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OPTION OF CONSTRUCTION TECHNOLOGY

ENHANCING TRAFFIC FLOW AND SAFETY THROUGH INNOVATIVE IMPLEMENTATION OF PEDESTRIAN BRIDGES (STAIRS AND RAMPS)

A project report submitted in partial fulfillment of the requirements for the award of an Advanced Diploma in civil engineering department, with option in Construction Technology

Academic year: 2023-2024

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DECLARATION

I'm, Henriette UWASE

I, hereby declare that the work presented in this dissertation "**ENHANCING TRAFFIC FLOW AND SAFETY THROUGH INNOVATIVE IMPLEMENTATION OF PEDESTRIAN BRIDGES (STAIRS AND RAMPS)"** is my own contribution to be the best of my knowledge. This work has never been submitted to any other University or Institution.

The candidate names: Henriette UWASE

Student's signature…… Date……. /……/2024

APPROVAL SHEET

This research project entitled "**ENHANCING TRAFFIC FLOW AND SAFETY THROUGH INNOVATIVE IMPLEMENTATION OF PEDESTRIAN BRIDGES (STAIRS AND RAMPS)"** was prepared and submitted by Henriette UWASE in partial fulfillment of the requirement for award of advanced diploma (A1) in civil engineering/ Construction Technology during academic year 2023-2024.

…….	…….
Signature of the Supervisor	Signature of the H.O.D
Name of the Supervisor	Name of H.O.D
Dr. MWIZERWA Fabrice	Eng Bonaventure NKIRANUYE

DEDICATION

This research is dedicated to:

Almighty God

My teachers

My colleagues

My Mom

My Brothers and Sisters

My friends

Thank you for all the support and encouragement you gave me during my studies

ACKNOWLEDGEMENTS

The success of this project has been a result of my dedication, and the immense contributions of individuals who have shown me their support, guidance, and encouragement. I would like to take this opportunity to express my heartfelt gratitude to these wonderful souls

First, I would like to acknowledge ULK POLYTECHNIC INTITUTE for granting me the opportunity to be a student in this great.

I would also express my appreciation to my project supervisor, for their unwavering mentorship for the entire duration of this project. Through their expertise, timely feedback, high standards, and support, I have been able to come up with quality work that I am immensely proud of.

I would like to acknowledge my research participants whose contributions provided me with the required data for this project. They gave me their precious time and provided me with valuable insights that made the process of data analysis without errors.

I am indebted to my family for their never-ending encouragement and support throughout my academic journey. Their unwavering life and belief in me have always propelled me to do better. Also, I would like to appreciate my friends for being with me on this journey and encouraging me to see this through despite the stress and difficulties encountered.

In conclusion, I am forever grateful for the gift of wonderful humans who have made the final year project a success. Their immense support fueled my passion and determination to excel. I am grateful to have been blessed with these amazing individuals and organizations. Thank you!

ABSTRACT

This project is entitled "**Enhancing Traffic Flow and Safety Through Innovative Implementation of Pedestrian Bridges (Stairs and Ramps)"** in Nyabugogo there is none pedestrian bridge even in Rwanda country there is no pedestrian bridge installed anywhere. This report explores a novel approach to reduce traffic congestion and accidents through the implementation of pedestrian bridges (Stairs and smart Ramps) in urban areas especially in Nyabugogo. Existing traffic management systems often struggle to cope with the increasing volume of vehicles, leading to gridlock and a higher risk of accidents. The proposed solution leverages advanced technology to improve traffic flow and enhance road safety. The main objective is to Enhancing traffic flow and safety through the innovative implementation of pedestrian bridges, particularly in high-traffic area like Nyabugogo.

This project located in City of Kigali, Nyarugenge-District, Kimisagara-Cell, Nyabugogo -Village. The study area is near the site of the biggest and main bus station in Rwanda (Nyabugogo Tax-park), Nyabugogo markets, Petrol stations, commercials building, Muhima police traffic station, Muhima nursery and primary school and etc. where there is a large plot which is able to hold all the building **Figures.**

Currently Rwanda does not have Pedestrian bridge or footbridges. many pedestrians walking and crossing the roads using Zebra crossing, many of them crossing in disorder and vehicles travelling speed is still high and does not allow pedestrians to move freely, and the mobility of physically challenged people has been forgotten and there is a need of introducing the pedestrian overpass bridges in clouded zones of the city center, Nyabugogo, Kicukiro and Remera-Giporoso areas of the City of Kigali. In the way of solving those issues, I made a decision of proposing this project of implementing pedestrian bridges at Nyabugogo which. I found those issue by making conversation with different ages of people walking and crossing the road in person day by day, I collected data by manually method of counting pedestrians crossing the roads in rush hours. I also collected existing data about accident records involving pedestrians near the road. Then I made drawings showing our pedestrian bridges and their locations, in this drawing showing first bridge is in circular shape at the crossroads. The road come down from Kimisagara, road from Giti Kinyoni, road from Gicumbi or Gatsata and the road going straight to the Muhima and the other side. The second crossing road bridge is located in front of the Equity bank branch Nyabugogo. I think this project is coming as a solution of the problems talked above.

It means This project will improve the quality and quantity of infrastructural in Rwanda, will provide job to many people, will solve the problem of several accidents. This project will improve safety for both pedestrians and vehicles.

In this study, I did not make cost estimation so that I recommend other researchers to do it, and also, I did not make a structural design of pedestrian bridges, so that I recommend researchers to do those designs.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

RP: Rwanda Polytechnic

ULK: Kigali Independent University

UPT: ULK Polytechnic Institute

ENG: Engineer

HOD: Head of Department

ADA: Standards for Accessible Design

AASHTO: American Association of State Highway and Transportation Officials

RCC: Reinforced Cement Concrete

MINIFRA: Ministry of Infrastructure

RTDA: Rwanda Transport Development Agency

CHAPTER 1: GENERAL INTRODUCTION

1.1 Background of the study

Rwanda is a country with speedy development and aim factor of this development is improvement in quality and quantity of its infrastructure. **Enhancing traffic flow and safety through innovative implementation of pedestrian bridges (stairs and ramps)** in Rwanda is a significant initiative aimed at revolutionizing transportation infrastructure in the country. These pedestrian bridges represent a modern solution to alleviate congestion, enhance accessibility, and improve safety for both pedestrians and vehicles.

Rwanda, a country known for its proactive approach to development, is embracing innovation to address transportation challenges. By introducing Pedestrian bridges, the country is not only focusing on improving traffic flow but also prioritizing safety measures to prevent accidents and ensure smooth movement within urban areas.

According to traffic police figures, between January 2020 and November 2022, a total of 21,459 road accidents were recorded. About 4,000 were recorded in 2020 and another 8,000 in 2021, while 8500 were recorded in 2022.

Table 1.1 below, the best alternative is to construct pedestrian bridge or other facilities for pedestrian. By doing this, we are not stopping-the traffic flow and at the same time, the number of Accident which involved the pedestrian, can be reduced.

Table 1.1: Road Accident rate in Rwanda (Rwanda National Police Annual Traffic Report,(2023)

Year	**Road accidents**
2020	**4000**
2021	**8000**
2022	**8500**

The concept of pedestrian bridge involves the construction of elevated pedestrian walkways or staircases that span across busy intersections or congested roads. These elevated pathways provide pedestrians with a safe and efficient route to navigate through traffic without hindering the flow of vehicles below. Additionally, they can incorporate features such as ramps and handrails to accommodate individuals with disabilities, ensuring inclusivity in urban mobility solutions.

The implementation of Pedestrian bridge in Rwanda demonstrates a forward-thinking approach to urban planning and infrastructure development. By investing in innovative solutions, the country aims to create more sustainable and livable cities while promoting economic growth and social well-being.

Furthermore, the adoption of such innovative transportation infrastructure aligns with Rwanda's commitment to becoming a model for smart and sustainable development in Africa. By leveraging technology and creative design, the country seeks to optimize its urban environment and enhance the overall quality of life for its citizens.

1.2 Problem statement

Currently Rwanda country does not have Pedestrian bridge (stair and smart ramps, the problem statement for enhancing traffic flow and safety through innovative implementation of pedestrian bridges in Rwanda would likely include several key components:

- **Current Traffic Congestion**: Describe the existing traffic congestion issues in Rwanda, particularly in urban areas or areas with high population density. This could include information on peak traffic times, bottlenecks, and areas prone to gridlock.
- **Safety Concerns:** Highlight any safety concerns related to current traffic conditions, such as accidents, pedestrian safety issues, or challenges for emergency vehicles navigating congested roads.
- **Infrastructure Limitations:** Discuss any limitations or challenges with existing road infrastructure that contribute to traffic congestion and safety hazards. This could include narrow roads, lack of proper signage, or inadequate pedestrian crossings.
- **Potential Solutions:** Introduce the concept of innovative pedestrian bridges as a potential solution to address traffic flow and safety issues. **Explain how these airway stairs would**

work, including their design, placement, and intended impact on traffic patterns and safety.

- **Expected Outcomes:** Describe the anticipated outcomes of implementing pedestrian bridge, including projected improvements in traffic flow, safety, and overall transportation efficiency.

By addressing these key points in the problem statement, stakeholders can gain a clear understanding of the traffic flow and safety challenges in Rwanda and the potential role of innovative implementation of pedestrian bridge in addressing these issues.

1.3 Objective of the study

1.3.1 Main objective

Enhancing traffic flow and safety through the innovative implementation of pedestrian bridges, particularly in high-traffic area like Nyabugogo.

1.3.2 Specific objectives

- Making site investigation by correcting all information and data which will be used in Architectural design and perspectives
- Making an Architectural design of Pedestrian Bridge (stair and Ramp)
- Making Renders and Animation

1.4 Scope of the study

The study of the project is limited on:

- To conduct geotechnical study.
- To do Architectural drawing and perspectives of the pedestrian bridges

1.5 Significance of the study

This project" will allow me to think how we can solve problems in the society using the knowledge we got in class and this project will increase my experience in designing.

This project will improve the quality and quantity of infrastructural in Rwanda, this project will provide job to many people, this project will solve the problem of several accidents. This project will improve safety for both pedestrians and vehicles, lastly this research will be the marketing of institutional to attract new students.

CHAP 2. LITERATURE RIVIEW

2. 1 Definition and introduction

2.1.1. Introduction

It is going to focus on the construction of the pedestrian bridge, stairways, and ramps These are the bridges that have various design and are constructed of various materials to allow the people to cross the street safely in different conditions including vehicular traffic, animal traffic, geographical formations, etc. in and out of the concentrations of people. It also has bridge or passage kind by which it is possible to allow passage for the pedestrians and other sizes of conveyance facilities like automobile, bicycle, train, etc., and on the other hand, it has bridges exclusively meant for the pedestrians only.

Pedestrian bridges are constructed in various structures and by using various materials in order to ensure safe passage of pedestrians in various situations such as vehicle traffic, animal traffic and natural formations in or out of the city centers.

The pedestrian bridges are an access structure which links two different are as in aesthetic way as a supplementary aspect of landscape and urban design. In most developed countries, the subject is taken into hand from the point of that the pedestrian bridges are designed as a work of art and a statue of city as well as their functionality. In the developing countries, the pedestrian bridges have been gained importance as the structures through which the people may access the trade centers where they may fulfil the health services, education opportunities and needs especially in the rural areas. It is possible to observe that especially the suspension bridge systems are more applied in the rural areas due to the easiness of material supply, easy installation, low labor force and cheapness.

The pedestrian bridges are called with different names depending on aspects such as their relation with the ground of bridges and their usage: footbridge,

Under bridge, skyway.

The One of the important pedestrian facilities is pedestrian bridges. According to (Demirarslan, Pedestrian bridges and passages, 2017), pedestrian bridges could be built from different structures

and constructed by using various materials for connecting people from one place to another by walking across them.

2.1.2. Definition of pedestrian bridge

Firstly, we need to know the definition of pedestrian bridges so that we can understand this study well. Then we need to know and master the real meaning of pedestrian bridges to study and know the problems related to this pedestrian bridge. From technical aspect, pedestrian bridge or 'footbridge' as defined by Dictionary of Scientific and Technical Term written by Daniel N. Lapades is; Footbridge- a bridge for people on foot only. According to this is the best solution for pedestrians to cross the road. Normally there are 2 types i.e. overhead footbridge and underpass but the most common in Malaysia is overhead. Then we will refer to pedestrian bridge as a small bridge which are designed and used for pedestrian only.

2.2. The pedestrian bridges, stairways and ramps within the historical process.

Pedestrian bridges, stairways, and ramps have played a significant role in urban development and architecture throughout history. These structures have evolved to meet the needs of society, offering safe and convenient passage over obstacles such as roads, rivers, and other challenging terrains. Here's an overview of their development through different historical periods. Here's an overview of their development through different historical periods:

2.2.1. Ancient Civilizations

- **Mesopotamia and Egypt**: Early bridges were made from materials like wood and stone, with designs focused on functional needs for trade and transport.

