Proposed Multi-Storey Terminal Parking for PUJs To Alleviate Traffic Congestion in Plaza Burgos, Guagua, Pampanga

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Abstract— Plaza Burgos in Guagua, Pampanga has high demand for public transportation. However, the space around it is not large enough to accommodate all vehicles. Having no permanent terminal for PUJs forced them to park on the road shoulder, which caused the main road to be congested. Conducted Cordon Volume Counts (CVC) and Short-Term Counts resulted in a low Peak Hour Factor (PHF), indicating unstable traffic flow within the area. The Black Hole Theory of road investment, also known as Braess' paradox, states that adding a road to a road network may restrict its flow. The solution is building more parking lots, such as vertical infrastructures, to provide better facilities and relieve traffic congestion. The researchers designed a three-story terminal car parking conforming to codes in NSCP 2015, UBC 1997, AISC, and ASEP with the aid of STAAD. The proponents concluded that designing a steel structure for terminal parking is lightweight, and its structural components improve the structure's sustainability. These building materials have advantages over other materials, including minimizing weight while maintaining high mechanical strength, permitting modular pieces, improving quality control, making prefabrication easier, eliminating moisture-related dimensional changes, and being inexpensive.

Indexed Terms— Queuing, Steel Structure, Structural Analysis and Design, Traffic Manual Counts

I. INTRODUCTION

In urban areas, the unavailability of public utility vehicle terminals has become a major concern in all areas urging passengers to stay and wait on roadsides or curbs for public vehicles. In some cases, loading and unloading on the roadside tends to lead to traffic congestion, obstructing traffic movement. The land transportation system is essential for economic events and the movement of goods, services, and individuals within and between areas, particularly in the Province of Pampanga. Transport terminals are some of the most important parts of the physical infrastructure for the smooth operation of people and goods transportation, and they can take up much space on land.

The biggest cities in the Philippines commonly suffer from traffic congestion, but several steps can be taken to decrease the problems it causes.

One of the boundaries where many commuters keep passing is the Municipality of Guagua, which is bounded on the north by the townships of Bacolor and Santa Rita; the municipalities of Sasmuan and Lubao on the south; by Macabebe and Sasmuan on the east; and on the west by Porac and Floridablanca.

As commuters, many employees and students travel around Plaza Burgos in Guagua, Pampanga, which causes the demand for public vehicles to increase. Two public transportation modes are used in Guagua: Public Utility Jeepneys (PUJs) and tricycles.

One of the issues the Municipality of Guagua is currently dealing with is traffic congestion and jams, particularly in Plaza Burgos. There are a lot of schools, stores, markets, and establishments accommodating many people's daily needs in Plaza Burgos. The Municipality of Guagua is considered one of the fastest-growing municipalities in Pampanga. However, the town, Plaza Burgos, has a small floor area to accommodate all the infrastructures needed for economic development and transportation.

Originally, the Zone 3 terminal was located on Ceferino de Mesa Street. Upon the contract's expiration, the landowner decided to construct an establishment instead of leasing it for a terminal. As a result, many commuters and jeepneys are actively involved in Guagua's transportation system. However, the jeepneys are left with a temporary terminal on the main road of Plaza Burgos. In line with this, the researchers proposed a vertical structure as terminal parking for the PUJs to have permanent shelter for the public vehicles and to maximize the width of the main road for the moving vehicles.

It is written in the Comprehensive Land Use Plan of Guagua that the Municipality of Guagua attracts a significant quantity of vehicle traffic due to its quite large resident population and the primarily service-oriented economy in the Central Business District. Thus, mobility and accessibility are one (1) of Guagua’s important concerns. Moreover, economic development, continuing population growth, and consistent upturns in vehicular trips that are internally generated or transitory through the town put pressure on the town’s accessibility and local circulation and local circulation. Therefore, it is a great distress that any further progress in the town must be maintainable in terms of its traffic-carrying capacity, or plans are identified to alleviate probable severe congestion.

The Traffic Volume Count of the Plaza Burgos, Guagua, Pampanga was conducted through the means of Cordon Volume Counts (CVC) and Short-Term Counts wherein the researchers manually counted all the vehicles that passed in streets that covered the Inner Cordon Line of the study. The peak hour factor was solved to determine the traffic flow around Plaza Burgos.

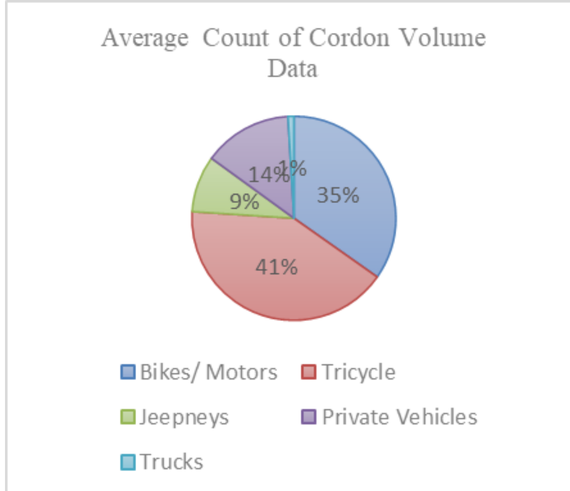

Fig. 1. Average Count of Vehicles in 1 Hour

The previous figure shows that the highest counted within 1 hour is the tricycle, one form of public transport in Guagua. The road also accommodates at least 9% of the jeepneys as the main public transportation for commuters around the area or just bypassing the area.

The table below shows how many jeepney trips per day cater to the transportation needs of commuters.

Table I. Average Jeepney Trips per Day

DAY	JEEPNEYS
1st Day	706
2nd Day	820
3rd Day	722
4th Day	816
5th Day	942
6th Day	931
7th Day	920
Average:	836.7142857

The data shows the importance of having a good transportation system in Guagua, Pampanga. Since the average number of trips per day of jeepneys is around 837, trips convey that the demand for public transportation is quietly high; thus, not having a proper transportation terminal for these jeepneys contributes to the traffic flow of Guagua.

Using the side part of the road as the terminal for 13 associations occupied the space intended for moving vehicles. Though the Municipality allowed the jeepney drivers to use some space on the road to becoming their terminals, it only caused heavy congestion. Road widening to ease congestion is impossible in Plaza Burgos because it has already reached the maximum width it can occupy.

Therefore, the researchers came up with the topic of proposing multi-story terminal parking to accommodate public vehicles and help alleviate the traffic congestion in Plaza Burgos.

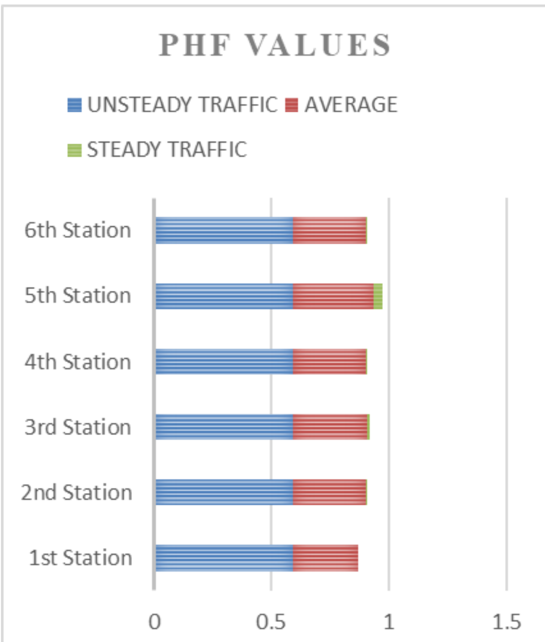

Fig. 2. Average PHF Values of Six Stations

The Peak Hour Factor graph that shows above overviews the stations in which station it has unsteady traffic, average traffic, and steady traffic. In this data, the 5th station has steady traffic, which means that the speed is not restricted, although maneuverability has somewhat diminished. This station is the street before turning left and going to the proposed terminal parking. In determining the location of the proposed structure, the researchers investigated traffic flow using the CVC data and peak hour factor.

