International Journal of Scientific Research and Engineering Development-– Volume 7 Issue 3, May-June 2024

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

PROPOSED ADVANCED MULTI-LEVEL PARKINGWITHREAL-TIMETRACKING AT DON HONORIO VENTURA STATE UNIVERSITY BACOLOR CAMPUS, PAMPANGA, PHILIPPINES

Mel Bryan C. Orozco[1], Darien D. Navarro[1], Graziel Janine Y. Ocampo[1],Vinz Nerick T. Padilla[1], James Son M. Parilla[1], Jessica S. Pring[1], Joshua Raymundo[1], Christian P. Dizon[2], Aaron S. Malonzo[2]

[1]Student, Department of Civil Engineering, College of Engineering and Architecture ,Don Honorio Ventura State University, Pampanga,Philippines

[2]*Faculty,* Department of Civil Engineering, College of Engineering and Architecture ,Don Honorio Ventura State University, Pampanga,Philippines

Corresponding Author**:** orozco.melbryan@gmail.com

Abstract: The escalating demand for parking facilities presents a challenge for educational institutions, including Don Honorio Ventura State University (DHVSU) Main Campus. This study proposes implementing a multi-level steel parking structure with real-time tracking to improve parking management efficiency, reduce congestion, and enhance campus mobility. An organized parking infrastructure aims to create a safer and more enjoyable environment for all community members and visitors.The On-Site Soil Investigation confirms the land's capability to support a multi-storey building, with adequate soil bearing capacity. Using steel as the primary construction material, the parking structure adheres to safety standards set by the National Building Code of the Philippines and is designed using the STAAD app to meet the National Structural Code of the Philippines 2015 requirements.The real-time parking system assigns spaces upon registration and QR code scanning, eliminating the need to search for spots and reducing lateness for students, faculty, and staff. This study highlights the importance of careful planning in enhancing campus mobility and safety through innovative parking solutions. Continuous improvement and collaboration within the academic community are vital for DHVSU's progress, optimizing parking infrastructure for the well-being of all campus constituents.

Key Words - *Parking Management, Real-time Tracking Systems, Campus Mobility, Infrastructure Construction, Multi-level Parking System.*

I. INTRODUCTION

Parking facilities are crucial in urban infrastructure, providing essential vehicle spaces and supporting daily efficiency. As population density and vehicle ownership rise, adequate parking becomes vital for urban functionality, aiding traffic flow and enhancing access to businesses, institutions, and residences. Insufficientparkingleadstocongestion,accidents,andfrustration. Inresponse,theconstructionofsteelparkingstructureshassurged globally,drivenbyurbanizationandincreasedvehicleownership. These durable, space-efficient buildings are popular in densely populated areas where land is scarce, with major shopping malls and business districts integrating multi-level steel parking facilitiestomeetthegrowingdemandforsecureparkingsolutions.

The Philippines has embraced the construction of steel parking structures as a response to this predicament, leveraging their durability and space-efficient design to address the challenges of limited parking space in densely populated areas. In a report of Navales(2022)[1],adjacenttotheconventioncenter,SMCity Clark in Pampanga has a steel deck parking structure for around 100vehicles.

As the university community at Don Honorio Ventura State University(DHVSU)expands,thedemandforparkingintensifies. Currentfacilitiesstruggletoaccommodatetheincreasingnumber of vehicles, leading to congestion, wasted time, and safety risks. Studentsandfacultyfacedifficultiesinfindingparking,impacting productivity and punctuality. The limited parking forces haphazard parking practices, compromising safety and impeding emergency vehicles. Additionally, the region's low bearing capacity soil complicates parking structure design. Integrating smart parking systems, which use sensors and data analytics, offers a solution. These systems guide drivers to available spots, reducing search times (Baqaeen et al., 2022) [2].

A proposed multi-level parking facility with real-time tracking at DHVSU aims to meet growing demands efficiently. This system allows users to check space availability online, streamlining the parking process and supporting sustainability by reducing emissions.Italsoalignswiththeuniversity'sgoalsofembracing technological innovation and creating a connected campus environment.This advanced multi-level smart parking represents a forward-looking strategy to alleviate traditional parking challenges, fostering a more efficient and user-friendly experience.

II. METHODOLOGY

The study involves a systematic process, and the methodological framework strives to offer a comprehensive comprehension and strategy for implementing the advanced parking system at DHVSU Main Campus.

Phase1–Methodsof data collection

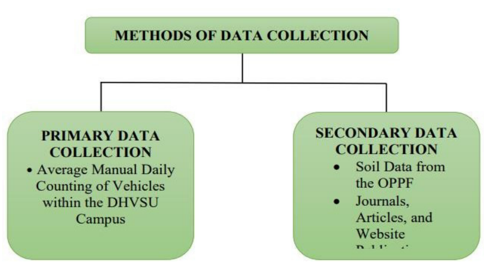
Theproponentsofthestudyusedbothprimaryandsecondarydata collection methods. For primary data, they conducted an average manual daily count of vehicles within the DHVSU Campus. For secondarydata,theyprocuredinformationfromjournals,articles, andwebsitepublications,andtheysentaletterofrequesttoobtain soil data and land survey records from the OPPF.

AverageManualDaily Counting ofVehicles within theDHVSU Campus, involves systematic observation and recording to determinethecorrelationbetweenthenumberofavailableparking slots designated for cars and motorcycles. To identify the percentage of vehicles that the multi-level parking can accommodate at Don Honorio Ventura State University (DHVSU), researchers conducted manual vehicle counts at two specifictimeperiods. Theselectionof thesespecifictime periods wasbasedonpriorobservationsbytheproponents,whichrevealed asignificantinfluxofvehiclesarrivingatandutilizingtheparking lot during these intervals.