  Footbridges, staircases, and inclines have held notable importance in the progress of cities and architectural design across various eras. These constructions have undergone changes to align with societal demands, providing secure and practical traversal over hindrances like highways, waterways, and other difficult landscapes. Presented here is a summary of their advancement through distinct historical epochs. (Wai-Fah Chen,Lian Duan , 2014) **Ancient Greece and Rome**: The Greeks and Romans improved bridge engineering significantly, using stone and concrete to build durable structures. The Roman use of arches in bridge design is particularly notable, allowing for longer spans and greater strength. (Chanson, Footbridges: Structure, Design, History, 2002)

2.2.2. Middle Ages

- **Medieval Europe**: Bridges in the Middle Ages were often constructed with stone and featured defensive elements like towers and gates. They were essential for connecting different parts of growing cities and for military and trade routes.
- Asia In China and Japan, wooden bridges were prevalent, often intricately designed and sometimes covered to protect from the elements.

2.2.3. Renaissance to Early Modern Period

- **Renaissance**: The period saw the blend of aesthetic considerations with engineering advancements. The Ponte Vecchio in Florence, Italy, is an example where shops were built along the span of the bridge.
- **Early Modern Period**: The use of iron and steel began to revolutionize bridge construction, allowing for longer spans and more intricate designs.

  Industrial Revolution

  - **19th Century**: This era marked significant advancements in materials and construction techniques. Iron and later steel became the primary materials, leading to iconic structures like the Brooklyn Bridge in New York (completed in 1883) and (the Eiffel Tower in Paris (1889; Idelberger, 2009)

2.2.4. 20th Century to Present

- **Modern Engineering**: The 20th century saw the rise of reinforced concrete and pre-stressed concrete, allowing for even more innovative designs. Pedestrian bridges began to incorporate elements of modernist architecture.
- **Late 20th and Early 21st Century**: Contemporary bridge design emphasizes not only functionality and durability but also aesthetic appeal. There is also a focus on accessibility, with ramps and other features ensuring usability for all individuals, including those with disabilities. Examples include the Millau Viaduct in France and the Gateshead Millennium Bridge in the UK. (Chen, 1997).

2.2.5. Evolution of Stairways and Ramps

- **Historical Stairways**: Stairs have been an essential architectural element since ancient times, with notable examples like the grand staircases of Egyptian pyramids, Roman amphitheaters, and medieval castles.
- **Modern Stairways**: Modern architecture often incorporates stairways as significant design elements, combining functionality with aesthetic appeal. The advent of skyscrapers brought innovations like emergency stairwells and aesthetically pleasing atriums with grand staircases. (Chatterjee, 1991).
- **Ramps**: Ramps have evolved significantly, particularly with the modern emphasis on accessibility. Ramps have come a long way, especially with the focus on accessibility. Old ramps can be seen in ancient sites like the pyramids but now they're everywhere in public spaces for wheelchairs, strollers and bicycles.

- **Pedestrian Pathways**: Modern urban planning often integrates pedestrian bridges, stairways, and ramps into the broader infrastructure, promoting walkability and connectivity within cities. Examples include the High Line in New York City, a repurposed elevated railway line turned into a linear park.
- **Sustainability**: There is a growing trend towards sustainable design in pedestrian bridges and pathways, incorporating green spaces, renewable materials, and energy-efficient lighting.

  Overall, pedestrian bridges, stairways, and ramps have continuously adapted to meet the evolving needs of societies, reflecting changes in technology, materials, and design philosophies while always prioritizing safety, accessibility, and functionality.

2.3. Use of pedestrian bridge

We already know pedestrian bridge provided to risk his own by crossing the road without using the pedestrian bridge. There-fore we need more careful to determine who make pedestrian bridge fully used. Pedestrian will use the pedestrian bridge at;

I. They are aware of the dangers that will befall them when crossing the road with a lot of vehicle flow and speed.
II. When they have to wait long to cross a busy road.

III. There is traffic enforcement officer who will impose legal action if there is a pedestrian crossing without using the pedestrian bridge.
IV. Walkers who cannot afford to move quickly to cross busy roads such as old aged and disabled physical.
V. Vehicle flows very busy and fast-moving vehicle in which it is difficult to pass without an accident.

As Usual the footbridge is constructed across the road with higher volume of traffic and pedestrians crossing the road. The objective is for the safety of the pedestrians and to maintain the traffic flow. According (Chanson, Footbridges: Structure, Design, History, 2002) the decision to build a footbridge based on the width of the road, traffic volume and the numbers of pedestrians crossed the road. But in other the footbridge is needed even though the demand was low.

2.4. Pedestrian Safety

The biggest factor in deciding to cross at a designated crossing is the distance to the destination (Handy, 1996)

Also pedestrian safety can be affected by signal settings at signalized crosswalks (pedestrian delay < 40 sec) (Garter J. , 1989).

2.5. Pedestrian crossings

It's well known that most pedestrian collisions happen when pedestrians are crossing the road and most research shows that the risk is higher away from crossing facilities than on a crossing (AA Foundation, 1994) and (Ghee et. al, 1998). National statistics show that 40% of pedestrian collisions in 2003 happened when the pedestrian was crossing the road away from a pedestrian crossing (Department for Transport, 2004). 9% of pedestrian collisions occur on a pedestrian crossing and 8% within 50m of a crossing " (Zhuang, Wu , 2011).National figures show more collisions at mid-block signalized crossings than other types of pedestrian crossing (zebra crossings, signal-controlled junctions and crossings with human control e.g. school crossing patrols) (Department for Transport, 2004). But this may be misleading as it doesn't take into account the number of each type of crossing. It's been said that signalized crossings have the risk

of crossing without them ((ACI), 1994) and that lack of crossing facilities affects older women more than anyone else as they were found to have difficulty understanding and monitoring the sequence of traffic movements and a tendency to monitor nearside and far side traffic independently as they cross the road (al, 1998). And of the collisions that do happen at crossings one study found the flashing pedestrian green phase at Pelican crossings has high collision rates (Ghee et. al, 1998)

2.6. Type of Road

National states show that most pedestrian collisions happen on built up roads (96%) which is roads with a 40mph speed limit or less (Transport, 2004). Note that these figures don't take into account exposure so it's possible that risk isn't higher but there are more pedestrians on, for example built up roads with 30mph or less speed limits. 8 Research by the (Foundation A. , 1994) found that in their study area the highest proportion of pedestrian casualties were on 'District Distributor' roads which were A or B roads with 40mph or less speed limits. According to one study road width is a factor in collision risk, risk increases as road width increases (VA, 1999).

2.7. Guidelines, manuals and standards on the accessible design of pedestrian bridges.

There are several important guidelines, manuals, and standards related to the accessible design of pedestrian bridges. I can provide an overview of some key resources:

1. Americans with Disabilities Act (ADA) Standards for Accessible Design: According to (AASHTO. (2009; AASHTO, 2009). These standards provide detailed requirements for accessibility in the United States, including specifications for pedestrian bridges.
2. Architectural Barriers Act (ABA) Standards: Similar to ADA, but applies specifically to facilities designed, built, altered, or leased with federal funds.
3. AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges: This guide from the American Association of State Highway and Transportation Officials provides structural design specifications, including accessibility considerations.
4. Manual on Uniform Traffic Control Devices (MUTCD): While primarily focused on traffic control, it includes guidance on pedestrian facilities, including bridges.

2.7.1. Design Criteria for Pedestrian Bridges, stairways and Ramps (Footbridges).

This guide was made by Highways England in 2020 and is for making footbridges, stairways and ramps for people in the UK. Aside from basic ideas, design and style, and rules, a whole part talks about sizes (Like the space to the road under the bridge, smallest width, room height on the bridge, flat parts and turns on ramps, curved and spiral ramps and stairs). Also, this guide has parts about walls, covered footbridges, water flow, path surfaces and lights.

The general accessibility requirements for bridges that can be used by pedestrians as

well as bicyclists and equestrians are as follows:

- Select spots with natural slopes or build slope to make the bridge accessible.
- Keep the detour short if there is one on an existing path.
- Make sure the slopes, rest areas, and turns fit all users, including those with mobility issues.
- Keep ramps and stairs simple, short, and follow the main path.
- Skipping stairs if ramps are the direct way to cross.
- Using stairs alone only in special cases and with local agreement.
- Make the bridge wide and tall enough for all applied to meet the needs of all potential users (see Figure 1)

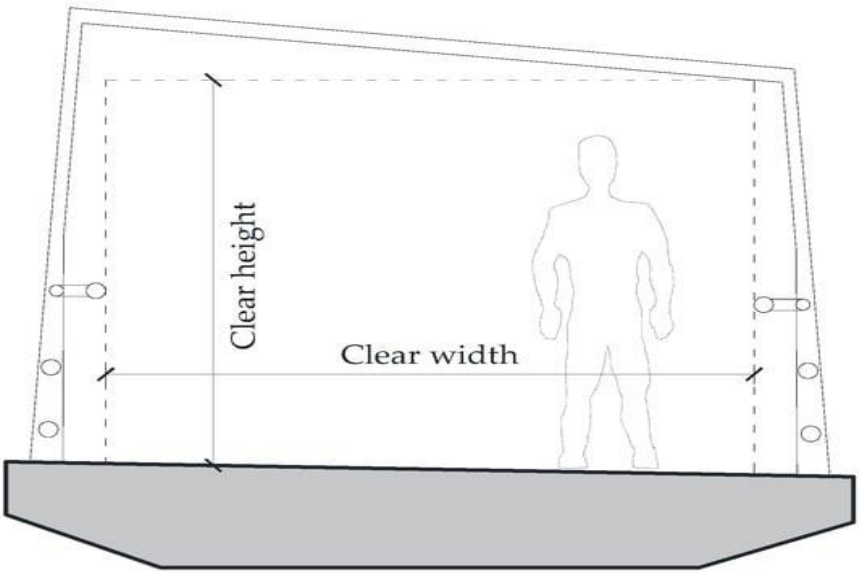


Figure 1: Definition of clear width and clear height of a bridge. (AASHTO. (2009)

Walkways, ramps, and stairs must be wide enough for people and, in some cases, bicycles or horses to use. For places with only pedestrians, the width should be 2m, or whatever is needed based on the number of people and the slope. For combined use with no segregation, the width should be 3.5m. Very specific dimensions are given for walkways for pedestrians and bicycles where they are separated. When combined, the walkway should be 1.5 to 2m, and the cycle path should be 2.5 to 3m, with a total width of 4 to 5m. The height must be 2.3m for pedestrians, 2.4m for pedestrians and cyclists, 2.7m for walking horses, and 3.7m for mounted ones. Slopes should not be more than 5%, but in some cases, they can be up to 8.3%. Handrails are needed on stairs and walkways with a slope over 5%, and there may need to be extra handrails if the walkway is over 3m wide.

2.7.2. Ramps (Sloped Paths).

Ramps can go straight or curve. The path's width must match the walk and bike path on the bridge. The ramp's slope is in the last part. Curved or spiral ramps need a 5.5m inside turn. For curves, slope and size are measured 90cm inside the turn. Ramps with a 4.5% slope need no breaks. For slopes above 4.5%, breaks should be put. For slopes of 4.5% to 5%, breaks should be every 2.5m in height. For slopes over 5%, breaks should be every 0.65m.

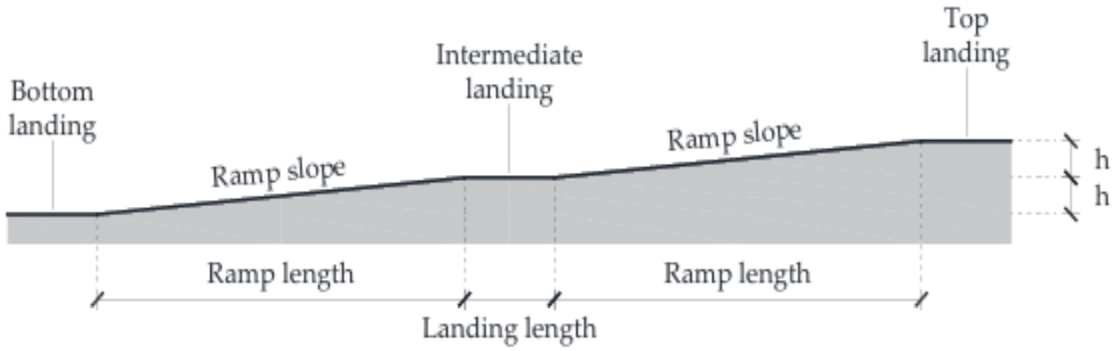


Figure 2: An example of a ramp with an intermediate landing. (ADA (2010)

The minimum length of a landing is 2m, while the width should be the same as the ramp width. Straightrampswithslopesgreaterthan5%shouldchangetheirhorizontalalignment atintervalsequaltoaverticalriseof3.5mbyeitherachangeindirectionofatleast30◦ or an offset in horizontal alignment of at least the width of the walkway. Exceptions can be made if no arrangement other than straight successive slope ramps is possible at the site, or if such an

arrangement would encourage pedestrians more strongly to use the pedestrian bridge by shortening the walking distance or improving the desire line.

The minimum ramp width for pedestrians is 1.1 m. The maximum height difference that a single ramp can overcome is 1 m, while for people with disabilities this is reduced to 0.5m. A greater height difference should be overcome by several ramps connected by

Flat landings.

