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SCHOOL OF BUILT ENVIRONMENT

DEPARTMENT OF CONSTRUCTION ECONOMICS AND MANAGEMENT

MASTER OF SCIENCE IN CONSTRUCTION MANAGEMENT (MSCM)

A COMPARATIVE ANALYSIS OF CONVENTIONAL RCC SLABS AND COMPOSITE STEEL DECK SLABS DURING THE CONSTRUCTION PHASE

CASE STUDY: PROPOSED KABIRA COUNTRY CLUB HOTEL EXTENSION ON PLOT 62-63A KIRA ROAD, BUKOTTO, KAMPALA-UGANDA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN CONSTRUCTION MANAGEMENT OF MAKERERE UNIVERSITY

MAY 2025

DECLARATION

I hereby declare that this research study has never been presented for any academic award in any institution or university. All sources used in this research study have been rightfully acknowledged.

Signed: .... Date: 30/05/2025

SANDE MUZAMIL

APPROVAL

I testify that this research report titled: "A COMPARATIVE ANALYSIS OF CONVENTIONAL RCC SLABS AND COMPOSITE STEEL DECK SLABS DURING THE CONSTRUCTION PHASE" - Case study: PROPOSED KABIRA COUNTRY CLUB HOTEL EXTENSION ON PLOT 62-63A KIRA ROAD, BUKOTTO, KAMPALA-UGANDA, has been prepared and reviewed by my academic supervisor as a requirement for the fulfillment of the Master's degree program in Construction Management.

Signed: .... Date: 02/07/2021 ....

Dr. MUSA MANGA

DEDICATION

I dedicate my academic works to my parents, Mr. Ibrahim Bigabwa and Mrs. Sifa Bigabwa who have supported me financially and guided me throughout my course of study.

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First of all, I am so grateful for the Almighty Allah for His Guidance, protection and blessings.

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RCC – Reinforced Cement Concrete

SSD – Structural Steel Deck

ABSTRACT

Concrete and steel are by far the most popular when it comes to construction materials in Uganda and the world at large, particularly for projects of medium and low height. In the past decades, Concrete has been used as the main composite material for build construction but recently we have witnessed an overwhelming adoption of Structural steel being used for the construction of tall buildings. This has mainly been attributed to the need to optimize costs and fast & timely delivery of project time lines which have been and are still the major challenges to construction projects

This study presents a comparative analysis of Reinforced Cement Concrete (RCC) slabs and Structural Steel Decked (SSD) slabs, with a particular focus on their cost and time efficiency during the construction phase. Using the proposed Kabira Country Club Hotel extension project as a case study, the research evaluates material and labour costs, construction durations, and key structural characteristics of each slab system. Data was collected through site observations, construction records, and project documents, and analysed using both qualitative and quantitative methods. The findings indicate that SSD slabs offer notable advantages over RCC slabs, including a 20.3% reduction in total construction cost and a 43.75% decrease in construction time. Additionally, SSD systems simplify labour requirements by eliminating traditional formwork and reducing reinforcement needs. The study concludes that SSD slabs are a more efficient alternative for modern construction projects where time and cost are critical considerations. Recommendations are made for broader adoption of SSD systems, further training for construction professionals, and additional research into long-term performance and sustainability factors.

CHAPTER ONE: INTRODUCTION

1.1 Background

Construction of buildings is believed to have kicked off around 4000BC, the period in which the tools available were made from natural materials including bone, antler, hide, stone, wood, grasses, animal fibers, and the use of water. People were living in caves and rock shelters and the first buildings were simple shelters and huts sometimes built as pit-houses meant to suit the basic needs of protection. The absence of metal tools placed limitations on the materials that could be worked, but it was still possible to build quite elaborate stone structures with ingenuity using dry stone walling techniques. (Karimov *et al*, 2024)

Building construction has evolved through the Neolithic construction (old stone age), Copper & Bronze Age construction, Iron Age construction (ancient Mesopotamia, Egypt, Roman, China and Greece), Medieval construction (from the 5th to 15th) to the now construction in the twentieth century in which elevators and cranes have made high rise buildings and skyscrapers possible, while heavy equipment and power tools decreased the workforce needed (Swenson *et al*, 2004)

In the 21st century, Skyscrapers are a feature of urban landscapes with technological advancements and a need for both efficient use of space and buildings to house a service-based economy. The ability to build taller buildings has been made possible by the development of a number of factors like the use of steel as a frame for a building in place of brick or stone bearing walls, introduction of reinforced concrete, elevator technology, fire safety systems, and structural designs all of which have contributed to the ability to construct the modern skyscrapers.Composite construction is the major form of building construction around the word especially on high-rise structures in which concrete and structural steel composite materials are used either independently or in combination with one another. (Johnson, 2004).

The construction industry has witnessed significant advancements in recent years, with a growing emphasis on efficient and sustainable building practices. Conventional Reinforced Cement Concrete (RCC) slabs have been a staple in construction for decades but composite steel deck slabs have emerged as a viable alternative, offering improved structural performance, reduced construction time, and enhanced cost-effectiveness.

Several studies and research have been made on both the reinforced cement concrete slab and structural Steel decked slabs with emphasis only on aspects of strength, performance and functionality. However, there is still limited information in regards to comparing the cost incurred and time spent on either system of slab construction. This has raised the necessity to determine the cost effectiveness and time component while determining choice of use and/or comparing the two systems.

1.2 Problem Statement

More than half of the world's population now lives in cities, a figure expected to rise to nearly 70% by 2050, posing significant challenges for jobs, housing and infrastructure (World Bank, 2022) . The World Bank is addressing these issues by investing $5 billion annually on average in sustainable urban development, focusing on resilient, low-carbon infrastructure and services, safe, adequate housing and buildings, vibrant local economies, and strong local governments. The construction industry faces numerous challenges, including project delays, cost overruns, and quality concerns. The choice of slab system can significantly impact the construction process, and it is essential to evaluate the performance, cost effectiveness of various slab systems during the construction phase for timely delivery and handover. (Srimaruthi *et al*, 2023).

Slab construction in buildings involves various systems to create suspended floors broadly categorized as either solid or composite and are further differentiated based on support methods, reinforcement types, and material combinations which include waffle slabs, hollow core slabs, reinforced cement concrete, precast slabs and steel decked slabs. The commonly used slab systems are the Reinforced Cement Concrete (RCC) slab and the Structural Steel Decked (SSD) slab, but there is major concern on how the two methods vary in terms of time and cost aspects especially during the construction phase. This alongside other factors have risen the need to substantiate cost and time parameters/indices to help the different construction stakeholders such as developers, project managers, engineers and others, to decide and determine which system to use.

This study seeks to address the question of which slab system between the conventional RCC or composite SSD slab, offers a cost effective and time saving advantage over the other during the construction phase.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective is to give a detailed cost and time analysis between the conventional Reinforced Cement Concrete (RCC) slabs and the composite Structural Steel Deck (SSD) slabs as used during building construction with particular emphasis on the construction phase of a project.

1.3.2 Specific Objectives

1. To examine the major characteristics of both the Reinforced Cement Concrete (RCC) slabs and the Composite Structural Steel Deck (SSD) slabs
2. To establish the Costs involved during construction of both systems mainly focusing on the material uses and labour cost incurred.
3. To establish the Time involved during the construction phase of both systems.

1.4 Significance of the Study

The significance of this study is improved construction efficiency (by comparing the construction time, labor requirements, and cost-effectiveness of both slab systems), informed decision-making (findings can provide valuable insights for construction professionals, enabling them to make informed decisions about the choice of slab system for their projects) and contribution to sustainable construction (through innovation of more sustainable construction practices).

1.5 Scope of the Study

The study will focus on the construction phase of Suspended floor slabs at the proposed Kabira Country Club Hotel Extension project basing on two systems of slab construction, Reinforced cement concrete (RCC) and structural steel decking (SSD). The study will involve a comprehensive comparison of conventional RCC slabs and composite steel deck slabs during the construction phase, examining the construction time, labor requirements, and cost-effectiveness of both slab systems and a detailed cost and time analysis associated with both slab systems.

CHAPTER TWO: LITERATURE REVIEW

2.1 REINFORCED CEMENT CONCRETE (RCC)

2.1.1 Introduction

Reinforced cement concrete is a composite building material wherein concrete is created by mixing aggregate of sand, binding material (cement), stone, water, coarse gravel, and admixtures as required. (Chudley et al, 2006). RCC slabs provide a horizontal planar surface for roofs, decks, floors used to construct numerous structures involving a combination of concrete and steel reinforcement. A reinforced concrete slab is the one of the most important components in a building designed for load-bearing capacity based on requirements. Conventional reinforced cement concrete (RCC) floor slabs, also known as beam-and-slab systems, are supported by beams and columns, with the slab's thickness typically smaller than the beam's depth, and loads transferred from the slab to the foundation via beams and columns.

