	-------	=	-------
Others: ----------	-------	*	-------	=	-------
----------	-------	*	-------	=	-------

Comments: ----------

Figure: 2.5. Forman's delay survey questionnaire (Alfeld, 1988 - Oglesby et al, 2002)

Depending on circumstance FDS can be conducted in several ways such as daily, with weekly reporting, daily for several weeks, or as needed (Oglesby et al, 2002). The results of FDS will show the major causes of work delay for each craft and the number of hours lost and by correlating the reported lost time with the causes of delays, project management can take action to resolve the problems and to eliminate the delays (Alfeld, 1988). The survey is widely used because it is simple and foreman can complete the form in a few minutes but the potential weakness of this technique is found in the survey reliance on gross estimates by foreman of how much time they actually lose and hence there is doubt on its validity (Alfeld, 1988).

CHAPTER 3

Methodology

3.1 Introduction

The preceding chapter described, in detail, the concept of productivity and argued that for full understanding of productivity, total productivity should be studied. However, construction industry research has not yet advanced sufficiently to be able to achieve this, and that partial productivity measures are generally used, the most common of which is labor productivity Furthermore, a detailed literature review was performed that culminated in identifying four productivity measurement methods and labor productivity factors.

In this chapter, a description of data collection procedure adopted for this research is described. A detailed methodology and tools used are described.

3.2 Research design

The term "research design" refers to the plan or organization of scientific investigation, designing or a research study involves the development of a plan or strategy that will guide the collection and analyses of data (Polit et al, 1999, cited in Madi, 2003). Research design is an action plan for getting from "here" to "there", where "here" may be defined as the initial set of questions to be answered, and "there" is some set of conclusion (answers) about the questions (Naoum, 1998). The research design is the logical sequence that connects the empirical data produced by research to the study's initial research questions and ultimately to its conclusions (yin, 1989, cited in El Sawalhi, 2002). One of the principal purposes of the design is to help avoid the situation in which the collected data does not address the initial research questions (Robson, 1993, cited in El Sawalhi, 2002). Site observations and structured questionnaire had been used in this research. Research sequence can be presented simply by the chart indicated in figure 3.1.

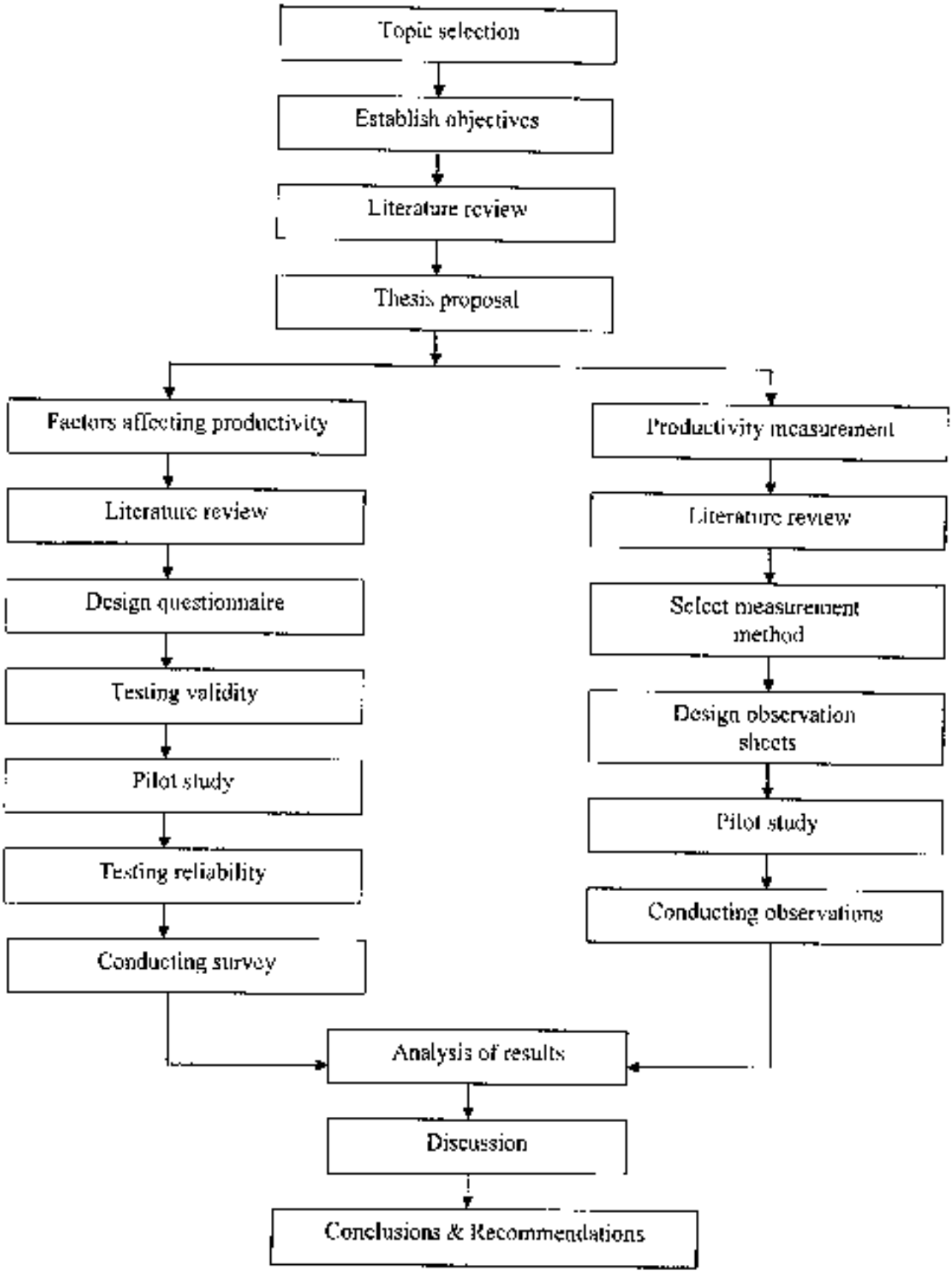

Figure 3.1: Flow chart of methodology

3.3 Research period

This research started on 1st of November 2002 when the initial proposal was approved. The literature review was completed on 20 March 2003. Observation method selection, observation sheets design, questionnaire building, validity testing and piloting completed on 1st of May 2003. The collection of data started on 1st of May 2003 and completed on 15th of July 2003. Preparing results, analysis, conclusions and recommendations were ready in November 2003.

3.4 Factors affecting productivity

A literature review of factors that affect labor productivity revealed a long list of factors as shown in Chapter 2. The list included the following factors (Kane et al (1980), Thomas et al (1991), Guhathakurta et al (1993), Lim et al (1995), Iema (1995), Olomolaiye et al (1996), Heizer et al (1996), Olomolaiye et al (1998), Kaming et al (1998), Teicholz (2001), Thomas et al (2001), Wachira (2001), Rojas et al (2003)):

1. Material shortages,
2. Tool shortages;
3. Crew motivation;
4. Labor skill;
5. Labor age;
6. Gang composition;
7. Workers relation;
8. Crew superintendent relation;
9. Labor absenteeism;
10. Job dissatisfaction;
11. Leadership characteristics;
12. Supervisors absenteeism;

13. Inspection delays;

14. Dispute with owner;

15. Acceleration of the work;

16. Rework;

17. Interference;

18. Extent of training;

19. Payment;

20. Overtime;

21. Working in confined space;

22. Methods of employment (direct work versus subcontracting);

23. Project feature;

24. Construction method;

25. Specification and design requirements;

26. Weather and environmental effects;

27. Safety;

28. Government regulations; and

29. Economics development.

These factors were related to studies performed in independent and stable countries and their applicability in the Gaza Strip environment could not be taken for granted. Indeed, some of the factors that may not be considered significant in these countries may have a profound influence on workers productivity in the Gaza Strip. Identification of the relevant factors in the Gaza Strip construction industry was therefore performed by asking ten building contractors to suggest factors which in their opinion affect labor productivity in the Gaza Strip construction industry.

3.4.1 Contractors' views

All of interviewed contractors were of the opinion that motivation and payment influence labor productivity. Seven interviewed contractors stated that material shortages, tool and equipment shortages, labor experiences, misunderstanding between Workers, misunderstanding between workers and superintendents, psychological status of worker, work surveillance, and overtime affect labor productivity. Five interviewed contractors believe that work planning, extent of training, safety, and weather affect labor productivity. Only two interviewed contractors agreed that labor age, gang size, worker loyalty, project feature, construction method, specification and design requirements, raw materials quality, quality of required work, evaluate problems facing works and resolve it, and height of working place affect labor productivity. The factors collected from literature and contractors formed the basis of questionnaire with the objective of rating the factors on the basis of the extent of influence on labor productivity.

3.4.2 Defining the factors affecting labor productivity in construction building projects in the Gaza Strip

A thorough literature review was conducted to identify factors which affect labor productivity as recognized by researchers and practitioners in this field. Combining this literature review with results of interviews of contractors sample, the factors negatively affect labor productivity were identified. They are categorized into 10 groups. Each group includes number of factors as shown in table 3.1.

Table.3.1. Factors negatively affecting labor productivity

No	Groups	Factors
1	Manpower issues	Increase of laborer age
		Lack of labor experiences
		Labor absenteeism
		Labor personal problems
		Labor dissatisfaction
		Labor disloyalty
		Misunderstanding among labor
		Lack of competition
2	Leadership issues	Misunderstanding between labor and superintendents
		Lack of labor surveillance
		Lack of periodic meeting with labor
3	Motivation issues	Lack of financial motivation system
		Lack of labor recognition programs
		Non-providing of transportation means
		Lack of place for eating and relaxation
		Payment delay
		Lack of training sessions
4	Time issues	Work overtime
		Working for 7 days of week without holiday
		Increasing No. of labor in order to accelerate work
		Misuse of time schedule
		Method of employment (using direct work system)

5	Materials / Tools issues	Material shortages
		Unsuitability of materials storage location
		Tool and equipment shortages
6	Supervision issues	Rework
		Supervisors absenteeism
		Inspection delay
		Drawings and specifications alteration during execution
7	Project issues	Type of activities in the project
		Construction method
		Interference
		Working in confined space
8	Safety issues	Violation of safety precautions
		Accidents
		Unemployment of safety officer in construction site
		Working at high places
		Bad ventilation
		Insufficient lighting
		Noise
9	Quality issues	Low quality of raw materials
		High quality of required work
		Inefficiency of equipment
10	External issues	Weather changes
		Augmentation of Government regulations related to the construction sector

3.4.3 Questionnaire design

According to the review of literature related to the concern subject and after interviewing sample of contractors. A well designed questionnaire was developed with mainly closed ended questions. The questionnaire was built from three sections that cover the main questions of the study. The first section is related to the company profile and it includes 7 questions about companies' name, year of establishment, degree of classification. number of permanent employees, number of executed projects during the last five years. and average value of executed projects per year during the last five years. Second section related to extent of importance of productivity topic in construction companies and it includes questions about productivity measurement, studying reasons of growth and decline of labor productivity, and availability of productivity development plans. Third section related to factors negatively affecting labor productivity. It includes 10 groups of factors such as manpower issues, leadership issues, motivation issues, time issues. materials / tools issues, supervision issues, project issues, safety issues, quality issues, and external issues. The original questionnaire was developed in English language English language questionnaire is attached in (Annex 1) Due to the researcher believes that questionnaire would be much effective and easier to be understood and to get more realistic results, the questionnaire was translated to the Arabic language and the Arabic language questionnaire is attached in (Annex 2) Unnecessary personal data, complex and duplicated questions were avoided. In each questionnaire, an explanatory letter was attached to explain the way of responding, the aim of the study and the security of the information.

A draft questionnaire was designed with the help of supervisor. This draft was discussed with a group of specialists. They advised some changes such as modifying the wording of some questions in section two and three. Some of them recommended adding questions in section three such as labor dissatisfaction and disloyalty. Some of them also recommended changing

the answer options in questions of section two from two options to five options. Other changes were also made after the pilot study to clarify confusion and ambiguity reported by the pilot study subjects.

3.4.4 Research population

The studied population includes contractors who have a valid registration by the Contractors Union in buildings specialization in the Gaza Strip. The total number of contractors who have valid registration under first, second and third category are 105 companies. The first class has 41 companies, the second class has 47 companies, and the third class has 17 companies.

3.4.5 Sample size

A systematic random sample to ensure a representative sample of all contractors was selected. Sample size calculated using formula 7 and formula 8 (Hogg et al, 1997 - Amer. 2002)

$$m = \frac{Z^2 \times P^* \times (1 - P^*)}{\varepsilon^2} \qquad (7)$$

$$n = \frac{m}{1 + \frac{m - 1}{N}} \qquad (8)$$

Where

m = sample size of unlimited population

n = sample size of limited population

Z = value (e.g. 1.96 for 95 % confidence level)

P* = Degree of variance between the elements of population (0.5)

ε = maximum error of the point estimate

$$m = \frac{(1.96)^2 \times 0.5 \times (1 - 0.5)}{(0.5)^2} = 384.16 = 385$$

$$n = \frac{385}{1 + \frac{385 - 1}{105}} = 82.67 = 83$$

To insure good representation of each stratum, the percentage of representation within strata was calculated as shown in table 3.2.

Table.3.2: Classification of sample size of the contracting companies

Class	No of Companies (buildings specialization)	% of the Whole population	No. needed from the sample size
First	41	39 %	33
Second	47	45%	37
Third	17	16 %	13

3.4.6 Sample method

The samples were selected randomly from each level of three contractor's categories. The contractor's union list is ordered by the company number, three lists of contractors were prepared to represent the first, second, and third categories. The randomly selection among three lists was done by the researcher using non-replacement random selection 33, 37, and 13 companies were selected from first, second, and third lists respectively to represent the total sample size.

3.4.7 Instrument validity

To establish quality of any research, the researcher must deal with the validity problem. The validity of an instrument is defined as "an integrated evaluative judgment of the degree to which empirical evidence and theoretical rational support the adequacy of inferences and actions based on test scores or other models of measurement" (Abu Kumboze, 2002, cited in Al-Ghuraiz, 2002). To improve validity, questions should be worded to increase the

likelihood that they will mean the same thing to each respondent. Also interviewing the respondents during the pilot studies enable to determine where questions were unclear or misleading (Noliske, 1995, Cited in El Sawalhi, 2002). Five experts in the field of the labor productivity were chosen to evaluate the study instrument. Each of them has full information about the research objectives, the scale of evaluation etc. The experts have been requested to rate the content relevance of each item using a 4 point rate. The adopted scale 1 = not relevant, 2 = not relevant unless major change, 3 = relevant after doing minor change, 4 = relevant (Abul kumbeize, 2002, Cited in El Sawalhi, 2002). The accepted item should take at least four points from five. Some items were added, modified, or deleted.

3.4.8 Pilot study

All questionnaires should initially be piloted; completed by a small sample of respondents (Fellows et al, 1997). The pilot study was conducted before the start of data collection to test response rate, size of effect, validity and suitability of questionnaire as well as areas of ambiguity. A pilot study provides a trial run for the questionnaire, which involves testing the wording of questions, identifying ambiguous questions, testing the techniques that used to collect data and measuring the effectiveness of standard invitation to respondents (Naoum, 1998). Six forms were distributed to sample of six contractors as a survey pretest. The chosen sample was invited to participate in the piloting so they received an explanation about the study and had been asked to complete the questionnaire. Some of them asked questions about the explanation of certain items. By the end, discussion with study sample about the meaning of questions took place to ensure the validity and reliability of questionnaire. The pretest shows the need to modify wording of some questions, and delete some irrelative questions. A number of phrasecology changes were made to make it more understandable. This pretest was useful to fit and cope precisely with the aim of the questionnaire.

