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Factors affecting construction labor productivity in developed and developing countries

Master thesis

International Master of Science in Construction and Real Estate Management
Joint Study Programme of Metropolia UAS and HTW Berlin

Submitted on 20.01.2020 from
Mahmoud Elazzazy
S0562612

First Supervisor: Architect Eric Pollock
Second Supervisor: Prof. Dr.-Ing. Dieter Bunte

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Copy of proposed conceptual formulation

Factors affecting construction labor productivity in developed and developing countries.

MASTER THESIS

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Joint Study Programme of Metropolia UAS and HTW Berlin

Submitted on 19.08.2019 from

Mahmoud Elazzazy

562612

Introduction:

The construction industry is regarded as a labor-intensive industry. The production in this area has the features of large scale, open job sites, and extensive fragmentation in the process. Therefore the construction industry has long been regarded as an incredibly inefficient sector. The industry's relatively low productivity compared with other sectors such as the manufacturing industry has caused its performance to be a great concern to clients and decision-makers.
Productivity is the one of the most important factor that affects overall performance of any small or medium or large construction industry. There are number of factors that directly affect the productivity of labor, thus it is important for any organization to study and identify those factors and take appropriate actions for improving the labor productivity. At the micro level, if we improved productivity, ultimately it reduces or decreases the unit cost of project and gives overall best performance of project.

Key Words: Construction productivity, Labor productivity, Labor factors, Developed and Developing countries.

Background:

The construction industry remains one of the few most labor intensive industries in the developed world. It is therefore imperative to understand the measure of construction labor productivity. Furthermore, recent institutional and industrial calls for an increase in productivity suggest a desperate need to get the measurement of productivity levels right. An earlier study highlighted that less than 50% of the industry actually actively measure and monitor productivity levels, with a majority of those companies that claim to measure, their measuring based on the basis of the intuition of key site management personnel. This may seem alarming, however, it was argued that productivity measurement techniques could be perceived as theoretical, hard and expensive for construction companies to adopt.

Construction industry makes a significant contribution to the national economics. For example, in developed countries, construction industry constitutes approximately 10% of the national income. Besides its economic size, construction industry also provides employment with rates of 7 % and 8 % in Europe and USA, respectively. However, the economic contribution of construction industry is more significant in developing countries compared with developed ones. In many developing countries, major construction projects account for 10% of their Gross Domestic Product (GDP) and approximately 50% of the wealth invested in fixed assets. Moreover, the development of the construction industry in developing countries lags far behind other industries in those countries compared to developed countries.
Although, construction industry made an appreciable improvement dependently to the technological development, non-value adding activities still comprise 50 to 70% of work time in a typical work site. Therefore, labor productivity becomes one of the most important factors that affect both time and cost performances of the construction projects.

There is no universal definition for productivity; the term has different meanings for different people. Generally, productivity is the relationship between the output produced and one or more of the associated inputs devoted to the production process. Productivity may be defined as the ratio of output to input, via the arithmetical ratio between the amounts produced (output) and the amount of any resources used during the process of production (input). In essence, it is a measure of how well we make use of the available resources effectively to produce the goods. A high productivity level represents good use of resources and high returns. There is divergence in opinion on how to measure output and input. A vast number of output-to-input ratios can be created; no single productivity measure works for all purposes. The selection of an appropriate concept of productivity depends on the objective of measurement, availability of data, and the researcher's preference.

Research problem:

There are various project cost components; labor cost component is considered the most risk compared to materials and equipment's, which are influenced by market prices and inflation. Labor cost in construction industry roughly accounts for 33%-50% of the entire project cost. Therefore, previous researches investigated the most critical factors affecting labor productivity, in the hope to increase the labor productivity performance and to increase the value-added activities, on the other hand to mitigate the loss in productivity and the non-value-added activities. In order to improve something, it is needed to measure it, however, measurement and definitions for labor productivity have always been a challenge in construction industry, there is non-consensus for the definitions and measurements, which creates confusion in assessing the productivity. This research aims to capitalize on the previously published researches that focused on the factors affecting labors productivity, by comparing and analyzing the results of these researches to find the common factors between developed and developing countries. Such perspective of this research is unique and was not investigated before, unlike the previous researches which were focused on individual countries to detect the factors.

Research Questions:

1- What are the different labor productivity definitions and concepts?
2- What are the different measurements used for labor productivity?
3- What are the critical factors affecting labor productivity in developed countries?

4- What are the critical factors affecting labor productivity in developing countries?
5- How the country's development status impact the labor productivity?

Research Methodology:

Comprehensive study of existing literature to determine and examine the existing definitions and measurements of labor productivity, in addition to detecting the critical factors affecting the levels of labors productivity. The literature study will be followed by cross sectional analysis of various case studies both in developed and developing countries in order to detect the common and uncommon critical factors affecting labor productivity.

Expected Results:

As the research still in its initial phase, solid/final results are still vague. However, the results of the initial research suggest that there are some analogy and variance in the critical factors both in developing and developed countries.

Signature of the Supervisor

Abstract

Construction industry is an intensive labor oriented industry, the level of productivity and performance of labor is a crucial factor for any project success. The research presented an overview for different definitions and concepts of construction productivity in the existing literature. It tried to investigate the recent methods, approaches, and levels for measuring labor and construction productivity and performance in current literature. In addition to a critical comprehensive review for factors affecting labor productivity in different countries, followed by an analysis for 6 case studies, in which cross case analysis for three case studies related to developed countries has been done, and the same process for three case studies related to developing countries, in order to detect the critical common factors affecting labor productivity for each developed and developing countries. Next step was an analysis for two case studies for how labor productivity can be measured and reported at construction sites, one case study illustrated the implementation of activity sampling technique to measure the productivity rate and the distribution of time spent of labors for block work activity, furthermore, the other case study revealed difficulties in choosing consistent construction metrics for output and lack of consensus for standard units. The research aimed to explore the different ways to improve the labor productivity in developing countries to meet the productivity level of labors in developed countries by applying best practices of site management principles presented in two case studies associated with author experiences and existing literature.

Key words: construction productivity, construction labor productivity, labor productivity improvement, factors , measurements.

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List of Abbreviations

GDP - Gross Domestic Product

BLS - Bureau of Labor Statistics

PFP - Partial Factor Productivity

TFP - Total Factor Productivity

MFP - Multi Factor Productivity

CLP - Construction Labor Productivity

GVA - Gross Value Added

RII - Relative Important Index

EPC - Engineering Procurement and Construction

PPC - Percent Plan Complete

CO – Change Orders

GCC - Gulf Cooperation Council

R&D – Research and Development

ICT - Information and Communication Technology

BIM - Building Information Modeling

GPS - Global Positioning Systems

MIS - Management Information System

EPFC - Engineering, Procurement, Fabrication and Construction

1 Introduction

Construction industry is considered to be one of the important contributor key factors in the economy of any country, especially the developing countries, in comparison to developed countries (Gerges, 2015). The value of any industry can be assessed through the contribution of this sector to the Gross Domestic Product (GDP) and the employment status for economy of the country (Sweis et al, 2009, cited in, Gerges, 2015). Many construction projects in a lot of developing countries constitute around 10% of the GDP and roughly 50% of the wealth as fixed assets (Gerges, 2015).

Construction industry relies mainly on labor productivity, as it is well known as labor oriented industry. Hanna & Sullivan (2004) referred that 33-50% of the total project costs accounted to labor costs. Moreover, non-value adding activities form around 50-70% of the total work time in a traditional construction site (Diekmann, J. et al, 2004, cited in, Kazaz et al. , 2016). Therefore, it is very essential to investigate and to detect the adverse factors that affect the productivity and performance of labor.

In order to improve the productivity of a construction labor, it is required to measure and evaluate it first. Chan and Kaka (2004) explained that less than 50% of the construction industry measure and monitor the productivity in reality, most of the companies which measure the productivity depends on intuition. They added that existing measurement techniques are seen as a theoretical approach more than empirical approach, in addition to it is high cost to be implemented by construction companies. Lorys (2018) explained that there is a confusion and in consistency in measuring productivity, due to the shortage of consensus in defining and measuring productivity.

A large amount of researches focused on determining and detecting the most critical factors affecting labor productivity, these studies were conducted in individual countries. This research tries to capitalize on the previously published researches that focused on the factors affecting labors productivity, by comparing and analyzing the results of these researches to find the common factors in developed countries from one side, and common factors in developing countries from other side. Such perspective of this research is unique and was not investigated before. Furthermore, the existing researches are very few in the field of improving the productivity of labor on construction sites and overcoming the adverse critical factors. This research tries to explore and investigate more in this field.

1.1 Research objectives

The research aims to: first, to determine the common critical factors in developed countries and the common critical factors in developing countries, through the analysis of case studies for both developed and developing countries with the integration of critical comprehensive review of the existing literature. Second, the research suggests some improvement actions related to site management, in order to improve the productivity and performance of labor in developing countries to meet the productivity of labors in developed countries on site, through the analysis of case studies, existing literature and author's experiences. Third, the research aims to demonstrate how labor productivity can be measured on site, through the analysis of case study.

1.2 Research Questions

The research questions are the following:

1. What are the different labor productivity definitions and concepts?

2. What are the different measurements used for labor productivity?

3. What are the critical factors affecting labor productivity in developed countries?

4. What are the critical factors affecting labor productivity in developing countries?

5. How labor productivity can be improved?

1.3 Structure of Thesis

The research comprises six chapters as follow:

Chapter one: it includes introduction, research objectives, research questions and research structure.

Chapter two: it introduces an overview for different definitions and concepts of productivity, and it investigates productivity measurement approaches, methods and challenges. It provides a comprehensive overview for critical factors affecting labor productivity in different countries.

Chapter three: it illustrates the research design, nature, data collection and approach.

Chapter four: it introduces case studies, main findings and analysis.

Chapter five: it summarizes the answers of the research questions.

Chapter six: it presents the conclusion and recommendation for future studies.

2 Literature review

2.1 Construction Productivity Definitions

2.1.1 Introduction

The construction industry is fragmented and complicated industry. A Substantial amount of craft workers, machines, materials, equipment's and tools, in addition to different construction methods are used in one construction project only, all of these reasons lead to a complexity of construction activities and inefficiency in cost controlling. The construction industry encompasses high percentage of temporary specialists, providers and workers entwined with different contractual and procurement agreements. Also, the concluding outcome of every single project is exceptional and distinctive in terms of design; however, there are many analogous features that are common during the design stage (Palop, 2016).

All of the above mentioned issues affect directly the productivity of construction industry, in particular the productivity of labor. In construction, the terms productivity is usually concerned and referred to labor productivity, as the construction industry is relies mainly on the physical input of workers. The labor productivity is highly influenced by various factors that will be discussed in the following sections.

2.1.2 Different Productivity Definitions and Concepts

The term "productivity" can be defined and measured in many different ways; there is no standard definition and measurement for productivity (Gerges, 2015). The productivity can be defined generally as the ratio of output to input, the ratio of the quantity produced (output) to the quantity of resources used in the production phase (input). The resources can be materials, manpower, land and machines, the productivity increases if the output increases for constant amount or reduced amount of input and if the input increases indirectly proportional to the output, the productivity will remain constant (Palop, 2016). The word "productivity" was historically mentioned for the first time in an article by Quesnay in 1776, after around one century in 1883, it was described as faculty to produce (Soham & Rajiv, 2013).

AbouRizk and Song (2008) have defined the productivity as the ratio of the quantity of input to the quantity of output. Another definition of productivity is the working hours in a particular time frame divided by the quantities achieved during the same time frame, this time frame is daily or weekly or throughout the whole project, it is called unit rate (Napolitan & Thomas, 1995). Durdyev and Mbachu (2011) stated that productivity as **"**Productivity is a measure of how well resources are leveraged to achieve set objectives or desired outputs (p, 19)**"**. Other definition for productivity is relationship of an output created by an organization and amount of input elements used by the organization to create that output (Herrala et al., 2011).
Nicolaou (1987) suggested a good interpretation for productivity as; the quantity of products and services created by a unit of a productive factor in a specific time and also assumed that the productive factors are land, machines, capital and labors, these factors do not depend on each other's but interdependent. Another definition was a measurement for productivity in terms of efficiency, in which it is the same ratio between output to input. Productivity can be defined also as the amount of work accomplished per hour, such as; how many meter squared of tiles fixed per hour or how many block units installed per hour (Nicolaou, 1987).

According to AbouRizk and Dozzi (1993), there are several terms to illustrate productivity such as; production rate, performance factor, unit person-hour and other terms. The most generic definition used is the ratio of input to output, however it was defined as; physical progress achieved per hour, is an example for how many person-hours per cubic meter of casted concrete (AbouRizk & Dozzi, 1993). Adrian (1987) defined construction labor productivity as: **"**Dollars of output per person-hour of labor input**"**. While Finke (1998) defined productivity as: **"**The quantity of work produced per man-hour, equipment-hour, or crew-hour**"**. Naoum (2015) defined productivity term as: **"**The maximization of output while optimizing input (p, 401)**"**. Table 1 shows the various definitions of productivity through different perspective investigated in the previous researches and literatures. The table is cited from the article of Tangen (2004) directly.

Definition	Reference
Productivity is what man can accomplish with material, capital and technology. Productivity is mainly an issue of personal manner. It is an attitude that we must continuously improve ourselves and the things around us.	(Japan Productivity Centre, 1958 (from Bjorkman, 1991))
Productivity = units of output/units of input.	(Chew, 1988)
Productivity =actual output/expected resources used**.**	(Sink and Tuttle, 1989)
Productivity = total income/(cost + goal profit)**.**	(Fisher, 1990)
Productivity =value added/input of production factors**.**	(Aspe´n et al., 1991)
Productivity is defined as the ratio of what is produced to what is required to produce it. Productivity measures the relationship between output such as goods and services produced, and inputs that include labor, capital, material and other resources.	(Hill, 1993)
Productivity (output per hour of work) is the central long-run factor determining any population's average of living.	(Thurow, 1993)
Productivity = the quality or state of bringing forth, of generating, of causing to exist, of yielding large result or yielding abundantly.	(Koss and Lewis, 1993)
Productivity means how much and how well we produce from the resources used. If we produce more or better goods from the same resources, we increase productivity. Or if we produce the same goods from lesser resources, we also increase productivity. By "resources", we mean all human and physical resources, i.e. the people who produce the goods or provide theservices, and the assets with which the people can produce the goods or provide the services.	(Bernolak, 1997)
Productivity is a comparison of the physical inputs to a factory with the physical outputs from the factory.	(Kaplan and Cooper, 1998)
Productivity= efficiency * effectiveness = value adding time/total time.	(Jackson and Petersson, 1999)
Productivity = (output/input) * quality =efficiency * utilization *quality.	(Al-Darrab, 2000)
Productivity is the ability to satisfy the market's need for goods and services with a minimum of total resource consumption.	(Moseng and Rolstadas,2001)

Table 1: Definitions of productivity (Tangen, 2004, p, 36).

After demonstrating and showing the different definitions and concepts of productivity, it is considered to be a verbal definitions and it does not have any relation with the mathematical perspective. Mathematical definitions can be employed to be the foundation of performance measurement. It's goal is to increase productivity not to explain it. It is hard to transform a verbal definition into a mathematical one. The mathematical one does not usually reflect all the attributes and features that express the concept of productivity, as a result the true meaning of productivity will not be produced (Amanuel, 2016).

Ghobadian and Husband,1990, cited in Amanuel (2016) explained that most of the productivity definitions can be located in one of three broad classifications. First classification is related to engineers and economists perspective, which is the traditional ratio between outputs to inputs, it can be the number of units produced per unit time. The second classification is the mixture efficiency (outputs/inputs) and effectiveness (outputs/goals). In this category the organization can measure the productivity efficiency and effectiveness; it can be the number of produced units divided by the number of expected units that should be produced per unit time that represents the target and the goal of the organization. The third classification is too wide and relevant to the organization level, the definition falls into anything that can make the function of organization better.

2.1.3 Productivity and Profitability

Many companies deny the significance of productivity, as they always link both productivity and profitability as one issue. Profitability is the main goal for the success and growth of any company and it is defined as ratio between revenue and cost (i.e. profit/assets). Profitability as a performance measure is mainly used by shareholders, however many researches do not suggest using profitability (money ratio), as it results in many disadvantages (Tangen, 2002). There is a usual confusion between productivity and profitability. Profitability considers the monetary aspects, while productivity refers to a real process that is produced by physical aspects and it is ratio is also outputs to inputs (Herrala et al., 2011).

The term profitability comprises productivity constituent, however it is highly affected by the prices which the company pays for the input and the money which earns for its produced outputs, if the company earns from the outputs more than the cost of the input, the profitability will increase even if the productivity minimizes (Tangen, 2002). Since profitability is an outcome or a result, and not as a participant to the processes like productivity, as a result it does not affect the processes strongly, it can improve the whole process and provides a true performance. However, profitability aspect can be integrated with productivity and performance in order to determine and detect the effects of monetary aspects like inflation, currency change and price changes, so it can provide a clear and true performance to the process (Grunberg, 2004).

2.1.4 Productivity and Performance

Performance can be considered as the broadest terms among productivity and profitability, as it can almost cover all the economical (profitability) and operational (productivity) features (Grunberg, 2004). Tangen (2004) described the performance as: **"**Performance can be described as an umbrella term for all concepts that considers the success of a company and its activities (p,40)**"**. Measuring and investigating performance includes two targets, first to link the goals and objectives of the organization to improvement and the second one is to establish a goal for improvement activity. Both can help to maximize the effect of any improvement initiative (Grunberg, 2004).

Goals are considered to be the highest priority and it cannot be formulated in a numerical form, it can be broke down into levels such as objectives which can be easily measured. Goals and objectives should be clearly illustrated and connected to the organization's role (Barney and Griffin, 1992, cited in Grunberg, 2004). The improvement program should be strongly linked to the performance goals and objectives. This connection helps in gathering all the contributors to work in the same route and all the organization's levels to understand it, which results in an easier allocation of all resources to the same goals and objectives (Grunberg, 2004). Figure 1 shows Triple P model demonstrating the relations of the terms performance, profitability, productivity, effectiveness and efficiency (Tangen, 2004).

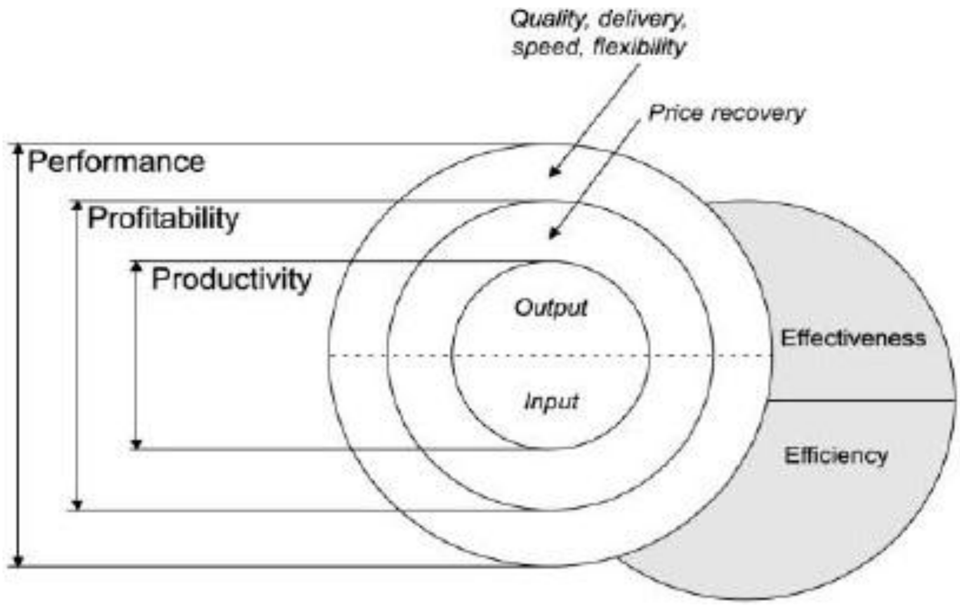

Figure 1: Triple P model (Tangen, 2004).

2.2 Construction Productivity Measurement

2.2.1 Task, Project, and Industry levels

As a result of the complexity of construction nature, construction productivity is needed to be measured at three levels: (1) task; (2) project; and (3) industry. Task level is concerned with the construction activities (e.g., steel reinforcement bars fixation or concrete pouring). Project level refers to the collection of all tasks needed for constructing a new building (e.g., the construction of new residential or office building) or the renovation of an old or current building. Industry represents the whole construction industry and the entire portfolio of projects (Huang et al., 2009). The measurement of the productivity for each level requires the improvement of both metrics (i.e., the most proper parameter that forms the foundation of calculation) and tools (i.e., identifies which construction discipline can achieve these metrics calculation). Metrics and tools will support the improvement of effective cost investment in productivity and also the life cycle construction processes, moreover, both tools will offer construction stakeholders with new measurements and evaluation abilities (Huang et al., 2009).

Stephen F. Weber and Barbara C. Lippiatt, 1983, cited in Huang et al. (2009) explained that the generic concept of construction productivity measures depends on the comparison of output of a task or project or industry with the production elements (input) needed to produce that output. Traditionally, productivity is usually generated from the ratio of output to one or more inputs, if one only input is used then it is single factor productivity measure as the output per labor hour, if all the inputs are used then it is multi factor productivity measure (Huang et al., 2009).

2.2.1.1 Task Level Productivity Measures

The usage of Task level metrics, are very common in construction industry, Most of task level metrics measurement concentrate on labor productivity and are often considered as single factor productivity measure (Huang et al., 2009). (R.S. Means, 2008, cited in Huang et al., 2009) explained task level metric measurements for task labor productivity in two ways: the first one is how much output will be produced by a crew of labors in an 8 hours normal day. In the first way, the denominator is the number of hours of the crew in a day and the numerator is amount of output, the higher output means higher task labor productivity with single factor productivity. In the second way, the output produced by a crew in an 8 hours normal day in addition to equipment, which the labors use, in this case it is multi factor productivity. The CII Benchmarking and Metrics Program show another metric measure for task labor productivity; it makes the output constant (e.g., cubic meters of cast in place concrete) and it tries to measure the amount of labor hours needed to produce the output. In this case, the denominator is constant output and the numerator is the amount of labor hours. The lower the labor hours means higher task labor productivity (Huang et al., 2009).

A study investigated task labor productivity measures for 200 construction activities in 22 years, they discovered that the average productivity increased. Moreover, the multi factor productivity increased for all segments except for the electrical work remained constant. Also Goodrum and Haas found a substantial long term productivity improvement in activities that had a dramatic change in equipment technology (i.e., hand tools and machinery) and also activities that had a noticeable change in material technology in terms of modularization, reduction in unit weight, or installation (Paul M. Goodrum, Carl T. Haas, and Robert W. Glover, 2002; Paul M. Goodrum and Carl T. Haas, 2002, cited in Huang et al., 2009).

2.2.1.2 Project Level Productivity Measures

Project level metrics measurement is much more complicated because it deals with a mix of tasks that constitutes a single project. It is very hard to unify the inputs and outputs for all the construction activities, (e.g., the input and output of a task of casting concrete is totally different than a task of steel reinforcement erection). Therefore, it is impossible to cumulate the individual raw task productivity metrics in project productivity metrics except in some modifications (Huang et al., 2009). The modifications which are required to use the project level productivity metrics, one of them is to use a reference data in order to determine the baseline value for each task. Moreover, information needed to know the task weight and how it is signifies to the overall project, information required to detect the task flows as some tasks are finished in parallel and the others are in sequence. The task flows aspects have an impact on the overall project productivity (Huang et al., 2009). Furthermore, Huang et al. (2009) demonstrated the project level productivity metrics elements as follow:

> Therefore, each component of the project productivity metric contains: (1) the task weight; (2) the raw task productivity baseline value in the denominator; (3) the raw task productivity value for that project in the numerator; and (4) a measure of the task mix (in parallel versus in series task flows). The project productivity index value is a function of the individual components (p, 35).

Another alteration for project level productivity index is an outcome of division two ratios, in each ration the numerator will be the value of construction put in place and the denominator will be the amount of work hours in site. The reference data is required also to put a baseline for the above mentioned ratio. Project level productivity index can be used to monitor the changes in the project productivity through the time. The project level productivity metrics helps in measuring how a single project can be compared to the overall average in the reference data, and it can be useful to assess and evaluate the worst or the best performing projects (Huang et al., 2009).

2.2.1.3 Industry Level Productivity Measures

In the industry level, the amount of output created by a unit of input can give an efficiency indicator for the industrial level measurement. The construction industry creates various types of products such as different types of buildings and infrastructures, for each product has a productivity measures, and it should be accumulated. The Bureau of Labor Statistics (BLS) conducted two common productivity measures, one of them is single factor labor productivity and the other is multifactor productivity. There are many reasons for increasing in labor productivity such as quality and the efforts of the labors, technology and increased capital utilization, however, the quality or the effort of the labor can remain the same (Huang et al., 2009). Huang et al. (2009) explained also that the increase in labor productivity leads to an increase in capital-labor ratio, which does not necessarily results in improving the quality of labors and their efforts. Therefore, they suggested that Multifactor productivity is more effective to use in measuring than labor productivity.

2.3 Approaches for Measuring Construction and Labor Productivity

There are several ways to measure productivity, the selection between them depends mainly on the purpose of the productivity measurement and the availability of data. Generally, the traditional concept for measuring productivity is the ratio of output to input. However, measuring productivity can be classified into two main broad approaches. The first one, single/partial factor productivity measures (PFP) and the second one is total/multi factor productivity measures (TFP) or (MFP) (OECD, 2001; Ying, 2004; Amanuel, 2016).

Total factor productivity (TFP) represents the measurement of output to a combination of input factors such as; labors, management, material, capital, technology and equipment's. The average weight of each input in the denominator reflects its share in the total expenditures. Shehata and El-Gohary (2012) presented the total factor productivity approach in an economical monetary aspect, as well as the department of Commerce, Congress, and other governmental agencies expressed TFP in equation 1.

Total factor productivity (TFP) =

$$\frac{\text{Total output}}{\text{Labor} + \text{Materials} + \text{Equipment} + \text{Energy} + \text{Capital}} \qquad (1a)$$

TFP =

$$\frac{\text{Dollars of output}}{\text{Dollars of input}} \qquad (1B)$$

It is suggested that TFP is commonly used in economic studies more than in construction industry (Palop, 2016; Shehata & El-Gohary, 2012). Moreover, equation 1 can be presented in another inverse form which can be used for estimating as equation 2, however, the first form (equation 1) is widely used in construction (Palop, 2016)

TFP =

$$\frac{\text{Dollars of input}}{\text{Dollars of outpu}} = \frac{\text{Labor} + \text{Equipment} + \text{Material} + \text{Capital}}{\text{Total output}} \qquad (2)$$

Ying (2004) explained Partial factor productivity as the relationship between output and a specific input or an incomplete partial combination shown in equation 3.

