INVESTIGATING SITE LAYOUT PLANNING AND IMPLEMENTATION PRACTICE IN BUILDING CONSTRUCTION PROJECTS:

(The Case of Selected Towns in Southern Nations Nationalities and Peoples Regional State)

MSc. THESIS

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HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

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A THESIS SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING
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ADVISOR'S APPROVAL SHEET

This is to certify that the thesis entitled "**Investigating Site Layout Planning and Implementation Practice in Building Construction Projects: (The Case of Selected Towns in Southern Nations Nationalities and Peoples Regional State)**" submitted in partial fulfillment of the requirements for the degree of Masters of Science with specialization in construction technology and management, the Graduate Program of the School of Civil Engineering, and has been carried out by **Sisay Temesgen**; **ID. No. PGCoTM/049/08**, under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence, hereby can submit the thesis to the school.

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We, the undersigned, members of the Board of Examiners of the final Open Defense by Sisay Temesgen, have read and evaluated his thesis entitled "**Investigating Site Layout Planning and Implementation Practice in Building Construction Projects: (The Case of Selected Towns in Southern Nations Nationalities and Peoples Regional State)**", and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement for the Degree of Masters of Science in Civil Engineering (Construction Technology and Management).

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DECLARATION

Here with I declare that, this thesis prepared for the partial fulfillment of the requirements for Msc. Degree in Construction Technology and Management entitled **"Investigating Site Layout Planning and Implementation Practice in Building Construction Projects: (The Case of Selected Towns in Southern Nations Nationalities and Peoples Regional State)"** is prepared with my own effort except for secondary sources which have been acknowledged, as listed in the bibliography. I have made it independently with the close advice and guidance of my advisor.

Sisay Temesgen

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Date: _____

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LIST OF ABBREVIATIONS

BC	Building Contractor
BIM	Building Information Modeling
CAD	Computer Aided Design
ECDSWC	Ethiopian Construction Design Supervision Works and Cooperation
FIDIC	Fédération Internationale Des Ingénieurs – Conseils
GC	General Contractor
H_A	Alternative Hypothesis
H_0	Null Hypothesis
HCB	Hollow Concrete Block
MS	Mean Score
PLC	Private Limited Company
SLP	Site Layout Plan
SNNPRS	Southern Nation Nationalities People Regional States
TF	Temporary Facilities

ABSTRACT

Building projects in SNNPRS experience challenges of meeting project objectives due to an improper initial work management plan, which includes a site layout planning. Lack of proper site layout planning contributes to cost and time overruns in projects of the Region. Site layout planning utilization has implications for project safety, construction efficiency, scheduling, and budgetary performance of a project. The main purpose of this research was to investigate site layout planning and implementation practice in building construction projects in SNNPRS. The objectives of this study were identifying effects of poor site layout planning in building construction activities, identifying the key factors which contribute to achieving an effective site layout planning, and studying site layout plan utilization practice in building construction projects in SNNPRS and finally to provide practical procedure that can be referenced when developing site layout plan. The main approaches used in collecting information for the study were through a questionnaire survey, and personal observations of some major construction sites in SNNPRS in case of selected towns. The questionnaire survey was distributed to 40 respondents and a total of 36 responses were received. For the analysis of the data, statistical analysis by using mean score ranking and descriptive statistics were employed. The finding of the research indicated that the main impacts of poor site layout planning in building construction activities were a decrease in the output from labour and machinery, construction materials lost and damage, and increased travel distance on site. Availability of access and exit road to the construction site, location of plant and equipment, and positioning of temporary facilities were the major key factors which were found to be contributing to achieving an effective site layout planning. In the research, site layout plan utilization practice in building construction projects was also studied which led to development of a procedure describing an approach of site layout plan in construction projects. The procedure incorporates important aspects associated with project constraint identification, plan necessity, data acquisition, plan development, communication, implementation and enforcement, monitoring and evaluating, and documentation. This research contributes by providing information (factors) that one has to examine in order to have an effective and efficient site layout planning and also by bringing practical procedures and recommendations that can be referenced when developing site layout plan on the construction site.

Keywords:

Building projects, site layout planning, SNNPRS, temporary facilities

1. INTRODUCTION

1.1 Background

Nowadays, construction projects in SNNPRS are increasing from time to time. The Second Growth and Transformation Plan of the Ethiopian Government, rapid growth of cities, and the increasing demand of housing have tremendously increased the number of construction projects in the region. Construction of industrial parks, international hotels, different multi-purpose buildings, highways, and irrigations being undertaken can be mentioned as examples. This shows the emphasis that is given for the construction sector in the region.

Site management, in general, involves many tasks, such as site investigation before construction process starts, material delivery and procurement management, keeping better site records, keeping good site communication and high level of information flow, monitoring performance regularly, establishing a well co-ordination system among different parts, and performing a good site layout planning (Elbeltagi, 2008).

Among the important tasks of site management is the *site layout planning.* Extensive time loss and cost overruns could result in large projects, where the number of manpower, subcontractors, and equipment involved are high, if there is no effective and systematic approach to site planning. A detailed planning of the site layout and location of temporary facilities can enable the management to make considerable improvement by minimizing travel time, waiting time, and increasing worker morale by showing better and safer work environment (Elbeltagi,2008).

The fundamental to any successful project carried out is the way and manner in which the construction site layout is efficiently planned. This challenging task, as part of the construction process, usually involves identifying supporting temporary facilities that will aid in the construction process, determining their shape and size, and locating them in areas that will not affect operations within the boundaries of the construction site. Among these temporary facilities are site offices, car parking lots, warehouses, batch plants, areas for maintenance, and area for fabrication.

According to Ballard and Howell (1998), construction of building is a production in a temporary factory. They referred to the site, as the ‘factory’ in which the production of buildings takes place. It is therefore very essential, that the process for the realization of any construction project

is well thought out and coordinated to arrive at the final goal, just as any production line in a factory. This is why site layout planning becomes very important.

Site Layout Planning is a decision making process for determining the location of temporary facilities within the boundary of a construction site identifying spatial relationships and developing best alternative solutions so that the efficiency of the construction process is improved over the project life cycle (Riley and Sanvido, 1995).

According to Riley and Sanvido (1995), Temporary Facilities are defined as those facilities and areas delineated to specific tasks that support the construction process. Temporary facilities are typically not part of the permanent structure and have relatively short life spans. Examples of temporary facilities associated with construction projects include: laydown areas, unloading areas, material paths, staging areas, personnel paths, storage areas, prefabrication areas, work areas, tool and equipment areas, debris paths, hazard areas, and protected areas (Riley and Sanvido, 1995). The number, type, and size of temporary facilities depend upon the project type, scale, design philosophy, and construction execution strategy. Basically, site layout planning is a trade-off problem in which decisions must be made based on project attributes (e.g., cost and safety) without sacrificing site plan quality (Ning et al., 2011). Site layout planning is a critical part of the project planning process due to its impact on construction activities, project duration, safety, and cost.

Site Layout Plans, also known as Jobsite Layout/Logistics Plans, are documents that depict the locations of temporary facilities within the construction site boundary. Site layout Plans are similar to the construction plan and schedule in that they are long-term and consider all aspects of the construction process (Mincks and Johnston, 2010). Optimum Site Layout Plans minimizes the labor involved with movement of materials so that workers can spend the majority of their time performing productive construction tasks. Jobsites that are clean and well-organized provide a working environment that has a positive impact on work morale and in turn results in higher production during the work shift. A site layout plan should include the following aspects:

1. Jobsite space allocation – areas on the jobsite for material delivery, material storage, temporary offices, and facilities
2. Jobsite access – access to and from the jobsite and to work areas within the jobsite, including haul roads
3. Material handling – including material movement on the jobsite, both horizontally and vertically; lifting equipment, including forklifts and cranes

4. Worker transportation – personnel movement and access to the jobsite
5. Temporary facilities – temporary offices, storage facilities, dry shacks, sanitary facilities, temporary water, power, heat, telephone, and internet connections
6. Jobsite security – temporary fencing, guard dogs, security patrols, electronic alarm systems, and watchmen
7. Signage and barricades – protection of the public from construction hazards on the jobsite (Mincks and Johnston, 2010).

Khalafallah and El-Rayes (2006) ascertain that the construction site layout plays a major role in attaining the "deliverables" in the construction industry. The "deliverable" here in refer to safety, quality, cost control and time. As construction progresses, however, the site layout may need to be adjusted dynamically at various stages of the construction to accommodate operational needs especially where there is limited space.

Site layout planning is one of the important parts of site mobilization. As per FIDIC (Fédération Internationale Des Ingénieurs – Conseils) document around 10% of total project cost is paid by client for site mobilization. Site layout planning is a main resource which allocates site space for temporary facilities which require for construction. Site layout planning will improve work efficiency and minimize the material handling cost.

1.2 Statement of the Problem

A poorly planned site layout and an untidy site is one of the reasons for accidents, delay and cost overrun on the construction sites. Limited spaces, especially in urban construction sites, have been a challenge to an effective site layout planning, and a site layout which does not properly address the health and safety needs of the workforce compromises on productivity. For safe and efficient running of all construction operations, it is very important that as part of preparation and budgeting proper planning is done by management.

Site layout planning has been cited by Calis and Yuksel (2010), as a major aspect in the construction process that has been treated lightly. The attitudes of the project managers and site engineers have been that it will be done as and when it is needed. It is imperative to note that the conditions posed by the site layout plan will be the one within which all the stakeholders involved in the project will have to stay with for the whole project duration. It is in this wise, that a cautious pre-planning of the site is needed. Labour cost constitutes a significant amount of the entire cost of a project, for substantial saving to be made then the safety, health and welfare

concerns of the workforce are to be considered in the planning of the layout (Elbeltagi and Hegazy, 2002).

Site layout planning in particular, has been the most neglected aspect in the construction industry (Ning et al., 2011). In Ethiopia, currently researches were not performing as expected that focus on identifying the practice of site layout planning. Therefore it is important to identify the state of the practice and answer questions such as:

1) Stakeholders: Who gets involved in the site layout plan development process?
2) Information: What information is required to develop an effective site layout plan? Furthermore, where does this information come from?
3) Timing: When does the development of the site layout plan begin? When does the plan need to be completely developed?
4) Content: What information should be included in the site layout plan?
5) Technology: Is software used to develop site layout plans? If so, what software is used?

A visit to some construction sites reveal that most of the temporary on-site facilities, as may have been originally planned, have not been provided. In some situations the plans are not implemented to the fullest.

This brings to the fore the relevance of construction site layout planning as an important process of construction management that cannot be underestimated. It is against this background that this research seeks to investigate site layout planning and implementation practice on building construction projects in SNNPRS.

1.3 Research Questions

The following research questions were proposed:

1. What are the effects of poor site layout planning on building construction activities?
2. What are the site layout plan utilization practices on building construction projects?
3. What are the key factors that contribute to achieve an effective site layout planning?

1.4 Objectives of the Study

1.4.1 General objective

The general objective of the research was to investigate site layout planning problems and implementation practices on building construction projects, the case of selected towns in SNNPRS.

1.4.2 Specific objectives

The specific objectives of the study were:

1. To identify the effects of poor site layout planning on building construction activities.
2. To identify the key factors which contribute to achieve an effective site layout planning.
3. To study site layout plan utilization practice on building construction projects.

1.5 Significance of the Research

The outcome of this study will be significant to the key stakeholders in the Ethiopian construction industry such as contractors, consultants, project owners (clients), educational institutions and professional associations. The study will provide relevant information on the practice of site layout plan utilization as employed as part of the construction processes in selected major projects. It brings to the fore the effects of poor site layout planning; it provides information in regards to the factors that one has to examine in order to have an effective and efficient site layout planning and it also brings practical procedures and recommendations that can be referenced when developing site layout plan on the construction site. This study could notably change the attitude of construction site managers in regards to site layout planning utilization, on how it is conceived and implemented.

1.6 Limitations of the Research

The main scope of this study was on on–going building construction projects within selected towns of SNNPRS. The study generally focused on investigating site layout planning and implementation practice on building construction projects in SNNPRS.

During the course of the study, finding literature written specifically on investigating site layout planning and implementation practice on building construction projects posed difficulties when the researcher was reviewing related literature. Time and financial constraints cannot be understated since a thesis of this nature and magnitude requires ample time and funds. Part of the data for this study was retrieved from secondary sources and questionnaire responses (primary) and therefore the authenticity of the data was dependent on the accuracy of the data accessed. Due to shortage of time and other constraints the study includes only building construction projects.

1.7 Organization of the Research

This thesis was divided into five chapters that organize, illustrate, and describe the steps taken to meet the defined research objectives. This thesis was organized as follows:

Chapter Two presents the literature review with general descriptions by different writers and researchers on site layout planning utilization.

Chapter Three discusses about the research methodology and design.

Chapter Four presents the results and discussion of the research findings.

Chapter Five contains the conclusions and recommendations based on what is discussed in the previous chapters.

2. LITRATURE REVIEW

2.1 Introduction

An extensive literature review was conducted to demonstrate relevant knowledge and existing research to establish a solid starting point to pursue the proposed study. Upon reviewing the literature, a significant amount of research focused on the development of algorithms that optimize the placement of temporary facilities and movement of equipment/material on a construction site. It was observed that limited consideration was given to the practical aspects of site layout planning such as:

1. The process of site layout planning.
2. When does the site planning process start?
3. Who gets involved in the development?
4. Do contractors typically develop one plan for the project or do they develop multiple plans?
5. How do contractors ensure that the developed plans are implemented and enforced?
6. What level of detail is incorporated in the plan?

Limited information emphasizing these aspects was found within publications where only a few articles did address any of these aspects. Thus, the literature review discusses different aspects of site layout planning and also it discusses optimization systems developed for site layout planning.

2.2 Site Layout Planning

Several researchers have attempted to define the site layout planning process. One of the more crisp and generic definitions was given by Tommelien et al (1992).

"The task of site layout consists of identifying the facilities needed to support construction operations, determining their size and shape and positioning them within the boundaries of the available on-site areas. Examples of these facilities include offices and tool trailers, parking lots, warehouses, batch plants, maintenance areas, fabrication yards or buildings, staging areas, and lay-down areas."

Site layout planning is the process of determining what temporary facilities (TF) will be needed during construction, where each TF will be placed on site and the duration each TF will occupy a finite area on site (Ning et al., 2011). The goal of site layout planning is to predict the activities

associated with a construction project and plan accordingly so that project duration and project cost can be minimized (Mawdesley et al., 2002).

To create an effective and safe site layout plan, health and safety factors must be incorporated into the plan. The storage locations of material and equipment have a significant impact on construction site safety. These locations need to be carefully selected so that the movement of material and equipment can be minimized (Elbeltagi et al., 2004). The successful implementation of an effective site layout plan will be reflected in project cost, quality of work, operations safety, and the environmental aspects of the work (Mawdesley et al., 2002). The development of comprehensive site layout plans may also decrease the amount of non-value adding work that is associated with poor site planning and coordination (Akinci et al., 1998).

During construction projects, many tasks are performed to produce a finished product within an allotted time frame. At any point during construction multiple tasks can be simultaneously underway and in many cases these task are in close proximity of one another so that production can be maximized (Thomas et al., 2006). To optimize the flow of resources for each task, comprehensive site layout plans must be developed. The development of optimal utilization plans consists of developing layout alternatives that promote a smooth flow of construction resources (e.g. personal, equipment, materials) while also satisfying project constraints (e.g. construction boundary, safety zones, protected areas, etc.). In many projects the available area for TF placement changes as the project progresses, thus the locations of TFs may need to be altered over the duration of the project. The combination of these factors creates a multi-objective problem that requires substantial thought so that the optimal solution can be designed (Thomas et al., 2005).

Site layout plans are typically secondary to project plans, schedules, resource allocation, and budgeting and in many cases they are neglected (Mawdesley et al., 2002). Often, after bidding and project startup, site layout decisions are left to the foremen and/or superintendent who normally handle day-to-day operations (Chau and Anson, 2002). This leads to instantaneous decisions on area allocation when space is needed for delivered material and equipment storage. When this form of site layout planning is used, job sites quickly become unorganized, cluttered, and difficult to manage. When site layout plans are developed, they are typically based on rules of thumb, heuristics, expertise, judgment, code of practice, preference, and previous experience of the personnel involved with the construction effort (Osman et al., 2003). Therefore, when plans are developed prior to project start up, the foremen and/or the superintendent need to be

involved due to their vast knowledge of material storage/handling and equipment operations. In addition, subcontractors also possess knowledge that may assist in the development of an effective site layout plan; however, site layout plan developers should be cautious about the information gathered from subcontractors as it may not always be in the best interest of the project (Thomas and Flynn, 2011).

2.2.1 Significance of Site Layout Planning

Many tasks are involved in managing a construction site, one of which is site layout planning. Typically, a project manager is responsible for developing a site layout plan based on past experience, knowledge, intuition, and imagination (Osman et al., 2003). In the absence of a well-developed site layout plan, many problems can occur resulting in time delays and cost overruns. Site layout planning overlaps with other planning tasks such as scheduling, selection of construction method, procurement and material planning, manpower and equipment planning, and financial planning (Elbeltagi, 2008). These interactions exist due to the fact that the timing for each plan must coincide at a precise moment so that the correct material, equipment, manpower, and finances are available to complete a planned task. Therefore, site layout planning is an essential task for successful management of a construction project.

Despite the importance of site layout planning, it is often done in a speedy manner or overlooked completely (Mawdesley et al., 2002). The results of such acts reflect in the day to day operations of the project, making it difficult to manage site operations. Despite the significant body of research on optimization methods, no well-defined optimization method can guarantee a solution that takes all possible elements into account (Chau and Anson, 2002). The decision to develop good site layout plan early on in a project can have a significant impact on later site operations.

Temporary facility and equipment placement is directly related to the construction sequencing and performance of a project. Poor site planning and management can lead to work delays, misplacement of materials, double handling of materials, schedule delays, capital loss, and unsafe working conditions (Mincks and Johnston, 2010). For construction to flow seamlessly, many projects specific factors must be considered during the space delineation process. Site space delineation should involve: i) site boundary identification, ii) temporary facility identification, iii) identification of temporary facility constraints, and iv) determining the relative position of each temporary facility so that the functionality and efficiency of temporary facility operations are maximized (Zouein et al., 2002). In addition, the scheduled timing of establishment and removal of each temporary facility should be determined (Mawdesley et al., 2002).

To allocate space effectively, the planner must have a clear understanding of the construction execution plan. It is imperative to realize the significance of site space constraints during the planning process due to the fact that site plans dictate the working conditions of site personnel for the duration of the project (Elbeltagi, 2008). Depending on the location of a construction project, site space may or may not be limited. Typically, urban areas (e.g., downtown/metro areas) have less space available for construction activities due to the structure/building encompassing the majority of the site. Therefore, space planning is critical and should be delicately handled so that construction activities can be executed efficiently. On the other hand, space planning for large construction sites tends to be pushed aside during project startup due to space abundance. In such a case, project managers tend to place facilities randomly within the site boundaries, creating an environment that becomes increasingly inefficient (Mawdesley et al., 2002). No matter the scenario, jobsite planning and organization is essential for construction projects to be productive and profitable.

Seetharaman *et al.* (2011) outlined some of the merits of implementing or employing site layout plan as part of the construction process:

1. Smooth and economic running of the project
2. Reduces the project duration
3. Material wastage and deterioration are reduced
4. Material transportation becomes easy, speedy and economical
5. Increases the output from labour and machinery
6. Provides more safety in the working of the project.

