Department of Public Works and Highways (DPWH)
In the Republic of the Philippines

Preparatory Survey
for
Second San Juanico Bridge Construction Project
in
the Republic of the Philippines

Final Report

(Advanced Disclosure Version)

November 2025

Japan International Cooperation Agency (JICA)

Joint Venture of
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*PHP: Philippines Perso

SUMMARY

1 Background and Objectives of the Survey

1.1 Background of the Survey

The Eastern Visayas Region, which is the target area of this project, has a particularly high poverty rate of 22.2%, and the region's population was approximately 4.1 million in 2010 and is projected that the population will increase to about 7.1 million in 2045. According to the Visaya Space Development Framework (2015-2045), it will be necessary to further expand the road network as a logistics improvement measure to accommodate the increase in traffic volume due to population growth and to reduce the poverty rate through economic development. Based on this context, although the DPWH is implementing of a high-standard road network development to connect regional cities, progress in the Visayas Region—unlike Luzon and Mindanao—has been limited. This is mainly due to geographical challenges of constructing infrastructure across its small and medium-sized islands. Under these circumstances, the technical cooperation project High Standard Highway Network Development Master Plan Project (HSH M/P) (Phase 2, 2019-2021), implemented by JICA, aimed to examine the national road network development plan with a view of developing local bases and improving domestic connectivity. The project was confirmed to have a high need for development support, given the urgency and technical difficulty associated with national highways. As a result, the existing San Juanico Bridge (the existing SJB) —an approximately 2,600-meter truss bridge connecting Leyte and Samar in the Eastern Visayas Region—has been identified as a supported section. In the aforementioned master plan project, traffic demand in the Visayas Region is projected to increase within the next ten years due to the economic development, making it necessary to expand its capacity. However, the bridge cannot be widened because of its truss structure.

This project involves the construction of the Second San Juanico Bridge (the SSJB), along with its approach roads on Leyte and Samar. It aims to respond to the increasing transportation and logistics demand while minimizing the impact of disruptions and restrictions on mobility between the two islands. The project is positioned as a priority project that will contribute in promoting the region's economic development.

1.2 Survey Area

The survey area covers Leyte and Samar Island in the Eastern Visayas Region.

The scope of study for the location of the SSJB encompasses the entire San Juanico Strait. This includes: the north area, which assumingly covers a relatively narrow section of the strait and the site recommended in the Pre-Feasibility Study (Pre-F/S) conducted under the HSH M/P, approximately 11 kilometers from the existing SJB; the middle area, near the existing SJB; the south area, which crosses the river near the city of Tacloban, including the approach roads.

For the examination of natural conditions, construction plans, and environmental and social considerations in this survey, the scope also includes land required for project implementation, which is to be provided by the executing agency.

1.3 Objectives of the Survey

The objective is to conduct surveys necessary for preparing the outline design, project cost, implementation schedule, and environmental and social considerations for the project, which will be carried out as a loan cooperation initiative with Japan.

2 Technical Feasibility of the Project

2.1 Consistency with the HSH M/P

This project involves the construction of a bridge as part of a high-standard highway connecting Samar Island and Leyte Island. Given the current deterioration of the existing SJB, which is the only existing route linking the two islands, this section is recognized as an area requiring urgent development. In the master plan for the high-standard highway, a route is recommended that connects the Maharlika Highway on the Samar side with the Tacloban City–Babatngon Road, approximately 11 km north of the existing SJB. In this study, this recommended route was considered alongside other potential options during the process of selecting the bridge location.

2.2 Selection of Bridge Location

Route selection is done in two steps.

In Step 1, six areas along the San Juanico Strait—extending 16 km north and 7.5 km south from the existing SJB—were evaluated from the perspectives of traffic improvement and connectivity, impact on the natural environment, project length, harmony with the surrounding environment, and constructability. As a result, two areas were shortlisted: the area recommended in the high-standard highway master plan and the area around the existing SJB.

A comprehensive evaluation of these two areas was then conducted, considering project benefits, construction costs, environmental and social considerations, harmony with the surrounding environment, and constructability. Based on this evaluation, the area around the existing SJB was selected.

In Step 2, within the existing SJB area, four alternative routes were proposed for comparison: C1 (2.8 km north of the existing SJB), C2a (1.7 km north), C2b (1.2 km north), and C3 (1.4 km south). These routes were designed with a design speed of 80 km/h, as they are located on a primary national road, and their alignments were determined based on appropriate road geometry. In setting the routes, control points such as navigational width and clearance were considered, and efforts were made to avoid or minimize impacts on natural environments such as mangroves and coral reefs, as well as on residential areas.

Based on traffic demand forecasts, the SSJB was determined to require two lanes, and the preliminary EIRR confirmed the viability of a two-lane project. Therefore, the study proceeded with the assumption of a two-lane bridge.

As in Step 1, a multi-criteria analysis was conducted using evaluation items such as differences in distance between major origin-destination (as a measure of project benefit), construction cost, environmental and social considerations, and constructability. In addition, horizontal and vertical alignments and O&M facility costs were included in the evaluation. As a result of the multi-criteria analysis, Alternative C2b was found to be relatively superior in terms of project benefits, construction cost, social environment, and constructability, and was recommended as the optimal bridge location.

Control Points

Symbol	Item	Avoidance Policy
	Village	Minimum impact
	Mangrove	Minimum impact
	Coral	Minimum impact
	Others	(Depends)
	Contour	Minimum structure
	Sea route	Vertical Clearance

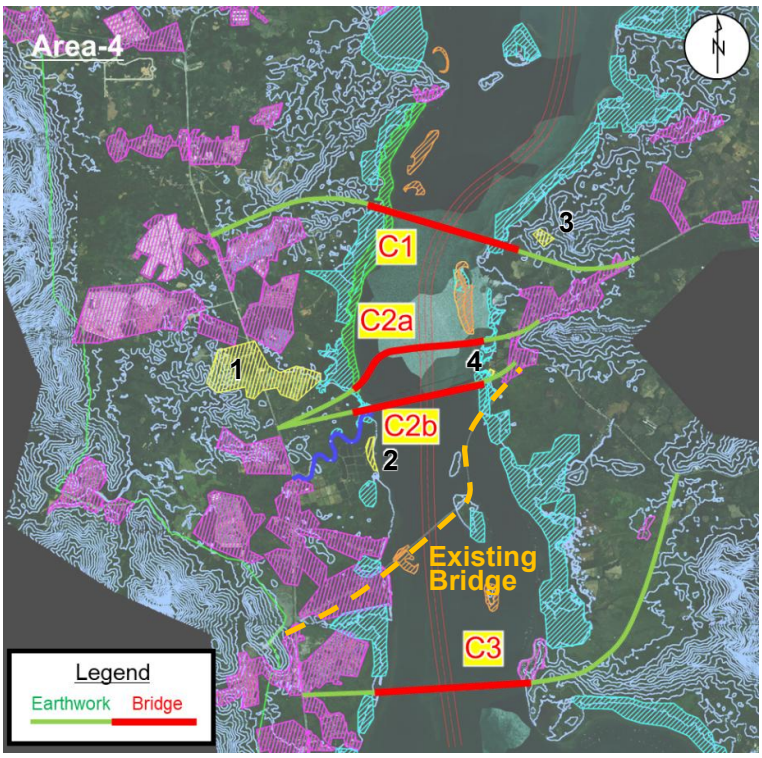
[Others]

1: Private Company's Area

2: Beach Resort

3: Resort Restaurant

4: View Deck



Source: JICA Survey Team

Figure 2-1 Proposed Alternatives for the Selection of Bridge Location

However, the recommended C2b option did not receive the consent of Samar Province. The reason is that a scenic deck is being developed allows views of the existing SJB from the land side. Under the C2b case, the SSJB would obstruct the view of the existing SJB from the scenic deck, thereby diminishing its tourism potential.

On the other hand, the alternative C2a allows for a panoramic view of both the new and existing bridges from the scenic deck, creating a new scenic landscape. For this reason, Samar Province agreed to proceed with the C2a option, and it was confirmed that DPWH would move forward with this plan.

After finalizing the route and bridge location for C2a, preliminary design, construction planning, and cost estimation were carried out. Since various costs considered during the route comparison—such as bridge unit prices, resident relocation compensation, and soft-ground countermeasures—have been scrutinized and updated, the route selection in Step 2 is re-evaluated to determine if the rankings change with the updated unit prices and quantities. In doing so, items evaluated by cost or that can be converted into costs are integrated into the overall cost.

The re-evaluation confirmed that C2a remains the most advantageous option, even when re-evaluated based on the updated information from the preliminary design.

2.3 Traffic Demand Forecast and Required Number of Lane

(1) Traffic Operations

Based on bridge route selection result of constructing a SSJB in close proximity to the existing one and DPWH's policy of continuing to utilize the existing SJB through future repairs and reinforcements, two traffic operation schemes were considered for the combined use of both bridges: a one-way traffic scheme and a two-way traffic scheme.

Table 2-1 Traffic Operations

	One-Way Traffic	Two-Way Traffic
Image		
Number of Lanes	SSJB： 2 / 4 lanes in one direction (both sides). Existing SJB: 2 lanes in one direction (both sides).	SSJB： one lane in one direction (one direction). Existing SJB ：one lane in one direction (one direction).

Source： JICA Survey Team

The damage identified in the condition survey of the existing SJB conducted in this study is not considered severe enough to immediately compromise the structural strength or stability of the bridge. However, considering that the bridge has already been in service for over 50 years and is expected to remain in use for the foreseeable future, it is desirable to maintain its overall load-bearing capacity at least at the current level.

To achieve this, a detailed inspection is proposed for the majority of the bridge sections that were not covered in this study. The purpose of this inspection is to assess the overall structural integrity of the bridge, identify areas requiring repair, and examine feasible repair methods that can be applied on-site.

(2) Required Number of Lanes

According to the results of the traffic demand forecast, the traffic volume between Leyte and Samar is 24,900 PCU/day in 2040 and 37,000 PCU/day in 2050. Based on the projected traffic volumes and the capacity of the existing roads, the traffic volume-to-capacity ratio was calculated, and the appropriateness of the number of lanes was assessed for the year 2050 using the concept of Level of Service (LOS). Since traffic capacity varies depending on the traffic operation scenario—whether one-way or two-way—each scenario was evaluated separately.

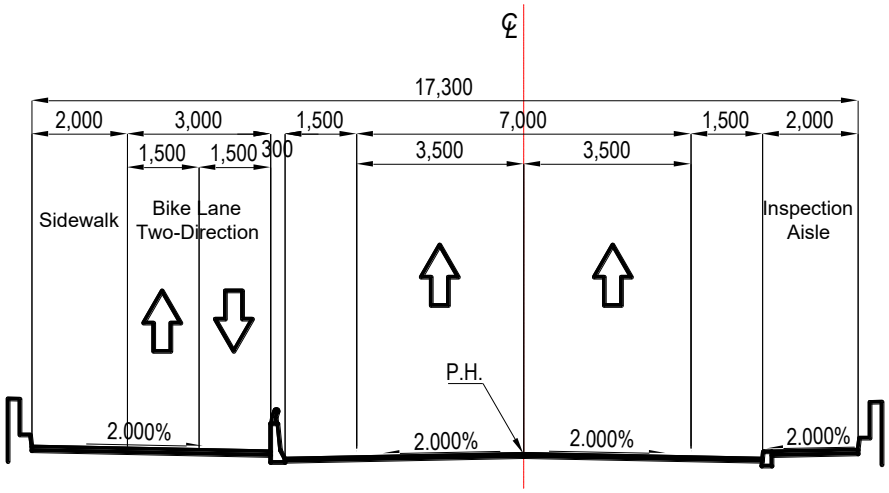
As a result, under all traffic operation scenarios, having two lanes each on the existing SJB and the SSJB would achieve LOS C, which is the target standard for high-standard roads in rural areas, even with the projected 2050 traffic volume. This confirms the appropriateness of constructing the SSJB with two lanes.

Furthermore, a comparison of one-way and two-way traffic scenarios from the perspective of Economic Internal Rate of Return (EIRR) showed that the one-way traffic scenario yielded more favorable results, as it allows for a higher speed limit due to improved driving safety.

2.4 Road Alignment and Standard Cross Section for the Bridge

At the selected bridge location, the total road length is 2,610.6 meters, with a bridge length of 1,560 meters. The lengths of the embankment sections are 360 meters on the Samar Island side and 690.6 meters on the Leyte Island side. The maximum longitudinal gradient was set at 3.3% to ensure the navigational clearance (113 m × 24.2 m).

The standard cross-sectional configuration includes bicycle lanes in accordance with the DPWH Department Order No. 263, Series of 2022, titled “Updated Guidelines and Standard Design Drawings for Bicycle Facilities along National Roads.” In addition, sidewalks and inspection walkways are to be arranged to accommodate tourists and provide access for maintenance inspections. The total roadway width is set at 17.3 meters, including two traffic lanes, bicycle lanes, sidewalks, and inspection walkways.



Source: JICA Survey Team

Figure 2-2 Proposed Standard Cross Section for the Bridge

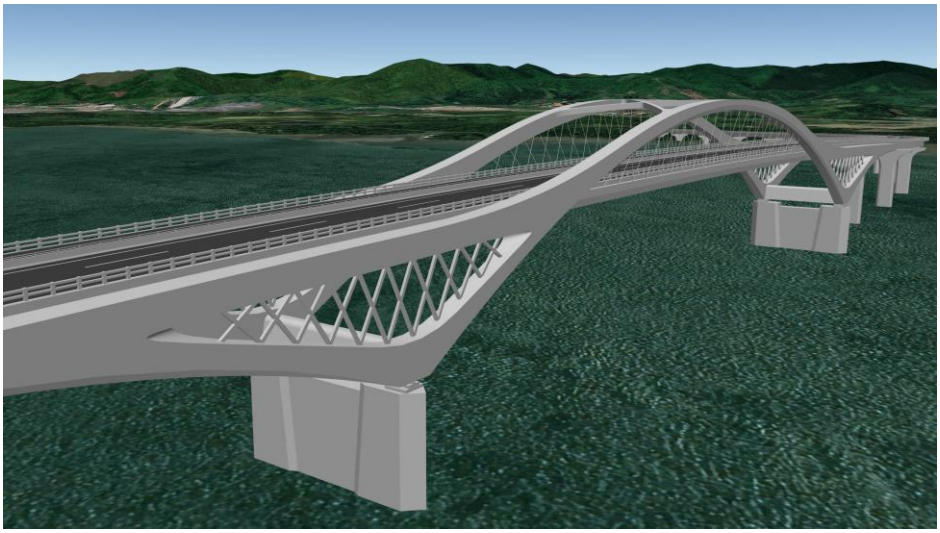
2.5 Bridge Structural Type and Preliminary Design

The superstructure of the main bridge was selected from structural types that satisfy the required navigational width and are well-suited for a span length of 195 meters, equivalent to that of the existing SJB. Based on a comprehensive evaluation considering economic efficiency, structural performance, constructability, maintainability, and environmental and aesthetic aspects, a steel arch bridge (an arch bridge with truss elements) was selected.

For the approach bridges, structural types suitable for span lengths of 40 to 80 meters were evaluated using the same criteria, and AASHTO girders were selected.

Regarding the foundation types, options suitable for the water depth and ground conditions at the bridge location were comprehensively evaluated from the perspectives of economic efficiency, structural performance, constructability, resistance to ship collision, and environmental and aesthetic considerations. As a result, multi-column foundations were selected for deep-water sections, cast-in-place piles for abutments, and spread foundations for shallow-water or onshore sections.

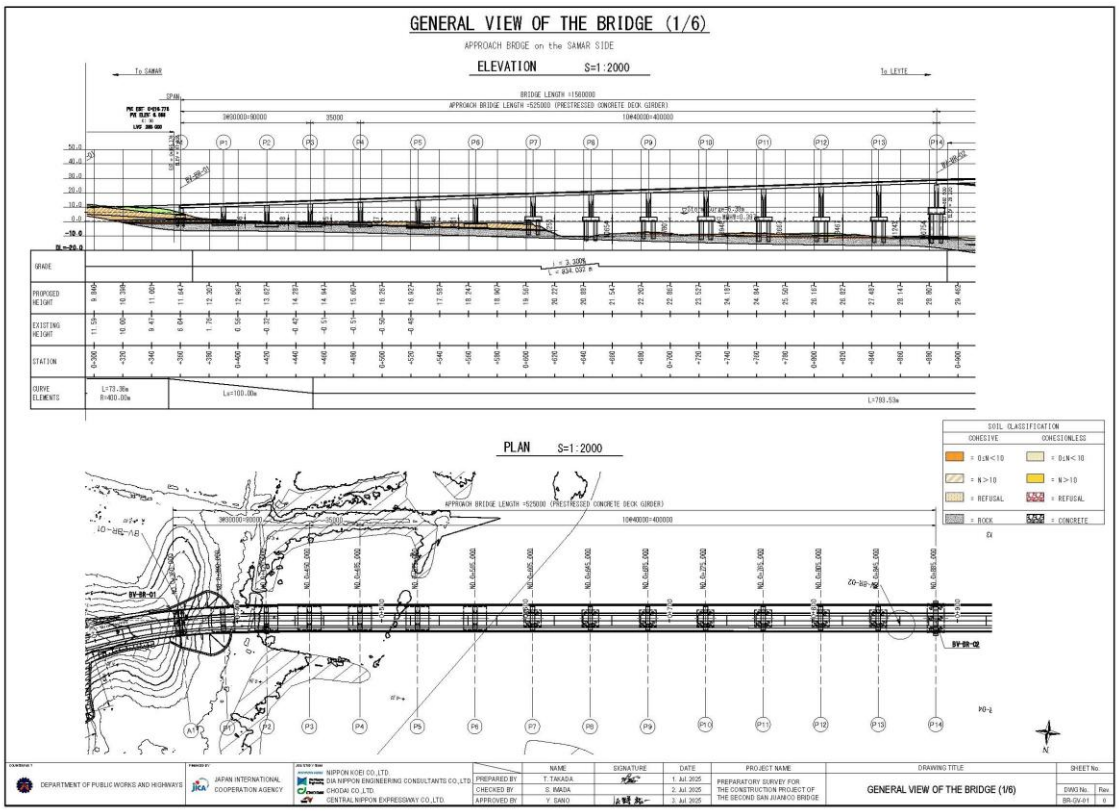
All selected structural types have sufficient construction precedents in Japan and are considered technically feasible under the local natural conditions. Upon completion, the main bridge will become the largest arch bridge in the Philippines.



Source: JICA Survey Team

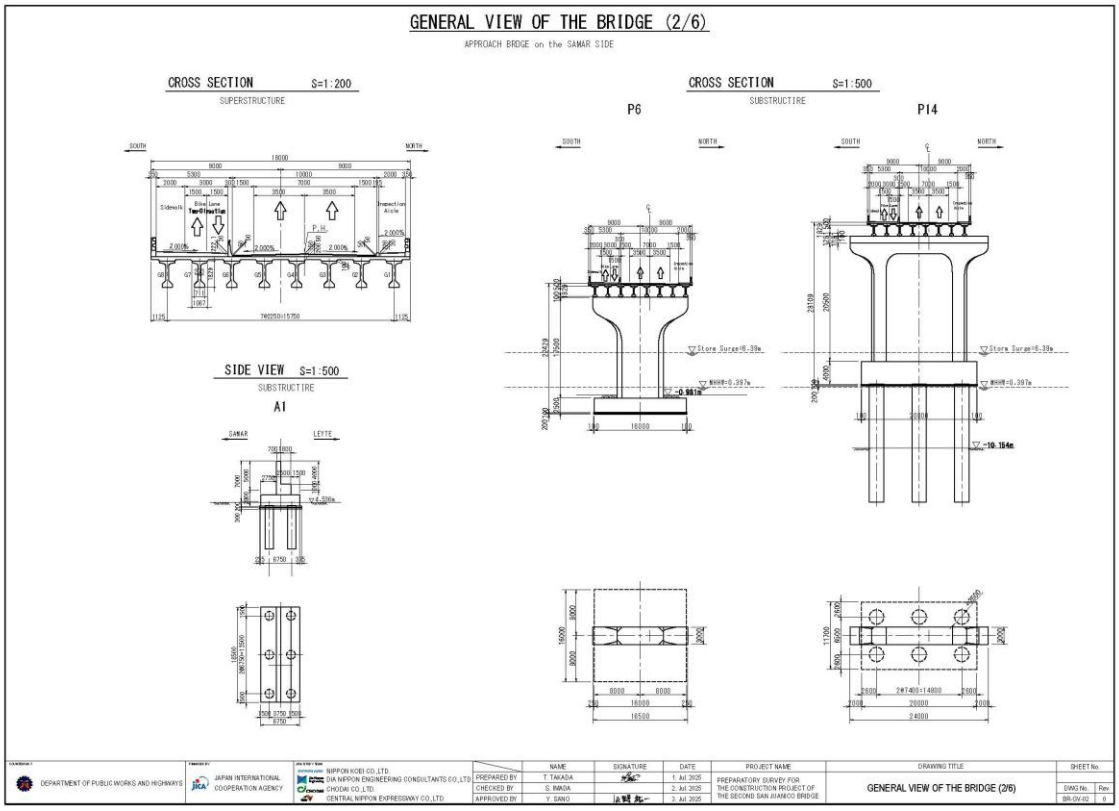
Figure 2-3 Perspective View of Proposed Main Bridge

Based on the bridge type selected through the evaluation of alternatives, the design was developed by incorporating the results of various natural condition surveys. The general layout of the bridge is shown below.



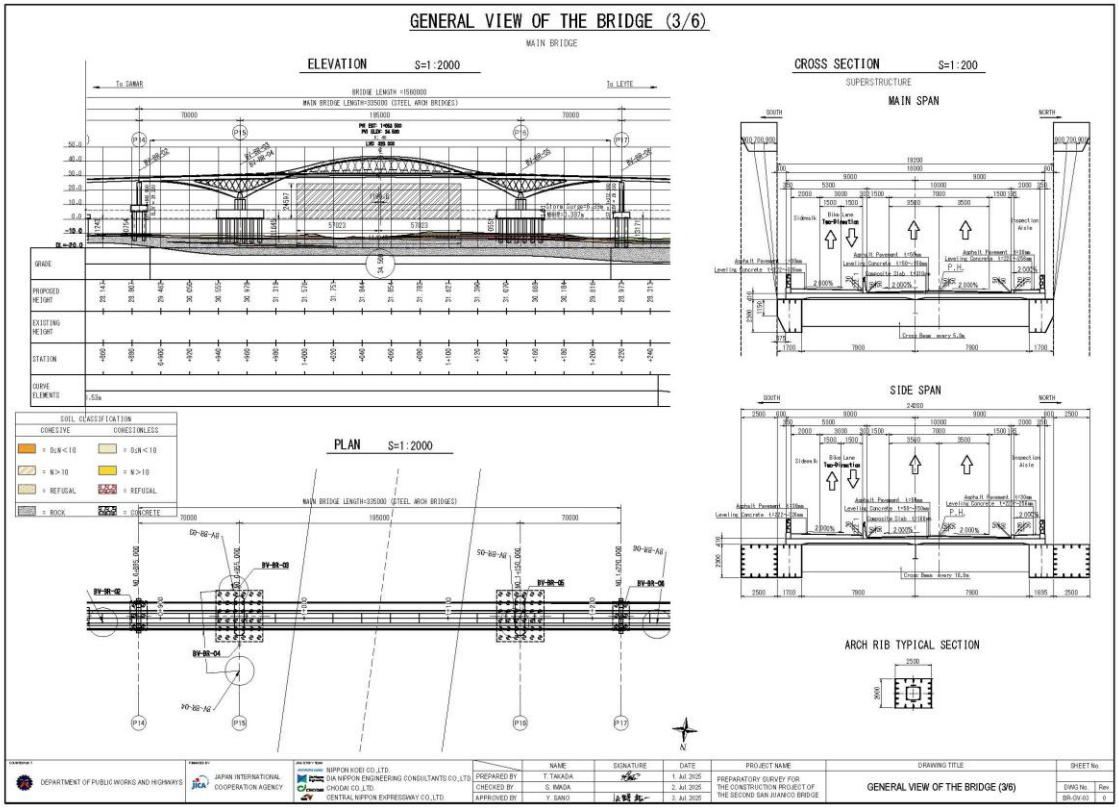
Source: JICA Survey Team

Figure 2-4 General View of Bridge Section (1/6)



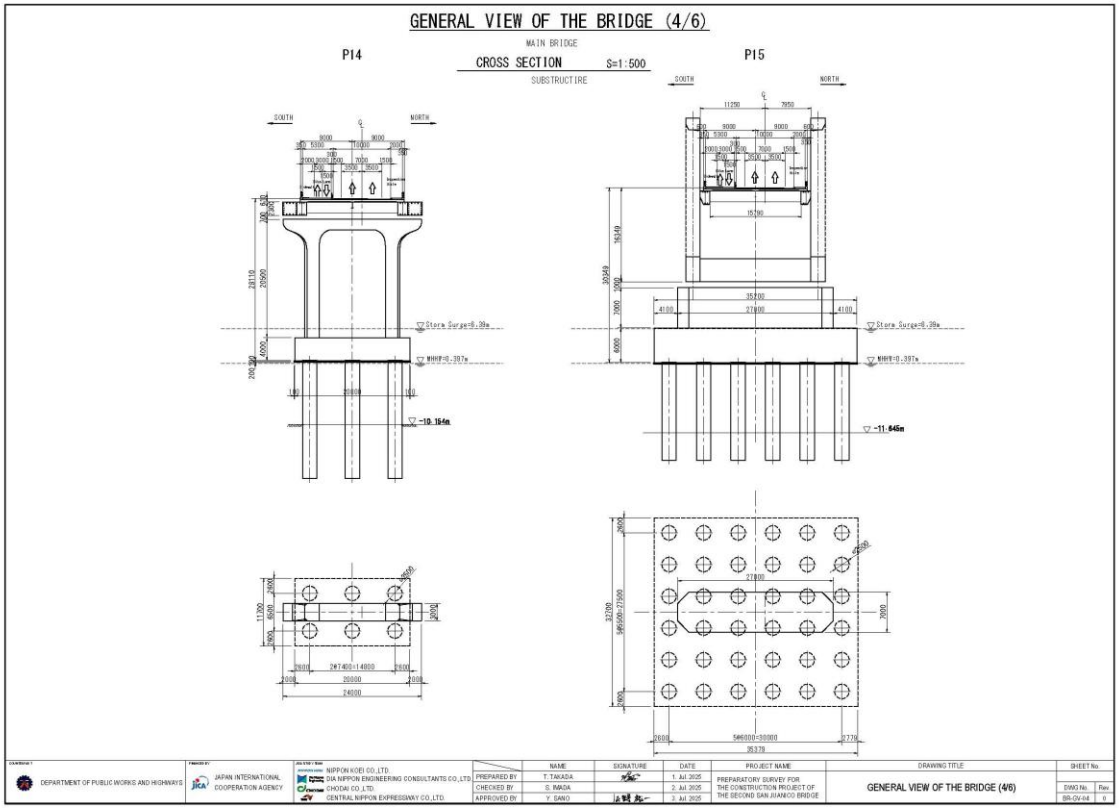
Source: JICA Survey Team

Figure 2-5 General View of Bridge Section (2/6)



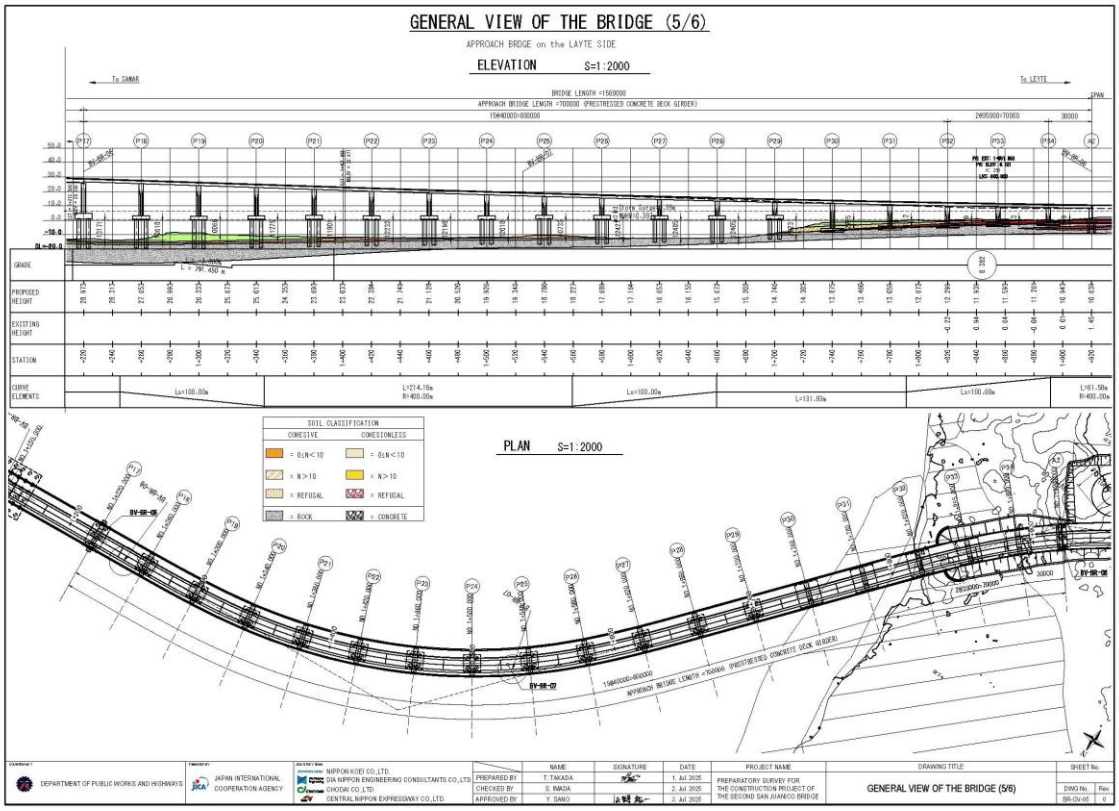
Source: JICA Survey Team

Figure 2-6 General View of Bridge Section (3/6)



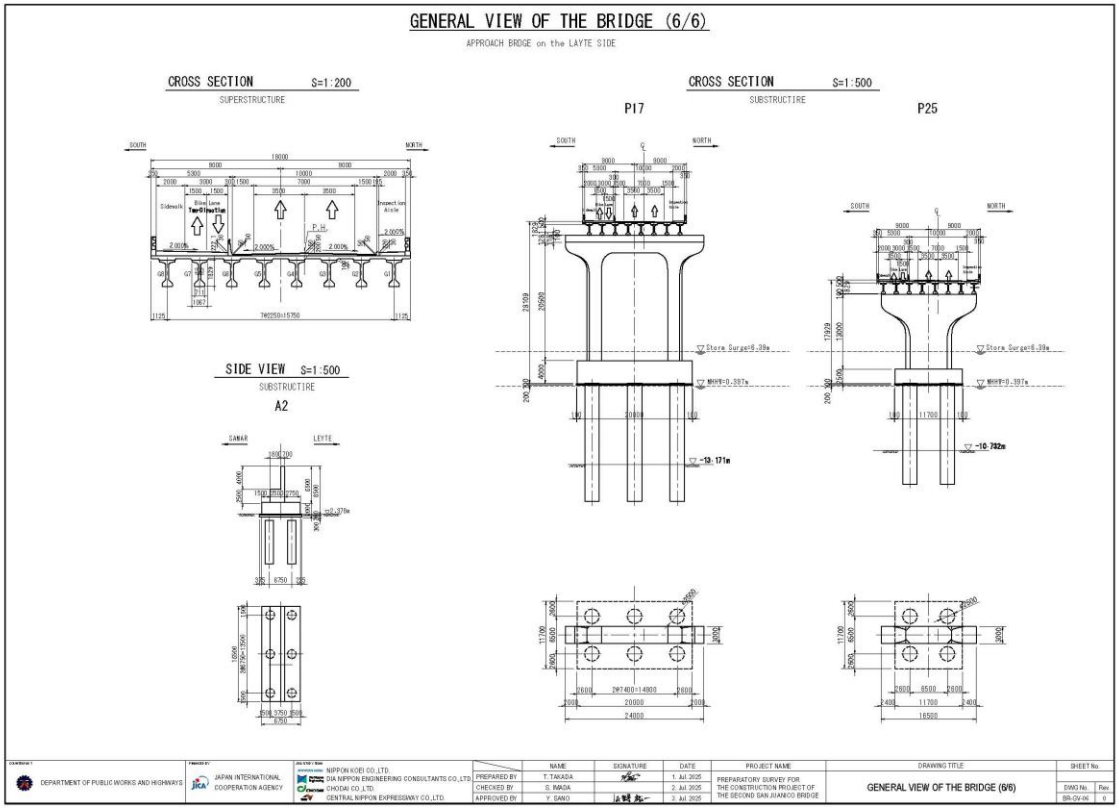
Source: JICA Survey Team

Figure 2-7 General View of Bridge Section (4/6)



Source: JICA Survey Team

Figure 2-8 General View of Bridge Section (5/6)



Source: JICA Survey Team

Figure 2-9 General View of Bridge Section (6/6)

2.6 O&M Facility Plan and Organizational Structure

(1) O&M Facility Plan

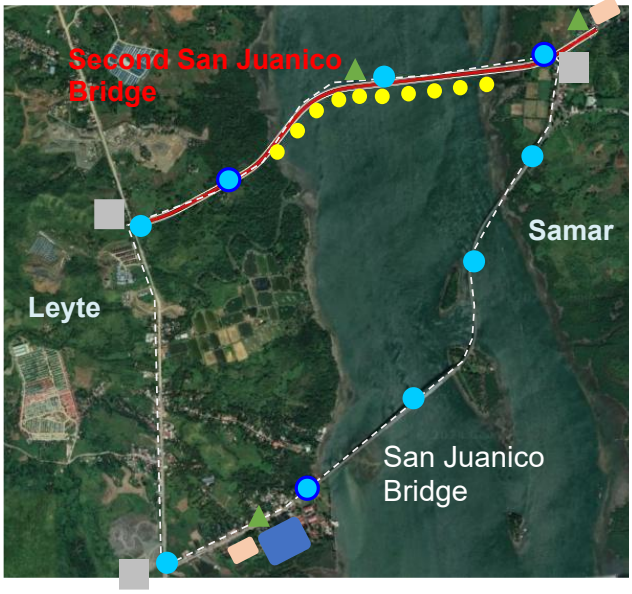
It is recommended to establish operation and maintenance facilities that assume integrated management of both the existing SJB and the SSJB. This includes installing a road traffic control center that comprehensively manages signals from newly installed equipment such as CCTV, WIM, weather monitoring devices, and seismometers. The control center will be set up by effectively utilizing the space within the existing SJB's maintenance office.

The facilities and equipment necessary for bridge operation have been planned as shown in the table and figure below.

Table 2-2 Outline of O&M Facilities and Equipment

Facility/Equipment	Location Plan	Overview
Road Control Center	Leyte side of the existing SJB	A system will be established to centrally manage data from instruments and sensors installed around the existing and second bridges, including traffic control systems, weight, traffic volume, weather, seismic, environmental.
Weigh-in-Motion (WIM) Stations	Both sides of the bridge	WIM will be used considering cost and operational efficiency.
CCTV	9 locations	Installation of CCTV and provision of information to the traffic control center.
Network	Loop configuration	A robust network will be developed using a loop configuration connecting both the existing and new bridges.
Information Provision Equipment	3 locations	Appropriate information will be provided to road users.
Lighting Equipment	10 road lighting points, navigation lights at each pier	Road lighting will be installed as required for traffic operations; navigation lights will be installed at each pier.
Traffic Measurement Equipment	2 locations	One unit will be installed on each of the existing and second bridges. These will also function as CCTV.
Meteorological Observation Devices & Seismometers	2 locations	One weather monitoring device will be installed on each of the existing and second bridges. Seismometers will be installed at the traffic control center and at the foundation of the WIM station on the Samar side.

Source: JICA Survey Team



No	symbol	Facilities	image
9.3.1		Road Control Center	
9.3.2		Axis Weigh Stations & Axis Weighing Equipment	
9.3.3 (1)		CCTV	
9.3.3 (2)		Network Equipment	
9.3.3 (3)		Information Provision Equipment	
9.3.3 (4)		Lighting Equipment	
9.3.3 (5)		Traffic Measurement Equipment	
9.3.3 (6)		Meteorological Observation Equipment and Seismographs	

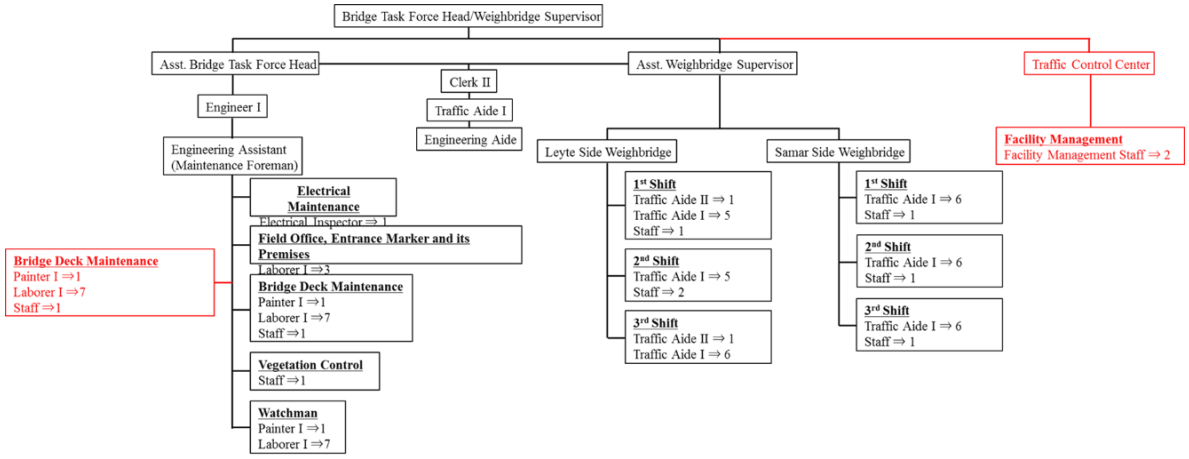
Source: JICA Survey Team

Figure 2-10 O&M Facility Layout Plan

(2) O&M Organizational Structure

A project implementation and operation & maintenance plan is proposed that ensures integrated management of both bridges. This includes consideration of potential future projects, such as the construction of the SSJB and large-scale rehabilitation works for the existing SJB after the SSJB is opened. The operation and maintenance framework should also reflect the outcomes of bridge, road, and facility design studies, while taking into account the current status of DPWH's road operation and maintenance organization, equipment, and budget.

As the post-completion framework for the SSJB, an efficient staffing plan is recommended, as illustrated in the figure below. Since the SSJB is similar in length and scale to the existing SJB, it is proposed to add one more Bridge Deck Maintenance team, equivalent to the team currently managing the existing SJB, to manage the SSJB. Additionally, as facilities for managing both the existing and second bridges are planned in this study, it is recommended to increase the number of Facility Maintenance Staff by two, in addition to the current Electric Inspector under Electric Maintenance, to ensure proper management of these facilities.



Source: JICA Survey Team

Figure 2-11 San Juanico Bridge Field Office Organizational Structure after the Opening of the SSJB

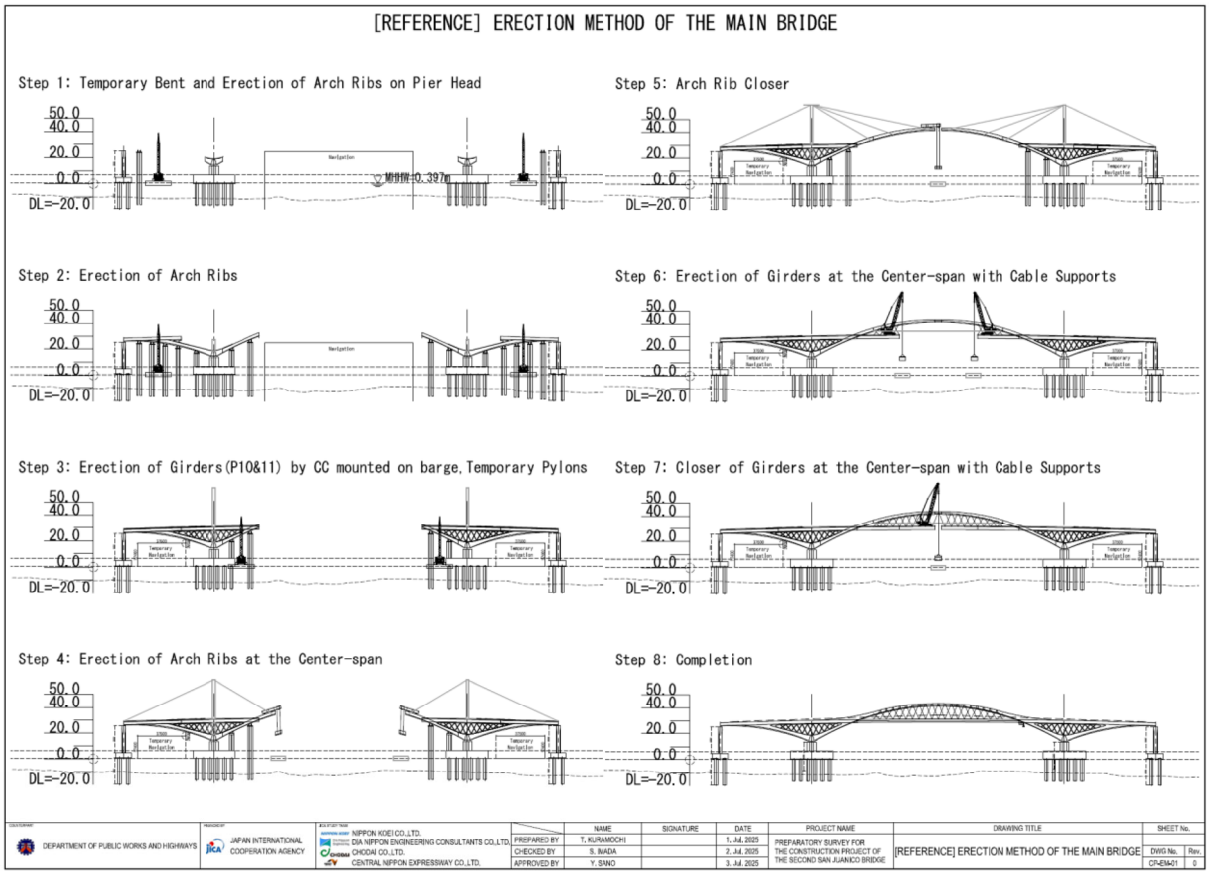
2.7 Construction Plan

(1) Construction Plan for Main Bridge

The feasibility of erecting large blocks for the main span of the main bridge was examined. While installation using large barges is technically possible, it was concluded that such a method would not be assumed at this stage of the preparatory survey. This is due to the lack of investigation into the availability of a large-scale assembly yard located away from the San Juanico Strait, and the presence of strong currents exceeding 2 knots.

As an alternative, erection of the arch ribs using an erection nose method was considered. The adopted construction method assumes the following steps, as illustrated in the figure below:

- Side spans will be erected using temporary bents.
- A temporary steel tower will be installed at the location of the central pier.
- Arch ribs will be erected block by block (each block: 5 meters) in a cantilevered manner using an erection nose.
- Deflection and member bending will be controlled by supporting the structure with cables from the temporary tower at appropriate positions.



Source: JICA Survey Team

Figure 2-12 Planned Erection Method of Main Bridge (Reference)

(2) Procurement Plan and Construction Schedule

2.8 Applicability of Japanese Construction Technology

For this project, it is considered advantageous to utilize the following Japanese construction technologies and materials from the perspectives of cost-effectiveness, constructability, and maintainability. These have been incorporated into the preliminary bridge design and cost estimates in this study:

- Long-life anti-corrosion steel
- Composite deck slabs
- Seismic isolation bearings

As described in Chapter 11, the cost of materials and services proposed to be procured from Japan is estimated to exceed 30% of the total construction cost. Therefore, the project is expected to be eligible for the “Special Terms for Economic Partnership (STEP)” under Japan’s ODA loan scheme.

2.9 Implementing Agency’s Capacity

DPWH has completed numerous road and bridge construction projects in the past, including projects of similar scale and technical complexity to this one, such as the Second Mactan Bridge (II) and Metro Cebu Road Development Project, and the Second Magsaysay Bridge and Bypass Road Construction Project, which were funded through Japanese ODA loans. Therefore, if this project is implemented under a yen loan and is designed, constructed, and supervised by experienced and capable consultants and contractors, DPWH is deemed to have the capacity to implement the project.

On the other hand, as noted in Section 12.3, several issues related to maintenance and operation have been identified in the aforementioned projects. These include the need for the development of manuals, technical training, and securing necessary budget allocations and personnel.

3 Feasibility in Terms of Environmental and Social Considerations

An Environmental and Social Impact Assessment (ESIA), including baseline surveys and public consultations, was conducted for the environmental aspects of the project. The results of the study identified potential negative impacts from project implementation—such as tree removal and effects on mangrove habitats—but appropriate mitigation measures have been planned to avoid or minimize these impacts.