3.4.9 Reliability analysis

Reliability concerns the consistency of a measure (Fellows et al, 1997). A question is reliable if it evokes consistent response (that is, a person would answer the questions the same way in the subsequent interviews). One cause of unreliable response is ambiguous wording of the questions (El Sawalhi, 2002). To compute the reliability of the questionnaire instrument, a random sample of five respondents was taken from population. These respondents were asked to fill the questionnaire in the beginning of May, 2003. and then they were asked to fill it again after two weeks. Reliability analysis was done by using test - retest analysis through SPSS program. The result shows that reliability of the instrument equals 0.89, which is acceptable for such instrument.

3.4.10 Measurement scales

The most popular scales are nominal scale and ordinal scale. Nominal scale is nominal numbering implies belonging to a classification. Ordinal scale is a ranking of a rating data that normally uses integers in ascending or descending order. The numbers assigned to the agreement scale (5, 4, 3, 2, 1) do not indicate that the interval between the scales are equal, nor they indicate absolute quantities (Naoum, 1998). They are merely numerical labels. This study used ordinal scale.

3.4.11 Data analysis

For analyzing data using ordinal scale, an importance index (I) was used. The importance index was computed using the following equation (Lim et al, 1995).

$$\text{Importance index} = \frac{5n5 + 4n4 + 3n3 + 2n2 + n1}{5(n1 + n2 + n3 + n4 + n5)} * 100 \qquad (9)$$

Where

n1 = number of respondents who answered "little effect"

n2 = number of respondents who answered "some effect"

n3= number of respondents who answered "average effect"

n4 = number of respondents who answered "high effect"

n5 = number of respondents who answered "very high effect"

The importance index (I) for all factors had been calculated. The indexes had been ranked. The group index had been calculated by taking the average of factors in each group.

3.5 Labor productivity measurement

The study aimed at collecting information on: average output per labor hour, labor productive time, labor contributory time, and labor unproductive time for block work operation. To achieve these objectives the following data collection procedure had been used.

3.5.1 Data Collection technique

The preceding chapter described in some detail four techniques of measuring labor productivity. These techniques are time study, activity sampling, craftsman questionnaire, and foreman questionnaire. The researcher decided to use activity sampling, because this technique has the following advantages (Lema, 1995):

1. Observation skills required in this technique are not as demanding as those required to accomplish similar objectives using other techniques such as time study;
2. It provides information on the extent of labor utilization on construction sites;
3. It is possible to identify in detail the sub-activities involved in the production process; and
4. It is possible to attach statistically quantifiable inferences to the results of the study.

3.5.2 Case study

Data collected from construction sites of Sheikh Zayed Township project through observations. Sheikh Zayed Township project includes construction of 70 five-storey buildings, twelve-storey building, mosque, school, shops, and two water reservoirs. It

includes also the construction of infrastructure works for the aforementioned Township. The project data reported in table 3.3.

Table 3.3. Sheikh Zayed Township project data

Project Name	Construction of Sheikh Zeyad Township
Funded by	Abu Dhabi Fund for Development
Consultant	DIWI Consult International
Main contractors	Consolidated Contractors Company
Subcontractor	Al-Zafer Group for Investment & Development
Beneficiary	Ministry of Housing
Budget	55345000 US Dollars
Duration	24 calendar months
Contract start date	1 / 2 /2001
Contract completion data	6 / 3 / 2003

There are 14 Block laying Gangs working in this project. A decision was made then to base initial studies in Sheikh Zayed Township project for a number of reasons:

- Sheikh Zayed Township project is the largest construction project in the Gaza Strip with a larger proportion of construction activities in comparison to any other location in the Gaza Strip;
- It was easier to obtain sites where productivity observation was conducted due to personal contacts;
- Amount of work is very large therefore there is continuity in construction activities;
- Data collection in one centre would facilitate comparison by limiting the number of variables.

3.5.3 Number of observations

Number of observations required to determine the proportions of productive, contributory and unproductive times of block work gang were calculated from following formula (Lema, 1995 - Harris et al, 1995 - Olomolaiye et al, 1998).

$$N = \frac{Z^2 \times P \times (1 - P)}{L^2} \qquad (6)$$

Where

N = sample size

Z= value obtained from statistical tables depending on the confidence level. This research used 95 % confidence level (Z = 2)

L = limit of accuracy which will be ± 5 %

P – percentage of activity observed

For maximum N, $\frac{dN}{dP} = \frac{Z^2}{L^2}(1 - 2P) = 0$

P = 0.5 (Lema, 1995)

Substituting P = 0.5, L = 0.05 and Z – 2 into the equation gives:

$$N = \frac{2^2 \times 0.5 \times (1 \quad 0.5)}{0.05^2} = 400$$

Thus if N = 400 is used, all possible proportions of P would meet the accuracy criteria. Further to activity sampling, quantification of skilled labor productivity per hour was recorded through actual physical measurement. The number of observations required for quantification of skilled labor productivity per hour is obtained by plotting the cumulative average productivity per hour against the number of observations. Observations stopped when the line stabilized (Olomolaiye et al, 1998).

3.5.4 Activity sampling procedure

The following procedure was adopted for conducting the field study to meet the research objectives:

1. Construction sites were visited and ongoing activities were identified in consultation with site staff;
2. Individuals to be included in the sample were identified ;
3. The block work operation was broken down into three groups of elements, namely productive, contributory, and unproductive activities (Oglesby et al, 2002);
   a) Productive elements: elements directly involved in the actual process of putting together or adding to a unit being constructed (Oglesby et al, 2002);
   b) Contributory elements: elements not directly adding to but essential to finishing the unit (Oglesby et al, 2002);
   c) Unproductive elements: not useful or idle or all other elements (Oglesby et al, 2002);

4. An appropriate study sheet with random observation intervals equal 5 minutes was designed (Currie, 1987 - Lema, 1995 - Harris et al, 1995 - Plicher, 1997 - Olomolaiye et al, 1998). A sample of the study sheet is presented in table 3.4, 3.5;

1. Before starting the actual observation, the following was ensured:
   - All persons involved in the activity were clearly identified and their specific roles were defined; and
   - Work completed prior to the start of the study was noted as accurately as possible. This enabled an accurate assessment of work accomplished during the observation interval;
2. Observations were made at pre-identified times. At any instantaneous observation, a record was made of the sub-activity being performed by each of the workers. A sample of observation record is included in table 3.4, 3.5;

7. An accurate physical measure of the work accomplished per hour was recorded;

8. Additional information such as labor age, labor experience, method of payment, general level of supervision, tools and equipment used, gang sizes, and general site conditions were recorded;

9. The data were summarized in a separate sheet at the end of each observation period. A sample summary sheet is presented in Table 3.6.

3.5.5. Pilot study

The main purpose of pilot study is to make sure that the identified activity elements are sufficient to record all the activities involved in the operation being studied, and modify it if necessary (Olomolaiye et al, 1998). Forty five observations had been carried for three block work gangs. The pilot study shows the need to modify and merge some other elements. The final classification of productive, contributory, and unproductive activities is shown in table 3. 7.

Table 3.4. Sample of activity sampling study sheet (Currie, 1987 - Lema, 1995 - Harris et al, 1995 - Plicher, 1997 - Olomolaiye et al, 1998)

ISLAMIC UNIVERSITY
Labor Productivity Measurement Research
Data Collection Sheet

1. Project Title. .....
2. Activity:..... 3. Location:.....
4. Day :..... 4. Time :.....
6. Skilled labor numbers :..... 5. Unskilled labor numbers :.....

No	Time	A	B	C	D	E	F	Notes
1	9:00							
2	9:05							
3	9:10							
4	9:15							
5	9:20							
6	9:25							
7	9:30							
8	9:35							
9	9:40							
10	9:45							
11	9:50							
13	9:55							
14	10:00							
15	10:05							
16	10:10							
17	10:15							
18	10:20							
19	10:25							
20	10:30							
21	10:35							
22	10.40							
23	10:45							
24	10:50							
25	10:55							

General Notes:

Productivity	8-9		9-10		10-11		11-12		12-13		13-14		14-15		15-16		16-17	
	Q	T	Q	T	Q	T	Q	T	Q	T	Q	T	Q	T	Q	T	Q	T
A																		
B																		
C																		

Table 3.5. Element codes and description

code	Description
A	Skilled laborer (1)
B	Skilled laborer (2)
C	Skilled laborer (3)
D	Unskilled laborer (1)
E	Unskilled laborer (2)
F	Unskilled laborer (3)
Q	Block quantity
T	Block type
Productive work	
1	
2	
3	
4	
Contributory work	
5	
6	
7	
8	
Unproductive work	
9	
10	

Table 3.6. Sample of activity sampling study summary sheet ((Lema, 1995 - Harris et al, 1995 - Plicher, 1997 - Olomolaiye et al, 1998)

ISLAMIC UNIVERSITY
Labor Productivity Measurement Research
Data Summary Sheet

1. Project Title: .....
2. Activity:..... 3. Location:.....,
4. Day :..... 4. Time :.....
5. Skilled labor numbers: ..... 6. Unskilled labor numbers: .....

Observation	Productive work				Contributory work				Unproductive work	
Activity	1	2	3	4	5	6	7	8	9	10
Number of observations										
Percentage of observations										

Productivity Computation:

Skilled labor productivity = volume of work done / hour

Table.3.7. Block work activities

activities	description
Productive activities	
Spreading mortar	Spreading mortar on the wall in preparation for laying blocks
Cutting blocks	Cutting blocks to required size
Laying blocks	Positioning and pressing the block on the course, and checking verticality and horizontality of blocks
Raking and pointing	Placing mortar into vertical gaps between blocks and Removing excess mortar
Contributory activities	
Making mortar	Mixing mortar and filling it in buckets
Ancillary work	Work relevant to block work such as fixing angles and setting scaffolding, Checking distances in line with drawings, taking instruction from supervisors.
Distributing blocks or mortar	Distribution of mortar and blocks to spots close to operators
Cleaning	Cleaning working site
Unproductive activities	
Idle	Not working
Rework	Removing and replacing already completed work due to operators fault or management fault

3.6 Productivity factors evaluation on construction sites

As shown above productivity studies were performed on Sheikh Zayed Township project focusing on block work only. Activity sampling, combined with the physical measurement of work performed, was used utilizing study forms (see Table 3.4 and 3.5). A systematic procedure for the evaluation of productivity factors was introduced. The personal interviews with skilled labor of block work gangs were used for filling the third section of questionnaire which includes factors negatively affecting labor productivity. It is a face to face interview, in which the interviewer asks the respondents questions and make a brief clarification for the ideas included in the questions. A personal interview approach was considered more practical for the skilled labor, because some of them may not have been able to read or write.

3.7 Study boundaries

Due to limited time available, limited resources such as educational materials, journals and books, and lack of logistic facilities, the study has the following limitations:

1. Research focus on studying productivity in the construction sector at the Gaza Strip only. Therefore, generalizability is reduced. To extend the generalizability of this study, future comparative research could perhaps focus on samples from other places in Palestine;
2. Research is concerned only with labor productivity without including total factor productivity and financial productivity;
3. Research is related with productivity measurement of block work only. Therefore, there is need for future research to focus on other activities in construction projects such as concrete work, tile work, painting work, Plastering work, … … etc;
4. The surveyed questionnaires also inherit another limitation related to the fact that it directs the participants to give opinions in regard to certain given statement. There could be other factors that affect labor productivity but not mentioned in the questionnaire and the respondents may have not the time to remember them.

CHAPTER 4

Results

4.1 Introduction

This chapter describes the results that have been obtained from field study using the Statistical Package for Social Science (SPSS) and Microsoft excel. Factors affecting labor productivity are illustrated in the first section. Productivity measurement of block work labor is illustrated in the second section.

4.2. Factors affecting labor productivity

In this section, the survey results are presented. First, the study's population characteristics are illustrated. Second, the ranking of the factors negatively affecting labor productivity are presented.

4.2.1. Study population characteristics

Figure 4.1 shows that 27 % only of contracting companies were established before the existence of Palestinian National Authority while 73 % of them were established after the existence of Palestinian National Authority.

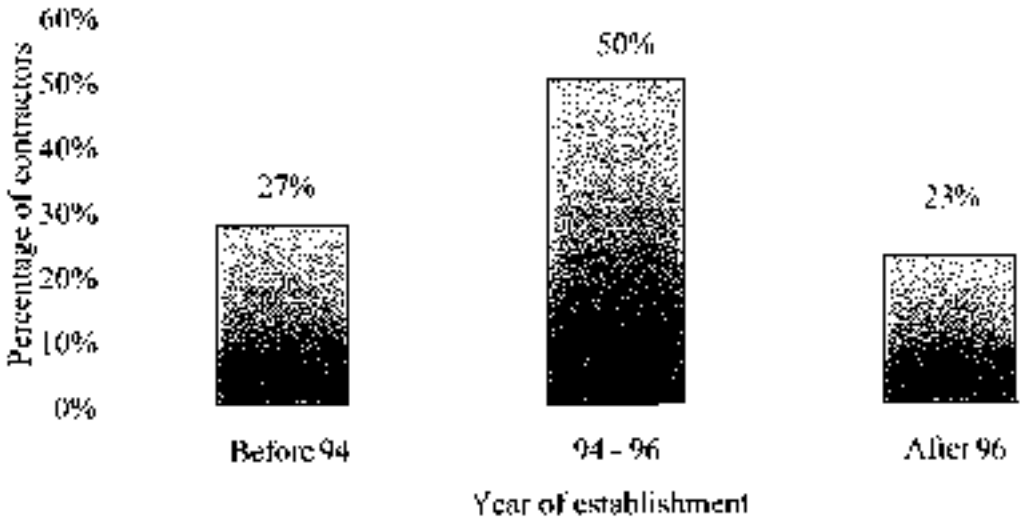

Figure 4.1. Establishment year of contracting companies

Figure 4.2 shows that more than half of the contracting companies have less than 10 permanent employees (58 %) whilst 36 % of contracting companies have from 11 - 30 permanent employees. 5 % of contracting companies have 31 - 50 permanent employees and only 1 % of contracting companies have more than 50 permanent employees.

Figure 4.2. Number of employees in contracting companies

Table 4.1 shows that 35.5 % of contracting companies executed less than 10 building projects during the last five years, and 33 % of contracting companies executed 11-20 building projects during the last five years while 10.5 % of contracting companies executed 21-30 building projects during the last five years, and 21 % of contracting companies executed more than 30 building projects during the last five years.

As shown in table 4.1, average value per year of executed projects during last 5 years in 20 % of contracting companies is less than 0.5 million US dollars whilst average value per year of executed projects during the last 5 years in approximately half of contracting companies (47%) is 0.51-2 million US dollars. Also average value per year of executed projects during the last 5 years in 33% of contracting companies is more than 2 million US dollars. The number and value of projects indicate that majority of executed projects are of small size.

Table 4.1. Distribution of number and value of projects

Variable		Contractors		
		Number	%	Total Number
Executed projects during last five years	≤ 10	27	35.5	76
	11 - 20	25	33	
	21 - 30	8	10.5	
	> 30	16	21	
Average value per year of projects executed during last 5 years (million $)	≤ 0.5	15	20	76
	0.51 - 1	17	22	
	1.1 - 2	19	25	
	> 2	25	33	

Regarding the classification of respondent contracting companies in buildings specialization, figure 4.3 illustrates that 42 % of the companies were classified as first class, 43.5 % of them were classified as second class, while only 14.5 % of them were classified as third class.