Data relevant to the study was collected with the help of the Traffic Management Unit, the Office of the Sangguniang Bayan, and some authorities of the Municipality of Guagua. To use the data gathered, the researchers analyzed and designed the structure using AUTOCAD (for the architectural plans) and STAAD.Pro V8i (SELECT.series6) (for the Structural Analysis and Design). The proponents deliberately planned and studied the routes thoroughly of the public vehicles, the Site and Location Analysis Approach, and Typological Approach before the design itself.

This study is intended to encourage the local government to start considering maximizing the land use and spaces in the municipalities that are rapidly growing.

II. REVIEW OF RELATED LITERATURE

A. Transportation System and Facilities

In the Philippines, Public Utility Jeepneys (PUJs) is the most accessible mode of public mass transit, carrying passengers to their destinations for the least amount of money. The continued rise of urban activities necessitates accommodating commuter movement around the clock. However, movement inside the area became increasingly difficult due to the ongoing expansion of urban activity. The growing number of people living in cities and the increasing number of private automobiles make transportation issues in cities worldwide more pressing than ever. With urbanization starting in the 1990s, when the Philippines' economy grew more quickly, a demand for effective transportation infrastructure and vehicles emerged. Due to the demand, there is an unmanageable rising volume of PUJs and non-franchised vehicles traveling on limited roadways, resulting in traffic congestion within an area [1].

Congestion on the roads is a problem that never goes away. It is a common issue for various forms of transportation and terminals. It causes delays, lost time, stress, energy use, environmental pollution, etc. Parking spaces are abundant on both sides of the street. The capacity of the carriageway has been reduced, putting pedestrians and motorists in danger. Improving traffic management and simulating and optimizing traffic control are required to reduce traffic congestion. Government authorities and administrative divisions demand a serious discussion about this certain issue. It is a problem that negatively affects the nation's economy and motorists [2].

The morning queue appears an accepted aspect of car traveling; everyday commuters often adjust their habits to live in the queue. Queues and parking issues are both effects of the popularity of the automobile. They are the effects of congestion, which is an unintentional result of a car-based transport system [3].

Today's urbanized communities are one of the most serious and obvious issues to solve urban transportation issues. While mobility is an important aspect of a society's socio-economic development, it is now widely acknowledged that the huge rise in private cars and mass transit over the past several years has resulted in new, more intense pressures on urban life [4]. Even if the economy of the Philippines is constantly expanding, if the problem of traffic congestion persists and gets worse, the nation could lose up to 6 billion pesos per day by 2030.

With the expansion of the number of public and private modes of transportation that leads to traffic congestion is the demand for parking places and transportation facilities. Parking is becoming increasingly difficult due to the annual rise in car ownership. Parking spaces are unavailable in small areas. Every car will park in multiple locations, including those at home, the office, the grocery store, etc. There are more automobiles on the road, and as cars are used more frequently in daily life, more parking spaces are needed for every vehicle [3]. Large megacities are afflicted by urgent issues like a severe lack of open spaces and parking spots. Many fewer spots are available than the number of vehicles that wish to leave their vehicle in the parking lot [5].

The solutions do not lie in adding more traffic signals or police but rather in building more parking lots with technical or creative solutions. It is necessary to make changes or adopt innovative countermeasures for parking-related issues, such as multi-level parking systems to provide better facilities and relieve traffic congestion [6]. The construction of vertical infrastructures changed progressively due to technological advancements. These structures are popular in urban areas because engineers and architects must work in limited spaces. In addition, horizontally built structures occupy more space than vertically built rises [7].

Multi-story car parks should be established to help solve and reduce some of the factors and issues that limit traffic management systems in urban centers, for instance, increase in the use of various forms of transportation, congestion, and lack of parking spaces [8]. The importance of creating and organizing multi-level parking lots is considerably increased by the lack of available free parking spaces and parking spaces for parking lots [5]. Furthermore, in Medan City, Indonesia, one approach to reducing traffic congestion is the design of vertical parking buildings. It can satisfy the need for parking places, which is frequently a challenge for drivers in finding a parking space.

Land ownership is one of the core components influencing how road space and parking are organized in an area. When parking spots are on municipal property, access to them on the grounds is theorized to be open to all interested persons. When a car park is located on property owned by a housing cooperative or community, this organization may, with the support of the residents, take action to control it. Parking spaces may also belong to a developer, who offers them for purchase alone or in conjunction with purchasing a property on the specified site. Therefore, the type of land ownership—in terms of the buildings, their surroundings, and the estate's common areas—becomes a formal framework for parking regulations [9].

Given the limited amount of space to construct new projects in inner-city locations, multi-story parking structures located there have tremendously desirable ground. This worth is based on the surrounding market's demand, the location's appeal, and other factors. When an existing adaptive infrastructure is present, such as multiple multi-story parking garages, only inner-city property becomes beneficial [10]. Parking is considered to be quite expensive from a property resource aspect. As a result, other financing sources are typically required to support the construction of parking buildings. In certain areas, parking space can be priced according to the user market, and parking garages can be a comparatively growing organization [11].

Regarding car parks, security, and safety have been crucial factors that come into play. This is especially true when the needs of pedestrians within parking structures are considered more. Addressing the physical proportions of the building, which are currently based on the automobile and related to planning betterment, is a considerable problem. The inadequate layout of ramps and staircases is the most frequently stated issue with multi-story parking structures. Its stability has been identified as a major factor in the engineering phase [12].

Prioritizing resources in non-motorized and public transportation above those in private transportation at a preliminary phase can have significant long-term advantages. Suppose the scale of motorization can be purposefully decelerated, especially during the early stages of the process, which frequently accompany periods of high economic expansion and urbanization. Such development goals are made considerably easier to implement in developing areas. Regions that are already huge and crowded—as is quite typical in cities throughout the low-income portions of the world—need better-balanced transportation systems more than ever since densely populated cities are highly prone to the adverse effects of congestion [13].

Steel-framed car park buildings without active or passive fire protection is recently common. The projected design is contrasted with a strategy that has frequently been pragmatic in many occurrences for car parks made using unprotected steel. Based on research into fire loads of contemporary cars, the fire load density was used to establish the structural design of parking buildings. Steel design structures are significantly safer than concrete, in accordance with the knowledge of the fire load and performance of cars [14].

Steel construction in Europe grows more quickly than concrete for multi-story parking. They control the structural stability established by the fire safety regulations in France, remarkably reducing the economics of steel solutions. The Centre Technique Industriel de la Construction Metallique (CTICM) and other European partners have introduced the significant performance of composite steel and concrete structures under natural fire conditions, demonstrating an odd behavior. The findings show that the first steel-frame parking in Paris was permitted in 2000 [15].