2.2.2 Dynamics of Site Layout Planning

The difficulty associated with site layout planning is that the construction process is inherently dynamic in nature. This time-space relationship means that TFs will not likely occupy the same space, quantity of space, and orientation within the site boundaries as a project progresses (Mahachi, 2001). This consequently means that the site layout plan must constantly evolve over the duration of the project, thus making the problem challenging (Mawdesley et al., 2002). During construction, space availability is governed by the construction schedule, construction methods, and the contractor's mobilization and demobilization of materials, equipment, and personnel on-site. As a construction project reaches its peak, the site can become overly congested and the corresponding layout can become confined. No matter the space scenario, there will always be a high demand for prime space (i.e., space typically immediately

surrounding the facility under construction) as travel distances increase for accessing the facility from more remote locations (Tommelein et al., 1992).

2.3 Construction Site Temporary Facilities

A temporary facility is a physical area within a construction site that has an associated time of establishment and removal during the project life cycle (Mawdesley et al., 2002). Many factors dictate what TFs are required on construction sites, some of which are: project type, scale, design, project location, and organization of construction work. The TFs included in a site layout plan differ from project to project, as well as the duration of the TF in a specified area (e.g. TF may need to be relocated instead of eliminated). The location and size of a TF is directly related to the project for which the layout plan is being developed. Many similarities can be found in site layout plans for different project; however, each project has its own unique features (i.e., construction boundary, building orientation, site topology, etc.) that control the space available for TF placement. In many cases, the locations and sizes of TFs interrelated with one another, thus adjusting one will affects the other. If construction site space is not abundant, which is the case in many scenarios, the size of TFs can sometimes be reduced while also keeping their functionality. On the other hand, projects that have an abundance of space also have unique challenges that must be anticipated. An abundance of space allows TFs to expand in size as a project progresses; however, the space preferred is usually the space immediately surround the building (e.g., prime space) (Tommelein et al., 1992). This preference of space can be of great value as the project reaches peak construction. During peak construction the prime space is heavily congested and if not controlled efficiently, productivity and construction flow can be significantly affected.

Riley and Sanvido, (1995) suggest that construction space can be broken down into “Areas” and “Paths”. Each of these construction spaces can further be broken down into the following subareas: layout area, unloading area, staging area, storage area, prefabrication area, work area, tool and equipment area, hazard area, protected area, material path, personnel path, and debris path. Additional spaces that may be included are: site ingress/egress points, office trailers, welfare facilities and delivery areas (Elbeltagi et al., 2004). Before beginning the selection process, it is important to determine which TFs are required for a particular project. If all TFs are not accounted for during the development of the site layout plans, the plan selected and implemented will not yield optimal space allocations, thus not allowing for a smooth and seamless flow of materials and equipment on the construction site.

In past research, Mawdesley *et al.,* (2002) interviewed practicing engineers and construction professionals to determine the importance of site layout. From the interviews, several key factors were identified as being of importance during the development of site layout plans. The key factors were: i) access and traffic routes, ii) material storage and handling, iii) administration building and welfare facilities, and iv) equipment, workshop, and services. Engineering and construction professionals also considered site layout planning to be: i) difficult to specify (e.g., difficult to define the best layout plan), ii) interrelated with other management task, iii) highly dynamic (e.g. optimal site layout is changing through the project duration), and iv) under researched.

2.3.1Temporary Facilities Characteristics

Elbelgati *et al.*, (2004) identified temporary facilities to have some basic characteristics that need to be understood before they are assigned on any site layout plan for any construction project. Six generic temporary facility characteristics where identified.

1. **Meeting safety and environmental requirement:** All temporary facilities should meet safety and environmental requirement. The batch plants should be given special attention due to its high pollution potential. Proper arrangement should be made by Planners to prevent the pollution of the air, water and also to keep noise at bearable levels.
2. **Different solutions for the same problem:** Arrangements of a temporary facility can be done in many ways. The site layout planner have several options to choose from, in a situation where he is to provide a warehouse, he can build, use existing facilities, rent, or plan a just in time delivery.
3. **Short life span on a specific location:** The duration of the project will determine how long the temporary facility stays on the site. Under normal circumstances they are dismantled immediately the project is completed.
4. **Reutilization with modified function at another location:** Temporary facilities on site have shorter life span because of this, planners always consider their reuse. With appropriate modifications, most of the temporary facilities can be used for more different purposes, thereby reducing construction cost significantly. To achieve this, the building material should be properly maintained and stored correctly to prevent deterioration of the material.
5. **Easy of assembly, dismantling, and exploitation:** Without any damage to the structure components, temporary facilities constructed in prefabricated modules can easily be assembled and dismantled when the project is completed. It also saves time, since its construction does not require any drying periods.

6. **Standardization of design:** The design of temporary facilities should be standardized for easy construction and utilization. This will reduce time and cost spent on constructing the facilities. It also makes their maintenance, storage and transportation easy. The gains obtained from continues usage, will results in increase productivity and high quality of work.

2.3.2 Identification of Temporary Facilities and its Selection

The type of temporary facilities needed in the execution of any construction project needs to be carefully identified and selected. This is a difficult task that requires you to consider the conditions and local regulations surrounding the project thoroughly. In recent times, project managers and site engineers produce site layout plans based on their past experience and common sense. All that they do is to revise any site layout plan done in a previous project, by so doing; they leave out some relevant facilities that are expected by authorities such as a post for first aid or an escape route in case of fire. Providing these facilities later can be more expensive and can lead to low productivity on site (Elbelgati et al., 2004).

Elbelgati, (2008) acknowledges that the choice of temporary facilities on any construction site will be influenced by the factors below:

1. **Project under construction:** The type of project under construction will determine the type of temporary facility needed on site. In constructing a power plant for instance, would require more storage and fabricating space for processing electrical and mechanical work than other projects.
2. **Type of contract:** The contract type or form has an influence in the choice of temporary facilities on site. In a contract such as turnkey, there can be a combination of both the administrative and construction operations by the contractor, which means for efficiency, fewer but larger temporary facilities can be used. In a situation where management of the project is by a number of different contracts, smaller temporary facilities units should be made available for the use of each individual contractor on site.
3. **Location of project:** Projects situated in remote areas or at locations where it is difficult to come by skilled labour, it is required that an additional facilities such as lodging should be provided. Project far from industrial centers would require special facilities to store materials and workshops to fabricate materials and equipment.
4. **Size of project:** Small projects can be handled from a small structure. Project that will take longer period to complete may require temporary facilities that are more permanent

in nature. Providing lodging facilities for workers on site, can be broken down into three categories as shown in Figure2.1:

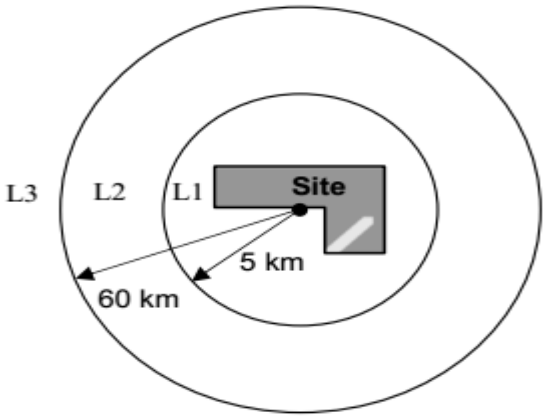


Figure 2.1: Work-force break-down

L1: local labour force within 5 km from site. Lodging facility not needed nor transportation required.

L2: nearby labour force within 5 to 60 km from site. Facility for lodging not needed, but daily transportation required.

L3: labour force far away from site, more than 60 km from site. Facilities for lodging required (Elbelgati, 2008).

In the case of providing for materials storage and warehousing the facilities needed depends on the nature of material and how they are stored to prevent deterioration. However, the nature and number of temporary facilities required in a particular work have to be ascertained before their sizing and location (Elbelgati, 2008).

Annex B gives the list of common temporary facilities that can be adopted in a construction project. This is to serve as a check list or a guide in the provision of temporary facility on any construction project. Some of the temporary facilities needed are project specific because of their justified uniqueness.

This list of temporary facilities was modified and used as a check list. It was primarily used to check the number of the temporary facilities that have been provided for each construction sites the researcher visited.

2.4 Construction Site Layout Plan Development

The development of a site layout plan consists of several factors. Before starting the development of a layout plan the developer must be aware of three important elements: i) what is

to be constructed, ii) what tasks are associated with construction, and iii) what method of construction will be used. With a comprehensive understanding of these elements the process of planning can begin; however, the development process is highly subjective and nontrivial and requires the developer to meet multiple prioritized objectives (Chau and Anson, 2002).

The nature of the utilization problem makes it extremely difficult to select a well-defined method that consistently yields a guaranteed solution. Researches have been able to identify key points to consider during the development phase. Mawdesley *et al.* (2002) recognized three key aspects that a complete site layout plan should address. The aspects are: what are the TFs that need to be established, what is the geographical layout of the TF, and at what point during the project are the TFs going to be installed and removed. Although these aspects do provide some ideas of what is to be expected upon the completion of a site layout plan, they do not provide a means on how to construct a layout plan. To help fill this gap of uncertainty, Elbeltagi *et al.*, (2004) suggested a five step approach for determining the TFs needed between any two dates. The steps as defined by Elbeltagi et al. are:

1. The necessary TFs must be identified and sized.
2. The project schedule must be developed.
3. The required activities of each TF must be defined.
4. The service times for each TF must be determined from the project schedule (e.g. TF start date and finish date).
5. The TFs that serve during a specific time interval can be defined and considered as the TFs needed on site in that interval.

Most research conducted on site layout planning focuses on space allocation on the exterior of the structure being built. Very little research has been conducted on space allocation within the structure. Riley and Sanvido, (1997) conducted research on space usage within multistory buildings and found that space usage was repeatable and predictable. By recognizing work flow patterns during construction, the area needed for a particular task could be predicted, as well as task duration, which could then help develop a layout plan (Riley and Sanvido, 1997). Thomas and Ellis, (2007) proposed a micro level planning process aimed at small contractors to describe effective prebid planning techniques. An element of the proposed planning strategy was to create a site layout plan.

2.5 Construction Site Layout Plan Management

For a project manager to create an effective site layout plan, he/she has to have ample knowledge of current construction practices. Normally, the scope of sequential construction projects a project manager would undertake varies considerably. Due to this variation, project managers must determine the elements (e.g., material, equipment, etc.) needed for construction, element schedule (e.g., arrival/departure times), and individuals (e.g., tradesmen, operators, etc.) associated with each element when starting a new project (Laufer et al., 1994). The ability to identify key elements of a project and choreograph an effective layout plan strongly influences the constructability of a project (Tatum, 1987).

Throughout the construction process, several tradesmen work concurrently at the site. With multiple tradesmen on site, congestion will occur in work and storage areas if a layout plan is not implemented. By implementing a site layout plan that incorporates staggered work schedules, housekeeping, and organization; congestion can be minimized, thus allowing labor productivity and performance to remain optimal throughout the project duration (Thomas et al., 2006).

When developing a site layout plan, it is critical to consider storage locations for certain materials so that workers are not constantly interfering with one another. To aid general contractors in the management of subcontractors, Thomas and Flynn, (2011) developed a "to do" list that highlights principles that focus on the management of people and work. By implementing these principles, general contractors can have a positive impact on subcontractors, thus increasing the likelihood of the subcontractor following the site layout plan (e.g., storing materials in the proper location, keep pathway clear of debris) selected for the project.

2.5.1 Material Management

Material management is an essential task that must be fulfilled to maximize worker efficiency and prevent project delays. The location of material storage areas on a site have to be incorporated into the site layout plan and these areas should be carefully selected. Ineffective site material management can contribute to waste in time and money. Thomas *et al.,* (2005) developed a list of principles that deal with site material management that should be considered when selecting the location of material storage areas. Some principles listed that would affect site layout planning are: i) locate parking lots, tool sheds, and spoil piles as far away from the building as possible, and ii) materials should be stored to allow easy access and retrieval (Thomas et al., 2005). It is extremely difficult to consider all the activities that could develop into a conflict when developing a site layout plan. To assist the space conflict resolution process,

Guo, (2002) established criteria to resolve space conflicts between activities. The major criteria listed are: i) logical sequence of activities, ii) critical path, iii) space divisibility, iv) location change, v) space size modification, vi) start time of conflicting space occupation, and vii) length of occupancy time (Guo, 2002). Using these criteria, a prototype decision support system was developed to solve the multi-objective problem. To identify dynamic conflict between activities, a CAD system was integrated with scheduling software (Guo, 2002).

2.5.2 Equipment Management

The movement of equipment on a construction site requires knowledge of how the equipment functions as well as the space required so that the equipment can operate safely. Kim and Kim, (2010) conducted a study to determine the effects of construction equipment on construction operations. This study applied a multiagent-based simulation model to a real word project and evaluated the efficiency of construction operations based on the equipment flow on-site. Several models were run, each having an increased volume of equipment on-site with hopes of increasing productivity. This volume increase resulted in traffic congestion and bottle necks, thus decreasing equipment speed by 48.8% and construction operation by 61.6% when compared to normal traffic operations (Kim and Kim, 2010). This indicates that for a project to operate efficiently, the project manager or engineer must know what equipment is required to construct a project and monitor the equipment delivered to the site. The concept of equipment utilization planning can be of great concern when dealing with large construction operations (e.g. highway construction) that require a significant amount of earth moving equipment.

2.5.3 Site Plan Observation

Evaluating the effectiveness of a site layout plan is an integral part of the site layout planning process. To consistently improve future site layout plans, the designer must be aware of on-site operations that are not able to transition to subsequent tasks due to ineffective temporary facility placement. An effective way to evaluate a site layout is by comparing the scheduled placement of temporary facilities with the actual placement of the facility (Menches and Hanna, 2006). Site layout planners must constantly be aware of unplanned events that occur on site that disrupt the site layout plan. There are numerous ways a site layout plan can become ineffective on-site. For instance, if materials are delivered earlier than planned available site area must be used to store the materials. This in turn starts a domino effect, which if not corrected, will continue to disrupt the construction process.

2.6 Problems Associated with an Unplanned Site Layout

Elbeltagi and Hegazy (2002) acknowledges that failing to plan the site layout right at the inception of the project, may lead to some inefficiency in the construction operations, and can substantially affect the overall cost of a project. They outlined some of the problems that may arise if there is no site layout plan, as follows below.

2.6.1 Wrong Location of Material Stacks

The delivery of materials on site, are sometimes off-loaded into areas where it has not been thought of as the correct point of delivery. This may result in a situation where the material will have to be handled severally before they are finally used. The material may be too remote from the work area or too far from the plant or equipment. Due to wrong location of materials traffic flow on site may be affected.

2.6.2 Plant and Equipment Wrongly Located

Plants and equipment needed for the project have to be identified and arrangement made for their arrival on site. On arrival at site, their location has to be determined, but because there is no plan made in connection with that some problems arise. These include:

a) The inaccessibility of the crane to deliver materials;
b) Inadequate storage space for aggregates;
c) all parts of the works cannot be reached by the fixed crane;
d) Capacity of hoist insufficient or not high enough to cater for the loads or wrongly sited to serve the building floors;

2.6.3 Limited Space to Stack Materials

In situations where the space allocated for material stacking is limited, materials are stacked too high or on access ways rendering it hazardous to workers. Spaces for operation may become too congested implying more space should be assigned with the consequent wasting of time as a result of moving materials to new locations.

2.6.4 Ineffective Usage of Site Huts Due to Their Location

Due to the lack of an efficient plan, site huts may be located in areas with conditions that are not conducive for work, or far away with little overview of the site which may render their use ineffective. Space allocated for warehousing may be inadequate and also located at an obscured place.

To avoid the above problems it is essential to plan a detail site layout, indicating where all equipment, materials storage areas, accommodation and ancillary areas for work will be located.

2.7 Factors to Consider in Planning a Site Layout

For an effective and efficient site layout to be achieved there are certain factors that have to be considered in the planning and implementation of a site layout plan. These factors when properly addressed, will aid in the smooth running of any construction process. From the review of literature, the factors below came to light.

2.7.1 Health and Safety

The health and safety concerns of all personnel and even the surrounding environment within which construction operations are performed should be of paramount interest to the site layout Planner on any construction site. To avoid claims as a result of accidents on the site, the site layout should be planned in a way that will prevent or minimize accidents on the site. Fire extinguishers are to be placed at vantage points identified on the site layout to help fight any fire outbreak (Khalafallah and El-Rayes, 2005; Elbelgati et al., 2004).

Medical services should be considered during the planning stage of the layout to provide first aid in case of injuries and in remote areas a well-equipped medical facility with medical personnel is recommended. Basic safety supplies like safety boots, helmets, goggles and gloves must be provided for the workers to use. The workers must be trained on health and safety issues pertaining to the site they are working on (Khalafallah and ElRayes, 2005; Elbelgati et al., 2004).

2.7.2 Site Accessibility

Good planning is needed to link the site roads to a major highway nearby. Roads within the site are needed to allow work to flow easily. Spaces for parking of vehicles are to be provided. Where space does not exist this facility must be planned and provided somewhere convenient. Easy movement will keep the morale of the equipment and vehicle drivers high, thus minimizing the chance of accidents. It will also save time in maneuvering in and out of the construction site ((Elbelgati et al., 2004; Seethraaman, 2011).

2.7.3 Information Signs

Signage as a form of communication should be of an outmost consideration during the planning of the site layout. It should be visible and in clear plain language that is easy to comprehend, indicating what to do and what not to do on site, to avoid unnecessary hit and falls resulting in accidents and injuries. There should be a site map which will show details of the project; this should be exhibited boldly in the site Engineers or project Managers office and also posted at the entry point. Strategically traffic regulatory signs should be located to direct traffic on the site to prevent accidents as much as possible (Elbelgati et al., 2004; Seethraaman, 2011).

On every floor an emergency escape routes should be displayed as construction progresses. Protect all services underground to save it from destructions. It is also important to mark out all hazardous areas with caution tape.

2.7.4 Security

The security of the site should be of prime consideration to the site planner if the project should end successfully. The whole site should be fenced and the entrance strategically located with a guard post to check the ins and outs movement of all personnel and vehicles in order to check pilfering. The whole site should be illuminated at night to prevent intruders to the site (Khalafallah and El-Rayes, 2005; Elbelgati et al., 2004).

2.7.5 Accommodation and Craft change-houses

Some form of accommodation should be provided for all categories of personnel involved in the project on site, especially when the project is large. On small or restricted site, accommodation for only the site engineer and the security man should be considered and arrangement should be made for others nearby.

Craft change-houses should be provided for workers to change, keep clothes, bath and relax during breaks. This space should have toilet facilities for their convenience (Elbelgati et al., 2004).

2.7.6 Site Offices

For an efficient and effective monitoring of the project site offices should be provided with meeting or conference room. All the offices should be close together and in a safe area. They are to be properly equipped to meet the needs of the project (Elbelgati et al., 2004).

2.7.7 Utilities (Electricity, Water, Telecommunication & Internet)

All the necessary utilities available should be harnessed to the advantage of the project. In areas where water is a problem arrangement can be made for tanker services or a borehole can be sunk to provide water. In areas with no power supply a generator plant can be installed to provide electricity. All of these should be strategically located so as not to impede operations of the construction (Elbelgati et al., 2004).

2.7.8 Handling of Materials

Elbelgati *et al.* (2004) posited that material handling makes up about one-third of all construction operations. The use of proper equipment for material handling and advance planning will minimize multiple handling which will result in direct cost and time savings.

2.7.9 Storage and Site Cleaning

It is necessary to plan and reserve storage areas for materials so that multiple movements of materials are prevented. Reserved areas for long term or short term storage of large materials and equipment should be clearly defined. Warehousing should be provided when there is the need to store materials and equipment for a relatively longer period.

It is necessary to have designated area to dispose of waste and debris on site (Khalafallah and El-Rayes, 2005; Elbelgati et al., 2004).