The average slope of the ramp plays a more important role than its length. The

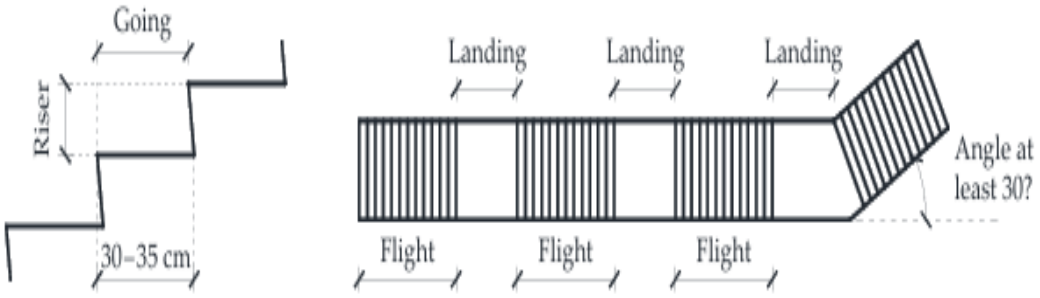
difficulty(Z)of the ramp can be calculated as the square of the average slope of the ramp

multiplied by its length, or as the square of the height difference divided by its length:

$Z=(h/L)2\times L=h2/L,$

2.7.3. Stairs

Public stairs must have 13 steps or less in one set. Steps should be the same size, with each step not more than 15 cm high and no less than 30 cm wide. The landing at the top should be as wide as the stairs or 2 m, whichever is bigger, measured in the middle of the stairs. The steps can have holes in them, but they must follow these rules: each hole can be at most 5 cm wide, and the open space cannot be more than 40% of the whole step.



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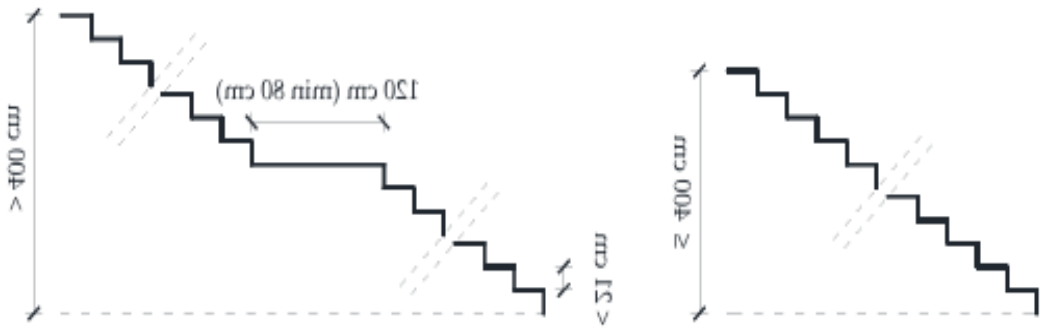
(CD353. (2015). Public Stair Design Standards.)

Figure 3: Public stairs adopted from CD353 (left): cross section;(right): in-plane arrangement) [5].

A maximum of three consecutive flights may be arranged in a line; adjacent flights have to change the direction at an angle of at least 30^0, as can be seen in Fig 3.

Stairs can go up 4 meters max. For bigger gaps, add landings. The tiniest size for landings is 80 by 80 cm. If you can, make it 120 by 120 cm. No extra stairs info given.



(CD353. (2015). Public Stair Design Standards.)

Figure 4: An example of maximum height of stairs (4m) and the minimum size of landings (0.8m).

2.8. Eco-friendly design practices for pedestrian bridges

More and more, I see pedestrian bridges in another country cities and nature, making it safer and nicer for people walking and biking. But building these bridges can harm nature. Luckily, there are ways to build these bridges in a way that's good for the environment. This review will look at important things to think about when designing eco-friendly pedestrian bridges.

2.8.1. Material Selection

Recycled and Reused Materials: Use recycled steel, concrete, or plastic wood to cut environmental impact. (Build., 2011).

- **Sustainable Materials:** Consider and Think about FSC-certified wood or fast-growing bamboo for a sustain optionable.
- **Durability:** Choosing long-lasting materials weathering steel or composite wood to limit replacements and lower environmental effect.

2.8.2. Construction Techniques

- **Prefabricated Components:** Building with ready-made parts means making less mess and putting things together quicker, using less energy and causing fewer problems in the area.
- **Minimizing Construction Footprint:** Thinking carefully before building can make sure we disturb less land, and keep local nature safe.

2.8.3. Energy Efficiency

- **Natural Lighting:** Strategically placed skylights or cutouts can illuminate the bridge walkway during daylight hours, reducing reliance on artificial lighting.
- **Solar Power:** Integrating solar panels into the bridge design can provide power for lighting or even information displays.

2.8.4. Additional Considerations:

- **Landscaping:** Use local plants near the bridge for a nicer look, making homes for animals, and maybe stopping land from washing away.
- **End-of-Life Planning:** Think about taking things apart and using them again in the future when making the design.

By implementing these eco-friendly design practices, architects and engineers can create pedestrian bridges that are not only functional and aesthetically pleasing but also minimize their impact on the environment. By using green design, builders can make walking bridges that work well, look nice, and don't hurt nature. This helps make our buildings better for the earth.

2.9. Pedestrian facilities

Began in the 1990s the preparation and construction of facilities for pedestrians has become an important matter. These facilities need to keep pedestrians safe and comfortable. Since the 1990s public studies have shown that we need to plan, fund, and keep up pedestrian facilities with more care. Places that pedestrians often use include traffic lights at crossings, zebra crossings, areas with street vendors, walkways over roads, and tunnels. (FHWA-RD-99-089, 1999).

The Transportation Equity Act for the 21st Century (TEA-21) said that road projects should think about adding pedestrian facilities, except in areas where people don't need them.

When designing and building facilities for pedestrians like footbridges (Pedestrian bridges), we have to think about many factors and standards. It's key to provide a pedestrian facility that meets. Pedestrian needs and behaviors vary significantly based on age, gender, and the surrounding environment. The speed and flow of pedestrians are crucial factors in designing effective pedestrian facilities. For instance, the place and density of individuals walking alone versus in

According to " (Chen, K., & Yu, L, 2007). Kids and older folks are also a key part of important pedestrian facilities (pedestrian bridge especially Ramps). Kids-walk slower than adults in their prime. So, we need to think about how long it takes an older person to cross the road compared to younger people. More-over many older people have trouble seeing and hearing, which can make them react more, More-over their situation can cause accidents caused by it is very difficult to them to see and listen road signals.

Plus, what pedestrians need varies from place to place. Towns see more foot traffic than rural areas. This happens because cities have more homes packed together, along with offices, schools, colleges, and lots of shops.

Residents typically use pedestrian facilities for the various destinations and purposes such as to work, appointments, recreation and shopping. Parking facilities that are less and also advances in technology transit systems cause an increase in pedestrians. Therefore, a system of pedestrian facilities more effectively and in accordance with the requirements of pedestrians should be provided.

CHAPTTER 3: METHODOLOGY

3.1. Introduction

My work to improve traffic flow and safety by trying new things includes building pedestrian bridges as a key project. We take a complete and organized approach to make sure the final design meets practical needs and looks good in the area. And in the part of methodology, I focused on the following methodologies; Site Location Visit, Site Selection Criteria, Data Collection, and Design Software.

I start by doing a thorough site survey. In this step, I gather and check all the important facts about where I plan to build the bridge. By checking these facts to make sure the design works well and is safe for people to use. This section emphasizes the density of pedestrians within the project study area (Nyabugogo).

After looking at the site, I move on to designing how the bridge will look. My design will have important parts like stairs and ramps. These parts will help people move across the bridge and, so there's less chance of accidents. During bridge design, I try to make these parts fit in well with what's already there. I also think about how to make the bridge look nice and fit in with its surroundings.

The next step to boost and present a clear and good picture of the planned footbridge, I'll create detailed renders and animations (images and videos). These visual aids will show how the bridge will blend with its surroundings and spotlight its design elements. They'll demonstrate how it will make traffic move better and keep pedestrian safer when walking.

3.2. Description of the study area

The study area is near the site of the biggest and main bus station in Rwanda (Nyabugogo Tax-park), Nyabugogo markets, Petrol stations, commercials building, Muhima police traffic station. where there is a large number of pedestrians and vehicles.

Figure 5: Nyabugogo pedestrians crossing roads.

3.2.1. Location of the plot of the study area

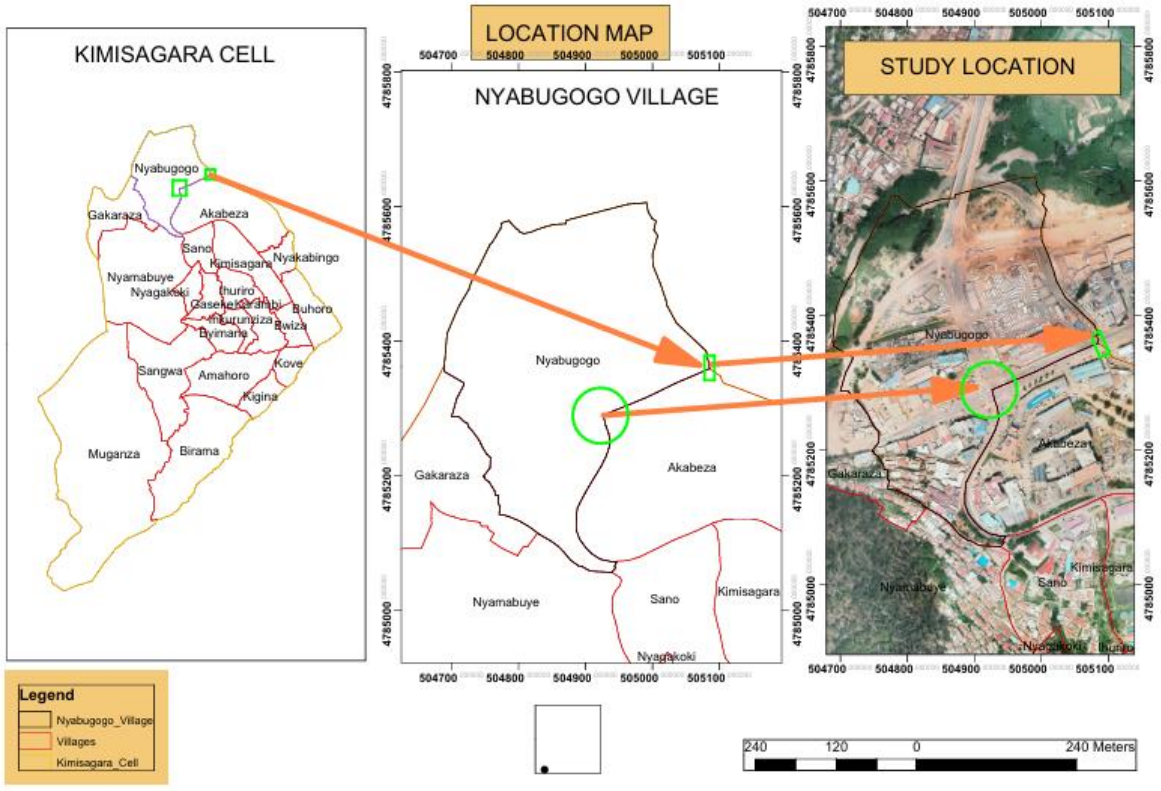


Figure 6: Location map (Study area)

3.2.2. Site (Study location) visit

Alright, folks, let's talk about choosing the perfect location for this project. The first the is no existing pedestrian bridges in the areas of I choose, especial in Rwanda there is no pedestrian bridge installed in any location, that is why I chose this topic as my final year project and I think it would be an innovation and solution for pedestrians. This is crucial to ensure we select the most suitable spot based on factors like time, environment, and other considerations. By doing this, we can guarantee that the research will yield positive results and make the most of our efforts. So, let's dive in and find the ideal location that will give positive results.!

3.2.3. Criteria to decide locations for installing pedestrian bridge

This study examined the mobility challenges faced by pedestrians in Nyabugogo, and proposed solutions to improve their safety and freedom of movement. Using a qualitative approach, the researchers uncovered the key issues hindering pedestrians in the city. With an engaging tone, the paper outlines the major obstacles and suggests alternative measures to enhance pedestrian mobility and security. Referring to the paper findings about the mobility challenges of pedestrians within the Nyabugogo, it is noted that the mobility of the pedestrians and their safety is still low and typical problems including road crossing viewed as the second challenges about pedestrians mobility, walking along very close to the road networks due to insufficient footpaths, lacking of enough road signs, lacking of information about pedestrian behavior on road networks, and improper functioning of existing traffic signals as the first challenge. The paper found that the majority of road networks in Nyabugogo did not provide walkways, traffics signals designs and availability is very poor and some of them not functioning, zebra crossing facilities were not provided adequately, pedestrians shelter on bus stop are almost absent and ignored, vehicles travelling speed is still high and does not allow pedestrians to move freely, and the mobility of physically challenged people has been forgotten and there is a need of

introducing the pedestrian overpass bridges in clouded zones of the city center especially Nyabugogo.

Figure 7: Critical area of Nyabugogo pedestrian crossing road

3.2.4. Pedestrian facilities and their contribution to safety

Any bad design of a pedestrian facility might provide a low level of service linked to discomfort in using them (Cepolina et al., 2015). Facilities provided for pedestrians are generally intended to reduce pedestrian conflicts that may arise with vehicles. Properly designed and placed crosswalk facilities greatly serve pedestrians, increase pedestrian compliance, and encourage crossing at designated places (Akin, 2000). Pedestrian facilities are needed in Cities and Towns to assist in playing a vital role in promoting economic growth and prosperity (Nandkishor et al., 2019) in the urban environment. Some researchers have outlined the benefits of pedestrian facilities (i.e., zebra crosswalks) and their contribution to safety like permitting pedestrians to cross in an orderly manner (Yang et al., 2022), facilitating crossing with perceived behavior control (O'Dell et al., 2022), giving priority to pedestrians waiting to cross (Budzynski et al., 2021), improving the living environment conditions of pedestrians (Zandieh et al., 2016) and managing the vehicle traffic volume. It should be noted that convenient and visible crosswalk facilities (Zegeer et al., 2002) are necessary to ensure pedestrian safety.

