RESEARCH ARTICLE OPEN ACCESS

A Proposed Design Steel Footbridge at Brgy. Sta. Catalina, Lubao Pampanga

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Abstract:

The individual's safety is an important factor to be considered when it comes to everyday life. It is amatter that needs to be looked upon with caution and importance. Footbridge, on the other hand, isgenerally overlooked as a mere structure that connects one place to the other on a land area. This studywill continuously provide the importance a footbridge can give in a given situation. A footbridge showshow progressive an area is because it serves as a connection in between and in different places or landmarks.

At present where accidents are commonly seen. One's safety is always questionedwhethersomething is built, or something is being done. Sta. Cruz, a barangay situated in the municipality of Lubaois now ripe for future urban development. With a current plan in the area that is certainly will attract manypeople, a highway that continuously brings challenges for people to cross due to high-speed vehicles, the area's safety will soon be questioned.

This study not only focuses on the importance and usage of a footbridge, but it also focuses on thedesign, analyzation, and also studying the properties that will be used on the footbridge through the use of STAAD.Pro. Steel might be the best viable option when designing a footbridge. Not only because of itsgiven numerous attributes but also because of the specific advantages it can provide in a footbridge tomaintain its integrity for a long period of time.

Keywords **—Footbridge, Safety, Steel, Accidents, STAAD.Pro V8i SS6**

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I. THE PROBLEM AND REVIEW OFRELATED LITERATURES AND STUDIES

1.1 Introduction

A pedestrian footbridge provides a safe way for people to cross barriers such as rivers or roadways. Perched above the earth, these pedestrian-only structures provide a secure barrier between oncoming car and train traffic.

The world's urban population has grown significantly since 1950 [1]. Due to rapid urbanization and motorization, safety is sometimes ignored or becomes an afterthought which could lead to some serious consequences.

Road accidents are steadily increasing as one of the leading causes of death around the world in recent times. According to the World Health Organization's 2018 Global Status Report on Road Safety, over 1.35 million individuals lose their lives on global roadways every year. About 20-50 million people experience non-fatal traffic injuries and other indirect health effects annually in addition to traffic deaths. Globally, traffic accidents rank seventh among all age groups, above diarrheal illnesses, HIV/AIDS, and tuberculosis, and are the top cause of mortality for young people between the ages of 5 and 29 [1].

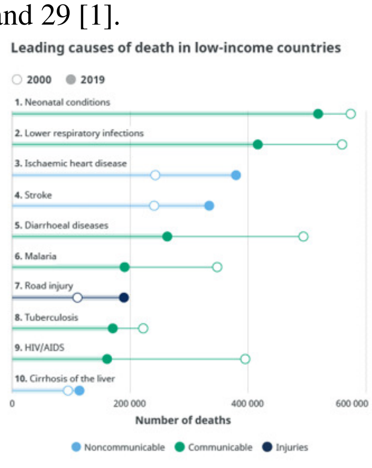


Figure 1.1. Causes of death rankings in low-income countries
Source: World Health Organization, 2020

	urban			rural			
	fatal	serious	minor	fatal	serious	minor	total
2008	773	12 257	88 896	1321	8628	46 380	158 255
2009	686	11 609	85 997	1172	8396	43 965	151 825
2010	539	11 067	82 369	1003	7666	41 463	144 107
2011	584	11 634	81 442	1037	7681	39 119	141 497
2012	570	11 757	77 547	911	7427	37 682	135 894
2013	493	10 716	73 044	951	7383	36 309	128 896
2014	550	11 198	79 090	926	7937	37 344	137 045
2015	552	10 870	75 546	910	7700	35 569	131 147
2016	536	11 751	71 573	957	8544	34 880	128 268
2017	581	13 120	69 284	954	8037	30 872	122 848
2018	592	13 533	64 561	927	8251	28 317	116 181
totals	6483	129 512	849 349	11 069	87 650	411 900	1 495 963

Table 1. Number of accidents throughout the period 2008–2018 in England and Wales according to their severity and the type of place where they happened.

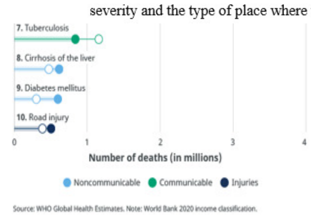


Figure 1.2. Causes of death rankings in lower-middle-income countries
Source: World Health Organization, 2020

Meanwhile, with a population of about 103

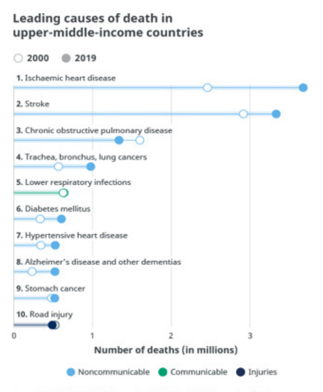


Figure 1.3. Causes of death rankings in upper-middle-income countries
Source: World Health Organization, 2020

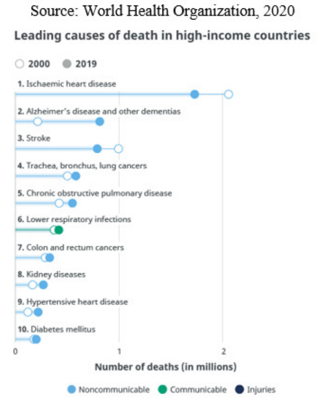


Figure 1.4. Causes of death rankings in high-income countries
Source: World Health Organization, 2020

million, the Philippines is a lower- middle-income archipelagic nation with major cities and economic activity concentrated on its major islands, which results in a high volume of motor vehicle traffic. In addition, privately owned automobiles (not for hire) climbed from 391,178 to 1,717,453, while the total number of registered vehicles increased from 446,142 to 1,904,305. In the Philippines, car accidents accounted for 1.87% of all fatalities (WHO), making it the second most common cause of injury deaths behind assault [2]. There are a few possibilities available for designing a safe path on a roadway for both vehicles and humans; the choice you make will depend on the area, practicality, quantity of citizens, and presence of accidents. Installing a footbridge is the option that sticks out the most among these since it disregards the danger of cars and people colliding on the same level. This study contributes to the eleventh target of the "United Nations Sustainable Development Goals," which offers a common framework for promoting peace and prosperity for people and the environment both now and in the future [3]. It also contributes to the “NEDA Ambisyon Natin 2040” that envisions everyone to lead a stable and comfortable life [4].

1.2 Review of Related Literature

1.2.1 Usage and Importance of a Pedestrian Footbridge

One of the keywords that has to be highlighted is “footbridge,” as it is significant to this study. Depending on where it is built, a footbridge may serve a variety of purposes, but its primary use is to link people to specific destinations from public transportation [5]. With the world’s motor vehicle population rising from 0.85 billion in 2000 to 2.1 billion in 2016, most people are now more exposed to traffic in recent decades. Urbanization and motorization have grown together [1].

Crash results can range from property damage to death and are produced by a variety of elements associated with the transportation system, which includes the road, its surroundings, vehicles, and road users. Notably, single-vehicle accidents and two-vehicle accidents are the two categories of classified collisions. Three categories apply to single- vehicle crashes: off-road, collision with a stationary object (parked car), and collision involving a pedestrian (animal). In addition, there are five types for two-vehicle incidents: head-on, angle, rear-end, and sideswipe crashes that occur in the same direction or opposite direction [6].

Calangain	2
Concepcion	18
Del Carmen	2
Don Ignacio Dimson	6
Lourdes (Lauc Pau)	20
Prado Siongco	21
Remedios	11
San Agustin	19
San Antonio	1
San Francisco	7
San Isidro	19
San Juan (Pob.)	1
San Matias	1
San Miguel	1
San Nicolas 1st (Pob.)	7
San Nicolas 2nd	18
San Pablo 1st	2
San Pablo 2nd	4
San Pedro Palcarangan	3
San Roque Arbol	21
San Roque Dau	22
San Vicente	1
Santa Barbara	4
Santa Catalina	2
Santa Cruz	86
Santa Monica	24
Santiago	1
Santo Niño (Prado Aruba)	9
Santo Tomas (Pob.)	35
Grand Total	**368**

Table 2. Total number of accidents at Lubao, Pampanga in 2018 [7].
Source: Lubao Municipal Police Station, 2019

In order to prevent conflicts between pedestrians and vehicles, pedestrian overpasses or footbridges are constructed. This enhances both the general safety and traffic flow of the streets underneath the overpasses. A rising number of studies have looked at the variables influencing the utilization of pedestrian overpasses [8]. Walking andcyclingarethemostactivemodesoftransportation,a ndtheyaretheleastdetrimental totheenvironmentandenhancethephysicalwell-beingofbicyclesandpedestrians.The mainissuepreventingpeoplefromchoosingtowalkand bikeistrafficsafety.Bridgesfor pedestrians and cyclists will make it possible for them to cross, travel safely, and arrive atworkorschoolwithoutincident.Thus,thedesignandt hematerialutilizedinthedesign arecrucialwhenandwheretheyareneeded.Both"functi onal"and"aesthetic"pedestrian and bicycle bridges are desirable [9]. Footbridges are an aspect of urban planning that requirestobethoughtfullyplannedandpositionedtoacc ommodatevarioustypesofusers. It must be remembered not to forget that the footbridge exists to improve pedestrian safety, accessibility, and walkability. A decent footbridge must be constructed in an appropriate location which is important when constructing a footbridge. This study is importantsincepedestriansarethefootbridges'primar yusers,andduetothis,footbridges should be made convenient for pedestrians to use [10].

1.2.2 Assessment for Implementation of Pedestrian Footbridge

Despite the fact that concerns about unequal access to places and modes of movement have a long history in transport and urban research, the field of research on transportation and mobility justice has grown rapidly recently [11]. The research proved that the socio-demographics, constructed environment, ramps, stairs, and proximity to the bridge all affect the decision to cross [12]. Additionally, it appears that elements like overcrowding only have an impact under very specific conditions. These findings show that a variety of built environments and design elements that are distinctive to a given site might affect how pedestrians choose their routes. To ensure the best use of resources, bridge construction must be carried out with meticulous and effective planning. This refers to the idea of value engineering (VE), which is a methodical way to boost a project's functional value by making the best use of its resources. Value Engineering can be used to apply a complete evaluation of cost, safety, structural strength, user needs, the surrounding environment, and other pertinent elements to the planning and constructionof bridges. Thus, VE assists in locating and eliminating non-value-added tasks, cutting down on long-term maintenance, and enhancing the performance and service life of bridges [13].

This research uses a case study of a footbridge that is situated on Jalan Ahmad Yani Pabelan Kartasura, a few hundred meters from the campus of the University of Muhammadiyah Surakarta (U.M.S.). The researchers used a variety of techniques to gather data on pedestrian-like footbridge physical characteristics, traffic flow, and pedestrian behavior in assessing the importance of

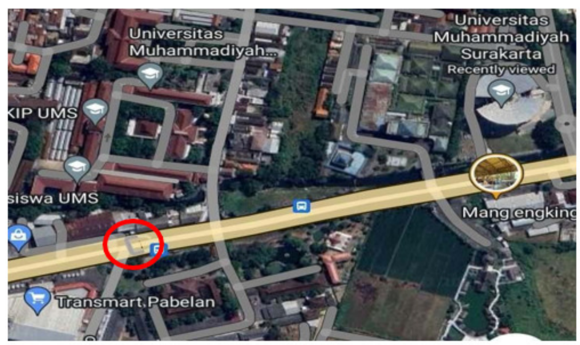


Figure 2. The pedestrian bridge's location on Jalan Ahmad Yani Pabelan Kartasura.

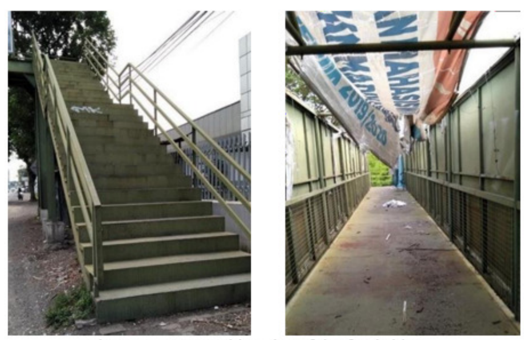


Figure 3. Steps and interior of the footbridge

the footbridge [14].

- Safety – this factor is the reason behind the necessity of the footbridge, which is to lower the quantity of traffic accidents.
- Distance - it is simpler for pedestrians to cross a footbridge with a more humane

design and constant connectivity between pedestrian lines.

- Aesthetics - the pedestrian footbridge's more aesthetically pleasing design will motivate people to adopt healthier habits, such as walking or taking public transportation. In addition to offering increased comfort, attractive footbridge design will play a significant role in building a sustainable city.

1.2.3 Types of Pedestrian Footbridge

Since ancient times, bridges have been needed to cross rivers, valleys, hills, and other obstacles. The earliest bridge may have been a fallen tree that was placed over these obstacles. The function of a bridge and the characteristics of the area in which it is to be built will determine its design. Natural bridges were created by the elements, starting with a fallen log or stones in a river. With a basic support and crossbeam configuration, the earliest bridges constructed by humans were most likely spans built of chopped timber logs or planks [15]. Timber footbridges must meet strength and serviceability standards. Because of their lightweight, the serviceability criteria for peak accelerations are the most exacting constraint in their design [16]. They were later replaced with stones [15]. The Vega Bridge was constructed in March 2017 to allow commuter trains in the municipality of Haninge to go over railroad tracks. The structure, which has three hinged arches, was manufactured, and elevated in position.

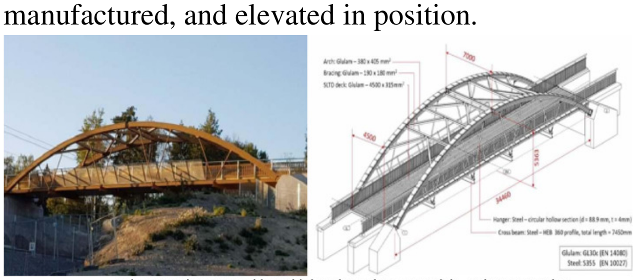


Figure 4. The Vega Bridge with its Dimensions, Materials, and Cross-section.

This deck is a Stress Laminated Timber Deck (SLTD), consisting of many glulam beams with a cross section of 142 x 315 mm³, transversally prestressed by steel rods spaced 60 centimeters apart [17].

Due to its advantages over other natural materials as well as its availability, malleability, strength, and durability, the stone became the primary building material used by ancient civilizations. Few bridges from ancient civilizations still stand today, but the stone constructions serve as a silent reminder of our ancestors' skill in creating bridges thousands of years ago. One of the most famous footbridges in the Philippines is the Zapote Bridge, the site of the 1897 Battle of the same name between Gen. Emilio Aguinaldo's revolutionary forces and Spanish forces. It was a stone arch pedestrian bridge that still stands today, bridging the provinces of Cavite and Rizal [10].

