In the name of Allah Almighty

The All Compassionate and

The Most Merciful

BE CIVIL ENGINEERING
PROJECT REPORT

MICROLEVEL EVAULATION OF WASTAGE FACTORS IN CONSTRUCTION INDUSTRY OF PAKISTAN AND ITS OVERALL IMPACT

Project submitted in partial fulfillment of the requirements for the degree of

BE Civil Engineering

SUBMITTED BY

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MILTARY COLLEGE OF ENGINEERING

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD, PAKISTAN

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This to certify that the

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Lt Col Dr. Mughees
Syndicate Advisor

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At the outset, we would like to thank Allah Almighty for giving us the strength to complete the research work assigned to us within the prescribed time and with a profound sense of satisfaction. Completion of this work is the result of co-operation of many dedicated and helpful people. It is difficult to gauge their contributions in helping us to carry out this research work. We are in great debt to those who made this research possible especially to our advisor Lt Col Dr. Mughees Aslam, Instructor at Military College of Engineering, Risalpur, who always encouraged us and under whose able guidance we were able to complete the magnanimous task at hand with great ease. They have always been symbols of great inspiration and encouragement for us. At the last, we would like to extend our special thanks to our parents for their continued encouragement and support.

DEDICATION

Dedicated to our beloved Parents and Teachers, whose prayers and guidance have been a source of motivation for us

Abstract

Despite the fact that construction industry is a main contributor in development of a country, it imposes negative impacts on economy and environment. As we know, wastes in construction industry have always been causing significant problems like cost overruns, time delays, and quality compromises, especially in developing countries like Pakistan. A lot of work has been done internationally on determining different causes of waste, its contribution to waste generation and evaluating percentages of waste of different materials. However, there is a lack in research on the contribution of construction waste on the micro level in Pakistan. This research therefore focuses on analyzing the most vital and frequent causes contributing to the various construction wastes in Pakistan and its overall impact on cost, time, quality and material of the project. Almost 120 questionnaires of well-designed structured questionnaires were distributed in two phases among architects, civil engineers, contractors, and quantity surveyors etc. All the factors contributing to non-value adding activities were identified by going through the literature and personal observation made by visiting ongoing projects. The top ten factors were finalized after the first phase by calculating the Relative Importance Index (RII) of each factor. Furthermore, construction professionals were asked to provide contribution of these factors affecting cost, time, quality and material based on their experience and knowledge in the construction field. In the second phase the subject matter experts were asked to score their judgments about these ten factors generating waste in construction projects in Pakistan for its overall quantification and validation. Finally, the data collected were statistically analyzed and processed. Moreover, interviews of construction professionals were conducted. Based upon their recommendations, mitigating measures to minimize waste in construction projects in Pakistan were added in this report. The top three factors as extracted from the data collected from the construction professionals and validated by the data collected from other subject matter experts shows that the top three factors contributing to the construction wastes in Pakistan are lack of training and awareness to workers, lack of waste reduction/poor management plan and inventory issues respectively.

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1 INTRODUCTION

1.1 Introduction

The construction sector has brought with it several issues such as waste because of its progressive nature and constant development. When it comes to defining construction waste, there are two schools of thought: some describe it as surplus and damaged products and materials created during new construction, repair, and demolition of structures, while others include non-value-adding operations.

Construction is thought to be a critical activity for infrastructure and economic development. In terms of the environment, though, it is unpleasant. During construction activities, a significant amount of waste is generated, up to 30%.

It is commonly acknowledged that the construction sector generates a substantial amount of garbage, both by obtaining inputs from them and by giving almost all of them waste. Because development has such a major and direct impact on so many other businesses, reducing or eliminating waste might save society a lot of money.

Construction waste is normally generated during the project's execution phase, although it is the result of a series of events that occur during the design, construction, and procurement phases.

This study focuses on determining the most critical factors contributing to waste in construction projects in Pakistan, their quantification and then determining their effect on cost, time, quality, and material of the construction projects. Mitigating

measures are also provided to curtail the waste production in construction industry of Pakistan due to these determined factors.

1.2 Background / General

Construction industry is one of the main industries which contribute in the nation economy. In Pakistan almost 7% of the workers are concerned with the construction industry as per the economic survey of Pakistan 2018-19 and construction industry contribute 5.8% to GDP. In the recent times when population is so much increasing constantly at the rate 3.4% per year in Pakistan according to World Bank, not only in Pakistan but all over the world.

When Pakistan got independence its population was just 30 million and according to the 2017 census of Pakistan it is almost 207 million which depicts 57% increase in just 19 years, so with the increase in population and the migration of people from villages to main cities the construction in main cities is increased because people need buildings to work, roads for transportation and other different type of constructions so, for this purpose as the construction is everywhere increased then the waste generated from this construction and the demolition of the older buildings and roads are also increased in a very huge manner (Nadia Qamar, 2017). Every industry faces their problems. In construction industry, construction waste is one of the biggest problems in worldwide and it is generated in almost all construction sites.

Construction is increasing constantly all over the world due to increase in population and the huge demand of new construction buildings for their unique purposes therefore, new construction carried out and also the old buildings and old

designs which does not match the new design requirements get demolished and some are demolished due to natural hazards like earthquake, floods, hurricane etc. This depicts the debris and demolished waste of the infrastructure on large basis and that creates problems for the local community and also for the newly constructed buildings.

1.3 Problem statement

Construction wastes are a huge source of creeps in costs, budgets, times and materials internationally but it is specifically significant in a developing country like Pakistan, it gains even more importance as on one hand the practices of avoiding construction wastes and efficient methodologies are minimum to none and on the other hand the financial capabilities are also limited because of poor economics. In today's world the construction industry is so much increasing constantly and also the demolishing of the old structures and construct new buildings, dams and roads. So the biggest industry of all other industries is producing also so much C&D waste in billions of tons every year.

1.4 Research Objectives

The objectives of this research are:

- To identify the factors causing waste in a construction project as a result of non-value adding activities overall but specially in Pakistan.

- To enumerate the most common factors causing construction wastes.
- To analyze the factors and find out their relative importance index
- To find the impact of these factors in regard to their contribution to the wastes in time, cost, quality and material.
- To validate results by conducting survey between subject matter experts and then comparing the results
- To formulate effective measures to mitigate and minimize the wastage caused in construction, may it be physical or non-physical.

1.5 Research questions

The research will help us understand the most significant sources of construction wastes, especially in Pakistan, and accordingly chart out the ways and practices to mitigate these construction wastes. The following are our main research questions.

- 'What are the most significant sources of construction wastes, especially in Pakistan?

- What is their relative importance in contributing towards the wastage of time, cost, quality and material?

- What are the ways and practices which can be adapted to counter and minimize these wastes?

1.6 Limitations

- While carrying out the research and interviews it was a major hindrance that in a developing country like Pakistan there is a huge lack of policies as well as adequate surveillance and monitoring practices due to which the respondents were not able to give exact figures and numbers.

- Moreover, it is also worth mentioning that in real life projects and construction works, the scope and horizons of expenditures is so vast and versatile that only a limited specification is possible among the various wastes. For example, only in the calculation of labor cost and its wastage one has to include all the minor events like the cost of loading/unloading, transporting, daily fluctuations in work hours and respective wages, the provision of food, shelter and safety to the workforce etc.

- Therefore, the numeric data had to be extracted from some international articles besides interviewing a few available sources in Pakistan which were available to provide some numeric data.

1.7 Thesis structure

Thesis work will comprise of seven chapters as under.

- Chapter – 1. Introduction
- Chapter – 2. Literature Review
- Chapter – 3. Research Methodology
- Chapter – 4. Survey Demography and Results
- Chapter – 5. Analysis and Discussion
- Chapter – 6. Mitigating Measures to reduce wastage
- Chapter – 7. Conclusion and Recommendations
- References
- Appendices

CHAPTER-2

2 LITERATURE REVIEW

2.1 Background

The construction business is quite important in most developing countries. It is currently facing significant barriers and challenges as a result of the massive amounts of building waste produced. Rising living standards, changing consumer preferences, and natural population growth are all factors that contribute to an increase in construction waste, as seen by large increases in the past two decades. Most environmental organizations prioritized the quantification of construction waste created by various construction operations. To demonstrate this, the “United States Environmental Protection Agency (EPA) reported 170 million tons of construction trash in 2002."

There has been extensive research into the many causes of waste, their contributions to waste generation, and the percentages of garbage generated from various materials.

This chapter highlights the work of several authors from different countries in various domains relating to construction waste.

2.2 Construction industry of Pakistan

The construction industry is in charge of creating the basic physical structures that humans require to live and survive. In emerging countries, increased development efforts have resulted in tremendous waste generation. It has grown in importance as a result of poor site management, and it has a variety of negative consequences for society and the environment. This underutilized waste material has a big environmental impact and will cost a lot of money to recycle, reuse, and dispose of. Pakistan, like other developing countries, spends a significant portion of its GDP on waste management in the building industry. Construction and demolition debris account for up to 30% of total solid waste created in Pakistan. Given that Pakistan creates "48.5 million tons of solid trash per year, which is growing at a pace of 2% per year", construction waste is estimated to be over 14 million tons per year (ITA, 2019). In Pakistan almost 7% of the workers are concerned with the construction industry as per the economic survey of Pakistan 2018-19 and construction industry contribute 5.8% to GDP. The sector employs 7.61% of the employed Pakistani labor force.

2.3 Definition of waste

Waste has defined in several ways. (Rajendran and Pathrose, 2012), defines the waste as "any loss resulted by construction activities that cause direct and indirect costs but does not add any value to the product from the customer's point of view." Similarly, (Formoso et al., 2002), define the construction waste as "the weight of products and materials generating from construction processes."

2.4 Construction Waste

Construction waste is material that is thrown away during the construction process and is often described as the difference between what is ordered and what is actually used on the job. Construction waste is a mixture of surplus materials such as bricks or blocks, concrete or crushed stones, sand, cement, wood, metals, and other items generated during the construction process.

Construction is thought to be a critical activity for infrastructure and economic development. In terms of the environment, though, it is unpleasant. During construction activities, a significant amount of waste is generated, up to 30%. Because this trash is not effectively managed in developing nations, it has a severe impact on the ecosystem and ecology, as well as causing serious environmental disturbance and pollution on a local and global scale.

All the non-value adding activities increasing the time and cost of the project are also included in construction waste.

2.5 Types of Construction Waste

Construction is accountable for a wide range of wastes. According to a study, building waste is divided into three categories: material, labor, and machinery waste. Cutting waste, application waste, transit trash, and theft and vandalism are all types of construction material waste. Construction, demolition, civil work, and renovation work waste are all types of waste.

2.6 Resources and Reasons of Construction Waste

Poor or multiple handling, inadequate storage and protection, over-ordering of goods, poor site control, lack of training, faulty stock control, and damage to items during delivery have all been documented as causes of waste production on construction sites. The largest contributor to construction waste generation is the oversupply of building materials. Furthermore, bad design, poor material handling, a lack of planning, unsuitable procurement, mismanagement, and other procedures are all reasons and sources of waste.

Other factors that influence construction waste generation include labor attitude and behavior, material management and design coordination, region, structural and functional type, building above ground, height underground, total floor area and project size, construction method, building type, human error, technical problem, and material storage method.

In addition, lack of experience and poor planning, design faults and errors, frequent design changes, and insufficient monitoring and control are all factors that contribute to the development of construction waste.

External variables such as theft and vandalism, as well as important stakeholders such as vendors, developers, architects, owners, designers, and contractors, all have an impact on trash generation.

2.7 Quantity of construction waste

Because of the changing nature of building operations, the quantity and composition of construction waste cannot be precisely measured with different construction methods and practices, as well as project specialization and phases. Construction waste accounts for between 25 and 30 percent of all solid waste created globally. According to current statistics, construction, and demolition trash accounts for 10 to 30 percent of waste at numerous disposal sites across the world.

According to a study, the United States generates around 136 million tons of construction and demolition debris each year. In the Netherlands, 1-10% of the amount purchased for each building material is wasted, depending on the type of material. Every year, around 70 million tons of C&D materials and soil end up in the United Kingdom. Construction waste accounted for 16-44 percent of total solid waste created in Australia each year. Construction operations account for almost 40% of the total municipal solid waste generated in China each year.

According to a survey, the amount of building trash generated in Mumbai, India is 5.8 million tons per year. Construction and demolition debris account for up to 30% of total solid waste created in Pakistan.

2.8 Composition of construction material wastage

Papers, wood, metal, brick, material packing, concrete, drywall, roofing, organic material, plastics, cardboard, and other waste components are produced by the

building industry. Construction trash typically consists of wood, metals, concrete, drywall, roofing, brick, and other materials.

According to a survey conducted on 30 building sites, the most common trash generated is concrete (12.32 percent), metal (9.62 percent), brick (6.54 percent), plastic (0.43 percent), wood (69.10 percent), and others (2 percent).

2.9 International work done on construction waste

2.9.1 In Iraq

This article is written by "Tareq Khaleel and Ahmed al Zubaidy who belong to Building and Construction Engineering Department, University of Technology, Baghdad, Iraq".

This study shows that the results have been generated by using the data collected by distributing a questionnaire survey from 100 respondents. The outcomes of this study show that succeeding three factors are the most significant based on their respective relative importance indexes (RII):

1) Damage of material on site (RII: 0.866)
2) Double handling of materials (RII: 0.844)
3) Incompetent contractor's technical staff (RII: 0.83)

Using these results the practitioners and the policy makers would be able to make effective waste reduction policies and improve factors regarding waste management performance.

2.9.1.1 Drawbacks

In this article the author is quite narrow; he did not incorporate several other major factors that are evidently common in other article and sources. These include:

1. Wastage due to change in orders,
2. Wastage due to improper worker's skills etc.

2.9.2 In Turkey

A study in Turkey on construction wastage was done by Gul Polat and Glenn Ballard.

The key objective of this study was to identify the main wastage causes in the Turkish construction industry. This would help in developing effective methods for the preventing and eliminating causes of wastage which are repetitive in a construction process.

For this study a total of 116 forms were distributed to contractors out of which 30 were project consultants. According to the findings of this study, the following factors are the most important on the basis of their percentage of frequency in causing wastage.