Deciding on the optimal locations for installing pedestrian bridges, plays a big role in how well they work and how much people use them.

You can choose a location for your pedestrian bridge that maximizes its functionality, **safety**, and **positive impact on the community**.

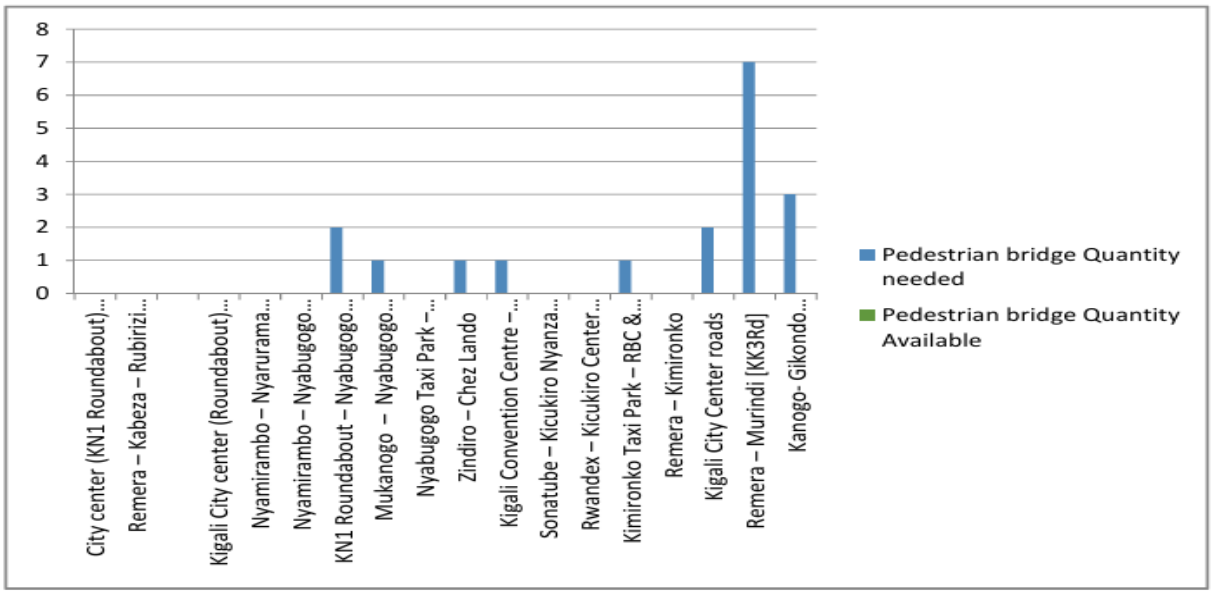


Figure 8: Comparison between Available and Needed Pedestrian Bridge Facilities

(Nkurunziza et al., 2021a; Nkurunziza and Tafahomi, 2020; Yang et al., 2022; Sun et al., 2022; Basile et al., 2010)

3.3. Pedestrian Density

Understanding pedestrian density is crucial for designing an efficient and safe pedestrian bridge. The project study area has been thoroughly analyzed to determine peak pedestrian flow times, high-traffic zones, and potential bottlenecks. Key observations include:

1. **Peak Hours**: The highest pedestrian density occurs during morning and evening rush hours, typically between 7-9 AM and 5-8 PM. This corresponds with the commuting times for local residents and workers.

2. **High-Traffic Zones**: Specific areas, such as near transit stations, shopping centers, and schools, exhibit higher pedestrian traffic. These zones require careful planning to ensure smooth pedestrian movement and prevent congestion.

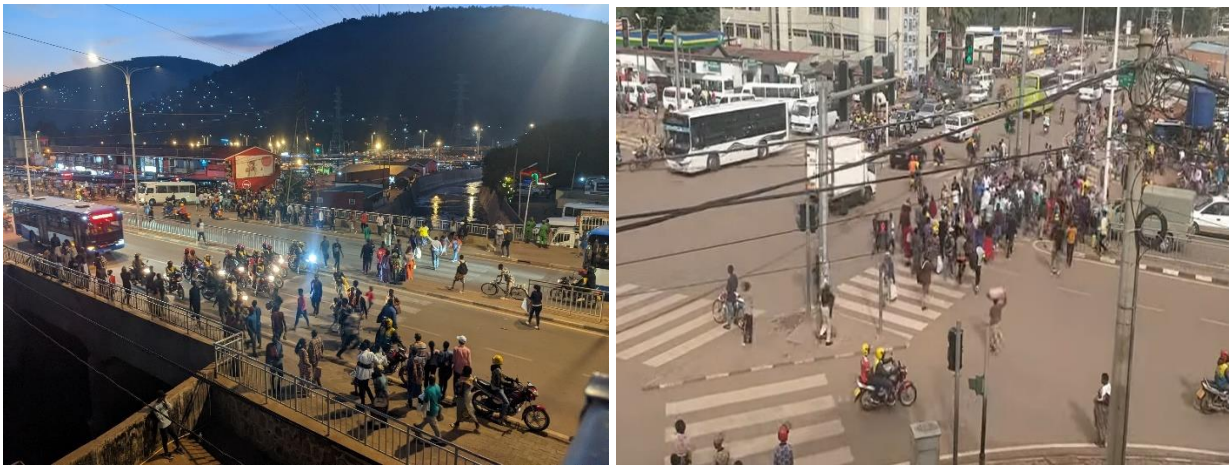


Figure 9: Nyabugogo Pedestrian crossing road during rush hour.

3.3.1 Pedestrian Bridge Components

To effectively manage pedestrian density and ensure safety, the pedestrian bridge design incorporates several essential components:

1. **Entrance and Exit Ramps**: These ramps are designed to handle peak pedestrian loads, with gentle slopes and wide pathways to facilitate easy access for all users, including those with disabilities.

2. **Walkway Width**: The width of the walkway is determined based on peak pedestrian density, ensuring ample space for movement and reducing the risk of overcrowding.

3. **Safety Railings**: Sturdy railings are installed along the bridge to prevent accidents and provide a sense of security for pedestrians.

4. **Lighting**: Adequate lighting is crucial for pedestrian safety, especially during early morning and late evening hours. The bridge is equipped with energy-efficient LED lighting to ensure visibility.

5. **Signage and Wayfinding**: Clear signage and wayfinding aids are essential for guiding pedestrians efficiently across the bridge. These include directional signs, information boards, and digital displays.

6. **Materials and Aesthetics**: The bridge is constructed using durable materials that require minimal maintenance. The design also incorporates aesthetic elements to enhance the visual appeal and integrate with the surrounding environment.

7. **Emergency Provisions**: In case of emergencies, the bridge includes provisions for quick evacuation, such as emergency exits and communication systems.

Figure 10: Flow Chart of Methodology

3.4. Data collection for pedestrian

3.4.1. Data Collection Methods

Data will be collected by pedestrian counts manually and automatic counts, it will be collected by Pedestrian Surveys, Observations and Existing data

1. **Pedestrian counts**

Manual counts: People keep track of foot traffic at set times within two hours for two different time; peak hour and off-peak. For the pedestrian who cross the road.

Automatic counters: Video analytics help count people as they walk.

2. **Pedestrian Surveys**

Intercept surveys: Talk to people walking and crossing the road in person.

3. **Observations**

Direct observation: Researchers observe pedestrian behavior on and around the bridge.
Video analysis: Record pedestrian activity and analyze it later.

4. **Existing data**

Accident data: Analyze traffic accident records involving pedestrians near the road.

3.4.2 Planning and design

a) **Site Assessment**

Experts check the spot looking at ground type, buildings nearby, and how it affects nature.

b) **Defining Needs**

Foot traffic, bikes or work trucks, and looks wanted shape how the bridge turns out.

c) **Material Selection**

Common choices include steel, concrete, wood, or combinations. Each has good and bad points about heft, toughness, and lasting power.

3.5. Architectural Design

These pedestrian bridges (Footbridges) are two bridges, the first bridge is crosses the road, the second one is circular bridge. These bridges are both have 5m of height. It is designed with the following features:

- **1st bridge (Cross road bridge)**
  - Four stairs all have 1.5 m width
  - Two ramps all have 1.5 m width
- **2st bridge (Circular shape)**
  - Eight stairs all have 1.5 width
  - Four ramps all have 1.5 width

3.5.1. Design Considerations

- **Strength and Stability:** The bridge needs to be strong enough to support all expected loads without failure or breaking.
- **Stiffness and Deflection:** Too much bending or swaying can make people feel unsafe or uneasy. Designers aim to keep the bridge from moving too much.
- **Durability and Maintenance:** Durability and Maintenance: A well-designed bridge should stand up to weather and need few repairs over its life.
- **Accessibility:** Ramps, railings, and wide paths matter a lot. They help make sure everyone can use the bridge.

3.5.2. Selection of Bridge Type

- Beam bridges
- Truss bridges
- Arch bridges and
- Cable-stayed bridges are some common options. Each offers advantages in terms of span length, aesthetics, and material usage.

3.5.3. Parts of pedestrian bridge

Bridges are intricate structures, designed with various components that work in harmony to ensure stability, safety, and functionality. While the specific elements may vary based on the bridge's design and materials, there are some common features that make these architectural marvels possible.

A. Structural Components

- **Deck:** The horizontal surface where pedestrians walk.
- **Girders or beams:** The main structural elements supporting the deck.
- **Columns or piers:** Vertical supports that transfer the bridge's weight to the foundation.
- **Abutments:** The end supports of the bridge, anchoring it to the ground.
- **Foundations:** The underground structures that support the bridge's columns or piers.

B. Additional Components

- **Railings:** Barriers to prevent pedestrians from falling off the bridge.
- **Handrails:** Assist pedestrians in maintaining balance.
- **Stairs:** Provide access to the bridge from different levels.
- **Ramps:** Accessible routes for people with disabilities.
- **Lighting:** Improves visibility, especially at night.
- **Drainage system:** Prevents water accumulation on the deck.
- **Expansion joints:** Allow for movement due to temperature changes.

3.5.4. Types of columns used on pedestrian bridge

Bridge columns, also known as piers and are important in holding the superstructure of a bridge. Type of column used is dependent on various factors such as **span length**, **load capacity**, **aesthetics** and **material availability**. classification of column is the following:

1. **Classification by Material**

- **Steel Columns:**

Wide Flange Columns: H-Shaped with good power and rigidity.

Cylindrical Columns: Tubular with an excellent ratio of strength to weight.

Rectangular or square columns: Boxes having very high torsional stiffness.

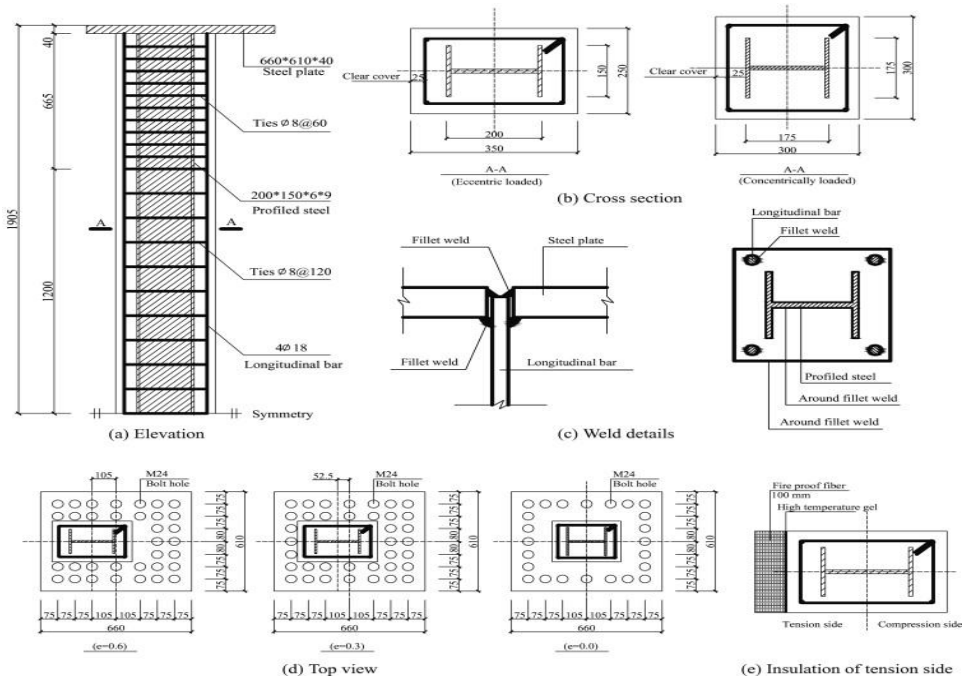


Figure 11: Difference Shape of Steel Column

- **Concrete Columns:**
- **Reinforced concrete columns**: It contains embedded steel for high compressive strength in concrete.
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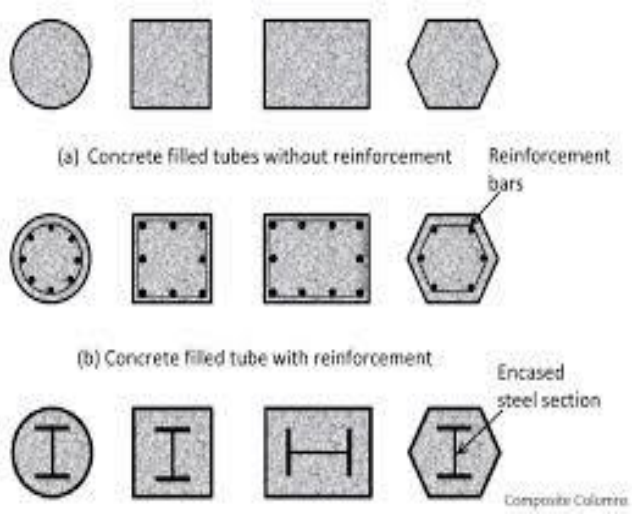

Figure 12: Difference Types of Reinforced Cement Concrete Column

Precast concrete columns: This is done elsewhere during construction for faster work completion.

