QUANTIFICATION OF MATERIAL WASTAGE AND THEIR CAUSES IN BUILDING CONSTRUCTION PROJECTS OF PAKISTAN

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in

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by

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Dedicated
To
My Family, Teachers & Friends

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Abstract

Construction Industry of Pakistan is vast; it is one of the largest sectors of the economy and sharing approximately 2.3% the country's GDP. A countable number of material industries are associated with the construction process. Waste generated by the construction processes has been proved to have significant negative impact on country's economy as well as on the environment. The contractor's profit margin is on the low which has seriously raised the competition to get more work. A significant volume of the wastes is generated by different type of the activities such as improper design, wrong material estimation, inaccurate ordering and procurement, changes in design, poor handling, improper storage, etc. Also the control and management of construction processes to reduce, reuse, recycle and effective disposal of the material wastes has a serious bearing on the final cost, quality and time of the project. Effective waste management can be helpful for reducing quantity of wastes generated from construction and in making a substantial contribution towards sustainable development and cost control.

In this research, a benchmarking approach has been introduced to quantify the material wastage in building construction projects of Pakistan in different cities and to identify the causes and factors for these wastes. This study focuses to evaluate the quantities of waste and causes contributing for the wastage in different type of building projects. A waste diagnostic survey was performed by interviewing different contractor's staff on thirty eight project sites. The study indicated that the most wasteful material were "Bricks", "Tiles", and " Plaster from mortar", and the most significant causes of material waste were "Improper worker's skill", "Poor supervision", "Lack of management", and "equipment malfunction". The summary results and discussion may lead the experts and decision makers to understand the actual situation of construction waste and to develop the tools through which waste can be reduced up to a certain limit.

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Chapter 1

Introduction

1.1 Study Background

The construction industry is accountable for generating a countable variety of material waste, the type and amount of which is reliant on different elements such as the type of construction project, common work practices and also the stage of construction. Waste in construction is considerable where poor management is the norm. Construction waste is highly variable and causes reduction in profit. This waste at site is grouped into physical and non-physical types. The physical waste includes loss of materials and damages while the waste comprises of cost and time overrun refers to non-physical waste.

The construction industry can be classified into two very broad types, i.e. general building construction and engineered construction. In the general building construction, projects such as residential, commercial, institutional and industrial buildings are included. Engineered construction is characterized by designs prepared by engineers rather than architects, the provision of facilities generally connected to the public infrastructure and thus owned by public-sector entities (Bennett 2003).

Building construction consumes 40% of global energy, produces 5-15% of GDP, and offers 5-10% of employment (EFEI 2011). At the same time, it consumes 40% of the world’s raw materials (NIBS 2007). According to Haseeb et al. (2011), building construction in Pakistan has a significant role in the overall progress of the country by providing employment to a huge bulk of population, brings foreign investment, provides housing to the nation, contributes in the growth of other industries by using raw materials from them and helps in the circulation of money within the country. The construction industry of Pakistan had 2.3% share in total GDP of Pakistan during 2009-10 and increased by 15.3% against a negative growth of 11.2% during 2008-09 (State Bank of Pakistan 2010).

According to American Institute of Architects Sustainability Discussion group (2008), 25% to 40% of total waste comes from building construction which is the significant reason for causing serious impacts on environment. European Commission on July 2^{nd}, 2014 has formally adopted the proposal for reuse and the recycling of up to 50% of the municipal waste till 2020 and they are setting the target of 70% till 2030. However building material waste is difficult to reuse due to large degree of heterogeneity.

In this research, a benchmarking approach has been introduced to quantify the material wastage in building construction projects of Pakistan and to identify the causes and factors for generation of these wastes. Results, conclusions and the recommendations related to material wastage in Pakistan's building construction industry have been derived after detailed descriptive and statistical analysis.

1.2 Research Significance

Building projects are the major part of Pakistan's construction industry. Economic development of the country largely depends on building construction. A lot of waste occurs during the construction which causes a huge loss to economy as well as to the environment. Rising cost of projects and competitive bidding have made it essential for the contracting firms to take serious action to reduce construction waste as profit margins are becoming narrower with every passing day. The reduction in construction waste can help to save significant amount in total profit of the project and to gain economic stability for country as well as for construction firms.

Project managers and construction staff usually fails to control the waste in construction projects and to identify the root causes for waste generation due to absence of appropriate tools to measure it. A little research on the subject topic has been carried out in Pakistan to find the types, causes and amount of waste in construction projects. The current study focuses on quantifying the waste and identifying the reasons of waste generation to develop the tools through which waste can be reduced up to a certain limit in the hope that it may aware the experts and decision makers about the situation of construction waste.

1.3 Problem Statement

In Pakistan, most of the building projects suffer from material wastage during construction partly due to ineffective management and partly due to unawareness. Thus the potential benefits assumed at the time of project planning are sometime not achieved up to the desired limit. Waste management on a recognized level is a practice scarce in Pakistan. Internationally, a lot of studies have been done on this issue in the recent past, yet in Pakistan, a lot more effort is required to be put in to estimate the quantities of waste and factors which are more specific to influence. By recognizing these factors, ranking them and further studying the high ranking factors in detail will make this effort reasonable. Such a study will also help to identify the critical factors causing waste of material in construction of building projects, thus improving the competence of construction process through counter measures

1.4 Objectives

Material waste management is vital for the investment in construction industry in Pakistan to gain maximum benefit from the project. The aim of this research is to quantify the material waste generation and causes contributing for wastage in Pakistan. Following are the objectives of this study.

1. To articulate from literature and records of previous results, material waste generation in building projects.

2. To investigate the quantity of material waste generation of selected materials.

3. To isolate the causes of material waste generation.

4. To suggest practical recommendations to reduce waste on construction sites.

1.5 Scope and Limitation

The scope of this research is restricted to building construction projects in Pakistan and mainly includes the perception of project site team of contractor including project managers, quantity surveyors, site supervisors, site engineers, etc. A struggle has been done to include maximum types of building construction projects for better understanding of the subject i.e. commercial, residential, mosques, public health buildings, schools, etc. Data was collected through semi-structured interviews from 30 construction companies/organizations working on 38 diverse projects in 12 different cities of Pakistan. Keeping in view the limited time and resources, the under construction projects located in Rawalpindi, Islamabad, Lahore, Wah Cantt., Peshawar, Gujranwala, Jhelum were visited personally for data collection whereas the data from other cities was collected through electronic methods. The major limitation being confronted was that very little research has been carried out in Pakistan in this area. It is quite difficult to gather real time data as contractor staff was hesitant to share the actual data of waste occurrence. The study covered construction companies working on project sites mostly registered with Pakistan Engineering Council (PEC) in C-1 to C-6 categories, but there were few companies included in the study which were not registered with PEC but were working in field of building projects.

1.6 Thesis Organization

This study comprises of five (5) chapters followed by references and appendices of subsidiary information presented in Figure 1.1.

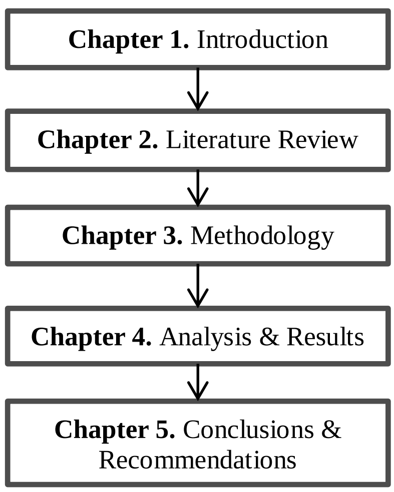


Figure 1.1 Organization of Thesis

1.7 Summary

Brief summary of the research is introduced in this chapter. Starting by reviewing the past literature that developed a need of this research is highlighted. Significance and important aims and objectives are presented. Scope with outline of the thesis chapters is also discussed.

Chapter 2

Literature Review

2.1 Introduction

This chapter presents brief review of the research studies already carried out on material wastage in building construction industry of developed and developing countries. The significance of waste is discussed and a detail research on material wastage is also carried out.

2.2 Characteristics of the Building Construction Industry

According to a famous French saying, "Everything moves, when construction moves". Construction industry is an essential contributor towards the process of development in many aspects; i.e. economy, society, industrial, etc. These works are the physical fundamentals on which development efforts and settled living standards are established. According to World Bank (1993), the construction industry usually accounts for 3% to 8% of Gross Domestic Product (GDP) in a developing country.

The characteristic of the building industry make it crucial in the development of any nation's economy. According to Kolawale (1994), the building industry has features which are separately shared by the other industries, but combination appears only in construction, making it worthy of separate treatment. The characteristic fall into four main groups:

1. The physical nature of the product
2. The assembly of the industry together with the association of the contribution process
3. The determination of demand, and
4. The method of price distribution

Kolawale (1994) further viewed the characterization of the building industry as a conglomeration of diverse fields that have been lumped together under a common heading for the convenience of reference, and further reported that for practical consideration, the broad spectrum of activities may be classified into two main categories:

1. Residential and non-residential buildings
2. Commercial and industrial buildings

2.3 Construction Industry of Pakistan

The construction industry in Pakistan plays a vital role for the economic development of the country by decreasing unemployment. This industry provides sufficient employment opportunities due to its linkage with other industries. The construction sector has strong influence on 40 building material industries; it maintains investments and helps in climate growth and poverty declination by creating employment opportunities for poor household. It provided jobs to 5.5% of the total working labour force or to 2.3 million persons including males and females during 2003-04 (Khan et al. 2008). According to State Bank of Pakistan (SBP) annual report (2010-2011), construction industry has a share of 2.5% in GDP.

According to Ali (2006), the construction industry of Pakistan is more labor concentrated, with relatively less use of mechanization. Therefore, in comparison with the other industries this industry is considered as being backward because of lack of use of the modern technology, dealings and management styles. Despite of these facts, the construction industry in Pakistan ingests almost 80% of the national development budget, and pays highest tax per million turn over. It provides jobs to countable number of skilled and un-skilled workers and also assists many other industries.

2.4 Waste definition

Waste has been defined in number of ways. According to latest production philosophy, waste should be understood as any incompetence that results in use of tools, material, labor, equipment and the capital in larger amount than those measured as essential for the construction. Waste comprises both material losses and excessive work, which produces extra cost to the project but do not add value to the product (Koskela 1992). Waste has been also defined as the losses formed by those activities that generate indirect or direct waste but do not add value from perspective of the client (Formoso et al., 1999). Another simple way to define the waste is “that can be eliminated without reducing value for the customer. It can be resources, rules, activities etc. (Polat and Ballard 2004). Waste refers anything other than the amount of equipment, material, worker’s time, space necessarily required to add value to the product (Arnold 1998).

2.5 Construction waste

Construction waste has been recognized as the major problem in construction industry. Waste is not only related to quantity of materials but it is also associated with wastage of resources and time.

Waste in construction has been considered as a major topic for the research in past few years throughout the world. As per Formoso et al. (1999), construction waste is not only related to material’s quantity, but also focused on different activities such as over production, waiting time, storage, material handling and worker’s time. Environmental damages have also been considered by some of the researchers. As per Macozoma (2002), construction site waste can be marked as non-hazardous by product generated from different activities during renovation and construction. Waste is generated during construction processes due to different factors such as human error, material damage, over procurement and poor site preparation. Chen et al. (2002) referred construction waste as the solid waste which contains no hazardous and liquid substances resulting from the construction process of different structures, including building, roads and bridges..

Environmental Protection Department of Honk Kong (2000) has defined waste in construction sites as unwanted material produced during the construction, including rejected materials and structures, surplus material, and the discarded material. Waste generates by a number of different activities performed by the contractor during execution of work and may include wood from formwork, material rapping, improper mixes, damaged materials and surplus cement.

A number of studies have also been done related to the economic aspect of waste in the construction industry. Tam et al. (2007) in a UK study reported an additional cost of 15% to construction projects cost overruns due to material wastage. Research had shown that housing construction is responsible for producing varieties of waste such as concrete, metal, bricks, ,roofing, wood, drywall, roofing, material packaging, plastics, papers, cardboard and others (Foo et al., 2013). The amount of waste generated is directly proportionate to the heavy demands of projects such as housing or residential projects, complexes or hypermarkets, and many infrastructure projects required for upgrading the living standards of Malaysian peoples (Nasaruddin et al., 2008; Begum et al., 2006).

Therefore, construction waste should be labeled as any loss in time, material and money resulted by different activities that do not contribute towards progress of the project and can be eliminated without side effects.

2.6 Material waste

Waste in building material can be described as the difference between the amount of delivered / on site accepted material and those correctly quantified and precisely measured in the work, after subtracting the cost saving of the replaced material transfer, in which extra time and cost may be incurred (Enshassi, 1996; McDonald and Smithers, 1998; Shen et al., 2004).

Ekanayake and Ofori (2000) referred material waste as “any material except earth material, which needs to be transported to some other place from construction site or used with in the construction site for some other purpose which was not specified, due to material damage, non-use or being a byproduct of construction process.

Formoso et al. (1999) summarized the study of Soibelman (1993) by providing following deductions:

1. Some companies do not focus on material waste, since they do not apply procedures to avoid on site waste. None of them had a proper material management policy, neither a waste reduction plan.

2. A noteworthy portion of waste is caused by complications which occur in stages prior to execution, such as inadequate design, lack of planning, flaws in the material supply system, etc.

3. The waste of building materials is much greater than the minor figures supposed by the companies while estimating cost of the project.

