Factors Affecting Productivity in Construction Projects

FINAL YEAR PROJECT UG – 2017

By

Muhammad Zaeem Khalid (G.L) **00000212872**

Mohammad Abubakar Khan **00000208842**

Muhammad Hamza Yousaf **00000228522**

Muhammad Jawad **00000208251**

Project Advisor: Dr. Muhammad Umer Zubair

NUST Institute of Civil Engineering (NICE)
School of Civil and Environmental Engineering (SCEE)
National University of Sciences and Technology (NUST)
Islamabad, Pakistan

Year 2021

CERTIFICATION

This is to certify that the thesis entitled

FACTORS AFFECTING PRODUCTIVITY IN CONSTRUCTION PROJECTS

Submitted by

Muhammad Zaeem Khalid (G.L)	00000212872
Mohammad Abubakar Khan	00000208842
Muhammad Hamza Yousaf	00000228522
Muhammad Jawad	00000208251

has been accepted towards fulfillment of the requirements

for the undergraduate degree

in

CIVIL ENGINEERING

_____

Dr. Muhammad Umer Zubair

Assistant Professor

NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Sciences and Technology, Islamabad, Pakistan

ABSTRACT

The construction industry being one of the largest and most profitable industries globally faces several problems. The main problems from which the construction projects suffer are cost, duration and quality of the construction. Cost, duration and quality mainly depend on the labor productivity. Several factors are involved in determining the efficiency of labor. Therefore, many researchers and experts have done research on the factors that are linked with the productivity of labors. But challenges and difficulties related to labor productivity still exist. The aim of carrying out this study is to identify the factors that affect the labor productivity in the construction industry and to determine the co-relation among the identified factors. To identify the factors affecting productivity, literature review was done in which more than 100 factors from several research papers were identified and were arranged based on Relative Importance Index (RII). Also, VosViewer was used in literature review to explore the topics of construction productivity that are being researched. 30 factors remained when pilot study was conducted with the help of experienced professionals. The questionnaire survey was then floated online and responses were collected. Stata and SPSS software were used to perform statistical analysis in order to determine the co-variance among the 30 identified factors. The results of the analysis provided 13 most influencing factors that were divided into three groups named as Consultant/Supervisor related factors, Human Resource (HR) related factors and Material, equipment and project related factors.

Based on this research, some recommendations have been proposed to improve the productivity in the construction industry. This research and its recommendations can be used by project managers, contractors, consultants and supervisors in Pakistan as well as in the countries that possess similar work environment as of Pakistan for enhancing the construction productivity.

DEDICATION

Dedicated to our parents and teachers, who have been a constant support for us!

ACKNOWLEDGEMENT

First and foremost, we are thankful to ALLAH Almighty who gave us the abilities and strength to complete our project and then write its progress report. We are grateful to our supervisor Dr. Muhammad Umer Zubair for his profound guidance and constant help that helped us to meet our targets and eventually complete the project. The value of his supervision cannot be overemphasized. We are also grateful to the respondents for their valuable contributions to this research, without their assistance we would not have been able to complete our project. Lastly, we are grateful to our family members who kept encouraging us throughout the research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

1.1 GENERAL

Construction industry is one of the largest industries in the whole world (World Construction Industry, 2010). It has its importance in the economy of Pakistan too. On average, the construction sector has contributed between 2.3% and 2.85% in the last five fiscal years to Pakistan's GDP (it was valued at Rs 316 billion in the Pakistan Economic Survey 2019-20), most economists estimate its value to stand between 10 and 12% of the total GDP (Will The Construction Industry Revive Pakistan's Economy?, 2020). This makes it essential to implement successful construction projects. A construction project can be deemed as successful if it is completed within specified time, within the allocated cost and meets the specifications of safety and quality. All this is achieved by ensuring the productivity in construction projects; therefore, it is such a crucial factor in all construction projects.

1.2 DEFINITION OF PRODUCTIVITY

Different sources have their own way of defining productivity, the one that best suits here is "Productivity is the effectiveness of productive effort, especially in industry, as measured in terms of the rate of output per unit of input." (Oxford Languages, n.d.)

$$Productivity = \frac{Output}{Input}\ (work\ hour)$$

The main aim behind productivity is to reduce costs and ensure timely completion of projects without compromising the quality.

1.3 BACKGROUND OF PRODUCTIVITY

Substantial work has been done on productivity across the globe and it has shown a lot of improvement in the construction sector especially in developed countries. Az Jasat, Senior Customer Success Manager at Autodesk recently said: “In recent years, we’ve been quick to criticize the construction industry’s safety record and low productivity trend. However, new evidence suggests the situation is improving; projects are becoming safer and the labour force is becoming more productive due to a commitment to innovation and process change.”

Pakistan is a developing country and has not been able to meet the standards of productivity. Advancement in technology and different innovative techniques could not produce the desired results. Most of the mega projects in Pakistan face cost overruns and time delays. In 2017, there were 1000 projects that faced cost overruns and delays. The recent examples have been the “Islamabad International Airport” project and the “Neelum-Jehlum” project (Over 1,000 projects face delays and cost overruns: PAC, 2017). Various factors play their part in cost overruns and delays, some of them have been diagnosed and efforts are being put in to mitigate them during projects while many are still hidden. A lot of research is still required in this field to impart the factors that are causing delays in project. If these factors are made known then by overcoming them, project productivity could be increased.

1.4 PROBLEM STATEMENT

Various factors affect the productivity of the construction projects due to which cost overruns, time delays and other adverse effects are very common. Every contractor wishes to achieve maximum productivity in a project but unfortunately, in most cases they are unable to identify the factors that are impacting the productivity. There identification can solve a major problem; it will become rather easy for the contractors to mitigate the known factors and achieve the desired productivity rather than wasting their energies on factors that either have very less or

no impact at all. Therefore, the objective of this research is to highlight and bring to sight some of the factors that are contributing to the delays and cost overruns in projects.

1.5 RESEARCH OBJECTIVES

The specific objectives of this research are:

1. Identification of factors affecting Labor Productivity.
2. Determining the co-relation/co-variance between factors affecting labor productivity in construction industry of Pakistan.
3. Determining the impact of attributes of a Project Manager on construction labor productivity.

For this purpose, a comprehensive study will be conducted in which the experiences of different developed countries will be utilized. Their findings will be correlated with the ones in our country and the factors that will come out after the extensive study will be selected and worked upon. In the second phase of the research, couple of projects in Pakistan will be compared, one of them will be the one that faced cost overruns and time delay while the second one will be the one that was cost effective and got completed in time.

Productivity could be improved to a great extent by becoming aware of the factors causing delays and cost overruns and then finding feasible solutions to tackle them.

Chapter 2

LITERATURE REVIEW

2.1 REVIEW OF LABOR PRODUCTIVITY FROM PREVIOUS STUDIES

Productivity can be defined as the ratio of output to input (Oxford Languages, n.d.). There are number of known factors which effect the labor productivity, some of them are controllable while some are uncontrollable. Along with the known factors there are some anonymous factors which need further research and brainstorming in order to bring them into spotlight. Productivity varies from company to company and from country to country. It is also dependent upon employee motivation. To get better productivity, one needs to optimally utilize the manpower, do accurate estimation of time and cost. In construction industry, productivity is one of the most important issue, both in developing and developed countries. Cost overruns, delays and productivity issues are associated with construction projects everywhere. There are many poor management practices that result in poor productivity, delay and cost overruns. Many researchers try to overcome these by recommendations, but these recommendations are yet to be implemented (Jergeas, 2009). It is a big challenge for any manager to find appropriate ways to increase productivity.

(Polat, 2005) arranged the factors that have a major impact on productivity according to their characteristics such as, design, working time, owner/consultant, execution plan, material, supervision, quality, safety, equipment, leadership and coordination, labor, health, organization and external factors.

2.2 FACTORS AFFECTING LABOR PRODUCTIVITY FROM PREVIOUS STUDIES

According to previous studies, there are dozens of factors that impact the productivity. The ones that have the greatest impact are discussed in detail below.

Material/tools Availability

According to Makulsawatudom (Makulsawatudom, 2002), material management is considered as one of the most crucial factors affecting productivity. Productivity is largely impacted if the required materials, tools, or construction equipment are not provided at the required place at the required location and right time (Alinaitwe, 2007). Timely provision of all necessary materials and equipment is essential to achieving productivity in a project. Selection of appropriate size and type of construction equipment often effects the amount of time required to perform an activity therefore, it is essential for site managers to have proper knowledge about different tools and equipment that are most used in construction. Laborers need a certain number and type of equipment to perform work effectively on site. If the improper tools and equipment are provided, then productivity may be affected. The material storage location also plays a significant role in productivity as laborers are required to move materials from the storage location to job site on daily basis hence it has time consequences.

Time

It is often believed that by increasing the working hours, productivity will enhance but this is not true as previous studies have shown that working overtime decreases the labor productivity. When labor works 7 days per week without any holiday, it is found to have greater impact while working additional hours during the working day has an average effect (Enshasi. Mohamed, 2007). Some of the consequences caused by overtime include increased accidents, decreased morale of labor, reduced supervision effectiveness, increased absenteeism and

relatively poor quality of work which causes higher rework. According to Alinaitwee (Alinaitwe, 2007), construction laborer only works 30% of his available time on productive activities while in his 8 hours working shift a worker works efficiently for only 3.5 hours. Site managers need to keep these figures in mind and then find optimal solutions to achieve maximum productivity in a construction project.