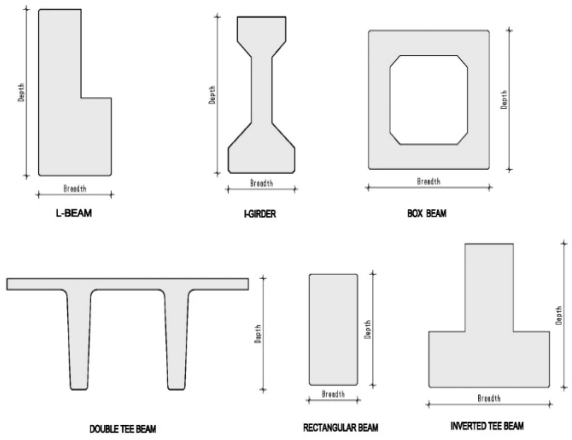

Figure 13: Difference Types of Reinforced Cement Concrete Column

- **Composite Columns:**

Steel-concrete composite columns: The combination of the strength of steel and concrete.

2. **Classification Based on Shape**

- **Circular columns:** Typically used for aesthetic reasons or in specific structural conditions.
- **Rectangular columns:** Offer good strength and stability.

CHAPTTER 4: DATA ANALYSIS AND RESULT INTERPRETATION

4.1. Introduction

Nyabugogo is an area characterized by a high pedestrian population and a complicated road network, creating very high demands in terms of needs for safe and efficient pedestrian movement. The research will focus on the sustainable solutions to improve pedestrian crossings in Nyabugogo. The primary objective of this work is to enhance safety and convenience for pedestrians using two bridge facilities, which are overpass structures made especially for pedestrian use. This introduction will outline the reasoning behind the solution proposed and briefly examine the types of construction methods suitable for these facilities.

The rapidly increasing volume of pedestrians at Nyabugogo has made the adoption of pedestrian infrastructural facilities quite necessary. Crossing the roads at the moment could be dangerous due to the high intensity of vehicular flow and the absence of adequate crossing points. In order to mitigate these issues, this study proposed the construction of two pedestrian overpass bridges. These structures will offer safe and dedicated crossing paths for pedestrians, improving the efficiency of the transportation network by reducing conflicts between pedestrians and vehicles.

In addition to proposing the overpass bridges or pedestrian bridges, this study will explore various construction techniques suitable for such facilities. Factors such as durability, cost, environmental impact, and integration with existing infrastructure will be considered to ensure that the chosen construction methods align with sustainability goals and provide long-term benefits for the Nyabugogo community.

By focusing on these sustainable solutions, this study aims to enhance pedestrian safety, improve traffic flow, and contribute to the overall quality of life in Nyabugogo.

4.2. Criteria to decide the location for installing a two pedestrian bridges.

Nyabugogo is the heart of road transport in Rwanda—it is a central hub from which many road journeys begin and end. Due to the high volume of people in this area, traditional solutions like zebra crossings and traffic lights are no longer sufficient to manage pedestrian and vehicular traffic

effectively. Therefore, I recommend the installation of pedestrian bridges to improve circulation for both pedestrians and drivers.

The figure below illustrates a proposed pedestrian bridge design that could address these issues.

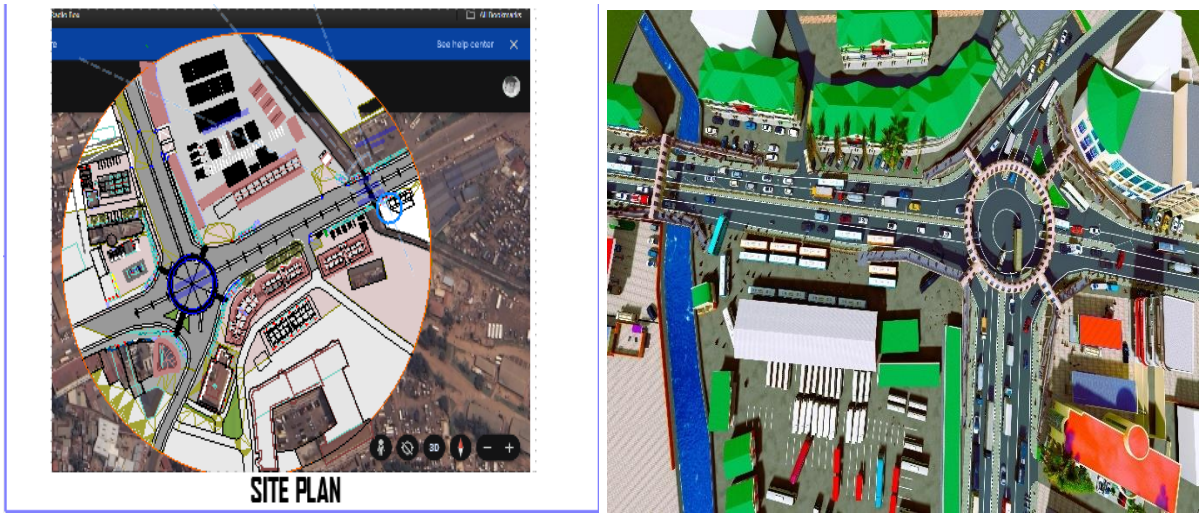

Figure 14: Proposed pedestrian bridges design that could address these issues.

4.3. Pedestrian facilities and their contribution to safety.

This pedestrian facility will feature various components designed to accommodate all categories of people, including those with disabilities, wheelbarrow users, and other vulnerable individuals. For people with disabilities and those requiring additional support, a ramp with a 10% slope will be provided to facilitate easy access. Additionally, a large staircase will be available for others, offering a convenient means of ascending and descending the bridge. The figure below illustrates the proposed arrangement of these facilities.

Figure 15: Proposed arrangement of Pedestrian bridge.

4.4. Pedestrian Density

In Nyabugogo, there is a location where we encounter a high volume of pedestrians crossing the road, as shown in the figure. The design of the pedestrian bridge is intended to enhance safety for both drivers and pedestrians. By referring to the design and dimensions of the pedestrian pathway, it is clear that this bridge will facilitate smooth circulation without any obstacles.

The project study area has been thoroughly analyzed to determine peak pedestrian flow times, high-traffic zones, and potential bottlenecks. Key observations include:

- **Peak Hours**: The highest pedestrian density occurs during morning and evening rush hours, typically between 7-9 AM and 5-8 PM. This corresponds with the commuting times for local residents and workers.

  Observation

  During rush hour (7-9 AM and 5-8 PM) in Nyabugogo, more than fifty (50) pedestrians cross the road within a single time period. This high volume of pedestrian traffic highlights the need for an efficient and safe crossing solution. The pedestrian bridge design aims to address this issue by providing a dedicated space that separates foot

traffic from vehicular movement, thereby reducing congestion and minimizing the risk of accidents. With this

- 

Figure 16: Before and after Nyabugogo proposed pedestrian bridge.

- **High-Traffic Zones**: Specific areas, such as near transit stations, shopping centers, and schools (Muhima nursery and primary school and Cyahafi school), exhibit higher pedestrian traffic. These zones require careful planning to ensure smooth pedestrian movement and prevent congestion.

Observation

Nyabugogo, there are numerous facilities such as markets, a bus station, a petrol station, banks, restaurants, and bars. These amenities attract a large number of people. Consequently, the existing zebra crossings are insufficient to accommodate the high volume of pedestrians. A sustainable solution would be to provide pedestrian bridges in

this area to better manage pedestrian traffic and improve safety.

Figure 17: Before and after Nyabugogo proposed pedestrian bridge.

- **Bottlenecks**: Narrow pathways, intersections, and areas with limited crossing points often create bottlenecks. Addressing these in the bridge design will help maintain a steady flow of pedestrian traffic.

  Observation

  According to the dimensions and spacing of the pedestrian pathways, each entrance and exit is equipped with both ramps and stairs. The ramps have a maximum width of 1.5 meters, allowing pedestrians with disabilities to navigate safely. The stairs are divided into two sections based on width: the first section has a width of 1.5 meters, and the second section has a width of 3 meters.

Figure 18: Ramp and Stair of proposed pedestrian bridge.

4.4.1 Pedestrian Bridge Component

To effectively manage pedestrian density and ensure safety, the pedestrian bridge design incorporates several essential components:

- **Entrance and Exit Ramps**: These ramps are designed to handle peak pedestrian loads, with gentle slopes and wide pathways to facilitate easy access for all users, including those with disabilities.

Observation

Each entrance to the pedestrian bridge opens up to a spacious area under the open sky, allowing natural light to flood the pathway. As you ascend to the apex of the bridge, the design transitions into a sheltered environment. The bridge's apex is covered with a blend of curved concrete and glass, creating a sleek, modern aesthetic. The curved form not only provides shade but also adds an architectural elegance, with the glass allowing filtered sunlight to create a dynamic play of light and shadow throughout the day. This combination

ensures both comfort and visual appeal for pedestrians as they cross the bridge.

Figure 19: Entrance of Pedestrian bridge

- **Walkway Width**: The width of the walkway is determined based on peak pedestrian density, ensuring ample space for movement and reducing the risk of overcrowding. A pedestrian walkway with a width of 3 meters is indeed spacious enough to accommodate the free movement of both pedestrians and wheelbarrow users. This width ensures that there is ample space for individuals to walk comfortably side by side, and for wheelbarrows to pass through without causing congestion. It is an excellent design choice for promoting accessibility and ease of movement in public spaces.

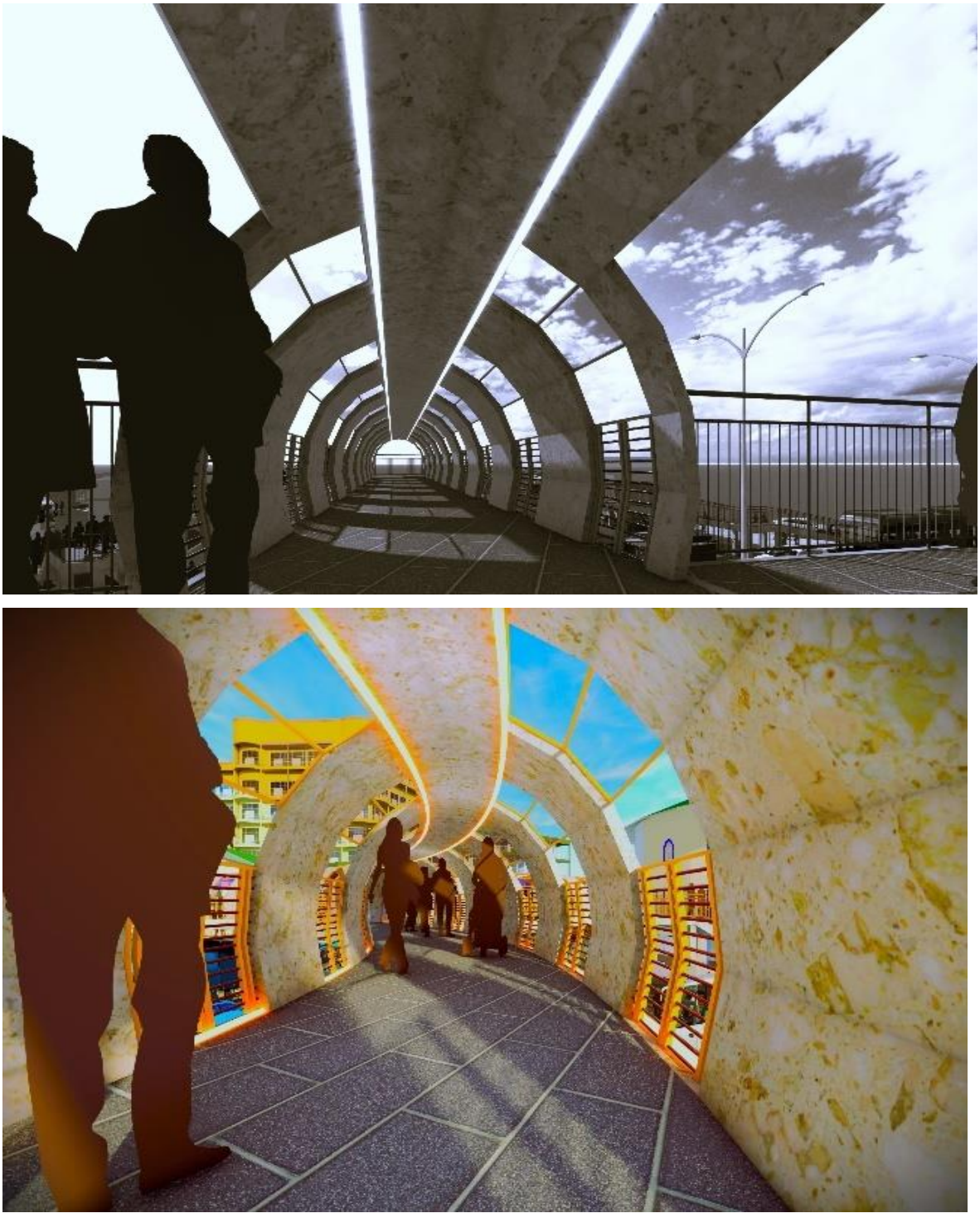

Figure 20: Pedestrian Bridge-walk way.