4. Mostly building firms did not know the amount of waste generated at site and its economic aspects due to lack of knowledge.

5. Flaws in management are more contributing cause of the wastage rather than lack of qualification and inspiration of workers. Waste is not an isolated occurrence as it is a combination of many factors.

6. Waste amount differs from site to site. Moreover similar sites might show different waste level for the same materials at different stages. This specifies that a significant amount of waste can be controlled.

2.7 Categorization of material waste

Waste occurs in many forms but generally categorized into following types

2.7.1 Waste by loss

This comprises of direct and indirect waste

Direct waste: It occurs when material is completely lost either damaged irreparably or just lost from the site. The direct loss can take place at every stage of material handling. Material stacking and storage places are centers where most of the direct waste occurs.

Indirect waste: It occurs when materials are either used for other purposes than those specified or in quantities which are in excess than measured. In this type of waste the material is not lost physically.

2.7.2 Waste by nature

Natural waste can be categorized as avoidable and unavoidable waste (Formoso et al., 1999).

Avoidable waste: When the cost of waste is significantly higher than the cost to avoid it.

Unavoidable waste: When the investment required for saving the waste is higher than the economy product. This type of waste is dependent on project site and on the company's attitude towards waste, since it is associated with the technological development level.

2.7.3 Waste by resource

This comprises of waste of materials, man-hours and machine hours which present direct cost wastage (Sharma, 2000).

2.7.4 Waste by source

Formoso et al. (1999) indicated that waste can also be categorized according to its source; the phase in which root cause of waste occurs, i.e. the phase that the main cause of waste is related to. Waste may arise during proceeding construction processes, such as labor training, material planning and supply, construction stage and also the material production.

2.8 Magnitude of waste in Construction

The magnitude of waste at construction sites is significant. Studies revealed that the waste rate was different in developed countries than that in developing countries as follows:

2.8.1 Magnitude of waste in construction in developed countries

Bossink and Brouwers (1996) found that in Netherland the waste amount of each building material is between 1% and 10% of the total amount acquired, depending on material type. It was also concluded that on average 9% of the total material used in the construction ends up as site waste in Netherland.

Construction and the Demolition (C&D) waste in Honk Kong have been considered a major problem due to limited space availability, high population density and infrastructure development. In year 2000, 37,690 tons per day demolition and construction waste was generated of which 7,480 tons per day was disposed of at landfills and 30,210 tons per day waste was transferred to public filling areas for reclamation use. The inactive waste materials (mainly bricks, sand and concrete) suitable for land formation works were disposed of at public filling areas while the non-inert portion (plastics, glass, paper, vegetation, bamboo etc.) were disposed of at municipal landfills. (Poon and Jaillon, 2002).

Quantities of waste disposed of at landfills in Honk Kong are shown in Table 2.1.

Table 2.1 Composition of C&D waste disposal of at landfills in Hong Kong 1995 (Poon and Jaillon., 2002)

Components	Composition of each class of construction and demolition waste received at landfill sites (percent by weight)				
	Road work material	Excavated soil	Destruction waste	Site clearance	Renovation
Bricks/ Tiles	0.8	0.4	12.1	1.4	9.6
Wood	0.6	0.9	10.5	13.3	7.1
Asphalt	24.7	0	0	0.2	0
Cement	1.7	0.4	3.2	15.6	3.3
Reinforced Concrete	14.2	0.4	5.8	0.9	7
Concrete/ Mortar	16.9	1.2	10.8	4.6	7.4
Soil/ Sand	23	73.8	21.5	33	19.4
Slurry/ Mud	1.8	9.7	1.5	1	3.1
Ferrous Metals	0.5	0	0.6	1	1.3
Rock/ Rubble	14.4	12.5	27.7	15	38.8
Nonferrous metals	0	0	0.7	0.2	0.1
Total	100	100	100	100	100
% of total C&D waste	5.2	59.4	8.5	14.6	12.3

A recent research in the United Kingdom directed that minimum 10% of the total raw material brought to the construction sites is wasted due to loss, over-ordering, damage etc. (Poon et al., 2004).

Researches in the United States of America suggested that almost 30% of the construction is rework, labor is used at 40% to 60% of potential efficiency, accidents account for 3% to 6% of the project cost and at least 10% of the material becomes waste (Datta, 2000). Similarly in many other developed countries construction waste is estimated as shown in Table 2.2.

Table 2.2 Construction waste production in tons country-wise (EEA, 2001)

No.	Country	Year	Amount of waste
1	United Kingdom	1995	70,000,000
2	Sweden	1990	1,500,000
3	Finland	1992	8,000,000
4	Austria	1995	6,400,000
5	Ireland	1995	1,520,000
6	Belgium	1994	7,718,000
7	Germany	1993	131,645,000
8	Netherlands	1994	13,650,000
9	Spain	1993	115,000
10	Greece	1992	3,400,000
11	Denmark	1995	3,427,000
12	Italy	1995	14,311,000
13	France	1997	24,000,000
14	EU	1995	290,385,000
15	Luxembourg	1996	1,499,000
16	Norway	1995	3,578,000
17	Portugal	1994	3,200,000

2.8.2 Magnitude of waste in construction in developing countries

In developing countries (Zimbabwe, Botswana and Zambia) the 40% of the construction is rework, labor potential is 30% to 40%, accidents cause 8% of the project cost and more than 20% material is wasted (Datta, 2000). Formoso et al. (2002) revealed that in Brazilian construction industry 20% to 30% of the material is wasted. In developing countries labor’s potential efficiency is only 46% of the total working time, while remaining 54% goes for idling, waiting and rest (Zhao and Chua, 2003).

Enhassi (1996) found from a study of 86 different housing projects in the Gaza that the material loss from direct and indirect waste was about 3.6% to 11% which was significantly greater than generally accepted values (2% - 4.5%). In Egypt, the results of waste after interviewing 30 different contractors were that waste percentage is 4% to 13% including unsatisfactory waste rates for steel and cement (Garas et al., 2001).

2.9 Causes of Construction site waste generation

There are different contributory factors to construction material waste generation. Waste occurs due to one or a mixture of many causes.

2.9.1 Causes of construction site waste generation in developed countries

According to Poon et al. (2001), study in Hong Kong described that there are many influential factors to this figure, and these are outlined in Table 2.3.

Table 2.3 Causes of construction site waste in Hong Kong (Poon et al., 2001)

	Causes for construction waste	**Examples**
Site Management Practices	Lack of quality management plan	Lack of waste management plan
	Improper Storage	Unsuitable pallet to protect cement bags from ground water
	Improper Handling	Damage, Breakage, Losses
	Oversized Foundations	More excavation and cuts due to over design
	Use of traditional construction methodology	Waste of timber formworks
	Limited Visibility	Poor lighting arrangements on site
	Untidy sites	Waste materials are not segregated from used material
	Poor workmanship	Poor workmanship for formwork
	Unsuitable protection to finished works	Finished staircases unprotected by boarding
Product Delivery	Over ordering	Over ordered concrete becomes waste
	Improper data of time and delivery method	No records for material delivery
	Transportation system	Materials dropped from forklift
	Packaging system	Poor protection to the materials

The study done by Bossink and Brouwers (1996) indicated that in Netherland sources and causes of construction waste are as outlined in Table 2.4.

Table 2.4 Source and cause of construction waste in Netherlands (Bossink and Brouwers, 1996)

Source of wastage Source	Cause for wastage Cause
Design	Error in contract documents
	Insufficient documents availability
	Changes in design
	Adoption of wrong specifications
	Choice of low quality
	Unawareness with product specification
	Lack of construction knowledge
Procurement	Over and under ordering
	Lack of options for ordering small quantities
	Use of unsuitable product
Materials handling	Damage during transportation
	Unsuitable storage
	Unpacked supply
Operation	Error by trade persons or labor
	Equipment malfunction
	Weather extreme
	Accidents
	Damage cause by subsequent trades
	Use of improper material
	Method for laying of foundation
	Requisite quantities are not fully known
Residual	Improper cutting
	Over mixings
	Waste from implementation process
	Improper packaging
Other	Theft
	Lack of onsite material management plan

2.9.2 Causes of construction site waste generation in developing countries

Developing countries are facing more material wastage than wastes generated in developed countries. In Singapore and Egypt causes of waste generation are described in Tables 2.5 and Table 2.6 accordingly.

Table 2.5 Source and factors of construction site waste in Singapore (Ekanayake and Ofori, 2000)

	Factors for construction waste
Design	Lack of attention towards dimensional coordination of product
	Changes in design during execution
	Unawareness of standard size of material's availability in market
	Unfamiliarity with alternate products
	Complex detailing in design
	Lack of information in drawings
	Error in contract documents
	Contract documents are incomplete
	Use of low quality products
Operational	Error by labor
	Accident causes by negligence
	Damaging due to other trade
	Improper material use
	Unclear required quantity
	Equipment malfunction
	Inclement weather
Material Handling	Loss during transportation
	Improper storage
	Materials supply in loose form
	Use of only closely available materials
	Unfriendly team attitudes
	Theft
Procurement	Ordering error
	Supply error
	Purchased product is not as required

Table 2.6 Dominant causes of waste in Egyptian construction (Garas et al., 2001)

No.	Causes of waste
1	Late information
2	Incomplete design
3	Insufficient specifications
4	Poor quality control
5	Superfluous worker's move
6	Unskilled team
7	Reworks
8	Poor equipment technology
9	Modifications in design
10	Transportation Losses

2.10 Estimation and auditing of the waste

The estimation of waste gives information about the amount of different types of wastes that will be generated from projects. Estimation of quantity of construction waste is pivotal for implementing waste minimization program. According to Poon et al. (2001), the construction waste at the work places can be projected and examined as follows:

2.10.1 Concrete waste

Recent study have relieved that the average level of concrete wastage is 4% which is also considered as norm while trading for concrete. However, wastage of concrete can be reduced up to 3% by careful handling and proper material ordering. The amount of concrete waste can be assessed as:

Concrete quantity in cum x material wastage in %

2.10.2 Brick / Block work waste

Inert granular waste produced from block/ brick work is estimated to be 10% of the total quantity of work in a building project. The estimate can be found as following:

Waste amount = Work done in sqm x thickness (m) x material wastage (%)

2.10.3 Waste from screeding and plastering

Waste from screeding and plastering is difficult to control, waste up to 15% has been observed. The estimate can be calculated as:

Waste amount = Work done in sqm x thickness (m) x material wastage (%)

2.10.4 Waste from timber formwork

Timber formwork is assumed to be used twelve times before discarded. This waste can be calculated as:

Waste amount = Formwork quantity in sqm x thickness (m)/ 12 (number of uses)

2.10.5 Packaging waste

Contractors usually have a little control on generation of packaging waste, which is supposed to be 5% of total volume of the materials that required packaging. It can be found as:

Waste amount = Total packaged material x 5%.

2.10.6 Other wastes

According to Poon et al. (2001), the waste percentage of different materials for public housing projects and private residential projects have been shown in Tables 2.7 and 2.8.

Table 2.7 Wastage of materials for public housing projects (Poon et al., 2001)

Trade	Material	% Wastage
Concrete	Concrete	3 – 5%
Dry wall	Fine aggregate	5%
Masonry	Blocks and bricks	6%
Wall plastering	Plaster	2%
Wall and floor tiling	Tiles	6 – 8%
Wall screeding	Ready mix cement	7%
Formwork	Timber board	5%
Reinforcement	Steel bars	3 – 5%
Ceiling plastering	Plaster	2%
Floor screeding	Ready mix concrete	1%
Installation of bathroom fitting	Sanitary fitting	2%
Installation of kitchen joinery	Kitchen joinery	1%

Table 2.8 Wastage of materials for private residential building (Poon et al., 2001)

Trade	Materials	Wastage %
Concrete	Concrete	4-5%
Dry Wall	Fine aggregate	6-10%
Formwork	Timber boards	15%
Reinforcement	Steel bars	1-8%
Floor screeding	Ready mix cement	4-20%
Masonry	Blocks and bricks	4-8%
Wall screeding	Ready mix concrete	4-20%
Wall plastering	Plaster	4-20%
Floor tiling	Tiles	4-10%
Ceiling plaster	Plaster	4-20%
Wall tiling	Tiles	4-10%

The actual amount of waste generated is reliant on the experience and practice of each company. The waste level should be compared with the standard, i.e. the average performance of the industry. Material waste audits should be performed in order to recognize the areas that need attention to reduce the wastage up tp a certain limit.

2.11 Material waste in construction site

Material wastage on sites include steel reinforcement, blocks, cement, mortar, concrete, formwork, pipes, tiles, aggregate (Poon et al., 2004; Shen et al., 2002; Formoso et al., 2002)

2.11.1 Steel reinforcement

It is relatively difficult to control the use of steel reinforcement in building sites due to cumbersome handling of steel because of its shape and high weight (Formoso et al., 2002). Wastage of steel occurs due to these causes:

1. Unusable pieces produced during cutting.

2. Some of the bars have overly large diameter due to fabrication problems trespassing.

Wastage of steel is shown in Figure 2.1.

Figure 2.1 Waste of steel reinforcement

2.11.2 Concrete

Concrete is of two types. One is ready mixed and the other one is concrete mixed at site. Twenty two sites were surveyed in Hong Kong by Poon et al. (2004) to find the type of concrete used and it was concluded that more than 80% of the total concrete work was done by using ready mix concrete with wastage of 3% to 5%. The main reason of wastage was over ordering, redoing and broken formwork.