Managerial Competency of a Project Manager

One individual who has greatest impact on productivity is a project manager. Negligence at his end effects every other department of construction project. Their skills and approaches have an essential effect on productivity. Due to inefficient management productivity decreases. Managers who have experience and show commitment can obtain surprising results from average lot of labor. The project manager must have an ability to lead the project until its accomplishment. A good manager uses his skills to plan, observe and control the progress of a project to get the desired results in an efficient manner.

Safety

Productivity is highly influenced by safety accidents. Lack of proper safety measures at site can result in various types of accidents which can result in losses of minor level to even casualties which may result in closure of a work for long time hence causing a great loss of productivity. When a person is injured during the work, loss of productivity occurs because that activity faces a shortage of a crew member. In order to demonstrate regulations related to safety, it is essential to recruit a safety officer which will result in reduction of accidents and losses due unsafe practices hence productivity will increase.

Type of Project

Attainment of productivity requires all crew members to have a levelheaded and enough space to perform their tasks. Interference from other crew members may have adverse impacts on

productivity. When large number of labors are appointed to carry out work in a defined area, probability of interference is large which results in decreased productivity. This interference is mostly caused by mismanagement on construction site. For example, if the framework of a carpenter is incomplete due to some reason, then consequently before fastening the reinforcement rods, steel-fixture group will face postponement. Different construction methods and varied form of activities also have a great effect on productivity of labor. In order to achieve good productivity managers should ensure minimum work collision of different crew members.

Motivation

An important factor that affects the productivity is motivation. The relationship between motivation and productivity is very important in construction industry. Productivity is directly linked to motivation and motivation in turn depends upon productivity (Kazaz, 2008). Laborers show great level of motivation when their personal goal are in line with the goals of the company and when they feel valued. Payment delays, a lack of financial motivation system, non-provision of proper transportation system and a lack of proper training session cause a reduction in motivation among the labor and hence reduction in productivity.

Quality

Decline in productivity is also caused by inadequacy of equipment and low quality of the raw material. Productivity achieved by using low quality equipment is always low. Equipment that has insufficient performance are subject to large number of failures, they also cause a lot of troubles for the labor, hence decreasing productivity. Low quality material also results in outcome that has a potential of being disapproved by the inspectors. This thus decreases the rate of production.

Natural Factors/Weather Conditions

Natural factors can cause huge delays, hence affecting productivity. Previous researches have shown various natural factors that affect labor productivity and these factors are usually situations of weather and geographical location. Fuel, water and minerals are among the other factors that impact productivity to certain level. Most severe effects on productivity are observed during extreme weather conditions such as during extreme rainfall or when the weather is too hot or too cold.

External Factors

Different external factors among which the most prominent are atmospheric conditions hinder the execution of any project. Severe weather conditions such as rains, scorching heat, winds decrease productivity specially for external works such as formwork, concrete casting, external plastering, external painting. Severe weather conditions usually act as a major barrier in continuation of work totally.

Political Factors

Various types of political factors influence the normal flow of work. These include law and order situation, change of governments, strikes and protests etc. The government's taxation policies also put impact on compliance to work.

2.3 FACTORS AFFECTING LABOR PRODUCTIVITY

Table 2.1 shows the possible factors that affect labor productivity in construction projects. These factors are gathered from previous studies and literature review. It does not take into consideration any significant value; they are arranged based on their frequency in different studies.

Table 2.1 Possible Factors Affecting Labor Productivity

Sr.#	Factors	Reference
1	Delays in Payment	(Mistry Soham, 2013), (Muhammad Irfan, 2020), (Abu Bakar Muzamil, 2014)
2	Site Supervision Skills	(E C Lim, 1995)
3	Delays in Inspection	(Muneer Anees, 2021), (Jiukun Dai, 2009), (Abid Hasan, 2018), (Jiukun Dai P. M., 2009), (A. Soekiman, 2011), (Saurav Dixit, 2019)
4	Design changes	(Khaled Mahmoud El-Gohary & Aziz, 2014), (Tareq Khaleel, 2018), (A. Soekiman, 2011), (Saurav Dixit, 2019)
5	Quality of Drawings (Omissions/Lack of details)	(Abdul Haseeb Aamir Sheikh, 2019)
6	Design Complexity Level	(Tareq Khaleel, 2018), (Mistry Soham, 2013), (Muhammad Irfan, 2020), (Abdulaziz M. Jarkas, 2012), (Abid Hasan, 2018)
7	Rework Due to Design Errors	(Abid Hasan, 2018)
8	Absenteeism (Absence of staff without any reason/strikes)	(Muneer Anees, 2021), (Park, 2006), (Jiukun Dai P. M., 2009), (E C Lim, 1995), (Arun Makulsawatudom, 2004), (Muhammad Irfan, 2020), (Khaled Mahmoud El-Gohary & Aziz, 2014), (Abdulaziz M. Jarkas, 2012), (Abid Hasan, 2018), (Tareq Khaleel, 2018), (Ismail Abdul Rahman, 2019), (Abu Bakar Muzamil, 2014), (Jiukun Dai P. M., 2009), (M Bierman, 2016), (A. Soekiman, 2011), (Saurav Dixit, 2019)
9	Managerial competency of a project manager	(Arun Makulsawatudom, 2004)
10	Communication skills of a project manager	(Arun Makulsawatudom, 2004)
11	Lack of incentives for the work force	(Muhammad Irfan, 2020)
12	Unclear instruction to labors	(Muhammad Irfan, 2020), (Abid Hasan, 2018), (Tareq Khaleel, 2018), (Abu Bakar Muzamil, 2014), (A. Soekiman, 2011)
13	Lack of Labor Training	(Muhammad Irfan, 2020)
14	Lack of appropriate crew size for an activity	(Muneer Anees, 2021), (Jiukun Dai P. M., 2009), (Mistry Soham, 2013), (Muhammad Irfan, 2020), (Khaled Mahmoud El-Gohary & Aziz, 2014), (Abdulaziz M. Jarkas, 2012), (Abid Hasan, 2018), (Jiukun Dai P. M., 2009), (M Bierman, 2016)
15	Lack of coordination among the work force	(Jiukun Dai P. M., 2009), (Abu Bakar Muzamil, 2014)
16	Labor Skills/Experience	(Park, 2006), (Khaled Mahmoud El-Gohary & Aziz, 2014), (Fida Siddiqui, 2016), (Muneer Anees, 2021), (Muhammad Irfan, 2020), (Khaled Mahmoud El-Gohary & Aziz, 2014), (Tareq Khaleel, 2018)

17	Motivation level of labors	(Saurav Dixit, 2019), (Abid Hasan, 2018)
18	Low Wages for labors	(Muhammad Irfan, 2020), (Khaled Mahmoud El-Gohary & Aziz, 2014), (Abid Hasan, 2018)
19	Overall health conditions of the work force	(Muneer Anees, 2021), (E C Lim, 1995), (Abid Hasan, 2018), (Tareq Khaleel, 2018), (Fida Siddiqui, 2016), (Abu Bakar Muzamil, 2014), (A. Soekiman, 2011)
20	Rework due to labor negligence	(Muneer Anees, 2021), (Park, 2006), (Arun Makulsawatudom, 2004), (Mistry Soham, 2013), (Muhammad Irfan, 2020), (Khaled Mahmoud El-Gohary & Aziz, 2014), (Saurav Dixit, 2019), (Abdulaziz M. Jarkas, 2012), (Tareq Khaleel, 2018), (Fida Siddiqui, 2016), (Ismail Abdul Rahman, 2019), (M Bierman, 2016), (Saurav Dixit, 2019)
21	Safety Consciousness of the work force	(Jiukun Dai P. M., 2009), (E C Lim, 1995), (Arun Makulsawatudom, 2004), (Abdulaziz M. Jarkas, 2012), (Abid Hasan, 2018), (Tareq Khaleel, 2018), (A. Soekiman, 2011)
22	Use of Drugs	(A. Soekiman, 2011)
23	Construction Technology (Construction Method and Materials used)	(Khaled Mahmoud El-Gohary & Aziz, 2014), (Abid Hasan, 2018)
24	Material availability	(Saurav Dixit, 2019), (Abid Hasan, 2018), (Tareq Khaleel, 2018), (Jiukun Dai P. M., 2009), (Saurav Dixit, 2019)
25	Equipment availability	(Jiukun Dai P. M., 2009)
26	Lack of adequate storage area	(Jiukun Dai P. M., 2009), (Abid Hasan, 2018), (Jiukun Dai P. M., 2009)
27	Project Complexity	(Park, 2006), (Abid Hasan, 2018)
28	Difficult project specifications	(Khaled Mahmoud El-Gohary & Aziz, 2014), (Abid Hasan, 2018)
29	Inadequate access to the site	(Muneer Anees, 2021)
30	Environmental Conditions (weather, frequent rains etc)	(Abid Hasan, 2018)

2.4 GROUPING OF FACTORS

Factors affecting productivity can be organized into different groups where a single group contains those activities that co relate to each other. Here, factors are organized into three different groups. These groups are:

1. Consultant/Supervisor related factors
2. Human Resource Related Factors
3. Material, Equipment and Project related factors

2.4.1 Consultant/Supervisor Related Factors

Following are the 7 factors grouped in the category of consultant/supervisor related factors:

Table 2.2 Consultant/Supervisor Related Factors

Sr.#	Factors
1.	Delays in Payment
2.	Site Supervision Skills
3.	Delays in Inspection
4.	Design changes
5.	Quality of Drawings (Omissions/Lack of details)
6.	Design Complexity Level
7.	Rework Due to Design Errors

2.4.2 Human Resource Related Factors

Following are the 15 factors grouped in the category of management factors:

Table 2.3 Human Resource Related Factors

Sr.#	Factors
1.	Absenteeism (Absence of staff without any reason/strikes)
2.	Managerial competency of a project manager
3.	Communication skills of a project manager
4.	Lack of incentives for the work force
5.	Unclear instruction to labors
6.	Lack of Labor Training
7.	Lack of appropriate crew size for an activity
8.	Lack of coordination among the work force
9.	Labor Skills/Experience
10.	Motivation level of labors
11.	Low Wages for labors
12.	Overall health conditions of the work force
13.	Rework due to labor negligence
14.	Safety Consciousness of the work force
15.	Use of Drugs

2.4.3 Material, Equipment and Project Specific Factors

Following are the 8 factors grouped in the category of material, equipment and project specific factors:

Table 2.4 Material, Equipment and Project Specific Factors

Sr.#	Factors
1.	Construction Technology (Construction Method and Materials used)
2.	Material availability
3.	Equipment availability
4.	Lack of adequate storage area
5.	Project Complexity
6.	Difficult project specifications
7.	Inadequate access to the site
8.	Environmental Conditions (weather, frequent rains etc)

Chapter 3

METHODOLOGY

3.1 INTRODUCTION

After a detailed literature review, pilot study was done using an online form having thirty most frequent factors appearing in literature review. The pilot study was done to short-list factors further to develop a questionnaire survey, the results of which will then be used for analysis. People working in the construction industry were approached and were sent the online form. Respondents had to select the intensity of each factor and they also had the option to add any other factors that they believe affects the construction productivity.

3.2 VOSVIEWER

3.2.1 Introduction

VOSviewer is a professional software program for drawing maps in a variety of knowledge fields primarily based on the principle of co-citation and coupling of literature. In this study, we employed VOSviewer software as a tool to perform the co-occurrence analysis and co-authorship analysis, and then to realize the visualization to evaluate the network linkage among the selected articles. Further hot topics of construction productivity research were explored via the cluster analysis of the keywords and draw a scientometric map by VOSviewer in the field of construction productivity.

3.2.2 Methodology

Figure 3.1 presents the methodology implemented in this study for using VOSviewer. First of all, literature relevant to our study is extracted from the Core Collection of Web of Science (WoS) search engine. Then, multiple analyses are conducted. The purpose is to emphasize

public's interest and researchers' interest in the keywords of this study. Methods used for this include keywords analysis, analysis of co-authorship, organizations affiliated, country origin and analysis of citation. Likewise, the relevant literature from the top journals is discussed. A wide-ranging list of factors is developed which is based on the comprehensive study of the extracted articles.

Figure 3.1 Methodology for VOSviewer

3.2.2.1 Retrieval of Literature

The literature relevant to current study is retrieved using the Core Collection of Web of Science (WoS) search engine. Mechanisms are established using detailed keywords and search strings to extract the appropriate literature. The search term includes keywords "construction" and "productivity" joined by "AND" Boolean operator. These articles are restricted to keep a relevant focus on the current study's theme. More, the publications' period is confined to 2006-2021 to keep a focus on recent studies. The searched articles are constrained to English language only. Likewise, the article categories are confined to conference papers, original research, book chapters and review just to bring in reliable and high-quality articles. A total of 427 research articles are extracted using this comprehensive retrieval mechanism from the Web of Science (WoS) search engine.

3.2.3 Analysis

After the preliminary literature retrieval, the retrieved articles are analyzed using VOSviewer. It is a wide-ranging tool for literature analysis that can create significant tables and graphs. VOSviewer is comprehensive in quantitative analysis. The results obtained are structured appropriately and easy to understand as compared to tools such as NVivo and Perish. More, the scopes for these tools are different. VOSviewer is used for quantitative analysis whereas NVivo is primarily used for qualitative analysis and Perish is used for retrieval of literature.

3.2.3.1 Co-occurrence analysis of keywords

The co-occurrence analysis of the keywords is carried out that are retrieved from the articles. A sum of 1414 keywords are extracted. To limit the number of keywords retrieved, a minimum inclusion criterion is set. This comprises the occurrence of the keyword in 10 articles at least. Figure 3.2 shows the top keywords retrieved. The top keyword is "productivity" with an appearance in 130 articles. This is followed by "labor productivity" with 74 articles.

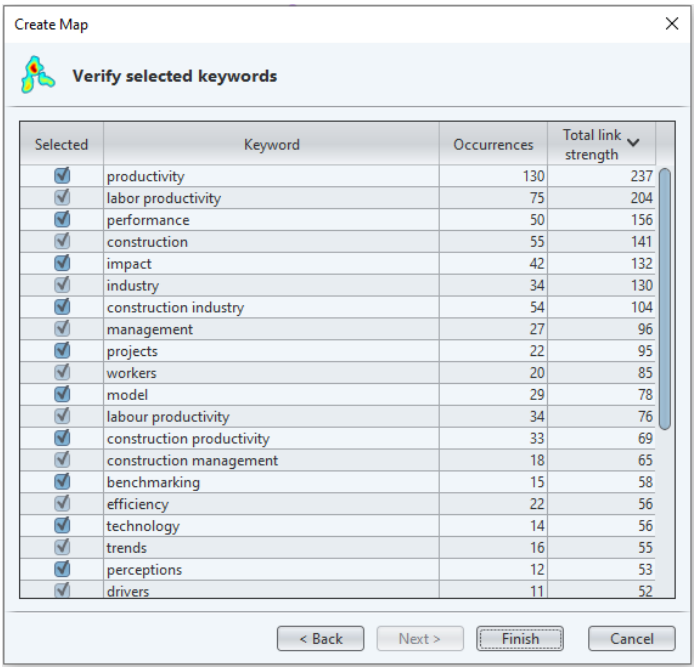


Figure 3.2 Top retrieved keywords

Figure 3.3 presents the mapping of the top keywords. It demonstrates the scientometric map for extracted keywords where the topmost keywords are highlighted and grouped into bigger bubbles subsequent to their considerable presence in the extracted literature. The frequency of occurrence is shown by the size of nodes. The arcs among the nodes correspond to their co-occurrence. The smaller distance between two nodes shows that the co-occurrence of the two keywords is higher.

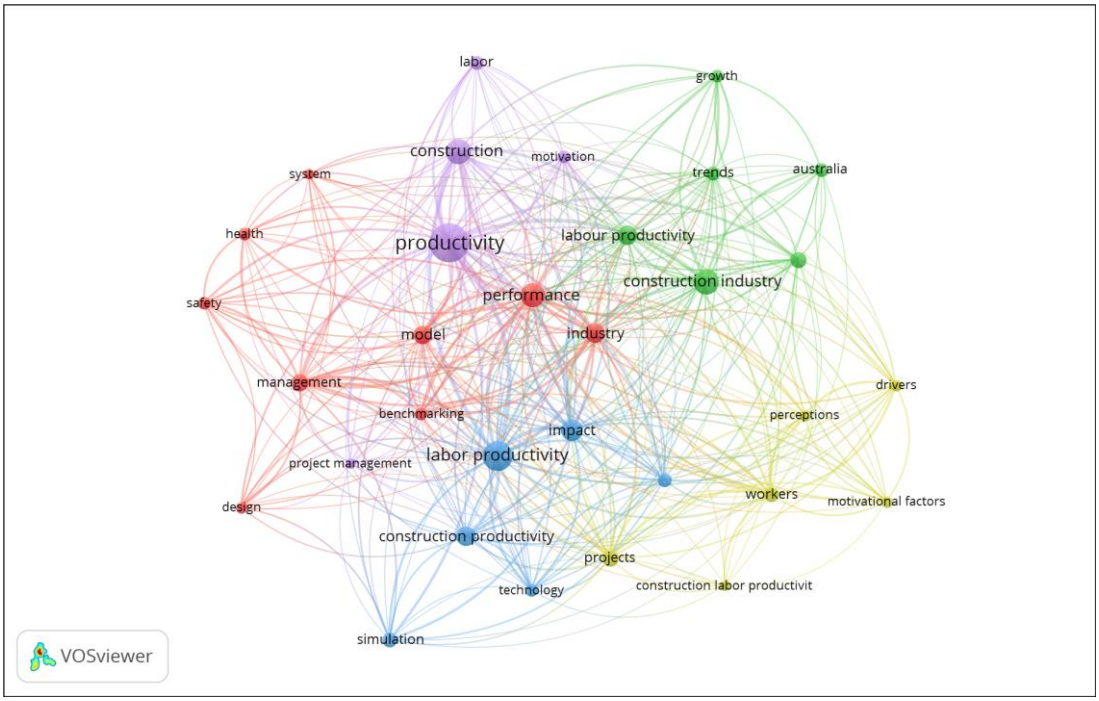


Figure 3.3 Keywords Mapping

3.2.3.2 Co-authorship analysis of authors

Co-authorship analysis is carried out by documenting all the names of the authors. VOSviewer co-authorship filter is used to count the citations to pertinent documents. At least, the contribution of 5 research papers by an author is set. A sum of 930 authors are documented. 12 authors come forward as top contributors after the minimum inclusion criteria is set. Figure 3.4 shows the best contributing authors and their citations for the extracted articles. Similarly,

Figure 3.5 shows the co-authorship of authors determined based on their number of co-authored documents.