- **Safety Railings**: Sturdy railings are installed along the bridge to prevent accidents and provide a sense of security for pedestrians.

Observation

The railing of the bridge stands at a height of 1 meter, providing a secure barrier for pedestrians, especially for children. The aligned balustrades are designed to enhance safety, preventing any accidental slips or falls. Above the railing, a wooden platform is integrated, offering pedestrians a comfortable spot to lean on and enjoy the gorgeous view. This thoughtful combination of safety features and aesthetic elements ensures that pedestrians can move across the bridge with peace of mind while taking in the surrounding scenery.

Figure 21: Proposed railing of pedestrian bridge.

- **Lighting**: Adequate lighting is crucial for pedestrian safety, especially during early morning and late evening hours. The bridge is equipped with energy-efficient LED lighting to ensure visibility.

  Lighting is essential for any pedestrian bridge, especially for this one with its curved shaded roof. The shaded concrete roof can create darker areas along the walkway, but by providing proper lighting inside, we can significantly enhance safety. The lighting not only improves security but also adds to the aesthetic appeal of the bridge.

- **Signage and Wayfinding**: Clear signage and wayfinding aids are essential for guiding pedestrians efficiently across the bridge. These include directional signs, information boards, and digital displays.

In the event of an emergency, it is crucial to have clear and visible emergency signs to guide pedestrians to safety. These signs should be strategically placed throughout the bridge to ensure they are easily noticeable and accessible from all points along the walkway.

Emergency signs will be installed at regular intervals and at critical locations such as entrances, exits, and along the length of the bridge. These signs will include clear directions to the nearest exit points, emergency contact information, and instructions on what to do in various emergency situations.

The signs will be illuminated to ensure visibility at all times, including during nighttime or in low-light conditions created by the shaded roof. They will be designed with universally recognized symbols and multilingual text to accommodate all users, ensuring that everyone, regardless of language or familiarity with the area, can quickly understand and follow the directions.

Additionally, the bridge will be equipped with emergency communication systems, such as intercoms or call boxes, allowing pedestrians to contact emergency services directly if needed. Regular drills and maintenance checks will be conducted to ensure that all emergency equipment and signage are in good working order and up to date.

Overall, the provision of well-placed and clearly marked emergency signs, along with comprehensive emergency communication systems, will greatly enhance the safety and preparedness of the bridge, ensuring that pedestrians can navigate emergency situations effectively and efficiently.

- **Materials and Aesthetics**: The bridge is constructed using durable materials that require minimal maintenance. The design also incorporates aesthetic elements to enhance the visual appeal and integrate with the surrounding environment.

  The pedestrian bridge is constructed using a variety of materials, each chosen for its specific properties and contributions to the overall design, functionality, and safety of the structure. The primary materials used are reinforced cement concrete, glass, and metal.

1. **Reinforced Cement Concrete (RCC)**:
    - **Columns, Beams, and Slab Shaded Curved Roof**: Reinforced cement concrete forms the backbone of the bridge, providing the necessary strength and durability. The columns and beams are constructed from RCC to support the weight and stresses of the bridge. Additionally, the shaded curved roof is also made of RCC, combining structural integrity with an aesthetically pleasing design. This material ensures that the bridge can withstand heavy loads and adverse weather conditions, offering long-lasting stability and support.
2. **Glass**:
    - **Top Roof Panels**: Glass is used in the top sections of the roof to ensure natural lighting within the pedestrian walkway. These glass panels are strategically placed to allow sunlight to penetrate during the day, creating a well-lit and welcoming environment for pedestrians. The transparency of the glass reduces the need for artificial lighting and enhances the overall aesthetic appeal of the bridge, giving it a modern and open feel. The glass also helps to create a connection with the surrounding environment, providing pedestrians with a more engaging and enjoyable experience.
3. **Metal**:
    - **Railings**: Metal is employed in the construction of the railings, which are essential for the safety of pedestrians. The metal railings are designed to be study and reliable, offering protection against accidental falls. The choice of metal for the railings ensures durability and resistance to wear and tear. Moreover, the sleek and modern design of the metal railings complements the overall architectural style of the bridge, adding to its visual appeal and enhancing the user experience.

By integrating these materials reinforced cement concrete for strength and durability, glass for natural lighting and aesthetic appeal, and metal for safety and modern design the pedestrian bridge achieves a harmonious balance of functionality and beauty. The thoughtful selection and

application of these materials result in a structure that is not only practical and safe but also visually striking and inviting.

4.4.2 Data Collection of Pedestrian

After analysis, we found that more than fifty (50) pedestrians cross the road within a single period during rush hour. This huge number of pedestrians, some of whom do not obey traffic rules, leads to consequences for both pedestrians and drivers, causing traffic jams and conflicts. These issues also result in accidents that can injure many pedestrians. A solution to this issue is to provide a pedestrian bridge (overpass).

- **Pedestrian counts**

Manual counts: People keep track of foot traffic at set times within two hours for two different time; peak hour and off-peak. For the pedestrian who cross the road.

- **Pedestrian Surveys**

Intercept surveys: Talk to people walking and crossing the road in personal.

Table 4.4 below, Showing Analysis and Results from Interviews with Pedestrians for the Proposed Pedestrian Bridge in Nyabugogo.

OBJECTIVE	PROPOSED ACTION	EXPECTED OUTCOME/ RESPONSE	TOTAL NUMBER OF PEDESTRIANS ASKED 50	PERCENTAGE%
-Making site investigation by correcting all information and data which will be used in Architectural design and perspectives	1. **Conduct a thorough site visit** to assess existing infrastructure, pedestrian traffic patterns, and potential environmental constraints. 2. **Gather and analyze data** from relevant sources, such as traffic studies, topographic maps, and historical records. 3. **Update and correct** any outdated or inaccurate information to ensure the design's accuracy.	A comprehensive understanding of the site conditions, including potential challenges and opportunities for the pedestrian bridge such as reduce pedestrian accidents, reduce traffic flow and etc…	48/50	96%
-Making an Architectural design of Pedestrian Bridge (stair and Ramp)	1. **Develop multiple design concepts** that address the specific needs and constraints of the site. 2. **Consider accessibility** by incorporating features such as ramps and handrails for people with disabilities. 3. **Prioritize safety** by incorporating elements like adequate lighting, signage, and pedestrian barriers.	A well-designed pedestrian bridge that is functional, aesthetically pleasing, and accessible to all users. **Urban Planning and Aesthetics**: Pedestrian bridges can also contribute to the aesthetic appeal of a city. Innovative of pedestrian bridge designs can improve the beauty of the city.	37/50	74%
-Making Renders and Animation	1. **Create high-quality 3D renderings** to visualize the proposed pedestrian bridge from various angles and perspectives. 2. **Develop animated sequences** to demonstrate the pedestrian flow and usage of the bridge.	A compelling visual representation of the pedestrian bridge that will help stakeholders understand its benefits and potential impact on the community. Construction of a pedestrian bridge that will improve safety, accessibility, and quality of life for the community.	43/50	86%

Table 2: Pedestrian Survey Analysis and Findings for the Proposed Pedestrian Bridge in Nyabugogo.

nterpretation of collected data from pedestrian

From data collection the following were pedestrian needs that were assessed and included crosswalks (Zebra crossings and over bridges), sidewalks (Paved ways and over bridges), Warning marks, buses shelters, road visibility, density of pedestrians, traffic lights availability.

During the assessment of pedestrian needs facilities in this survey, it was found that they are needed for some places like at KN1 Round About to Nyabugogo (KN8Ave & KN1Rd) Network as an alternative of Zebra crossings, at KK2Ave & KN68St on the leveled side as an alternative to the zebra crossing for they are located in danger zone.

4.4.3. Planning and design

Site Assessment

Experts check the spot looking at ground type, buildings nearby, and how it affects nature.

By implementing this proposed pedestrian bridge, I recommend the City of Kigali to expropriate some buildings that will be affected by this pedestrian bridge. The bridge has a diameter of 37 meters, and the stairs and ramps extend a long distance to facilitate the smooth flow of pedestrians. Due to the large dimensions of the bridge, it will impact some facilities. Therefore, for a good solution, the government must provide the owners of these facilities with fair compensation before implementation for sustainable solution.

4.5. Architectural Design

These pedestrian bridges (Footbridges) are two bridges, the first bridge is crossing the road, the second one is circular bridge. These bridges are both have 5m of height. It is designed with the following features:

- **1st bridge (Cross road bridge)**
  - Four stairs (two of them have 1.5m of width while the other two stairs have 3m of width)
  - Two ramps all have 1.5 m of width

Figure 22: First bridge crossing road near Equity bank branch Nyabugogo.

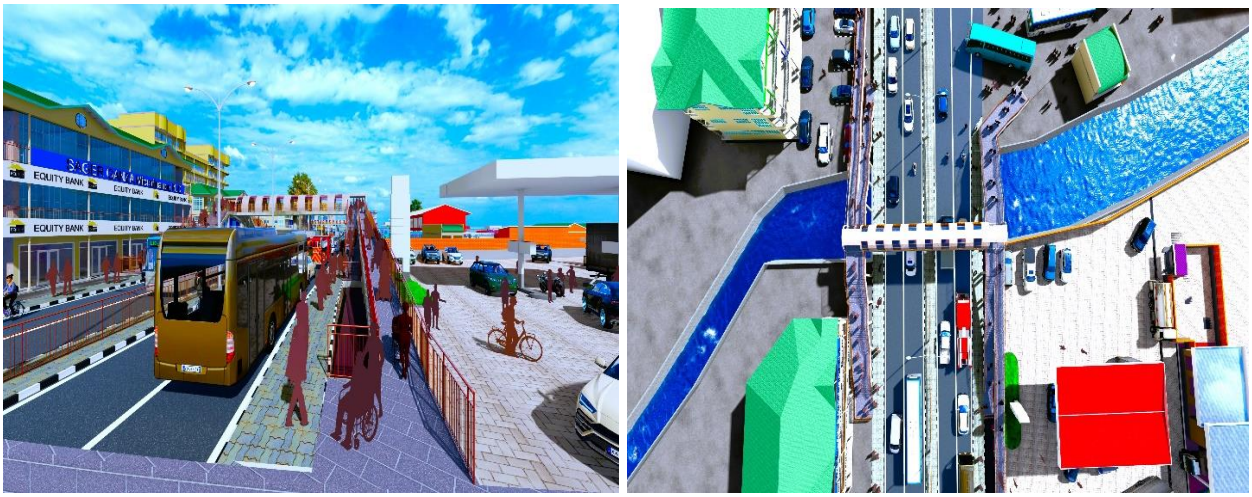

Figure 23: Proposed First bridge crossing road near Equity bank branch Nyabugogo.

- **2st bridge (Circular shape)**
  - Eight stairs (Four of them have 1.5m of width while the other four stairs have 3m width)
  - Four ramps all have 1.5 width

Figure 24: Second bridge intersection road near amashyirahamwe Nyabugogo.

Figure 25: Proposed second bridge intersection road near amashyirahamwe Nyabugogo.

4.5.1. Design Considerations

- **Strength and Stability:** The bridge needs to be strong enough to support all expected loads without failure or breaking.
- **Stiffness and Deflection:** Too much bending or swaying can make people feel unsafe or uneasy. Designers aim to keep the bridge from moving too much.
- **Durability and Maintenance:** Durability and Maintenance: A well-designed bridge should stand up to weather and need few repairs over its life.

- **Accessibility:** Ramps, railings, and wide paths matter a lot They help make sure everyone can use the bridge.

In this report, we did not work on structural analysis, so we recommend that other researchers work on it to improve the strength and stability of this pedestrian bridge.

4.5.2. Selection of Bridge Type

- Beam bridges

4.5.3. Parts of pedestrian bridge.

Bridges are intricate structures, designed with various components that work in harmony to ensure stability, safety, and functionality. While the specific elements may vary based on the bridge's design and materials, there are some common features that make these architectural marvels possible.

A. Structural Components

- **Deck:** The horizontal surface where pedestrians walk.
- **Girders or beams:** The main structural elements supporting the deck.
- **Columns or piers:** Vertical supports that transfer the bridge's weight to the foundation.
- **Abutments:** The end supports of the bridge, anchoring it to the ground.
- **Foundations:** The underground structures that support the bridge's columns or piers.