As civil engineering advanced, other types of bridges, such as “Steel and RCC bridges,” were created, and today they are a symbol of development for any nation [15]. Steel footbridges are the preferable option when structural steel elements are readily available, and the bridges have large spans. There is a plenty of technical information accessible regarding these members. Moreover, regional producers and suppliers of steel members offer their standard forms and technical details. This facilitates the designer's selection of common shapes and allows the steel bridge to be

Figure 5. Stone-arched footbridge located at Las Pinas, Metro Manila [18].

designed using members that are readily available in the neighborhood market, leading to low-cost manufacturing. The fact that steel has a higher strength-to-mass ratio than concrete or wood makes it an excellent choice. Furthermore, painted steel has a pleasing aesthetic [19].

Figure 6. Steel Footbridge located at Espana-Blumentritt [10].

Footbridge have drawn a lot of attention due to small loads and a short span with the use of lightweight and high-strength materials. Footbridges have increasingly become longer, lighter, and more flexible, bringing their frequencies into range with pedestrian frequencies [20].

Figure 7. Butterfly-shaped arch footbridge located at Hong Kong Polytechnic University [21].

Glass fiber reinforced polymer (GFRP) composites are increasingly being used in the building of footbridges. This arises from the mechanical and structural advantages of GFRP composites: their light weight allows for faster construction, less interruption, and lower labor costs. While its outstanding longevity and durability against corrosion allow for cheaper upkeep, it is especially well-suited for replacing deteriorating footbridges. Pultruded GFRP (pGFRP) is a method of producing regular GFRP structural section forms. The combination of 1 modular construction and 2 adhesive bonding connections was used on a limited number of pGFRP footbridges. The closest examples are the Leri and Dawlish footbridges. As a result, using the suggested pGFRP sandwich panel in footbridges in conjunction with these two elements can broaden the variety of feasible GFRP footbridge designs [22].

Figure 8.1: Leri Footbridge [23]. Figure 8.2: Dawlish Station Footbridge [24].

1.2.4 Design Method and Design for Pedestrian Footbridge

A bridge is a building that allows passage across an obstruction without blocking the path below. Footbridges are more compact, lighter constructions. Various types of steel footbridges allow people to crossroads easily and safely without blocking traffic. The benefit of footbridges is that they offer a safer route to pass across rivers, roads, railroads, and other obstructions. A disadvantage of footbridges can be a high cost if there an elevators or long ramps for wheelchair users that will be installed on the footbridge [25]. The steel-concrete composite structure has evolved into growing in popularity because to its quick construction and economy as well. Steel is very strong for its weight. As a result, the dead weight of steel construction is quite small. This quality makes steel an extremely appealing structural material for tall buildings, long-spanning bridges, etc. [26]. The important factor that will be considered is the cost, especially suited for undeveloped countries with large populations. Therefore, the LRFD method should be considered highly for undeveloped countries with large populations. This variation of a factor of safety and ultimately cost reduction can be typically used for all steel footbridges with unpredictable loading that have spans of any value [19]. The planning of pedestrian bridges holds great significance within civil engineering, and the selection of the appropriate design approach is crucial for guaranteeing the safety and effectiveness of these structures.

The most popular benchmark or standard for bridge design that other international standards are compared to is the AASHTO specification. The

Load and Resistance Factor Design for Bridges approach was accepted by AASHTO, which released its first Bridge Design Specifications in 1994. Reviewing the load and resistance components may be necessary when adapting the AASHTO Bridge Design Specification to a nation with traffic patterns and building practices distinct from those in the US [27]. The Load and Resistance Factor Design (LRFD) technique has risen as a prominent method in engineering, offering a more comprehensive and dependable framework for creating various structures, including pedestrian bridges. This method, which has been extensively studied and applied in practice, is attracting growing attention within the field of pedestrian bridge engineering. This offers valuable insights into the application of the LRFD approach in pedestrian bridge design. While a thorough examination of the article's content is necessary for deep comprehension of its discoveries, it's clear that the LRFD technique is being utilized to enhance the structural dependability and safety of pedestrian bridge designs. The article likely addresses factors such as load considerations, resistance elements, and the cost-effectiveness of the LRFD method in pedestrian bridge design. The adoption of LRFD in pedestrian bridge design represents a promising advancement, aligning with worldwide trends in structural engineering. By incorporating this method, engineers aim to attain the utmost safety, functionality, and cost-effectiveness in constructing pedestrian bridges, especially in regions susceptible to natural disasters or heavy traffic demands. This article's emphasis on LRFD in pedestrian bridge design underscores the significance of this methodology in assuring the structural robustness of these vital infrastructure components [28].

In designing and analyzing the foot over the bridge there is a need for proper estimation. Optimizing the design of foot bridge and use more resources is one of the proper estimations that will consider, it will save a lot of money and resources [29].

1.2.4.1 STAAD.Pro

STAAD.PRO software was used for analyzing the footbridge’s different components, including the main truss, columns, and footings, and the most economical and safe sections are being carried out through manually design. In comparison to reinforced concrete structures, the cost of building a footbridge has been reduced by using steel as the construction material. The footbridge’s components were designed with the highest level of safety and the adaptability of the structure to the upcoming modifications that has been also given due consideration. The LRFD and ASD methods are two designs that will be taken into consideration when creating a design of a structure using STAAD.PRO software. The ASD design method used only one factor which is the factor of safety. Against failure, the ASD design method cannot provide a true factor of safety, although its application is very simple. All of the uncertainties in the material and loading resistance are included in the safety factor for the ASD method. The LRFD design approach has two factors which are the load type and resistance. This approach is more reliable because it utilizes two factors, and it takes into consideration the fact that live load has greater uncertainty than dead load [30]. Around the world, steel truss is typically utilized to build footbridges of various lengths. Steel is a very useful material that can provide solution that can be proven. Including the design and analysis of the footbridge using STAAD.PRO software, observes that the study mainly includes the static and dynamic seismic analysis, specifically seismic coefficient method and response spectrum method was used in designing and analyzing steel footbridge but, bay spacing for economical design of steel foot over bridge has not been yet studied. In the present dissertation work, it is suggested to implement bay spacing for optimized/economical design of a steel footbridge. Several studies indicate that conventional reinforced cement concrete (RCC) or Prestressed concrete (PSC) bridges produce massive amounts of bulk unit weight which may result in uneconomical conditions by cost as well as by efficiency parameters such as deflection, high cost, and construction time, etc. it concludes that footbridges with a steel structure are more affordable and quicker to build, thus they are practical [31]. The various components of the footbridge namely the Main Truss, Columns along with footings have been analyzed using STAAD.PRO software and the most economical and safe sections are accomplished through manual design. Using of steel on a footbridge as the construction material has resulted in the overall economy of construction when compared to Reinforced Concrete structure. The components of the footbridge are designed for the maximum safety and the adaptability of the structure to future changes has also been given due consideration [32].

1.3 Statement of the Problem

The study addresses the lack of safety measures or structures despite the presence of some important establishments in the area and it has become an obvious concern at present. With a planned urbanization in the near future, the domino effect of what urbanization can do will become increasingly noticeable. This study sought to find evaluations to the following statements:

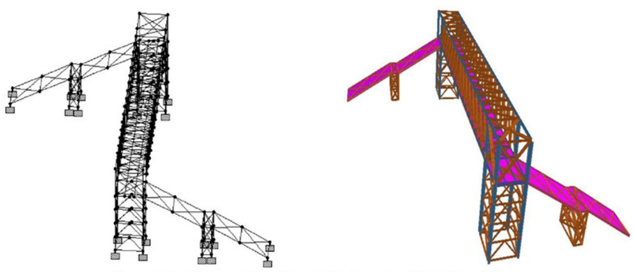


Figure 9. Footbridge modeling side and 3D view under STAAD.Pro [33].

1. What are the steps, conditions, requirements and building parameters when proposing a footbridge?
2. What will be the scope of the plan for the proposed footbridge?
3. What are the design parameters in designing a footbridge?

1.4 Objectives

1.4.1 General Objectives

The objective of this title is to create a new passageway and at the same time keeping the pedestrians and vehicles to pass safely at the two highways on Santa Catalina Lubao, Pampanga. To ensure the structural integrity of a building or any construction, it's essential to thoroughly analyze and address all the possible structural components and potential issues.

1.4.2 Specific Obejectives

- To assess the feasibility of the specific area about the need for a pedestrian footbridge in the future.
- To provide a blueprint that illustrates and specifies the proposed footbridge whole design.
- To design a pedestrian footbridge that meets the safety structural standards, code requirements, and aesthetic consideration.

1.5 Scope and Limitations

The general intent of this study will be developing on the design of a pedestrian footbridge itself. It is mainly composed of pedestrian footbridge and bike ramp for cyclists. This study is convenient and accessible for the students, employees, and cyclists. The research will be conducted to support and guide the development of the study.

The scope of this study is limited to the design aspect of the footbridge and its potential implementation. The main arch and tension bars that are made in the plan will not be present in the structural analysis of the study due to the absence of specifications on both elements. The DPWH also cannot provide a sample plan of a tied-arch footbridge to the researchers because of the unavailability of such design to be a reference in the study. It also does not delve into concerns like elevator plans, or PWD ramps since they are outside the purview of the researchers and because they are expensive and require high maintenance. The focus is solely on the structural and architectural and electrical elements of the footbridge, excluding other infrastructural considerations.

II. METHODOLOGY

The researchers will use both quantitative and qualitative method for this study. Quantitative research is a type of study that uses natural science techniques to generate concrete facts and numerical data. On the other hand, qualitative research is employed to obtain a comprehensive grasp of human behavior, experience, attitudes, intentions, and motives through observation and interpretation to learn about people's thoughts and feelings [34].

Under quantitative and qualitative method, descriptive research is one of the important factors for this study. The purpose of using descriptive research is to use naturalistic observation to characterize people, things, or occurrences. The variables are only described, with no manipulation of any kind occurring with them. Additionally, descriptive research is the only design that can investigate a single variable in addition to multiple variables [35].

2.1 Methodological Framework

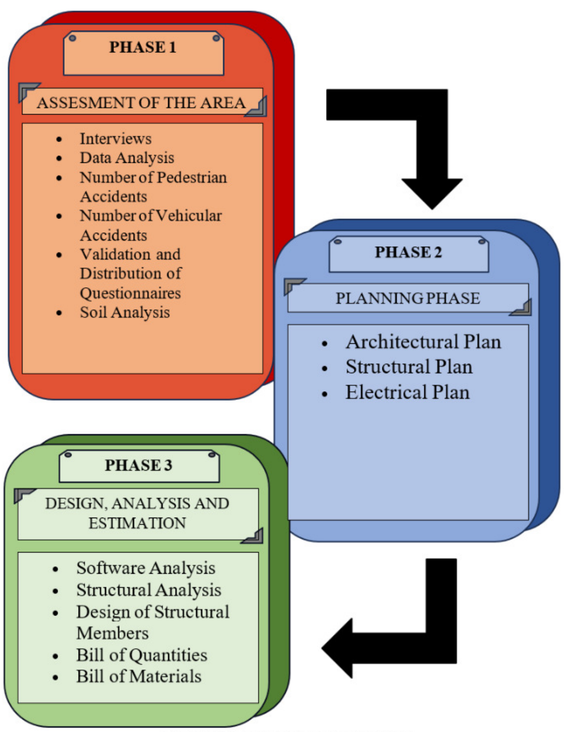


Figure 10. Process Flow for Footbridge Design

2.2 Phase 1: Assessment of the Area

2.2.1 Government Agencies

The researchers will conduct an interview to collect data and information on PampangaPoliceProvincialOfficeforobtainingnumberofaccidentsandvehicleonthe specific area, Department of Public Works and Highways (DPWH) and Municipal EngineeringOffice–Lubao,Pampangatoknowanddeterminetherequirementsandthe things to be consider in implementing and designing a steel footbridge.

2.2.2 Research Locale

Located in Pampanga's southwest is the first-class municipality of Lubao [36]. Santa Catalina is a barangay in the municipality of Lubao, in the province of Pampanga. By the 2020 Census, the population as determined was 5,648 residences. This represented 3.26% of the total population of Lubao [37]. Also, the Municipality of Lubao and DHVSU Lubao Campus was built near the proposed footbridge where to be build. The study will be conducted at Santa Catalina Lubao, Pampanga, this place is selected for knowing the convenience and safety of the people crossing the two-highway road and for them to feel the comfortable while crossing the highway road. The researchers choose this place in order to get the needed information to proceed in designing the footbridge. It is a decent location for the footbridge and also for interview since the researcher will be able to get the right number of respondents especially the students at DHVSU Lubao Campus that are needed for the study.

2.2.3 Soil Analysis

Another crucial consideration when assessing an area is the ability of the soil itself. The researchers will for the look for the soil bearing capacity data that determines the stability and strength of the soil on where the footbridge will be built. Every building project must have its soil examined; failing to do so could have disastrous effects on the project's beneficiaries.

2.2.4 Research Instrument

In this study, the researchers intend to employ survey questionnaires as a means of data collection to determine whether the study also benefits pedestrians. The questionnaires are a set of orderly arranged questions carefully prepared to answer by the group of people designed to collect facts and information.

The Likert scale contains 4 Likert items. The items are inside a table, each column has a corresponding scale (strongly agree, agree, fair, disagree,) in which respondents chooses his or her response by checking tick marks.

The instrument is convenient for the parts both the research and the respondents because it saves the respondents some time, especially when they are busy.

2.2.5 Sample Determination

The researchers tend to use the Yamane's formula for determining the research sample. Mathematical statistician Taro Yamane developed a formula for determining or figuring out sample size in regard to the population being studied.

$$n = \frac{N}{1 + N(e)^2}$$

Equation 1. Yamene's Formula

2.2.5.1 Sample Size

In determining its sample size there's a formula which is n=N/1+N(e)^2. Yamane's formula is developed by Taro Yamane in 1967, where N is the population, e is the acceptable margin of error, n is the sample size (or number of surveys) needed.

2.2.5.2 Sampling Technique

The researchers will use a non-probability sampling technique which is purposive sampling. Purposive sampling is a technique where the researchers will just pick a unit of selected people because of the characteristics that you need in a sample.

2.2.6 Formulation and Validation of Questionnaires

Once the researchers have collected the required number of samples, for their research they will proceed to develop their survey questionnaires. This step is crucial as the questions will directly impact the quality and pertinence of the data collected. After formulating the survey questions the researchers will seek out an expert with the study's background and objectives to review them. The validator will assess the questions to ensure they are pertinent, understandable and aligned with the study's aims. By validating the questionnaires before distribution, the researchers can enhance the accuracy and consistency of their research findings ensuring that the data gathered is relevant to their analysis.

2.4 Phase 2: Planning Phase

The researchers will look for an architect who can help them with the planning stage of a footbridge project. They want to find someone who is knowledgeable and experienced in architectural design. Working closely with the researchers to comprehend their goals and specifications for the footbridge will be an integral part of the architect's job. The architect will use this data to create conceptual designs that analyze several options in terms of utility, structural integrity, and aesthetics. Once a conceptual design is agreed upon, the architect will provide accurate dimensions, material specifications, and designing details in comprehensive working drawings.

2.3.1 Architectural Plan

Architectural blueprints are documents containing information about a buildings design and construction details. These detailed drawings, which encompass floor plans, elevations, sections and other necessary views offer a view of the structure. In depth notes accompanying designs provide details, like area calculations, construction methods and specified materials to be used.