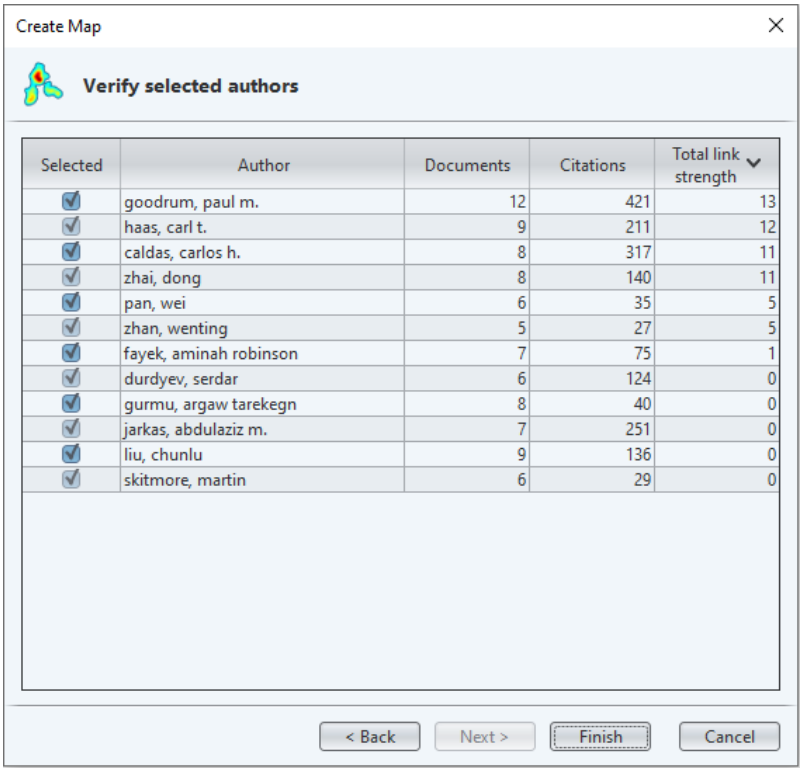


Figure 3.4 Keywords Mapping

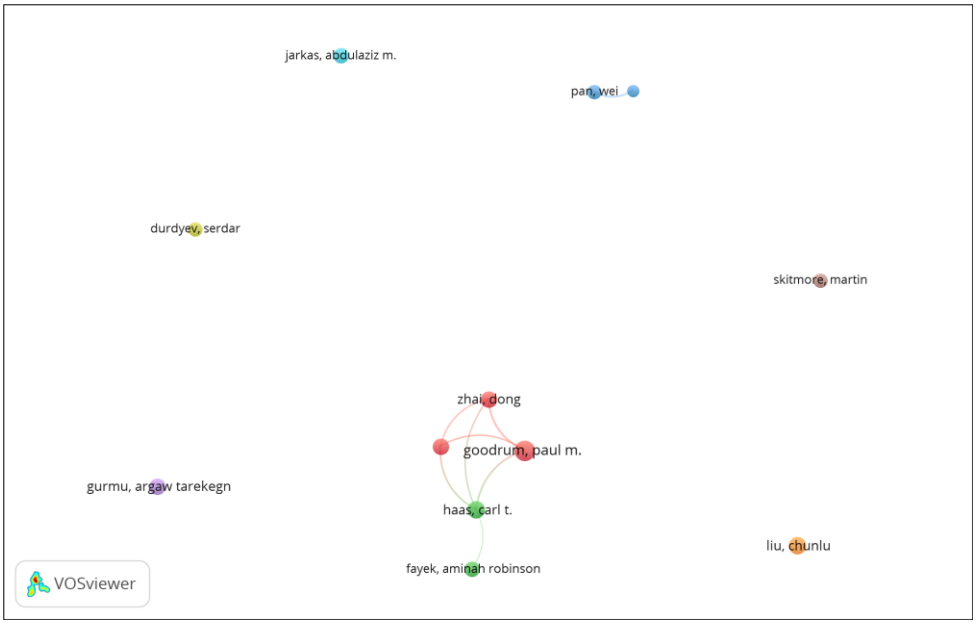
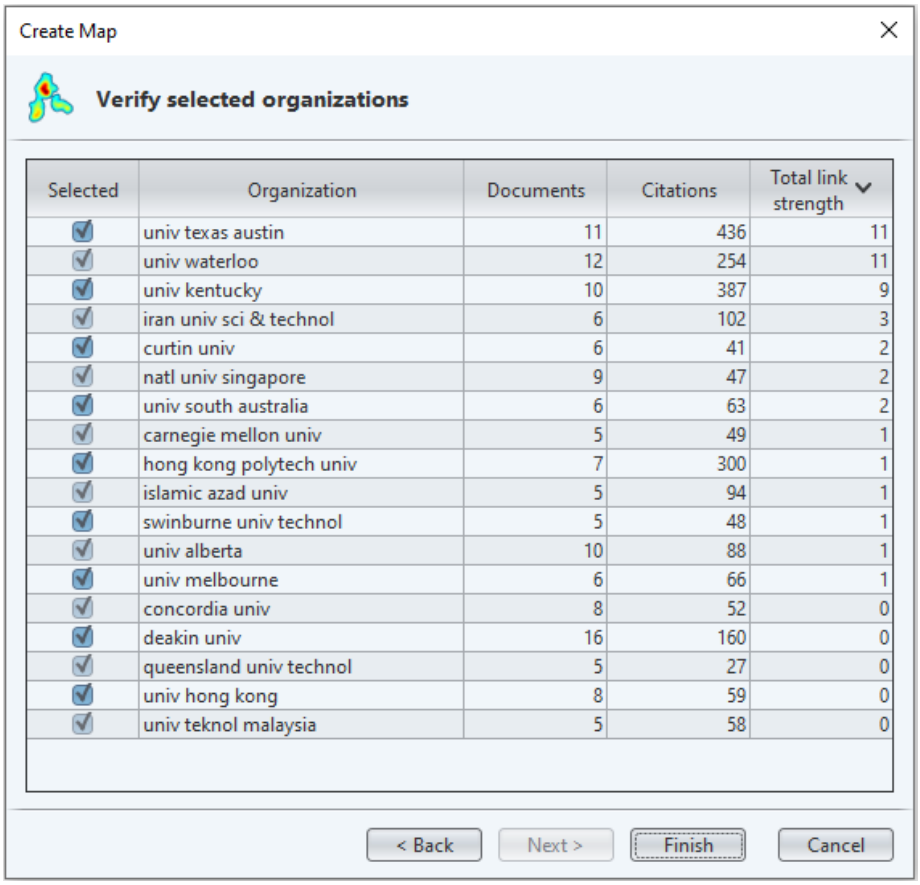


Figure 3.5 Co-authorship mapping

3.2.3.3 Organizational affiliation analysis

For analyzing the affiliation of the organization of authors, a minimum inclusion benchmark of five articles per organization is set. A sum of 447 organizations are affiliated with extracted articles. Accordingly, 18 organizations are shortlisted as shown in Figure 3.6. It provides a listing of the best contributing organizations based on the quantity of extracted articles.



Selected	Organization	Documents	Citations	Total link strength
☑	univ texas austin	11	436	11
☑	univ waterloo	12	254	11
☑	univ kentucky	10	387	9
☑	iran univ sci & technol	6	102	3
☑	curtin univ	6	41	2
☑	natl univ singapore	9	47	2
☑	univ south australia	6	63	2
☑	carnegie mellon univ	5	49	1
☑	hong kong polytech univ	7	300	1
☑	islamic azad univ	5	94	1
☑	swinburne univ technol	5	48	1
☑	univ alberta	10	88	1
☑	univ melbourne	6	66	1
☑	concordia univ	8	52	0
☑	deakin univ	16	160	0
☑	queensland univ technol	5	27	0
☑	univ hong kong	8	59	0
☑	univ teknol malaysia	5	58	0

Figure 3.6 Top organizations

3.2.3.4 Analysis of the country of origin

The countries contributing the most documents are also investigated. An analysis based on the country is performed where the minimum inclusion standard is set to 5 documents per country. A sum of 62 countries have participated. A sum of 28 countries are selected after applying the limits, as shown in Figure 3.7. Similarly, Figure 3.8 shows the map for top contributing

countries based on the quantity of citations and documents extracted. USA contributes the highest documents (76 documents), followed by Australia (71 documents) and China (48 documents). In terms of the citations, the USA tops with 1369 citations, trailed by Australia (746) and China (521).