On the social side, a Resettlement Action Plan (RAP) study was conducted. It was found that land acquisition (47,588 m²) and the relocation of 15 households would be required along the selected route. However, appropriate measures for affected residents have been planned, including an Entitlement Matrix, a grievance redress mechanism, and a livelihood restoration plan.

Therefore, the project is considered feasible in terms of environmental and social considerations. The ESIA and RAP were approved by the Environmental and Social Safeguards Division (ESSD) of DPWH on June 2, 2025.

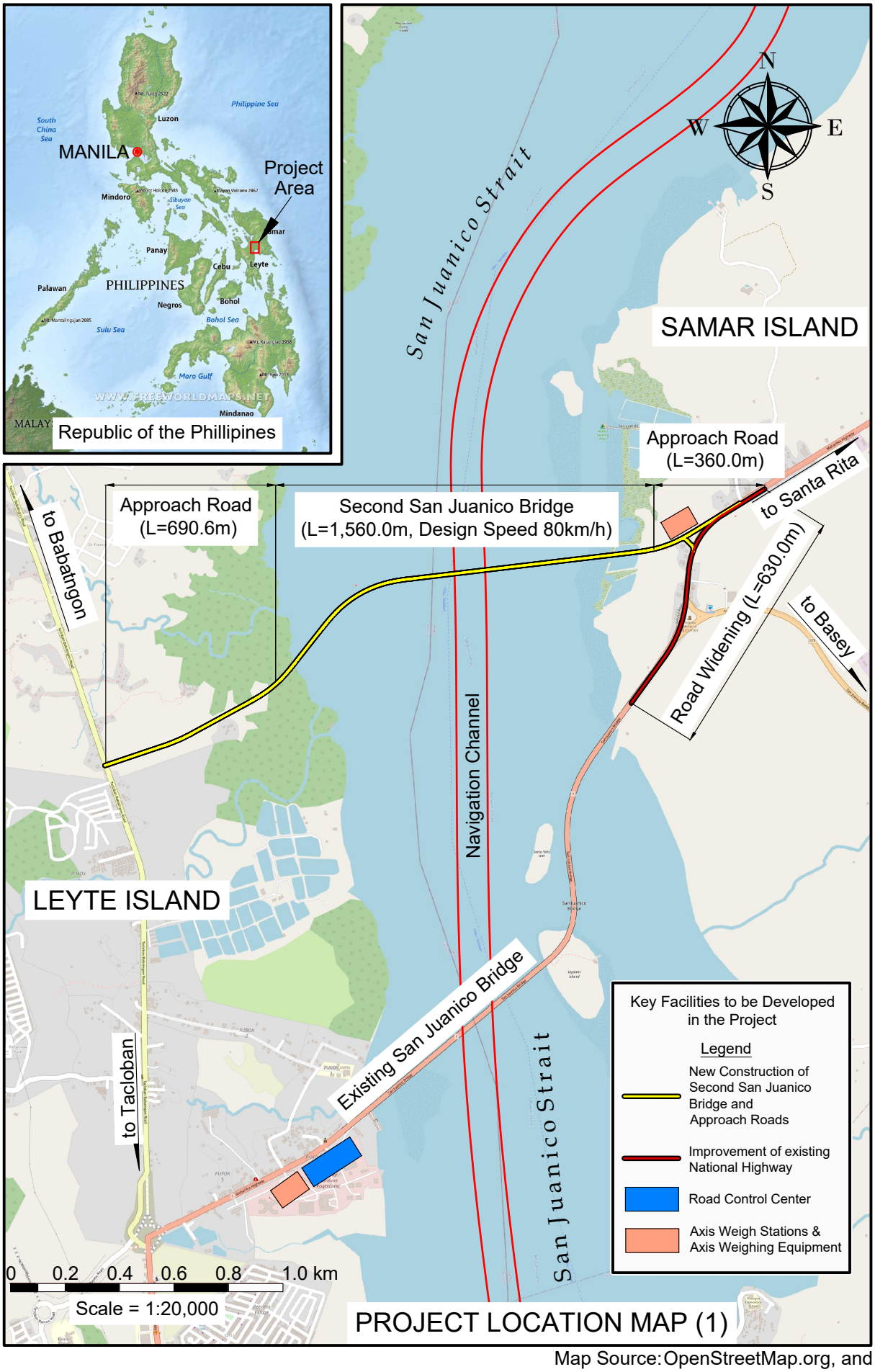
4 Economic Feasibility

4.1 Estimated Project Cost

4.2 Economic Evaluation

Based on the estimated project cost, operation and maintenance costs, and projected benefits, an economic evaluation was conducted using a 30-year evaluation period and a social discount rate of 10%. As a result, the Economic Internal Rate of Return (EIRR) was calculated at 17.5%, the Benefit-Cost Ratio (B/C) at 1.4, and the Economic Net Present Value (ENPV) at PHP 5,309 million. Therefore, the project is considered economically feasible.

The implementation of this project is expected to promote economic development in the areas surrounding the San Juanico Strait, including Leyte and Samar Islands, and to generate economic benefits through the promotion of tourism.



PROJECT LOCATION MAP (1)

Map Source: OpenStreetMap.org, and FreeWorldMaps.net


Samar
Catbalogan City Airport
Catbalogan
Legend
Second San Juanico Bridge
Existing San Juanico Bridge
Pan-Philippine Highway AH26
Widening of Maharlika Highway
Tacloban Bypass (Completed)
Tacloban Bypass (Ongoing)
Palo Bypass
Major city, village
Existing building
Under construction
Future project
Tourist attraction
Hospital
High school, university
DPWH office, city hall, barangay hall
Widening of Maharlika Highway
AH26
Second San Juanico Bridge
Port of Babatngon
Santa Rita
Babatngon
Proposed Sta. Rita Boardwalk
Proposed Viewing Deck
Tacloban Bypass
Existing San Juanico Bridge
Strait Viewing Deck
East Visayas Regional Medical Center
Basey
Tacloban
Daniel Z. Romualdez Airport
Port of Tacloban
Leyte
Palo Bypass
0 5 10 km
Scale 1:350,000
Project Location Map (2)
Source: Modified on OpenStreetMap

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Separate Volume

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Abbreviations

Abbreviation	English
AASHTO	American Association of State Highway and Transportation Officials
AMWP/PB	Annual Maintenance Work Program /Performance Budget
AQMS	Air Quality Monitoring Station
AR	Augmented Reality
BCR	Benefit-Cost Ratio
BIM/CIM	Building Information Modeling / Construction Information Modeling
BIV	Bridge Inspection Vehicle
BMC	Bridges Management Cluster
BOD	Biochemical Oxygen Demand
BSDS	Bridge Seismic Design Specification
CADT	Certificate of Ancestral Domain Title
CBR	California Bearing Ratio
CCA	Climate Change Adaptation
CENRO	City Environment and Natural Resources Office
CHO	City Ecological Profile
CLUP	Comprehensive Land Use Plan
CMR	Compliance Monitoring Report
CMVR	Compliance Monitoring and Validation Report
CNC	Certificate of Non-Coverage
CO	Central Office
COD	Chemical Oxygen Demand
COR	Crude Death Rate
CPA	Conservation Priority Area
CPI	Consumer Price Index
DAO	DENR Administrative Orders
DBH	Diameter at breast height
DCP	Dual-Mass Dynamic Cone Penetrometer
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DEO	District Engineer Office
DEPDev	Department of Economy, Planning and Development
DF/R	Draft Final Report
DGCS	Design Guidelines, Criteria and Standards
DICT	Department of Information and Communications Technology
DIV	Dutch Intervention Values

Abbreviation	English
DO	Dissolved Oxygen
DOF	Department of Finance
DOST	Department of Science and Technology
DPWH	Department of Public Works and Highways
DSWD	Department of Social Welfare and Development
DTM	Digital Terrain Model
DWT	Deadweight Tonnage
ECA	Environmentally Critical Areas
ECC	Environmental Compliance Certificate
ECP	Environmentally Critical Projects
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EIS	Philippine Environmental Impact Statement System
EM/P	Environmental Management Plan
EMB	Environmental Management Bureau
EMoP	Environmental Monitoring Plan
ENIPAS	Expanded National Integrated Protected Areas System
ENPV	Economic Net Present Value
EO	Executive Order
ESC	Environmental and Social Considerations
ESSD	Environmental and Social Safeguards Division
F/R	Final Report
F/S	Feasibility Study
FIRR	Financial Internal Rate of Return
GAA	General Appropriations Act
GAD	Gender Assessment Development Plan
GDP	Gross Domestic Product
GES	General Effluent Standards
GHG	Greenhouse Gas
GIS	Geographic Information System
GOP	Government of the Philippines
GRDP	Gross Reginal Domestic Product
GVW	Gross Vehicle Weight
HGDG	Gender and Development Harmonization Guidelines
HOV	High Occupancy Vehicle
HSH	High standard highway
IBA	Important Bird Area

Abbreviation	English
IC/R	Inception Report
ICAO	International Civil Aviation Organization
ICB	International Competitive Bidding
ICT	Information and Communication Technology
IEC	Information, Education and Communication
IEE	Initial Environmental Examination
IEEC	IEE Checklist
IEER	Initial Environmental Examination Report
IMR	Infant Mortality Rate
IPAP	Indigenous Peoples' Action Plan
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
IT/R	Interim Report
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
JSCE	Japan Society of Civil Engineering
JV	Joint Venture
KBA	Key Biodiversity Area
LCT	Land Craft Tank
LGU	Local Government Unit
LiDAR	Light Detection and Ranging
LIT	Line Intercept Transect
LMWD	Leyte Metropolitan Water District
LOA	Length Overall
LRFD	Load and Resistance Factor Design
LTFRB	Land Transportation Franchising & Regulatory Board
M/P	Master Plan
MASCOT	Microclimate Analysis System for Complex Terrain
MBFDP	Mangrove Beach Forest Development Program
MCA	Multi-Criteria Analysis
MHHW	Mean Higher High Water
MHW	Mean High Water
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MLLW	Mean Lower Low Water
MLW	Mean Low Water
MMR	Maternal Mortality Rate
MMT	Multipartite Monitoring Team

Abbreviation	English
MSL	Mean Sea Level
NAAQG	National Ambient Air Quality Guidelines
NAMRIA	National Mapping and Resource Information Authority
NCCA	National Commission for Culture and the Arts
NCCAP	National Climate Change Action Plan
NCIP	National Commission on Indigenous Peoples
NCM	Normal Cubic Meter
NDRRMC	National Disaster Risk Reduction and Management Council
NF/SCC	National Framework Strategy on Climate Change
NGO	Non-government Organization
NGP	National Greening Program
NH	National Highway
NICTHS	National ICT Household Survey
NIPAS	National Integrated Protected Areas System
NOAA	National Oceanic and Atmospheric Administration
NPCC	National Pollution Control Commission
NPV	Net Present Value
NSWMC	National Solid Waste Management Framework
O&M	Operation and Maintenance
OD	Origin and Destination
ODA	Official Development Assistant
ODS	Ozone Depleting Substances
OHCA	United Nations Office for the Coordination of Humanitarian Affairs
PAGASA	Philippine Atmospheric, Geophysical and Astronomical
PAR	Philippine Area of Responsibility
PC	Prestressed Concrete
PCB	Polychlorinated Biphenyl
PCG	Philippines Coast Guard
PCP	Project Concept Paper
PD	Presidential Decree
PEIS	Programmatic EIS
PEISS	Philippine Environmental Impact Statement System
PENRO	Province Environment and Natural Resources Office
PGS	Performance Government System
PH	Philippines
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PhP	Philippine Peso

Abbreviation	English
PMO	Project Management Office
PNSDW	Philippine National Standards for Drinking Water
POP	Persistent Organic Pollutants
PPA	Philippines Port Authority
PPP	Public-Private Partnership
PRA	Philippine Reclamation Authority
PRECUP	Philippine Registry of Cultural Property
Pre-F/S	Pre-Feasibility Study
PSA	Philippine Statistics Authority
PSRTI	Philippine Statistics Research and Training Institute
RAP	Resettlement Action Plan
RCP	Representative Concentration Pathways
RET	Rare, Endangered and Threatened
RO	Regional Office
ROW	Right of Way
SEP	Self-Elevating Platform
SINP	Samar Island Natural Park
SJB	San Juanico Bridge
SJBFO	San Juanico Bridge Field Office
SMR	Self-Monitoring Report
SPCR	Samar Pacific Coastal Road
SSJB	Second San Juanico Bridge
SSP	Shared Socioeconomic Pathways
STEP	Special Terms for Economic Partnership
SUC	State Universities and Colleges
TOR	Terms of Reference
TTC	Threshold of Toxicological Concern
UDHA	Urban Development and Housing Act
UFC	Ultra-High-Strength Fiber-Reinforced Concrete
USD	United States Dollar
USEPA	United States Environmental Protection Agency
VAT	Value-Added Tax
VMS	Variable Massage Sign
VOC	Volatile Organic Compound
WEEE	Waste Electrical and Electronic Equipment
WGI	Worldwide Governance Indicators
WIM	Weigh in Motion

Abbreviation	English
WQG	Water Quality Guidelines
WRF	Weather Research and Forecasting model
YCMR	Young Child Mortality Rate

1 Approaches to Implementing the Survey

1.1 Background of the Survey

In the Philippine Development Plan 2023-2028, the medium-term development plan of the Republic of the Philippines (the Philippines), the expansion and qualitative improvement of infrastructure networks are key priorities. Achieving seamless and inclusive connectivity is one of the main strategies in the transportation infrastructure sector. In particular, the Eastern Visayas Region, which is the target area of this project, has a particularly high poverty rate of 22.2% (Philippine Statistics Bureau, 2021). The region's population was approximately 4.1 million in 2010. It is projected that the population will increase to about 7.1 million in 2045 (Philippine Statistics Bureau, 2010). According to the Visaya Space Development Framework (2015-2045), it will be necessary to further expand the road network as a logistics improvement measure to accommodate the increase in traffic volume due to population growth and to reduce the poverty rate through economic development. Based on this context, although the Department of Public Works and Highways (DPWH, 2021) is implementing of a high-standard road network development to connect regional cities, progress in the Visayas Region—unlike Luzon and Mindanao—has been limited. This is mainly due to geographical challenges of constructing infrastructure across its small and medium-sized islands. Specifically, only one project—the approximately 57-km Cebu Ring Road—is planned for implementation in the region, compared to the total extension of about 1,400 km of high-standard roads in the above plan. Under these circumstances, the technical cooperation project High Standard Highway Network Development Master Plan Project (HSH M/P) (Phase 2, 2019-2021), implemented by the Japan International Cooperation Agency (JICA), aimed to examine the national road network development plan with a view of developing local bases and improving domestic connectivity. The project was confirmed to have a high need for development support, given the urgency and technical difficulty associated with national highways. As a result, the existing San Juanico Bridge (the existing SJB) —an approximately 2,600-meter truss bridge connecting Leyte and Samar in the Eastern Visayas Region—has been identified as a supported section. Constructed with Japan's financial cooperation as part of post-war compensation, the bridge has supported the economy, life, and logistics of the two islands for about half a century, serving as their only road link since its completion in 1973. The existing SJB has long been regarded as the longest bridge in the Philippines and also acts as a major tourist attraction in the region. Although repairs have been carried out through the ODA loan projects Japan-Philippines Friendship Road Rehabilitation Project (1, 2), Regional Road Improvement Project (I, II, III), and Arterial Road Improvement Project III (Loan Agreement signed in 1998), damage to the bridge deck plates and progressive deterioration have made large-scale rehabilitation or even renewal necessary. In the aforementioned master plan project, traffic demand in the Visayas Region is projected to increase within the next ten years due to the economic development, making it necessary to expand its capacity. However, the bridge cannot be widened because of its truss structure. For this reason, the DPWH has decided to construct a new Second San Juanico Bridge

(SSJB) while continuing to use the existing SJB as a tourism asset and cultural heritage site. To address aging issues, measures such as restricting vehicle loads, repairing the deck slab, and other maintenance works will be implemented.

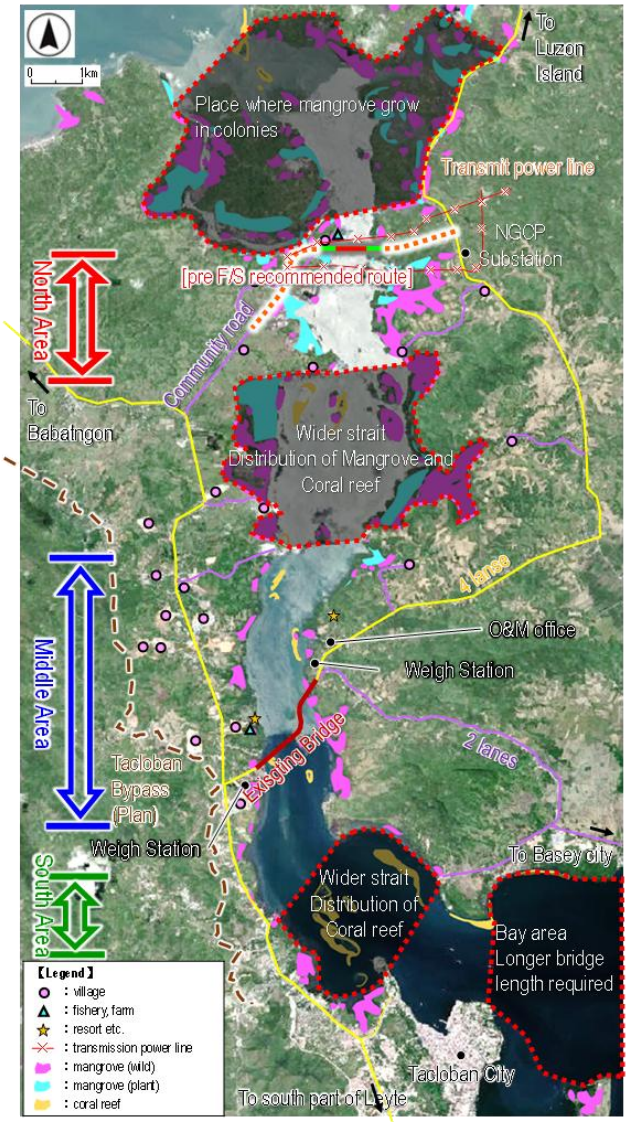
This project involves the construction of the SSJB, along with its approach roads on Leyte and Samar. It aims to respond to the increasing transportation and logistics demand while minimizing the impact of disruptions and restrictions on mobility between the two islands. The project is positioned as a priority project that will contribute to promoting the region's economic development.

1.2 Survey Area

The survey area covers Leyte and Samar Island in the Eastern Visayas Region.

The scope of study for the location of the SSJB encompasses the entire San Juanico Strait. As shown in Figure 1-1, this includes: the north area, which assumingly covers a relatively narrow section of the strait and the site recommended in the Pre-Feasibility Study (Pre-F/S) conducted under the HSH M/P, approximately 11 kilometers from the existing SJB; the middle area, near the existing SJB; the south area, which crosses the river near the city of Tacloban, including the approach roads.

For the examination of natural conditions, construction plans, and environmental and social considerations in this survey, the scope also includes land required for project implementation, which is to be provided by the executing agency.



Source：JICA Survey Team

Figure 1-1 Survey Area

1.3 Objectives of the Survey

The objective is to conduct surveys necessary for preparing the outline design, project cost, implementation schedule, and environmental and social considerations for the project, which will be carried out as a loan cooperation initiative with Japan.

1.4 Scope of Work

The scope of work specified between JICA and the Consultant is as follows:

1) Preparation and discussion of the Survey Implementation Plan
2) Preparation and discussion of the Inception Report
3) Confirmation and appreciation of the background and necessity of the project
4) Survey of current conditions in and around the project area, including extraction of risks and issues
5) Examination of alternatives
6) Natural condition surveys
7) Traffic count survey and future traffic demand forecasting
8) Survey of the existing condition of the existing SJB
9) Examination of the applicability of Japanese construction technology
10) Confirmation of matters to be borne by the Executing Agency
11) Basic design
12) Construction plan and project implementation schedule
13) Confirmation of tax exemption measures
14) Examination of notes for project implementation
15) Consulting services
16) Project cost estimation
17) Evaluation of the project
18) Formulation of the procurement plan
19) Examination of project implementation and operation/ maintenance system
20) Environmental and social considerations
21) Land acquisition and involuntary resettlement
22) Examination of gender-related issues
23) Collection and analysis of information related to the formation of deals to address climate change
24) Briefing sessions for Japanese companies
25) Consultation with expert group
26) Preparation of materials for proof engineering
27) Preparation and discussion of Interim Report (IT/R), Draft Final Report (DF/R), and Final Report

1.5 Implementation Approaches and Methodology of the Survey

1.5.1 Technical Approach and Methodology

In order to ensure the survey is conducted efficiently and effectively, it will follow the technical approach and methodology shown in Table 1-1.

Table 1-1 Technical Approach and Methodology

No.	Technical Approach	Methodology
1	Clarification of project status and prompt consensus-building on the number of lanes and bridge location based on scenarios	・ Propose multiple maintenance scenarios, including the number of lanes, focusing on the repair level of the existing SJB ・ Propose a traffic operation scenario that combines the existing SJB with the SSJB ・ Tentatively determine the number of lanes based on provisional value of the traffic volume estimates using preliminary traffic volume survey results in this study ・ Conduct a two-step study: (1) compare three regions, and (2) compare multiple cross-linking position proposals in the selected region
2	Consideration of appropriate benefits and ensuring a reliable internal rate of return	・ Reduce project costs through bridge plans that meet navigation route clearance requirements while pursuing greater rationality (related to Basic Policy 3) ・ Consider additional benefits beyond the normal travel time reductions and travel cost savings
3	Rationalization of the bridge plan by reviewing the span length and bridge type of the main bridge	・ Determine the span length of the main bridge based on the conditions: not be shorter than the span length of the existing SJB; not obstruct the navigation width during the construction of the bridge piers and pier fenders; and ensure a safe route width after completion ・ Select the most economical bridge type for the determined span length
4	Bridge planning, design, and maintenance considering wind resistance and utilizing Japanese technology	・ Set highly accurate wind loads through weather simulations and incorporate appropriate aerodynamic measures into bridge design ・ Examine the utilization of Japanese technology in bridge planning, with consideration for traffic safety, workability, environmental impact, maintenance and management, and landscape integration
5	Appropriate assessment of environmental and social impacts	・ Based on a review of existing documents and field surveys, identify the survey items that have the greatest impact, conduct those priority surveys in advance, and reflect the findings in the route selection process ・ Establish a communication system with key local stakeholders and relevant organizations to obtain cooperation in conducting local re-commissioned natural environment and gender surveys for optimal route proposals.

Source：JICA Survey Team

1.5.2 Management Approaches

Table 1-2 shows the major milestones and progress. The JICA Survey Team implemented the necessary processes step by step, in a systematic matter, and in agreement with JICA/DPWH.

Table 1-2 Major Milestones of the Study

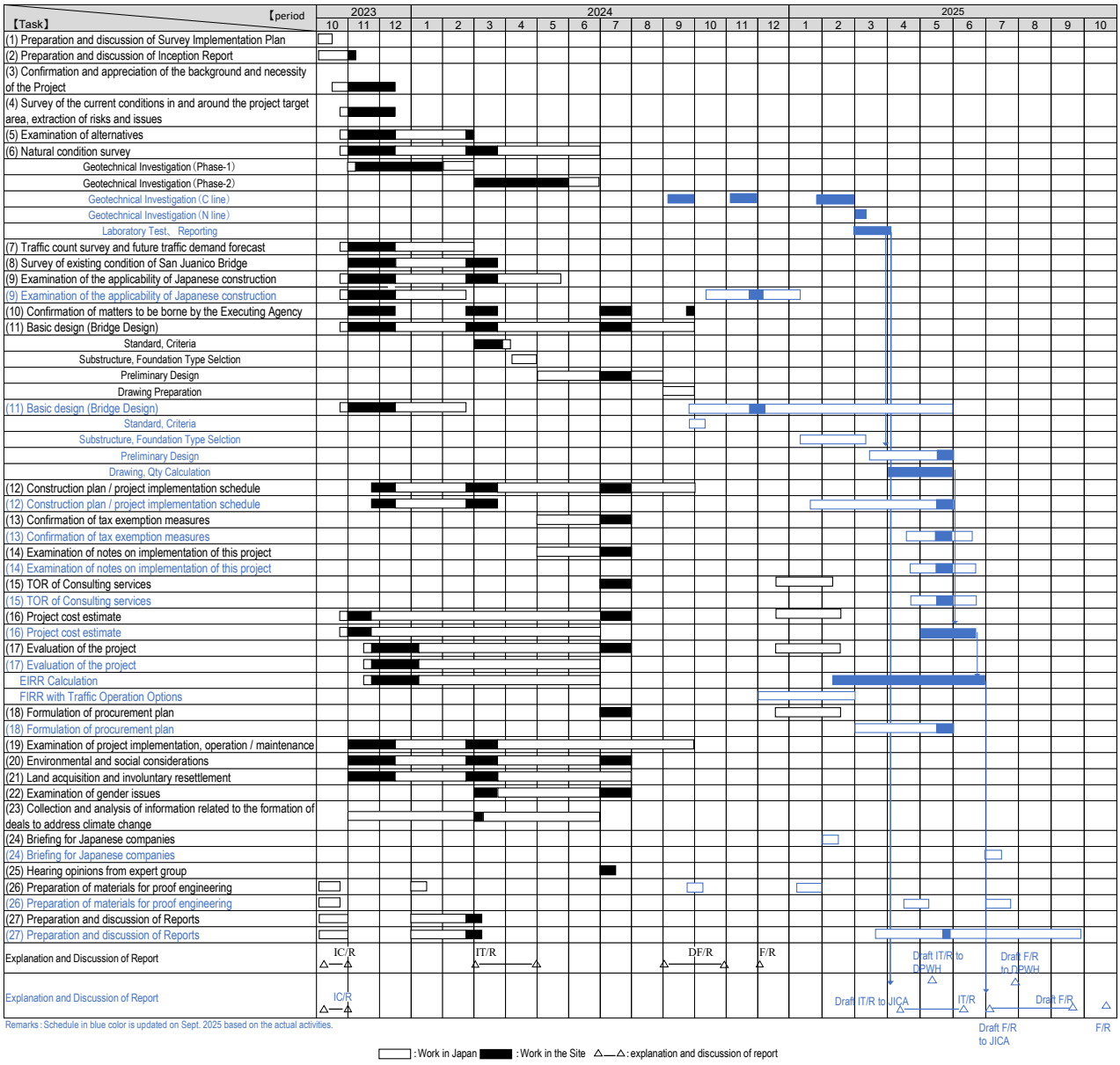
No.	Milestones	Schedule and Progress
1	Inception Report explanation / discussion	Completed on November 16, 2023
2	Tentative determination of the number of lanes	Discussed with BMC on February 21, 2024, including tentative EIRR
3	Determination of area for bridge location	Discussed with BMC on February 21, 2024
4	Determination of bridge location and bridge type	Discussed with DPWH Sr. USEC on March 13, 2024, February 25, 2024, and April 30, 2025; consensus obtained
5	Interim Report submission	First draft: Submitted in February 2024 Second draft: Submitted in April 2025 Final ITR: submitted end-June 2025
6	Completion of existing condition survey related to maintenance of the existing SJB	Conducted mid-March 2024; completed
7	Examination of project effect (calculation of provisional value of IRR)	Discussed with DPWH Sr. USEC on March 13, 2024; FIRR discussed in February 2025
8	Project cost estimation	July 2025
9	End of examination of project effect	July 2025
10	Submission of DF/R	Early September 2025
11	Submission of final report	Late November 2025

Source: JICA Survey Team

1.6 Work Schedule

The work schedule is shown in Table 1-3.

Table 1-3 Work Schedule



Source：JICA Survey Team

1.7 Study Team Member

The JICA Survey Team consists of the following 20 engineers and specialists, as shown in Table 1-4.

Table 1-4 JICA Survey Team Members

No.	Name	Position
1	Yuichi SANO	Team Leader/Bridge Planning 1
2	Shimpei IMADA	Sub Team Leader/Bridge Planning 2
3	Takeyuki TAKADA	Bridge Design (Superstructure)
4	Nobuhiko TAKAGI	Bridge Design (Substructure/Foundation)
5	Eichi YOKOTA	Highway Design 1
6	Hironori SHINADA	Highway Facility Design
7	Yuki SUGIYAMA	Economic and Financial Analysis/Traffic Demand Forecast 1
8	Ryoma YAE	Traffic Survey/Traffic Demand Forecast 2
9	Hikaru TANAKA	Natural Condition Survey (Nature/Natural Disaster/Meteorology/Hydrology/Climate Change)/Road Design 2
10	Tatsumune HAYASHI	Natural Condition Survey (Geology/Topography)
11	Tomonori TANABE	Environment (Nature - EIA)
12	Tomoko OTA	Environment (Social - Resettlement Action Plan/Gender)
13	Akihito SAKURAI	Environment (Nature - Mangrove)
14	Shinji MUROI	Survey and Repairment Work Planning of Existing Bridge
15	Osamu KITAGUCHI	Operation and Maintenance Planning
16	Takuya KURAMOCHI	Procurement/Construction Plan and Cost Estimate
17	Teppei MATSUI	BIM/CIM/Bridge Design (Landscape)
18	Yohei ONOMURA	Road Design 3/Coordinator
19	Takashi MATSUO	Natural Condition Survey (Geology/Topography) 2
20	Yoshinori UCHIUMI	Natural Condition Survey (Geology/Topography) 3

Source：JICA Survey Team

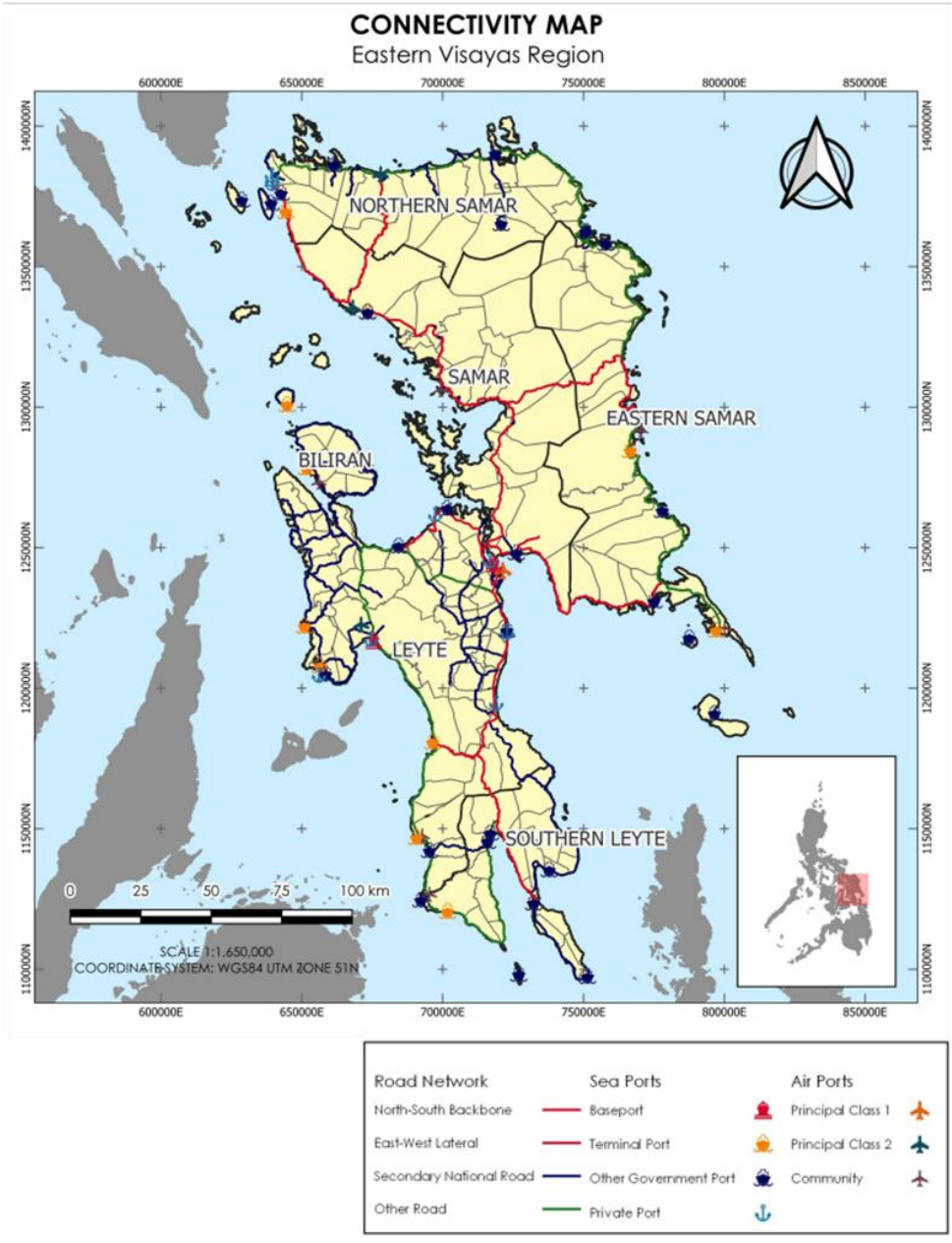
Due to the subcontractor's performance deficiencies and unforeseen site conditions such as stronger-than-expected tidal currents during the geological survey, additional measures, including the installation of a Self-Elevating Platform (SEP), were required. Consequently, two additional personnels for Natural Condition Surveys (Geology/Topography) 2 and 3 were added to address the subcontractor's re-procurement and to strengthen site management.

2 Background and Current Status of the Project

2.1 Current Situation and Issues of the Road and Bridge Sector in the Project Area

The region under consideration, Region VIII (Eastern Visayas), is intersected by the National Highway 1 (Maharlika Highway). This highway forms a network of roads, bridges, and ferry services spanning 3,517 km, connecting the major islands of Luzon, Visayas, and Mindanao (Figure 2-1). It serves as a critical transportation backbone for the nation. Region VIII boasts the second-longest stretch of national roads, covering 2,560 km, trailing only to Region VI (Western Visayas) (

Table 2-1). The road network also encompasses a total of 579 bridges, totaling 23,820 m.



Source：Eastern Visayas Regional Development Plan 2023-2028, additionally written by the JICA Survey Team

Figure 2-1 Current Road Network in Eastern Visayas

Table 2-1 Condition of Road Bridges in Eastern Visayas (2021)

	GOOD	FAIR	POOR	BAD	NOT ASSESSED	TOTAL
Roads ［length in km］	1,213.50	742.15	295.46	129.64	179.63	2,560.38
Bridges ［Number］	362	200	16	1	0	579

Source：DPWH 2021. National Road Length by Surface Type and Condition (Regional Summary)

Despite the maintenance of the total length of national roads, travel time between key corridors has increased due to several ongoing construction activities and obstructions, such as parked vehicles and drying of rice along the roads, among others. Moreover, civil works and utility installation require better coordination, as road widening activities are often out of sync with the relocation of electrical and communication poles. This mismatch continuous to pose a challenge for traffic management. Addressing these issues will require the construction of an expanded and accessible road network based on design principles. Enabling sustainable transportation options, such as bicycle lanes and conducting periodic road maintenance will also be essential but challenging.



Source：JICA Survey Team

Figure 2-2 Unrelocated utilities

2.2 Economic and Social Conditions, Logistics (Including Shipping), Tourism, and Other Industry Conditions in the Project Area

According to the Philippine Department of Trade and Industry, the current industrial situation in Region VIII is as follows (Profile of Region VIII, DTI website).

Region VIII is composed of Leyte, Samar, and Biliran islands, consisting of six provinces: Biliran, Northern Samar, Eastern Samar, Samar, Leyte, and Southern Leyte. It comprises a total of 136 municipalities.

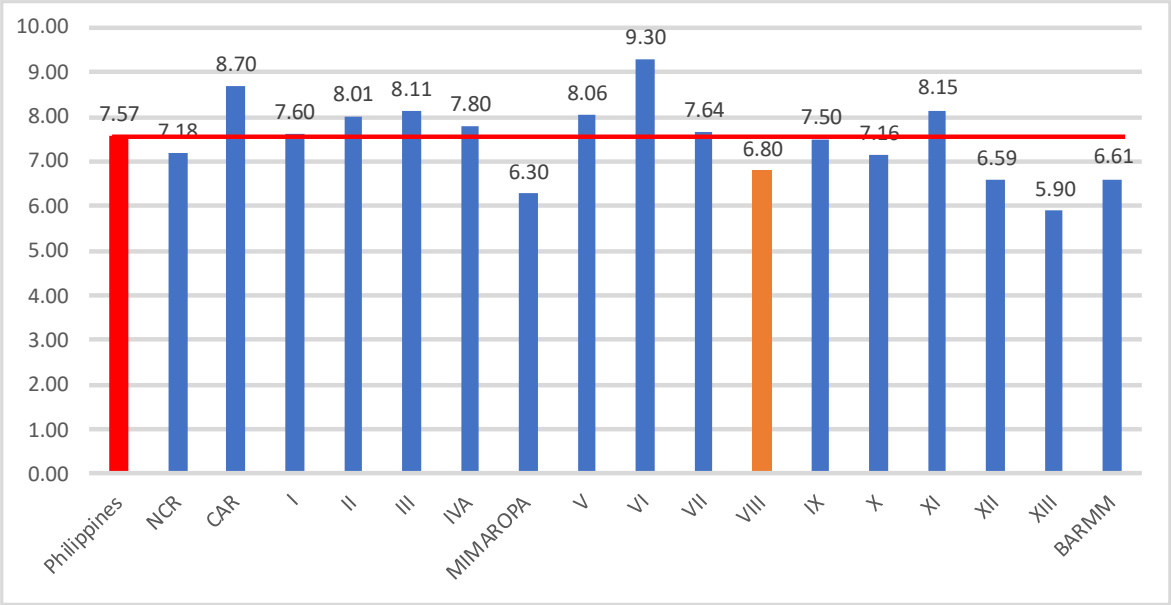
Region VIII is bordered by the Pacific Ocean to the east, the Visayan Sea to the west, and the Mindanao Sea to the south. Positioned within the transport network connecting Luzon to the Mindanao Region, Samar and Leyte islands play a crucial role in terms of road transportation. These two islands are connected by the existing SJB, which has also become a notable tourist attraction.

This region covers a land area of 2,156,285 hectares, and according to the 2020 Philippine Statistics Authority (PSA) census, the population of Region VIII is 4,547,150, representing an increase of approximately 107,000 people over the past five years.

The coastal and inland waters of this region serve as abundant sources of saltwater and freshwater fish, as well as other marine resources. It is also one of the regions engaged in exporting fish domestically. The inland areas of the islands host numerous forest reserves, while the region's

mineral deposits include chrome ore, uranium (in Samar Island), gold, silver, manganese, magnesium, bronze, nickel, clay, coal, limestone, pyrite, and gravel.

Moreover, Region VIII has abundant geothermal energy and water resources, capable of supporting the needs of medium and heavy industries. The annual average growth rate of the gross regional domestic product (GRDP) for the region is 6.80% (2021-2022), which is 0.77 points lower than the national GDP. Nevertheless, all regions, including Region VIII, are experiencing positive growth.

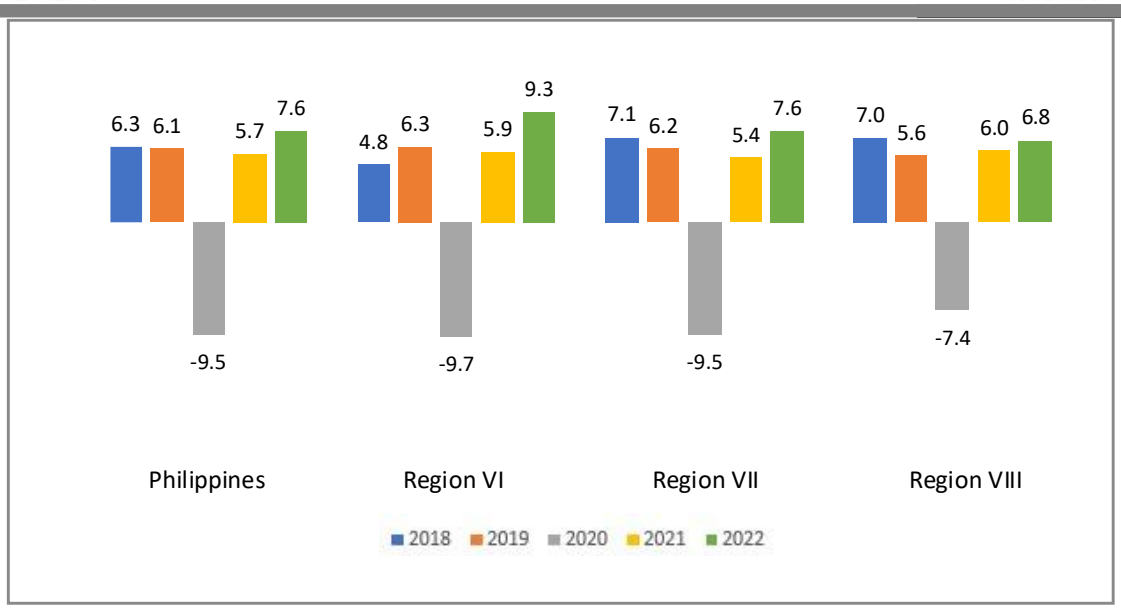


Source：Philippine Statistics Authority, additionally written by the JICA Survey Team

Figure 2-3 GDP/GRDP Growth Rate (At Constant 2018 Prices)

Over the past four years, excluding 2020, the economic growth of Region VIII has been in positive territory (Figure 2-4). Similar trends are observed nationally and across the Visayas region. Due to the Coronavirus disease 2019 (COVID-19) pandemic, the Philippines implemented lockdowns in March 2020 to curb the spread of the virus. These measures effectively reduced the spread and limited the pressure on the vulnerable healthcare system but resulted in persistent and temporary business closures, delayed investment, reduced production capacity, significant production contraction, widespread unemployment, and decreased household income and consumption.

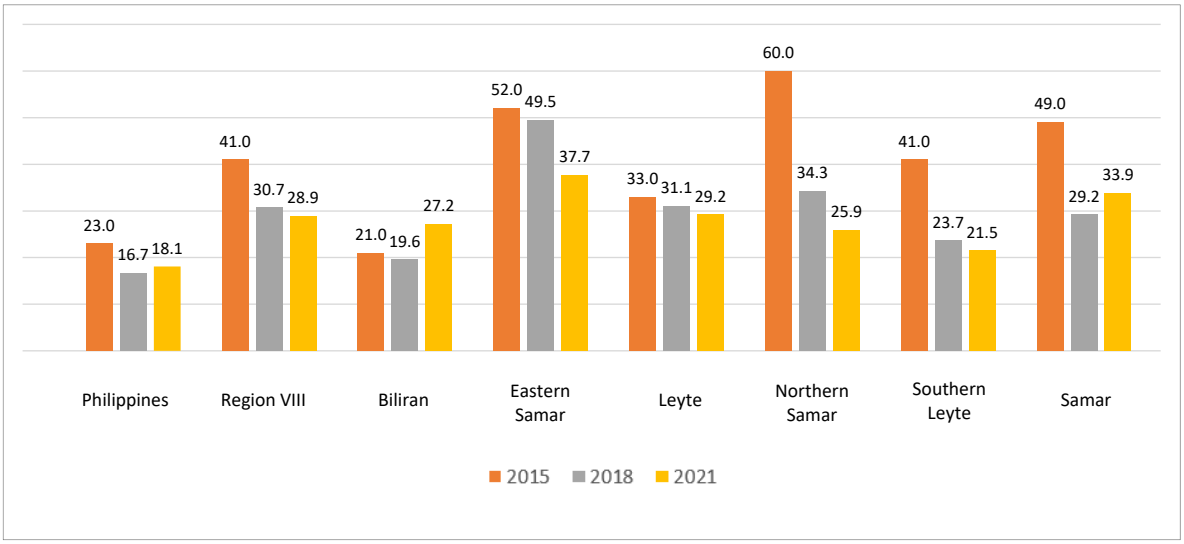
Like other Visayan regions, Region VIII experienced a regional economic decline of -7.4% in 2020, with substantial decreases seen in all sectors: agriculture, forestry, and fisheries (1.2 points); industry (11.2 points); and services (18.1 points).



Source：OpenSTAT PSA

Figure 2-4 GRDP Levels in the Visayas Region, 2018-2022 (At Constant 2018 Prices, in PhP Billion)

The poverty rate in Region VIII has gradually decreased. While it is higher than the national average, the percentage of the total regional population living in poverty has decreased from 41.0% in 2015 to 30.7% in 2018, and further to 28.9% in 2021 (Figure 2-5). This indicates that from 2015 to 2018, 411,100 people rose above the poverty line, and an additional 31,200 people lifted themselves out of poverty between 2018 and 2021. It should be noted that the economic downturn due to the pandemic in 2020 may have influenced the latter figure. The same trend is observed in the provinces of Eastern Samar, Leyte, Northern Samar, and Southern Leyte. The substantial reduction in poverty from 2015 to 2018 is attributed to sustained rapid economic growth over six years, increased investment in human capital, and the expansion of the poverty reduction program–the Pantawid Pamilyang Pilipino Program (4Ps)–initiated in 2013.