The wastage is mainly occurred due to mismatch between quantities required and quantities ordered (Shen et al., 2002).

2.11.3 Timber formwork

Timber formwork is one of the leading contributor to waste accounting for 30% of all waste estimated at sites in Honk Kong. Timber is very popular material because it is less expensive, has high load bearing capacity and it is light in weight. It is easily workable and readily cut to give shapes for producing different forms of concrete elements. However it is less durable and little reusability makes it material with high percentage of waste. The main causes of timber wastage are deterioration and cutting. Both are difficult to control (Shen et al., 2002). An example of wastage of timber is shown in Figure 2.2.

Figure 2.2 Waste of timber

2.11.4 Cement

Analyzing waste of cement is relatively difficult due to fact that it is used as a component of concrete and mortar in different processes, such as plastering, screeding, brick and block works. Cement is relatively an expensive material and have high rate of wastage in Brazil (Formoso et al., 2002)

Plastering is normally done by applying mortar and cement on to the wall and trowelling it smooth. The generation of plastering waste is mainly due to poor storage and excessive mixing. Off cuts, residual remained in bags and packaging are also significant causes of plastering waste (Poon et al., 2004).

Mortar is used to set bricks and blocks and to to give finishing to the buildings. The major contributory reasons for mortar waste are scraping out from the spaces between the facing bricks, mixing too much mortar, and residuals in tubes and wheelbarrows. The suppliers are usually blamed because contractors usually faced such situations when small quantities are required and they have to purchase in larger amount (Bossink and Brouwers, 1996).

Formoso et al. (2002) concluded that cement waste occurs due to following reasons:

1. Mortar production at sites
2. Transportation and handling of mortar
3. Joints in brickwork
4. Thickness of plaster
5. Floor screeding

2.11.5 Brick and block

Blocks and bricks are the most common materials for walling. Unpacked supply, improper cutting, broken damage and unused bricks left on site are the main causes of wastage (Shen et al., 2002).

In most of the poorly performing sites, different causes of waste were mostly related to the waste of blocks and bricks. At many sites, there were complications in delivery of material, such as lack of control in damage during unloading operation. The major source of wastage was found to be poor handling and transportation. As in the case of mortar, multiple handling of same batch of bricks, due to intermediate stocks along the process flow was observed at mostly sites. Poor site layout, improper pathways, and inadequate equipment are significant reasons for wastage (Formoso et al., 2002). An example of wastage of bricks is shown in Figure 2.3

Figure 2.3 Waste of bricks

2.11.6 Stone tablets

Stone tablets are used for building facing. These are made up of clay. The typical dimensions of stone tablets are 20 cm x 5 cm x 10 cm. Bossink and Brouwers (1996) summarized the main causes of waste as follws:

1. Cutting
2. Shape
3. Quality
4. Order too much
5. Storage and handling
6. Cracking

2.11.7 Ceramic tiles

The main reason of wastage is cutting of tiles, on floors (15 sites), 35 % of the pieces had to be cut and on walls (23 sites), 27.4 % of the pieces had to be cut. Flaws in integration between structural and architectural design and lack of modular coordination were the main causes of the cuts. It was noted that lack of planning in distribution of materials was one of the most significant cause of waste (Formoso et al., 2002).

2.11.8 Pipes and wires

The activity of wiring and piping is usually subcontracted and disjoint on sites so it is difficult to find the exact amount of material wastage. These materials are usually provided by special sub-contractors. Such materials frequently move into and out of the construction sites and design of these is not properly detailed and modifications come on later stage. The main causes of waste are cut pieces, poor planning and distribution, and the replacement of elements by the others (Formoso et al., 2002).

2.11.9 Average waste of construction materials on site

Chen et al. (2002) got the data from specialty contractors from different countries including China, Brazil, UK, USA, Hong Kong, Korea and presented a comparison of waste as displayed in Table 2.9.

Table 2.9 Average wastage rate of construction materials on site (Chen et al., 2002)

Material	Mean Wastage %					
	USA	China	UK	Korea	Brazil	Hong Kong
Blocks/Bricks	3.5	2	4.5	3	17.5	NA
Concrete	7.5	2.5	2.5	1.5	7	6.7
Drywall	7.5	NA	5	NA	NA	9
Formwork	10	7.5	NA	16.7	NA	4.6
Glass	NA	0.8	NA	6	NA	2.3
Mortar	3.5	5	NA	0.3	46	3.2
Nail	5	NA	NA	NA	NA	NA
Rebar	5	5	NA	NA	21	8
Tile	6.5	NA	5	2.5	8	6.3
Wallpaper	10	NA	NA	11	NA	NA
Wood	16.5	NA	6	NA	32	45

2.12 Material waste in building constructions in Pakistan

Developing countries are facing more construction waste problems as in Pakistan wastes in building construction are causing huge economic loss. Unfortunately no proper study has been carried in this regard in Pakistan. Quantifying the waste and identify the causes of waste generation can help to save economic loss as well as to rise a better environment in Pakistan.

Chapter 3

Research Methodology

3.1 Introduction

The aim of this chapter is to describe the detailed methodology adapted for this study in order to achieve research purpose and objectives that were introduced in Chapter 1. It includes the study tools used, data collection method applied, and the data analysis tools used. This research comprises of desk study and interviews with the professionals.

This study was conducted to quantify the material wastage in building construction projects of different nature and identify the factors and causes of wastage from the contractors' perspective. A literature review only does not give much information on the wastage of materials in Pakistan's construction industry. So, the best way to obtain information on the material wastage and the factors that contribute for waste in our construction industry is interview technique. Interviews, along with a four page questionnaire, are the main source of information gathering. Materials and factors to be include in interview questionnaire were shortlisted after detailed study of different research works already carried out in this area by (John and Itodo 2013), (Babatunde and Olusola 2012) and (Foo et al., 2013). The interview participants were asked to give percentages of different material's wastage and to rank the causes of material wastage on Likert scale. The schematic plan of the research is shown in Figure 3.1.

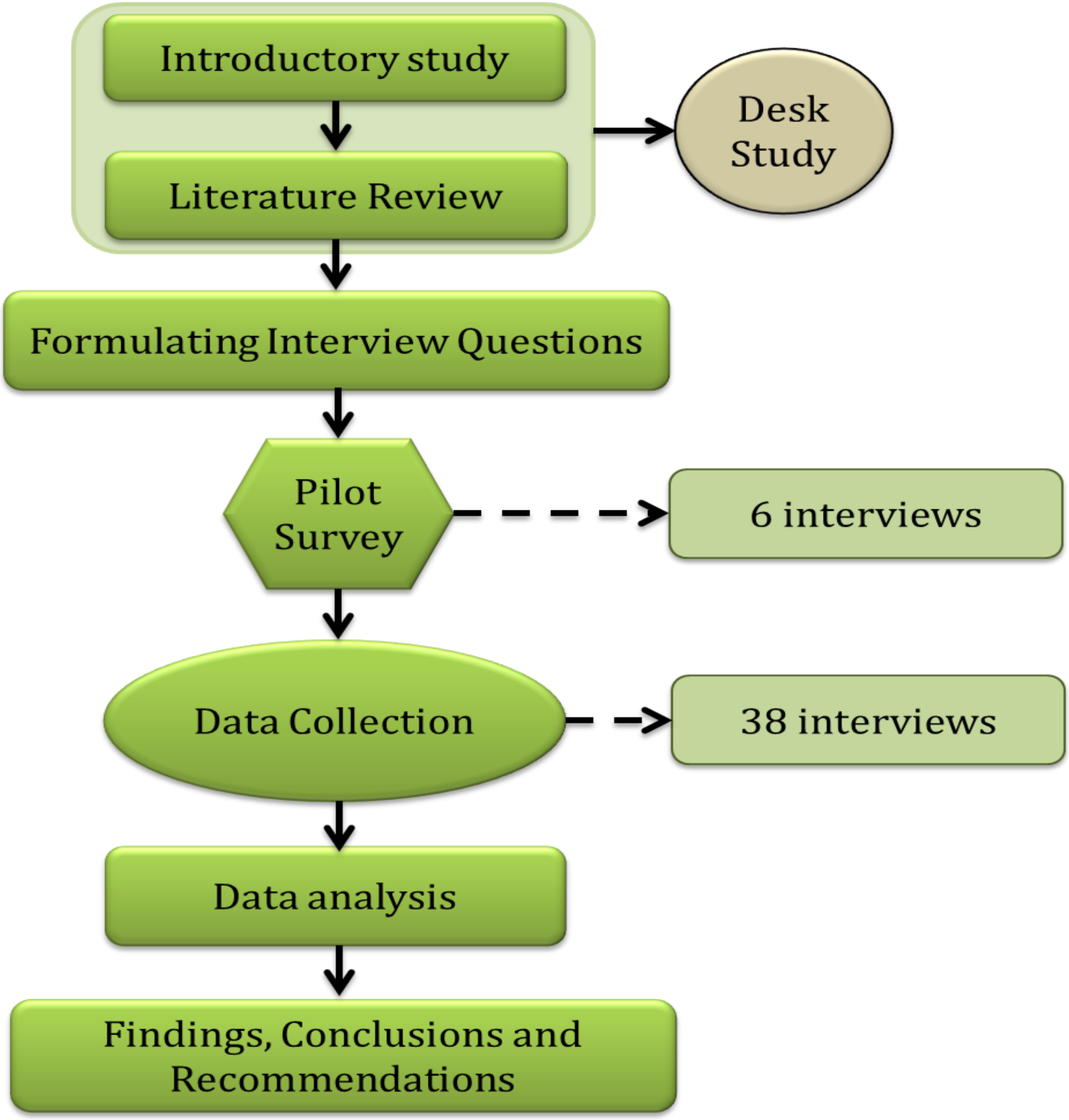


Figure 3.1 Schematic Plan of the research

As per the plan, an introductory study of the topic was performed at the beginning, followed by a comprehensive literature review. Different questionnaires and interview guides from the studies connected to this topic were studied. Before the questionnaire survey begun, a pilot test was carried out, which comprised of a panel of 6 professional engineers with more than 10 years of work experience in field of construction. The respondents were requested to shortlist the materials which contribute maximum in building construction projects in Pakistan and quantify the wastage of these materials. The respondents were further requested to shortlist different causes of material waste. Based on the literature review and their input, the particular interview questions for this study were formulated.

3.2 Design of Questionnaire survey

Survey is well defined as “data collected from different projects through organized measurement and explored to produce the results (Bryman (2004) and Trochim (1997) debated that in applied social research , surveys are mostly carried out by interviews and questionnaires. Bryman (2004) concluded that surveys are basically cross sectional study and data collected by surveys is generally quantitative in nature and can be used to correlate multi variables. The design of survey selected for this study is shown in Figure 3.2. (adapted from Shuwei 2009).

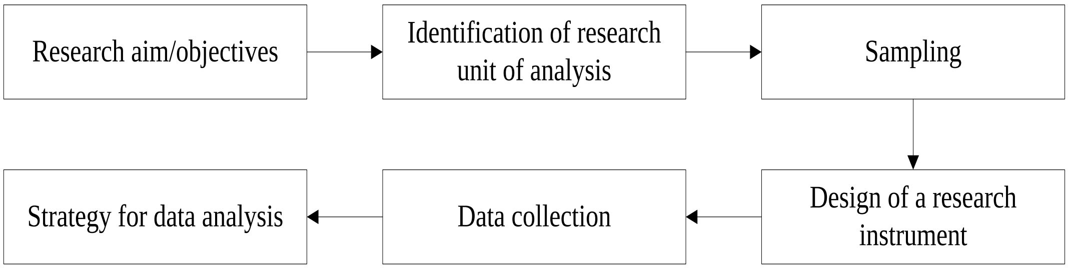


Figure 3.2 Survey Design Process

The questionnaire was distributed into two sections, first section comprised of questions about respondent’s name, company’s name, and experience in years etc. Second section was further divided in to three parts consisted of a total of 48 questions (Appendix 1). In first part wastage of 26 materials which were shortlisted after detail literature review and pilot survey were asked to quantify upon the bases of experience. In second part respondents were questioned to rank the causes of wastage on five point likert scale ranging from ‘very low’ to ‘very high’ where “1= very low” and “5= very high” and in the last part, three open ended questions were asked. In third part participants were asked three open ended questions regarding client / consultant behavior, key responsible for waste generation and method for control of wastage.

3.3 Data Collection

The data collection remained a challenging task. Material wastage was assessed to be a topic not very well understood by majority of stake holders. It is for this reason; an introduction to material wastage was made first part of our questionnaire. Bell in 2005 argued that by hand distribution of questionnaire to respondents have many advantages as healthier understanding of the research purpose can be achieved and difficulties can be discussed and resolved easily by face to face communication. Therefore different types of buildings contractors were personally visited. The cities of Rawalpindi, Islamabad, Lahore, Gujranwala, Sargodha, Jhehlum, Faisalabad and Kalar Kahar were physically visited while data from other cities was gathered through e-mails and telephone. It is worth mentioned that thirty one (31) responses collected are more than the sample size (Mason 2010).