Create Map

Verify selected countries

Selected	Country	Documents	Citations	Total link strength
☑	australia	71	746	34
☑	usa	76	1369	33
☑	peoples r china	48	521	23
☑	canada	35	436	17
☑	new zealand	17	260	15
☑	malaysia	20	94	12
☑	england	23	295	9
☑	iran	17	289	9
☑	singapore	9	47	7
☑	kuwait	7	251	5
☑	nigeria	8	18	5
☑	mexico	5	27	4
☑	qatar	5	49	4
☑	scotland	5	71	4
☑	south korea	25	81	4
☑	germany	8	73	3
☑	india	16	83	3
☑	poland	5	63	3
☑	saudi arabia	8	103	3
☑	south africa	11	28	3

< Back | Next > | Finish | Cancel

Figure 3.7 Top countries

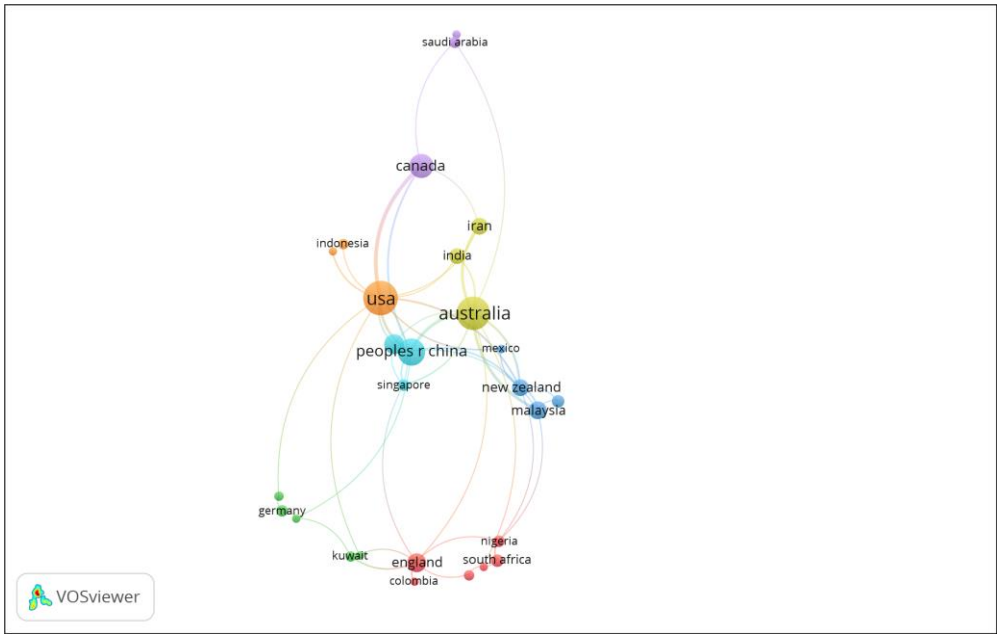


Figure 3.8 Countries mapping

3.3 RESEARCH DESIGN

The study was done in two main phases. The first phase included identification of variables affecting productivity in construction projects through literature review. To strengthen the model, an industrial perspective was taken through pilot study. Then, a conceptual model of factors affecting productivity in Pakistan was proposed.

The second phase consisted of organizing a questionnaire survey and the results to be used for exploratory factor analysis. This helped in identifying themes in the survey data and ultimately identify correlation among the variables.

The survey respondents were contacted online, through various means. The intension and objective of the study was thoroughly explained and proper instructions were given to make sure the survey was completed fully. The secrecy of the personal data of respondents was also ensured.

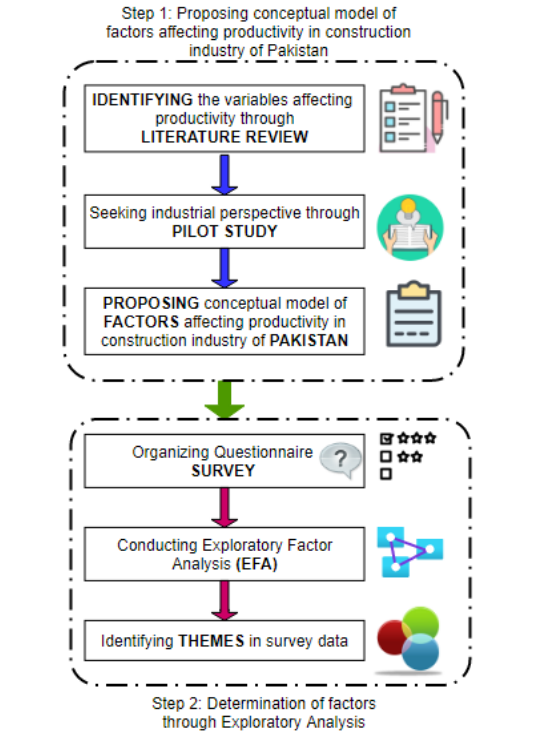


Figure 3.9 Methodology Flowchart

3.4 CONSIDERATIONS FOR THE SURVEY

It was ensured that the survey questionnaire was easily understandable and comfortable for the respondents. The survey form was divided in different parts with respect to the three categories of factors i.e. Consultant/Supervisor Related Factors, Human Resource Related Factors and Material, Equipment and Project Specific Factors. A progress bar was added in the form to let the respondents know of the progress of their form completion. These measured ensured that maximum individuals submit the form after completing the whole form, and not leave in the middle due to frustration. The form was initially tested to rule out any missing aspects and errors.

3.5 QUESTIONNAIRE

The questionnaire survey was based on Linkert Scale. It was arranged as to first develop the personal profile of the respondent and then several factors were given to rate them according to their impact on productivity. The questions about the respondents included their name, email address, education level, organization they work for and years of experience they have.

The next part of the survey form consisted of top 30 factors from the literature review divided into 3 categories. Each respondent had the option to rate each factor on a scale of 1 to 5 with 1 meaning that the factor is ‘slightly significant’ and 5 meaning the factor is ‘extremely significant’. The responses were based on the perception, technical know-how and experience of the respondents. This simplified approach were adopted to rank the factors and group them at a later stage.

3.6 PILOT STUDY AND QUESTIONNAIRE REVISION

To modify the questionnaire, pilot study was done involving experts of the construction industry. In this part, an online form was used with factors from the literature review to shortlist them for the main survey and for better development of the survey.

10 experts were approached, and a week's time was dedicated for the successful completion of pilot study. After analyzing the survey responses using Relative Importance Index, it was concluded that all 30 factors must be proceeded with since all had a mean value of greater than 3.

After the pilot study, the main questionnaire was sent out to people working in the construction industry. This task of getting responses took 1 month's time and ultimately the responses were analyses using statistical software that helped us refining the factors further.

3.7 SUMMARY

In this chapter, the methodology adopted for this research was explained. The main method of research used was questionnaire survey. The details about the pilot study and VOSViewer analysis is also included. Several considerations for the survey are also discussed.

Chapter 4

DATA ANALYSIS AND RESULTS

4.1 INTRODUCTION

This chapter will discuss the data analysis and the results of our project. Firstly, the questionnaire survey was floated among professionals having different designations, this was done to achieve a ranking of factors according to their productivity. The activities considered to find productivity were not specified rather the gate was left open for any activity to become a part of our list that was causing counter-productivity in a construction project.

4.2 QUESTIONNAIRE SURVEY

4.2.1 Characteristics of respondents

The Questionnaire survey was floated among professionals belonging to different fields of construction industry. A total of 71 responses were collected out of which 1 was found invalid and thus removed. Hence, this analysis is based on 70 valid responses. The respondents are characterized such that 5.1% were diploma holders, 48.6% were graduates while 42.9% people had a master's degree. Grouping and frequencies of respondents are shown in figure 4.1.

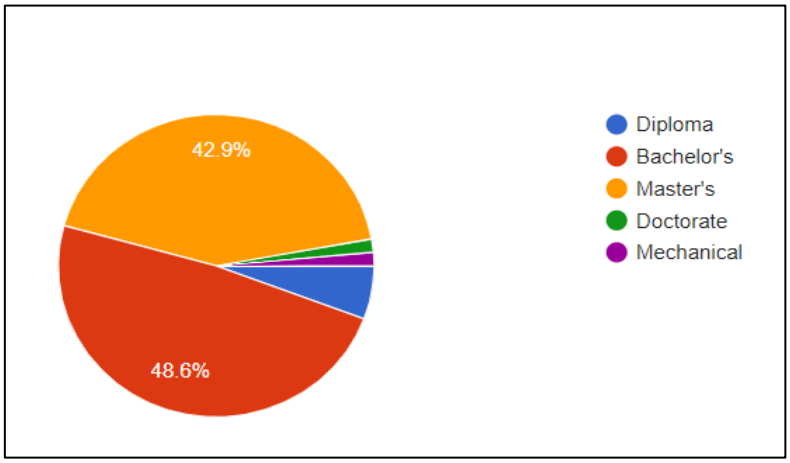


Figure 4.1 Classification of respondents based on their education

The respondents were also categorized based on their experience in the construction industry. Out of 70 people 25.7% had an experience between 6-10 years, 61.4% had an experience between 1-5 years, 5.7% had 11-15 years of experience while 4.3% had been working for more than 26 years. The grouping and frequencies are shown in figure 4.2.