Thecollection ofsoil data serves as aguidefortheresearchersto acquirethesoilbearingcapacityfromtheOfficeofPhysicalPlant andGeneralServices(OPPF),whichisafundamentaldatafortheproposed multi-storey parking to be designed properly.

TheresearchersensuredcompliancewithRepublicAct10173,the DataPrivacyActof2012,byimplementingmeasurestoguarantee theconfidentialityofthecollecteddata.Thisdatawasusedsolely forthepurposesofthisstudy.Participationinthisresearchdidnot causeanyphysicaloremotionalharmtotherespondents,andtheir datawillnotbeusedforanyfutureendeavorswithouttheirexplicit consent.

Figure1.DataCollectionMethodStructure



Phase2– AnalysisandInterpretation

1. DataAnalysis
   Indataanalysisforaveragemanualcounting,researchersconductedastudy.Theysystematically talliedthevehiclespresentduringdesignatedtimeslots. By utilizing Excel's functionality, they presented the information in a clear, accessible format. This enabled them to gather comprehensive data on the parking demandatDHVSUoveratypicalweek.Theresearchers thensoughtassistancefromseveralprofessorsandother authorized personnel.

2. Loadanalysis
   In the development of a multi-level parking structure, various loads were carefully analysed to ensure the structural integrity and safety of the facility. Firstly, dead loads, which encompass the permanent and static weights of the structure itself, including the parking decks,columns,andotherpermanentcomponents,were assessed. Live loads, representing the dynamic forces exerted by vehicles, pedestrians, and potential equipment within the parking facility, are crucial to consider.

   Moreover, environmental loads such as seismic forces wereevaluatedtodeterminethestructure's resilienceto natural elements and potential ground movements.

3. StructuralAnalysis
   The culmination ofthe comprehensiveidentification of the types of loads the structure encountered yielded the intricate stage of designing the foundation through structuralanalysis.Thisservedasthefoundationforthe succeeding processes, which involved the use of 3D modelling and design utilizing the CAD and STAAD tools.
   This structural software was essentially utilized to analyse the specific foundation suited for the soil type and soil bearing capacity of the proximity of DHVSU. This analysis ensured a thoroughly designed parking facility,takingintoaccountsite-specificconditionsand structural integrity, ultimately contributing to the optimization ofspaceand functionality in theenvisioned multi-level structure.

Phase3–Design

1. StructuralDesign
   Following structural analysis,the building underwent a design phase where dimensions of components were determined based on analysis outcomes. Initial estimations were field-validated to meet design criteria forstability,strength,andrigidityaspercodestandards. Structural software like STAAD and CAD tools were utilizedthroughoutthedesignprocess.Thisensuredthe structure not only adheres to general safety and functionalityprinciplesbutalsomeetsspecificDHVSU authorities'criteria,includingconsiderationsforseismic activity, weather conditions, andotherlocal constraints affecting safety and durability. Another aspect to consider extensively for a steel structure is the connection between the steel members. In the study of Manson (2006) [32],

Boltconnectionsarenotedfortheireffectivenessinsteel structures,efficientlytransferringforcesbetweenplates and accommodating both axial tension or compression andtransverseshear.Thestudyunderscoresthebenefits ofhigh-strengthfrictiongrip(HSFG)bolts,particularly in slip-critical situations and under fatigue loads, enhancingstructuralintegrityandreliability.Therefore, the design of the envisioned steel multi-level structure involves incorporating bolted connections.

2. SystemDesign
Designing a comprehensive website system for multi-level parking with real-time tracking at DHVSU Main Campus involves rigorous attention to various components such as parking space allocation, security measures, user experience, and sustainability. The system'sdesignfocusesonkeyelementssuchusadmin and guard accounts, as well as the registration process and scanning of QR codes for digital identification. Throughtheprioritizationofadvancedtechnologiesand user-centric design principles, the research aims to uncover strategies for optimizing parking facility systems. Ultimately, the goal is to enhance efficiency and convenience for administrators and users, while simultaneously improvingoverallcampus mobility and contributing to sustainability efforts.

III. RESULTSANDDISCUSSION

Inthissection,we'lldiscussthedatagatheredforourstudyonthe steel parking structure. We'll present the data in tables and explanations, including info from software like STAAD. The design will follow the safety guidelines set by the National Construction Safety Procedures (NCSP).

3.1 SoilBearing Capacity

To ensure a safe and cost-effective design,the foundation will be based on the minimum allowablebearing capacity obtained from the3boreholetestsatadepthof2.0meters.Thevalueofallowable bearing capacity was used to determine the most suitable foundationtype forthedesiredstructuralstrength.As the bearing capacity is less than 150 kPa, an isolated footing design was employed. This type of foundation typically requires a larger footing size compared to other options.Also, the analysis of the resultsforeachboreholearestatedanddeterminedbasedonhthe proper consultation from the right personnel.

Table 1.3. Minimum Allowable Bearing Capacity of the 3 borehole tests at the depth of 2.00 meters

at depth 2.00 m of borehole	Minimum Allowable bearing capacity (kPa)
2.00 m	**110.13 kPa**

3.2 VehicleManual Counting

The data from DHVSU Main Campus shows an average of 678 vehicles during peak hours. The parking can accommodate 64.31%ofvehicles,withfluctuationsincarandmotorcyclecounts throughout the day. Mornings averaged 270 cars and 381 motorcycles,withslightlyhighercountscomparedtoafternoons. Onaverage,morningshad692vehicles,whileafternoonshad664. This data informs plans to reduce congestion and improve transportation efficiency during peak hours.