After the finalization of questionnaire, interviews were started by personally meeting with all the respondents. A total of 38 interviews were conducted across different cities of Pakistan. All the interviews were taken by the contractor's perspective. The interview participants were 16% Quantity Surveyors, 18 % Project Managers, 29 % Site Engineers/ Planning/ Supervisors, 5 % General Managers, 24 % owners and 8 % Construction Managers from the firms with PEC Category ranging from C-A to C-6, and also some of the contractors having no PEC registration. The respondents were working on different type of building projects including commercial, residential, industrial projects etc. The respondents were mostly site staff members of contracting firms including graduate engineers and diploma holders with countable professional experience related to construction and were having a sound knowledge of material wastage.

3.4 Sample Size

The number of sub-categories included in the study controls the total size of sample needed for guaranteeing statistical validity. Regardless of the possibility that the total population is constant, e.g. the size of the industry is fixed, the larger of sub-population will result in a fairly larger sample size (Naoum 2007). This implies that for keeping the sample size convenient and manageable, a small number of sub-categories should be considered, possibly reducing the scope. Moreover, for different populations, there are different indicators to be utilized. Indicators particular to the project require number of projects as the population, indicators particular to the firm require number of firms as the population, and indicators particular to the industry require number of sub-categories as the population. It was a challenge to arrange an ideally representative sample due to the shortage of resources, thus a convenient sample is studied.

To answer the selection of sample size, a study (Sarah and Edwards 2012) was referred which compiled different opinions of scholars and researchers about the question: "How many qualitative interviews are enough in a qualitative analysis?". Some of them are described here: according to Howard S. Becker (Tricks of the Trade, 1972), proficient scholars know that there is no reasonable answer to this question. The only possible way is to stop at the number which gives enough data and observations to support the conclusions. Julia Brannen of the University of London replied that there is no rule of thumb for the number of interviews required in a qualitative study. Patricia A. Adler of the University of Colorado and Peter Adler of the University of Denver suggested a sample of roughly around thirty (30); it has the advantage of enquiring a lesser number of people without forcing the adversity of unending information collecting, particularly when there are time and resource constraints. Alan Bryman of the University of Leicester stated that in qualitative studies, there are minimum requirements for the sample size. For an interview-based qualitative study, the minimum number of must be between twenty (20) and thirty (30). According to Jennifer Mason of the University of Manchester, normally it is better to have less number of interviews, innovatively and interpretively investigated, than a bigger number where researcher could not have proper time to analyze justifiably. According to Charles C. Ragin of the University of Arizona, a common but convincing answer is twenty (20) for Master's thesis and fifty (50) for a Ph.D. (Mason 2010) describes that the qualitative study based on interviews for doctoral thesis in the United Kingdom and Ireland have the range for number of interviews between 1 to 95 (the mean was 31 and the median 28).

Krejcie and Morgan (1970) referred the following formula for the calculation of sample size:

$$\text{Sample Size} = \frac{\left(\frac{\text{Range}}{2}\right)^2}{\left(\frac{\text{Accuracy level}}{\text{Confidence level}}\right)^2}$$

Where,

Confidence level = 95% or 0.95

Accuracy level = 95% or 0.95

Range = 90 ± 5

Therefore sample size calculated was 25.

3.5 Selection of materials

After going through literature review and concerning with the professionals following materials were shortlisted

- Bricks
- Steel Rebar's
- Plain cement concrete
- Glass
- Plastic pipes
- Bitumen
- Paints
- Ceramics
- Natural Rocks
- Metals
- Mild steel sections
- Thermo pore sheets
- Water proofers
- Wood
- Plaster from mortar
- Reinforced cement concrete
- Aluminum
- Polythene sheets
- Wires and cables
- Tiles
- Marble
- Ceiling Boards
- Steel Railings
- Mild steel GI pipes
- Anti-termites
- Diesel

These materials were shortlisted on the bases that in building construction projects in Pakistan, these materials contribute maximum towards total material cost.

3.6 Factors effecting the wastage

Following are the main factors which contribute towards material wastage in building construction projects

3.6.1 Management

This main factor involves following reasons:

- ‘Poor supervision’: Lack of materials supervision, quantities estimation and auditing.
- ‘Lack of management’: Management does not focus much on material wastage and economic aspects as they consider it unavoidable.
- ‘Lack of waste reduction plan’: Contractors usually do not prepare any plan for reduction of wastes on site.
- ‘Absence of site waste manager’: There is no designation of material waste manager in organogram of company.

3.6.2 Operation

It incorporates the following reasons:

- ‘Rework’: Rework due to mistake of workers and due to revisions in drawings.
- ‘Weather’: Wastage due to unexpected and extreme weather conditions.
- ‘Accidents’: Accidents caused by breakage, opening of scaffoldings, and worker’s dispute etc.
- ‘Improper worker’s skill’: Untrained and unskilled labor, masons, steel fixers and foreman.
- ‘Equipment malfunctions’: Usage of outdated and rough surfaced equipment and formwork.

3.6.3 Design

This main factor includes the following reasons:

- 'Changes in design': Design changes due to lack of information about size of materials and change in scope.
- 'Error in contract documents': Inadequate or incomplete information about the material specification and usage.

3.6.4 Material Handling

This main factor contains following reasons:

- 'Improper packaging': Damage due to deficient packaging of materials.
- 'Storage': Wastage due to inadequate stock piling of the material.
- 'Cutting': Excessive cutting due to non-consideration of manufactured size of materials.
- 'Transportation': Wastage while transporting the materials from suppliers place to storage place and also while transferring from storage place to site.

3.6.5 Procurement

This main factor comprises of the following reasons:

- 'Ordering error': Over ordering due to mistakes in quantity surveying and poor coordination of construction crews and procurement team.
- 'Supply error': Over and under supply due to miss communication or due to shortage of required material.

3.6.6 Others

These are the other reasons:

- 'Poor quality control': Wastage due to less productivity, use of unacceptable products and poor field service etc.
- 'Theft/ vandalism': Wastage of materials due to pilferage or theft.

3.7 Data Analysis Strategy

Once data was collected, it was analyzed to produce descriptive statistics. The results were based duly from inference drawn through descriptive statistics using SPSS (Statistics Package for Social Sciences V 18).

To get the reliable and practical outcomes out of received data from respondents across the country, data analysis strategy is divided into following steps:

- Distribution of received questionnaires into respective building types
- Acceptance/ rejection of questionnaire forms for final data analysis.
- Entering of complete data into SPSS Program for its analysis.
- Checking the normality, reliability and correlation of complete data.
- Carrying out of parametric/ non parametric tests.
- Identification of themes and concepts in the data.
- Carry out diagramming to understand complex relationships.
- Writing of data reflective notes for conclusions and future recommendations.

3.7.1 Test for Normality

Normality test is adopted to relate the shape of sample distribution to the shape of Normal Curve. Shapiro Wilk test is more commonly used for comparing the normality of the data set lesser than 2000 elements. The Shapiro- Wilk test exploits the null hypothesis principle to inquire whether sample belongs to normally distributed population or not. Null hypothesis for the test is that the population is normally distributed. Therefore if the p-value is fewer than the selected alpha value, which is 0.05 in this case, then the null hypothesis is rejected and it is clear that data is not normally distributed. On the other hand, if the p-value is larger than chosen alpha value, then the null hypothesis that data is collected from normally distributed population is accepted.

3.7.2 Test for Reliability

In SPSS, widely used methods for measuring reliability comprise Cohen's Kappa Coefficient for categorical data and Cronbach's Alpha for continuous data (Likert-scale type items). Among them, Cronbach's Alpha is most popular method (Hinton et al. 2004 and Leech et al. 2005). Cronbach's alpha is coefficient of internal consistency. Hinton et al. (2004) clarified that value ranging from 0 (un-reliable) to 1 (reliable) with 0.75 being most sensible value. They have also delivered a guide line to assess the reliability of data as shown in Table 3.1.

Table 3.1Cronbach's Alpha Value

a.	0.9 & above	Excellent reliability	**b.**	0.7 to 0.9	High reliability
c.	0.5 to 0.7	Moderate reliability	**d.**	0.5 and below	Low reliability

3.8 Summary

Chapter three discusses the detail of formulation of interview questionnaire form and identification 26 materials for quantification of wastage and 19 causes contributing for material wastage in building construction projects in Pakistan. Chapter also briefs in detail regarding the sample size and data collection procedures for data analysis. Finally the chapter tells about the adoption of various steps towards the data analysis strategy.

Chapter 4

Data Analysis and Results

4.1 Introduction

In this chapter, detailed analysis of data collected is presented. For this purpose, the widely and most understandable software for practical statistical and descriptive analysis were used i.e. MS Excel 2010 and SPSS Ver.18.0. Since manual calculations cannot make an error-free analysis from a large amount of data (Gaur & Gaur 2009), MS Excel 2010 was used for the descriptive and comparative analysis, and statistical tests such as reliability and normality tests were conducted using SPSS.

4.2 Statistical Analysis

Following statistical tests were applied to the data collected from the interviews to find the data reliability as well as to achieve the research objectives. Following statistical tests were applied to the data gathered from the interviews to find the reliability of data as well as to obtain the objectives of the research.

4.2.1 Reliability Analysis

Before descriptive statistics is carried out, reliability of the data collected from interviews should be assessed. Repeating any measurement that produces the same result is considered a reliable measurement (Gaur & Gaur 2009). Leech et al. (2005) argued that the reliability test is done to check whether each item in the scale is free from error of measurement. Hinton et al. (2004) have defined the reliability as a questionnaire verified to study ant topic at different times across different populations, if generates the same outputs, the questionnaire is 'reliable'.

In SPSS, Cohen's Kappa Coefficient Test for the categorical data and Cronbach's Aplha Test for the continues data (Likert scale type data) was conducted for checking the reliability. Hinton et al. (2004) concluded that Cronbach' Aplha value ranges from 0 (un-reliable) to 1(reliable) with value 0.75 reflecting the most sensible value.

Cronbach’s Aplha values for the wastages of Materials was 0.828 and for the causes of wastages was 0.820 which are considered sensible, as shown in Table 4.1 below.

Table 4.1 Results of Reliability Test

<table>
<tr><td colspan="4">Case Processing Summary For Material Wastages</td><td rowspan="3">Cronbach's Alpha</td><td rowspan="3">0.828</td></tr>
<tr><td colspan="2"></td><td>N</td><td>%</td></tr>
<tr><td rowspan="3">Cases</td><td>Valid</td><td>36</td><td>94.7</td></tr>
<tr><td>Excluded</td><td>2</td><td>5.3</td><td rowspan="2">Number of Items</td><td rowspan="2">24</td></tr>
<tr><td>Total</td><td>38</td><td>100.0</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="4">Case Processing Summary For Causes of wastages</td><td rowspan="3">Cronbach’s Aplha</td><td rowspan="3">0.820</td></tr>
<tr><td colspan="2"></td><td>Number</td><td>Percentage</td></tr>
<tr><td rowspan="3">Case</td><td>Valid</td><td>38</td><td>100</td></tr>
<tr><td>Excluded</td><td>0</td><td>0</td><td rowspan="2">Total Items</td><td rowspan="2">19</td></tr>
<tr><td>Total</td><td>38</td><td>100</td></tr>
</table>

Detailed results of the reliability test are shown in **Appendix IVA & IVB.**

4.2.2 Tests of Normality

Another significant evaluation of the collected data is to check the normality to analyze whether the data is parametric or non-parametric i.e. the data is normally distributed or not. Shapiro-Wilk test is usually conducted when the available elements are less than 2000. If the significance value is more than 0.05, it shows that data is non-significant. For sample size larger than 2000 the test used is Kalmogrov- Smirnov. For this study Shapiro-Wilk test is used. The methodology is shown in Figure 4.1

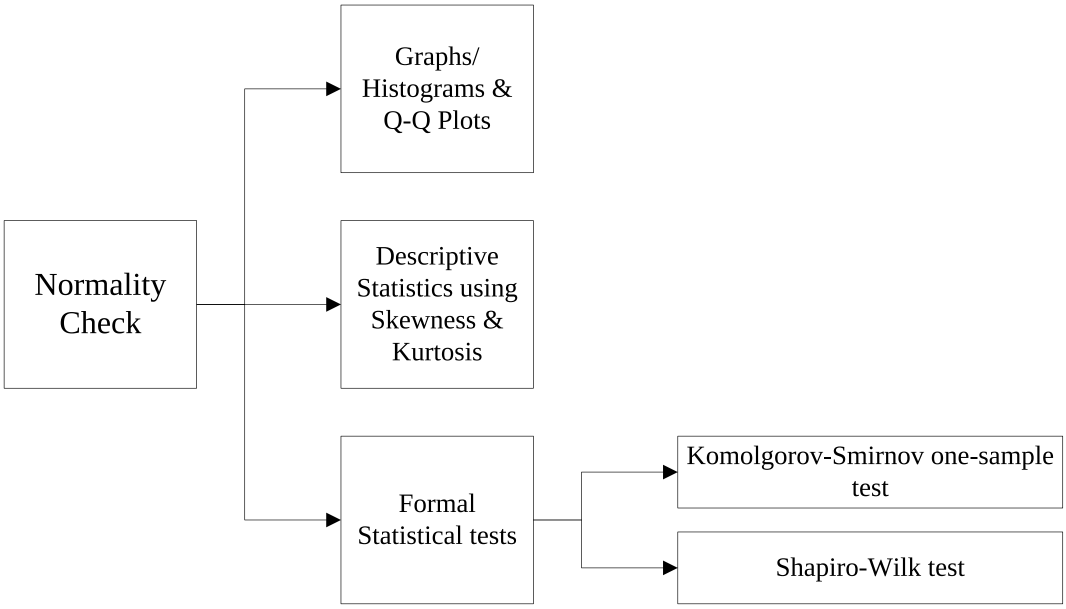


Figure 4.1 Three approaches to check the normality of the quantitative data

Through analysis by normality test, the significance level for the both Materials and Causes of the Wastages came out lesser than 0.05, for most of the value it was near 0 as shown in Table 4.2