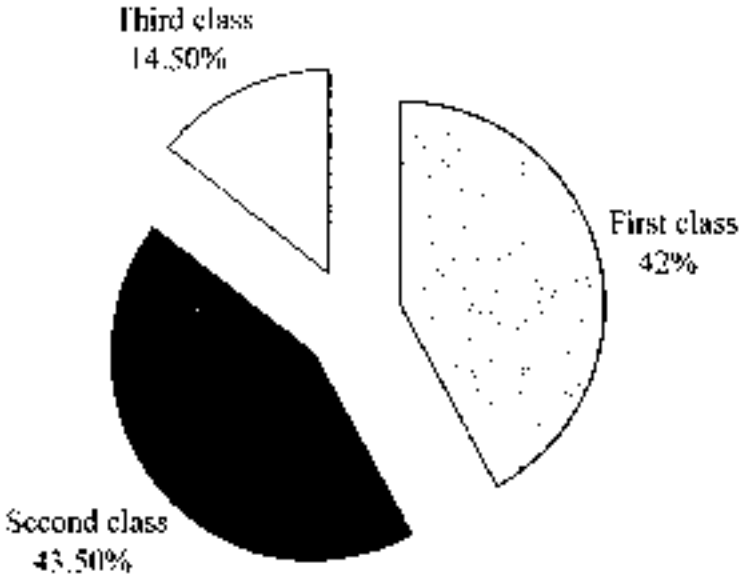

Figure 4.3. Classification of respondent contractors

Figure 4.4 shows that 46 % of respondents were company presidents, 33 % of respondents were projects managers, and 21 % of respondents were site engineers. The higher position of respondents gives more confidence in the quality of answers and also expresses the

respondent's high concern to deal seriously with this research.

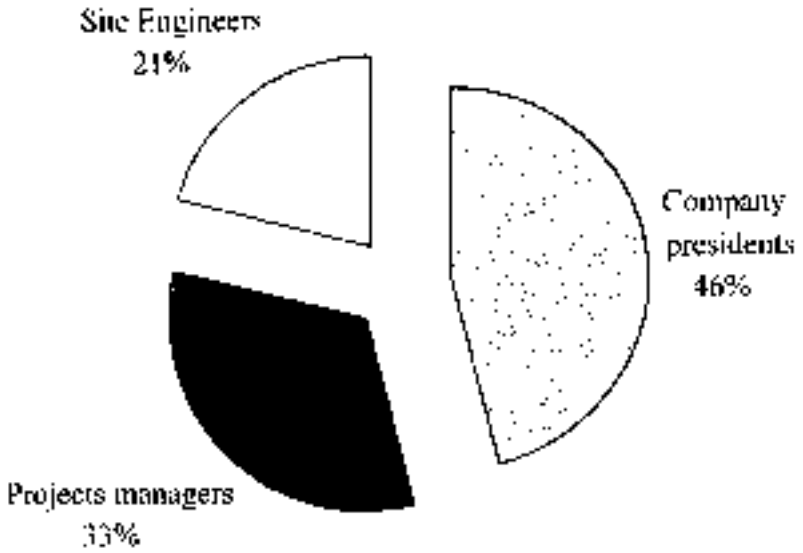

Figure 4.4 Distributions of respondent's occupation

4.2.2. Study degree of contractors concerned in the productivity

Figure 4.5 shows that approximately half of contracting companies (45%) always measure labor productivity in their projects, whilst 39% of contracting companies usually measure labor productivity in their projects. On the other hand, a small percentage of contracting companies never measure labor productivity in their projects (3%). This shows that measuring labor productivity is a very important topic in contracting companies. It should also be noted that the majority of contracting companies which do not measure labor productivity have no technical cadres capable of measuring labor productivity.

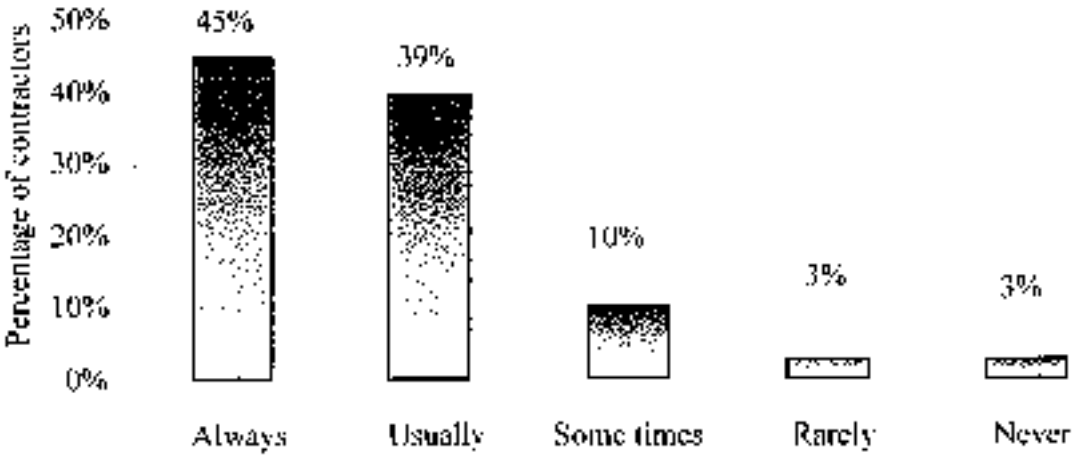

Figure 4.5 Degree of labor productivity measurement in contracting companies

From table 4.2. it is observed that more than half of contractors (59%) use "measuring required time for performing the work during implementation" as a tool for measuring labor productivity. whilst around one third of contractors (31%) use "analysis data recorded in daily reports to measure the number of hours needed to accomplish the work" as a tool for labor productivity measurement. Also it should be noted that small number of contractors (7%) use both methods for measuring labor productivity in their projects.

Table 4.2. Methods of measuring labou productivity in contracting companies

Method of productivity measurement	Number	Percentage
Analysis of data recorded in daily reports	24	31
Measuring required time during implementation	45	59
Use of both methods	5	7

Figure 4.6 indicates that site engineers measure labor productivity in more than half of contracting companies (58%), meanwhile foremen and projects managers measure labor productivity in one third of contracting companies' (34%). On the other hand, only 7 % of contracting companies hired specialist engineers for measuring labor productivity.

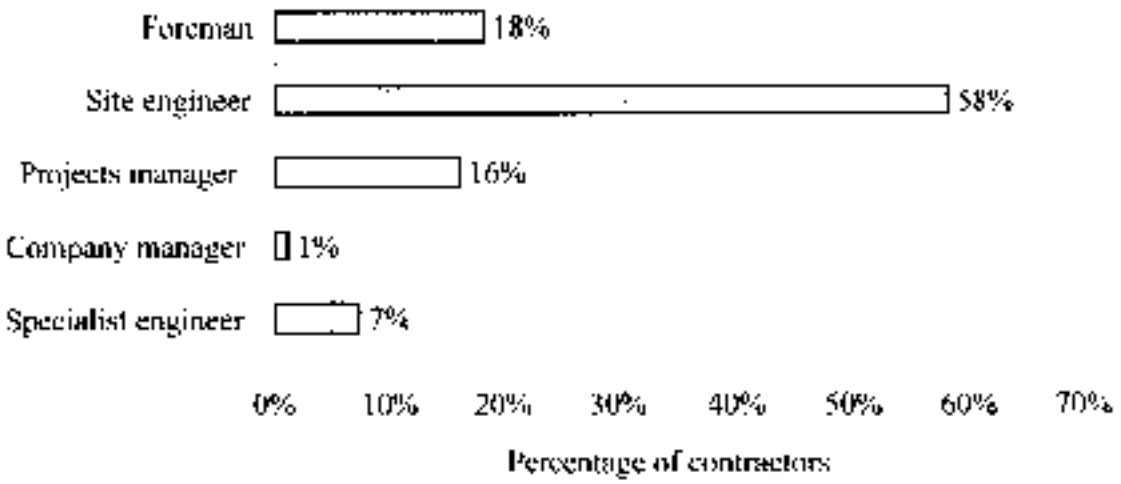

Figure 4.6. Distributions of administration title of officer who measure labor productivity

Table 4.3 indicates that around half of contracting companies (43%) always study reasons of decline and increase of labor productivity in their projects, and more than one-fourth of contracting companies (32%) usually study reasons of decline and increase of labor productivity in their projects. In addition to, 21 % of contracting companies sometimes study reasons of decline and increase of labor productivity in their projects. On the other hand, only 4 % of contracting companies do not care about studying reasons of decline and increase of productivity in their projects.

Table 4.3. Degree of studying reasons of decline and increase of productivity in contracting companies

Studying reasons of decline and increase of productivity	**Always**		**Usually**		**Some times**		**Rarely**		**Never**	
	No.	%	No.	%	No.	%	No.	%	No.	%
First class	14	44	12	37	6	19	0	0	0	0
Second class	14	42	8	24.5	8	24.5	2	6	1	3
Third class	5	46	4	36	2	18	0	0	0	0
Total	33	43	24	32	16	21	2	3	1	1

As shown in table 4.4, more than two - third of contracting companies (69 %) depend on monitoring work during implementation for studying reasons of decline and increase of productivity and 11 % of contracting companies interviewing company engineers and labor in the projects to study reasons of decline and increase of productivity. Also it should be noted that 16 % of contracting companies use both methods (interviewing engineers and labor and monitoring the work during implementation) for investigating the reasons of decline and increase of productivity in contracting companies.

Table 4.4. Tools of studying reasons of decline and increase of productivity in contracting companies

Tool	Number	%
Consulting specialist in the field of labor productivity	0	0
Making interviews with company engineers and labor in the projects	8	11
Distributing questionnaire to company engineers and labor and analyze it	2	3
Monitoring work during implementation	53	69
Making interviews with engineers and labor and monitoring the work during implementation	12	16

As shown in table 4.5, 13 % of contracting companies always have plans for developing productivity in their projects and 43 % of them often have plans for developing productivity in their projects. In addition, approximately one - fourth of these companies sometime have plans for developing productivity in their projects. On the other hand, a small number of contracting companies (8 %) rarely have plans for developing productivity in their projects and only 12% of contracting companies does not care about productivity development. 55 % of contracting companies which sometime have, rarely have or have no plans for developing labor productivity, stated that there is no need for such plans because of labor working in company is not permanent. Also 37% of them stated that most of activities in company

projects executed by subcontractors and only 8 % of them stated that company does not have technical cadres capable of applying such plans.

Table 4.5. Degree of availability of plans for developing labor productivity in contracting companies

Availability of plans for developing labor productivity	Always		Often		Some times		Rarely		Never	
	No.	%	No.	%	No.	%	No.	%	No.	%
First class	6	19	16	50	7	22	2	6	1	3
Second class	4	12	14	42.5	8	24.5	3	9	4	12
Third class	0	0	3	27.3	3	27.2	1	9	4	36.5
Total	10	13	33	43	18	24	6	8	9	12

As listed in table 4.6, more than one - fourth of contractors (28.5 %) depend on good planning and monitoring of work to improve labor productivity, meanwhile 18 % of contractors apply motivation system to improve labor productivity. In addition 13.5 % of contractors use time schedule techniques and 9 % of them enhance labor loyalty toward company to improve productivity. Also it is observed that approximately one third of contractors (31%) use two tools or more from tools no 1,2,4,5.

Table 4.6. Tools of productivity development plans in contracting companies

Tool No.	Tool	No.	%
1	Good planning and monitoring of work	19	28.5
2	Applying motivation system	12	18
3	Conducting training courses for labor	0	0
4	Using time schedule techniques	9	13.5
5	Enhancing labor loyalty toward company	6	9
6	Use of two or more from tools No. 1,2,4,5	21	31

4.2.3. Factors negatively affecting labor productivity

The questionnaire included 45 factors, which derived from both previous studies, and those factors related to local contracting companies in the Gaza Strip. The factors were distributed into ten groups.

4.2.3.1 Manpower factors

Results indicate that lack of labor experiences is the most important factor in the manpower group (Table 4.7). Also labor disloyalty is rated second while labor dissatisfaction rated third in this group. On the other hand, labor absenteeism and labor personal problems are lowest factors negatively affecting labor productivity in this group. Testing correlation for agreement on important indexes of manpower factors between first class, second class, and third class revealed that there is very high correlation between first class and second class (rho = 0.952). Also there is high correlation between first class and third class (rho = 0.815) and there is high correlation between second class and third class (rho = 0.861). T-test indicated that the correlation is significant at the 0.01 level. Therefore, it can be concluded with 99 % confidence that there is an association between the important indexes of first class, second class, and third class contractors.

Table 4.7. Ranking manpower factors

Group	Factors	Imp. Index	Rank
Manpower factors	Increase of laborer age	62.63	6
	Lack of labor experiences	84.21	1
	Labor absenteeism	55.00	7
	Labor personal problems	54.74	8
	Labor dissatisfaction	72.11	3
	Labor disloyalty	78.55	2
	Misunderstanding among labor	71.58	4
	Lack of competition	66.84	5

4.2.3.2 Leadership factors

As shown in table 4.8, lack of labor surveillance and misunderstanding between labor and superintendents are very important factors negatively affecting labor productivity. On the other hand, respondents believe that lack of periodic meeting with labor to study the problems that encounter work have some effect on labor productivity. Testing correlation for agreement on important indexes of leadership factors between first class, second class, and third class revealed that there is very high correlation between first class and second class (rho = 1). Also there is very high correlation between first class and third class (rho = 0.997) and there is very high correlation between second class and third class (rho = 0.996). T-test indicated that the correlation is significant at the 0.05 level. Therefore it can be concluded with 95 % confidence that there is an association between the important indexes of first class, second class, and third class contractors.

Table 4.8. Ranking leadership factors

Group	Factors	Imp. index	Rank
Leadership factors	Misunderstanding between labor and superintendents	80.26	2
	Lack of labor surveillance	83.42	1
	Lack of periodic meeting with labor	56.84	3

4.2.3.3 Motivation factors

Table 4.9 indicates that payment delay has an important effect on labor productivity but lack of some accommodations for labor and lack of training sessions has low effect on labor productivity. Also table 4.9 shows that lack of financial motivation system rated second and lack of labor recognition programs rated third in this group. Testing correlation for agreement on important indexes of motivation factors between first class, second class, and third class revealed that there is very high correlation between first class and second class (rho = 0.943). Also there is high correlation between first class and third class (rho = 0.744) and there is

high correlation between second class and third class (rho = 0.677). T-test indicated that the correlation is significant at the 0.01 level. Therefore it can be concluded with 99 % confidence that there is an association between the motivation factors, important indexes of first class, second class, and third class contractors.

Table 4.9. Ranking motivation factors

Group	Factors	Imp. index	Rank
Motivation factors	Lack of financial motivation system	68.95	2
	Lack of labor recognition programs	61.84	3
	Non-providing of transportation means	56.05	4
	Lack of place for eating and relaxation	55.53	5
	Payment delay	78.68	1
	Lack of training sessions	50.26	6

4.2.3.4 Time factors

Table 4.10 indicates that working for 7 days of week without taking a holiday is rated first (imp. Index = 76.58) in the time factors group whilst misuse of time schedule techniques in managing work rated second (imp. Index = 74.74) in this group. Also method of employment rated third (imp. Index = 65.79), increasing No. of labor in order to accelerate work rated fourth (imp. Index = 64.47) and work overtime rated fifth in time group (imp. Index = 62.37). It should be noted that all time factors have some important effect on labor productivity. Testing correlation for agreement on important indexes of time factors between first class, second class, and third class revealed that there is very high correlation between first class and second class (rho = 0.898). On the other hand, there is a moderate correlation between first class and third class (rho = 0.561) and there is little correlation between second class and third class (rho = 0.2). T-test indicated that the correlation between first class and second class contractors only is significant at 0.05 level. Therefore it can be concluded with 95 %

confidence that there is an association between the time factors, important indexes of first class and second class contractors only.