2.3.2 Structural Plan

Structural design is very important in civil engineering since it helps to ensure the safety of the structure. To guarantee that any buildings constructed adhere to all safety measures, structural design includes a variety of details that include foundation information, floor types, wall types, beam types, roof types and material quality. That is why structural engineers must consider aesthetics in their designs, so that they support loads and withstand stresses without collapsing. Any building which doesn't put into account the design of its structure will always have a higher chance of failure. It is essential to every construction project because structural design directly affects the durability and safety of buildings.

2.3.3 Electrical Plan

The footbridge also requires an electrical plan, for reasons. Primarily it ensures that the electrical setup is tailored to meet the needs of the footbridge, such as the number and types of sockets, light fittings, and devices. This helps prevent circuit overloads and ensures the efficient functioning of the system.

2.4 Phase 3: Design, Analysis and Estimation

A footbridge's design and analysis are essential to its construction since they guarantee its structural soundness, appeal, use, and environmental impact. A properly designed footbridge can withstand the weight of pedestrians as well as the pressures of the environment.

2.4.1 Design Parameters and Procedures

The design footbridge will follow the codes and provision of NSCP 2015 and DPWH Design Guidelines, Criteria and Standards (DGCS) 2015. The aforementioned books will be applied when designing the pedestrian footbridge using the researchers' application, STAAD.Pro.

2.4.2 Software Analysis

Licensed by Bentley, STAAD is a well-constructed program. Structure Analysis and Design is referred to as STAAD. Designing several members takes a week, but STAAD.pro is a highly strong program that completes the task in an hour. The greatest substitute for tall structures is STAAD. Since STAAD is currently used in the design of the majority of high-rise structures, civil engineers must be familiar with this program. In accordance with different national codes, this program may be used to transport RCC, steel, bridges, trusses, etc. [38]. The systematic investigation of structural design is structural rigidity, strength, and stability. The fundamental design of a structure that can withstand all applied loads without failing over the course of its intended life is the goal of structural analysis and design. The principal purpose of a structure is to sustain loads. If the structure is incorrectly designed, or when actual applied loads surpass the design parameters, the device is inclined to malfunction and may encounter serious consequences [39].

2.4.3 Design of Structural Members

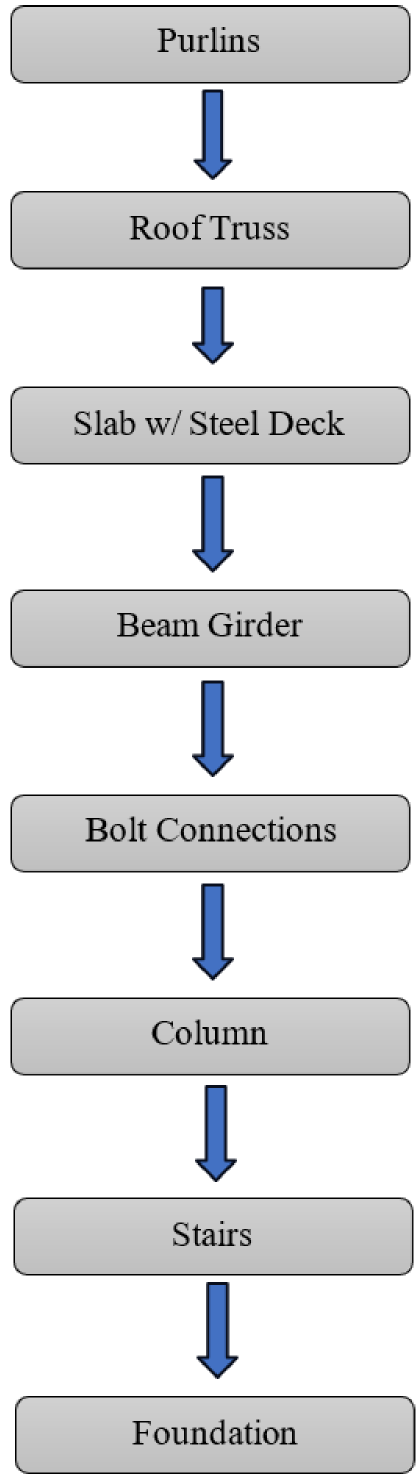


Figure 11. Structural members in the footbridge design

2.4.4 Bill of Quantities (BOQ)

The Bill of Quantities (BOQ) for enhancing the pedestrian footbridge with a steel design provides a detailed document listing the quantities of materials essential for the construction project. It includes descriptions of each item, specifying the required quantities and the corresponding units of measurement. The BOQ encompasses materials like steel beams, concrete, and finishing elements for the footbridge. Researchers utilize the BOQ to estimate costs associated with the proposed steel curved footbridge, aiding in effective budgeting and procurement planning. This document plays a crucial role in ensuring that the envisioned footbridge is not only aesthetically pleasing but also structurally sound and economically viable.

2.4.5 Bill of Materials (BOM)

The Bill of Materials (BOM) for enhancing the pedestrian footbridge with a steel design outlines the essential components and raw materials required for construction. This comprehensive list includes a detailed description of items such as curved steel beams, concrete for foundations, non-slip surfacing for the pedestrian deck, and safety handrails. Each item is accompanied by quantities, units of measurement, and unit costs, facilitating researchers in estimating materials needed for the proposed curved footbridge. The BOM serves as a vital tool for making informed decisions on procurement, ensuring that the construction process is well-planned and resource efficient.

III. RESULTS AND DISCUSSION

3.1 PHASE 1: Assessment of the Area

3.1.1Pedestrian and Vehicular Accidents

Important information on the number of accidents in the Lubao municipality, particularly in Santa Catalina, was acquired by the researchers. First, the researchers went to Pampanga Police Provincial Office to gain permission for the needed data of the study. After gaining permission, the researchers then went to Lubao Municipal Police Station to gather the data. The information acquired will give a clearer picture of the present state of the whole municipality of Lubao.

Number of PedestrianAccidents 2019-2023		Number of Vehicular Accidents 2019-2023	
BARANGAY	**Number of Incidents**	**BARANGAY**	**Number of Incidents**
Baruya (San Rafael)	1	Balantacan	1
Concepcion	16	Bancal Sinubli	1
Don Ignacio Dimson	6	Baruya (San Rafael)	2
Lourdes (Lauc Pau)	19	Concepcion	29
Prado Siongco	23	Don Ignacio Dimson	8
Remedios	21	Lourdes (Lauc Pau)	43
San Agustin	16	Prado Siongco	39
San Antonio	4	Remedios	39
San Francisco	2	San Agustin	30
San Isidro	28	San Antonio	3
San Juan (Pob.)	4	San Francisco	3
San Miguel	1	San Isidro	37
San Nicolas 1st (Pob.)	10	San Juan (Pob.)	5
San Nicolas 2nd	34	San Miguel	2
San Pablo 1st	1	San Nicolas 1st (Pob.)	19
San Pablo 2nd	10	San Nicolas 2nd	62
San Pedro Saug	1	San Pablo 1st	2
San Roque Arbol	22	San Pablo 2nd	8
San Roque Dau	37	San Pedro Palcarangan	2
Santa Barbara	3	San Roque Arbol	25
Santa Catalina	5	San Roque Dau	48
Santa Cruz	77	Santa Barbara	5
Santa Maria	2	Santa Catalina	7
Santa Monica	12	Santa Cruz	201
Santa Rita	2	Santa Maria	1
Santa Teresa 1st	2	Santa Monica	28
Santiago	2	Santa Rita	2
Santo Domingo	1	Santa Teresa 1st	3
Santo Niño (Prado Aruba)	6	Santiago	4
Santo Tomas (Pob.)	35	Santo Niño (Prado Aruba)	13
Grand Total	**403**	Santo Tomas (Pob.)	72
		Grand Total	**744**

Table 3. Pedestrian and Vehicular Accidents in Lubao from 2019 – 2023

The current status of the Santa Catalina in terms of accidents is low compared to the other barangays of Lubao which are more populated and commercialized and urbanized. One of the researchers' main goals in this study is to prevent the possible increase of accidents in Santa Catalina which is now being urbanized recently. The domino effect it might cause will be concerning in the near future.

3.1.2 Site of Proposed Footbridge

Figure 12. Proposed location of the footbridge

The researchers organized an interview with Engr. Denise Marie M. Pantig the municipal engineer of Lubao to discuss the possible placement of the footbridge in this study. Important locations close to the proposed footbridge include the DHVSU Lubao Campus, the Lubao Municipal Hall, and a Lubao Rural Health Unit I

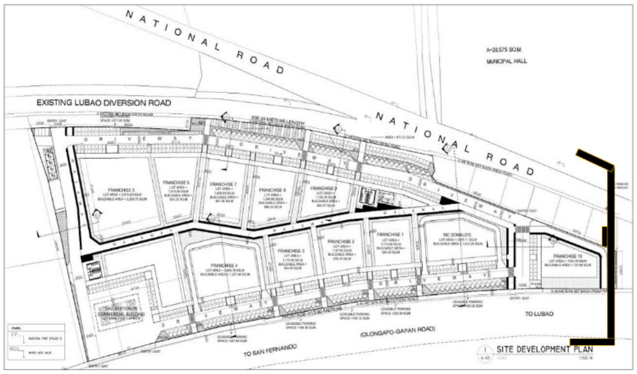


Figure 13. Site Development Plan of BC Architects Design Corp. and final location of the footbridge.

During the interview, the municipal engineer informs the researchers to look for the current plans of the open area in front of DHVSU Lubao Campus first since the footbridge will pass through the property and construction is happening at present. The researchers then set out to find the blueprints they needed in order to determine the precise location of the footbridge.

Currently, there are plans to build a "One-Stop Shop" in Lubao on the open lot. The project was handled by the BC Architects Design Corp. Eleven franchise buildings, a commercial structure, and a petrol station make up this complex. The researchers then discussed with the architects of the project about the possible and final location of the footbridge for this study.

3.1.3 Soil Analysis

Soil Analysis plays an important role in building or designing a structure especially on the early parts of the planning phase. It serves as one of the factors whether a structure can be possibly built in a specific location. Compaction, permeability, strength, composition, and chemical characteristics of soil are all studied by engineers through soil analysis. The researchers gathered data from the soil analysis of the two-story DHVSU Lubao Campus building, which is the closest soil analysis performed.

FINAL DEPTH						20.00m
GROUND WATER ELEV						3.00m
BOREHOLE						HOLE #1
DEPTH (m)	SPT BLOWS PER 15cm			N Value	Consistency	SCRIPTION
1.5	6	5	7	12	STIFF	Brown, Sandy SILT, slightly plasticity
3	7	8	8	16	MEDIUM DENSE	Gray, Well Graded SAND, fine to coarse grained, with traces of gravel, non plastic
4.5	9	10	10	20	MEDIUM DENSE	Gray, Well Graded SAND with silt, fine to coarse grained, with traces of gravel, non plastic
6	11	10	13	23	MEDIUM DENSE	Gray, Well Graded SAND with silt, fine to coarse grained, with traces of gravel, non plastic
7.5	14	14	15	29	MEDIUM DENSE	Gray, Well Graded SAND with silt, fine to coarse grained, with traces of gravel, non plastic
9	16	15	18	33	DENSE	Gray, Well Graded SAND with silt, fine to coarse grained, with traces of gravel, non plastic
10.5	18	20	20	40	DENSE	Gray, Well Graded SAND with silt, fine to coarse grained, with traces of gravel, non plastic
12	21	19	20	39	DENSE	Gray, Well Graded SAND with silt, fine to coarse grained, with traces of gravel, non plastic
13.5	22	23	22	45	DENSE	Gray, Well Graded SAND with silt, fine to coarse grained, with traces of gravel, non plastic
15	24	24	25	49	HARD	Brown, Sandy SILT, slightly plasticity
16.5	25	26	26	52	HARD	Gray, Sandy SILT, slightly plasticity
18	27	28	28	56	HARD	Gray, Sandy SILT, slightly plasticity
19.5	31	30	30	60	HARD	Gray, Sandy SILT, slightly plasticity
20	33	32	35	67	HARD	Gray, Sandy SILT, slightly plasticity

Table 4. Standard Penetration Test Results for BH – 1

FINAL DEPTH						20.00m
GROUND WATER ELEV						4.50m
BOREHOLE						HOLE #2
DEPTH (m)	SPT BLOWS PER 15cm			N Value	Consistency	SCRIPTION
1.5	5	6	6	12	STIFF	Brown, Sandy SILT, slightly plasticity
3	7	8	8	16	MEDIUM DENSE	Gray, Well Graded SAND with SILT, fine to coarse grained, with traces of gravel, non plastic
4.5	9	8	9	17	MEDIUM DENSE	Gray, Silty SAND, fine to coarse grained, with traces of gravel, non plastic
6	10	12	11	23	MEDIUM DENSE	Gray, Silty SAND, fine to coarse grained, with traces of gravel, non plastic
7.5	12	11	13	24	MEDIUM DENSE	Gray, Well Graded SAND with SILT, fine to coarse grained, with traces of gravel, non plastic
9	13	14	14	28	MEDIUM DENSE	Gray, Well Graded SAND, fine to coarse grained, with traces of gravel, non plastic
10.5	15	17	17	34	DENSE	Gray, Silty SAND, fine to coarse grained, with traces of gravel, non plastic
12	19	19	21	40	DENSE	Gray, Silty SAND, fine to coarse grained, with traces of gravel, non plastic
13.5	22	20	23	43	DENSE	Gray, Silty SAND, fine to coarse grained, with traces of gravel, non plastic
15	25	25	26	51	VERY DENSE	Gray, Silty SAND, fine to coarse grained, with traces of gravel, non plastic
16.5	26	28	27	55	VERY DENSE	Gray, Silty SAND, fine to coarse grained, with traces of gravel, non plastic
18	29	29	32	61	HARD	Brown, Sandy SILT, slightly plasticity
19.5	31	33	33	66	HARD	Brown, Sandy SILT, slightly plasticity
20	24	33	34	67	VERY DENSE	Gray, Silty SAND, fine to coarse grained, with traces of gravel, non plastic

Table 5. Standard Penetration Test Results for BH – 2

The results show that Santa Catalina has a various type of soil profile type. From brown sandy silt with slight plasticity to silty sand, fine to coarse grained, with traces of gravel, non plastic and SPT blows that ranges from 5-35 blows.

Table 208-2 - Soil Profile Types

Soil Profile Type	Soil Profile Name / Generic Description	Average Soil Properties for Top 30 m of Soil Profile		
		Shear Wave Velocity, V_S (m/s)	SPT, N (blows/ 300 mm)	Undrained Shear Strength, S_U (kPa)
S_A	Hard Rock	> 1500		
S_B	Rock	760 to 1500		
S_C	Very Dense Soil and Soft Rock	360 to 760	> 50	> 100
S_D	Stiff Soil Profile	180 to 360	15 to 50	50 to 100
S_E[1]	Soft Soil Profile	< 180	< 15	< 50
S_F	Soil Requiring Site-specific Evaluation. See Section 208.4.3.1			

[1] *Soil Profile Type S_E also includes any soil profile with more than 3.0 m of soft clay defined as a soil with plasticity index, $PI > 20$, $w_{mc} \geq 40\%$ and $s_u < 24$ kPa. The Plasticity Index, PI, and the moisture content, w_{mc}, shall be determined in accordance with approved national standards.*

Table 6. Soil Profile Types

Based on the recorded data, the soil profile type of the area near the location of the footbridge varies from SD which is the stiff soil profile and SC which is the very dense soil and soft rock type.