Table2.Daily averagenumberofvehicles

Day	Time Duration	Cars	Motorcycles		Total
1	8am - 9am	237	435		672
	1pm - 2pm	282	421		703
2	8am - 9am	301	420		721
	1pm - 2pm	287	415		702
3	8am - 9am	289	432		721
	1pm - 2pm	294	429		723
4	8am - 9am	267	409		676
	1pm - 2pm	251	423		674
5	8am - 9am	316	443		759
	1pm - 2pm	304	419		723
6	8am - 9am	229	374		603
	1pm - 2pm	174	285		459
Average (8am - 9am)					**692**
Average (1pm - 2pm)					**664**
Daily Average Number of Vehicles					**678**

Percentage of Vehicles = 64.31 %

3.3 SiteDevelopmentPlan

Figure6.SiteDevelopment Plan.

The proposed multi-level parking with real-time tracking is situated at the existing car park of DHVSU-Extension. Through the process of site analysis, the dimensions of the lot the researchersobtainedare104.05metersinlengthand18metersin width and with the lot area of 1872.9 square meters.

Figure6.1.RoutePlan

Based on Figure 6.1 outlines the planned trajectory for vehicles navigatingfromtheentrypointoftheadvancedmulti-level parking facility to the exit, aimed at enhancing overall mobility within the structure. The depicted route serves to optimize traffic flow and minimize congestion, thereby facilitating smoother transitions for both entering and exiting vehicles. By delineating thispath,thedesignaimstostreamlinetheparkingexperienceand improve accessibility within the facility.

3.4 ArchitecturalPlan

Inarchitecturalplanning,theresearcherssystematicallydeveloped theplansthroughaseriesofiterativeprocessesinvolvingdetailed drafting, consultations, and revisions to ensure practicality and innovationinourdesigns.Byemployingadvancedsoftwaretools suchasAutoCAD,Enscape,andSketchUp,researcherswereable to create Figure6.1. Route Plan 35 Figure 7.1. Second floor plan of the multi-level precise and scalable drawings, enhancing our ability to visualize and modify layouts effectively. Collaborative sessionswithmentorsprovidedcriticalinsightsthathelpedrefine our concepts, focusing on maximizing space utilization,aesthetic appeal, and environmental sustainability.

Figure7.Groundfloorplanofthemulti-level

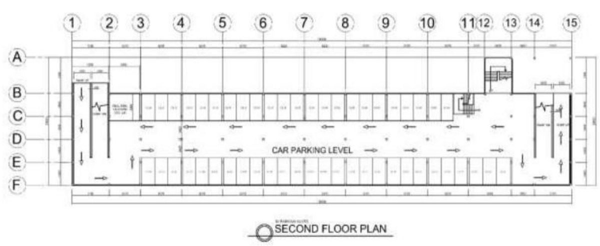


Figure7.1.Secondfloorplanofthemulti-level

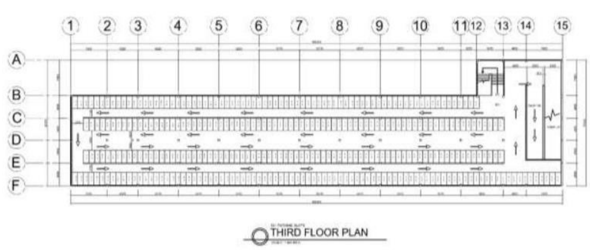


Figure7.2.Third floorplan ofthemulti-level

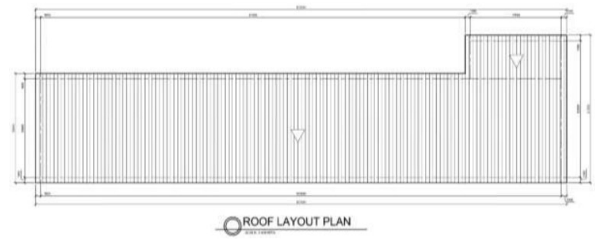


Figure7.3.Rooflayout plan ofthemulti-level

3.5 NumberofVehicleSlot

Through adhering to the provisions outlined in the National BuildingCodeofthePhilippines(NBCP),themulti-levelparking structurehasallocatedatotalof436parkingslotsasshowninthe Figures 7.1, 7.2, and 7.3. Among these, 109 slots have been designatedFigure7.2.Thirdfloorplanofthemulti-levelFigure 7.3. Roof layout plan of the multi-level 37 for cars, while the remaining 327 slots are designated for motorcycles. It comprises 59accessibleslotsforcarsand6motorcycleson thegroundfloor aswellas50slotsonthe2ndfloor,and321slotsformotorcycles on the 3rd floor. This distribution ensures that there is sufficient space for both cars and motorcycles, catering to the various transportation needs of the students,faculty,and staff atDHVSU Maincampus.Italsodemonstratescommitmenttocomplyingwith relevant regulations and standards to create a safe and efficient parking facility.

3.6 Elevations

The structure maintains a uniform elevation of three meters between each floor, from ground level to the second floor, and from the second floor to the third. However, this architectural configuration poses limitations on its ability to accommodate public vehicles, as the height restrictions prevent larger vehicles such as buses or trucks from entering. Consequently, the steel parking facility primarily caters to private vehicles, ensuring efficient utilization of space while providing convenient parking solutions.