Table 4.10. Ranking time factors

Group	Factors	Imp. index	Rank
Time factors	Work overtime	62.37	5
	Working for 7 days of week without taking a holiday	76.58	1
	Increasing No. of labor in order to accelerate work	64.47	4
	Misuse of time schedule	74.74	2
	Method of employment (using direct work system)	65.79	3

4.2.3.5 Materials / Tools factors

All materials / tools factors have high influence on labor productivity (see table 4.11). Indeed material shortages are the most important factor in this group. Also shortage of tools and equipment has high impact on labor productivity (imp. Index = 75.26) On the other hand, unsuitability of materials storage location has less impact than above two factors on labor productivity. Testing correlation for agreement on important indexes of materials / tools factors between first class, second class, and third class revealed that there is very high correlation between first class and second class (rho = 0.94). Also there is very high correlation between first class and third class (rho = 0.979) and there is high correlation between second class and third class (rho = 0.99). T-test indicated that the correlation is not significant at the 0.05 level. Therefore, it can be concluded that there is no association between the materials and tools factors important indexes of first class, second class, and third class contractors

Table 4.11. Ranking materials / tools factors

Group	Factors	Imp. index	Rank
Materials / Tools factors	Material shortages	89.47	1
	Unsuitability of materials storage location	69.21	3
	Tool and equipment shortages	75.26	2

4.2.3.6 Supervision factors

Table 4.12 shows that drawings and specifications alteration during execution is the most important factor among other supervision issues. Inspection delay ranked second while rework ranked third in supervision factors group. The least important factor in this group is supervisors absenteeism. Indeed all supervision factors have high influences on labor productivity. Testing correlation for agreement on important indexes of supervision factors between first class, second class, and third class revealed that there is high correlation between first class and second class (rho = 0.790). There is moderate correlation between first class and third class (rho = 0.575) and there is a moderate correlation between second class and third class (rho = 0.466). T-test indicated that the correlation is not significant at the 0.05 level. Therefore it can be concluded that there is no association between the supervision factors important indexes of first class, second class, and third class contractors

Table 4.12. Ranking supervision factors

Group	Factors	Imp. index	Rank
Supervision factors	Rework	75	3
	Supervisors absenteeism	71.84	4
	Inspection delay	77.63	2
	Drawings and specifications alteration during execution	80.00	1

4.2.3.7 Project factors

The degree of importance of project related factors is described in table 4.13. The important factors in project factors group are working in confined space and interference. Construction method and type of activities in the project have low importance in effecting labor productivity. Testing correlation for agreement on important indexes of project factors between first class, second class, and third class revealed that there is very high correlation between first class and second class (rho = 0.955). On the other hand, there is little correlation between first class and third class (rho = 0.156) and there is little correlation between second class and third class (rho = 0.271). T-test indicated that the correlation is significant at the 0.05 level between first class and second class only. Therefore it can be concluded with 95 % confidence that there is an association between the project factors important indexes of first class and second class contractors only.

Table 4.13. Ranking project factors

Group	Factors	Imp. index	Rank
Project factors	Type of activities in the project	61.58	4
	construction method	62.11	3
	Interference	67.11	2
	Working in confined space	70.26	1

4.2.3.8 Safety factors

As illustrated in table 4.14, accidents and violation of safety precautions have large effect on labor productivity. On the other hand bad ventilation, working at high places, unemployment of safety officer in the construction site and noise have low effect on labor productivity. Indeed insufficient lighting has average influence on labor productivity. Testing correlation for agreement on important indexes of safety factors between first class, second class, and third class revealed that there is high correlation between first class and second class (rho =

0.704). Also there is very high correlation between first class and third class (rho = 0.905) and there is high correlation between second class and third class (rho 0.851). T-test indicated that the correlation is significant at the 0.05 level. Therefore, it can be concluded with 95 % confidence that there is an association between the safety factors important indexes of first class, second class, and third class contractors.

Table 4.14. Ranking safety factors

Group	Factors	Imp. index	Rank
Safety factors	Violation of safety precautions	67.63	2
	Accidents	72.37	1
	Unemployment of safety officer in the construction site	53.16	6
	Working at high places	58.68	5
	Bad ventilation	61.32	4
	Insufficient lighting	64.74	3
	Noise	48.42	7

4.2.3.9 Quality factors

As detailed in table 4.15, inefficiency of equipment and low quality of raw materials approximately have same effect on labor productivity. In fact, all quality factors have large effect on labor productivity. Testing correlation for agreement on important indexes of quality factors between first class, second class, and third class revealed that there is no correlation between first class and second class and there is no correlation between first class and third class. But there is moderate correlation between second class and third class (rho 0.61). T-test indicated that the correlation is not significant at the 0.05 level. Therefore it can be concluded that there is no association between the quality factors important indexes of first class, second class, and third class contractors.

Table 4.15. Ranking quality factors

Group	Factors	Imp. index	Rank
Quality factors	Low quality of raw materials	71.32	2
	High quality of required works	67.89	3
	Inefficiency of equipment	71.58	1

4.2.3.10 External factors

Looking at table 4.16 showed that weather changes ranked first in external factors group whilst augmentation of Government regulation related to the construction sector ranked second in this group. Testing correlation for agreement on important indexes of external factors between first class, second class, and third class revealed that there is correlation between first class and third class (rho = 1). On the other hand there is no correlation between first class and second class and there is no correlation between second class and third class. T-test indicated that the correlation between first class and third class is significant at the 0.01 level. Therefore it can be concluded with 99 % confidence that there is an association between the external factors important indexes of first class and third class contractors.

Table 4.16. Ranking external factors

Group	Factors	Imp. index	Rank
External factors	Weather changes	63.95	1
	Augmentation of Government regulations related to the construction sector	60.79	2

4.2.3.11 overall ranking of factors negatively affecting labor productivity

As indicated in table 4.17, the most five important factors negatively affecting labor productivity are material shortages, lack of labor experiences, lack of labor surveillance, misunderstanding between labor and superintendents, drawings and specifications alteration

during execution. Also results indicate that lowest factors which effects labor productivity are :ebor absenteeism. labor personal problems, unemployment of safety officer in the construction site, lack of training sessions, and noise. Furthermore, results indicate that payment delay, labor disloyalty, inspection delay, working all days of week without taking holidays, tool and equipment shortages and rework have high effect on labor productivity and should be avoided to improve labor productivity. Testing correlation for agreement on ranking factors negatively affecting labor productivity between first class, second class, and third class revealed that there is very high correlation between first class and second class (rho = 0.894). Also there is high correlation between first class and third class (rho = 0.784) and there is high correlation between second class and third class (rho = 0.751). T-test indicated that the correlation is significant at the 0.01 level. Therefore it can be concluded with 99 % confidence that there is an association between the first class, second class, and third class contractors in ranking factors negatively affecting labor productivity.

Table 4.17. Overall ranking of factors negatively affecting labor productivity

Groups	Factors	Imp. index	Rank
Manpower factors	Increase of laborer age	62.63	30
	Lack of labor experiences	84.21	2
	Labor absenteeism	55.00	41
	Labor personal problems	54.74	42
	Labor dissatisfaction	72.11	14
	Labor disloyalty	78.55	7
	Misunderstanding among labor	71.58	17
Leadership factors	Lack of competition	66.84	25
	Misunderstanding between labor and superintendents	80.26	4
	Lack of labor surveillance	83.42	3
	Lack of periodic meeting with labor	56.84	38

4.3 Labor productivity measurement

The labor productivity measurement on construction sites was based on studying block work in the Gaza Strip. The main reasons for block work productivity studies on construction sites were:

a. The significance of the cost contribution of block work in relation to other building activities;
b. Block work would provide an opportunity to study a variety of factors;
c. Its inputs and outputs are easily quantifiable;
d. It is a relatively easy activity to observe and quantify because of its intensity.

Block work productivity observations and productivity factors were evaluated as follows: Activity sampling along with the physical measurement of output per hour was used. An evaluation of productivity factors during the process was also performed.

Specialized teams performed all block work operations in construction sites. They are also responsible for hiring all equipment for the project's task. These comprised hammer, trowel, bucket, axe, hatchet and spirit level. Contractor provided all materials. Block work would normally start daily at 8 A.M and finish at 5 P.M. there is one hour break for lunch from 12 o'clock to 1 o'clock therefore day working hours of block work gang are 8 hours. There are two types of blocks mainly used for block work. First type is block 20 and second type is block 10. The size of block 20 is (20cm * 40cm * 20cm). The size of block 10 is (10cm * 40cm * 20cm).

4.3.1 Study of sample characteristics

Figure 4.7 shows that more than half of the skilled labor sample (58.33 %) were aged below 30 years. This indicated that block work is young men trade.

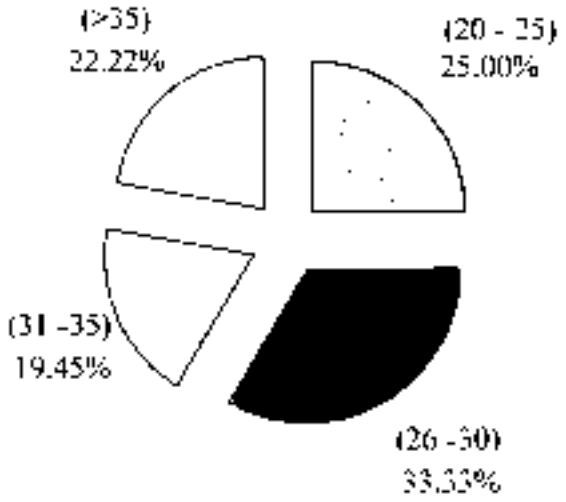

Figure 4.7. Distributions of skilled labor age

As shown in figure 4.8, one fourth of skilled labor sample has experiences less than 5 years, more than half of skilled labor sample has experiences between 5 years and 15 years, and 22.22 % of skilled labor sample have experiences more than 15 years.

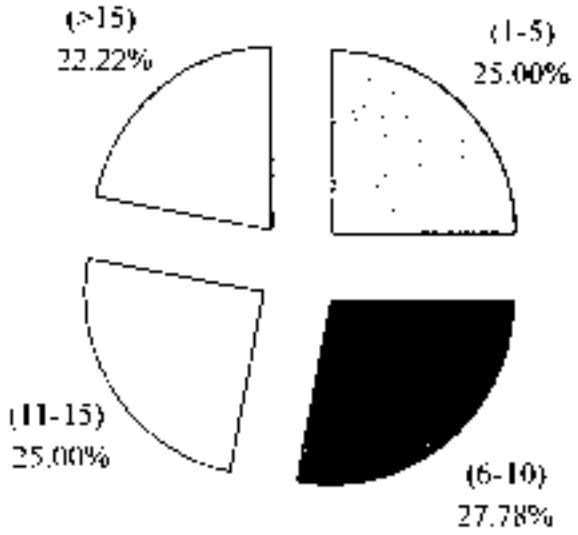

Figure 4.8. Distributions of skilled labor experiences

Figure 4.9 shows that 11.11% of skilled labor sample have elementary degree, whilst more than half of skilled labor sample (55.5 %) has preparatory degree. Also one third of skilled labor sample have secondary degree, and none of skilled labor sample has university degree.

This means that most of block work labor have not high education. All of skilled labor sample trained on-site learning from their seniors and they were not formally trained in trade schools.

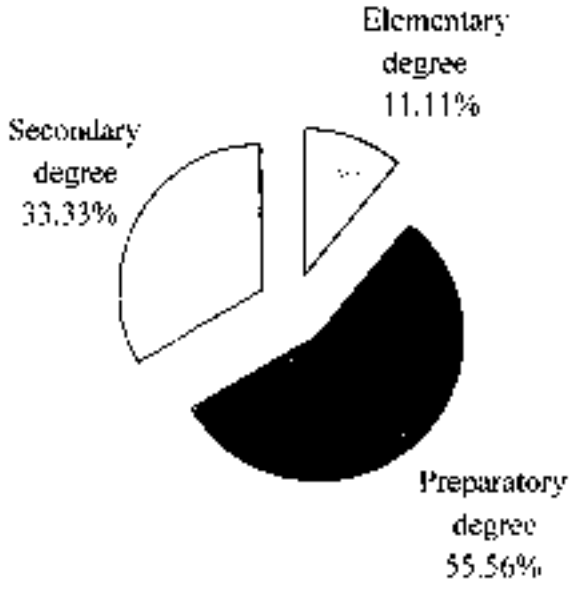

Figure 4.9. Distributions of skilled labor education background

4.3.2 Distributions of Block work working time

Table 4.19 shows that productive time of skilled labor is 77.01% of working time whilst productive time of unskilled labor is 9.34% of working time. Also productive time of block work gang is 48.28% of working time. Contributory time of skilled labor is 9.76 % of working time. On the other hand, Contributory time of unskilled labor is 54.66% of working time. Contributory time of block work gang is 28.72% of working time. Finally unproductive time of skilled labor is 13.23% of working time, unproductive time of unskilled labor is 36% of working time, and unproductive time of block work gang is 23% of working time.

Table 4.19: Block work working hour's basic statistics

Mean parameter	Statistics	Skilled labor	Unskilled labor	Gang
Productive time	Mean	77.01%	9.34%	48.28%
	Std. Deviation	9%	8.23%	8.58%
Contributory time	Mean	9.76 %	54.66%	28.72%
	Std. Deviation	6.6 %	18.62%	9.2%
Unproductive time	Mean	13.23%	36%	23%
	Std. Deviation	6.67%	14%	7.1%

Table 4.20 indicates that spreading mortar on the wall take 21.17% of skilled labor working time, 0.55 % of unskilled labor working time and 12.25 % of block work gang working time. Cutting blocks to required size take 5.69% of skilled labor working time, 5.58 % of unskilled labor working time and 5.55 % of block work gang working time. Positioning and pressing the block on the course, and checking verticality and horizontality of blocks take 38.87% of skilled labor working time, 2.25 % of unskilled labor working time and 23.76 % of block work gang working time. Placing mortar into vertical gaps between blocks and removing excess mortar take 11.28% of skilled labor working time, 0.96 % of unskilled labor working time and 6.72 % of block work gang working time. Mixing mortar and filling it in bucket take 0.20% of skilled labor working time, 22.55 % of unskilled labor working time and 9.47 % of block work gang working time. Distribution of mortar and blocks to spots close to operators take 0.52% of skilled labor working time, 23.59 % of unskilled labor working time and 10.61% of block work gang working time. Work relevant to block work such as (fixing angles, setting scaffolding, checking distances in line with drawings, and taking instruction from supervisors) takes 6.68% of skilled labor working time, 6.81 % of unskilled labor working time and 6.40% of block work gang working time. Cleaning working site takes 2.36% of skilled labor working time, 1.71 % of unskilled labor working time and 2.24% of

block work gang working time. 12.74% of skilled labor working time is idle whilst 36 % of unskilled labor working time is idle. Removing and replacing already completed work due to operator fault or management fault take 0.49 % of skilled labor working time and 0.25% of block work gang working time.

Table 4.20. Distributions of block work activities

Type of work	Activities	Skilled labor	Unskilled labor	Gang
Productive activities	Spreading mortar	21.17%	0.55%	12.25%
	Cutting blocks	5.69%	5.58%	5.55%
	Laying blocks	38.87%	2.25%	23.76%
	Raking and pointing	11.28%	0.96%	6.72%
Contributory activities	Making mortar	0.20%	22.55%	9.47%
	Ancillary work	6.68%	6.81%	6.40%
	Distributing blocks or mortar	0.52%	23.59%	10.61%
	Cleaning	2.36%	1.71%	2.24%
Unproductive activities	Idle	12.74%	36%	22.75%
	Rework	0.49%	0%	0.25%

4.3.3 Block work skilled labor productivity

Table 4.21 indicates that skilled laborer average productivity per hour in laying blocks 20 is 38.40 blocks. On the other hand, skilled laborer average productivity per hour in laying blocks 10 is 40.5 blocks. Skilled laborer productivity in laying blocks 10 is greater than skilled laborer productivity in laying blocks 20 because blocks 20 is heavier than blocks 10.

Table. 4.21. Block work skilled labor productivity statistics

Block type	Mean (blocks/Hour)	Std. Deviation
Blocks 20	38.40	11.86
Blocks 10	40.50	12.52

Frequency histograms were drawn for skilled labor productivity in blocks 20 and blocks 10 to provide a visual illustration of the frequency distributions of skilled labor productivity in both types of blocks. These have been presented in figure 4.10, 4.11. Both figures show a high variation of skilled labor productivity in both blocks 20 and blocks10.