3.1.3.1 Soil Allowable Bearing Capacity

The following data will be used on the structural analysis of the footbridge. The soil bearing capacity was a result from the Standard Penetration Test (SPT) and laboratory test procedures.

Depth (m)	Net Allowable Bearing Capacity (kPa)
0.5 – 1.0	**95**
1.0 – 1.5	**105**
1.5 – 3.0	**130**

Table 7. Net Allowable Bearing Capacity

3.1.4 Seismic Source Type

Table 208-5 Near-Source Factor N_a [1]

Seismic Source Type	Closest Distance To Known Seismic Source[2]		
	≤ 2 km	≤ 5 km	≥ 10 km
A	1.5	1.2	1.0
B	1.3	1.0	1.0
C	1.0	1.0	1.0

Table 208-6 Near-Source Factor, N_v [1]

Seismic Source Type	Closest Distance To Known Seismic Source[2]			
	≤ 2 km	5 km	10 km	≥ 15 km
A	2.0	1.6	1.2	1.0
B	1.6	1.2	1.0	1.0
C	1.0	1.0	1.0	1.0

Notes for Tables 208.5 and 208.6:

[1] *The Near-Source Factor may be based on the linear interpolation of values for distances other than those shown in the table.*

[2] *The closest distance to seismic source shall be taken as the minimum distance between the site and the area described by the vertical projection of the source on the surface (i.e., surface projection of fault plane). The surface projection need not include portions of the source at depths of 10 km or greater. The largest value of the Near-Source Factor considering all sources shall be used for design.*

Table 8. Seismic Source Type

Through the use of maps, Santa Catalina is under the Seismic Zone 4 with a Factor Z = 0.4. Using the Fault Finder website by Philippine Institute of Volcanology and Seismology (PHIVOLCS), the nearest active fault from the barangay is the Iba Fault which is 52.2 kilometers away. Santa Catalina will be under Seismic Source Type A (Na= 1.0, Nv= 1.0).

3.1.5 Sample Size

3.1.5.1 Yamane's Formula

The researchers used the Yamane's Formula to determine the needed participants for a survey. The total population of each barangay in the municipality of Lubao was given by the municipal hall of Lubao. In their 2023 census, the total population of Lubao is 192,778, wherein Santa Catalina has a total population of 5,576.

where:

$$n = \frac{N}{1 + N(e)^2}$$

P- Percentage e- margin of error

n - number of respondents

Given:

N= 5,576 e= 0.09 or 9%

$$n = \frac{5576}{1 + 5576(0.09)^2}$$

n = 120 respondents

3.1.5.2 Weighted Mean

$$X_w = \frac{\sum_{i=1}^{n} WiXi}{\sum W}$$

Equation 2. Formula for Weighted Mean

W = weighted average

n = number of terms to be averaged

wi = weights applied to x values

Xi = data values to be averaged

3.1.5.3 Mean

$$\bar{x} = \frac{\sum_{i=1}^{n} Xi}{n}$$

Equation 3. Formula for Mean

3.1.5.4 Standard Deviation

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n - 1}}$$

Equation 4. Formula for Standard Deviation

s = population standard deviation

N = the size of the population

Xi = each value from the population

$\bar{x}$ = the population mean

3.1.5.5 Mean Interval for Four Point Likert Scale

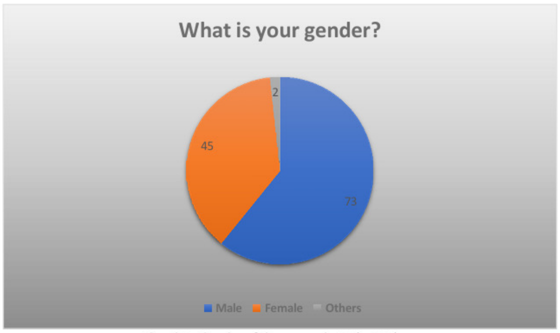
Mean Interval	Result Interpretation
3.26 – 4.00	**Strongly Agree (SA) / Very Important**
2.51 – 3.25	**Agree (A) / Important**
1.76 – 2.50	**Disagree (D) / Barely Important**
1.00 – 1.75	**Strongly Disagree (SD) / Not Important**

Table 9. Mean Interval

3.1.6 Survey Results and Interpretation

Section 1: Demographic

3.1.6.1 Respondent's Gender

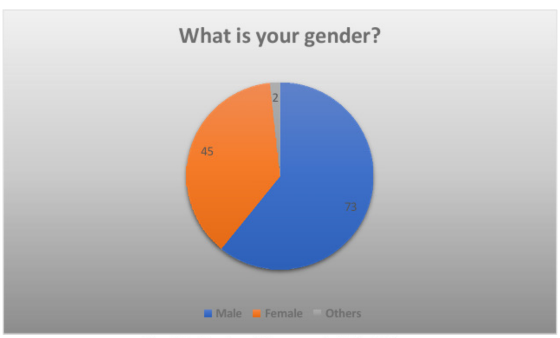


Graph 1. Gender of the respondents (n=120)

Gender	Frequency	Percentage
Male	**73**	**60.83%**
Female	**45**	**37.5%**
Others	**2**	**1.67%**
Total	**120**	**100%**

Table 10. Frequency of the respondents on gender

3.1.6.2 Respondent's Age

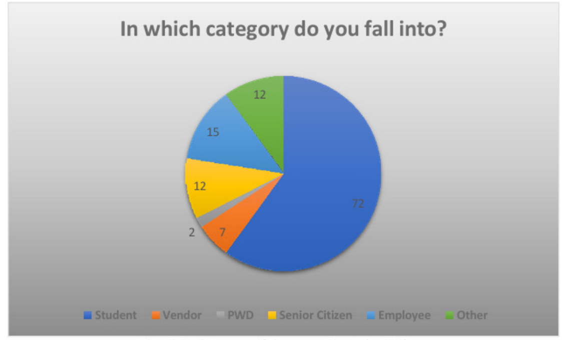


Graph 1. Gender of the respondents (n=120)

Gender	Frequency	Percentage
Male	**73**	**60.83%**
Female	**45**	**37.5%**
Others	**2**	**1.67%**
Total	**120**	**100%**

Table 10. Frequency of the respondents on gender

3.1.6.3 Respondent's Occupation

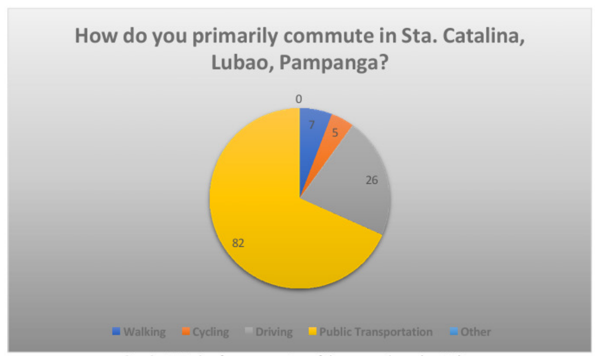


Graph 3. Category of the respondents (n=120)

Occupation	Frequency	Percentage
Student	**72**	**60%**
Vendor	**7**	**5.83%**
PWD	**2**	**1.67%**
Senior Citizen	**12**	**10%**
Employee	**15**	**12.5%**
Other	**12**	**10%**
Total	**120**	**100%**

Table 12. Frequency of the respondents on different occupation

3.1.6.4 Respondent's Mode of Transportation



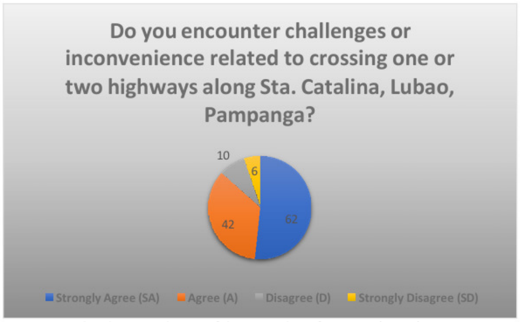
Graph 4. Mode of transportation of the respondents (n=120)

Transportation	Frequency	Percentage
Walking	**7**	**5.83%**
Cycling	**5**	**4.17%**
Driving	**26**	**21.67%**
Public Transportation	**82**	**68.33 %**
Other	**0**	**0%**
Total	**120**	**100%**

Table 13. Frequency of the respondents on mode of transportation

3.1.7 Section 2: Assessment of the Area

Item 1



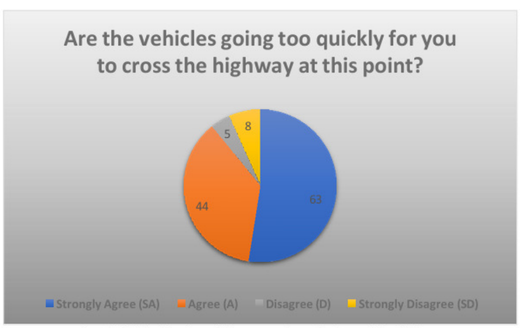
Graph 5. Distribution of the respondents for item 1 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.33	26.73	Strongly Agree

Table 14. Weighted mean and standard deviation for item 1

Graph 5 shows that out of 120 respondents, 62 (51.67%) strongly agreed, 42 (35%) agreed, 10 (8.33%) disagreed and 6 (5%) strongly disagreed with the question about challenges and inconvenience on crossing the highways. The majority had their challenges or inconvenience related to crossing the said two (2) highways because of the large quantity of vehicles passing by.

Item 2



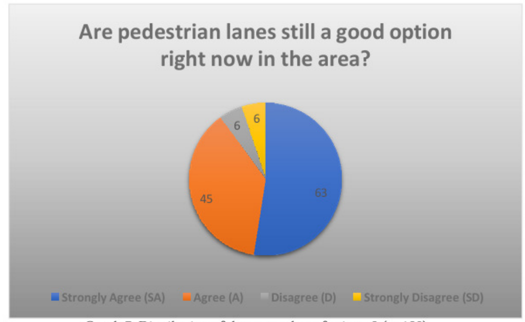
Graph 6. Distribution of the respondents for item 2 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.35	28.25	Strongly Agree

Table 15. Weighted mean and standard deviation for item 2

Graph 6 shows that out of 120 respondents, 63 (52.5%) strongly agreed, 44 (36.67%) agreed, 5 (4.167%) disagreed and 8 (6.67%) strongly disagreed with the question about vehicles traveling too fast for them to cross the highway despite the presence of a pedestrian lane. According to some of the respondents, the absence of an enforcer made things harder for them to cross the highway despite having a pedestrian lane in the area.

Item



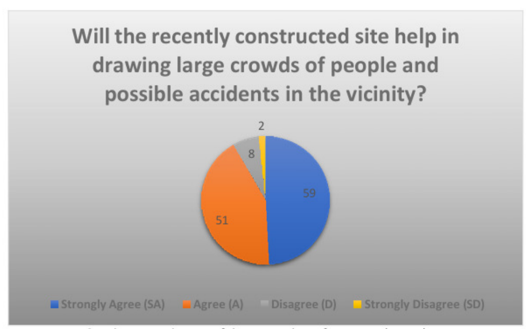
Graph 7. Distribution of the respondents for item 3 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.38	28.67	Strongly Agree

Table 16. Weighted mean and standard deviation for item 3

Graph 7 shows that out of 120 respondents, 63 (52.5%) strongly agreed, 45 (37.5%) agreed, 6 (5%) disagreed and 6 (5%) strongly disagreed with the question of pedestrian lanes still a good option at present. The pedestrian lane is still favored by the majority of respondents despite the high risk they are taking in crossing one or two highways of Santa Catalina.

Item 4



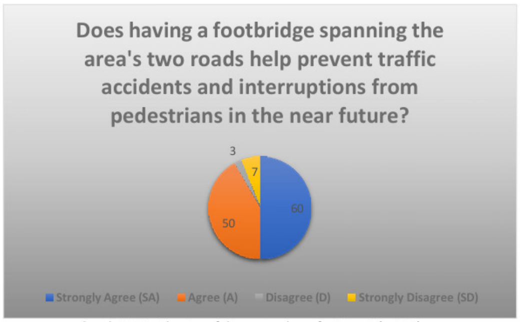
Graph 8. Distribution of the respondents for item 4 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.39	29.15	Strongly Agree

Graph 17. Weighted mean and standard deviation for item 4

Graph 8 shows that out of 120 respondents, 59 (49.17%) strongly agreed, 51 (42.5%) agreed, 8 (6.67%) disagreed and 2 (1.667%) strongly disagreed with the question about the recent project in Santa Catalina will help on drawing more people with it in the near future. Almost all the respondents believed that the recent "One Stop Shop" project will help on drawing large amount of people someday because of the franchises that will be built in this project.

Item 5



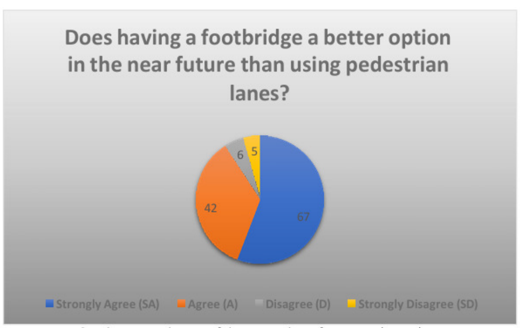
Graph 9. Distribution of the respondents for item 5 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.36	29.20	Strongly Agree

Table 18. Weighted mean and standard deviation for item 5

Graph 9 shows that out of 120 respondents, 60 (50%) strongly agreed, 50 (41.67%) agreed, 3 (2.5%) disagreed and 7 (5.83%) strongly disagreed with the question about a footbridge will prevent traffic accidents and interruptions along the highway in Santa Catalina especially when the "One Stop Shop" project is finished.

Item 6



Graph 10 Distribution of the respondents for item 6 (n=120)

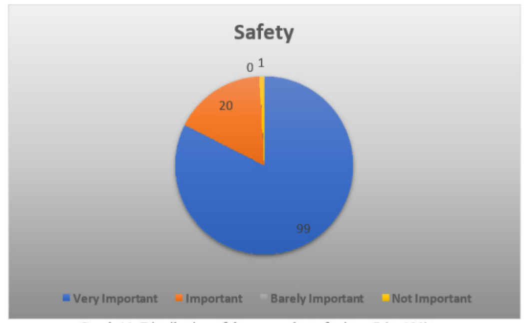
Weighted Mean	SD (σ)	Result Interpretation
3.43	30.08	Strongly Agree

Graph 19. Weighted mean and standard deviation for item 6

Graph 10 shows that out of 120 respondents, 67 (55.83%) strongly agreed, 42 (35%) agreed, 6 (5%) disagreed, 5 (4.17%) strongly disagreed with the question of having a footbridge a better option for them to use in the near future. The majority believed that a footbridge would give them a new designated spot now where they can cross the highways without risking their lives.