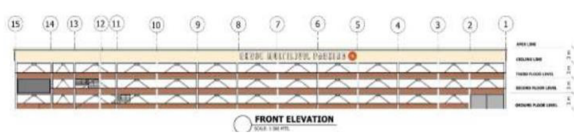


Figure8.Frontelevationofthemulti-levelparking

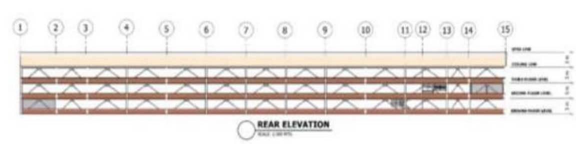


Figure8.1.Rearelevationofthemulti-level parking

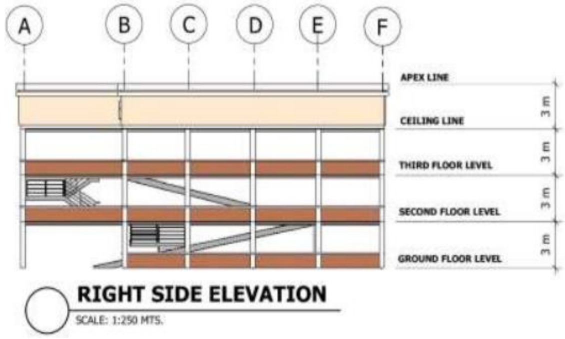


Figure8.2.Rightsideelevation ofthemulti-level

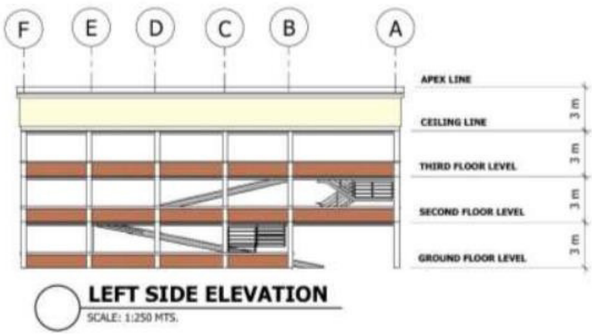


Figure8.3.Leftsideelevationofthemulti-levelparking

3.7 Perspectives.

The perspective of the multi-level parking structure, showcasing its outer design. Despite being constructed primarily of steel, the proponents of the study advocate for a realignment of the structure'scoloranddesigntoharmonizewiththenaturalaesthetic of every building within Don Honorio Ventura State University. Toachievethisintegration,theresearchersproposedaddingmetal cladding. This innovative approach not only enhances the visual appeal of the parking facility but also ensures a cohesive architectural theme throughout the university campus, promoting a sense of unity and identity within the built environment.

Figure9.Exteriorperspectivesofthemulti-level parking

Figure9.1.Groundlevelinterior perspective

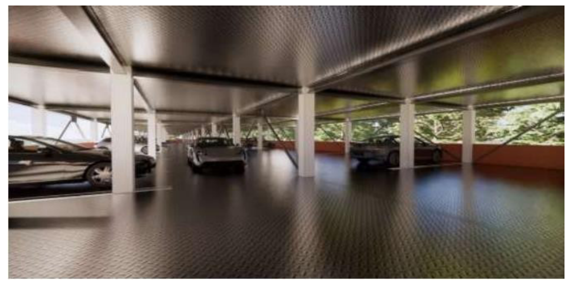


Figure9.2.Secondlevelinteriorperspective

Figure9.3.Thirdlevelinterior perspective

3.8 StructuralPlans

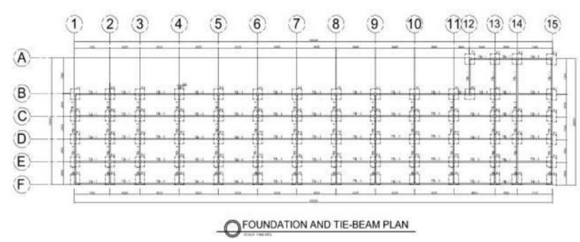


Figure10.Foundation and tie-beamplan ofthemulti-level

Thefoundationandtie-beamplanoftheadvancedmulti-levelsteel parking. It illustrates the layout and dimensions of the building's foundation indicating the placement of footings, columns to evenly distribute the structure's weight and the arrangement and dimensions of tie-beams,crucial for connecting verticalelements and enhancing structural integrity against dynamic loads of the multi-level parking.

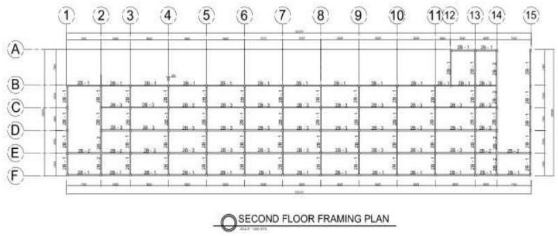


Figure10.1.Second floorframing ofthemulti-levelparking

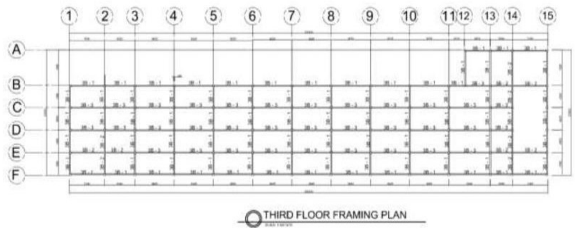


Figure10.2.Thirdfloorframingofthemulti-levelparking

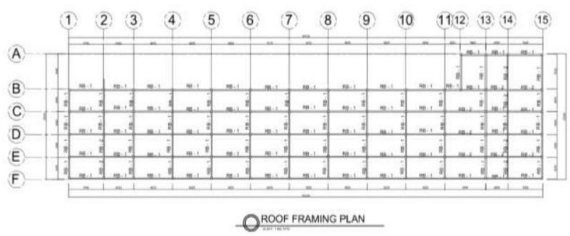


Figure10.3.Roofbeamframingofthemulti-level parking

The framing plans detail the skeleton of the multi-level steel parking, dictating how loads are transferred downwards and how the building maintains its shape and support. Each plan plays a crucial role in ensuring the safety, longevity, and functionality of the structure, working together to create a cohesive architectural design.