Partial factor productivity (PFP) =

$$\frac{\text{Total output}}{\text{Partial input}} \qquad (3)$$

Moreover, the concept of the incomplete combination of inputs agrees with the following equations conducted by Shehata and El-Gohary (2012). Shehata and El-Gohary (2012) provided a precise measurement for productivity that is used by governmental agencies for specific program planning and by the private sector for conceptual estimates on individual projects. Example for that is the design specialists use productivity measurement in the following form.

Productivity =

$$\frac{\text{Output}}{\text{Labor} + \text{Equipment} + \text{Materials}} = \frac{\text{Square feet}}{\text{Dollars}} \qquad (4)$$

Single factor productivity measures are mostly used in two approaches, the most famous is to measure construction labor productivity (CLP) and capital productivity. Amanuel (2016) defined capital productivity as the relation between output to a capital input. The term "capital" means a physical capital not as an economical aspect, it is the machines and equipment's, it is measured as a depreciated value, the capital input is the how much the equipment is consumed during the production of output related to wear and tear. The relation is illustrated in equation 5.

Capital productivity =

$$\frac{\text{Output}}{\text{Capital input}} \qquad (5)$$

For Construction labor productivity (CLP) (Thomas et al., 1990, cited in Shehata & El-Gohary, 2012) suggested that at the construction sites, contractors are focusing on measuring labor productivity in several ways presented in the following equations.

CLP =

$$\frac{\text{Output}}{\text{Labor cost}} \qquad (6)$$

Or CLP =

$$\frac{\text{Output}}{\text{Work} - \text{hour}} \qquad (7)$$

Shehata and El-Gohary (2012) added that some contractors prefer to use the inverse as there are no standard measurements and definitions for labor productivity. Equation 8 indicates that if the output increases on the denominator, this reflects a higher productivity and vice-versa and it is called unit rate.

CLP =

$$\frac{\text{Labor cost or Work} - \text{hours}}{\text{Output}} \qquad (8)$$

R.M.W. Horner and B.T. Talhouni, 1998, cited in Shehata & El-Gohary (2012) stated that The Construction Management Research Unit at Dundee University has other three methods for measuring labor productivity.

First way is: CLP =

$$\frac{\text{Output}}{\text{Total time}} \qquad (9)$$

"Where total time, is total paid time (p, 322)**"**.

Second way is: CLP =

$$\frac{\text{Output}}{\text{Available time}} \qquad (10)$$

"Where available time is total time minus unavoidable delays, principally meal breaks and (p, 322)**"**.

Third way is: CLP =

$$\frac{\text{Output}}{\text{Productive time}} \qquad (11)$$

"Where productive time is available time minus avoidable delays (p, 322)**"**.

CII Productivity Measurements Task Force, 1990, cited in Lorys (2018) introduced performance factor or productivity index as a ratio of planned productivity to actual productivity. Moreover, (Shehata & El-Gohary, 2012)referred that some contractors still depend on the concept of performance factor to measure productivity. Equation 12 shows the productivity represented by performance factor.

Performance factor =

$$\frac{\text{Estimated unit rate}}{\text{Actual unit rate}} \qquad (12)$$

The baseline productivity is another approach for measuring CLP was introduced by (Randolph H. Thomas, 2000, cited in Shehata & El-Gohary, 2012). Disruptions have a significant impact on the labor productivity, the productivity increases when the disruptions decreases or do not occur, this is called baseline productivity. Thomas suggested a sample of working days that includes 10% of the total work days, the n is the number of days which comprises the highest productivity, and this n represents the baseline subset. For the total daily productive, he calculated the average and this is the baseline productivity. However, W. Ibbs and Min Liu, 2005 did not agree with Thomas baseline's method because it is not a proof that a sample of 10% of the total work days can reflect the best performance or productivity for the contractor to accomplish and it also represents only 10% of the total project at the end.

Another approach is called cumulative productivity, which can be explained as the accumulation of the total work hours required to achieve an activity divided the total amount of output installed up till now. It is helpful to identify the rate of productivity of an activity and to evaluate task as a whole. Equation 13 shows this relation (Shehata & El-Gohary, 2012).

Cumulative productivity =

$$\frac{\text{Total work hours charged to a task}}{\text{Total quantity installed}} \qquad (13)$$

Dar Aliyah (2013) proposed another measurement for labor productivity by introducing Gross Value Added (GVA), if the GVA increases, while the denominator factors decreases or remains constant, but if the GVA is stable and the denominator factors increases, then the labor productivity mitigates. Equation 14 illustrates this relation.

Labor productivity =

$$\frac{\text{Real GVA}}{\text{Number of jobs} \times \text{Number of average hours worked}} \qquad (14)$$

2.4 Methods for Measuring Labor Productivity

Lema (1995) explained that Labor productivity standards can be produced throughout two techniques which are; accountancy based and engineering-based techniques. The accountancy based depends on the studying and breaking down the historical accounting data, in order to create the work hours required for a particular task, on the other hand, the engineering based depends on fragmenting the work processes into small sections to facilitate the analysis process for the time required to achieve these processes. On construction sites, there are four measurement methods for measuring labor which are; time study, activity sampling, craftsman questionnaire and foreman delay survey (Abo Mostafa , 2003).

2.4.1 Time Study

The time study was initially presented to improve productivity, and it was applied in the late of 19th and 20th centuries by Taylor and Gilbreth, it is considered to be one of the fundamental commonly used methods currently. Barnes (1980) discussed that It is an important method to detect the time needed for a qualified and trained person to perform a task at a normal speed, furthermore, Armstrong (1990) added that it can be the foundation for controlling and monitoring the human resources costs efficiently, and it helps in supplying standards and increasing productivity (Abo Mostafa , 2003).

Time study equipment

There are several equipments to measure and record the output such as; stop watch, study board, ready study sheets, calculator, tape for measuring, micrometer and so on. There are two types of stop watch for measuring the time consumed by a labor; small hand stop watch which records one revolution in 30 minutes, however it is not highly recommended as it can generate accumulative error when it stopped and work again after each revolution, the large stop watch is better to use, as it records one revolution in one minute and it consists of 100 minutes (Harris et al, 1995; Olomolaiye et al, 1998, cited in, Abo Mostafa , 2003).

Rating

The time taken by workers for performing a similar task is different, as a result, the time observer should put into consideration the variability of the time taken, and it would be essential to judge and evaluate personally on the effective rate of working. The study time observer should have a proper idea of the standard rating, which results from the experiences, efforts, training, skills and stability of the time study observer. Different factors affect the rating such as; effectiveness, which includes proper choice of tools, avoiding unnecessary activities, choosing the shortest distance while movement, organizing of tools and choosing the most effective methods, in addition to other factors as skills and speed (Harris et al, 1995; Olomolaiye et al, 1998, cited in, Abo Mostafa , 2003).

Basic time

It is the time required for a specific task to be accomplished, if this job was carried out at a standard rating, it can be computed as the following equation; The basic time for a task= (Observed time* Observed rating)/ Standard rating. (Pilcher, 1997, cited in, Abo Mostafa , 2003).

Relaxation allowances

It is necessary to calculate basic time for job but it is associated with some elements of relaxation that can be done by the labor, hence it affects the basic time such as; going to the toilet, fatigue and drinking water, as a result these allowances add a percentage for the basic time (Pilcher, 1997, cited in, Abo Mostafa , 2003).

Contingency allowance

Other additional time elements can be added to the basic time as a percentage as well such as; maintenance and adjustment of tools, shortage of materials, equipment break down, unforeseen weather and poor site conditions, design changes and training of labor himself (Harris et al, 1995, cited in, Abo Mostafa , 2003).

Standard time

It is the standard time needed to finish a specific task performed by a qualified labor at a standard rating. The standard rate can be explained as the summation of basic time, relaxation allowances and contingency allowance (Harris et al, 1995; Olomolaiye et al, 1998, cited in, Abo Mostafa , 2003).

Time study procedure

According to Barnes (1980) as cited in Abo Mostafa (2003), there are several procedures should be taken into account such as; (a) identifying the objective of the study and choosing the job that should be observed, (b) fragmenting the job into elements, (c) choosing the proper equipment that should be used, (d) preparing a sketch for the work area, (e) making sure that labors and foremen will accept to be observed, (f) recording details as much as possible about the job required to be observed.

There are some shortcoming and challenges that could hinder the utilization of time study method for measuring labor productivity (Olomolaiye et al, 1998, cited in, Abo Mostafa , 2003), these hinders are;

- The high cost associated for hiring many observers to manually record and observe many number of labors, as one observer will not be enough for undertaking time study for several labors.
- The data attained by the time study observer are covering only the own records and information he observed, which can be understood differently, and it may not include interrelations between elements and the causes for long and short time element times, hence it minimizes the accuracy of the work done.
- Relaxation allowances and contingency allowance will always exceed the basic time, as a result the variability of data will occur and the collection and gathering of data will not be accurate.

Shehata and El-Gohary (2012) added also that there are other common measurement methods used for measuring labor productivity also such as: motion analysis and group timing methods along with time study, activity sampling, and foreman delay surveys methods.

2.4.2 Activity Sampling

It is a technique, which is applied by undertaking a huge amount of instantaneous observations that are concerned to labors, equipments and activities in a particular time, each observation records the events that occur during that moment, hence, the percentage of observations carried out for a specific activity or a delay is considered to be the measurement of the percentage of the time for the activity or the delay. Activity sampling is a great method in order to detect the time consumed by labors and it helps to determine the causes of the delay, and it can help in improving productivity (Thomas et al, 1986, cited in, Abo Mostafa , 2003). Furthermore, one of the main benefits of activity sampling that it allows the integration of many elements during observations as large number of workers and machines to be observed and studied at one time, which is better than other methods which focus only on a particular group or element to be studied (Pilcher, 1997, cited in, Abo Mostafa , 2003).

Activity sampling method consists of two main facts; the first fact is that the working day comprises 3 main time elements, which are; productive, contributory and unproductive time. Productive time is the actual time consumed directly to install or add or to put a particular element in a process to generate the final output. Contributory time is the time consumed in elements that do not directly add value for the output, but it can associate or necessary for generating the output at the end. Unproductive time is the idle, waiting and wasted times which do not add any value for the output (Oglesby et al, 2002, cited in, Abo Mostafa , 2003). The second main fact for activity sampling is that it is related to statistics and theories of probabilities, because it relies on sampling, as a result, the occurrence of chances should be avoided, and it should be represented according to statistical rules (Abo Mostafa , 2003). In construction industry, it is acceptable to use 95% as confidence level with

±5 level of errors, and it was concluded also in construction, that 384 observations is the minimum amount of observations to be used, in order to provide expected results (Pilcher, 1997, cited in, Abo Mostafa , 2003).

According to Lema (1995) and Harris et al. (1995) cited in Abo Mostafa (2003), the activity sampling procedures are; (a) identifying the objective of the study and choosing the task that should be observed, (b) with respect to confidence and error levels, number of observations should be calculated, (c) determine the names of labors and the activities that should be studied, (d) prepare all the necessary paper sheets for recording the data, (e) Select a suitable position for taking observations.

2.4.3 Craftsman Questionnaire

It is a method to explore and determine the challenges that affect the productivity and motivation of labors negatively. Craftsmen are responsible for providing information about the area of losses, the importance of the problems that adverse productivity and trying to rank it, and also to provide solutions for these problems (Olomolaiye et al, 1998, cited in, Abo Mostafa , 2003). Oglesby et al. (2002) discussed the areas in which the questionnaire will be applied for each specific craft and activity such as; Materials management and availability, lack and availability of required tools, equipment availability and its break down, occurrence of rework and it is causes, interference of crews and if they are from the same craft or not, overcrowding in each crew, shortage in instructions and other necessary data, and finally inspections and if it is done at the right time or suffer from delays (Abo Mostafa , 2003).

There is another approach for craftsman questionnaire which is craftsman questionnaire sampling, it is a sample of labors, who have been chosen and then they will be surveyed according to the abovementioned areas covered. The method of activity sampling is quite similar to craftsman questionnaire sampling, in which the observer will choose labors and supervisors from the site in a random way, and then they will be asked if they participated in productive or contributory or unproductive works (Olomolaiye et al, 1998, cited in, Abo Mostafa , 2003).

2.4.4 Foreman Delay Surveys

It is a method in which the foremen present the productivity problems which occurs daily among the crew, it helps to determine the reasons of delay. The main objective of this method is to identify the issues of productivity and delays that are not in the scope of the foremen responsibilities (Olomolaiye et al, 1998; Oglesby et al, 2002, cited in, Abo Mostafa , 2003). It is commonly used method and simple, the foremen can finish it in short time, it helps to establish a relationship between causes of delay and the lost hours, so that it could provide a better knowledge for project managers to eradicate delay and find solutions for productivity problems (Alfeld, 1988, cited in, Abo Mostafa , 2003).

2.5 Challenges associated Measuring Productivity in Construction

Numbers of difficulties have been faced to measure productivity at the four levels; trade or task level, project level, company level and industry level. Challenges to measure the productivity at the project level rely mainly on the point that there is no similar constructed element, even if these constructed elements have the same soil and location condition, as a result, utilization the data to be a benchmarking will be difficult (SCAL & SCCCI, 2016).

At the trade level, the single construction project includes several amounts of different activities undertaken by several skilled labors, performed in several locations, and at different phases of the project itself. The single trade itself lasts for a specific portion of time among the life time span of the project besides the continuous complicated movement of labors to and from the site. Hence, it is challenging to calculate the time consumed by the labors to accomplish any single activity and all the assumed estimations will differ from one project to another (SCAL & SCCCI, 2016). At the industry level, the challenges depend mainly on the consensus of the output and input labor measurement, whether the output will be measured using gross output or the value-added, and the input labor will be measured using work hours for all labors, or only non-supervisory labor or number of employees only rather than number of hours. The following challenge for industry level measurement is how the reliability and accuracy of data gathered and how to agree for the method or the approach for measurement. Other important issue concerning industry level measurement is the different market conditions and prices, which affect the consistency and stability of data of construction output and input (SCAL & SCCCI, 2016).

There are many other issues when it comes to practical occurred in different countries to measure productivity such as; excessive paper works for measuring productivity, extra employees employed for measuring productivity, additional cost for measuring productivity of construction, shortage of a clear consistent definition for productivity in construction, shortage of direct benefits from measuring productivity and lack of knowledge for what exactly should be measured. Moreover, it is difficult to compare productivity data generated from different countries, companies and projects, due to the no consensus of productivity definitions, methods of measurement applied, and the surrounding condition where the activity has been performed (SCAL & SCCCI, 2016).

The construction activities are so varied and sometimes are interrelated, even each activity consists of different trades and tasks so that the activity to be finished at the end, and hence, it is difficult to unify and to produce a consistent construction metrics for the output data which will be reported, different metrics will be reported at the end. Different projects with different standards to measure productivity, therefore, complexity of construction metrics occurs, and so many construction managers decide which construction metrics to be used. As a result, construction metrics are not consistent, and cannot be standardized (Lorys, 2018).

2.6 Overview of Factors affecting Construction Labor Productivity in Existing Literatures

2.6.1 Introduction

There are a wide range of factors that affect construction labor productivity. Different researchers from all over the world have investigated and discussed these factors, several researches suggested and concluded the most critical factors and ranked these factors according to their relative important index (RII). Survey and interviews were the most typical methods for conducting these researches, these extensive studies were a helpful tool in order to attain the knowledge for detecting labor productivity factors and improving it, thus, it reflects better results on cost and time as an indicator of better project performance. The classification of these factors and categorizing it in groups was an essential duty to attain better understanding and managing those factors.

2.6.2 Factors affecting Labor Productivity

2.6.2.1 Material management

Hasan et al. (2018) did a comprehensive systematic review on the most common studies, which discuss the construction productivity factors published from 1986 to 2016, throughout 46 published works. They concluded that non-availability of materials have been cited the most among the 46 articles. Naoum (2015) and Hasan et al. (2018) considered the management of materials is as the one of the major universal concern that has been cited and affect labor productivity. Naoum (2015) in addition to Easeph and Maarof (2017) classified material management on site as a factor affecting labor productivity in a group of factors related to activities during construction stage. While Lorys (2018) categorized the lack of materials under the group of labor related factors.

Abdul Kadir et al. (2005) classified the lack of materials as most critical factor, it occurs due to the obstructions as trash during the access or the movement of it, the huge time for delivering it causes the labors to be idle waiting for it. Moreover, the construction activities are inter-reliant, the lack of critical materials have a great impact on the workflow and sequence of activities. The shortage of materials arises from negligence of project managers, lack of proper planning for its availability and sometimes the damages that happen during storage. Additionally, the shortage of spaces in some construction sites result in multiple handling because materials might be delivered earlier, therefore generates loss of man-hours (Abdul Kadir et al., 2005).

Several researchers stated that the lack or non-availability of material on site is the most crucial influential factor among all the other factors, it was concluded after different surveys with different practitioners of construction industry (Zakeri et al.,1996; Makulsawatudom et al.,2004; Kaming et al.,1997).

Moreover, Ng et al.(2004) concluded that the material availability was considered the top ranked factor for time loss in different projects generated from different surveys. There are several causes for the shortage of materials discussed in the former studies such as; (1) waste due to negligence and sabotage. (2) On site mobilization and transportation challenges as distribution of materials and site congestion makes difficulties in movement in general and between labors, and difficulties in distribution of materials in high rise buildings especially in populated density areas. (3) Inappropriate material handling and storage, in which some companies use advanced equipment to handle it and others do not. (4) Shortage of material storages. (5) Inappropriate usage of materials according to specifications. (6) Inefficient work plan or non-adequate preplanning by site managers or foremen causes delay as consuming materials in non-critical activities. (7) Delay of payment, issues of procurement and contractors financial problems, they have difficulties to provide required material to site, hence it affect the sequence of work flow and causes loss in productivity. (8) Improper coordination between site and office. (10) Changes in design by vendors cause disruption in the deliverance of the material quickly, there is no sufficient time for management to order the required materials and also challenges associated when vendors supply the non-required materials or damaged or the materials that exceed the allowable tolerance. (11) The high demand for materials, shortage of materials and the variation of the material prices in market (12) Excessive paperwork for materials requisition. (13) Improper sorting, distribution and marking the materials. (Ng et al., 2004; Zakeri et al.,1996; Makulsawatudom et al.,2004; Kaming et al.,1997).

Kaming et al (1997) stated that material cost is the highest constituent of overall construction costs for high rise buildings in Indonesia with 65%, because of the difficulties of allocation and distribution of materials in populated density areas where there are insufficient storage areas, so the contractors should consider the management of materials as a high priority. Kazaz et al.(2008) referred that lack of materials causes idle times and costs overrun, because the labors will not consume the available supplies and they will decrease their output, waiting for the availability of materials.

2.6.2.2 Equipment and tools management

Productivity increases with the efficient and effective usage of tools and equipment, however, a crucial effect can happen, it was estimated that 4.6 hour lost per operative per week due to the shortage of proper tools and equipment, thus resulting in productivity loss (Zakeri et al.,1996). This agrees with Klanac and Nelson (2004), they explained that if the proper tools and equipments are not available on site, contractor will struggle from productivity loss due to his responsibility for tools and equipments management. Similarly, Lorys (2018) categorized the lack of tools and equipment under the group of labor related factors. Naoum (2015) classified equipment and tools management on site as a factor affecting labor productivity in a group of factors related to activities during construction stage.

Many significant causes associated to the management of tools and equipment that result in productivity loss such as; non-availability and non-sufficient required equipment and tools on site, continuous use of outdated and old construction equipment, lack of spare parts, shortage of knowledge to maintain the equipment resulting in inefficient utilization of it, damages occur while operating it, loose usage of equipment, some project managers over-rate the ability of a specific equipment, ignoring to provide the site with other important machines leading to non-adequate number of machinery. These causes increase the idle time significantly as in the case of non-availability of materials, in which labors anticipate for it. (Abdul Kadir et al, 2005; Zakeri et al.,1996; Makulsawatudom et al.,2004).

Naoum (2015) added that productivity is hugely affected by the management policy and regulations of the firm in terms of choosing the type and the number of plants and machines, also the policy of maintenance and the replacement of these equipments is an important decision strategy for the company. Alinaitwe et al. (2007) discussed that the available tools on site are usually supplied to the full time labors, however, casual temporary labors take substandard inefficient tools, and thus it is important to enhance the tools availability to increase productivity. Ng et al. (2004) mentioned that insufficient tools, stealing of tools, lost tools, broken tools and the waiting time to replace the stolen or damaged tools are some causes for productivity loss.

(Goodrum and Haas, 2004 cited in, Naoum, 2015) discovered that construction activities associated with technology of equipments had a remarkable labor productivity improvement more than activities which did not implement technology of equipments, however, there is a cost accompanied with adopting technology. It is very important recently to implement new techniques, innovation and technology in order to improve the productivity, also clients force and encourage the construction organizations to adopt of innovation in order to mitigate cost and decrease the delays especially in the big construction companies. Moreover, it maintains the sustainable development of the construction industry and increases the cooperation between the private and public sectors (Naoum, 2015). Yi and Chan (2014) mentioned that technology of materials and information has a positive impact on construction labor productivity. (Baldwin 1990 cited in Naoum, 2015) explained that **"**Rapid mechanization within the industry has resulted in increasing productivity by the introduction of structural steel, system form work, pre-casting techniques, prefabrication and component manufacture, but the construction industry requires more innovation to remain competitive among other sectors.**"**(p, 410).

2.6.2.3 Lack of proper Supervision

According to Hasan (2018), lack of proper supervision is considered to be the second most influential factor after Lack of material affecting construction labor productivity. Enshassi et al. (2007) suggested that delay of inspection and Supervisors’ absenteeism are among the factors under supervision group. For inspection delay, it leads to disruption of the sequence activities and contributes in the overall schedule delay, it is well known that the contractor cannot pour concrete unless the formwork and steel work are inspected. And for Supervisors' absenteeism, it results in delay or postponing the inspection of the work that has already done on site and ready to be inspected, thus it delays the start of the new successor activity. Moreover, the activities which require the attendance of supervisors will be stopped, as pouring concrete and backfilling (Enshassi et al., 2007).

Ng et al. (2004) claimed that inexperienced, incompetent and unskilled supervisors can affect negatively the productivity on site and generates a huge time waste, because as a result of knowledge shortage and failure to check and determine the conflicts and technical aspects in drawings, supervisors are not able to provide quick decisions for craftsmen and labors and deliver the issues to the engineers to solve it (Ng et al., 2004). Kazaz et al. (2008) investigated that the capability of controlling and managing the labors of subcontractor is difficult than the management of the engaged or employed labors within the general contractor. The size and the area of the site has a relation to the number of site engineers and supervisors, they also proposed that the long existence of many supervisors on site close to labors may adverse the overall efficiency because labors feel stressed and embarrassed and they cannot work freely (Kazaz et al., 2008).

2.6.2.4 Labor related factors

It is well known that the construction industry is a labor oriented industry, it highly depends on the skills and experiences of both labors and supervisors on construction sites. As a result, recruitment of skilled experienced labors and supervisors encounter big challenges in some countries. Alinaitwe et al. (2007) concluded that lack of labor skills to be the second ranked factor affecting labor productivity in their study. They explained that lack of labor skills has a great impact on construction productivity, it affects the cost, time and the quality of the work. In addition to, in New Zealand, the level of skills and experiences for labors have been ranked the most effective sub-factors under the workforce broad category of on-site labor productivity constraints (Durdyev & Mbachu, 2011).

In some countries as Palestine and Singapore, the shortage of a huge amount of local skilled and experienced labors, thus, most of the construction companies will hire low skilled and inexperienced foreign labors and staff, which strongly affect productivity (Mahamid, 2013; Lim & Alum, 1995). Moreover, in Malaysia, Construction industry has a severe problem with the absence of local skilled experienced labors, as labors prefer to work in more profitable and comfortable environments as manufacturing and services sectors (Abdul Kadir et al., 2005). Kaming et al.(1997) pointed that in Indonesia, most of construction workers are originally farmers from remote areas, with low skills, low experiences and low wage, and this has a negative impact on productivity. Alwi (2003) showed that in developing countries, the young labors start their career as unskilled and inexperienced, and then they become skilled or semiskilled labors, they learnt through skills through trial and error on sites. Moreover, most of labors highly depend on the instruction of supervisors and foremen in order to check their work performed, most of labors do not have the ability to understand site drawing, and they rely on supervisors and foremen. That's why, client, contractors and construction practitioners face challenges to recruit skilled and trained labors, because labors are usually trained in officially by the master craftsman on site and not in an official training institute. There is a huge shortage of training institutes in developing countries (Alwi, 2003). This agrees with 86 % of labors have been trained by their senior craftsmen Kaming et al. (1997) and 95% also have been trained on site in Iran (Zakeri et al., 1996). Some local or international construction companies have a negative motivation for training labors because of the huge amount of work and its variability and economic condition (Jarkas et al., 2012; El-Gohary and Aziz, 2014 cited in Hasan et al., 2018).

Labor markets conditions are always have been considered the responsibility of the contractor. If a great change arises in the local labor market, the contractor is required to employ not qualified labor, which leads to productivity loss. If the wage for labors is high, the contractor is free to hire skilled labor that can meet his required expectations (Klanac & Nelson, 2004). The following labor market conditions are; **"**(1) size and the skills of local labor pool. (2) Union versus nonunion labor rules. (3) Rewards and wages. (4) Craft turnover and absenteeism. (5) Cultural aspects such as; holidays and religious events. (6) Abuse of drugs and alcohol**"** (Klanac & Nelson, 2004, p, 227).

Turnover is another challenging issue for labor productivity in many countries, (CII RT-252, 2013 cited in, Lorys, 2018) explained that turnover was underrated factor to affect productivity, however, it become a considerable factor and it is defined as a process of hiring and terminating employees and workers. Another study was conducted by Nicholls and Eady (2011) to show the significant effect of the cost of workforce turnover on productivity in China and Singapore, and they suggested that the stable and safe work environment in addition to stable and enough wages are reasons for preventing turnover and terminating workers. Gundecha (2012) discussed that the absence of one labor working among a crew, will affect the overall productivity rate of the crew, because the remaining crew will work without less crew members. Zakeri et al. (1996) mentioned that the reasons for absenteeism are inevitable absences such as illness or it can be on purpose, as the labors tend to search for another profitable work. Other reasons for absenteeism are also excessive overtime or pressure or boredom at work. Absenteeism can affect productivity and generate losses, it was concluded that from 0 to 5 percent absenteeism, it does not affect labor productivity, while from 6 percent to 10 percent causes a significant loss in labor productivity with roughly 24 percent (Hanna, Menches, Sullivan, & Sargent, 2005 cited in Lorys, 2018). (Heizer and Render, 1990, cited in Gundecha, 2012) showed that misunderstanding between labors about their roles, duties and borders can create loss in productivity, moreover, labor age can decrease productivity as well, because the physical abilities of the labor will be minimized by the time.