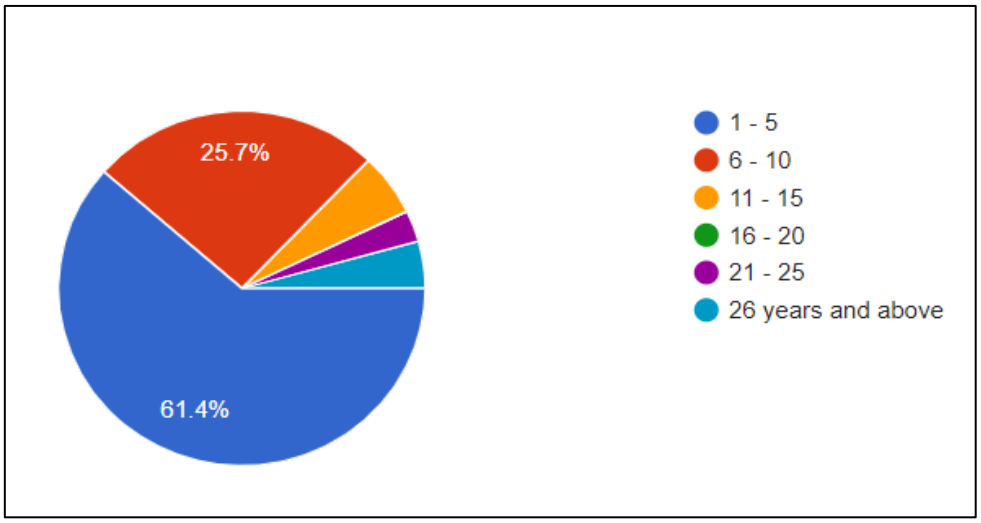


Figure 4.2 Classification of respondents based on their years of experience

The respondents belonged to various organizations, some of them include:

- NHA
- Matracon Pakistan private limited
- FWO
- Nespak Pakistan
- Atkins
- MPPL
- NESCON
- Allied Contractors
- Faisalabad Development Authority
- HkUst
- Moinsons Private Limited
- Lootah Contracting-Dubai
- Paradigm Pakistan Builders and Developers (Pvt) Ltd.
- Forella Group

4.3 PILOT STUDY

A pilot study can be defined as an initial study to test research procedures, data collection methods, and other research related practices in preparation for a larger study. This is an important stage of a research project as it helps in identification of potential problem areas. For performing pilot study ten (10) distinguished professionals were made to fill a questionnaire survey having thirty (30) factors. The data obtained was then used to perform the pilot study in following way.

4.3.1 Relative Importance Index

The data collected through the questionnaire survey was ranked after analyzing it based on RII. Using the equation 4.1, RII was calculated for all the 30 factors in the questionnaire survey. This was done by transforming scale and assigning weighting, it was then used to determine the ranks of each factor.

$$RII = \frac{\sum W}{A \times N} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \ (\mathbf{0} \leq \mathbf{RII} \leq \mathbf{1}) \qquad \mathbf{(4.1)}$$

Where:

W = Weight that is given to each factor by the respondents. It ranges from 1 to 5 where ‘1’ is ‘Slightly Significant and ‘5’ is ‘Extremely Significant’.

A = Highest weight (i.e. 5 in this case)

N = Total number of respondents who filled the form (i.e. 10 in this case)

Based on the analysis, the results that were obtained are presented and discussed in table below.

Table 4.1 Relative Importance Index of Factors

Sr.#	Factors	RII
1.	Delays in Payment	0.900
2.	Site Supervision Skills	0.800
3.	Delays in Inspection	0.760
4.	Design changes	0.800
5.	Quality of Drawings (Omissions/Lack of details)	0.700
6.	Design Complexity Level	0.660
7.	Rework Due to Design Errors	0.820
8.	Absenteeism (Absence of staff without any reason/strikes)	0.680
9.	Managerial competency of a project manager	0.780
10.	Communication skills of a project manager	0.740
11.	Lack of incentives for the work force	0.600
12.	Unclear instruction to labors	0.800
13.	Lack of Labor Training	0.660
14.	Lack of appropriate crew size for an activity	0.700
15.	Lack of coordination among the work force	0.740
16.	Labor Skills/Experience	0.700
17.	Motivation level of labors	0.660
18.	Low Wages for labors	0.660
19.	Overall health conditions of the work force	0.680
20.	Rework due to labor negligence	0.680
21.	Safety Consciousness of the work force	0.640
22.	Use of Drugs	0.540
23.	Construction Technology (Construction Method and Materials used)	0.780
24.	Material availability	0.920
25.	Equipment availability	0.840
26.	Lack of adequate storage area	0.640
27.	Project Complexity	0.660
28.	Difficult project specifications	0.660
29.	Inadequate access to the site	0.700
30.	Environmental Conditions (weather, frequent rains etc)	0.800

As evident from the above table, the top factor which affects productivity is material availability during execution. The second most impactful factor is delays in payment while the

third is equipment availability. The least impactful factor according to the above table is use of drugs.

The above 30 factors are divided into three groups, their ranking according to their respective group is discussed below.

Consultant/supervisor related factors Group

In consultant/supervisor related factors group, “delays in payment” is ranked has most highly affective with RII of 0.90 while “design complexity level” is least affective with RII of 0.660. The ranking of factors according to RII is shown in table.

Table 4.2 Consultant/Supervisor Related Factors

Sr.#	Factors	RII
1.	Delays in Payment	0.900
2.	Site Supervision Skills	0.800
3.	Delays in Inspection	0.760
4.	Design changes	0.800
5.	Quality of Drawings (Omissions/Lack of details)	0.700
6.	Design Complexity Level	0.660
7.	Rework Due to Design Errors	0.820

Human Resource Related Factors Group

In human resource related factors group, “Unclear instruction to labors” is ranked has most highly affective with RII of 0.80 while “use of drugs” is least affective with RII of 0.540. The ranking of factors according to RII is shown in table.

Table 4.3 Human Resource Related Factors

Sr.#	Factors	RII
1.	Absenteeism (Absence of staff without any reason/strikes)	0.680
2.	Managerial competency of a project manager	0.780
3.	Communication skills of a project manager	0.740
4.	Lack of incentives for the work force	0.600
5.	Unclear instruction to labors	0.800
6.	Lack of Labor Training	0.660
7.	Lack of appropriate crew size for an activity	0.700
8.	Lack of coordination among the work force	0.740
9.	Labor Skills/Experience	0.700
10.	Motivation level of labors	0.660
11.	Low Wages for labors	0.660
12.	Overall health conditions of the work force	0.680
13.	Rework due to labor negligence	0.680
14.	Safety Consciousness of the work force	0.640
15.	Use of Drugs	0.540

Material, Equipment and Project Specific Factors Group

In material, equipment and project specific factors group, “material availability” is ranked has most highly affective with RII of 0.920 while “Project Complexity” and “Difficult project specifications” are least affective with RII of 0.660 each. The ranking of factors according to RII is shown in table.

Table 4.4 Material, Equipment and Project Specific Factors

Sr.#	Factors	RII
1.	Construction Technology (Construction Method and Materials used)	0.780
2.	Material availability	0.920
3.	Equipment availability	0.840
4.	Lack of adequate storage area	0.640
5.	Project Complexity	0.660
6.	Difficult project specifications	0.660
7.	Inadequate access to the site	0.700
8.	Environmental Conditions (weather, frequent rains etc)	0.800

4.3.2 Determining the Mean Value

Mean value was calculated for all individual factors. The criterion was that the factors having mean value greater than 3 will be considered for further analysis. Since the relative mean of all the factors was greater than 3, so all factors were taken forward for the survey. The formula used for calculating mean is shown in figure equation 4.2.

$$Item\ Mean = \frac{\sum W}{N} \quad \textbf{(4.2)}$$

Where:

W= Weight that is given to each factor by the respondents. It ranges from 1 to 5 where '1' is 'slightly significant' and '5' is 'extremely significant'.

N= Total number of respondents (i.e. 10 in this case)

The values of mean obtained are shared in the table below.

Table 4.5 Mean values of Factors

Sr.#	Factors	Item Mean
1.	Delays in Payment	4.5
2.	Site Supervision Skills	4.0
3.	Delays in Inspection	3.8
4.	Design changes	4.0
5.	Quality of Drawings (Omissions/Lack of details)	3.5
6.	Design Complexity Level	3.3
7.	Rework Due to Design Errors	4.1
8.	Absenteeism (Absence of staff without any reason/strikes)	3.4
9.	Managerial competency of a project manager	3.9
10.	Communication skills of a project manager	3.7
11.	Lack of incentives for the work force	3.0
12.	Unclear instruction to labors	4.0
13.	Lack of Labor Training	3.3
14.	Lack of appropriate crew size for an activity	3.5
15.	Lack of coordination among the work force	3.7

16.	Labor Skills/Experience	3.5
17.	Motivation level of labors	3.3
18.	Low Wages for labors	3.3
19.	Overall health conditions of the work force	3.4
20.	Rework due to labor negligence	3.4
21.	Safety Consciousness of the work force	3.2
22.	Use of Drugs	2.7
23.	Construction Technology (Construction Method and Materials used)	3.9
24.	Material availability	4.6
25.	Equipment availability	4.2
26.	Lack of adequate storage area	3.2
27.	Project Complexity	3.3
28.	Difficult project specifications	3.3
29.	Inadequate access to the site	3.5
30.	Environmental Conditions (weather, frequent rains etc)	4.0

4.4 STATISTICAL ANALYSIS

In order to verify the statistical validity of our collected data, we performed various tests, the details of which are discussed below. Different softwares were used in this regard, which include:

- SPSS Statistics v26
- Stata 15.0

4.4.1 Suitability of the Sample

Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy is a statistic technique used to indicate the proportion of variance in the variables. This variance might be caused by underlying factors. High (i.e. close to 1.0) values indicate that a factor analysis will be useful with the data. The results of factor analysis, probably, will not be very useful if the value is less than 0.50.