3.9 DesignLoads

3.9.1 DeadLoads(D)

Instructuraldesign,incorporatingtheactualweightofmaterialsis paramount for ensuring the safety and cost-effectiveness of the structure throughout its lifecycle. This necessitates utilizing established building codes, engineering references, and manufacturer specifications during the design process.

Theunitweightshallbeasfollows:

ReinforcedConcrete=23.6kN/m3
Steel Floor Finish = 77.3 kN/m3
Steel Member = 77.3 kN/m3

3.9.2 LiveLoads(L)

Live loads, also known as imposed loads or variable actions, constitute a critical aspect of structural design. They encompass the gravitational forces exerted on a structure due to its use and occupancy.
OccupancyorUseUniformLoad

PublicParkingand Ramps=4.8 kN/m2

3.9.3 EarthquakeLoad(E)

Static Force Procedure The total design base shear, V, in a given direction, shall be determined from the following equation:

$V = (Cv * I) * W / (R * T)$ - NSCP Equation 208-8
Where,Cv=seismiccoefficient -NSCPTable208-844 I = importance factor - NSCP Table 208-1
R=numericalcoefficient-NSCPTable208-11A T = elastic fundamental period of vibration
$T = Ct \times (hn)^{3/4}$ -NSCE Equation 208-12
Where,Ct=0.0853forsteelmoment-resisting hn = height above the base level to n
W=totalseismicdeadload Seismic

Parameter

- Category 1
- Seismiczone=Zone 4
- Soilprofiletype =SE
- Importancefactor =1.0
- Seismiczonefactor,Z=0.4
- NearSourceFactor,Na=1.0
- NearSourceFactor,Nv =1.0
- Seismiccoefficient,Ca=0.44
- Seismiccoefficient,Cv=0.96

CalculationofDesignBaseShear Force
StructuralSystem:Moment-ResistingFrame System

Ct=0.0853then,T=Ctx(hn)^3/4 T = 0.64 sec
R=8.5
hn = 9 meters
V =0.276xW
Table3.EarthquakeLoadLoadings

V_{Design} = [(Cv x I)/RT] x W	V_{max} = [(2.5 x Ca x I)/R] x W	V_{min1} = 0.11 x Ca x I x W	V_{min2} = [(0.8 x Z x Nv x I)/ R] x W
0.1764705882 x W	0.1294117647 x W	0.0484 x W	0.03764705882 x W

Vmax<Vdesign>Vmin,Hence,VDesign

3.10 StructuralAnalysis

Figure11.STAAD Model

The provided figure depicts a three-dimension model, generated usingSTAADProsoftware,withtheuseofsteelstructure.The structure reaches 9 meters in height with each floor reaches to 3 meters. The lot possesses 1,872.90 square meters, having the frontage of 103.05 meters. The steel structure itself, utilizes verticalsteelcolumnsforprimarysupport,horizontalsteelbeams, and steel bracing to enhance its overall stability.

Table4.Scheduleof SteelSection

SCHEDULE OF STEEL SECTION		
MARK	**MEMBER TYPE**	**SECTION**
1C-1	COLUMN	W12×65
2C-1	COLUMN	W12×65
3C-1	COLUMN	W12×65
2B-1	BEAM	W12×40
2B-2	BEAM	W12×72
2B-3	BEAM	W12×58
3B-1	BEAM	W12×40
3B-2	BEAM	W12×72
3B-3	BEAM	W12×58
RB-1	BEAM	W10×22
RB-2	BEAM	W12×30

3.11 Slab Design

Table5.Scheduleof SteelSection

MARK	T (mm)	Materials	REMARKS
SOG-1	150 mm	Concrete and Metal deck	Ground Floor Slab
SOG-2	1/8", 3/16" BAR THICKNESS	Steel Grating	Second Floor Slab
SOG-3	1/8", 3/18" BAR THICKNESS	Steel Grating	Third Floor Slab
SOG-4	1/8", 3/16" BAR THICKNESS	Steel Grating	Roof Floor Slab

3.12 SteelBeamDesign

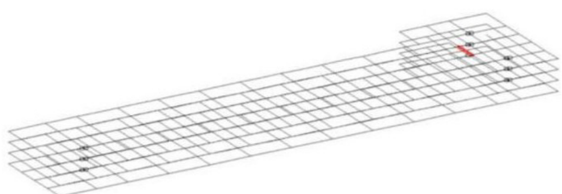


Figure12.DesignofCriticalBeam: Safe

Based on the figure displays a beam with a red mark, signifying itsstatusasthecriticalbeamwhereitsupportstherampportionof the structure, bearing the weight of moving live loads. Upon analysisusing theSTAADtool,itwas determinedthatthedesign specifications of this critical beam met safety standards. Consequently,thisimpliesthattheotherbeamsinthestructureare alsoconsideredsafegiventheirsimilarityindesignandstructural properties, thus affirming their overall safety and integrity. (See STAAD results of Steel BeamDesigninAppendix B)