2.6.2.5 Design, procurement and buildability related factors

The issue of incomplete design and drawings has been addressed in several researches. It is well recognized that design errors, problems associated with design processes are one of the major roles for productivity loss, delay and rework in construction sites. Naoum (2015) put design and procurement methods as a factor under the group Factors related to pre-construction activities, similarly, Easeph and Maarof (2017) put design management factor under the group Impacting Factors in preconstruction Stage. Moreover, Naoum (2015) concluded that delay caused by design error and variation orders factor is the second most influential factor in his study, as well as, Dai et al. (2007) in which they ranked engineering drawing management as the second most significant factor in their work study.

Many craft workers complained about the slow reply and reaction from engineering department regarding drawing errors and issues, they believed that these errors can be minimized through a design orientation for foremen before the construction phase (Dai et al., 2007). There are several causes for incomplete design that produces a substantial productivity loss on site such as; impractical design in which it cannot be executed on site, inadequate drawing details provided by the designer, inexperienced and unskilled draftsmen who can make mistakes during performing the drawings and lack of time for them, lack of checking the approved drawings as it sometimes introduced to site with errors and without checking and in ability to completely check and survey the site (Hughes & Thorpe, 2014). Makulsawatudom et al (2004) added that the revision and the clarification of drawings and specifications causes a dramatic delay on sites, in this study, the incomplete design ranked the second factor also. They claimed that the main reason for the incomplete drawings is because the client seeks to accelerate the bidding process, as a result, client forces the designers to have a constrained limited time and funds. Consequently, the drawings suffer from errors and in complete and impractical and full of clashes (Makulsawatudom et al., 2004). The delay of drawings issuance by consultants is another critical factor which contributes in the issue of incomplete drawings provided for site workers, thus it results in idle of workers, and it produces loss of man-hours. It refers to a poor coordination between consultant team (Abdul Kadir et al., 2005).

The design process has become more sophisticated, complex and many design details should be introduced in drawings, therefore, the final design output became in efficient and inadequate to be built. This affects the productivity rate. However, productivity can be improved through design practicality and constructability, mechanization and prefabrication. Moreover, the encouragement for integration of design and construction, and the merge of contractor's experiences in the pre-construction phase, especially in the design process could increase the overall productivity during the construction phase (Naoum, 2015). A study was conducted to illustrate the high effect of incomplete design to the expected cost during the construction stage, this study was done by COAA Construction Owners Association of Alberta (2009). It was concluded that if the design is more completed before the commencement of the construction works, the cost growth of construction phase will decrease, it was found the optimum value between 60 to 70 % of complete design, after that the cost will start to increase again. Figure 2 shows the relation between the design completed and cost.

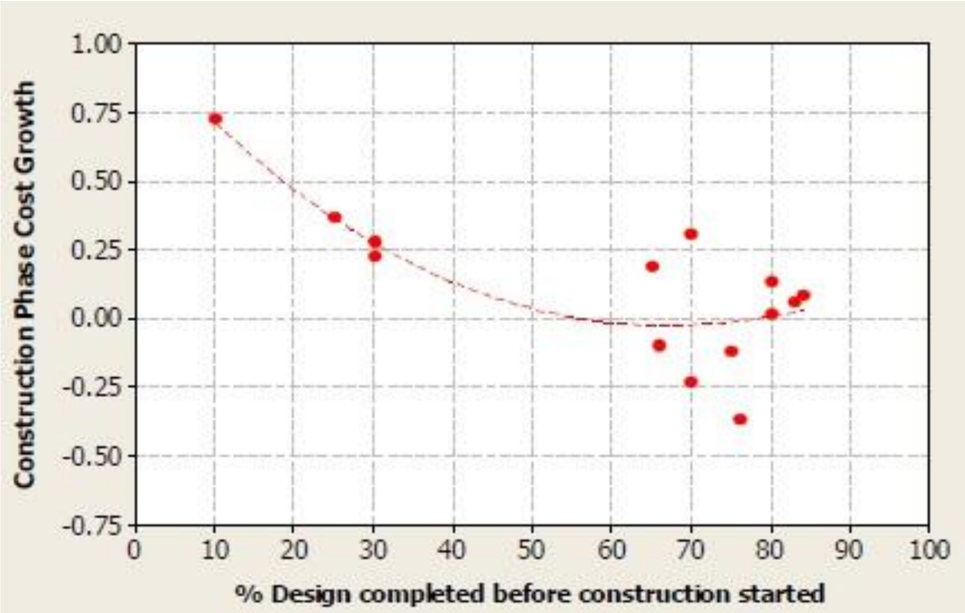

Figure 2: Percentage of design completed before construction starts (COAA Construction Owners Association of Alberta, 2009).

Types of contract schemes between owner and contractor can have an impact on the outcome and the performance of the projects. In the past, the lump-sum contract was common, in which the contractor is required to complete the project within the time and budget frame stated in the contract. In lump-sum scheme, the owner pays a fixed price to the contractor, however, any unexpected or unforeseen risk, which is not documented in the original contract, the contractor will bear the risk for it. However, it can be an advantage for the contractor and disadvantage when the contractor cannot cover it's cost. Other type of contract, which is cost-reimbursable contract, contractor can cover it's cost on a regular basis and paid according to his progress. As a result, the risk will be distributed between owner and contractor in cost reimbursable more than the lump-sum scheme, thus the performance, outcome and productivity of the contractor will increase because the owner will have more control. Recently, owners are promoting the design-build /EPC contractors, EPC refers to engineering procurement and construction, in order to implement the approaches of sustainability in the design, procurement and construction phases.

Moreover, the owner wants to be assured that their cost was spent in reasonable way or not (Galloway, 2009).

Naoum (2015) indicated that the huge transformation in the types of contracts from traditional ones to new methods of procurement was a big step to improve the cooperation and relationship between building team and improve the supply chain management process. He added that, several studies support the non-traditional schemes of contracts as design and build, management contracting and partnering, hence, it would improve management, coordination and logistics (Naoum, 2015). Loosemore (2014) conducted a study to highlight the perspective of subcontractors for improving productivity. He concluded that, supply chain management has a big responsibility towards improving productivity, he suggested also promoting collaboration and mandatory strong relationship between sub-contractors and the general contractor. Also, he encouraged subcontractor to communicate earlier with the principal contractor and it is important for sub-contractor to involve earlier in the design phase to share new ideas and increase productivity (Loosemore, 2014).

Buildability concept has several definitions, in USA, it is known as constructability, it can be defined as the ideal integration and utilization of all construction information and experiences in planning, procurement, design and execution on site, in order to accomplish the planned goals (Easeph & Maarof, 2017). Mydin et al. (2011) indicated that, if the buildability is considered appropriately in the design phase, the design outcome will meet all the standards that have been planned for. The design team is responsible for the implementation of the buildability into the design. This can be achieved by changing some features of design such as; respecting the dimension tolerance of an element, changing in the structure of some elements because it suffers from congestion of steel rebar. Furthermore, they suggested that if the constructability is adopted, the outcome will meet the expectations of the owner in terms of reasonable low cost and good quality of the constructed building. As a result, they explained that buildability attributes should be implemented and integrated from the early first stage of the whole building lifecycle, in order to meet the project objectives and reasonable cost for the client (Mydin et al., 2011). Figure 3 represents the buildability contribution framework.

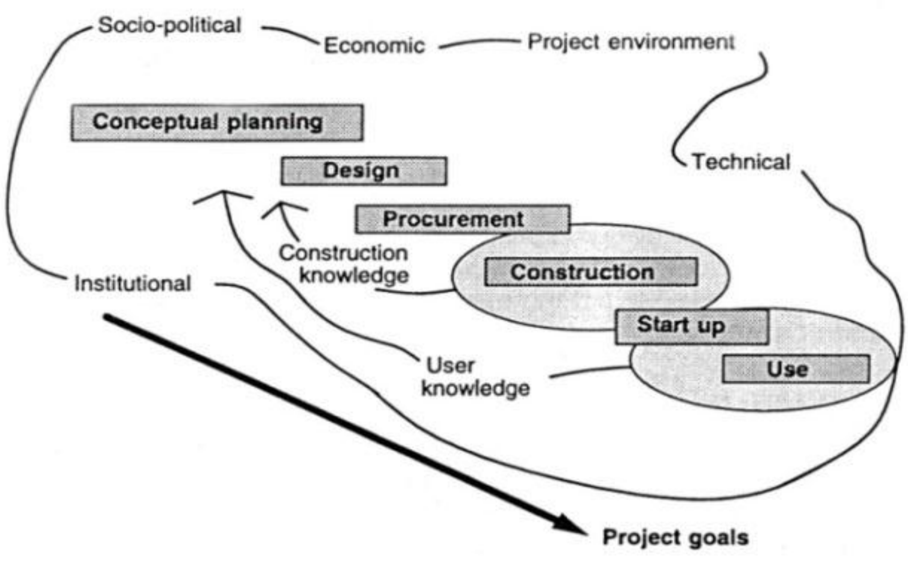

Figure 3: Buildability contribution framework (Mydin et al., 2011).

Mydin et al. (2011) discussed several buildability attributes such as; (1) the importance of method of construction which agrees with (Jarkas, 2012 cited in, Naoum, 2015)), he explained that method of construction is an important attribute in which there are 4 major factors affecting the casting process as; workability, steel bars congestion, height of the casted element to the ground, volume of pours. (2) Increase prefabricated elements as precast toilets and kitchens, it could minimize the wet activities on site. (3) Increase the standardization by repeating axes, modules and sizes of the elements, thus it will decrease learning time for site team, cost and increase productivity. (4) increase simple detailing as much as possible, in order to decrease the learning time for the site team, suggested mock-up for the complicated details to easily predict the problems before executing. (5) Increase the flexibility of the components, through the compatibility and the adaptability of elements in case of changes based on actual site conditions (Mydin et al., 2011).

2.6.2.6 Project management related factors

Project planners, project managers and construction managers create several expectations and prediction regarding the planning of construction activities, allocation of resources, compatibility of methods of constructions and the condition of the completed activities during the execution phase, they do not consider the pre-construction planning before the commencement of the activities on site, as a result, it can affect the productivity of labor during the execution phase such as; delay, rework and increases the cost (Naoum, 2015). This agrees with study conducted by Doloi (2008). He concluded that pre-planning and programming before the construction starts as the most crucial factor affecting labor productivity. He indicated that pre-planning includes scheduling for manpower and physical resources that will occur during execution phase, scheduling the activities, site planning and expected cash flow. However, he claimed that preplanning is difficult to achieve, due to the constrained time provided to contractor after the tender phase and before the construction phase, the contractor will not be able to gather the required resources in a short time (Doloi, 2008).

It is expected that overtime arises when there are many delays in an early time of the project, overtime believed to be a result for schedule compression, the way to shorten the duration of the successor activities, in order to minimize the disruption and to finish on time. As a result, the contractor will try to add more labor man hours to complete the assigned task within the time frame and with respect to the compressed schedule. This causes high productivity loss, due to the lack of materials, tools and equipment for the extra hours, moreover, it leads to challenges in coordinating and planning the tasks, and the shortage of experienced labors (National Electrical Contractors Association, 1983, cited in Gundecha, 2012).
(Awad, Sullivan, & Taylor, 2005, cited in Lorys, 2018) emphasized that acceleration of schedule creates a high productivity loss, it resulted from several reasons such as; (1) Additional workers, (2) overtime, (3) Additional shifts. They highlighted that these reasons will increase the overall cost strongly. They also explained that non-constrained schedule will have a positive impact on the allocation of resources, as it will be more stable and gradually allocated over the whole project. Figure 4 illustrates the influence of overtime and additional shifts on the labor man-hour outputs.

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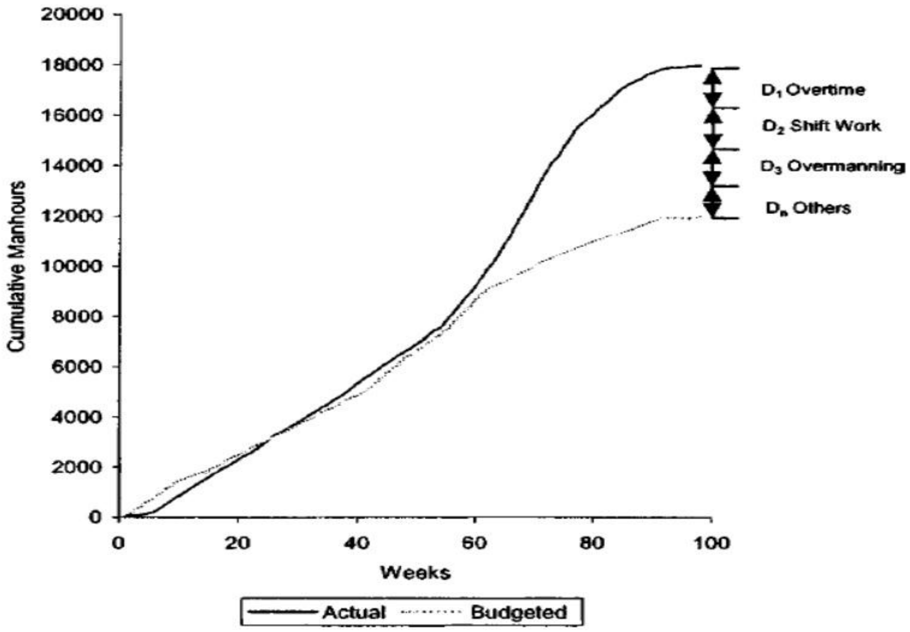


Figure 4: Relation between cumulative man-hours with overtime and shift (Awad, Sullivan, & Taylor, 2005, cited in Lorys, 2018).

Additional shift works is another way to compensate the delay and disruption occurred in the early project time, it appears when the fast track and compressed schedules are implemented. (Hanna, Chang, T., & Lackney, 2008, cited in Lorys, 2018) defined shift works as additional man-hours done by another group to complete a specific task, if the first group could not complete it. (Awad S., Chul-Ki, Kenneth T., & Jeffery A., 2008, cited in Lorys, 2018) detected that night shift causes high cost due to additional security, administration, management and proper lighting during night. Moreover, the labor cannot adapt the night shift easily, it requires from 10 to 12 days to adapt. The Business Roundtable (1983) indicated an interesting aspects about over-time and it's impact on productivity. The study showed that scheduled overtime generates a great decline in the productivity in the first week, however, at the end of the first week, it starts to improve again. The productivity within the second and third week is steady and improves slightly, and then it starts to drop down again significantly. Figure 5 illustrates the impact of overtime on productivity (The Business Roundtable, 1980, cited in Lorys, 2018).

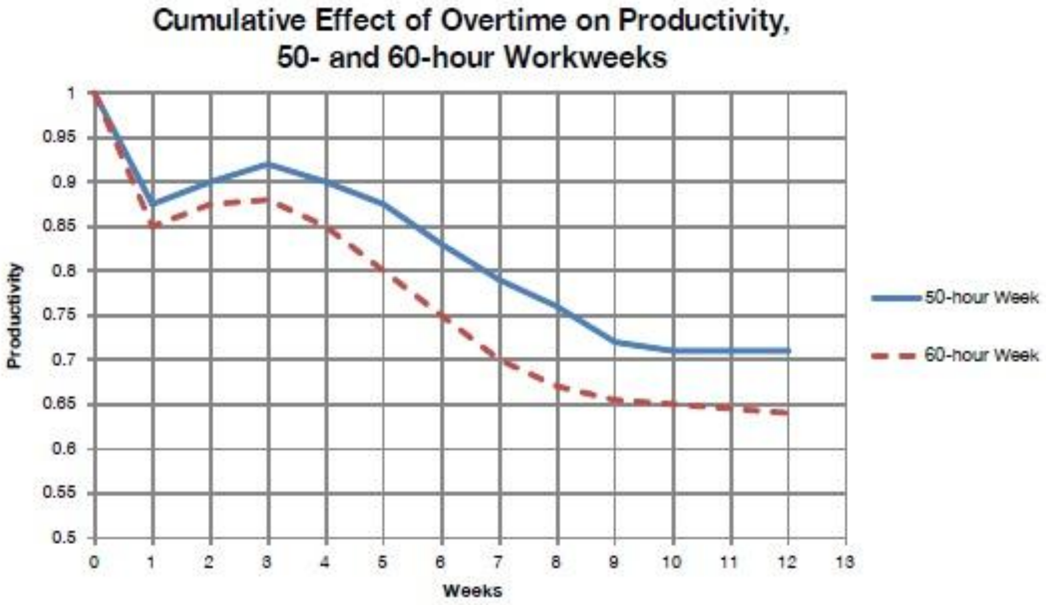


Figure 5: Cumulative effect of overtime on productivity (The Business Roundtable, 1980, cited in Lorys, 2018).

2.6.2.7 Construction site management and layout

Site congestion and overcrowding issues are almost generated as a result of improper site management and poor layout. Overcrowding creates a disruption and obstacles to achieve the required productivity on construction sites due to, the poor planning for site activities leads to overcrowding of workers, hence affecting productivity rate of labors (Naoum, 2015). Interference between labors can be produced if several labors work on a specific task in a confined space area or when various construction trades are performing their tasks in the same work area. Thus, site congestion and overcrowded issues occurs, due to the improper planning and management on site. More adequate space for each worker is needed to perform his task without interruption with other worker or another trade crew (Gundecha, 2012). Smith 1987 proposed that the density should not exceed one labor per 30 meters squared, moreover, 40 percent productivity loss will be achieved if the working space area declines from 30 meters squared to 10 meters squared (Naoum, 2015).

Poor site layout contributes in minimizing productivity of labors, it refers to the distribution and location of tools, facilities and storages, in which affect directly on labors productivity and workflow, therefore, it has an impact on time and cost (Kazaz et al., 2008). This agrees with Klanac anf Nelson (2004), they explained that poor site conditions can have a negative impact on labor productivity such as; the access of site and it's distance from the labor residency, overcrowding of labors and safety restrictions. Several issues lead obstruction to productivity and are related to poor site conditions such as; lack of material storages and it's far distance from the workplace, inadequate of material storages size, lack of temporary facilities, shortage of weather protection and improper mobilization of vehicles (Dai et al., 2007).

2.6.2.8 Management and leadership skills

Naoum (2015) pointed that the factor of success and failure in any construction project dramatically depends on the efficient and effective management of construction resources and leadership style. He also indicated that, there are two aspects that significantly affect the productivity, which are; management skills and proper management and allocation of manpower, he believed that managerial and leadership styles are considered to be the most influential outlines that cover most of the factor argued in his study. Moreover, contractual schemes of the project and leader of the staff can highly affect the productivity and performance of all disciplines of the project (Naoum, 2015).

The Charismatic and participative leadership can create satisfaction among the team members. The successful design team leaders should be a high role model for other team members and provides them a sufficient area to innovate and contribute in the design phase (Cheung et al., 2001). Gundecha (2012) discussed that, even though technology implemented and labor training, productivity can be affected because of low managerial skills. Management skills and knowledge can help labors to work efficiently with the latest technology. Moreover, professional and intelligent managers can earn high productivity from mediocre workers.

2.6.2.9 Change orders and changes of project scope

Changes of the project scope have a strong correlation with the decline of project performance and labor productivity. Variation in work flow can be a result from changing of project scope. Liu et al. (2011) discussed the relationship between workflow variation and labor productivity. They investigated in the relationship between percent plan complete (PPC), which is the ratio of total task completion to planned tasks and labor productivity. They concluded that labor productivity is not highly affected with high performance of PPC, but it is strongly improved with the non-variability of work flow, thus it is recommended to keep work flow expectable (Liu et al., 2011). Ibbs (2012) demonstrated that changes are mostly addition or removal to the scope of project, which results in rework, delay, interruption, postponing or even acceleration of schedule. Hence, direct labor cost and overhead will increase and decline in labor productivity, consequently, decreasing the profitability of the contractor. He added also, that changes in contract will be reflected on the price or the time of contract. Moreover, any change performed by the owner, the consequences cost and schedule effects are merged in the original contract under change orders (CO). As a result, adjustment can be performed according to the contract, however, owners and contractors have always disputes regarding CO processes.

Hasan et al. (2018) mentioned that CO occurs due to the owner requests for changes, and usually the contractor has no responsible for it. It results from, low participation of owner in design process, design errors or even sudden change of opinion by the owner. Alwi (2003) discussed that change of orders can be resulted from, material acquisition and other unexpected situations such as legal requirements. Moreover, design changes may exist in architectural, structural, mechanical, electrical, and plumbing or any construction discipline. Zakeri et al. (1996) explained that, CO elongate the construction time frame, lead to disappointment of operators due to the lack of progress and the elimination of the completed work, workflow variation, overtime, rework and destroying workers motivations. It was concluded that change work, rework and disruption have a high impact on labor productivity, with daily loss in efficiency from 25-50% (Thomas & Napolitan, 1995).

2.6.2.10 Rework

Rework was extensively investigated in several existing literature, as one of the critical factors that adverse the construction labor productivity. Mahamid (2013) ranked rework, as the most critical factor among overall factors which affecting labor productivity in his study. He defined rework, as the needless work of second performing and repeating an activity or a task that has been wrongly executed, so that it could meet the original required specification (Mahamid, 2013).

There are several causes for rework mentioned in various studies such as; lack of labor skills, incompetent supervisors and craftsmen; in which lack of knowledge for drawings regarding craftsmen and inefficient supervision skills related to supervisors causes rework. Other causes, as incomplete drawings and design errors, poor planning, poor quality of materials, a lot of change orders, construction errors and omissions, improper coordination and communication, complexity of design and overtime work. (Makulsawatudom et al., 2004; Hughes & Thorpe, 2014; Mahamid, 2013; Hasan et al., 2018).

Ng et al. (2004) and Kazaz et al. (2008) agreed that rework is considered to be a demotivating factor for most of workers. Since labors have much pride to perform and redo work again which was already done by their hands and it is completely disappointing and dissatisfying for them. This can reflect on their productivity and performance. Zakeri et al. (1996) argued that the main reason for rework is the poor workmanship which is poor instruction, supervision and control. Furthermore, they indicated that high amount of revisions and change orders; which is produced from shortage of a particular material in the market or change by heart from the owner, in addition to, errors and incomplete design.

Rivas et al., 2011 cited in Hasan et al. (2018) concluded that major reasons for rework are change orders done by owners and design errors, however, only 20 percent of rework generated from misunderstanding and site errors. A study conducted by Love and Li (2000) illustrated the effect of rework on the cost of the construction projects, they added that a change in construction methods to enhance buildability, changes in design and omissions are major reasons for rework. They concluded that total cost of rework for two case study projects with different contractual schemes, as a result of design and construction issues accounted for 3.15 and 2.40 % of the total cost.

2.6.2.11 Poor communication

In order to improve productivity on site, it is believed that proper communications between construction parties is inevitable. Labors feel comfortable if there is a non-variable and clear flow of information from middle and top management. Proper flow of information between labors, proper knowledge for site changes, appropriate employing of qualified employees with respect to the required assigned tasks, lead to productivity improvement (Choudry, 2017). Lack of communication and cooperation between construction members such as; client, contractor, sub-contractor, consultant and suppliers lead to several challenges and difficulties. It is recommended that all members should involve in the early stage of the project. Poor communication leads to delay in decision making, design changes, lack of resources, misunderstanding and rework. This factor was ranked the second most influential factor in the study of Mahamid (2013). It is highly suggested that documentation is mandatory over the verbal unofficial communication, in order to minimize improper communication (Makulsawatudom et al., 2004).

Poor precise instructions, in accurate drawings, illiteracy among labors, lack of technical training for labors, verbal communication, and communication challenges due to shortage of regular meetings between client, contractor and consultant were factors found for poor communication (Alinaitwe et al., 2007). Different languages and traditions among labors because of foreign labors on site, Non considering and respecting productivity improvement of the labors, shortage of the big image between labors for the project, shortage of communication between site management are attributes of poor communication (Dai et al., 2007).

2.6.2.12 Weather conditions

Weather conditions have been addressed to be a considerable important contributor in productivity loss in several previous studies. Construction activities exist in an open outdoor environment, as a result, heat, cold, high wind, high humidity and rain are external factors have an impact on site condition and productivity of labors (Soham & Rajiv, 2013; Ghoddousi & Hosseini, 2012). Zakeri et al. (1996) explained that extreme rainfall and bad weather conditions lead to a huge amount cost to many construction projects in Iran every year. In Gulf countries, Gulf Cooperation Council (GCC) enacts a break in the middle of a working day on construction sites, in case if the temperature exceeds 50°C and if the humidity exceeds 90 percent, in which it is usually associated with heavy wind and sandstorms (Jarkas et al., 2012, 2015, cited in Hasan et al., 2018).

2.7 Distribution of Time spent for a Construction Operation

In 1982, Drewin investigated the different activities which are associated in the construction operation, furthermore, Drewin explored the reasons that formed the total time of the construction operation. Drewin classified the total time of an operation in to two main categories; Total work content and Total ineffective time. Total work content included; (A) the basic work content, it is the quantity of work performed with respect to total man hours and/or equipment hours, which is undertaken in the premium conditions without any kind of disruption and anything that interrupts the flow of work. Nevertheless, the actual operation time is often associated with adverse additional elements such as; unforeseen conditions and weather (B), improper design and incomplete drawing (C), Improper construction methods and poor site layout (D), Lack of material and equipment management (E) and issues of labor behavior and attitudes (F). Drewin suggested that in order to achieve productivity and improve it, the total time of an operation should be limited only to A+B only. Figure 6 shows the construction operation time elements from the view point of Drewin (Ying, 2004).

However, some researchers introduced the construction operation in terms of value-adding. They classified the operation into value adding and non-value-adding activities. Value added activities refers to accomplishing the customer's requirement through transforming all the required input to produce the necessary output, While non-value-added activities refers to activities that consume money more than planned budget, time and resources without contributing to add value at the end, it is also called waste, this it does not fulfill the customer requirement and satisfaction (Ying, 2004). Furthermore, non-value-adding activities comprises in to contributory activities and unproductive activities. Contributory activities are not directly adding a value to the final output, but it can facilitate, participate and frequently are necessary to perform an operation such as; handling and storing of materials, cleaning work spaces, checking drawings and organizing the site. Unproductive activities are not necessary and do not even participate in undertaking an operation, it could generate wastes and increases cost, it can be eliminated from the process and it does not have any impact on the value of the output such as; idle, waiting for materials, walking empty handed, rework, and omission (Olomolaiye et al., 1998, cite in Ying, 2004).