Table 4.2 Results of Normality Test

Sr. No	Causes of wastage	Sig	Wastage of materials	Sig
1	Poor supervision	.000	Brick	.151
2	Lack of management	.000	Wood	.074
3	Lack of waste reduction Plan	.000	Steel rebar's	.031
4	Absence of site waste manager	.001	Plaster from Mortar	.002
5	Rework	.002	PCC	.001
6	Weather	.004	RCC	.000
7	Accidents	.007	Glass	.002
8	Improper workers Skill	.000	Aluminum	.000
9	Equipment malfunction	.001	Plastic pipes	.001
10	Change in design	.000	Polythene sheets	.000

Sr. No	Causes of wastage	Sig	Wastage of materials	Sig
11	Error in contract documents	.003	Bitumen	.000
12	Improper packaging	.001	Wires and cables	.000
13	Storage	.000	Paint	.004
14	Cutting	.000	Tiles	.035
15	Transportation	.000	Ceramic	.004
16	Ordering error	.003	Marble	.115
17	Supply error	.000	Natural rock	.000
18	Poor quality control	.001	Ceiling boards	.000
19	Theft	.001	Metal	.000
20			Steel railings	.000
21			MS sections	.000
22			MS GI Pipes	.000
23			Thermo pore Sheet	.002
24			Anti-termites	.000
25			Water proofer	.000
26			Diesel	.000

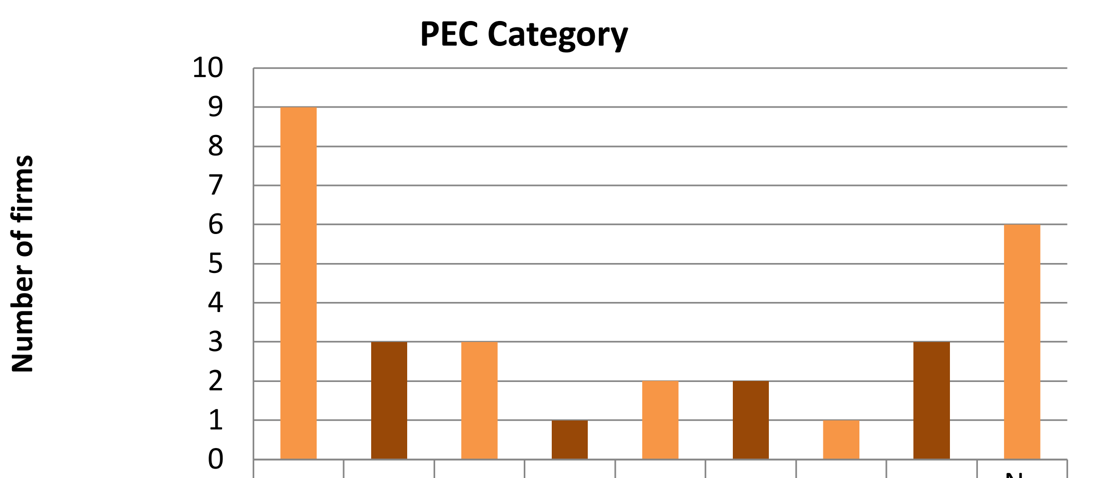
Results showed that the data was not normally distributed and thus further analysis was carried out in MS Excel 2010 for the non-parametric data. Detailed results are attached in **Appendix VA & VB**.

4.3 Characteristics of Respondent's firms

Thirty (30) contractors on the building projects were approached in this research and thirty eight (38) valid responses were collected through different contractor staff. The purpose of the first part of the questionnaire was to investigate the characteristics of the respondents and their firms. The aim of doing so was to highlight that the data is collected from respondents with technical qualification and experience and also to show that respondents belonged to well reputed organizations.

4.3.1 Registration Criterion of firms

From the thirty contracting firms, nine (9) were C-A contractors (No-Limit contractors), three (3) were C-B contractors (Construction cost limit up to 3000 million), three (3) were C-1 contractors (Construction cost limit up to1800 million), one (1) was C-2 contractor (Construction cost limit up to 800 million), two (2) were C-3 contractors (Construction cost limit up to 400 million), two (2) were C-4 contractors (Construction cost limit up to 150 million), one (1) was C-5 contractors (Construction cost limit up to 50 million), three (3) were C-6 contractors (Construction cost limit up to 20 million) and six (6) were the contractors that were not registered with Pakistan Engineering Council but working in the field of building constructions for many years as shown in Figure 4.2.



	C-A	C-B	C-1	C-2	C-3	C-4	C-5	C-6	No Registration
PEC Category	9	3	3	1	2	2	1	3	6

Figure 4.2 Distribution of respondents based on PEC category

4.3.2 Experience of the contracting firms

The contracting firms were working in the field of building construction for many years. Fifteen (15) firms had an experience of more than ‘15’ years in the building projects, four (4) firms had an experience of ‘10 to 15’ years, seven (7) firms had an experience of ‘05 to 10’ years, and four (4) firms had an experience of

‘0 to 5’ years as shown in the Figure 4.3. The complete list of respondents with their designation and experience in the construction industry is provided in the **Appendix III.**

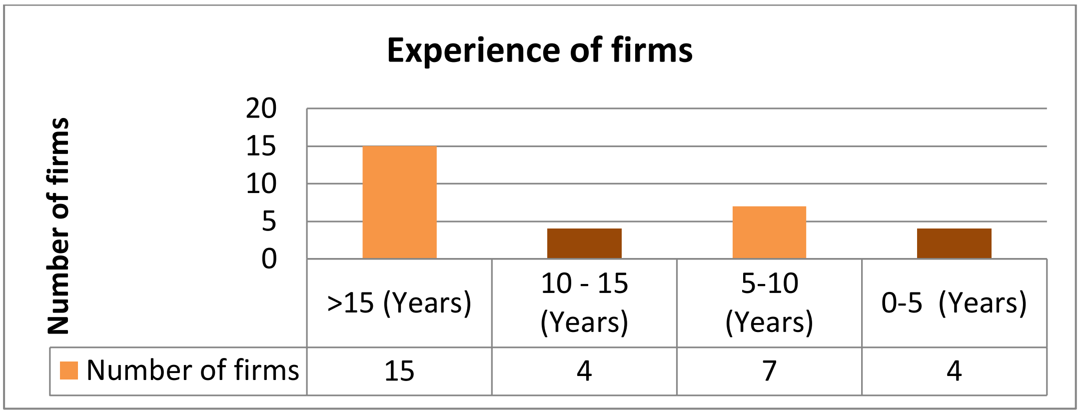


Figure 4.3 Experience of contracting firms

4.3.3 Type of building project

The respondents were working on different type of building projects. Twelve (12) out of thirty eight (38) respondents were working on ‘commercial buildings’ three (3) were working on ‘Public health buildings’, five (5) were working on ‘Private housing’, four (4) were working on ‘Public housing’, four (4) were working on ‘Industrial’, four (4) were working on ‘Buildings in Infrastructures’, four (4) were working on ‘Schools’ and two (2) were working on construction of ‘Mosques’ as shown in the Figure 4.4.

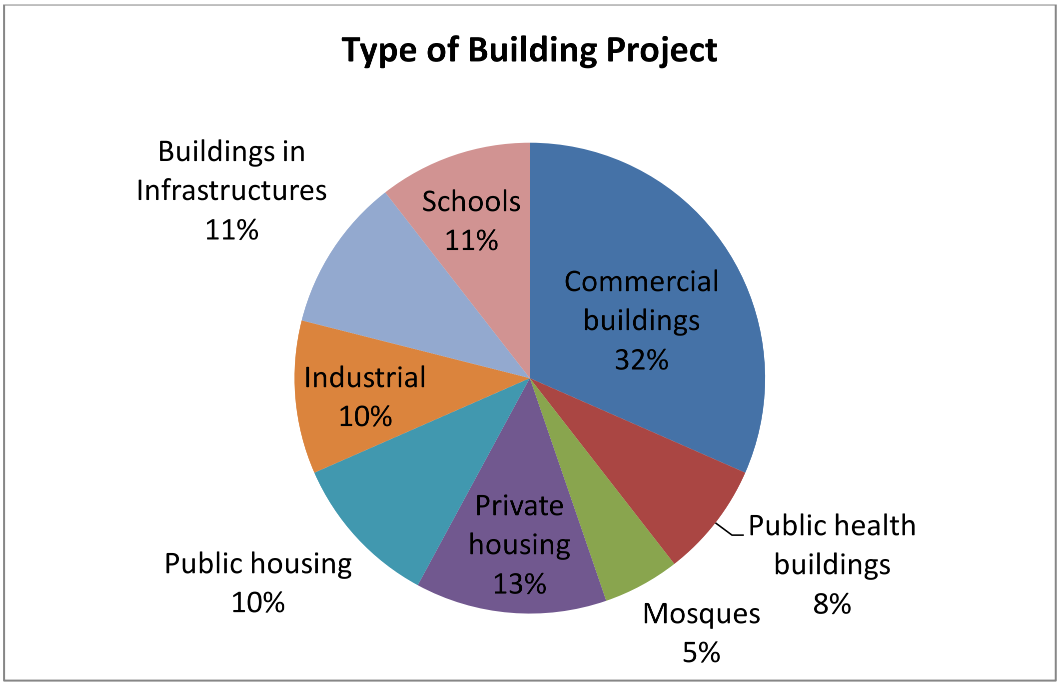


Figure 4.4 Type of building project

4.3.4 Designation of respondents

Data was mainly collected by contractor's staff working on site or directly involved and concern with material wastage. Six (6) respondents were 'Quantity Surveyors', seven (7) were 'Project Managers', Eleven (11) were 'Site / Planning Engineers', two (2) were 'General Managers', nine (9) were 'Proprietor/ Contractors', and three (3) were 'Construction Managers' as shown in Figure 4.5

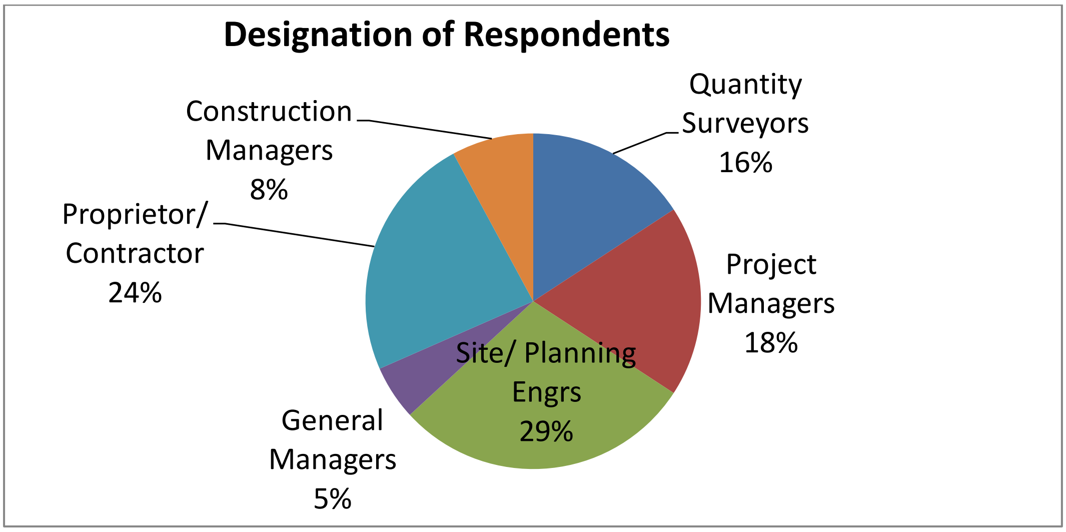


Figure 4.5 Designation of respondents

4.3.5 Experience of respondents

Data was mainly collected by experienced contractor's staff. Eight (8) out of 38 respondents were having experience of 'more than 15' years, twelve (12) were having experience of '10 to 15' years, five (5) were having experience of '5 to 10' years and thirteen (13) were having experience of '0 to 5' years as shown in Figure 4.6

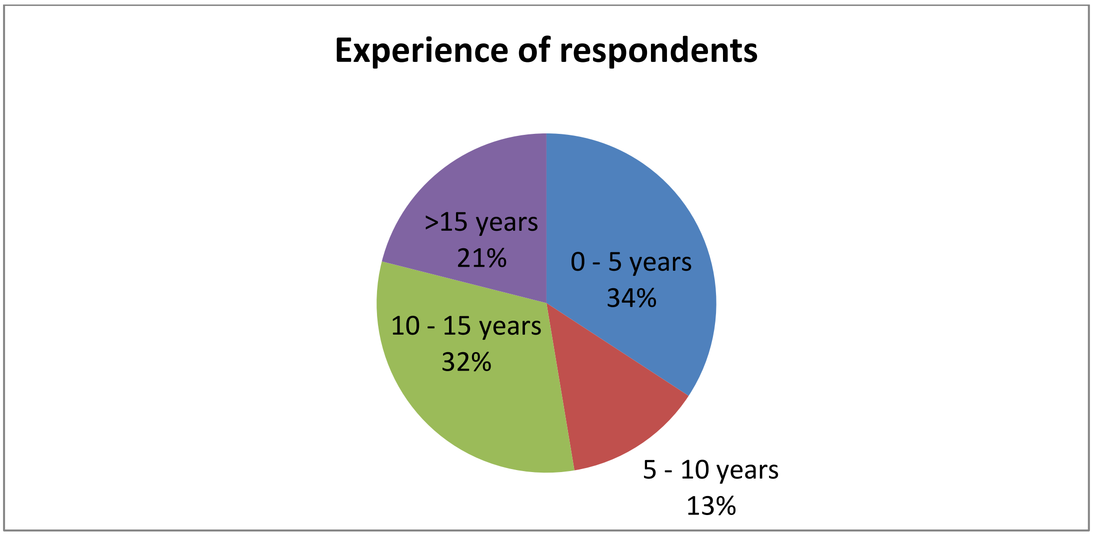


Figure 4.6 Experience of respondents

4.3.6 Qualification of respondents

Data was mainly collected from the graduate engineers; however others were also considered who have good knowledge of wastage. Twenty three (23) out of thirty eight (38) respondents were 'Graduate engineers', three (3) respondents were having qualification of 'Masters', nine (9) respondents were having qualification of Diploma (DAE) and three (3) respondents were those who did not have formal education but working in the field of construction from many years as shown in the Figure 4.7.