Steel-Framed or Light Steel-Framed structural components improve the sustainability of a structure. These materials, which have a great deal of potential for reuse and recycling, not only enable us to preserve the environment and natural resources. These building materials have advantages over other materials, including minimizing weight while maintaining high mechanical strength, permitting modular pieces, improving quality control, making prefabrication easier, eliminating moisture-related dimensional changes, and being inexpensive. Steel has a high heat conductivity, which could be a disadvantage if not properly planned and implemented because it could result in thermal bridges. Applying continuous thermal insulation when building light steel-frame such as slabs and walls is crucial [14].

Hot-rolled steel may easily be altered into any desired shapes and sizes since it is rolled above the temperature at which it recrystallizes. These types of steel are thicker than cold-formed steel, so they are typically used for large beams and columns, railway tracks, and other steel sections that do not need to be as accurate in size and shape as cold-formed steel. Hot-rolled steel is also widely used in industrial buildings, roof sheeting, floor decking, and prefabricated frames or panels. Cold-formed steel is sometimes referred to as light gauge steel constructions. On the other hand, cold-formed steel is typically thinner and spans from 0.4 mm to 6.4 mm. Compared to hot-rolled parts, cold-form sections are more susceptible to local bending. [15].

Hot-rolled steel and steel bars, or high-strength steels, have stated that many influencing factors, such as heating temperature, chemical composition, steel type, manufacturing process, cooling method, loading history, etc., will affect the final residual properties. According to Mechanical properties of hot-rolled and cold-formed steels after exposure to elevated temperature [16].

The suggested connection contains a beam end plate and stiffeners, with the end plates being used for structural assembly through bolting the usage stiffeners to reduce the trade-off of a pure end-plate connection due to its poor strength and stiffness compared to the welded connection [17].

III. METHODOLOGY

The research study was conducted in three phases: Phase 1 - Data Gathering, Phase 2 - Design and Analysis for Vertical Terminal Parking, and Phase 3 - Assessment and Evaluation of Proposed Plan.

Phase 1: Data Gathering
The beginning of the research process is data gathering. This phase is divided into five (5) stages: request municipal ordinances implemented for vehicles; measure the traffic characteristics using Cordon Volume Counts and Short-Term Counts; classify the routes that are associated with the study; determine the average number of jeepney trips per day; and review the specifications needed to design the structures based on NSCP 2015 and identify the parameters.

Stage 1: Request municipal ordinances implemented for vehicles.
In this stage, the researchers refer to the municipal ordinances implemented for vehicles. With this, the researchers identified the traffic directions, provision in on-street parking areas, loading and unloading zones, and obstructions, which was considered.

Stage 2: Measure the traffic characteristics using Cordon Volume Counts and Short-Term Counts.
Cordon Volume Counts (CVC) measure the traffic counts at an assigned area that flows in one direction to know how vehicles and people travel across the region. The gathered data includes the number of vehicles and passengers that drive various types of vehicles and modes of transport. In obtaining the needed data, all vehicles entering and departing the inner cordon line were noted for the survey.

On the other hand, Short-term Traffic Count is conducted over a limited period, usually a week or less. Some are done manually by hand-tallying the observation of vehicles. This method is executed by using field sheets for traffic count, identifying where it was collected, and knowing what type of data was accumulated. Then, a report is made according to the classification of vehicle counts.

The researchers applied both methods in collecting the required data. Using the Cordon Volume Count and Short-term Traffic Counts combined, accumulating data that enters and exits the designated location within the given time limit was conducted for seven (7) days

Fig. 3. shows the cordon line in the following barangays of Guagua that are relevant in the study: Sto. Cristo, Plaza Burgos and Sto. Niño.

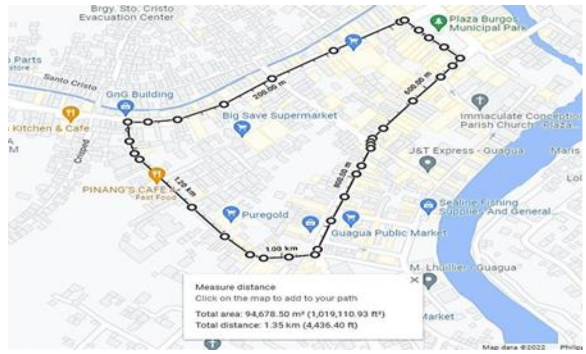

Fig. 3. Cordon Line Map

After gathering the figures, the researchers computed Peak Hour Factor (PHF) to determine the steadiness of the traffic. The PHF calculates the reliability of the data on the number of vehicles on a certain period where:

$$\text{PHF} = \frac{V}{\textit{Maximummum flow rate}} = \frac{V}{4 \times V_{m15}}$$

Where:
V = hourly volume in veh/h
Vm15 = maximum volume during the peak 15-min of the analysis period (veh/15-min)
Veh/h = vehicle per hour
The proponents collected the statistics taken from one (1) hour of the peak hour that has fifteen (15) minutes intervals. The PHF is then classified using the following figures:

If PHF is equal or close to 1, it indicates steady traffic. The lower the PHF, the more unstable the flow.

The average PHF for a hypothetical small town is within the range of 0.63 to 0.90.

Stage 3: Classify the routes that are associated with the study.

The researchers evaluated the routes of jeepneys utilizing a geological map. Determining the routes is necessary to know the possible entrance and exit directions of PUJs in the route flow planning process. The following were the associations involved in the study and were catered with the proposed structure:

Table II. Jeepney's Associations

ASSOCIATIONS	PRESIDENT
Diladila Jeepney Drivers Association	Nhar Mercado
San Basilio Jeepney Drivers Association	Ricardo Sampang
Gasak Driver Association	Ernie Lumba
Guagua – Bacolor - SM	Ferdinand Manalansan
Guagua – Betis – Bacolor Transport Coop	Eduardo Beller
Plaza Lubao, Guagua	Almario Bartolome
Pasbul Lubao, Guagua	Alfredo Vitug
Dinalupihan Sta. Cruz Lubao	Vice Pres. Eric Bamba
Dau Maquaipo - Guagua	Benito Acedera
Floridablanca	Allan Fajardo
Ebus/ Natividad, Guagua	Jerry Bacani
Pulungmasle/ Lambac - Guagua	Wilson Cortez

Stage 4: Determine the average number of jeepney trips per day within the zone.

The PUJ drivers conduct an every-day tally of operating jeepneys since not all are allowed to operate within a specific day due to car coding. This data is summed up for seven days to get the average number of traffic entering the area daily.

Stage 5: Review the specifications needed in designing the structures based from NSCP 2015 and identify the parameters needed.

Seismic load analysis determines the additional stresses or deformations that an earthquake would produce to see how a structure would react during an earthquake. Considering that, Seismic Importance factor table 208-1 from NSCP 2015 is the reference.

In order to increase the yield level for significant structures, the seismic importance factor is utilized in the calculations for the seismic response coefficient. It is a multiplier used to vary the design base shear in accordance with various occupancy classes or a building's important class. Using the Figure 208-1 Referenced Seismic Map of the Philippines to determine whether the proposed structure will be located in Zone 2 or Zone 4 and to establish the seismic zone factor, table 208-3 from NSCP 2015 is used.