2.7.10 Workshops

Workshops should be provided, if possible for all tradesmen working on the project. Workshops are used to fabricated materials and equipment on site. They include plumbing, electrical, carpentry, mechanical, and steel works. If possible there should be a laboratory for testing with all the essential equipment and qualified personnel to be in charge of it (Khalafallah and El-Rayes, 2005; Elbelgati et al., 2004).

2.7.11 Nature of Project

This will play a great role in the preparation of the site layout. If it is a multistoried building project then it will require a centrally located layout scheme. On the other hand if it is a highway construction project then it will require a number of construction centers at suitable locations (Elbelgati et al., 2004; Seetharaman et al., 2011).

2.7.12 Construction Methods

The method of construction will to a large extent influence the planning of the site layout. The construction method can be either cast in-situ or the use of precast elements. If it is to be of precast element then provision for casting yard should be included in the layout planning (Elbelgati et al., 2004).

2.7.13 Plot size and Shape

The size and shape of the plot should be assessed during the planning of the site layout. The size of the plot will determine what can be accommodated on the site. A site with limited space needs proper planning, facilities that are more necessary should be located on site. Where there is the luxury of space the layout plan can have all the necessary facilities that will aid in the construction process. In situations where space is limited, alternative arrangement should be made to cater for the needed facilities on site (Elbelgati et al., 2004).

2.7.14 Location of Project

The location of the project will to some extent determine the outcome of the final site layout plan. How far or closer it is will also tell the kind and size of temporary facilities to be provided. In situations where skilled laborers are not readily available, special arrangement should be made to accommodate those that are being imported for their lodging. Again special on site services must be provided for projects that are far away from industrial centers. These include batch plant, maintenance workshops, warehousing, and even recreational centers must be provided. Alternative arrangement should be made for areas where there is no electricity, water or telecommunication service (Elbelgati et al., 2004).

2.8 Present Practice in Site Layout Planning

In any construction project there are a number of preplanning tasks that needs to done before the commencement of actual work. These tasks include scheduling, selection of construction method, procurement and material planning, manpower and equipment planning, and financial planning. The planning of the site layout is of equal importance just as any of the other tasks in construction planning. It is the site layout that will provide the space within which the other tasks can be accomplished. On the contrary Project Managers turn to overlook this important aspect of the construction process or treat it lightly (Elbelgati et al., 2004).

Project Managers and site Engineers usually design the layout and allocate the various temporary facilities required on site. Their design is based on past experience, common sense, and the use of similar site layouts in allocating spaces for temporary facilities on site. In most cases they fail in keep in mind of all the factors that affected their selection, location, and the functional relationship that existed between all the facilities they have allocated (Elbelgati et al., 2004).

2.9 Site Layout Optimization

The development of a universal site layout optimization tool has long been the focus of many researchers. Within the last two decades, several researchers have developed software systems that allocate space based on a set of predetermined constraints and an optimization function. This method of optimization planning can also be found in many other areas of research such as: i) manufacturing (Singh, 2006), ii) architecture (Liggett, 2000), and iii) computer chip design (Kozminski and Kinnen, 1984). Each of these areas has unique challenges that must be addressed so that a solution can be obtained; however, the optimization of construction site operations is significantly more complex due to the fact that construction is dynamic in nature.

2.9.1 Optimization Methods

Most of the facility layout optimization systems previously developed operate by allocating site space to predetermined TFs based on criteria (e.g., area requirements) that must be met and/or optimizing an objective function (e.g. cost of moving materials) (Liggett, 2000). The categories in which site optimization solution techniques are typically classified are: i) constructive methods, ii) improvement methods, iii) trajectory methods (e.g., simulated annealing), iv) population based methods (e.g., genetic algorithms and swarm intelligence), and v) hybrid approach methods (Liggett, 2000). The constructive method builds a layout solution in a step-by-step fashion, locating TFs one by one. This method is not suitable for complex projects but can be used to develop simple layouts. Improvement methods, trajectory methods, and population based methods generate solutions based on space availability. The performance of each generated solution is then evaluated against a predefined objective function. This optimization strategy is known as meta-heuristics.

2.10 Previous Studies

Several studies about site layout have been done before. Elements and facilities needed at the construction site were discussed in Elbeltagi (2008). The problems that occur on construction sites are also have been described in (Ibid).

Next, the effect of unplanned site layout to the construction project can be found in Yang (2010). In addition, a study on the causes of the accident at the construction site has been done in Elbeltagi and Hegazy (2002). There were three main causes of accidents on construction sites, namely the weakness of the management, the weakness of the workers, and the condition of the construction site. Based on the study of Elbeltagi and Hegazy (2002), it was clear that the condition of the site and the site layout can be the cause of the accident to a worker at a construction site.

Another topic that has been studied was the optimal site layout that considers the safety and environmental aspects Neszmelyi and Vattai (1995). This research has produced a model layout of the site and uses algorithms to model the optimal site layout. Based on this study, a case study has been made to do a comparison between the model generated site layout and a real construction site. However, the case studies conducted in the country of Egypt.

Productivity issues during site planning can be found in Elbeltagi *et al.* (2004).This article presents a layout planning approach that considers both safety and productivity. Consideration for restricted sites also is explained in Elbeltagi *et al.* (2004). While the characteristics of the

facilities at the construction site and appropriate position for each facility in construction sites are described in Haytham *et al.* (2008).

Upon reviewing the literature, it was apparent that a significant amount of research focused on the development of algorithms that optimize the placement of temporary facilities and movement of equipment/material on a construction site.

It was observed that limited consideration was given to the practical aspects of site layout planning such as:

1. Stakeholders: Who gets involved in the site layout plan development process?
2. Information: What information is required to develop an effective site layout plan?
3. Timing: When does the development of the site layout plan begin?
4. Content: What information should be included in the site layout plan?
5. Technology: Is software used to develop site layout plans?

Limited information emphasizing these aspects was found within publications. Therefore, the main objective of the present study was to investigate site layout planning and implementation practice on building construction projects.

2.10.1 Research Gap Identification

Site layout planning has implications for project safety, construction efficiency, scheduling, and budgetary performance of a construction projects. However, much research has not been done on an important aspect of site layout planning by researchers in Ethiopian construction industry. Also the basic information/ principles of site layout planning have not been identified by researcher that can be used as base for site planners to make their decisions. In the process of making site layout planning, this particular body of knowledge greatly depending on one's experience within the construction industry. Therefor to create an effective site layout planning, this basic knowledge needs to be identified and documented so that practitioners to use it.

3. MATERIALS AND METHODS

3.1 Introduction

Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically (Kothari, 2004). As data and methodology are highly interdependent, the methodology to be used for a particular research problem must always take into consideration the nature of the data that will be collected to resolve the research problem (Leedy and Ormrod, 2005).

The goal of the research is to investigate site layout planning and implementation practice on building construction projects in SNNPRS. It is anticipated that the identification on site layout planning and implementation practice on building construction projects may lead to project safety, construction efficiency, scheduling and, budgetary performance of a project. This chapter presents the methodology adopted and identifies the tools and techniques employed in conducting this study.

3.2 Description of the Study Area

The study area of this research was in Southern Nation Nationalities People Regional State (SNNPR) in case of selected towns (i.e. Hawassa, Dilla, Wollayta Sodo, and Arba Minch). A survey was administered to major projects which are now active (on-going) in the selected towns. The goal of the research was to investigate site layout planning and implementation practice on building construction projects in SNNPRS in case of selected towns.

3.3 Study Subject

In this research, determined number of volunteers participants were included. The study was intended to get in depth information about site layout planning and implementation practice on building construction projects in SNNPRS, so it was good to have adequate sample size. The participants included in this research were professionals in the construction companies, and consulting firms.

3.4 Study design

The types of study used in this research were mainly descriptive and exploratory. It was attempted to collect data from the relevant respondents (contractors, and consulting firms) to investigate site layout planning and implementation practice on building construction projects.

There are three, frequently used approaches of inquiry. These are quantitative approach, qualitative approach, and mixed methods approach (Creswell, 2009). Each of these approaches

has its own strengths and weaknesses. The basic features of the three approaches are summarized below to select the methodology that best suits the research objective.

The quantitative research approach is one in which the researcher primarily uses post positive claims for developing knowledge. Post positivism assumes that causes determine outcomes (Creswell, 2009). The approach involves the generation of data in quantitative or numerical form which can be subjected to rigorous quantitative analysis in a formal and rigid fashion (Kothari, 2004). Similarly, Creswell (2009) states that, in the quantitative approach the researcher use survey or experiment to collect data needed to see causes and effect relationship among variables of interest. The quantitative approach follows deduction in that it tests existing theories to verify them. The major benefit of the quantitative approach is that it enables the researcher to utilize statistical techniques to make generalization about the population. As the data in quantitative approach are numerical, the numbers are readily collected, coded, summarized and analyzed. The major weakness of a quantitative research is that the researcher knows only about the collective or average experience of study participants but not their individual experiences (Dunn, 1999).

The qualitative approach is defined by Creswell (2009), as one in which the researcher often makes knowledge claims based primarily on constructivist perspective. In other words, in this approach the researcher tries to develop theories from the individual experiences of study participants. Qualitative data are not numerical nor are they usually subjected to statistical methods of analysis. Rather they are examined in their raw form (Dunn, 1999). Hence, in qualitative methodology the researcher follows induction, as the researcher collects open-ended data with the primary intent of developing theory from the data. The main benefit of using qualitative approach as stated by Dunn (1999), is that the information gathered is of no fixed variety; hence, it represents *open systems view*. The openness of the approach becomes very useful when it comes to developing hypothesis in the early stages of investigating a topic. However, the disadvantages of qualitative researches are the fact that the data cannot be quickly, easily, or efficiently summarized nor is it often possible to generalize from given qualitative observation to another situation (Dunn, 1999).

The mixed methods approach tries to combine the benefits of both quantitative and qualitative approaches. It integrates the two approaches for the purpose of gaining better insight into a social phenomenon (Baker, 2010). Baker (2010), further argues that the mixed methods approach is better than either method alone because it provides not only more information but also better quality of information. Therefore, in the mixed methods approach the researcher uses both the

qualitative and quantitative approaches together at the same time or sequentially. As cited in (Ibid), the advantages of mixed methods approach as: (1) the ability to choose from among all the quantitative and qualitative tools in order to perform a comprehensive study of the research problem, (2) the ability to answer more in-depth research questions, (3) the ability to combine both inductive and deductive reasoning. They also stated the disadvantages of using a mixed methods approach include: (1) more resources are needed to implement the study and collect the necessary data, (2) mixed methods research can be complicated to perform and difficult to sort out the results, and (3) researchers must be skilled in both quantitative and qualitative techniques in order to use this method.

Based on the features, strengths and weaknesses of different research approaches discussed above, the researcher found the mixed methods approach to be suitable for this study. The use of mixed methods approach for this research was intended to drive the benefits of both quantitative and qualitative approaches. The quantitative features in this case enabled the researcher to generate data from the sample size about different variables then to generalize the results to the population, whereas, the qualitative features will allow the researcher to explore the current status of site layout planning and implementation practice on building construction projects. Mainly primary data was used in this study. More specifically, the researcher used questionnaire survey. In addition observation was used in order to substantiate results obtained from different data sources and types.

3.4.1 Sampling Technique and Sample Size Determination

The population for a research has been defined by Parahoo (1997) as the total number of units from which data can be collected, and this includes individuals, artifacts, events or organizations. Also, Burns and Grove (2003) defined population as all the elements that meet the criteria for inclusion in a study. Sampling is the process of selecting a group of people, events or behavior with which to conduct a study (Ibid).

The sample size of this research paper was selected from building construction projects that were under construction in SNNPRS in case of four selected towns. The main principle behind selecting sample size was to come up with projects that use site layout planning and companies that were willing to cooperate for the research. Also in selecting sample size on going (live) construction projects were considered, this made it possible for the researcher to observe, live utilization of a site layout planning. As mentioned above for the selecting criteria of sample size it became difficult in the four towns to know the specific number of building projects, therefore a

non-random (non-probabilistic) sampling technique was preferred to be used. From this technique a purposive sampling method was adopted to select the sample for the study.

Therefore, this study was planned to be conducted on twenty (20) building construction projects that are being constructed by construction firms of GC/BC grade one, two and three only and the sample size may include office buildings, hospital buildings, educational buildings, hotels (resorts) and multi-purpose projects in the selected towns. Also this sample size was decided based on the time and budget constraints, and the characteristics of the respondents. Therefore, taking sufficiently large sample becomes practically impossible in this context. The selected twenty building construction projects were distributed as follows depending on the development and availability of investments in the selected cities. From Hawassa, ten (10) projects were selected because many projects were available compared to the other cities. From Arba Minch, four (4) projects were selected. From the remaining two towns, three (3) projects were selected for each.

After determining the number of sites to study it came to the selection of those who will respond to the questionnaires on the various sites. The target respondents to the questionnaires on the various sites in this research include contractors (i.e. project manager, project engineer, site engineer and office engineer) and consultants (i.e. resident engineer/supervisor).The researcher adopted a purposive sampling method to select respondents from the contractor side; the reason for this was that all professionals on the site did not have adequate knowledge on the topic. Typically, the project manager is responsible for developing the site layout plan (Osman et al. 2003). During the site visit the researcher gave priority for the project manager from the contractor side. When the project manager became busy and absent during the site visit the respondent would be selected by giving priority in the following order i.e. (1) project engineer, (2) site engineer and (3) office engineer. From the consulting firm the site supervisor (resident engineer) was selected. In all forty (40) respondents were contacted two (i.e. contractor and consultant) from each construction site to give out relevant information pertaining to the research objectives and questions.

Table 3.1: Summary on Research Questionnaire Respondents

Towns	Number of projects from each cities	Respondents from each construction projects	Total
Hawassa	10	2×10	20
Arba Minch	4	2×4	8
Dilla	3	2×3	6
Wollayta Sodo	3	2×3	6
Total Respondents			**40**

3.5 Data Collection Tools/Instruments

Among the different tools used to collect data, questionnaire in the form of both close and open-ended questions, and observation were used to collect all the relevant data used to answer the research question.

The questionnaire design was based on an extensive review of literatures dealing with the site layout planning on building construction projects and the researcher's knowledge on the current site layout planning practices on the construction industry. The questionnaire designed for this research includes both the opened and closed ended forms of questions. In the opened ended part of the questionnaire respondents were asked to express their opinion or to reply in whatever content they like for the questions asked, concerning the site layout planning issues mentioned in this research. In the closed ended part of the questionnaire the respondents were asked simply to show their level of agreement on the statements outlined and for which they are given five different levels of agreement for each.

Three sets of closed and opened-ended questionnaires were designed: for the contractors, and consultants for each projects on the selected towns. The questionnaires for the categories of respondents consisted of four sections. The first section looked at the respondents' background information. The second section identified the effects of poor site layout planning on building construction activities on the site. The third section of the questionnaire identified the key factors which contribute to achieving an effective site layout planning. The last section of the questionnaire studied site layout plan utilization practice on building construction sites.

In addition to the questionnaires, field observations of the sites were made. For the field observation check list was prepared that shows temporary facilities provided on each construction project sites. Where it was allowed photographs of the organized site were taken during the observation. The site observation provided useful insights into how the sites have

been organized into work areas, temporary facility locations, access road, signage, positioning of plant and equipment, waste collecting areas etc. Also the field observation was used as a tool to check the adopted temporary facilities in the construction projects. Personal observation was also used during fieldwork to gather relevant information, especially in situations where the researcher was prevented from writing or taking photographs.

3.5.1 Pilot study

The piloting was done to test whether the questionnaire was intelligible, unambiguous and easy for respondent to understand and respond to. The professionals participated in this research were contractors and consultants. Pilot study of the questionnaire was conducted by investigating sample questionnaires. Six (6) questionnaires were distributed to construction professionals such as projects managers, site engineers, office engineers and resident engineer who have a strong practical experience in the industry. Their sufficient experiences are a suitable indication for pilot study. From the distributed six questionnaires all of the questionnaires were returned. The following are summary of the main results obtained from pilot study:

1. Some factors and sentences should be modified or represented with more details.
2. Some factors were repeated more than one time with the same meaning. So, it should be eliminated.
3. Some factors and sentences should be modified in order to give more clear meaning and understanding.
4. There are some parts of questionnaire required to be regulated well.
5. Some factors should be rearranged in order to give more suitable and consistent meaning.
6. There are some questions which are not practical or realistic with respect to local situations of building construction projects. Such questions should be removed or modified to be realistic and fit to practical situations.

Based on the comments obtained from the pilot study, the questionnaire was modified and corrected and as a result the final questionnaire have been made more clearer by replacing ambiguous words with simple and understandable ones.

3.5.2 Reliability and Validity of Data Collection Instrument

Sound measurement must meet the tests of reliability and validity. In fact, these are the two major considerations one should use in evaluating a measurement tool.

In the widest definition, reliability can be described as clearness degree of measurement results from random errors (Cohen et al., 2007). Up to today, lots of reliability coefficients have been

recommended for estimating reliability of measurement tools. Alpha coefficient developed by Cronbach (1955), is generally used in acquiring reliability in terms of internal consistency regarding a single test especially in combined measurements. This coefficient is also known as Cronbach's alpha coefficients.

The classification performed by Cohen et al., (2007) was used while interpreting the significance of influence quantities in the study. According to this classification, influence quantities are classified as,

1. Weak between 0.00 and ±0.10
2. Small between ± 0.10 and 0.30
3. Moderate between ± 0.30 and 0.50
4. Strong between ± 0.50 and 0.80
5. Very strong over ± 0.80

In this study Cronbach's alpha coefficients was used to check the reliability of the data collection tool and the internal consistency was indicated according to Cohenet al., (2007) classification.

Validity refers to how fairly you can generalize your findings to other groups or other situations. Also it can refer to the most critical criterion and indicates the degree to which an instrument measures what it is supposed to measure. But the question arises: how can one determine validity without direct confirming knowledge? The answer may be that we seek other relevant evidence that confirms the answers we have found with our measuring tool (Kothari, 2004).

In this study the researcher applied the following validity strategies to make the research trustworthy and accurate. Frist pilot study was done to test whether the questionnaire was intelligible, unambiguous and easy for respondent to understand and respond to. Pilot study of the questionnaire was conducted by investigating sample questionnaires. Second prolonged time was spent on the visited construction site. In this way, the researcher developed an in-depth understanding of the site layout planning. Third triangulation of data was made; by doing this data was collected through different source (i.e. questionnaire survey, observation/site visit and document analysis).

3.6 Data Management and Analysis

The study was analyzed based on descriptive statistics analysis method; descriptive statistics gives numerical and graphic procedures to summarize a collection of data in a clear and

understandable way. The data collected through questionnaire were analyzed using SPSS and computer programs including Microsoft excel sheet.

The outcome of the study was correspondingly assessed with the research objectives. The results were analyzed statistically using Mean Score Ranking to determine the effects of poor site layout planning on building construction activities on the site and the key factors which contribute to achieving an effective site layout planning. Percentages were used to analyze site layout plan utilization practice on building construction sites and the findings were presented in the form of bar charts to understand easily. Some multiple choice questions allowed respondents to check more than one answer if it applied; therefore, the sum of percentages may exceed 100%. Moreover, reviewed literature was also used as one of the main backbone for the analysis of the findings.

As mentioned above in the analysis, the "Mean Score" method is adopted to establish the relative effects of poor sits layout planning and factors contributing for effective site layout planning. Scale of ordinal measures of agreement towards each statement (5, 4, 3, 2 and 1) was used to calculate the mean score for each factor that is used to determine the relative ranking.