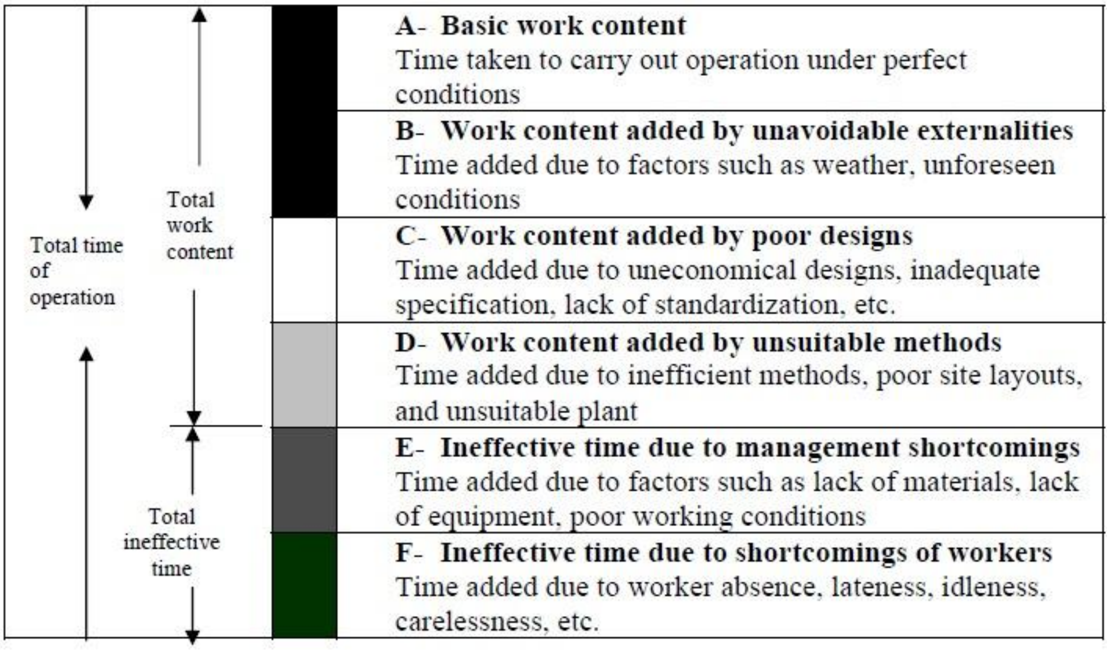


Figure 6: Construction operation time elements (Drewin, 1982, cited in, Ying, 2004).

A study conducted by Christian and Hachey (1995) on seven construction sites to analyze the working time for operations. They concluded that, around 46% accounted to value-adding activities, 15% went to contributory necessary activities and 39% were idle and waiting, which shows that non-value-adding activities are more comprise more than half of the time spent by the labor to perform a construction operation. Figure 7 shows the distribution of time spent by labor according to the study of Christian and Hachey (Ying, 2004).

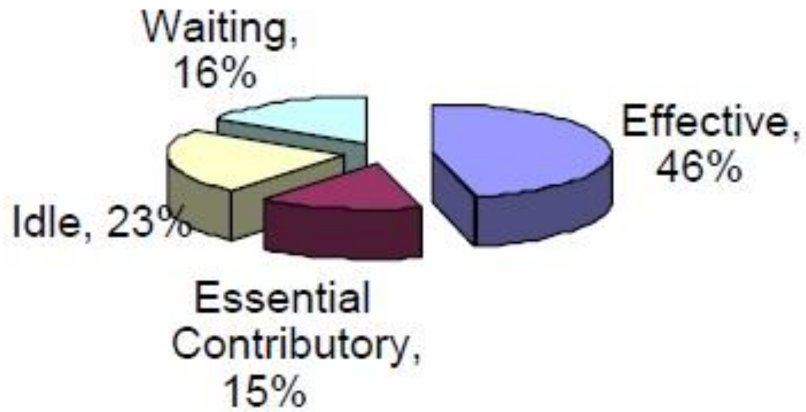


Figure 7: Distribution of time spent by labor (Christian and Hachey, 1995, cited in, Ying, 2004).

2.8 Construction Productivity Improvement

2.8.1 Approaches to Construction Productivity Development

In some countries as Australia, the construction industry has been developed recently through incentives for contractors to encourage them to replace and implement technology for labors, the availability of local experienced labors, and the contractors are interested to invest money for training and developing the skills of labors (SCAL & SCCCI, 2016). In U.S, similarly, the implementation of technology, availability of skilled and experienced labors, offsite fabrication and modularization, and the usage of best practices were the factors that lead to improvement of productivity (Huang, Chapman, & Butry, 2009).

In the United Kingdom, there are some challenges addressed which adversely affect productivity such as; (1) low integration in the supply chain process, associated with high dependency on sub-contracting, which results in a disconnection between design and construction management, and also between management of construction and execution, (2) Low investment in ` Research and Development), (3) Shortage in collaboration and transferring experiences and knowledge from one project to another, at the end of the project the team members will leave, so the learning points will be lost, (4) Weakness in procurement processes leads to a higher construction costs in comparison with other competitors from different companies.

However, it is expected by 2025 that these challenges will be solved by applying some strategies as; (1) adoption of technology and leading the world in research and innovation through implementing digital design, advanced materials (2) achieving 33% reduction in the initial cost of construction, (3) achieving 50% reduction in the overall time for the execution of a new building, (4) improving the procurement process (SCAL & SCCCI, 2016).

There are key factors that enhance and improve productivity in general which includes; project management, human resources management, and technology adoption:

- Project management: planning and coordination should be developed between general and sub-contractors and between owner and contractor, enhancing job site efficiency through linking between materials, people, processes, information and machines, utilization of the most effective measurement tools, identification and determination of roles of project participants, monitoring the sub-contractor progress, proper material management and handling of materials and logistics (SCAL & SCCCI, 2016).
- Human resources management: promoting and supporting incentive programs and rewards systems, adopt training and knowledge transfer through all levels, feedback for the workers about their performance (SCAL & SCCCI, 2016).
- Technology adoption: Implementation of prefabrication, pre-assembly, modularization, offsite fabrication, mechanization and automation as much as possible. Applying ICT (information and communication technology), BIM (Building Information Modeling), and GPS (and global positioning systems) (SCAL & SCCCI, 2016).

2.8.2 Motivation

Motivation is one of the key factors that improve productivity of labor, it can be increased through supporting and maximizing the motivators which help the labor to be satisfied about the job, and trying to reduce the demotivators that make the labor not satisfied. The labors will be motivated if they see their work finished or the progress of their work is ongoing. Motivation can be seen in two aspects; the first one, is the behavior and the attitude when labor arrives the construction site, which comes from social background, family, religion, and even the events of daily life. The second aspect is related to the influence of management practices on the different tasks performed by the labor. As a result, management related factors that increase motivations of labors, hence increase their productivity are; proper planning, good communication, good work environment, protection from severe weather conditions, and rewards (AbouRizk & Dozzi, 1993).

2.8.2.1 Good planning

A high level of planning for different stages of project, helps in generating an efficient sequencing of the phases, e.g., efficient complete design should come first and to be finished before the preparation of construction drawings, and construction activities should start only after the sufficient drawings are available, in addition to the non-variability of the workflow and the proper sequencing of the trades, and the availability of sufficient material in order to proceed the progress. Furthermore, good planning practices encompass; proper utilization of scheduling techniques, procurement, and site lay out planning. Therefore, good planning highly motivates labors and brings high stability in their progress, eliminates interruptions and improves productivity (AbouRizk & Dozzi, 1993).

2.8.2.2 Communication

The laborer should be told precisely what kind of tasks should be assigned to him, so the clarity and the explanation of the tasks are highly required for him, furthermore, the employees as supervisors and engineers should know exactly what are the sources of their instructions, thus, the instructions should be from a visible known communication chain and the unknown instructions should not be used. Moreover, better communication between bottoms and top management is strongly desirable. Instructions and construction drawings are both tools for communication and they should be completed and on time, an example for that; a foreman should receive reports concerning his/her responsibilities, thus, the foreman will only focus on the required task and achieves productivity (AbouRizk & Dozzi, 1993).

2.8.2.3 Work environment

Providing the proper work climate for the labors can create a great motivation for the labors, the basic comfort needs for the labor as an individual is important, if the management ignores the comfort needs of the labor, it could be changed into a demotiavtor for work and changes the attitude of the labor. These needs are; adequate of sanitary facilities, site access, availability of water to drink, protection from severe conditions of weather, and availability of transportation (AbouRizk & Dozzi, 1993).

2.8.2.4 Rewards

Rewards can be considered as a social recognition or as a monetary compensation, or it can be seen as a pat on shoulder, or as an expressing of satisfaction from achieving a task in a good way. However, the labor should know why he/she was rewarded and what is the nature and type of the reward. Moreover, the magnitude of the reward should meet and be equal to the amount of work done, in which big rewards could affect negatively the attitude and the productivity of the labor (AbouRizk & Dozzi, 1993).

Nicolaou (1987) emphasized that implementation financial incentive programs will achieve a significant increase in labor productivity and increases the motivation of worker. The worker will be paid based on his/her performance, as a result, the measured score should be compared to a predetermined standard such as: the comparison between worker's man-hours for a specific output to a standard predefined man-hour. Other way, the task can be divided into sections, and each section has specific standard man-hours, after the finishing of task, the total actual time spent will be compared to the standard time.

2.8.3 Human factors

Construction industry is known as labor intensive industry, labors are one of the most dominant elements in construction process, and as a result human factors are considered the key for the success of any project, however, the human factors are not credited a high attention. Human factors consist of two groups; 1st one includes: individual factors, physical limitation, learning curve, and teamwork, the 2nd one includes: the environment factors surrounding the labor as noise, weather, and workspace (AbouRizk & Dozzi, 1993).

2.8.3.1 Individual factors

There are some personal attributes, if it will be available in the worker or the individual, it will help the person to be initiative and the person will be able to creative and solve problems, hence, it will improve the productivity of labor. These features are; optimistic, positive attitude, sense of humor which decreases the stresses, healthy person also contributes in increasing productivity, the availability of leadership skills which includes responsibility, honesty, cooperation, and being a good listener, construction crews need an efficient leader with big experiences to produce better productivity and to develop the teamwork (AbouRizk & Dozzi, 1993).

2.8.3.2 Physical limitations

Humans need fuel to work and to produce energy, it is well known that most of construction activities are highly physically demanded. The type of the activity the labors do will determine how many times they will need to rest and restore their energy again to continue working. It was noticed that a young average male of 25 years can generate around 5 kilocalories per minute of energy as a maximum value, and if the labor does a light work, he will be able to keep his energy reservoir to be full and he will continue working for a longer time, however, if the task needs than 4 kilocalories, the labor should rest to restore energy and the reservoir will be almost be empty. Short term fatigue for labor can be decreased through performing tasks which do not comprise; pushing heavy objects and carrying heavy loads, these can be solved by trying to use tools or devices as an alternative for muscular activities. If the labor does a specific task in a non-comfortable way or in a strange position, this will lead to injuries, labor will take a lot of breaks and will be unproductive. Back injuries are so common in construction, this can be resulted from; working overhead and bending for a long time (AbouRizk & Dozzi, 1993).

2.8.3.3 Learning curve

Labor usually works slowly during performing the task for the first time in his life, because labor learns how to do it. But after several times for performing the same task and several repetitions, the labor will not need much time to perform it, as a result, it is highly recommended to keep the same labor doing this task better than replacing him with a new labor who will need to learn from the beginning. The changing of labors will lead to an interruption time between the repetitive tasks (AbouRizk & Dozzi, 1993).

2.8.3.4 Crews and teamwork

Teamwork between crew members can be improved and maintained through proper and open two way communication, it means that the opinion, labors proposals and solution for a problem is valuable and it practically solve the issues. It was suggested, that group of labors can meet and produce solutions to their tasks, and thus, managers should provide an environment which facilitates the teamwork and the meeting between labors. It is also recommended that the competition between labors to find solution for problems can achieve high productivity, the supervisors can benefit by the level of competency and sense of duty of labors (AbouRizk & Dozzi, 1993).

2.8.3.5 Environmental factors

Ogelsby et al. (1989) cited in, AbouRizk & Dozzi (1993) stated that:

> Human beings perform relatively continuous physical or mental work most effectively when the temperature falls between 10 and 21C at a relative humidity (R.H.) of 30 to 80%, under dry conditions, with the atmosphere clear of dust and other atmospheric pollutants, and without excessive noise. Departures from these conditions have adverse effects on productivity, comfort, safety and health (p, 23).

Labors can adapt working in hot weathers, however, heat stresses exist if the temperature exceeds 49C with R.H. of 10%, and at 31C with R.H. 100%, in addition to heat stresses, accompanied heat injuries will exist such as; sun burn, exhausting, cramps and heat stroke. These issued can be avoided, if labors take breaks, protection cloths, and water and salt supplies. In cold weather, proper cloths, availability of heaters, and temporary shelters close to the work place, around 5C, it is assumed to be the lowest minimum temperature the labor can work with it especially indoor, and with -28C, it is assumed that the labor will not be able to work (AbouRizk & Dozzi, 1993).

Workspace should be organized and clean, and also should be established on basis of safety, healthy, comfortable and well ventilated. Cleaning will give a better image for the site and it will reflect a high level of organization on site, therefore, it creates a better productivity among labors. Noise can prevent the labors form hearing and receiving instructions, it can have a negative impact on the quality of the work especially if some tasks need focusing and it is full of details, it was recommended that if the noise level is 90 decibels or above, it may damage hearing abilities and minimize the performance of work, so labors must wear ear-plugs to avoid that (AbouRizk & Dozzi, 1993).

2.8.4 Job site planning

The efficient utilization of the construction facilities will result in improving productivity, the good quality of planning a site relies on the complexity of the project not on the size of the project. A lot of participants need information which is in the site plan, in order to attain construction permits, and thus it allows them to commence activities, as a result, the availability of these permits promptly reduces the delay. Lead time should be considered at the project planning phase to deal with the environmental issues such as; removing contaminated materials and other wastes. Temporary access points for preliminary and final ramps should be executed to reduce the interference and to facilitate the mobility (AbouRizk & Dozzi, 1993).

The adequate power requirements in construction sites should be considered also, to minimize the delay while performing the activities, lack of temporary lighting system will increase the percentage of unproductive work and creates safety issues. The distribution of lighting system should be proper, existence sufficient lighting outlets, should be safe to use, and finally the ability to use the electrical tools and machines properly, obviously will increase the productivity. The job site plan should consider the location of offices for different participants of the project such as; owner, general and sub-contractors, and the consultant should be planned to be close to the site and close to each other's. Moreover, the good condition of sanitary facilities for labors and their location to the work place should be planned so as the labor do not waste time for going to and from their workplace in addition to the storages and lunch facilities of labors should be located in a proper place for them (AbouRizk & Dozzi, 1993).

3 Research Design and Methodology

3.1 Research Approach and Nature

There are two types of research approaches, which are: deductive and inductive approach. Deductive approach is when the researcher introduces a theory or a hypothesis and to plan and design the research, in order to test this hypothesis. Inductive approach is when the researcher collects data and then followed by an analysis of these data, in order to conclude or develop a theory at the end. In this research inductive and deductive approaches are used (Saunders, Lewis, & Thornhill, 2007).

The nature of this research is exploratory. It is exploratory, in which the author tried to investigate and explore the different concepts and measurements for productivity, in addition to investigate the factors affecting productivity and ways to improve it. In this research, a combination of qualitative and quantitative data collection technique and also the analysis procedures is used, which is known as "Mixed-model research". This method combines both, and even the analysis procedure combines both as well, an example for that is a researcher can use quantitative data and transform it into qualitative, which can be in a narrative form, thus it can be analyzed qualitatively and vice versa. This method also has an advantage for the adoption of triangulation between qualitative and quantitative to exist (Saunders, Lewis, & Thornhill, 2007). The mixed model research method can be represented in this research through the following: the usage of previously done surveys which include quantitative results, the author of this study converted these results into a narrative qualitative form through the analysis sections for case studies 1-6.

3.2 Data Collection

There are two main types of data constituting any kind of academic researches, which are: primary data and secondary data. Saunders et al. (2007) explained that the primary data utilized in the research are mainly collected individually by the researcher through different research strategies such as: observation, semi-structured, in-depth and group interviews, and also through using questionnaires. (Saunders, Lewis, & Thornhill, 2007). The secondary data are collected through: Documentary (written and non-written materials), reports, governmental publications, books, scientific journals, and Ad hoc surveys (governmental surveys, organizational and academic surveys) (Saunders, Lewis, & Thornhill, 2007). In this research, secondary data was used, moreover, the combination of qualitative and quantitative techniques and procedures were used throughout the research from book, researches and case studies.

Advantages of Secondary data are many such as: it is less expensive, saves time and easily accessible more than primary, however, it can still be costly if the researcher requires to buy some important secondary data, but it is still less expensive than to start from the beginning as in primary data collection. It also saves time, as in primary data collection, a huge time will be consumed to receive the results of the survey or performing interviews. While conducting a secondary research using secondary data, this will allow the researcher to use longitudinal data, which enriches the researcher with large scope of data, longitudinal data allows the researcher to address and analyze phenomena in all aspects over a long period of time unlike the primary research which is concerned and limited to study the phenomena in a specific period of time which is known as cross sectional data. Furthermore, secondary data depends on a professionally collected data which is the primary data, because the primary data was initially collected by experienced researchers, who have conducted their researches and used the instruments in an efficient way (How to do your dissertation secondary research in 4 steps, 2017).

Two main disadvantages for secondary data, first is that the data may not fit or does not match the purpose or the research question, second, is that the quality of data may be doubtable, because it can be un reliable or not valid, and also the original researcher may not mention or provide sufficient information about the instrument used or the sample size or if it is representative or not. (How to do your dissertation secondary research in 4 steps, 2017).

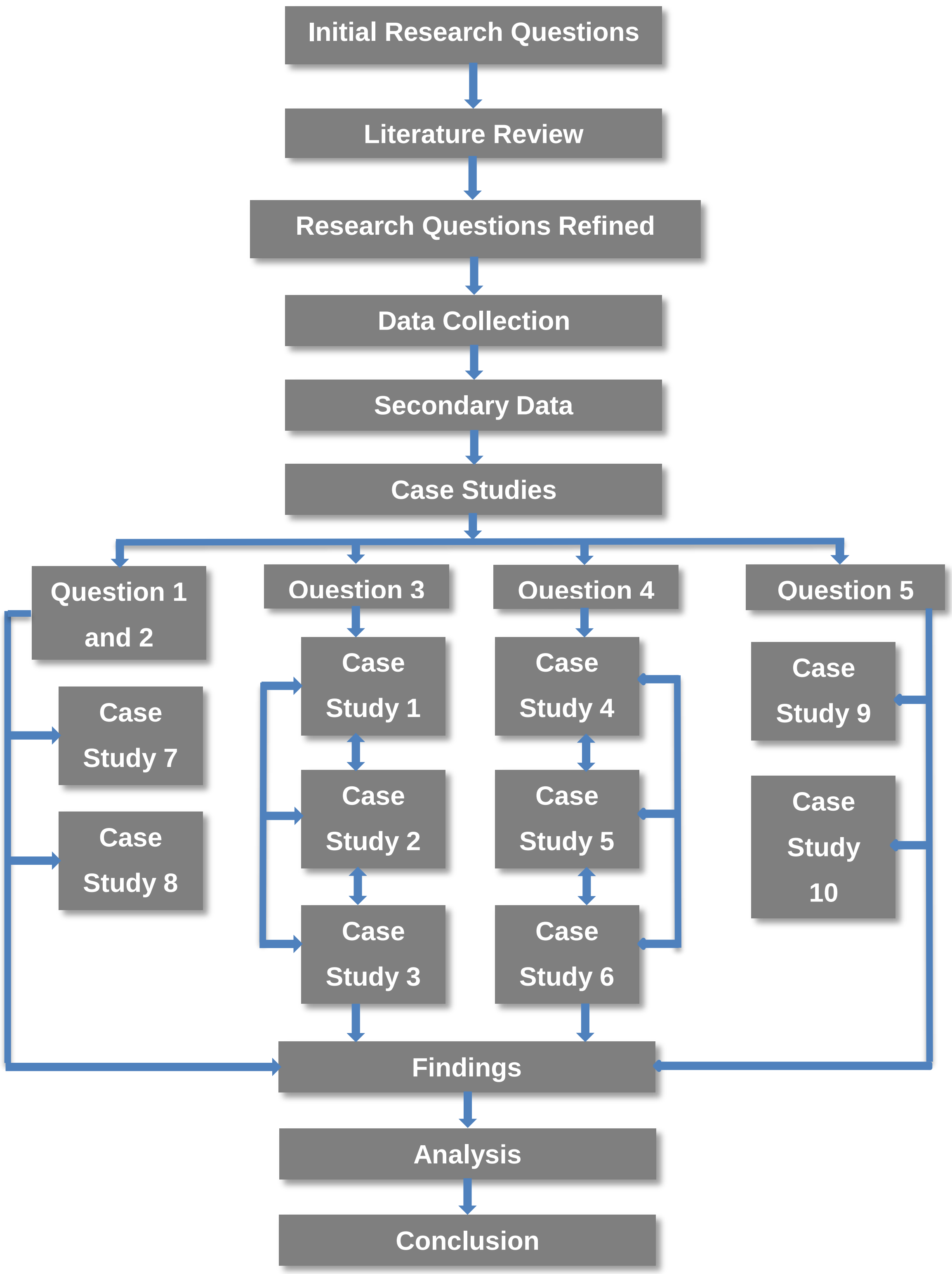
3.3 Data Reliability

The secondary data was used in this research which comprised the following: governmental and organizational reports, books, scientific journal articles, and academic researches. The reliability and validity for the questionnaire, sampling and interviews extracted from the academic researches and used as case studies were examined and checked properly. Furthermore, these case studies including surveys and interviews were compared with other similar conducted researches, in order to select the most proper validated reliable among them before using it. The concept of combining qualitative and quantitative data and the triangulation between them creates diversity in data used. The attempt to use the most updated data whenever possible also has been done to increase the reliability of data.

3.4 Research Design

The research phases were executed according to the conceptual framework presented below in figure 8. Research question number 5 was refined to be compatible with the objective of the research. It was changed from "how the country's development status impacts the labor productivity?" to "how labor productivity can be improved?" The strategy adopted was to utilize the secondary data as case studies to contribute in answering the research question. The case studies were investigated to find the common findings, in which case studies 1, 2, and 3 were cross checked to find the common findings, the same process was applied on case studies 4, 5, and 6. All the findings of case studies were analyzed and then used along with literature review to answer the research questions.

Figure 8: Research conceptual framework.



4 Case Studies and Main Findings

4.1 Introduction

Different case studies are presented in this section, some of these case studies were included in a book, and some of it were extracted from researches, report and journal articles, that were conducted before. Case study 1, 2 and 3 are concerned to investigate the research question no. 3 which is: *What are the critical factors affecting labor productivity in developed countries?* Case studies 4, 5, and 6 are concerned to investigate the research question no. 4 which is: *What are the critical factors affecting labor productivity in developing countries?* Case studies 7 and 8 are concerned to investigate the research questions 1 and 2 which are: *What are the different labor productivity definitions and concepts?* And *what are the different measurements used for labor productivity?* Case studies 9 and 10 are concerned to investigate the research question no. 5 which is: *How labor productivity can be improved?*

4.2 Important Considerations for selecting Case Studies

During the selection of the previously done questionnaire, several criterions were done to make sure that the selected surveys meet the objectives of this research and it is reliable, valid, representative and efficient to answer the research questions such as:

- The availability of the pilot study in all the surveys that have been chosen, which is important to rectify the questions and to receive feedbacks before sending the final questionnaire.
- Reliability of the questionnaires that were selected, in which the same results can be obtained if it was done by other researches, the results also cannot be changed, if it was done in different time.
- Validity of the questionnaires that were selected, in which the results of these questionnaires match with the reality and the results are a true record of what is actually going on currently.

- The samples of all questionnaires selected were representative and represented a wide range of different construction specialists from different construction disciplines with wide range of experience. Many of the participants were holding managerial positions. Most of the samples' sizes were calculated with confidence level of 95 % which reflects a high accuracy.
- The response rate of the respondents for all questionnaires selected was high, which gives more validity and reliability for the results.
- The availability of both open and close ended questions in all questionnaires selected, which reflects the non-bias attitude of the researchers and the flexibility of the likert scale to give the a free space for the respondent to answer freely.

4.3 Case Study 1

This case study was a part of an academic research (Master Thesis). The research was conducted by Mahesh Madan Gundecha in 2012. The aim and the objective of the study were to determine the various critical factors affecting labor productivity at a building construction projects all over USA. The survey method was chosen as a questionnaire in a web-survey format. Email was the tool used to send the survey questionnaire. The factors were critically reviewed in the literature review based on the previous studies, and then a list of 40 factors was generated to be surveyed.

4.3.1 Methodology used

A pilot study has been done through sending the questionnaire by email to laborers, contractors, architectures, owners, project managers, and project engineers of different building construction organizations. A total 155 Questionnaires were sent and 25 responses received, 5 were not completed and not valid and 20 were valid, the feedback helped the researcher to refine the questionnaire in a proper way (Gundecha, 2012).

Regarding the distribution of the Questionnaire, the targeted groups were different professionals and experts from different building construction organizations in USA. Hence, a list of 255 building construction organizations represented sample frame or sample from a finite population, was attained from the Engineering News-Record. As a result, it was calculated that 55 building construction organizations should receive the questionnaire, to achieve a 94% of confidence level (Gundecha, 2012). According to the date collection from the web survey, 255 Questionnaire was sent and 54 responses were received. The response rate was around 21.17%, in addition to 26 invalid data, and 28 valid data which was used in the research study. As a result, the total response rate for only valid data was 11%. The total description profile of the respondents that answered the questionnaire was representative. Relative Important Index (RII) was a method applied in order to analyze the survey results, and it was used to rank the various factors (Gundecha, 2012).

4.3.2 Respondents Profile

Several considerations were undertaken such as; the average number of employees in an organization should not be less than 36 and the number of projects per year should not be less than 3 years. Moreover, the profile included type of construction projects, the job title for each respondent and the budget of the project for each respondent's company (Gundecha, 2012). Table 2 shows the different profiles for each respondent that participated in the questionnaire.

Construction Organizations	**Number of Respondents**
Residential	6
Commercial	6
Industrial	5
Government	1
Engineering	2
Architecture	5
Owner	3
Job title of Respondents	**Number of Respondents**
Project Manager	4
Project Engineer	11
Architecture	3
Others [(**APM**): Assistant Project Manager, **(APE)**: Assistant Project Engineer, Scheduler and Estimator].	10
Typical Size of Project	**No. of Projects**
0-5 Millions	11
5-10 Millions	9
10-100 Millions	7
> 100 Millions	1

Table 2: Profile of the respondents (Gundecha, 2012).

4.3.3 Results

The results of the survey comprised 40 factors affecting labor productivity identified and the RII for each factor was calculated. Moreover, the factors were categorized into 5 groups named by; manpower factors, external factors, communication factors, resources factors, and miscellaneous factors (Gundecha, 2012). Table 3 shows the overall ranking of 40 factors and their ranking in groups.