Bartlett's test of sphericity

Bartlett's test of sphericity is used for testing the hypothesis that the correlation matrix is an identity matrix. This would signal that the variables are not related and this not suitable for structure detection. For the data to be useful, the significance level must have small values (i.e. less than 0.05)

The table below illustrates the results that were obtained from the KMO and Bartlett's tests. Our data proved useful as the values were within the specified ranges.

Table 4.6 KMO and Bartlett's test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.783
Bartlett's Test of Sphericity	Approx. Chi-Square	1117.114
	df	435
	Sig.	.000

4.4.2 Categorization of the factors

For categorizing of factors and shortlisting the ones having greatest impact, various tests and rotations were performed, the details of which are discussed below. The whole process accounts for Exploratory Factor Analysis (EFA).

Horn Parallel Analysis

For the determination of number of components that must be kept in a principal component analysis or factors to keep in exploratory factor analysis, we performed a statistical technique known as Horn Parallel Analysis. This method compares the eigenvalues generated from the data matrix to the eigenvalues generated from a Monte-Carlo simulated matrix that are created from random data of the same size. Horn Parallel Analysis is considered as a more accurate

method for determining the number of factors or components that are to be retained. The software used to perform Horn Parallel Analysis is STATA 15.0.

Stata is a powerful statistical software that enables its users to analyze, manage, and produce graphical visualizations of data. It determines the number of components/categories in the data available. The categorization is based on the eigenvalue. The factors with adjusted eigenvalue greater than 1 make a component. Stata was used to analyze the data available the results of which are shared in the table below. Horn parallel analysis was performed to obtain the following data.

Table 4.7 Horn Parallel Analysis

Component or Factor	Adjusted Eigenvalue	Unadjusted Eigenvalue	Estimated Bias
1	7.5698298	8.8757464	1.3059165
2	1.8664702	3.0895246	1.2230544
3	1.3126079	2.3687405	1.0561326
4	.76562692	1.750716	.98508906
5	.48352301	1.4042114	.92068839
6	.59490483	1.3020412	.70713639
7	.55883043	1.2352728	.67644238
8	.54104122	1.0843117	.54327047
9	.56113869	.95898861	.39784992
10	.50820708	.81117332	.30296624
11	.53293073	.7671411	.23421037
12	.61474877	.74485224	.13010347
13	.70693981	.68763446	-.01930535
14	.64924301	.60195406	-.04728895
15	.6389776	.53428609	-.10469151
16	.67966916	.48703338	-.19263577
17	.63790447	.41639638	-.22150809
18	.7049298	.40094951	-.30398029
19	.6734443	.34811499	-.3253293
20	.72304726	.33167804	-.39136922
21	.72904617	.27888907	-.45015711
22	.78971272	.24524879	-.54446393
23	.8007896	.23520321	-.56558639
24	.82800467	.20806931	-.61993536
25	.85566347	.19312416	-.6625393
26	.90932196	.17834281	-.73097914
27	.89423486	.14706414	-.74717072
28	.96243454	.13592961	-.82650493
29	.95051515	.10140082	-.84911433
30	.95626148	.07596131	-.88030017

Criterion: retain adjusted components > 1

Varimax Analysis

To clarify the relationship among factors we used Varimax Analysis. This technique involves adjustment of the coordinates of data that result from a principal components analysis. The adjustment, or rotation, is done to maximize the variance that is shared among different items. By maximizing the shared variance, we get the results that represents how data correlate with each principal component, that too in discrete form. Maximizing the variance refers to increasing the squared correlation of items related to one factor, while decreasing the correlation on any other factor. In other words, the varimax rotation simplifies the loadings of items by removing the middle ground and more specifically identifying the factor upon which data load.

The results obtained after the analysis are as follows:

Table 4.8 Final Rotated Component Matrix

Rotated Component Matrix[a]			
	Component		
	1	2	3
Site Supervision Skills		0.331	0.684
Quality of Drawings (Omissions/Lack of details)			0.840
Rework Due to Design Errors			0.624
Lack of labor training	0.799		
Lack of appropriate crew size for an activity	0.695	0.349	
Lack of coordination among the work force	0.799		
Labor Skills/Experience	0.740	0.358	
Motivation level of labors	0.666		
Rework due to labor negligence	0.667		0.436
Material Availability		0.892	
Equipment availability		0.903	
Managerial Competency of a Project Manager	0.352	0.663	
Lack of adequate storage area		0.650	0.389
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 5 iterations.			

4.5 SUMMARY

In this chapter data analysis and results have been discussed. Different analysis and statistical techniques were used to get the output from the collected data. Thirty (30) factors in three groups are analyzed using STATA 15.0 and IBM SPSS Statistics v26 to assess the factors that affects construction labor productivity in Pakistan. Data for this was obtained from several construction companies, most of which were national, and some were international.

KMO and Barlett's test of sphericity were performed so that the suitability of our data could be checked. This was also important to see whether or data was acceptable for analysis or not. In our case our data came out to be within range and hence rotations and tests were performed on it to get categories and shortlisted factors belonging to them. The top factors that were drawn out after our analysis are as follows:

1. Lack of labor training
2. Lack of coordination among the work force
3. Labor Skills/Experience
4. Lack of appropriate crew size for an activity
5. Rework due to labor negligence
6. Motivation level of labors
7. Equipment availability
8. Material Availability
9. Managerial Competency of a Project Manager
10. Lack of adequate storage area
11. Quality of Drawings (Omissions/Lack of details)
12. Site Supervision Skills
13. Rework Due to Design Errors

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter deals with the conclusion and recommendations for factors that affect the productivity in construction industry of Pakistan. The recommendations and results of this research will help the organizations and firms of Pakistan to reduce delays in the project and to avoid cost overruns as well as time overruns throughout the duration of projects.

5.2 REVIEW OF RESEARCH OBJEVTIVES

The specific objectives of this research were:

1. Identifying the factors that affect Labor Productivity.

2. Determination of co-relation/co-variance among factors that affect labor productivity in construction industry of Pakistan.

3. Determination of the impact of attributes of a Project Manager on overall productivity.

The first objective of our research was achieved by extensive literature review in which we manually studied more than 20 research papers from several journals. Apart from that, we also used VosViewer for literature review which helped us to know about the work which has already been done regarding this topic. We also came to know about the regions of the world where extensive work has been done on this topic.

These efforts helped us to identify top 30 factors with respect to Relative Importance Index (RII). The other objectives were achieved by detailed analysis. A questionnaire survey was designed which was floated in several renowned construction firms of Pakistan and was filled

by civil engineers which had a vast experience in the construction fields of Pakistan. The results of the questionnaire survey were used for the statistical analysis in which we used softwares like Stata and SPSS to achieve our objective of determining co-relation and co-variance among the identified factors.

5.3 CONCLUSION

The portion of the thesis deals with the conclusions about the findings made by the research work. 13 factors were identified after extensive study related to the factors affecting productivity of labor, which were grouped in three main categories which are:

- Factors related to consultant/supervisor
- Factors related to human resource
- Factors related to material, equipment and project

5.3.1 Factors Related to Consultant/Supervisor

This category groups related factors that depend on consultant or supervisor's skills and capabilities. It is observed many times that errors in drawings and specifications exist in almost every project. If a labor has done some part of the project and later he comes to know that there was an error due to negligence of consultant who gave him drawings. This will cause rework, increased cost and wastage of time and will adversely affect productivity. Moreover, supervision skills also have a great effect on enhancing the productivity. If the mentioned factors are managed in a good way, it will increase productivity of labors and will avoid cost overrun and time overrun.

Table 5.1 Final Consultant/Supervisor related factors

S.No	Factors affecting labor productivity
1.	Site supervision skills
2.	Quality of drawings
3.	Rework due to design errors

5.3.2 Factors Related to Human Resource

This category includes the factors that are related to human workforce i.e. labors who are the sole topic of this study. Productivity in construction mainly depends on the labors. If labors are poorly trained and unskilled labors operate, there will be low and faulty outputs that will be rejected and will require rework which will result in extensive rework and/or repairs, which increases the costs as well. On the other hand, experienced operatives possess good intellectual abilities, and have practical solutions against difficult situations and also possess high technical skills. Moreover, motivated labors are more enthusiastic. Their motivation makes them work harder and they adapt to conditions and instructions faster. This increases their pace of work. These all will lead to higher productivity, decreased cost, and better quality of output. This category includes 6 factors.

Table 5.2 Final Human Resource related factors

S.No	Factors affecting labor productivity
1.	Lack of labor training
2.	Lack of appropriate crew size for an activity
3.	Lack of coordination among workforce
4.	Labor skills/experience, motivation level of labors
5.	Motivation level of labors
6.	Rework due to labor negligence.

5.3.4 Factors Related to Material, Equipment and Project

This category deals with the factors related to material, equipment and project characteristics. It is commonly observed that due to inadequate material and equipment storage location, labors waste their important time in unproductive work. If material storage location is far away from

construction site, it will result in wastage of time due to transportation of material from storage area to construction site. Also if material and equipment are readily available to labors, their work pace will increase and will increase productivity of labors. This category contains 4 factors.