The Mean Score (MS) for each variable was computed by using the following formula:

$$MS = \frac{\sum(F \times R)}{N} \quad \text{..... Equation 3.1}$$

Where:

MS= Mean Score

F= Frequency of responses for each rating

R= Rating given to each factor (from 5 to 1)

N= Total number of responses concerning each factor

Nonparametric inferential statistics was also used to analyze the collected data; the Spearman (Rho) rank correlation coefficient was used for measuring the differences in ranking between two groups of respondents scoring for various factors (Contractors versus Consultants). The Spearman (Rho) rank correlation coefficient for any two groups of ranking is given by the following formula (Naoum, 1998):

$$Rho(\rho cal) = 1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)} \quad \text{.....Equation 3.2}$$

Where:

Rho (ρcal) – Spearman rank correlation coefficient

d_i – The difference in ranking between each pair of factors

N – Number of factors (variables)

Accordingly, in this study after determining the mean values for all variables described in the questionnaire, ranks were given based on their respective mean value of ratings calculated. Then, since the respondents for the questionnaire were from two parties in the building construction projects, rank correlation coefficients were determined among contractors and consultants; then based on rank order correlation coefficients the agreement between the two groups were checked by hypothesis testing.

Procedure for hypothesis testing:

1. Define the null hypothesis (H_0) and the alternative hypothesis (H_A).
2. Choose a value for ρ. (i.e. choose the significance level)
3. Calculate the value of the test statistic, Rho (ρcal).
4. Compare the calculated value with a table of the critical values of the test statistic.
5. If the calculated value of the test statistic is less than the critical value from the table, accept the null hypothesis (H_0). If the absolute (calculated) value of the test statistic is greater than or equal to the critical value from the table, reject the null hypothesis (H_0) and accept the alternative hypothesis (H_A).

The Null Hypothesis (H_0): There is no agreement in the ranking order between the two groups of respondent.

The Alternative Hypothesis (H_A): There is agreement in the ranking order between the two groups of respondent.

The detailed data analysis and discussion were presented in the next chapter of the research paper.

4. ANALYSIS AND DISCUSSION

4.1 Introduction

This section discusses the findings from the analysis of the data collected. It used methods of data analysis discussed under the previous chapter. A thorough analysis was done using descriptive statistics in terms of percentages and frequencies. Again the mean score ranking was employed in the data analysis. The results and discussion sections of the research was devised in three main parts in line with the objectives of the research and also the sections of the questionnaire. The first part tried to present the finding for the first specific objective of the research on the effects of poor site layout planning on building construction activities on the site and discuss about what this findings means. The second part of the results and discussion contains the findings of the questions directed towards identifying the key factors which contribute to achieving an effective site layout planning and the results were discussed. The third part was focused on studying site layout plan utilization practice on building construction projects and presents the results of the questions directed towards this. The last part of the result and discussion section tried to present procedures that can be referenced when developing site layout plan and the result of site observation on building construction projects about site layout planning practice.

4.1.1 The General Information of Questionnaire Response

In this research a total of forty (40) questionnaires were distributed; 20(50%) to the contractors and 20(50%) to the consultants. The general response rate for contractors and consultants was 90% and the total number of respondents for the two parties was 36 out of 40 respondents. The response rate of contractors was 47.5 % (19 out of 20 respondents) and 42.5 % (17 out of 20 respondents) from the consultant side. Table 4.1 below shows the summary of questionnaires distributed and the responded rate.

Table 4.1: Summary of questionnaire distributed and responded

Category	Number of Questionnaire Distributed		Number of Questionnaire Returned	
	Number	Percentage (%)	Number	Percentage (%)
Contractor	20	50	19	47.5
Consultant	20	50	17	42.5
Total	**40**	**100**	**36**	**90**

4.1.2 Profile of Survey Respondents

The profile features of the respondents for this study had three components, namely, level of education, position in the company, and experience in the construction industry as shown in Table 4.2. The educational level of the respondents was also examined. From the majority of the respondents Bsc holders dominated the study with 84.21% from the contractor side and 70.59% from the consultant side. Msc holders accounted for 15.79% from the contractor side and 17.65% from the consultant side of the respondents. Diploma holders accounted 11.76% from the consultant side of the respondents.

The area of expertise was also examined. From Table 4.2, more than half (68.42%) of the survey respondents were Project managers from the contractor side. From the consultant side all of the respondents (100%) were resident engineers. Working experience of the respondents was also examined. Most of the respondents 47.37% were with working experience of 5 to 10 years from the contractor side and 52.94% were with working experience of above 10 years from the consultant side.

Table 4.2: Profile of survey respondents

Profile		Contractor		Consultant	
		Frequency	Percent	Frequency	Percent
Education	Diploma	0	0	2	11.76
	Bsc degree	16	84.21	12	70.59
	Msc degree	3	15.79	3	17.65
	PhD	0	0	0	0
Position	Project Manager	13	68.42	-	-
	Office Engineer	3	15.79	-	-
	Site Engineer	3	15.79	-	-
	Consultant/ RE	-	-	17	100
Experience	Less than 5 years	2	10.53	1	5.88
	5 to 10 years	9	47.37	7	41.18
	Above 10 years	8	42.10	9	52.94

4.2 The Effects of Poor Site Layout Planning on Building Construction Activities

In this section, the effects of poor site layout planning on building construction activities by the contractors and consultants were indicated according to their agreement level; and the result was

shown in Table 4.3. From the views of the contractors side among the effects of poor site layout planning: increase distance travel in the construction site was indicated as the first effect with the mean score of 4.58, construction materials lost and damage was ranked as the second with mean score of 4.53 and decrease the output from labour and machinery as the third effect with the mean score of 4.47. On the other hand, from the consultants perspective decrease the output from labour and machinery was ranked as the first with a mean score of 4.53, construction materials lost and damage; affect the coordination of all tasks on the project were ranked as the second and third effects with the mean score of 4.29 and 4.24 respectively. A demoralized worker was ranked as the least effect for poor site layout planning with the mean score of 3.74 and 3.71 by the contractors and consultants respectively.

The results obtained confirmed with the reviewed literatures; according to literatures reviewed increase distance travel in the construction site, construction materials lost and damage, decrease the output from labour and machinery, and affect the coordination of all tasks on the project were among others which are considered as the effects of poor site layout planning on construction sites.

Table 4.3: Effects of Poor Site Layout Planning on Building Construction Activities

The effects of poor site layout planning on building construction activities	Contractor		Consultant		Average	
	MS	Rank	MS	Rank	MS	Rank
Increase distance travel in site	4.58	1	4.18	4	4.38	3
Increase completion time of project	3.89	9	3.88	8	3.89	8
Increase cost of projects	4.21	5	4.12	5	4.17	5
Accident occurs at the site	3.95	8	4	6	3.98	7
Construction materials lost and damage	4.53	2	4.29	2	4.41	2
Reduce the quality of work	4	7	3.65	9	3.83	9
Decrease the output from labour and machinery	4.47	3	4.53	1	4.5	1
Decrease the security to the workforce and machinery	4.05	6	3.94	7	4	6
It affect the coordination of all tasks on the project	4.37	4	4.24	3	4.31	4
Demoralized workers	3.74	10	3.71	10	3.73	10

4.2.1 Correlation Tests for Agreements on the Effects of Poor Site Layout Planning on Building Construction Activities

The purposes of this analysis was to investigate whether there is an agreement or not on the attitudes of the respondents on ranking order of the effects of poor site layout planning on building construction activities. Hence in this section, rank order correlation test among the two group of respondents was checked using Spearman rank correlation coefficients, to see if there was a difference in ranking between the two groups of respondents; contractors versus consultants. The purpose of a hypothesis test is to avoid being deceived by chance occurrences; the tests also helped to evaluate whether consensus of opinions exist among respondents. In order to decide whether to accept or reject the null hypothesis, the level of significance 95% (P = 0.05) was used. This allows to state whether or not there is "agreement" between respondents response.

The spearman's correlation coefficient is calculated using equation 3.2 and the result is tabulated as shown below in Table 4.4. The summarized spearman correlation coefficient indicates that there is strong correlation between the two groups on the ranking order of the effects of poor site layout planning on building construction activities. Therefore the null hypothesis that there is no significant agreement between the respondents is rejected i.e. the null hypothesis is rejected.

From Table 4.4, it can be concluded that there is strong correlation between the attitudes of the respondents and hence the null hypothesis should be rejected and the alternative hypothesis shall be accepted. This means that contractors and consultants have the same perception about the effects of poor site layout planning on building construction activities.

Table 4.4: Summary of correlation test on the ranking the effects of poor site layout planning on building construction activities

Respondent	Rho (ρcal)= $1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)}$	Critical Value of ρ (Annex F)	Significance for P < 0.05	Reject / don't reject the Null Hypothesis
Contractor verses Consultant	0.85	0.7818	Significant	Reject

4.2.2 Cronbach Alpha Coefficient Test Result on the Effects of Poor Site Layout Planning

Reliability pertains to the consistency of scores. The less consistency within a given measurement, the less useful the data may be in analysis. In this study the researcher need to understand score reliability because of the possible impact reliability has on the interpretation of research results. Cronbach's alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach's alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale. Table 4.5 below indicates the result of Cronbach Alpha Coefficient on the effects of poor site layout planning on building construction activities. According to the classification performed by Cohen et al., (2007) the result on the table 4.5 indicates that there was very strong internal consistency for items in the scale.

Table 4.5: Cronbach Alpha Coefficient Test Result on the Effects of Poor Site layout planning

Respondents	Cronbach Alpha Coefficient
Contractor	0.845
Consultant	0.898

4.3 Factors which Contribute to Achieving an Effective Site Layout Planning

In this section, it became crucial to determine the factors that are considered in attaining an effective site layout planning on construction sites. Respondents were asked to indicate the factors they regard as prime in attaining an effective site layout planning by ranking their level/degree of agreement from 5 to 1, where 5=strongly agree, 4=agree, 3=neutral, 2=disagree, and 1=strongly disagree.

According to the data obtained from the questionnaire survey of factors which contribute to achieving an effective site layout planning was ranked as shown in Table 4.6; contractors agreed on the ranking of well-defined areas for material storage and handling as the first with a mean score of 4.68; the location of plant and equipment and location of building were ranked as the second important factors with a mean score of 4.63. Also allocation and positioning of temporary facilities was ranked as third important factor by the contractors with the mean score of 4.58. On the other hand from the consultants perspective availability of access and exit road to the construction site was ranked as the first with a mean score of 4.82, location of plant and equipment; method of construction were ranked as the second and third factors with the mean score of 4.65 and 4.53 respectively. The type of contract was ranked as the least factors for

effective site layout planning on construction sites with the mean score of 3.68 and 3.29 by the contractors and consultants respectively.

In establishing the relevance of the variables on the five-point Likert scale rating, a success criterion was seen as significant if it obtained a mean value of equal to or greater than 3.0. As illustrated in Table 4.6, the results of the survey revealed that many of the sixteen factors are essential in achieving an effective site layout planning. With mean values above 4.0, it can be concluded that the factors are crucial to facilitating site layout planning on construction sites.

Table 4.6: Factors which contribute in achieving an effective site layout planning

The key factors which contribute in achieving an effective site layout planning	Contractor		Consultant		Average	
	MS	Rank	MS	Rank	MS	Rank
Location of plant and equipment	4.63	2	4.65	2	4.64	2
Availability of waste handling and disposal areas are well located	4.26	9	4.41	5	4.34	7
Allocation and positioning of temporary facilities	4.58	3	4.47	4	4.53	3
Availability of access and exit road to the construction site	4.53	4	4.82	1	4.68	1
Adequate security (fencing, check points, security, etc.)	4.42	6	4.35	6	4.39	6
Well defined areas for material storage and handling	4.68	1	4.35	6	4.52	4
Shape and size of land	4.5	5	4.06	11	4.28	9
Type of contract	3.68	13	3.29	14	3.49	14
Access to utilities (electricity, water, etc.)	4.21	10	4.29	7	4.25	10
Workshop position clearly defined	4.05	12	4.18	9	4.12	11
Health and safety concerns	4.16	11	4.47	4	4.32	8
Surrounding environment (soil, nearness to water, vegetation, etc.)	4.05	12	3.82	13	3.94	13
Method of construction	4.53	4	4.53	3	4.53	3
Location of building	4.63	2	4.24	8	4.44	5
Location of the site	4.37	7	4.12	10	4.25	10
Adequate knowledge of the designer, who design the site layout plan	4.32	8	3.88	12	4.1	12

4.3.1 Correlation Tests for Agreements on the Key Factors Which Contribute in Achieving an Effective Site Layout Planning

In this case also, with a significance level of 95% (P = 0.05), the calculated value of ρ for the respondents (contractors and consultant) was greater than the critical values of ρ, so the hypothesis that there is no significant agreement between the respondents is rejected i.e. the null hypothesis is rejected. In Table 4.7, it is shown that there is strong rank order correlation between the attitudes of the respondents (contractors and consultant); and hence the null

hypothesis should be rejected and the alternative hypothesis shall be accepted. This means that most of the respondents have the same perception on ranking the key factors which contribute in achieving an effective site layout planning. Therefore the result indicated that there is perfectly strong rank order correlation among the contractor and consultant side on ranking the key factors which contribute in achieving an effective site layout planning.

Table 4.7: Summary of correlation test on the ranking of the key factors which contribute in achieving an effective site layout planning

Respondent	Rho (ρcal)= $1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)}$	Critical Value of ρ (Annex F)	Significance for P < 0.05	Reject / don't reject the Null Hypothesis
Contractor verses Consultant	0.68	0.6324	Significant	Reject

4.3.2 Cronbach Alpha Coefficient Test Result on Key Factors Which Contribute in Achieving an Effective Site Layout Planning

Table 4.8 below indicates the result of Cronbach Alpha Coefficient on the key factors which contribute in achieving an effective site layout planning. According to the classification performed by Cohen et al., (2007) the result on the table indicates that there was very strong internal consistency for items in the scale.

Table 4.8: Cronbach Alpha Coefficient Test Result on Key Factors

Respondents	Cronbach Alpha Coefficient
Contractor	0.827
Consultant	0.894

4.4 Site Layout plan Utilization Practice on Building Construction Projects

Project planning is critical in order to deliver a construction project on time and within budget. Many practitioners and researchers have recognized site layout planning as a critical step in construction planning, and if an effective and systematic approach to site layout planning is not used, extensive time losses and cost overruns may result (Elbeltagi, 2008; Ning et al., 2011).

Of all the survey respondents regarding their philosophy in the creation of site layout plan from the contractor side, 15(78.95%) stated that they create site layout plans for every project they construct; and 4(21.05%) only develop site layout plans when site space available is very limited. From the consultant side, 15(88.24%) stated that they create site layout plans for every project

they construct; 1(5.88%) only develop site layout plans when site space available is very limited; and 3(17.65%) indicated that project characteristics dictate site layout plan development, as shown in Figure 4.1.

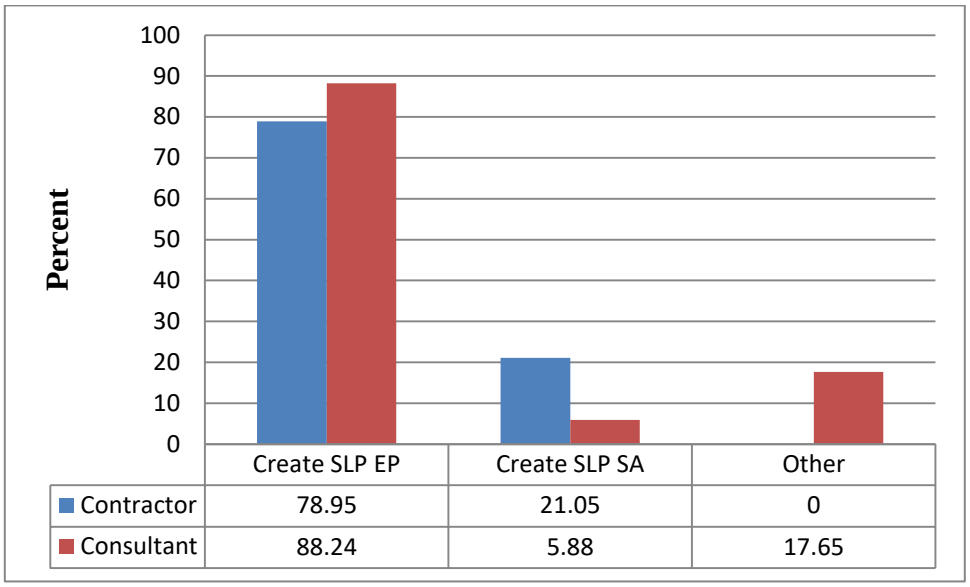


Figure 4.1: Site Layout Plan Creation Philosophies

4.5 Design Aspects of Site Layout Planning

Many aspects must be considered when designing the site layout of a construction site. It is important to recognize that comprehensive site layout plans cannot be developed before other planning tasks are completed. Conversely, some planning tasks (e.g., construction sequencing) are affected by the site layout (Mawdesley et al., 2002). In order to successfully develop a site layout plan, one must know the following: Personal Involved with Site Layout Planning, Time Frame for Developing the Plan, and Factors Affecting the Layout. These factors are discussed in the following sections.

4.5.1 Site Layout Plan Developer

Typically, the project manager is responsible for developing the site layout plan (Osman et al., 2003). This trend was observed in around sixty three percent (63.16%) of the respondents; while around forty two percent (42.11%) of the respondents reported that the project engineer is responsible for the development of the plan. Interestingly, around forty two percent (42.11%) of the respondents stated that this process is a collaborative decision making process where the project manager, project engineer and other supervisory personal are involved, as shown in Figure 4.2.

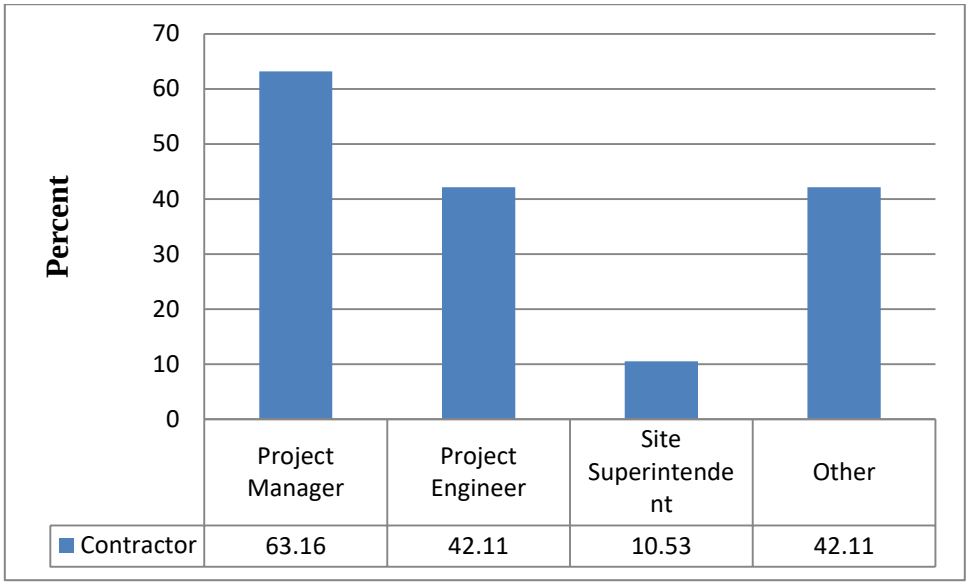


Figure 4.2: Typical Site Layout plan Developer

4.5.2 Consultant Participation

Contractors are not the only project participants who can contribute helpful information in regards to the development of site layout plans. Consultants can provide information that can be critical to the success of a project. Around seventy nine percent (78.95%) of the respondents from the contractor side indicated that consultant typically get involved in the development of site layout plans. Also hundred percent (100%) of the respondents from the consultants side indicated that consultant typically get involved in the development of site layout plans. Communication between the project manager and consultants needs to be established and maintained throughout the project lifecycle so that construction related events affecting the project can be minimized. Figure 4.3 shows the involvement of consultant in the development of site layout plan.