3.13 SteelColumn Design

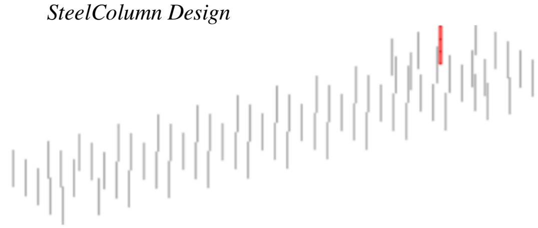


Figure13.DesignofCriticalColumn:Safe

The figure clearly identifies the column marked in red as the critical column within the parking structure. This column is situated in the ramp portion, where it bears the weight of moving live loads. Utilizing the STAAD tool efficiently, the analysis demonstrates that the design of this critical column is considered safe. Consequently, the safety of the remaining columns can be implied, as they are not subjected to the same level of stress and strainasthecriticalcolumn(SeeSTAADresultsofSteelColumn Design in Appendix B)

3.14 Bracing

Table6.SteelBracing Section

SECTION	LENGTH (m)	WEIGHT (kN)
HSSP 6×0.125	961.79	102.008

3.15 DesignofSteel-to-Steel Connection

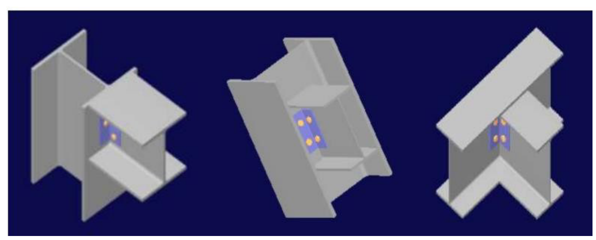


Figure14.3DmodelofBeam-Column-Flange,Beam-Column Web & Beam-Girder Connections.

(SeeSTAADresultsofSteelConnectioninAppendixB)

3.16 DesignofBaseplate

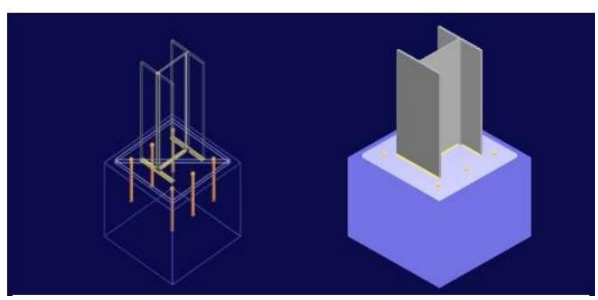


Figure15.3DModelofPedestalwithBaseplate

(SeeSTAADresultsofDesignofBaseplateinAppendix B)

3.17 DesignofTieBeam

Table 7.Scheduleof TieBeam

MARK	A (mm)	B (mm)	REINFORCEMENTS	
			TOP	BOTTOM
TB-1	200	400	2 – ⌀20mm	6 – ⌀20mm

(SeecomputationsofDesign ofTieBeamin Appendix B)

3.18 DesignofFooting

Table8.Scheduleof Footing

FOOTING MARK	FOOTING SIZE (mm)			DEPTH OF FOOTING	REINFORCEMENTS (BOTHWAYS)	SPACING	REMARKS
	A	B	THICKNESS				
F1 (outer)	1800	1800	300	2000	6 – ⌀20mm	320	ISOLATED
F2 (inner)	2200	2200	350	2000	9 – ⌀20mm	250	ISOLATED

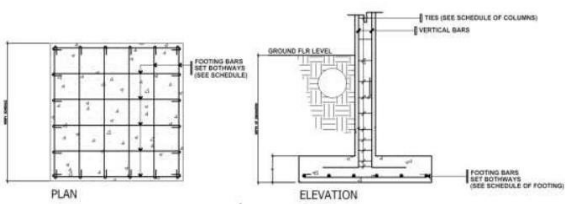


Figure16.DetailofFoundation

(SeecomputationsofDesignofFootinginAppendixB)

3.19 System Design

Designing a comprehensive website system for multi-level parking with real-time tracking at Don Honorio Ventura State UniversityMainCampusisamultifacetedendeavorthatdemands meticulous attention to various components and considerations. From effectively managing parking space allocation to ensuring strong security measures, and from enhancing user experience to promoting sustainability, every aspect plays a significant role in the success of the system. The system design explores the intricacies of designing such a system, focusing specifically on admin and guard accounts,as well as theregistration process and scanning of QR codes, which serve as theirdigital identifiers. By prioritizing the utilization of advanced technologies and the integration ofuser-centricdesign principles,this research aims to uncover strategies for optimizing parking facility systems. Ultimately,the goal is to enhance efficiency and convenience for administrators and users while simultaneously improving overall campus mobility.

Figure18.AdminLoginPage

IV. CONCLUSION AND RECOMMENDATIONS

In response to the campus's growing population, the meticulous design and strategic implementation of advanced technologies, suchasreal-timetrackingsystems,areanticipatedtosignificantly improve parking management efficiency, minimize congestion, and enhance overall campus mobility. Moreover, by creating a more organized and accessibleparking infrastructure, asafer and moreenjoyableenvironmentforallDHVSUcommunitymembers and visitors is aspired.

TheanalysisofOn-SiteSoilInvestigationdataconfirmstheland's capability to support infrastructure construction. With a proven soilbearingcapacitythataccommodatesuptoa3-storeybuilding, the potential of the land has been maximized in the design. Utilizing steel as the primary component, the parking structure meets safety standards 63 outlined in theNational Building Code of the Philippines, ensuring a secure environment for vehicles. ThroughtheSTAADapp,thestructurehasbeensecurelydesigned to handlevarious loads, adhering to theNational Structural Code of the Philippines 2015.

In addition, an advanced multi-level steel real-time parking system has been developed to further enhance campus mobility. Thissystemeliminatestheneedfordriverstosearchendlesslyfor parking spots by providing designated spaces upon registration and QR code scanning. This innovation is expected to greatly benefit students, faculty, and staff by minimizing lateness to classes and work.