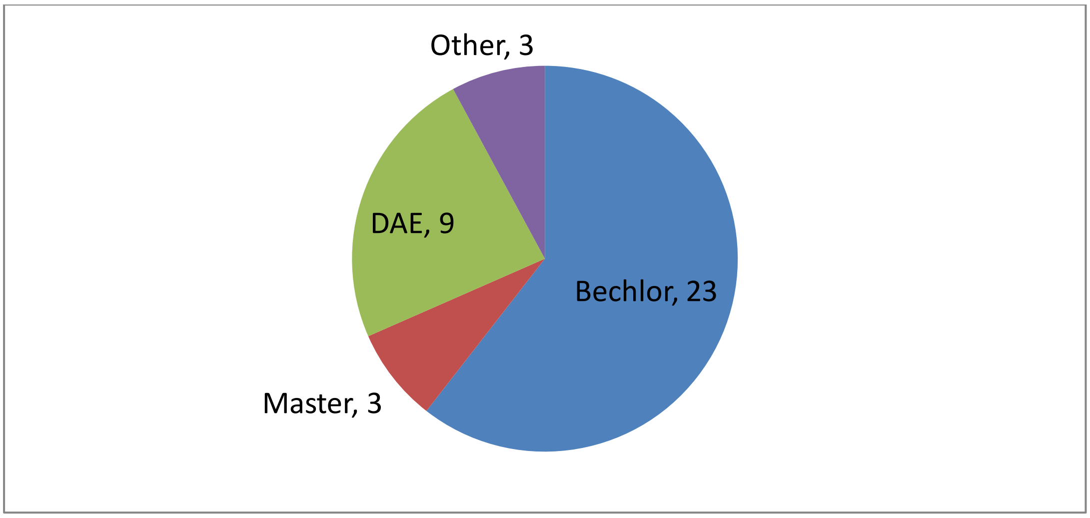


Figure 4.7 Qualification of respondents

4.4 Wastage of Materials

In data collection the emphasis was given on twenty six (26) important materials that are being used in most of the building construction projects in Pakistan. Data was collected from thirty eight (38) construction sites. Competent technical people were fully involved in the data collection. Direct observations were also made during the execution of interviews and records of materials delivered at site and actually used were noted. Data was collected from different construction sites at different stages of execution. Some buildings were completed, in some buildings super structure was in progress, in some buildings finishing work was in progress and some buildings were also visited in which foundation work was carried out only. Data after detailed observations and interviews was transferred into MS Excel 2010 for descriptive analysis. The result of answering the interviews by the respondents on percentages of waste during construction operations was listed and it significant variations were observed for some materials such as bricks (2-12%), wood (2-15%), and PCC (1-10%). The diverse range of material losses is may be due to the reason that applied technology and performance varies from contractor to contractor. This study revealed that bricks had uppermost portion of wastage with 6.82% followed by tiles with wastage of 6.68% and plaster with wastage of 6.63%. On the other hand anti termites, water proofers and diesel were found to be the materials with least wastage of 2.92%, 2.61% and 2.34% accordingly. Mean values and relative importance for all the materials were derived by using MS Excel 2010. Following materials were ranked according to their mean % wastage as shown in Table 4.3.

Table 4.3 Results for wastage of materials

Serial #	Materials	% Waste	Rank
1	Bricks	6.82%	1
2	Tiles	6.68%	2
3	Plaster from mortar	6.63%	3
4	Wood	6.41%	4
5	Paints	6.00%	5
6	Ceramics	5.51%	6
7	Wires and cables	5.34%	7
8	Reinforced cement concrete	5.16%	8
9	Thermo pore sheets	5.16%	9
10	Plastic pipes	4.95%	10
11	Glass	4.92%	11
12	Polythene sheets	4.89%	12
13	Steel rebar's	4.76%	13
14	Aluminum	4.74%	14
15	Plain cement concrete	4.39%	15
16	Marble	4.37%	16
17	Ceiling boards	4.32%	17
18	Bitumen	4.29%	18
19	Natural Rocks	4.14%	19

Serial #	Materials	% Waste	Rank
20	Steel railings	4.00%	20
21	Metals	3.61%	21
22	Mild steel GI pipes	3.57%	22
23	Mild steel sections	3.41%	23
24	Anti-termites	2.92%	24
25	Water proofers	2.61%	25
26	Diesel	2.34%	26

Few finding in this research tends to support the results of earlier studies that plaster is most wasteful material on construction sites (Formoso et al. 2002). Babatunde and Solomon (2012) stated that bricks are the most wasteful material while performing quantitative assessment of transit waste on sites. There were also few findings that were not supporting the previous studies as in Pakistan construction industry contractors overall ranked the wastage of tiles at third position while in other studies tiles are not that much prominent material for wastage.

4.5 Factors Affecting the Wastage

Different factors which were short listed after detailed literature review and expert opinion were included in the interview. Detailed analysis was carried out after transferring the data into MS Excel 2010 and different findings were observed. It was relieved that most prominent factor of wastage was the 'Management' with the mean ranked value of 3.78 followed by 'Material handling (3.51)', 'Operation (3.48)', 'Design (3.38)', 'Procurement (3.36)' and 'Other' with mean value of 3.17 as shown in Figure 4.8.

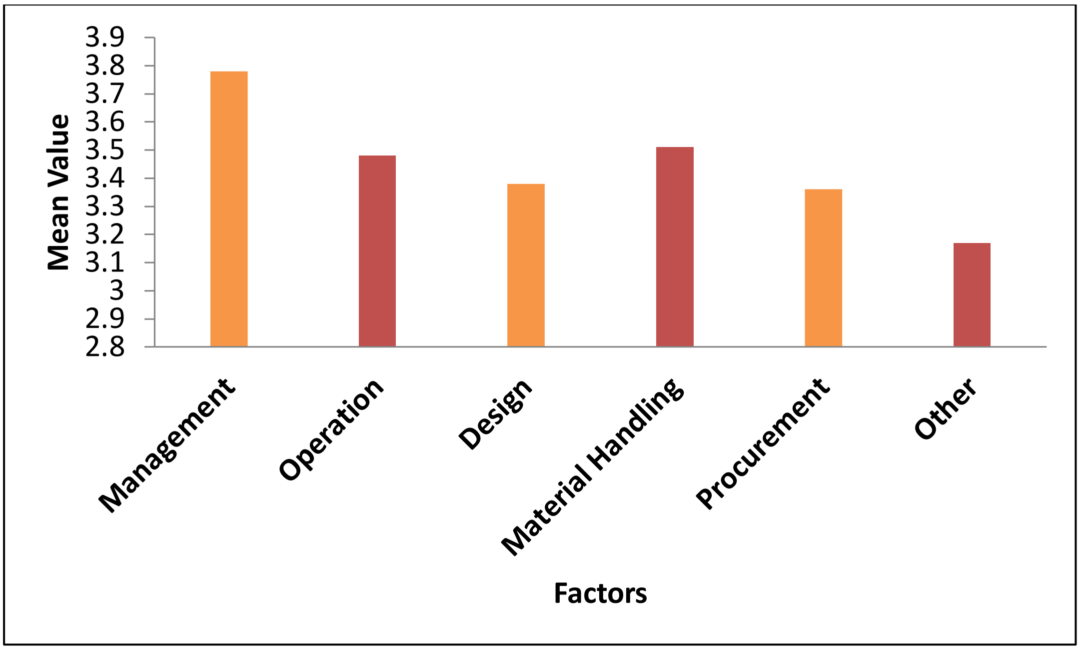


Figure 4.8 Factors of waste

4.6 Causes of Material Wastage

A detailed breakdown of factors was required for understanding of the root causes of wastage. So factors were further sub divided into different causes which were ranked on the likert scale according to their effect on wastage. Data after collection was transferred into MS Excel 2010 for further analysis. All the causes were ranked after finding their mean values for effect on wastage. It was observed that most contributing cause of material wastage is 'improper worker's skill' with mean value of 4.08 followed by 'poor supervision' with mean value of 4 and 'lack of management' with mean value of 3.81. The causes which contribute relatively less towards material wastage are 'theft/ vandalism' and 'accidents' with mean value of 2.66 and 2.74 respectively as shown in Table 4.4

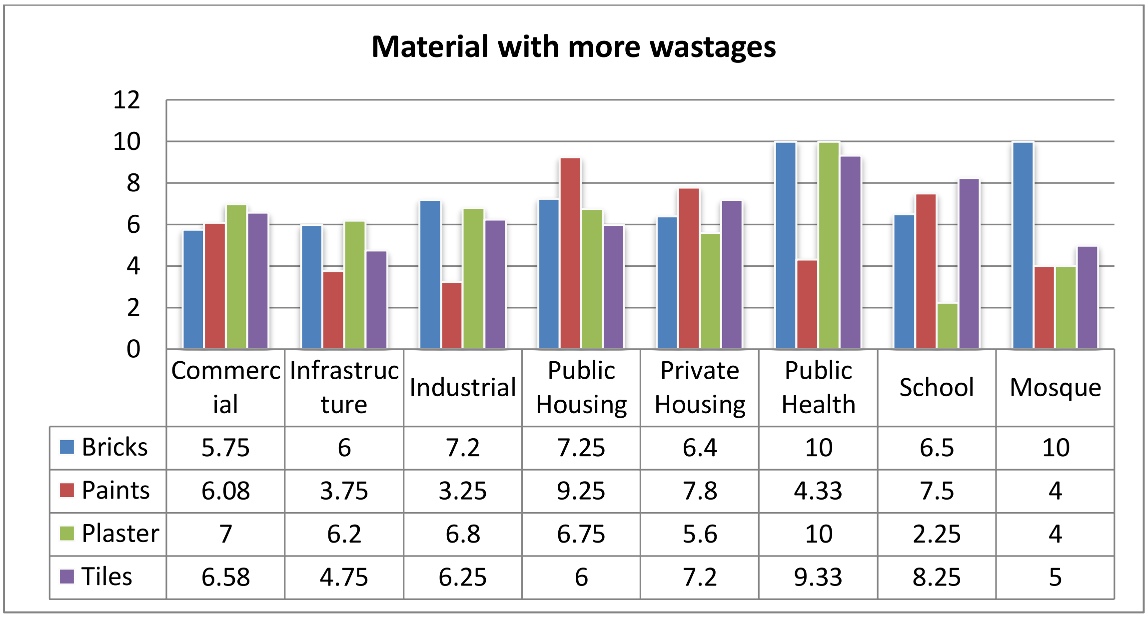
Table 4.4 Results for causes of wastage

Sr No.	Factors	Causes	Mean Value	Rank
1	Management	Poor Supervision	4	2
2		Lack of management	3.81	3
3		Lack of waste reduction plan	3.71	5
4		Absence of site waste manager	3.61	10
5	Operation	Rework	3.47	11
6		Weather	3.31	14
7		Accidents	2.74	18
8		Improper worker's skill	4.08	1
9		Equipment malfunction	3.79	4
10	Design	Changes in design	3.66	9
11		Error in contract documents	3.10	17
12	Handling	Improper packaging	3.45	12
13		Storage	3.71	6
14		Cutting	3.66	8
15		Transportation	3.23	16
16	Procurement	Ordering error	3.45	13
17		Supply error	3.26	15
18	Other	Poor quality control	3.68	7
19		Theft/ Vandalism	2.66	19

Few finding in this research tends to support the results of previous studies that ‘Poor supervision’ and ‘Improper worker’s skill’ are most prominent causes towards material wastage (John and Itodo, 2013). On the other hand ‘theft/ vandalism’ was ranked last by contractors in Pakistan construction industry, which was one of the top causes of wastage in many other studies.