1) Ordering materials that do not fulfill requirements of projects **(86%)**
2) Delay in material supply **(72%)**
3) Imperfect planning of construction **(61%)**

2.9.2.1 Limitations

The main hurdle in carrying out this survey was to maximize the response rate. It is a commonly known fact that the more a survey uses face to face interviews the lesser is a response rate. As the study was based partially on interviews so it faced the issue of less response rate.

2.9.3 In UAE

This research is done by "A. Alhaj, PhD, Heriot Watt University and K. Hamani, MSc, Heriot Watt University". It was somewhat detailed case study of 4 construction projects which also incorporated a survey of the perspective of the contractors on the respective issue. It looked at past research on waste sources and the mitigation methods that were suggested. Consequently, the author charted out a number of waste causing factors on the basis of direct as well as indirect wastage and ranked each factor separately.

2.9.3.1 Direct causes of waste

1) Deficiency of workers' awareness
2) Poor design (resulting into off-cuts)
3) Inexpert labor and rework
4) Time burden
5) Complications of material handling

2.9.3.2 Indirect causes of waste

1) Lack of Government legislation and policies
2) Lack of contractual incentives
3) Lack of local reprocessing facilities
4) Lack of support from the company administrators

2.9.3.3 Measures for Material waste minimization

This study also recommended several wastes minimization measures which are ranked as follows on the basis of their effectiveness.

1) Adequate storage of materials
2) Ordering the right amount of material
3) Awareness and training of staff
4) Measuring and keeping record of different waste streams

2.9.3.4 Conclusion

This was quite a detailed and comprehensive study on the concerned issue as it incorporated the factors from quite a broad perspective and recommended the measures to mitigate in a comprehendible and understandable manner. Moreover, the emergence of case studies with interviews made this study relatively unique from other conventional research.

2.10 National work done on construction waste

2.10.1 In Punjab Province

This article is written by "Khalid Iqbal who belongs to Department of Environmental Engineering, Institute of Environmental Sciences and Engineering (IESE), School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Islamabad, Pakistan and Muhammad Anwar Baig from Institute of Environmental Sciences and Engineering (IESE), School of Civil and Environmental Engineering (SCEE), National University of Sciences and Technology (NUST), Islamabad, Pakistan".

This study focused on analyzing mainly four types of construction waste i.e., cutting waste, transportation wastes, waste during application and waste due to theft and vandalism. A huge number of questionnaires were issued to numerous civil engineers, architects, contractors, and quantity surveyors for this purpose, with the request that they rate their judgments in percentage categories. The percentage of respondents is shown in figure 1.

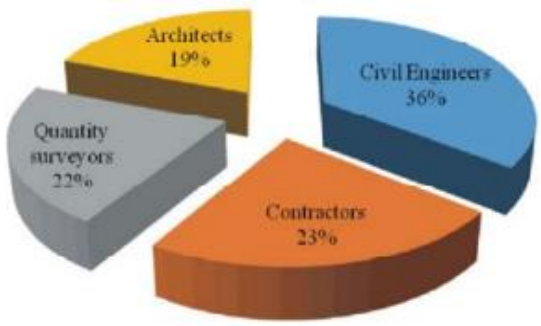


Figure 1: Percentage of respondents

This study further gave the quantitative assessment of the 4 major wastage types mentioned above. By calculating the mean wastage using the quantitative assessment of the above mentioned wastage types and their sub types, the article charts out the following ranking:

1) Theft and vandalism
2) Cutting waste
3) Transit waste
4) Applictaion waste

2.10.1.1 Drawbacks

This article focuses on the wastage of materials only and does not inculcate other important constraints like time, cost and quality.

2.10.2 General construction industry of Pakistan

2.10.2.1 Introduction

This article is written by "Husnain arshad, Muhammad qasim, Muhammad Jamal ud din thaheem and farooq gabriel all of them belong to NUST Islamabad".

The study is based on the waste diagnostic survey in which sites of 38 projects were surveyed.

This study quantifies the wastage of material and the respective causes found in different sorts of construction project.

2.10.2.2 Most wasted materials

It was revealed from the survey responds results that following are the most wasteful materials:

1) Bricks
2) Tiles
3) Plasters from mortar

Moreover, it was observed from the results of this study which factors were the most significant in causing wastage.

2.10.2.3 Most effective factors

The factors are ranked according to their significance as follows:

1) Improper workers' skill
2) Poor supervision
3) Lack of management
4) Equipment malfunction
5) Lack of waste reduction and minimization plan

2.10.2.4 Drawbacks

Like the previous national study, this one also focused only on the material wastage and didn't incorporate time, cost and quality constraints. Moreover, the span and domain of surveys is also somewhat limited and narrow.

CHAPTER-3

3 RESEARCH METHODOLOGY

3.1 Methodology Hierarchy

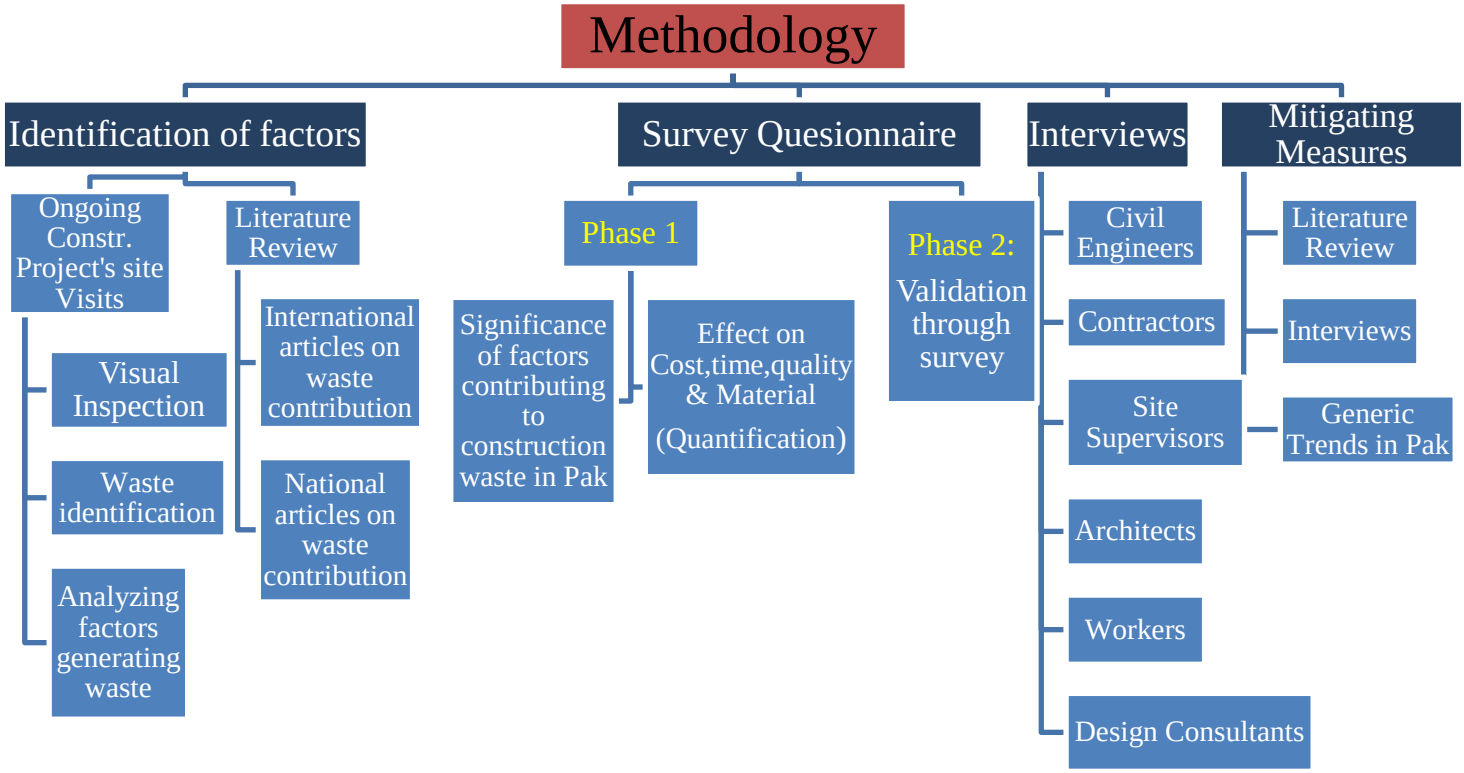


Figure 2: Flowchart showing Methodology hierarchy

3.2 Introduction

This study employs a quantitative method, with a questionnaire survey serving as the major data collection technique. Secondary data was gathered through a survey of the literature. Other methodologies adopted for determining data for quantification of factors contributing to waste generation in Pakistan includes direct observation by our syndicate members; survey via telephone, interviews; on-site analyzing waste contributing factors and data acquiring through employees of construction companies.

Data for this study was gathered via a structured questionnaire distributed to civil engineers, architects, site supervisors, contractors, and design consultants from across Pakistan. The questionnaire's numerical questions were designed to elicit information regarding the respondent's opinion, behavior, expectation, and understanding of the elements that contribute to construction waste development. A total of 200 questionnaires were provided to these individuals who were involved in various operations at various levels in various Pakistani cities. Along with their educational qualifications and work experience, respondents were asked to rate their opinions on a variety of factors in the first phase. A total of 120 copies were found to be appropriate for the study, indicating a response rate of 60%.The data collected were presented in excel sheets to the project advisor and was analyzed using graphical representations, relative importance index (RII), summation, percentage and mean representations. factors contributing to waste in the construction industry of Pakistan, according to their intensities and significance along with the effect of these factors on Cost, Time, Quality and Material. The most critical factors were finalized after the first phase by calculating the Relative

Importance Index (RII) of each factor. In the second phase the respondents were asked to score their judgments about these critical factors generating waste in construction projects in Pakistan on percentage of five construction wastage classes: 00-20%, 21-40%, 41-60%, 61-80%, and 81-100% for its overall quantification.

3.3 Research Design

Following the identification of factors that contribute to waste in construction projects in Pakistan, the research was conducted in mainly two phases.

3.3.1 Identification of factors

The factors which were to be added in the survey questionnaire were finalized by visiting different ongoing construction project sites. Visual inspection of site was carried out which helped in waste identification. Finally the factors contributing to waste were analyzed and were added in the survey questionnaire draft. Secondary data was collected through literature review; both international and national articles were consulted and were thoroughly read by the syndicate members. Tables were presented to the project advisor which included the factors mentioned by respective authors and its ranking was done by the syndicate members; attached in the appendixes. A final table; table 1 was presented which showed the most common factors recognized internationally and in Pakistan, separately. The factors added in the final survey questionnaire were finalized by the project advisor.

Legends:

(Red: internationally recognized factors)

(Green: Common factors in Pakistan)

(Black: Other factors)

Sr #	Factor
1.	Improper worker's skills
2.	Poor supervision/Lack of management
3.	Equipment malfunction/ poor quality equipment
4.	Lack of waste reduction/management plan
5.	Error in contract document /poor document
6.	Changes in design / client changes
7.	Damage of material on site/poor quality material
8.	Inadequate storage / Inventory away from site
9.	Wrong handling of material & equipment
10.	Over ordering of material/mistake in quantity surveying
11.	Material delivery schedule /delay in material supply
12.	Delay in cashflow/ regular payments
13.	Lack of training/ awareness
14.	Rework due to workers mistake
15.	Theft and vandalism
16.	Non availability of equipment
17.	Weather contingency
18.	Complicated design
19.	Long project duration ->change in material price
20.	Poor product knowledge
21.	Poor coordination & communication btw senior mngt and workers
22.	Lack of incentives

Table 1: Identified factors

3.3.2 First Phase

In the first phase the survey questionnaire was made on google forms as well as hard copies were distributed among civil engineers, architects, site supervisors, contractors and design consultants, hailing from various cities of Pakistan. The questionnaire's numerical questions were designed to elicit information regarding factors leading to waste in construction projects in Pakistan based on the respondent's knowledge and expertise in the sector. A total of 140 questionnaires were provided to these individuals who were involved in various operations at various levels in various Pakistani cities. A total of 90 copies were discovered to be eligible for examination; 65 responses on google forms and 25 responses after interviews and distribution on the field; which depicts the response rate of almost 65%. The data collected were presented in excel sheets to the project advisor and was analyzed using graphical representations, relative importance index (RII), summation, percentage and mean representations. In the first phase, the respondents were primarily asked to score their judgments about various factors contributing to waste in the Pakistani construction industry, according to their intensities and significance, as well as the effect of these factors on Cost, Time, Quality, and Material for quantification. The most critical factors were finalized after the first phase by computing each factor's Relative Importance Index (RII) RII is given by:

Formula of Relative Important Index (RII)

$$RII = \frac{\sum W}{(A \times N)}$$

Where :

W = Weightage given by the respondent to each factor

A = Highest Weightage

N = Total number of respondent

Relative Importance Index (RII) = $\frac{(5n5+4n4+3n3+2n2+1n1)}{5n}$

In our situation, weights run from 1 to 5, with 1 being the least significant (very low) and 5 being the most significant (very High). A stand for the highest weight (in this case, 5), and N stands for the total number of responders.

3.3.3 Effect of factors on Cost, Time, Quality and Material

Other part of the first phase was the general quantification of the factors on Cost, Time, Quality and Material solely based upon the experience and knowledge of the respondents. The average number of years respondents had worked in the field was about five. As a result, it is possible to conclude that the respondents were suitable and had gained sufficient relevant experience in the building business. As a result, the information provided by these respondents was deemed trustworthy and credible based on this analysis.