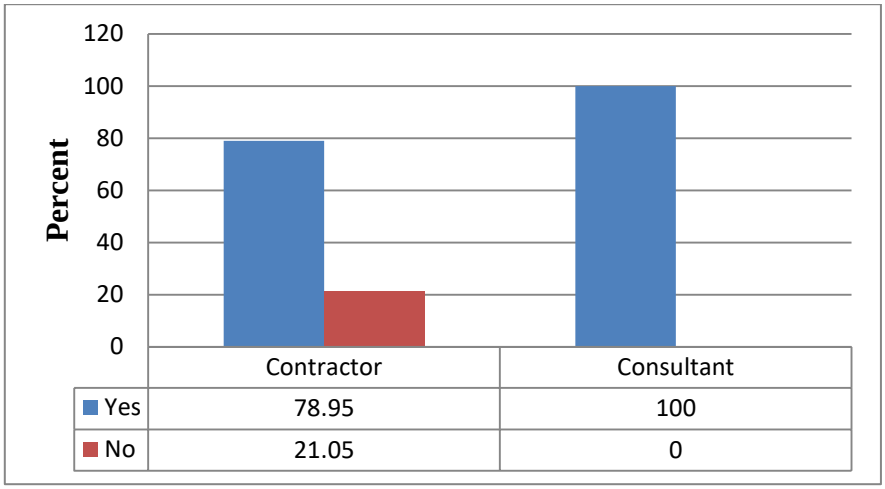


Figure 4.3: Consultant Involvement in the Development of Site Layout Plan

4.5.3 Time Frame for Site Layout Planning

Site layout plans are as important as other planning tasks that have to be accomplished. Before moving on-site, detailed site plans need to be prepared showing the positions of all temporary facilities within the site boundaries (Elbeltagi, 2008). Unfortunately, the greatest failure of contractors in the construction industry is the lack of preconstruction planning. However, preconstruction planning can provide significant benefits including project control and organization which leads to increased productivity, fewer accidents, and increased profitability (Plumbing-Heating-Cooling Contractors (PHCC) National Association, 2002).

As shown in Figure 4.4, the majority of the respondents from the contractors (36.84%) and consultants (35.29%) agreed/stated that site layout planning are continuously updated over the course of the project; also some of contractors (36.84%) and consultants (23.53%) responded site layout planning begins after arriving on site; and while the remaining contractors (21.05%) and consultants (29.41%) respondents stated that site layout planning begins prior to arriving on site. Considering the dynamic nature of a construction site, it is clear that a fixed site layout plan established early in a project lifecycle will not work with site conditions through project maturity. Therefore, site layout planning needs to be an ongoing process.

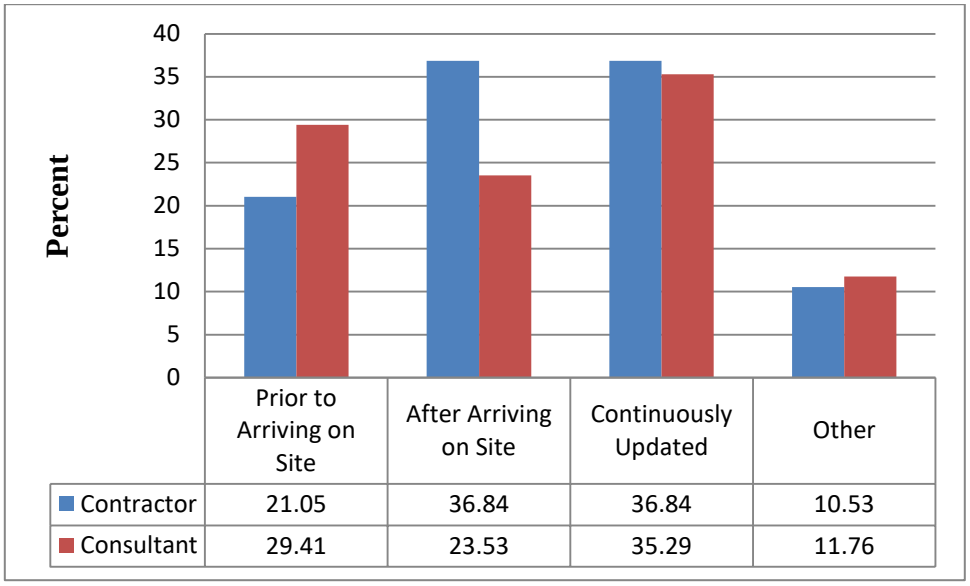


Figure 4.4: Time at which Site Layout Plans are Fully Developed

4.5.4 Elements of Planning

Space management involves three primary elements: site layout planning, path planning, and space scheduling (Guo, 2002). When beginning the site layout planning process, the site layout planning team must determine the basic site space requirements based on the project scope, schedule, and construction method. The following sections provide insight into these factors based on participant responses.

4.5.4.1 Temporary Facilities

Temporary facilities play an important role in supporting construction activities over projects duration. The planner must understand the characteristics of each temporary facility before planning the site layout, as unsystematically placed temporary facilities can significantly affect productivity (Elbeltagi, 2008). A generic list of temporary construction site facilities was developed based on past research and in-person interviews. From this generic list the researcher prepared a check list that can be filled while visiting the construction projects. As shown in the Annex C, facilities that were included in site layout plans by many projects were: parking lot location, site office location, access to job site, staging area, building footprint, on-site storage location, and etc. In addition to the temporary facilities shown in Annex B, some projects used additional temporary facilities that are included on site layout plans. These additional temporary facilities are: crane locations and radii, construction fencing locations, existing buildings, best management practices for erosion and above ground utilities. Most of the temporary facilities listed in the check list where applicable to site layout planning but not always used. Thus, one could argue that the temporary facilities required for construction are based on project type,

project location, and schedule complexity. To decide which temporary facilities to utilize on a project, the construction management team needs to take the project's unique characteristics into consideration.

4.5.4.2 Site Route Planning

Site route planning is a process for determining the shortest, collision-free path within the construction boundary for construction equipment and operations. Equipment and material flows can have a significant effect on the efficiency of construction operations (Kim and Kim, 2010). Any interruption to normal equipment/material flows can result in serious degradation of performance and labor productivity (Thomas et al., 2002). Typical applications of route planning on construction sites include large vehicles routing, heavy-lift operations, and cut/fill operations (Guo, 2002).

The respondents from the contractor side were asked to identify which movement planning operations are typically considered during site layout plan development. An overwhelming majority indicated that the two main movement operations to consider during site planning were equipment movement (100%) and material movement (100%). Ninety percent (90%) of the respondent indicated that they also considered on-site personnel movement during the planning phase, as shown in Figure 4.5.

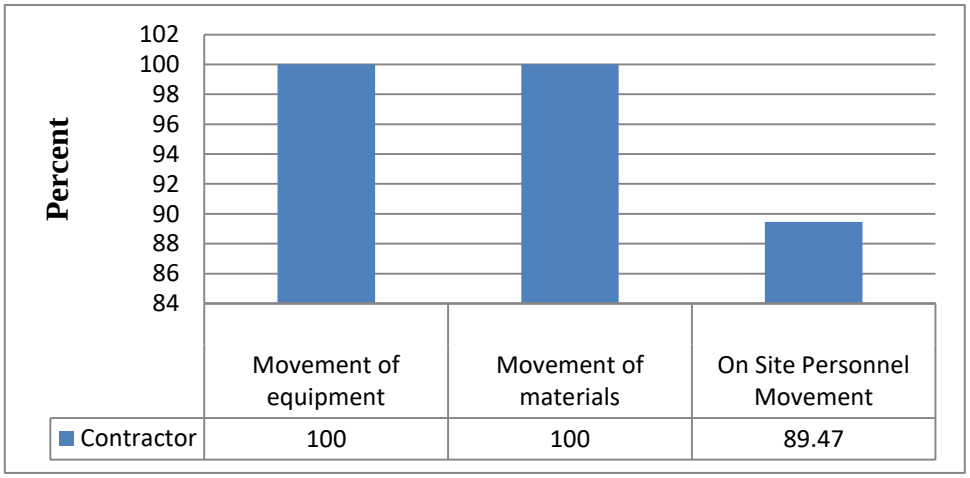


Figure 4.5: Construction Site Route Planning

Based on these responses, it is apparent that most respondents understand the impacts that can arise from neglecting movement planning. Most likely these elements of the site plan are considered separately based upon project specific characteristics when developing site layout plans.

4.5.4.3 Temporary Facility Locating

Once the temporary facilities required for a project are selected, the construction team must determining the geographical space requirements for the temporary facilities, as well as their locations within the construction boundary. This part of the planning process is intended to decrease congested work areas that can result from stacking trades, mismanagement of material deliveries and storage, and poor waste management on site (Thomas et al. 2006).

The physical characteristics of each temporary facility should be well understood before selecting its location on-site. The positioning of on-site temporary facilities is directly linked to the site conditions and special relationships between construction activities, equipment, and material. In some situations, local by-laws, such as required emergency access routes, may be a controlling factor during the locating process (Elbeltagi 2008). Project owners can also influence the location of temporary facilities by providing specific site layout instructions within the contract documents to ensure their operational needs are met. Respondents were asked to identify the methods most commonly used to determine the locations of temporary facilities within the construction site boundary. Hundred percent (100%) of the respondents indicated that they developed site layout plans primarily based on past experience obtained from previous projects, as shown in Figure 4.6.

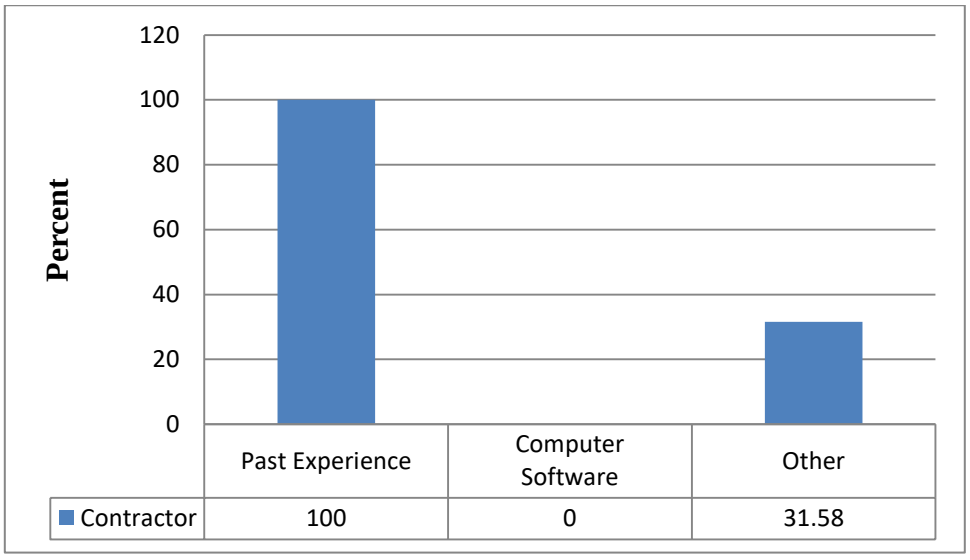


Figure 4.6: Methods for Locating On-Site Temporary Facilities

While some respondents (31.58%) stated that site conditions, contract documents, and utilities influence the locations of temporary facilities, the main method used for locating temporary facilities was experience. As shown above, no one of respondents used computer software for site layout planning. The lack of site layout planning software usage within the construction

industry suggests that either software capable of making complex decisions based on project specific constraints is not readily available to the industry or the software(s) available do not currently meet construction industry standards for site planning. None the less, the main focus of several past research efforts has been to develop site layout planning software systems that make complex decision based on many constraints (Chau and Anson, 2002; Mawdesley et al., 2002; Ning et al., 2011; Osman et al., 2003). The construction industry is historically slow to adopt new technologies (McGraw-Hill Construction, 2012). However, as younger professionals emerge within the construction industry, software system implementation will most likely increase.

4.5.4.4 Planning Detail

When designers are creating construction drawings, it is critical to include a high level of detail on the drawings so pertinent information can be clearly transferred between all stakeholders. Depending on the project size, the amount of detail needed cannot be effectively illustrated on a single drawing. Thus, construction drawings are usually broken down into phases (e.g., site, structural, etc.). This also holds true for site layout plans.

Around thirty seven (36.84%) of the respondents from the contractors side and around thirty (29.84%) percent of the respondents from the consultants side agreed to create multiple site layout plans for different phases of construction as opposed to a single master site layout plan, as shown in Figure 4.7. But this is not necessary due to the ever changing space requirements on-site when the construction process progress.

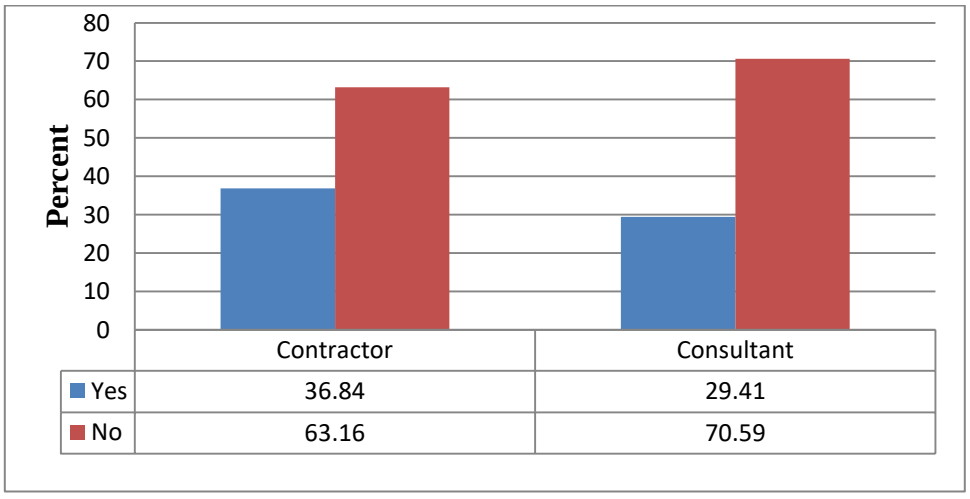


Figure 4.7: Creation of Multiple Site Layout Plan

As Figure 4.8 shown surprisingly, fifty three percent (52.63%) of the respondents from the contractor side and eighty two percent (82.35%) of the respondents from the consultant side agreed on the development of site layout plans for the entire project duration, not just the critical phases. This suggests that construction management teams have recognized the benefits of having a well-organized job site throughout the project life cycle.

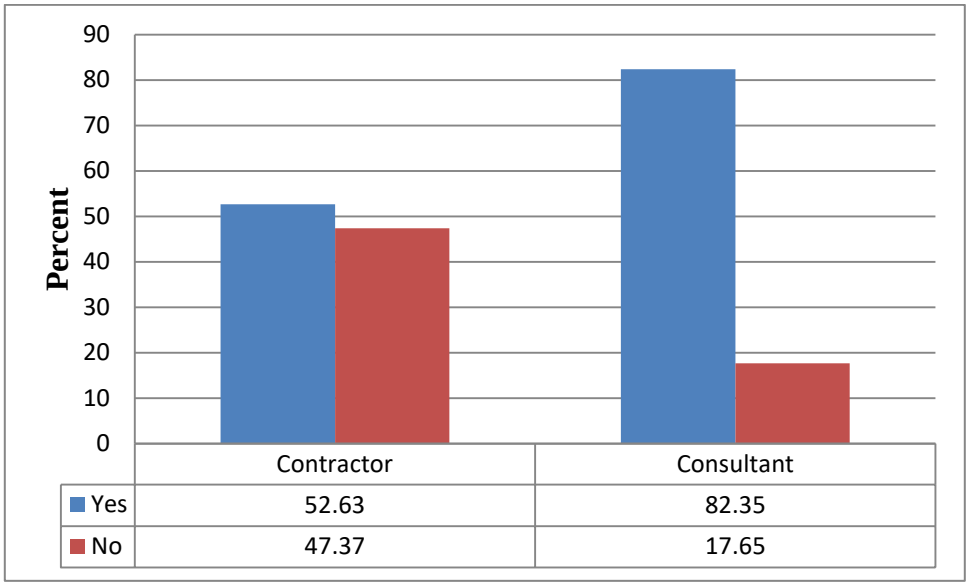


Figure 4.8: Develop Site Layout Plan for the Entire Project Duration

Construction drawings are usually very detailed; site layout plans are typically the opposite. Around fifty three present (52.63%) of the respondents specified that a medium level of detail is incorporated into most site plans with only essential temporary facilities and storage locations shown on the plans, as Figure 4.9 indicates.

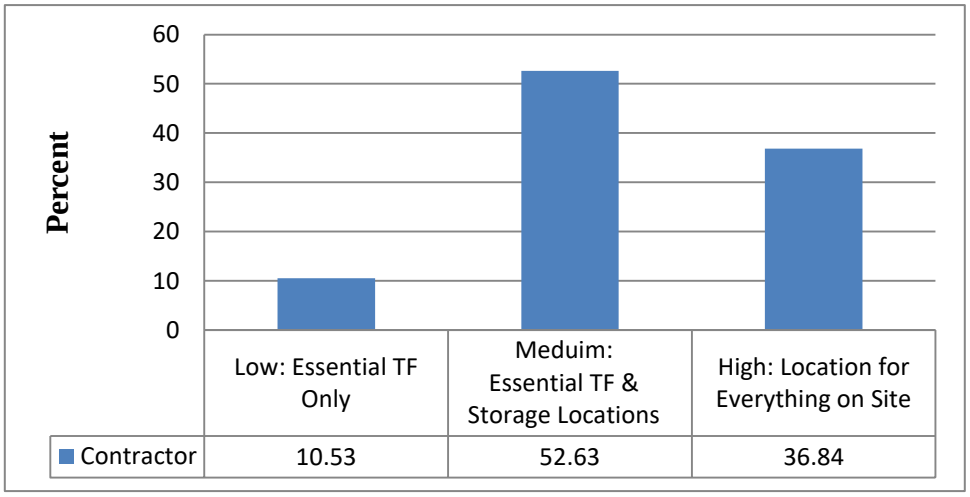


Figure 4.9: Site Layout Planning Detail

The time it takes to develop a site layout plan is a function of the project scope and complexity. The majority of respondents indicated that time spent to developing site layout plans for most projects falls between eight and forty hours, as shown in Figure 4.10.

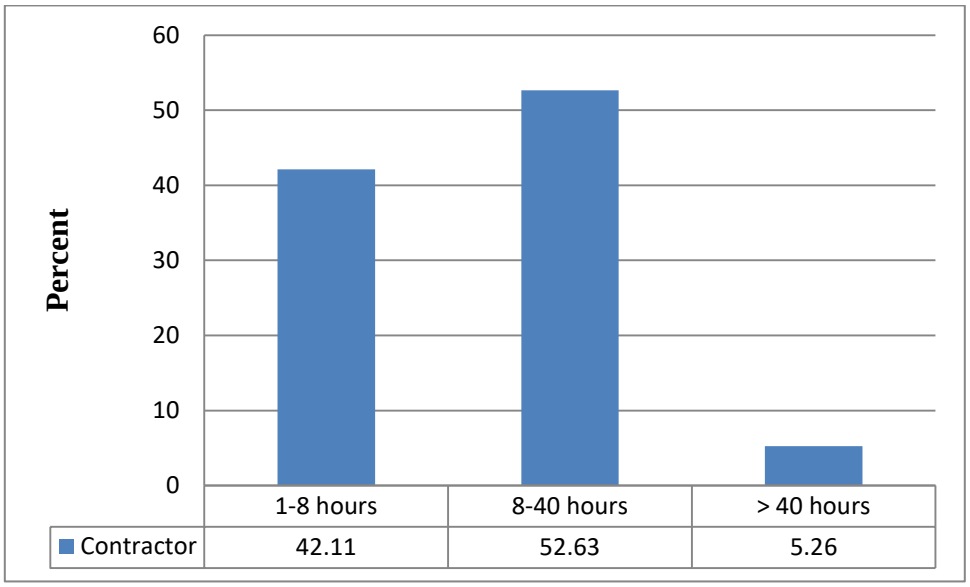


Figure 4.10: Site Layout Planning Time Investment

Intuitively, people want to know how long it takes to complete a certain task. This applies to many aspects of construction. Knowing the typical amount of time spent on site layout plan development is important during project cost estimation. A project planner's time is valuable and should be effectively utilized. Understanding that a typical site layout plan takes between eight and forty hours to develop, project estimators can quantify the additional cost associated with site plan development.