2.1.2 Components of an RCC slab

a) Concrete Slab

RCC slabs are made of concrete, a composite material formed by mixing aggregates (sand, stone, gravel), cement, water, and sometimes admixtures, which mainly provides the compressive strength necessary for supporting and withstanding horizontal loads whether dead or live. The thickness of the slab is determined by the load-bearing requirements and the span of the slab which are normally determined by the calculations made by the structural engineer who then issues structural drawings.

b) Steel Reinforcement

Steel reinforcement, in the form of bars (rebars) is embedded within the concrete to provide tensile strength, as concrete alone is weak in tension. The steel reinforcement is strategically placed within the slab to resist tensile stresses that occur due to bending and other loads. Common types of steel reinforcement include, main reinforcement (which provide the primary tensile strength in the main direction of the slab), distribution reinforcement (which distribute loads and prevent cracking), and stirrups/ties (used in conjunction with the main reinforcement to resist shear forces).

c) Formwork

Formwork is a temporary structure used to support the fresh concrete until it gains sufficient strength and to define the shape and dimensions of the slab, made of various materials, including wood, metal, or plastic. This usually the most critical component simply because it is what gives the shape, size and appearance of the final element meaning that extra care has to adhered to during the erection of the forms as well as during removal of the shuttering items.

2.1.3 Forms of RCC slabs

A. Prefabricated Concrete Slabs

Are cast in a factory and then transported to the site ready to be lowered into place between steel or concrete beams. They may be pre-stressed, post-stressed, or unstressed. Care should be taken to see that the supporting structure is built to the correct dimensions to avoid trouble with the fitting of slabs over the supporting structure. Precast slabs offer advantages such as faster construction, improved quality control, and reduced labour costs.

B. In situ concrete slabs

In-situ concrete slabs are concrete slabs cast directly at the construction site, using formwork, rather than being precast and transported to the site. Are built on the building site using formwork, a box-like setup in which concrete is poured for the construction of slabs. It allows for greater flexibility in design and can be used for complex shapes and configurations

2.1.4 Steps of construction of RCC slabs

a. Shuttering

The process of constructing the RCC slab especially for suspended floors commences by erecting the centring and shuttering. Once the shuttering has been laid in a level, it has to be cleaned properly to avoid any particles that don’t form part of the RCC slab element. The formwork is commonly built from wooden planks and boards, plastic, or steel. Wooden shuttering is usually provided for the purpose although steel shuttering is recommended for getting a good under surface of the slab.

b. Reinforcement fixing

The reinforcement bars are clearly marked on the structural drawings specifying the type, size, shape and location such that the design calculations are followed to avoid mis-interpretations and misplacements. Laying and placing of steel reinforcement (rebar) should be made according to design specifications to ensuring proper spacing, bending, and tying of rebar at different positions of the structural elements.

c. Mixing Concrete

All raw materials, cement, sand, coarse aggregates and water should be measured as per requirement of mix design. The raw materials are then mixed uniformly, while ensuring that a proper water-cement ratio is maintained which is just enough to impart sufficient workability needed to pour concrete. Mixing can either be done onsite with a concrete mixer or be delivered inform of ready-mix concrete being delivered by concrete trucks from a concrete plant away from the site.

d. Pouring Concrete

The concrete whether in-situ or ready mix is then laid continuously to the required thickness and compacted using a needle vibrator to ensure that the cement slurry adequately fills the gaps between aggregates, vibrated effectively such that no air gaps are left in the concrete. After the concrete has been poured, it should be finished with a steel float to ensure that the top surface is finished smooth and to make the adjustments for uniform slab thickness.

e. Curing

Curing is critical for a good quality concrete slab and it is commonly done by flooding the slab with water after dividing the slab into smaller portions with cement mortar partitions. The curing of slab should begin the next day of casting and continue for at least 14 days for adequate concrete strength. Inadequate curing will result in poor quality concrete and can undo the benefit of an appropriate mix and good quality mixing and compaction.

2.1.5 Advantages of RCC Slabs

i. Mouldability

RCC can be designed into different shapes to suit different architectural and construction requirements. RCC slab designs are known to be compatible with diverse construction methods and techniques. It can be shape-d into numerous formwork configurations or shuttering to accommodate different loads, spans, and aesthetic preferences. Being a conventional option, the skill level for casting RCC slabs is commonly available.

ii. Strength & Durability

Reinforced concrete slabs can withstand harsh environmental conditions and heavy loads with high compressive and tensile strength. They are suitable for long-term use with excellent durability and in addition, provides permanent durable roofing, capable of multi-storied construction.

iii. Economical

The materials required for RCC such as steel, cement, and aggregates, are widely available and the maintenance cost is reduced due to its durability, making it suitable for long-term usage. Moreover, the versatile design minimizes design and retrofitting expenditures. RCC slabs can be a cost-effective option for construction, especially for large projects or those with complex designs

iv. Fire Resistance

The primary components of RCC slabs, such as concrete and aggregates, are non-combustible materials and chemically inert with a slow heat transfer rate. Slow heat transfer delays temperature rise within a structure while the minimal combustible content minimizes the fire risk and spread.

v. Sound Insulation

The density and mass of RCC slabs contribute to effective sound insulation, reducing noise transmission between floors and creating a quieter working or living environment. In addition, the structural solidity minimizes vibrations and noise levels. It complements soundproofing measures for comprehensive noise control.

2.2 COMPOSITE STRUCTURAL STEEL DECKING (SSD)

2.2.1 Introduction

A composite member is formed when a steel component, such as an I-beam, is attached to a concrete component, such as a floor slab or bridge deck. In such a composite I-beam the comparatively high strength of the concrete in compression complements the high strength of the steel in tension. The fact that each material is used to the fullest advantage makes composite Steel-Concrete construction very efficient and economical. This system is also referred as 'composite deck', 'composite slab' or 'composite floors. Cold formed profile decks are used as a permanent form work for a composite deck system. The real attraction of such construction is based on having an efficient connection of the Steel to the Concrete, and this connection that allows a transfer of forces and gives composite members their unique behavior. (Charantimath *et al*, 2014).

Composite floor system consists of steel beams, metal decking and concrete which are combined in a very efficient way so that the best properties of each material can be used to optimize construction techniques. Earlier, the composite deck system was considered as an optimum solution to the building floors for high-rise steel framed structures only but in recent years, it is becoming more popular for low - medium rise steel and R.C.C. buildings. These profile decks also act as tensile reinforcement, if the strength of profile steel sheet is utilized. (Vrunda R Laddha *et al*, 2021).

When concrete hardens it will combine structurally with profiled steel sheet to form a composite element and therefore the behavior of composite slab depends on deck profile, thickness of steel sheet, material properties, span length, construction details, etc. The design Considerations of this system are; steel deck thickness (must be sufficient to provide adequate tensile strength and support the concrete), concrete thickness (the concrete layer must be sufficient to provide adequate compressive strength and durability) and shear connection (the connection between the steel deck and concrete must be designed to resist shear forces and ensure composite action).

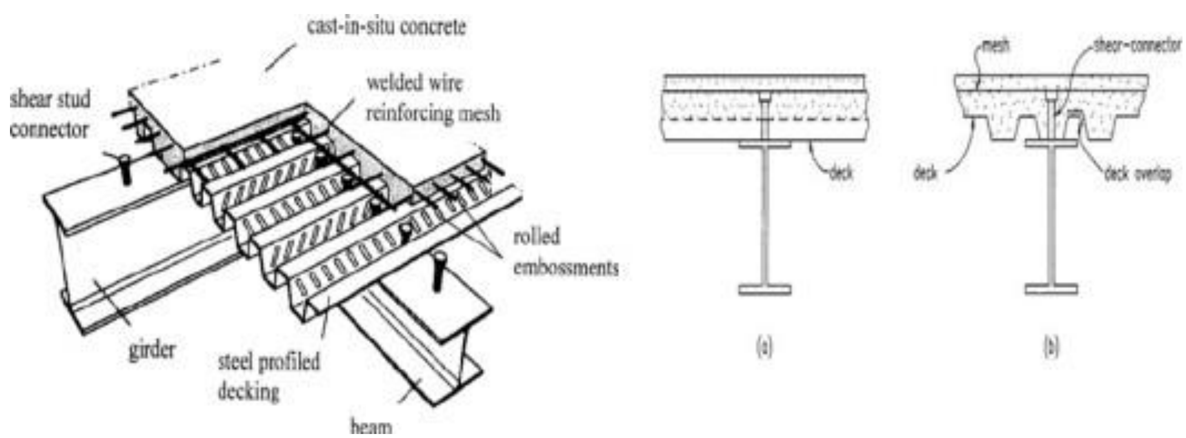

Figure 2 1. A cross-section of a typical structural steel decked slab

2.2.2 Components of SSD slabs

a. The decking

The metal deck, also known as profile deck is one of the important structural parts of composite deck system. Metal deck profiles have indentations and embossments rolled into them, which serve to create a mechanical interlock between the concrete and the deck itself, enhancing the shear bond between them. The re-entrants and ribs also effectively act to keep the deck and the composite slab as one unit. Thin-walled cold-formed profiled steel decks used to build the slab specimens are made of structural quality steel sheets conforming to ASTM A653 (2008) and IS 1079 (1994). A galvanized surface coating with an average thickness of 0.0254 mm is finished on each face of the steel deck. The profiled decking sheet must provide the resistance to vertical separation and horizontal slippage between the contact surface of the concrete and the decking sheet. (Thomas *et al*, 2022).

b. The beams

Composite beams are a series of parallel I-beams with thin wide flanges in which the flange is in compression and steel beam is largely in tension. Composite beam is subjected mainly to bending, under load each component of structure acts independently with relative movement or slip occurring at the interface. Composite beams have less depth than non-composite beams and often are used in structures having long spans. Though steel and concrete are the most commonly used materials for composite beams, other materials such as pre-stressed concrete and timber can also be used. Concrete is stronger in compression than in tension, and steel is susceptible to buckling in compression.

c. The columns

Concrete filled columns consist of circular, square and rectangular, hollow sections which is filled with concrete. They use the advantages of both steel and concrete and can be used in many structural applications, especially for columns in high rise buildings and bridge piers. Infill concrete in steel tube delays local buckling and improves compression stress and durability whereby the size of this column is smaller, so that increases the usable floor area.

d. The Connectors

Composite construction consists of providing monolithic action between prefabricated units like steel beams or pre-cast reinforced concrete or pre-stressed concrete beams and cast-in-situ concrete, so that the two act as one unit. Although there is bound to be a certain amount of natural bond between concrete and steel at least at the initial stages, this bond cannot be relied upon as the same is likely to be deteriorate due to use and over load.