Table 5. 3 Final Material, Equipment and Project related factors

S.No	Factors affecting labor productivity
1.	Material availability
2.	Equipment availability
3.	Managerial competency of a Project Manager
4.	Lack of adequate storage area

5.4 RECOMMENDATIONS:

As we know that construction projects are very costly to construct, this imposes negative effects in attaining construction projects. In order to execute a project timely and in a successful way, the work environment of construction companies should be easily adoptable. So our research recommends some important factors in order to alleviate progress and productivity of construction. These are as follows:

- Supervision of labors, progress and site should be done often and skills of supervisor to be improved in order to increase productivity.
- Consultant should recheck drawings for quality and errors so that drawings are easily understandable and free of errors.
- Design errors should also be checked to avoid rework which will decrease productivity and cause time and cost overruns.
- Material and equipment availability to the workers should be ensured on a regular basis to increase efficiency of workers.

- Apart from material and equipment availability, a storage area should also be provided which is closest to construction site and is large enough in size to contain all the material and equipment needed by labors for their work.
- A competent Project Manager with sound managerial and technical capabilities who can manage site in a better way should be hired.
- Labors with training should be selected for the work or proper training should be provided to them.
- Appropriate crew size should be chosen for an activity which contain enough workers to perform an activity.
- Proper coordination among the workforce to be ensured in order to avoid miscommunication and errors or faulty results.
- Experienced and skillful labors that have knowledge and experience to execute their work properly.
- Labors should possess motivation and should be dedicated to their work so that they can perform their tasks without considering it as a burden.
- Work and progress on site should be monitored regularly to avoid rework that may occur due to negligence of labor.
- Standard working hours should be 8 hours per day and 40 hours per week.
- A proper defined schedule for the provision of materials should be offered by contractor for every project.
- Safety of workers should be ensured by providing safety training sessions and proper safety tools and lightning should be provided on site to reduce accidents.
- Friendly communication and collaboration should be managed among the workers and they should be informed about the significance of communication.

- Incentive schemes be proposed on regular basis to create a competition for the workers and timely payments also be ensured to increase efficiency and speed of work.
- Drug usage should be prohibited among the labors and action should be taken against the ones who is found to be involved in such types of activities.
- Absenteeism of workers should be minimized by incorporating paid leaves and holidays for employees.

REFERENCES

(n.d.). Retrieved from Oxford Languages: https://languages.oup.com/google-dictionary-en/

A. Soekiman, K. P. (2011). Factors Relating to Labor Productivity Affecting the Project Schedule Performance in Indonesia. *Procedia Engineering, 14*, 865-873.

Abdul Haseeb Aamir Sheikh, M. I. (2019). Evaluation of key factors influencing process quality during construction projects in Pakistan. *Grey Systems Theory and Application*.

Abdulaziz M. Jarkas, C. G. (2012). Factors Affecting Construction Labor Productivity in Kuwait. *Journal of Construction Engineering and Management, 138*(7).

Abid Hasan, B. B. (2018). Factors affecting Construction Productivity: a 30 year Systematic Review. *Engineering, Construction and Architectural Management, 25*, 916-937.

Abu Bakar Muzamil, B. K. (2014). Analysis of Labour Productivity of Road Construction in Pakistan. *International Journal of Engineering and Advanced Technology, 3*(3).

Alinaitwe, M. H. (2007). Factors affecting the productivity of building craftsmen. *Journal of Civil Engineering and Management*, 169-176.

Arun Makulsawatudom, M. E. (2004). Critical Factors Influencing Construction Productivity in Thailand. *The Journal of KMITNB, 14*.

E C Lim, J. A. (1995). Construction productivity: Issues encountered by contractors in Singapore. *International Journal of Project Management, 13*(1), 51-58.

Enshasi. Mohamed, M. (2007). Factors Affecting labour productivity in building projects in GAZA strip. *Journal of civil engineering and management*, 245-254.

Fida Siddiqui, T. A. (2016). Labor Productivity In The Construction Industry of Pakistan.

Ismail Abdul Rahman, A. H. (2019). Factors Affecting the Labour Productivity in Construction Projects of Pakistan. *MATEC Web of Conferences*.

Jergeas. (2009). *Improving construction productivity on Alberta Oil and Gas Projects.* Alberta: Department of Civil Engineering Schulich School of Engineering University of Calgary Alberta, Canada.

Jiukun Dai, P. M. (2009). Construction Craft Workers' Perceptions of the Factors Affecting Their Productivity. *Journal of Construction Engineering and Management, 135*(3).

Jiukun Dai, P. M. (2009). Latent Structures of the Factors Affecting Construction Labor Productivity. *Journal of Construction Engineering and Management, 135*(5).

Kazaz, M. U. (2008). Effects of basic motivational factors on construction workforce productivity in Turkey. *Journal of Civil Engineering and Managemnet*, 95-106.

Khaled Mahmoud El-Gohary, M., & Aziz, R. F. (2014). Factors Influencing Construction Labor Productivity in Egypt . *Journal of Management in Engineering* .

M Bierman, A. M. (2016). Productivity management in the South African civil construction industry - factors affecting construction productivity. *Journal of the South African Institution of Civil Engineering*.

Makulsawatudom, E. (2002). Critical factors influencing construction productivity in Thailan. *CIB 10th International Symposium on construction Innovation and global competitiveness.* Cincinnati.

Mistry Soham, B. R. (2013, April). CriticalFactorsAffecting Labour Productivity InConstruction Projects:Case Study Of South Gujarat Region Of India. *International Journal of Engineering and Advanced Technology*.

Muhammad Irfan, H. Z. (2020). Determinants of Labor Productivity for Building Projects in Pakistan. *Journal of Construction Engineering, Management & Innovation*.

Muneer Anees, M. S. (2021). 5 Identification of Factors Affecting Construction Productivity in Pakistan Industry . *Sir Syed University Research Journal of Engineering and Technology*.

Over 1,000 projects face delays and cost overruns: PAC. (2017, October 25). Retrieved from Express Tribune: https://tribune.com.pk/story/1540651/1-1000-projects-face-delays-cost-overruns-pac

Park, H.-S. (2006). Conceptual Framework of Construction Productivity Estimation. *KSCE Journal of Civil Engineering*.

Polat, G. a. (2005). The JIT Management System in developing countries. *Construction Management and Economics*, 697-712.

Saurav Dixit, S. N. (2019). Evolution of studies in Construction Productivity: A Systematic Literature Review (2006–2017). *Ain Shams Engineering Journal*.

Tareq Khaleel, Y. N. (2018). Identification and analysis of factors affecting labour productivity in Iraq. *MATEC Web of Conferences*.

Will The Construction Industry Revive Pakistan's Economy? (2020, October 28). Retrieved from Aurora: https://aurora.dawn.com/news/1143877#:~:text=Although%20formally%2C%20on%20average%2C%20the,12%25%20of%20the%20total%20GDP.

World Construction Industry. (2010, June 29). Retrieved from Economy Watch: https://www.economywatch.com/world-industries/construction/world.html

ANNEX 1

SURVEY QUESTIONNAIRE

Factors Affecting Productivity in Construction Projects

We are final year students of Civil Engineering at NUST Islamabad doing this survey for our final year project.

This Questionnaire Survey aims to determine the impact of several factors on the productivity in Construction Projects.

All responses to this survey will be treated with the strictest confidentiality and only consolidated results will be used in reports and publications.

* Required

Personal Information

1. Your Name

_____

2. Email

_____

3. Education *

Mark only one oval.

- ◯ Diploma
- ◯ Bachelor's
- ◯ Master's
- ◯ Doctorate
- ◯ Other: _____

4. Organisation you work for

_____

5. Years of experience *

Mark only one oval.

- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 years and above

Consultant/Supervisor Related Factors

Please rate the significance of the following factors on construction productivity on a scale of 1-5 ('1 – slightly significant', '2 – fairly significant ', '3 – significant ', '4 – very significant ' and '5 – extremely significant').

6. Delays in Payment *

Mark only one oval.

1	2	3	4	5

7. Site Supervision Skills *

Mark only one oval.

1	2	3	4	5

8. Delays in Inspection *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

9. Design Changes *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

10. Quality of Drawings (Omissions/Lack of details) *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

11. Design Complexity Level *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

12. Rework Due to Design Errors *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

Human Resource Related Factors

Please rate the significance of the following factors on construction productivity on a scale of 1-5 ('1 – slightly significant', '2 – fairly significant ', '3 – significant ', '4 – very significant ' and '5 – extremely significant').

13. Absenteeism (Absence of staff without any reason/strikes) *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

14. Managerial Competency of a Project Manager *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

15. Communication Skills of a Project Manager *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

16. Lack of incentives for the work force *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

17. Unclear instruction to labors *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

18. Lack of labor training *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

19. Lack of appropriate crew size for an activity *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

20. Lack of coordination among the work force *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

21. Labor Skills/Experience *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

22. Motivation level of labors *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

23. Low Wages for labors *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

24. Overall health conditions of the work force *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

25. Rework due to labor negligence *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

26. Safety Consciousness of the work force *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

27. Use of Drugs *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

Material, Equipment And Project Specific Characteristics

Please rate the significance of the following factors on construction productivity on a scale of 1-5 ('1 – slightly significant', '2 – fairly significant ', '3 – significant ', '4 – very significant ' and '5 – extremely significant').

28. Construction Technology (Construction Method and Materials used) *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

29. Material Availability *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

30. Equipment availability *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

31. Lack of adequate storage area *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

32. Project Complexity *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

33. Difficult project specifications *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

34. Inadequate access to the site *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

35. Environmental Conditions (weather, frequent rains etc) *

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

Additional Factors

36. If there are any other factors that you think affect the productivity of a construction project, then you may write them down here:

_____

This content is neither created nor endorsed by Google.

Google Forms