Source：OpenSTAT PSA

Figure 2-5 Poverty Incidence in Region VIII Provinces, Philippines

2.3 Development Plan and Land Use Plan in the Project Area

The Region VIII Office of the Department of Economy, Planning, and Development (DEPDev) (formerly known as National Economic and Development Authority) has developed the Eastern Visayas Regional Development Plan 2023-2028, in accordance with the Philippine Development Plan 2023-2028.

Within this plan, the project is positioned as a solution to the following problems：

Increase the capacity of the road network to facilitate the movement of people and goods.

Maintain driving comfort, smoothness, accessibility, and safety by improving road surface quality.

2.4 Consistency with High-level Plans and Related Measures in the Road and Bridge Sector

The Philippine Development Plan 2023-2028, developed by DEPDev, places significant importance on the expansion and improvement of infrastructure. The transportation strategies outlined in the plan include the following:

- Seamless Transportation System Building: Develop a seamless regional transportation system to facilitate the movement of people and goods, enhancing connectivity between land, sea, and air transport.
- Asset Management and Conservation: Implement thorough asset management and conservation of road surfaces based on international standards, incorporating robust and innovative solutions.

In line with the goal of enhancing connectivity across land, sea, and air transportation, DPWH is formulating nationwide road expansion plans. This includes the conversion of National Highway 1 to six lanes and the expansion of major maritime highways to four lanes. As depicted in the diagram, the existing SJB aligns with these transportation strategies, serving as a key bridge on National Highway 1.



Source：Performance Government System (PGS) Strategic Plan

Figure 2-6 National Highway 1 and Nautical Highway Network

2.5 Economic Position of Eastern Visayas, Leyte Island, and Samar Island in the Philippines

Position of the Eastern Visayas Region and Leyte and Samar Islands in the Philippine Economy

As indicated in

Table 2-1, the target region boasts the second-longest stretch of national roads, forming a crucial network connecting major urban areas. According to the Eastern Visayas Regional Development Plan 2023-2028, Samar Province is nationally recognized for its high poverty rates. The existing SJB, the focus of this project, serves as the sole road transportation linking Leyte and Samar islands and also contributes to the region's tourism. Due to its strategic significance, a prolonged closure is necessitated for refurbishment or aging-related rehabilitation could significantly impact economic activities in the region.

In light of these considerations, this plan aims to minimize the impact of transportation and logistical disruptions by constructing a SSJB connecting both islands, while simultaneously contributing to the region’s economic development.

2.6 Background to the Request for the Project, and Necessity and Details of the Project

At the Japan-Philippines Joint Committee on Economic Cooperation Infrastructure, both countries agreed to promote cooperation in infrastructure development. Japan has made significant contributions to the Philippines’ infrastructure development and is currently implementing multiple projects. Consequently, there is considerable anticipation for Japan's support in the country’s road and bridge development initiatives.

In the Philippines, although progress is being made in implementing the high-standard road network development plan—covering approximately 1,400 km to connect regional cities—the Visayas region faces challenges due to its geographical conditions. As of now, only the Cebu Circumferential Road, spanning approximately 57 km, is scheduled for implementation. Additionally, addressing the increased traffic demand resulting from population growth will require further expansion of the road network.

In this context, the Japan International Cooperation Agency (JICA), through its Technical Cooperation Project – High Standard Road Network Development Master Plan Project 2 (Phase 2), identified sections of the national high-standard road network that exhibit high urgency, technical complexity, and support needs. Among these, existing bridges in the region face issues of insufficient traffic capacity and aging, particularly as the region's economic development progresses. Under this project, a review of the visual inspection report prepared by DPWH, as well as a detailed visual inspection of the existing SJB, was conducted. The inspections identified several sections requiring urgent repair, suggesting that long-term traffic closures due to deck slab rehabilitation and other maintenance works may become unavoidable following the opening of the SSJB. As the existing SJB currently serves as the sole road transport route between the islands, any closure may result in significant disruptions to traffic and logistics.

In the project area, the planned development of Babatngon Port in Leyte and Catbalogan Airport in Samar is expected to improve regional accessibility. The existing SJB, a symbolic link between the two islands, continues to attract a significant number of tourists. As such, the construction of the SSJB and the maintenance of the existing one are expected to support tourism promotion. Moreover, these infrastructure works are anticipated to generate employment opportunities and contribute to the industrial development of the region.

Considering these challenges, the master plan prioritizes the construction of a SSJB connecting both islands. The implementation of this project was requested as it is seen not only as vital for revitalizing inter-island road transportation but also for promoting economic development and enhancing connectivity, especially in the economically disadvantaged Eastern Visayas Region.

2.7 Status and Future Plans for Cooperation with Other Donors and International Organizations in the Economic, Social, Industrial, and Infrastructure Sectors

The development and land use plans in the vicinity of the project area are summarized as follows:

Table 2-2 Development Plan in Region VIII

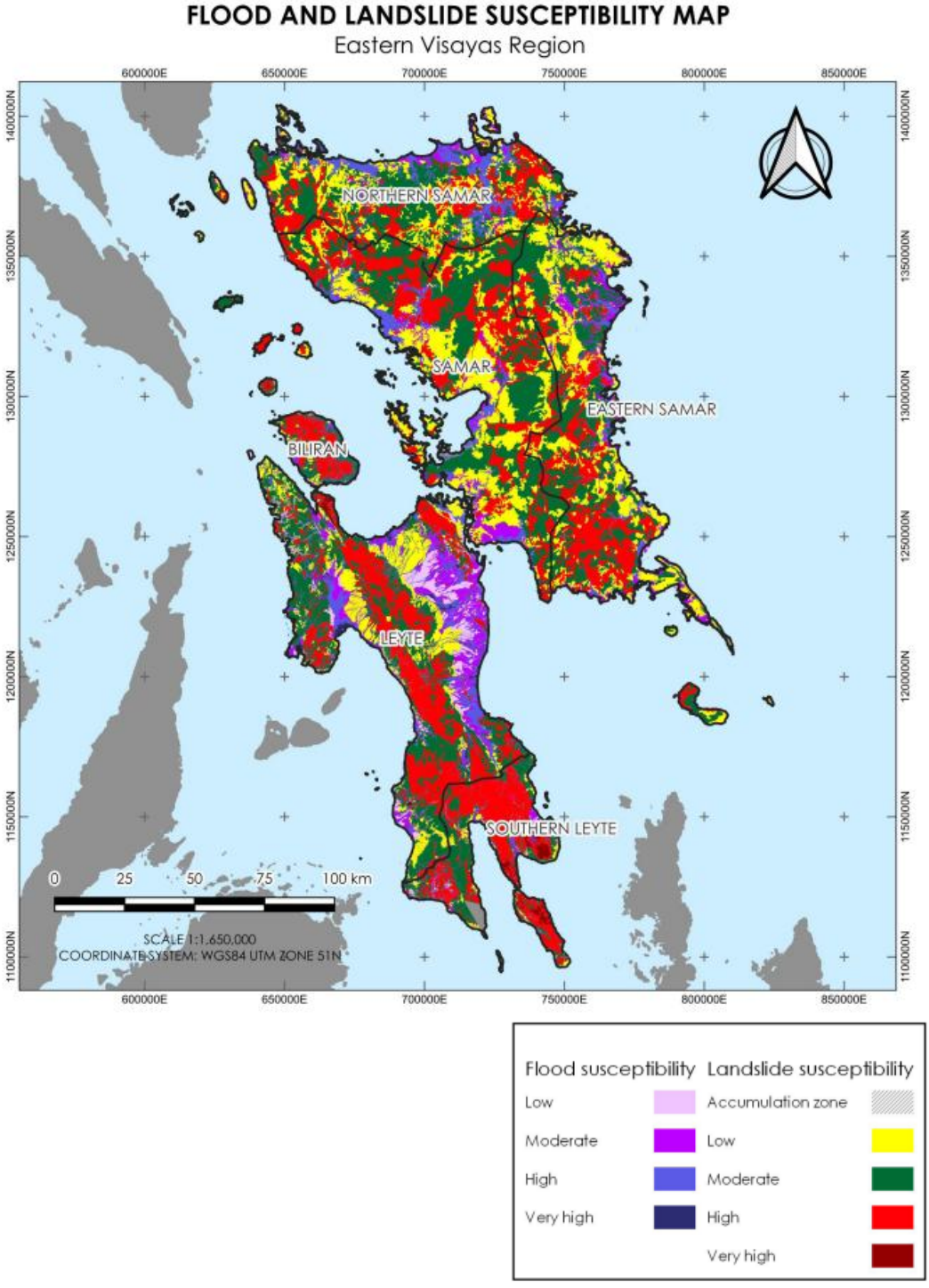
Project Name	Donor	Cost (PhP)	Period
Proposed Rehabilitation of Daang Maharlika Highway from Allen to the existing SJB Approach	JICA	14.51 billion	In progress
Feasibility Study for Catbalogan Airport Development Project	PPA	2.62 billion	2019-2026
Construction of Tacloban City Bypasses Road Extension, Leyte	GOP	12.8 billion	2018-2023 and onwards
Economic Re-Evaluation of Samar Pacific Coastal Road	Korea	1.9 billion	2012-2014
Port of Babatngon Project	PPA	160.8 million	2004-2028
Sta. Rita Baywalk Project	Provincial Government of Samar	97.6 million	2023-2024

Source：JICA Survey Team

3 Survey of Current Conditions In and Around the Project Area, Identification of Risks and Issues

3.1 Natural and Social Environment and Economic Activities

The target region lies within the Pacific Ring of Fire, making it susceptible to natural disasters. The flat plains of Leyte Island are prone to flooding, while the central mountain ranges are vulnerable to landslides triggered by heavy rainfall.



Source : Eastern Visayas Regional Development Plan 2023-2028, additionally written by the JICA Survey Team

Figure 3-1 Areas Subject to Flooding and Landslides in Eastern Visayas

In November 2013, Typhoon Yolanda made landfall on Leyte Island, resulting in a death toll and missing persons over 7,000. Even a decade later, multiple temporary housing areas can still be identified. Furthermore, in April 2022, Typhoon Agaton struck the region, causing widespread flooding and landslides, resulting in 122 fatalities and one person missing. Despite being classified as a weak typhoon, Agaton inflicted approximately PhP 942.9 million in damages to the agricultural sector and damaged 1,008 houses.

The Eastern Visayas Region is rich in flora and fauna, with seven protected areas covering land and water resources totaling to 789,949.48 hectares. This includes four terrestrial and three coastal/marine areas, classified according to the National Integrated Protected Areas System (NIPAS) criteria. Additionally, the region contains 19 watersheds spanning 552,707.50 hectares, which are crucial for supplying irrigation water to the national irrigation system.

The area also features extensive limestone formations and is home to endangered, critically endangered, and endemic species, some of which are exclusive to Eastern Visayas.

3.2 Status of Software and Hardware Infrastructure

Improvements have been made to the national road network, including the construction of bypass roads such as the Samar Pacific Coastal Road (SPCR) in Northern Samar, which is expected to facilitate the movement of goods and people on land. Together with ongoing road improvements, the total length of domestic roads increased slightly from 2,495 km in 2016 to 2,560 km in 2021. Similarly, the length of paved national roads and bridges along domestic roads has also increased. The construction of bypass roads, including the SPCR, continues, aiming to support and improve land transportation of goods and people.

However, despite ongoing road improvements, from 2018 to 2021, 2.64% of bridges along major highways deteriorated from "good" to "fair" condition. This decline is attributed to aging and natural disasters. As of October 2021, approximately 17.86% of the total road length in the region—equivalent to 425.10 km—was either deteriorated or in poor condition, regardless of other road classifications. Moreover, increased traffic volume and load capacity contribute to further degradation of road conditions.

Regarding air transport, the COVID-19 pandemic in 2020 caused a significant reduction in flight frequency by about 54% and a drop in passenger numbers of approximately 75% compared with the previous year. Since then, gradual recovery has been observed, with continued improvements.

Maritime transport was also significantly affected by the pandemic and frequent typhoons. In 2020, travel restrictions and temporary suspension of maritime operations resulted in a 29.19% decrease in port calls and a 67.87% decrease in passenger numbers compared with the previous year. Additionally, Typhoon Odette, which struck in March 2021, caused damages amounting to PhP 8.8 million.

The Free Public Wi-Fi Program of the Department of Information and Communications Technology (DICT) has significantly increased the number of regions being provided with internet access. In 2021 alone, a total of 338 access points were installed in the region. However, since

2020, priority has been given to state universities and colleges (SUCs), hospitals, vaccine centers, and other health facilities to support the government's pandemic recovery and response efforts.

Despite these achievements, they remain insufficient to support the rapid transition to digitalization in the new normal. Evaluation by DICT Region VIII indicates that many communities, including Biliran Province, Southern Leyte, and the entirety of Samar Island, still lack adequate digital infrastructure services. The following points are the main observations causing the general lack of services in the region:

- Difficulty in building networks in remote or rural areas
- Vulnerability of ICT facilities to system downtime during disasters
- Limited personnel, budget, and resources of DICT
- Insufficient ICT infrastructure to provide free public Wi-Fi throughout the region

According to the Annual Poverty Indicators Survey (APIS) in 2020, only 9% of households in Eastern Visayas had broadband internet subscriptions, ranking it fifth lowest among all regions in the country.

Results from the National ICT Household Survey (NICTHS) conducted by the Philippine Statistics Research and Training Institute (PSRTI) in 2019 under the commission of DICT, identified the top three reasons why households in this region do not subscribe to internet services.

- High cost of ICT equipment, including computers, mobile phones, modems, and Wi-Fi routers
- High cost of internet subscriptions
- Unavailability of internet services in the region

3.3 Surrounding Conditions

The existing SJB is part of the national highway, i.e., Maharlika Highway, connecting Luzon to Mindanao. It serves as a crucial transportation route. However, having been in operation for approximately 50 years, it requires significant repair. Therefore, the construction of the SSJB is urgently needed to address this situation. The SSJB is expected to enhance the stability and efficiency of transportation, thereby contributing to the economic development of the region.



Source: JICA Survey Team

Figure 3-2 Existing SJB



Figure 3-3 Large Vehicles Passing Under the Existing SJB

The existing SJB accommodates the passage of more than 1,500 large vehicles daily. When these vehicles cross the bridge, they pass through axle load scales managed by DPWH, as

illustrated in Figure 3-4 and Figure 3-5. These scales record the total weight as well as the starting and ending points of each vehicle. Axle load scales are installed on both sides of Leyte and Samar islands.



Source: JICA Survey Team

Figure 3-4 Weigh in Motion



Figure 3-5 Maximum Allowable Gross Vehicle Weight (GVW)

In recent years, there has been a nationwide emphasis on strengthening infrastructure development, with projects underway to expand major national highways from two lanes to four lanes. For road widening, additional land acquisition has been carried out, and Right-of-Way (ROW) signs are consistently placed in sections where the two-lane expansion is not yet completed. In bridge sections, two lane connections or new bridge constructions have been implemented, as shown in Figure 3-6 and Figure 3-7.



Source: JICA Survey Team

Figure 3-6 ROW Limit Signs



Figure 3-7 Bridge Widening at ALAL-ON BRIDGE II, Samar Island

The existing SJB has a maximum gradient of 5% and operates as a two-lane section. Heavy vehicles travel at approximately 20 km/h, causing situations where smaller vehicles cannot overtake and are forced to follow behind them.

Additionally, bottlenecks have emerged in the surrounding road areas due to incomplete four-lane expansion and deteriorating pavement conditions.



Source: JICA Survey Team

Figure 3-8 Two-lane Section



Figure 3-9 Poorly Paved Section

3.4 Maintenance Status and Future Plans for Existing Bridges and Connecting Roads

The maintenance and management status, along with future plans, are gathered through information collection from relevant agencies. Based on this collected information, on-site inspections are conducted to incorporate the JICA Survey Team's plans into the maintenance, management, and future plans of these infrastructure projects.

The current maintenance and management status, along with future plans, have been organized to identify challenges and consider appropriate response strategies. The existing SJB undergoes routine deck inspections approximately two to three times per week, with detailed inspections, surveys, and repair work carried out as needed. Budget constraints pose challenges, limiting the introduction of new technology, facilities, and the availability of human and material resources for maintenance.

Additionally, the Philippine government's policy emphasizes a commitment to continue utilizing existing SJB. While large-scale projects, such as deck replacement, may be necessary in the future, they are relatively uncommon in the Philippines, presenting potential technical challenges. The kick-off meeting for this survey, held on November 16, 2023, outlined the future maintenance plan. DPWH expressed the intention to secure operation and maintenance (O&M) expenses through toll collection and to explore concession options for private outsourcing to maintain both bridges. Further consideration of these plans is requested as part of the current task. A preliminary study on toll collection and O&M concession is presented in Chapter 18.

3.5 Licensing in Planning and Implementing Projects

During hearings with relevant agencies, such as DPWH, DENR, and LGUs, the necessary permits and approvals for project planning and implementation were confirmed. The information,

timelines, and costs required to obtain these permits are organized for clarification and approval of the project.

(1) Project Planning Phase

As of March 31, 2023, the DPWH has issued Department Order No. 47, Series of 2022, titled "Guidelines on the Conduct of Feasibility Studies for Roads, Bridge, Flood Control, Drainage and Other Water-Related Projects." This department order defines the Master Plan (MP), Feasibility Study (FS), Project Concept Paper (PCP), outlining their requirements. It also specifies the roles in the DPWH approval process.

According to the department order, an FS is required for projects with a total cost, including construction and land acquisition expenses, of PhP 10 billion (approximately JPY 3.7 billion) or more. The Planning Service Bureau, which also serves as the secretariat of the DPWH Investment Coordination Committee, acts as the interface for all activities related to road and bridge infrastructure projects prior to DEPDev approval. This role includes reviewing and implementing the FS, preparing necessary documents, and submitting them to DEPDev.

The department order further outlines the items to be included in the FS, as shown in Table 3-1, and stipulates the application of multi-criteria analysis (MCA) in route selection and structural form selection.

Table 3-1 FS Requirements in the DPWH Department Order

Item	Details of the Study
a. Traffic Impact Study	A transportation impact assessment that evaluates existing and projected traffic conditions in the project impact area, based on a comprehensive traffic management plan during construction. It involves comparing alternative solutions related to improve capacity, enhance safety measures, and optimize network performance.
b. Development Impact Study	A development impact assessment that provides a detailed analysis of the long-term sustainable effects of the project or interventions on various aspects of the daily lives of the area's residents.
c. Technical Analysis	Technical analysis (1) formulates and selects options based on the geographical and geological characteristics of the project site, and (2) designs the infrastructure functions of the selected options in line with DPWH's infrastructure policies, responsibilities, and accountability. The selection process uses comprehensive multi-criteria analysis (MCA), considering strategic fit, social impacts, and environmental impacts. The analysis also includes discussions on innovations in construction methods that enhance infrastructure quality or improve project implementation efficiency.
d. Economic Analysis	An economic analysis that presents the economic feasibility of the project through the identification and quantification of economic benefits such as reducing vehicle operating costs, reducing harmful emissions, and improving land use, among other factors, to the extent possible. The analysis includes economic indicators—Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR)—and provides recommendations based on the values derived from these indicators.
e. Social Impact Assessment	A social impact assessment that identifies affected individuals, families, and assets; determines the scope and significance of potential risks such as changes in health and lifestyle; and estimates land acquisition costs based on Republic Act 10752, and establishing a timetable for implementing the Resettlement Action Plan (RAP), including land acquisition, and incorporates gender-specific needs in line with the Gender and Development Harmonization Guidelines (HGDG) and the Gender and Development (GAD) Toolkit. For projects falling under Republic Act 8371 (the Indigenous Peoples' Rights Act of 1997), the assessment also includes an Indigenous Peoples' Action Plan (IPAP) compliant with the relevant National Commission on Indigenous Peoples (NCIP) administrative orders.
f. Environmental Impact Assessment	An environmental impact assessment that covers existing conditions of four environmental components—land, water, air/noise, and people— within the impact area of the proposed project. It identifies, predicts, and evaluates the range and significance of the project's major potential impacts and formulates mitigation measures required to address them.
g. Institutional Analysis	An institutional analysis that presents the functional structure and serves as a stakeholder analysis of all government and private agencies, development organizations, special interest groups, and citizen communities involved in implementing and supporting public projects.
h. Implementation Plan	An implementation plan that presents the most suitable schedule and execution methods for the project, taking into consideration various proposed schemes or scenarios, construction stages, and packaging.
i. Mode of Financing	An evaluation of at least three alternative funding schemes, including the General Appropriations Act (GAA), Official Development Assistance (ODA), and Public-Private Partnership (PPP). If the project is suitable

Item	Details of the Study
	for PPP, a financial analysis and market risk assessment must also be conducted.
j. Financial Analysis	A financial analysis to determine the project's financial sustainability and viability. The study should include assumptions in estimating financial indicators, sensitivity analysis, and evaluation metrics such as cost-effectiveness.
k. Market Risk Assessment	A systematic examination of uncertainties related to the project and associated market risks. Market risk is defined as the extent to which private sector provision of infrastructure services is exposed to demand risks governed by market constraints related to economic cycles and situations, reasonable pricing perception of tariffs, payment willingness, and the availability of alternative options for services.

Source: DPWH Department Order No.47 Series of 2022, March 31, 2023

As described in Section 3.4 above, the study on the O&M concession is related to (i) Mode of Financing and (j) Financial Analysis.

(2) Licenses and Approvals for Construction Implementation

For environmental and social considerations in implementation of the project, the permitting procedures are detailed in Chapters 13 to 15. For construction-related permits and approvals, the requirements are summarized in Table 3-2.

Table 3-2 Licenses and Approvals for Construction Implementation

Item	Licensing Authorities
a. Licenses and approvals for construction work and temporary structures within the San Juanico Channel	The project proponent is required to submit a project plan, including bridge location and navigation settings, to PCG District Eastern Visayas for review and evaluation before applying for approval. This requirement is stipulated in Memorandum Circular MC01-14 dated April 16, 2014, regarding Navigational Clearance for Road Bridges and Other Structures over Navigable Inland Waters. Additionally, the contractor (project implementer) must submit the construction schedule to the Coast Guard Station Eastern Leyte in Tacloban City to serve as the basis for monitoring construction activities.

Source: JICA Survey Team

3.6 Considerations, Risks, and Issues to be Considered in the Study of Constructability and Alternatives

This section aims to identify points to be considered when studying constructability and alternatives, and organize risks and issues in the project. In particular—disaster risks, such as bridge collapse, structural damage, or road failure—caused by natural phenomena, as these events can severely impact the social and economic state of the region. Accordingly, disaster-related risks should be investigated as comprehensively as possible during the route selection stage. The information collected will be investigated and organized to support decisions on avoidance or, where necessary, to serve as the basis for identifying and investing in viable alternative options.

Table 3-3 Organizational Items for Assuming Risks Arising from the Natural Environment

Risk Item	Availability of Risks at Potential Bridge Sites/Sources of Information	Potential Impacts	Response Policy for Alternatives Consideration
Landslide	Available – Hazard Map (https://www.geoportal.gov.ph/)	Higher construction costs and extended period due to slope stabilization and countermeasure work	Avoid alignment in high-risk areas as much as possible
Liquefaction	Available – Hazard Map prepared by PHIVOLCS (https://www.phivolcs.dost.gov.ph/index.php/gisweb-hazard-maps)	Increased construction cost and extended project timeline due to increase in size of ground improvement work and bridge foundations	Minimize areas at risk
Active Fault (Fault Displacement)	Unavailable – Hazard Map prepared by PHIVOLCS	—	—
Insufficient Support for Strata Bridge Foundations in the Straits	Available – Exposed rock surfaces observed during field survey revealed the Ryukyu Lime Formation, a coral-like and light porous formation from very dense plutonic rock.	In the case of the Ryukyu Lime Formation, the strength variation is very large and engineering handling is very difficult. Therefore, it is generally desirable to penetrate the piles during pile installation, which increases construction costs and extends the construction period due to the increased scale of bridge foundations.	Avoid regions confirmed to contain presence of Ryukyu limestone through borehole investigations, or carefully reflect such conditions in foundation type selection and construction costs.
Existence of Reefs (Outside Existing Navigation Channels)	Available – NAMRIA-issued nautical charts	Limited ability to secure alternative routes during main bridge construction, potentially affecting construction method and schedules.	Give priority to alignments where alternative routes can be secured. Subsequently, the construction method and alternative routes should be confirmed based on depth surveys conducted after determining the bridge location.
Topographic Undulation	Available – Contour maps generated from satellite imagery	In coastal areas with undulating terrain of over 20 meters, securing adequate space for construction yard may become challenging.	Prioritize areas around bridge locations where flat and sufficiently spacious sites for construction yards can be secured.

Source: JICA Survey Team

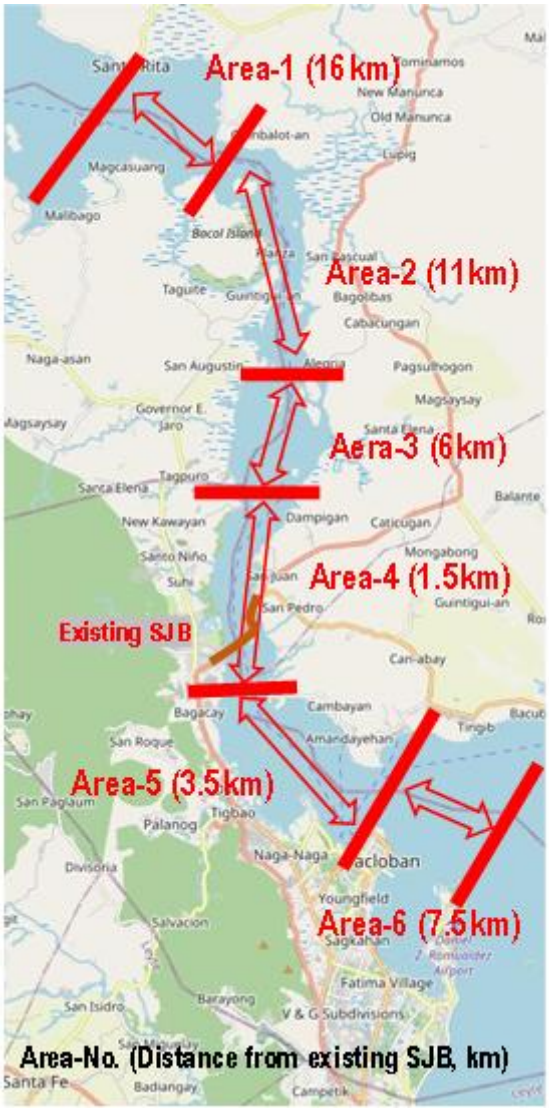
4 Examination of Alternatives

4.1 Overview of the Alternative Plan Examination

While referring to the Pre-F/S conducted in the high-standard highway M/P, the SSJB location and route will be selected considering the consistency with the development project planned in the surveyed area after the completion of the Pre-F/S.

Route selection is done in two steps. First, the San Juanico Strait, which extends about 30 km, is divided into six areas based on the strait width. Through a preliminary evaluation, this is narrowed down to two or three areas. In Step 1, representative outline routes are set for each area and compared. Once agreement is reached on the optimal cross-linking area, and the required number of lanes is determined based on the traffic demand forecast, a number of alternative routes are then developed. In setting these alternatives, control point accuracy is improved, enabling a more precise comparison design than in Step 1. For these alternative routes, Step 2 is performed, applying a multi-criteria analysis to select the optimal route.

In parallel with the selection of the optimum cross-linking route, a comparative study is conducted on the bridge types (superstructure). After the optimal plan is finalized by examining these alternatives, a natural condition survey and basic design are conducted. The examination results are outlined below.



Source: JICA Survey Team

Figure 4-1 Candidate Bridge Location Area (Long List)

4.2 Selection of Passing Area (Step 1)

4.2.1 Extraction of Passing Area Alternatives

The San Juanico Strait consists of areas with varying strait widths, and the potential cross-linking zone extends to about 30 km. Therefore, the areas are divided at the points where the strait width changes into six areas as shown in Figure 4-1. Area 1 is located within a bay approximately 16 km north of the existing SJB, with a width of 3 to 5 km. Additionally, mangrove forests are widely distributed in the area, with coral reef formations also present. Area 2 is situated about 11 km north

of the existing SJB, aligning with the route recommended in the Pre-F/S. Here, the strait width is small at 0.7 to 1.5 km. While mangrove distribution is relatively dense along the coast, no coral reefs have been identified. Area 3 is an area with a relatively large strait width (2 to 3 km) located about 6 km north of the existing SJB. Mangroves are densely distributed along the coast, and coral reefs are present around the islands. Area 4 has a relatively small strait width of 1 to 1.5 km, including the section of the existing SJB. In this area, both mangroves and coral reefs are limited. Area 5 is located 3.5 km south of the existing SJB on the Leyte Island side, and it is an area that passes through the city. The width of the strait is relatively wide, ranging from 1.5 to 3 km with coral reefs widely distributed. Area 6 is about 7.5 km from the existing SJB and includes the airport. Although the strait is large, ranging from 3 to 6 km in width, mangroves and coral reefs are very limited.

The items shown in Table 4-1 in the long list of six areas are evaluated on a three-point scale of good (〇), normal (△), and inferior (X), and are narrowed down to two or three areas with relatively excellent results.

Table 4-1 Evaluation Items for Narrowing Down from the Long List of Route Selection in Step 1

Evaluation Items	Evaluation Contents / Criteria
1. Traffic Improvement / Connectivity	Evaluate whether the cross-linking will improve traffic flow or accessibility to existing roads and development planning areas.
2. Effects on the Natural Environment 1) Mangroves	Based on the existing mangrove vegetation distribution map, it will be evaluated by the size and width of the vegetation range in each area.
2) Coral Reef	Since coral reefs are difficult to regenerate or transplant, it will be evaluated within the range of influence based on existing coral reef distribution maps.
3. Strait Width and Length of Road to be Attached to Existing Roads (Construction Cost)	The wider the strait, the longer the bridge section and the greater the cost. Evaluation also consider cases where the connecting road length to existing roads becomes extremely long.
4. Harmony with the Surrounding Landscape	Evaluate whether planning and design of the SSJB need to account for the development status of the surrounding area and the presence or absence of symbolic structures such as the existing SJB.
5. Impact on Construction	Evaluate items such as material transportation distance, utility relocation, distance to urban areas, aviation restrictions, and other factors that may affect construction feasibility.
Evaluation Result	If there are multiple items rated as X (inferior), that area will not be adopted.

Source: JICA Survey Team

Table 4-2 shows the evaluation results. Area 2, which was the Pre-F/S recommended area and Area 4, located around the existing SJB, were shortlisted since neither received any inferior ratings in the evaluation items. These two extracted areas will be compared in more detail at the next stage.

Table 4-2 Result of Evaluation for Narrowing Down from the Long List of Route Selection in Step 1

Evaluation Items	Area 1 Bay Area	Area 2 Pre-F/S Recommended Area	Area 3 Area with Large Strait Width	Area 4 Existing SJB Area	Area 5 Tacloban City Area	Area 6 Bay Area
Traffic improvement / connectivity	Accessibility to the planned site of Babatngon Port (O)	Accessibility to the planned site of Babatngon Port (O)	Accessibility to the Tacloban Bypass, planned site at Babatngon Port (O)	Accessibility to Tacloban bypass (O)	Induction of traffic congestion in urban areas (X)	Induction of traffic congestion in urban areas (X)
Environmental impact Mangrove	Large (X)	Medium (△)	Large (X)	Small (O)	Medium (△)	Small (O)
coral reef	Small (O)	None (O)	Small (O)	Small (O)	Large (X)	Small (O)
Channel width, mounting road length (construction cost)	3-5 km (X)	0.7-1.5 km (○)	2-3 km, mounting road length about 3 km (X)	1-1.5 km (○)	1.5-3 km (△)	3-5 km (X)
Harmonization with surrounding landscape	No restriction (O)	No restriction (O)	No restriction (O)	Harmony with existing SJB (△)	Landscape from the city area (△)	Landscape from the city area (△)
Impact on construction	Increased cost due to long material transportation distance (△)	Possibility of relocation of high-voltage electric wires (△)	Large-scale construction at sea (△)	Traffic management required near the existing SJB (△)	Construction pollution in urban areas (△)	Construction pollution in urban areas, aviation regulations (△)
Evaluation result	Not adopted	**Selected**	Not adopted	**Selected**	Not adopted	Not adopted

Remarks: ○: Good △: Fair X: Inferior

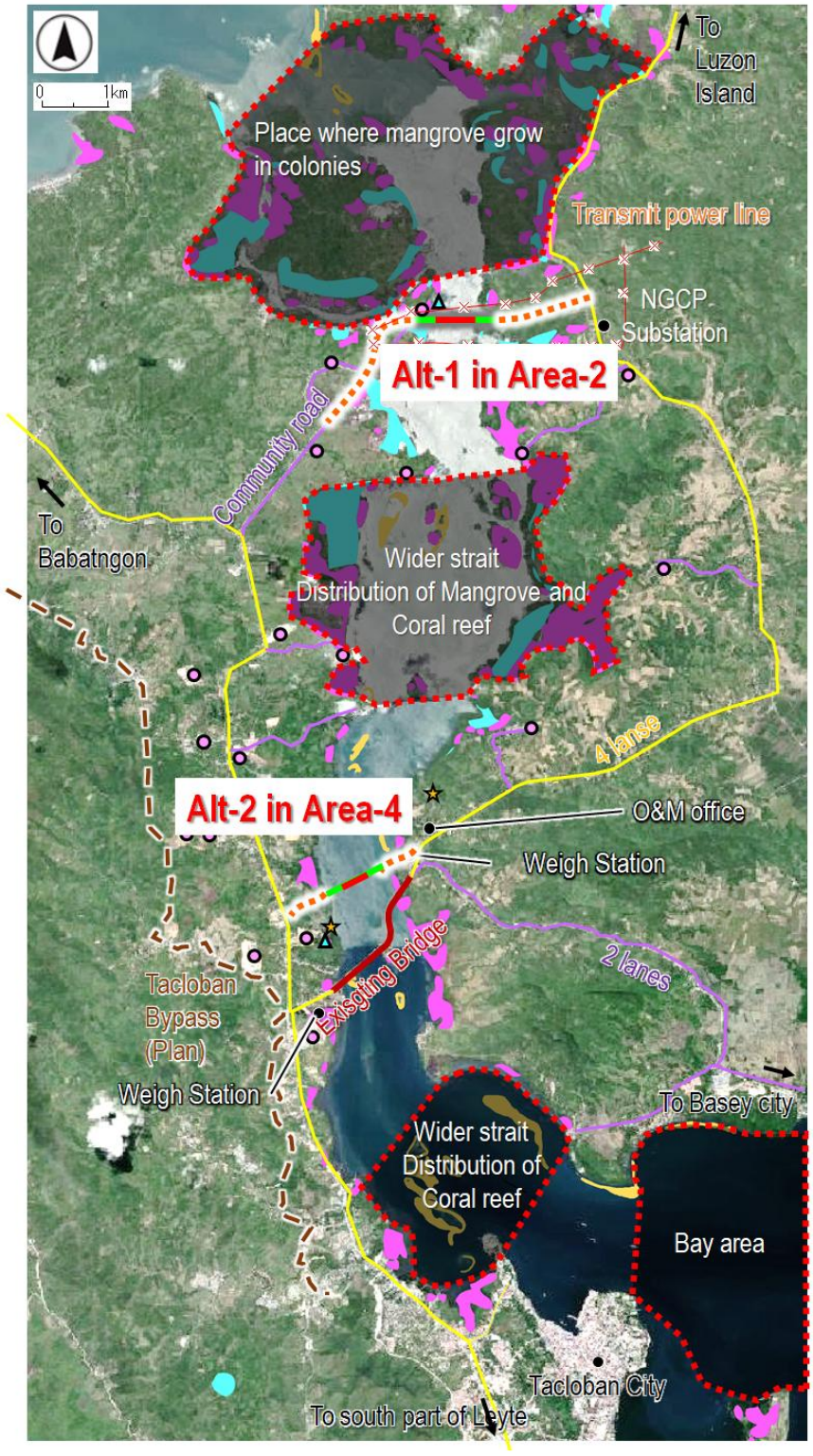
Source: JICA Survey Team

4.2.2 Comparative Evaluation of Passing Areas

To make the comparison easier, a representative route is selected among the shortlisted areas. As shown in Figure 4-2, two routes are established for evaluation: the route recommended by the Pre-F/S (Alt-1) in Area 2, and the route running parallel to the north side of the existing SJB (Alt-2) in Area 4.

The evaluation method adopts a multi-criteria analysis in accordance with the DPWH Department Order No.47, Series of 2022, Guidelines on the Conduct of Feasibility Studies for Roads, Bridge, Flood Control, Drainage and Other Water-Related Projects. The evaluation considers five main items, namely: the project effect in terms of the difference in distance between the major origin-

destination (OD) pairs, construction costs, environmental and social considerations, harmony with the surrounding environment, and construction requirements. The weight of each item is generally set at five (5). However, for harmony with the surrounding environment, which has relatively lesser impact on project implementation, and for construction requirements, which involve only temporary effects, the weight is set at three (3).



Source: JICA Survey Team

Figure 4-2 Candidate Passing Area (Short List)

Table 4-3 Evaluation Items for the Short List of Route Selection in Step-1

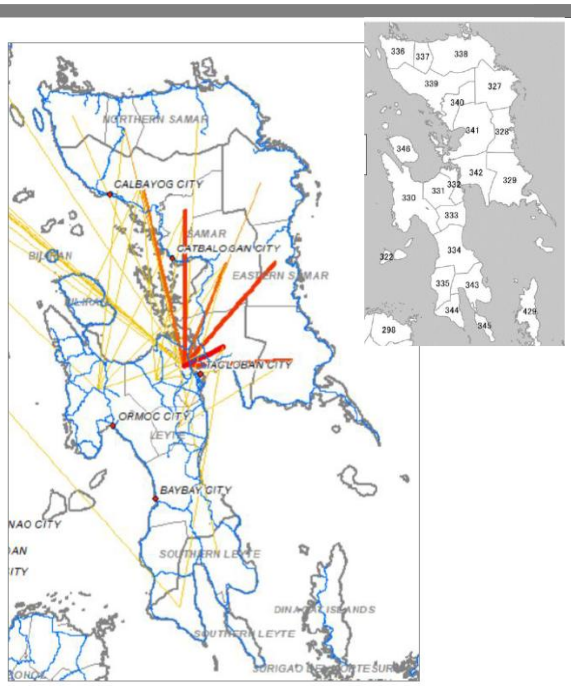
Classification	Item	Weight	Score	Weighted Score
Project effect	1) Travel time (distance)	5	5	25
Construction cost	2) Construction cost Main bridge (steel arch bridge), approach bridge (PC bridge), access road	5	5	25
Environmental and social considerations	3) Natural environment (25% each) - Impact on mangroves - Landslide risk - Liquefaction risk - Geology } Risk of increasing construction costs and extending the construction period	5	5	25
	4) Social environment (50% each) - Number of affected houses - Land price in ROW	5	5	25
Harmonization with surrounding landscape	5) Development status of the surrounding area and presence of symbolic structures such as existing SJB	3	5	15
Workability	6) Workability (50% each) - Impact of construction - Construction period	3	5	15
Weighted Total Score				130

Source: JICA Survey Team

The contents of each evaluation are shown below.

(1) Project Effect (travel time / distance)

According to the Pre-F/S, the main OD in the project area is between the northern and central parts of Samar Island and Tacloban City, as shown in Figure 4-3. This OD pair accounts for about 80% of the total OD in the region. Therefore, the distance of the representative route of this section is evaluated.



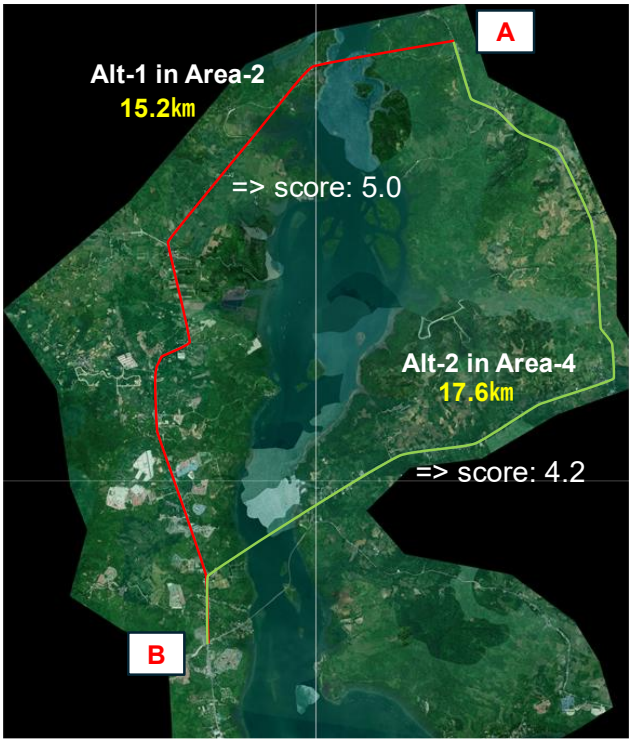
Source: JICA Study Team

Figure 17.2-2 Trips Pattern of Traffic at the San Juanico Bridge (2019 Data)

Source: Pre-F/S

Figure 4-3 OD in the Project Area (2019 Data)

The distances between points A and B, as shown in Figure 4-4, are15.2 km in Alt-1 and 17.6 km, which is 2.4 km longer, in Alt-2. The scoring is as follows: the option with the shortest distance is assigned maximum of five points, while the other option uses the formula: maximum points - [(distance of the option / distance of the shortest option - 1) × maximum points].



Source: JICA Survey Team

Figure 4-4 Difference in Distance Between Two Points

(2) Construction Cost

At this stage, since the bridge type has not yet been determined and a detailed estimate has not been prepared, the unit price of the main bridge (steel arch bridge), the mounting bridge (PC girder bridge), and the mounting road (fill, cut) in the Pre-F/S was used. The superstructure construction cost was calculated by extending each substitute route. For the utility relocation cost, the number of utility poles along the alignment was confirmed through on-site reconnaissance and reflected in the comparison plan. Regarding power poles, the result showed that Alt-1 in Area 2 had a greater quantity due to the presence of existing roads and adjacent villages that interfere with the alignment. This outcome was considered reasonable given the extent of use of electric wires.

The construction cost of Alt-1 is 103% of that of Alt-2. The option with the lowest cost is given the maximum score of five points, while the other option is scored using the formula: maximum points - [(cost of the option / the cost of the lowest option - 1) × maximum points].

Table 4-4 Construction Cost Comparison (Step-1)

Item	Unit Cost* (Million PhP/km) (a)	Alt-1 in Area 2		Alt-2 in Area 4		Difference (c)-(e)	Reason of Difference
		Length (km) (b)	Cost (Million PhP) (c)=(a)x(b)	Length (km) (d)	Cost (Million PhP) (e)=(a)x(d)		
Approach Road: Embankment (fill)	142.48	2.35	335	0.9	128	207	Approach road length of Alt-2 is shorter.
Approach Road: Embankment (cut)	233.8	1.37	320	0	0	320	No cut road is expected in Alt-2.
Approach Road: Embankment (upgrade existing road)	71.24	0	0	0	0	0	Widening of existing roads required in Alt-1 is almost finished.
Main Bridge (steel arch, superstructure)	11182.5	0.6	6,710	0.6	6,710	0	No difference is assumed
Main Bridge (steel arch, substructure)	1417.28	0.6	850	0.6	850	0	No difference is assumed
Approach Bridge (PC Girders, superstructure & substructure)	832.92	0.36	300	0.7	583	(283)	Approach bridge length of Alt-2 is longer.
Relocation of Power Transmission Line	20 per nos.	1 location	20	0	0	20	Relocation of one tower is assumed in Alt-1.
Relocation of Electricity Pole	0.05 per nos.	20 nos.	1	5 nos.	0.25	0.75	Roughly estimated based on site observation
Total		**4.68**	**8,536 (103%)**	**2.2**	**8,271 (100%)**	**265**	

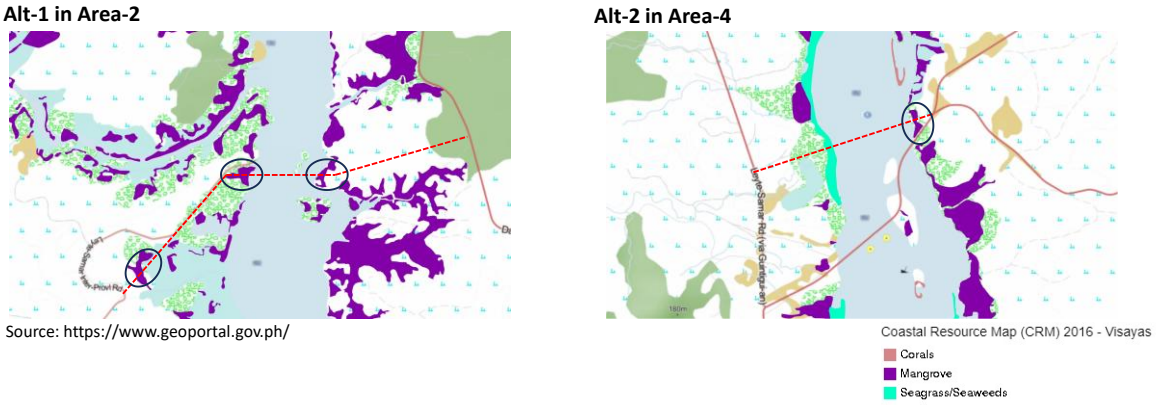
Note: Unit Costs of the Pre-FS
Source: JICA Survey Team

(3) Natural Environment

1) Impact on Mangrove

When selecting bridge areas, avoidance route options, and construction yards, the range of mangroves within a band width of about 200 m along each assumed representative route is compared in consideration of securing the area. During field reconnaissance, about 3.7 ha of mangroves were affected in Alt-1, where 28 species were confirmed, including five rare species. On the other hand, a total of 22 species were confirmed in Alt-2, including two rare species, at about 0.6 ha. Details are further provided in Section 13.7, Environmental and Social Consideration Survey.