Mechanical shear connectors are therefore provided to help the steel and concrete element to act in a composite manner ignoring the contribution made by the inherent natural bond towards this effect. Primarily shear connectors are intended to resist the horizontal movement between the concrete slab and the steel beam and to transmit the horizontal shear between the two. Shear Connectors are also called upon to prevent vertical separation of the slab from the steel girder at the contact surface. Therefore, shear connectors are to be designed to cater for integral action of the composite structure at all load conditions on the basis of transmission of longitudinal shear along the contact surface without slip and prevention of vertical separation of the in-situ RC slab from the pre-fabricated structural beam.

There are different types of shear connectors which include; rigid Connectors (designed to be bent proof with little inherent power of deformation by deriving their resistance from bearing pressure of the concrete, distributed evenly over the surface because of the stiffness of the connectors), flexible connectors (such as studs, channels welded to the structural beams which can accommodate some degree of movement between the steel deck and the support, reducing the risk of damage or failure due to thermal expansion, as well as being ductile enough to deform without failing) and bond/anchorage connectors (derive their resistance through bond and/or anchorage action consisting of the inclined bars with one end welded to the flange of the steel unit and the other suitably bent. They improve composite action between the steel deck and the concrete, increase the load capacity of composite structures by providing a strong bond between the steel deck and the concrete and also reduce slip between the steel deck and the concrete thereby improving the structural integrity).

2.2.3 Steps of construction of SSD slabs

i. Structural steel installation

This is a process that starts with cutting the sections (I-beams, steel plates, z-purlins) into required sizes then they are joined together by welding. After the right shapes or sizes of the members are confirmed, they are carried/hoisted manually or by crane into position. This is followed by adding secondary and distribution members forming a horizontal frame unto whic the steel deck sheets are fixed with screws, ensuring proper alignment forming a rigid platform. Painting of the structural steel members is very key as it prevents the steel from corroding or rusting due to exposure to atmospheric water.

ii. Reinforcement steel fixing

Onto the steel deck, low classes of high yield rebars can be assembles to provide the compressive strength required to achieve a strong composite slab. The rebars can be inform of a mesh (BRC) or it could be a series of rebars laid in a matt pattern so as to distribute the tensile forces to both sides of the slab into the beams then to columns

iii. Concreting

Pouring concrete is done over the steel deck usually in a small layer/thickness ensuring the concrete is well spread with very minimal compaction to avoid potentially damaging the sheet. Setting and curing then proceeds while applying finishes such as smoothing or texturing can then be carried out.

2.2.4 Advantages of SSD slabs

i. No requirement for traditional removable formwork and its associated forest of props.
ii. Overall reduction in slab self-weight and therefore in loading on the steel frame and foundations with resultant reduction in materials.
iii. Reduction in the amount of reinforcement required.
iv. Rapid installation, even on complex steel layouts.
v. Provision of a safe working platform and cover for following trades immediately after installation.
vi. Enhanced structural stability with metal decking contributing to lateral restraint of the frame and tensile reinforcement of the slab and, in some cases, to diaphragm action that transfers wind loads back to the structure.
vii. Useful as a safe working platform
viii. Facilitate the access to installations
ix. Acoustic and thermal insulation.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This study aims to conduct a comparative analysis of conventional RCC slabs and composite steel deck slabs during the construction phase, using the proposed Kabira Country Club Hotel extension as a case study. Based on the fact that both slab systems have been used on this project.

The research will investigate the construction cost and time aspects involved for both slab systems, providing insights for construction professionals and stakeholders. The methodology employed will combine both qualitative and quantitative approaches to gather, analyse, and interpret data relevant to cost and time efficiency

3.2 Research Design

This study will employ a mixed-methods research design, combining both quantitative (e.g., cost figures, time durations, unit rates) and qualitative approaches (e.g., construction processes, labour requirements). The practical experience attained due to my involvement of this project which will then then help in a comprehensive and comparative evaluation of the two slab systems under actual project conditions

3.3 Study Population

The research will be on an ongoing construction project "Proposed Kabira Country club Hotel". The project comprises three blocks of 15 floors and two basements each, with a Gross Floor Area (GFA) of 65,613 sqm. Key stakeholders involved in the study included engineers, contractors, site managers, and other professionals directly engaged in the project.

Table 3 1. Project details of the case study project

Project	Proposed Kabira Country club Hotel Extension on plot 62-63A Kira Rd, Kampala
Scope	‘’3No. blocks’’ of 15 floors and 2 basements each Gross Floor Area (GFA) of 65,613 sqm Net Floor Area (NFA) of 55,787 sqm
Contract Sum	Thirty Million US Dollars ($39,000,000)
Client	MEERA INVESTMENTS LTD
Architect	DESIGN 256

	P.O.Box Kampala
Structural Engineer	CONSTULKA (CTK) services P.O.Box 74639, Kampala Uganda
Project Start Date	May 2021
Original Project Completion Date	September 2026
Current work progress	60%
Contractor	VCON construction Ltd P.O.Box 36630, Kampala Uganda

3.4 Data Sources

The study will utilize both primary and secondary data sources in which primary data will be collected through site observations, interviews with construction professionals, and surveys whereas secondary data will be obtained from existing literature, site reports, construction documents, and industry reports.

3.5 Data collection Methods

This study will employ several methods of data collection but particularly; site observations through recording construction activities, progress, and challenges, and analysis of construction documents like site drawings, specifications, material order lists, personnel registration records, weather records and bills of quantities.

3.6 Data Analysis

Quantitative data will be obtained by using various such as Microsoft excel, Microsoft project to obtain statistical tables which will converted into graphic representations inform of bar graphs, pie charts and histograms for easy analysis, reading and interpretation. It will involve summarizing the shape and pattern of the values of a single variable, at different levels of measurement, understanding the role of variability in evaluations and the study of relationships to identify similarities, differences and patterns.

Qualitative data will be verbal or other symbolic materials will be gathered by a variety of methods and techniques based on experience, knowledge and input such as, structured text (site reports stories, surveys), unstructured text (observations, interviews, focus groups, conversation), recordings (graphics, art, pictures, visuals). The data is cleaned and sorted ready for analysis with an aim examining the meaningful and symbolic content of the qualitative data.

The two methods will involve the following steps.

i. Define the purpose and scope by clearly state the goal, identifying the subjects and establishing the criteria.
ii. Data collection and preparation through gather relevant information: Collect data from various sources (surveys, experiments, documents, organizing and categorizing the collected data in a way that facilitates comparison and ensuring data quality to verify the accuracy and reliability of the information.
iii. Comparison and Analysis by identifying similarities and differences, analysing relationships and exploring the connections and patterns between the subjects and using appropriate tools to analyse the data.
iv. Interpretation and conclusion. Draw conclusions based on the analysis, synthesizing findings to address the research questions.

3.7 Ethical Considerations

The study will adhere to the required ethical considerations such as obtaining informed consent from all the project participants about the purpose and scope of the study, confidentiality of participants and the construction company which has to be maintained and finally data protection for which the data will be stored securely and protected from unauthorized access. Citations will be used for information from secondary data obtained to credit original authors for their work.

CHAPTER FOUR: RESULTS AND FINDINGS

4.1. SLAB CHARACTERISTICS

Reinforced Cement Concrete Slabs are majorly comprised of concrete (mixture of cement, aggregates and water). reinforcement (Steel bars or mesh) providing tensile strength and resistance to cracking and finally formwork in form of temporary molds or shutters to support the concrete until it sets. Whereas, SSD (Steel Sheet Decking) Slabs are comprised of a steel deck usually a profiled steel sheet serving as permanent formwork and providing tensile strength, concrete (usually a small layer, poured over the steel deck) to providing compressive strength and lastly shear connectors (studs, wires) that connect the steel deck to the concrete to achieve composite action.