3.3.4 Second Phase

In the second phase the survey questionnaire was made on google forms and was only distributed among subject matter experts with a minimum qualification of bachelors and a minimum experience of 5 years in the construction field. After the first phase, the respondents were asked to evaluate their opinions on the top 10 factors, which were then finalized by computing the Relative Importance Index (RII) for each component; generating waste in construction projects in Pakistan on percentage of five construction wastage classes: 00-20%, 21-40%, 41-60%, 61-80%, and 81-100% for its overall quantification and validation of results of phase 1. The Center for Strategy Research suggests a minimum sample size of 30 respondents or more for a questionnaire survey to accurately estimate reality. A total of 60 questionnaires were issued to subject matter experts, and 30 responses were received, indicating a response rate of 50%. The data collected were presented to the project advisor and was analyzed using graphical representations; shown in the further chapters. The questionnaire used in the second phase is also attached in the appendix. The formula used for analysis was

$$\text{Mean} = \frac{(1n1+3n2+5n3+7n4+9n5)}{5}$$

Where:

N = number of respondents

3.4 Interviews of Construction Professionals

Interviews were also conducted throughout the research to know the trends in the construction industry of Pakistan. Following population was covered in this phase of the research:

- Civil Engineers
- Contractors
- Site Supervisors
- Architects
- Design Consultants
- Workers

Professionals with degrees in modern fields of civil engineering such as Green and Energy Efficient Buildings helped a lot in formulating methodologies to counter and minimize the waste generation in construction projects in Pakistan.

3.5 Construction process improvement methodology

Traditional problem-solving methodology was modified into a universal approach for performance improvement. The goal of general issue solving is to rectify a situation where what is happening is less than what is required. The methodology is typically used to analyze and enhance a current construction project. A flow diagram of the methodology's main steps is shown in Figure 3. The methodology

comprises numerous loops, as illustrated in the diagram, to correct problems that may develop during the improvement process owing to the unique characteristics of the scenario (management style, labor characteristics, performance requirements, etc.). The methodology includes various lessons learnt after repeated use, which provide an essential source of information for future improvement methods. This is an essential feature.

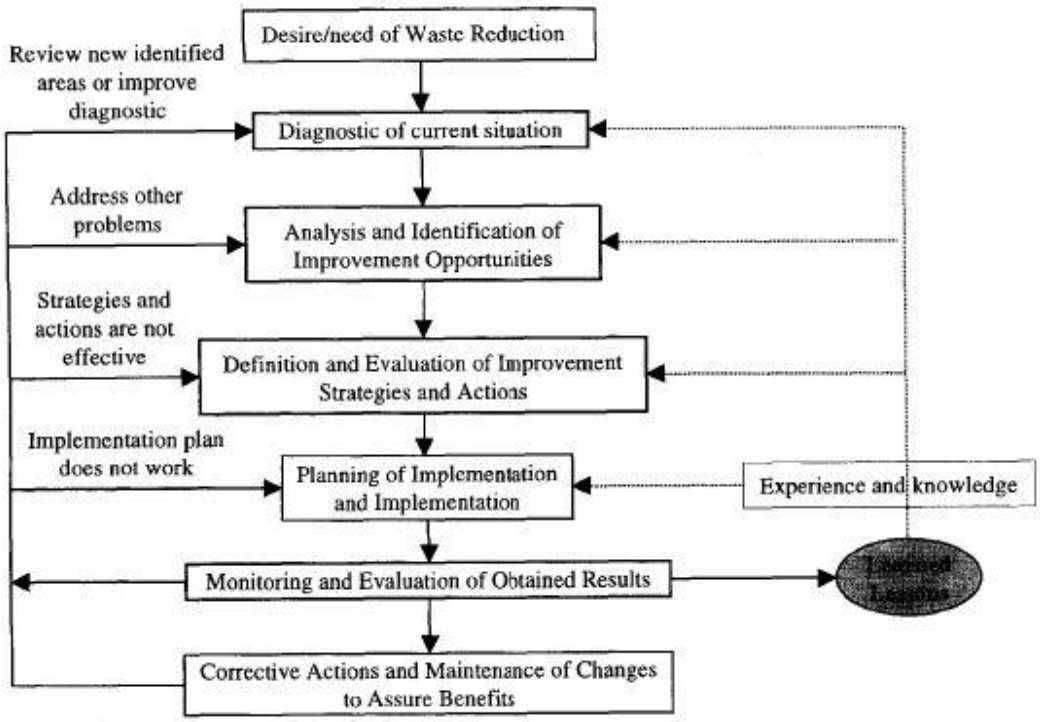


Figure 3: Flowchart of construction process improvement methodology

(Alfredo Serpell and Luis Fernando Alarcon)*

CHAPTER-4

4 SURVEY DEMOGRAPHY AND RESULTS

4.1 Questionnaire design

Two structured questionnaires: the first questionnaire's questions were numerical and were designed to elicit information based on the respondent's knowledge and experience in the construction field. The respondents were primarily asked to rate the intensity and significance of several factors contributing to waste in the Pakistani construction sector, as well as the impact of these factors on Cost, Time, Quality, and Material, in order to quantify it. The questionnaire used a 5-point Likert scale, with 1 representing "very low," 2 representing "low," 3 representing "medium," 4 representing "high," and 5 representing "extremely high." Respondents were asked to evaluate their opinions on the top ten factors in the second questionnaire, which was then concluded by computing the Relative Importance Index (RII) for each factor after the completion of first phase; generating waste in construction projects in Pakistan on percentage of five construction wastage classes: 00-20%, 21-40%, 41-60%, 61-80%, and 81-100% for its overall quantification.

4.2 Questionnaire Survey Conduct

Questionnaire surveys are conducted to gather information about any particular issue, project or simply any phenomenon. Basic aim is to collect information from as many related individuals as possible through simple to understand questions. Individuals selected for questionnaire should essentially be related to the topic under the research so that relevant information can be gathered.

4.3 Questionnaire Development and Planning

Questionnaire development process included exploration of key factors to be covered by the questionnaire. The factors to be included in the survey were discussed with project advisor. Several things were kept in mind while formulating the questionnaire such as the structure was kept as general as possible and yet keeping an easy to answer format. The questionnaire was to be filled by a very specific population which included individuals who were directly related to the construction industry of Pakistan. These included individuals from MES, FWO, NLC and many private construction companies in Pakistan.

4.4 Survey Reporting and Results

After the conduction of survey and collection of data, reporting process is done in which data received is analyzed and it is converted into an easy to understand format. From this Survey reports result is formulated which are inferred from the outcome of report.

4.5 Survey Conducted for first phase

We conducted a survey by first formulating a questionnaire finalized by the project advisor and then asking concerned individuals to answer it. Our main target individuals were those who were directly related to the construction industry of Pakistan, which were the civil engineers, architects, site supervisors, contractors and design consultants. Figure 4 shows the survey cycle adopted for both the phases.

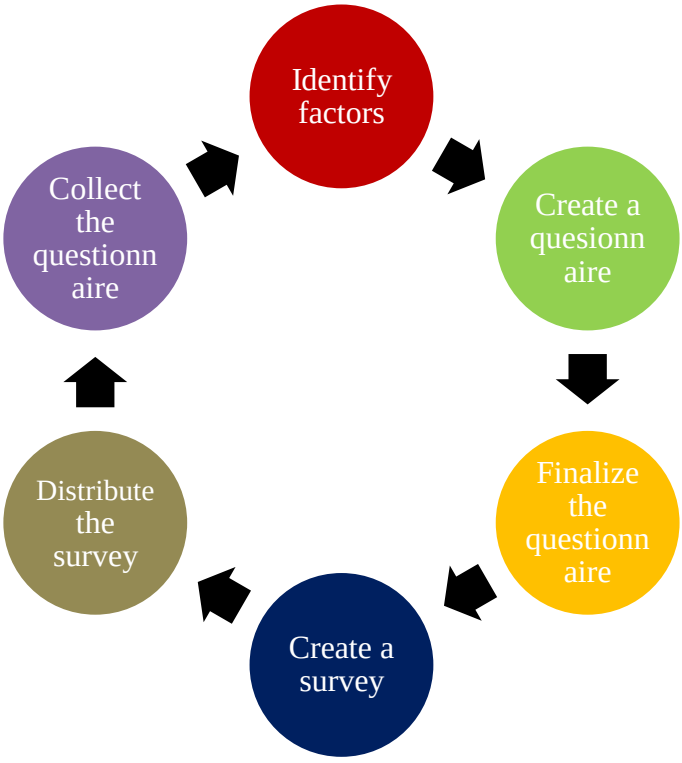


Figure 4: Survey cycle

4.6 Survey Conducted for second phase

In the second phase the survey was conducted by making a questionnaire on google forms and was only distributed among people related to construction industry with a minimum qualification of bachelors and a minimum experience of 5 years in the construction field.

4.7 Survey Population

The survey questionnaire was distributed among the following construction companies/ firms of Pakistan:

1. Frontier Works Organization (FWO)
2. National Logistic Cell (NLC)
3. Military Engineer Services (MES)
4. Comrades Planning & Design Consultants (Pvt) Ltd
5. Ideal Building Designer (Pvt) Ltd
6. Mariam Sher Associates (Pvt) Ltd
7. Tahir Builders (Pvt) Ltd
8. Pyramid Design consultants (Pvt) Ltd
9. Taameer Associates (Pvt) Ltd
10. ECON GRUNE INGENIEURE (Pvt) Ltd
11. HIM Enterprises (Pvt) Ltd
12. M&H Constructions (Pvt) Ltd

Other than these firms, the questionnaire was also distributed among private and government contractors.

4.8 Survey Results

After the conduction of survey, the results were collected and analyzed. There were mainly 2 phases in which results were divided; in the first phase the results gave us the significance of different factors promoting waste in Pakistani construction projects. The results of questionnaire are shown in the form of bar graph here with values depicting significance of each factor from 65 respondents. In the second phase the results give the quantification of the most critical factors that are contributing most to the generation of construction waste in Pakistan.

4.8.1 Results of first phase

Results are shown in the form of four graphs here in figure 5-8. These results show different intensities marked by respondents in the survey questionnaire. Factors are marked on x-axis, whereas number of respondents are shown on y-axis.