4.7 Material Wastage in Different Building Projects

This study identified that four most wasteful materials in all types of building project were bricks, paints, plaster and tiles. These materials were overall ranked at top among all other building materials. A comparative study of top ranked materials was done on the basis of data collected and following trends were observed as shown in Figure 4.9



	Commercial	Infrastructure	Industrial	Public Housing	Private Housing	Public Health	School	Mosque
Bricks	5.75	6	7.2	7.25	6.4	10	6.5	10
Paints	6.08	3.75	3.25	9.25	7.8	4.33	7.5	4
Plaster	7	6.2	6.8	6.75	5.6	10	2.25	4
Tiles	6.58	4.75	6.25	6	7.2	9.33	8.25	5

Figure 4.9 Materials with more wastage

4.7.1 Wastage of Bricks

It was observed that the bricks were the most wasteful material in the projects of 'Public Health' and 'Mosque' which may be due to the reason that mosque structure have more curves and domes like elements which cause more cutting of bricks while placing them in curved manners. Similarly in Public health buildings partitions and walls are large in number so produce more wastage of bricks.

4.7.2 Wastage of Paints

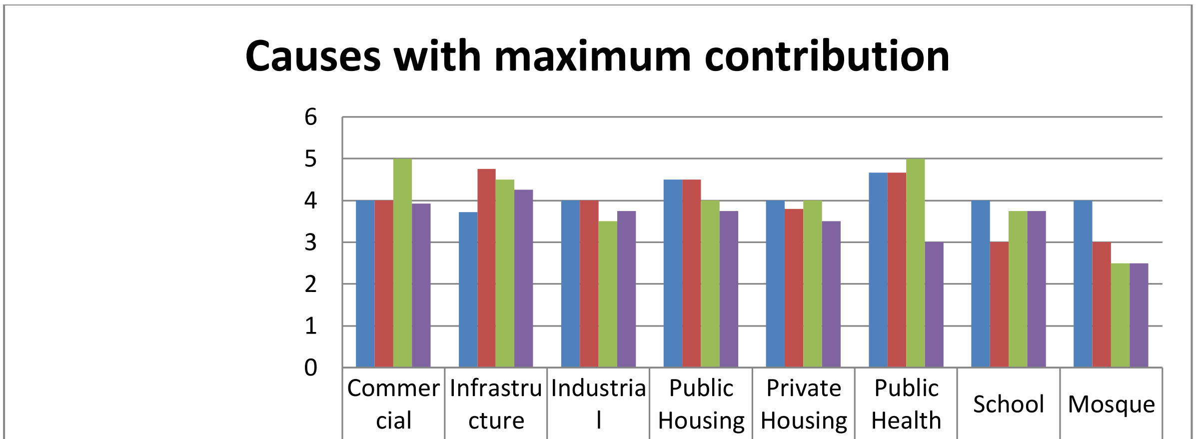
It was observed paints were most wasteful in 'Private and Public Housing' projects due to the reason that housing construction usually has more color schemes for better architectural look of the building. Application of different types of paints is a normal practice in housing construction. Type of paints also varies in different elements of building as on exterior surfaces weather sheet is normally used, distemper is used at inner side of the building and enamel is used in kitchen etc.

4.7.3 Wastage of Plaster and tiles

It was also observed that plaster and tiles were most wasteful materials in construction of 'Public health' projects as hospitals and care centers are usually the major projects under public health and these account for large tiling and masonry works so cause more wastage of plaster and tiling works

4.8 Causes of Wastage in Different Building Construction Projects

A comparative study of top ranked causes was also done on basis of data collected. The four top ranked causes that were identified as the reason of wastage by most of the contractors in construction industry in Pakistan were 'Improper worker's skill', 'Poor supervision', 'Equipment malfunction' and the 'Lack of management'. A comparative analysis is shown in the Figure 4.10



	Commercial	Infrastructure	Industrial	Public Housing	Private Housing	Public Health	School	Mosque
Improper worker' skill	4	3.72	4	4.5	4	4.67	4	4
Poor supervision	4	4.75	4	4.5	3.8	4.67	3	3
Equipment malfunction	5	4.5	3.5	4	4	5	3.75	2.5
Lack of management	3.92	4.25	3.75	3.75	3.5	3	3.75	2.5

Figure 4.10 Causes with maximum contribution

4.8.1 Improper worker's skill

It was observed that 'improper worker's skill' were the most contributing causes towards wastage in 'Public housing' and 'Public health' projects which may be due to the reason that these projects usually account for more architectural and diverse works and masons hired were not fully familiar with that type of works. Masons for plaster work when go for tile work they produce more wastage.

4.8.2 Equipment malfunction

Equipment malfunction is the major cause towards wastage in projects of ‘Public health’ and ‘Infra structure’ which may be due to the reason that these projects have usually larger work scope and small tools and equipment’s were not designed particularly for each type of work.

4.8.3 Poor supervision and lack of management

In projects of infrastructures major causes of waste were ‘poor supervision’ and ‘lack of management’ as these projects are widely spread and have more quantum of works so wastage occurs mostly due to poor supervision and lack of management

4.9 Summary

In this chapter, detailed statistical, descriptive and comparative analysis has been offered. Following the already defined strategy for data analysis, the detailed analysis was carried out includes: reliability test, normality test, descriptive statistics and comparative statistics. Results of data collected have been presented and discussions have been made. In the next chapter conclusions and recommendations are developed on bases of results of data analysis.

Chapter 5

Conclusions and Recommendations

5.1 Introduction

This chapter closes the study with final remarks. The initial research objectives of the study are reviewed and conclusions are drawn on basis of research findings. As part of an academic endeavor, recommendations for control and improvement are given.

5.2 Review of research objectives

The objectives of this study were

1. To articulate from literature and records of previous results, material waste generation in building construction projects.
2. To investigate the quantity of material waste generation of some selected materials
3. To identify the causes of material waste generation
4. To suggest practical recommendations and implementable strategy to reduce material wastage on construction sites.

The 1st objective was met by doing detailed literature review for the material wastage in building projects worldwide as well as in Pakistan. Unfortunately no significant work has already been carried out in Pakistan on material wastage. Research on magnitude of wastage and causes of waste in different projects across the world was studied in detail to understand the wastage of materials in building projects. Second and third objectives were met by collecting data from thirty eight (38) respondents working on eight (8) different types of building projects by personally interviewing and then analyzing the data using MS- EXCEL 2010 and SPSS-18. Fourth objective was met by identifying the root causes of wastage and suggesting solutions and by providing recommendations to reduce the wastage in different types of building projects in Pakistan.

5.3 Conclusions

Following conclusions are drawn based on data analysis:

a) The results obtained from the analysis of data as discussed in Chapter 4 indicate that, on the basis of overall ranking, the top five material wastages were bricks, tiles, plaster from mortar, wood and paints. The materials with least wastage were diesel, water proofers and anti-termites.

b) It was revealed that prominent factors of wastage were management, material handling, operation and design. The most contributing root causes were improper worker's skill, poor supervision, lack of management, absence of site waste manager, and the reworks. The least contributing causes were supply error, poor quality control and the theft/ vandalism.

c) It was cocluded that material type and percentage wastage varies in different types of building projects as shown in Table 5.1.

Table 5.1 Materials with more wastage

Type of Building Project	Wastage of Materials			
	Bricks	**Paints**	**Plaster**	**Tiles**
Commercial	5.75%	6.08%	7%	6.58%
Infra-structure	6%	3.75%	6.2%	4.75%
Industrial	7.25%	3.25%	6.8%	6.25%
Public Housing	7.25%	9.25%	6.75%	6%
Private Housing	6.4%	7.8%	5.6%	7.2%
Public Health	10%	4.33%	10%	9.33%
School	6.5%	7.5%	2.25%	8.25%
Mosque	10%	4%	4%	5%

d) It was observed that causes effecting wastage varies in different types of building project as shown in Table 5.2.

Table 5.2 Causes with maximum contribution

Type of Building Project	Causes of Waste			
	Improper Worker's skill	**Poor Supervision**	**Equipment Malfunction**	**Lack of Management**
Commercial	4%	4%	5%	3.92%
Infra-structure	3.72%	4.75%	4.5%	4.25%
Industrial	4%	4%	3.5%	3.75%
Public Housing	4.5%	4.5%	4%	3.75%
Private Housing	4%	3.8%	4%	3.5%
Public Health	4.67%	4.67%	5%	3%
School	4%	4%	3.75%	3.75%
Mosque	4%	3%	2.5%	2.5%

e) It was further revealed that labor and masons are most responsible for waste generation followed by engineers, petty contractors, supervisors/ foremen and procurement team.

f) It was also observed that clients/ consultants also have very great influence on wastage as improper design and specifications, change orders and rework are countable causes of material wastage

5.4 Recommendations

Some recommendations are derived based on the research discoveries while some are provided by the respondents. These can be helpful to reduce material wastage in building construction projects and will enhance the efficiency of building construction industry of Pakistan. Following are the recommendations inferred from the data and suggested by the respondents:

a). Hiring skilled laborers and masons can reduce the wastage.

b). Training of hired labor and mason can significantly reduce the wastage.

c). Hiring a full time waste manager on large projects can help efficiently minimize the wastage of materials.

d). Using proper formwork is very essential to reduce loss of material.

e). Implementing a waste reduction plan from start of the project.

f). Preparing bill of materials at start of the project and monitoring it throughout the execution.

g). Finalize the project design before start of work and to avoid reworks.

h). Using proper tools and equipment.

i). Arranging proper storage place.

j). Full awareness of material’s size and shape availability in market.

k.) Arrangement of proper security at site.

5.5 Recommendations for Future Research

a). Similar type of research can be carried out for road projects and other construction projects to find the magnitude of material wastage and the causes contributing towards wastage.

b). Research can also be carried out separately to estimate the amount of unavoidable material wastage.

c). Detailed case study of 2 to 3 building projects can be done.

5.6 Summary

It is anticipated on the basis of conclusions and recommendations that additional research within Pakistan could disclose more potential statistics to minimize the loss of material due to wastage in building projects.

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Appendix I

(Covering Letter)

SCHOOL OF CIVIL & ENVIRONMENTAL ENGINEERING (SCEE)

Dear Sir,

It is believed that construction industry is the largest user of materials. An enormous amount of material wastage in building construction projects have been recorded all over the world. This research is important for project stakeholders to execute safe and economic construction.

In partial fulfillment of the requirements for the degree of Master of Science in Construction, Engineering & Management from NUST, H-12, Islamabad, the undersigned intends to conduct survey on quantifying material wastage and ranking the probable cause of wastage for development of better economic framework in building construction projects in Pakistan. As a representative of the client/consultant/contractor, you are kindly requested to take few minutes from your valuable time to add your input to quantify and identify the likely cause of material wastage in building construction.

All the information provided in this regard will only be used for academic purposes and kept confidential.

Thanks for your support and cooperation in advance.

Yours Sincerely,

Muhammad Qasim

Post Graduate Student-
Construction Engineering & Management

Contact: 0321-5648000
Email: qasim.nust@gmail.com

Appendix II

Interview Performa

SECTION A

1. Name:____
2. Email:____
3. Contact Number:____
4. Name of Project: ____
5. Name of Contractor:____
6. Contractor is working since (Years):

   a) 0 to 5
   b) 5 to 10 c) 10 to 15
   d) >15

7. PEC Category of Contractor: ____________________________
8. Type of Building Project:

   a) Infra structure b) School

   c) Public Housing d) Public Health

   e) Industrial f)
   Commercial Project g) Mosque
   h) Private Housing

   I) Other (Please Specify) :

9. Your Designation: ____________________________________
10. Your Experience in years:

    a) 0 to 5
    b) 5 to 10 c) 10 to 15
    d) >15

11. Qualification:

    a) Bachelor b) Masters
    c) PhD d) DAE
    e) Other

SECTION B

Name of Material	Percentage of Wastage
Bricks	
Wood	
Steel Rebar’s	
Plaster from Mortar	
Plain Cement Concrete	
Reinforced Cement Concrete	
Glass	
Aluminum	
Plastic Pipes	
Polythene Sheets	
Bitumen	
Wires and Cables	
Paints	
Tiles	
Ceramics	
Marble	
Natural Rocks	
Ceiling Boards	
Metals	
Steel Railings	
Mild Steel Sections	
Mild Steel/ GI Pipes	
Thermo pore Sheets	
Anti-Termites	
Water Proofers	
Diesel	
Others: please specify	

Rank the factors as contribute towards wastage on 1 to 5 Likert Scale based on your experience:

where 1= very low, 2= low, 3= medium, 4= high, 5= v. high (**Tick only in one**)

Cause	Factors	V. low	low	Med	High	V. High
Management	1. Poor supervision 2. Lack of management 3. Lack of waste reduction plan 4. Absence of site waste manager					
Operation	1. Rework 2. Weather 3. Accidents 4. Improper Workers' skills 5. Equipment malfunction					
Design	1. Changes in design 2. Error in contract documents					
Material Handling	1. Improper packaging, 2. Storage 3. Cutting 4. Transportation					
Procurement	1. Ordering error 2. Supply error					
Others	1. Poor quality control 2. Theft/ Vandalism					

According to your opinion:

1. What measures should be taken to reduce waste?

2. Who is the most responsible for waste generation?

3. To what extent client and consultant behavior effect wastage?

Appendix III

List of Interviewees

List of Respondents

ID	Name	Project	Name of Contractor	PEC Category	Designation	Qualification
1	Fazail Hassan	Audit House Islamabad	Perk Engineers & Contractors	CA	Assistant Q.S	DAE
2	Muhammad Ashraf	Residential Complex at Indian High Commission	Guarantee Engineers	CA	Site Engineer	Masters
3	Muhammad Sadiq	Service Area Kalar Kahar	Haji Noor Engineering	C1	Q.S	DAE
4	Saqib Ilyas	BIAFO Islamabad	Kestral SPD Pvt Ltd	CB	Site Engineer	Bachelor
5	Muhammad Atif Khalil	Grand Hyatt Islamabad	Guarantee Engineers	CA	Site Engineer	Bachelor
6	Muhammad Asim Masud	Rehablitation Center Building at Jinnah Berrage	Descon Engineering	CA	Planning Incharge	Bachelor
7	Muhammad Naveed	FFC Head Quarter	Guarantee Engineers	CA	Site Engineer	DAE