Table 4 1. Main characteristics of both Reinforced Cement Concrete Slab and the Structural Steel Decked slab

Conventional RCC SLAB	
Primary members	
Columns	600 x 600mm
Beams	300 x 400mm
Slab	200mm thick solid slab
Steel reinforcement	
	25mm diameter as main bars
	16mm diameter barsas secondary bars
	12mm diameter bars as stirrups
	10mm diameters bars
	8mm diameters bars
Concreting	
Concrete	75mm thick slab
	Class 25(1:1.5:3), 20mm aggregates
	Wooden float finish
Form work	
Slab shuttering	MDF boards 12mm thick, smeared
	4" x 2" sawn timber supports
	10mm diametre props

Structural Steel Decked SLAB	
Primary members	
I-Beams	203 x 203x 46kg/m for beams
	MS plate 12mm thick
	R/Bolts M20 x 150mm long for columns
	M16 x 300mm long for beams
Secondary members	
Purlin recievers	Angle 125 x 50 x 2mm
Sag rods	Angle 25 x 25 x 2mm
Decking/Flooring	
Sheets	Aluminium zinckle G2 sheets
	Self tapping screws
Concreting	
Concrete	75mm thick cocrete topping
	Class 25(1:1.5:3), 20mm aggregates
	Wooden float finish

The building considered here is a commercial building project and the study is carried out on the same building plan/section for both RCC and Composite SSD construction. The SSD slabs are mainly termed are mezzanine or intermediate slabs simply because they may not form part of the original building frame and they can as well be used to divide the slab-to-slab heights into two.

A building that has a slab-to-slab height of 6.5 meters and above will most likely require an intermediate floor which may not necessarily carry the weight of the rest of the building but rather provide an extra floor space just to accommodate light weight loads like offices or storage space for light objects or items.

4.1.1 Characteristics of an RCC slab

Reinforced Cement Concrete slabs are mainly characterized by high strength, durability, versatility, and fire resistance. They are designed to span in one or two directions, relying on a combination of concrete's compressive strength and steel reinforcement's tensile strength.

As dead load is a substantial part of the total load on RC structures, any saving in depth of members can represent a substantial saving in material cost, in terms of total height of structures, load on foundations, heating, electrical, plumbing, wall and partition surfaces. While this can be achieved by using high-strength materials, these are limited by considerations of cracking and deflection. These limitations of RC are largely overcome by prestressed concrete.

The main features of an RCC slab are;

i. Monolithic construction: RCC slabs are cast in situ, creating a single, solid structure.
ii. High strength and durability: RCC slabs possess high compressive strength, durability, and resistance to weathering.
iii. Flexural strength: RCC slabs can withstand flexural stresses, making them suitable for large spans.
iv. Fire resistance: RCC slabs have excellent fire resistance due to the non-combustible nature of

4.1.2 Characteristics: of an SSD slab

The steel sections are normally designed to be unpropped during construction, and must be sized to support the self-weight of the slab, and other construction loads, in their non-composite state. The weight of extra concrete from ponding of the slab should be allowed for in the design of the beams when the deflection of the decking under the wet weight of the concrete exceeds one tenth of the depth of the slab, in accordance with both BS EN 1994-1-1 and BS 5950-4.

Careful consideration should be given to the correct allowance for the weight of the concrete when ‘mass flood’ levelling techniques are adopted as well as checking the resistance of the steel beams, this will involve an assessment of their stiffness. Beams that are not suitably stiff will deflect excessively during concrete placement, and the extra concrete should be allowed for in the design.

The construction loading should be applied in addition to the self-weight of the concrete, reinforcement and decking. To use a steel beam economically, the top (compression) flange needs to be restrained laterally. The restraint provided by the decking to the beams depends on the decking orientation and the fixings. The restraint provided by decking spanning in a direction parallel to a beam is normally assumed to be negligible, but decking spanning perpendicularly to a beam can provide restraint if it is adequately connected.

The main features of an SSD slab are

i. Composite construction: SSD slabs consist of a steel deck and concrete, working together to resist loads.
ii. Fast construction: SSD slabs enable rapid construction, reducing labor costs and project timelines.
iii. Lightweight: SSD slabs are lighter than RCC slabs, making them suitable for high-rise buildings or structures with limited foundation capacity.
iv. Long spans: SSD slabs can accommodate long spans, reducing the need for intermediate supports

4.2 COST COMPARISON

4.2.1 Material Cost Comparison

Material costs are expenses associated with purchasing the items necessary for a construction project. These costs can include: building materials (cement, sand, aggregate, bricks, steel, wood) and finishing materials (paint, tiles, flooring, doors, windows, etc.) These vary depending on location, suppliers, Quality/class of the item' quantity as well as the specifications. Proper estimation of material costs is crucial for construction projects to ensure Budgeting through staying within budget and avoiding cost overruns, cost control by managing expenses and making informed decisions and lastly profitability by ensuring the project's profitability for contractors and developers.

Table 4 2. Material costs for Reinforced Cement Concrete Slab and Structural Steel Decked Slab

MATERIALS	**Associated Costs (Ushs)**		**Cost Difference (Ushs)**	**%age difference**
	Reinforced Cement Concrete (RCC) slab	**Structural Steel Decked (SSD) slab**		
Structural Steel	-	203,043,424	-203,043,424	0
Shuttering/formwork	83,757,014	-	83,757,014	100%
Reinforcement Steel	154,116,567	36,581,333	117,535,233	76%
Concrete	93,808,000	28,158,000	65,650,000	70%
TOTAL COST (Ushs)	**331,681,581**	**267,782,757**	**63,898,824**	**19%**
Cost per SQM (722 sqm)	**459,393**	**370,890**	**88,503**	

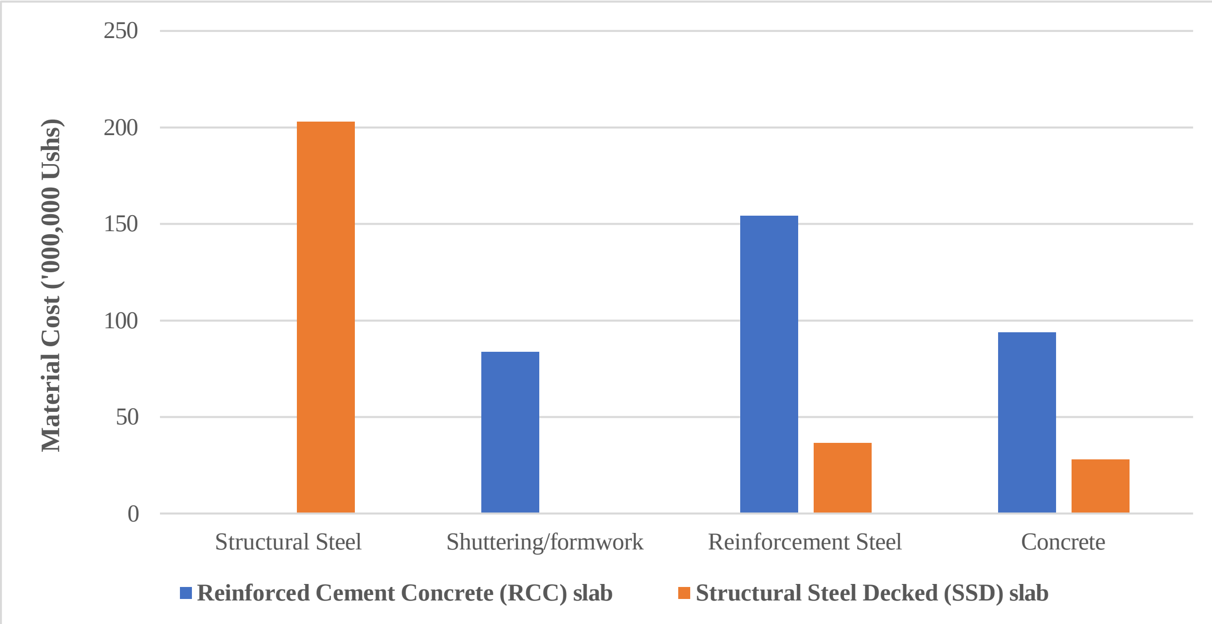

Figure 4 1. Cost comparison (materials) between the RCC slabs and the SSD slabs

Fig 4.1 above shows how the material costs of the different steps of construction of both the RCC and SSD slabs vary from one another. It is quite clear that the RCC does not require any structural steel just like the SSD has no shuttering required during installation.

The reinforcement steel inform of rebars is significantly high with RCC slabs 76% more than is used in SSD slabs since a lot of steel of different sizes is used in beams as well as a double matt in the slab which is not the case with SSD slab where even a single layer of BRC mesh can be used. Concrete required for an RCC slab is also much, 70% more than that of SSD slabs since more concrete is consumed in beams and also the thickness of slabs varies.