B. Additional Components

- **Railings:** Barriers to prevent pedestrians from falling off the bridge.
- **Handrails:** Assist pedestrians in maintaining balance.
- **Stairs:** Provide access to the bridge from different levels.
- **Ramps:** Accessible routes for people with disabilities.
- **Lighting:** Improves visibility, especially at night.
- **Drainage system:** Prevents water accumulation on the deck.

- **Expansion joints:** Allow for movement due to temperature changes.

4.5.4. Types of columns used on pedestrian bridge

Bridge columns, also known as piers and are important in holding the superstructure of a bridge. Type of column used is dependent on various factors such as **span length**, **load capacity**, **aesthetics** and **material availability**. classification of column is the following:

3. **Classification by Material**

- **Concrete Columns:**

Reinforced concrete columns: It contains embedded steel for high compressive strength in concrete.

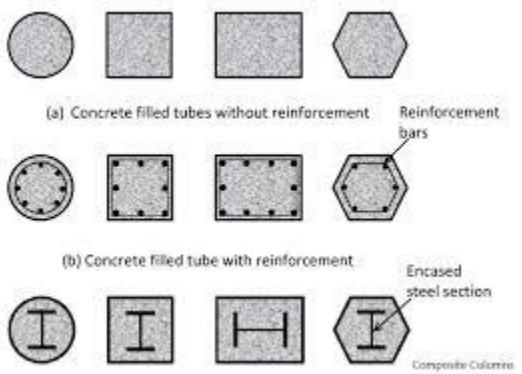

Figure 26: Difference Types of Reinforced Cement Concrete Column

4. **Classification Based on Shape**

- **Circular columns:** Typically used for aesthetic reasons or in specific structural conditions.

I chose to use a circular column because it lacks sharp edges, making it a safer and more effective option for road design. Circular columns help reduce the risk of accidents and injuries, as there are no sharp edges that could pose a hazard to vehicles or pedestrians. This design

consideration is particularly important in high-traffic areas where safety is a top priority.

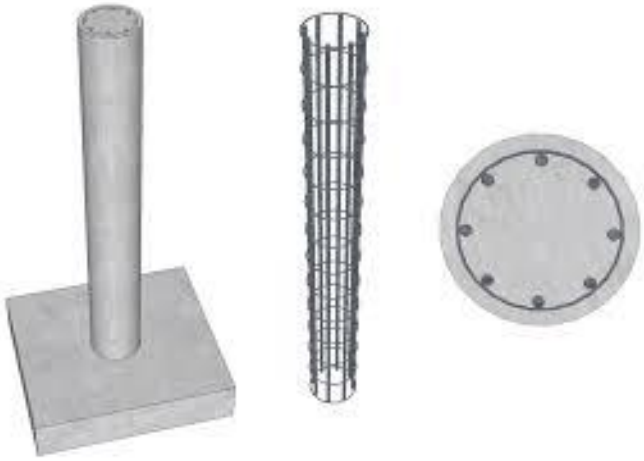

Figure 27: Circular Column

- **Rectangular or square columns:** Offer good strength and stability.

Below the stair and ramp, we use square columns despite their sharp edges because they are positioned slightly away from the road lane, which maintains safety. This placement ensures that the sharp edges do not pose a direct risk to vehicles or pedestrians on the road.

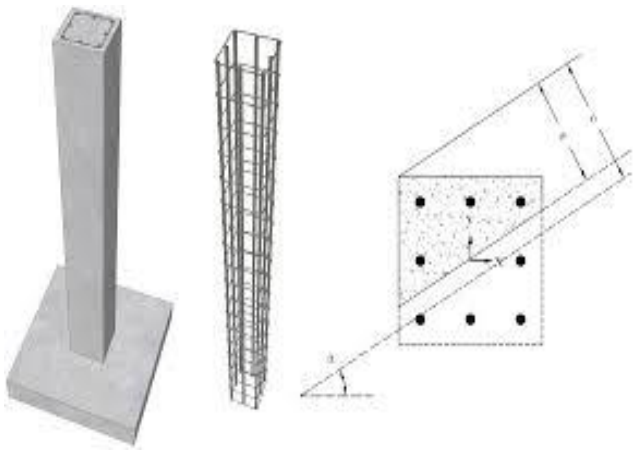

Figure 28: Square Column

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The construction of a pedestrian bridge in Nyabugogo is a vital infrastructure improvement that addresses several critical issues faced by both pedestrians and drivers. The high volume of pedestrian traffic during rush hours has led to frequent traffic jams, conflicts between pedestrians and drivers, and a significant number of accidents. Implementation of pedestrian bridges will enhance safety by providing a dedicated crossing point, thereby reducing the risk of accidents and easing traffic congestion.

In addition to improving safety and traffic flow, the proposed pedestrian bridge, with its robust (powerful) and aesthetically pleasing beam design, will serve as a functional and attractive addition to the city's infrastructure. However, the construction process may require the expropriation of some buildings and facilities to accommodate the bridge's dimensions. It is essential that the government ensures fair compensation for the affected property owners.

Moreover, while this report does not delve into the structural analysis of the bridge, it is recommended that further research be conducted to optimize the strength and stability of the bridge. By addressing these considerations, the City of Kigali can successfully implement a pedestrian bridge in Nyabugogo, ultimately enhancing the urban environment and improving the quality of life for its residents.

In conclusion, the proposed development of two pedestrian overpasses at Nyabugogo is critical to enhancing safety, improving mobility, and ensuring sustainable urban development. The construction of these bridges would create a more pedestrian-friendly space that promotes economic growth and is attractive to individuals seeking safe and secure places to live, visit, and do business.

5.2 Recommendations

From the findings the recommend were gives to:

- City of Kigali would project in their implementation and financing them.
- For better research, the Ministry of Infrastructure (MININFRA) should emphasize consulting with pedestrians about their issues in order to identify critical locations for placing such pedestrian bridges.
- In this project, I did not address the structural design or cost estimation of the pedestrian bridge. Therefore, I recommend that other researchers undertake these aspects of the design.
- We recommend that other researchers use a beam pedestrian bridge because it provides a strong and aesthetically pleasing structure for this project.
- The same project must be applicable in other areas in the city of Kigali where we find a lot of Pedestrians struggling of crossing road.
- RTDA (Rwanda Transport Development Agency)

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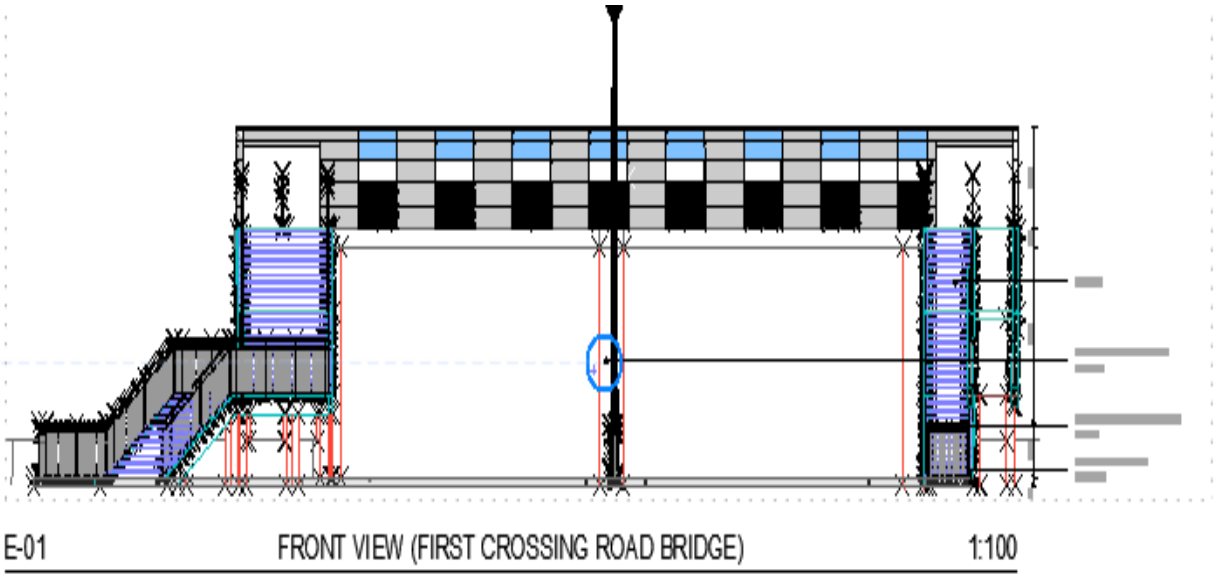
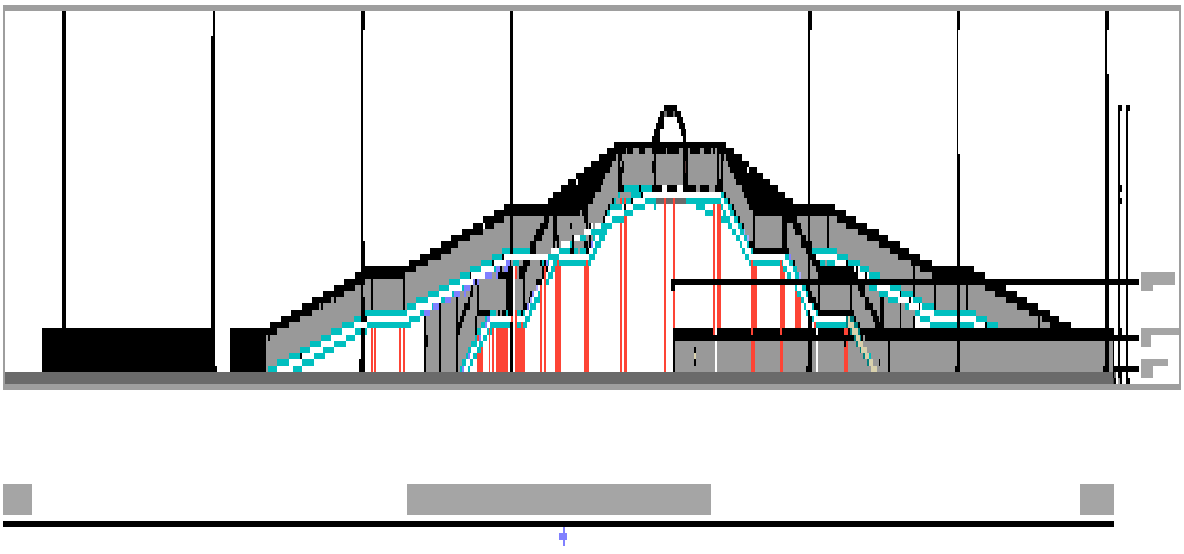
APPENDICES

The appendices contain the drawings and renders of the views of pedestrian bridges.