Tofinalizethisstudy,throughouttheendeavortoenhancecampus mobility and safety through innovative parking solutions, the importance of meticulous planning and strategic implementation hasbeendemonstrated.AsDHVSUmovesforward,itisessential toremainsteadfastinthecommitmenttocontinuousimprovement andcollaborationwithintheacademiccommunity.Byembracing emerging technologies and best practices, the parking infrastructurecanbefurtheroptimizedtoensurethewell-beingof all constituents.

1. Regular parking needs assessment: The DHVSU campus should conduct regular assessments to anticipate future parkingdemands andplan for growth. This includes considering acquiring additional land for parking and accommodating larger vehicles.
2. Steel parking design as a model: The researchers recommendusingthesteelparkingdesignasamodelfor future developments due to its potential for creating sustainable parking solutions.
3. Technology integration: The researchers recommend incorporatingfeatureslikereal-timeparkingavailability trackingandsecureuserregistrationwithverificationon awebsite.Thiswillimproveefficiencyandreducetime spent searching for parking.
4. Collaborationwithlocalauthorities:Collaborationwith local authorities is crucial to address infrastructure challenges, ensure structural integrity, navigate regulations, acquire permits, and optimize construction processes.
5. Comprehensive cost analysis: A comprehensive cost analysis should considernot only obvious expenses but alsodetaileddesignelementslikemechanical,electrical, andplumbingforaccuratecostprojectionsandefficient project execution.

6. Community engagement: Community engagement initiatives like awareness campaigns and feedback mechanismswillempowerstakeholderstocontributeto responsible parking practices. This will allow for continuous evaluation and improvement of parking strategies for a sustainable system.

References

[1] R.Navales,“SMexec:Clarkisthefuture,”SunStarPublishing Inc., Mar. 30, 2022. [Online] Available: https://www.sunstar.com.ph/pampanga/business/sm-execclark-is-the-future[Accessed May 07, 2024].

[2] D.Baqaeen,R.Liang,M.Piotrowski,andA.Jung,“Cost Effective Smart Parking System on Campus,” 2022 International ConferenceonSoftware,TelecommunicationsandComputer Networks(SoftCOM),September2022,[Online]Available: https://doi.org/10.23919/softcom55329.2022.9911417.[Accessed: November 27, 2023]

[3] D. Brown and S. Hong, “A design of an automated parking systemonasmartcampus,IssuesinInformationSystems,”2019, zaly, Parking Spaces in Taylor’s University: Problems and Solutions,” ResearchGate, March 2020, [Online]. Available: https://doi.org/10.21834//e-bpj.v5i13.2035. [Accessed: November 27, 2023]

[4] I. Filzani, M. Fareez, and M. Aishah, “Parking Spaces in Taylor’s University: Problems and solutions,” ResearchGate, March 2020, [Online] Available: https://doi.org/10.21834//e-bpj.v5i13.2035.[Accessed: November 27, 2023]

[5] R. Boob, and A. Biswas, “Analysis for the Need of Parking ManagementSystem inCampus ofMIT College”International Research Journal of Engineering and Technology (IRJET), May 2018, [Online]. Available: https://www.irjet.net/archives/V5/i5/IRJET-V5I5179.pdf[Accessed: April 30, 2024]

[6] M.Level,“EmbracingUrbanEfficiency:ThePowerofMulti-Level Parking Garages,” www.linkedin.com Feb. 1, 2024. [Online] Available: https://www.linkedin.com/pulse/embracing-urban-efficiency-power-multi[Accessed Apr. 29, 2024].

[7] S. Yuanda, “Efficient Parking for Modern Living: The Advantages of Multi-Level Parking Garages,” www.linkedin.com. February 7, 2024 [Online] Available: https://www.linkedin.com/pulse/efficient-parking-modern-living-advantagesrzpsc[Accessed April 29, 2024].

[8] “Parking Garages |American InstituteofSteel Construction,” Aisc.org, 2024. [Online] Available: https://www.aisc.org/why-steel/resources/parking-garages/[Accessed April 29, 2024].

[9] “SteelFrameStructures|SteelFraming|SteelStructures,” UnderstandBuildingConstruction,2024.[Online].Available: https://www.understandconstruction.com/steel-frame-structures.html[Accessed April 30, 2024].

[10] S.Hanumanthakari,“(PDF)Intelligentandreal-timeParking System,” ResearchGate, January 2024, [Online] Available: https://doi.org/10.1051//e3sconf//202447203003. [Accessed: April 30, 2024]

[11] B. Farhan, “Smart Parking System Designed by using the Arduino for University park,” ResearchGate, May 25, 2021. [Online] Available: https://www.researchgate.net/publication[Accessed April 29, 2024].

[12] S. Gosavi,A. Kokane, and Prof. P. Utkarsh Nehete, “Smart ParkingSystemforInstitute,”Internationaljournalofscientific research in computer science, engineering and information technology, May 2023, [Online]. Available: https://doi.org/10.32628/cseit239035.[Accessed November 22, 2023]

[13] B.AL-Rakabi,“SmartParkingSystemDesignedbyusingthe Arduino for University Park,” ResearchGate, April 2019, [Online]. Available: https://doi.org/10.31185//ejuow.Vol7.Iss1.108. [Accessed: November 27, 2023]

[14] M. Lubis, R. Fauzi, and A. Lubis, “Analysis of Project Integration on Smart Parking System in Telkom University,” ResearchGate, September 2018, [Online]: https://doi.org/10.1109//CITSM.2018.8674270. [Accessed: November 27, 2023]

[15] A. Mishra, A. Sahu, A. Dass, & A. Nayak, “Automatic Car Parking Assistance using Arduino,” ResearchGate, November 2023, [Online]. Available: https://doi.org/10.5281//zenodo.10146943. [Accessed: November 23, 2023]

[16] S. Alkhuraiji, “Design and Implementation of an Android Smart Parking Mobile Application,” ResearchGate, November 2020. [Online]. Available: https://doi.org/10.18421//TEM94-06[Accessed: November 22, 2023]

[17] M. Gautam and A. Tiwari, “Intelligent Mode of Parking System,” ResearchGate, February 2016. [Online]. Available: https://www.researchgate.net/publication/312498653[Accessed Apr. 29, 2024].