Two seismic zones separate the archipelago of the Philippines. Zone 2 comprises the provinces of Palawan (apart from Busuanga), Sulu, and Tawi-Tawi, whereas Zone 4 encompasses the remaining part of the Philippines.

Near-source factors depend on the earthquake's magnitude and proximity to a seismic source. These variables are also based on the faults' rate of activity. Thus, the Near-Source Factor, Na, and Nv values based on Table 208-5 and Table 208-6 of NSCP 2015, respectively.

The seismic coefficients gauge the expected ground acceleration at the site. The seismic zone and kind of soil profile affect the coefficient and, consequently, the anticipated ground accelerations. Hence, to establish the values of Ca and Cv, after determining the soil profile type and the seismic zone, the proponents referred to the NSCP 2015' Table 208-7 and Table 208-8, respectively.

Earthquake-Force-Resisting Structural Systems generally refer to a series of vertically oriented structural elements above the foundation that are anticipated to work as a unit to withstand design earthquake stresses and inter-story drifts. Therefore, the proponents used the parameter based on Table 208-11B (Earthquake-Force-Resisting et al. of Steel).
One essential consideration in designing the structure is the loads that the structure carry. And with that, the researchers used the Load Combinations Using Load and Resistance Factor Design, considered the structure period, and used Table 204-1 Minimum Densities for Design Loads from Materials, and Table 204-2 Minimum Design Loads that can be found in NSCP 2015.

Phase 2: Design and Analysis for Vertical Parking
The second phase is the analysis and design of vertical parking. This part is focused on the land use and

design of the structure. It has four (4) stages: setting the characteristics and compatibility of the chosen area for the parking space using the Site and Location Analysis Approach; designing the architecture of the proposed vertical structure as terminal parking for PUJs based on the function and geometry of the building using the Typological Approach; assign the properties of steel members accordingly; design the structural framing plan, structural members and connections in accordance of assigned loads.

Stage 1: Setting the characteristics and compatibility of the chosen area for the parking space using Site and Location Analysis Approach

This method is taken by observing the location and area in depth by outlining the individual components, namely surveying and site visitation. The course of surveying and examining the current environment to determine how it affected the building design, structure, and site layout is known as site analysis. The site visit is typically the initial step in any design process. After a site visit, a thorough site analysis must be performed to understand the site's aspects fully. When designing, these features are significant.

The site analysis and location approach is the process of analyzing the contextual factors that impact a building, such as how to place a building on a site, the shape of the building, the layout and orientation of building spaces, and the articulation of its enclosure.
Collecting physical site data is the first step in any site survey or analysis.

Design the architecture of the proposed vertical structure as terminal parking for PUJs based on the function and geometry of the building using Typological Approach.

The data gathered in Phase 1 is used in the typological approach to finalize the structure's design. This strategy was implemented by determining the typology of the vertical building for parking that was designed with function and geometry in mind. This method's goal is to enable a complete understanding of the design object.

Stage 3: Assign the properties of steel members accordingly.

In designing the steel structure, the properties of steel members should be assigned accordingly. With the help of ASEP: Columns, Beams, and Girders were assigned using the W Shapes Dimensions and Properties. However, the design for floor joists refers to Channels (American Standard) Dimensions and Properties. As for the bracing, the proponents refer to Pipe Dimensions and Properties to determine its material specification according to ASTM and the parameters of bracing.

Stage 4: Design the structural framing plan, structural members and connections in accordance of assigned loads.

Based on LRFD specification, the design process of structural members for various cross sections and connections is examined. The proposed multi-storey terminal parking for PUJs was designed with every article of the code considered.

Phase 3: Assessment and Evaluation of Proposed Plan
The last phase of this study is the analysis and evaluation of the proposed plan which consists of three (3) stages: create a route flow plan for the jeepney associations involved; analyze the structural designs with the aid of STAAD and NSCP 2015 as reference; and estimate the bill of materials.

Stage 1: Create a route flow plan for the jeepney associations involved.
This stage is important to be considered since the current location of the temporary terminals of PUJ associations included in the study will be relocated on the site of the proposed multi-storey terminal parking structure. Considering the ordinances of the municipality and the flow of the movement of vehicles, the entrance and exit routes of the PUJ associations was planned accordingly.

Stage 2: Analyze the structural designs with the aid of STAAD and NSCP 2015, UBC 1997 and AISC as reference and specifications.

After designing the structural and assigning the properties of it, the proposed structural design needed to undergo structural analysis and design to make sure the factor of safety of the proposed terminal and the adequacy of the materials on structural members. The result of the structural analysis and design is calculated and provided by the Staad after the assigning load combinations and designing proper and will be discussed to conclude the factor of safety of each members' analysis.

Stage 3: Estimate the Bill of Materials
In proposing a structure, it is essential to present a bill of materials to know the construction project's cost. The materials' quantity and total cost were estimated by the researchers using Microsoft Excel.

IV. RESULTS AND DISCUSSION

(1) PHF Values

A. Station 1

Table III. PHF Values at Station 1

Day	PHF
1st	0.779166667
2nd	0.906458797
3rd	0.776132404
4th	0.930650685
5th	0.970779221
6th	0.767026578
7th	0.968534483
PHF	0.8712

The 1st, 3rd, and 6th day have the lowest PHF measured and had a very low PHF because the numbers of vehicles were lesser than the other days computed. The Average Peak Hour Factor (PHF) is 0.8712. This value indicates that the traffic flow in this station has more inconsistent traffic flows.

B. Station 2

Table IV. PHF Values at Station 2

Day	PHF
1st	0.964454976
2nd	0.911504425
3rd	0.801744186
4th	0.905054645
5th	0.87773224
6th	0.937279152
7th	0.942994505
PHF	0.9058

For station 2, there is little difference in the values because almost all were computed at 0.90 and above. Even though the numbers are close to 1, it still means there is uncertainty with the traffic flow. The 3rd and 5th days have had a lower PHF than the others. This data means that the traffic in this area is not consistent. The Average Peak Hour Factor (PHF) is 0.9058.

C. Station 3

Table V. PHF Values at Station 3

Day	PHF
1st	0.93387471
2nd	0.930155211
3rd	0.938333333
4th	0.916847826
5th	0.834767642
6th	0.95
7th	0.866180049
PHF	0.9100

The Average Peak Hour Factor (PHF) is 0.9100. It may be slightly higher but it is still below 1 and it concludes that the traffic flow is still inconsistent. In this station, the 5th and 7th days have inconsistent traffic flow. Again, in these data, there is still no one still reached the PHF of 1.

D. Station 4

Table VI. PHF Values at Station 4

Day	PHF
1st	0.873313343
2nd	0.9704
3rd	0.915134371
4th	0.90679677
5th	0.948313783
6th	0.813006073
7th	0.898348158
PHF	0.9036

This station has one of the highest PHF recorded, with a value of 0.9704 on the 2nd day. Moreover, the lowest PHF is on the 6th day, with 0.8130. As shown in the table of the number of vehicles, it can be observed that the data on the 6th day are the highest in this station, but the outcome was a lower PHF. The Average Peak Hour Factor (PHF) is 0.9036. The traffic flow is still uncertain because the PHF is below 1.