3.1.7 Section 3: Sample Size

Item 7



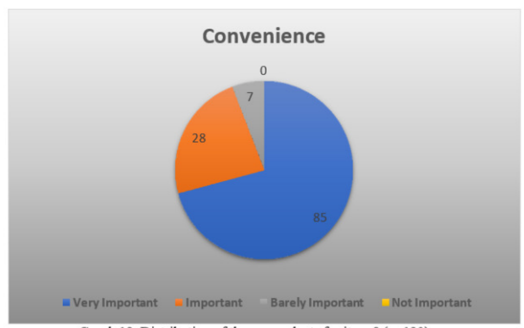
Graph 11. Distribution of the respondents for item 7 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.81	46.91	Very Important

Table 20. Weighted mean and standard deviation for item 7

Graph 11 shows that out of 120 respondents, 99 (82.5%) answered very important, 20 (16.67%) answered important, and only 1 (0.833%) answered not important.

Item 8



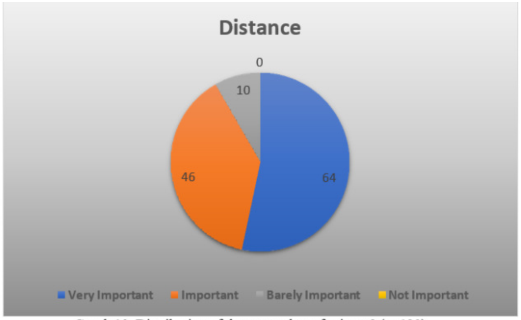
Graph 12. Distribution of the respondents for item 8 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.65	38.55	Very Important

Table 21. Weighted mean and standard deviation for item 8

Graph 12 shows that out of 120 respondents, 85 (70.83%) answered very important, 28 (23.33%) answered important and 7 (5.83%) answered barely important.

Item 9



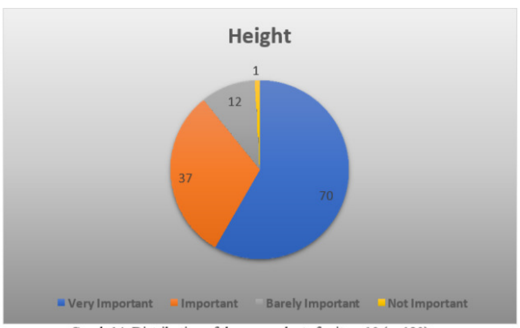
Graph 13. Distribution of the respondents for item 9 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.45	30.07	Very Important

Table 22. Weighted mean and standard deviation for item 9

Graph 13 shows that out of 120 respondents, 64 (53.33%) answered very important, 46 (38.33%) answered important and 10 (8.33%) answered barely important.

Item 10



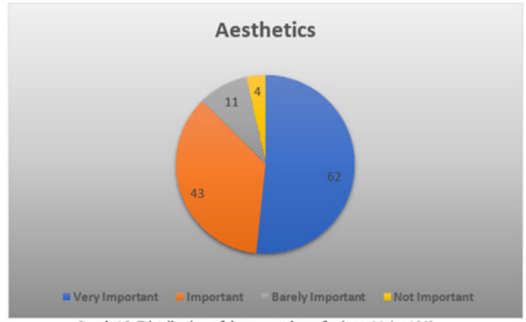
Graph 14. Distribution of the respondents for item 10 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.47	30.63	Very Important

Table 23. Weighted mean and standard deviation for item 10

Graph 14 shows that out of 120 respondents, 70 (58.33%) answered very important, 37 (30.83%) answered important, 12 (10%) answered barely important and 1 (0.83%) answered not important

Item 11



Graph 15. Distribution of the respondents for item 11 (n=120)

Weighted Mean	SD (σ)	Result Interpretation
3.36	27.26	Very Important

Table 24. Weighted mean and standard deviation for item 11

Graph 15 shows that out of 120 respondents, 62 (51.67%) answered very important, 43 (35.83%) answered important, 11 (9.17%) answered barely important and 4 (3.33%) answered not important.

3.2 Phase 2: Planning Phase

3.2.1 Acquiring and Discussions with the Architect

Following the assessment of the area, the researchers looked for a licensed architect to draft the blueprints of the footbridge. Through lengthy discussions with the architect, specific measurements in the specific area where the footbridge is planned are required. This includes the width of the two highways and the width of the private property that is between the two highways. The site development plan that was given by the BC Architects Design Corp. and through the use of Google Earth website, the researchers gained knowledge about the specific measurements that the researchers needed in this study.

Figure 14. Locating the exact locations of landmarks

The researchers determined the distance per highway and the total distance for the span of the footbridge. The Lubao Diversion Road is a two-lane highway that has 16.28 meters width.

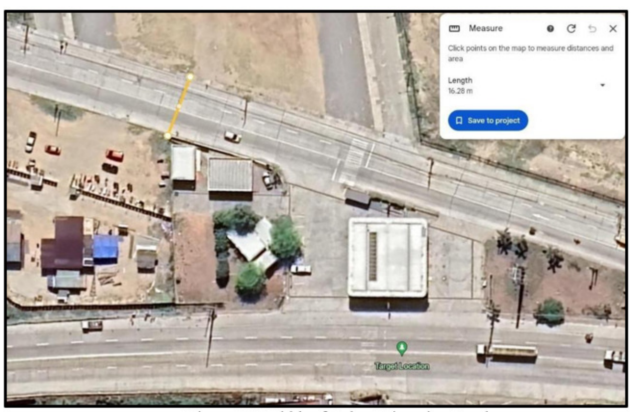


Figure 15. Width of Lubao Diversion Road

The other side of the aforementioned highway is the Jose Abad Santos Avenue Road. It is a four-lane highway that has a width of 22.8 meters.

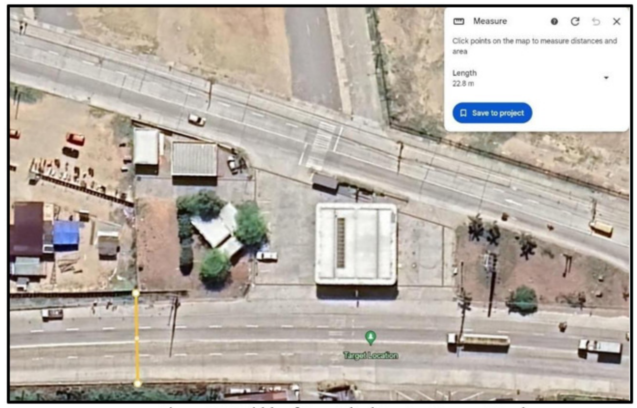


Figure 16. Width of Jose Abad Santos Avenue Road

The Jose Abad Santos Avenue Road is categorized as a National Road in the Philippines. All kinds of heavy vehicles are passing through this highway meaning the vertical clearance of the footbridge should be higher than all the possible vehicles that will pass through the highway. The proposed footbridge will have 4 piers because of its length and distance coverage. Pier 1-2 and 3-4 will be in a same distance which is 45.86 meters and Pier 2-3 is where the third installation of stairs will

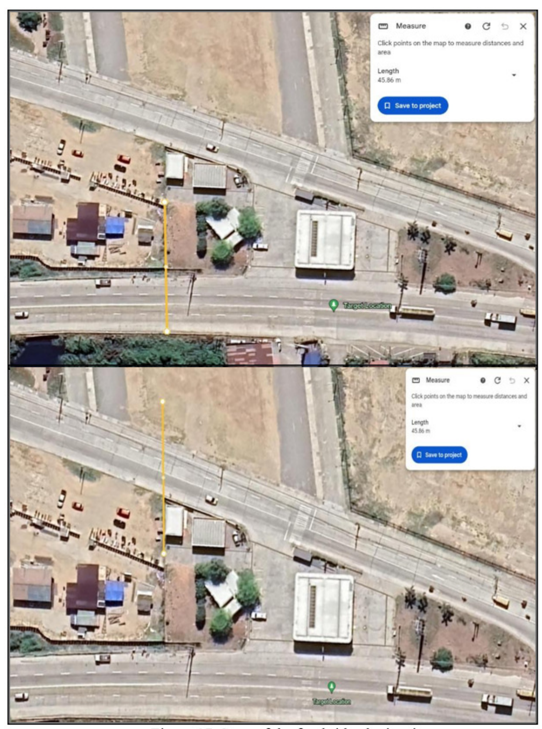


Figure 17. Span of the footbridge by its piers

be designed.

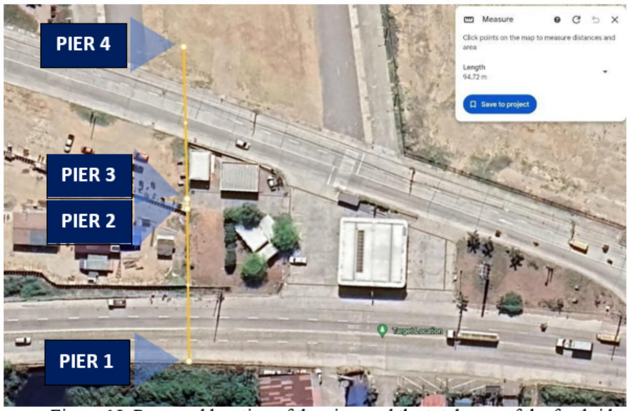


Figure 18. Proposed location of the piers and the total span of the footbridge

3.2.2 Sample Footbridge Design

The researchers needed a sample plan of a footbridge in order to guide them on formulating their own footbridge design. The sample footbridge plan was provided by the DPWH Pampanga 1st District Engineering Office. The given plan was the footbridge design at Our Lady of Fatima in City of San Fernando, Pampanga. The DPWH set a minimum height of 5.33 meters for the vertical clearance of a footbridge, ensuring that all of passing vehicles will pass through safely below the footbridge.

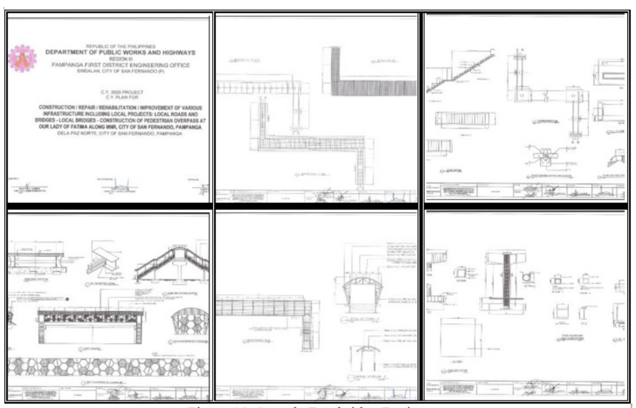


Figure 19. Sample Footbridge Design

3.2.33D Perspective

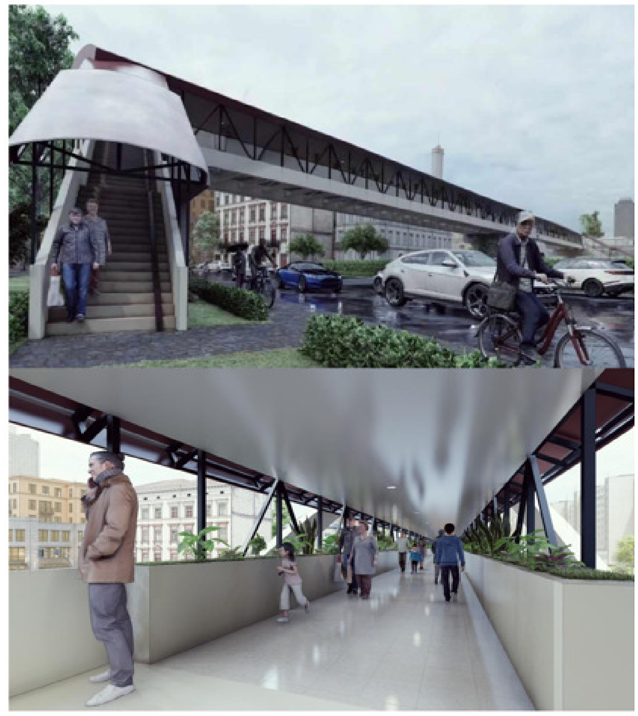


Figure 20. Side and Interior View of the Footbridge

Figure 21. Rear and Side View of the Footbridge

3.2.4Architectural Plan

AutoCAD was the application used to create the architectural, structural, and electrical plan of the footbridge.