[18] “Smart Campus Parking – Parking Made Easy,” ResearchGate, January 2019, [Online] Available: https://doi.org/10.1007//978-3-030-22750-0_6. [Accessed: April 30,2024]

[19] O.Victor,“DesigningaStrapFoundation|WorkedExample -STRUCTURESCENTRE,”STRUCTURESCENTRE,Aug.28, 2023.[Online].Available:https://structurescentre.com/designing-a-strap-foundation-worked-example[Accessed April 29, 2024]

[20] T.Guzman,“PracticalSolutionsSTRUCTUREmagazine Heavily Loaded Strap Footings Design,Detailing and Behavior,” April 2014. [Online]. Available: https://www.structuremag.org/wp-content/uploads/2014/08/c-practicalsolutionsguzman-April101.pdf [Accessed:April30, 2024]

[21] HousingNewsDesk,“Strapfooting:Meaning,types,design, advantages and disadvantages,” Housing News, April 10, 2023, [Online]. Available: https://housing.com/news/strap-footing/[Accessed April 30, 2024].

[22] N. Nadimi, S. Afsharipoor, and A. Amiri, “Parking Demand vs Supply: An Optimization-Based Approach at a University Campus,” Journal of Advanced Transportation, vol. 2021, pp. 1–15, January 19, 2021, [Online] Available: https://doi.org/10.1155/2021/7457021.[Accessed:November27, 2023]

[23] A. Wang, Z. Qin, and Y. Dong, “Development of an IoT-Based Parking Space Management System Design,” ResearchGate, July 2023, [Online]. Available: https://doi.org/10.47738//ijaim.v3i2.54.[Accessed: November 27,2023]

[24] R.Robles,“PhilkotsePSA:ThereissuchathingasMinimum Parking Requirements,” philkotse.com, Mar. 16, 2023, [Online]. Available:https://philkotse.com/safe-driving/philkotse-psa-there-

is-such-a-thing-asminimum-parking-requirements-5740 [Accessed Dec. 05, 2023].

[25] C.Herr,"ActionResearchasaResearchMethodinArchitecture andDesign,"February2017.[Online].Availbale: https://www.semanticscholar.org/paper/Action-Research-as-a-Research-Methodin-and-Design-Herr/52a29624a7b5e7a7f116784f6c2022fe27abe883[Accessed: November 29, 2023].

[26] M. Alba. "Enscape and Real-Time Rendering for Architecture Models," Engineering.com, February 21, 2020, [Online].Available:https://www.engineering.com/story/enscape-and-real-time-rendering-forarchitecture-models[Accessed April 30,2024]

[27] A. Hassan, "EFFECTIVENESS OF 3D MODELING IN CONSTRUCTION INDUSTRY USING SKETCHUP IN REDUCINGTIMEANDCOSTOFPROJECT,"ResearchGate, March 2016, [Online] Available: https://doi.org/10.13140//RG.2.1.1596.8404.[Accessed:April30 2024]

[28] B. Kolhe, Prof. S.S. Manal, and Prof. D.M. Pandit, "Design and Analysis of Multi-storey (G+6) Residential Building using Staad pro And AutoCad," International Journal of Advanced Research in Science, Communication and 69 Technology, pp. 332–341, April 2024, [Online]. Available: https://doi.org/10.48175/ijarsct-17044.[Accessed: April 30, 2024]

[29] J. Paľo, J. Caban, M. Kiktová, and Ľ. Černický, "The comparison of automatic traffic counting and manual traffic counting," IOP conference series. Materials science and engineering, vol. 710, no. 1, pp. 012041–012041, Dec. 2019, [Online] Available: https://doi.org/10.1088/1757-899x/710/1/012041.[Accessed: Apr. 30 2024]

[30] G.Agarwal,"ExcelFullCourse-in2hours|Beginner Level,"AnalyticsVidhya,Nov.24,2021.[Online].Available: https://www.analyticsvidhya.com/blog/2021/11/a-comprehensive-guide-onmicrosoft-excel-for-data-analysis/[Accessed: November 29, 2023]

[31] "NATIONAL BUILDING CODE Minimum Requirement," NationalbuildingCodeofthePhilippines,April30,2005,[Book]. Available:THENATIONALBUILDINGCODEOFTHE PHILIPPINES and Its Revised Implementing Rules and Regulations [Accessed: December 3, 2023]

[32] L. Manson, "Analysis and Comparison of Connections in SteelStructures"B.S.,CivilandEnvironmentalEngineering,June 2006,[Online]Available:https://dspace.mit.edu/bitstream/handle[Accessed: May 4, 2024]

[33] "PowerfulPartnerships.PowerfulResultsVULCRAFT® STEEL BAR GRATING" [Online]. Available: https://vulcraft.com/catalogs/Grating/Vulcraft_Grating_Manual_JAN21.pdf[Accessed: May 23, 2024.]