E. Station 5

Table VII. PHF Values at Station 5

Day	PHF
1st	0.924342105
2nd	0.975917431
3rd	0.903846154
4th	0.967479675
5th	0.94809322
6th	0.912593985
7th	0.926070039
PHF	0.9369

With the data gathered in this specific station, the numbers are all above 0.90. It means that the traffic flow in this area is becoming more stable compared to the other stations. However, even when the flow is becoming more stable, the data area is still below 1, indicating the traffic still has some unsteadiness. The Average Peak Hour Factor (PHF) for this station is 0.9369. The value in this station is the highest among all the other stations; therefore, it has a lesser discrepancy in traffic flows. The Peak Hour Factor (PHF) is 0.9369. The value in this station is the highest among all the other stations; therefore, it has a lesser discrepancy in traffic flows.

F. Station 6

Table VIII. PHF Values at Station 6

Day	PHF
1st	0.870598592
2nd	0.945414847
3rd	0.833575581
4th	0.845901639
5th	0.928571429
6th	0.973290598
7th	0.916984733
PHF	0.9020

This station's PHF data is almost divided into less stable and more stable. The 1st, 3rd, and 4th day PHF are when the traffic is not as smooth as the 2nd, 5th, 6th, and 7th day PHF. The 6th day has the highest counted PHF in this area, showing a much more manageable traffic flow. The Average Peak Hour Factor (PHF) is 0.9020. The value is still lower than 1. Therefore, the flow of traffic is still at inconsistent pacing.

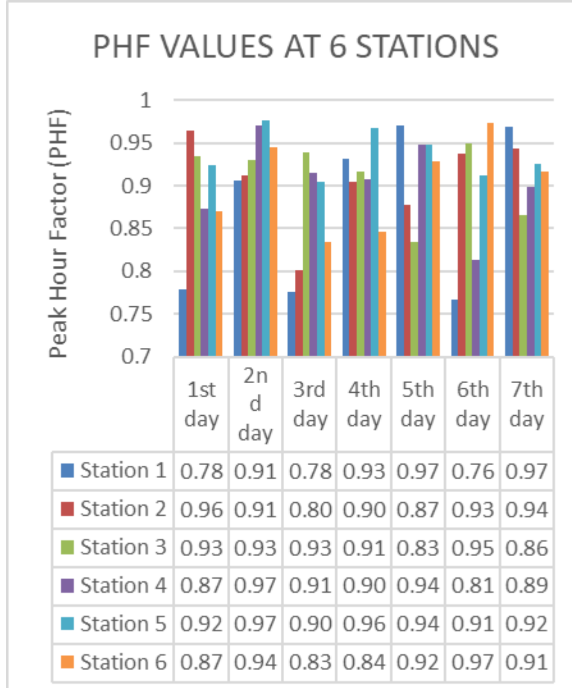

Fig. 4. PHF Values of Six Stations

The consistency of the values of the Peak Hour Factor (PHF) is shown in the graph above. On the first day, Station 2 had the highest value with 0.9645, and Station 1 had the lowest value with 0.7792. The highest value on the second day is Station 5 with 0.9759, and the lowest is 0.9065 in Station 1. The peak on the third day is Station 3 with 0.9383 and Station 1 with 0.7761 on the lower side. On the fourth day, Station 5 has a more consistent flow with 0.9675, while Station 6 has the lowest with 0.8459. The fifth day has the highest PHF of 0.9708 at Station 1 and the lowest PHF of 0.8348 at Station 3. On the sixth day, Station 6 had more consistency in traffic flow with 0.9733, while Station 1 had a lesser consistency with 0.7670. Furthermore, lastly, on the seventh day, the peak PHF is at Station 1 at 0.9685, and on the bottom is Station 3 at 0.8662.

Comparing all the data and values garnered in this study, the Peak Hour Factor (PHF) with the highest number on Station 5 is 0.9759. This data means that the traffic flow in the location is much smoother and more consistent than all the other stations. Moreover, the station with less consistency and uncertainty is station 1, which has a value of 0.7670. The flow in this station is different from station 5 because it has a lower

PHF. The more discrepancy that was correlated to 1, the more unstable the traffic flow.

(2) Current Routes and Proposed Routes

Usually, traffic affects the choice of route of public utility vehicles, but the routing system can also contribute to congestion. The following illustrations show the current route and the planned routing system for PUJ's around Guagua, Pampanga.

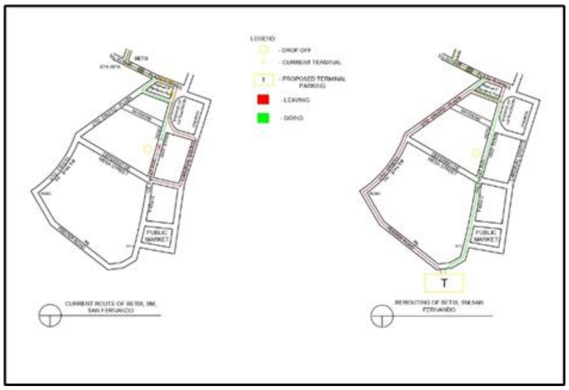

Fig. 5. Betis, SM, San Fernando Routes

The first figure shows the current route of Betis, SM, and San Fernando terminals. The jeepneys enter the narrow road, go around the plaza, and use the same road to drop off passengers and leave the circle. The second figure on the right is the planned route, considering the width of the road to reduce traffic and the location of the proposed terminal parking space. The new route for this association has a longer distance than the current route, but it may also be effective since the queuing of vehicles around the plaza was lessened, and it may have a smooth flow since there are no parked jeepneys on the side of the main road.

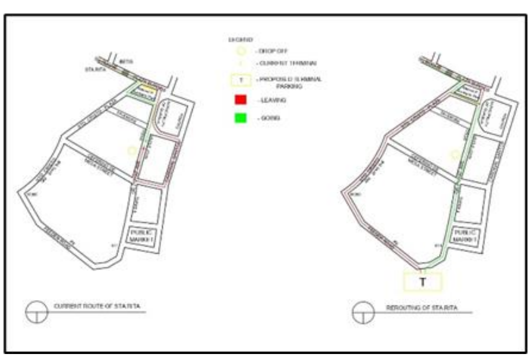

Fig. 6. Sta. Rita Routes

The current route of Sta. Rita terminal passes Plaza Burgos, using the same road to drop off and leave the area. This causes more traffic because the drop-off is in the middle of Gil Puyat Avenue road. The planned route considered the available road to the terminal parking and the traffic flow in the area. The new routes for the associations of Sta. Rita has the same new routes for the Betis, SM, and San Fernando associations. It also has a longer distance than the current ones. These two associations occupied the same lane in Plaza Burgos, where they are currently parked. Since the Municipality of Guagua has the ordinances implemented of only "One Way" lanes, the researchers shall consider rerouting jeepneys from the proposed terminal parking, causing the distance to be longer than before.