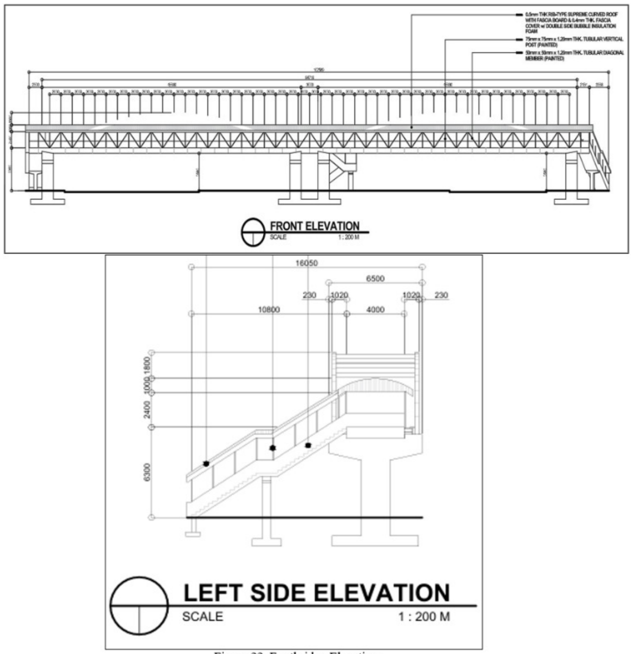


Figure 22. Footbridge Elevations

3.2.5 Structural Plan

3.2.5.1 Foundation Plan

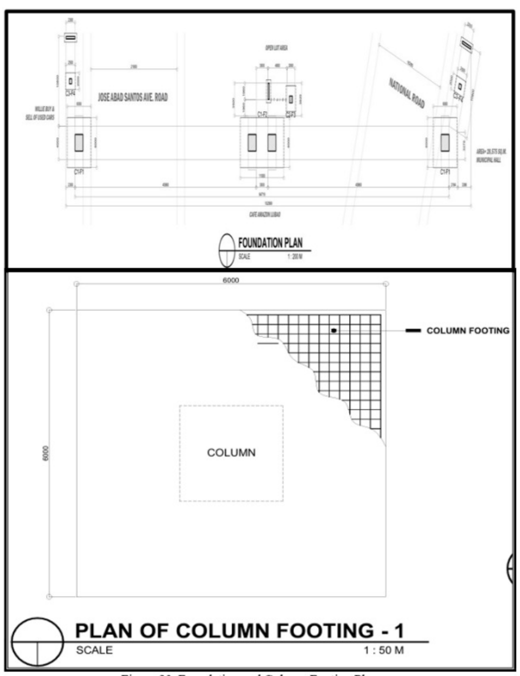


Figure 23. Foundation and Column Footing Plan

3.2.5.2 Section of Stairs

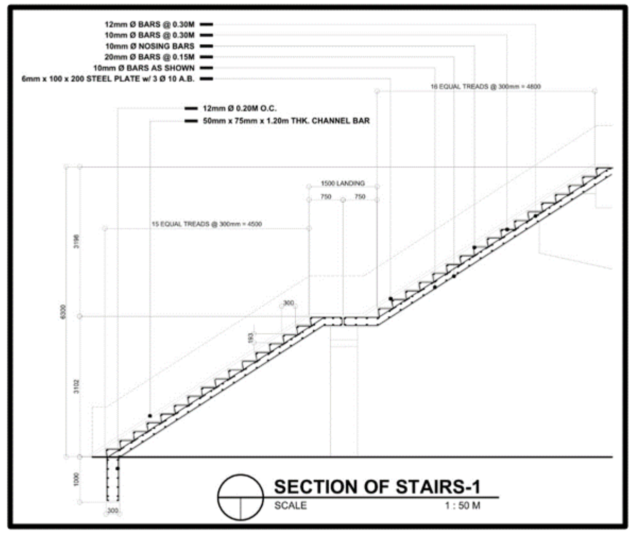


Figure 24. Section of Stairs

3.2.5.3 Roof Framing Plan

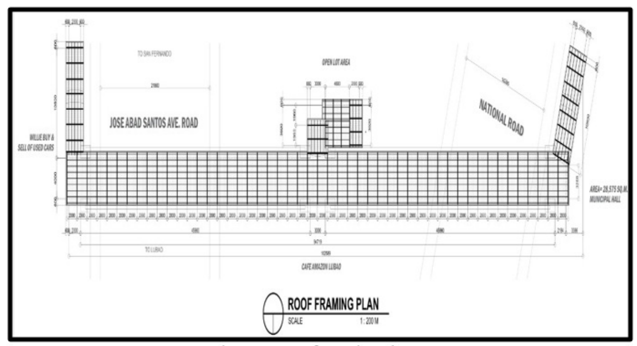


Figure 25. Roof Framing Plan

3.2.5.4 Details of Truss

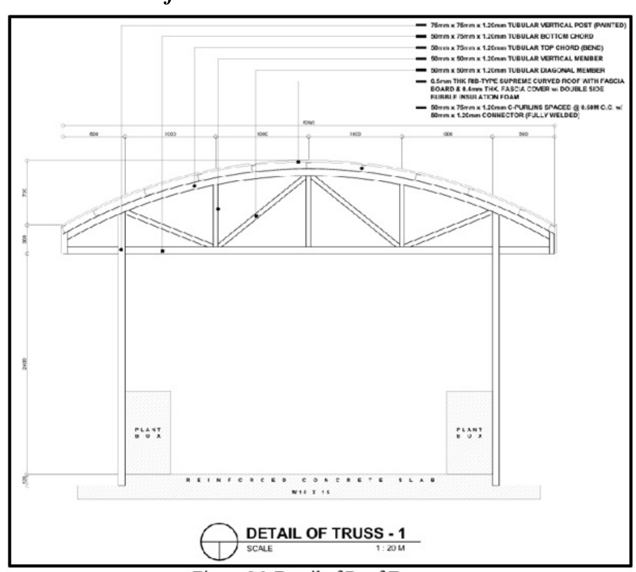


Figure 26. Detail of Roof Truss

3.2.5.5 Details of Slab and Steel Deck

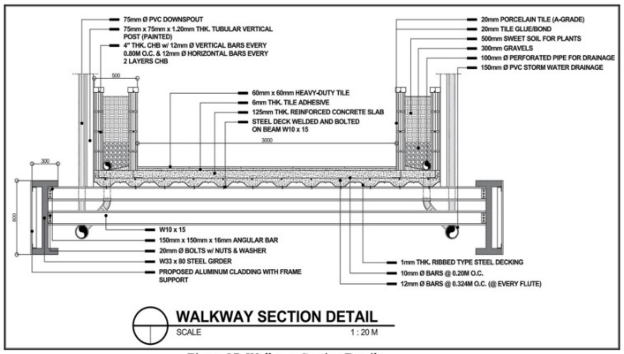
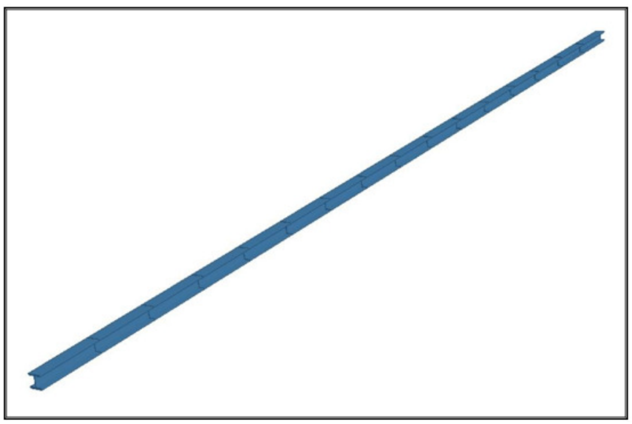


Figure 27. Walkway Section Detail

3.2.5.6 Beam Design

3.2.5.6.1 W12x170



Properties:

Ax = 50 in2 D = 14 in

tw = 0.96 in bf = 12.60 in

tf = 1.56 in Zx =275 in3

Ix = 35.60 in4 Zy =126 in3

Iy = 517 in4 Iz = 1650 in4

3.2.6 Electrical Plan

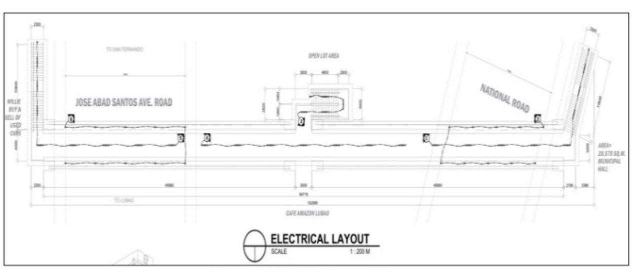


Figure 28. Electrical Layout Plan

3.3 Phase 3: Design, Analysis and Estimation

3.3.1 Load Combinations

The following load combinations were based on National Structural Code of the Philippines 2015. If load combinations are not properly taken into account, the structure may become unstable and collapse or experience extreme deflection or deformation, endangering nearby infrastructure and pedestrians. As a result, load combination analysis is essential to guaranteeing footbridge dependability and safety.

LOAD COMBINATIONS:

- 1.4 DEAD
- 1.2 DEAD + 1.6 LIVE
- 1.2 DEAD + 1 LIVE
- 1.2 DEAD
- 1.2 DEAD + 1 LIVE + 1 SEISMIC (1)
- 1.2 DEAD + 1 LIVE + 1 SEISMIC (2)
- 0.9 DEAD
- 0.9 DEAD + 1 SEISMIC (1)
- 0.9 DEAD + 1 SEISMIC (2)

3.3.2 Applied Codes, Standards and Criteria

The researchers used the following reference codes to do the structural analysis of the footbridge.

- National Structural Code of the Philippines, Vol I – 2015 Edition
- DPWH Design Guidelines, Criteria and Standards (DGCS) 2015
- UBC 1997

Concrete

Concrete compressive strength Foundation

All footings fc' = 28.00 MPa

Slab

All Suspended slab fc' = 28.00 MPa Beams

Tie beams, lower & upper ground floor beams fc' = 28.00 MPa Columns

All columns from footing to roof beams fc' = 28.00 MPa Rebar yield strength

Grade 60 reinforcements for 20mmØ and higher fy = 415.00 MPa Grade 40 reinforcements for 16mmØ and lowerfy = 275.00 mPa Unit weight of concrete ɣc = 23.54 kN/m³

Steel

Steel yield strength (A36) Fy = 248.00 mPa

Steel ultimate strength (A36) Fu = 400.00 mPa

Unit weight of steel members ɣsteel = 77.00 kN/m³

Soil Properties

Unit weight of soil ɣsoil = 18.00 kN/m³

Dead Loads

Floor Loads

All superimposed dead loads on slab as shown are based on Section 204, Table 204-2, Minimum Design Dead Loads.

Slab selfweight (125 mm thk.)

Selfweight slab = 2.94 kPa Flooring & Ceiling

Solid flat tile on 25mm mortar base

Superimposed Floor loads = 1.20 kPa

Live Loads

All superimposed live loads shown are based on Section 205, Table 205-1, Min. Uniform and Concentrated Live Loads.

Floor Loads

Pedestrian bridges and WalkwaysLL =4.80 kPa

Wind Loads

Wind loads calculations are computed on staad which is based on ASCE-7 and Section 207 - Windloads of NSCP 2015

Occupancy category (Standard) OC = II

Basic Wind Speed v = 250 kph 69.44 m/s

Wind Directionality Factor kd = 0.85

Importance Factor I = 1.00

Exposure Category EC = B

Gust Effect Factor G = 0.85

Type of Structure = Steel Structure

Approximate Natural Frequency ha = 2.87 > 1, Rigid Structure

Building Damping Ratio b = 0.01

Enclosure Classification EC = Open

Building height hn = 9.70 m

Building length normal to the wind L = 99.32 m

Building length along the direction of wind B = 6.50 m

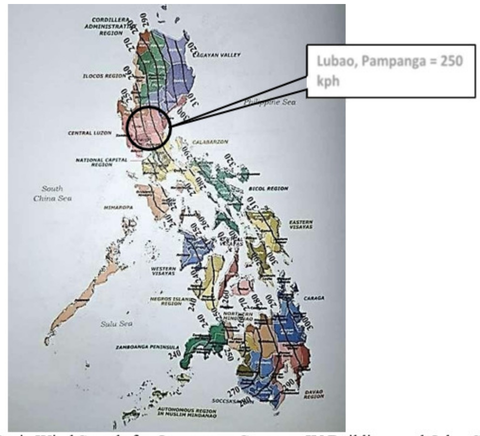


Figure 29. Basic Wind Speeds for Occupancy Category IV Buildings and Other Structures

Seismic Loads

Earthquake loads calculations are computed on STAAD.Pro which is based on UBC 1997 and Section 208 - 'Earthquake Loads of NSCP 2015. The seismic analysis performed in this calculation is static force procedure with consideration of accidental torsions.

Seismic Importance FactorNSCPTable 208-1 I = 1.00

Soil Profile Types NSCP Table 208-2 = SD

Seismic Zone Factor (Zone 4)NSCP Table 208-3 Z = 0.40

Seismic Source Type, M > 7.0NSCP Table 208-4 M = A

Near-Source Factor NSCP Table 208-5 Na = 1.00 ≥ 10 km

Near-Source Factor NSCP Table 208-6 Nv = 1.00 ≥ 15 km

Seismic Coefficient NSCP Table 208-7 Ca = 0.44 Na

Seismic Coefficient NSCP Table 208-8 Cv = 0.64 Nv

Response Modification FactorNSCP 208-11A R = 8.50

Ct for calculation of structure period,TNSCP 208.5.2.2 ct = 0.0731

Structure height hn = 9.70 m

Structure Period using method A NSCP 208.5.2.2 T = 0.4018sec. > 0.70 sec. Max. Inelastic Response Displacement, since T < 0.70 sec

$\Delta M = 0.025h$

Δs, for story drift $\Delta s = 0.0042017h$

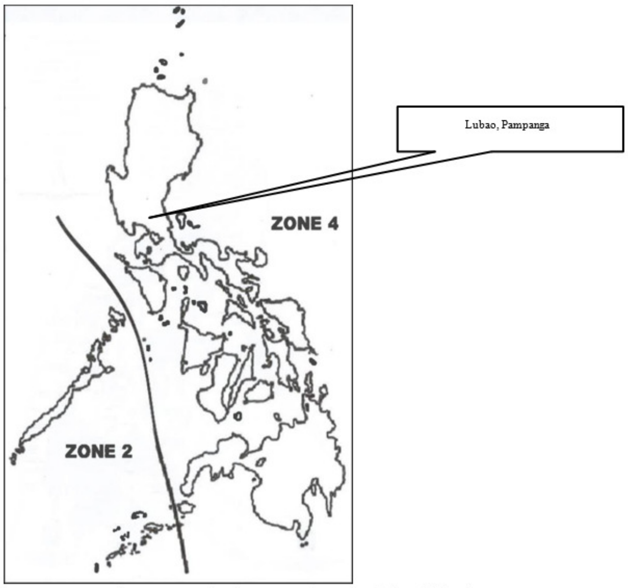


Figure 30. Seismic map reference of the Philippines

3.3.3 Structural Modeling

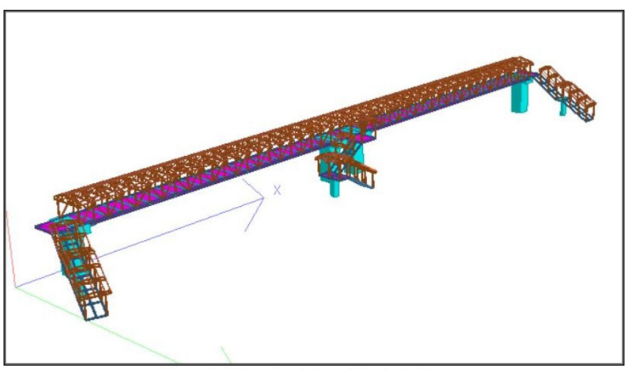


Figure 31. 3D rendered view of the footbridge.

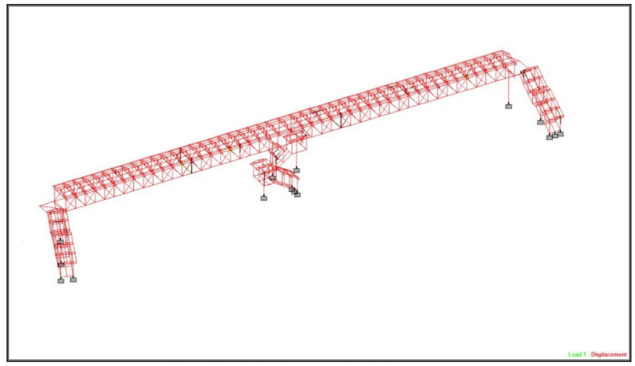


Figure 32. Deflection on a selected load case

3.3.4 Structural Analysis

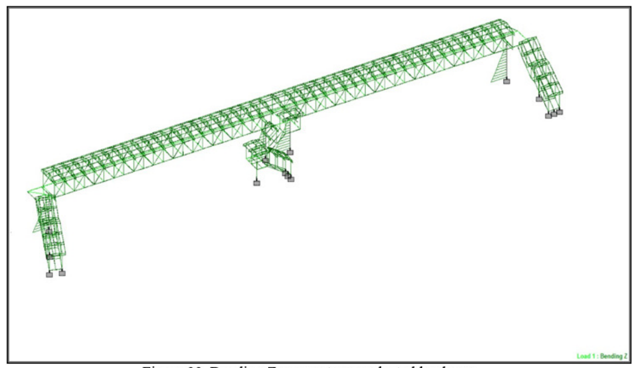


Figure 33. Bending Z moment on a selected load case.