Rank in Group	Group name	Factors affecting labor productivity in construction	RII	Rank
1	Resource Factors	Lack of required construction material	558	1
1	Miscellaneous Factors	Shortage of power and/or water supply	552	2
2	Miscellaneous Factors	Accidents during construction	546	3
2	Resource Factors	Lack of required construction tools/equipment	540	4
4	Resource Factors	Poor site condition	510	5
3	Resource Factors	Insufficient lighting	510	6
3	Miscellaneous Factors	Weather condition	510	7
5	Resource Factors	Differing site conditions from plan	504	8
6	Resource Factors	Material storage location	504	9
4	Miscellaneous Factors	Working overtime	504	10
7	Resource Factors	Poor access within construction site	492	11
1	Manpower Factors	Lack of experience	488.75	12
1	External Factors	Supervision delays	488.75	13
2	External Factors	Variations in the drawings	488.75	14
8	Resource Factors	Violation of safety laws	486	15
3	External Factors	Incomplete drawings	483	16
9	Resource Factors	Quality of required work	480	17
2	Manpower Factors	Absenteeism	477.25	18
4	External Factors	Rework	471.5	19
5	External Factors	Design changes	465.75	20
1	Communication Factors	Change orders from the designer	465.75	21
6	External Factors	Inspection delays from the authorities	448.5	22
7	External Factors	Payment delays	442.75	23
2	Communication Factors	Change orders from the owner	442.75	24
5	Miscellaneous Factors	Project objective not well defined	442.75	25
10	Resource Factors	Inadequate transportation facilities for workers	438	26
8	External Factors	Complex design in the provided drawings	437	27
11	Resource Factors	Inadequate construction material	437	28
3	Communication	Misunderstanding among owner,	431.25	29

	Factors	contractor, and designer		
3	Manpower Factors	Alcoholism	425.5	30
4	Manpower Factors	Misunderstanding among laborers	419.75	31
9	External Factors	Implementation of government laws	419.75	32
10	External Factors	Training sessions	414	33
5	Manpower Factors	Age	408.25	34
4	Communication Factors	Disputes with designer	396.75	35
12	Resource Factors	Increase in material price	396	36
5	Communication Factors	Disputes with the owner	391	37
6	Manpower Factors	Lack of competition among laborers	379.5	38
7	Manpower Factors	Disloyalty	373.75	39
8	Manpower Factors	Personal problems	368	40

Table 3: Overall ranking of 40 factors in USA and their ranking in groups(Gundecha, 2012).

4.4 Case Study 2

The case study was a part of a research paper (journal article). The journal is Construction Innovation. The research was conducted by Rami Hughes and David Thorpe and it was published in 2014. The aim and the objective of this study were to determine the perception and the view points of the project managers towards the main factors affecting construction productivity in the Australian context. Hence, the research was conducted in the Australian environment with a specific consideration to the south east of Queensland. A total 47 factors were selected for this study, the factors were identified based on the literature review, and it was stratified into 22 primary and 25 secondary factors that were expected to contribute to 3 main primary factors which are; incomplete drawings (7 factors), lack of material (10 factors) and lack of tools and equipment (8 factors).

4.4.1 Methodology used

A semi-structured questionnaire was sent to project managers in order to rank the factors affecting productivity. A list of 89 of experienced project managers were selected from professional project manager organization and a construction industry association, 89 project managers were surveyed and 36 finished the survey. Hence, 40.4% response rate has been achieved. It was found that 36 respondents for primary factors, while 34 respondents for secondary factors. Relative Important

Index (RII) was a way in order to analyze the survey results, and it was used to rank the various factors (Hughes & Thorpe, 2014).

4.4.2 Respondents profile

Regarding the background of the respondents, it was concluded that, all the respondents were male, all of them were over 30 years and 50% of them were over 50 years old. It was found also, that only 17% of them had 6 years experiences and 42% are over 20 years experienced. Moreover, 42% had Bachelor degree while 39% had post graduate degrees. Furthermore, it was detected that 36% of them were still employed for their firm for more than 10 years during the time of the survey. Also, it was investigated that 78% worked for general contractor and 3 percent only for sub-contractor. The project managers who were surveyed had wide experiences in all practices of construction activities (Hughes & Thorpe, 2014). Table 4 shows the employment experience of all the project managers surveyed.

Type of construction	**Years of Experience**					
	0-2 years	2-5 years	6-10 years	10-20 years	Over 20	Total
Residential (%)	19.4	22.2	16.7	8.3	11.1	100
Commercial (%)	6.7	3.3	33.3	30.3	26.7	100
Industrial (%)	11.1	5.6	44.4	16.7	22.2	100
Civil (%)	12.5	31.3	6.3	18.8	31.3	100
Other (%)	20	40	10	30	0	100

Table 4: Experience of all the project managers surveyed (Hughes & Thorpe, 2014).

4.4.3 Results

The results of the survey explored the most critical primary 15 factors affecting construction productivity in the Australian construction context and the RII for each factor was calculated (Hughes & Thorpe, 2014). Table 5 shows the top ranked 15 primary factors including the number of respondents and the rating on Likert scale for each factor.

Rank	Factors	RII
1	1-Rework	0.917
2	2-Incompetent supervisor	0.896
2	3-Incomplete drawing	0.75
4	4-Work overload	0.604
5	5-Lack of material	0.583
6	6-Poor communication	0.576
7	7-Poor site conditions	0.514
7	8-Poor site layout	0.514
7	9-Overcrowding	0.514
10	10-Inspection delay	0.507
11	11-Absenteeism	0.5
11	12-Worker turnover	0.5
13	13-Accident	0.465
13	14-Tools/equipment breakdown	0.465
13	15-Lack of tools and equipment	0.465

Table 5: Top ranked 15 primary factors affecting Australian Construction industry (Hughes & Thorpe, 2014).

4.5 Case Study 3

The case study was a part of a research paper (journal article). The journal is International Journal of Productivity and Performance Management. The research was conducted by Shamil George Naoum in 2015. The objective and aim of this study was to detect the most critical factors affecting construction labor productivity in UK from the perception of construction contractors, especially from contract managers and site managers. The factors were investigated under 5 main groups; pre-construction activities; factors during construction; managerial and leadership issues; organizational factors; and motivational factors (Naoum, 2015).

4.5.1 Methodology used

The research methodology of this study was accomplished through two main stages. The first stage was; a comprehensive, extensive and critically reviewed secondary data of researches related to construction productivity from 1974 to 2014, the output was generated from several sources which are (Naoum, 2015):

> Nine top-ranked construction journals were included in the first round of the desktop search stage: Construction Engineering and Management (JCEM), Journal of Management in Engineering (JME), Construction Management and Economics (CME), Engineering, Construction and Architectural Management (ECAM), International Journal of Project Management (IJPM), Journal of Productivity and Performance Management, Journal of Computing in Civil Engineering, Journal of Construction Innovation and Journal of Built Environment. These journals were selected because they are known to have frequently published scholarly papers in the field of CLP. Moreover, they have been ranked highly by several research activists in construction management such as the list by Chau (1997) (p, 403).

The second stage was; face to face interviews were undertaken with 36 professionals and experts (19 contract managers and 17 site managers) associated with a structured close-ended questionnaire (Naoum, 2015). The questionnaire included 5 main sections, each section represents a group of factors mentioned previously, and each group contained the related factors. In total of 46 factors adopted and generated from the literature were classified under the 5 groups. Regarding the pilot study, the questionnaire was tested initially through interviewing five local contractors, this test helped the researcher to refine and modify the original questionnaire properly (Naoum, 2015).

The interviewers, who were interviewed finally, were 19 contract managers working at the head office and 17 site managers with experience over 10 years. The organizations were large scale companies, and the nature of the projects varied from commercial and industrial. RII was calculated, in order to rate each factor and represents ultimately the overall most critical factors (Naoum, 2015).

4.5.2 Results

Table 6 shows the overall ranking of 46 factors affecting construction labor productivity according to their RII and the group they are classified under, in United Kingdom from the perspective of contractor's professionals.

Factor	RII	Rank	Group name
1. Ineffective project planning	0.835	1	Pre-construction activity
2. Delay caused by design error and variation orders	0.825	2	Pre-construction activity
3. Communication system	0.825	2	Pre-construction activity
4. Work environment	0.82	3	Motivational and social
5. Constraints on a worker's performance	0.82	3	Motivational and social
6. Design and buildability-related issues	0.815	4	Pre-construction activity
7. Management/leadership style	0.81	5	Managerial factor
8. Procurement method	0.805	6	Pre-construction activity
9. Lack of integration of the management information system for the project	0.805	6	During construction
10. Management of material on site	0.805	6	During construction
11. Team/group integration during construction	0.8	7	Motivational and social
12. Experience and training	0.8	7	Organizational
13. Control system on site	0.795	8	During construction
14. Group co-ordination/overcrowding on site	0.795	8	During construction
15. Project structure/authority and influence on site	0.795	8	Managerial
16. Specification	0.78	9	Pre-construction activity
17. Ineffective site planning leading to program disruption	0.78	9	During construction
18. Supervision of subordinate	0.775	10	During construction
19. Delay/rework	0.77	11	During construction
20. Site safety	0.77	11	During construction
21. Clarity of tasks	0.745	12	During construction
22. Clarity of client brief and project objectives	0.74	13	Pre-construction activity
23. Site managers involvement at contract stage	0.74	13	Pre-construction activity
24. Accuracy of tech. information	0.735	14	During construction
25. Construction technology and methods	0.735	14	Organizational
26. Poor scheduling of project activities	0.725	15	Pre-construction activity
27. Sub-contractor involvement	0.715	16	Pre-construction activity
28. Co-ordination of sub-contractors	0.715	16	During construction
29. Direct V sub-contract labor	0.71	17	During construction
30. Job security	0.71	17	Motivational and social
31. Availability of skilled workers	0.71	17	Organizational
32. Interference on workmanship	0.7	18	During construction

33. Poor selection of project personnel	0.696	19	Pre-construction activity
34. Lack of consultation in the decision-making process	0.695	20	During construction
35. Attitude of site personnel	0.695	20	During construction
36. Mismatch of beliefs among personnel on site	0.69	21	Motivational and social
37. Management of equipment/use of inappropriate tools/equipment for operations	0.685	22	During construction
38. Resentment of company policy	0.645	23	Motivational and social
39. Contract administration skill	0.645	23	Organizational
40. Delegation of responsibilities	0.64	24	Motivational and social
41. Knowledge of techniques	0.63	25	During construction
42. Inefficient site layout	0.625	26	During construction
43. Response to employee grievances	0.6	27	Motivational and social
44. Salary and incentives	0.585	28	Motivational and social
45. Reappraisal of site managers and promotion	0.585	28	Motivational and social
46. Opportunities to exercise skill	0.535	29	Motivational and social

Table 6: Overall ranking of 46 factors affecting labor productivity in UK (Naoum, 2015).

4.6 Main Findings and Analysis for Case Studies of Developed countries

To develop a better understanding for critical factors affecting construction labor productivity in developed countries, an analysis has been undertaken by the author for the final findings of case study 1 in USA, case study 2 in Australia, and case study 3 in UK. The cross case analysis process comprised an overall comparison between tables of the resulted top ranked critical factors concluded from the mentioned case studies, in order to detect similar critical factors and determining their rankings and their significant importance, and then followed by an analysis for the most influential factors included in the three case studies. The analysis was performed by the researchers of these case studies and the author of this study.

4.6.1 Analysis of Influential Factors in Case Studies related to Developed Countries

Lack of labor experience was ranked the top in manpower group and the 12th among 40 factors in case study 1, experience and training factor related to organizational group factors was ranked 7th among 46 factors in case study 3. The results are supported and acceptable, as the level of skills and experience of the workforce was ranked the top in the workforce group of internal constraints in New-Zealand (Durdyev & Mbachu, 2011). Moreover, it is supported by the study of (Palop, 2016) in Europe, it was concluded that shortage of skilled and experienced labors ranked 4th among 40 factors and in the same study, the Lack of training/orientation program for workers was ranked the 10th among 40 factors. The experience and knowledge of labor can enhance and increase the physical and mental skills, thus, increasing the productivity (Gundecha, 2012).

Incompetent supervisor was ranked 2nd in case study 2. The result can be supported by a study conducted to identify the most demotivating factors affecting construction productivity in Hong Kong, in which Foremen incompetence was ranked the 7th among the demotivating factors (Ng, Skitmore, Lam, & Poon, 2004). Inexperienced supervisors do not have the abilities to respond quickly to the issues related to incomplete drawings and the workers have to wait for the answers from the site engineers (Ng, Skitmore, Lam, & Poon, 2004). The quality of supervision decreased significantly over the years, as the old supervisors retire and they do not pass their knowledge to the new young one, moreover, supervisors who have specific trades are considered the best, due to their knowledge and experiences to know how to build. As a result, competency decreases resulting in productivity decline. (Loosemore, 2014).

Labor absenteeism was ranked 11th in case study 2, while it was ranked 18th among 40 factors and 2nd in manpower group in case study 1. This result can be supported with the study conducted in Singapore by (Lim & Alum, 1995), it was concluded that absenteeism at work site ranked the 4th among 17 factors. **Labor Turnover** was ranked 11th in case study 2. This result is justified by the study of (Lim & Alum, 1995). In Singapore, there have been challenges in hiring supervisors and labors, due to the shortage of local workers and supervisors, resulting in the relying on the foreign worker, the main challenge occurred because the local workers are not committed to the regulation rules of employment and the foreign workers returned back home at the end of their contracts, these issues caused a high rate of turnover and absenteeism (Lim & Alum, 1995). Gundecha (2012) explained that the transitory and unstable nature of the local labors cause turnover and the contractors can easily recruit new labors to overcome the issue of absenteeism.

Rework was ranked the top in case study 2, while it was ranked 19th among 40 factors and it was ranked 4th in the external group in case study 1. The result is supported by the study in Europe by (Palop, 2016), in which it was ranked 17th among 40 factors, and finally it was ranked the top in the study of (Ng, Skitmore, Lam, & Poon, 2004) in Hong Kong, moreover, it was ranked the top also in the group of internal constraints in the study of (Durdyev & Mbachu, 2011) in New Zealand. In U.S, the time spent for rework was 4.92 to 7.73 hours per week for a labor (Yates & Guhathakurta, 1993). In general, several causes for rework such as; incompetence and inexperienced craftsmen and supervisors, errors in drawings, low skills and experience of labors, omission, change over and low communication between 2 shifts and change orders from the designer or the owners.

Inspection delay was ranked 10th in case study 2, while it was ranked 22nd among 40 factors and 6th in the external group in case study 1. The result can be justified because inspection delay was ranked the 5th in the most demotivating factors in the study of (Ng, Skitmore, Lam, & Poon, 2004), also Stoppages because of rejection of work by consultants factor was among the most critical factors in the study of (Lim & Alum, 1995), it can cause the delay for starting the successor activity because the predecessor activity was not fully completed due to the rejection of the inspection. In U.S, the average loss hours per week for a worker were 2.06 to 4.06, because of inspection delay (Yates & Guhathakurta, 1993).

Design related factors include factors as; incomplete drawings, variation in the drawings, delay caused by design errors, complex design in the provided drawings, and design and buildability related issues. Incomplete drawing was ranked 3rd among 15 factors in case study 2, while variations and incomplete of the drawing were ranked 14th and 16th and complex design in the provide drawings ranked 27th among 40 factors in case study 1. Delay caused by design error and design and buildability related issues ranked 1st and 3rd respectively in case study 3. These results showed the significant impact of design related factors and it’s reflection on labor and construction productivity in general. The results are supported by the study conducted in Europe by (Palop, 2016), in which design changes, errors and omissions ranked the top among 40 factors. Also, it was concluded that design and buildability related issues ranked the top in the group of project characteristics in the study by (Durdyev & Mbachu, 2011). Moreover, the study of (Dai, Goodrum, & Maloney, 2007) revealed that errors and incomplete drawings ranked the 2nd factor from the perspective of the craft workers. Lack of design details, complex of design, impracticality of design, changes in design and inexperienced draftsmen can cause loss in productivity (Hughes & Thorpe, 2014).

Poor communication and relationship management factor, poor communication was ranked 2nd in case study 2, and communication system factor was ranked the 2nd in case study 3. In case study 3, communication system is related to pre-construction activities, and lack of integration of the management information system (MIS) for the project factor during construction ranked 6th. This result is a great indicator that communication factor is highly important in increasing productivity in site. Proper communication is necessary in the management of projects, especially within various diverse teams with different cultural back grounds (Hughes & Thorpe, 2014). This agrees with the study in Singapore, different work force from different nationalities with different language affect the productivity, as a result communication problems with foreign workers ranked 4th in this study (Lim & Alum, 1995). This result is strongly supported with the study in Europe by (Palop, 2016), as communication problems between management and workers ranked the 2nd among 40 factors.

Some respondents from craftsmen claimed that the relationship between site staff and them should be improved more, because the site staffs are managing their jobs behind the desk using computer, and they spend less time on site, as a result, it develops poor communication with sub-contractors, insufficient knowledge with the site processes (Loosemore, 2014). The integration of strong MIS on site increases the chance an effective decision making process, as it is considered to be the bond between decision making, supervision and communication. MIS facilitates the access to accurate data and information and improves the flow of this data from one group to another, therefore, decreases rework and delay and increases the productivity (Naoum, 2015).

Poor site condition and layout related factors include factors as; differing site conditions from plan, poor access with in construction site, and insufficient lighting. Poor site condition ranked the 7^{th} similarly with poor site layout in case study 2. While poor site condition, insufficient lighting, differing site conditions from plan, and poor access with in construction site ranked 5^{th}, 6^{th}, 8^{th}, 11^{th} respectively in case study 1 among 40 factors. Sufficient lighting is one of the necessary requirements in construction sites, insufficient lighting will result in accidents, death and errors during performing tasks. Differing site conditions from plan can highly affect the performance of the contractor, increases the cost for the contractor and causes delay in the project, in which unforeseen conditions, that were not covered in the contract between owner and contractor such as; different soil layers and unforeseeable objects resulted from excavation can be a burden for the contractor to proceed his work. All of these factors cause delay and decrease the productivity (Gundecha, 2012).

Lack of required material was ranked the 5^{th} in case study 2, while it was ranked the top in case study 1 and material shortage location ranked the 9^{th} among 40 factors in the same study. Management of material on site ranked the 6^{th} among 46 factors in case study 3. The result is acceptable, because the issue of material is a global problem affecting labor productivity. The result is supported by the study of (Dai, Goodrum, & Maloney, 2007) in US, in which it highlighted to be one of the most significant factors from the perspective of craftsmen and foremen, in Singapore it was ranked 8^{th} among 17 factors in a study conducted by (Lim & Alum, 1995). Moreover, it was ranked the 13^{th} among 40 factors in Europe in a study undertaken by (Palop, 2016). Furthermore, in US, the transporting of material to workers generates an average loss between 6.40 to 8.40 according to a study conducted by (Yates & Guhathakurta, 1993).

Lack of tools and equipments was ranked 4^{th} among 40 factors in case study 1, while lack of tools and equipment, and equipment breakdown was ranked 13^{th} among primary factors in case study 2. The result is can be supported by (Palop, 2016) in which Unavailability of tools and equipment factor was ranked 16th among 40 factors in Europe. In addition to, the lack of tools was among the most demotivating factors in Hong Kong study conducted by (Ng, Skitmore, Lam, & Poon, 2004). In the US, an average of 3.41 to 5.08 hours per week for a worker lost due to the shortage of tools according to the study conducted by (Yates & Guhathakurta, 1993).

Change orders related factors include factors as; change orders from the designer, change orders from the owner and design changes. Delay caused by Variation orders ranked the 2nd among 46 factors in case study 3, while design changes, change orders from the designer and change orders from the owner ranked 20th, 21st and 24th among 40 factors in case study 1 respectively. This can be justified because design changes factor ranked the top among 40 factors affecting labor productivity in Europe in a study by (Palop, 2016). Furthermore, the result can be acceptable because changes resulted from the owner or any changes in design lead to several losses, it could delay the activities, it leads to rework, increases the cost for the contractor and decreases the productivity, as a result the owner is responsible for any cost variances and any design changes, which can be considered as unforeseen events for the contractor.

Overtime working was ranked the 4th among primary factors in case study 2 and it was ranked 10th among 40 factors in case study 1. The result is acceptable because working for more than 40 hours per week can highly affect the productivity of the labor, it causes fatigue and results in an increase rate of absenteeism, and thus it reduces the productivity. Working overtime is usually implemented when there is a compression or an acceleration of the schedule due to the delay which occurred in projects.

Overcrowding on site was ranked 7th among primary factors in case study 2 and it was ranked 8th among 46 factors in case study 3. The result is justified because overcrowding was ranked the 2nd in Hong Kong in the most demotivating factors in the study undertaken by (Ng, Skitmore, Lam, & Poon, 2004) and it was ranked 18th among 35 factors affecting labor productivity in Spain in a study conducted by (Robles, Stifi, Ponz-Tienda, & Gentes, 2014). Interfering between crews from different trades in the same area, overcrowding for many workers in a specific task which does not need more workers than required according to the manpower allocation for the activity, as a result it leads to labor productivity loss, idle and increases the cost.

Accidents during construction were ranked 3rd among 40 factors in case study 1 and ranked 13th among primary factors in case study 2. Accidents in general can lead to a significant negative impact on productivity. A stop-work order, because of accidents on site was one of the most critical factors in Study of Singapore, which was concluded by (Lim & Alum, 1995). It can be a total stop of work for days as a result of the death of a worker during construction, the delays reflect a high loss for cost and time. Moreover, the worker who is injured will stop work completely causing a disruption of the task performed by him, furthermore, the morale of the workers will be decreased and the accident will affect their performances.

4.7 Case Study 4

The case study was a part of an academic research (Master Thesis). The research was conducted by Michael Gerges in 2015. The aim and objectives of the study were, first to determine the factors that have an impact on the productivity of labors in the Egypt and secondly, was to suggest key strategic drivers that can improve the labor productivity in Egyptian construction industry. A questionnaire followed by interviews has been undertaken in this research to identify and rank the factors, and finally to recommend the possible ways to manage and minimize the impacts of these factors was done face to face by using interviews (Gerges, 2015).

4.7.1 Methodology used

A list of 41 factors in Questionnaire was classified under four main categories: human/labor factors, management factors, external factors, and material factors. A five point scale Likert was applied in order to indicate the degree of the importance of the factors. The Questionnaire was surveyed in Arabic language to make sure that all respondents understood the survey. A pilot study has been done, a sample of the questionnaire has been sent to 13 construction project managers with more than 10 years' experience representing 5% from the 258 questionnaires should be sent to complete the survey (Gerges, 2015). The population was the 16400 contractors registered in the Egyptian Federation of Construction and Building Contractors (EFCBC). The contractors in Egypt are classified into 7 groups: annual income, number of employees, projects size, tool and equipment rented or owned, number of engineers, and years of contractor experience. Eventually, the available target population was chosen according to the first 3 groups accounting for 776 contractors. With 95% confident level, the representative sample size was calculated. Therefore, 258 Egyptian contracting companies were surveyed. The Relative Importance Index (RII) technique was implemented to rank the factors. A total 258 questionnaire sent, and a total 227 of questionnaire received accounting for 87.98% as a response rate.

4.7.2 Respondents profile

The profile of the 227 respondents including the task of the respondents and the years of experience is shown in table 7. Table 8 shows the results of the survey including the ranking of factors and groups (Gerges, 2015).

Respondent	**Number of respondents**
Engineers	98
Foremen	33
Site Supervisors	32
Construction Managers	27
Project Managers	18
Quantity Surveyors	12
Architects	7
Years of Experience	**Number of respondents**
0-5 years	37
5-10 years	94
10-15 years	62
15-20 years	20
20+ years	14

Table 7: Profile of the respondents (Gerges, 2015).

Factors	RII	Rank	Group
Tools and equipment shortages	85.79%	1	Material
Delay in material delivery on site	83.42%	2	Material
Payment delay	82.76%	3	Management
Undisciplined labor	82.55%	4	Human/Labor
Material shortage	82.37%	5	Material
Rework	82.11%	6	Management
Labor experience and skill	81.96%	7	Human/Labor
Low quality of raw material	81.84%	8	Material
Waiting for equipment to arrive	81.78%	9	Material
On site accident	81.58%	10	External
Access to site	80.79%	11	External
Lack of supervision leadership	80.53%	12	Management
Personal/family problems	80.37%	13	Human/Labor
Incapability of contractor's site management to organize site activities	79.94%	14	Management
Working 7 days a week without rest	79.47%	15	Human/Labor
Absenteeism	79.21%	16	Human/Labor
Pick and drop facility	78.68%	17	Management
Poor site condition	78.38%	18	External
Labor motivation	77.62%	19	Human/Labor
Shortage of power supply/water	76.42%	20	External
Late payment from client to contractor	75.79%	21	Management
Arguments between workers	75.67%	22	Human/Labor
Weather	75.00%	23	External
Physical fatigue	74.47%	24	Human/Labor
Labor age (old/young)	74.27%	25	Human/Labor
Damaged material on site	72.93%	26	Material
Design changes	72.63%	27	Management
Communication problems between labor and supervisor	71.58%	28	Human/Labor
Security (crime and theft)	71.32%	29	External
Unrealistic scheduling	70.46%	30	Management
Inefficient use of material on site	70.36%	31	Material
Offered services for labor	69.84%	32	Management
Perks	69.81%	33	Management
Incentive scheme	68.95%	34	Management
Insufficient lighting	68.91%	35	External
Inspection delay	67.89%	36	Management
Lack of periodic meeting with labor	65.79%	37	Management
Lack of training sessions for laborers	65.53%	38	Management
Regulations change by government	65.26%	39	External
Increase of material price	62.47%	40	Material
Natural disaster (flood and hurricane)	60.31%	41	External

Table 8: Overall ranking of 41 factors in Egypt and their groups (Gerges, 2015).

4.8 Case Study 5

The case study was a part of an academic research (Master Thesis). The research was conducted by Zeyad Ahmed Abo Mostafa in 2003. The main objectives and aim were to identify the factors affecting labor productivity in building projects in Gaza Strip. A close ended questionnaire was conducted in order to achieve the objective of the research to detect the factors.

4.8.1 Methodology used

The questionnaire was designed to survey the factors affecting labor productivity and it was classified under 10 groups, which are; manpower issues, leadership issues, motivation issues, time issues, materials / tools issues, supervision issues, project issues, safety issues, quality issues, and external issues. The Questionnaire was translated into Arabic language to guarantee a better understanding for questions. A pilot study has been conducted by sending 6 Questionnaires to 6 contractors, as a result, some modifications have been implemented to the questionnaire to fit the original purpose of the study (Abo Mostafa , 2003).