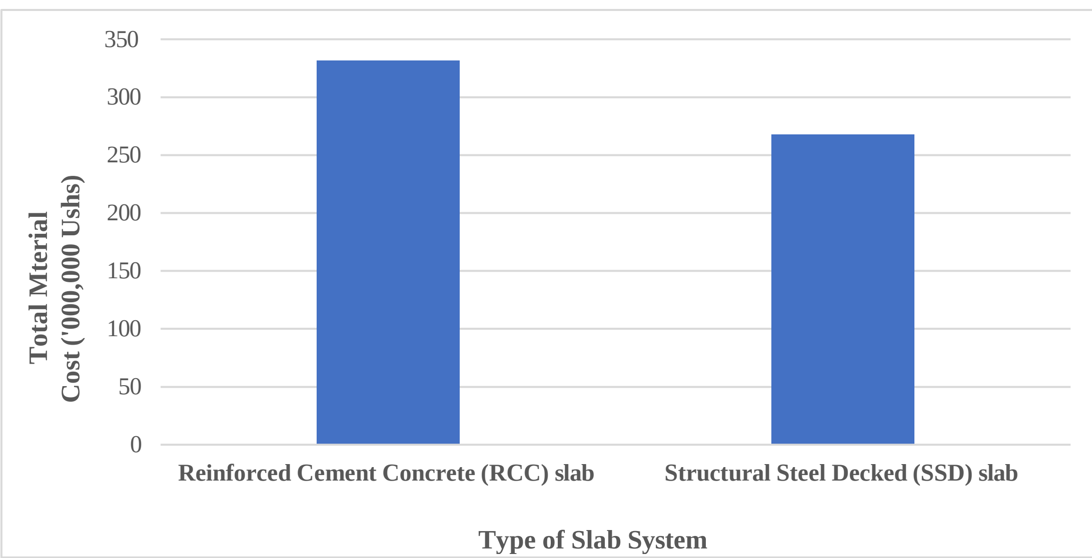

Figure 4 2. Material Cost Variations between the RCC slabs and the SSD slabs

Fig.4.2 above shows the variation in cost of all materials used in the construction process for both the SSD slab and RCC slab. The Overall material cost for RCC slab is slightly higher, about 19% more than SSD slabs since all of reinforcement steel, concrete and formwork contribute to the that cost as opposed to RCC slabs where its mainly the structural steel that comprises the biggest portion of the material cost with literally not formwork is required at all.

4.2.2 Labour Cost Comparison

Labour costs are expenses associated with hiring workers to perform specific tasks or jobs on a construction project. These costs can include Wages and salaries (payments made to workers for their time and effort), benefits and allowances, overtime and bonuses (extra payments for working beyond regular hours or achieving specific targets and trainings to improve their worker skills and productivity. These costs vary depending on location, level of skills, complexity of the project, amount of working time, workplace conditions and level of productivity required.

Table 4 3. Labour costs for both Reinforced Cement Concrete Slab and Structural Steel Decked Slab

MATERIALS	**Associated Costs (Ushs)**		**Cost Difference (ushs)**	**%age difference**
	Reinforced Cement Concrete (RCC) slab	**Structural Steel Decked (SSD) slab**		
Carpentry	9,030,000	-	9,030,000	100%
Structural Steel works	-	6,150,000	-6,150,000	0
Reinforcement Steel works	4,300,000	1,220,000	3,080,000	72%
Concrete	630,000	220,000	410,000	65%
TOTAL COST (Ushs)	**13,960,000**	**7,590,000**	**6,370,000**	**46%**
Cost per SQM (722 sqm)	**19,335**	**10,512**	**8,823**	

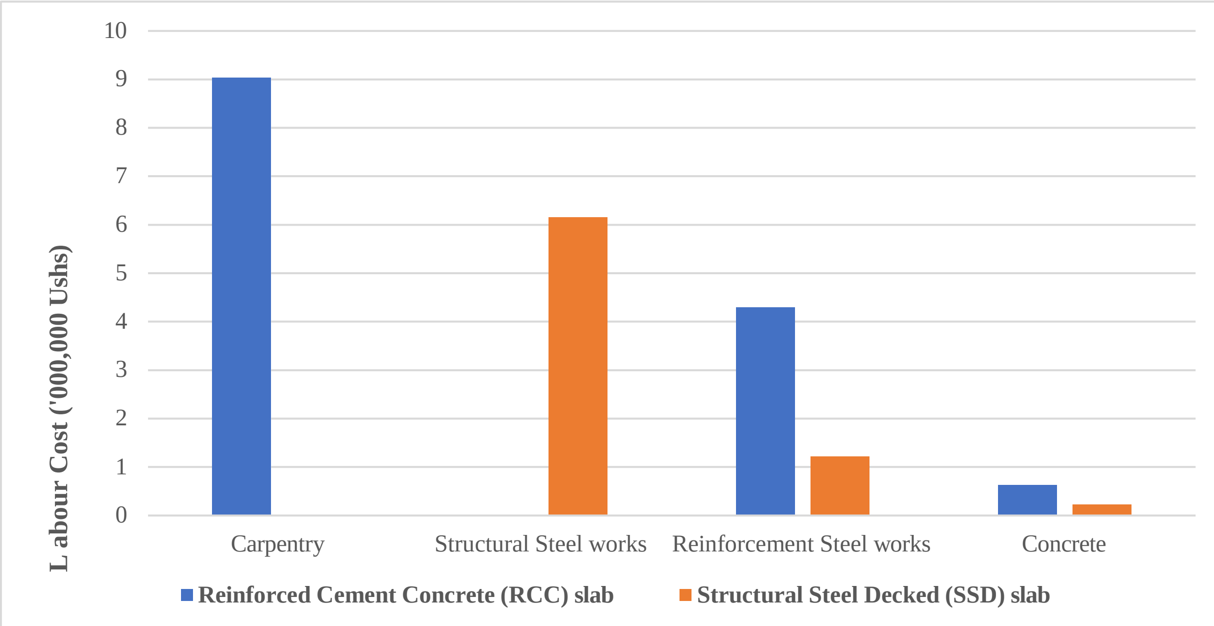

Figure 4 3. Labour Cost comparison between the RCC slabs and the SSD slabs

Fig 4.3 shows how the construction costs of labour for the RCC slab varies from that of SSD slabs in which there this absolutely no carpentry labour cost incurred for SSD slabs since there is no formwork required as well as there is equally no structural steel labour costs incurred for RCC slabs as there is no requirement for structural steel installation.

The reinforcement steel labour costs are incurred for either slab systems but the RCC slabs incur over 72% labour costs more than the SSD slabs since a lot of steel is incorporated into the beams as well as slabs especially double matt slabs. Alot more labour costs are incurred in RCC slabs 65% more than in SSD slabs due to the element of concrete in beams and also the slab thickness which may require thorough compaction hence requiring more man power.

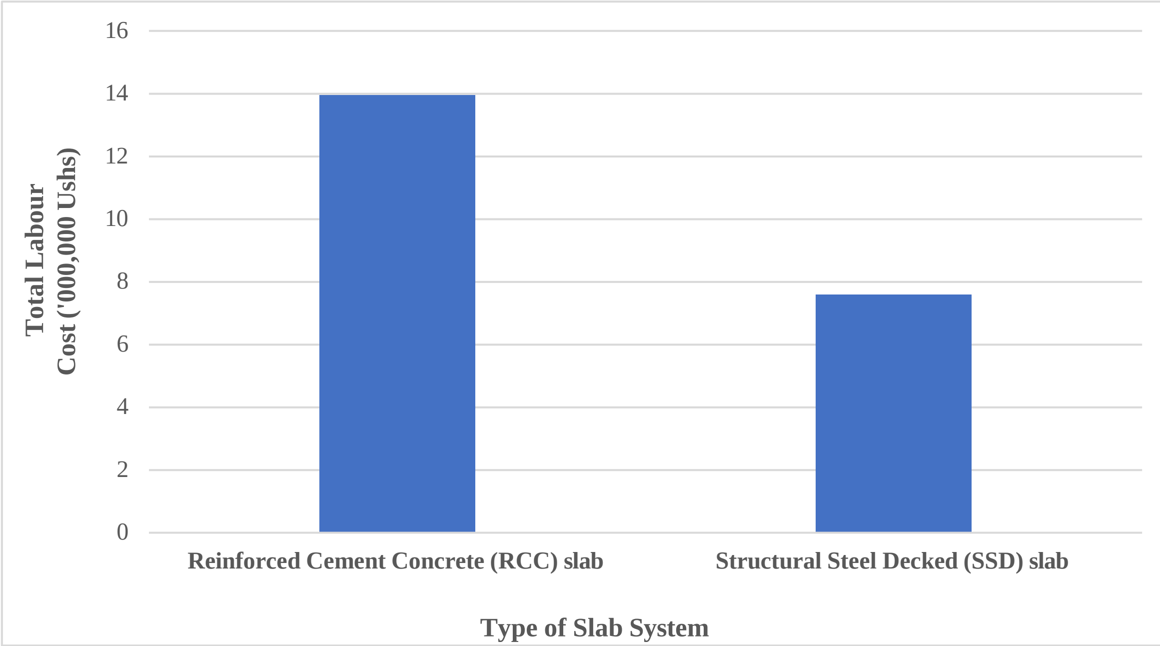

Figure 4 4. Overall, Labour Cost Variations between the RCC slabs and the SSD slabs

Fig 4.4 shows the Overall construction costs on labour incurred for both RCC and SSD slabs where it is evident that the RCC slabs consume much labour costs 46% much more than the SSD slabs. This is mainly attributed to fact that there more manpower required during shuttering works and steel reinforcement works in RCC slabs and the reverse is true for SSD slabs

4.2.3 Material Costs and Labour Costs combined

Material costs and labour costs are all classified as direct costs and cobine to form a Unit Rate which refers to the total cost of a specific construction activity or component, including both material and labour costs. It's often expressed as a cost per unit of measurement.