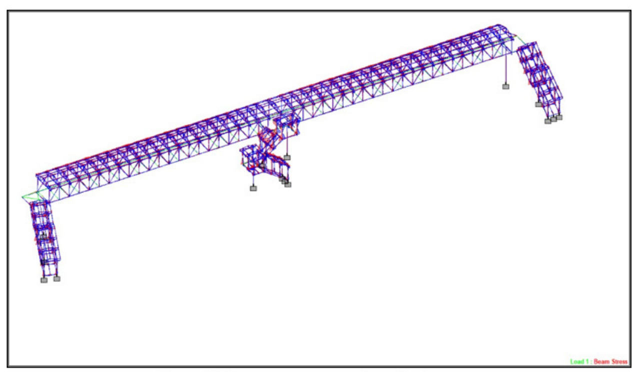


Figure 34. Beam stresses on a selected load case.

Through the help of STAAD.Pro running analysis, the researchers can easily look through their needed information for their footbridge analysis. The summarized results showed the largest nodal displacement that has occurred in the load combination of ULC, 1.2DL + 1.6LL at node number 283. The result along Y axis is -348.556 millimeters.

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm	Rotational rX rad	rY rad	rZ rad
Max X	327	6 ULC, 1.2 D	**68.424**	-111.949	0.127	131.204	-0.000	-0.000	0.063
Min X	551	6 ULC, 1.2 D	**-67.808**	-101.575	-0.312	122.129	-0.000	0.000	-0.092
Max Y	903	6 ULC, 1.2 D	-0.876	**25.242**	0.021	25.257	0.006	-0.000	0.006
Min Y	283	6 ULC, 1.2 D	0.659	**-384.556**	0.211	384.557	0.002	0.000	0.001
Max Z	1191	5 ULC, 1.4 D	2.169	-6.250	**16.614**	17.882	0.006	-0.003	-0.001
Min Z	1173	5 ULC, 1.4 D	3.274	-6.901	**-7.502**	10.706	-0.003	-0.002	-0.001
Max rX	1191	5 ULC, 1.4 D	2.169	-6.250	16.614	17.882	**0.006**	-0.003	-0.001
Min rX	931	5 ULC, 1.4 D	0.766	-4.776	-0.049	4.838	**-0.003**	-0.001	-0.000
Max rY	638	6 ULC, 1.2 D	16.086	-155.104	-0.530	155.937	-0.000	**0.024**	-0.050
Min rY	637	6 ULC, 1.2 D	16.085	-155.876	-0.519	156.704	-0.000	**-0.024**	-0.050
Max rZ	618	6 ULC, 1.2 D	46.467	-103.198	-0.426	113.178	-0.000	0.019	**0.120**
Min rZ	548	6 ULC, 1.2 D	-47.717	-101.999	-0.299	112.609	-0.000	-0.019	**-0.118**
Max Rs	283	6 ULC, 1.2 D	0.659	-384.556	0.211	**384.557**	0.002	0.000	0.001

Table 25. Summary of Nodal Displacements

The maximum vertical (Max Fy) in the summary of support reactions is located at node 7 on the load combination of ULC, 1.2DL + 1.6LL. The result on Max Fy is 2762.904 kN

	Node	L/C	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN	Moment Mx kN-m	My kN-m	Mz kN-m
Max Fx	7	6 ULC, 1.2 D	**1457.767**	2762.904	12.685	26.847	-91.734	-4225.779
Min Fx	11	6 ULC, 1.2 D	**-1487.172**	2439.790	-5.961	31.833	20.716	3416.843
Max Fy	7	6 ULC, 1.2 D	1457.767	**2762.904**	12.685	26.847	-91.734	-4225.779
Min Fy	3	4 LIVE	-5.203	**-18.515**	15.496	22.166	1.370	6.498
Max Fz	3	6 ULC, 1.2 D	-19.693	29.569	**54.301**	85.137	2.192	23.559
Min Fz	2	10 ULC, 1.2	1201.454	2276.910	**-160.902**	-1218.871	-6.064	-2712.712
Max Mx	11	5 ULC, 1.4 D	-972.443	2104.102	13.257	**175.693**	-2.408	2251.636
Min Mx	2	6 ULC, 1.2 D	1443.705	2515.080	-155.302	**-1221.242**	-158.281	-3272.043
Max My	2	2 EQZ	-0.447	-3.031	-34.273	-214.374	**120.556**	5.215
Min My	2	6 ULC, 1.2 D	1443.705	2515.080	-155.302	-1221.242	**-158.281**	-3272.043
Max Mz	6	6 ULC, 1.2 D	-1401.192	2753.002	-14.714	-125.830	29.873	**3927.192**
Min Mz	7	6 ULC, 1.2 D	1457.767	2762.904	12.685	26.847	-91.734	**-4225.779**

Table 26. Summary of Support Reactions

Results on beam stresses show the maximum and minimum value of stresses are located at node 1419 and 1420 respectively. The value of Maximum Mz is 5357.475 kN- m that resulted from the load combination ULC, 1.2DL + 1.6LL. The value of Minimum Mz is -5245.818 kN-m that resulted from the load combination ULC, 1.2DL + 1.6LL.

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	3	6 ULC, 1.2 D	7	**2762.904**	-1457.767	12.685	-91.734	-26.847	-4225.779
Min Fx	2083	6 ULC, 1.2 D	589	**-888.338**	7.312	4.767	0.023	-8.364	16.777
Max Fy	4	6 ULC, 1.2 D	11	2439.790	**1487.172**	-5.961	20.716	-31.833	3416.843
Min Fy	3	6 ULC, 1.2 D	7	2762.904	**-1457.767**	12.685	-91.734	-26.847	-4225.779
Max Fz	3595	6 ULC, 1.2 D	1496	291.916	-737.924	**769.368**	-2699.287	-65.894	-142.334
Min Fz	3586	6 ULC, 1.2 D	1492	213.154	-770.972	**-753.738**	2680.750	64.096	-119.504
Max Mx	3586	6 ULC, 1.2 D	1492	213.154	-770.972	-753.738	**2680.750**	64.096	-119.504
Min Mx	3595	6 ULC, 1.2 D	1496	291.916	-737.924	769.368	**-2699.287**	-65.894	-142.334
Max My	3595	6 ULC, 1.2 D	1420	291.916	-851.019	769.368	-2699.287	**1472.842**	1446.609
Min My	3586	6 ULC, 1.2 D	1419	213.154	-884.068	-753.738	2680.750	**-1443.380**	1535.536
Max Mz	2906	6 ULC, 1.2 D	1419	1795.144	1487.172	5.961	20.716	-67.002	**5357.475**
Min Mz	2908	6 ULC, 1.2 D	1420	1847.815	-1443.705	155.302	-158.281	304.958	**-5245.818**

Table 27. Summary of Beam Stresses

3.3.4.1 Utilization Ratio

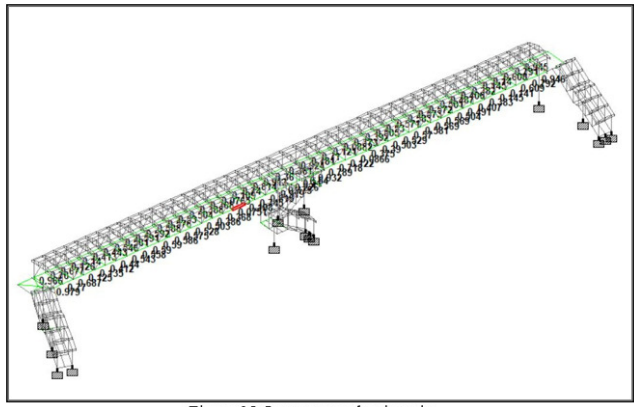


Figure 35. Lowest member in ratio

Beam	Analysis Property	Design Property	Actual Ratio	Allowable Ratio	Normalized Ratio (Actual/Allowable)	Clause	L/C	Ax cm2	Iz cm4	Iy cm4	Ix cm4
3539	W12X170	W12X170	0.141	1.000	0.141	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3540	W12X170	W12X170	0.145	1.000	0.145	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3541	W12X170	W12X170	0.383	1.000	0.383	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3542	W12X170	W12X170	0.407	1.000	0.407	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3543	W12X170	W12X170	0.491	1.000	0.491	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3544	W12X170	W12X170	0.504	1.000	0.504	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3545	W12X170	W12X170	0.569	1.000	0.569	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3546	W12X170	W12X170	0.569	1.000	0.569	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3547	W12X170	W12X170	0.581	1.000	0.581	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3548	W12X170	W12X170	0.570	1.000	0.570	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3549	W12X170	W12X170	0.529	1.000	0.529	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3550	W12X170	W12X170	0.503	1.000	0.503	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3551	W12X170	W12X170	0.390	1.000	0.390	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3552	W12X170	W12X170	0.375	1.000	0.375	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3553	W12X170	W12X170	0.087	1.000	0.087	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3554	W12X170	W12X170	0.122	1.000	0.122	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3555	W12X170	W12X170	0.718	1.000	0.718	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3556	W12X170	W12X170	0.789	1.000	0.789	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3557	W14X426	W14X426	0.932	1.000	0.932	Eq. H1-1b	6	806.450	274.71273E	98230.620	13777.260
3558	W12X170	W12X170	0.210	1.000	0.210	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3559	W12X170	W12X170	0.475	1.000	0.475	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3560	W14X426	W14X426	0.919	1.000	0.919	Eq. H1-1b	6	806.450	274.71273E	98230.620	13777.260
3561	W12X170	W12X170	0.819	1.000	0.819	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3562	W12X170	W12X170	0.745	1.000	0.745	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3563	W12X170	W12X170	0.108	1.000	0.108	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3564	W12X170	W12X170	0.075	1.000	0.075	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3565	W12X170	W12X170	0.368	1.000	0.368	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3566	W12X170	W12X170	0.386	1.000	0.386	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3567	W12X170	W12X170	0.503	1.000	0.503	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3568	W12X170	W12X170	0.528	1.000	0.528	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3569	W12X170	W12X170	0.575	1.000	0.575	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3570	W12X170	W12X170	0.586	1.000	0.586	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3571	W12X170	W12X170	0.590	1.000	0.590	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3572	W12X170	W12X170	0.590	1.000	0.590	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3573	W12X170	W12X170	0.558	1.000	0.558	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3574	W12X170	W12X170	0.543	1.000	0.543	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3575	W12X170	W12X170	0.440	1.000	0.440	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3576	W12X170	W12X170	0.412	1.000	0.412	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3577	W12X170	W12X170	0.135	1.000	0.135	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3578	W12X170	W12X170	0.125	1.000	0.125	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3579	W12X170	W12X170	0.687	1.000	0.687	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3580	W12X170	W12X170	0.770	1.000	0.770	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3581	W12X170	W12X170	0.540	1.000	0.540	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3582	W12X170	W12X170	0.226	1.000	0.226	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784

Table 28. Value of the lowest member ratio

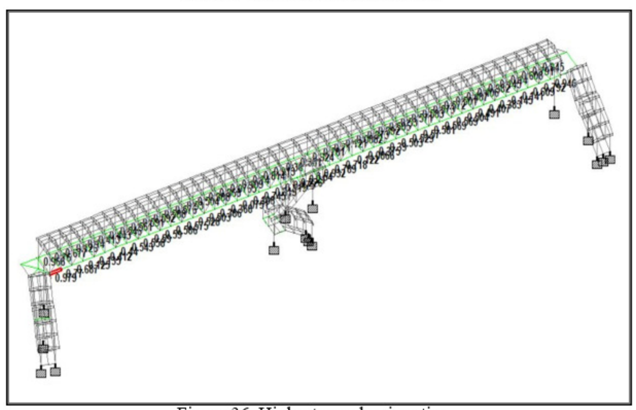


Figure 36. Highest member in ratio

All / Failed Members

Beam	Analysis Property	Design Property	Actual Ratio	Allowable Ratio	Normalized Ratio (Actual/Allowable)	Clause	L/C	Ax cm2	Iz cm4	Iy cm4	Ix cm4
3464	W14X426	W14X426	0.924	1.000	0.924	Eq. H1-1b	6	806.450	274.71273E	98230.620	13777.260
3465	W12X170	W12X170	0.781	1.000	0.781	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3466	W12X170	W12X170	0.710	1.000	0.710	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3467	W12X170	W12X170	0.121	1.000	0.121	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3468	W12X170	W12X170	0.088	1.000	0.088	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3469	W12X170	W12X170	0.373	1.000	0.373	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3470	W12X170	W12X170	0.392	1.000	0.392	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3471	W12X170	W12X170	0.505	1.000	0.505	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3472	W12X170	W12X170	0.530	1.000	0.530	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3473	W12X170	W12X170	0.571	1.000	0.571	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3474	W12X170	W12X170	0.583	1.000	0.583	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3475	W12X170	W12X170	0.573	1.000	0.573	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3476	W12X170	W12X170	0.572	1.000	0.572	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3477	W12X170	W12X170	0.501	1.000	0.501	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3478	W12X170	W12X170	0.487	1.000	0.487	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3479	W12X170	W12X170	0.406	1.000	0.406	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3480	W12X170	W12X170	0.382	1.000	0.382	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3481	W12X170	W12X170	0.145	1.000	0.145	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3482	W12X170	W12X170	0.140	1.000	0.140	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3483	W12X170	W12X170	0.608	1.000	0.608	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3484	W12X170	W12X170	0.791	1.000	0.791	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3535	W14X426	W14X426	0.979	1.000	0.979	Eq. H1-2	6	806.450	274.71273E	98230.620	13777.260
3536	W14X426	W14X426	0.946	1.000	0.946	Eq. H1-1b	6	806.450	274.71273E	98230.620	13777.260
3537	W12X170	W12X170	0.792	1.000	0.792	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3538	W12X170	W12X170	0.609	1.000	0.609	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3539	W12X170	W12X170	0.141	1.000	0.141	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3540	W12X170	W12X170	0.145	1.000	0.145	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3541	W12X170	W12X170	0.383	1.000	0.383	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3542	W12X170	W12X170	0.407	1.000	0.407	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3543	W12X170	W12X170	0.491	1.000	0.491	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3544	W12X170	W12X170	0.504	1.000	0.504	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3545	W12X170	W12X170	0.569	1.000	0.569	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3546	W12X170	W12X170	0.569	1.000	0.569	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3547	W12X170	W12X170	0.581	1.000	0.581	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3548	W12X170	W12X170	0.570	1.000	0.570	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3549	W12X170	W12X170	0.529	1.000	0.529	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3550	W12X170	W12X170	0.503	1.000	0.503	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3551	W12X170	W12X170	0.390	1.000	0.390	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3552	W12X170	W12X170	0.375	1.000	0.375	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3553	W12X170	W12X170	0.087	1.000	0.087	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3554	W12X170	W12X170	0.122	1.000	0.122	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3555	W12X170	W12X170	0.718	1.000	0.718	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3556	W12X170	W12X170	0.789	1.000	0.789	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3557	W14X426	W14X426	0.932	1.000	0.932	Eq. H1-1b	6	806.450	274.71273E	98230.620	13777.260
3558	W12X170	W12X170	0.210	1.000	0.210	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3559	W12X170	W12X170	0.475	1.000	0.475	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3560	W14X426	W14X426	0.919	1.000	0.919	Eq. H1-1b	6	806.450	274.71273E	98230.620	13777.260
3561	W12X170	W12X170	0.819	1.000	0.819	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3562	W12X170	W12X170	0.745	1.000	0.745	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3563	W12X170	W12X170	0.108	1.000	0.108	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3564	W12X170	W12X170	0.075	1.000	0.075	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3565	W12X170	W12X170	0.368	1.000	0.368	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3566	W12X170	W12X170	0.386	1.000	0.386	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784
3567	W12X170	W12X170	0.503	1.000	0.503	Eq. H1-1b	6	322.580	68678.183	21519.164	1481.784