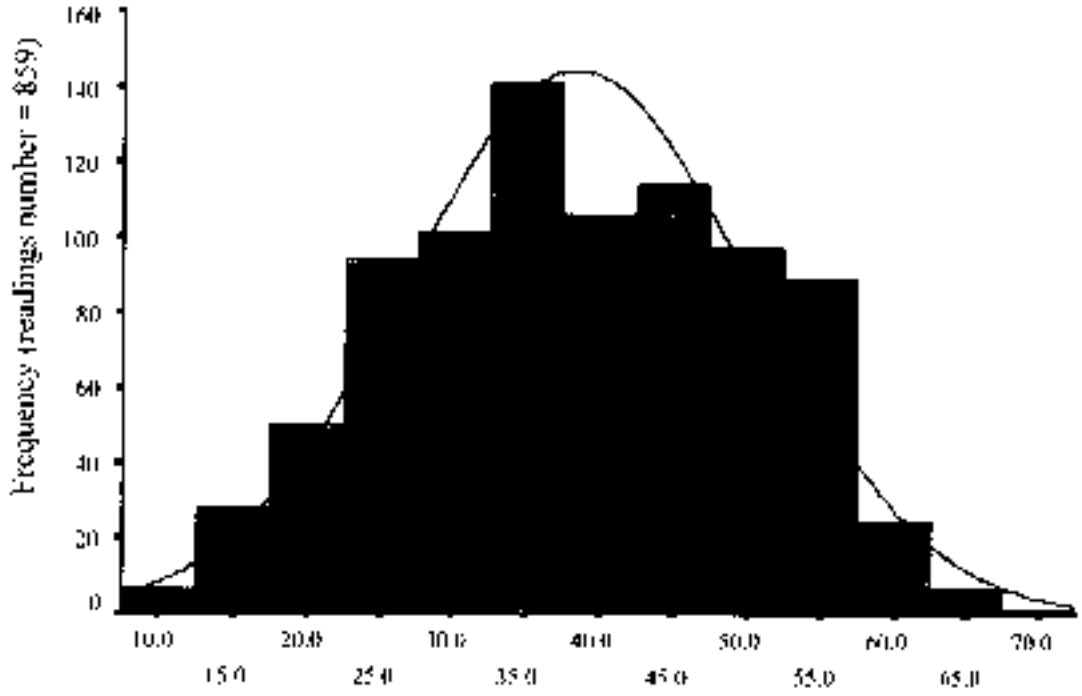

Figure 4.10. Frequency histogram of skilled labor productivity in Blocks 20

Results indicate that skilled labor has highest productivity from 9 o'clock to 11 o'clock and from 2 o'clock to 3 o'clock and they have lowest productivity from 8 o'clock to 9 o'clock and from 4 o'clock to 5 o'clock for both types of blocks (figure 4.12). But it should be noted that skilled labor productivity in morning hours higher than skilled labor productivity in afternoon

hours for blocks 10 but skilled labor productivity in morning hours approximately equals skilled labor productivity in afternoon hours for blocks 20.

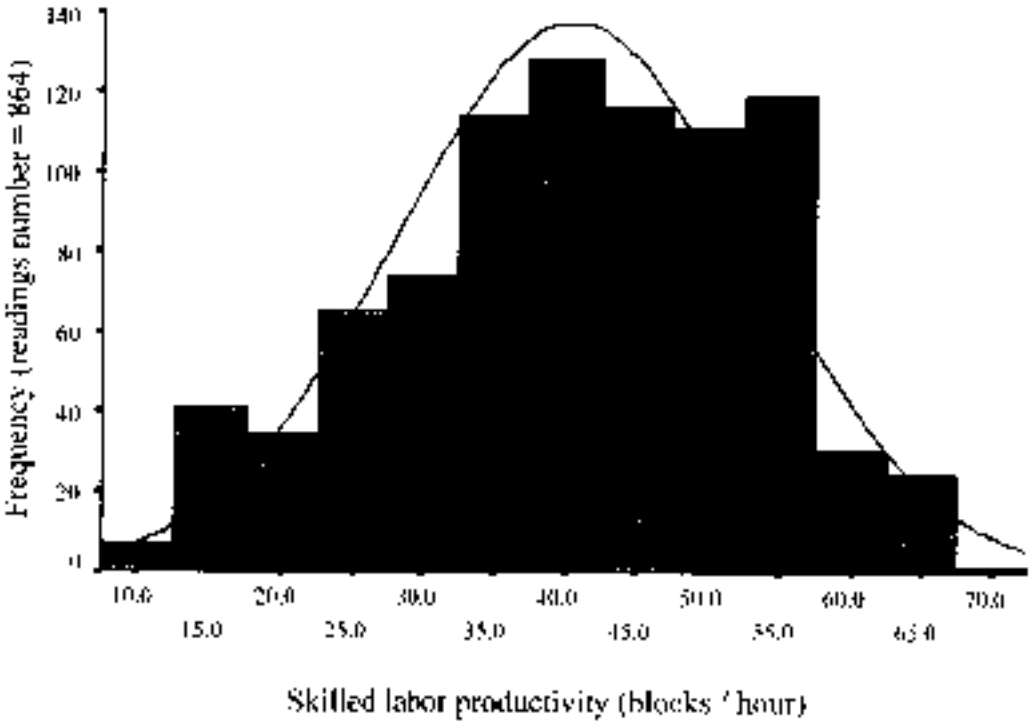

Figure 4.11. Frequency histogram of skilled labor productivity in Blocks 10

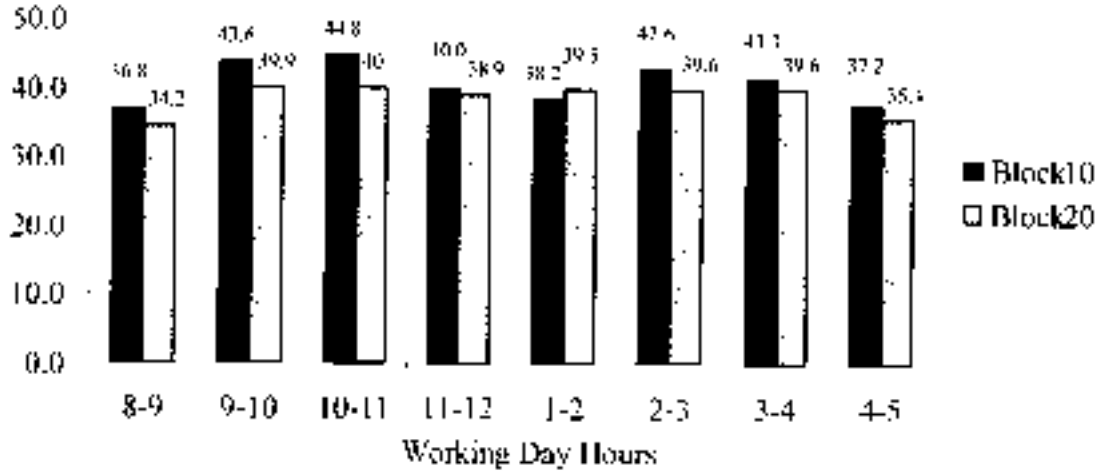

Figure 4.12. Histogram representing skilled labor productivity in hours of day

Results indicate that skilled labor has highest productivity on Sunday for blocks 10 (figure 4.13) whilst they have highest productivity on Wednesday for blocks 20. On the other hand, skilled labor has lowest productivity on Thursday for both types of blocks. Also it should be

noted that skilled labor productivity is high on Monday and Wednesday for both types of blocks.

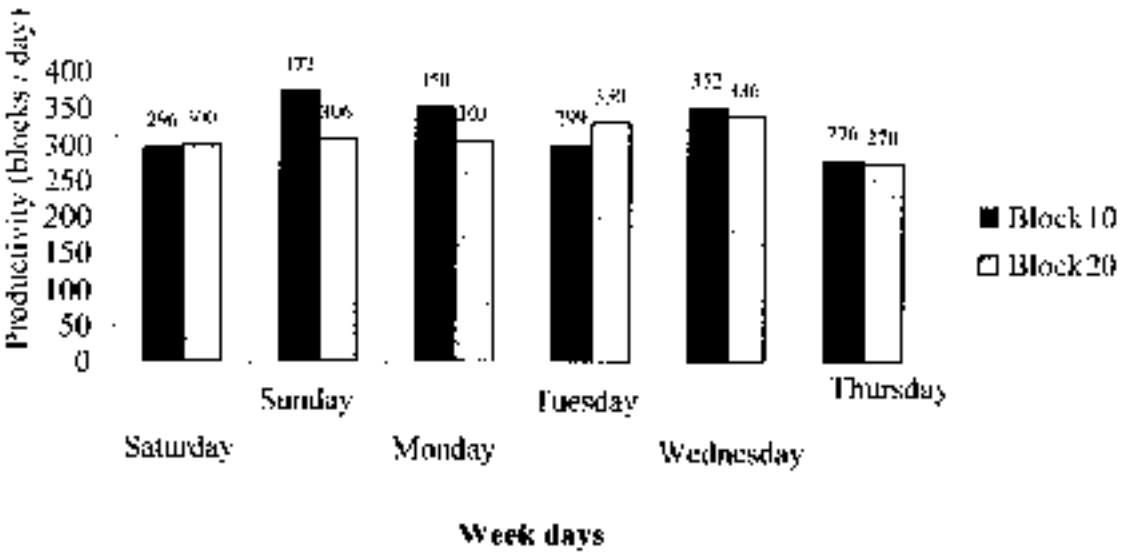

Figure 4.13. Histogram representing skilled labor productivity in week days

4.3.4 Site evaluation of factors affecting labor productivity

Some factors that may have some influence on productivity were recorded during block laying operation. Some relationships between them and productivity have also been explored These factors are:

1. Skilled laborer age;
2. Skilled labor experiences;
3. Skilled labor wage;
4. Number of skilled labor in working gang

Table 4.22 indicates that there is strong positive impact of skilled labor wage on productivity (partial correlation = 0.55). On the other hand, there is low negative impact of skilled laborer age on productivity (partial correlation = -0.20). Number of skilled labor in working gang has positive impact on productivity but its impact is very low (partial correlation = 0.12). Skilled labor experiences have very high positive impact on productivity in the first five years

(partial correlation = 0.80) but after 5 year of experiences the impact of increase of experiences on productivity decreased, therefore, correlation between skilled labor and productivity became low (partial correlation = 0.277).

Table 4.22. Correlation between different factors and skilled labor productivity

Parameter	Partial correlation	P
Skilled labor age	- 0.20	0.477
Skilled labor wage	0.55	0.034
Number of Skilled labor in working gang	0.12	0.68
Experiences from 1 year to 5 years	0.80	0.055
Experiences	0.277	0.317

To identify the important factors negatively affecting productivity of block work skilled labor. The personal interviews with skilled labor of block work gangs were used for filling the third section of questionnaire which includes factors negatively affecting labor productivity. Table 4.23 shows skilled labor evaluation of factors negatively affecting productivity. As mentioned in table 4.23 skilled labor believe that most five important factors negatively affecting productivity are material shortages, rework, payment delay, low quality of raw materials. and lack of labor experiences. Skilled labor agreed that lowest factors which effect labor productivity are supervisors absenteeism, unemployment of safety officer in construction site, non-providing of transportation means, lack of training sessions, and lack of place for eating and relaxation. Also skilled labor agreed that misunderstanding between labor and superintendents. interference. insufficient lighting, tool and equipment shortages, and labor disloyalty are important factors which should be considered. Testing correlation for agreement on ranking factors negatively affecting labor productivity between contractors and skilled labor revealed that there is a moderate correlation between contractors and skilled labor in ranking factors negatively affecting labor productivity (rho = 0.522). T-test indicated

that the correlation is significant at the 0.01 level. Therefore, it can be concluded with 99 % confidence that there is an association between the contractors. and skilled labor in ranking factors negatively affecting labor productivity.

Table 4.23. Skilled labor ranking of factors negatively affecting labor productivity

Groups	Factors	Imp. index	Rank
Manpower factors	Increase of laborer age	40.00	32
	Lack of labor experiences	70.00	5
	Labor absenteeism	54 44	18
	Labor personal problems	32.22	39
	Labor dissatisfaction	47.78	26
	Labor disloyalty	63.33	10
	Misunderstanding among labor	57.78	15
	Lack of competition	34.44	37
Leadership factors	Misunderstanding between labor and superintendents	68.89	6
	Lack of labor surveillance	41.11	31
	Lack of periodic meeting with labor	61.11	12
	Lack of financial motivation system	44.44	29
	Lack of labor recognition programs	60.00	13
Motivation factors	Non-providing of transportation means	26.67	43
	Lack of place for eating and relaxation	23.33	45
	Payment delay	72.22	3
	Lack of training sessions	25.56	44
Time factors	Work overtime	55 56	17
	Working for 7 days of week without holiday	58.89	14
	Increasing No. of labor in order to accelerate work	31.11	40

	Misuse of time schedule	56.67	16
	Method of employment (using direct work system)	43.33	30
Materials / Tools factors	Material shortages	97.78	1
	Unsuitability of materials storage location	62.22	11
	Tool and equipment shortages	64.44	9
Supervision factors	Rework	76.67	2
	Supervisors absenteeism	30.00	41
	Inspection delay	33.33	38
	Drawings and specifications alteration during execution	53.33	19
Project factors	Type of activities in the project	45.56	28
	Construction method	35.56	36
	Interference	67.78	7
	Working in confined space	53.33	20
Safety factors	Violation of safety precautions	46.67	27
	Accidents	52.22	20
	Unemployment of safety officer in construction site	28.89	42
	Working at high places	38.89	34
	Bad ventilation	50.00	24
	Insufficient lighting	66.67	8
	Noise	38.95	33
Quality factors	Low quality of raw materials	71.11	4
	High quality of required work	52.22	21
	Inefficiency of equipment	37.78	35
External factors	Weather changes	51.11	23
	Augmentation of Government regulations related to the construction sector	48.89	25

Table.4.24 shows that block work skilled labor ranked materials / tools factors group most important among all groups of productivity factors on the contrary they ranked motivation factors group least important among all factors groups. They ranked leadership factors group second important and quality factors group third important.

Table.4.24. Skilled labor ranking of factors negatively affecting productivity among groups

Factors groups	**Imp. index**	**Rank**
Materials / Tools factors	74.81	1
Leadership factors	57.04	2
Quality factors	55.93	3
Time factors	51.33	4
Manpower factors	50.00	5
Supervision factors	48.33	6
External factors	48.15	7
Project factors	47.78	8
Safety factors	46.04	9
Motivation factors	40.93	10

Chapter 5

Discussion

5.1 Introduction

This study is conducted to investigate the labor productivity of the construction sector in the Gaza Strip. The main objectives for the study are to explore the factors affecting labor productivity in building construction and labor productivity measurement of block work. This issue is of a particular importance to the Gaza Strip projects as a new developed area and due to expected huge amount of projects planned to be done in the near future. In this chapter, the findings of this study will be discussed in further detail. Findings of factors affecting labor productivity are discussed in the first section and findings of labor productivity measurement of block work are discussed in the second section.

5.2 factors affecting labor productivity

The sample size of the study was selected randomly to represent the study population of first, second, and third class categories of contracting companies in buildings specialization at the Gaza Strip contractors union. The total sample size was 83 contracting companies. The general response rate, was 91.5 %, the majority of sample (76 contracting companies) were responded and participated in the study. The high response rate reflect the relevant importance that was paid by contracting companies in the Gaza Strip to the objectives of the study and personal follow up by researcher, which has increased the accuracy of the study.

5.2.1 Sample size characteristics

The results showed that around three-fourth of contracting companies in buildings specialization of contractors union were established after the existence of Palestinian National Authority in 1994. This means that most contracting companies in the Gaza Strip are newly established so they have short period of experience "nine years".