Table 4 4. Combined labour and Material costs for both Reinforced Cement Concrete Slab and Structural Steel Decked Slab

MATERIALS	Associated Costs (Ushs)		Cost Difference (ushs)	%age difference
	Reinforced Cement Concrete (RCC) slab	Structural Steel Decked (SSD) slab		
Material Cost	331,681,581	267,782,757	63,898,824	19%
Labour Cost	13,960,000	7,590,000	6,370,000	46%
TOTAL COST (Ushs)	**345,641,581**	**275,372,757**	**70,268,824**	**20%**
Cost per SQM (722 sqm)	**478,728**	**381,403**	**97,325**	

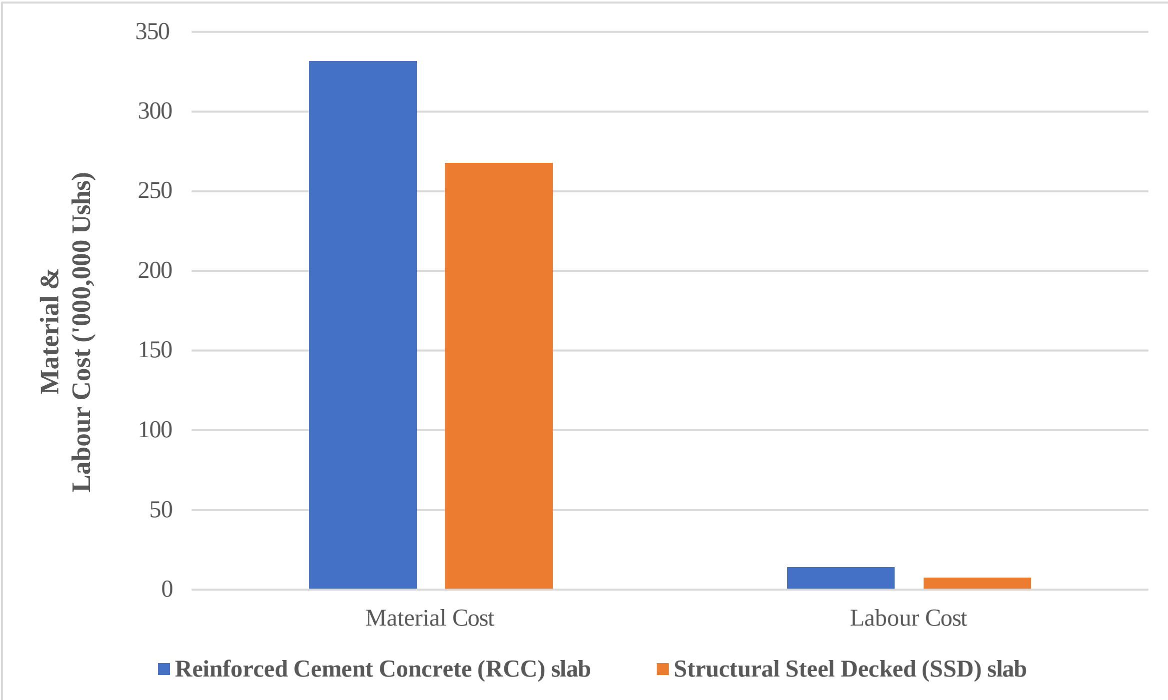

Figure 4 5. Cost Variations (Labour and Materials) between the RCC slabs and the SSD slabs

Fig 4.5 shows the cost variation of both labour and materials for the slab systems where the material costs for either system is always higher than the labour cost with the Labour cost being between 3% to 4% of the overall construction cost.

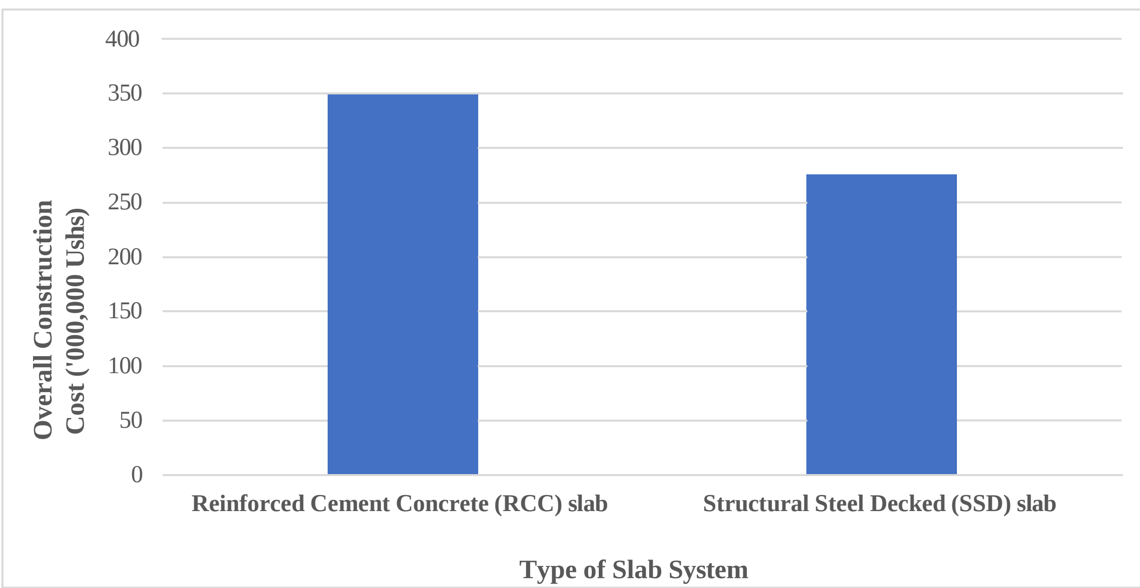

Figure 4 6. Cost Comparison (Combined Labour and Materials) between the RCC slabs and the SSD slabs

Fig 4.6 shows the overall material and labour cost comparison between the RCC slabs and SSD slabs especially during the construction phase. The total construction cost for RCC slabs is 20% more than that of SSD slabs which is attributed to majorly the extra cost of steel reinforcement to be used in beams and also the extra cost of carpentry works (material and labour).

The overall rate per sqm to construct an RCC slab is about Ushs 478,728 and that of SSD slab is Ushs 381,403 making a difference of about Ushs 97,325. This difference is quite important in making a decision based on resources available, area coverage of the building as well as prices of construction materials.

4.3 TIME COMPARISON

The time component refers to the scheduling and timeline aspects of a project. It involves planning, organizing, and controlling the project schedule to ensure timely completion. The main aspects of the time include project duration (total time required to complete the project), task duration (time required to complete individual tasks or activities), dependencies/relationships between tasks that affect the project timeline, critical path (the longest path in a sequence of tasks that determines the minimum project duration), milestones (significant events or points in the project timeline) and lastly, deadline with specific dates or times by which tasks or milestones must be completed.

Table 4 5. Construction Time/Durations for both the RCC and SSD slabs

ACTIVITY	**DURATION (Days) 8hrs @ day**		**Difference in time**
	Reinforced Cement Concrete (RCC) slab	**Structural Steel Decked (SSD) slab**	
Carpentry	21	0	**21**
Structural Steel works	0	15	**0**
Reinforcement Steel works	10	2	**8**
Concrete	1	1	**0**
TOTAL Duration	**32**	**18**	**14**