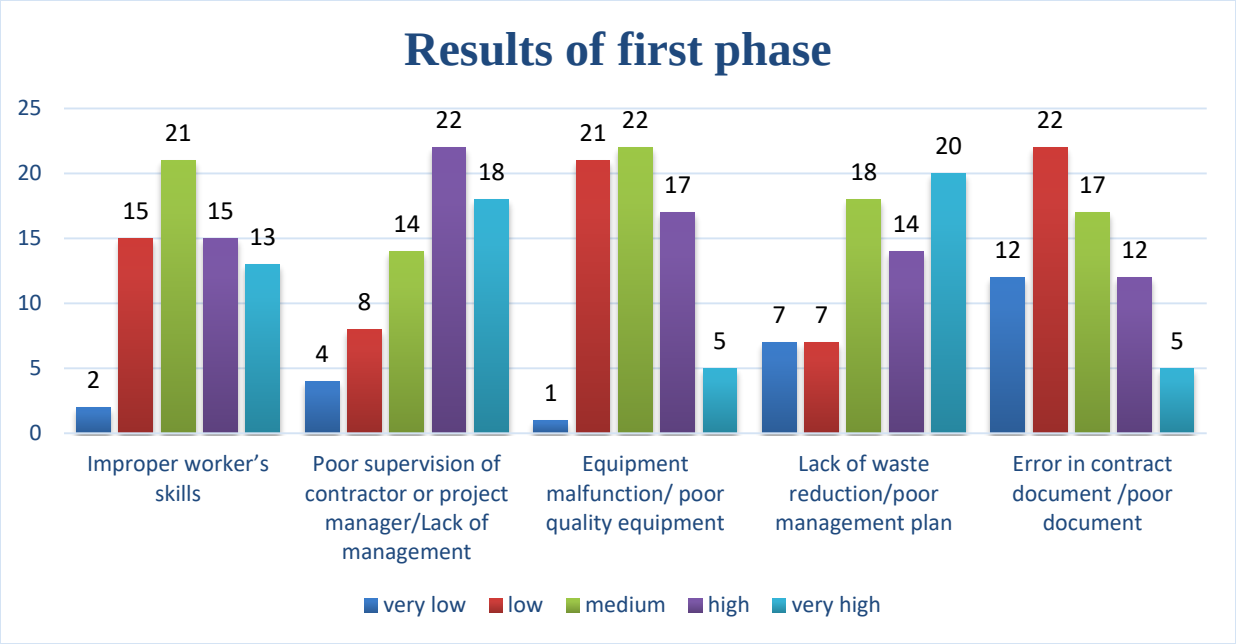


Figure 5: Results of Phase 1

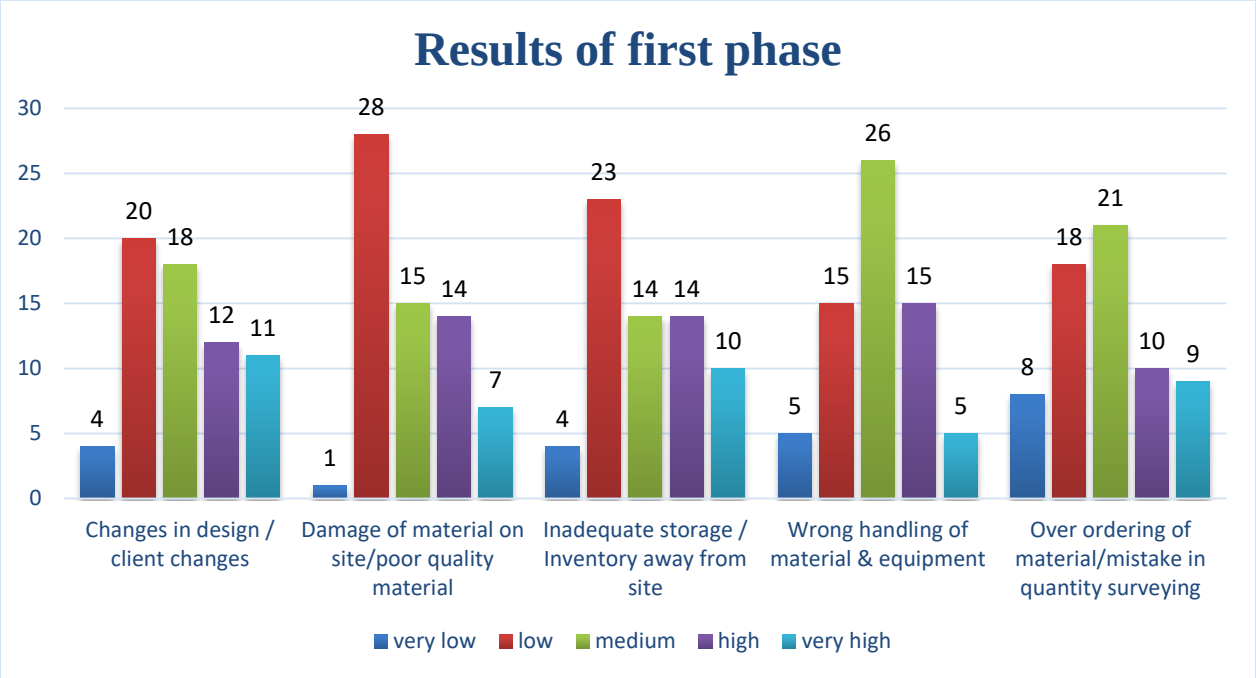


Figure 6: Results of Phase 1

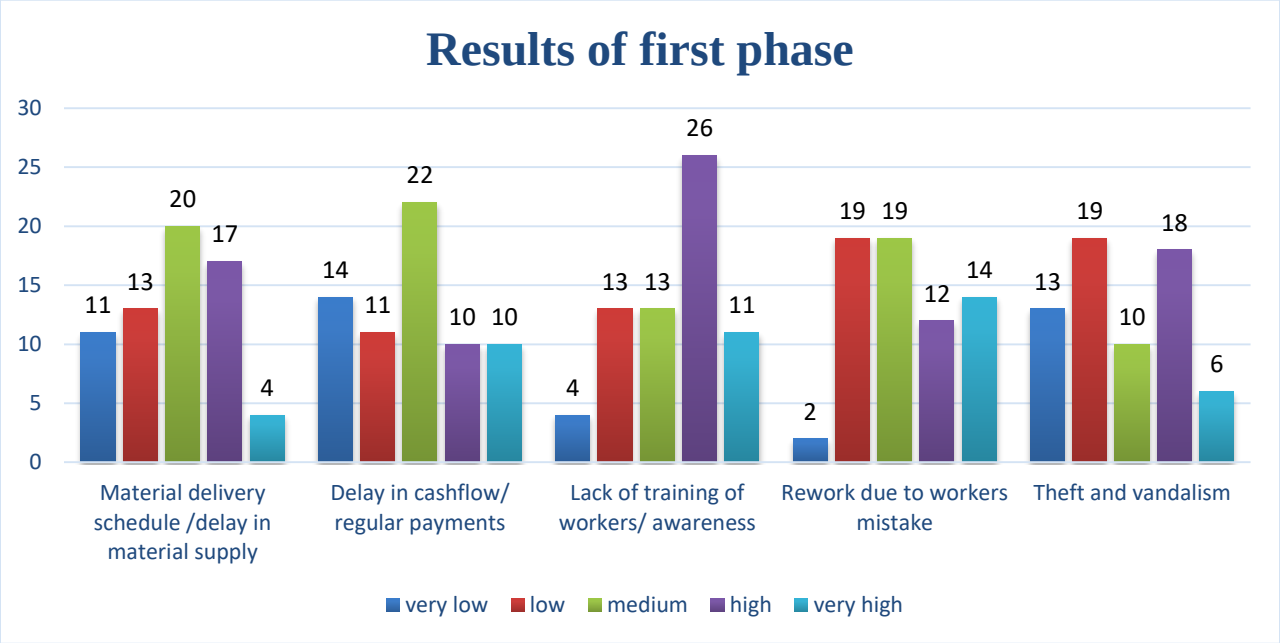


Figure 7: Results of Phase 1

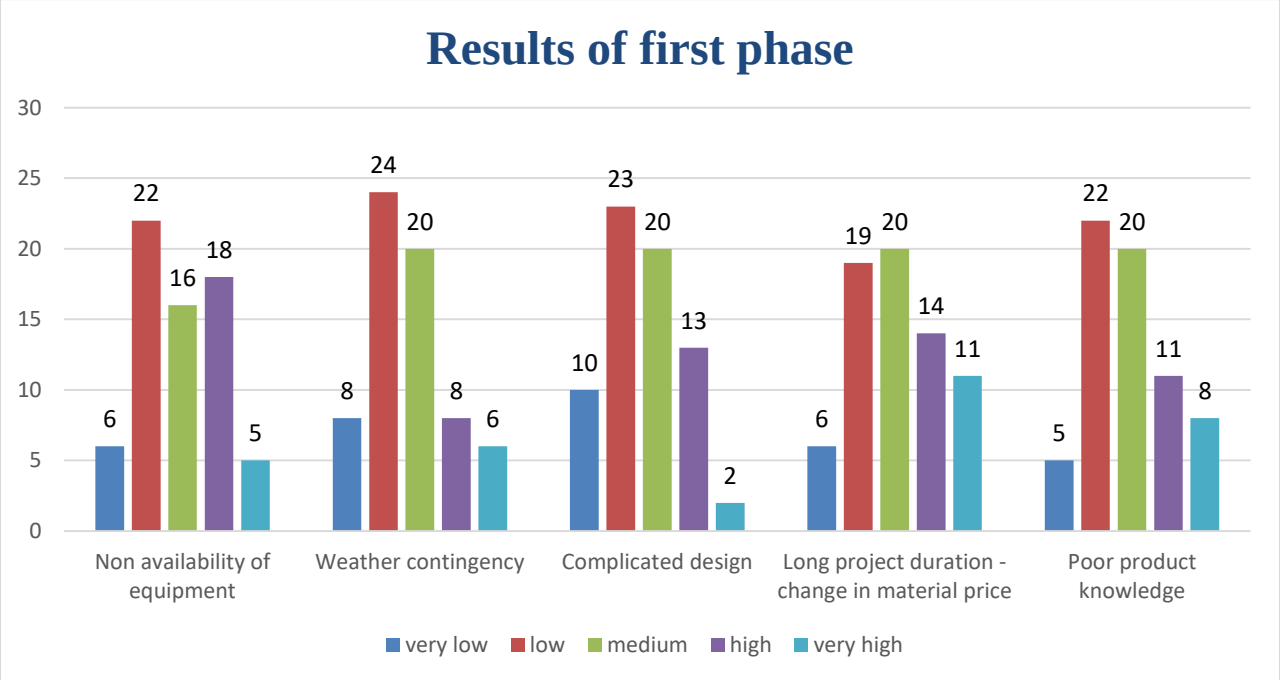


Figure 8: Results of Phase 1

4.8.2 Results of second phase

Results are shown in the form of two graphs here in figure 9-10.

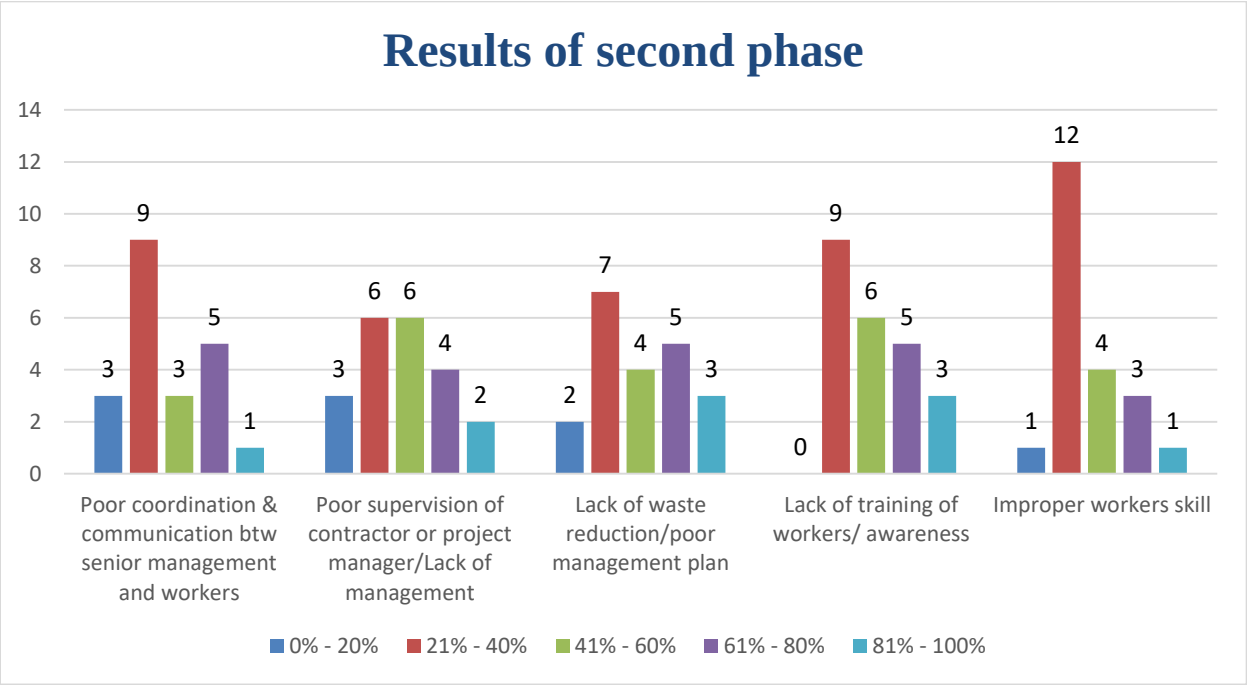


Figure 9: Results of Phase 2

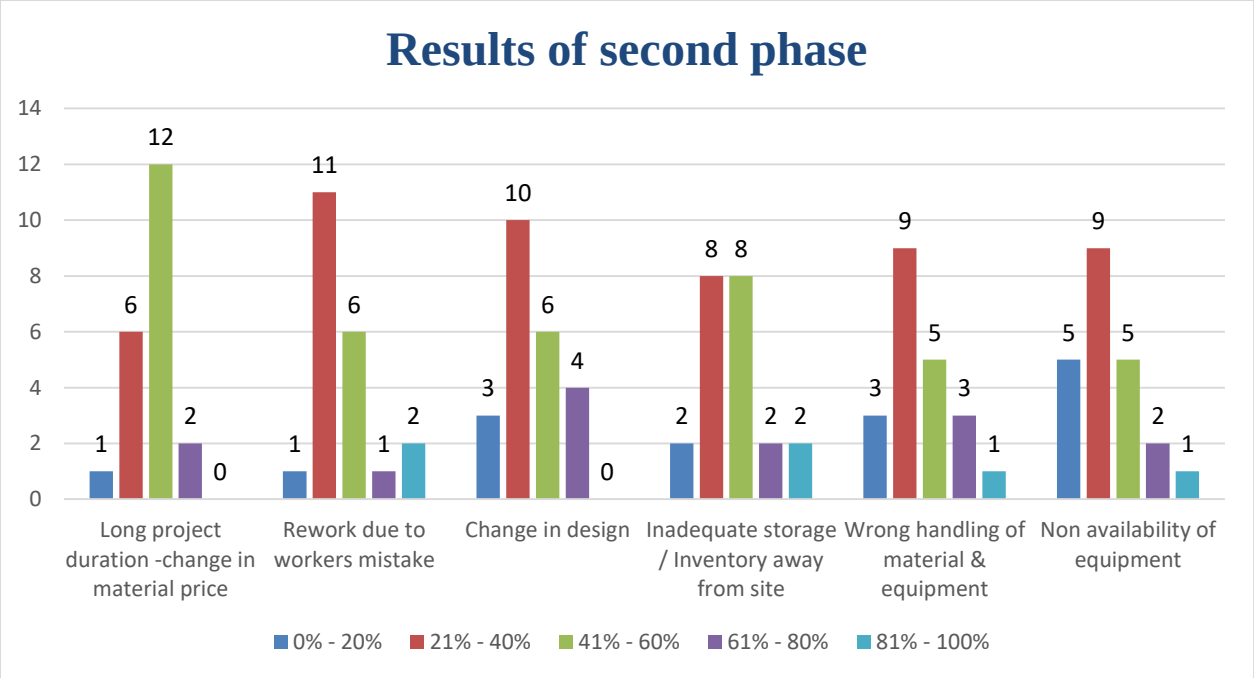


Figure 10: Results of Phase 2

CHAPTER-5

5 ANALYSIS AND DISCUSSION

5.1 General

In this chapter all the results are analyzed using different formulas and then discussed based on the inference from results. It also includes the comparison of different analysis made from the results. Other than this all the important aspects of the study are analyzed and discussed in the headings below using different techniques and methodologies.

5.2 Inference from Results

After analyzing the data obtained and formulating the result we worked upon inferring the the outcome from the questionnaires. We sorted the result in three phases.After the first questionnaire was collected, the top ten factors based on their Realtive Importance Index (RII) value were selected for phase two. In the second phase, the effect of these factors on Cost,Time,Quality and Material was inferred in the form of mean value from the percentages given by the respondants.In the third phase, the quantification of most common factors causing waste in construction projects in Pakistan was inferred.

5.2.1 Inference from Results of first phase

Table 2 shows identified factors with RII value and its ranking according to respective RII value.

S/No.	FACTORS	RII VALUE	IMPORTANCE
1	Improper worker's skills	0.6769	5
2	Poor supervision of contractor or project manager/Lack of management	0.7292	2
3	Equipment malfunction/ poor quality equipment	0.6215	7
4	Lack of waste reduction/poor management plan	0.7107	3
5	Error in contract document /poor document	0.5538	16
6	Changes in design / client changes	0.6184	8
7	Damage of material on site/poor quality material	0.5938	12
8	Inadequate storage / Inventory away from site	0.6092	9
9	Wrong handling of material & equipment	0.6092	9
10	Over ordering of material/mistake in quantity surveying	0.5907	13
11	Material delivery schedule /delay in material supply	0.5692	14
12	Delay in cashflow/ regular payments	0.5907	13
13	Lack of training of workers/ awareness	0.7015	4
14	Rework due to workers mistake	0.6615	6
15	Theft and vandalism	0.563	15
16	Non availability of equipment	0.6	10
17	Weather contingency	0.5476	18
18	Complicated design	0.5477	17
19	Long project duration -change in material price	0.6615	6
20	Poor product knowledge	0.5938	12
21	Lack of incentives	0.5969	11
22	Poor coordination & communication btw senior management and workers	0.8215	1

Table 2: Inference from results of phase 1

5.2.2 Inference from effect of these factors on Cost, Time, Quality & Material

This inference is based on the impact of the most critical factors contributing to construction waste on cost, time, quality and material and careful consideration is given to all aspects. Generally, the inference is not a direct process, in its place careful analysis of data and results is required. The analysis and inference were done by taking mean of answers to each factor affecting these four components.