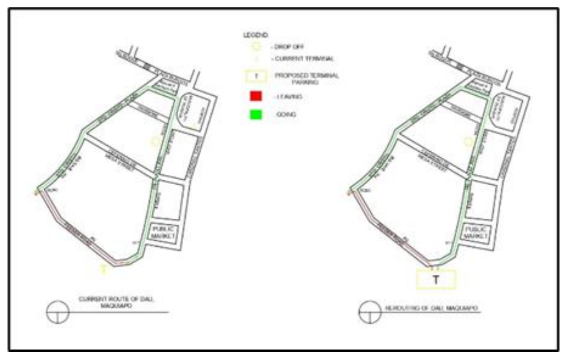

Fig. 7. Dau, Maquaipo Routes

Dau and Maquiapo terminal's current route is not as different from the planned route considering the terminal. The current terminal used by the associations of Dau-Maquaipo Associations was already located at the location of the proposed terminal parking. The additional parking space will help the jeepney associations find space for their drivers and passengers to have easier access to the terminals.

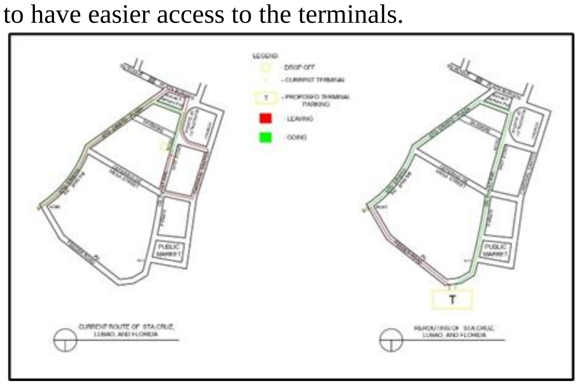

Fig. 8. Sta. Cruz, Lubao, Florida Routes

Sta. Cruz, Lubao, and Florida terminal's current routes are not as wide as planned. The problem causing the traffic is that the PUJs pass the same road to go and leave the plaza, which is the Sto. Cristo road, as seen in the figure. The planned route focuses on giving a much more organized and wider road for jeepneys around Guagua, also considering the location of the terminal parking space.

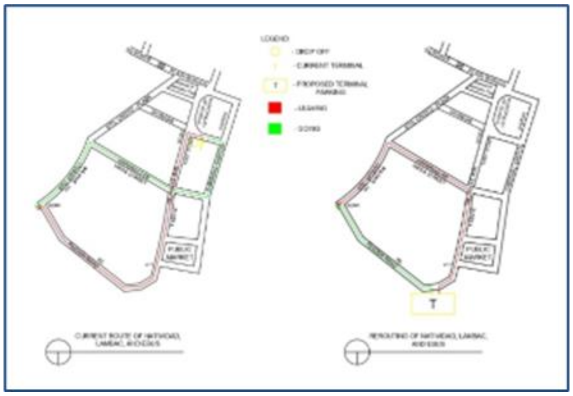

Fig. 9. Natividad, Lambac, Ebus Routes

The current route of Natividad, Lambac, and Ebus passes the feeder road, Sto. Cristo, Cardinal Santos Avenue, and Gil Puyat Avenue. The proposed planned road for the terminal is straight from where the jeepneys enter Guagua to the terminal parking space.

The alternative routes shown above were devised while considering the location of the terminal parking. The researchers also paid attention to the width of the chosen roads for the rerouting that will accommodate the size of the public utility jeepneys. This rerouting plan also considered the drop off of the passenger around the area to have access to public markets, stores, schools, school supplies stores, and fast foods or restaurants where everyone can eat.

(3) Architectural Perspective

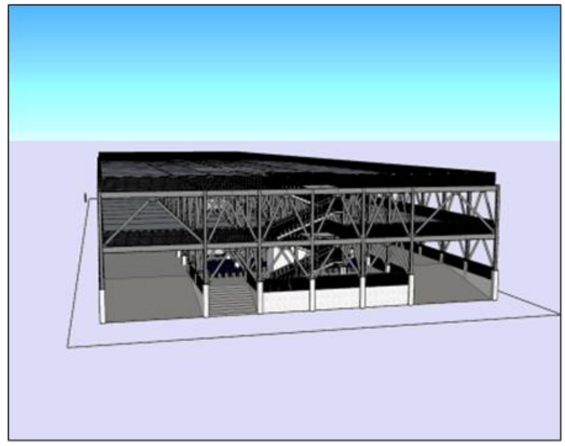

Fig. 10. Architectural Rendered View

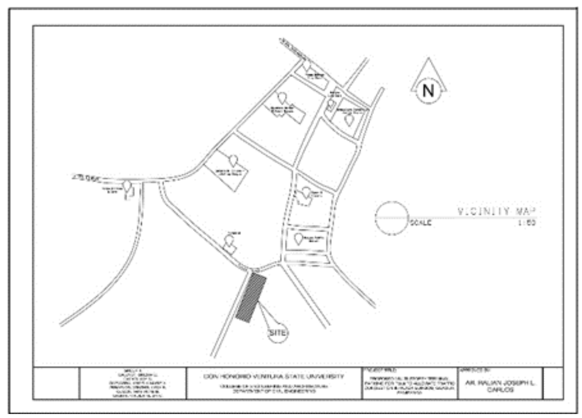

Fig. 11. Vicinity Map

The architectural perspective presented on the previous page of this paper and the vicinity map was designed and considered thoroughly. The site location, the Cervantes in Feeder Road, was chosen among the vacant lots around the area since it can accommodate the jeepneys that travel, stay, and wait for passengers in the area. Considering the wider space is important since the structure's occupants will be the jeepneys with a maximum dimension of 3x9 meters parking spot.

(4) Structural Analysis and Design

It is important to check the adequacy of the materials used for properties for the factor safety of the structure considering the design loads. The proponents used the software STAAD.Pro V8i (SELECTseries 6) for the structural design and analysis incorporated with the following specifications: NSCP 2015, UBC 1997, and AISC.

The materials listed below passed the analysis of the STAAD. Therefore, using it and building the proposed multi-storey terminal parking is safe

Table IX. Structural Loads

1. GRAVITY LOADS	
1.1 DEAD LOADS	
CONCRETE	23. 6 kPa
COLUMN W12X190 W12X252 W12X305 W12X210 W14X500 W36X848 W14X605	 283 kg/m 375 kg/m 454 kg/m 313 kg/m 744 kg/m 13, 093 kg/m 10, 684 kg/m
BEAM W8X18	 27 kg/m
GIRDER W18X50 W18X119	 kg/m kg/m
STEEL INTERLOCKING FLOOR PANELS (CHECKERED PLATE 4-MM THICK)	34.37 kg/m2
STEEL JOIST	14.58 kg/m
PIPE STRUT/ TENSION PIPE	21.8 kg/m
STEEL PLATES (MILD STEEL PLATES – 25MM THICK)	196. 253 kg/m2
CHB (100MM THICK)	2.0 kPa
ZINC COATING	0.1427 kg/m2
1.2 LIVE LOADS	
1.2.1 FLOOR LIVE LOADS	
PARKING GARAGES AND RAMPS RESTROOM VEHICLE	4.8 kPa 2.4 kPa 5000 kg
2. LATERAL LOADS	
2.1 SPECIAL LIVE LOADS	
BALCONY/ RAILINGS AND GUARDRAILS	0.30 kN/m

Table X. Seismic Parameters

Parameter	Value
Zone	0.4
Importance Factor	1
Soil Profile Type	4
Near Source Factor (Na)	1
Near Source Factor (Nv)	1
CT Value	0.0853
R	8.0

Structural Analysis of Structural Members

A. Steel Joists Analysis Result

Table XI. C4X9 as Steel Joists

PROPERTY	LENGTH (m)	ASSUMED SPACING (m)	ACTUAL SPACING (m)	CONCLUSION
C4X9	1.725	0.420	0.560	Adequate
C4X9	1.270	0.420	0.670	Adequate
C4X9	1.380	0.457	0.539	Adequate
C4X9	1.380	0.380	0.573	Adequate
C4X9	1.500	0.420	0.457	Adequate

Based on the structural plan for steel floor joists spacing, the property used was C4x9 and has different lengths depending on the width of the slab. The structure has at least five different dimensions of the slab by beam and girder connection. The assumed spacing of the steel joists was compared to the actual spacing using the formula based on NSCP 2015. Hence, the result for steel joists is all adequate. In observation, the actual spacing is greater than the assumed spacing. Therefore, the assumed spacing is safe because the actual spacing is also the allowable spacing for the steel joists slab.