For the evaluation criteria, when there is no effect (0 ha), the score is set at the maximum of five points, while 5 ha is proportionally distributed with a score of zero point.



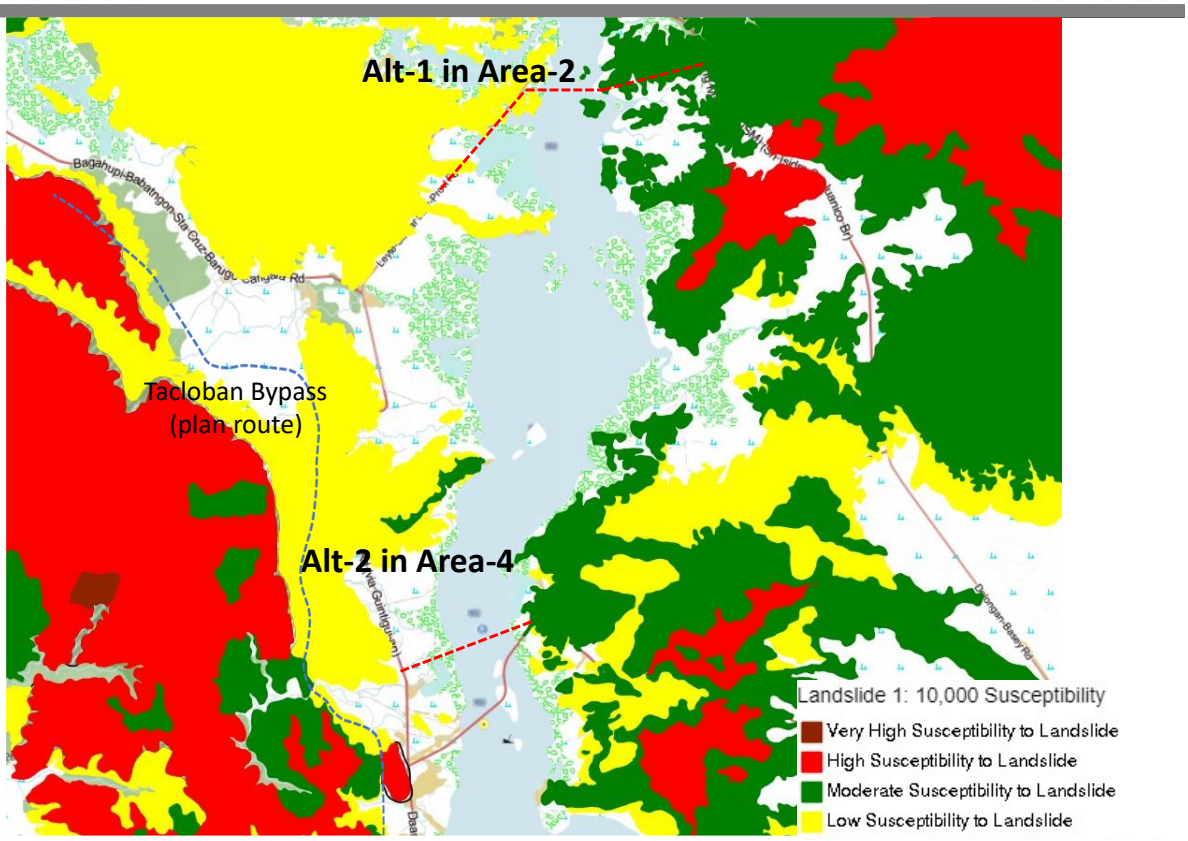
Source: JICA Survey Team added to Geoportal's base map

Figure 4-5 Influence on Mangroves

2) Landslide Risk

According to the landslide hazard map prepared and published by the Philippine Institute of Volcanology and Seismology (PHIVOLCS), landslides are likely to occur near the top of the mountainous area. The contour intervals from the flat land along the San Juanico Strait to the mountainous area near the urban area of Tacloban are almost uniform. Therefore, the risk of landslide damages in areas where bridges are planned is considered low.

In comparing the two areas based on the risk assessment of the hazard map, the maximum score of five is assigned when the representative route does not pass through a risk area. If the route passes through a very high-risk area, it is scored according to the risk with a score of one. On the Leyte Island side, both routes pass through low-risk areas, whereas on the Samar side, they pass through medium-risk areas.



Source: https://www.geoportal.gov.ph/

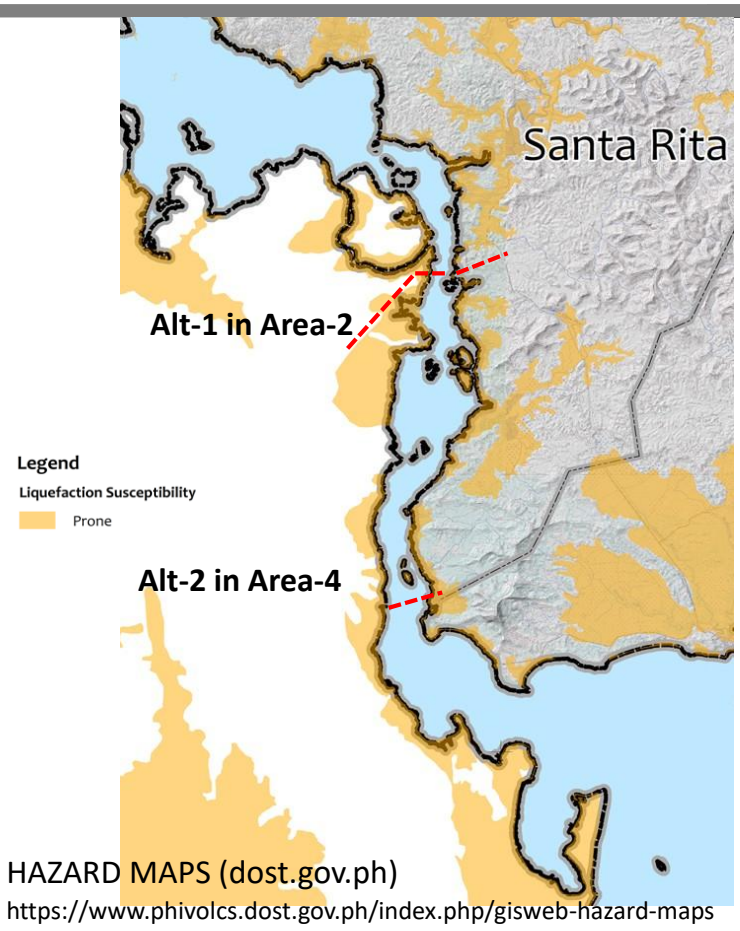
Source: JICA Survey Team added to Geoportal's base map

Figure 4-6 Risk Assessment on Landslide Hazard Map

3) Liquefaction Risk

According to the liquefaction hazard map created and published by the PHIVOLCS, the coastal areas from the urban area of Tacloban to Alt-1 and Alt-2, located on the flat land of the Leyte Island side, consist of wetlands with scattered mangrove forests. In addition, the groundwater level is considered high because the surface soil is persistently wet, and significant amounts of mud are found in the cultivated land and fish farms found in the vicinity of the flat land. Although the same trend is observed on the Samar Island side, the liquefaction risk there is considered limited to certain coastal areas due to geographical factors, with less flat land compared with the east coast of Leyte Island. Based on these observations, it can be concluded that the ground properties on both banks of the San Juanico Strait are poor and that the risk of liquefaction is high.

The evaluation criteria assign a maximum score of five points when the route does not pass through a risk area. If the route passes through a risk area on one side, the points are reduced by -2.5 points, and by -5.0 if it passes through a risk area at both sides. On the Leyte side, both routes pass through the risk areas, while on the Samar side, Alt-1 is able to avoid the risk area.



Source: JICA Survey Team added to Geoportal's base map

Figure 4-7 Risk Assessment on Liquefaction Hazard Map

4) Geology

The following describes the geological conditions as confirmed by the field survey conducted in November 2023 and the borehole survey conducted in March 2025 for each of the representative route.

First, Alt-2 is located near the existing SJB. On the Leyte side, the area includes a fish farm, a resort facility with a beach, and a mangrove forest. The ground condition from the beach to the mangrove forest transitions from sandy to rocky. Examination of exposed rock surfaces revealed igneous rocks that appear to have melted and drifted; these are believed to be rhyolite, formed through the slow cooling of magma. The rocks are dense and hard.

The surface layer on the Leyte side was wet and muddy. The borehole survey indicated that the shallow layer consists of clayey soil mixed with sand. The groundwater level was detected at GL-2 m from the surface, while sandstone and basalt were found as the supporting layers between GL-4 m to GL-6 m. On the Samar side, porous igneous rocks, formed by the rapid cooling and solidification of lava post-eruption, were observed. These were occasionally overlain with sedimentary layers such as sandstone. The surface layer on land was also wet, and borehole

survey results showed that it consists of sandy silt, with the groundwater level generally around GL-3 m. The supporting layer of sandstone was noted between GL-2 m to GL-6 m.

The risk of liquefaction in the shallow soils of the Leyte-Samar overland areas was assessed in accordance with the Guidelines for Bridges and their Commentary V: Seismic Design (Chapter 8: Effects of Ground Instability during Earthquakes). The assessment indicated that liquefaction is unlikely.

In Alt-1, sandstone was exposed on the surface from the coastal area on the Leyte side to the inland area. On the Samar side, light, porous, coral-like layers are noticeable from the surface to depths below sea level. These layers are thought to be part of the Ryukyu Lime Formation, found along the coast from Okinawa to parts of the Philippines. This formation, prevalent in Okinawa, presents complicated stratigraphy and contains cavities formed by groundwater influence. The formation's strength varies significantly, posing considerable engineering challenges. Reports indicate that pile foundations typically penetrate from 5 to 20 m on land and 40 to 60 m at sea; hence, the construction complexity must be carefully considered when selecting bridge locations.



Porous layer of what appears to be “Ryukyu Limestone” on Area 2, Samar Island side. The Leyte side consisted primarily of sandstone.



Dense layers due to “igneous rocks” on the Leyte side of Area 4. Similar strata were identified on the Samar Island side.

Source: Photographed by the JICA Survey Team

Figure 4-8 Geological Status of Exposed Rock along the Coastal Area

Moreover, two borehole surveys were conducted along both representative strait sections, with the details provided in Section 5.5, Soil Survey. The survey results showed that in Alt-1, firm sandstone bearing layers were identified from the seafloor surface, while in Alt-2, firm sandstone and shale bearing layers appeared at shallow depths.

As summarized in Table 4-5, Alt-1 presents potential risks that could increase foundation construction costs due to the presence of Ryukyu Limestone, while Alt-2 may lead to additional costs for soft ground remediation in the earthwork section. Since structural risks are considered more critical, a score difference was assigned. The main bridge construction is deemed as the

critical phase of the work; therefore, the risk of construction schedule delays is considered to be negligible.

Table 4-5 Summary of Geological Assessments

Item	Alt-1（Area 2）	Alt-2（Area 4）
Geological conditions from coastal to inland areas (Results of visual survey)	Leyte side: Composed of sandstone from the coast to inland. Samar side: The coastal area is composed of Ryukyu Limestone which is also exposed inland.	On both coastal, igneous rocks are exposed. Inland, the surface layer is slightly wet and soft, but a good support layer was identified a few meters depth.
Geological conditions in the strait area (Results of Borehole surveys)	Sandstone was identified from shallow layers.	Sandstone and shale were confirmed from shallow layers.
Qualitative Assessment	There is a risk that the geological composition on the Samar side will increase the width and pile length of the approach bridge foundations, including the abutments, thereby affecting construction cost.	There is a risk that soft ground measures (replacement, improvement, etc.) will be required in the earthwork section, thereby affecting construction cost.
Score	2	4

Note: Scoring Criteria for risks affecting construction period and cost:

1 point: Both earthwork and bridge construction are affected.

2 points: Only bridge construction is affected.

3 points: Presence of deep soft ground in earthwork or limited impact in bridge construction.

4 points: Only earthwork is affected.

5 points: No impact.

Source: JICA Survey Team

(4) Social Environment

1) Number of Affected Houses

Based on satellite images obtained for this survey, the number of houses along each representative route, assuming a tentative right-of-way (ROW) of 60 m, was counted. In Alt-1, the count from the satellite images matched the result from the Pre-F/S. Using the same method, the number of houses was counted for Alt-2 and compared. Alt-1 has 59 houses, while Alt-2 has 30 houses.

For scoring, the option with the lowest number of houses is assigned the maximum score of five points, while the other option is scored as follows: maximum points - [(nos. of the option / the nos. of the lowest option - 1) × maximum points].

17.8.3 Size and Areas of Land Acquisition and Resettlement

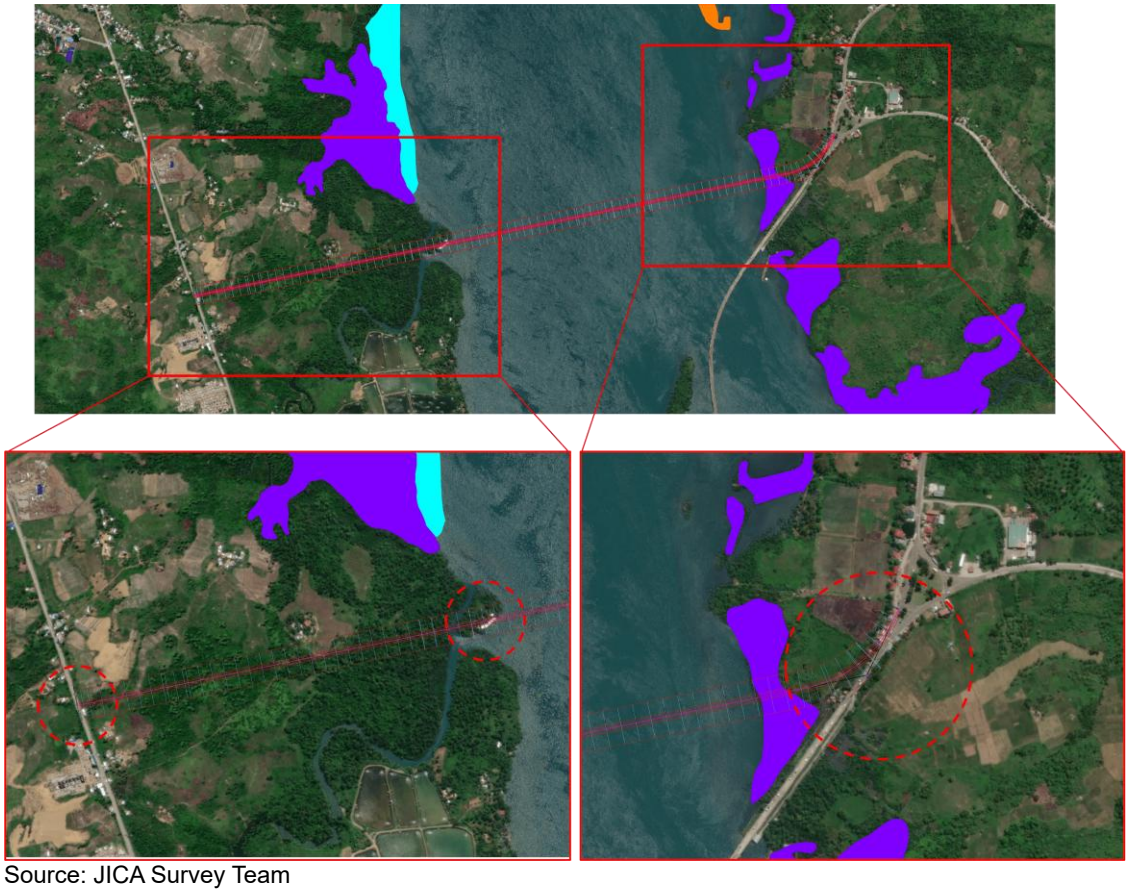
The project requires land acquisition and resettlement for construction of approximately 3.6 km road section (embankment and high-cut), an approximately 1.2 km bridge as well as 3 intersections. Rough estimate of necessary land acquisition areas and roughly counted affected structures are shown in **Table 17.8-1**.

Table 17.8-1 Rough Estimation of Land Acquisition and Resettlement of SSJB

Component	Approx. Length	Number	Land acquisition	Affected Structures	Remarks
1. Road Sections	3.6 km	-	21.6 ha	59	Estimation with fixed width of 60 m
2. Bridge	1.2 km	20	Small amount		Limited within abutment areas
3. Interchange	-	3	15 ha	-	Estimation with fixed area of 5 ha per one interchange
Total	-	-	**Approx. 37 ha**	**59**	

Source: Pre-FS

Figure 4-9 Number of Affected Houses in Alt-1 in Pre-F/S



Source: JICA Survey Team

Figure 4-10 Number of Affected Houses in Alt-2 based on Satellite Images

2) Land Price in ROW

Land acquisition costs can serve as an indicator of the difficulty of acquiring land. Since detailed information cannot be obtained at this time, the land price within the ROW of 60 m was calculated

as a rough estimate based on published land prices for relative comparison. Land unit prices were obtained from the website of the Philippine Internal Revenue Service. On the Leyte side, Babatngon was adopted as the representative price of Area 2, and Tacloban was adopted for Area 4 in 2024. On the Samar Island side, the 2010 prices of Bagalibas for Area 2 and San Juan for Area 4 were adjusted to 2024 prices using the Consumer Price Index (CPI). The land was classified as residential areas and cultivated land.

Table 4-6 shows the calculation results. The land price in Alt-1 is 123% of that in Alt-2. For scoring, the option with the lowest land price is assigned the maximum of five points, and the other option is scored as: maximum points - [(land price of the option / land price of the lowest option - 1) × maximum points].

Table 4-6 Comparison of Rough Estimated Land Prices in ROW

Area Classification		Alt-1 in Area 2				Alt-2 in Area 4			
		Unit rate*1/ (PhP/m²) (a)		area (m²) (b)	Cost (PhP) (c)=(a)x(b)	Unit rate*1/ (PhP/m²) (d)		area (m²) (e)	Cost (PhP) (f)=(d)x(e)
Leyte Side	Residential Area	Babatngon	2000	8,380	16,759,792	Tacloban	4000	1,738	6,952,000
	Cultivate Area*2/		90	133,914	12,052,284		350	47,552	16,643,200
Samar Side	Residential Area	Sta.Rita (Bagalibas)	416	1,461	607,898	Sta.Rita (San Juan)	416	3,419	1,422,304
	Cultivate Area*2/		20	104,288	2,085,761		20	26,229	524,580
Total				248,043 m²	31,505,736 **(123%)**			78,938 m²	25,542,084 **(100%)**

Remarks: *1/ Unit price source: https://www.bir.gov.ph/index.php/zonal-values.html
*2/ average of Riceland Irrigated, Coco Land, Banana Land and Vegetable Land
Source: JICA Survey Team

(5) Harmonization with the Surrounding Environment

Area 2 has no landmark structures or major development areas. Both the bridge and embankment sections in the alternative route pass through areas close to the natural state, except for some residential zones, so there is minimal consideration for the landscape. On the other hand, Area 4 contains the existing SJB, a symbolic structure in the region, making harmony with the existing SJB an important consideration in the planning and design of the SSJB.

For this reason, Area 2 is assigned the highest with five points, while Area 4 receives four points due to these important considerations.


Area 2 Leyte Side


Samar Side


Samar Side


Area 4 Existing SJB

Source: Photographed by the JICA Survey Team

Figure 4-11 Surrounding Environment in Area 2 and Area 4

(6) Construction Requirement

1) Impact due to Construction Work

The evaluated items regarding the “Impact due to Construction Work” for route selection are summarized in Table 4-7.

Table 4-7 Evaluated Items Regarding Impact due to Construction Work

Items		Study Points and Remarks
1.	Environment impact by construction	Evaluates how the expected construction yard and temporary jetty will affect mangroves and coral reef.
2.	Social impact by construction	Evaluates how the expected construction yard and temporary jetty will affect surrounding communities and fishing area.
3.	Terrain	Assess the extent of terrain modification required for the expected construction yard. Large altitude variations make the site less suitable.
4.	Safety for surrounding	Assess third-party safety during construction, considering whether the construction yard or temporary access road affects residences or access roads.
5.	Obstacle	Evaluates potential impacts of the construction yard and temporary jetty on existing structures and utilities.
6.	Length of temporary jetty	Evaluates the length of the temporary jetty needed from the coastal line to maintain a water depth of 5 fathoms (1 fathom = 1.83 m) based on existing sea map.
7.	Navigation control	Evaluates the management of navigation control during construction.
8.	Site access (Shipping to site)	Evaluates the distance from Tacloban, the nearest major city with a port, for site access. *Only applicable in Step-1

Source：JICA Survey Team

The following conditions are required for the selection of the construction yard and temporary jetty:

- The construction yard should be located close to the bridge crossing point along the coastal alignment.
- Design controls such as mangroves, coral reefs, villages, and other sensitive areas should be avoided as much as possible.
- An approximate 300 m x 300 m area should be allocated for steel and concrete bridge construction.

  *Reference: other project practice
- A temporary jetty is needed for LCTs at the site.

  *Existing ports are not suitable for large-sized shipping barges based on PPA's suggestions, and existing bridges have load limitation for land transportation.

  *LCT means "Land Craft Tank", which allows materials to be directly shipped to the site and unloaded at the temporary jetty.
- The existing road must not be interfered with. There are many equipment and vehicle activities in the construction yard, so the existing road should remain outside the construction yard to ensure safety of the existing traffic.
- The construction yard should not be divided by the river, meaning that a temporary bridge will not be constructed, in order to avoid increased temporary facility costs and complexity in the construction yard arrangement.

The referred composition and required area of the construction yard for the project are shown in Table 4-8. For the alternative routes, the construction yard plan will be selected as part of the route selection.

Table 4-8 Example of Required Area of Construction Yard

Composition of the Construction Yard		Required Area
1.	Office (Engineer, Contractor, Sub-contractor)	10,000 m^2
2.	Motor pool	5,000 m^2
3.	Material stock yard (Substructure 5,000 m^2, Rebar arrangement 5,000 m^2, PC etc. 5,000 m^2, road construction 5,000 m^2)	20,000 m^2
4.	Steel bridge assembling yard	10,000 m^2
5.	Concrete batching plant	10,000 m^2
6.	Casting and fabrication of PC girders	10,000 m^2
7.	Temporary roads in yard and others (it will be flexible depending on availability of yard area	25,000 m^2*

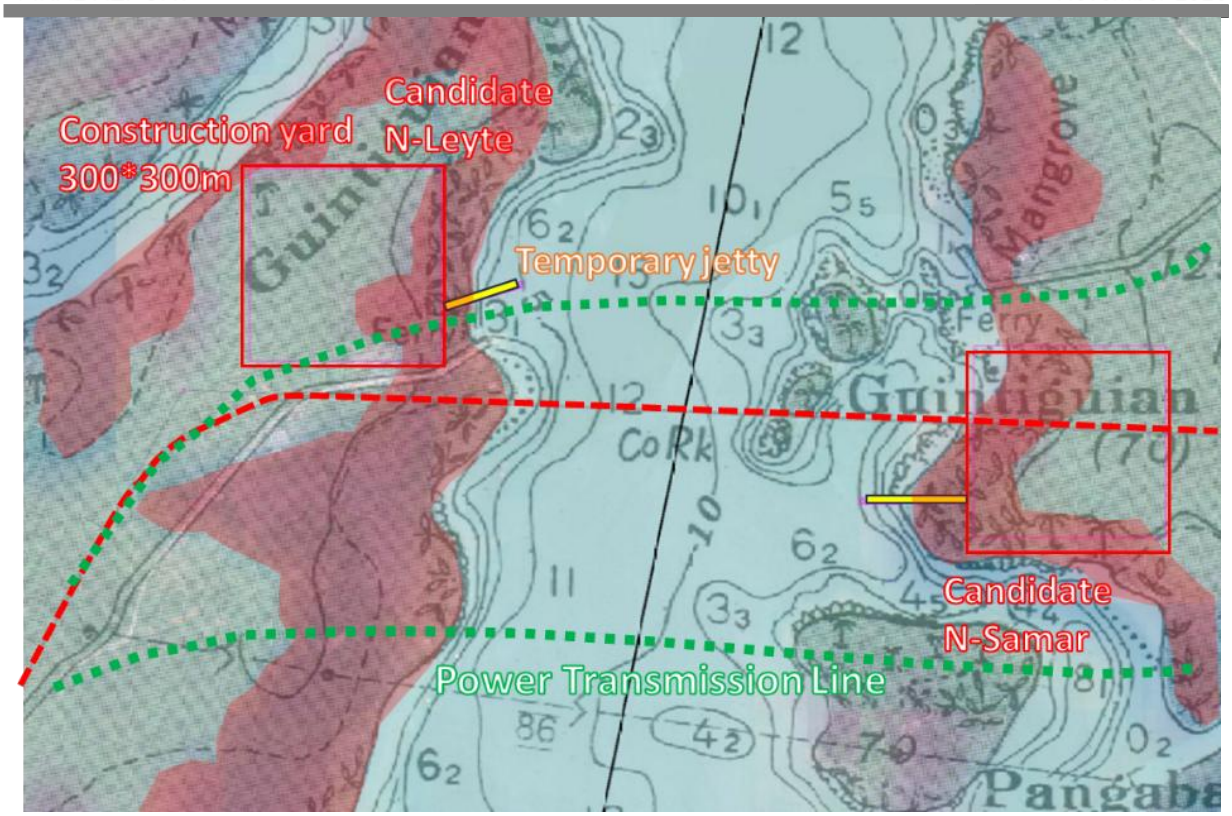
Source：JICA Survey Team

[**Evaluation Criteria for All Steps of Route Selection Regarding Construction Yard Area and Location**]

The best condition for the construction yard is considered/evaluated to be its ability to be established directly at the bridge crossing point with an appropriate area. Any route that cannot provide appropriate area at the bridge crossing point is automatically evaluated as inferior to those that can. Therefore, candidate construction yards located away from the bridge crossing point are excluded from the evaluation. This criterion is set based on the understanding that a temporary jetty is necessary to access the foundation and pier construction by utilizing temporary jetty overhanging on the condition that “cranes mounted on barge cannot access to the pier location near costal line because of the shallow depth of sea water”. In addition, even if the plan proposes locating the jetty and yard apart from the bridge crossing point to avoid environmental impacts on mangroves and coral reefs along the coastal line, it would still require a temporary jetty and a yard to access the foundation and pier construction. Based on this understanding, the evaluation criterion was established.

In Step-1, considering the site conditions at the bridge crossing point, the main construction yard location was selected on one side—either in Leyte or Samar—and then evaluated in comparison with the candidate routes.

For Alt-1 in Area 2, the construction yard candidate is shown in Figure 4-12. On both sides, Leyte and Samar, it is not possible to avoid mangroves and fishing areas. Especially, the Samar side has a large impact on mangroves. Moreover, the length of temporary jetty is longer than on Leyte side due to the wide mangrove-covered coastal area. Therefore, the main construction yard was selected on the Leyte side and evaluated against the other route candidate.

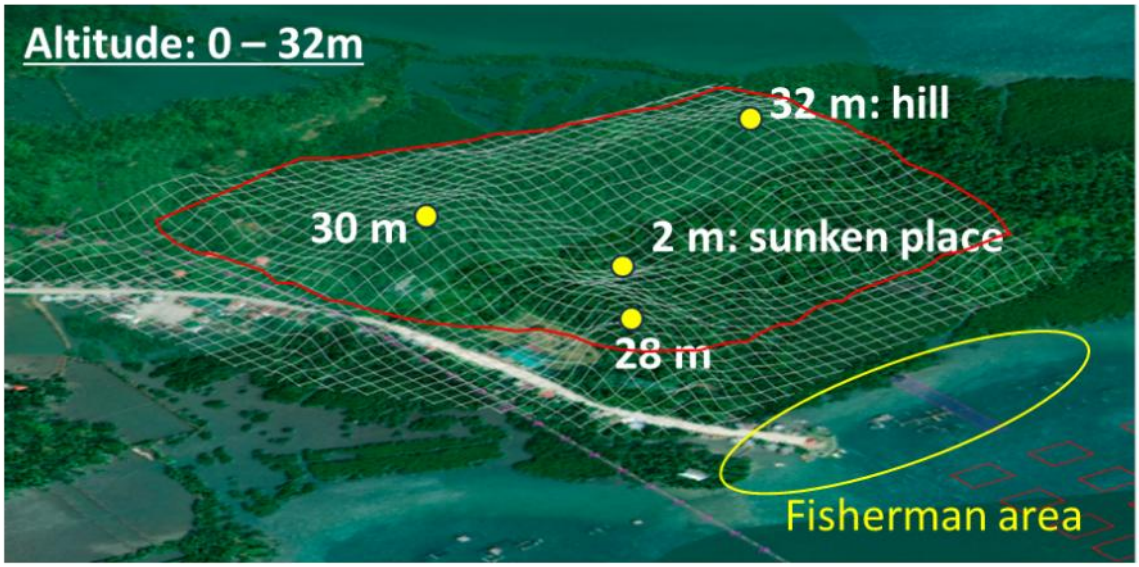


Source：JICA Survey Team

Figure 4-12 Expected Area of Construction Yard and Jetty for Alt-1 in Area 2

The details of the terrain and surroundings of the main construction yard on the Leyte side for Alt-1 in Area 2 are shown in Figure 4-13. The altitude in this area ranges from 0 to 32 m, making it an inappropriate location for a construction yard due to the significant terrain modifications that would be necessary.

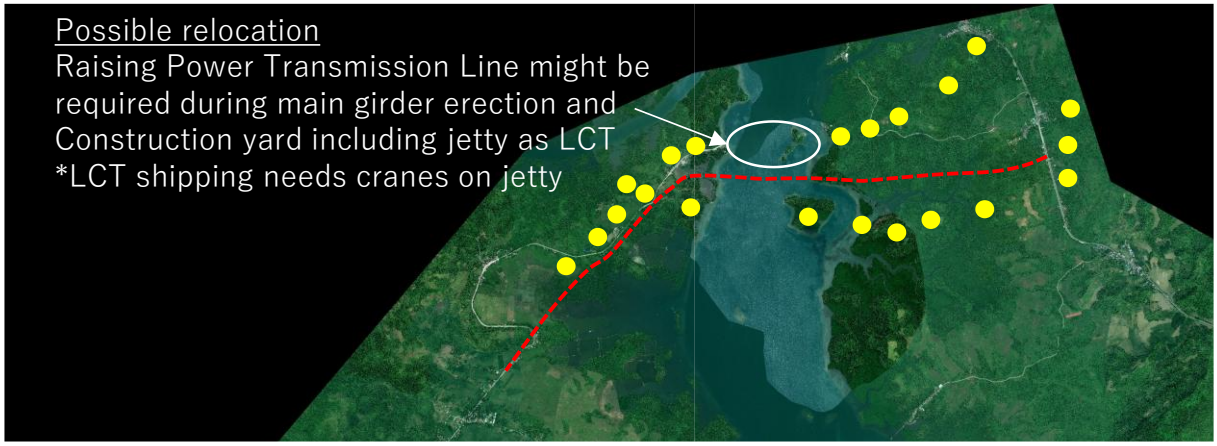
Additionally, ensuring the safety of third parties will be challenging because residential area is located along the existing road. Around the temporary jetty, fishing areas are distributed. During construction, measures will be needed to support livelihoods of local residents, including compensation for the economic activities that may be affected.



Source：JICA Survey Team

Figure 4-13 Terrain and Surroundings of the Main Construction Yard (Leyte) for Alt-1 in Area 2

In the aspect of obstacles in the site, two transmission lines run parallel along the route. Major contents of construction work involve bridge activities, which require large size of cranes operating at high levels. Therefore, relocation of transmission lines and towers will be necessary prior to the commencement of works.



Source: JICA Survey Team

Figure 4-14 Location of Transmission Line

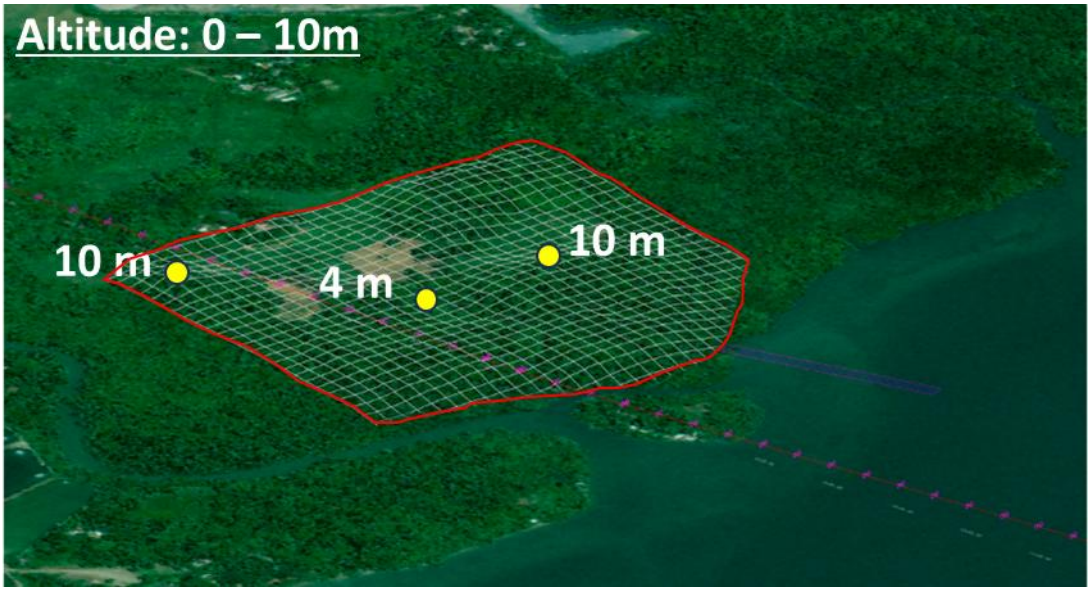
For Alt-2 in Area 4, the construction yard candidate is shown in Figure 4-15. The Leyte side will have minimal impact on mangroves. Therefore, the main construction yard is selected on the Leyte side and evaluated alongside the other route candidate.



Source：JICA Survey Team

Figure 4-15 Expected Area of Construction Yard and Jetty for Alt-2 in Area 4

The details of the terrain and surroundings of the main construction yard (Leyte side) for Alt-2 in Area 4 are shown in Figure 4-16. The altitude ranges from 0 to 10 m, making this area more suitable for a construction yard with minimal terrain modification compared with Alt-1 in Area 2. In addition, there appears to be no residential areas or significant obstacles. Regarding environmental impact, this area is expected to have smaller impact than Alt-1 in Area 2.



Source：JICA Survey Team

Figure 4-16 Terrain and Surroundings of the Main Construction Yard (Leyte) for Alt-2 in Area 4

[**Accessibility to Bridge Crossing Point and Construction Yard**]

Accessibility to the bridge crossing point and construction yard is evaluated for both routes. Two modes of transportation—maritime and land shipping—are evaluated, as shown in Table 4-9. Regarding maritime shipping, no significant difference between both routes is expected, as shipments originate from other cities (Manila and Cebu) or overseas. Therefore, both routes are evaluated as having equivalent conditions.

Maritime shipping is considered the major transportation to the site, while land shipping is expected to occur at a minimal volume. In this regard, Area 2 is evaluated as inferior to Area 4 because the distance from the nearby major city of Tacloban, which has a port, is twice that of Area 4 (see Figure 4-17).

Land shipping via existing road will also affect access to the site. The evaluation is considered equal for both areas due to the following reasons:

- Alt-1: The community road cannot be separated from the residential area for construction use.
- Alt-2: A new site access road shall be constructed specifically for construction use.

Table 4-9 **Accessibility to Bridge Crossing Points and Construction Yards**

Comparison Item	**Alt-1 in Area-2 (N-route)**	**Alt-2 in Area-4 (C-route)**
Maritime shipping	Both of routes need temporary jetty for LCT loading for maritime shipping. => No difference	
Land shipping *distance from nearby big city / port	- Approximately **20** km - The **existing community road** from a trunk road (TB road) is already maintained to the bridge crossing point. However, 4-lanes section is only 500m, other 1.5km is 2-lanes. Along the road, houses and fishing area are located. Transportation to the site will be interfered by existing traffic on this community road. It is **difficult to separate living use and construction purpose**.	- Approximately **10** km - **NO existing road** from a trunk road (TB road) to the bridge crossing point. The length of site access road is approximately only 800m. The site access road will be constructed on ROW prior to permanent road. Therefore, the purpose of road is only for construction.
Evaluation	**[Fair] 2/3**	**[Good] 3/3**

Source：JICA Survey Team



Source：JICA Survey Team

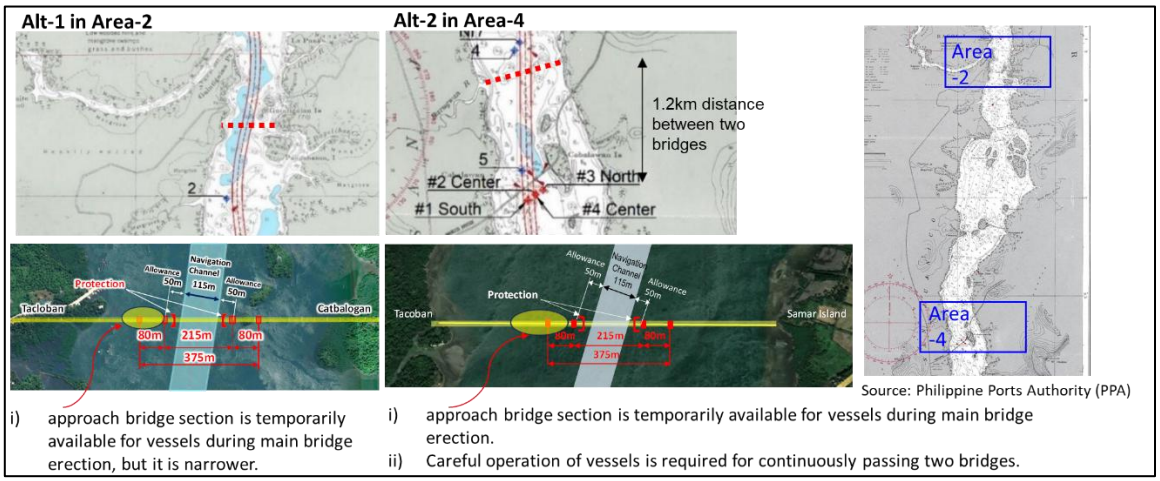
Figure 4-17 Distance from Tacloban, the Nearest Major City, to Bridge Crossing Points

[**Alternative Navigation Channel**]

The alternative navigation channel on the main span of the bridge is evaluated. Both Alt-1 and Alt-2 are assessed to allow the navigation channel to shift to the side span during the main span erection based on the obtained sea map. Therefore, both options are considered to have the same score.

However, comparing the main navigation channel, temporary control and limitations of navigation cannot be avoided due to the shallower and narrower navigation channel.

In Figure 4-18, a temporary width of the navigation channel of 115 m was set, and confirmation of navigation conditions must be discussed with the PCG and other relevant authorities. In addition, for the selected route, an alternative navigation channel will be studied based on the bathymetric survey.



Source：JICA Survey Team

Figure 4-18 Alternative Navigation Channel during Main Bridge Erection

The evaluation results, based on the selected construction yard for each route described above, are summarized in Table 4-10. In each item, Alt-2 is evaluated to have the least impact due to construction.

Table 4-10 Evaluation of Impact due to Construction for Step 1

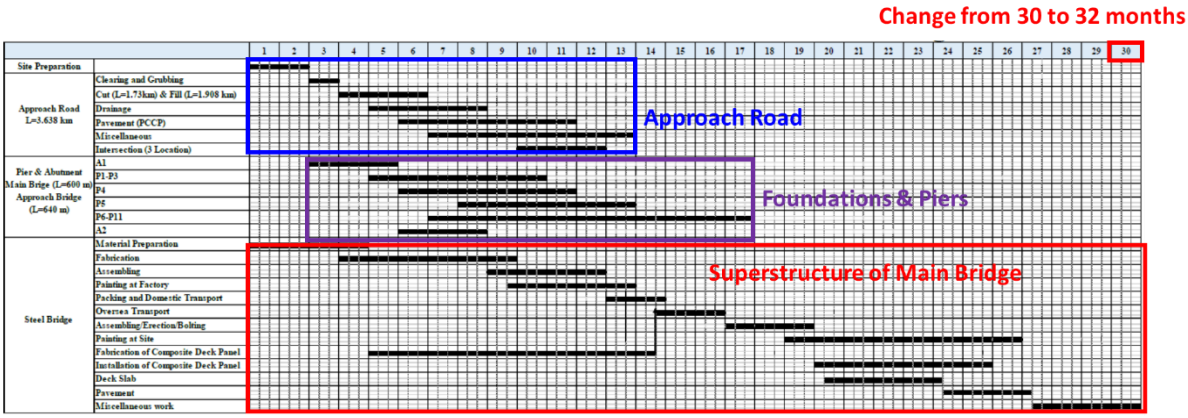
Comparison Item	Alt-1 in Area-2 (N-route)	Alt-2 in Area-4 (C-route)
Environment impact By construction yard	[Bad] 1/3: Bigger impact for mangroves	[Good] 3/3: Smaller impact for mangroves
Social impact By construction yard	[Bad] 1/3: Bigger impact for fishing area and citizen living	[Good] 3/3: Smaller impact for citizen
Terrain	[Bad] 1/3: Big terrain change is necessary (Altitude: 0-32m)	[Fair] 2/3: Small terrain change (Altitude: 0-10m)
Safety for surrounding	[Bad] 1/3: Interfering existing road and people. Construction yard cannot be isolated from living place.	[Good] 3/3: No big impact
Obstacle	[Bad] 1/3: Power transmission line must be affected for construction	[Good] 3/3: No obstacles
Length of temporary jetty	[Fair] 2/3: About 130 m for 5-fathom depth	[Fair] 2/3: About 130 m for 5-fathom depth
Site access (Shipping to site)	[Fair] 2/3: About 20km from Tacloban	[Good] 3/3: About 10km from Tacloban
Navigation control	[Good] 3/3: No problem	[Good] 3/3: No problem
Evaluation	Points 12 out of total 24 (= 2.5 / 5 score)	Points 22 out of total 24 (= 4.6 / 5 score)

Source: JICA Survey Team

2) Construction Schedule

The construction schedule was initially planned for 30 months in the Pre-F/S. However, since this schedule did not account for “Mobilization and Demobilization”, two months have now been added for these activities. Thus, a total of 32 months for construction is proposed instead of 30 months.

There is no significant difference in the scope of work between the two alternatives, referring to the quantities and contents of the critical work of the main bridge. Therefore, the evaluation of the construction period for both alternatives results in a 5.0 score.



Source: JICA Survey Team with edits on the Pre-F/S schedule

Figure 4-19 Review of Pre-F/S Construction Schedule

(7) Evaluation Result

Table 4-11 summarizes the evaluation results for each of the above items. Since Area 4 scored 111.2 out of 130 points, exceeding Area 2's score of 96.0 points, Area 4 was selected as the optimum bridge passing area.