List of Respondents						
8	Muratib Ali	Saudi Defence Office Islamabad	M/S Expertise Pvt Ltd	C1	Q.S	DAE
9	Waqas Athar	OEC Tower Project Islamabad	Builders Associate	CA	Project Engineer	Bachelor
10	Ijaz Iqbal	Mari Gas Head Office Extension Islamabad	EKL Pvt Ltd	CB	Q.S	DAE
11	Muhammad Mumtaz	EOBI House Islamabad	Builders Associate	CA	CM	Bachelor
12	Ali Abbas	Construction of multiplex Cinema Islamabad	Skyways Pvt Ltd	CA	Site Engineer	Bachelor
13	Syed Imran Haider	SSS NUST	Izhar Constructors	CA	Project Manager	Bachelor
14	Azhar Naveed Bajwa	Construction of Outfall chennel center building Chashma	EKL Pvt Ltd	CB	General Manager	DAE

List of Respondents						
15	Muhammad Umar	Construction of central building at lubricating plants Lahore	EKL Pvt Ltd	CB	Q.S	Bachelor
16	Arslan Anjum	Rehablitation Center Building at Jinnah Berrage	Descon Engineering	CA	Site Engineer	Bachelor
17	Muneer Ahmad	Extension of Fatima Jinnah Woman University Rawalpindi	Kestral SPD Pvt Ltd	CB	Senior QS	Bachelor
18	Naveed Fakhar	Construction of rooms ag GC Faisalabad	M& N Constructors	C6	Project Manager	Bachelor
19	Muhammad Sarwar	Construction of 10 Marla House at Commercial Market RWP	Muhammad Sarwar Chaddar		Owner	Bachelor

List of Respondents						
20	Adil Hafeez	Construction of rooms ag GBELS Sargodha	Hafeez Construction	C5	Director	Masters
21	Muhammad Irfan Ali	B-Type 10 Number Gracey lane rwp	AICON Associates	C6	Contractor	Masters
22	Hassan Ali Qureshi	C-Type 10 Number Gracey Lane rwp	Alhasan Constructions		Contractor	Others
23	Saif-ur-Rehman	C-C-H	Malik Abdul Hanan	C1	CM	Bachelor
24	Rashid Tameez	Water Treatment Area in I 10 Isd	Highrise Construction	C2	PM	Bachelor
25	Murtaza Ahmad	Construction of One Kanal House at Wapda Town, Gujranwala	Murtaza Abbasi		Contractor	Others

List of Respondents						
26	Tayyab Ahmad	Construction of Messing Facility at IQRA Uni Rwp	Usmani Associates	C3	Senior Engineer	Bachelor
27	Ali Javed	Construction of Multi Purpose Hall in PIMS G8 Islamabad	Ali Javed Associates		Director	Bachelor
28	Waleed Iftikhar	10 Marla House in PWD Rwp	Waleed Babar Constructors		Owner	Others
29	Jamal Khan	Extension of CPSB Building G8 Isd	Ali Noor Engineers	CB	Site Engineer	Bachelor
30	Zeeshan Ahmad	Extension of NADRA Building Gujranwala	SHS Bros	C3	Project Manager	DAE
31	Muhammad Iqbal	Construction of Askari Bank Branch in G-11	OMD Builders	C4	Project Manager	DAE

List of Respondents						
		Islamabad				
32	Ch. Zohaib Khalid	Coca Cola Plant and building construction in RYK	Aljadeed Builders	C6	Owner	Bachelor
33	Amjad Hussain	Construction of Schools in Muslim Bagh Balochistan	Kestral SPD Pvt Ltd	CB	Project Manager	Bachelor
34	Ali Ajwad Niazi	Bank of Punjab Building Extension Lahore	Arc Tech Associates	C4	Project Manager	Bachelor
35	Kashif Bashir	Power House Head Baloki	SKB	CA	Site Engineer	Bachelor
36	Zafar Iqbal	Construction of three houses of 1 Kanal in PWD Rwp	Zafar Iqbal		Owner	DAE

List of Respondents						
37	Ahad Waseem Butt	Construction of Parliament Lodges Islamabad	Habib Rafique Limited	CA	Site Engineer	Bachelor
38	Sajid Rasheed	Construction od Driver and Avis rooms in World Bank Building	LAC	CA	General Manager	Bachelor

Appendix IV A

Reliability Test Results of

‘Causes of wastages’

RELIABILITY

/VARIABLES=Poor_Supervision Lack_of_Management Lack_of_waste_reduction_Plan Absence_of_Site_Waste_manager Rework Weather Accidents Improper_workers_Skill Equipment_malfunction Change_in_Design Error_in_contract_Documents Improper_packaging Storage

Cutting Transportation Ordering_Error Supply_Error Poor_Quality_Control Theft

/SCALE('ALL VARIABLES') ALL

/MODEL=ALPHA

/STATISTICS=DESCRIPTIVE.

Reliability

Notes

Output Created		15-Dec-2014 18:01:57
Comments		
Input	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	38
	Matrix Input	
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.

	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=Poor_Supervision Lack_of_Management Lack_of_waste_reduction_Plan Absence_of_Site_Waste_manager Rework Weather Accidents Improper_workers_Skill Equipment_malfunction Change_in_Design Error_in_contract_Documents Improper_packaging Storage Cutting Transportation Ordering_Error Supply_Error Poor_Quality_Control Theft /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE.
Resources	Processor Time	00:00:00.031
	Elapsed Time	00:00:00.029

[DataSet0]

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	38	100.0
	Excluded[a]	0	.0
	Total	38	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.820	19

Item Statistics

	Mean	Std. Deviation	N
Poor_Supervision	4.0000	.98639	38

Lack_of_Management	3.8158	.98242	38
Lack_of_waste_reduction_Plan	3.7105	1.06309	38
Absence_of_Site_Waste_manager	3.6053	1.17495	38
Rework	3.4737	1.05873	38
Weather	3.3158	1.04248	38
Accidents	2.7368	1.15511	38
Improper_workers_Skill	4.0789	.88169	38
Equipment_malfunction	3.7895	1.09441	38
Change_in_Design	3.6579	1.07241	38
Error_in_contract_Documents	3.1053	1.03426	38
Improper_packaging	3.4474	.97807	38
Storage	3.7105	.86705	38
Cutting	3.6579	.78072	38
Transportation	3.2368	1.02494	38
Ordering_Error	3.4474	1.08297	38
Supply_Error	3.2632	.94966	38
Poor_Quality_Control	3.6842	.93304	38
Theft	2.6579	.99394	38

Appendix IV B

Reliability Test Results of

‘Wastages of Materials’

```
RELIABILITY
  /VARIABLES=Brick Wood Steel_Rebars Plaster_from_Mortar PCC RCC Glass Aluminium
Plastic_pipes Polythene_Sheets Bitumen Wires_and_Cables Paint Tiles Ceramic Marble
Natural_Rock Ceiling_boards Metal Steel_railings Thermopore_Sheet Anti_termits
Water_proofer Diesel
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE.
```

Reliability

Notes

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Comments		
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	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	38
	Matrix Input	
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=Brick Wood Steel_Rebars Plaster_from_Mortar PCC RCC Glass Aluminium Plastic_pipes Polythene_Sheets Bitumen Wires_and_Cables Paint Tiles Ceramic Marble Natural_Rock Ceiling_boards Metal Steel_railings Thermopore_Sheet Anti_termits Water_proofer Diesel /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE.
Resources	Processor Time	00:00:00.062
	Elapsed Time	00:00:00.064

[DataSet0]

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	36	94.7
	Excluded[a]	2	5.3
	Total	38	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.828	24

Item Statistics

	Mean	Std. Deviation	N
Brick	.0689	.02649	36
Wood	.0664	.03081	36
Steel_Rebars	.0475	.02222	36
Plaster_from_Mortar	.0669	.02816	36
PCC	.0442	.02579	36
RCC	.0522	.03432	36
Glass	.0467	.03431	36
Aluminium	.0467	.02888	36
Plastic_pipes	.0486	.02929	36
Polythene_Sheets	.0478	.03099	36
Bitumen	.0431	.02516	36
Wires_and_Cables	.0536	.03449	36
Paint	.0608	.03434	36
Tiles	.0672	.02972	36
Ceramic	.0556	.02348	36
Marble	.0433	.01971	36
Natural_Rock	.0419	.03454	36
Ceiling_boards	.0444	.02853	36
Metal	.0358	.02170	36
Steel_railings	.0408	.02781	36
Thermopore_Sheet	.0536	.03788	36
Anti_termits	.0297	.02091	36

Water_proofer	.0253	.01383	36
Diesel	.0233	.01171	36

Appendix V A

Normality Test Results of

‘Causes of wastages’

```
GET

  FILE='C:\Users\Husnain\Desktop\ch 4\SPSS\Reliablity
Causes\Untitled1.sav'.

DATASET NAME DataSet1 WINDOW=FRONT.

EXAMINE VARIABLES=Poor_Supervision Lack_of_Management
Lack_of_waste_reduction_Plan Absence_of_Site_Waste_manager Rework
Weather Accidents Improper_workers_Skill Equipment_malfunction
Change_in_Design Error_in_contract_Documents Improper_packaging
Storage

Cutting Transportation Ordering_Error Supply_Error
Poor_Quality_Control Theft

  /PLOT NPPLOT

  /STATISTICS DESCRIPTIVES

  /CINTERVAL 95

  /MISSING LISTWISE

  /NOTOTAL.
```

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Poor_Supervision	.239	38	.000	.813	38	.000
Lack_of_Management	.285	38	.000	.855	38	.000

Lack_of_waste_reduction_Plan	.186	38	.002	.864	38	.000
Absence_of_Site_Waste_manager	.237	38	.000	.874	38	.001
Rework	.217	38	.000	.899	38	.002
Weather	.218	38	.000	.906	38	.004
Accidents	.173	38	.006	.915	38	.007
Improper_workers_Skill	.247	38	.000	.825	38	.000
Equipment_malfunction	.208	38	.000	.874	38	.001
Change_in_Design	.204	38	.000	.866	38	.000
Error_in_contract_Documents	.201	38	.000	.901	38	.003
Improper_packaging	.240	38	.000	.877	38	.001
Storage	.241	38	.000	.860	38	.000
Cutting	.327	38	.000	.795	38	.000
Transportation	.245	38	.000	.871	38	.000
Ordering_Error	.187	38	.002	.903	38	.003
Supply_Error	.255	38	.000	.824	38	.000
Poor_Quality_Control	.211	38	.000	.879	38	.001
Theft	.266	38	.000	.886	38	.001

a. Lilliefors Significance Correction

Appendix V B

Normality Test Results of

‘Wastages of Materials’

```
GET

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Materials\Reliability Materials.sav'.

DATASET NAME DataSet1 WINDOW=FRONT.

EXAMINE VARIABLES=Brick Wood Steel_Rebars Plaster_from_Mortar PCC RCC
Glass Aluminium Plastic_pipes Polythene_Sheets Bitumen
Wires_and_Cables Paint Tiles Ceramic Marble Natural_Rock
Ceiling_boards Metal Steel_railings MS_Sections MS_GI_Pipes

Thermopore_Sheet Anti_termits Water_proofer Diesel

  /PLOT NPPLOT

  /STATISTICS DESCRIPTIVES

  /CINTERVAL 95

  /MISSING LISTWISE

  /NOTOTAL.
```

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Brick	.130	36	.130	.955	36	.151
Wood	.138	36	.082	.945	36	.074
Steel_Rebars	.233	36	.000	.933	36	.031
Plaster_from_Mortar	.213	36	.000	.893	36	.002
PCC	.209	36	.000	.870	36	.001

RCC	.304	36	.000	.669	36	.000
Glass	.184	36	.004	.892	36	.002
Aluminium	.287	36	.000	.808	36	.000
Plastic_pipes	.203	36	.001	.876	36	.001
Polythene_Sheets	.249	36	.000	.865	36	.000
Bitumen	.225	36	.000	.854	36	.000
Wires_and_Cables	.292	36	.000	.760	36	.000
Paint	.179	36	.005	.904	36	.004
Tiles	.143	36	.061	.935	36	.035
Ceramic	.184	36	.003	.902	36	.004
Marble	.145	36	.052	.951	36	.115
Natural_Rock	.269	36	.000	.697	36	.000
Ceiling_boards	.256	36	.000	.834	36	.000
Metal	.174	36	.008	.852	36	.000
Steel_railings	.232	36	.000	.779	36	.000
MS_Sections	.198	36	.001	.863	36	.000
MS_GI_Pipes	.195	36	.001	.819	36	.000
Thermopore_Sheet	.177	36	.006	.890	36	.002
Anti_termits	.245	36	.000	.774	36	.000
Water_proofer	.204	36	.001	.849	36	.000
Diesel	.251	36	.000	.857	36	.000

a. Lilliefors Significance Correction