The questionnaire targeted the first, second, third class of total 105 contractor companies, which has valid registration by the Contractors Union in buildings specialization in Gaza Strip. Systematic random sample technique was applied, in order to select the representative sample from the 105 contractor companies, and then a random sample technique was applied to select number of companies from each class. As a result, 83 contractor companies as the sample size should be surveyed to be representative with a confidence level 95%. The validity of the questionnaire was tested through the pilot study and also 5 experts who have a strong relevant to the objectives of the study and expert in the field of labor productivity were chosen to test and evaluate the instrument of the research. Moreover, the reliability of the survey was assessed by 5 random respondents to answer the survey 2 times, to be sure about the consistency of the survey and then the survey was tested by SPSS program to confirm the reliability of the study. The importance index technique to analyze data was applied. A total of 83 questionnaires were sent, 76 respondents of contracting companies received with a response rate 91.5% (Abo Mostafa , 2003).

4.8.2 Respondents profile

Figure 9 shows the distribution of the responses and the profession of the respondents, which reveals that a big percentage of the respondents having high managerial titles.

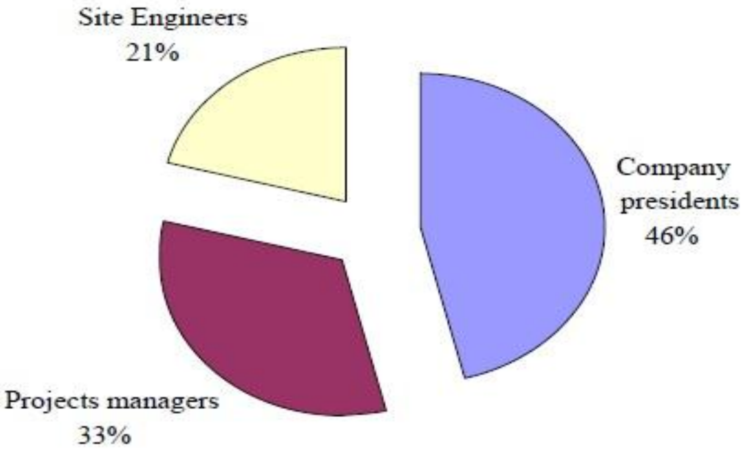


Figure 9: Distribution of respondents (Abo Mostafa , 2003).

4.8.3 Results

The result of the questionnaire was a total of 45 factors affecting labor productivity in the building projects in the Palestinian construction industry have been concluded and ranked according to the importance index categorized under 10 groups. Table 9 shows the overall ranking of factors and their groups (Abo Mostafa , 2003).

Group	Factors	Importance Index	Rank
Materials /Tools factors	Material shortages	89.47	1
Manpower factors	Lack of labor experiences	84.21	2
Leadership factors	Lack of labor surveillance	83.42	3
Leadership factors	Misunderstanding between labor and superintendents	80.26	4
Supervision factors	Drawings and specifications alteration during execution	80	5
Motivation factors	Payment delay	78.68	6
Manpower factors	Labor disloyalty	78.55	7
Supervision factors	Inspection delay	77.63	8

Time factors	Working for 7 days of week without taking a holiday	76.58	9
Materials /Tools factors	Tool and equipment shortages	75.26	10
Supervision factors	Rework	75	11
Time factors	Misuse of time schedule	74.74	12
Safety factors	Accidents	72.37	13
Manpower factors	Labor dissatisfaction	72.11	14
Supervision factors	Supervisors absenteeism	71.84	15
Quality factors	Inefficiency of equipment	71.585	16
Manpower factors	Misunderstanding among labor	71.58	17
Quality factors	Low quality of raw materials	71.32	18
project factors	Working in confined space	70.26	19
Materials /Tools factors	Unsuitability of materials storage location	69.21	20
Motivation factors	Lack of financial motivation system	68.95	21
Quality factors	High quality of required work	67.89	22
Safety factors	Violation of safety precautions	67.63	23
project factors	Interference	67.11	24
Manpower factors	Lack of competition	66.84	25
Time factors	Method of employment (using direct work system)	65.79	26
Safety factors	Insufficient Lighting	64.74	27
Time factors	Increasing No. of labor in order to accelerate work	64.47	28
External factors	Weather changes	63.95	29
Manpower factors	Increase of laborer age	62.63	30
Time factors	Working overtime	62.37	31
project factors	Construction method	62.11	32
Motivation factors	Lack of labor recognition programs	61.84	33
project factors	Type of activities in the project	61.58	34
Safety factors	Bad ventilation	61.32	35
External factors	Augmentation of Government regulations related to the construction sector	60.79	36
Safety factors	Working at high places	58.68	37
Leadership factors	Lack of periodic meeting with labor	56.84	38
Motivation factors	Non-providing of transportation means	56.05	39
Motivation factors	Lack of place for eating and relaxation	55.53	40
Manpower factors	Labor absenteeism	55	41
Manpower factors	Labor personal problems	54.74	42

Safety factors	Unemployment of safety officer in construction site	53.16	43
Motivation factors	Lack of training sessions	50.26	44
Safety factors	Noise	48.42	45

Table 9: Overall ranking of factors in Gaza and their groups (Abo Mostafa , 2003).

4.9 Case Study 6

The case study was a part of an academic research (Master Thesis). The objectives and aim of this study were; to investigate the critical factors affecting labor productivity in building construction projects in Addis Ababa, Ethiopia. A questionnaire has been applied with mainly close ended questions and some open ended questions. (Amanuel, 2016).

4.9.1 Methodology used

The survey targeted the contractor companies in Ethiopia. A total 37 Questionnaire were sent to building construction projects with grade three and above, and also three grade and above for the local contractors, and 23 was received. In addition to, a total 25 questionnaires were sent to contractors' head offices and 15 were received. As a result, a total 62 questionnaires were distributed and a total 38 was responded successfully, with response rate 61% (Amanuel, 2016).

4.9.2 Respondents profile

It was concluded that 41% of respondents were building contractors of grade one, 35% general contractor of grade one, 21% building contractor of grade 3. It was found also, that 46% of the companies were running 5 to 10 projects at the moment of the survey, 38% with 10 to 20 active projects and around 13% with above 20 projects (Amanuel, 2016). Figure 10 shows the position and title of the respondents, who responded to the questionnaires. Results of survey included; Top ten of critical factors with severity index. Table 10 shows the top ten factors (Amanuel, 2016).

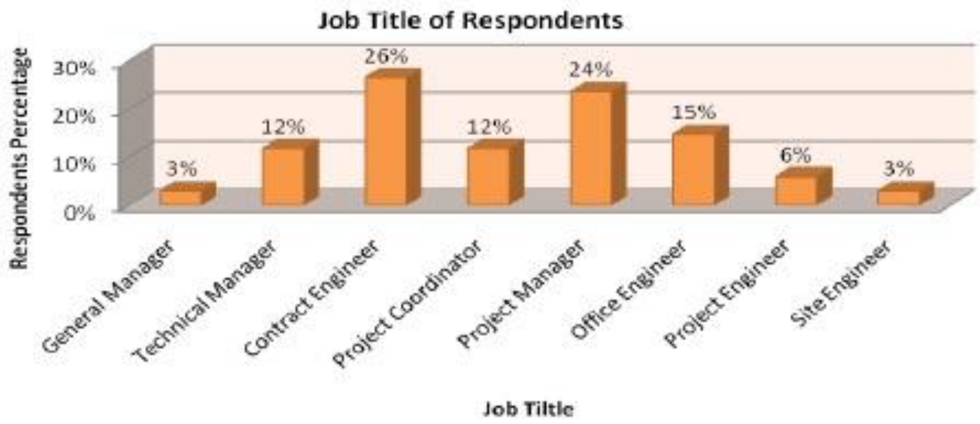


Figure 10: Job titles of the respondents (Amanuel, 2016).

Rank	Top Ten Factors having Critical Impact	Responsible Stakeholder	SI
1	Shortage of material	Contractor	0.612
2	Delays in decisions making	Consultant	0.597
3	Incomplete and Inaccurate drawings	Consultant	0.574
4	Lack of follow up the work progress	Contractor	0.560
5	Financial difficulties of the owner/Payment delay	Client	0.547
6	Incomplete facilities (water & power supply, and sanitary)	Contractor	0.544
7	Inspection and Instruction delay	Consultant	0.540
8	Lack of Motivation	Contractor	0.531
9	Frequent damage of equipments	Contractor	0.523
10	Change of work order/Variation	Consultant	0.513

Table 10: Top ten factors in Addis Ababa (Amanuel, 2016).

4.10 Main Findings and Analysis for Case Studies of Developing Countries

To develop a better understanding for critical factors affecting construction labor productivity in developed countries, an analysis has been undertaken by the author for the final findings of case study 4 in Egypt, case study 5 in Gaza Strip, and case study 6 in Addis Ababa. The cross-case analysis process comprised an overall comparison between tables of the resulted top ranked critical factors concluded from the mentioned case studies, in order to detect similar critical factors and determining their rankings and their significant importance, and then followed by an analysis for the most influential factors included in the three case studies. The analysis was performed by the researchers of these case studies and the author of this study.

4.10.1 Analysis of Influential Factors in Case Studies related to Developing Countries

Material related factors: Lack of materials was ranked the top in case study 5 among 45 factors and ranked the top also in case study 6 among 53 factors, while it was ranked 5th among 41 factors in case study 4. Delay in material delivery on site was ranked 2nd in case study 4, in addition to the law quality of materials was ranked 8th, 18th in case studies 4 and 5 respectively. The result reveals that material issues are a global problem. The result is supported by several past studies; availability of material was ranked the first among 30 factors in Egypt (El-Batreek, Ezeldin, & Elbarkouky, 2013), lack of materials ranked the 5th among 31 factors in West Bank in Palestine (Mahamid, 2013), shortage of materials was ranked 4th among 27 factors in India (Soham & Rajiv, 2013), it was the top in Thailand among 23 factors (Makulsawatudom, Emsley, & Sinthawanarong, 2004), availability of materials in site was ranked the 2nd among 40 factors in Yemen (Alaghbari, Al-Sakkaf, & Sultan, 2017) and lack of materials was ranked 1st according to the perspective of craftsmen in Indonesia (Kaming, Olomolaiye, Holt, & Harris, 1997).

In Egypt, after the revolution, the suppliers of materials wanted to guarantee profit, as a result they kept the prices, another issues related the transportation of the material because of the maintenance and the extension processes of roads after the revolution, hence, the delivery and availability of materials will challenge difficulties. These circumstances are in the line with Yemen, after revolution, materials are not easily imported, the same situation in Gaza as it is under the siege of Israel, the materials are not easily imported to the sites on time, furthermore, factors as inflation, supply and demand, market conditions in general can participate in material availability issue [(Gerges, 2015); (Mahamid, 2013); (Alaghbari, Al-Sakkaf, & Sultan, 2017)].

Some other reasons for material shortage are the financial weakness condition for the contractors in Thailand, as contractors cannot procure the required materials (Makulsawatudom, Emsley, & Sinthawanarong, 2004). Moreover, it was found that on site transportation, in sufficient planning and coordination and shortage of material storages were the main causes for material shortage in Indonesia from the perspective of craftsmen especially in high buildings, where the cost of materials can reach 65% of the total budget (Kaming, Olomolaiye, Holt, & Harris, 1997). In Egypt, the low quality of material is an important issue, as the suppliers do not deliver the required material to the site according to the proper specification and the quality does not meet even the lowest allowable degree due to the intendancy of the suppliers to save money and sometimes deceiving by replacing required specified material with another cheap with low quality one (Gerges, 2015).

Tools and Equipments related factors: Tools and equipments shortage was ranked the top among 41 factors in case study 4, ranked 10th among 45 factors in case study 5. Frequent damage of equipment was ranked 9th among 53 factors in case study 6, while inefficiency of equipment ranked 16th among 45 factors in case study 5, finally, waiting for equipment ranked the 9th among 41 factors in case study 4. The result shows how much the importance of the efficiency and the availability of tools and equipment in developing countries. The result is supported by several studies; Lack in equipment ranked the 6th among 31 factors in West bank Palestine (Mahamid, 2013), lack of tools and equipment ranked the 4th in Thailand among 23 factors (Makulsawatudom, Emsley, & Sinthawanarong, 2004), Equipment required for work on the project was ranked 10th among 40 factors in Yemen (Alaghbari, Al-Sakkaf, & Sultan, 2017), lack of tools and equipment ranked 4th among 36 factors in Uganda (Alinaitwe, Mwakali, & Hansson, 2007), it was ranked 3rd among 31 factors in Iran (Ghoddousi & Hosseini, 2012), and finally, lack of tools and equipment breakdown factors were ranked 5th and 6th respectively in Indonesia (Kaming, Olomolaiye, Holt, & Harris, 1997).

Shortage of spare parts for equipment, irregular and lack of preventive maintenance, continuous usage of old equipment lead to equipment break down (Makulsawatudom, Emsley, & Sinthawanarong, 2004), availability of workshops and areas for regular maintenance for the contractors is essential to keep the good condition of the equipment (Alinaitwe, Mwakali, & Hansson, 2007), in Iran, the high price of equipment imposes the contractors not to buy it, in addition to the continuous dependency on the old equipment lead to breakdown of it (Ghoddousi & Hosseini, 2012), in Egypt after the revolution, contractors only purchase tools or rent equipment when they perform work on site because they are not sure if the project will continue or not, also many tools are exposure to be stolen and equipment to be improperly misused due to lack of security and safety on site and storages (Gerges, 2015).

Lack of labor skills and experiences: it was ranked the 2nd among 45 factors in case study 5, while it was ranked 7th among 41 factors in case study 4. The result is highly acceptable, because in developing countries, it is not easy to find skilled and experienced labors due to the lack of training, education and knowledge. The result is supported by many studies; it was ranked the top among 40 factors in Yemen (Alaghbari, Al-Sakkaf, & Sultan, 2017), ranked also the top among 23 factors in Turkmenistan (Durdyev, Ismail, & Abu Bakar, 2012), it was ranked 4th among 31 factors in Palestine (Mahamid, 2013), ranked 9th among 27 factors in India (Soham & Rajiv, 2013), shortage of experienced labor and skills of labors factors ranked 2nd and 5th among 42 factors in Trinidad and Tobago (Hickson & Ellis, 2014), it was ranked 2nd among 36 factors in Uganda (Alinaitwe, Mwakali, & Hansson, 2007).

In Palestine, Egypt and Turkmenistan, several worker tend to immigrate or search for better countries that can provide them higher wages as in Egypt and Palestine, the skilled and experienced workers travelled to Gulf countries, the same as Turkmenistan after the break down of Soviet unions. This results in leaving the market with low experienced and skilled labors which affect the productivity in a negative way. [(Gerges, 2015); (Mahamid, 2013); (Durdyev, Ismail, & Abu Bakar, 2012)]. In Uganda, the government promised to provide technical schools in order to train and educate the workers, and in the long term, the skills will be improved (Alinaitwe, Mwakali, & Hansson, 2007). As a result, in many developing countries, the lack of experienced and skilled workers in market will lead to hiring unskilled and non-experienced young workers by contractors, hence, the output of workers will be full of errors and will be rejected by the inspection of the super visor and consultants, moreover, many contractors are not willing to pull their labor in the middle of the working day in order to be trained and labors do not prefer to go to training institutes, because they think it is a waste of time and investing wasted money, therefore, these factors cause rework and delay in construction activities (Gerges, 2015).

Labor undisciplined and personal problems: undisciplined labor factor and persona/ family problems ranked 4th and 13th respectively among 41 factors in case study 4, labor disloyalty ranked 7th among 45 factors in case study 5. The result can be justified, because labors in Egypt are undisciplined and they are not fully committed to the work during day, they tend to chat, eat and leave the site during the working day. In the survey of case study 4, most of the engineers estimated that 25-30% of labors in construction sites are undisciplined. Furthermore, the lack of meeting labors with their families because the most of the labors originally come from remote areas, in addition to the economic issues after the revolution cause some pressures on labors, which highly affect their productivity performances (Gerges, 2015).

Lack of supervision skills related factors: The lack of supervisor experiences, the incompetent supervisor, supervisor absenteeism, misunderstanding between supervisors and labors, all of these factors are related to the concept of skilled and experienced supervisor, these factors were introduced in many ways in literature and factors surveyed by several studies. Lack of supervision leadership ranked 12th among 41 factors in case study 4, while lack of labor surveillance, misunderstanding between labors and superintendents and supervisor absenteeism ranked 3rd, 4th and 15th respectively among 45 factors in case study 5. The results indicate the huge importance of supervision of labors. The results are supported by several studies; Lack of superintendents experience ranked 12th among 31 factors in Palestine (Mahamid, 2013), incompetent supervisors ranked 3rd among 23 factors in Thailand (Makulsawatudom, Emsley, & Sinthawanarong, 2004) and ranked 2nd in Uganda (Alinaitwe, Mwakali, & Hansson, 2007) leadership skills of supervisors ranked 2nd among 14 factors in UAE (Ailabouni & Gidado, 2012), Choose an adequate staff and site supervision efficiency factor ranked 11th among 40 factors in Yemen (Alaghbari, Al-Sakkaf, & Sultan, 2017).

Studies conducted by Jarkas (2012) concluded that labors are highly involved into many unproductive activities as result of lack of supervision experience. Moreover, supervisors leave the construction sites for some personal things, which affects the workflow of the supervised activities and encourage the labor to be idle and waiting for the instructions of the supervisors (Gerges, 2015) Unskilled supervisors cannot provide the accurate information and instructions to the labors, resulting in errors and sometimes rework, furthermore, rejection of the inspected works due to the low knowledge, skills, experiences of supervisors and their incapability to give the correct instructions for labors. Therefore, some misunderstanding between labors and supervisors will occur, and causes lack of confidence of the managerial and skills abilities of the supervisors.

Payment delay: it was ranked 6th out of 45 factors in case study 5, was ranked 5th out of 53 factors in case study 6 and ranked 3rd out of 41 factors in case study 1. The results are acceptable and are in line with several studies as; financial status of the owner ranked 3rd among 31 factors in Palestine (Mahamid, 2013), ranked 7th among 42 factors in Trinidad and Tobago (Hickson & Ellis, 2014), and ranked 8th among 23 factors in Turkmenistan (Durdyev, Ismail, & Abu Bakar, 2012). Most of the contractors who are not financially strong will not afford the daily construction costs, due to the late payments from the owner and disruption in the cash flow, as a result, impacts on the relation between contractor and labors, lack of labor motivation, in ability to purchase materials and rent equipment (Mahamid, 2013). In Egypt, many labors have family needs, so the contractors pay their wages from their own money because of the delay of payment from the owner, hence, delay in payment from the owner leads to delay in the project time and increases the cost, moreover, it affects the motivation, satisfaction of labors and decreases their performance and productivity on site (Gerges, 2015).

Incomplete drawings: it was ranked the 3rd among 53 factors in case study 6. This result can be supported by; clarity of technical specifications ranked 3rd among 27 factors in India (Soham & Rajiv, 2013), incomplete drawings ranked 2nd out of 23 factors in Thailand (Makulsawatudom, Emsley, & Sinthawanarong, 2004), incomplete drawings ranked 14th among 36 factors in Uganda (Alinaitwe, Mwakali, & Hansson, 2007). In Yemen, factors related to providing drawing details and simplicity of design ranked 6th and 7th out of 40 factors, the simplicity of the architectural and structural design refers to the buildability approach, which is essential to be implemented to facilitate the execution on site and increases the productivity (Alaghbari, Al-Sakkaf, & Sultan, 2017). The errors, incompleteness, impracticality and conflicts in drawings generated when the owner do not give the designer enough time to perform his job properly because of the bidding process, as a result, delays for revision and clarification will occur for drawings and specifications. Therefore, it affect the productivity, increases the time of the project, frustration for workers because they wait for the correct or the completed drawings after a long revision, and finally some overtime will occur to catch up the schedule [(Zakeri, Olomolaiye, Hold, & Harris, 1996); (Makulsawatudom, Emsley, & Sinthawanarong, 2004)].

Management of site activities related factors: Lack of follow up the work progress factor was ranked 4th among 53 factors in case study 6, Misuse of time schedule ranked 12th among 45 factors in case study 5, Incapability of contractor's site management to organize site activities ranked 14th out of 41 factors in case study 4. The result is supported by many past studies as; unrealistic schedule ranked 11 out of 27 factors in India (Soham & Rajiv, 2013), unrealistic schedule was ranked 2nd in Trinidad and Tobago among 42 factors (Hickson & Ellis, 2014), planning, and the flow of works continuity, and planning during heavy works in site ranked 16th out of 40 factors in Yemen (Alaghbari, Al-Sakkaf, & Sultan, 2017), and the tasks are not properly planned and realistically sequenced ranked 10th among 31 factors in Iran (Ghoddousi & Hosseini, 2012).

It is well known, that the proper scheduling of site activities is the responsibility of an efficient site manager and planning engineers, miss planning the activities will cause disruption and delay in the project progress, so to maintain a good workflow in schedule, planning should be done correctly. Allocation of manpower and resources is also important during scheduling to prevent overcrowding and over manning, as a result, any disruption in schedule will increase cost and decrease motivation and productivity of construction workers.

Change orders related factors: change of work order/variation ranked the 10th out of 53 factors in case study 6, drawings and specifications alteration during execution ranked 5th among 45 factors in case study 5 and design changes ranked 27th from 41 factors in case study 4. The results are supported by other studies as; change orders ranked 12th among 23 factors in Thailand (Makulsawatudom, Emsley, & Sinthawanarong, 2004), Interruption of the work (change designs/specifications) ranked 6th out of 40 factors in Yemen (Alaghbari, Al-Sakkaf, & Sultan, 2017), the extent of variation/change orders during execution ranked 16th among 42 factors in Trinidad and Tobago (Hickson & Ellis, 2014), design changes was rated to be in the top ten affecting schedule performance in Indonesia (Soekiman, Pribadi, Soemardi, & Wirahadikusumah, 2011), and design changes ranked 14th among 36 factors in Uganda (Alinaitwe, Mwakali, & Hansson, 2007).

There is a correlated relation between change of works and efficiency, as the efficiency will decrease if the changes in work are performed, it was concluded that disruptions are the root causes for efficiency due to the changes occurred during work, as a result, it was found that around 30% loss of efficiency happen when works change (Thomas & Napolitan, 1995). Change orders and design changes lead to increase the time frame of the project, the project tempo can be disturbed, hence, contractors will suffer from over time and increases in cost. Therefore, it decreases the overall productivity of labors and their morale and motivations because their work can be removed after it was done resulted from alteration in design and change orders (Zakeri, Olomolaiye, Hold, & Harris, 1996).

Rework: it ranked 6th out of 41 factors in case study 4 and it was ranked the 11th among 45 factors in case study 5. The results are acceptable and in line with several conducted studies; it ranked 10th among 23 factors in Thailand (Makulsawatudom, Emsley, & Sinthawanarong, 2004), ranked also 10th out of 42 factors in Trinidad and Tobago (Hickson & Ellis, 2014), was in the top out of 31 factors in West Bank Palestine (Mahamid, 2013), ranked 3rd among 36 factors in Uganda (Alinaitwe, Mwakali, & Hansson, 2007), 2nd according to the perspective of craftsmen in Indonesia (Kaming, Olomolaiye, Holt, & Harris, 1997), and 5th among 23 factors in Turkmenistan (Durdyev, Ismail, & Abu Bakar, Factors Constraining Labour Productivity : Case Study of Turkmenistan, 2012).

The results show how significant the impact of rework on the labor productivity. There are several causes for rework mentioned in past studies such as; change orders, errors and incomplete drawings, wrong instructions and improper supervision from supervisors, poor workmanship, unskilled and incompetent labors, craftsmen and supervisors, high amount of revision for drawings, high amount of alteration of design during execution, complexity of the design [(Zakeri, Olomolaiye, Hold, & Harris, 1996); (Makulsawatudom, Emsley, & Sinthawanarong, 2004); (Kaming, Olomolaiye, Holt, & Harris, 1997)]. In Turkmenistan, it was concluded that the cost of rework constitutes from 2 to 12% of the contract value of the project (Durdyev, Ismail, & Abu Bakar, Factors Constraining Labour Productivity : Case Study of Turkmenistan, 2012). In Egypt, it was investigated, that contractors recruit low wage and unskilled labors to save money in projects that need skilled labors, as a result, errors in work occurred, hence, contractors start to recruit skilled labor again to overcome the errors in work performed. Therefore, the time between hiring low skilled to high skilled labors increases, thus rework leads to project delay and increases the overall cost of the project (Gerges, 2015).

Absenteeism: it was ranked 16th among 41 factors in case study 4. The result can be justified by many past studies; it ranked 5th out of 23 factors in Thailand (Makulsawatudom, Emsley, & Sinthawanarong, 2004), ranked 6th out of 30 factors in Egypt (El-Batreek, Ezeldin, & Elbarkouky, 2013), and ranked 6th among 10 top factors affecting schedule performance in Indonesia (Soekiman, Pribadi, Soemardi, & Wirahadikusumah, 2011). Several reasons for absenteeism was investigated in past studies; many craftsmen have another profession, part time workforces who participate only in site when they are free, irresponsible craftsmen who drink alcohol and they cannot come the next working day, searching for another profitable work, illness, physical fatigue resulted from working overtime and finally holidays [(Zakeri, Olomolaiye, Hold, & Harris, 1996); (Makulsawatudom, Emsley, & Sinthawanarong, 2004)]. In Egypt, labors tend to be absent in a day after several days working so that they can spend more time with families and spend the money they earned, they can leave their current work for better opportunity as a site close to their home or even if another contractor will pay more to them (Gerges, 2015).

4.11 Case Study 7

The case study was a part of an academic research (Master thesis). The objectives of the study were; 1st to explore the complicated relationships between critical factors affecting construction productivity, 2nd to explore the different definitions and measurements for productivity. Five case studies on five projects performed by company A were conducted through semi-structured, in depth interviews with construction experts in the Company A, each case study 2 interviews have been done. Company A is considered to be one of the biggest EPFC (i.e. engineering, procurement, fabrication and construction) and maintenance provider in the world. The 5 projects were large with a huge budget of 1 billion euros or more (Lorys, 2018).

The answers and responses of interviewees for questions related to definitions and measurements of productivity in the case study 7 are summarized and discussed for each project from the 5 projects as below.

The questions included in case study 7 were stated as (Lorys, 2018):

> What is construction productivity? How construction productivity is measured (what is considered as input/output)? Which departments are involved in progress/ productivity tracking? Which data/programs are used to track progress (quantities, man-hours, cost, etc.)? (p,105).

4.11.1 Project A

- Both experts defined productivity as measurement of certain amount of quantity installed by man-hours, where man hours are related to cost (Lorys, 2018).
- The certain quantity encompasses number of activities with percentage of each activity, an example for this; in order to install one meter of pipe, number of activities exist as; 30% for installing the pipe, 10% for locating it, and 30% for welding and so on (Lorys, 2018).
- Both experts did not agree completely about the split of pipe activities, they added that equipments and materials were not added to the measurement during progress reporting (Lorys, 2018).