4.6 Software

Technology plays a big role in the construction industry as it provides a communication tool that enhances the delivery and exchange of information among different parties involved in a construction project. Unfortunately, a software system specifically designed to create site layout plans has yet to emerge within the construction industry. When asked about software systems, sixty eight percent (68.42%) of the respondents from the contractor side indicated that a software system was used to create site layout plans. The common software system identified was CAD, as shown in Figure 4.11. Additional site planning systems identified was hand sketch depending on the type of projects.

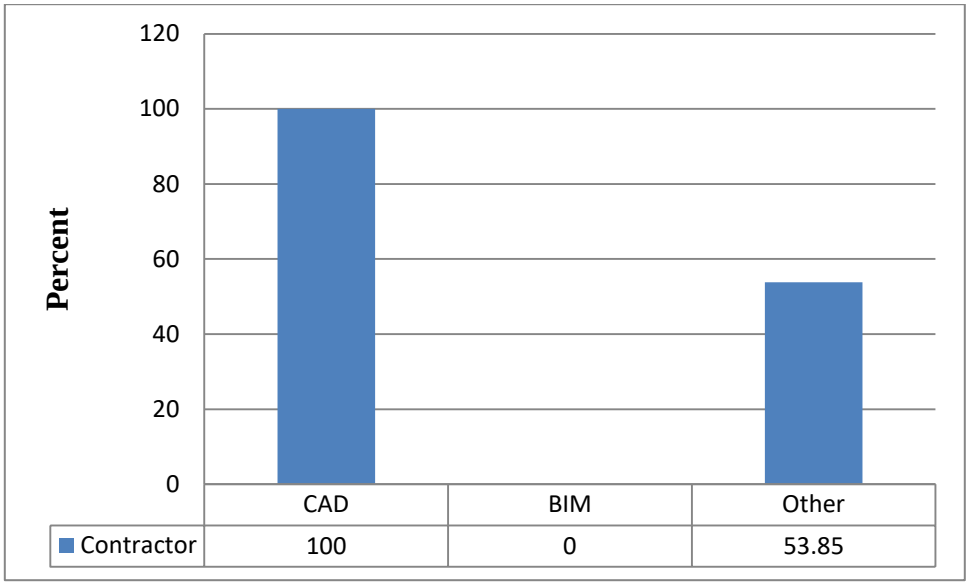


Figure 4.11: Software Used for Site Layout Plan

4.7 Cost Associated With Site Layout Plans

The indirect cost associated with establishing and eliminating temporary facilities has yet to be documented. Although this cost can vary greatly depending on the project scope and size, an average cost associated with temporary facilities needs to be established to provide inexperienced site planners with a perspective on the capital invested in temporary facilities. For this reason, the respondents were asked what percentage of the total project cost is allocated to temporary facilities. The majority of the respondents (68.42%) indicated that between 0% and 2% of the total project cost is allocated to temporary facilities, as shown in Figure 4.12.

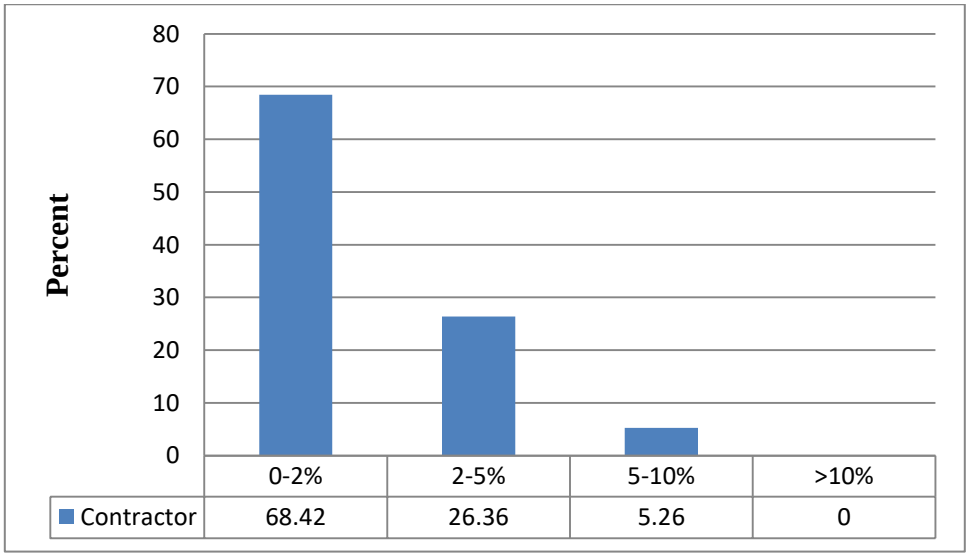


Figure 4.12: Percent of Total Project Cost Allocated to Temporary Facilities

Costs associated with temporary facilities can become significant on multi-million birr project. This cost can impact the general contractor's profit margin considerably if not accurately integrated into the bid. Site planners not only need the skills to accurately develop a site plan, but they also need the ability to estimate the implementation cost of their site plan. Sixty three percent (63.16%) of the respondents from the contractor side stated that the monetary size of a project influence the decision to develop site layout plans. But this look was not good for efficient completion of project; so without depending on the amount of the contract price it is better to establish site layout planning for a given projects. In contrast the perception of the consultant shows that eighty eight percent (88.24%) stated that the monetary size of a project does not influence the decision to develop site layout plans.

4.8 Implementation and Monitoring

A well-developed site layout plan can greatly enhance construction operations. However, if not properly implemented at project start up and monitored over the entire project duration, costly non-value adding activities can occur. In order to properly implement a site layout plan, all tradesmen involved with the project need to be well informed of site space allocation. This can be accomplished by posting signage throughout the site indicating the locations of temporary facilities and/or displaying the site layout plan on an information board that can be viewed by all. Signage and/or posted site layout plans should be updated over the course of the project and verbal announcements of updates should be made at meetings. To ensure that the contractor abides by the site plan, specific terms need to be included in contractual documents specifying the punitive actions for non-compliance. When asked about punitive actions imposed on contractor for non-compliances, eighty two percent (82.35%) of the respondents from the consultant side indicated that actions would be taken to sway the contractor to follow the site layout plan. Common punitive actions identified were verbal warnings, written warnings, monetary penalties, and disposal of incorrectly stored items, as shown in Figure 4.13.

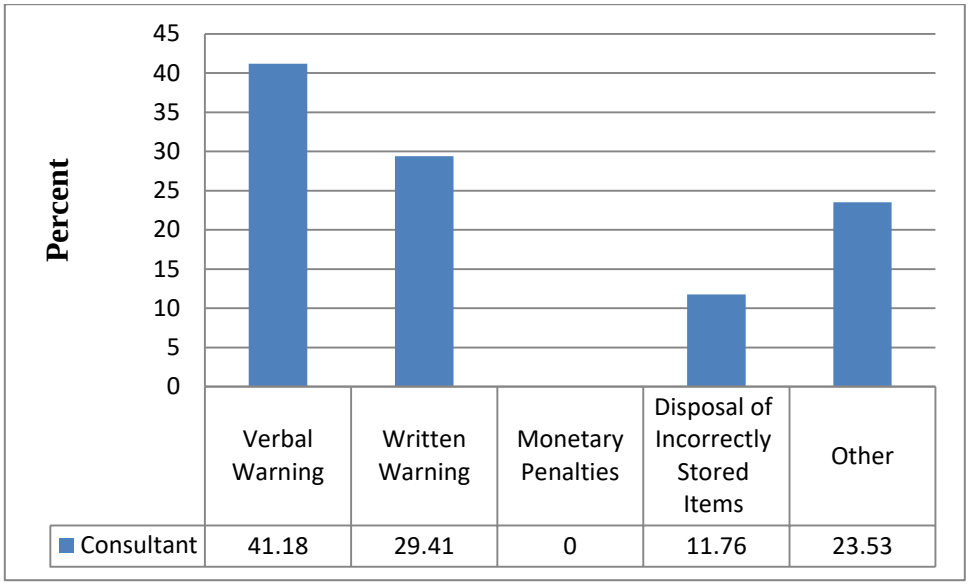


Figure 4.13: Common Non-Compliance Actions

When insubordinate arise, a simple discussion on why site layout plans are used and their effect on construction operations is usually the only action needed to adjust contractor behavior.

Monitoring and managing implemented site layout plans usually falls under the responsibility of the site superintendent. Site superintendents run the day-to-day operations on construction sites and control short term scheduling. Site logistics should be second nature to site superintendents and they should always know the locations of material, equipment, and personnel on their jobsite. Knowing the jobsite layout has as much to do with jobsite safety as it does productivity and other aspects of a project. When monitoring construction operations, site superintendents need the ability to identify problems quickly and provide solutions that minimize disruption to other construction activities.

4.9 Documenting

Final project reports have become a standard practice among many construction companies. These reports contain a vast amount of information pertaining to problems encountered during a project and sometimes include lessons learned on the project. These documents are ideal sources of information that can help less experienced employees learn about site layout planning and strategies used to overcome problems encountered during construction. Around sixty three percent (63.16%) of the respondents from the contractor side stated that they document knowledge acquired on site layout planning over the course of a project. Documenting this information and making it available to all management personnel is one method of distributing knowledge to prevent similar mistakes on future projects. As shown in Figure 4.14, ninety one

percent (91.67%) of the respondents store documentation in Personal files (e.g. filing cabinet, personal computer, etc.) accessible by management personnel throughout their organization.

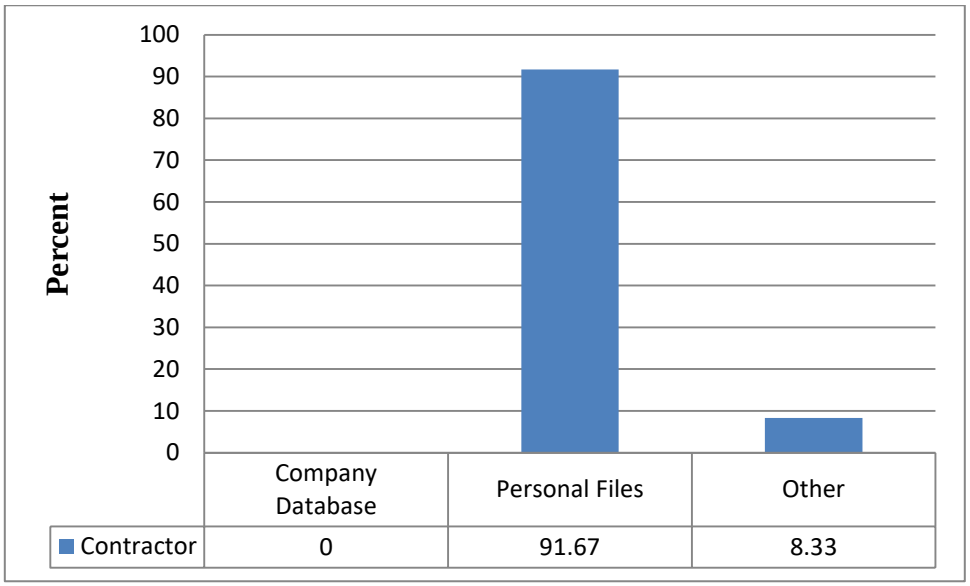


Figure 4.14: Methods for Documenting Acquired Knowledge

By storing information systematically within Personal files (e.g. filing cabinet, personal computer, etc.), employees are able to quickly refer information and determine if their current situation has occurred on past projects. If similar documented situations are found, the information may provide guidance on how to handle the current problem or author contact information may be listed to enable collaboration and assistance in solving the current problem.

Finally the respondents were asked about their impression about the site layout plan they are working with; around fifty eight percent (57.89%) of the respondents from the contractor side and around fifty nine percent (58.82%) of the respondents from the consultant side indicated that, their impression about the site layout plan they are working with is a good layout. Meanwhile, around twenty six percent (26.32%) of the respondents from the contractor side and around twenty three percent (23.53%) of the respondents from the consultant side indicated that their impression about the site layout plan they are working with is the better site layout plan, as shown Figure 4.15.

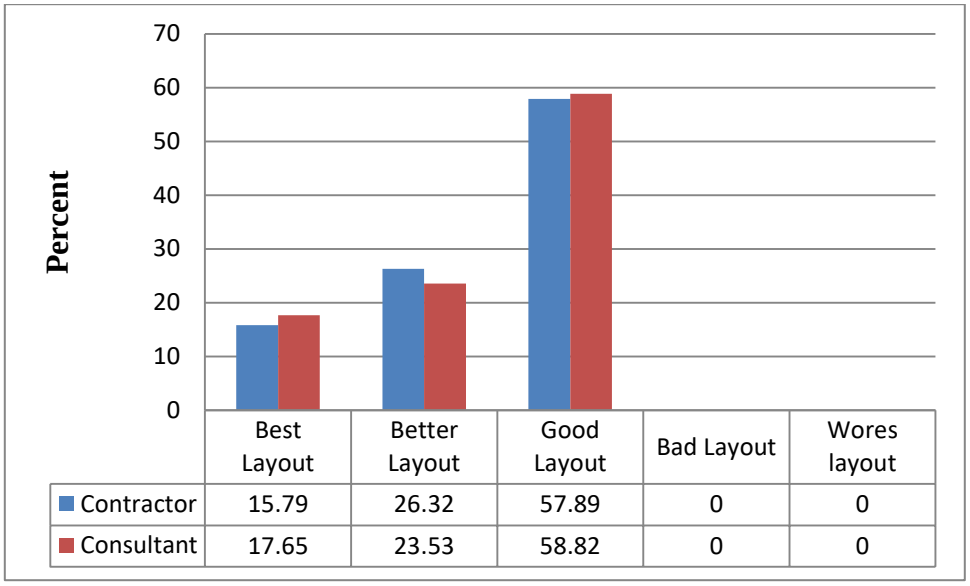


Figure 4.15: Impression of the Site Layout Plan Working With

4.10 Procedure for Site Layout Planning

This topic addresses the development of a procedure that can provide guidance during the site layout plan development phase of a construction project. The first step in developing a process for site layout planning is to acquire industry information on current methods used for site layout planning in the construction industry. The site layout planning procedure presented in this topic is based on data collected through the evaluation of published literature, questionnaire survey, site visits, and interviews.

To develop the procedure, a comprehensive review of published research literature was performed. The key terms reviewed include construction site layout planning, best practices of construction site layout planning, and construction site logistics planning. Also pertinent literature on current means and methods used in the development, implementation, and management of site layout planning was critically assessed to have information for the development of the procedure.

The findings were reported in this chapter from a comprehensive questionnaire survey of construction industry professionals from different construction projects. This survey queried individuals on site layout planning practice within the industry, design aspects of site layout planning, implementation and monitoring practices, documentation methods, site layout planning software, and implementation cost. Using these findings, the formation of a standard process for site plan development was initiated.

Site visits and interviews with construction industry professionals were conducted to develop a comprehensive understanding of current site layout planning utilization practices. While making the interview with construction industry professionals on the current practices and procedures on the site layout planning process used to delineate construction site space for temporary facilities. Many construction professionals are unaware of the elements that need to be considered during the site layout planning phase. A need exists for the development of a means for creating an effective site layout plan to prevent future unjustified cost overrun and time delays. As a result, it was important to develop a procedure for creating site layout plans that represent current industry standards which promote efficiency, productivity, and safe work flows.

The procedure was developed to serve as a reference document that can be used to create individualized site layout planning strategies. This will allow companies to customize the process to suit their individual needs. The procedure contains eight steps. Each step outlines important aspects that need to be considered during site layout plan development. The procedure was developed in a manner that allows easy modification. This allows individual preferences to be incorporated into the procedure. The basic purpose of the procedure is to provide inexperienced site planners with a generic guideline on site layout plan development and management. The procedure is outlined below.

Step One: Preliminary Study

1. Conduct an in-person investigation of the site and surrounding areas.
2. Identify local regulatory requirements, safety requirements.
3. Develop an understanding of the project scope and complexity.
4. Analyze the potential impact of severe weather on site operations.
5. Develop the Master Construction Schedule.

Step Two: Examine if Site layout Plan Development is Necessary

Determine if a site layout plan is required for the project considering the following factors:

1. Project complexity
2. Scope of work
3. Site investigation
4. Regulatory requirement
5. Project safety requirement

The development of the site layout plan should be a team effort that includes input from the management team under the leadership of the project manager, project engineer, consultant, owner, subcontractors.

Step Three: Collecting Data for Site Layout Plan Development

A. Identify all clauses set forth in the contract documents that may influence the site layout.
B. Involve the owner in the site layout plan development. Information from the owner that may affect site layout includes:
    1. Site entry/issue
    2. Traffic Routes
    3. Allotted Area for Construction
    4. Existing Facility Operations
    5. As-Built Drawings of Existing Facilities
    6. Availability of Offsite Storage Areas
    7. Safety Requirements
    8. Parking Area Availability
    9. Environmental Concerns
    10. Utility Connections
    11. Local Regulatory Requirements
C. Involve subcontractors in the site layout plan development. The subcontractors may provide the following information that could affect the site layout:
    1. Parking Requirements
    2. Toolsheds (Type/Size)
    3. Material Security Requirements
    4. Equipment Space and Access Requirements
    5. Material Supply/Delivery Schedules
    6. Type of Storage (Outdoor/Indoor)
    7. Storage Requirements
    8. Estimated Number of Site Workers

Step Four: Site Layout Plan Development

1. Decide what information should be included in the plan based on project requirements.
2. Determine if multiple site layout plans are required (for a project with multiple phases) or if a single plan will sufficient.
3. Identify existing site conditions on the site layout plan. These may include:

a) Site Topography
b) Parking Lots
c) Protected Areas
d) Roadways, Sidewalks
e) Best Management Practices for Erosion and Sediment Control
f) Drainage Areas
g) Buried / Overhead Utilities
h) Fire Hydrants
i) Existing Facilities/Buildings
j) Undisturbed Areas

4. Determine the location of each temporary facility. This is typically achieved by applying construction knowledge that has accumulated over many years. Temporary facilities that may be indicated on a site layout plan include:

Table 4.9: Temporary Facilities

TEMPORARY FACILITIES			
1	Construction Site Fencing and Gates	15	Water Tank Location
2	Site Offices Location	16	Crane Location and Swing Radii
3	Meeting(Conference) Room	16	Prefabricated Rebar Storage Yard
4	Cafeteria(Dining, Break) Area	17	Rebar Fabrication Yard
5	Information and Guard Office	18	Fabricated Rebar Storage Yard
6	Frist Aid Stations	19	Storage Yard for Timber
7	Toilet and Bathroom Facilities	20	Storage Yard for Formed Timber
8	Utilities (Water, Electricity)	21	Wood Workshop Area
9	Parking Lot Locations	22	Scaffolding Storage Yard
10	Access to Job Site	23	Soil Storage Area
11	Batch Plant Location	24	Waste Dump Location
12	On-site Aggregate Storage Area	25	Sampling/ Testing Lab
13	Off-site Aggregate Storage Area	26	Building Footprint
14	Cement and Material warehouse	27	Equipment Area

5. Consider the following logistics when selecting temporary facility locations:
    a) Public and Worker Safety
    b) Crane Lift Radii

c) Temporary Facility Interrelationships
d) Material Movement
e) Equipment Movement
f) Subcontractor Interrelationships

6. Identify construction routes on and off site. These may include:
    a) Material Delivery Routes
    b) Traffic Detour Routes
    c) Material Paths (Vertical & Horizontal)
    d) Traffic Flow
    e) Equipment Paths
    f) Personnel Paths, Haul Routes

The level of detail identified on a Site Layout Plan will depend on the operational control requirements. It is important to keep the plan flexible in order to cope with the uncertainties associated with the construction process.