B. *Steel Slab – Beam - Girder Analysis Result*

Table XII. Slab-Beam-Girder Analysis

Properties	Dimensions (m)	Mucap (kN-m)	Mmax kN-m	Conclusion
Floor Panel	2.1 x 1.380	-	-	ok
Beam (W8x 18)	L = 2.1	76.007	5.012	ok
Girder (W8x 50)	L= 6.9	456.351	335.699	ok
Girder (W18 x50)	L = 4.2	329.361	167.557	ok
Floor Panel	2.1 x 1.267	-	-	ok
Beam (W8x 18)	L = 2.1	76.007	9.662	ok
Girder (W18 x50)	L = 3.8	388.039	140.954	ok
Girder (18x50)	L = 4.2	329.361	157.711	ok
Floor Panel	2.1 x 1.267	-	-	ok
Beam (W8x 18)	L = 2.1	76.007	9.662	ok
Girder (W18 x119)	L = 3.8	388.039	140.954	ok

As for the analysis of the steel slab-beam-girder relationship, the table above showed the dimensions or length of each structural member and was concluded in one way or two since Ly/Lx is less than 2.0 of the indicated slab above. Hence, they are considered as a two-way slab. In addition, the beam and girder computed the maximum moment of each structural member that carried dead loads, and live loads were compared to the maximum capacity of each structural member based on their properties and using the specifications in NSCP 2015 to determine the adequacy of each structural member in accordance to the carried loads. To conclude the analysis results of the said structural members, all slab, beam, and girders are adequate.

C. *Column Analysis Result*

Table XIII. Steel Column Analysis

Properties	L (m)	Pu *(kN)*	Pact *(kN)*	Conc.
W12 x 190	2.4	10, 590.77	9, 457.49	Ok
W12 x 190	3.2	10, 012. 30	4, 572.14	Ok
W12 x 252	2.4	14, 104.13	12, 593.81	Ok
W12 x 252	3.2	13, 373.71	6, 110.64	Ok
W12 x 305	2.4	17, 095.07	14, 393. 41	Ok
W12 x 305	3.2	16, 249.61	6, 555.96	Ok
W12 x 210	2.4	11, 111.09	11, 669.52	Ok
W12 x 210	3.2	11, 741.20	6, 272.58	Ok
W14 x 500	2.4	28, 604.16	28, 110.42	Ok
W14 x 500	3.2	27, 752.20	15, 273.01	Ok
W14 x 500	2.4	28, 604.16	15, 373.94	Ok
W14 x 500	3.2	27, 752.20	28,211.35	Ok
W36 x 848	2.4	48, 345.38	48, 082.48	Ok
W36 x 848	3.2	46, 797.70	26, 337.58	Ok
W14 x 605	2.4	34, 628.46	33, 442.93	Ok
W14 x 605	3.2	33, 650.81	17, 925.53	Ok

Column Analysis of the structure was determined and calculated through the specifications of NSCP 2015, wherein the actual load of the column that will carry is greater than the allowable load of the column depending on its properties. The 2.4 meters length indicated in the table is the length of the column between the ground floor and the second floor, which means it carries heavier loads than the 3.2 meters column between the second and third floor.

D. Steel Connections Analysis Results

Table XIV. Connections Analysis

Connection	Type	An (mm^2)	0.85(Ag) mm^2	Conc.
Beam-Column	Bolted	5 091.41	54 996	ok
Column Cap	Bolted	15, 453.99	16, 263.07	ok
Beam-Splice	Bolted	5, 902.03	6, 177.55	ok
Column-Beam-Brace	Bolted	7, 735	8, 423	ok

On the other hand, the analysis of the steel connections was done using the specifications of NSCP 2015, wherein the design strength for LRFD was computed in terms of gross area and net area. The net area was compared to the gross area with a 0.85 reduction factor to know the adequacy of each steel member's connections connected with mild and gusset plates. Since all the computed gross area with the reduction factor is greater than the net area, all the connections are adequate.

E. Slab-On-Grade Analysis

Table XV. Slab-On-Grade Analysis

Load Calculation	
P	144.63 kN
Actual Soil Pressure	
Qsoil	5.357 kPa
Tributary Area for each wheel	
Aw	6.75 m^2
Actual Point Load	
P	36.281 kN
Shear Area	
P_a	225 000 mm^2
Actual Shear	
V_a	0.161 MPa
Allowable Shear	
Vallowable	1.746 MPa
Pr	392. 894 kN
Pr > Pu, therefore it is safe.	
Reinforcement needed: 4 bars of 10 mm dia. Per 1 meter strip of slab-on-grade.	

In calculating the slab-on-grade analysis and design, the parameters such as load calculations, actual soil pressure, tributary area for each wheel, and actual point load were identified to determine the value of the shear area, actual shear, and allowable shear. To conclude the safety factor and desirable strength of the slab-on-grade, the allowable load and maximum load were compared. The table above shows that the required load is greater than the allowable load. Therefore, it is safe. In addition, to design the reinforcement of the slab-on-grade, the area of the slab was computed in terms of its base with a 1-meter strip and its thickness of 150mm. Therefore, the reinforcement needed is 4 bars of 10 mm. in diameter.

F. Baseplate Analysis

Table XVI. Baseplate Analysis

Steel Column	Assumed thickness (m)	Allowable thickness (m)	Conclusion
W12 x 190	0.0178	0.011	Adequate
W12 x 252	0.0178	0.011	Adequate
W12 x 305	0.0178	0.012	Adequate
W12 x 210	0.0178	0.013	Adequate
W14 x 500	0.0178	0.015	Adequate
W36 x 848	0.0178	0.012	Adequate
W14 x 605	0.0178	0.017	Adequate

The assumed thickness should be greater than the allowable thickness to avoid the failure of structural members to determine the adequacy of the thickness of the baseplate connected to the steel column and pedestals. As presented in the table above, the assumed thickness has only one design that considers the dead load. Since the assumed thickness is greater than the allowable, there will be no problem with the adequacy of the material involved in the analysis and design as long as the design criteria are met, and the specifications of NSCP 2015 are not compromised.

G. *Anchor Bolts Analysis*

A. For W12x190, W12x252, W12x305, W12x210, W14x500, W14x605 Steel Columns

Table XVII. Anchor Bolts Analysis I

Baseplate	0.7 x 0.7 x 0.0178 m
Design bolt diameter	A32 (25 mm dia.)
Capacity	230 kN
Ta	2 886.12 kN
V	
Ta > T/C, therefore it is adequate.	
Vr	4, 104 kN
Vr > V, therefore it is adequate.	