The findings indicate that majority of contracting companies (94 %) have less than 30 employees. These results reveal the simple organization of contracting companies in the Gaza Strip.

It has been found that the majority of contracting companies have executed less than 30 projects in the last five years. This finding indicates that number of building projects which executed by different organizations during a year is very small (2 – 6). It was also found that value of building projects per year executed by majority of contracting companies is small (0.5 million – 2 million). The results regarding both number of executed building projects and their value depicts that the size of building projects in Gaza Strip is classified as small and simple projects.

The results demonstrate that more than three-fourth (79 %) of respondents designation are either company president or projects manager. The higher designation of respondents increases the accuracy of the results and also expresses the respondent's high concern to deal seriously with this study.

5.2.2. Degree of contractors concerned in the productivity

Findings illustrate that about half of contracting companies always measure labor productivity and study reasons of decline or increase of labor productivity in their projects. This might be justified as contracting companies become distressed by labor productivity in recent years because the number of projects increased and owners forced contractors to comply with the contract duration in many projects especially international projects. But it should be noted that contractors only concerned about labor productivity of critical activities which may cause projects delay.

Findings indicate that more than half of contracting companies use "measuring required time during implementation" as a tool for measuring labor productivity in construction sites. Also findings show that more than half of contracting companies depend on "monitoring the work

during implementation" as a tool to investigate the factors affecting productivity in their projects. This findings show that contracting companies depend on monitoring the work in construction sites to study labor productivity in their projects.

More than half of contracting companies depend on site engineers to measure labor productivity in construction sites. This result might be interpreted as number and value of projects are small therefore contracting companies did not hire specialist engineer to measure labor productivity in construction sites.

Results show that around half of contracting companies often have plans for developing labor productivity in their projects while one – fourth of contracting companies some times have plans for developing productivity in their projects. This result reflects that contracting companies in the Gaza Strip do not pay enough attention for improving labor productivity in their projects. 55 % of contracting companies which answered some time have, rarely have or have no plans for developing labor productivity stated that there is no need for such plans because labor working in company are not permanent. Also 37% of them stated that most of activities in company projects executed by subcontractors and only 8 % of them stated that company does not have technical cadres capable of applying such plans.

Around half of contracting companies monitors the work in construction sites and use motivation system to improve labor productivity in their projects. Also it should be noted that around one – third of contracting companies use two methods or more for improving labor productivity in their projects.

5.2.3 Factors negatively affecting labor productivity

In this study, 45 factors negatively affecting labor productivity in buildings construction of the Gaza Strip have been considered and their importances have been analyzed. All factors selected by a careful review of literature and suggestion of a sample of building contractors. The factors have been classified into 10 groups. These groups are classified as manpower,

leadership, motivation, time, materials / tools, supervision, project, safety, and external factors.

5.2.3.1 Manpower factors group

The results show that under group of manpower factors, the most important factor is lack of labor experiences followed by labor disloyalty, labor dissatisfaction, misunderstanding among labor, lack of competition, increase of laborer age, labor absenteeism, and labor personal problems.

More than half of respondents (51%) rated lack of labor experiences with very high degree of effect on labor productivity. This indicates that lack of labor experiences have very high effect on labor productivity. This result is supported by Paulson (1975) (cited in Lema, 1995) who mentioned that experiences of the craftsmen affect labor productivity. Also this result supported by Heizer et al (1996) who mentioned that experience of workforce affects job site productivity. This result is justified as experience improves intellectual and physical abilities of labor which consequently increase labor productivity.

Labor disloyalty had high effect on labor productivity and ranked in the second position in manpower group with important index 78.55. Labor disloyalty also ranked seventh among all factors negatively affecting labor productivity. Results also indicate that labor dissatisfaction has high effect on labor productivity. This result is supported by Robbins (1998) who mentioned that organization with more satisfied employees tended to be more effective than organization with less satisfied employees.

Furthermore, results indicate that misunderstanding among labor has average effect on labor productivity. This factor was ranked 17 among all factors negatively affecting labor productivity. This result is justified as misunderstanding among labor creates disagreement among labor about responsibilities and work bounds of each laborer. This disagreement leads to a lot of mistakes in work and consequently decreases labor productivity.

Findings also show that 41 % of respondents rated lack of competition with average effect on labor productivity. This factor ranked at position 25 among all factors negatively affecting labor productivity. Findings also show that 32 % of respondents rated increase of laborer age with average effect on labor productivity. This factor ranked at position 30 among all factors negatively affecting labor productivity. Heizer et al (1996) support this result who mentioned that age of workforce affect job site productivity. This result is justified as labor speed, agility, and strength decay over time and contributes to reduced productivity.

Labor absenteeism had low effect on labor productivity and ranked at position 41 among all factors negatively affecting productivity, whilst this factor had high effect on labor productivity in Indonesia and Nigeria. This result might be justified as labor of the construction sector in the Gaza Strip working on daily basis therefore contractor can hire additional labor to cover absenteeism of any laborer. Personal problems have low negative effect on labor productivity and ranked in position 42 among all factors negatively affecting labor productivity. This result might be justified as personal problems cause only mental distraction for labor. Mental distraction affects labor safety more than labor productivity.

5.2.3.2 Leadership factors group

The results illustrate that the three factors under leadership factors, were ranked as follows: lack of labor surveillance, misunderstanding between labor and superintendents, and lack of periodic meeting with labor. Lack of labor surveillance has high effect on labor productivity (imp. index = 83.42) and ranked in position 3 among all factors negatively affecting labor productivity. This result is justified as lack of labor surveillance increases labor mistakes at work and also delays correction action for these mistakes.

Misunderstanding between labor and superintendents have high effect on labor productivity (imp. index = 80.26) and ranked in position 4 among all factors negatively affecting labor productivity. This result is justified as misunderstanding between labor and superintendents

originate bad relation between them. This bad relation has adverse effect on labor mood and consequently decreases his productivity. Finally lack of periodic meeting with labor has low effect on labor productivity and ranked in position 38 among all factors negatively affecting labor productivity. This result might be justified because building projects in the Gaza Strip are small and problems facing work can be discussed at any time with superintendents, therefore, there is no need for periodic meeting with labor to discuss these problems.

5.2.3.3 Motivation factors group

The result of this study indicates that under motivation factors group, the six factors were placed on descending order according to their importance as follows: payment delay, lack of financial motivation system, lack of labor recognition programs, non-providing of transportation means, lack of place for eating and relaxation, lack of training sessions. Results demonstrate that payment delay has high effect on labor productivity (imp. index = 78.68) and ranked in position 6 among all factors negatively affecting labor productivity. This result is justified as payment delay has very bad effect on labor mood and consequently decreases its productivity.

Contractors believe that lack of financial motivation system has more bad impact on labor productivity than lack of labor recognition programs and ranked lack of financial motivation system in position 21 whilst they ranked lack of labor recognition programs in position 32 among all factors negatively affecting labor productivity. But skilled labor of block work did not support these results and stated that lack of labor recognition programs has more bad effect on labor productivity than lack of financial motivation. Regardless of which type of motivation is more effective, motivation is essential for labor as it gives workers satisfaction at work site such as achievement, sense of responsibility and pleasure from the work itself.

Non-providing of transportation means and place for eating and relaxation have low effect on labor productivity and ranked in positions 39 and 40 among all factors negatively affecting

labor productivity. This result is not supported by Lema (1995) who mentioned that non financial benefits such as (transport, meals, and uniform) have high effect on labor productivity. These results might be justified in the Gaza Strip because area of the Gaza Strip is small and transportation to any place in the Gaza strip can be available easily, therefore, there is no need to provide transportation to labor. Also Palestinian labor is not sensitive about place of eating. According to their culture, any place can be used for eating and there is no need to provide a special place for eating and relaxation.

Furthermore, findings illustrate that lack of training sessions have low effect on labor productivity and ranked in position 44 among all factors negatively affecting labor productivity. Surveyed contractors illustrate that there is no need for training sessions and labor can be trained more effectively in site by working with experienced workers.

5.2.3.4 Time factors group

the results show that the five factors under group of time factors were ranked according to their importance in affecting labor productivity as follows: "working for 7 days of week without holiday" was first, " misuse of time schedule" was second, "method of employment (using direct work system) " was third, "increasing workforce to accelerate work" was fourth, and "work overtime" was fifth.

Working for 7 days of week without holiday have high effect on labor productivity whilst working additional hours in working day have average effect on labor productivity. Hinze (1999) supported these results and stated that working additional days and hours have negative impact on labor productivity. These results are not surprising because working additional days and hours create an adverse effect on the motivation, and physical strength of labor and thus decrease their productivity. But the impact of additional hours for short period may be not noticeable or may be non existent.

Results also demonstrate that misuse of time schedule has high negative impact on labor productivity. This result is acceptable because good use of time schedule leads to many advantages such as: continuous flow of work, reduced amount of rework, and minimize confusion and misunderstanding.

Using daily work system instead of unit rate system has average negative effect on labor productivity and ranked in position 31 among all factors negatively affecting labor productivity. This result is justified as labor desire to work by unit rate system to earning more money therefore labor work too hard to finish the greatest amount of work when working by unit rate system.

Increasing workforce in construction site has a moderate effect on labor productivity and ranked in position 28 among all factors negatively affecting labor productivity. This result was also supported by Hinze (1999) who mentioned that increase of workforce in construction site has adverse impact on labor productivity. This result is justified as increasing workforce in construction site cause overcrowding of labor and interference between labor and gangs which consequently reduce labor productivity.

5.2.3.5 Materials / Tools factors group

The results demonstrate that three factors under materials / tools factors group were ranked according to their importance in effecting labor productivity as follows: material shortages, tool and equipment shortages, and unsuitability of materials storage location. The findings show that, the most important factors among all factors negatively affecting labor productivity is material shortages. Important index of material shortages is 89.47 and three classes of contracting companies ranked this factor first among all factors. This is understandable in that work can not be done without the necessary materials. Material shortages rated in first position among factors affecting labor productivity in US, UK, Indonesia, Nigeria, Singapore, and Kenya (Guhathakurta et al, 1993 - Jim et al, 1995 -

Olomolaiye et al, 1996). This result is justified in the Gaza Strip as most of materials used in construction projects are imported from Israel therefore any closure of crossing points between the Gaza strip and Israel stop work in large numbers of construction projects.

Results also show that tool and equipment shortages have high effect on labor productivity and ranked in position 10 among all factors negatively affecting labor productivity. Tool and equipment shortages also have high effect on labor productivity in US, UK, Indonesia, and Nigeria (Guhathakurta et al, 1993 - Olomolaiye et al, 1996). This result might be justified as labor needs a minimum number of tools and equipment to work effectively. If there is lack of equipment and tools, the productivity will decrease.

Results also illustrate that unsuitability of materials storage location have average effect on labor productivity and ranked in position 20 among all factors negatively affecting labor productivity. This result was supported by Thomas et al (1990) (cited in Lema, 1995) who stated that size and organization of materials storage location have significant impact on masonry productivity. This result is justified as labor needs more time in fetching required materials from unsuitable storage location and this negatively affects productivity.

5.2.3.6 Supervision factors group

All supervision factors have high impact on labor productivity and ranked according to their importance as follows: drawings and specifications alteration during execution, inspection delay, rework, and supervisors absenteeism.

Drawings and specifications alteration during execution is the most important factor in supervision factors group and ranked within the 10 most important factors negatively affecting productivity with imp. index 80. This result is supported by Thomas et al (1995) who stated that there is a 30% loss of efficiency when work changes are being performed. This result can be interpreted as changes of specifications and drawings require additional

time for the adjustments of resources and manpower so that the change can be met. Also labor morale is affected by extensive numbers of changes.

Inspection delay is second important factor in supervision factors group and also ranked within the 10 most important factors negatively affecting productivity. Inspection delay also has high impact on labor productivity in US, UK, Nigeria, and Indonesia (Guhathakurta et al. 1993 – Olomolaiye et al. 1996). This result is justified as work inspection by supervisor is an essential process to proceed in work, for example contractors can not cast concrete before inspection of formwork and steel work therefore inspection delay contributes to delays of work activities.

Supervisors absenteeism is the last factor in supervision factors group but it is ranked in position 15 among all factors negatively affecting labor productivity. This is not surprising in the Gaza Strip projects as absenteeism of supervisors stop work totally in some activities which require attendance of supervisors such as casting concrete and backfilling. Also supervisors absenteeism delays inspection of ready work which leads to delay commencement of new work.

5.2.3.7 Project factors group

The most important factor in this group was working in a confined space followed by interference, construction method, and type of activities in project. Working in confined space ranked in position 19 among 45 factors negatively affecting labor productivity. This result supported by Andersson et al (1996) which reported that one of common reasons for low productivity is working in a confined space. This result might be justified as confined spaces reduce free movement of labor and consequently reduce their productivity.

Interference has average impact on labor productivity and ranked in position 24 among all factors negatively affecting labor productivity. Interference also has significant impact on labor productivity in US, UK, Nigeria, and Indonesia (Guhathakurta et al. 1993 - Olomolaiye

et al, 1996). Interference between gangs and workers is caused by mismanagement in construction sites. Steel fixers suffer more of this. Perhaps this is because they are more dependent on other trade. The steel fixers have to wait before fixing the reinforcement rods if the carpenters have not completed the formworks.

Results also indicate that construction method and type of activities in project have low importance and ranked in positions 32 and 34 among 45 factors negatively affecting labor productivity. This result is not supported by Thomas et al (1992) who mentioned that construction method and project features have high impact on labor productivity. This result might be justified because the building projects in the Gaza Strip are not complex and with small size therefore activities in different projects approximately have same features and also there is no major difference between methods used in construction.

5.2.3.8 Safety factors group

The result depicts that the seven factors under safety group are placed in descending order as follows: accidents, violation of safety precautions, insufficient lighting, bad ventilation, working at high places, unemployment of safety officer in construction site and noise.

Accidents have high impact on labor productivity and ranked in position 13 among 45 factors negatively affecting labor productivity. These results were supported by Thomas et al (1990) (cited in Lema, 1995) who stated that accidents have significant impact on labor productivity. There are three types of accidents as follows:

a) Accidents resulting in the death of an injured worker, this type of accident leads to total stoppage of work a number of days.

b) Accidents which cause an injured laborer to be hospitalized for at least 24 h, this type of accident decreases the productivity of gang in which this injured laborer was working.

c) Small accidents which result from nails and steel wires, it affect productivity only in few cases.

Insufficient lighting has average impact on labor productivity and ranked in position 27 among all factors negatively affecting labor productivity. This result is justified as labor need a sufficient lighting to work effectively and consequently insufficient lighting has negative impact on labor productivity. Bad ventilation and working at high places has low importance and ranked in positions 35, 37 among all factors negatively affecting labor productivity. This result is justified as most of building projects in the Gaza Strip are upgrade and have little number of stories therefore labor seldom faces these problems in building projects in the Gaza Strip.

Results also indicate that unemployment of safety officer in construction site has low impact on labor productivity. This result is justified in the Gaza Strip as contractors seldom employ safety officers in building projects, therefore they, are not aware of the importance of employing safety officer in construction sites. It should be noted that employment of safety officer in construction sites helps labor to understand the required safety regulations and then follow it. This prevents or at least reduces number of accidents in construction sites which consequently improve labor productivity. Noise also had low impact on labor productivity and ranked in last position among all factors affecting productivity. This result is justified as equipment and tools used in building projects at the Gaza Strip cause little noise

5.2.3.9 Quality factors group

The results depict that the three factors under quality factors group are placed in descending order as follows: inefficiency of equipment, bad quality of raw materials, and high quality of required work. The surveyed companies have more tendencies to place inefficiency of equipment as most important factor within this group with imp. index 71.585. This result might be justified as productivity rate of inefficient equipment is low and this consequently has adverse impact on labor productivity depending on this equipment. Also type of equipment affects labor productivity. New and modern equipment have high productivity

rate. On the other hand, old equipment have low productivity rate and subjected to large number of breakdowns. Andersson et al (1996) mentioned that machine breakdown is one of the common reasons of low productivity.