5.2.2.1 Inference of Cost Analysis

Figure 11 shows the inference made from the cost analysis. The inference shows that long project duration- change in material price contributes most to the cost wastage, that is up to 6-7 %.

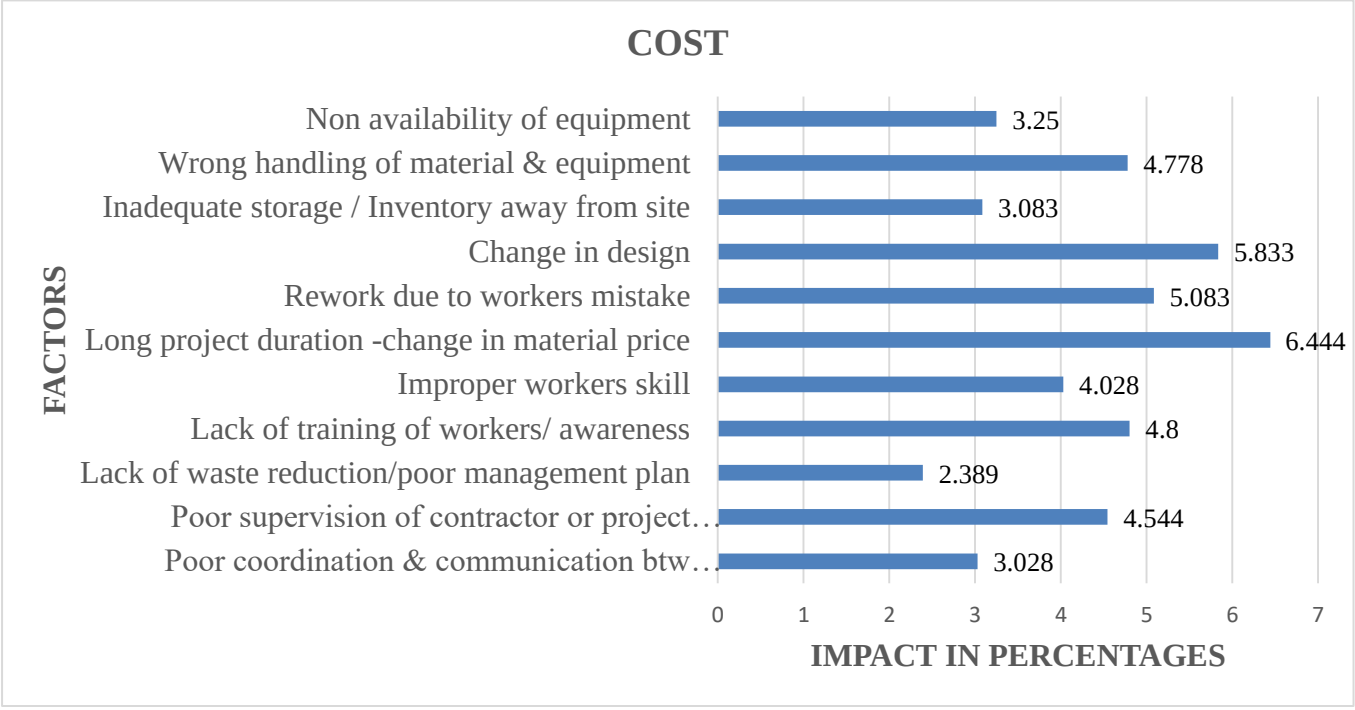


Figure 11: Inference of Cost Analysis

5.2.2.2 Inference of Time Analysis

Figure 12 shows the inference made from the time analysis. The inference shows that change in design contributes most to the time wastage, that is up to 7 %.

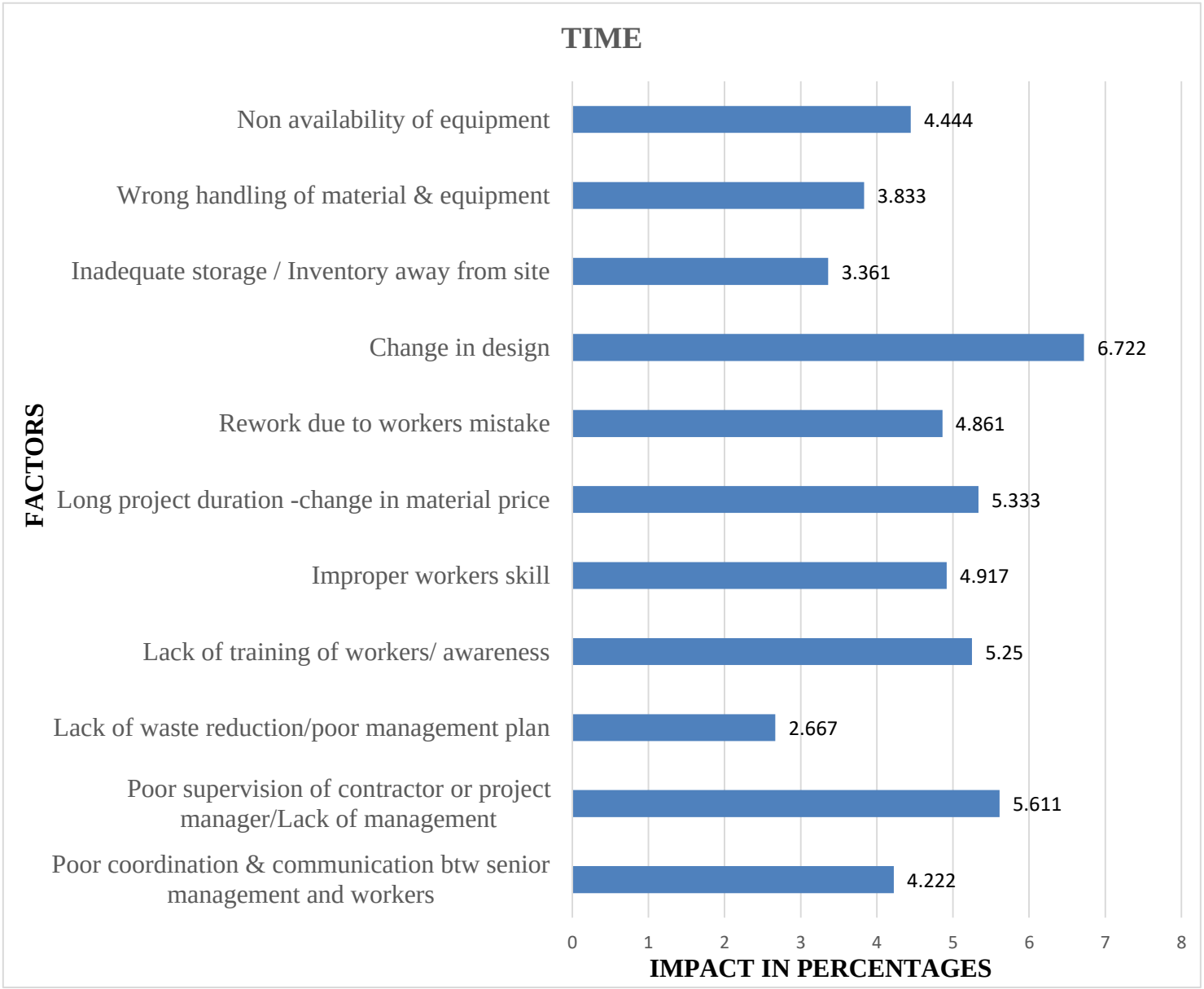


Figure 12: Inference of time analysis

5.2.2.3 Inference of Quality Analysis

Figure 13 shows the inference made from the quality analysis. The inference shows that lack of training of workers contributes most to the quality wastage, that is up to 7 %.

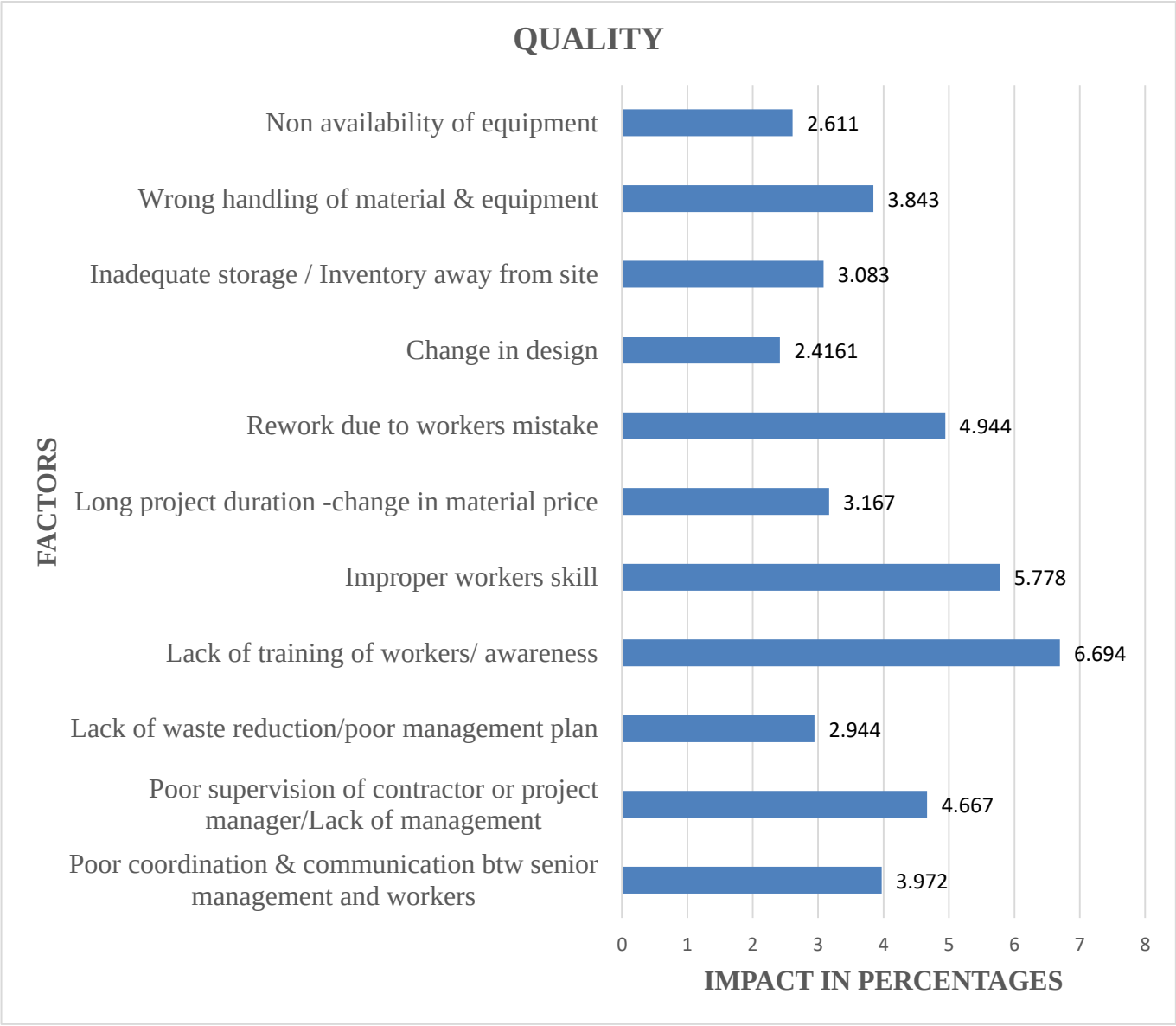


Figure 13: Inference of quality analysis

5.2.2.4 Inference of Material Analysis

Figure 14 shows the inference made from the material analysis. The inference shows that rework due to workers' mistake contributes most to the material wastage, that is up to 5 %.

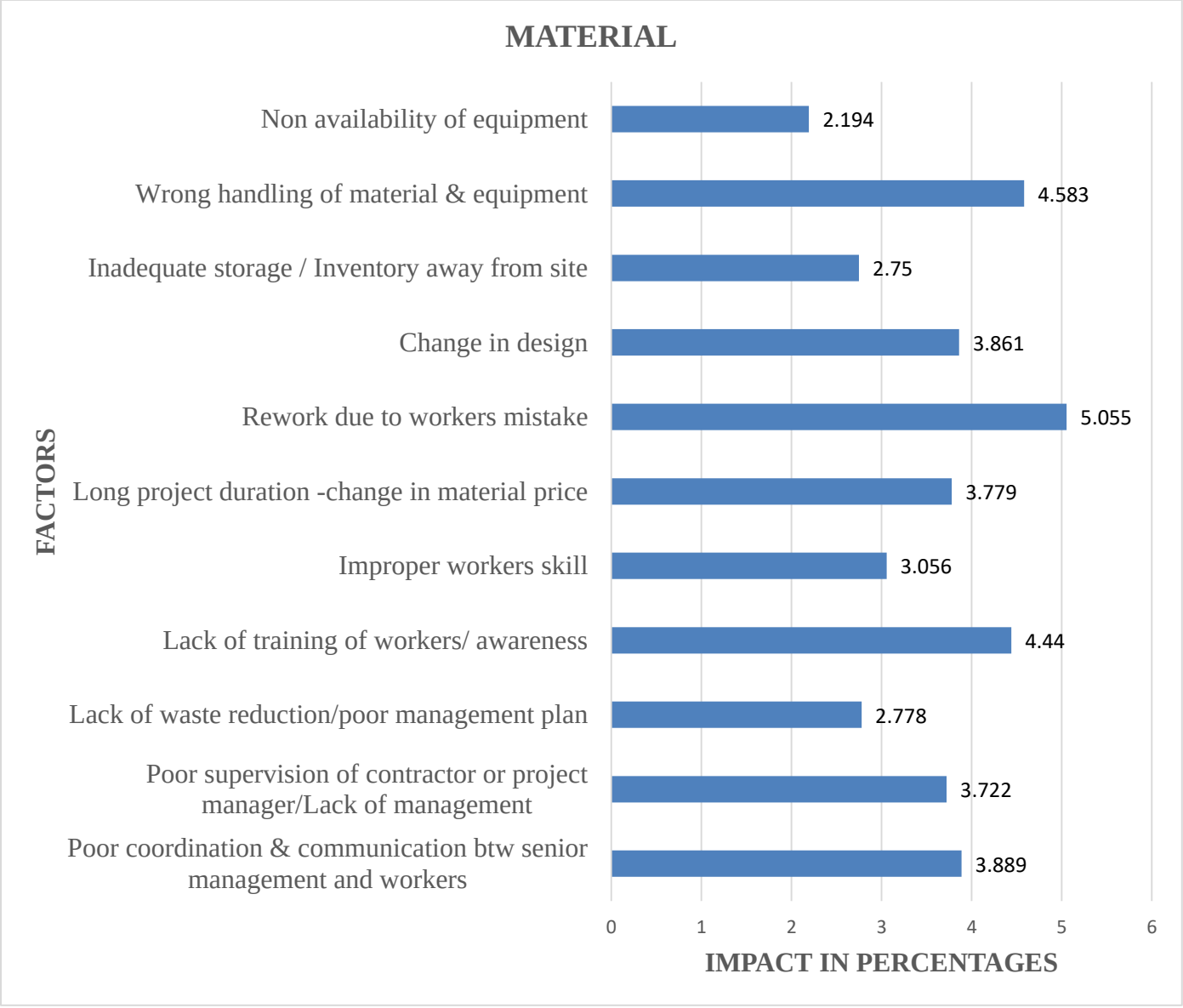


Figure 14: Inference of material analysis

5.2.3 Inference from Results of second phase

Inference was made from the results of second phase by using mean/average formula given in Chap 3. Figure 15 shows the overall quantification of the most critical factors, it is further explained in the paragraphs below. Whereas figure 16 shows the RII values of the most critical factors based on the responses obtained from the subject matter experts.