7. Utilize software (CAD, BIM, etc.) technology when developing site plans.

Step Five: Communicate

1. Allow all stakeholders to review and provide feedback on the site layout plan.
2. Ensure that all stakeholders buy-in to the site layout plan before construction initiation.
3. Maintain communication with all stakeholders throughout the construction process.
4. Establish and clearly communicate the consequences of non-adherence to all the subcontractors.

Step Six: Implement and Enforce

1. Distribute the finalized site plan to all stakeholders. Effective methods for informing subcontractors and workers on space allocation are: a) displaying a large scale site plan onsite that can be easily seen; b) posting signage throughout the site identifying temporary facility areas; and c) distributing an electronic copy of the site plan to all subcontractors.
2. Enforce effective housekeeping rules at all times so that laydown areas and roads are maintained and kept free of trash and debris that would otherwise hinder movement of material and equipment.

Step Seven: Monitor and Evaluate

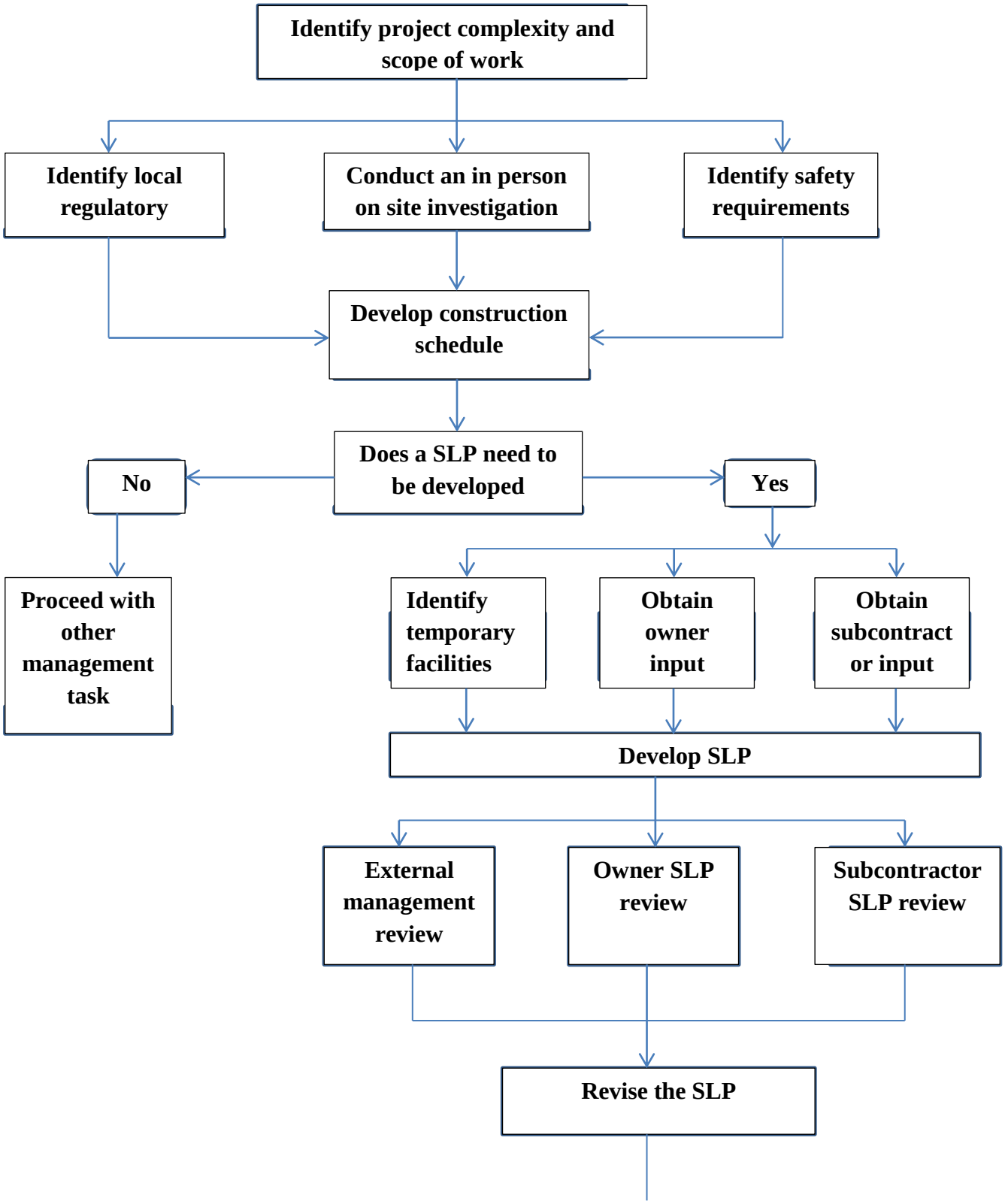
1. The site engineer should monitor and evaluate the plan on a day-to-day basis.

2. If the plan works properly, continue using it. If problems arise determine if the problems are related to noncompliant subcontractors or unforeseen conditions.
3. If non-compliant subcontractors are an issue, discuss the purpose of the site layout plan with the subcontractor. If problems continue, punitive actions may need to be taken.
4. Typical punitive actions include:
    a) Verbal Warnings
    b) Written Warnings
    c) Monetary Penalties
    d) Subcontractors Back-Charges
    e) Removal of Insubordinate Staff
    f) Contract Termination
5. If unforeseen conditions are an issue, revise the plan and correct the issues.
6. Update the plan on a regular basis, communicating the updates to all stakeholders.

Step Eight: Document Lessons Learned

1. Document lessons learned at the end of each project.
2. Develop a system for distributing documented information throughout the organization. A method commonly used for information distribution is a company database that can be access on-line by all management staff. Also developing a systematic personal files (e.g. filing cabinet, personal computer, etc.) that employees are able to quickly refer information.

Site Layout Planning Process Flow Chart



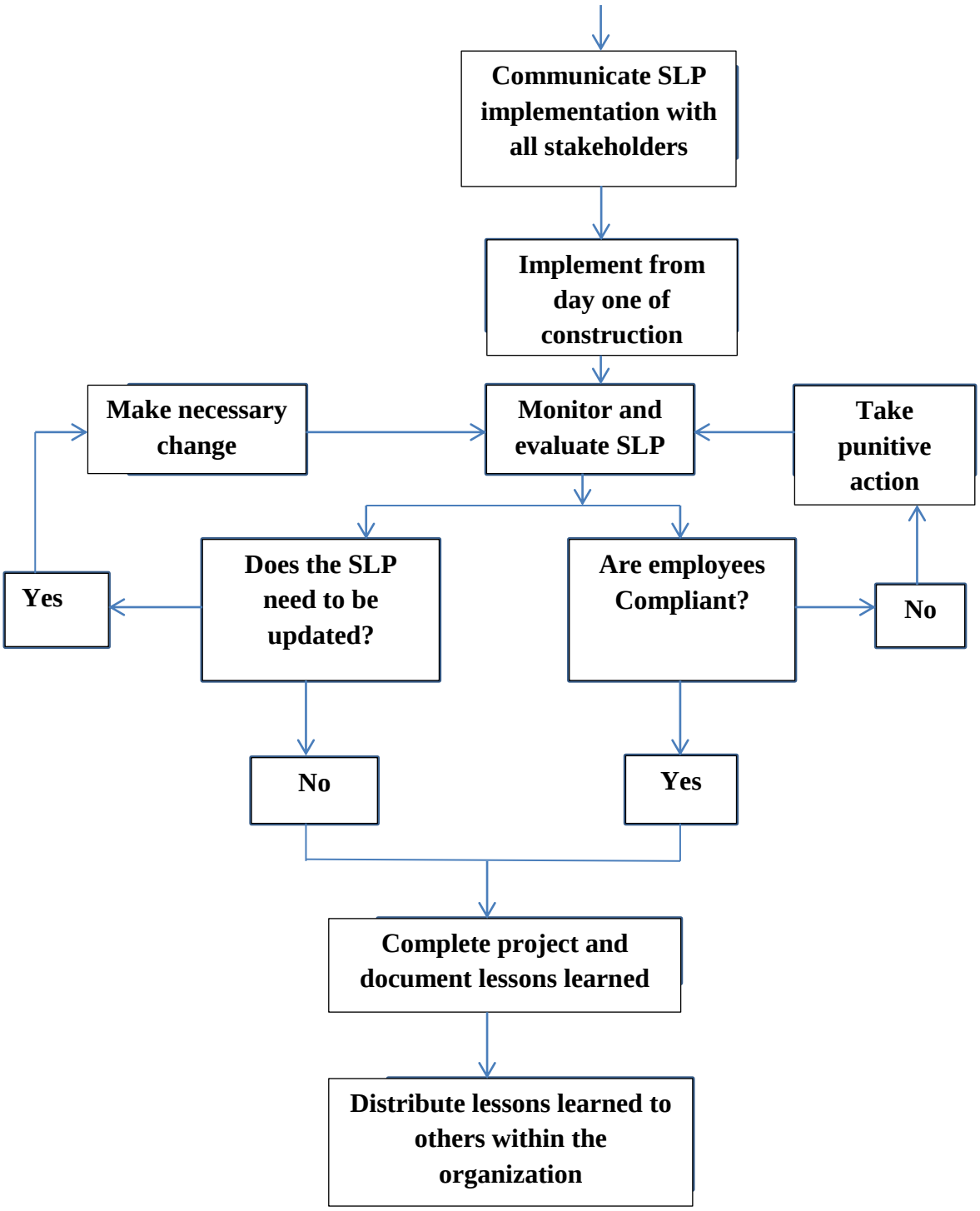


Figure 4.16: Site Layout Planning Flow Chart

4.11 Critical Analysis

This section presents the results of the study findings from the questionnaires survey. The effects of poor site layout planning on building construction activities; the key factors which contribute to achieving an effective site layout planning; and site layout plan utilization practice on building construction sites are discussed.

From the questionnaires survey, the effects of poor site layout planning on building construction activities were ranked and the most frequent were identified. As ranked on questionnaires survey response previously it is evident that the first effects of poor site layout planning on building construction activities was decrease the output from labour and machinery. Productivity and progress on any construction site is either enhanced or adversely affected by the outcome of the site layout plan. A good and an efficient site layout plan having all the necessary temporary facilities on site can eliminate or to a large extent reduce the negative influence on labour output. The provision of all the welfare facilities such as rest room, toilets, canteen, medical aid, etc. will have the morale of the workers uplifted and thereby increase their output leading to productivity (Tommelein et al. 1992).

Construction materials lost and damage was the second significant effects of poor site layout planning on building construction activities. The third effects of poor site layout planning on building construction activities increase distance travel in site. The work of Samaneh Z. and Javier I. (2014) indicated that site personnel or construction workers will spend most of the construction time within construction sites. If construction workers be able to easily and quickly move within the site, it helps to save time and increase productivity as well as safety. Good site layout is important to promote safe and efficient operations, minimize travel time, decrease material handling, and avoid obstructing material and equipment movements (Tommelein et al. 1992).

As per this study, the key factors which contribute to achieving an effective site layout planning were ranked and the most frequent were identified. Availability of access and exit road to the construction site was the first key factors which contribute to achieving an effective site layout planning. Good planning is needed to link the site roads to a major road nearby. Roads within the site are needed to allow work to flow easily. Spaces for parking of vehicles are to be provided. Where space does not exist this facility must be planned and provided somewhere convenient. Easy movement will keep the morale of the equipment and vehicle drivers high, thus minimizing

the chance of accidents. It will also save time in maneuvering in and out of the construction site (Elbelgati et al., 2004; Seethraaman et al., 2011).

The second key factor which contributes to achieving an effective site layout planning was location of batching plant and equipment. According to the responses found from the questionnaire, Allocation and positioning of temporary facilities; and method of construction used on site were the third key factors which contribute to achieving an effective site layout planning. Literature reviewed from Mawdesley et al. (2002) recognized three key aspects that a complete site utilization plan should address about temporary facility positioning. The aspects are: what are the temporary facilities that need to be established, what is the geographical layout of the temporary facility, and at what point during the project are the temporary facility going to be installed and removed. Also according to reviewed literature; the method of construction will to a large extent influence the planning of the site layout. The construction method can be either cast in-situ or the use of precast elements. If it is to be of precast element then provision for casting yard should be included in the layout planning (Elbelgati et al**.,** 2004).

With regard to site layout plan utilization practice on building construction sites comprehensive survey of construction industry professionals from different projects were conducted. This survey queried individuals on site layout planning practice within the industry, design aspects of site layout planning, implementation and monitoring practices, documentation methods, site planning software, implementation cost, and impression about the site they are working with. Starting from section 4.4 – 4.9 it discusses about site layout plan utilization practice on building construction sites.

4.12 Site Observation

This process of information gathering afforded the researcher the opportunity to have first-hand information and actually see and experience what is on the ground in the planning and implementation of site layout plans for construction works. It was very evident that site layout plans as part of the construction process could not be circumvented.

From the field survey and observation it was clear managers and supervisors in the construction industry understood and appreciated the relevance of implementing site layout plans. Theoretically they knew what to do in that regard, but some construction companies fell to adapt to its full practical implementation and utilization on the ground. There are two general objectives which site layout plan developer should seek to meet through careful organization of the site for construction. First, the site must be designed to maximize efficiency of operations in

order to promote worker productivity, to shorten project time and to reduce cost. Second, the final plan must create a project with a good work environment in order to attract and retain the best personnel and thus contribute to better work quality and productivity (Elbelgati et al**.,** 2004).

During the site visit to different projects the researcher tried to observe the type and number of temporary facilities provided on site by using checklist. A check of these facilities provided on site in comparison with what was adopted from the review of literature showed implementation inadequacies. Annex B is a table that shows temporary facilities provided on each construction project sites. It was evident that construction site managers were mainly focused in the provision of site offices, warehouses, toilets, water thank location, rebar fabrication yard and storage spaces than the rest of the other facilities.

Most of the construction projects had site offices for the company personnel and site supervisor. From the observation it was evidenced that majority of the contractor offices were constructed by corrugated sheet; but this has its own disadvantage during weather change. On the contrary the majority of the consultant offices were constructed using HCB with good finishing. According to Elbelgati *et al.,* (2004), site offices can be made from container, ready-made (pre-assembled building), constructing on site, and by using existing or under construction building. Site management office is expected to include: office rooms, meeting rooms, sub-contractor offices (if contracted), first- aid room, office-technology rooms, refreshment room (tea, food), and toilet.

The picture below shows site offices constructed for contractor and consultant. For an efficient and effective monitoring of the project site offices should be provided with meeting or conference room. All the offices should be close together and in a safe area. They are to be properly equipped to meet the needs of the project (Elbelgati *et al.*, 2004).

a) Office construction for the consultant in Hawassa project

b) Office construction for the consultant in Arba Minch project

c) Offices used by contractor & consultant in Hawassa project

d) G+1 office used by contractor due to space limitation in Hawassa project

Figure 4.17: Site Offices Constructed on Different Construction Sites

During observation many of the construction sites visited had not canteens; if canteens are available on site it was not constructed in good manner. Those without canteen on the construction sites their workers go outside the premises for food, tea and coffees during break. This could result in loss of working time due to unnecessary travelling (Tommelein et al., 1992).

Steel reinforcement bars are common materials used in building. Controlling the use of steel reinforcement in building sites is relatively difficult because it is cumbersome to handle due to its weight and shape. The main problems that affect steel are damages during storage, putting on bare ground and rust. To minimize defects that can occur on steel it is better to make stage before storage and select the appropriate place to store. The picture below shows steel handling on construction sites due to poor site layout planning.

a) Rebar on bare ground in Wollayta Sodo project

b) Rebar on bare ground in Arba Minch project

Figure 4.18: Steel Reinforcement Handling Due to Poor Site Layout Planning

In the visited site it is common to see aggregates (fine and course) which are stored improperly in the building construction sites due to poor site layout planning. Common problems which occurred due to improper handling and storing of aggregate at the construction sites are; segregation of aggregate, degradation of aggregate, contamination of materials by deleterious substances, inconsistent or undesirable moisture content, and also poor handling and storing of aggregate was indicated as the major sources of construction waste. Aggregates should be stored on clean, dry and hard surface and also the aggregates should not be dumped on loam or grass. Also coarse and fine aggregates should be stored and handled in appropriate manner to maintain the quality of the resulting concrete.

a) Coarse aggregate handling in Wollayta Sodo Project

b) Fine aggregate handling in Arba Minch project

Figure 4.19: Aggregate (fine and course) Handling Due to Poor Site Layout Planning

Many of the projects did not have areas designated to collect and handle waste. This improper waste handling on site has some impact in reducing productivity and causing accidents; so it is good to have appropriate waste handling and disposal area. Also according to reviewed literature; waste management for construction activities has been promoted with the aim of protecting the environment and the recognition that wastes from construction and demolition works contribute significantly to the polluted environment. The construction industry plays a vital role in meeting the needs of society and enhancing the quality of life. However, the responsibility for ensuring the construction activities and products in consistent with environmental policies needs to be defined and good environmental practices through reduction of wastes need to be improved. Normally, the best way to deal with material wastes is not to create it in the first place (Shen, 2002). The following picture shows waste handling on site.

a) Poor waste handling in Arba Minch project b) Poor waste handling in Dilla project

Figure 4.20: Waste Handling Due to Poor Site Layout Planning

Security wise, most of the construction site were fenced and protected by security guards. The security of the site should be of prime consideration to the site planner if the project should end successfully. The whole site should be fenced and the entrance strategically located with a guard post to check the ins and outs movement of all personnel and vehicles in order to check pilfering. The whole site should be illuminated at night to prevent intruders to the site (Khalafallah and El-Rayes, 2005; Elbelgati et al., 2004).

Most of the construction sites did not have workshops for forming and fabrication of materials needed for the construction projects. In all projects the production yard for rebar was provided. Also it was observed that, on most of the sites, no proper spaces were made available for first aid or clinic. What were available mostly were first aid kits. Vehicle parking spaces were inadequate on few of the sites; this was due to space constraint.

After interacting with the construction company professionals and site supervisors it came to light that those who couldn't fully implement their site layout plans had problems with the available space utilization.

The construction companies indicated that cost was an issue to them to develop site layout plan, in the sense that a full implementation of site layout planning will take a substantial amount of money to their initial mobilization. They think the funds can be used for something else rather than investing in something that is temporary. Also most of the construction companies aims at maximizing profit so they provide what they think are necessary. Time was also a

challenge to construction companies because it takes some time before you can set up fully site layout planning so only the facilities that seem necessary to them are provided for construction projects. Also some construction companies who wish to do more had the problem with space constraint. Due to this the construction companies adopt temporary facilities what they considered as most important for the execution of the project. Among this most important temporary facilities are the stores for materials and office for the construction personnel which in some cases served as a meeting room.

5. CONCLUSION AND RECOMMENDATION

5.1 Introduction

This research project focused on three specific objectives: identifying the effects of poor site layout planning on building construction activities on the site, studying site layout plan utilization practice on building construction projects, and identifying the key factors which contribute to achieving an effective site layout planning. The conclusion and recommendations for future work are addressed in the following sections.