Table 4-11 Evaluation Result of Route Selection (Step 1)

Classification	Item	Evaluation Criteria	Weight	Area 2 (Alt-1)		Area 4 (Alt-2)	
				Score	Weighted Score	Score	Weighted Score
Project Effect	Travel time (distance)	The score for the shortest distance = 5, with deductions applied depending on the distance	5	5.0	25.0	4.2 = 5-(17.6/15.2-1) x 5	21.0
Construction Cost	Construction cost of the main bridge (steel arch bridge), approach bridge (PC bridge), and access road	The score for the lowest cost = 5, with deductions applied depending on the cost	5	4.8 = 5-(8,536/8,271-1) x 5	24.0	5.0	25.0
Environmental and Social Considerations	Natural environment - Impact on mangroves	25% each When there is no passage, score = 5, with deductions depending on the affected area	5	2.13 = (1.0+3.0+2.5+2.0) x 25%	10.6	2.75 = (4.0+3.0+0+4.0) x 25%	13.8
	- Landslide risk	When no passing through the risk area, score = 5, with deductions depending on the passage					
	-Liquefaction risk	When no passing through the risk area, score = 5, with deductions depending on the passage					
	- Geology	Qualitative evaluation					
	Social environment - Number of affected houses	50% each Score of the lowest nos. = 5, with deductions depending on the affected nos.	5	2.0 = (0.2 + 3.8) x 50%	10.0	5.0 = (5.0 + 5.0) x 50%	25.0
	- Land price in ROW	Score of the lowest cost = 5, with deductions depending on the land price					
Harmonization	Harmonization with the surrounding environment	Score = 5 if there are no considerations Scores are based on considerations	3	5	15.0	4	12.0
Construction Requirement	Construction requirement - Impact due to construction work	50% each	3	3.8 = (2.5 + 5.0) x 50%	11.4	4.8 = (4.6 + 5.0) x 50%	14.4
	- Construction period						
Weighted score total				**96.0/130**		**111.2/130 (Selected)**	

Source: JICA Survey Team

4.3 Selection of Bridge Location (Step 2)

4.3.1 Route Selection

(1) Design Speed and Highway Class

The existing SJB is located on National Route 1 (N1), and the proposed SSJB will also be part of N1. Both bridges will form integral sections of this primary national route.

N1 is a key component of the Philippine Highway Network, running from Luzon to Mindanao. It is also known as the Pan-Philippine Highway and designated as Asian Highway 26 (AH26).

According to the Design Guidelines, Criteria & Standards, Volume 4: Highway Design, 2015, roads are classified into urban roads and rural roads, with rural roads further classified into the following three classes:

1) Local Rural Roads;
2) Rural Collector Roads;
3) Rural Arterial Roads.

N1 is classified as **a Rural Arterial Road.** The above-mentioned Design Guidelines, Criteria & Standards recommend the design speed of rural arterial roads as follows:

> Rural arterials other than expressways should be designed for speeds of 60 to 120 kph, depending on terrain, driver expectancy, and, in the case of reconstruction projects, the alignment of the existing facility.

Thus, the recommended design speed of N1 ranges from 60 km/h to 120 km/h. N1 is the only trunk road in and around the project area, especially on Samar Island side. On Leyte Island side, N1 at the entry point to the existing SJB is located in the suburbs of Tacloban City. On Samar Island side, N1 is fully utilized as the community road for the villages located adjacent to N1.

Taking into consideration the function of N1 as a community road and the traffic safety in the village areas, 80 km/h is proposed as the design speed of the project.

The Project for Masterplan on High Standard Highway Network Development (Phase 2), 2021 also applied the design speed of 80 km/h for the Pre-F/S of the SSJB.

(2) Geometric Design Standards of Highway

Table 4-12 shows the geometric design standards proposed for the project highway. The minimum curve radius is set at the desirable value of 400 m for a design speed of 80 km/h, as specified in the Road Structure Ordinance. Although part of the project area traverses hilly terrain, most of the alignment passes through flat land or over the sea, making it feasible to adopt relatively generous geometric conditions. The desirable minimum curve radius in the Road Structure Ordinance is intended for such topographic conditions and is therefore applied in consideration of the terrain and road classification of this project. While this plan applies R = 400 m throughout the entire project road, the adoption of a curve radius smaller than 400 m is acceptable as long as it does not fall below the standard minimum value.

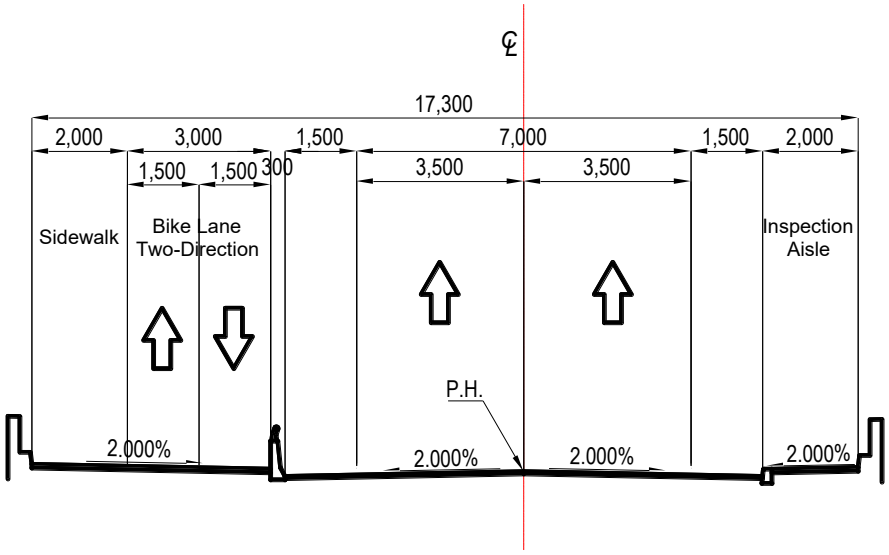
Table 4-12 Design Standards for the Project Highway

Design Item	Unit	HSH Master Plan		AASHTO	DGCS	Japan Road Structure Ordinance ( ): Exceptional		**Adopted**
		HSH Class-1	HSH Class-2	Inter-Urban	National Road	Specified Value	Recommended	**National Road**
		Inter Urban	Regional High Standard	Rural	Primary	Class 3 Type 1		**Primary**
Terrain	-	Flat	Flat	Level	Flat	Flat	-	**Flat**
Design Speed	km/h	80-120	60-80	80	80	80 (60)	-	**80**
Minimum Radius	m	-	-	229	220	280 (230)	400	**400**
Maximum Grade	%	-	-	6 (Level) 8 (Rolling) 10 (Mountainous)	4 (Level) 5 (Rolling) 7 (Mountainous)	4 (7)	-	4

Source: JICA Survey Team

(3) Standard Cross Section for the Bridge

The proposed standard cross section for the bridge is shown in Figure 4-20. Following Department Order No. 263, Series of 2022, Updated Guidelines and Standard Design Drawings for Bicycle Facilities along National Roads, bicycle lanes are included.



Source: JICA Survey Team

Figure 4-20 Proposed Standard Cross Section for the Bridge

(4) Location of Navigation Channel and Navigation Clearance

The exact location of the navigation channel and required navigation clearance have not yet been provided by the concerned agencies. Therefore, for the route selection purpose, the location of the navigation channel was referenced from the existing marine chart, and the required navigation clearance was obtained from construction records displayed on the monumental nameplate of the existing SJB at the site.

(5) Control Points to be Considered

In the project area (Area 4), mangroves are widely observed, and coral reefs are also found in some areas of the strait. It is strictly requested to eliminate or minimize the project impact over such natural environment to preserve the existing conditions. From a social environment perspective, in addition to the ordinary barangays, there are temporary houses for people affected by Typhoon Yolanda in 2013. The project route shall be carefully chosen to minimize any displacement of project-affected persons (PAPs).

A beach resort area has been developed on the Leyte Island side, and the proposed project alignment is also requested to avoid traversing this area.

Area 4 generally features gentle terrain; however, some areas show hilly topography. In order to establish the appropriate alternatives, it is intended to avoid large-scale structures while taking into consideration the abovementioned natural and social environments.

(6) Four Proposed Alternatives of Bridge Location

Considering the locations of various control points, four alternatives—C1, C2a, C2b and C3—were proposed in Area 4, which was selected in the previous Step 1 study.

Control Points

Symbol	Item	Avoidance Policy
	Village	Minimum impact
	Mangrove	Minimum impact
	Coral	Minimum impact
	Others	(Depends)
	Contour	Minimum structure
	Sea route	Vertical Clearance

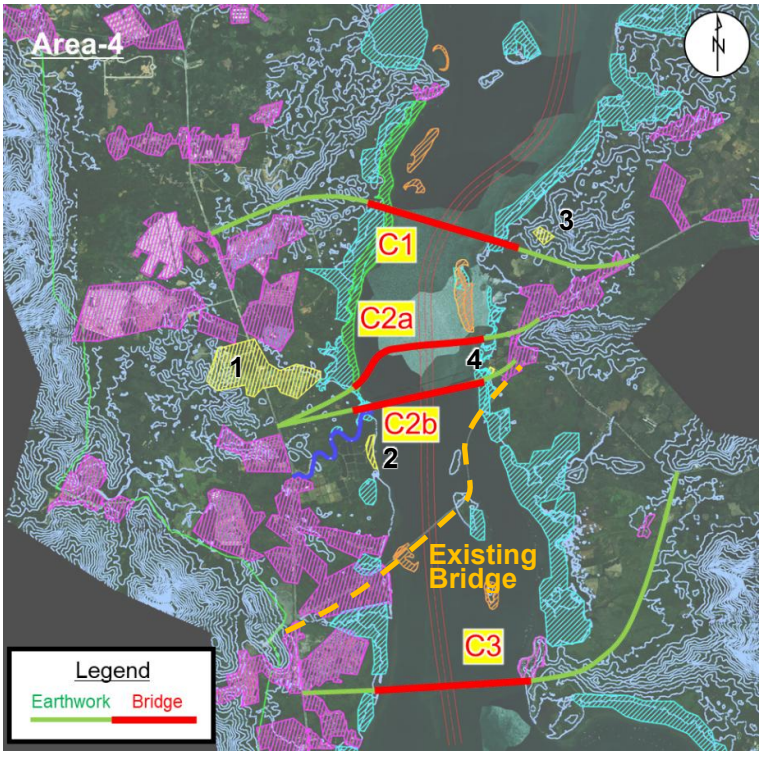
[Others]

1: Private Company's Area

2: Beach Resort

3: Resort Restaurant

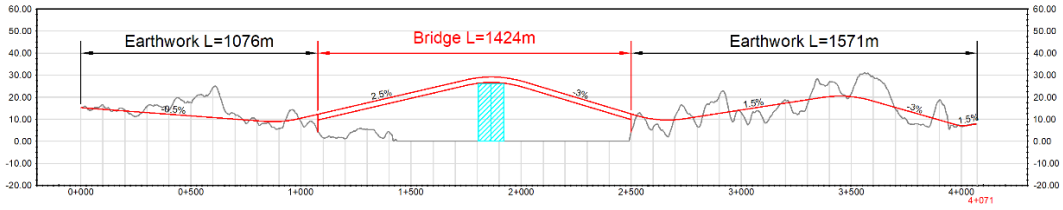
4: View Deck



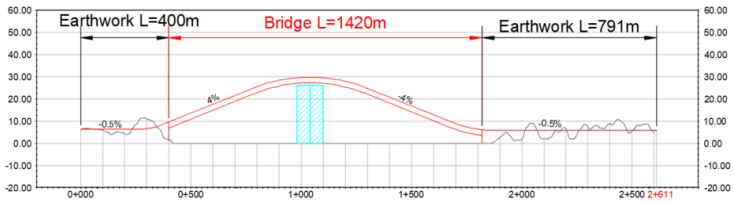
Source: JICA Survey Team

Figure 4-21 Proposed Alternatives for the Selection of Bridge Location

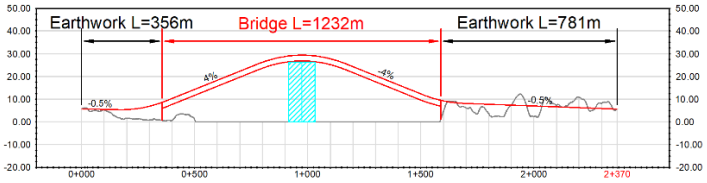
Proposed Vertical Alignment of Alternative C1



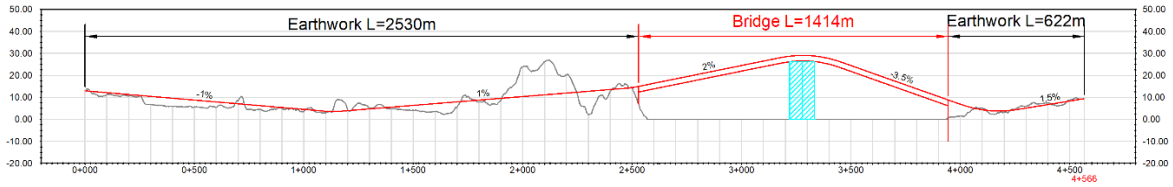
Proposed Vertical Alignment of Alternative C2a



Proposed Vertical Alignment of Alternative C2b



Proposed Vertical Alignment of Alternative C3



Source: JICA Survey Team

Figure 4-22 Proposed Vertical Alignment of Alternatives in Step 2

4.3.2 Evaluation Items in Step 2

As in Step 1, the evaluation method is based on a multi-criteria analysis of differences in travel distance between major ODs, construction costs, environmental and social considerations, and workability. For Step 2, horizontal/longitudinal alignment of each alternative route was added to the evaluation items. The weight is generally set to five, but workability is set to three because it has a temporary effect and a lesser impact on project implementation than other factors.

Regarding landscape considerations, these were evaluated in Step 1 during the selection of the bridge location area, based on the presence of surrounding structure requiring harmony. The selected area includes an existing SJB, which necessitates special consideration. Since the four alternatives compared in Step 2 is relatively close to the existing SJB, it is difficult to objectively and quantitatively differentiate them in terms of landscape. Furthermore, landscape evaluation will be conducted during the bridge type selection stage. Therefore, it was determined that landscape evaluation is not necessarily required in Step 2.

Table 4-13 Evaluation Items and Weight for Multi-Criteria Analysis in Step 2

Category	Evaluation Items in Multi-Criteria Analysis	Weight	Max Score	Weighted Score
Project Effect (Connectivity)	(1) Travel Time (Distance) (Focus on major OD in the project area, OD trip between Samar ⇔ Tacloban City account for 80% of total OD)	5	5	25
Safety and Driving Comfort	(2) Horizontal/ Vertical Alignment in terms of Minimum radius and maximum grade	5	5	25
Construction Cost	(3) Total Cost of Approach Road, Main Bridge, Approach Bridge, and Operation and Maintenance Facility/Equipment Costs	5	5	25
Environmental and Social Consideration	(4) Natural Environment - Affected area of mangrove (40%) - Affected area of seagrass and seaweeds (10%) - Affected area and size of corals (50%)	5	5	25
	(5) Social Environment (50% each) - Nos. of affected structure/population - Land price of area inside ROW	5	5	25
Risk of Natural Disaster	(6) Risk of Natural Disaster (1/3 each) - Risk of occurrence of the landslide - Risk of occurrence of the liquefaction - Risk of active fault } Risk on increase cost, extend construction period	5	5	25
Construction Requirement	(7) Construction Requirement(50% each) - Available land for construction yard, jetties, etc. - Construction period	3	5	15
Weighted Total Score				165

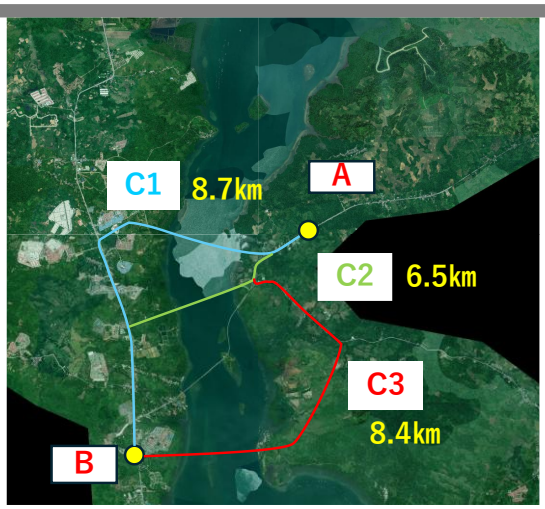
Source: JICA Survey Team

The following subsections show the evaluation results:

(1) Evaluation Item 1: Project Effect (Travel Time/Distance)

According to the Pre-F/S, the main OD in the project area is between the northern and central Samar Island and Tacloban City, as shown in Figure 4-3, accounting for about 80% of the total OD. Therefore, as in Step 1, the distance of the representative route for this section is evaluated.

The distances between points A and B, shown in Figure 4-23, are 8.7 km for C1, 6.5 km for C2a and C2b, and 8.4 km for C3. As for scoring, the option with the shortest distance is assigned the maximum of five points, while other options are scored using the formula: maximum points - [(distance of the option / the distance of the shortest option - 1) × maximum points]. As a result, C2a and C2b receive a score of 5.0, C1 receives 3.3, and C3 receives 3.5.



Source: JICA Survey Team

Figure 4-23 Difference of Route Length between Two Points (Step 2)

(2) Evaluation Item 2: Safety and Driving Comfort

Table 4-14 shows the minimum radius and maximum slope of each alternative route, as presented in Section 4.3.1 (6). The minimum radius is R = 400 m for C2a and C2b, with its maximum gradient of i = 4%.

Table 4-14 Linear Element Applied Values

Item	C1	C2a	C2b	C3
Minimum Radius	750 m	400 m	400 m	900 m
Maximum Gradient	3%	4%	4%	3.5%

Source: JICA Survey Team

The evaluation criteria are as shown in Table 4-15, based on the necessity of superelevation with respect to the applicable radius, from the viewpoint of driving comfort and smoothness.

Table 4-15 Evaluation Criteria for Horizontal Alignment

Minimum Radius	Conditions (according to the Road Structure Ordinance in Japan)	Point	Remark
3,500 m	Normal cross slope (2%) is applicable	5	Japan Road Structure Ordinance
400 m	Lower limit of the desired curve for comfort	4	Japan Road Structure Ordinance
280 m	Superelevation: 4%	3	DGCS
260 m	Superelevation: 6%	2	DGCS
220 m	Superelevation: 8%	1	DGCS

Source: JICA Survey Team

For vertical alignment, since the limit length for the applied gradient is related to the speed reduction of heavy vehicles, points are assigned based on the gradient, as shown in Table 4-16. The limit length mentioned as an evaluation criterion is based on the DGCS description. However, the Japan Road Structure Ordinance does not specify a limit length for a design speed of 80 km/h and a longitudinal gradient of 4%. The DGCS presents it as a guideline rather than a control value.

Therefore, it is not a strict requirement, but is adopted as an evaluation criterion for the longitudinal gradient.

Table 4-16 Evaluation Criteria for Vertical Alignment

Maximum Gradient	Conditions (according to the Road Structure Ordinance)	Point	Remark
2%	No limit length	3	DGCS
3%	Limit length: 500 m	2	DGCS
4%	Limit length: 340 m	1	DGCS

Source: JICA Survey Team

Table 4-17 shows the evaluation results, with a 50% weighting for both planar linear and longitudinal linear. Overall, C1 scored the highest at 3.7 points, while C2a, C2b, and C3 each scored 2.8 points.

Table 4-17 Evaluation Results of Driving Safety and Comfort

Item	C1			C2a			C2b			C3		
	Value	Point	Score	Value	Point	Score	Value	Point	Score	Value	Point	Score
Horizontal Alignment (50%)	750m	4/5	2.0/ 2.5	400m	4/5	2.0/ 2.5	400m	4/5	2.0/ 2.5	900m	4/5	2.0/ 2.5
Vertical Alignment (50%)	3%	2/3	1.7/ 2.5	4%	1/3	0.8/ 2.5	4%	1/3	0.8/ 2.5	3.5%	1/3	0.8/ 2.5
Total Score (max: 5.0)	-	-	3.7/ 5.0	-	-	2.8/ 5.0	-	-	2.8/ 5.0	-	-	2.8/ 5.0

Source: JICA Survey Team

(3) Evaluation Item 3: Construction Cost

Same as in Step 1, at this route selection stage, the bridge type has not yet been selected, and a cost estimate has not yet been conducted. Therefore, unit rates (main bridge, approach bridge, approach road) are set by referencing other projects, and the rough estimated cost for the four alternative routes in Area-4 was evaluated. In addition, the cost of O&M facilities and equipment—such as the management center, axle load measurement, and meteorological observation—is also considered.

The option with the lowest cost is C2b, due to its shorter road and bridge length. The costs of C1 and C3 are 113% and 112% of C2b, respectively, and that of C2a is 106% of C2b. The option with the lowest cost is assigned the maximum score of five points, while other options are scored as follows: maximum points - [(cost of the option / the cost of the lowest option - 1) × maximum points].

Table 4-18 Comparison of Estimated Cost Based on Pre-F/S Unit Rates (Step 2)

Item	Unit cost (Million PhP/km)	C1		C2a		C2b	
		Length (km)	Cost (Million PhP)	Length (km)	Cost (Million PhP)	Length (km)	Cost (Million PhP)
Approach Road: Embankment (fill)	236.82	1.076	254.8	0.675	159.9	0.717	169.8
Approach Road: Embankment (cut)	388.6	1.571	610.5	0.516	200.5	0.42	163.2
Main Bridge (steel arch, superstructure)	13,404.37	0.385	5,160.7	0.385	5,160.7	0.385	5,160.7
Main Bridge (steel arch, substructure	2,542.55	0.385	978.9	0.385	978.9	0.385	978.9
Approach Bridge (PC girders, superstructure, and substructure)	2,659.99	1.039	2,763.7	1.035	2,753.1	0.848	2,255.7
Roundabout	37	1 L.S	37	1 L.S	37	-	0
O&M Facilities and Equipment	-	1 L.S	1,005	1 L.S	904	1 L.S	879
Total Length (km)		**4.071 km**		**2.611km**		**2.370km**	
Total Cost (Million PhP)		**10,811**		**10,194**		**9,607**	
Cost Ratio (%)		**113%**		**106%**		**100%**	
Score		**4.4**		**4.7**		**5.0**	

Item	Unit cost (Million PhP/km)	C3		Reason of Difference
		Length (km)	Cost (Million PhP)	
Approach Road: Embankment (fill)	236.82	2.03	480.7	Approach road length (fill) of C2a is shortest
Approach Road: Embankment (cut)	388.6	1.122	436.0	Approach road length (cut) of C2b is shortest
Main Bridge (steel arch, superstructure)	13,404.37	0.385	5,160.7	No difference is assumed
Main Bridge (steel arch, substructure	2,542.55	0.385	978.9	No difference is assumed
Approach Bridge (PC Girders, superstructure, and substructure)	2,659.99	1.029	2,737.1	Approach bridge length of C2b is shortest
Roundabout	37	-	0	C1 and C2a need a roundabout on the Samar side.
O&M Facilities and Equipment	-	1 L.S	987	Difference due to length of optical fiber cable and electric line, and number of lighting fixtures (see Table 4-19)
Total Length (km)		**4.566 km**		
Total Cost (Million PhP)		**10,780**		
Cost Ratio (%)		**112%**		
Score		**4.4**		

Source: JICA Survey Team

Table 4-19 shows the breakdown of the estimated costs for O&M facilities and equipment. For network equipment, redundancy is proposed to ensure that communication continues even if part of the cable fails or is damaged. This involves connecting the two bridges in a loop configuration, including the road section between the SSJB and existing SJB in the length of the optical communication cable. Therefore, the cable length varies for each alternative. Additionally, differences in quantities arise due to road extension for main road lighting and power lines.

Furthermore, regarding O&M costs during operation, the differences in bridge locations are considered to have minimal impact on human and structural arrangements, resulting in negligible differences between alternatives. Thus, only the initial costs of O&M facilities and equipment were compared and evaluated. Additionally, the replacement period for communication cables was assumed to be approximately 1.5 times the depreciation period specified by the Japanese Ministry of Finance, indicating that replacement would not be necessary during the 30-year project evaluation period.

Table 4-19 Cost Breakdown of O&M Facilities and Equipment

Cost of Unit: million PhP

Item	Content	Unit	C1		C2a		C2b		C3	
			Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost
Management Center	Main office building, water tank and septic tank, power receiving and distribution equipment	m^2	900	476	900	476	900	476	900	476
Axle Load Control Office		m^2	200	65	200	65	200	65	200	65
CCTV	CCTV main unit, pole and monitor	set	9	35	9	35	9	35	9	35
Traffic Measuring Equipment	Vehicle detector, monitor	set	4	12	4	12	4	12	4	12
Optical Fiber Cable Network	Cables and conduits	km	12.5	181	7.9	127	6.7	113	11.5	169
Axle Load Cell	WIM, portable axle load cell, monitor	set	2	20	2	20	2	20	2	20
Information Display Equipment	Information board, pole, monitor, control panel	set	3	55	3	55	3	55	3	55
Lighting Equipment	Main line light fixtures, pole, control panel	set	16	26	10	19	10	19	18	28
	Pier flood light	set	6	8	6	8	6	8	6	8
	Navigation light	set	6	8	6	8	6	8	6	8
Electric Line Equipment	Electric line	km	12.5	111	7.9	70	6.7	59	11.5	102
Meteorological Observation Equipment	Wind direction and speed, rainfall meter	set	1	2	1	2	1	2	1	2
	Seismograph	set	2	3	2	3	2	3	2	3
	Weather monitor	set	1	2	1	2	1	2	1	2
Transportation Cost		L.S	1	3	1	3	1	3	1	3
Total				1,005		904		879		987

Source：JICA Survey Team

(4) Evaluation Item 4: Natural Environment

The project's impacts on mangroves, seagrass and seaweeds, and corals both adjacent to and within the ROW of the alternative alignments were assessed. The total score for each item was calculated using weights of 40% for mangroves, 10% for seaweed, and 50% for coral reefs, considering the difficulty of transplantation. The ROW was confirmed to be 27.0 meters through consultation with DPWH. Details are provided in Section 13.7 of the Environmental and Social Considerations Survey results.

Evaluation results for the impacts on mangroves, seagrass and seaweeds, and corals, as well as a summary of the impact assessments, are presented in Table 4-20 to Table 4-25.

1) Impact on Mangroves

The range of influence on mangroves is largest in C1, followed by C2b, while C2a and C3 have equivalent impacts. The maximum score is 5.0 when the influence area is 0 ha, and the score is proportionally reduced to 0 in case the influence area reaches 0.4 ha.

Table 4-20 Impact on Mangrove

Alternative	Mangrove Area (ha)			Score (1)
	Leyte Side	Samar Side	Total	
C1	0.103	0.213	0.315	1.1
C2a	0.179	0.000	0.179	2.8
C2b	0.051	0.173	0.224	2.2
C3	0.151	0.000	0.151	3.1

Source：JICA Survey Team

The evaluation was conducted based on the number of species and the diversity indicator derived from the simplified quadrat survey results. On the Samar side, C2a had 18 species, including four RET species, indicating a relatively high diversity indicator of 2.44, which shows a low number of individuals of specific tree species. Therefore, the score for both evaluation items was set to 2. In contrast, C1 and C3 had fewer species and a lower diversity indicator, indicating a high number of individuals of specific tree species. Thus, the score for both evaluation items was set to 5.

Table 4-21 Evaluation of Mangrove Diversity

Alternative	Variety			Diversity	
	No. of Species	RET	Score (2)	Diversity Indicator (H')	Score (3)
C1	5	0	5	Leyte: 1.39 Samar: 1.06	5
C2a	18	4	2	Leyte: 2.08 Samar: 2.44	2
C2b	6	0	5	Leyte: 1.91 Samar: 2.09	3
C3	4	0	5	Leyte: 1.21 Samar: 1.77	5

Source：JICA Survey Team

The following table shows the evaluation results of the impact on mangroves. C3 is the route with the lowest impact.

Table 4-22 Evaluation of Impact on Mangroves

Alternative	Affected Area (1)	Variety (2)	Diversity (3)	Score {(1)+(2)+(3)}/ 3
C1	1.1	5	5	3.7
C2a	2.8	2	2	2.3
C2b	2.2	5	3	3.4
C3	3.1	5	5	4.4

Source：JICA Survey Team

2) Impact on Seaweeds

The table below shows the distribution area of seagrass beds within the ROW (27 m) of the four routes. The impact is evaluated based on the inhabit area. The impact range is largest in the order of C2a, C3, and C1, and no impact is observed for C2b. The maximum score is 5.0 when the influence area is 0 ha, and the score is proportionally reduced to 0 if the influence area reaches 0.4 ha.

Table 4-23 Impact on Seagrass and Seaweeds

Alternative	Area (ha)			Score
	Leyte Side	Samar Side	Total	
C1	0.137	0.000	0.137	3.3
C2a	0.182	0.000	0.182	2.7
C2b	0.000	0.000	0.000	5.0
C3	0.170	0.000	0.170	2.9

Source：JICA Survey Team

3) Impact on Coral Reefs

The evaluation of coral reefs was based on the results of on-site surveys conducted by subcontractors, considering quality (size and condition), type (number of common and rare species), and density (coverage %).

In C1, juvenile corals were observed in the shallow area (<1 m) outside the Mantato survey site on the Leyte side. Across the entire C1 route, five common species and one rare species were identified, with coverage of less than 10%, classifying it as extremely poor.

In C2a, nine common species and two rare species were identified. On the Samar side, more corals were observed compared to the other routes. Based on the evaluation criteria for coral reef condition by coverage, these corals can be classified as 'extremely poor (0% to less than 10%)' or 'poor (10% to less than 25%)'.

In C2b, small colonies of reef-building corals were sparsely observed at quadrat points on the Samar side. Eleven common species and three rare species were identified, with coverage of less than 10%, classifying it as extremely poor, similar to C1.

In C3, multiple species of reef-building corals in encrusting, branching, and massive forms were sparsely observed along the Mantato survey site on the Leyte side. Eight common species and one rare species were identified, with coverage of less than 10%, classifying it as extremely poor.

Table 4-24 Impact on Corals

Alternative	Quality		No. of Species			Density		Score
	Size, Condition	Score (1)	Normal	RET	Score (2)	Coverage (%)	Score (3)	{(1)+(2)+(3)}/ 3
C1	Juvenile corals were observed in the shallow areas (<1 m) outside of the manta tow points at Leyte side	4	5	1	4	Less than 10% Extremely poor	5	4.3
C2a	Small colonies of hard corals sparingly observed at the photo-quadrat survey points at Samar side	2	9	2	3	17.8% along the coast, 10.8% in average, poor	4	3.0
C2b	Small colonies of hard corals sparingly observed at the photo-quadrat survey points at Samar side	3	11	3	2	Less than 10% Extremely poor	5	3.3
C3	Small colonies of hard corals were sparingly observed along the manta tow points at Leyte side. Sparse colonies of encrusting, branching, and massive hard coral life forms of various species were sparingly observed along the manta tow points at Samar side	2	8	1	3	Less than 10% Extremely poor	5	3.3

Source：JICA Survey Team

From the above comparison, C2 has a smaller impact on the natural environment than other alternatives.

Table 4-25 Scoring Summary of Natural Environment Impacts

Alternative	Score	Remarks
C1	4.0	3.7 x 0.4 +3.3 x 0.1 +4.3 x 0.5
C2a	2.7	2.3 x 0.4+2.7 x 0.1+3.0 x 0.5
C2b	3.5	3.4 x 0.4+5.0 x 0.1+3.3 x 0.5
C3	3.7	4.4 x 0.4+2.9 x 0.1+3.3 x 0.5

Source：JICA Survey Team

(5) Evaluation Item 5: Social Environment

1) Number of Project-affected Structure and People

Based on the satellite image study and site reconnaissance, the number of project-affected structures within the assumed ROW of 27 m width was counted. All structures were regarded to be houses. From this information, the number of project-affected people was estimated following the 2022 Philippine Statistical Yearbook (PSA), which introduced the average household size of 4.0 for Leyte and 4.4 for Western Samar.

Among alternatives, C3 affects the largest number of people (78 people), followed by C1 (50 people), C2a (39 people), and C2b (34 people), which has the smallest impact.

Table 4-26 Number of Project-affected Structure and People

Alternative Route	No. of Affected Structure	No. of Affected People
C1	12 (Leyte: 6, Samar: 6)	50 persons Leyte: 6 structures x 4.0 persons/structure Samar: 6 structure x 4.4 persons/structure
C2a	9 (Leyte: 2, Samar: 7)	39 persons Leyte: 2 structures x 4.0 persons/structure Samar: 7 structure x 4.4 persons/structure
C2b	8 (Leyte: 2, Samar: 6)	34 persons Leyte: 2 structures x 4.0 persons/structure Samar: 6 structure x 4.4 persons/structure
C3	18 (Leyte: 2, Samar: 16)	78 persons Leyte: 2 structures x 4.0 persons/structure Samar: 16 structure x 4.4 persons/structure

Source：JICA Survey Team

The option with the lowest number of affected people is assigned the maximum of five points. Other options are scored as: maximum points - [(number of the option / the number of the lowest option - 1) × maximum points]. Scoring results are presented in Table 4-27.

Table 4-27 Scoring Results on Project-affected Structure and People

Alternative Route	Score
C1	2.6
C2a	4.3
C2b	5.0
C3	0.0

Source：JICA Survey Team

2) Land Price within ROW

As in Step 1, the difficulty of land acquisition is used as an index, and the land price within the ROW (27 m) is estimated based on published land prices and compared relatively. Unit rates for the Leyte side as of 2024 are used. Since only unit rates for the Samar side as of 2010 are available, they are adjusted using the CPI to reflect 2024 prices.

Table 4-28 shows the calculation results. C2a has the lowest price, while the prices of C1, C2b, and C3 are 296%, 106%, and 189% of C2a's price, respectively.

Table 4-28 Comparison of Land Prices within the ROW

Area Classification		Unit Rate*1/ (PhP/m²) (a)	C1		C2a		C2b		C3	
			Area (m²) (b)	Price (x1000 PhP) (c)=(a)x(b)	Area (m²) (d)	Price (x1000 PhP) (e)=(a)x(d)	Area (m²) (f)	Price (x1000 PhP) (g)=(a)x(f)	Area (m²) (h)	Price (x1000 PhP) (i)=(a)x(h)
Leyte (Tacloban)	Residential Area	4000	2,630	10,520	140	560	140	560	2,400	9,600
	Cultivate Area*2/	350	42,800	14,980	22,500	7,525	22,100	7,735	14,600	5,110
Samar (San Juan)	Residential Area	416	910	378.6	1,900	790.4	1,700	707.2	2,220	923.5
	Cultivate Area*2/	20	37,700	754	6,500	130	28,000	560	67,300	1,346
Total Area/Cost (Cost Ratio)			84,040 m²	26,632.6 (296%)	51,940 m²	9,005.4 (100%)	51,940 m²	9,562.2 (106%)	86,520 m²	16,979.5 (189%)
Score			0.0		5.0		4.7		0.6	

Remarks: *1/Unit price source: https://www.bir.gov.ph/index.php/zonal-values.html

*2/ Unit rate of Cultivate Area is average of Riceland Irrigated, Coco Land, Banana Land and Vegetable Land.

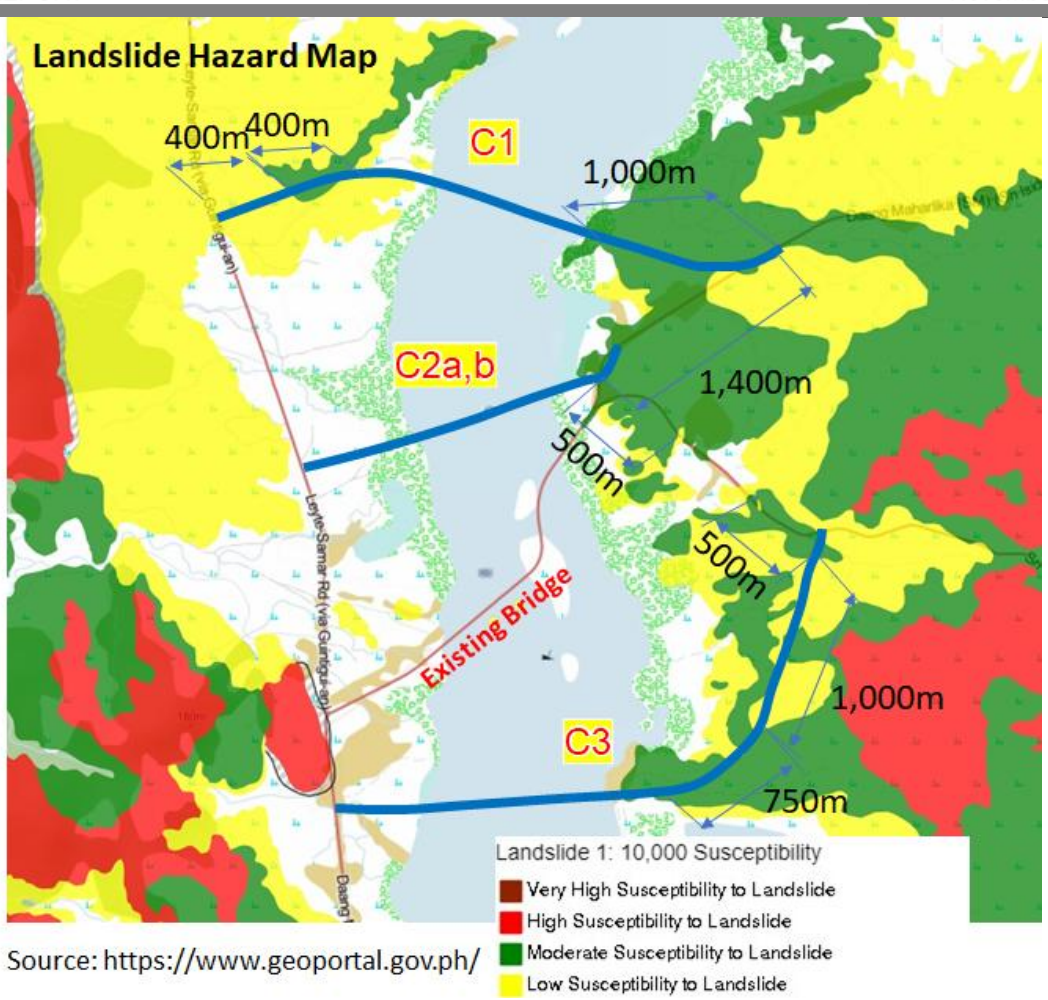
Source：JICA Survey Team

(6) Evaluation Item 6: Risk of Natural Disaster

The risk of increasing construction costs, extended construction periods during the design and construction stages, and potential impacts on the socio-economic conditions and livelihoods of local residents during operation is comparatively evaluated based on landslides, liquefaction hazard maps, and active fault distribution maps. Regarding geology, it was judged that there are no significant differences within Area 4; therefore, geology was not included in the evaluation under Step 2.

1) Risk of Landslide

In the landslide hazard map shown in Figure 4-24, published by PHIVOLCS, a comparative evaluation of the alternatives is conducted based on an indicator calculated as the product of the likelihood of occurrence and the passing length through the area.



Source: JICA Survey Team added to Geoportal's base map

Figure 4-24 Risk Assessment on Landslide Hazard Map

The option with the lowest value of "Possibility x Passing Length (m)" is assigned the maximum of five points, and other options are scored as: maximum points - [(the value of the option / the value of the lowest option - 1) × maximum points], with a minimum score of 0.

The results showed that none of the routes passed through areas with a high probability of occurrence. C3 has the highest likelihood, while other routes (C1, C2a, and C2b) have equivalent lower likelihood.

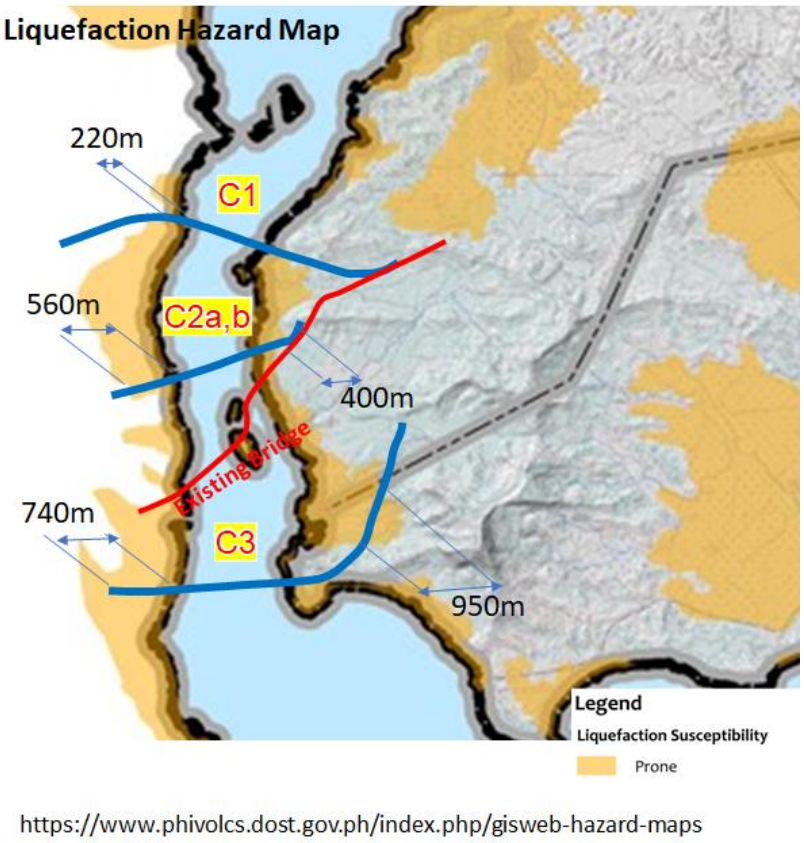
Table 4-29 Evaluation Results on Risk of Landslide Occurrence

Alternative Route	Possibility x Passing Length (m)					Score
	Very high x 2.0	High x 1.5	Moderate x 1.0	Low x 0.5	Total	
C1	0	0	1,400	200	1,600	**4.3**
C2a	0	0	1,400	0	1,400	**5.0**
C2b	0	0	1,400	0	1,400	**5.0**
C3	0	0	3,150	500	3,650	**0.0**

Source: JICA Survey Team

2) Risk of Liquefaction

Since the liquefaction hazard map does not classify possibility of occurrence, the comparison is made by extending the road passing through the risky area.



Source: JICA Survey Team added to Geoportal's base map

Figure 4-25 Risk Assessment on Liquefaction Hazard Map

The option with the lowest passing length (m) is scored the maximum of five points. Other options are scored as: maximum points - [(the length of the option / the length of the lowest option - 1) × maximum points], with a minimum score of 0.

The results indicate that C1 has the lowest likelihood.

Table 4-30 Evaluation Results on Liquefaction Risk

Alternative	Total Passing length (m)	Score
C1	220 m	5.0
C2a	960 m	0.0
C2b	960 m	0.0
C3	1,690 m	0.0

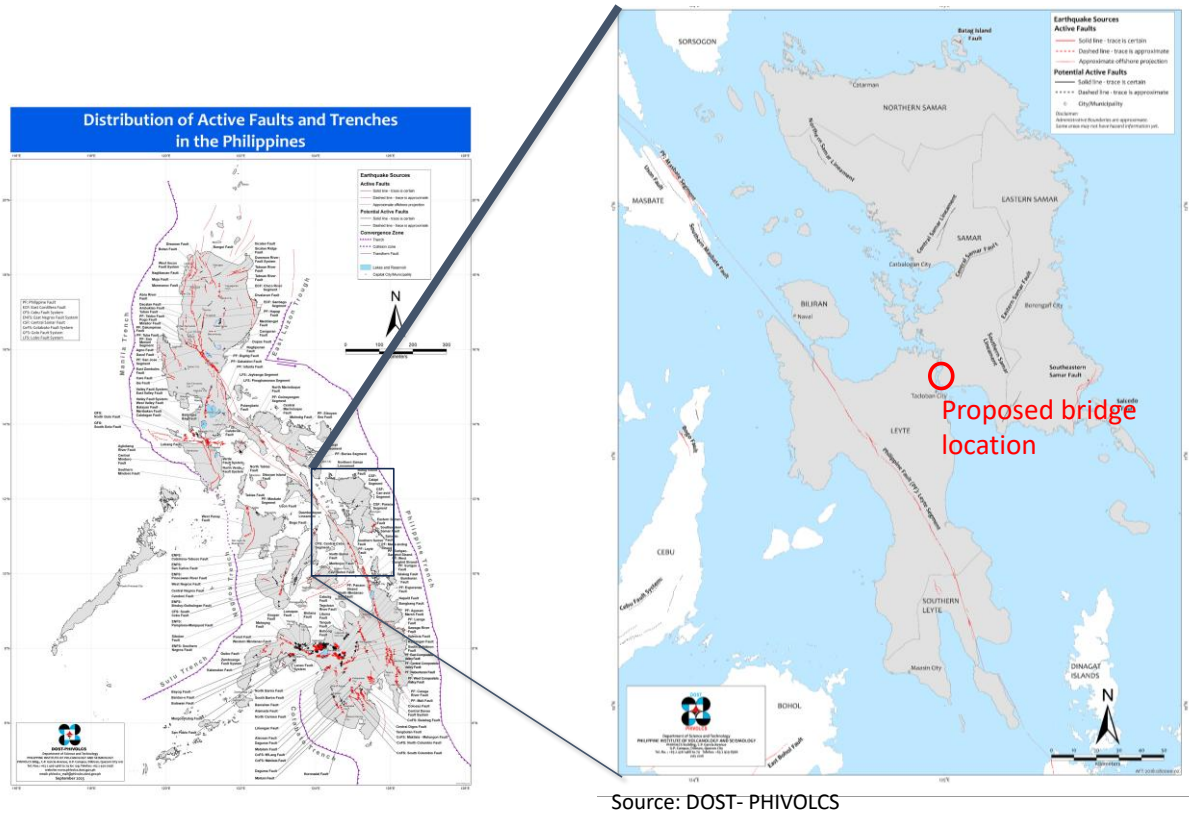
Source: JICA Survey Team

3) Risk of Active Fault

According to the active fault map (September 2023) prepared and published by PHIVOLCS, it is unlikely that active faults have developed at least around the San Juanico Strait and the candidate bridge sites on Leyte Island and Samar Islands.