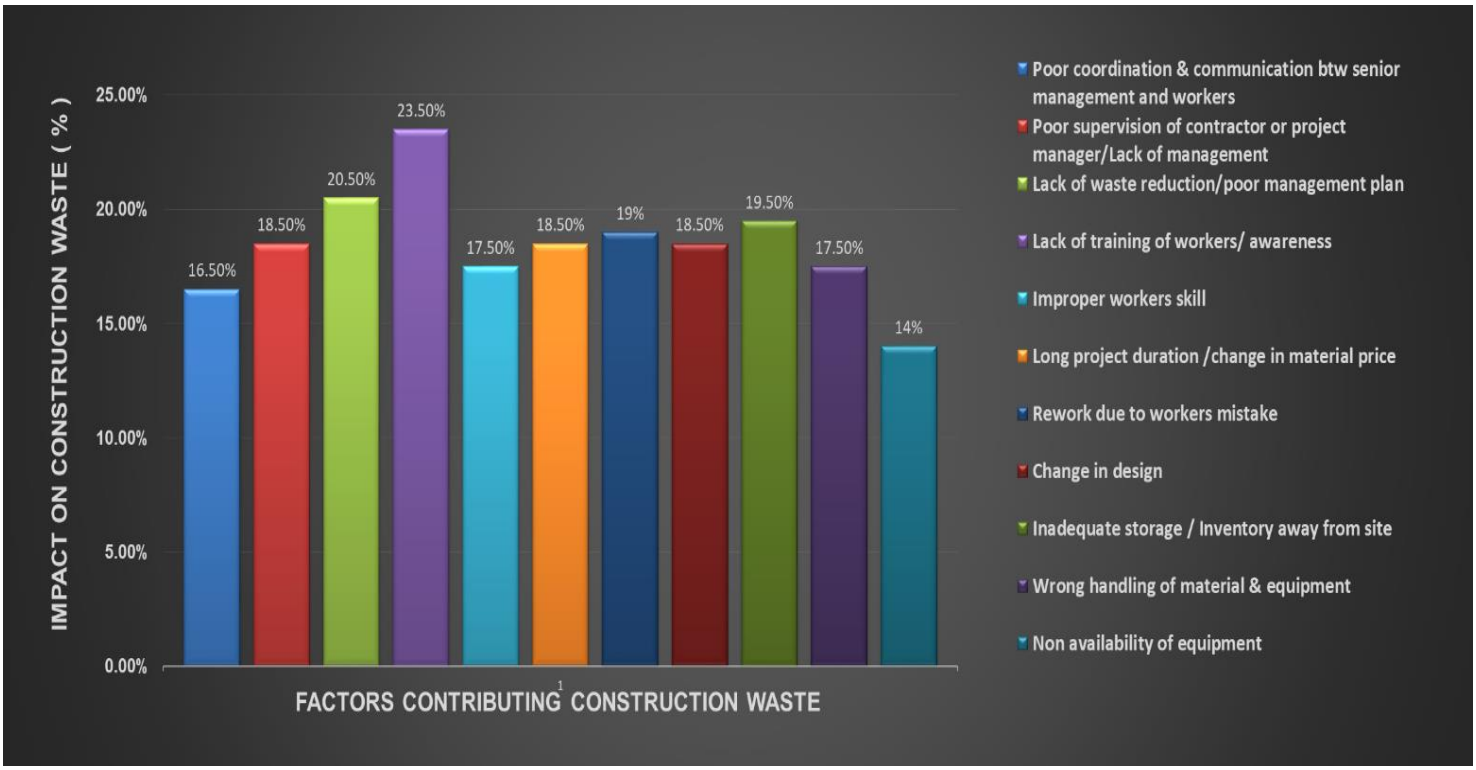


Figure 15: Inference from results of phase 2

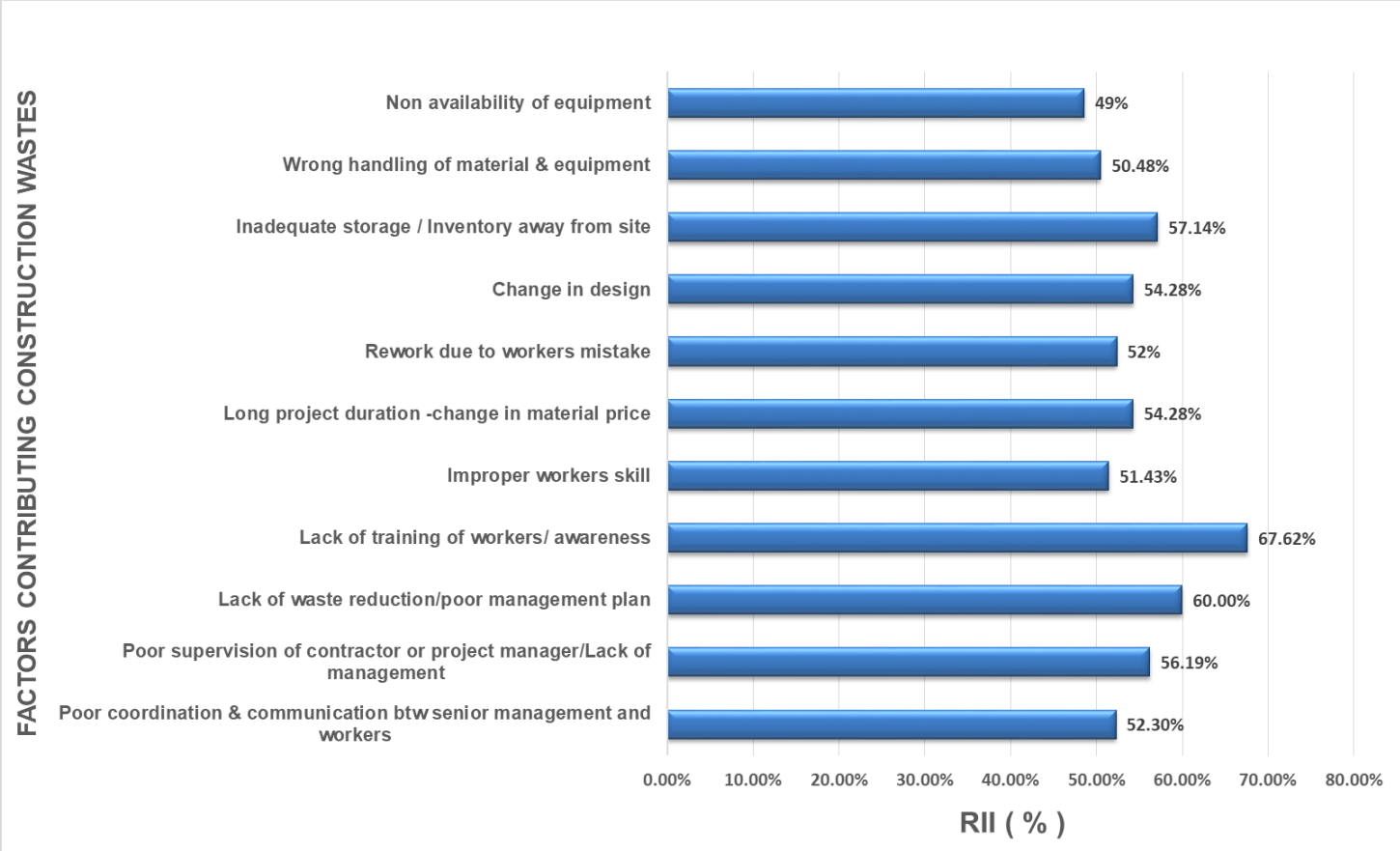


Figure 16: RII values of most critical factors obtained from experts

5.2.3.1 Poor coordination & communication between senior management and workers

The results from the survey show that poor coordination and communication between senior management and workers contributes to construction wastage up to 16-17 %. Based on the RII percentages; of the most critical factors contributing to waste, calculated by the responses of subject matter experts, this factor is ranked number 6.

5.2.3.2 Poor supervision of contractor or project manager/Lack of management

The results from the survey show that poor supervision of contractors or project manager due to the lack of management contributes to construction wastage up to 18-19 %. Based on the RII percentages, this factor is ranked number 4.

5.2.3.3 Lack of waste reduction/poor management plan

The results from the survey show that the lack of waste reduction and management plan contributes to construction wastage up to 20-21 %. Based on the RII percentages, this factor is ranked number 2. But there is a contradiction between the results of phase 1 and phase 2 for this factor. The results of phase 1 show that this factor only contributes to the wastage up to 10-11 %. It is further explained in the recommendation portion.

5.2.3.4 Lack of training of workers/ awareness

The results from the survey show that the lack of training/awareness of workers contributes to construction wastage up to 23-24 %. Based on the RII percentages; of the most critical factors contributing to waste, calculated by the responses of subject matter experts, this factor is ranked number 1. This shows that this factor is the major contributor to the construction waste.

5.2.3.5 Improper worker's skills

The results from the survey show that improper worker's skills contribute to construction wastage up to 17-18 %. Based on the RII percentages, this factor is ranked number 7.

5.2.3.6 Long project duration -change in material price

The results from the survey show that improper worker's skills contribute to construction wastage up to 18-19 %. Based on the RII percentages, this factor is ranked number 5.

5.2.3.7 Rework due to worker's mistake

The results from the survey show that rework due to worker's mistake contribute to construction wastage up to 18-20 %. Based on the RII percentages; of the most critical factors contributing to waste, calculated by the responses of subject matter experts, this factor is ranked number 6.

5.2.3.8 Changes in design / client changes

The results from the survey show that changes in design by the client contribute to construction wastage up to 18-19 %. Based on the RII percentages, this factor is ranked number 5.

5.2.3.9 Inadequate storage / Inventory away from site

The results from the survey show that the inadequate storage problem contributes to construction wastage up to 18-19 %. Based on the RII percentages, this factor is ranked number 3.

5.2.3.10 Wrong handling of material & equipment

The results from the survey show that wrong handling of material and equipment contributes to construction wastage up to 17-18 %. Based on the RII percentages; of the most critical factors contributing to waste, calculated by the responses of subject matter experts, this factor is ranked number 8.

5.2.3.11 Non availability of equipment

The results from the survey show that non availability of equipment contributes to construction wastage up to 13-15 %. Based on the RII percentages, this factor is ranked number 9.

5.3 Comparison of results of phase 1 and phase 2

Figure 17 shows comparison of results of both the surveys. It can be clearly seen that the results for all the factors are compatible expect the third factor i.e., lack of waste reduction and management plan. It is further discussed in the last chapter. So, we can conclude that the quantification obtained is reliable.

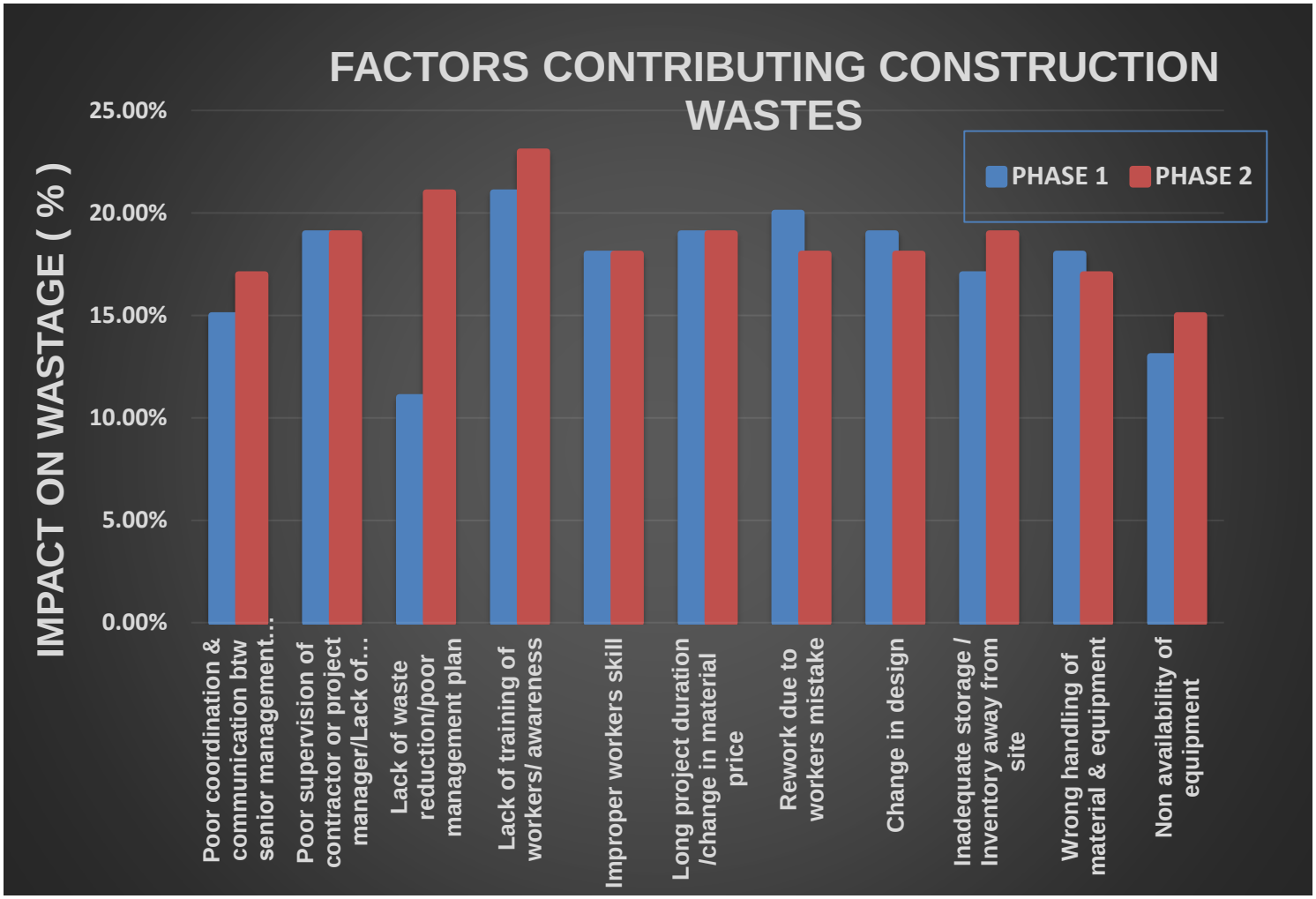


Figure 17: Validation of Results

5.4 Respondent's profile

5.4.1 Percentage of respondents in the survey

Figure 18 shows percentage of different respondents in our survey. Almost 50 % of our respondents were civil engineers and the highest percentage of respondents are of contracts i.e., 36%.