- It was found that construction metrics have been chosen according to the preferences of the construction discipline managers, resulting in to inconsistences in reporting the progress for different units in project A. The welding process was reported according to the number of welds without considering the type of welding, as the time needed for different types of welding varies, however, it was then reported by determining the different welding types, and finally, it was proposed to use inch unit instead of number of welds during reporting the progress. The construction data representing the progress was reported the project control department daily from the site supervisor (Lorys, 2018).

4.11.2 Project B

- Both experts defined productivity as measurement of certain amount of quantity installed by man-hours, as a ratio of output to input (Lorys, 2018).
- Both experts agreed that there is no standard common available construction metrics for reporting the progress, in addition to the preferences of construction managers, as a result there are several ways for reporting the progress (Lorys, 2018).
- The data that represented the progress in man hours were sent to the project control department every week, and both experts mentioned that the data related to man hours sent, was introduced in the form of earned value management concept including actual and earned man hours (Lorys, 2018).

4.11.3 Project C

- Both experts defined productivity as measurement of certain amount of quantity installed by man-hours, as a ratio of output to input. Both experts emphasized on the importance of tracking the actual and earned man hours against the burnt hours (Lorys, 2018).
- One of the experts explained that there variety in construction metrics, but he used specific standard, as for heavy, light and medium steel, all are measured by ton, in addition to other light steel additional connections should be factored and put into consideration for measurement, the expert preferred to

rely on the number of welds regardless the size and types, he has chosen cubic yards for concrete, and for piping he preferred length, diameter, and number (Lorys, 2018).

- It was found that owner's unit rate for productivity is used, this is because the owner affected the percentage of the activity split (Lorys, 2018).

4.11.4 Project D

- Both experts defined productivity as measurement of certain amount of quantity installed by a man, as a ratio of output to input, and compared against the estimated values (Lorys, 2018).
- One of the experts explained that the activity of performing 1 cubic meter of concrete is split into different activities, generating around 50 hours, those hours varies according to weather and different regions (Lorys, 2018).
- The other expert discussed that there is inconsistency for using construction metrics and added that it is very complicated, and added that there is no proper coordination between the construction department and project control department concerning the reporting of progress data. Both experts agreed that construction progress should be tracked against the expenditure every month, due to the high relevant between productivity and budget (Lorys, 2018).

4.11.5 Project E

- Both experts defined productivity as an input of amount of spent hours in order to install a certain quantity (Lorys, 2018).
- Both experts agreed that there is shortage in existing tools to report the construction progress data, and the productivity measurement including output quantities and input man hours are used in the form of cost data (Lorys, 2018).
- They explained that there is various amount of construction activities and it varies according to regions, as a result, no standard construction metrics for measuring and assessing it (Lorys, 2018).

4.11.6 Main Findings for Case study 7

- There was a consensus for most of the project's experts about the definition of productivity, which is a measurement of certain amount of quantity installed by man-hours, as a ratio of output to input (Lorys, 2018).
- It was concluded that construction productivity in all projects were measured by the amount of man-hours (input) required to install a certain amount of quantity (output), without considering the materials and equipments in measurement (Lorys, 2018).
- The terms "efficiency" and "effectiveness" were not used by managers for productivity measurements in all projects (Lorys, 2018).
- In each construction discipline, there is a complexity and various amount of construction activities, even the split of each construction activity in to percentages encountered a great challenge. (Lorys, 2018).
- Inconsistency for choosing the construction metrics for output due to the complexity, big number of different activities, and each activity is split into sub activities with different units, and preferences of managers for choosing construction metrics (Lorys, 2018).
- Construction measurements were tracked against the estimated values, as burnt or actual man hours against the planned man hours (Lorys, 2018).

4.12 Case Study 8

The case study was conducted for measuring labor productivity. The aim of the study is to measure labor productivity for block works on building projects in the Gaza Strip for skilled and unskilled labor by using activity sampling method. Data gathered and used for this study were from construction sites of sheikh Zayed township project through observations. The project comprised 70 buildings with 5 floors in each building, 5 buildings with 12 floors in each building, and other facilities with overall budget 55,345000 million dollars and time frame 2 years, in addition to 14 block laying gangs performed the block works (Enshassi et al.,2011).

4.12.1 Activity for Measurement

Block work activity has been chosen to be measured in this study, because; it's inputs and outputs parameters are easily counted, the cost of block work is higher than other activities comparatively, it is easily observed and analyzed relatively than other activities. The daily working hours of block work gangs start from 8am to 5 pm, including 1 hour break from 12 to 1pm. Two types of block have been used, the first one was block 20 (20cm * 40cm * 20cm), while the second one was block 10 (10cm * 40cm * 20cm) (Enshassi et al.,2011).

Enshassi et al.(2011) classified the block work activity into 3 main groups, each group contained number of sub-activities. They stated 3 groups as follows;

> 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 is unproductive activities which included "idle time", and "removing and replacing already completed work due to operator fault or management fault" (p, 109).

4.12.2 Method of Measurement

Activity sampling techniques has been chosen because; it offers a great opportunity to recognize sub activities contributed in the process and the provides data about how much labor can be used on sites, it introduces a quantitative and statistical approach to the results, the observation efforts required to achieve the needed objectives are easier than other techniques such as time study. The block work activity was broken down into 3 main groups; productive, contributory, and unproductive activities. The number of observations needed to identify the proportions and percentages of the productive, contributory and unproductive times of block work gang were calculated with regard to confidence level of 95%, therefore, 400 observations were used. A precise physical output measure of work done per hour was recorded (Enshassi et al.,2011).

4.12.3 Results

The results of the case study included; the distribution of proportion of block work activities percentages of the working time for skilled and unskilled labors, and the productivity of laying block 20 and 10 by skilled labor per hour. It was concluded that the average productivity per hour for skilled labor for laying block 20 was 38.40 blocks, while the average productivity per hour for laying block 10 was 40.5 blocks (Enshassi et al.,2011). Table 11 shows the main findings of the case study concerning the distribution 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%	36.00%	22.75%
	Rework	0.49%	0.00%	0.25%

Table 11: Distribution of block work activities (Enshassi et al.,2011).

4.12.4 Main Findings for Case Study 8

- The skilled labor productivity was mainly concentrated on the productive activities with 77.01% of his working time, which means more than 3/4 of his total working time, while skilled labor spent 9.76% in contributory activities of his working time. The unproductive time for skilled was 13.23% (Enshassi et al.,2011).

- The unskilled labor productivity was mainly concentrated on contributory activities with around 54.66% of his working time, which indicated more than half, and only 9.34% on productive activities. The unproductive time for unskilled was 36% (Enshassi et al.,2011).
- The result is reasonable because the main task for skilled labor is laying the blocks, that's why the proportion of productive activities was higher for skilled than unskilled, on the other hand, it is well known that unskilled labor is just an assistant and provides necessary tools and materials for skilled to achieves his work, thus the main task for unskilled was focused on contributory (Enshassi et al.,2011).
- The overall working time of the gang was 77% constituting productive activities from their working times (Enshassi et al.,2011).
- The average productivity per hour for skilled labor in laying block 10 (3.24 m2/h) was higher than block 20 (3.07 m2/h), this is reasonable as the block 10 is lighter in weight, which facilitates the handling and laying processes (Enshassi et al.,2011).

4.13 Case Study 9

The case study was extracted from a book, this case study was for a building **"**Smeal College of Business Administration Building**"** in **"**Penn State University campus**"** in United States of America (Thomas & Ellis Jr., 2017, p, 184 and 185). The building consisted of 4 floors with total site area of 324,000 ft2 and the foot print was 46,000 ft2. The building was constructed in 2004-2005 within overall cost of 68 million dollars, the general contractor executed the project was local (Thomas & Ellis Jr., 2017).

4.13.1 Fundamental Principles applied in the project

This case study deomnstartes the influences and the significant importance of proper construction site management in improving labor productivity on site. In this case study the approach of sequential scheduling practices was highlighted to determine the effects on labor productivity, especially, the results from not performing the high-value work simultaneously with the low-value work (Thomas & Ellis Jr., 2017).

Some principles were adopted in that project during the execution, which helped in improving the daily productivity for labors from the perspective of the book's authors such as (Thomas & Ellis Jr., 2017):

> A crew should be viewed as a collection of flexible size work teams. Staff the activity with labor resources that are consistent with the amount of work available to be performed. This includes taking adequate account of the variability in the project (p, 156).

Other principles were not adopted or not used such as (Thomas & Ellis Jr., 2017):

> Where possible, use a 4-10 work schedule. Make the primary focus of the crew’s work directed to high-value work. Never stop working on high-value work. Work on low-value subtasks concurrently with high-value work. Perform incidental and cleanup work concurrently with high-value work. (p, 156).

4.13.2 Activity Description

During obseravtions for executing activities, the observations were concerned to the intsallation process of the frame of interior walls and few for some exterior walls. The activity to construct the interior walls comprised different sequential sub activities, first, the layout should be done, which was considered low-value work, second, the installation of the top tracks was done, which was considered high value-work, third, installation of ducts and fireproofing works were done, fourth, the bottomn tracks and the vertical studs were done. It was obsereved within 30 days, which was the scope of this case study, that layout and top tracks were achived, however, the upper tracks installed during the 30 days accounted around 12% only from the overall amount of the top tracks. (Thomas & Ellis Jr., 2017).

4.13.3 Operation of the Activity

The crew size was 3 to 7 carpenters, the works related to interior walls was sequentially performed, and the crew consumed time in lying out and then followed by installation of the upper tracks. A considerable amount of idle wasted time was observed, besides, there was some carpenters did not find anything to do, and because they were waiting for the layout to be done, which it usually takes 2 persons only. Even, when the installation of top tracks were executed, the crew might have been overstaffed, as a result, it was observed that 33% only was spent for both layout and installation, which they were both executed during the same day (Thomas & Ellis Jr., 2017).

However, the overall activity for the interior wall was symbiotic, which means it is a cooperative work done by several crews of different trades or crews from different contractors, in which the work is passed from one crew to another. It is a challenge, because the crew which performs symbiotic works, is always in the standby mode, they always wait for the work to return back to them to continue, and they always rely on the works of other crews. In this case Study, the upper tracks were installed by the carpenters crew, then the incompleted walls were passed to the crews of fireproofing and duct installation, and then finally, the work will return back again to the carpenters to continue working on the bottom tracks and vertical studs. Therefore, time lags and buffers should be applied, especially, the top tracks should be completed first, then the bottom tracks start. Figure 11 illustrates the symbiotic nature of the wall frame operation (Thomas & Ellis Jr., 2017).

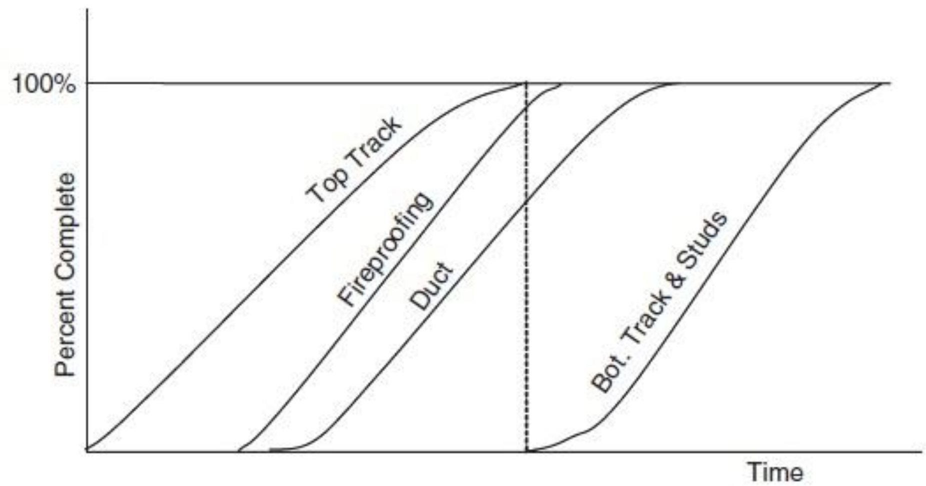


Figure 11: Symbiotic nature of wall frame operation (Thomas & Ellis Jr., 2017).

4.13.4 Challenges affected Performance

The weather adversely affected the daily productivity, because the building was not properly sealed and enclosed, as a result, some rainy water entered some areas of the building and the cold temperature lead the water to freeze, which postponed and stopped working in these areas. Some implication of not proper heating occurred, warming was not adequately supplied for the crew members. During the days which were impacted by weather, layout works were only achieved, which reflected low labor productivity (Thomas & Ellis Jr., 2017).

Poor layout was another hinder for the daily productivity, the work area was divided into six sub areas, however, there was no a specific guide planning to distribute work in an efficient way and how to move from one area to another, the crew worked in any available sub area without planning (Thomas & Ellis Jr., 2017). Two days from the 30 days, the daily productivity was declined due to the design errors and the delay of shop drawings approval. Six days from 30 days were also affected from improper material management issues, because the supervisor did not order the exact required amount for the tracks (Thomas & Ellis Jr., 2017). Figure 12 depicts the daily productivity within the 30 days, and showing the challenges that hindered the productivity. As long as the productivity number is low, it represents high productivity. Figure 13 illustrates the number of carpenters each day during the 30 days, which shows high variability of the daily crew size (Thomas & Ellis Jr., 2017).

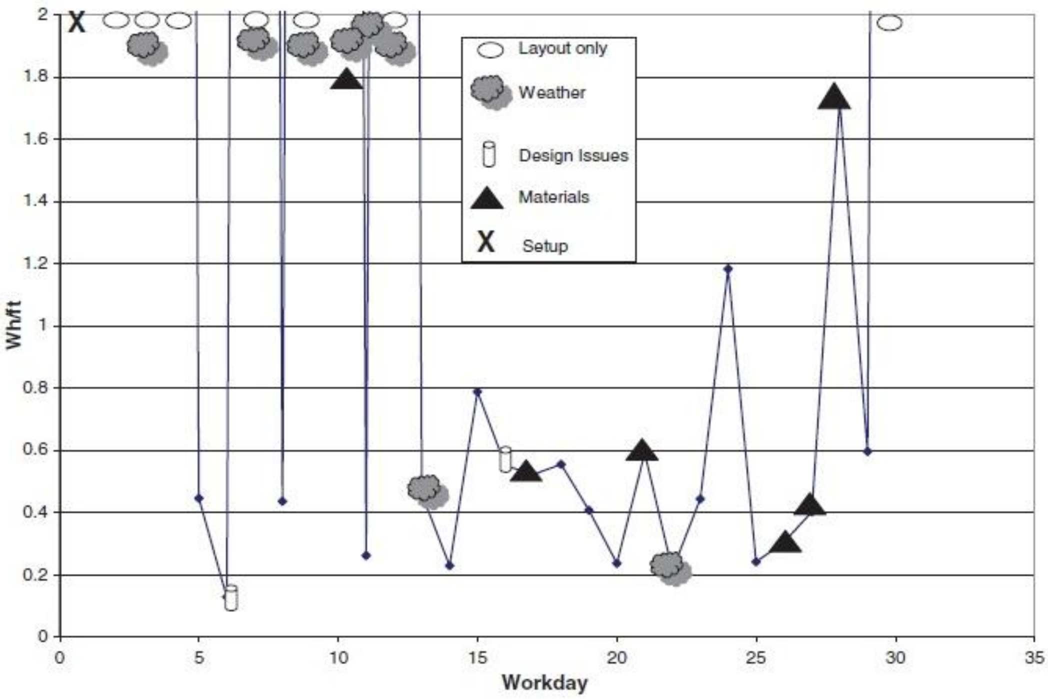


Figure 12: Daily productivity of the crew (Thomas & Ellis Jr., 2017).

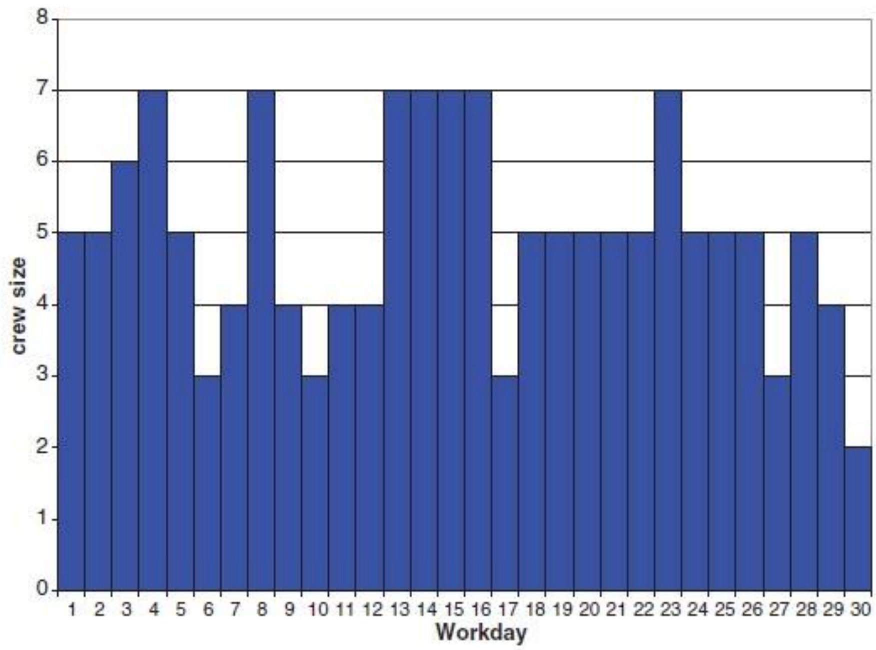


Figure 13: Daily crew size (Thomas & Ellis Jr., 2017).

4.13.5 Results and Main Findings

It was concluded that the best performance achieved was 5 days out of 30 days, with an average daily productivity 0.211 wh/ft, during these 5 days, the crew accomplished around 40% from the overall output work that should be done during the 30 days, as a result, the other 60% of the overall output consumed the other 25 days. According to the rate 0.211 wh/ft, if the contractor had maintained this value, the contractor should have performed 488 hours for the total work, however, the total work hours consumed were 1201 hours resulting in 731 inefficient work hours. This high amount of inefficient work hours were manily resulted from the improper utilization of the workforce, not working high and low value works concurrently, and consequences of the sequential works (Thomas & Ellis Jr., 2017). It was observed also that around 56 work hours lost in two consequtive days, because the crew did not work. Other 6 days, it was observed, that low-value works were dominant as layout works, in which layout was only executed, the total inefficient work hours were 128 work hours, with 35 dollars/h cost. Thus, the losses associated from not doing high-value works simalteneously with low-value works was 4500 dollars (Thomas & Ellis Jr., 2017).

4.14 Case Study 10

The case study was extracted from a book, this case study was for a building **"**Beaver Avenue Parking Garage**"** in **"**downtown State College, Pennsylvania**"** in United States of America (Thomas & Ellis Jr., 2017, p.149). The building consisted of 6 floors. The building was constructed in 2005 within an estimated cost of 11 million dollars. The whole structure of the building was precast concrete, the execution time for column consumed around 45-60 minutes, while other structural pieces as beams, slabs and stairs consumed around 15-30 minutes for each. The contractor used Manitowoc 2250 crane, and a crew of 10 ironworkers for the precast execution. The erection of precast consisted of 5 phases, in this case study phases 1 and 2 were only observed (Thomas & Ellis Jr., 2017).

4.14.1 Fundamental Principles applied in the project

This case study deomnstartes the influences and the significant importance of proper construction site management particularly the good material management in sites, in order to improve labor productivity. In this case study the approachs of vendor or fabricator relations with contractor for material delivery, and the concept of erection directly from the truck were highlighted to address the positive effects on labor productivity, (Thomas & Ellis Jr., 2017).

Some principles were adopted in that project during the execution, which helped in improving the daily productivity for labors from the perspective of the book's authors such as (Thomas & Ellis Jr., 2017):

> Mark stored materials so that they can be readily distinguished from similar materials. Make effective use of surge piles (stockpiles) to ensure that work (components) are always available for the crew. Whenever possible, especially if storage space is limited, consider final staging of large materials at an off-site location. Whenever possible, erect deliveries directly from the delivery trucks. Ensure that deliveries are properly sequenced to be consistent with the work plan. Make sure that the delivery rate from vendors is compatible with the installation rate of the field crew (p, 126).

4.14.2 Operation of the Activity

The precast works consisted of two types, permit and non-permit types. The non-permit type, which is not big with small width precast pieces, it did not require a transportation permit to be delivered to site, while the other precast type is larger and required a transportation permit. The contractor used a free space area, which was 4 miles away from site as a staging area for delivering the non-permit pieces from the vendor, this staging area included a stockpile (Thomas & Ellis Jr., 2017).

The permit pieces were delivered daily to the site according to a specific time, which was 10 am in the morning only, this agreed with the fundamental principle which the authors highlighted (Make sure that the delivery rate from vendors is compatible with the installation rate of the field crew). Moreover, the utilization of stockpiles for non-permit pieces allowed and facilitated the labors to work at the beginning and the end of every shift, as the supervisor can ask for the non-permit pieces to be delivered at any time, this agreed with the fundamental principle (Make effective use of surge piles (stockpiles) to ensure that work (components) are always available for the crew). Furthermore, the fundamental principle also concerned the direct erection for the non-permit and permit pieces from the truck has been applied successfully.

The principle concerning the coordination between the vendor and the contractor (Ensure that deliveries are properly sequenced to be consistent with the work plan) was applied effectively and efficiently (Thomas & Ellis Jr., 2017).

The pieces were oriented in a correct way when it was loaded in the trucks, in order to offload it quickly and properly at the time of erection, furthermore, the pieces were delivered in a proper rate according to the execution plan. The supervisor planned to erect 14 pieces each day, according to an estimated value 5.75 work hours/piece, however, this value was even exceeded in some days, this value reflected high rate of productivity because of the adoption of proper management principles for material. Figure 14 shows the daily productivity for precast pieces (Thomas & Ellis Jr., 2017).

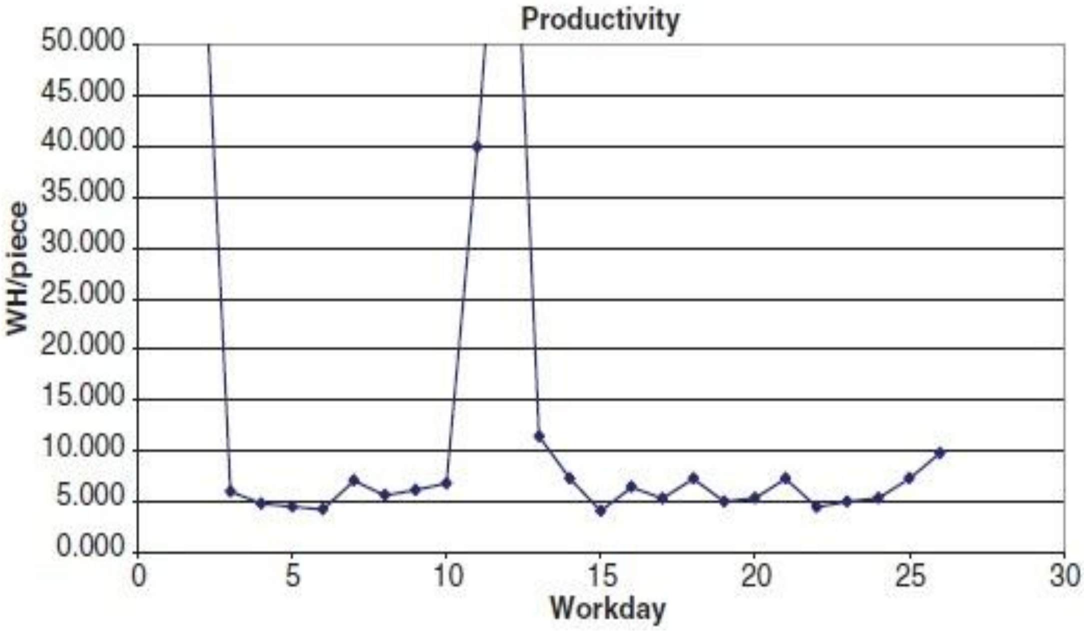


Figure 14: Daily productivity for precast pieces (Thomas & Ellis Jr., 2017).

4.14.3 Results and Main Findings

It was observed that there was a little percentage of an idle time, because the coordination and communication between the contractor and the vendor was very good and efficient, in which the delivery process of both permit and non-permit pieces was accurately on time, and also the staging area stockpile helped a lot in the availability of non-permit pieces, which resulted in mitigation of the idle time for workers and allow them to work all the day (Thomas & Ellis Jr., 2017). It was observed that there was some variability in the daily productivity, because the time required to erect column was two to four times longer than the other pieces, as well as the stairs were executed in a longer time. There was an accident in work day 2, design errors found in work day 7and 8, the crane was moved from phase 1 to phase 2 in work day 11and 13, however, the daily productivity was good in general due to the implementation of the principles concerning management of materials on site (Thomas & Ellis Jr., 2017).

5 Research Questions and Answers

5.1 First Research Question

"What are the different labor productivity definitions and concepts?"

No standard definition for productivity in existing literature, however, there is a wide range of different ways for defining productivity in lietrature.

The productivity can be defined generally as the ratio of output to input, the ratio of the quantity produced (output) to the quantity of resources used in the production phase (input). The resources can be materials, manpower, land and machines, the productivity increases if the output increases for constant amount or reduced amount of input. Another definition of productivity is the working hours in a particular time frame divided by the quantities achieved during the same time frame, this time frame is daily or weekly or throughout the whole project, it is called unit rate. Productivity is a measure of how well resources are leveraged to achieve set objectives or desired outputs. Productivity is the maximization of output while optimizing input.

There are three broad categories, where the productivity can be located. First classification is related to engineers and economists perspective, which is the traditional ratio between outputs to inputs, it can be the number of units produced per unit time. The second classification is the mixture efficiency (outputs/inputs) and effectiveness (outputs/goals). In this category the organization can measure the productivity efficiency and effectiveness; it can be the number of produced units divided by the number of expected units that should be produced per unit time that represents the target and the goal of the organization. The third classification is too wide and relevant to the organization level, the definition falls into anything that can make the function of organization better.

5.2 Second Research Question

"What are the different measurements used for labor productivity?"

There is no standard or a consistent way for measuring productivity in general and labor productivity in particular worldwide currently, however, the most traditional typical way to measure labor productivity can be seen as the ratio between output to input, or vice versa. The output is usually the physical installed amount and the input is usually the man-hours consumed by a labor in a day.

The answer of this question encompasses the analysis of findings for case studies 7 and 8 along with the findings from literature review.

Due to the complexity nature of construction industry, construction productivity is required to be measured at 3 major levels: Trade or task or activity level, project level and industry level. The measurement of the productivity for each level requires the improvement of both metrics (i.e., the most proper parameter that forms the foundation of calculation) and tools (i.e., identifies which construction discipline can achieve these metrics calculation).

At task or trade level, the focus of measuring productivity is often on labor productivity, and it is usually considered as single factor productivity. There are two ways to measure labor productivity at the trade level, first one by R.S. Means: to measure how much output generated from a designated crew in 8 hours working day, in this case, higher output means higher productivity. The second one by The CII Benchmarking and Metrics Program, it makes the output constant and it tries to measure the amount of labor hours needed to produce the output, in this case lower labor hours accounts for higher productivity.