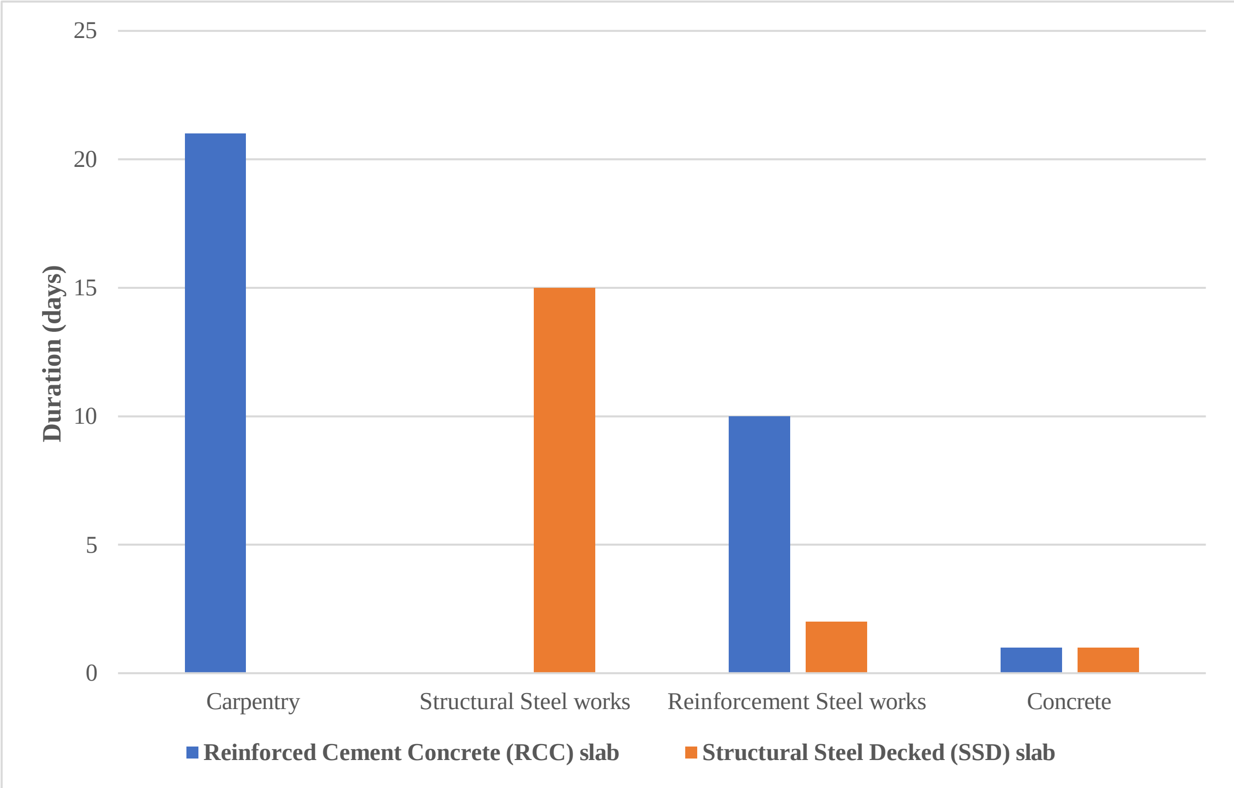

Figure 4 7. Time Comparison between activities of both the RCC slabs and the SSD slabs

Fig 4.7 shows the time taken in days to perform the various activities for construction of either the RCC slab or SSD slab. It is evident that no duration on carpentry works during SSD slab construction since for shuttering is required as well as there no duration under structural steel installation for RCC slabs since no structural steel is involved.

Reinforcement steel works for RCC slabs taken longer, about 8 days more compared to SSD slabs simply because a lot of steel fixing is done in beams and slabs for RCC slabs than in SSD slabs whereby only a BRC mesh may be fixing requiring on a few mins not even a day.

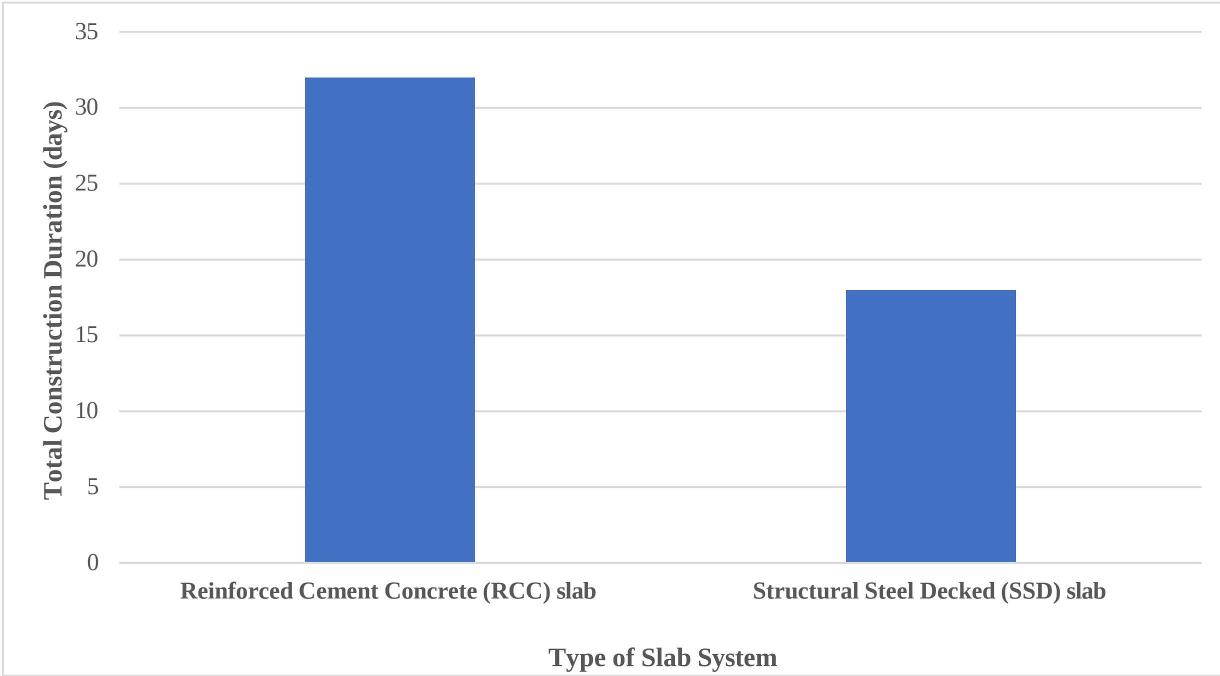

Figure 4 8. Overall Time Comparison between the RCC slabs and the SSD slabs

Fig 4.8 shows the overall construction duration for the two slab systems in which it takes over 32 days to cover an area of 722 sqm of an RCC slab and only takes 18 days to construct an SSD slab for the same area. There is essentially a difference of 14 more days to construct an RCC slab and this is as a result of a lot of time consumed under carpentry works as well as extra days for fixing reinforcement steel in beams and slab.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The study found that SSD slabs are approximately 20.3% cheaper than RCC slabs when considering the total costs of materials and labor. Additionally, SSD slabs require significantly less time to construct 18 days compared to 32 days for RCC slabs representing a 43.75% reduction in construction duration. This time efficiency is largely due to the elimination of traditional formwork and the reduced need for extensive reinforcement and carpentry work, which are both labor intensive and time consuming.

From the comparative analysis conducted between Reinforced Cement Concrete (RCC) slabs and Structural Steel Decked (SSD) slabs, it is evident that the SSD system offers significant advantages in terms of both cost and time efficiency.

These findings suggest that SSD slabs not only contribute to faster and more economical construction but also enhance the functional and structural performance of buildings for which this greatly helps different stakeholders in decision making.

5.2 RECOMMENDATIONS

Based on the findings, it is recommended that construction professionals, including developers, engineers, and project managers, consider adopting SSD slab systems for projects where cost savings and time efficiency are critical. SSD systems are particularly suitable for fast-tracked developments and projects in urban areas where construction timelines are tight and labour costs are high.

Greater awareness and technical training should be promoted to encourage the use of SSD systems, especially in regions where RCC slabs are still predominantly used due to tradition or lack of exposure to alternative systems. In some projects, a hybrid approach combining RCC and SSD systems may be appropriate, depending on architectural complexity and functional requirements.

Finally, it is advised that future research explores additional performance parameters of these slab systems, such as structural durability, fire resistance, acoustic behavior, and environmental impact, to provide a more comprehensive basis for decision-making in building construction.

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Appendices

CONVENTIONAL RCC SLAB

S/N	Item	Unit	Qty	Rate	Amount (UGX)
a)	**Materials**				
	Formwork				
	Shuttering boards	pcs	326	95,000	30,960,764
	timber (4"x2")	pcs	1,955	11,000	21,509,583
	Assorted nails	kgs	4,400	6,000	26,398,125
	Props (poles)	pcs	978	5,000	4,888,542
					83,757,014
	Steel reinforcement				
	25mm dia high yield bars	pcs	69	180,000	12,474,000
	20mm dia high yield bars	pcs	437	120,000	52,400,000
	16mm dia high yield bars	pcs	92	80,000	7,378,000
	12mm dia high yield bars	pcs	12	42,000	485,100
	10mm dia high yield bars	pcs	2,022	33,000	66,712,800
	8mm dia high yield bars	pcs	667	22,000	14,666,667
	Binding wire	Kgs	500	6,500	3,250,000
					154,116,567
	Concrete (CLASS 25 (1:1.5:3)				
	Ready mix concrete	Cum	180	520,000	**93,808,000**
	Total of material cost				**331,681,581**
b)	**Labour**				
	Carpentry (21 days)				
	Senior carpenters - 4no.	per day	84	40,000	3,360,000
	Junior carpenters - 6no.	per day	126	20,000	2,520,000
	Helpers - 15no.	per day	315	10,000	3,150,000
					9,030,000
	Reinforcement Steel works (10 days)				
	Senior steel benders - 3no.	per day	30	35,000	1,050,000
	Junior steel bender - 5no.	per day	50	20,000	1,000,000
	Helpers - 15no.	per day	150	15,000	2,250,000
					4,300,000
	Concreting (1 day)				
	Senior mason - 2no.	per day	2	55,000	110,000
	Junior mason - 4no.	per day	8	35,000	280,000
	Helpers - 20no.	per day	20	12,000	240,000
					630,000
	Total of labour cost				**13,960,000**
	Overall cost (at construction phase)			**Ugx**	**345,641,581**