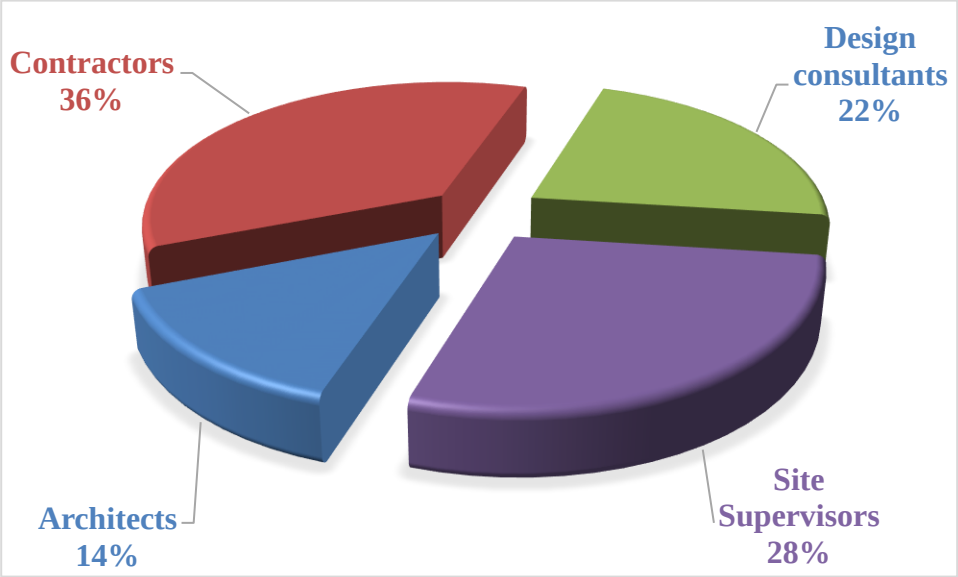


Figure 18: Percentage of Respondents

5.4.2 Educational qualification of Respondents

Figure 19 shows percentage of qualification of different respondents. More than 50 % of our respondents were having bachelor's degree and almost 22 % of the respondents were having master's degree.

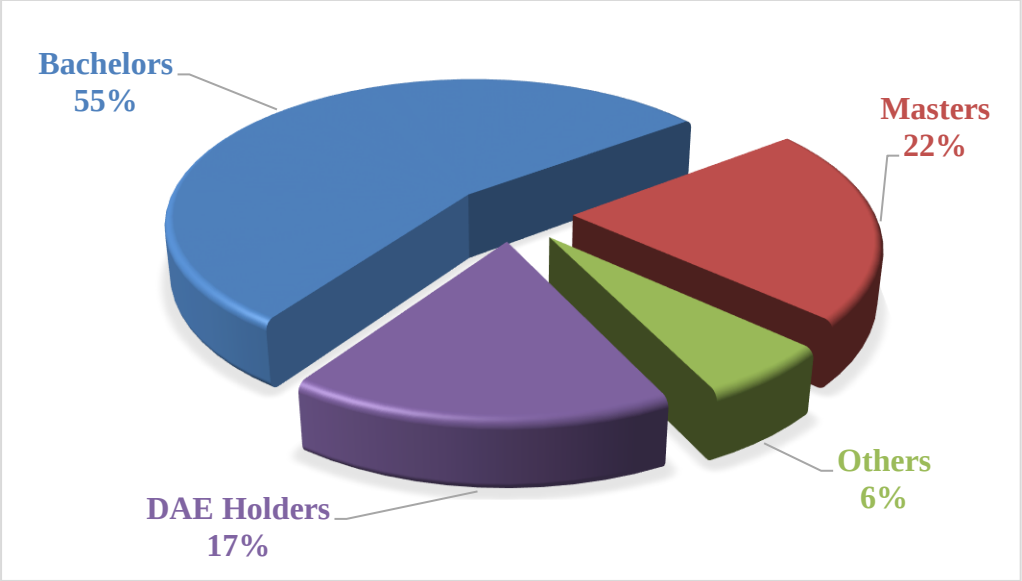


Figure 19: Qualification of Respondents

5.4.3 Experience of Respondents

Figure 20 shows percentage of experience of our respondents. 30% of our respondents were having experience between 1-5 years and almost 18% were having experience of more than 30 years.

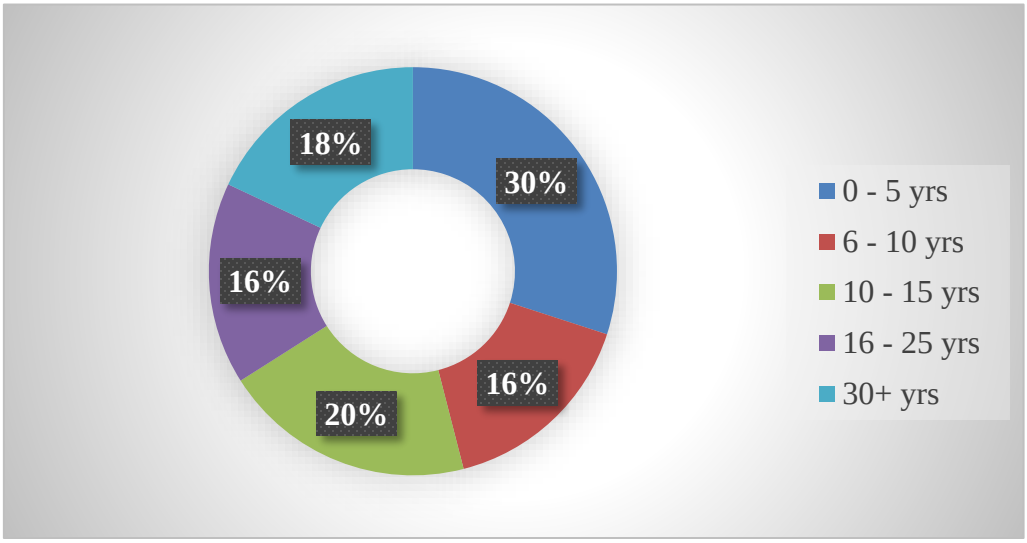


Figure 20: Experience of Respondents

CHAPTER-6

6 MITIGATING MEASURES TO REDUCE WASTE

6.1 Background

After determining the most vital factors contributing to waste in construction industry of Pakistan, mitigating measures to counter these are explained in this chapter. These measures are not based on the analysis rather they are generic and are advised, based on observing general trends in the industry of Pakistan. Construction professionals were also asked to advise mitigating measures to counter these factors while conducting interviews, which are also included in this chapter.

6.2 Measures to address non availability of equipment

This issue can be mitigated by taking following measures:

- Taking correct and detailed quantity take offs
- Dealing with reliable sources of procurement
- Consider the benefit of availability while making “buy or rent” decision
- If same equipment is to be used in multiple places in a project, scheduling it accordingly from beginning and updating in the Gantt chart

6.3 Measures to mitigate wrong handling of material & equipment

This issue can be mitigated by taking following measures:

- Professional personnel on the field
- Awareness about handling of materials to the labor
- Proper system of maintenance and storage in the warehouse
- Surveillance on the workforce during handling

6.4 Measures to mitigate inventory/storage issues

This issue can be mitigated by taking following measures:

- Proper chain of command for the surveillance and maintenance at the inventories of big projects to ensure regular checks etc.
- Adequate security measures for safety
- Adequate structural and other (temperature and moisture adjustments etc. if needed), measures at the inventory

6.5 Measures to reduce change in design

This issue can be mitigated by taking following measures:

- Professional consultation at the very first phase of the project planning

- Absolute clarity and coordination between owner and architect in the planning
- Use of the latest useful software and models etc. while planning
- Ensuring all the structural and architectural requirement's fulfillment in the design phase of the project
- Ensuring compliance with the national, international, and local standards of structure, design, and all other requirements
- Regular upgradation, verification, and approval as the project proceeds
- Absolute coordination between architect and contractor, contractors, and sub- contractors

6.6 Measures to reduce rework due to worker's mistake

This issue can be mitigated by taking following measures:

- Hiring professional contractors with professional teams
- Contract teams such that everyone tries his best to avoid mistakes
- Proper and clear briefing to workers
- Constant supervision
- Incentives for the working teams

6.7 Measures to mitigate long project duration-change in material price issues

This issue can be mitigated by taking following measures:

- Compression of project schedule as much as possible

- Proper inventory must be provided where the materials are stocked periodically according to the quantity take off sheets
- Procurement must be done as quickly as possible

6.8 Measures to enhance worker's skills

Worker's skills can be enhanced by taking following measures:

- Reliable contractors with reliable team and sub-contractors
- Training and awareness of the operation of construction machinery
- Awareness about the continuously modifying construction methodologies and techniques
- Not excessively hastening the workforce; to compel the workers to work below their required quality standards (giving them enough time to practice their best skills)
- Incentives for commendable delegation and works
- Match tasks to skills
- Communicate effectively
- Keeping and defining goals clear and focused

6.9 Measures to reduce lack of training of workers/ awareness issue

This issue can be mitigated by taking following measures:

- Provision of training sessions to workers specially in large projects

- Institutes for the training of workers should be introduced
- Strict policies by the government to ensure labor rights, so that the labor force should not search for jobs in developed countries

6.10 Measures to address lack of waste reduction/poor management plan issue

This issue can be mitigated by taking following measures:

- Incorporation of waste reduction plans from the beginning of the project
- Working effectively on it and keeping track of it to ensure it is followed
- Encouraging Communication between and within the different tiers to avoid management issues
- Strict policies by the government to provide proper waste reduction plan for the project approval

6.11 Measures to enhance poor supervision of contractor or project manager

This issue can be mitigated by taking following measures:

- Effective chain of command, systematic and regular reports from supervisor/ contractor
- Assigning responsibilities to the supervisor or concerned personnel clearly to avoid the blaming of each other
- Strict policies by the senior management

6.12 Measures to mitigate poor communication & coordination between workers & senior management issue

The issue of poor communication and coordination between the workers and senior management can be mitigated by following measures:

- Direct interactive sessions with the workers by the senior management frequently
- Provide opportunities for workers to convey their grievances anytime through representatives
- Frequent site visits by the senior management team

CHAPTER-7

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

- This study concludes and enumerates the top factors contributing to wastage in construction industry of Pakistan and quantifies its impacts on the different constraints of time, cost, material, and quality and recommends some measures to mitigate them.
- The top three factors as extracted from the data collected from the construction professionals and validated by the data collected from other subject matter experts shows that the top three factors contributive to the building/ construction wastes are lack of awareness and training to workers, lack of waste reduction/poor management plan and inventory issues respectively with the second being differed in ranking by the construction professionals but more emphasized by the subject matter experts as in a progressing country like Pakistan, there is a meager planning and implementation of the waste reduction and management plans in the planning phase of the project, however the modern studies and analysis have proven to the subject matter experts its significant impact.
- The top factor, lack of training contributes 21- 24 percent to the overall wastage and can be mitigated by measures like provision of training sessions to workers specially in large projects and introduction of institutes for the training of workers.

- The second factor, lack of waste reduction plan, although differed in the two phases contributes 20-21 percent to the overall construction wastage and can be mitigated by incorporation of waste reduction plans from the beginning of the project and working effectively on it and keeping track of it to ensure it is followed.
- The third factor, inventory issues, contributes 19-20 percent, and can be mitigated by introducing proper chain of command for the surveillance and maintenance at the inventories of big projects to ensure regular checks etc. and by taking adequate security measures for safety.

7.2 Recommendations

- The study recommends that lack of waste reduction and management plan is a major contributor to wastage in construction industry of Pakistan but there is a contradiction between the results obtained from subject matter experts and construction professionals on the field. This is due to the ignorance of latest trends and modern techniques in the construction field by developing countries like Pakistan.
- Subject matter experts have analyzed the importance of this factor by following the new trends followed by developed countries.
- However further research can be done on this factor by analyzing different case studies in Pakistan.

- Furthermore, the research can also be validated by taking data from different ongoing projects in Pakistan and comparing the estimated time, cost, quality and material required for the project, before and after the project completion.
- Mitigating measures should be identified analytically for the most critical factors for waste minimization.

References

A, B., A, H. M., M, H., I, A. R., & S, J. A. (2022). Risk Level of Design and Procurement Factors Causing Construction Waste Generation. *Journal of Applied Engineering Sciences*.