At project level, productivity measurement is more difficult because it deals with a mix of tasks that constitutes a single project. It is very hard to unify the inputs and outputs for all the construction activities, (e.g., the input and output of a task of casting concrete is totally different than a task of steel reinforcement erection). Moreover, the utilization of labor productivity LP and total factor productivity TFP (it includes labors, management, material, capital, technology and equipment's) make it more complicated for productivity to be measured. LP at project level can be measured as square meter of built up floor per man in a day, while TFP is difficult to be used because it contains many input factors as labors, machines and materials which must be measured in a monetary value, due to the changes in market prices and business cycles.

At industry level, The Bureau of Labor Statistics (BLS) used two common productivity measures, one of them is single factor labor productivity LP and the other is multifactor productivity MFP. According to SCAL & SCCCI (2016), they refereed to MFP as the combination of labor and capital inputs, while TFP as the combination of labor, capital and intermediate inputs, they also suggested that it is difficult to adopt TFP and MFP at industry level and LP is preferred. However, Huang et al. (2009) prefered MFP over LP, as LP does not represent the whole image for the industry productivity.

There are many approaches for measuring construction productivity as it was mentioned above such as: single/partial factor productivity measures PFP and the second one is total/multi factor productivity measures TFP or MFP. The equations which represents for TFP are 1a, 1b, and 2. Single factor productivity which mainly refers to construction labor productivity CLP measurements are represented in equations: 5, 6, 7, 8, 9, 10, and 11. Another approach for measuring CLP is the baseline productivity, it is well known that disruptions have a significant impact on the labor productivity, the productivity increases when the disruptions decreases, Randolph H. Thomas in 2000 suggested a sample of working days that includes 10% of the total work days, the n is the number of days which comprises the highest productivity, and this n represents the baseline subset. For the total daily productive, Thomas calculated the average and this is the baseline productivity. (See section 2.3).

Other approach for measuring productivity is related to effectiveness and efficiency. AbouRizk and Dozzi (1993) explained effectiveness measurement concentrates on the quality of the output, and how well the crew members are managed, how the materials, equipments and tools are available, while the efficiency measurements focuses mainly on the amount of work done or output achieved by labors in a specific time. It can be understood that the terms "efficiency" and "effectiveness" were not used by managers for productivity measurements in all projects of case study 7, it is well known, that improving quality is quite expensive and cost will increase, so it is preferable for managers to focus on goals or amount of work done, however, both effectiveness and efficiency are not commonly used in measuring productivity.

There are several methods for measuring labor productivity on construction sites such as: time study, activity sampling, craftsman questionnaire and foreman delay survey. In case study 8, activity sampling method was applied to measure labor productivity for a block work activity. The author of this research discussed that activity sampling method is more efficient and easier to be applied more than time study method. For time study, high cost associated for hiring many observers to manually record and observe many number of labors, as one observer will not be enough for undertaking time study for several labors. The data attained by the time study observer are covering only the own records and information he observed, which can be understood differently, and it may not include interrelations between elements and the causes for long and short time element times, hence it minimizes the accuracy of the work done. Relaxation allowances and contingency allowance will always exceed the basic time, as a result the variability of data will occur and the collection and gathering of data will not be accurate. While for activity sampling, it is a great method in order to detect the time consumed by labors and it helps to determine the causes of the delay, and it can help in improving productivity. Furthermore, one of the main benefits of activity sampling that it allows the integration of many elements during observations as large number of workers and machines to be observed and studied at one time, which is better than other methods which focus only on a particular group or element to be studied.

In case study 8, the time spent for an operation was efficiently highlighted, due to the implementation of activity sampling method, which measured the distribution for time consumed by skilled and unskilled for performing a block work activity, these times are spent on productive, contributory, and unproductive activities. As a result, managers can measure the work hours per man for skilled and unskilled labors to install a specific quantity and the distribution of these work hours through observations, which help them later to expect the rate of productivity and to decrease or eliminate the wasted hours.

In case study 7, it reveals and highlighted several challenges and facts about measuring productivity in general and labor productivity in particular. The construction activities are so varied and sometimes are interrelated, even each activity consists of different trades and tasks so that the activity to be finished at the end, and hence, it is difficult to unify and to produce a consistent construction metrics for the output data which will be reported, different metrics will be reported at the end. Different projects with different standards to measure productivity, therefore, complexity of construction metrics occurs, and so many construction managers decide which construction metrics to be used. As a result, construction metrics are not consistent, and cannot be standardized. It was concluded in case study 7, that construction productivity in all projects studied were measured by the amount of man-hours (input) required to install a certain amount of quantity (output), without considering the materials and equipments in measurement, which means also in other way that LP or CLP is the main dominant way for measuring productivity regardless TFP and MFP, therefore, most of the companies focus mainly on measuring productivity at trade or task level.

5.3 Third and Fourth Questions

***Q3:"What are the critical factors affecting labor productivity in developed countries?*" and *Q4:"What are the critical factors affecting labor productivity in developing countries?*"**

The answer of question 3 was generated from the integration of comprehensive cross-case analysis of case studies 1, 2, and 3 related to developed countries and comprehensive analysis of literature, in addition to some observations of the author's experience. This can be seen in 4.6.1.

The answer of question 4 was generated from the integration of comprehensive cross-case analysis of case studies 4, 5, and 6 related to developing countries and comprehensive analysis of literature, in addition to some observations of the author's experience. This can be seen in 4.10.1.

5.4 Fifth Research Question

***"How labor productivity can be improved?*"**

In fact, the answer of this question is not an easy task, it is well known that construction industry productivity usually faces decline in comparison to other industry sectors, although there are several amount of attempts to improve construction productivity and labor productivity in particular currently, but this area is still deep and rich for further investigation, however, the answer of this question encompasses the analysis of findings for case studies 4, 5, 6, 9 and10 along with the findings from literature review, and author's experiences.

There are several general key factors that help to improve construction productivity and performance on construction sites such as:

- Project management: planning and coordination should be developed between general and sub-contractors and between owner and contractor, enhancing job site efficiency through linking between materials, people, processes, information and machines, utilization of the most effective measurement tools, identification and determination of roles of project participants, monitoring the sub-contractor progress, proper material management and handling of materials and logistics.
- Human resources management: promoting and supporting incentive programs and rewards systems, adopt training and knowledge transfer through all levels, feedback for the workers about their performance.
- Technology adoption: Implementation of prefabrication, pre-assembly, modularization, offsite fabrication, mechanization and automation as much as possible. Applying ICT (information and communication technology), BIM (Building Information Modeling), and GPS (and global positioning systems).

Regarding improving labor productivity, several approaches can be used to increase the performance and productivity of worker from a side, and also mitigate the inefficient hours or lost hours on construction sites from other side such as: motivation, human factors and adoption of proper managerial practices on site to improve labor productivity.

Motivation is one of the key factors that improve productivity of labor. The labors will be motivated if they see their work finished or the progress of their work is ongoing. Motivation can be seen in two aspects; the first one, is the behavior and the attitude when labor arrives the construction site, which comes from social background, family, religion, and even the events of daily life. The second aspect is related to the influence of management practices on the different tasks performed by the labor. As a result, management related factors that increase motivations of labors, hence increase their productivity are; proper planning, good communication, good work environment, protection from severe weather conditions, and rewards. (See sections: 2.8.2.1 to 2.8.2.4). Human factors are considered the key for the success of any project, however, the human factors are not credited a high attention. Human factors consist of two groups; 1st one includes: individual factors, physical limitation, learning curve, and teamwork, the 2nd one includes: the environment factors surrounding the labor as noise, weather, and workspace. (See sections: 2.8.3.1 to 2.8.3.5).

In case studies 9 and 10, two areas have been discussed which were: workforce management especially the effect of sequential scheduling principles on labor productivity, and also the proper material management effects on labor productivity. In case study 9, loss in productivity occurred because of not applying fundamental principles of weather, layout, and materials. The weather adversely affected the daily productivity. During the days which were impacted by weather, layout works were only achieved, which reflected low labor productivity. Poor layout was another hinder for the daily productivity, in addition to design errors and the delay of shop drawings approval. Six days from 30 days were also affected from improper material management issues. While the most important principle for workforce which was performing high and low value-work concurrently was not achieved as well, leading to a high amount of inefficient hours.

In case study 10, high daily productivity was accomplished due to applying the fundamental principles of proper material management such as: good relations and coordination between fabricator and contractor for material delivery, applying the concept of erection directly from the truck, the compatibility and consistency of material delivery with the work plan, and the availability of staging areas for storage at an offsite location. These factors lead to an overll good daily productivity, even it exceeded the estimated or planned rate of daily productivity.

5.4.1 Improving labor productivity in developing countries

The aim of this section is to highlight the most critical adverse factors concluded from case studies of developing countries and existing literature, in addition to suggest some actions to be done, in order to improve labor productivity in developing countries to meet the productivity in developed countries. Some of these actions are from the auther's professional experience in Egypt and others are from literature.

5.4.1.1 Material management

Thomas and Ellis Jr. (2017) in their book introduced fundamental principles related to proper material management on site, these principles if applied during execution phase, the labor productivity is expected to increase, such as:

(Outside) Storage Area:

1. The materials which are stored in the Semi-permanent Storage areas must be marked, so that it could be easily identified and handled, and also differentiated from other identical materials (Thomas & Ellis Jr., 2017).
2. Materials must be organized in an easy proper way, in order to facilitate the access and the returning back of it in the storage areas (Thomas & Ellis Jr., 2017).
3. Materials must be organized and laid on pallets or timbers, in order to protect and avoid it from possible mud and water, especially, when it is placed close or directly on the ground (Thomas & Ellis Jr., 2017).
4. "Avoid multiple staging areas at the site because this can lead to double-handling of materials and inefficiencies when unloading materials at the site (Thomas & Ellis Jr., 2017, p, 126)".
5. Large materials are recommended to be stored at off-site locations, in case if the storage spaces at site are constrained or small areas (Thomas & Ellis Jr., 2017).

Work Face (Interior) Storage Area:

1. The quantity of materials located on the workface area must be few and be maintained to minimum as much as possible, in order not to disrupt and be an obstacle during working (Thomas & Ellis Jr., 2017).
2. "Preassemble components into larger components or subassemblies (Thomas & Ellis Jr., 2017, p, 126)".

3. Materials must be preloaded on the workface as much as possible, so that it could be available for the labors to be used, moreover, it should be properly distributed, in order not to obstruct with other works (Thomas & Ellis Jr., 2017).
4. Materials should be stored as much as possible in areas which will not be in the work plan sequence or in areas that will be executed later (Thomas & Ellis Jr., 2017).
5. "Ancillary tasks like unpacking, cutting, reshaping, and preassembly should be done away from the work face when practical (Thomas & Ellis Jr., 2017, p, 126)".

Vendor Relations and Deliveries:

1. "Whenever possible, erect deliveries directly from the delivery trucks (Thomas & Ellis Jr., 2017, p, 126)".
2. Deliveries from the fabricator or vendor should be sent accurately and according to plan of the erection sequence (Thomas & Ellis Jr., 2017).
3. Delivery rate from the vendor or fabricator should meet the erection rate of the crew members (Thomas & Ellis Jr., 2017).

5.4.1.2 Equipments and tools management

Some actions applied on during the usage of equipments and tools, to guarantee a better productivity, prevent the break down of equipments and availability of tools on sites such as:

1. Avaialable of spare parts for equipments.
2. Regular preventive maintenance.
3. Not to rely on the continous usage of equipment, and not to over-rate using a specific machine, ignoring the need for other machines.
4. Availability of workshops and areas for regular maintenance for the contractors is essential to keep the good condition of the equipment.
5. Knowledge of how to use the equipment, and decision for buying or renting it.
6. Availability of security systems and storages to prevent the tools to be stolen or broken or lost.
7. Availability of sufficient tools for full time and casual temporary labors as well.

5.4.1.3 Labor and supervisor skills and experiences

Some actions should be implemented from the government and the contractors to improve the skills and experiecnces of labors such as:

1. Adequate and satisfactory wages to encourage skilled and experienced labors not to immigarte to more rich countries, seeking higher wages..
2. Government should provide training institutes for young labors, and to take care for secondary education system, which reflects a better awareness and knowledge for the labors in general.
3. Contractors should provide training courses for young labors, and not to rely on the experiences will be gained during learning in the project, which will create errors, losses of productive hours and rework.
4. Availability of competent experienced supervisors is very crucial, due to their abilities of checking drawings, and giving proper instructions to labors.
5. Minimizing the absence of supervisors, because the inspection for some critical tasks will be delayed or postponed casuing variability for the work flow and loss in productivity.

5.4.1.4 Weather

Thomas and Ellis Jr. (2017) in their book introduced fundamental principles related to weather mitigation on site, these principles if applied during execution phase, the labor productivity is expected to increase, such as:

1. Whenever possible and according to specific situation of a project, the schedule can be accelerated for some activities to minimize the implication of the winter cost (Thomas & Ellis Jr., 2017).
2. "Where possible, reserve some work that can be done on inclement workdays (Thomas & Ellis Jr., 2017, p, 94)".
3. Building should be sealed, especially from rainy weather, to protect the building from mold, sealing is related to springtime. Also building should be enclosed, which is related to winter activities. Sealing and enclosing the building can be achieved by temporary enclosures or permanent windows (Thomas & Ellis Jr., 2017).
4. Whenever possible, try to shift the work hours earlier, if the work is performed in a severe hot or cold temperature (Thomas & Ellis Jr., 2017).

5. Breaks must be imposed to protect labors from extreme hot or cold temperature (Thomas & Ellis Jr., 2017).
6. Materials must be organized and laid on pallets or timbers, in order to protect and avoid it from possible mud and water, especially, when it is placed close or directly on the ground (Thomas & Ellis Jr., 2017).

5.4.1.5 Rework

Some actions can be done to reduce the percentage of rework starting from the design phase to the execution phase such as:

1. Providing complete sufficient design drawings including sufficient details for construction team.
2. Providing design drawings without errors with less design complexity.
3. Minimize the amount of change orders and design changes.
4. Experienced supervisors and craftsmen, and their knowledge for the task and their knowledge for checking the drawings, which could decrease the rework.
5. Recruiting high wage skilled labors rather than low wage unskilled labors.
6. Minimize construction errors, and omissions.
7. Overtime and additional shifts cause fatigue for labors, which leads to omissions and rework.
8. Proper workmanship, communication and coordination.

5.4.1.6 Design and Buildability

Some actions can be applied during design and execution phase to increase the buildability, reduce rework, errors, delay, and cost such as:

1. Avoid impractical design, which can not be executed on site.
2. Availability of skilled draftsmen.
3. Avoiding the late of approval for shopdrawings, and providing quick respone for request for information RFI. These actions facilitate the workflow on site, and reduce delay, and idle among labors.
4. Avoiding incomplete drawings by allowing sufficient time for design team to finish their job completely, because usually the client seeks to accelerate the bidding process. No enough time leads to errors, clashes and in complete drawings.

5. Involvment of general and sub-contractor in the early design phase is important to improve the constructability and the efficiency of drawings.
6. Increase the adoption of prefabrication elements.
7. Increase the standardization by repeating elements.
8. Increase the flexibility of the elements to meet any design change later.
9. Adoption of pre-assembly, modularization, offsite fabrication, mechanization and automation as much as possible.
10. Improve construction methods.

5.4.1.7 Layout conditions

Thomas and Ellis Jr. (2017) in their book introduced fundamental principles related to developing site lay out plan on site, these principles if applied during execution phase, the labor productivity is expected to increase, such as:

1. Accurate drawings for the site and the offsite areas should be available. Pump trucks and cranes should be located and installed in accurate locations, to facilitate the work of the crane in reaching all the points of the site, and to achieve proper mobilization for the vehicles and trucks from and to the site (Thomas & Ellis Jr., 2017).
2. Ingress and Egress points must be positioned and planned properly on site. These different accesses can facilitate the movement of delivery trucks for materials, labors, trash removal trucks and concrete pumps (Thomas & Ellis Jr., 2017).
3. "Locate concrete discharge and crane pick points (Thomas & Ellis Jr., 2017, p, 80)".
4. Do not locate on site material storage areas, material storages are recommended to be located as much as possible off site or close to traffic routes, and also to be connected to the ingress points (Thomas & Ellis Jr., 2017).
5. "Map drainage routes (ditches) and locate retention basin (Thomas & Ellis Jr., 2017, p, 80)".
6. Temporary facilities as offices, sanitary facilities and parking areas should be located as much as possible away from the constructed area (Thomas & Ellis Jr., 2017).

5.4.1.8 Payment delay and Rewarding

It is important for the contractor to receive the payment every month or every targeted milestone achieved according to the contract, this leads to the guarantee for labors to get paid their daily wages. Labors rely on daily paid wages to support their family financial situation. Any delay in payment will result in decrease in labor morality, motivation and decreases productivity. Another important thing which is the implmentation of incentive program scheme, which the labors can participate in the process and have a share from the overall rewards or bonus according to their performance. Hence, the motivation and productivity for labor will increase. Disruption in cash flow will lead the contractor to weakness in purchasing materials required and renting equipments, moreover, the relationship between contractor and labors, hence, it decreases the productivity of labor.

5.4.1.9 Absenteeism and turnover

Turnover can be mitigated by providing a safe workenviornment for labor, the labor should feel secured. Many contractors hire and terminate labors regularly , in order to reduce the cost, however, turnover will result in lack of motivation and lack of security for the labor. Absenteeism can be controlled by decreasing the overtime, which causes physical fatigue for labor, providing enough wages for labors so that they will not search for other more paid offer. Awareness of labor for health and safety rules on sites will mitigate the accidents to occur, hence, the percentage of absenteeism will decrease as well. The availability of social and medical insurance will encourage labors to work and feel safe, as a result, they will become more loyal to the company, absenteeism or leaving the job will decrease.

5.4.1.10 Workforce management

Thomas and Ellis Jr. (2017) in their book introduced fundamental principles related to workforce management, activity sequencing and avoiding congestion, these principles if applied during execution phase, the labor productivity is expected to increase, such as:

1. The allocation of labors as manpower should be scheduled properly and consistent with the quantity of work, there should not be more labors assigned to a task, in other words avoid over manning (Thomas & Ellis Jr., 2017).
2. It is recommended to set the goals and share with the crew the expectations about the finishing dates for tasks and the expected working hours, because if the crew suggested the date of completion, this will be achieved and more realistic (Thomas & Ellis Jr., 2017).
3. The crew should work without disruption or any obstacles, in order to maximize efficiency and achieve the goals (Thomas & Ellis Jr., 2017).
4. The crew must be focused and directed to perform the high-value work, furthermore, performing high-value work with low-value work concurrently is highly recommended, and however, many times high and low value tasks are performed sequentially (Thomas & Ellis Jr., 2017).
5. Preassemblies and modules should be performed to minimize the total work hours required to install a duct as an example, and also it mitigates the usage of labor physical element (Thomas & Ellis Jr., 2017).
6. Mitigate the symbiotic activities, which mean it is a cooperative work done by several crews of different trades or crews from different contractors, in which the work is passed from one crew to another. It is a challenge, because the crew which performs symbiotic works, is always in the standby mode, they always wait for the work to return back to them to continue, and they always rely on the works of other crews (Thomas & Ellis Jr., 2017).
7. "Make use of buffers (time lags) between activities to allow crews to work at an uninhibited pace (Thomas & Ellis Jr., 2017, p, 192)".
8. "Where possible, schedule all noncritical path work at times so as not to interfere with critical path work (Thomas & Ellis Jr., 2017, p, 216)".
9. Housekeeping should be done regularly to keep the workface not interrupted and disrupted by un used materials and trash and to make sure that crew will work in an unimpeded pace (Thomas & Ellis Jr., 2017).

5.4.1.11 Managing Sub-contractors

Thomas and Ellis Jr. (2017) in their book introduced fundamental principles related to managing sub-contractors, these principles if applied during execution phase, the labor productivity is expected to increase, such as:

1. The sub-contractors should be participate in the development of the project and schedule plans, moreover, the general contractor should monitor the sub-contractor performance regularly according to the schedule, and it is important to provide the sub-contractor with up to date best management practices (Thomas & Ellis Jr., 2017).
2. General contractor must treat all the involving sub-contractors in a fair way, which enhances the level of trust and empowers the relationship (Thomas & Ellis Jr., 2017).
3. General contractor should avoid involving in Bid-shopping, because it is not an ethical practice, and there are many consequences result from it such as; lower performance, lower quality, un fair competitions and disputes at the end (Thomas & Ellis Jr., 2017).
4. Pre-bid meeting must be done, the attendance and commitment between general and sub-contractors is obligatory in the meeting, it leads to develop a trust, this meeting includes; the obligation of general contractor to provide the materials required, and how the general contractor will manage the submittals and invoice payments (Thomas & Ellis Jr., 2017).
5. General contractor should provide and offer help and assistance from time to time to sub-contractor, even if some kind of help is not included in the contract, furthermore, the general-contractor team should know the workers and staff team of the sub-contractor, hence, the trust between both parties will increase (Thomas & Ellis Jr., 2017).
6. General contractor should demonstrate the expectation and objectives to the sub-contractor such as: level of quality required, scheduling, safety and rate of productivity for sub-contractor's craftsmen (Thomas & Ellis Jr., 2017).
7. "Develop a Submittal Schedule and Change Order Log (Thomas & Ellis Jr., 2017, p, 232)".
8. "Prequalify subcontractors based on their previous work, safety, and financial situation (Thomas & Ellis Jr., 2017, p, 229)".

9. "Every proposed change order should be reviewed by all subcontractors (Thomas & Ellis Jr., 2017, p, 229)".

6 Conclusion and Recommendations

6.1 Conclusion

Productivity in construction is one of the important terms that indicates or represents the performance of a labor, project, company or the industry in general. Construction industry relies mainly on labors, as a result, construction productivity is usually concerned or refered to labor productivity. However, theortically and empirically, productivity is very challenging to be defined. Hence, The definition can be generated from different perspectives. Therefore, there is no consistent standard definition for productivity. In general, productivity can be defined as the ratio of output to input, this can be applied for both construction and manufacturing sectors as an example. The output refers usually to the targeted quantity produced, while the input usually refers to the quantity of resources used during the production process of the output. In case study7, it was concluded from the interviews done with construction experts from different projects, that productivity is a measurement of certain amount of quantity installed by man-hours, as a ratio of output to input.

Measuring productivity is an essential duty, in order to improve the productivity. Measuring productivity is also a challenging mission at different levels such as: trade or task level, projects level, company level, and industry level. Regarding, the trade level, which is the main focus of the research, how to measure labor or craft performance and productivity. Practically, it was concluded from case study 7, that the terms "efficiency" and "effectiveness" were not used by managers to measure labor productivity. In addition to, inconsistency for choosing the construction metrics for output due to the complexity of project, huge number of different activities, and each activity is split into sub activities with different units, even in each activity, there are different trades with different metrics. Therefore, reporting construction metrics for the outcome is difficult, this results also different preferences from managers to choose construction metrics at the end. In case study 9, activity sampling technique was a good method for measuring the distribution of time spent by skilled and unskilled labors for block work activity. This method is easier, cheaper and applied in many countries, it also represents the percentage and distribution of the time consumed by labor in productive, contributory and un productive times, besides, it shows the idles time as well. It was concluded from case study that skilled labors spent mainly 77.01% of their working time on productive activities, while unskilled labors spent 54.66% of their working time on contributory activities. The average productivity per hour for skilled labor in laying block 10 (3.24 m2/h) was higher than block 20 (3.07 m2/h), this is reasonable as the block 10 is lighter in weight, which facilitates the handling and laying processes.

From existing literatures and case studies from 1-6, it was concluded, that there critical factors affecting labor productivity in both developed and developing countries. In developing countries there are some detected critical factors that have a negative significant impact in comparison to developed countries or it has relatively the same impact as well such as:

- Lack of required materials, equipments and tools: These factors were ranked in the top lists in several studies for developing countries in comparison for developed countries.
- Lack of labors and supervisors skills and experiences: These factors were ranked in the top lists for developing countries, while it was relatively critical in studies of developed countries.
- Absenteeism and Turnover: These factors exist in both developed and developing countries, which mean it is relatively the same.
- Rework: It was concluded that it ranked in higher positions in developing countries, while it was not that critical in developed countries.
- Payment delay: This factor is considered to be critical in developing countries when it compared to developed countries.
- Design issues and buildability: Design changes, incomplete drawings, errors in drawings, and buildability issues exist in both developed and developing countries, the ranking for these factors is slightly the same in many studies. However, in developed countries, concepts as prefabrication, preassembling, modularization and standardization are adopted more. Even BIM is not commonly used developing countries as in developed countries.

Labor productivity in general can be improved by several ways, this study focused on the best practices and principles if it is applied on some adverse factors, labor productivity and performances will increase, these principles are related to proper site management concerning workforce management, managing subcontractors, material management, tools and equipment management, how to avoid rework, how to mitigate design errors and incomplete drawings, how to increase buildability improving labor skills and experiences, how to mitigate the impact of weather, adoption of incentive programs and rewards, avoiding payment delay for labors, how to develop a proper layout plan, and finally how to minimize absenteeism and turnover. This can be seen in details in the answers of question 5, section 5.4.1.

In case study 10, it was concluded that the daily productivity for labors can be increased through applying material management principles especially, the concept of erection of precast elements directly from the truck, the good relations with the vendor or the fabricators, availability of staging and semi-permanent storages areas, consistency of material delivery with respect to work flow, and finally avoiding double and triple handling. In case study 9, it was concluded that daily productivity declined, because; the symbiotic activities existed, working high and low value works were not applied concurrently, not sealing and enclosing the building allowed the weather to minimize productivity, over-manning existed due to the improper allocation of resources, layout planning for distribution of works was poor, and finally design errors and late of shop-drawing approval occurred.

6.2 Recommendations for future studies

- In existing literature, the critical factors affecting labor productivity are many, it is almost impractical to investigate all of them, each factor is important or critical according to the perspective of the project or the company itself, this results in the inconsistency for the importance of each factor. As a result it is recommended to investigate and to understand the startegies and the criterion for each project and company first, when ranking the factors regarding its criticallity.

- The existing critical factors are usually detected from the managerial point of view. Hence, it is recommended to conduct the surveys or interviews with craftsmen and foremen as well, who will provide more insight and reliability for the results.

- It is highly recommended to investigate more in the area of measuring labor productivity especially to develop attempts to unify or standardize the units or the construction metrics for different construction discipline. Which will avoid inconsistency in choosing metrics, and generating standard construction metrics for output and facilitate the reporting process for it.

- The area of labor productivity development is not rich enough in recent literature, in which many researchers concentrate more on detecting the critical factors without exploring more about how to tackle these factors and improve the productivity of labors.

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