Professor Nakata of Hiroshima University, together with a joint research team from PHIVOLCS, created a topographic image viewable stereoscopically based on a numerical topographic model (DTM: Digital Terrain Model) of a 5-meter grid using coherence synthetic aperture radar, as described in Seismic Potential from the Viewpoint of the Active Fault Distribution in the Philippines (2017). The report states that "In Leyte Island, volcanic zones are traversed by active faults in the Philippine fault system", and this distribution aligns with the latest active fault map (September 2023). In addition, in his research from 2015 to 2017, Research on Comprehensive Understanding of Earthquake-Related Terrain in the Philippines and Improvement of Earthquake Occurrence Prediction Accuracy, it was concluded that "In Samar Island ... only a few linear structures (linear patterns that appear when active faults occur) have been certified, but active faults could not be certified even by this reading work", which is also consistent with the latest active fault map.

Based on the above, it is assumed that there are no active faults at the candidate bridge sites for cross-linking, and the evaluation is five for all alternative routes.



Source: DOST- PHIVOLCS

Source: Philippine Institute of Volcanic and Seismic Research PHIVOLCS, September 2023

Figure 4-26 Active Fault Distribution Map

(7) Evaluation Item 7: Available Land for Construction Yard, Jetties, etc.

1) Impact due to Construction Work

During route selection in Step 2, appropriate areas of construction yard on both the Leyte and Samar islands are considered to minimize environmental impact and terrain alteration. The most suitable main construction yard is then selected.

【C1】The construction yard candidate of C1 is shown in Figure 4-27. On the Samar side, mangroves are affected, making it difficult to avoid environmental impact. Therefore, the Leyte side is selected as the main construction yard.

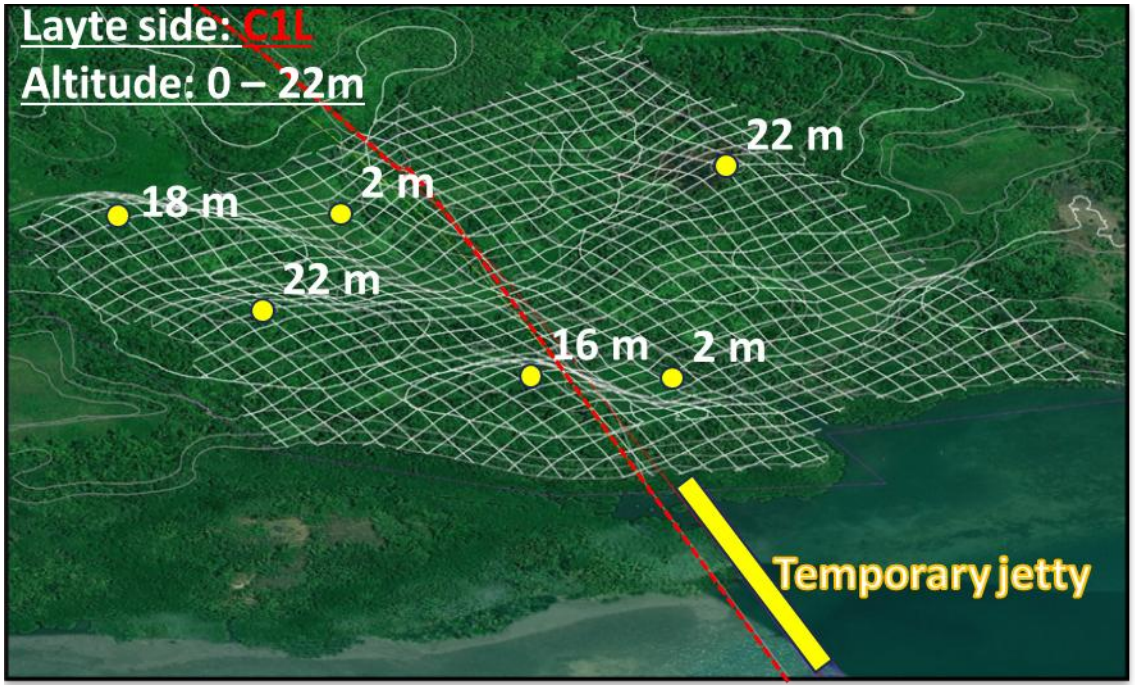
Both sides require the construction of new access roads to the yards. From the viewpoint of site access, this is one of the negative points among the routes.



Source：JICA Survey Team

Figure 4-27 Expected Area of Construction Yard and Jetty for C1

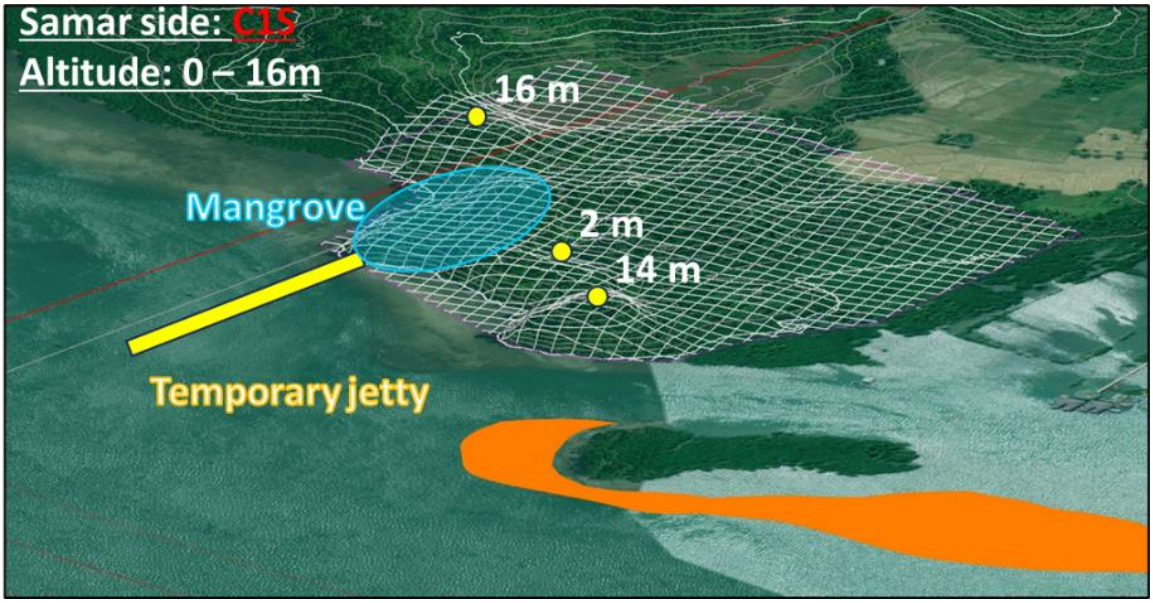
The altitude range of the construction yard on the Leyte side is 0-22 m, evaluated as the largest terrain change among all candidates in Step 2. The expected length of the temporary jetty is about 280 m, which is the longest length compared with the other alternatives.



Source：JICA Survey Team

Figure 4-28 Terrain and Surroundings of Main Construction Yard (Leyte) for C1

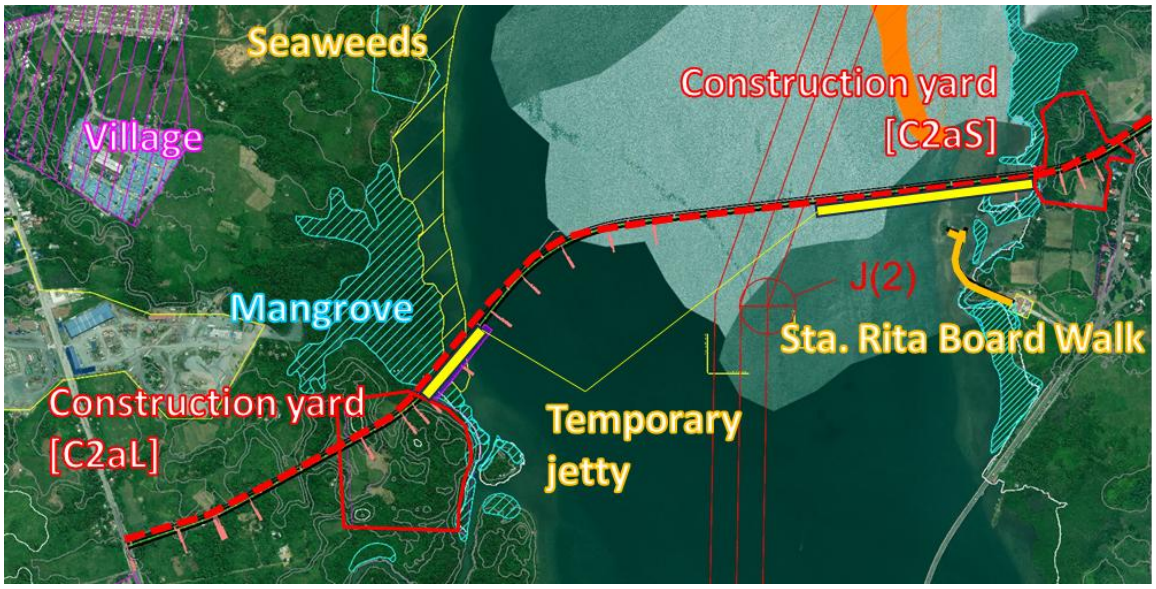
The altitude range of the construction yard on the Samar side is 0-16 m. The expected length of the temporary jetty is approximately 160 m, which is longer compared with the other alternatives. In the expected area of construction yard, mangroves are distributed closer to the route, making it difficult to avoid affecting the mangrove.



Source：JICA Survey Team

Figure 4-29 Terrain and Surroundings of Construction Yard (Samar) for C1

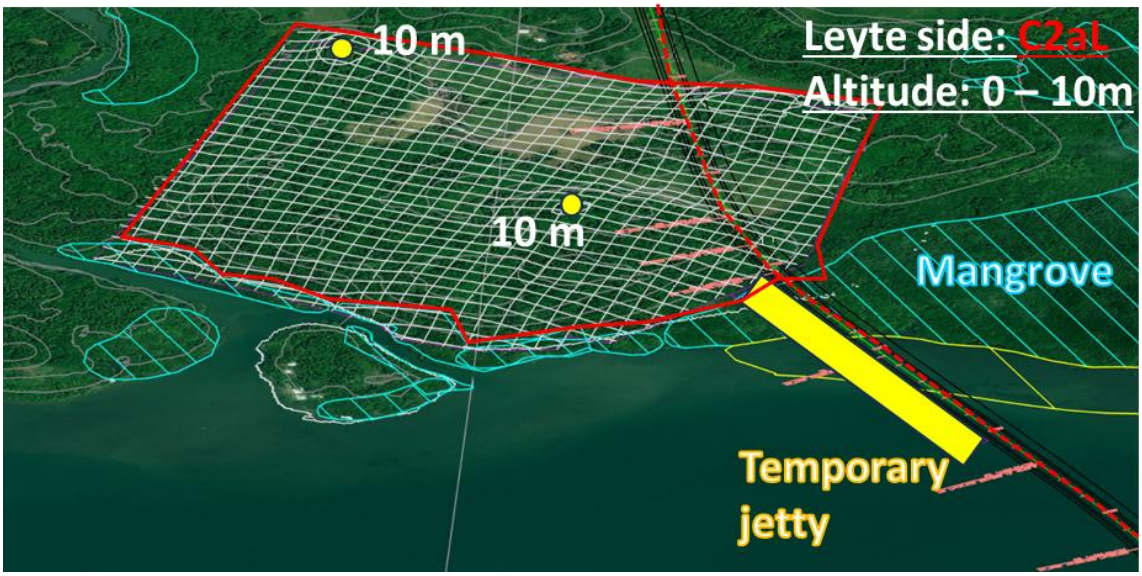
【C2a】The construction yard candidate of C2a is shown in Figure 4-33. On the Leyte side, a temporary jetty must be constructed over mangroves. On the Samar side, a temporary jetty with 480 m length is required to maintain five-fathom water depth. Both sides are suitable as main construction yards due to their relatively flat terrain. On the Leyte side, a new pilot access road within the ROW must be constructed, whereas the Samar side is adjacent to the existing trunk road. Thus, both sides allow relatively easy access to the construction yards.



Source：JICA Survey Team

Figure 4-30 Expected Area of Construction Yard and Jetty for C2a

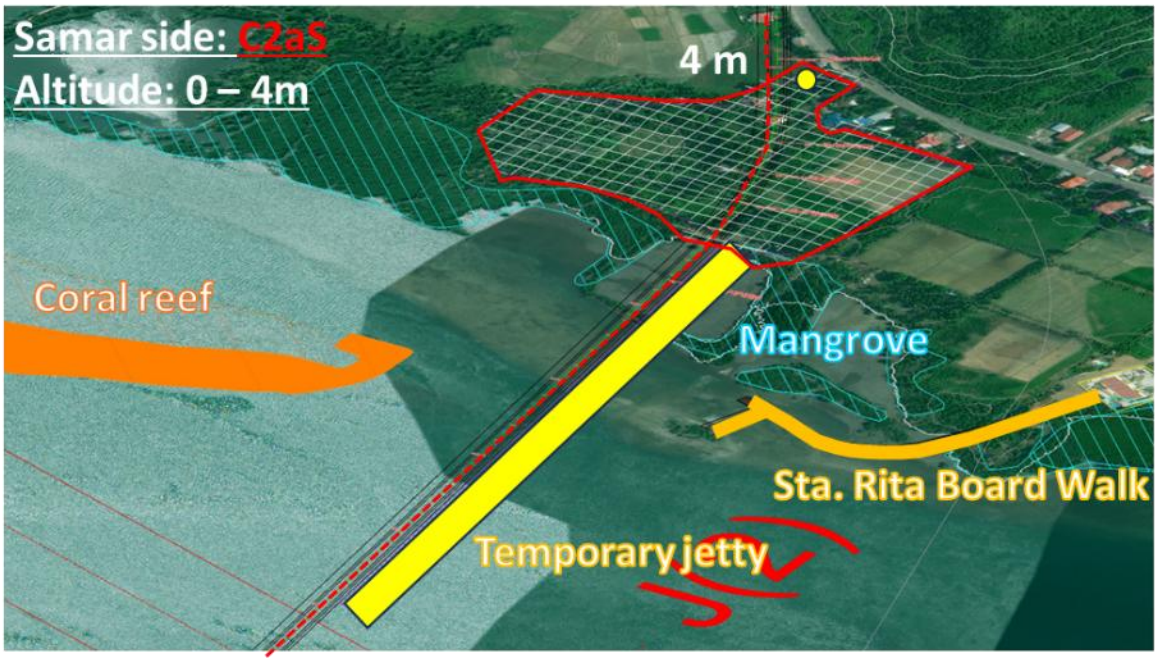
The altitude range of the construction yard on the Leyte side is 0-10 m. The expected length of the temporary jetty is approximately 130 m, which is evaluated as an average length compared with the others. The temporary jetty will inevitably impact the mangroves.



Source：JICA Survey Team

Figure 4-31 Terrain and Surroundings of Main Construction Yard (Leyte) for C2a

The altitude range of the construction yard on the Samar side is 0-4 m, making it the flattest area among the candidates. The expected length of the temporary jetty is about 480 m, which is evaluated as longest compared with the others.

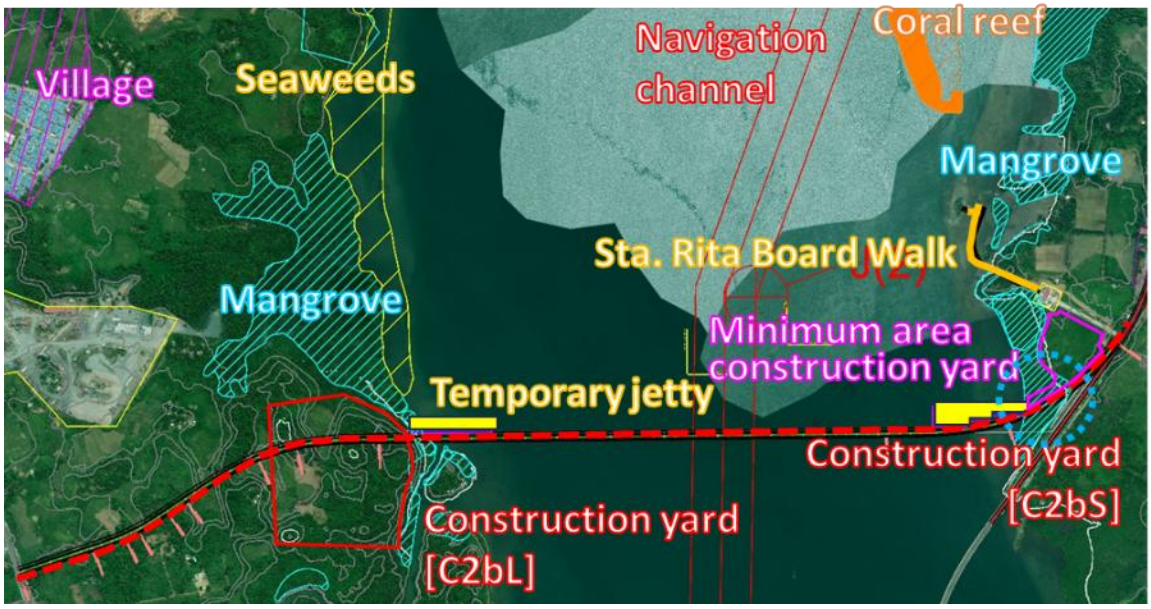


Source：JICA Survey Team

Figure 4-32 Terrain and Surroundings of Main Construction Yard (Samar) for C2a

【C2b】The construction yard candidate of C2b is shown in Figure 4-33. Both sides are restricted by mangroves, especially on the Samar side, where reclamation is required due to the extensive distribution along the coastal line. Therefore, the Leyte side is selected as the main construction yard.

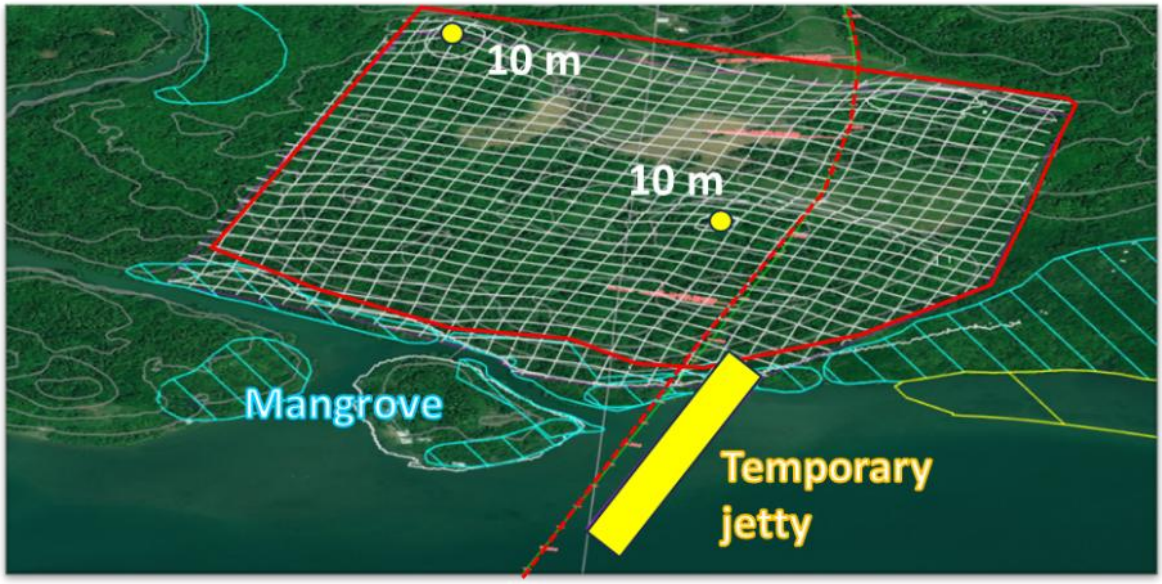
Both sides are relatively flat and suitable for construction yard development. On the Leyte side, a new pilot access road within the ROW must be constructed, whereas Samar side is adjacent to the existing trunk road. Thus, both sides allow relatively easy access to the construction yards.



Source：JICA Survey Team

Figure 4-33 Expected Area of Construction Yard and Jetty for C2b

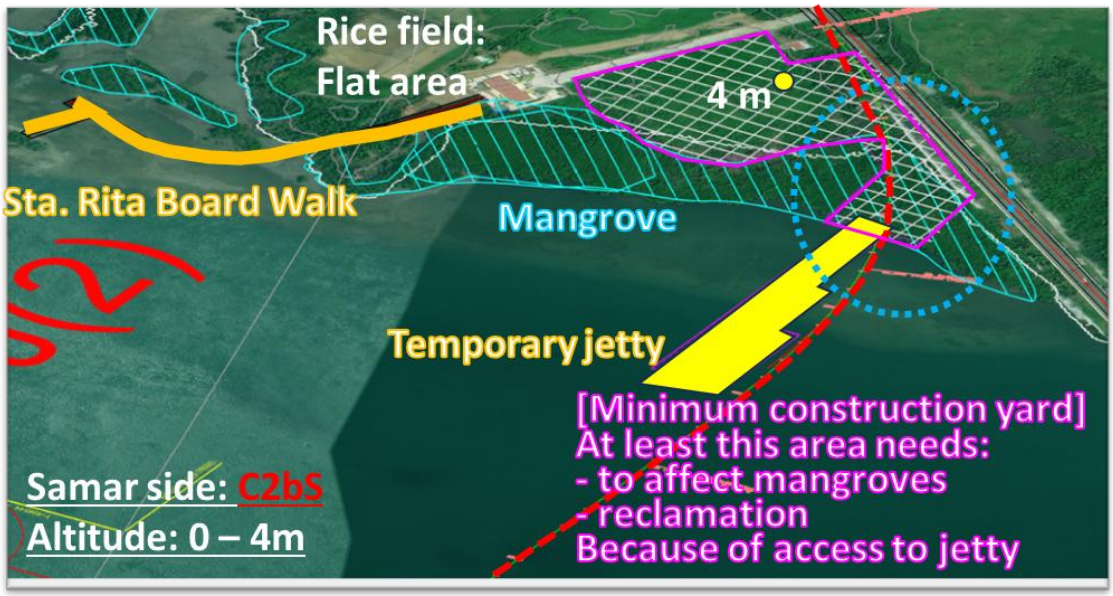
The altitude range of the construction yard on the Leyte side is 0-10 m. The expected length of the temporary jetty is about 130 m, which is evaluated as an average length compared with the other alternatives. The temporary jetty will inevitably impact the mangroves.



Source：JICA Survey Team

Figure 4-34 Terrain and Surroundings of Main Construction Yard (Leyte) for C2b

The altitude range of the construction yard on the Samar side is 0-4 m, making it the flattest area among candidates. The expected length of the temporary jetty is about 150 m, which is considered as an average length compared with the others. The temporary jetty will inevitably impact the mangroves. Due to the restricted area caused by mangroves and the existing road, the Samar side is considered as a sub-construction yard to support the Leyte side.



Source：JICA Survey Team

Figure 4-35 Terrain and Surroundings of Main Construction Yard (Samar) for C2b

【C3】The construction yard candidate of C3 is shown in Figure 4-36. The Samar side is restricted by a village located on the northern side of the route. In addition, there is only one existing access road to the village. Therefore, it is difficult to separate the living area from the construction area without affecting the residents. The safety of local residents is a major concern.

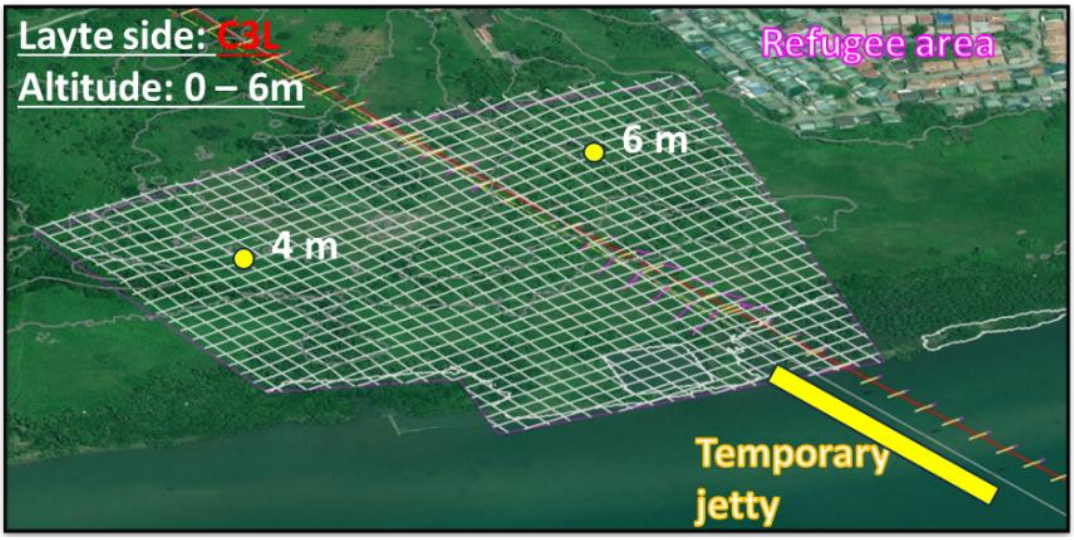
On the Leyte side, a refugee area is located near the expected area of the construction yard, raising concerns about vibration and noise. In conclusion, despite these concerns, Leyte side is selected as the main construction yard.



Source：JICA Survey Team

Figure 4-36 Expected Area of Construction Yard and Jetty for C3

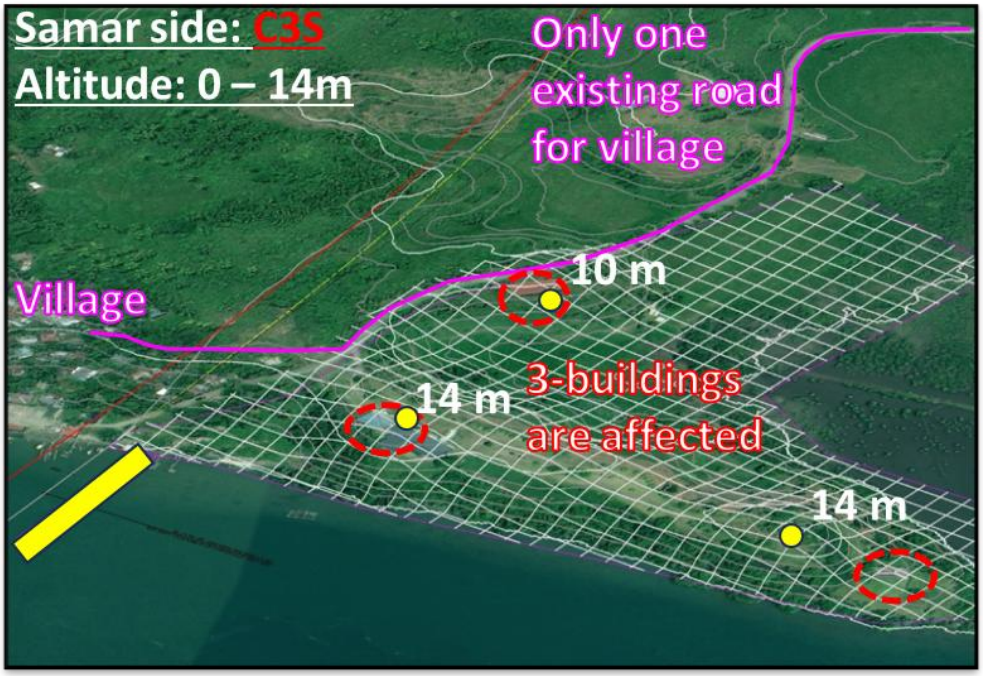
The altitude range of the construction yard on the Leyte side is 0-6 m. The expected length of the temporary jetty is about 150 m, which is relatively longer compared with the others.



Source：JICA Survey Team

Figure 4-37 Terrain and Surroundings of Main Construction Yard (Leyte) for C3

The altitude range of the construction yard on the Samar side is 0-14 m. The expected length of the temporary jetty is approximately 80 m, which is shorter compared with the other alternatives. Within the expected area of the construction yard, three buildings are observed and scattered, making it difficult to secure appropriate space without affecting them. In addition, only one existing road provides access to the village at the end of the route, making it challenging to separate the living area from the construction area without causing disruption.



Source：JICA Survey Team

Figure 4-38 Terrain and Surroundings of Main Construction Yard (Samar) for C3

The evaluation results, based on selection of construction yards for each route described above, are summarized in Table 4-31. In each item, C2 is evaluated as having the minimum impact from construction activities.

Table 4-31 **Evaluation of Impacts due to Construction Yard Selection under Step 2**

Item	C1	C2a	C2b	C3
Environment impact	**[Bad] 1/3** Can not avoid affecting to mangroves	**[Bad] 1/3** Can not avoid affecting to mangroves	**[Bad] 1/3** Can not avoid affecting to mangroves	**[Good] 3/3** Not affected
Social impact	**[Good] 3/3** Smaller impact of PAP	**[Good] 3/3** Smaller impact of PAP	**[Good] 3/3** Smaller impact of PAP	**[Bad] 1/3** - Close to refugee area - Affect to 3-buildings on the area
Terrain	**[Bad] 1/3** Large terrain change is necessary (Altitude: 0-22m)	**[Good] 3/3** Small terrain change (Altitude: 0-10m)	**[Good] 3/3** Small terrain change (Altitude: 0-10m)	**[Fair] 2/3** Small terrain change (Altitude: 0-14m)
Safety for surrounding	**[Good] 3/3** No big impact	**[Good] 3/3** No big impact	**[Good] 3/3** No big impact	**[Bad] 1/3** Interfering existing road.
Obstacle	**[Good] 3/3** No obstacles	**[Good] 3/3** No obstacles	**[Good] 3/3** No obstacles	**[Bad] 1/3** 3 buildings on the area

Item	C1	C2a	C2b	C3
Length of temporary jetty	**[Fair] 2/3** About 440m in total (=280+160)	**[Bad] 1/3** About 770m in total (=190+480)	**[Good] 3/3** About 280m in total (=130+150)	**[Good] 3/3** About 230m in total (=150+80)
Navigation control	**[Good] 3/3** No problem	**[Good] 3/3** No problem	**[Good] 3/3** No problem	**[Good] 3/3** No problem
Evaluation	Points **16** out of total 21 (= **3.8 / max 5 score)**	Points **17** out of total 21 (= **4.0 / max 5 score)**	Points **19** out of total 21 (= **4.5 / max 5 score)**	Points **14** out of total 21 (= **3.3 / max 5 score)**

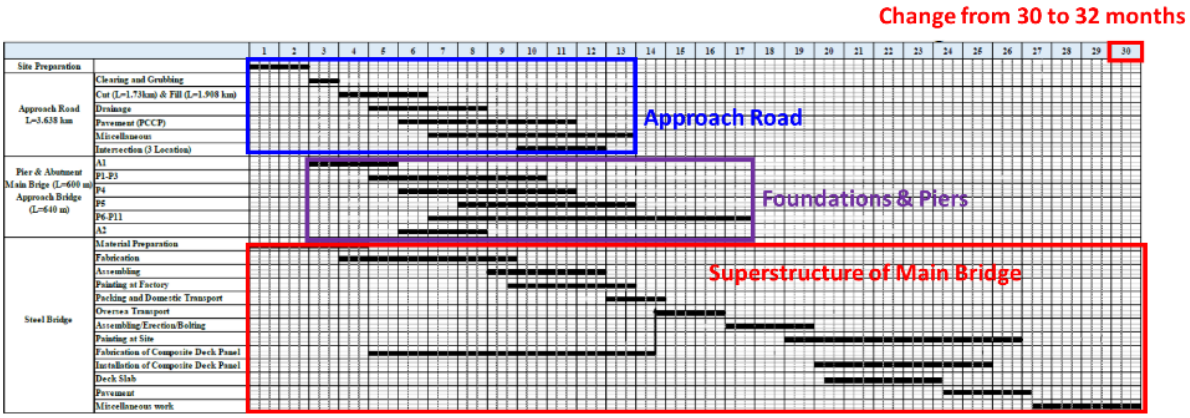
Source：JICA Survey Team

2) Construction Schedule

As in Step 1, a total construction duration of 32 months is proposed, instead of 30 months, based on the review of the construction schedule in the Pre-F/S.

There is no significant difference in the scope of work among the four alternatives, with reference to the quantities and content of critical work for the main bridge. Therefore, the evaluation of construction period results in a score of 5.0 for all options.

Table 4-32 Evaluation of Impacts due to Construction Schedule under Step 2



Source: Added on Construction Schedule prepared in Pre-FS by JICA Survey Team

(8) Evaluation Summary of Alternatives

Table 4-33 shows the evaluation summary of the alternatives. C2a and C2b demonstrate high project effectiveness (benefits) due to connecting the main OD over the shortest distance, and its construction costs are also low. However, the vertical alignment of C2a and C2b is inferior to C1 because the distance to the navigation height is shorter. In terms of environmental and social considerations, C2b is superior. Regarding landslide and liquefaction risks, C1 is advantageous, as it passes through the shortest distance within hazard areas. There is no significant difference in constructability among the alternatives. As a result, C2b scored 136.9 out of a full score of 165.0,

exceeding C1's score of 120.6, C2a's score of 129.5, and C3's score of 94.4. Based on this evaluation, C2b was selected as the most appropriate alternative for the construction of the SSJB.

Table 4-33 Evaluation Summary of Alternatives

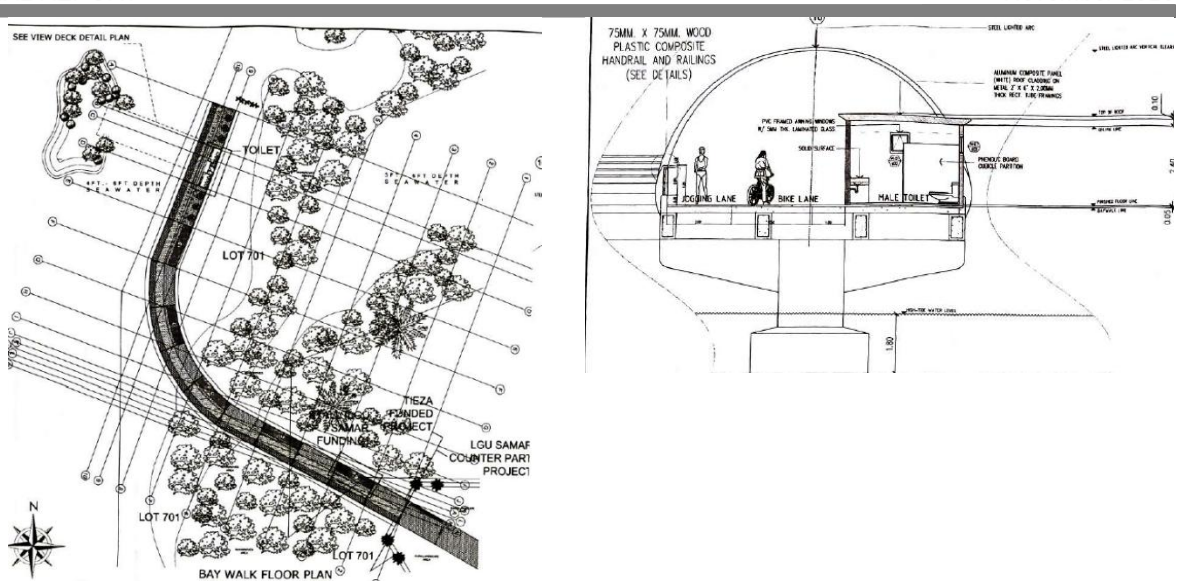
Category	Evaluation Item	Weight	C1		C2a		C2b		C3	
			Score	W. Score	Score	W. Score	Score	W. Score	Score	W. Score
Project Effect (Connectivity)	(1) Travel Time (Distance)	5	3.3	16.5	5.0	25.0	5.0	25.0	3.5	17.5
Safety and Comfortability of Driving	(2) Horizontal/ Vertical Alignment	5	3.7	18.5	2.8	14.0	2.8	14.0	2.8	14.0
Construction Cost	(3) Total Cost of Approach Road, Main Bridge, Approach Bridge, O&M Facilities and Equipment	5	4.4	22.0	4.7	23.5	5.0	25.0	4.4	22.0
Environmental and Social Consideration	(4) Natural Environment - Affected area of mangroves - Affected area of seagrass and seaweeds - Affected area, quality, and size of corals	5	4.0	20.0	2.7	13.5	3.5	17.5	3.7	18.5
	(5) Social Environment - No. of affected structure and people - Land price of area inside ROW	5	1.3 = (2.6+ 0) x 50%	6.5	4.65 = (4.3+ 5.0) x 50%	23.3	4.85 = (5.0+ 4.7) x 50%	24.3	0.3 = (0.0+ 0.6) x 50%	1.5
Risk of Natural Disaster	(6) Risk of Natural Disaster - Risk of landslide occurrence - Risk of liquefaction occurrence - Risk of active fault	5	4.77 = (4.3+ 5.0 +5.0) x 1/3	23.9	3.33 = (5.0+ 0+ 5.0) x 1/3	16.7	3.33 = (5.0+ 0+ 5.0) x 1/3	16.7	1.67 = (0+ 0+ 5.0) x 1/3	8.4
Construction Requirement	(7) Construction Requirement -Available land for construction yard, jetties, etc. -Construction period	3	4.4 = (3.8+5.0) x 50%	13.2	4.5 = (4.0+5.0) x 50%	13.5	4.75 = (4.5+5.0) x 50%	14.3	4.15 = (3.3+5.0) x 50%	12.5
Total Weighted Score			**120.6**/165		**129.5**/165 (2nd rank)		**136.9**/165 **(1st rank)**		**94.4**/165	

Note: W. Score: Weighted Score

Source：JICA Survey Team

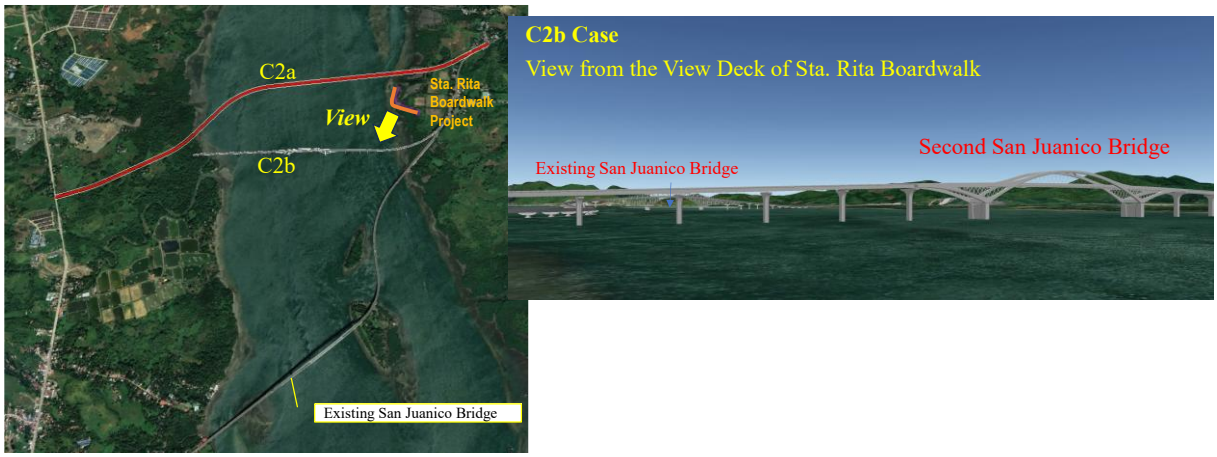
However, the recommended C2b option did not receive the consent of Samar Province. The reason is that a scenic deck is being developed, as shown in Figure 4-39, allows views of the existing SJB from the land side. As illustrated in Figure 4-40, under the C2b case, the SSJB would obstruct the view of the existing SJB from the scenic deck, thereby diminishing its tourism potential.

On the other hand, the alternative C2a allows for a panoramic view of both the new and existing bridges from the scenic deck, creating a new scenic landscape. For this reason, Samar Province agreed to proceed with the C2a option, and it was confirmed that DPWH would move forward with this plan.



Source：TIEZA（Tourism Infrastructure and Enterprise Zone Authority）

Figure 4-39 Plan of the Scenic Deck in the Sta. Rita Boardwalk Project



Source：JICA Survey Team

Figure 4-40 View of the Existing SJB from the Scenic Deck

Based on the comprehensive examination of the bridge passing area (Step 1), the bridge location (Step 2), the study of the required number of lanes based on the traffic demand forecast (Chapter 6), and the quantitative project effects (Chapter 18), it was confirmed that a new two-lane bridge adjacent to the existing SJB will be constructed. One-way operation will be integrated with the existing SJB to enhance safety, driving comfort, and smoothness. This will also contribute to improving the benefits by allowing bridges to complement each other as alternative routes during maintenance or emergencies. This approach is in line with DPWH's basic policy (as noted in the minutes of the Inception Report meeting dated 16 November 2023, 6) of Summary of Major Points to be confirmed) that existing SJB will continue to be used while undergoing repair and reinforcement. It is expected that the functionality of the existing SJB will be enhanced, and the area around existing SJB will be further developed.

4.3.3 Re-evaluation of Route Selection

After finalizing the route and bridge location for C2a, preliminary design, construction planning, and cost estimation were carried out. Since various costs considered during the route comparison—such as bridge unit prices, resident relocation compensation, and soft-ground countermeasures—have been scrutinized and updated, the route selection in Step 2iwas re-evaluated to determine if the rankings change with the updated unit prices and quantities. In doing so, items evaluated by cost or that can be converted into costs were integrated into the overall cost. As described in Section 4.3.2 (8), C2b was excluded from this re-evaluation.

The construction cost was updated using the unit prices after the preliminary design, construction planning, and estimation for C2a. For C2a, the abutment location was revised from the time of route selection, and the approach bridge length was extended and reflected. Regarding environmental and social considerations, the costs of relocating mangroves, land acquisition based on the RAP survey results, house and structure compensation, and compensation for affected residents were also considered. For the reflection of natural disaster risks into costs, landslide risk is considered moderate to low, with a relatively low likelihood of occurrence. Although small-scale cut slope collapses may occur during operation, large-scale slope protection measures are not necessary; therefore, no additional cost was included. The liquefaction risk was determined as low based on soil test results for the C2a approach road and the Japan Road Bridge Specifications and Commentary V Seismic Design Edition, so liquefaction countermeasures were not included. On the other hand, since it was confirmed that soft ground is deposited 3 to 5 meters on the surface, the cost of soil replacement using good quality material was reflected for each route according to the sections at risk indicated on the liquefaction risk hazard map. Constructability and the construction period were considered within the construction cost, as they were estimated based on the construction plan for C2a.

The results of the cost conversion under these conditions are shown in Table 4-34, with C2a having the lowest converted cost.

Table 4-34 Comparison of the Integrated Costs in Route Selection (Step 2)

Alternative Route					C1		C2a		C3	
Item			Unit Rate		Qty	Cost (mil. PhP)	Qty	Cost (mil. PhP)	Qty	Cost (mil. PhP)
Construction Cost	Embankment section	normal embankment	276	mil. PhP/km	0.856	236.3	0.115	31.7	1.29	356.0
		soft soil treatment (replacement soil)	534	mil. PhP/km	0.22	117.5	0.56	299.0	0.74	395.2
	Cut section		452	mil. PhP/km	1.571	710.1	0.376	170.0	1.122	507.1
	Main Bridge (Superstructure)	Steel Arch Bridge	9,994	mil. PhP/km	0.335	3,348.0	0.335	3,348.0	0.335	3,348.0
	Main Bridge (Substructure)	Bored Piles	3,853	mil. PhP/km	0.335	1,290.8	0.335	1,290.8	0.335	1,290.8
	Approach Bridge	AASHTO Girder+Bored Pile /Spread Foundation	2,878	mil. PhP/km	1.089	3,134.1	1.225	3,525.6	1.079	3,105.4
	Roundabout at Samar side		37	mil. PhP/location	1	37.0	1	37.0	1	37.0
	O&M Facilities		—		1	1,005.0	1	904.0	1	987.0
Environmental and Social Consideration	Natural	Mangrove Transplant	36	mil. PhP/ha	0.315	11.3	0.179	6.4	0.151	5.4
	Social	Land Cost	511	PhP/m2	84,040	42.9	51,940	26.5	86,520	44.2
		Structure/House Cost	331,000	PhP/no.	12	4.0	9	3.0	18	6.0
		Transitional Allowance	27,000	PhP/PAP	50	1.4	39	1.1	78	2.1
Total					**9,938.3**		**9,643.0**		**10,084.2**	
Score					**4.8**		**5.0**		**4.8**	

Note: The option with the lowest cost will be scored at a maximum of five points, and other options will be scored as: maximum points - [(cost of the option / the cost of the lowest option - 1) × maximum points]

Source: JICA Survey Team

For comparison items that are difficult to convert into costs, project effect represents the economic benefits, equivalent to those considered in B/C or EIRR evaluations. However, for this route selection, VOC and TOC for each route have not been calculated; instead, differences in distance were used as a simple measure. It is desirable to evaluate these quantitatively, similar to the converted costs.