The surveyed companies ranked bad quality of raw materials at position 18 among all factors affecting labor productivity with imp. index 71.32. This result might be justified as time needed to build materials of bad quality is higher than time needed to build materials of proper quality. Also wastage in materials of bad quality is high especially during handling. Furthermore, using materials of bad quality leads to a work of bad quality which consequently is rejected by supervisor.

Quality of required work has average impact on labor productivity and ranked in position 22 among 45 factors negatively affecting labor productivity. This result is acceptable as time required to finish work depends greatly on allowed tolerance of required work i.e. labor worked slowly when allowed tolerance of required work is very low to avoid unacceptable mistakes.

5.2.3.10 Weather factors group

The results demonstrate that two factors of external factors group are ranked according to their importance as follows: weather changes and augmentation of government regulations related to the construction sector. Weather changes have average impact on labor productivity and ranked in position 29 among all factors affecting labor productivity. Thomes et al (1999) support this result in his study of analysis factors affecting productivity in US. Temperature in the Gaza Strip is normal therefore increase and decrease of temperature has low effect on labor productivity but adverse weather in winter such as winds and rains reduce labor productivity especially at external work such as formwork, steel work, concrete casting, external plastering, external painting, and external tiling. Adverse weather sometimes stopped work totally.

Augmentation of government regulations related to the construction sector has low importance and ranked in position 36 among all factors negatively affecting labor productivity. This result might be justified in the Gaza Strip as government regulations of construction projects is subjected to minor changes only in the last years.

5.2.3.11 Overall ranks of all factors negatively affecting labor productivity

The results depict that the most five important factors negatively affecting labor productivity are material shortages, lack of labor experiences, lack of labor surveillance, misunderstanding between labor and superintendents, drawings and specifications alteration during execution with imp. indexes 89.47, 84.21, 83.42, 80.26, and 80. On the other hand results indicate that labor absenteeism, labor personal problems, unemployment of safety officer in construction site, lack of training sessions, and noise were lowest factors negatively affecting labor productivity with imp. indexes 55, 54.74, 53.16, 50.26, and 45 respectively.

The Spearmen's correlation test for the agreement on ranking of factors negatively affecting productivity revealed that there is very high correlation between first class and second class (rho = 0.894). Also there is high correlation between first class and third class (rho = 0.784) and there is high correlation between second class and third class (rho = 0.751). Furthermore, correlation is significant at the 0.01 level. These results mean that contracting companies in the Gaza Strip have similar opinions regarding the factors negatively affecting labor productivity.

5.2.3.12 Degree of effectiveness of the various groups on labor productivity

The results demonstrate that the ten groups and their factors were ranked according to their importance as follows: rank 1 is "materials / tools factors", rank 2 is "supervision factors", rank 3 is "leadership factors", rank 4 is "quality factors", rank 5 is "time factors", rank 6 is

"manpower factors", rank 7 is "project factors", rank 8 is "external factors", rank 9 is "motivation factors", and rank 10 is "safety factors".

It is noted that "materials / tools factors" group was ranked first among ten factors groups negatively affecting labor productivity. This result is justified as any project can not be executed without availability of materials and tools. Current political situation in the Gaza Strip causes frequent closures of crossing points between the Gaza Strip and Israel which consequently result in shortage of materials and some tools in local market. This situation affects labor productivity too much. On the other hand, "safety factors" group were ranked last among the ten groups affecting labor productivity, this can be readily interpreted as safety is a new topic in the construction sector in the Gaza Strip, so contracting companies have little awareness about the impact of safety factors on labor productivity, therefore, they rated that safety factors had either average impact or low impact only on labor productivity.

5.3 Labor productivity measurement

This section discusses findings obtained from observations of block work operation in construction sites. The researcher carried observations of block work operation in construction sites of Sheikh Zeyad Township project. This project is selected because it is the largest construction project in the Gaza Strip with a larger proportion of construction activities and continuous work compared to any other location in the Gaza Strip.

5.3.1 Case study characteristics

Observations of block work operation were carried out in construction sites of Sheikh Zeyad Township project. Buildings of Sheikh Zeyad Township project were 70 five storey buildings, twelve storey building, mosque, school, and 2 shops. Block work gangs worked in Sheikh Zeyad Township project were 14. Block work gangs consisted of 36 skilled labor and 23 unskilled labor.

More than half of the block work skilled labor was aged below 30 years. This indicated that block work are young men trade. Also more than half of block work skilled labor had experiences between 5 years and 15 years and a preparatory degree. This indicated that block work skilled labor start their career at early age. Furthermore, all block work skilled labor trained on site, learning from their seniors. This confirms the limited attention paid by Palestinian Authority to a proper skill based education and training. It would also seem that contractors are not interested in any formal skill acquisition programs for block work labor working in their sites. This result also matches with low rating of the factor "lack of training seasons" by both contractors and skilled labor.

5.3.2 Distributions of block work working time

The researcher divided block work operation into three groups of activities. First group, productive activities which included "spreading mortar on the wall in preparation for laying blocks", "cutting blocks to required size", "positioning and pressing the block on the course, and checking verticality and horizontality of blocks", and "placing mortar into vertical gaps between blocks and Removing excess mortar". Second group, contributory activities which included "mixing mortar and filling it in buckets", "ancillary work such as fixing angles and setting scaffolding, Checking distances in line with drawings, taking instruction from supervisors", "distribution of mortar and blocks to spots close to skilled labor", and "cleaning working site". Third group, unproductive activities which included "idle time", and "removing and replacing already completed work due to operator fault or management fault". Findings show that skilled labor spent more than three-fourth (77.01%) of his working time in productive work. On the other hand, skilled labor spent only 9.76% of his working time in contributory work. This indicates that skilled labor work mainly in productive activities. Findings also show that unskilled labor spent only 9.34% of his working time in productive work. On the other hand unskilled labor spent more than half (54.66%) of his working time in

contributory work. This indicated that unskilled labor work mainly in contributory activities. Unproductive time of skilled labor was 13.23% of his working time whilst unproductive time of unskilled labor was 36% of his working time.

Results illustrate that the most important activity done by skilled labor was laying blocks which had taken 38.87% of skilled labor working time. Second important activity done by skilled labor was spreading mortar on wall which had taken 21.17% of skilled labor working time. On the other hand, the most important activity done by unskilled labor was distribution blocks and mortar which had taken 23.59% of unskilled labor working time. Second important activity done by unskilled labor was making mortar which had taken 22.55% of unskilled labor working time. This result is acceptable as the main job of skilled labor is laying blocks while the main job of unskilled labor is providing materials required for skilled labor to perform his work.

Results also indicate that skilled labor and unskilled labor spent approximately equal time in cutting blocks. Also skilled labor and unskilled labor spent approximately equal time in ancillary work. This is because some gangs depend on skilled labor for cutting blocks and ancillary work and other gangs depend on unskilled labor to perform these two activities.

As mentioned in results, idle time of unskilled labor (36%) is higher than idle time of skilled labor (12.74%). This indicates that the work is not well distributed between skilled and unskilled labor. Findings also indicated that skilled labor lost only 0.49 % of his working time in rework. This result might be interpreted as block work in all buildings of Sheikh Zeyad Township project is typical from ground storey to last storey therefore block work is repeated from storey to storey and from building to building. This repetition of work helped skilled labor to understand drawing and specification requirements and consequently reduce rework. Findings illustrate that block work gangs spent more than three-fourth (77%) of their

working time in working activities. This percentage is acceptable but it could be improved by effective distribution of work between skilled and unskilled labor.

5.3.3 Skilled labor productivity in block work

Findings indicate that the average productivity of skilled laborer in laying blocks 20 is 38.40 blocks per hour while average productivity of skilled laborer in laying blocks 10 is 40.50 blocks per hour. Skilled laborer productivity in laying blocks 10 greater than skilled laborer productivity in laying blocks 20 because blocks 10 is lighter than blocks 20 thus blocks 10 is easier than blocks 20 in handling and fixing .

Skilled labor productivity in laying both blocks 10 and blocks 20 were high from 9 o'clock to 11 o'clock. On the other hand, skilled labor productivity in laying both blocks 10 and blocks 20 were low from 8 o'clock to 9 o'clock and from 4 o'clock to 5 o'clock. High productivity from 9 o'clock to 11 o'clock because these hours are first hours of working day thus skilled labor in these hours is vital and have more power and ability for production. The Low productivity from 8 o'clock to 9 o'clock because skilled labor spent approximately 10 minutes of first hour preparing mortar required to start block laying and Low productivity from 4 o'clock to 5 o'clock because skilled labor was tired by that hour.

Skilled labor had high productivity in laying blocks 10 on Sunday, Monday, and Wednesday whilst they were had medium productivity on Saturday, and Tuesday. On the other hand, skilled labor had low productivity in Thursday. Skilled labor had high productivity in laying blocks 20 on Tuesday, and Wednesday whilst they were had medium productivity on Saturday, Sunday, and Monday. On the other hand, skilled labor had low productivity on Thursday. Low productivity in laying blocks in Thursday might be interpreted as this day is last working day in the week thus skilled labor were tired and fatigued in that day. Also skilled labor was subjected to mental distraction in that day because they plan for the method of spending weekend.

5.3.4 Summary of labor productivity measurement

Labor productivity measurement was carried for block work operation in construction sites of Sheikh Zeyad Township project. Skilled labor productivity for blocks 10 and blocks 20 was observed. Also the researcher studied the productive time, contributory time and unproductive time of skilled and unskilled labor of block work. As shown in table 5.1 the average productivity of skilled labor in laying blocks 20 is 38.40 blocks per hour (3.07 m2/h) while average productivity of skilled labor in laying blocks 10 is 40.50 blocks per hour (3.24 m2/h). Also table 5.1 indicates that productive time of skilled labor was 77.01% of his working time while productive time of unskilled labor was 9.34% of his working time. Also contributory time of skilled labor was 9.76 % of his working time while contributory time of unskilled labor was 54.66% of his working time. Unproductive time of skilled labor was 13.23% of his working time while unproductive time of unskilled labor was 36% of his working time.

Table 5.1 Block work operation productivity basic statistics

Main parameter	Mean
Skilled labor Productivity rate per hour in laying blocks 10	40.50 blocks (3.24 M2)
Skilled labor Productivity rate per hour in laying blocks 20	38.40 blocks (3.07 M2)
Skilled labor productive time	77.01%
Skilled labor contributory time	9.76 %
Skilled labor unproductive time	13.23%
Unskilled labor productive time	9.34%
Unskilled labor contributory time	54.66%
Unskilled labor unproductive time	36%

5.4 Factors affecting labor productivity of block work

Some factors that may have influence on productivity were recorded during block laying operation. These factors were skilled labor age; skilled labor experiences; skilled labor wage; and number of skilled labor in working gang. Findings show that value of skilled labor wage had significant impact on his productivity (partial correlation = 0.55). This is acceptable as increase of wage motivate labor to increase his productivity.

Labor experiences had high impact on labor productivity when experiences are less than five years (partial correlation = 0.80) while the impact of labor experiences become low when exceeded five years (partial correlation = 0.277). This is acceptable because labor always has low productivity when it starts his career and productivity increase rapidly by increase of experiences till certain limit. After this limit, increases of his experiences do not affect his productivity. Skilled labor age and number of skilled labor in working gang had low impact on productivity of skilled labor working in construction sites with partial correlation -0.2 and 0.12 respectively.

To identify the important factors negatively affecting productivity of block work skilled labor. The personal interviews with skilled labor of block work gangs were used for filling the third section of questionnaire which includes factors negatively affecting labor productivity. Findings depict that the most five important factors negatively affecting block work skilled labor productivity are material shortages, rework, payment delay, low quality of raw materials, and lack of labor experiences with imp. indexes 97.78, 76.67, 72.22, 71.11, and 70. Skilled labor also agreed that the lowest factors which affect labor productivity are supervisors absenteeism, unemployment of safety officer in construction site, non-providing of transportation means, lack of training sessions, and lack of place for eating and relaxation with imp. indexes 30, 28.89, 26.67, 25.56, and 23.33. Also skilled labor agreed that

misunderstanding between labor and superintendents, interference, insufficient lighting, tool and equipment shortages, and labor disloyalty are important factors and should be considered.

CHAPTER 6

Conclusions and Recommendations

6.1 Conclusions

6.1.1 Introduction

The main objective of this research was to study measurement of labor productivity in the Palestinian construction industry. Productivity formed the focal area of the study because it is the main value adding function in the construction sector. Identification of factors that influences construction productivity was based on a careful review of literature and suggestion of a sample of building contractors. Productivity measurement carried out for block work because of its significance in building construction and its specific characteristics which make it more interesting to study.

Generally, these objectives have been achieved and some actions that may contribute to the productivity improvement in the construction industry have been recommended.

6.1.2 Factors negatively affecting labor productivity in building projects

An exploration of factors negatively affecting labor productivity in building projects was conducted in order to find the degree of importance for each factor. The result of analysis of 45 factors considered in the questionnaire filled by representative sample of contracting companies registered in buildings specialization at contractors union in the Gaza Strip concluded that the main factors negatively affecting labor productivity are;

1. Material shortages;
2. Lack of labor experiences;
3. Lack of labor surveillance;
4. Misunderstanding between labor and superintendents;
5. Drawings and specifications alteration during execution;

6. Payment delay;

7. Labor disloyalty;

8. Inspection delay;

9. Working for 7 days of week without holiday; and

10. Tool / equipment shortages.

Furthermore 45 factors considered in the study were distributed among 10 groups, which are ranked in importance order as follows:

1. Materials / tools factors group;

2. Supervision factors group;

3. Leadership factors group;

4. Quality factors group;

5. Time factors group;

6. Manpower factors group;

7. Project factors group;

8. External factors group;

9. Motivation factors group; and

10. Safety factors group.

Also results indicated that three classes of contracting companies have similar opinions regarding the factors negatively affecting labor productivity.

6.1.3 Distributions of labor working time in block work

The research studied the distributions of skilled labor time and unskilled labor time in working day. The findings indicate that skilled labor work mainly in productive activities as they spend 77.01% of their working time in productive activities. Also it is indicated that unskilled labor work mainly in contributory activities as they spend 54.66% of their working time in contributory activities. Also findings highlight that the work is not well distributed

between skilled labor and unskilled labor as idle time of unskilled labor (36%) is higher than idle time of skilled labor (12.74%).

6.1.4 Skilled labor productivity in block work

Productivity of skilled labor is another issue that was studied in this research. The findings confirm that average productivity of skilled labor in laying blocks 20 is 38.40 blocks per hour (3.07 m2/h) while average productivity of skilled labor in laying blocks 10 is 40.50 blocks per hour (3.24m2/h). Skilled labor productivity in laying both blocks 10 and blocks 20 were high from 9 o'clock to 11 o'clock. On the other hand, skilled labor productivity in laying both blocks 10 and blocks 20 were low from 8 o'clock to 9 o'clock and from 4 o'clock to 5 o'clock. Moreover the findings show that skilled labor has high productivity in laying blocks 10 on Sunday, Monday, and Wednesday while lowest productivity of skilled labor in laying blocks 10 on Thursday. On the other hand, skilled labor has highest productivity in laying blocks 20 on Tuesday, and Wednesday while skilled labor has lowest productivity in Thursday.

6.1.5 Factors affecting labor productivity of block work

In investigating the factors affecting skilled labor productivity of block work, impact of skilled labor experiences; skilled labor wage; skilled labor age; and number of skilled labor in working gang were recorded during block laying operation. Findings show that value of skilled labor wage has significant impact on skilled labor productivity. Labor experiences have high positive impact on labor productivity when experiences are less than five years while the positive impacts of labor experiences become low when it exceeded five years. On the other hand skilled labor age and number of skilled labor in working gang have low impact on productivity of skilled labor working in construction sites.