APPENDIX 1: ARCHITECTURAL DRAWINGS USED





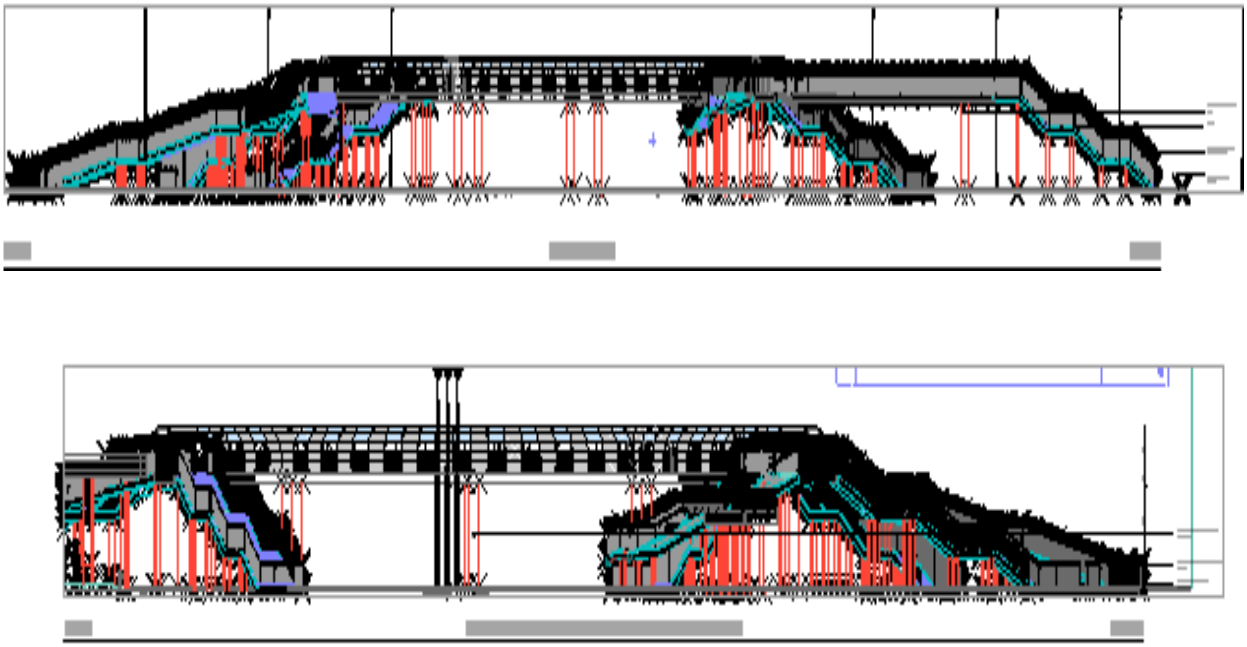


Figure 1: Elevations of pedestrian bridges

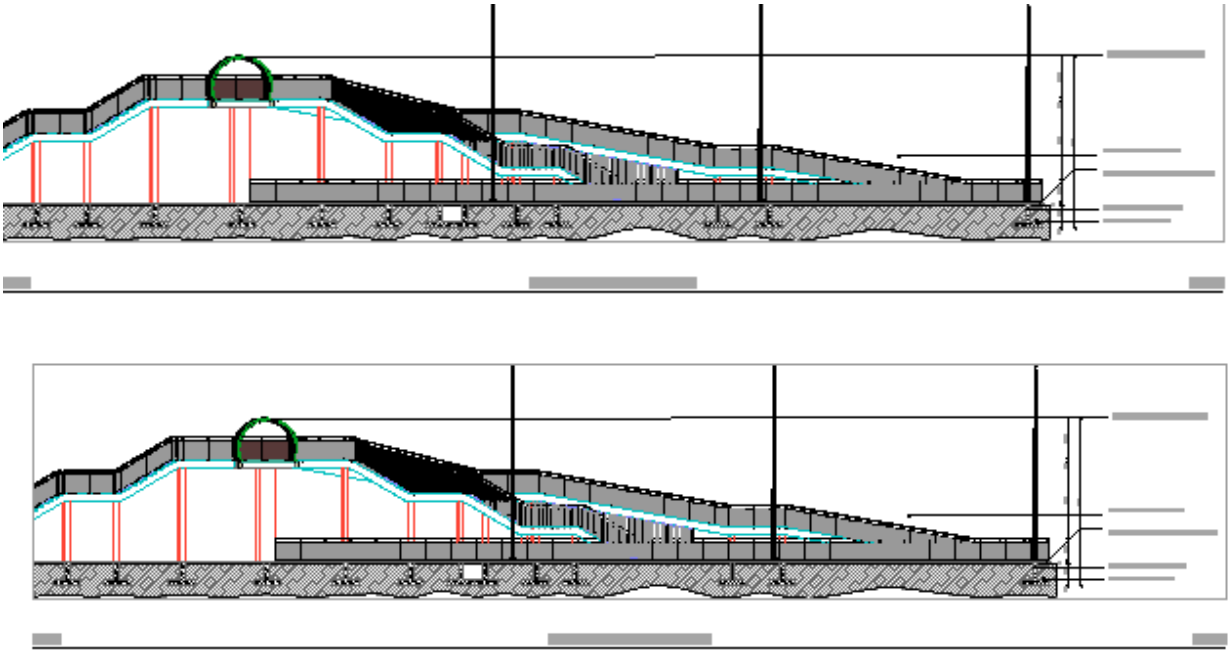


Figure 2: Section of pedestrian bridges

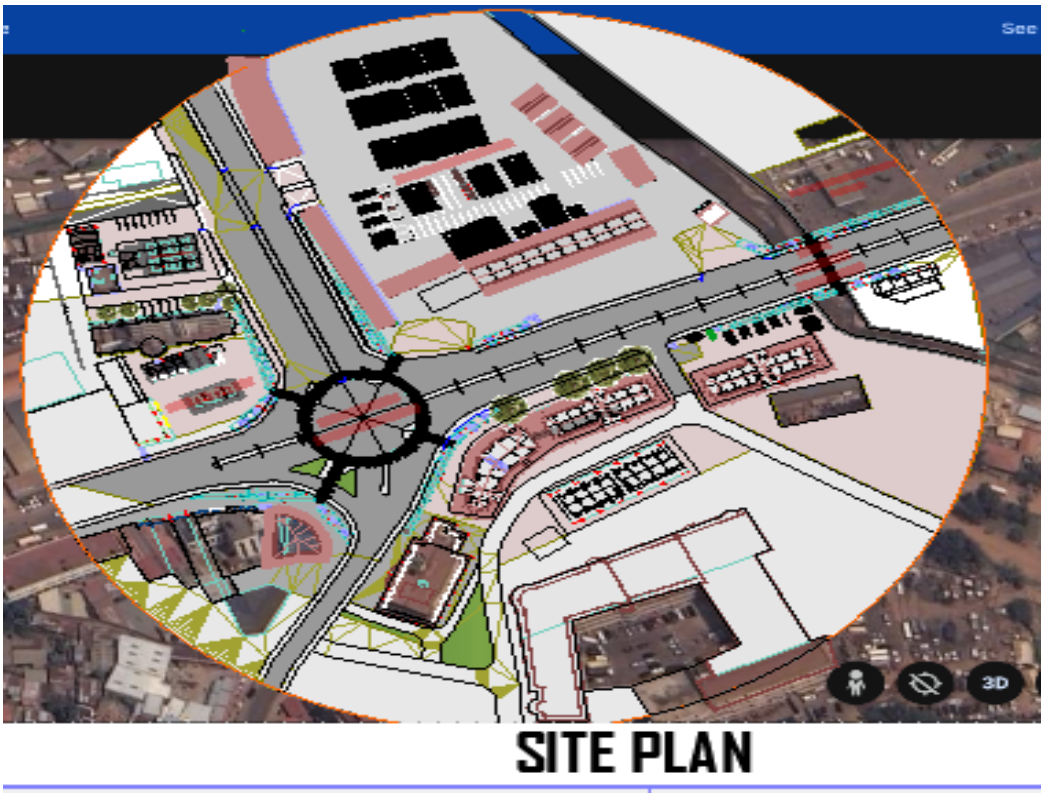


Figure 3: Site plan

APPENDIX 2: RENDERS USED

Figure 4: First crossing road bridge

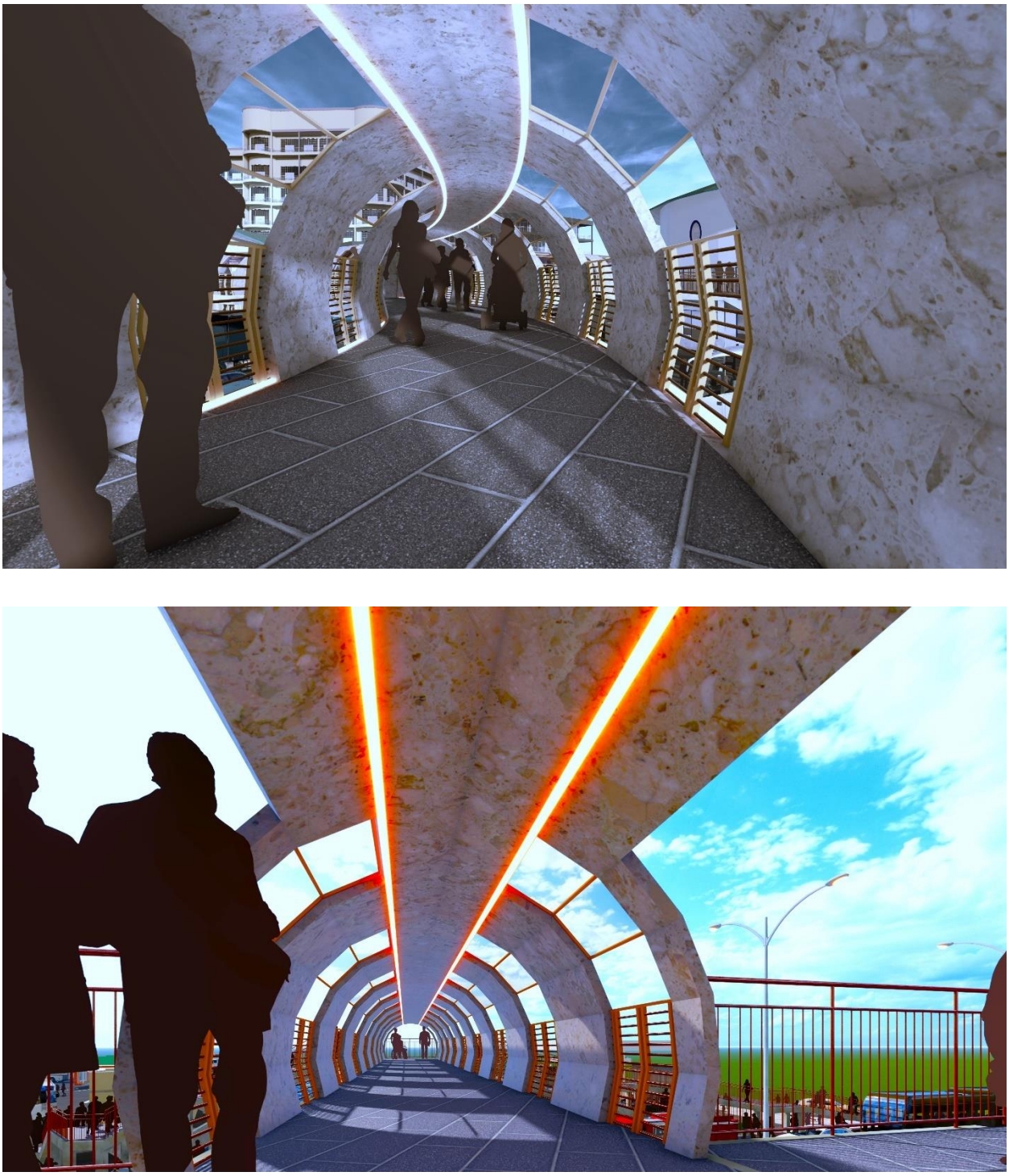


Figure 5: Walkway for the pedestrian


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Figure 6: Second bridge in circular shape

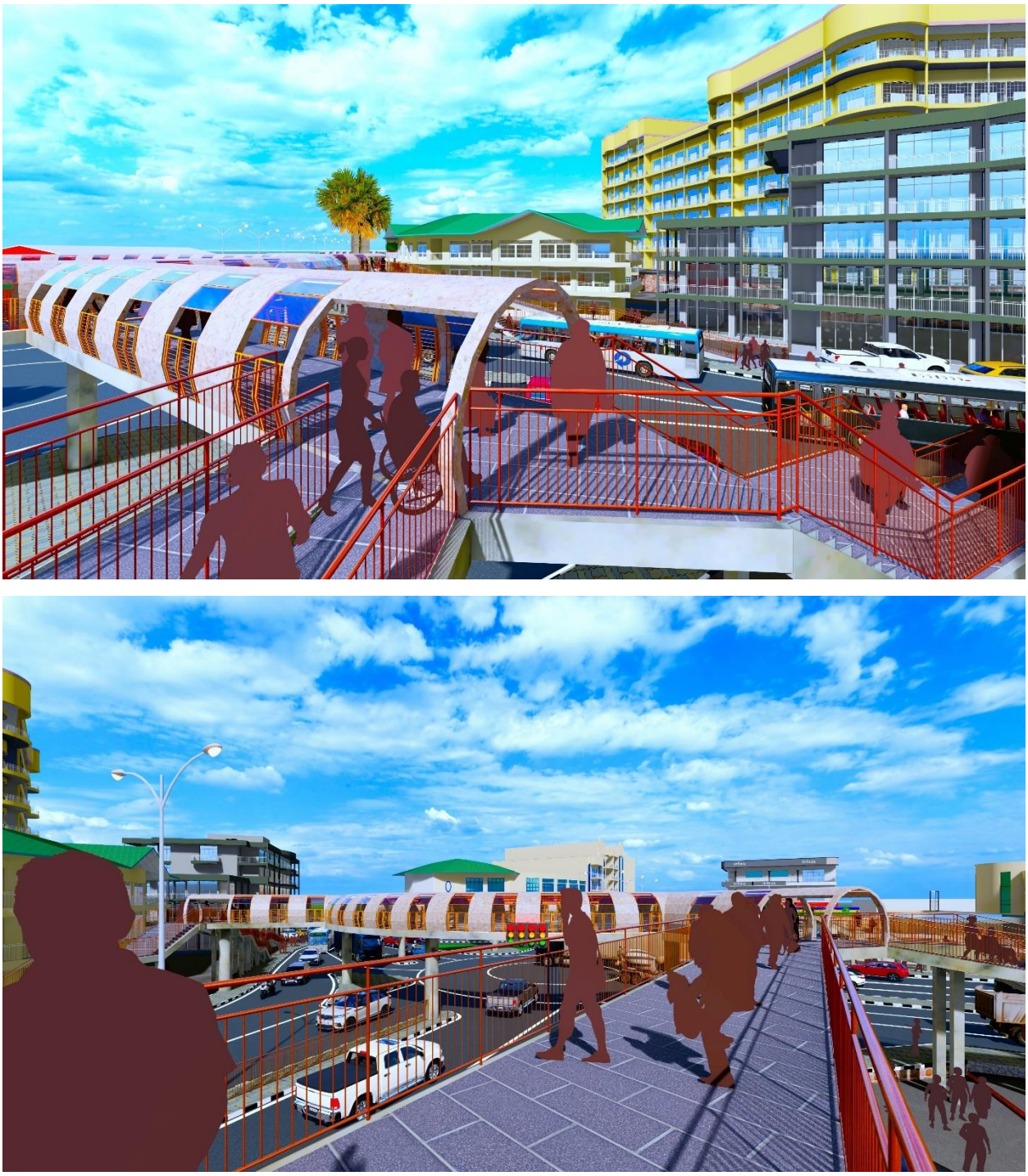

Figure 7: Entrance & Exit of pedestrian bridge