Driving safety and comfort were considered separately from the converted costs, as the alignment of each alternative route meets the conditions but varies in width, which can affect factors such as performance under rainy weather and the proportion of large vehicle traffic.

As shown in Table 4-35, the re-evaluation confirmed that C2a remains the most advantageous option, even when re-evaluated based on the updated information from the preliminary design.

Table 4-35 Re-evaluated Results of Route Selection (Step 2)

Category	Evaluation Item	Weight	C1		C2a		C3	
			Score	W. Score	Score	W. Score	Score	W. Score
Integrated Cost	Construction, Environmental and Social Consideration, Construction Requirement	5	4.3	21.5	4.5	22.5	4.2	21.0
Project Effect (Connectivity)	Travel Time (Distance)	5	3.3	16.5	5.0	25.0	3.5	17.5
Safety and Comfortability of Driving	Horizontal/Vertical Alignment	5	3.7	18.5	2.8	14.0	2.8	14.0
Total Weighted Score			**59.0**/75		**64.0**/75 **(selected)**		**55.5**/75	

Source: JICA Survey Team

Regarding the comparison of Alt-1 (Area 2) and Alt-2 (Area 4) in Step 1, the simple depth survey (see Figure 5-30) from the boring survey (Phase 1) supports that Alt-1 (Area 2) would require a bridge approximately 600 meters long. On the other hand, Alt-2 (Area 4) is located in relatively shallow water, resulting in a bridge length of 335 meters based on the preliminary design, confirming further cost advantages.

4.4 Bridge Type Selection

4.4.1 Purpose of Survey

The most appropriate bridge type for the SSJB, planned to cross the San Juanico Strait, will be selected using this study's results and the existing regional development plans.

4.4.2 Survey Items

The survey items and explanations are summarized in Table 4-36.

Table 4-36 Summary of Survey Items

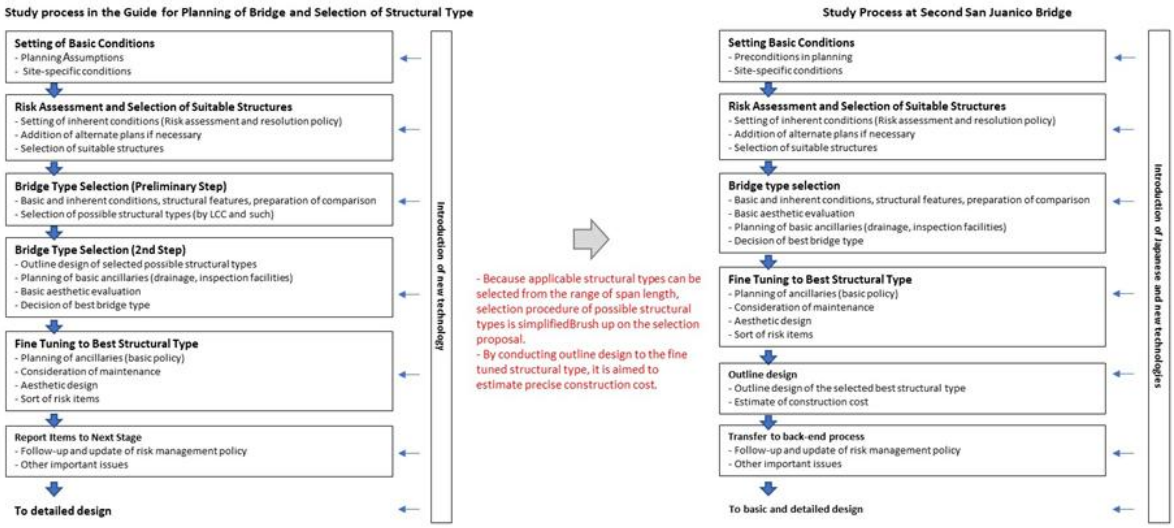
Survey Item	Explanation
(1) Design Standards and Design Conditions	Selection of design standards and development of design conditions to be applied in the bridge design.
(2) Study of Span Lengths of Main Bridges	Determination of the span length of the main bridge, considering the current navigation situations of the strait, safety for future navigation of large vessels, and the constructability of piers in the strait.
(3) Comparison of Bridge Types	Comparison of main and approach bridge types in terms of structural applicability, constructability, maintainability, construction cost, and aesthetic characteristics.

Source: JICA Survey Team

4.4.3 Survey Method

(1) Procedure of Survey

For bridge type selection, this study follows the procedure outlined in Guide for Planning of Bridge and Selection of Structural Type, 2023.5, JSCE. The following page summarizes both the process used in this study and the procedure detailed in the guide.



Source: "Guide for Planning of Bridge and Selection of Structural Type, 2023.5, JSCE"

Figure 4-41 Bridge Type Selection Process

(2) Applicable Design Standards

The Design Guidelines, Criteria, and Standards for Public Works and Highways (DGCS of the Philippines) and the Bridge Seismic Design Specification (BSDS) are applied in this study.
The Japanese Design Standard for Highway Bridges and the related AASHTO Bridge Design Specifications will also be applied as necessary.

(3) Surrounding Situation Around the Bridge Location

1) San Juanico Strait

The strait separating Leyte and Samar islands is the narrowest strait in the Philippines.



Source: AW3D ortho imagery purchased from the Remote Sensing Technology Center of Japan (RESTEC)

Figure 4-42 Perspective of the San Juanico Strait

The narrow and winding strait runs from north to south. Edged on both sides by mountains and forests with small islands, the strait offers visitors scenic views of a calm sea, tropical forests, blue skies, and a coastal landscape. No massive or tall structures, such as high-rise buildings or infrastructure facilities, exist alongside the strait, except within the urbanized area of Tacloban, where a few houses and aquaculture facilities are present. These buildings are low-rise and do not obstruct the scenic views; instead, they accentuate the life and culture of the area.



Source: JICA Survey Team

Figure 4-43 Marine Aquaculture Facilities



Source: JICA Survey Team

Figure 4-44 Houses in Villages

The sea surface is typically calm, with waves occurring only occasionally. On windless days, the strait becomes mirror-like, reflecting the surrounding landscape.



Source: JICA Survey Team

Figure 4-45 Scenery of Calm Strait

The San Juanico Strait is also widely recognized as a tourist destination in the region, famous for its leisure activities and cruise tours.



Source: https://sanjuanicocruises.com/



Source: https://sanjuanicocruises.com/

Figure 4-46 Cruise Boat Tours

2) San Juanico Bridge

As the only bridge connecting Leyte and Samar islands, the existing SJB plays a critical role in supporting the local economy through ground transportation and logistics, and is beloved by local residents. Construction of the bridge started in 1969 under Japanese Official Development Assistance (ODA) as a post-wartime compensation project for the Pacific War and was completed in 1973. It is regarded not only as a symbol of unity between the two islands of Leyte and Samar, but also as a symbol of friendship between the Philippines and Japan.







Source: JICA Survey Team

Figure 4-47 San Juanico Strait





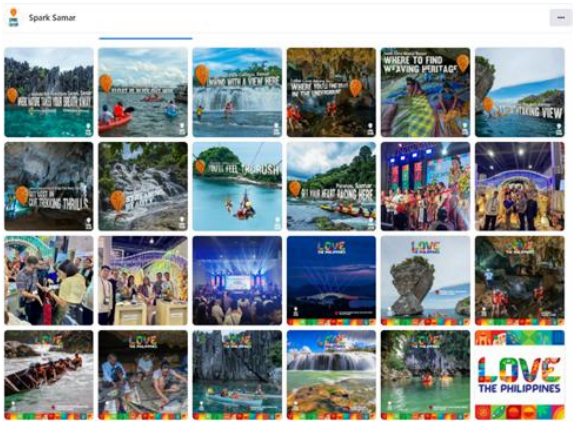
Source: JICA Survey Team

Figure 4-48 Bridge Plates

The existing SJB has also become a tourist attraction due to its elegant structure, with visitors often seen taking pictures with the bridge or the view of the straits.

At night, the bridge undergoes a captivating transformation. Illuminated with vivid and powerful lights, it becomes a breathtaking spectacle often compared to a fireworks display. This illumination project, launched by SPARK SAMAR, a tourism initiative of the Samar Tourism Department, highlights the bridge as a key regional attraction and a source of pride for the Samar Region.



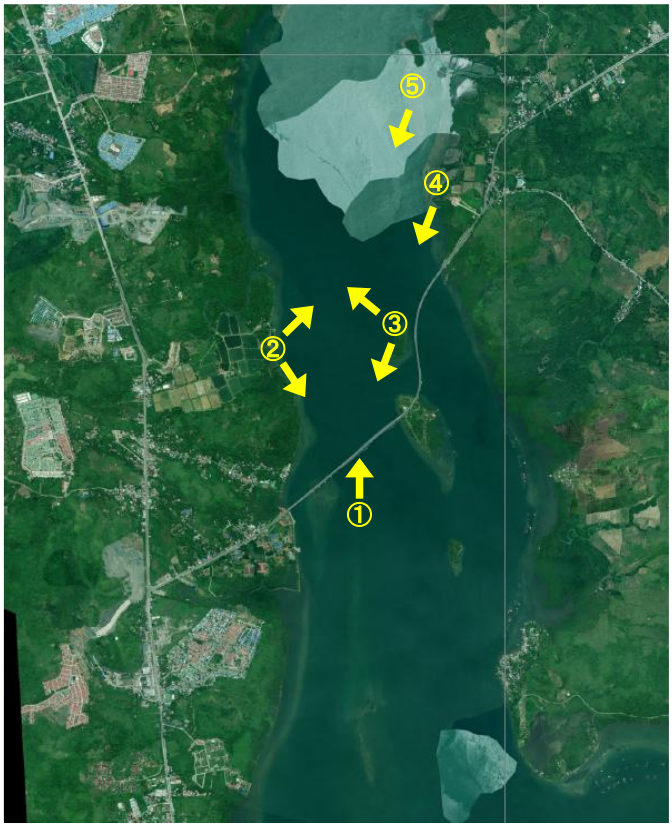


Source: SPARK SAMAR Official Facebook

Figure 4-49 Illumination of the San Juanico Bridge and Contents of SPARK SAMAR

3) Viewpoints of the Second San Juanico Bridge

The proposed location of the SSJB is approximately 1.2 km north of the existing SJB. This close proximity means there are several viewpoints along the strait offering a panoramic perspective that encompasses both bridges.



Source: JICA Survey Team

Figure 4-50 View Points

Viewpoint 1: Navigation Channel of the Existing SJB

Figure 4-51 shows the vantage point from a cruise boat approaching the existing SJB while navigating the San Juanico Strait.

From these tranquil waters, the SSJB can be seen rising behind the existing SJB, framed by the mountains and expansive sky. This viewpoint offers a clear perspective across the strait, allowing simultaneous observation of both bridges' main spans.



Source: JICA Survey Team

Figure 4-51 View from the Boat

Viewpoint 2: Beach Resort on the Leyte Side

Figure 4-52 shows the viewpoint from a tourist-oriented resort restaurant situated on the Leyte side of the strait.

From the shoreline, the existing SJB is visible to the south, while the SSJB appears to the north. This placement offers visitors distinct perspectives of both the old and new bridges, depending on their field of vision.



Source: JICA Survey Team

Figure 4-52 View from the Beach Resort

Viewpoint 3: On the Existing SJB

Figure 4-53 illustrates the view from the deck of the existing SJB, near the approach section to the Samar River.

With the existing SJB and the SSJB visible in close proximity to the south and north, respectively, visitors can enjoy unobstructed views simply by shifting their gaze. This vantage point also provides a greater appreciation for the structural nuances of each bridge compared to Viewpoint 2.



Source: JICA Survey Team

Figure 4-53 View from the Existing SJB

Viewpoint 4: Santa Rita Boardwalk (Planned)

Figure 4-54 shows the viewpoint from the Tourist Information Center site on the Samar Island side of the strait. From this location, visitors looking south across the beach will see the SSJB in the foreground, with the existing SJB behind it.



Source: JICA Survey Team

Figure 4-54 View from the Boardwalk

Viewpoint 5: Floating Restaurant

Figure 4-55 shows the viewpoint from a floating restaurant on the Samar Island side of the strait.

From this location, looking south, the SSJB will be seen in front of the existing SJB, although on a smaller scale compared from Viewpoint 4.



Source: JICA Survey Team

Figure 4-55 View from the Floating Restaurant

(4) Design Conditions

The design conditions for setting the bridge type are shown below.

1) Navigation Condition

[Navigation Route]

The navigation route is set as shown in Figure 4-56, based on the buoy coordinates provided by the PCG on January 25, 2024, and the navigation light coordinates of the existing SJB confirmed through Geoportal PH. The buoy coordinates define the boundary on the Samar Island side.

Table 4-37 Coordinates of the Buoys

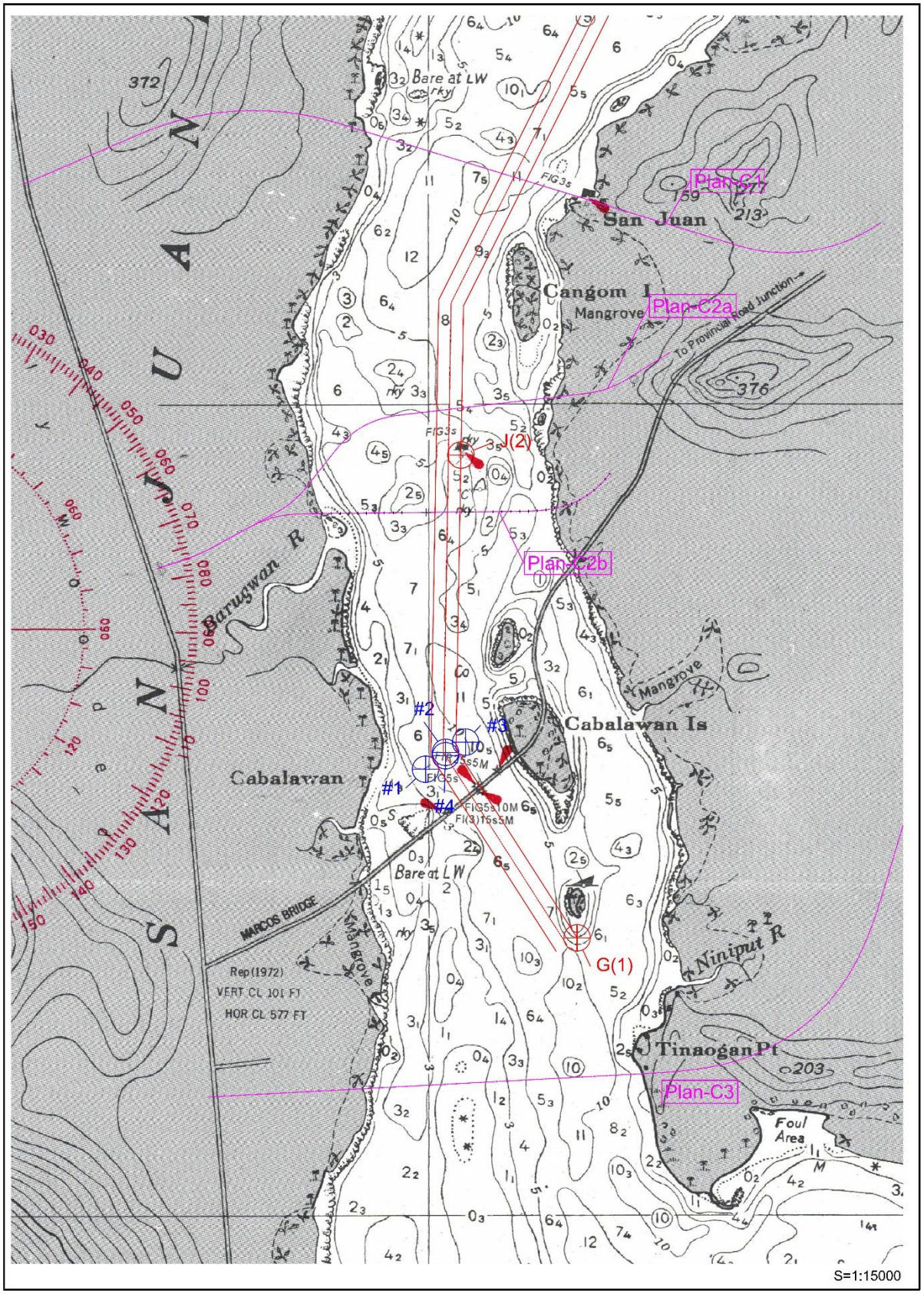
SJS BUOY	latitude	conversion	longitude	conversion
SJS BUOY G (1)	11° 17'36.10"N	11.293361	124° 58'26.70"E	124.974083
SJS BUOY J (2)	11° 18'47.41"N	11.313169	124° 58'09.30"E	124.969250
SJS BUOY M (3)	11° 20'03.80"N	11.334389	124° 58'37.20"E	124.977000
SJS BUOY F (4)	11° 20'27.70"N	11.341028	124° 58'49.30"E	124.980361
SJS BUOY L (5)	11° 22'05.90"N	11.368306	124° 59'02.90"E	124.984139
SJS BUOY H (6)	11° 22'28.80"N	11.374667	124° 58'50.90"E	124.980806
SJS BUOY E (7)	11° 22'42.20"N	11.378389	124° 59'05.70"E	124.984917
SJS BUOY D (8)	11° 22'52.10"N	11.381139	124° 58'51.20"E	124.980889
SJS BUOY I (9)	11° 23'03.70"N	11.384361	124° 58'51.10"E	124.980861
SJS BUOY A (10)	11° 23'30.00"N	11.391667	124° 58'56.90"E	124.982472
SJS BUOY K (11)	11° 23'57.30"N	11.399250	124° 58'50.40"E	124.980667
SJS BUOY B (12)	11° 24'40.60"N	11.411278	124° 58'58.60"E	124.982944
SJS BUOY O (13)	11° 24'59.60"N	11.416556	124° 58'48.00"E	124.980000
SJS BUOY N (14)	11° 25'14.00"N	11.420556	124° 58'54.90"E	124.981917
SJS BUOY C (15)	11° 25'15.40"N	11.420944	124° 58'41.89"E	124.978303
SJS BUOY P (16)	11° 25'23.80"N	11.423278	124° 58'40.10"E	124.977806
SJS BUOY T (17)	11° 25'31.00"N	11.425278	124° 58'17.80"E	124.971611
SJS BUOY R (18)	11° 25'39.10"N	11.427528	124° 57'49.80"E	124.963833
SJS BUOY Q (19)	11° 25'37.00"N	11.426944	124° 57'25.90"E	124.957194
SJS BUOY S (20)	11° 27'02.80"N	11.450778	124° 52'37.80"E	124.877167

Source: Obtained Coordinates from the PCG (2024.01.25)

Table 4-38 Coordinates of the Navigation Lights

Name	latitude	longitude
#1 South (outer)	11.3002780	124.9677780
#2 Center (North)	11.3009720	124.9686110
#3 North (outer)	11.3013890	124.9694440
#4 Center (South)	11.3008330	124.9686110

Source: Geoportal PH



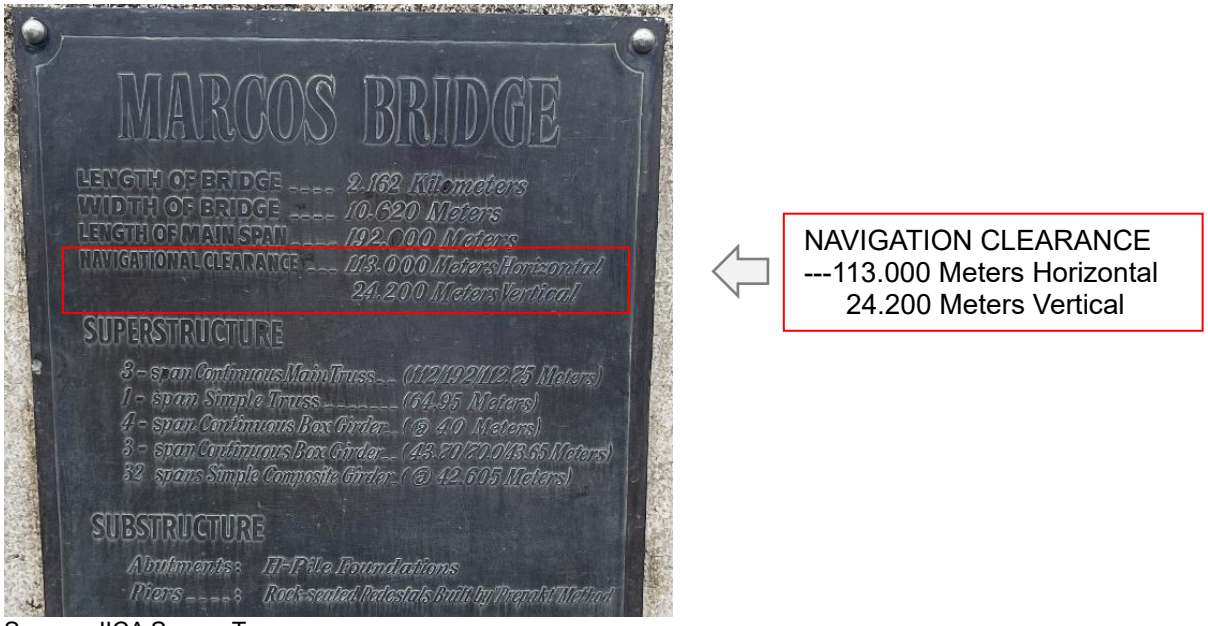
Source: Sea Map (Philippines Nautical Charts and Special Publications, 4464 San Juanico Strait and Janabatas Channel, NAMRIA) with JICA Survey Team's Additions

Figure 4-56 Navigation Route (Around Existing SJB)

[Navigation Clearance]

The navigational clearance is set based on the existing SJB nameplate specifications:

Horizontal Channel: 113.0 m ; Vertical Clearance: 24.2 m above MHHW

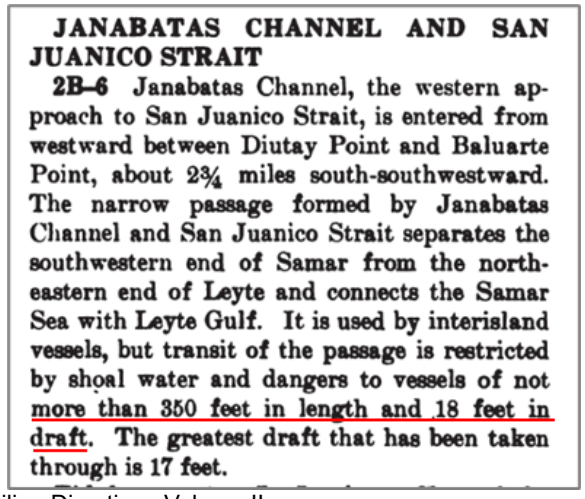


Source: JICA Survey Team

Figure 4-57 Nameplate of the Existing SJB

[Design Vessel]

According to the Philippine Islands Sailing Directions Volume II (United States Coast and Geodetic Survey, 1975), the maximum size of a vessel permitted to pass through the San Juanico Channel is listed as 350 ft (107 m) in length with a full draft of 18 ft (5.5 m). Based on the standard specifications of the target vessels (Figure 4-59), the maximum size of a vessel that can pass through the San Juanico Strait is 3000 DWT.



JANABATAS CHANNEL AND SAN JUANICO STRAIT

2B–6 Janabatas Channel, the western approach to San Juanico Strait, is entered from westward between Diutay Point and Baluarte Point, about 2¾ miles south-southwestward. The narrow passage formed by Janabatas Channel and San Juanico Strait separates the southwestern end of Samar from the northeastern end of Leyte and connects the Samar Sea with Leyte Gulf. It is used by interisland vessels, but transit of the passage is restricted by shoal water and dangers to vessels of not more than 350 feet in length and 18 feet in draft. The greatest draft that has been taken through is 17 feet.

Source: Philippine Islands Sailing Directions Volume II

Figure 4-58 Navigable Vessel Size

DWT (ton)	Length (m)	Beam (m)	Draft (m)
1,000	67	10.7	3.8
2,000	82	13.1	4.8
3,000	92	14.7	5.5
5,000	107	17.0	6.4
10,000	132	20.7	8.1

Source: AASHTO and MLIT (Study on Ship Dimensions by Statistical Analysis - Standard of Main Dimensions of Design Ship (Draft) - Hironao TAKAHASHI, Ayako GOTO and Motohisa ABE ,RESEARCH REPORT of National Institute for Land and Infrastructure Management No.28, March 2006)

Figure 4-59 Typical Dimensions of Vessels

Since the average number of vessels using the Port of Tacloban is only about one to two per day, it can be concluded that the number of vessels navigating the San Juanico Strait is low.

2023

Tacloban Baseport Vessels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Tramping - Domestic	10	13	18	17	15	11	18	17	20	20	14	12	185
Tramping - Foreign	4	4	7	6	6	7	3	7	6	4	5	5	64
Tugboat	1		2				1	1					5
Navy Vessel			1		1							1	3
Yatch					1								1
Containerized - LOLO	19	21	25	20	25	19	19	24	21	23	23	22	261
Containerized - STORO (LCT)	3	4	6	5	5	4	2					2	31
	37	42	59	48	53	41	43	49	47	47	42	42	550

2022

Tacloban Baseport Vessels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Tramping - Domestic	19	13	17	13	18	18	21	18	17	15	15	17	201
Tramping - Foreign	3	7	4	5	6	5	4	6	10	8	5		63
Tugboat	2		3	2	3	3	5	4	3	2	3	3	33
Navy Vessel													0
Yatch													0
Containerized - LOLO	24	27	25	25	28	24	24	20	18	19	20	23	277
Containerized - STORO (LCT)	6	5	7	4	6	6	8	6	6	5	5	6	70
	54	52	56	49	61	56	62	54	54	49	48	49	644

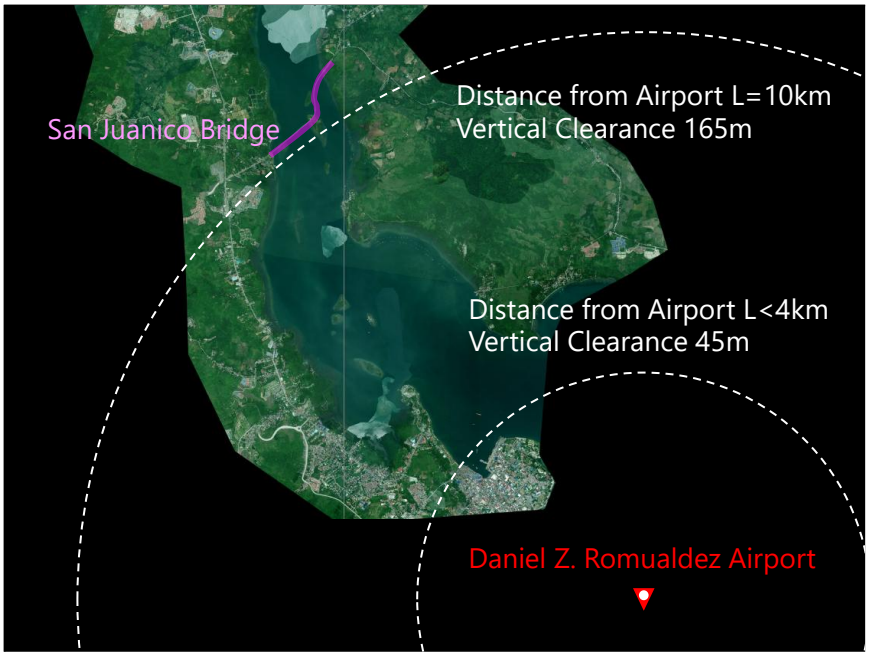
Source: Obtained Coordinates from the PPA (2024.01.31)

Figure 4-60 Number of Vessels Using Tacloban Port

2) Air Clearance

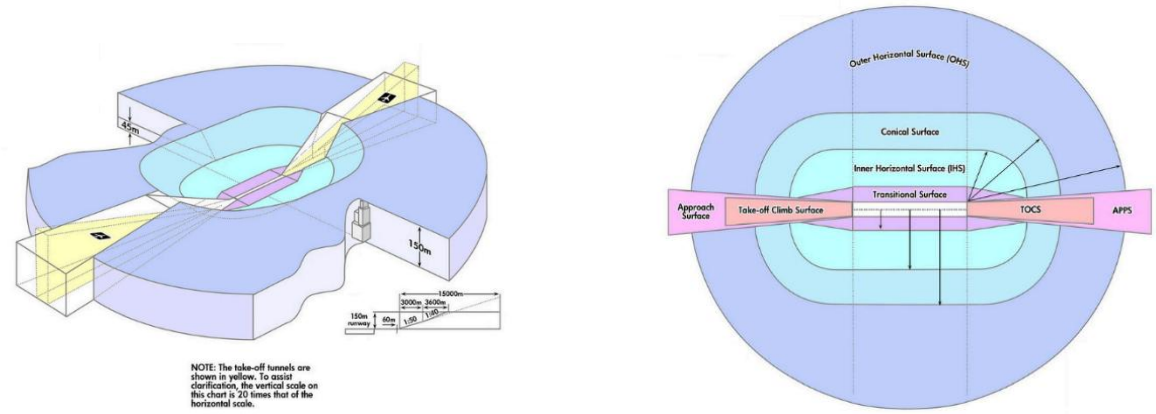
The bridge location is approximately 11 km away from the Daniel Z. Romualdez Airport, where the altitude limit is about 195 m. Therefore, this does not pose a constraint in the selection of the bridge type.

1. L < 4 km: 45 m, 2. 4 km < L < 7.0 km: 45 m + (L - 4000) / 50
3. 7.0 km < L < 10.6 km: 105 m + (L- 7000) / 40
4. 10.6 km < L: 195 m



Source: JICA Survey Team

Figure 4-61 Location of the Bridges and Airports



Source: International Civil Aviation Organization (ICAO)

Figure 4-62 Obstacle Limitation Surface

3) Natural Condition

Refer to the results of the natural conditions survey presented in Chapter 5.

4) Design Conditions

The basic conditions for selecting the bridge type are summarized below.

Table 4-39 Design Conditions (1)

ITEM	DESIGN CONDITIONS	REMARKS
1. PREREQUISITES		
(1) BRIDGE IMPORTANCE		
① Route	National Highway No. 1 (N1) and Asian Highway 26 (AH26)	
② Road Classification: Road Class Classification	Class 1 National Highway, Major Local Road (HSH Class-1 in the High Standard Highway Master Plan Project).	
③ Position in the Logistics Network		
・Important Logistics Road	Yes (Designation is uncertain, but importance is high as it is the only arterial road around the bridge location).	
・Weight Restricted Road	No	
・Height Restricted Road	No	
④ Position in Disaster Prevention Plan		
・Emergency Transportation Route	Yes (Designation is uncertain, but importance is high as it is the only arterial road around the bridge location).	
・Tsunami Evacuation Plan	Located in a tsunami warning area, but the bridge is planned at a height that avoids the estimated tsunami height (approx. 5.0m).	Hazard Hunter PH
⑤ Bridge Importance in Seismic Design	OC-1 Critical Bridges (Since the main bridge is a special bridge and the existing bridge may also be damaged during an earthquake, OC-1 is applied, including the approach bridge).	BSDS2019
⑥ Route Redundancy		
・Availability of Detour Routes in Case of Bridge Damage	No detour route (There is an existing bridge to cross the island, but it may be damaged in an earthquake).	
・ Restrictions on Detour Routes	Weight restrictions apply.	
・Restrictions When the Bridge Serves as a Detour Route	No restrictions.	
(2) DESIGN SERVICE LIFE (DURABILITY OF MEMBERS ETC.)		
① Main Girder	Steel girder: 100 years (assuming maintenance by repainting)	Consider adoption of long-life paint. C-5 paint system is standard.
② Deck Slab	RC Deck Slab, Composite Deck Slab: 100 years	
③ Substructute	RC Pier: 100 years	
④ Foundation	Placement Caisson, Multi-Column Foundation, SPSP, etc.: 100 years	
⑤ Ancillaries		Type, etc. to be considered in DD
・Bearing	Seismic Isolation Bearings: As appropriate, Rigid Structure: 100 years	Replacement assumed, consider jacking up
・Expansion Joints	As appropriate	Replacement assumed. Deterioration of watertightness is a concern. Need to consider increased paint thickness at girder ends, etc.
・Railings	Steel railings: as appropriate	Flexible safety barriers are standard for offshore sections
・Drainage Pipes	As appropriate	Replacement assumed
・Inspection Paths	As appropriate	Replacement assumed
・Attached Utility Lines	None	To be confirmed in DD

Source: JICA Survey Team

Table 4-40 Design Conditions (2)

ITEM	DESIGN CONDITIONS	REMARKS
2. SITE-SPECIFIC CONDITIONS		
(1) ROUTE CONDITIONS		
① Road Planning		
・Planned Traffic Volume	16,700 PCU/day	
・Effective Width	17.3m [2.0m (Inspection Aisle) + 1.5m +7.0m +1.5m +0.3m +3.0m (Bike Lane) +2.0m (Sidewalk)]	
・Widening	No Plan	
・Emergency Parking Bay	No Plan	
・Utility Lines	No Plan	To be confirmed in DD
② Intersection Conditions		
・San Juanico Strait	Navigation Channel Width: 113m, Navigation Channel Height: 24.2m	
	Future Plans: None	
	Separation Conditions: No specific designation	
(2) NATURAL ENVIRONMENTAL CONDITIONS		
① Topographic & Geological Conditions	Strait between islands. Sandstone is exposed.	Confirm ground investigation results
② Weather Conditions	Subtropical climate. Frequent typhoons throughout the year.	
③ Distance from Coast	0km (Salt damage due to airborne salt)	
④ Anti-icing Agent Application	None	
⑤ Snowfall	None	
⑥ Frost Damage	None	
⑦ Rainfall Intensity	120mm/h (10-minute duration, 3-year return period)	
⑧ Water Level	MHHW＝1.945m	
(3) SURROUNDING ENVIRONMENT		
① Land Use	Used as a strait for ships	
② Surrounding facilities	No surrounding facilities such as schools.	
③ Adjacent Land Condition	Houses and others are present.	
④ Noise Prediction	Few houses, etc. in the surrounding area, no special consideration required.	
⑤ Vibration Prediction	Few houses, etc. in the surrounding area, no special consideration required.	
⑥ Shading Impact	No properties will be affected by shadowing from the bridge construction.	
⑦ Rare Wildlife and Plant Status	Mangroves and coral reefs are present along the coast.	Evaluate during the study of the bridge types of the approach bridges.
⑧ Intersection Object Usage Status	Navigation route usage. No restrictions such as fishing rights.	
(4) MATERIAL PROPERTIES & MANUFACTURING CONDITIONS		
① Concrete Plant Location	Planned to install a concrete plant at the construction yard.	
② Handling of Admixtures		
③ Precast Plant		

Source: JICA Survey Team

Table 4-41 Design Conditions (3)

ITEM	DESIGN CONDITIONS	REMARKS
(5) CONSTRUCTION CONDITIONS		
① Construction Access Road Availability	None	
② Nearby Facilities	Houses, etc. within the ROW	
③ Topographic & Geological Conditions	Maximum depth of 10m at the bridge location. Bearing layer expected at shallow depth.	
④ Adjacent Land Condition	Houses, etc. within the ROW	
⑤ Structure Before and After the Site Embankment	Embankment structures on both Samar and Leyte sides.	
⑥ Position in Route Construction Plan	None in particular (This bridge is the final completed structure of this project)	
⑦ Construction Period and Other Restrictions	None in particular	
(6) LANDSCAPE CONDITIONS		
① Color Restrictions	None	DPWH consultation is necessary
② Landscape Considerations	Yes	Harmony with the existing bridge and the sorroundings
(7) MAINTENANCE PLAN		
① Restrictions related to intersection maintenance	None	
② Inspection Plan	Not yet considered	Inspectability will be evaluated during bridge type selection
③ Bearing Replacement Plan	Not yet considered	To be conducted in DD
④ Possibility of Falling Objects	Not specifically considered due to low vessel traffic	
⑤ Snow removal and others	None	

Source: JICA Survey Team

5) Specific Conditions

The specific conditions, summarizing risk assessment and response policies, are shown in Table 4-42.

Table 4-42 Specific Conditions

RISK ITEM	RISK PRESENCE (FOR THIS BRIDGE)		CAUSE OF RISK OCCURRENCE	STAGE AT WHICH RISK OCCURS	RISK EVALUATION							RESPONSE POLICY			ITEMS TO BE HANDED OVER
					PROBABILITY AND FREQUENCY OF OCCURRENCE		COST AND SCHEDULE IMPACT		EVALUATION		RESPONSESTAGE	RESPONSE POLICY	COST & EFFECTIVENESS	
							STRUCTURE	SOCIAL IMPACT	BASIC	CHANGE				
1. RISKS FROM NATURAL DISASTERS															
TSUNAMI DAMAGE	SUPERSTRUCTURE	YES	EARTHQUAKE	DURING CONSTRUCTION AFTER	While no significant tsunami damage has been confirmed in the area to date, hazard maps predict a potential tsunami of	BIG	Outflow of the superstructure due to tsunami wave force and buoyancy is a concern.	Although alternative routes exist, the repairs will require significant cost and time.	BIG	BIG・BIG = QUADRANT 1		FS (Feasibility Study)	Risk is mitigated by setting the girder underclearance higher than the estimated	LOW COST, HIGH EFFECT	
WIND DAMAGE	SUPERSTRUCTURE	YES	TYPHOON ETC.	DURING CONSTRUCTION	The area in question is prone to frequent typhoons, making the impact of wind on structures unavoidable.	BIG	The structure is vulnerable to typhoon damage during the unstable erection stage.	Repair of erected members, etc., will impact subsequent processes.	BIG	BIG・BIG =QUADRANT 1		FS	A bridge type with a short period of unstable structure during erection is selected.	LOW COST, HIGH EFFECT	
				AFTER COMMISSION			After commissioning, wind-induced vibrations may occur in the cables.	If divergent vibrations occur, significant cost and time will be required for closures and repairs.	BIG	BIG・BIG = QUADRANT 1		FS DD	Select a bridge type with high wind resistance. Conduct wind tunnel tests during DD to determine wind mitigation measures.	MODERATE COST, HIGH EFFECT	Conduct wind tunnel testing during DD to test wind resistance measures.
FAULT DISPLACEMENT	–	NO	EARTHQUAKE												
GEOHAZARDS	–	NO	WEAK GROUND												
COASTAL FLOODING	SUPERSTRUCTURE	YES	TYPHOON	DURING CONSTRUCTION AFTER	The area suffered storm surge damage during Typhoon Haiyan (Yolanda) in 2013. The possibility of future storm surge	BIG	There are concerns about potential collisions with the superstructure from vessels adrift due to	While alternative routes are available, repairs will be costly and time-consuming.	BIG	BIG・BIG = QUADRANT 1		FS	The bridge clearance will be set higher than the highest historically recorded storm surge to	LOW COST, HIGH EFFECT	
VOLCANIC ERUPTION	–	NO	VOLCANO												
2. RISKS DUE TO HUMAN ERROR															
CONSULTATION WITH RELEVANT AUTHORITIES	ATTACHED PIPES	YES	No response received regarding the	DETAILED DESIGN, DD	If confirmed during the detailed design stage, and incorporated into the design, the risk will be	SMALL	Revising the detailed design	Design process delay	SMALL	BIG・BIG = QUADRANT 4		DD (Detailed Design)	During DD, the necessity of attached utility pipes will be confirmed and	LOW COST, HIGH EFFECT	
	LIGHTING CONSIDERATIONS	YES	INCOMPLETE CONSIDERATION OF LIGHTING	DETAILED DESIGN, DD	If considered during the detailed design stage and incorporated into the design,	SMALL	Revising the detailed design	Design process delay	SMALL	BIG・BIG = QUADRANT 4		DD	Lighting design considerations will be conducted during DD and incorpora	LOW COST, HIGH EFFECT	
3. RISKS FROM INADEQUATE PLANNING OR INSUFFICIENT INFORMATION															
INSUFFICIENT SOIL DAT	ESTIMATED BEARING STRATUM	YES	ESTIMATED SLOPE OF THE DESIGNATED LAYER	DURING CONSTRUCTION	If just-boring is not conducted, depending on the bearing layer location, footing height and foundation height may need to be altered.	SMALL	Detailed design rework, foundation reconstruction.	Construction schedule delay	BIG	SMALL・BIG = QUADRANT 2		FS	Bridge type selection will be based on the assumed supporting strata.		Conduct additional boring at each pier location during the detailed design
												DD	Additional boring will be conducted based on the selected bridge type.	LOW COST, HIGH EFFECT	
INSUFFICIENT WIND DAT	WIND LOAD	YES	WIND LOAD SETTING	AFTER COMMISSION	If appropriate wind loads are not established, it will lead to damage after service commencement / during operation.	SMALL	Post-construction repair and reinforcement.	Road closures, repairs and reinforcement	BIG	SMALL・BIG = QUADRANT 2		FS	Wind loads will be determined based on wind analysis		Conduct wind observation (minimum one year) at the existing bridge location before the detailed
												DD	The reliability of the established wind loads will be verified by conduct	LOW COST, HIGH EFFECT	
4. RISKS ARISING FROM ACCIDENTS INVOLVING THIRD PARTIES															
SHIP COLLISION WITH P	PIER	YES	VESSEL UNCONTROLLABLE	AFTER COMMISSION	Large vessel traffic is minimal, therefore occurrence frequency is low.	SMALL	Post-construction repair and reinforcement.	Road closures, repairs and reinforcement	BIG	SMALL・BIG=QUADRANT 2		DD	Ship collision analysis will be performed to ensure the safety of bridge piers.	LOW COST, HIGH EFFECT	

Source: JICA Survey Team

4.4.4 Study of Main Span Length

The main bridge span is set at 195 meters, based on the following two policies:

(1) Main Span Length Determined by Previous Experience with Ship Collisions

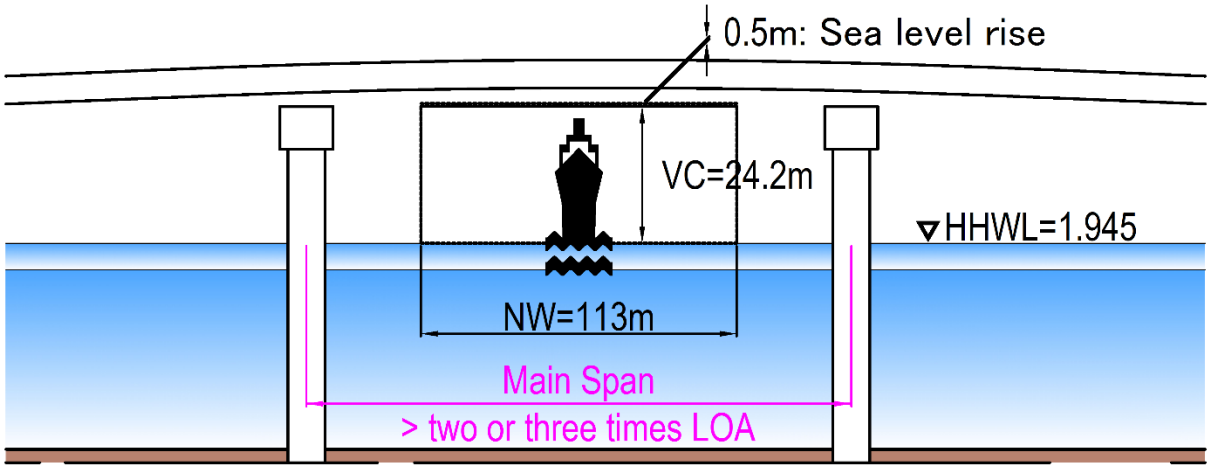
According to the AASHTO Vessel Collision Design of Highway Bridges (2009), analysis of past vessel collisions shows that "bridges with a main span less than two or three times the design vessel length, i.e., length overall (LOA), are particularly vulnerable to vessel collision".

> Figure 1 depicts the typical relationship between a vessel transiting the waterway and the main (navigation) span of a bridge. Using historical vessel collision data, the following guidelines for planning the navigation span of a new bridge have been developed:
>
> - Bridges with main spans, *S*, less than two or three times the design vessel length, *LOA*, are particularly vulnerable to vessel collision.