Finally, findings show that the highest ten factors negatively affecting labor productivity of block work operation are: material shortages, rework, payment delay, low quality of raw

materials, lack of labor experiences, misunderstanding between labor and superintendents, interference, insufficient lighting, tool and equipment shortages, and labor disloyalty.

6.2 Recommendations

1. **Materials procurement**

It is recommended that contracting companies have to provide materials supply schedule for each project. This schedule should include the time required to supply materials and the availability of materials in the local market to furnish the required materials in the suitable time. Also contracting companies should select a suitable storage location for purchased materials in each project. This storage location should be easily accessible and close to constructed buildings to avoid wastage of labor time in fetching materials.

2. Materials and tools quality

Contracting companies have to give more attention to the quality of construction materials and tools used in their projects as using perfect materials and tools reduce the time taken to finish the work and wastage of materials. Also using perfect materials and tools have positive effect on the quality of work which consequently improves labor productivity.

3. Leadership characteristics

Project management has to assign or recruit the right people to do the job. Also it should keep a close eye on labor work to make sure that they understand instruction. Furthermore it ought to keep a friendship relation with labor and make them know that they are important to the organization and involve them in the making of decisions affecting their jobs such as method improvements.

4. Use of scheduling techniques

It is necessary to use project scheduling techniques such as computer-aided construction project management in each project to optimize the times of related activities and make sure

that works allow continuous task performance so as to reduce the idleness of the labor force to a minimum.

5. Use of motivation system

It is important for each contracting companies to adopt motivational or personnel management measures to boost workers' morale. For example, tie compensation to performance; ensure that pay, fringe benefits, safety, and working conditions are all at least adequate; and enlarge the jobs to include challenge, variety, wholeness, and self-regulation.

6. Productivity study

Contracting companies have to conduct productivity study at the activity/operation level such as studying factors affecting labor productivity and labor productivity measurement to describe the detailed tasks performed for an activity / operation by individual or group in order to find out problem areas and propose ways to improve labor productivity. Also contracting companies are encouraged to keep historical data of productivity study in finished projects to improve the effectiveness and accuracy of cost estimation of future projects.

7. Project procurement system

There is a need to change the traditional system of project procurement to design build system. This new procurement system will enable contractors to participate in design process which minimize change orders during project execution.

8. Improving contract condition

It is necessary to improve the contract condition towards adopting more use of management practices. Contract should include statements about time planning and productivity management to be implemented in a regular base through projects life cycle.

9. Training in productivity improvement programs

It is necessary to conduct training courses and seminars in the topics that will improve productivity in construction projects. The training effort should be tailored to improve the

abilities to use the project scheduling techniques such as Microsoft project and Primavera. Also the training effort should be tailored to improve the methods of studying productivity and ways of productivity improvement in construction sites.

10. Trade's schools

There is a need to increase the number of trade's schools which focus on teaching construction trades such as block work, formwork, painting, plastering, plumbing .....etc to improve the abilities and skills of craftsmen working in construction projects.

11. Transferring of technology

More efforts should be spent by contracting companies to get the use of what other developed countries had achieved through transferring of technology and best use of benchmarking.

6.3 Proposed additional studies

The study has proposed some actions that could lead to labor productivity improvement in the construction industry. A number of areas of further research have also been identified. These include:

1. The effect of different ten groups on labor productivity was evaluated in this study. However, the researchers are encouraged to examine separately each group with more associated factors to find out their relative importance on labor productivity.
2. There is a need for further studies in factors affecting labor productivity in the Gaza Strip construction industry to develop labor productivity models based on actual site observations to quantify the effects of different factors on labor productivity.
3. This study investigate factors affecting labor productivity, however, there is a need to more studies that investigate factors affecting financial productivity and total factor productivity.
4. This study is related with productivity measurement of block work only. Therefore there is need for further researchs to focus on other activities in construction projects such as concrete work, tile work, painting work, plastering work, ... etc.

5. Further studies are recommended to relate between performance at various levels in the construction industry that is operative, project, company, and industry level.

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List of Annexes

Annex 1

THE ISLAMIC UNVIRSITY - GAZA

Higher Education Deanship

Faculty of Engineering – Civil Engineering Department

Questionnaire

STUDYING FACTORS AFFECTING LABOR PRODUCTIVITY OF BUILDING PROJECTS

A Thesis Submitted in Partial Fulfillment of the Requirements for Degree of Master of Science in Construction Management

Researcher

Eng. Zeyad Abo Mostafa

Supervisor

Professor Dr. Adnan Enchassi

Professor of Construction Management

May, 2003 / Rabi Awwal, 1424

Questionnaire for aims to study factors affecting labor productivity in the Gaza Strip

Dear contractor,

To start, I would like to present my appreciation and thanks to you for taking part of your time and effort to complete this questionnaire.

This questionnaire aims to study factors affecting labor productivity in the construction sector at the Gaza Strip (buildings projects).This is part of partial fulfillment of the requirements for degree of Master of Science in construction management from Islamic University.

Contents of Questionnaire:-

1. Company Profile.
2. Degree of contractors concerned in the productivity.
3. Factors affecting labor productivity.

Information in the questionnaire:-

All information in the questionnaire will be used for research with complete commitment for absolute secrecy to your information.

First Part:

Company Profile

1. Name of the Company: .....
2. Year of establishment: .....
3. Classification of the company / according to Contractors Unions:

☐ First Class ☐ Second Class ☐ Third Class

4. The position of officer who fills the questionnaire:

☐ Company Manger ☐ Projects Manger ☐ Site Engineer ☐ Foreman

5. Number of Company's Employees:

☐ Less than 10 ☐ 11 - 30 ☐ 31 – 50 ☐ More than 50

6. Number of executed projects during the last five years:

☐ Less than 10 ☐ 11 - 20 ☐ 21 – 30 ☐ More than 30

7. Average value per year of executed projects during the last five years (in million dollars):

☐ Less than 0.5 ☐ 0.51 - 1 ☐ 1.1 – 2 ☐ More than 2

Second Part:

Degree of contractors concerned in the productivity

8. Your company measure labor productivity:

☐ Always ☐ Usually ☐ Sometime ☐ Rarely ☐ No

8.1 Labor productivity is measured through:

☐ Analyzing the data recorded in the daily reports to estimate the number of hours needed for performing a task

☐ Measuring the time needed for executing a task during implementation

☐ Another method, define (.....)

8.2 The title of the employee who measures the labor productivity is:

☐ Specialist Engineer ☐ Site Engineer ☐ Foreman ☐ Other

8.3 Reason of not measuring labor productivity is:

☐ Measuring labor productivity is not necessary

☐ Measuring labor productivity is costly

☐ There are no cadres capable of measuring labor productivity

☐ Another reasons, define (.....)

9. Your company studies the reasons of increase and decline of productivity:

☐ Always ☐ Usually ☐ Sometime ☐ Rarely ☐ Never

9.1 Studying of causes of increase and decline of productivity is done through:

- ☐ Consulting specialist in the field of labor productivity
- ☐ Making interviews with company engineers and labor who work in the projects
- ☐ Distributing questionnaire to company engineers and labor who work in the projects and analyze it
- ☐ Monitoring work during implementation
- ☐ Another method, define (.....)

10. Your company has plans for developing labor productivity:

☐ Always ☐ Usually ☐ Sometime ☐ Rarely ☐ Never

10.1 Method upon which labor productivity development plans is dependent on:

- ☐ Good planning and monitoring the work
- ☐ Applying motivation system to encourage the labor to increase productivity
- ☐ Conducting training course for the labor
- ☐ Enhancing the labor loyalty toward company
- ☐ Using time schedule techniques
- ☐ Another method, define (.....)

10.2 Reason of unavailability of labor productivity development plans is:

- ☐ There are no cadres capable of applying these plans
- ☐ Labor in the company is not permanent
- ☐ Most of activities in company projects executed by subcontractors
- ☐ Another reasons, define (.....)

Third Part:

Factors affecting labor productivity

11. In the table below there are numbers of factors negatively affecting labor productivity in building projects. Please define the degree of importance of these factors in affecting labor productivity taking into consideration the under mentioned table.

Symbol	Meaning
1	Affects with little degree
2	Affects something
3	Affects with average degree
4	Affects with large degree
5	Affects with very large degree

No	Groups	Factors affecting labor productivity	Degree of importance
1	Manpower issues	Increase of laborer age	1 2 3 4 5
		Lack of labor experiences	1 2 3 4 5
		Labor absenteeism	1 2 3 4 5
		Labor personal problems	1 2 3 4 5
		Labor dissatisfaction	1 2 3 4 5
		Labor disloyalty	1 2 3 4 5
		Misunderstanding among labor	1 2 3 4 5
2	Leadership issues	Lack of competition	1 2 3 4 5
		Misunderstanding between labor and superintendents	1 2 3 4 5
		Lack of labor surveillance	1 2 3 4 5
		Lack of periodic meeting with labor	1 2 3 4 5
3	Motivation issues	Lack of financial motivation system	1 2 3 4 5
		Lack of labor recognition programs	1 2 3 4 5
		Non-providing of transportation means	1 2 3 4 5
		Lack of place for eating and relaxation	1 2 3 4 5
		Payment delay	1 2 3 4 5
		Lack of training sessions	1 2 3 4 5

4	Time issues	Work overtime	1	2	3	4	5
		Working for 7 days of week without holiday	1	2	3	4	5
		Increasing No. of labor in order to accelerate work	1	2	3	4	5
		Misuse of time schedule	1	2	3	4	5
		Method of employment (using direct work system)	1	2	3	4	5
5	Materials / Tools issues	Material shortages	1	2	3	4	5
		Unsuitability of materials storage location	1	2	3	4	5
		Tool and equipment shortages	1	2	3	4	5
6	Supervision issues	Rework	1	2	3	4	5
		Supervisors absenteeism	1	2	3	4	5
		Inspection delay	1	2	3	4	5
		Drawings and specifications alteration during execution	1	2	3	4	5
7	Project issues	Type of activities in the project	1	2	3	4	5
		Construction method	1	2	3	4	5
		Interference	1	2	3	4	5
		Working in confined space	1	2	3	4	5
8	Safety issues	Violation of safety precautions	1	2	3	4	5
		Accidents	1	2	3	4	5
		Unemployment of safety officer in construction site	1	2	3	4	5
		Working at high place	1	2	3	4	5
		Bad ventilation	1	2	3	4	5
		Insufficient Lighting	1	2	3	4	5
		Noise	1	2	3	4	5
9	Quality issues	Low quality of raw materials	1	2	3	4	5
		High quality of required work	1	2	3	4	5
		Inefficiency of equipments	1	2	3	4	5
10	External issues	Weather changes	1	2	3	4	5
		Augmentation of Government regulations related to the construction sector	1	2	3	4	5

Annex 2

بسم الله الرحمن الرحيم

الجامعة الاسلامية - غزة

عمادة الدراسات العليا

كلية الهندسة – قسم الهندسة المدنية

استبيان

دراسة العوامل المؤثرة في إنتاجية العمال فى صناعة التشييد
(مشاريع البناء)
وذلك كجزء من البحث التكميلي لنيل درجة الماجستير في إدارة التشييد

إعداد

م . زياد أبو مصطفى

أشراف

الأستاذ الدكتور : عدنان إنشاصي

أستاذ إدارة التشييد

ربيع أول 1424 هجري / مايو 2003 ميلادي

الرقم	المجموعة	العوامل المؤثرة على الإنتاجية	درجة التأثير				
			5	4	3	2	1
1	عوامل متعلقة بالقوى البشرية (العمال)	زيادة عمر العامل	5	4	3	2	1
		قلة خبرة العامل	5	4	3	2	1
		غياب احد او بعض العمال في مجموعة العمل	5	4	3	2	1
		المشاكل العائلية والخاصة التي يتعرض لها العامل	5	4	3	2	1
		عدم رضا العامل عن عمله (عدم وجود رضا وظيفي)	5	4	3	2	1
		عدم شعور العامل بالانتماء والولاء للشركة	5	4	3	2	1
		عدم التفاهم بين العمال في مجموعة العمل	5	4	3	2	1
		عدم وجود روح التنافس بين العمال في مجموعة العمل	5	4	3	2	1
2	عوامل متعلقة بالقيادة	غياب التفاهم بين العمال والمراقب او المهندس المسئول عن العمل	5	4	3	2	1
		عدم مراقبة ومتابعة العمال اثناء العمل من قبل المراقب او المهندس المسئول عن العمل	5	4	3	2	1
		عدم عقد اجتماعات دورية مع العمال لدراسة المشاكل التي تواجه العمل ومحاولة حلها	5	4	3	2	1
3	عوامل متعلقة بالحوافز	عدم استخدام نظام الحوافز المادية	5	4	3	2	1
		عدم استخدام نظام الحوافز المعنوية	5	4	3	2	1
		عدم توفير المواصلات للعامل	5	4	3	2	1
		عدم توفير مكان للراحة والاكل للعامل	5	4	3	2	1
		التاخير في دفع رواتب العمال	5	4	3	2	1
		عدم حصول العامل على دورات تدريبية	5	4	3	2	1
4	عوامل متعلقة بالوقت	العمل لساعات اضافية	5	4	3	2	1
		العمل كل ايام الاسبوع بدون اخذ يوم اجازة	5	4	3	2	1
		زيادة عدد العمال في موقع العمل بغرض تسريع العمل	5	4	3	2	1
		عدم استعمال الجداول الزمنية في ادارة المشاريع	5	4	3	2	1
		العمل بنظام اليومية بدلا عن نظام المقاولة	5	4	3	2	1
5	عوامل متعلقة بالمواد/المعدات	نقص المواد	5	4	3	2	1
		بعد مكان تخزين المواد في المشروع عن مكان العمل	5	4	3	2	1
		النقص في عدد المعدات والالات	5	4	3	2	1
6	عوامل متعلقة بالإشراف	اعادة العمل بسبب رفض العمل من قبل الاشراف	5	4	3	2	1
		غياب جهاز الاشراف	5	4	3	2	1
		تاخر فحص الاعمال الجاهزة من قبل الاشراف	5	4	3	2	1
		التغيير في المواصفات والخرائط اثناء التنفيذ	5	4	3	2	1

7	عوامل متعلقة بطبيعة المشروع	نوع الاعمال والفعاليات المطلوب تنفيذها في المشروع	5	4	3	2	1
		الطريقة الفنية المتبعة في تنفيذ الاعمال في المشروع	5	4	3	2	1
		التداخل مع مجموعات أخرى في العمل (مثلا عمل عامل القصارة وعامل البلاط او الدهان في نفس المكان)	5	4	3	2	1
		ضيق مساحة منطقة العمل	5	4	3	2	1
8	عوامل متعلقة بالسلامة والأمان في المشروع	عدم اتباع اجراءات السلامة والامان اثناء العمل	5	4	3	2	1
		وقوع الحوادث في موقع العمل	5	4	3	2	1
		عدم تعيين موظف مسئول عن اجراءات السلامة والامان في موقع العمل	5	4	3	2	1
		ارتفاع مكان العمل	5	4	3	2	1
		سوء التهوية في مكان العمل	5	4	3	2	1
		ضعف الاضاءة في مكان العمل	5	4	3	2	1
		وجود ضوضاء في موقع العمل	5	4	3	2	1
9	عوامل متعلقة بالجودة	سوء جودة صناعة المواد الاولية المستخدمة	5	4	3	2	1
		ارتفاع جودة العمل المطلوب تنفيذه	5	4	3	2	1
10	عوامل خارجية	قلة كفاءة المعدات المستخدمة في العمل	5	4	3	2	1
		التغير في الاحوال الجوية	5	4	3	2	1
		ازدياد القوانين الحكومية والبلدية المتعلقة بقطاع التشييد	5	4	3	2	1