A.Al-Hajj, & Hamani, K. (2011). Material Waste in the UAE construction Industry: Main Causes and Minimization Practices. *Architectural Engineering And Design Management, Vol 7, no. 4*, 221-235.

Ahsan Riaz Khan, A. D. (2021). Determinants and implications of environmental practices for waste management and the minimization in the construction industry: a case study of Pakistan. *Environmental Science and Pollution Research*.

Akhund, M. A., Memon, A. H., Memon, N. A., Ali, T. H., Khos, A. R., & Imad, H. U. (2019). EXPLORING TYPES OF WASTE GENERATED: A STUDY OF CONSTRUCTION INDUSTRY OF PAKISTAN. *journal of building performance,vol 10*.

Formoso, e. a. (2002). Material waste in building industry: main causes and prevention. *Journal of construction engineering and management 128 (4)*, 316-325.

Iqbal, K., & Baig, M. (2016). Quantitative and Qualitative Estimation of construction waste material in punjabprovince of paksitan. *American-Eurasian J. Agric. & Environ. Sci.,16(4)*, 770-779.

Khaleel, T., & Al- Zubaidy, A. (2018). Major Factors Contributing to the Construction Waste generation in Building Projects of Iraq. *MATEC Web of Conferences 162*.

Polat, G., & Ballard, G. (2004). Waste in Turkish Construction: NEED FOR LEAN CONSTRUCTION TECHNIQUES .

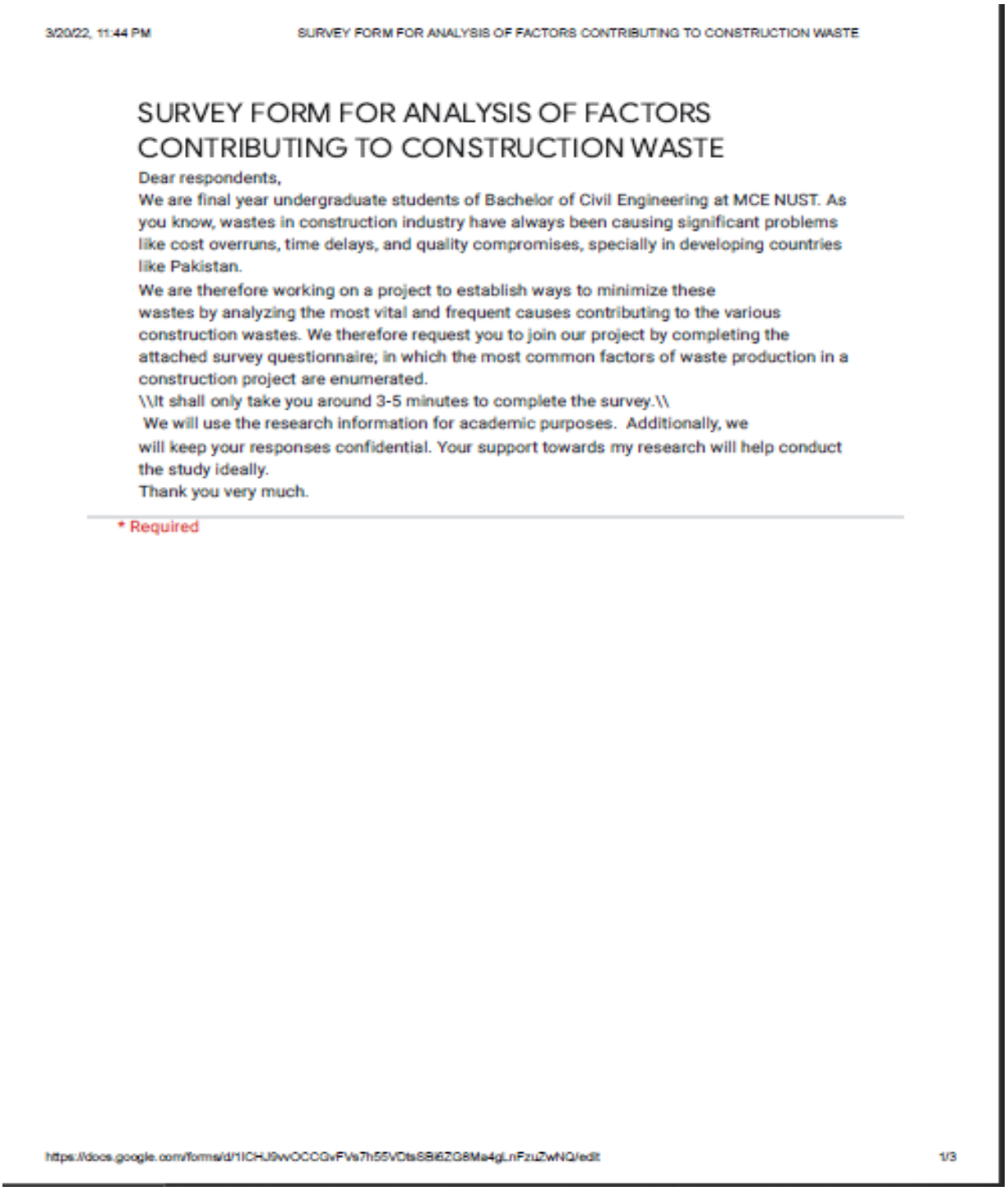
Qamar, N., & Khurram, A. A. (2017). Assessment of construction waste to identify issues that disrupt sustainable development : case studies in Sindh, Pakistan. *Recent Trends Civil Engg Technol 7 (2)*, 10-17.

Rajendran, P., & Gomez, C. P. (2012). Implementing BIM for waste minimization in the construction industry : A literature Review. *2nd internaltional conference on Management, Malaysia*, 557-570.

Serpell, A., & Alarcon, L. F. (1998). Construction process improvement methodology for construction projects. *International Journal of Project Management Vol. 16, No. 4*, 215-221.

Appendices

Appendix A – Survey Questionnaire Phase 1



3/20/22, 11:44 PM SURVEY FORM FOR ANALYSIS OF FACTORS CONTRIBUTING TO CONSTRUCTION WASTE

SURVEY FORM FOR ANALYSIS OF FACTORS CONTRIBUTING TO CONSTRUCTION WASTE

Dear respondents,

We are final year undergraduate students of Bachelor of Civil Engineering at MCE NUST. As you know, wastes in construction industry have always been causing significant problems like cost overruns, time delays, and quality compromises, specially in developing countries like Pakistan.

We are therefore working on a project to establish ways to minimize these wastes by analyzing the most vital and frequent causes contributing to the various construction wastes. We therefore request you to join our project by completing the attached survey questionnaire; in which the most common factors of waste production in a construction project are enumerated.

\\It shall only take you around 3-5 minutes to complete the survey.\\

We will use the research information for academic purposes. Additionally, we will keep your responses confidential. Your support towards my research will help conduct the study ideally.

Thank you very much.

* Required

https://docs.google.com/forms/d/1ICHJ9vvOCCGvFVa7h55VDtsSBl6ZG8Ma4gLnFzuZwNQ/edit 1/3

1. FACTORS CONTRIBUTING TO CONSTRUCTION WASTE *

Based on your knowledge and experience you are requested to put a "tick mark" in front of each of the factors ;contributing to waste in the construction industry, in the respective tabs according to their intensities and significance. ""There is space left in the end, where you can mention any other factor that is not already mentioned in the table.""

Check all that apply.

	VERY LOW	LOW	MEDIUM	HIGH	VERY HIGH
Improper worker's skills	☐	☐	☐	☐	☐
Poor supervision of contractor or project manager/Lack of management	☐	☐	☐	☐	☐
Equipment malfunction/ poor quality equipment	☐	☐	☐	☐	☐
Lack of waste reduction/poor management plan	☐	☐	☐	☐	☐
Error in contract document /poor document	☐	☐	☐	☐	☐
Changes in design / client changes	☐	☐	☐	☐	☐
Damage of material on site/poor quality material	☐	☐	☐	☐	☐
Inadequate storage / Inventory away from site	☐	☐	☐	☐	☐
Wrong handling of material & equipment	☐	☐	☐	☐	☐
Over ordering of material/mistake in quantity surveying	☐	☐	☐	☐	☐
Material delivery schedule /delay in material supply	☐	☐	☐	☐	☐
Delay in cashflow/ regular payments	☐	☐	☐	☐	☐
Lack of training of workers/ awareness	☐	☐	☐	☐	☐
Rework due to workers mistake	☐	☐	☐	☐	☐

Theft and vandalism	☐	☐	☐	☐	☐
Non availability of equipment	☐	☐	☐	☐	☐
Weather contingency	☐	☐	☐	☐	☐
Complicated design	☐	☐	☐	☐	☐
Long project duration -change in material price	☐	☐	☐	☐	☐
Poor product knowledge	☐	☐	☐	☐	☐
Lack of incentives	☐	☐	☐	☐	☐

2. ANY OTHER FACTOR THAT IS NOT MENTIONED...

3. NAME OF COMPANY/FIRM (IF ANY): *

FOR INTERVIEWS:

SURVEY FORM FOR ANALYSIS OF FACTORS CONTRIBUTING TO CONSTRUCTION WASTE

INTRODUCTION:

Dear respondents,
We are final year undergraduate students of Bachelor of Civil Engineering at MCE NUST. As you know, wastes in construction industry have always been causing significant problems like cost overruns, time delays, and quality compromises, specially in developing countries like Pakistan. We are therefore working on a project to establish ways to minimize these wastes by analyzing the most vital and frequent causes contributing to the various construction wastes. We therefore request you to join our project by completing the attached survey questionnaire; in which the most common factors of waste production in a construction project are enumerated. It shall only take you around 3 5 minutes to complete the survey. We will use the research information for academic purposes. Additionally, we will keep your responses confidential. Your support towards my research will help conduct the study ideally. Thank you very much.

RESPONDENT INFORMATION:

NAME OF COMPANY/FIRM (IF ANY): _____.

NAME OF RESPONDENT: _____.

DESIGNATION OF RESPONDENT: _____.

SIGNATURE (respondent): _____. ***DATE:*** _____.

FACTORS	% CONTRIBUTION TO WASTE			
	COST	TIME	QUALITY	MATERIAL
Poor coordination & communication btw senior management and workers				
Poor supervision of contractor or project manager/Lack of management				
Lack of waste reduction/poor management plan				
Lack of training of workers/ awareness				
Improper worker's skills				
Long project duration -change in material price				
Equipment malfunction/ poor quality equipment				
Changes in design / client changes				
Inadequate storage / Inventory away from site				
Wrong handling of material & equipment				
Non availability of equipment				

Appendix B – Survey Questionnaire Phase 2

SURVEY FORM FOR QUANTIFICATION OF FACTORS CONTRIBUTING TO CONSTRUCTION WASTE

Dear respondents,
We are final year undergraduate students of Bachelor of Civil Engineering at MCE NUST. As wastes in construction industry have always been causing significant problems like cost overruns, time delays, and quality compromises.
Therefore you are request to join our project by completing the attached survey questionnaire; in which the most common factors of waste production in a construction project are enumerated.
Thank you very much.

* Required

1. NAME OF RESPONDENT/DESIGNATION: *

2. NAME OF COMPANY/FIRM (IF ANY):

3. FACTORS CONTRIBUTING TO CONSTRUCTION WASTE *

Based on your knowledge and experience you are requested to select one of the option in front of each of the factors; contributing to waste in the construction industry, according to their intensities and significance.

Check all that apply.

	0% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%
Poor coordination & communication btw senior management and workers	☐	☐	☐	☐	☐
Poor supervision of contractor or project manager/Lack of management	☐	☐	☐	☐	☐
Lack of waste reduction/poor management plan	☐	☐	☐	☐	☐
Lack of training of workers/ awareness	☐	☐	☐	☐	☐
Improper worker's skills	☐	☐	☐	☐	☐
Long project duration -change in material price	☐	☐	☐	☐	☐
Rework due to workers mistake	☐	☐	☐	☐	☐
Changes in design / client changes	☐	☐	☐	☐	☐
Inadequate storage / Inventory away from site	☐	☐	☐	☐	☐
Wrong handling of material & equipment	☐	☐	☐	☐	☐
Non availability of equipment	☐	☐	☐	☐	☐

Appendix C – Identification of Factors

PAPER	OUTCOME/AIM	FACTORS	RANKING	AUTHOR REF	DOI
Quantification Of Material Wastage In Construction Industry Of Pakistan: An Analytical Relationship Between Building Types And Waste Generation.	To Quantify The Material Wastage And Its Causes In Different Types Of Building Projects	• Poor Supervision • Lack Of Management • Lack Of Waste Reduction Plan • Absence Of Site Waste Manager • Rework • Weather • Accidents • Improper Worker's Skill • Equipment Malfunction • Changes In Design • Error In Contract Documents	2 3 5 10 11 14 18 1 4 9 7 6	Husnain Arshad, Muhammad Qasim, Muhammad Jamaluddin Thaheem Hamza Farooq Gabriel	Https://Doi.Org/10.21315/Jcdc2017.22.2.2
Exploring Types Of Waste Generated: A Study Of Construction Industry Of Pakistan	To Investigate The Types Of Construction Waste Generated On Site And Their Relative Impact Of The Project Cost In Construction .	• Contractor • Consultant • Client • Planner Engineer	1 2 3 4	Muhammad Akram Akhund, Aftab Hameed Memon, Nafees Ahmed Memon , Tauha Hussain Ali , Ali Raza Khos	Http://Spaj.Ukm.My/Jsb/Index.Php/Jbp/Index
Composition And Characteristics Of Construction Waste Generated By Residential Housing Project	To Categorize Waste Assists And The Segregation Of Construction Waste And Increases The Potential For Reuse And Recycling.	Packaging Storage Cutting Transportation Ordering Error Supply Error Poor Quality Control Theft/Vandalism	Nill	Lau.H., Whyte, And Law, P.L.	
Waste Management In The Australian Construction Industry: A Human Factors Approach	To Identify Social And Psychological Factors Which May Determine Behaviour In Waste Management Within One Of Australia's Largest Construction Firms	Plan Errors Shipping Errors Improper Storage Human Error Leftover Scrap Detail Errors Ordering Errors Deterioration Tradesperson	Nill	Helen Lingard, Peter Graham And Guinevere Smithers	