Table 29. Value of the highest member ratio

3.3.5 Bill of Quantities

: FOOTBRIDGE							
DESCRIPTION	QTY	UNIT	UNIT MATERIAL COST	TOTAL MATERIAL COST	UNIT LABOR COST	TOTAL LABOR COST	TOTAL COST
EARTHWORKS				**78,664.56**		**27,532.60**	**106,197.16**
Excavation	204.80	cu.m	-	-	550.00	112,640.55	112,640.55
Backfill & Compaction	108.90	cu.m	-	-	550.00	59,895.72	59,895.72
Gravel	46.86	cu.m	1,250.00	58,579.56	437.50	20,502.85	79,082.41
Sweet Soil	33.48	cu.m	600.00	20,085.00	210.00	7,029.75	27,114.75
CONCRETE WORKS (3000psi)				**3,168,030.00**		**1,108,810.50**	**4,276,840.50**
Concrete 3000 psi	201.00	cu.m	6,000.00	1,206,000.00	2,100.00	422,100.00	1,628,100.00
25mm dia. X 6.0m RSB	310.00	pcs	956.00	296,360.00	334.60	103,726.00	400,086.00
20mm dia. X 6.0m RSB	216.00	pcs	820.00	177,120.00	287.00	61,992.00	239,112.00
16mm dia. X 6.0m RSB	654.00	pcs	550.00	359,700.00	192.50	125,895.00	485,595.00
12mm dia. X 6.0m RSB	2,776.00	pcs	350.00	971,600.00	122.50	340,060.00	1,311,660.00
10mm dia. X 6.0m RSB	497.00	pcs	250.00	124,250.00	87.50	43,487.50	167,737.50
#16 G.I. Tie Wire	20.00	rolls	1,650.00	33,000.00	577.50	11,550.00	44,550.00
FORM WORKS				**508,548.00**		**177,991.80**	**686,539.80**
Plywood	106.00	pcs	850.00	90,100.00	297.50	31,535.00	121,635.00
Coco Lumber 12ft	882.00	pcs	180.00	158,760.00	63.00	55,566.00	214,326.00
Nails	42.00	box	1,750.00	73,500.00	612.50	25,725.00	99,225.00
Consumables	1.00	lot	32,236.00	32,236.00	11,282.60	11,282.60	43,518.60
Scaffolding	1.00	lot	153,952.00	153,952.00	53,883.20	53,883.20	207,835.20
ROOFING WORKS				**1,519,325.88**		**531,764.06**	**2,051,089.93**
Tubular 2x3x1.2mm	124.00	pcs	887.00	109,988.00	310.45	38,495.80	148,483.80
Tubular 2x2x1.2mm	81.00	pcs	646.00	52,326.00	226.10	18,314.10	70,640.10
2X3X1.2mm Thk C- Purlins	217.00	pcs	1,100.00	238,700.00	385.00	83,545.00	322,245.00
#24 Roof Gutter	121.00	pcs	1,200.00	145,200.00	420.00	50,820.00	196,020.00
0.5mm Ribtype Sheet	502.00	ln.m	550.00	276,100.00	192.50	96,635.00	372,735.00
Hardieflex Facsia	235.00	pcs	800.00	188,000.00	280.00	65,800.00	253,800.00
#24 Roof Flashing	250.00	pcs	700.00	175,000.00	245.00	61,250.00	236,250.00
Gutter Bracket	449.68	pcs	512.00	230,234.45	179.20	80,582.06	310,816.51
10mm Double Sided Insulation	11.00	rolls	3,000.00	33,000.00	1,050.00	11,550.00	44,550.00
Consumables	1.00	lot	70,777.42	70,777.42	24,772.10	24,772.10	95,549.52
STEELWORKS				**5,269,691.00**		**1,844,391.85**	**7,114,082.85**
W33x80	36.00	pcs	53,300.00	1,918,800.00	18,655.00	671,580.00	2,590,380.00
W10x15	105.00	pcs	6,800.00	714,000.00	2,380.00	249,900.00	963,900.00
Angle bar 3x3x6mm	27.00	pcs	1,500.00	40,500.00	525.00	14,175.00	54,675.00
Chanel bar 2x3x1.2	21.00	pcs	996.00	20,916.00	348.60	7,320.60	28,236.60
800x800x12mm base plate	4.00	pcs	3,500.00	14,000.00	1,225.00	4,900.00	18,900.00
Gi pipe 2"	19.00	pcs	1,195.00	22,705.00	418.25	7,946.75	30,651.75
3x3x1.2mmm tubular	150.00	pcs	1,050.00	157,500.00	367.50	55,125.00	212,625.00
12mm Steel Plate	151.00	pcs	15,770.00	2,381,270.00	5,519.50	833,444.50	3,214,714.50
ELECTRICAL				**290,950.00**		**101,832.50**	**392,782.50**
THHN Copper Wire 3.5mm2	1,176.00	m	40.00	47,040.00	14.00	16,464.00	63,504.00
20mm Ø UPVC	408.00	pcs.	280.00	114,240.00	98.00	39,984.00	154,224.00
32 W FLUORESCENT LIGHT	27.00	pcs.	2,500.00	67,500.00	875.00	23,625.00	91,125.00
32 W ALL WEATHER UPWARD LIGHTIN	23.00	pcs.	650.00	14,950.00	227.50	5,232.50	20,182.50
Two Gang Switch	6.00	set	410.00	2,460.00	143.50	861.00	3,321.00
Three Way Switch	6.00	set	410.00	2,460.00	143.50	861.00	3,321.00
Utility Box	40.00	pcs.	50.00	2,000.00	17.50	700.00	2,700.00
Junction Box	43.00	pcs.	50.00	2,150.00	17.50	752.50	2,902.50
Panel Board	1.00	pcs.	11,000.00	11,000.00	3,850.00	3,850.00	14,850.00
20 Ampere-Trip Molded-Case Circuit Breaker	2.00	pcs.	350.00	700.00	122.50	245.00	945.00
Consumables	1.00	lot	26,450.00	26,450.00	9,257.50	9,257.50	35,707.50
PLUMBING WORKS		.		**1,099,155.75**		**384,704.51**	**1,483,860.26**
75mm PVC Pipe	430.00	pcs.	1,000.00	430,000.00	350.00	150,500.00	580,500.00
75mm PVC Pipe Coupling	861.00	pcs.	405.00	348,705.00	141.75	122,046.75	470,751.75
75mm PVC Pipe Elbow	32.00	pcs.	85.00	2,720.00	29.75	952.00	3,672.00
100mm PVC Pipe	86.00	pcs.	1,500.00	129,000.00	525.00	45,150.00	174,150.00
100mm PVC Pipe Coupling	173.00	pcs.	560.00	96,880.00	196.00	33,908.00	130,788.00
100mm PVC Pipe Elbow	18.00	pcs.	120.00	2,160.00	42.00	756.00	2,916.00
100mm PVC Pipe Cleanout	11.00	pcs.	850.00	9,350.00	297.50	3,272.50	12,622.50
Dome Strainer	49.00	pcs	600.00	29,400.00	210.00	10,290.00	39,690.00
Consumables	1.00	lot	50,940.75	50,940.75	17,829.26	17,829.26	68,770.01
FINISHES				**1,569,253.64**		**549,238.78**	**2,118,492.42**
Steel Painting Works	2,475.90	sq.m	200.00	495,180.48	70.00	173,313.17	668,493.65
Concrete Painting Works	515.68	sq.m	550.00	283,621.80	192.50	99,267.63	382,889.43
Porcelain Tiles 60x60	1,735.00	pcs	200.00	347,000.00	70.00	121,450.00	468,450.00
Ceramic Tiles 60x60	1,172.00	pcs	100.00	117,200.00	35.00	41,020.00	158,220.00
Cement	196.00	bags	250.00	49,000.00	87.50	17,150.00	66,150.00
Sand	48.70	cu.m	1,500.00	73,050.00	525.00	25,567.50	98,617.50
Adhesive	400.00	bags	298.00	119,200.00	104.30	41,720.00	160,920.00
Tile Grout	137.00	bags	75.00	10,275.00	26.25	3,596.25	13,871.25
Consumables	1.00	lot	74,726.36	74,726.36	26,154.23	26,154.23	100,880.59
GRAND TOTAL COST:							**18,229,885.42**

Table 30. Bill of Quantities of the Footbridge

3.3.6 Bill of Materials

: FOOTBRIDGE		
DESCRIPTION	QTY	UNIT
EARTHWORKS		
Excavation	204.80	cu.m
Backfill & Compaction	108.90	cu.m
Gravel	46.86	cu.m
Sweet Soil	33.48	cu.m
CONCRETE WORKS (3000psi)		
Concrete 3000 psi	161.00	cu.m
25mm dia. X 6.0m RSB	310.00	pcs
20mm dia. X 6.0m RSB	9.00	pcs
16mm dia. X 6.0m RSB	654.00	pcs
12mm dia. X 6.0m RSB	2,371.00	pcs
#16 G.I. Tie Wire	17.00	rolls
FORM WORKS		
Plywood	106.00	pcs
Coco Lumber 12ft	882.00	pcs
Nails	42.00	box
Consumables	1.00	lot
Scaffolding	1.00	lot
ROOFING WORKS		
Tubular 2x3x1.2mm	124.00	pcs
Tubular 2x2x1.2mm	81.00	pcs
2X3X1.2mm Thk C- Purlins	217.00	pcs
#24 Roof Gutter	121.00	pcs
0.5mm Ribtype Sheet	502.00	ln.m
Hardieflex Facsia	235.00	pcs
#24 Roof Flashing	250.00	pcs
Gutter Bracket	449.68	pcs
10mm Double Sided Insulation	11.00	rolls
Consumables	1.00	lot
STEELWORKS		
W33x80	36.00	pcs
W10x15	105.00	pcs
Angle bar 3x3x6mm	27.00	pcs
Chanel bar 2x3x1.2	21.00	pcs
800x800x12mm base plate	4.00	pcs
Gi pipe 2"	19.00	pcs
3x3x1.2mmm tubular	150.00	pcs
12mm Steel Plate	151.00	pcs
ELECTRICAL		
THHN Copper Wire 3.5mm2	1,176.00	m
20mm Ø UPVC	408.00	pcs.
32 W FLUORESCENT LIGHT	27.00	pcs.
32 W ALL WEATHER UPWARD LIGHTIN	23.00	pcs.
Two Gang Switch	6.00	set
Three Way Switch	6.00	set
Utility Box	40.00	pcs.
Junction Box	43.00	pcs.
Panel Board	1.00	pcs.
20 Ampere-Trip Molded-Case Circuit Breaker	2.00	pcs.
Consumables	1.00	lot
PLUMBING WORKS		.
75mm PVC Pipe	430.00	pcs.
75mm PVC Pipe Coupling	861.00	pcs.
75mm PVC Pipe Elbow	32.00	pcs.
100mm PVC Pipe	86.00	pcs.
100mm PVC Pipe Coupling	173.00	pcs.
100mm PVC Pipe Elbow	18.00	pcs.
100mm PVC Pipe Cleanout	11.00	pcs.
Dome Strainer	49.00	pcs
Consumables	1.00	lot
FINISHES		
Steel Painting Works	2,475.90	sq.m
Concrete Painting Works	515.68	sq.m
Porcelain Tiles 60x60	1,735.00	pcs
Ceramic Tiles 60x60	1,172.00	pcs
Cement	196.00	bags
Sand	48.70	cu.m
Adhesive	400.00	bags
Tile Grout	137.00	bags
Consumables	1.00	lot

Table 31. Bill of Materials for the Footbridge

IV. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusions

After examining all the gathered data on the proposed footbridge in Brgy. Sta. Catalina, Lubao, Pampanga the following conclusions were drawn:

1. The footbridge design takes into account the typical ergonomic concerns faced by pedestrians and adheres to NSCP 2015, ASCE, and DGCS guidelines, incorporating both steel and concrete materials.
2. The study indicates a clear need for a safe crossing infrastructure, such as a pedestrian footbridge, along the JASA highway in Brgy. Sta. Catalina, Lubao, Pampanga. Local surveys revealed strong support for the footbridge, citing challenges pedestrians face, increasing pedestrian traffic, future area development plans, and the high volume of fast-moving vehicles.
3. Constructing a pedestrian footbridge in Sta. Catalina, Lubao, Pampanga, would greatly benefit pedestrians, especially students from DHVSU Lubao Campus, and staff from Lubao Municipal Hall. It would facilitate safer street crossings and enhance access to public facilities. Given potential future developments in the area, the footbridge's construction is deemed essential.

4.2 Recommendations

The study focuses on the architectural, electrical, and initial structural specifications of the proposed footbridge, along with manual calculations for structural member and frame analysis using STAAD.Pro V8i SS6.

However, the complete set of detailed plans, material quantities, construction budget, implementation management, and maintenance plan and management will not be covered in the research. As a result, the following recommendations are provided.

1. Conducting a real soil investigation on the proposed location, rather than relying simply on soil analysis from the closest structure in Brgy. Sta. Catalina, Lubao, Pampanga, would enhance the accuracy of structural analysis data.
2. It is highly recommended that the recipient of the study proceeds with designing elevators for individuals with disabilities, as the researchers did not address this aspect. Implementing elevators would greatly benefit persons with disabilities in the area.
3. Consider implementing advanced safety features such as pedestrian-friendly lighting and anti-slip surfacing to enhance the usability and safety of the footbridge, especially during nighttime or adverse weather conditions.

ACKNOWLEDGMENT

The researchers would like to express gratitude to all individuals whose contributions made the study possible. Throughout this journey, their unwavering support, invaluable insight, and constant encouragement have played significant roles. Furthermore, their expertise and meticulous feedback significantly enriched the quality of this research. Sincere appreciation is extended to the following individuals:

First and foremost, to our Almighty God for giving the researchers patience, protection, and strength to accomplish this study.

To Engr. John Robert D. Gabriel, the research coordinator, for his endless support, constructive feedback, and knowledge that contributed to the quality of our research.

To Engr. Francis Cayanan, the research adviser, for his invaluable insight, expertise, and pieces of advice that make the content of this study truly valuable.

To Ar. Janiel S. Serrano, for his assistance in the planning and design of the footbridge. His expertise and guidance were instrumental in shaping the project's success.

To Engr. Edel Dimarucut and Engr. Angelo Tolentino, for their continuous guidance and for helping us expand our knowledge through software applications.

To the panelist of the oral examination, for their critical feedback and recommendations during our presentation which lead to the improvement of our study.

To all our family, relatives, friends, classmates and loved ones who serve as an inspiration and source of motivation and for their invaluable emotional, physical, and financial support throughout this journey.

And finally, the researchers wish to acknowledge everyone who was not named but helped make this study possible.

- The Researchers

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