5.2 Conclusion

The results obtained in the analysis of the questionnaires survey have been discussed and presented in the previous chapter in detail. Therefore, based on the results from the analysis, the following major conclusions have been derived and summarized:

1. From the questionnaire survey result it was identified that increase distance travel in the construction site, construction materials lost and damage, and decrease the output from labour and machinery were indicated as the major effects of poor site layout planning on building construction activities by the contractors; on the other hand the consultants indicated decrease the output from labour and machinery, construction materials lost and damage, and affect the coordination of all tasks on the project as the effects of poor site layout planning on building construction activities.
2. The study suggested that well-defined areas for material storage and handling, the location of plant and equipment; location of building, and allocation and positioning of temporary facilities were some of the key factors which contribute to achieving an effective site layout planning by the contractors; on the other hand the consultants indicated access and exit road to the construction site, location of plant and equipment, and method of construction as the key factors which contribute to achieving an effective site layout planning.
3. Different key aspects of site layout plan utilization practice on building construction projects, were identified through the survey. These aspects include: site layout planning practice within the industry, design aspects of site layout plan, implementation and monitoring practices, documentation methods, site planning software, implementation cost, and impression about the site they are working with. Then by using these findings, the formation of a standard process for site layout plan development was initiated.
4. Effective site layout planning requires exceptional decision making skills. There are many aspects that must be considered during the development of a site layout plan. In

order to make correct decisions, one must make a significant effort to collect the requisite data that affects the success of the site layout plan and one must be considerably knowledgeable on construction operations and methods. Finally, establish and maintain effective communication with all stakeholders involved with the project. This helps all stakeholders recognize the current status of the project and understand what needs to be accomplished in order for the project to remain on schedule and within budget.

5. The developed procedure clearly defines the steps that may be used by industry professionals when developing a site layout plan. The procedure involves project constraint identification, data acquisition, plan development, communication, implementation and enforcement, monitoring and evaluating, and documenting. The procedure presents a robust set of policies and practices for developing site layout plans.
6. The research contributes by providing information (factors) that one has to examine in order to have an effective and efficient site layout planning and also by bringing practical procedures and recommendations that can be referenced when developing site layout plan on the construction site.

5.3 Recommendations

The following recommendations are made based on the findings in this research and are forwarded to stakeholders and practitioners in the construction industry to improve the effective adaptation of site layout planning on construction projects.

1. Stakeholders in construction industry must take the initiative to create awareness for construction professionals on site layout planning.
2. The procedure developed under this research is generic in that it summarizes important aspects of the site layout planning process, leaving specific space delineation methods up to the planners. It is recommended that site planners continuously develop the procedure and make necessary modification so their individual planning techniques are reflected in the procedure. By doing so, their standards of planning will emerge in the means and methods used for site layout plan development. Over time, the individualized site layout planning procedure will gain significant value as a document of reference.
3. The construction companies are encouraged to develop a method for collecting lessons learned at the end of each project. The information gathered can be organized and file cabinet or uploaded to a company database and made available to construction management/planning personnel. By developing a method for gathering and distributing lessons learned information, non-value adding events that occurred on past project can be anticipated and prevented on future projects.
4. The results of this research provide a basis for developing a workshop that can provide training on the site layout planning process. The workshop would need to be general enough to accommodate different company planning practices but, at the same time, remain detailed enough to provide sufficient guidance. Examples of past site layouts can be incorporated into the workshop illustrating effective and ineffective site operation as compared to the planning technique applied. Approaches for documenting lessons learned can be discussed, as well as potential benefits of sharing lessons learned within the company.

5.4 Suggestion for Future Study

1. Future research efforts need to focus on the development of robust optimization systems which incorporate the findings of this research.
2. Further research can be conducted on the best practice framework for facilitating the effective adoption of proper site layout planning on construction sites.

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ANNEXES

ANNEX A: Questionnaires for Contractors and Consultants

Investigating Site Layout Planning and Implementation Practice on Building Construction Projects: (The Case of Selected Towns in Southern Nations Nationalities and Peoples Regional State)

Detail of the Researcher:

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This research study titled "**Investigating Site Layout Planning and Implementation Practice on Building Construction Projects: (The Case of Selected Towns in Southern Nations Nationalities and Peoples Regional State)**" is undertaken by Sisay Temesgen at Hawassa University Institute of Technology, Civil Engineering Department to investigate site layout planning and implementation practice on building construction projects. Please answer ALL questions.

Thanks in advance for your co-operation and help!

Sincerely,

Sisay Temesgen

Note:

1. ***Site layout Planning is a decision making process for the placement of construction materials, equipment, and facilities within the boundary of a construction site.***
2. ***Site layout plan is a document that identifies the location of construction materials, equipment, and facilities within the construction boundaries.***
3. ***Temporary facilities are defined as those facilities and areas defined to specific tasks that support the construction process. Examples of temporary facilities are site offices, material stores, laydown areas, warehouses, parking lots, etc.***

Questionnaire for Contractors

SECTION A: GENERAL INFORMATION

1. Name of the company _____
2. Grade of the company _____
3. Educational background
   ❑ Diploma ❑Bsc degree ❑Msc degree ❑PhD
4. Your current position in the company: _____
5. Experience in the construction industry:
   ❑Less than 5 years ❑5 to 10 years ❑Above 10 years

SECTION B: The effects of poor site layout planning on building construction activities on the site.

[Note: Site layout Planning is a decision making process for the placement of construction materials, equipment, and facilities within the boundary of a construction site.]

The under listed are the effects of poor site layout planning on building construction activities on the site. Please use the ranking below to indicate your level/degree of agreement:

5- I strongly agree 4- I agree 3- Neutral 2- I disagree 1- I strongly disagree

No.	The effects of poor site layout planning on building construction activities	Rankings				
		Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
1	Increase distance travel in site					
2	Increase completion time of project					
3	Increase cost of projects					
4	Accident occurs at the site					
5	Construction materials lost and damage					
6	Reduce the quality of work					
7	Decrease the output from labour and machinery					
8	Decrease the security to the workforce and machinery					
9	It affect the coordination of all tasks on the project					
10	Demoralized workers					

SECTION C: The key factors which contribute to achieving an effective site layout planning.

To what extent would you agree that the under listed key factors contribute to achieving an effective site layout planning? Please use the ranking below to indicate your level/degree of agreement:

5- I strongly agree 4- I agree 3- Neutral 2- I disagree 1- I strongly disagree

No.	The key factors which contribute to achieving an effective site layout plan	Rankings				
		Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
1	Location of plant and equipment					
2	Availability of waste handling and disposal areas are well located					
3	Allocation and positioning of temporary facilities					
4	Availability of access and exit road to the construction site					
5	Adequate security (fencing, check points, security, etc.)					
6	Well defined areas for material storage and handling					
7	Shape and size of land					
8	Type of contract					
9	Access to utilities (electricity, water, etc.)					
10	Workshop position clearly defined					
11	Health and safety concerns					
12	Surrounding environment (soil, nearness to water, vegetation, etc.)					
13	Method of construction					
14	Location of building					
15	Location of the site					
16	Company professionals who design the site layout plan					

SECTION D: Site layout plan utilization practice on building construction projects.

[Note: Site layout plan is a document that identifies the location of construction materials, equipment, and facilities within the construction boundaries.]

1. Please choose the statement that accurately reflects your philosophy in the creation of site layout plan.
   - ❏We create a site layout plan for every projects we construct
   - ❏We create a site layout plan only for projects where space available is very limited
   - ❏Other_____

2. Dose the contract price of the project influence the decision to develop site layout plan?
   - ❑Yes
   - ❑No
3. Does the company use software to develop site layout plan?
   - ❑Yes
   - ❑No

   If yes, which software do you used to develop site layout plan?
   - ❑CAD
   - ❑BIM (Building Information Modeling)
   - ❑Other_____
4. Who is typically in charge of the development of site layout plan?
   - ❑project manager
   - ❑project engineer
   - ❑site superintendent
   - ❑other_____
5. Does the consultant typically get involved in the development of site layout plan?
   - ❑Yes
   - ❑No
6. On an average, what percent of the total project cost is allocated to temporary facilities? ***[Note: Temporary facilities are defined as those facilities and areas defined to specific tasks that support the construction process. Examples of temporary facilities are site offices, material stores, laydown areas, warehouses, parking lots, etc.]***
   - ❑0-2%
   - ❑2%-5%
   - ❑5%-10%
   - ❑>10%
7. Does your company specifically consider the following when developing site layout plan? ***(you can tick more than one)***
   - ❑Movement of equipment
   - ❑Movement of materials
   - ❑Movement of personnel on site
8. How is the location of each on site temporary facilities determined? (Select all that apply)
   - ❑Past experience of the site layout plan developers
   - ❑Computer software
   - ❑Other_____
9. Does your company create multiple site layout plans for different phase of construction? For instance, developing site layout plan for substructure, superstructure phase etc.
   - ❑Yes
   - ❑No

10. What level of detail is incorporated into the site layout plan?

    ❏**Low**: Only the locations of essential temporary facilities (e.g. site offices, material stores, laydown areas, warehouses, parking lots, etc.) are selected

    ❏**Medium**: The location of materials/equipment storage are selected; as well as, the essential temporary facilities

    ❏**High**: Almost every item within the site boundary has a predetermined location

11. On an average, how much time is invested in the preparation and development of site layout plan?

    ❏1-8 hours

    ❏8-40 hours

    ❏> 40 hours

12. At what point are site layout plans completely developed?

    ❏Prior to arriving on site

    ❏After arriving on site

    ❏The site layout plans are continuously updated over the course of the project

    ❏Other_____

13. Are site layout plans developed for the entire project duration? For instance developing site layout plans that describes space from the time first contractor arrives on site until the last contractor leaves the site.

    ❏Yes

    ❏No

14. Do you document the knowledge gained (e.g. new idea, lessons learned, etc.) on each project referring to site layout plan for future use?

    ❏Yes

    ❏No

    If yes, how are the records kept?

    ❏Company database

    ❏Personal files (e.g. filing cabinet, personal computer, etc.)

    ❏Other_____

15. What is your impression about the site layout plan you are working with?

    ❏Best layout

    ❏Better layout

    ❏Good layout

    ❏Bad layout

    ❏Worst layout

Questionnaire for Consultants

SECTION A: GENERAL INFORMATION

1. Name of the company _____
2. Grade of the company _____
3. Educational background
   ❑ Diploma ❑Bsc degree ❑Msc degree ❑PhD
4. Your current position in the company: _____
5. Experience in the construction industry:
   ❑Less than 5 years
   ❑5 to 10 years
   ❑10 years and above

SECTION B: The effects of poor site layout planning on building construction activities on the site.

[Note: Site layout Planning is a decision making process for the placement of construction materials, equipment, and facilities within the boundary of a construction site.]

The under listed are the effects of poor site layout planning on building construction activities on the site. Please use the ranking below to indicate your level/degree of agreement:

5- I strongly agree 4- I agree 3- Neutral 2- I disagree 1- I strongly disagree

No.	The effects of poor site layout planning on building construction activities	Rankings				
		Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
1	Increase distance travel in site					
2	Increase completion time of project					
3	Increase cost of projects					
4	Accident occurs at the site					
5	Construction materials lost and damage					
6	Reduce the quality of work					
7	Decrease the output from labour and machinery					
8	Decrease the security to the workforce and machinery					
9	It affect the coordination of all tasks on the project					
10	Demoralized workers					

SECTION C: The key factors which contribute to achieving an effective site layout planning.

To what extent would you agree that the under listed key factors contribute to achieving an effective site layout planning? Please use the ranking below to indicate your level/degree of agreement:

5- I strongly agree 4- I agree 3- Neutral 2- I disagree 1- I strongly disagree

No.	Key factors considered	Rankings				
		Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
1	Location of plant and equipment					
2	Availability of waste handling and disposal areas are well located					
3	Allocation and positioning of temporary facilities					
4	Availability of access and exit road to the construction site					
5	Adequate security (fencing, check points, security, etc.)					
6	Well defined areas for material storage and handling					
7	Shape and size of land					
8	Type of contract					
9	Access to utilities (electricity, water, etc.)					
10	Workshop position clearly defined					
11	Health and safety concerns					
12	Surrounding environment (soil, nearness to water, vegetation, etc.)					
13	Method of construction					
14	Location of building					
15	Location of the site					
16	Company professionals who design the site layout plan					

SECTION D: Site layout plan utilization practice on building construction projects.

[Note: Site layout plan is a document that identifies the location of construction materials, equipment, and facilities within the construction boundaries.]

1. Please choose the statement that accurately reflects your philosophy in the creation of site layout plan.
   - ❑We create a site layout plan for every projects we construct
   - ❑We create a site layout plan only for projects where space available is very limited
   - ❑Other_____
2. Dose the contract price of the project influence the decision to develop site layout plan?
   ❑Yes ❑No

3. Does the consultant typically get involved in the development of site layout plan?
   ❑Yes ❑No
4. Does your company force to create multiple site layout plans for different phase of construction? For instance, developing site layout plan for substructure, superstructure phase etc.
   ❑Yes ❑No
5. At what point are site layout plans completely developed?
   ❑Prior to arriving on site
   ❑After arriving on site
   ❑The site layout plans are continuously updated over the course of the project
   ❑Other_____
6. Are site layout plans developed for the entire project duration? For instance developing site layout plans that describes space from the time first contractor arrives on site until the last contractor leaves the site.
   ❑Yes ❑No
7. Are there actions taken by the consultant when the contractor do not implementing the prepared site layout plans?
   ❑Yes ❑No
8. What are the actions taken by the consultants when the contractor do not implementing the prepared site layout plans?
   ❑Verbal warning
   ❑Written warning
   ❑Monetary penalties for noncompliance
   ❑Disposal of items stored incorrectly
   ❑Other_____
9. What is your impression about the site layout plan you are working with?
   ❑Best layout
   ❑Better layout
   ❑Good layout
   ❑Bad layout
   ❑Worst layout

ANNEX B: List of Temporary Facilities Provided on Site

No.	Temporary Facilities
1	Access to job site
2	Site offices
3	Information and guard office
4	First aid office
5	Meeting(conference) room
6	Dining(cafeteria) room
7	Toilet on site
8	Bathroom on site
9	Parking lot locations
10	Water tank location
11	Batch plant
12	Aggregate storage area
13	Cement warehouse
14	Material warehouse
15	Prefabricated rebar storage yard
16	Rebar fabrication yard
17	Fabricated rebar storage yard
18	Storage yard for timber
19	Storage yard for formed timber
20	Wood workshop area
21	Scaffolding storage yard
22	Soil storage area
23	Sampling/ testing lab
24	HCB production yard
25	Waste handling area

ANNEX C: Check List of Temporary Facilities Provided on the Visited Construction Projects

No.	TEMPORARY FACILITIES	CONSTRUCTION PROJECTS																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Access to job site	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2	Site offices	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3	Information and guard office	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4	First aid office										√										
5	Meeting(conference) room	√			√			√			√		√	√						√	
6	Dining(cafeteria) room				√		√								√	√	√	√		√	
7	Toilet on site	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
8	Bathroom on site										√										
9	Parking lot locations	√	√		√	√	√	√				√	√	√	√	√	√	√	√	√	√
10	Water tank location	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
11	Batch plant	√	√					√				√	√		√					√	
12	Aggregate storage area	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
13	Cement warehouse	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
14	Material warehouse	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
15	Prefabricated rebar storage yard	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
16	Rebar fabrication yard	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
17	Fabricated rebar storage yard	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
18	Storage yard for timber	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
19	Storage yard for formed timber	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
20	Wood workshop area				√								√							√	
21	Scaffolding storage yard	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
22	Soil storage area		√		√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√
23	Sampling/ testing lab																				
24	HCB production yard		√			√							√		√	√	√	√		√	
25	Waste handling area	√	√		√	√	√				√						√	√		√	

ANNEX D: The Visited Construction Projects

No.	Name of Construction Projects	Contractor	Consultant
	Hawassa Projects		
1	All in One (HU)	Yirgalem Construction PLC	Zeleke Belay Architects PLC
2	Dormitory-1 (HU Iot)	Homa Construction PLC	Obon Voyage Architects PLC
3	Nib International Bank Hawassa	Santa Maria Construction PLC	Bereket Tesfaye Architects & Engineers
4	Sidama Traditional Hall	Yirgalem Construction PLC	BET Architects
5	Dormitory-2 (HU Iot)	Abara Lisanu BC	Obon Voyage Architects PLC
6	Southern Teachers Association Building	Atem BC	South Design & Supervision Enterprise
7	Civil Service Office Building	Desalegn Asrade Construction	South Design & Supervision Enterprise
8	Ethiopia Revenue & Customs Authority Building	Bereket Endashaw GC	ECDSWC
9	Hawassa City police Department Office Building	Man GC	ECDSWC
10	Commercial Bank of Ethiopia Hawassa Branch	Zamra Construction PLC	Addis Mebratu Architects
	Arba Minch Projects		
11	Student Clinic	FE Construction PLC	Bereket Tesfaye Architects
12	UG & PG Class Room	Etete Construction PLC	QTC Architects
13	Library	Romadi Construction	K2N Architects
14	PG Class Room	Mod Con Engineering	Hilltech Engineering Consulting
	Wollayta Sodo Projects		
15	Library	Abara Lisanu BC	YTH Architects
16	Class Rooms	Yohannes Haile Construction	MH Engineering PLC
17	Dormitory	Etete Construction PLC	YTH Architects
	Dilla Projects		
18	Dilla University Administrative Building	FE Construction PLC	ECDSWC
19	Dilla Teaching & Referral Hospital	Flintstone Engineering	ECDSWC
20	PG & Research School	Unity Engineering	K2N Architects

ANNEX E: Pictures from Some of the Visited Construction Projects


Fencing Used by Construction Projects


Site offices on Construction Projects


Aggregate Storage on Site


Modified Batching Plant


Strategically Located Crane on Site


Water Tank Used on Site

Scaffolding and Panel Handling on Site

Construction Equipment Used on Site

Rebar Storage and Fabrication Yard

ANNEX F: Spearman Test Static Table

n	.001	.005	.010	.025	.050	.100
4	—	—	—	—	.8000	.8000
5	—	—	.9000	.9000	.8000	.7000
6	—	.9429	.8857	.8286	.7714	.6000
7	.9643	.8929	.8571	.7450	.6786	.5357
8	.9286	.8571	.8095	.7143	.6190	.5000
9	.9000	.8167	.7667	.6833	.5833	.4667
10	.8667	.7818	.7333	.6364	.5515	.4424
11	.8364	.7545	.7000	.6091	.5273	.4182
12	.8182	.7273	.6713	.5804	.4965	.3986
13	.7912	.6978	.6429	.5549	.4780	.3791
14	.7670	.6747	.6220	.5341	.4593	.3626
15	.7464	.6536	.6000	.5179	.4429	.3500
16	.7265	.6324	.5824	.5000	.4265	.3382
17	.7083	.6152	.5637	.4853	.4118	.3260
18	.6904	.5975	.5480	.4716	.3994	.3148
19	.6737	.5825	.5333	.4579	.3895	.3070
20	.6586	.5684	.5203	.4451	.3789	.2977
21	.6455	.5545	.5078	.4351	.3688	.2909
22	.6318	.5426	.4963	.4241	.3597	.2829
23	.6186	.5306	.4852	.4150	.3518	.2767
24	.6070	.5200	.4748	.4061	.3435	.2704
25	.5962	.5100	.4654	.3977	.3362	.2646
26	.5856	.5002	.4564	.3894	.3299	.2588
27	.5757	.4915	.4481	.3822	.3236	.2540
28	.5660	.4828	.4401	.3749	.3175	.2490
29	.5567	.4744	.4320	.3685	.3113	.2443
30	.5479	.4665	.4251	.3620	.3059	.2400

Source: Daryl S. Paulson 2003