Figure A 1. Quotation showing pricing and costing of an RCC slab

STRUCTURAL STEEL DECKED SLAB

S/N	Item	Unit	Qty	Rate	Amount (UGX)
a)	**Materials**				
	Structural steel				
	12mm thick MS plates (1.22 x 2.44 sheet)	Pcs	4	1,768,600	7,003,656
	203 x 203 x 46kg/m IPE beams - 6m long	Pcs	60	2,000,000	120,120,000
	100 x 50 x 20 x 2mm Z-purlins - 6m long	Pcs	205	139,000	28,439,494
	Sag rods, R/bar 16mm	Pcs	57	110,000	6,243,600
	12mm through bolts and nuts (min. 300mm long)	Pcs	106	10,000	1,056,000
	20mm Hilti bolts (min. 150mm long)	Pcs	317	10,000	3,168,000
	Self tapping screws 1"	Pcs	2,970	150	445,500
	Angle cleats (100 x 100 x 6mm thick), 6m long	Pcs	24	383,000	9,352,852
	Aluminium zinckle G24 x 6.6m long sheet (217 pcs)	Mtrs	945	23,100	21,835,321
	Metal Primer - 4ltr	Tins	9	65,000	600,600
	Super gloss paint - 4ltr	Tins	21	70,000	1,478,400
	Cutting dics	Pcs	50	25,000	1,250,000
	Drill bits	Pcs	20	65,000	1,300,000
	Welding rods	box	50	15,000	750,000
					203,043,424
	Reinforement steel				
	10mm dia high yield bars (double cage)	Pcs	962.67	38,000	**36,581,333**
	Concrete (CLASS 25 (1:1.5:3)				
	Ready mix concrete	Cum	54	520,000	**28,158,000**
	Total of material cost				**267,782,757**
b)	**Labour**				
	Structural Steel welding works (15 days)				
	Senior welders - 2no.	per day	30	65,000	1,950,000
	Junior welders - 4no.	per day	60	40,000	2,400,000
	Helpers - 6no.	per day	90	20,000	1,800,000
					6,150,000
	Reinforcement Steel works (2 days)				
	Senior steel benders - 5 no.	per day	10	50,000	500,000
	Helpers - 18 no.	per day	36	20,000	720,000
					1,220,000
	Concreting (1 day)				
	Senior mason - 1no.	per day	1	50,000	50,000
	Junior mason - 2no.	per day	2	25,000	50,000
	Helpers - 10no.	per day	10	12,000	120,000
					220,000
	Total of labour cost				**7,590,000**
	Overall cost (at construction phase)			**Ugx**	**275,372,757**

Figure A 2. Quotation showing pricing and costing of an SSD slab

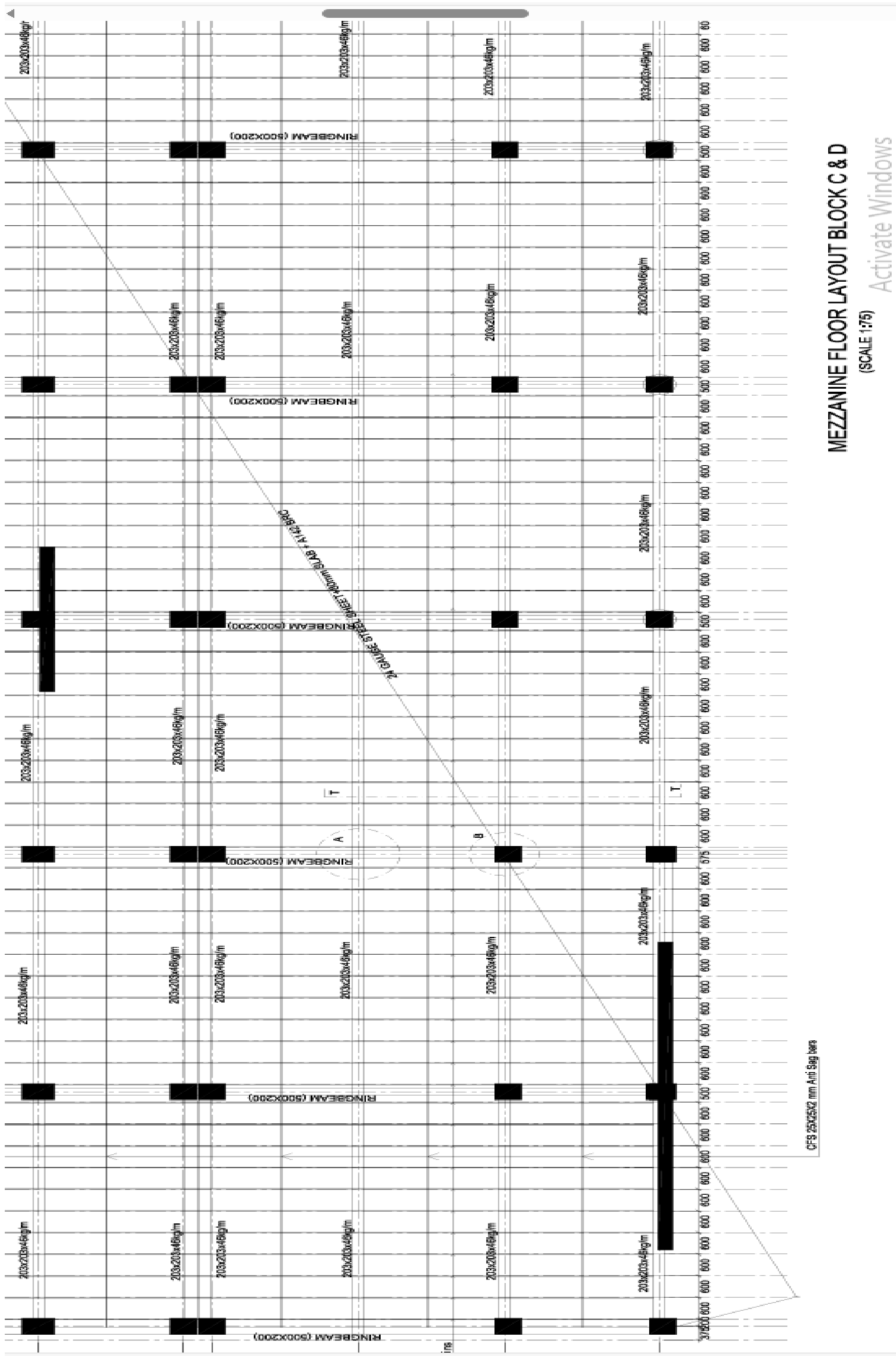

Figure A 3. A structural drawing showing the layout and arrangement of structural members in an SSD slab

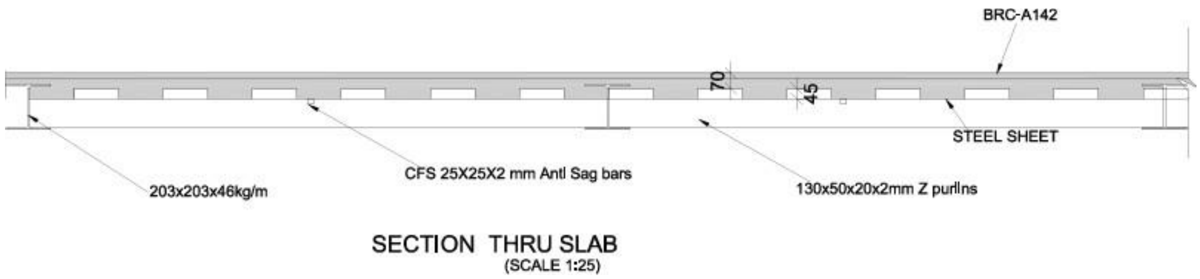

Figure A 4. A cross-section of an RCC slab

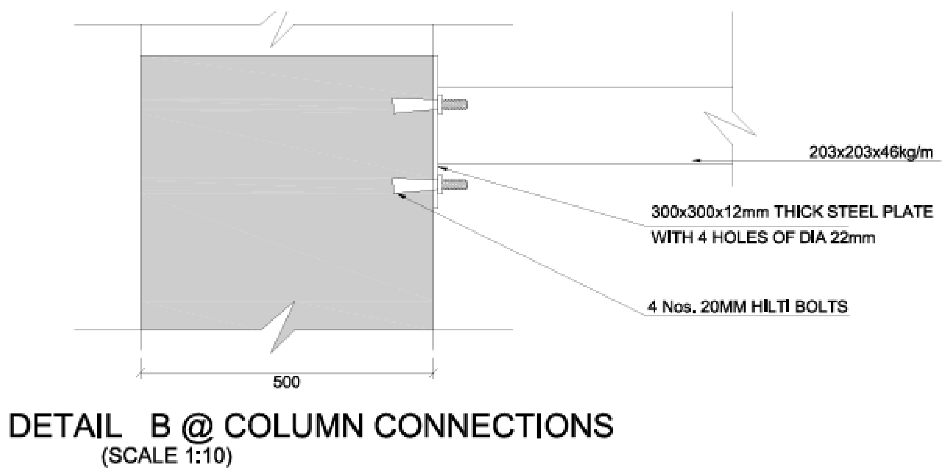

Figure A 5. Sectional details of connections in an RCC slab

Figure A 6. A photo showing the different floor/levels on BLOCK A of the project

Figure A 7. A photo showing the different floor/levels on BLOCK B of the project

Figure A 8. A photo showing the soffit of an SSD slab.

Figure A 9. A photo showing the integration of an SSD slab within an RCC framed structure

Figure A 10. A photo showing the soffits of an RCC slab

Figure A 11. A photo showing the position of an SSD slab as an intermediate/mezzanine slab