B. For W36x848 Steel Colum

Table XVIII. Anchor Bolts Analysis II

Baseplate	1.1 x 1.1 x 0.0178 m
Design bolt diameter	A32 (25 mm dia.)
Capacity	230 kN
Ta	3, 153. 76 kN
V	
Ta > T/C, therefore it is adequate.	
Vr	5, 016 kN
Vr > V, therefore it is adequate.	

In analyzing and designing the anchor bolts attached to every baseplate and pedestal, the parameters needed are baseplate dimensions, design bolt diameter, and the capacity of the design bolt diameter using the NSCP 2015 as a reference. In determining the adequacy of the A32 25mm dia. bolt diameter to support the baseplate from the following steel column: W12x190, W12x252, W12x305, W12x210, W14x500, W14x605 the tension or compression load were compared to the actual tension of bolts that is 2,886.12 kN > 2 031.98 kN, therefore, it is adequate. On the other hand, to support the baseplate from steel column W36x848 the load was compared to the actual tension of anchor bolts and that is 3, 153.76 kN > 2,429.18 kN. As for the shear resistance in designing anchor bolts is important. The shear resistance and calculated base shear were measured. Thus, it is safe if the shear resistance is greater than the calculated base shear.

H. *Ramp Analysis Result*

Table XIX. Steel Ramp Analysis

Properties	Lateral Torsional Buckling	Conclusion
Beam (W8x18)	$L_p > L_b > L_r$	Adequate
Girder (W18x119)	$L_p > L_b < L_r$	Adequate

Table XX. Concrete Ramp

W_c	2, 829.6 kN
Q_s	36.499 kPa
P_u	717.21 kN
P_a	5, 196, 152. 42 mm²
V_{act}	0.138 MPa
$V_{allowable}$	1.51 MPa
P_r	7, 846.19 kN
A_s	2, 700 mm²
N_b	9 bars per 1000mm
S	110 mm O.C. bothways

In the structural plans of the proposed terminal parking, the researchers considered two types of ramps: concrete ramps and steel ramps. It is important to ensure the materials' adequacy in designing ramps for moving loads, approximately a maximum weight of 5000 kg.

The steel ramp was designed using W8x18 and W18x119 with a length of 1.9 m to pass the load they're carrying until it is passed down to the column that supports the ramp. The lateral torsional buckling for W8x18 was Lp > Lb > Lr, hence, it is adequate. In addition, the lateral torsional buckling for W18x119 was Lp > Lb < Lr, hence, it is safe to use.

As for the concrete ramp design for the entrance and exit of the structure, it has the weight of concrete of 2, 829.6 kN, and an actual soil pressure of 36.499 kPa. The actual shear solved was 0.138 MPa, concurrently the allowable shear was 1.51 Mpa since the allowable shear was greater than the actual shear, hence, it is safe. To design the reinforcement bars for the concrete ramp, use 9 bars of 20 mm ø per 1000 mm that has 110 mm spacing on the center both ways.

Table XXI. Concrete Stairs Analysis

Wu	16.82 kPa
d	124 mm
Mu	3.285 kN-m
ρmin	0.00507
ρmax	0.027917
ρact	0.000086
Main bars (12 mm Ø)	150 mm O.C.
Temp bars (10 mm Ø)	200 mm O.C.

The stairs in the proposed structure have the concrete type in the lower part of it. The factored load that will be considered in the design was solved to determine the number of bars needed. The effective depth, rho, and the moment needed were also computed to get the main and temperature bars needed and their spacing. In designing the reinforcement bars, use 12 mm ø bars as main bars with 150 mm spacing on the center. On the other hand, use 10 mm ø as temperature bars with 200 mm spacing on the center.

(5) Estimates of Materials

The estimates for the general requirements for the proposed structure exceed at least 393, 000, 000 pesos. These general requirements are important to consider before erecting the structure. As for the cost of structural works, the pedestals, slab-on-grade, masonry works, stairs, and ramp are estimated and it cost PHP 213, 150; PHP 2, 552, 250; PHP 5, 979; PHP 10,584; and PHP 583, 130 respectively. An estimation for formworks of concrete is needed from the reinforced concrete. Hence the total cost for formworks is PHP 25, 816.70. Since the proposed structure is steel, the estimation for steel members is quietly high, and it also needs coating to resist corrosion. The total costs for the steel members and painting works are PHP 84, 204, 976.82 and PHP 1, 469, 913, respectively. The total direct cost considering the general requirements, structural, and metal works, is PHP 89, 458, 799.52. In addition, the sum of the cost for labor cost, miscellaneous costs, VATS/taxes, and overhead/profit must be considered in the total cost for the construction cost. Therefore, the total construction cost without considering the plumbing and electrical is PHP 161, 025, 839.13.

CONCLUSION

Upon observing the data gathered using the Cordon Volume Counts (CVC), it can be seen that the number of vehicles that can cause traffic congestion can increase by the day. Solutions for this kind of everyday problem should always be considered considering that the commuters' only way of transport is public vehicles.

This study proposed multi-story terminal parking for public utility jeepneys. The researchers aim to lessen the traffic in Guagua, specifically in the central business district of Guagua, Plaza Burgos, San Roque, Sto. Niño, and Sto. Cristo. The growing congestion in Guagua is affecting commuters and drivers.

Road widening is not the only solution for traffic congestion, it may be a solution, but it will only last for a short time due to the increasing number of private vehicles and motors. Instead of road widening, the researchers devised another solution to lessen traffic: building a terminal for jeepneys that stays on the roadside around the plaza, leading to heavy congestion around the place. This research may help commuters, enforcers, and drivers suffering from traffic. The research also included rerouting for PUJs.

Both proper routing and transportation systems are crucial in solving traffic issues around Guagua, Pampanga. The proposed multi-story terminal parking for PUJs to accommodate public vehicles and investigate the problem of traffic congestion.

Designing steel structures for terminal parking is lightweight, and its structural components improve the sustainability of a structure. These materials, which have a great deal of potential for reuse and recycling, not only enable us to preserve the environment and natural resources. These building materials have advantages over other materials, including minimizing weight while maintaining high mechanical strength, permitting modular pieces, improving quality control, making prefabrication easier, eliminating moisture-related dimensional changes, and being inexpensive. Thus, the total estimated construction cost for a 3,651 m², three-story-terminal parking is PHP 161, 025, 839.13.

ACKNOWLEDGMENT

This study would not have been possible without the guidance and help of several individuals who, in one way or another, contributed and extended their valuable assistance in the preparation and completion of this study. The researchers would like to express their deepest gratitude and appreciation to the following individuals:

The researchers thanked the Lord for giving the group enough knowledge and guidance to fulfill the thesis and blessed them with wisdom for the succession of their paper.

To their parents, who supported and motivated them to complete the study. The unmeasurable inspiration and contributions they gave the group until the end of the study. They are truly grateful to have been blessed with encouraging parents.

They thank their instructors, who helped them start their study.

To their thesis advisers, who continuously guided them and gave them a helping hand to know their study's path.

To the panelists, for enlightening the group on what the paper lacks and giving them enough chance to transform it to its purpose.

To the professionals and people who gave them the data, helped them through consultations, and provided enough support to fulfill their thesis.

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