Source: AASHTO Vessel Collision Desigh of Highway Bridge 2009

Figure 4-63 Guideline for Determination of Span Length in AASHTO

Although the San Juanico Strait does not usually experience heavy vessel traffic, the policy is to provide a branch length of at least 184 m (92 m*2) to 276 m (92 m*3), which is twice the length of the design vessel.



Source: JICA Survey Team

Figure 4-64 Relationship Between Vessel Size and Span Length

(2) Main Span Length by Current Navigational Safety

It is undesirable for the SSJB to reduce the current navigational safety of the San Juanico Strait. As stipulated by DPWH, the span length must be equal to or greater than that of the existing SJB (Figure 4-65). Therefore, the main span of the SSJB over the navigation channel shall be at least 192 meters, corresponding to the minimum navigational span of the existing SJB. While a span length of 130 to 140 meters may be sufficient based on the shipping lane width, the SSJB would appear to have a narrower navigable range than the existing SJB when viewed from a ship. This perception is unfavorable for navigational safety; therefore, the SSJB's span length must exceed that of the existing SJB (Figure 4-66).

- Team Leader Yuichi Sano noted that for the determination of bridge type, the span length or the distance between the main piers is critical. He asked DPWH to coordinate with PPA and PCG for the approval of the span length. Senior Undersecretary Emil K. Sadain responded that this kind of design must be similar with the existing given the short distance between the existing San Juanico bridge and SSJB.

Source: Appendix-J (DPWH Central Office Kick-Off Meeting)

Figure 4-65 Excerpt from Kickoff MOM



Source: JICA Survey Team

Figure 4-66 Case with a Span of 135 m

(3) Main Span Length

The span length of the SSJB is 195 m. Since the span length is not determined by navigational restrictions, it is set at 195 m regardless of the road surface position.

4.4.5 Bridge Type Selection – Main Bridge –

(1) Selection of Alternatives

Table 4-43 presents the relationship between various bridge types and applicable span lengths.

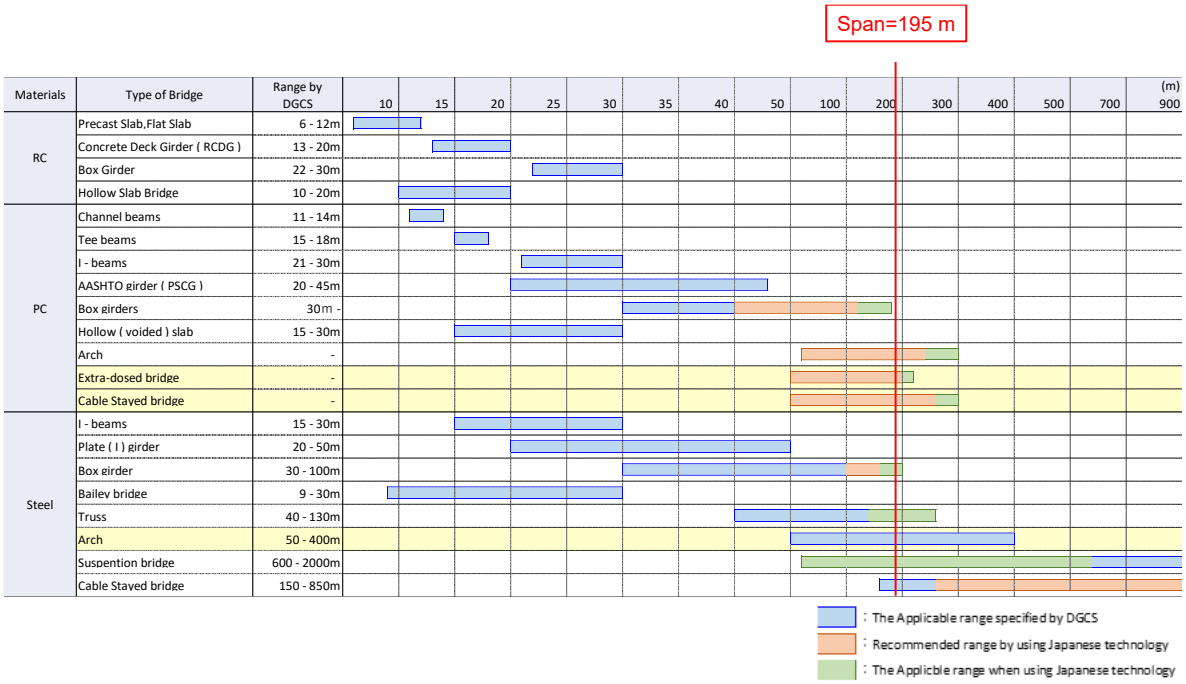
Three bridge types are chosen for each material: concrete and steel. The selection process is with reference to the DGCS and relevant Japanese manuals.

For concrete bridges, the arch, extradosed, and cable-stayed types are capable of achieving the required main span. However, the through arch (tied arch) bridges present construction difficulties at this span length and little implementation records in concrete. Therefore, it was excluded from comparison, and only the extradosed and cable-stayed bridges are considered.

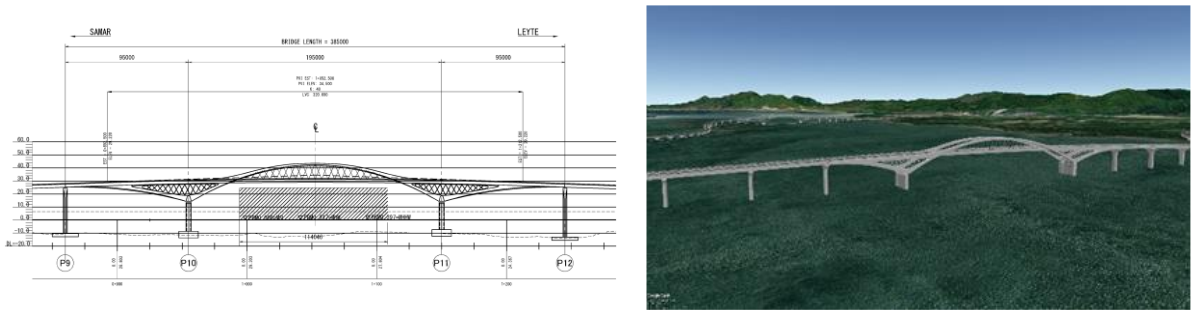
For steel bridges, the candidate options include steel box girder, truss, arch, suspension, and cable-stayed types. Among these, suspension and cable-stayed bridges are excluded as they are

less economical; truss bridges are not considered due to maintenance issues; steel box girders with orthotropic decks are also excluded, given the construction and maintenance difficulties, especially with local asphalt paving. As a result, only the arch bridge is selected for steel bridge comparison.

Table 4-43 Applicable Bridge Types for Each Span Length

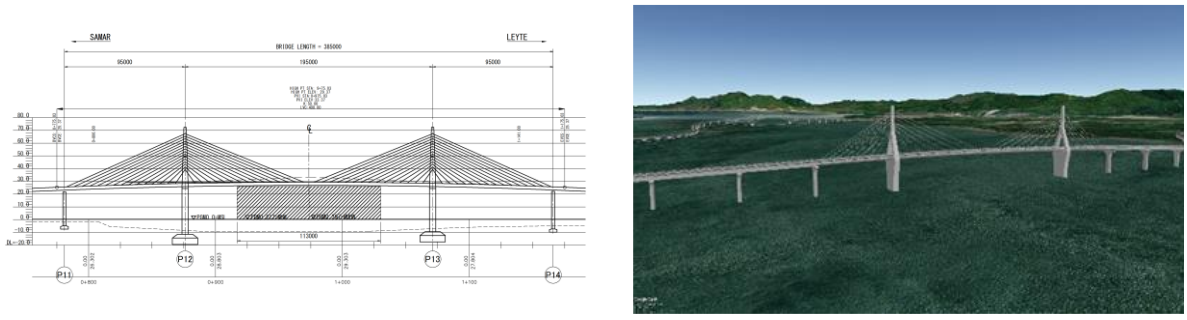


Source: JICA Survey Team has prepared the material with reference to the DGCS and Japanese expressway specifications.



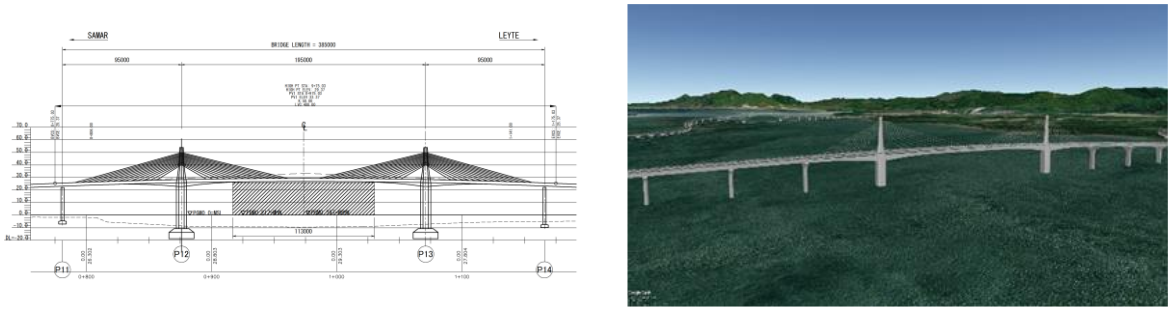
Source: JICA Survey Team

Figure 4-67 Alternative 1: Steel Arch Bridge



Source: JICA Survey Team

Figure 4-68 Alternative 2: PC Cable-stayed Bridge



Source: JICA Survey Team

Figure 4-69 Alternative 3: PC Extra-dosed Bridge

(2) Evaluation Items

The selection of the bridge type is based on a comprehensive evaluation, with particular emphasis on economic efficiency. The items and perspectives of the comparative evaluation are summarized below.

1) Cost

Given that the EIRR in the Pre-F/S was relatively low, and the main bridge accounts for a large proportion of the project cost, economic efficiency is an important item of evaluation. Since the O&M of the existing SJB is an issue, a comparison is made based on life cycle cost (LCC), including O&M cost, assuming a 100-year service life. The preliminary construction cost estimates are based on the assumption of a multi-pile foundation.

2) Structural Property

- **Track Record**

Bridge types with proven track records and fewer structural challenges are given higher evaluation scores.

- **Wind Resistance**

The project site lies in a typhoon-prone region (reference to 5.3.1 Typhoon). Notably, during Typhoon Haiyan in 2013, the existing SJB was damaged and closed to traffic for several months for repair work. Due to its narrow width compared with its length, the rigidity of the existing SJB in the right-angled direction is relatively low, making the structure susceptible to swaying. For the SSJB, the wind-resistant design will be considered to have sufficient capacity against wind loads with a 700-year mean recurrence interval. Therefore, structural forms that are less vulnerable to divergent vibration and vortex-induced vibration are highly valued.

Table 4-44 Bridge Types Requiring Dynamic Wind Resistance Design

Bridge Types \ Phenomenon		Divergent Vibration		Vortex Induced Vibration	
		Deflection	Torsion	Deflection	Torsion
Suspension Bridge · Cable Stayed Bridge	Truss Bridge	Not Required	Required	Not Required	Not required
	Steel Box Girder	Required	Required	Required	Required
	PC Box Girder	Not required	Required	Required	Required
Steel Girder	Box Girder	Required	Not Required	Required	Not Required
	Plate Girder	Required	Required	Required	Required

Source: Wind Resistant Design Manual for Highway Bridges

- **Seismic Resistance**

The project site is located in an earthquake-prone region (reference to 5.3.2 earthquake). While seismic safety in bridge design is verified based on standards to ensure the required performance, it is advantageous to realize a structure with excellent redundancy to account for uncertain factors in actual seismic behavior. Structures in which the action of inertia forces are relatively small are rated more favorably in the evaluation.

3) Workability

The project site is subject to seismic and typhoon events that may occur during construction. To ensure safe construction, bridge types will be evaluated in terms of stability during erection and the overall construction period.

- **Stability During Construction**

Bridge structures can become unstable during erection, particularly in the case of cantilever girder construction. Bridge types with a shorter period of instability will be highly evaluated.

- **Construction Period**

The SSJB will serve as a replacement for the existing SJB during the reinforcement work of the existing SJB, early completion is essential to achieve the benefits of the road improvement as soon as possible. Therefore, bridge types with shorter construction periods will be highly evaluated.

4) Operation and Maintenance

For the regional road network to function promptly, especially during emergencies, the bridge must be evaluated in terms of frequency of repair and ease of inspection.

- **Frequency of Repair**

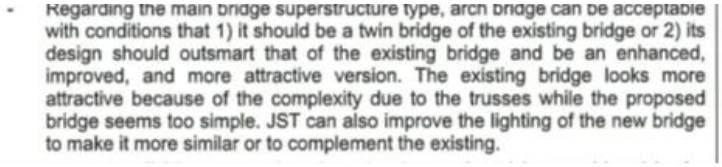
Given the bridge's long length and high road elevation, repair works are expected to be extensive and require installation of scaffolding.

- **Ease of Inspection**

The ability to reliably and easily ascertain the condition of the bridge is important for securing network functionality, particularly in the event of a disaster. Bridge types that require fewer inspection points and provide easy access to these points will be highly evaluated.

5) Landscape

The location of the SSJB is in close proximity to the existing SJB. In response to DPWH's request, particular emphasis will be placed on achieving a more aesthetically designed structure that integrates with the existing SJB. Therefore, landscape and aesthetics are considered important factors in selecting the bridge type and will remain in the subsequent preliminary design process.


- Regarding the main bridge superstructure type, arch bridge can be acceptable with conditions that 1) it should be a twin bridge of the existing bridge or 2) its design should outsmart that of the existing bridge and be an enhanced, improved, and more attractive version. The existing bridge looks more attractive because of the complexity due to the trusses while the proposed bridge seems too simple. JST can also improve the lighting of the new bridge to make it more similar or to complement the existing.

Source: Appendix-J Meeting with DPWH on Interim Report

Figure 4-70 Excerpt from Minutes of Vice-Ministerial Meeting (2024.03.13)

i) Considerations Around the Bridge Location

Based on the results of the field survey, the following items have been extracted as landscape considerations in the planning of the SSJB:

- **Harmony with Mountain Form**

The San Juanico Strait offers scenic views of lush green mountains, the sky, and calm waters. The existing SJB complements these natural features, blending with the surrounding mountain forms and the peaceful atmosphere of the strait without obstructing the scenery. Similarly, the SSJB should also reduce its visual dominance and harmonize it with the mountain forms.

- **Landmark**

The existing SJB is already recognized as a major sightseeing resource for this area, enhanced at night by its brilliant and powerful illumination. The SSJB also aims to become a symbol of this area.

- **Harmony with the Existing SJB**

The SSJB is close to the existing SJB; visual harmonization between the existing and the new bridge is important, as the two bridges can be viewed at the same time.

ii) Design Concept

Based on the considerations organized in the previous section, the design concept established is as follows:

A New Symbol of the San Juanico Strait Together with the Existing SJB

The design concept aims to give hope and vitality to the area by serving as a new symbol of the San Juanico Strait, complementing the existing SJB.

iii) Evaluation Item

Based on the concept, the following two items are set as landscape evaluation criteria for selecting the bridge type:

- **Harmony with Surroundings including the Existing SJB**

A structure type that harmonizes well with the existing SJB and surrounding mountains, when viewed as part of the landscape, will be highly evaluated. Since DPWH seeks a more design-oriented and somewhat complex bridge—similar to the existing SJB rather than a simple structure—forms that feature gentle, curved outlines that do not conflict with the mountain ridges, as well as structure types with a low structural height that blend harmoniously into the scenery will be highly evaluated.

- **Design of the Bridge Itself**

Considering the site conditions and the bridge's expected role as a tourist attraction, structure types with superior standalone design will be highly evaluated. Specifically, forms that inherit the design of the existing SJB, incorporate distinctive features as a tourist landmark, and exhibit a well-balanced overall design will receive high marks.

6) Weight of the Evaluation Items

The weights of the evaluation items are shown in Table 4-45, referring to the guidelines for preliminary bridge design by the MLIT. Cost is set as the most significant factor with a score distribution of 50 points. Other criteria were allocated five, six, and two points. Driving comfort and smoothness are not included in the evaluation, as it does not differentiate among the alternatives.

(Example of Weighting)
1. Cost: 40-50 points, 2. Structure: 10-15 points, 3. Workability: 10-15 points,
4. Road Performance: 0-5 points, 5. Environmental Impact: 0-5 points, 6. O&M: 20-25 points

Source：Hokuriku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

Figure 4-71 Reference for Weighting

Table 4-45 Weight of Evaluation Items

Category	Evaluation Item	Weighted Score	
1. Cost	1.1) Const. Cost: Life Cycle Cost = Initial cost + Maintenance cost	50	
2. Structure	2.1) Track Record: Based on track record, bridge types will be highly evaluated for its low structural challenges.	5	15
	2.2) Wind Resistance: Typhoons occur frequently at the bridge location. A bridge type that is less likely to cause vibrations is highly rated.	5	
	2.3) Seismic Resistance: Earthquakes occur frequently at the bridge location. Seismically resistant bridge types are highly rated.	5	
3. Workability	3.1) Stability: Structures with high structural stability during construction are rated.	5	15
	3.2) Period: Structural types with short construction periods are highly rated.	5	
	3.3) Const. Yard: Structural types that require a small construction yard are highly rated.	5	
4. O&M	4.1) Frequency and Scale of Repair: Bridge types that require less frequent repairs and small scale of repair are highly rated.	5	10
	4.2) Ease of Inspection: The structural type which requires fewer inspections and allows easy access to the areas of interest is highly rated.	5	
5. Landscape*	5.1) Harmony with the surroundings: The aesthetic harmony of the structure with the surroundings and the existing SJB is highly rated.	5	10
	5.2) Bridge Aesthetics: An excellent design of the bridge itself is highly rated.	5	
Total Weighted Score		100	

* The assessment of landscape quality incorporates the opinions of experts. (Appendix-I Opinions on the Landscape Design of the SSJB)

Source：JICA Survey Team

The following is a comparison with the evaluation items in the Guide for Bridge Planning and Bridge Type Selection, which serves as a reference for bridge type selection.

Table 4-46 Comparison with the Evaluation Items

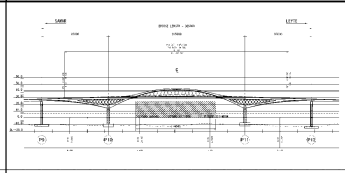
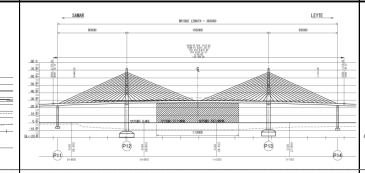
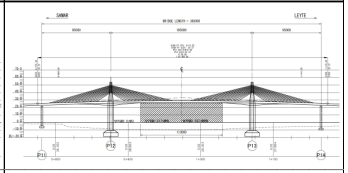
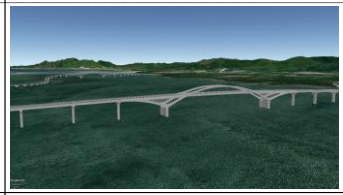
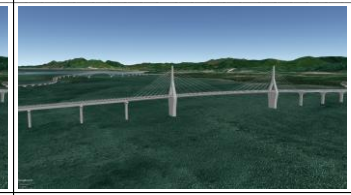
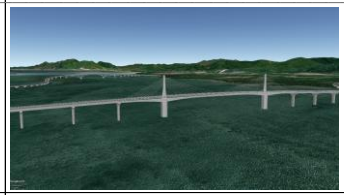
Evaluation Items in the "Guide for Bridge Planning and Bridge Type Selection"		Response at SSJB
Structural Complementarity (Structural Properties)	Safety and reliability of the structure (whether verified by actual performance, new technology, etc.)	Evaluation by (2.1)
	Seismic performance of the structures and restoration after functional failure	Evaluation by (2.3)
	Driving safety (e.g., consideration for crossing over, icy road surfaces, falling snow, etc.)	Not applicable since there is no difference in the comparison proposal.
Reliability and Ease of Maintenance (Maintenance)	Difficulty of repair (damage expected is common, need for alternative paths)	Evaluation by (4.1)
	Environmental conditions (e.g., proximity to overseas lines, effects of anti-freeze, etc.)	recorded in the economics of (1.1)
	Constraints such as crossing property, etc. (construction time constraints for repair, construction yard)	Not applicable since there is no difference in the comparison proposal.
	Reliability and ease of periodic inspection (proximity inspection method, inspection flow line, etc.)	Evaluation by (4.2)
Certainty and Ease of Ensuring Construction Quality (Workability)	Construction time constraints, regulations, and impact	Evaluation by (3.2)
	Whether or not girders, etc. can be transported to the bridge location, the entry road, etc. to the site	Evaluation by (3.3)
	Long and short on-site construction period	Evaluation by (3.2)
	Reliability of general or special construction methods	No special construction methods are used in each proposal.
	Safety during construction	Evaluation by (2.2)
	Impact on completed construction in the case of tentative construction	It is a construction in a completed system.
Harmony with the Surrounding Environment (Environmental)	Noise and vibration during construction and operation	Not applicable because there are no private houses, etc. in the vicinity.
	Impact on valuable species and ecosystems	Considerations when selecting routes
	Impact on properties with crossings	Evaluation by (3.2) as a navigation regulation.
	Bridge beauty and harmony with the surrounding environment	Evaluated by (5.1) and (5.2)
Economy (Saving Money)	Life cycle cost (initial construction cost + maintenance cost)	Evaluation by (1.1)

Source：JICA Survey Team

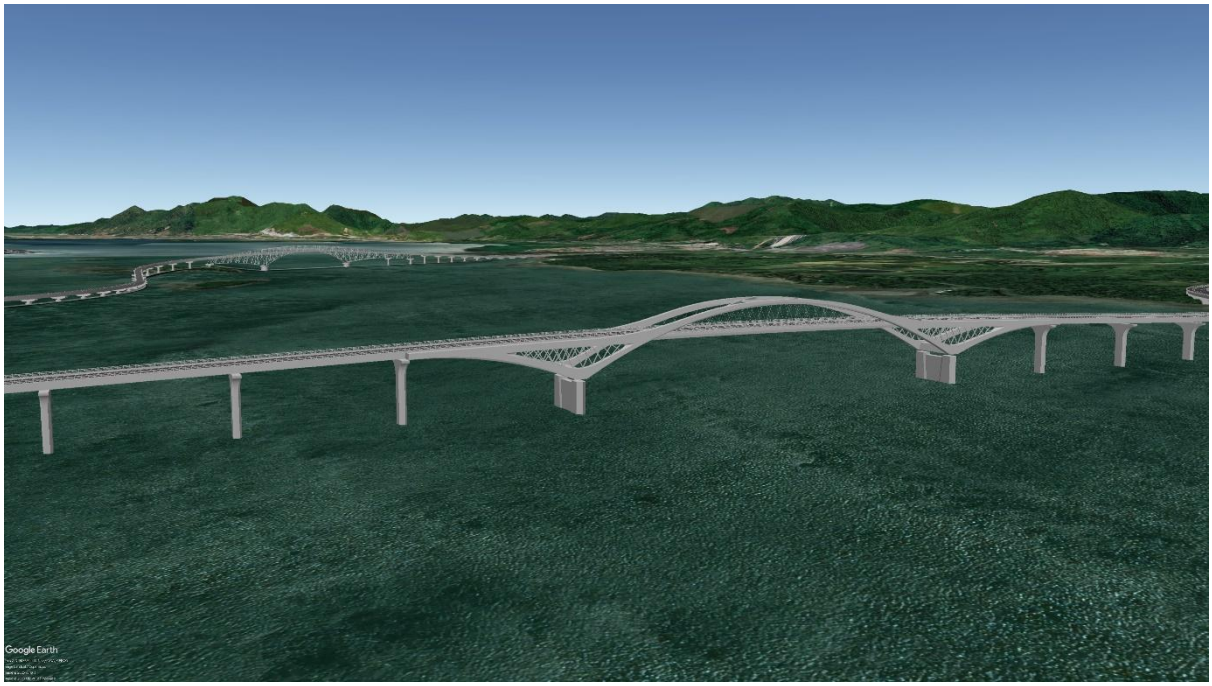
(3) Results of Bridge Type Selection for the Main Bridge

As a result of the multi-criteria evaluation, “Proposal 1: Steel Arch Bridge”, which offers excellent structural and scenic qualities and achieved the highest overall score, was selected as the structural type for the main bridge of the SSJB, despite being less favorable in terms of economic efficiency. The comparison study is shown in Table 4-47.

Table 4-47 Results of the Bridge Type Selection for the Main Bridge

				Alternative 1: Steel Arch Bridge				Alternative 2: PC Cable Stayed Bridge				Alternative 3: PC Extra-dosed Bridge			
Structual Drawing			Side View												
			Image												
Outline				This is a structurally feasible design for the main span length of this bridge. The steel arches and girders are connected by vertical and diagonal members, with the arches supporting their own weight and loads through compression.				This is a structurally feasible bridge design for the main span length of the Honbashi Bridge, featuring a bridge structure in which prestressed concrete girders are directly supported by cables stretched diagonally from the main towers.				A bridge structure in which the main girders are supported by outer cables consisting of a main tower and diagonal members. Although this is a somewhat challenging structural form for the span length of this bridge, it has a proven track record in the Philippines.			
Item		PTS.	Points to be Evaluated	Evaluation of Each Alternatives											
Cost		50	Initial Cost Ratio	1.04				1.00				1.02			
			Maintenance Cost Ratio	1.00				1.04				1.02			
			Total Cost Ratio	1.03				1.00				1.01			
		50	Economic evaluation	least economical			48	most economical			50	2nd most economical			49
Structural Property	Track Record	5	The structure with more proven track records (existing bridges) are highly rated.	Within the general applicable span.	★★★★★	5	13	Within the general applicable span.	★★★★★	5	9	Although This structure has the longest span length, There is a track record of 185 m span on the Philippines.	★★★★☆	4	10
15	Wind Resistance	5	A structural type that is less likely to cause divergent and vortex vibrations is highly rated.	-Due to the two arch ribs, It has a in-plane high rigidity and torsional rigidity. -Vibrations may occur for winds from perpendicular directions.	★★★★☆	4		-Torsional flutter and vortex vibration may occur in the main girder, which is less rigid than Alt 3. -It is also necessary to take measures to make the cable wind resistant.	★★☆☆☆	2		It is necessary to take measures to make the cable wind resistant.	★★★☆☆	3	
	Seismic Resistance	5	Structures in which the action of inertia forces is relatively small will be highly rated.	The structure is light and has a low structural height, resulting in low seismic inertia forces.	★★★★☆	4		The pylon is heavy and high, resulting in high seismic inertia forces.	★★☆☆☆	2		The Pylon is heavy but lower than the second proposal, resulting in moderate seismic inertia.	★★★☆☆	3	
Workability	Const. Safety	5	Structures with high structural stability during construction are highly rated.	The period of cantilever construction is long, and there is a high possibility to be damaged by a typhoon since the structure is relatively unstable.	★★★☆☆	3	9	The period of cantilever construction is long, and there is a high possibility to be damaged by a typhoon since the structure is relatively unstable.	★★★☆☆	3	9	The period of cantilever construction is long, and there is a high possibility to be damaged by a typhoon since the structure is relatively stable.	★★★☆☆	3	10
10	Const. Period	5	Structural types with short construction periods are highly rated.	Has the longest construction period amongst the alternatives.	★★☆☆☆	2		The construction period ranks 2nd amongst the alternatives.	★★★☆☆	3		The construction period is shorter than the other alternatives.	★★★★☆	4	
	Const. Yard	5	Structural types that require a small construction yard and have a short usage period are highly rated.	A temporary storage area for girders and a big concrete plant are not required.	★★★★☆	4		A temporary storage area for girders and a concrete plant are required. The yard is smaller than Alt 1, but the period is long.	★★★☆☆	3		A temporary storage area for girders and a concrete plant are required. The yard is smaller than Alt 1, but the period is long.	★★★☆☆	3	
O&M	Frequency and scale of Repair	5	Structural types that require less frequent repairs are highly rated.	Repainting of the entire structure will be necessary every 50 years.	★★★☆☆	3	7	Repair of the main girder and main tower is required every 30 years, but the scale is small.	★★★★☆	4	6	Repair of the main girder and main tower is required every 30 years, but the scale is small.	★★★★☆	4	7
10	Ease of Inspection	5	The structural type which requires fewer inspections and allows easy access to the areas of interest is highly rated.	-Because of the wide spacing between cables, almost the main girders can easily be accessed by the inspection vehicles. -Accessible because of the low height of the structure. -The cables are few and short	★★★★☆	4		-Because of the narrow spacing between cables, the main girders cannot be accessed by bridge inspection vehicles. -The pylon is high and it is difficult to inspect the outside of the main tower. -There are many and long cables. Difficult to maintain and manage the cables.	★★☆☆☆	2		-Because of the narrow spacing between cables, the main girders cannot be accessed by bridge inspection vehicles. -The pylon is lower, making it easier to access compared to the Case 3. -There are many and long cables. Difficult to maintain and manage the cables.	★★★☆☆	3	
Landscape	Harmony with Surroundings	5	Harmony with the surroundings including existing bridge is highly rated.	It is in harmony with the curve of the existing bridge. Does not obstruct the surrounding mountain ridgeline.	★★★★☆	4	8	-Because it is composed of straight lines, It is not in harmony with the curve of the existing bridge. -It obstructs the ridgeline of the surrounding mountains.	★★☆☆☆	2	4	-Because it is composed of straight lines, It is not in harmony with the curve of the existing bridge. -Because it has lower pylon, it does not obstruct the ridgeline of the surrounding mountains.	★★★☆☆	3	6
10	Bridge Aesthetics	5	An excellent design of the bridge itself is highly rated.	The curves of the arch ribs are beautiful.The design gives a sense of individuality when viewed from the side.	★★★★☆	4		Proportions are inferior to other cases because the height from the girder to the top of the pylon is higher than the height from sea level to the girder.	★★☆☆☆	2		Because of its linear and simple impression, It is difficult to design a facility that appeals as a tourist attraction.	★★★☆☆	3	
		100					85				78				82

Source：JICA Survey Team

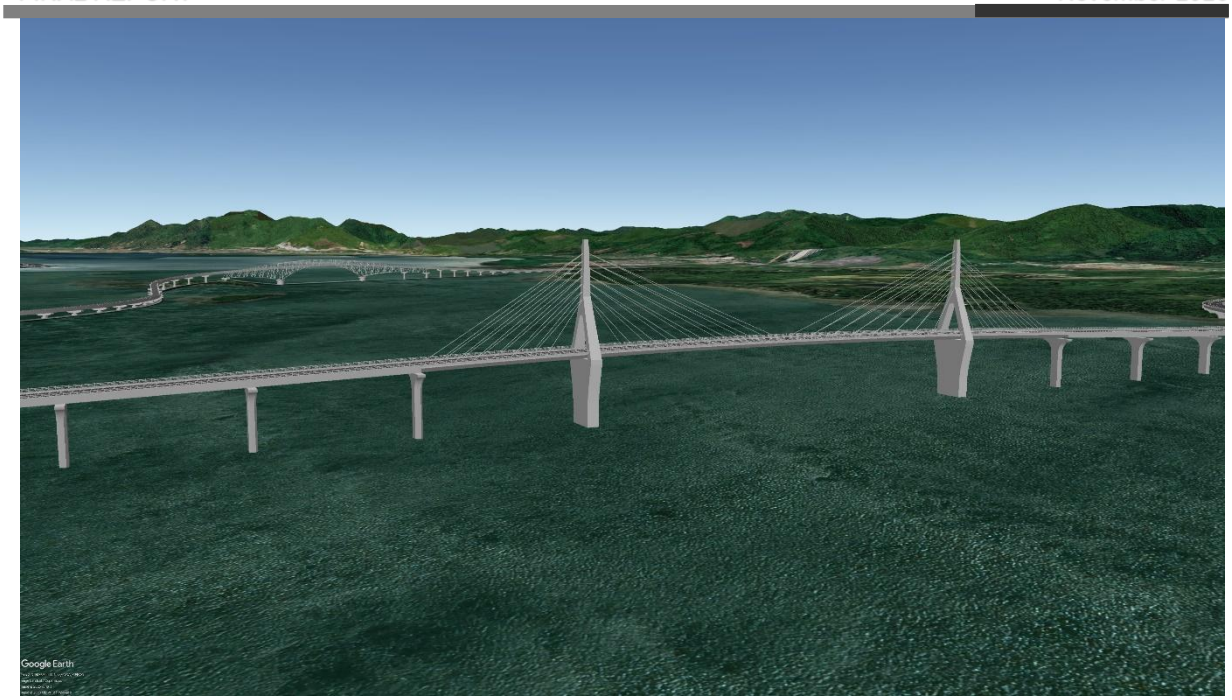


Source: JICA Survey Team



Source: JICA Survey Team

Figure 4-72 Alternative 1: Steel Arch Bridge

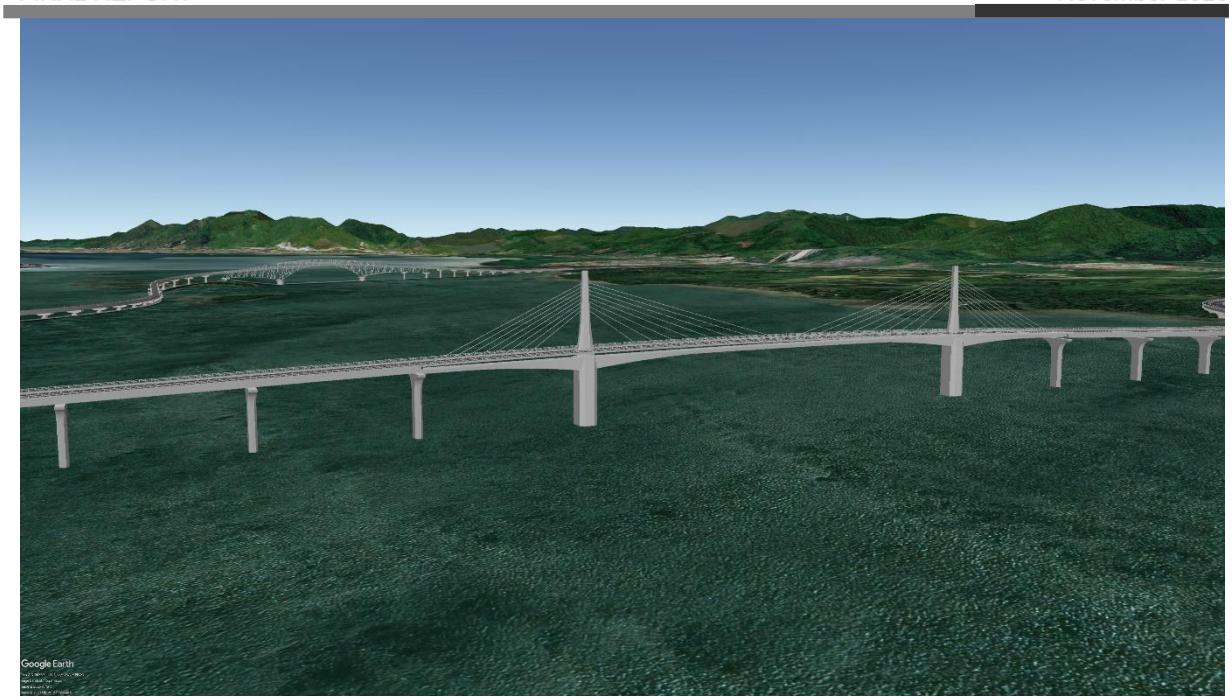


Source: JICA Survey Team



Source: JICA Survey Team

Figure 4-73 Alternative 2: PC Cable-stayed Bridge



Source: JICA Survey Team



Source: JICA Survey Team

Figure 4-74 Alternative 3: PC Extra-dosed Bridge

4.4.6 Bridge Type Selection – Approach Bridge –

(1) Choice of Alternatives

1) Approach Bridge on the Samar Island Side

The following policies guide the selection of bridge types for comparison on the Samar side:

Policy 1: The approach bridge span will generally be 40 meters, replicating the existing SJB. However, considering the impact of bridge piers at sea on cost, workability, maintainability, and aesthetics, spans of 60 and 80 meters will also be compared.

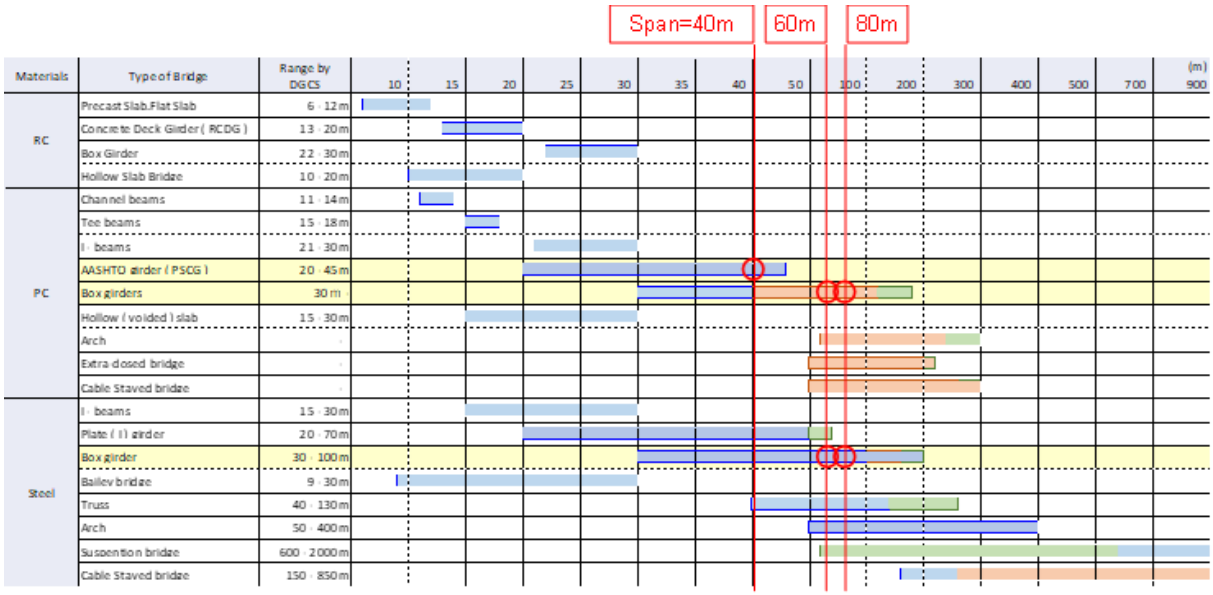
Policy 2: Continuous girder bridges are preferred for its superior earthquake resistance and maintainability.

Policy 3: Continuous girder bridges will be the standard type due to its superior earthquake resistance and maintainability.

Policy 4: According to the DGCS: “In the Philippines, AASHTO girders (precast prestressed concrete girders) are basically adopted from the perspective of workability, and only other bridge types are adopted when the span and other conditions do not conform to the application conditions for AASHTO girders.” Since a span of 40 m is within the scope of application for AASHTO girders, the only bridge type proposed for a span of 40 m is the AASHTO girder.

Policy 5: Guss asphalt pavement, which is commonly used on steel deck slabs, cannot be procured locally for construction machinery (asphalt finishers, cooker trucks, etc.), resulting in increased initial construction costs. Additionally, it poses challenges for maintenance and management. While alternative pavements are possible, they are not recommended due to their susceptibility to early and extensive damage.

Table 4-48 Applicable Bridge Types for Each Span Length on the Samar Island Side



Source: JICA Survey Team

Based on the above policies, the following bridge types are selected as the structure of the Samar approach bridge:

40 m span: AASHTO girder; 60 m span: Steel plate girder, steel narrow box girder, PC box girder; 80 m span: Steel narrow box girder, PC box girder

2) Approach Bridge on the Leyte Island Side

The following policies guide the selection of bridge types for comparison on the Leyte side:

Policy 1: The span length of the approach bridge will be based on the existing approach span of 40 m or more. However, since the piers will be located in the sea, reducing the number of piers will have a significant impact on cost, constructability, maintenance, and the surrounding landscape. Therefore, a comparative study will also be conducted on bridge types with span lengths of 60 m and 80 m.

Policy 2: Steel plate girders with low torsional rigidity will not be considered because certain sections have small curve radii.

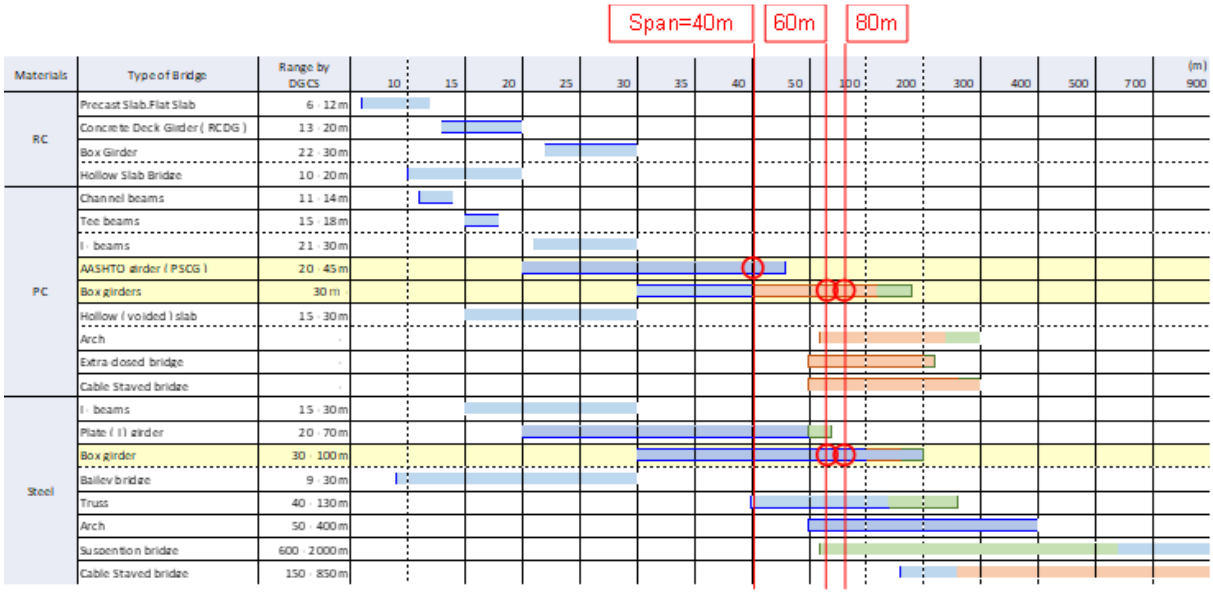
Policy 3: Continuous girder bridges will be the standard type due to its superior earthquake resistance and maintainability.

Policy 4: From the perspective of cost-effectiveness, special bridges will not be adopted; girder bridges will serve as the basic type.

Policy 5: According to the DGCS: “In the Philippines, AASHTO girders (precast prestressed concrete girders) are basically adopted from the perspective of workability, and only other bridge types are adopted when the span and other conditions do not conform to the application conditions for AASHTO girders.” Since a span of 40 m is within the scope of application for AASHTO girders, the only bridge type proposed for a span of 40 m is the AASHTO girder.

Policy 6: To minimize maintenance challenges, steel deck plates will not be used. The Philippines has limited capacity for producing bituminous macadam, the preferred paving material for steel decks. While alternative pavements are possible, they are not recommended due to their susceptibility to early and extensive damage.

Table 4-49 Applicable Bridge Types for Each Span Length on the Leyte Island Side



Source: JICA Survey Team

Based on the above policies, the following bridge types are extracted as the structure of the Leyte approach bridge.

40 m span: AASHTO girder; 60 m span: Steel box girder, steel narrow box girder, PC box girder; 80 m span: Steel narrow box girder, PC box girder.

(2) Evaluation Items

Bridge type selection is based on a comprehensive evaluation, prioritizing economic efficiency. The items and perspectives used in the comparative evaluation are summarized below.

1) Cost

In this project, the EIRR in the Pre-F/S is low, and the cost of the main bridge accounts for a large proportion of the project cost. Therefore, economic efficiency is an important item of evaluation. In addition, since O&M of the existing SJB remains an issue, the comparison is made based on LCC, including O&M costs, assuming a 100-year service life.

2) Structural Properties

- **Wind Resistance**

The site is frequently impacted by typhoons, as exemplified by Typhoon Haiyan in 2013, when the existing SJB was damaged and closed to traffic for several months due to repair works. To mitigate future risks, the SSJB design will prioritize structural forms resistant to divergent and vortex-induced vibrations, ensuring sufficient capacity against wind loads with a 700-year mean recurrence interval.

Table 4-50 Bridge Types Requiring Dynamic Wind Resistance Design

Bridge Types \ Phenomenon		Divergent Vibration		Vortex Induced Vibration	
		Deflection	Torsion	Deflection	Torsion
Suspension Bridge · Cable Stayed Bridge	Truss Bridge	Not Required	Required	Not Required	Not required
	Steel Box Girder	Required	Required	Required	Required
	PC Box Girder	Not required	Required	Required	Required
Steel Girder	Box Girder	Required	Not Required	Required	Not Required
	Plate Girder	Required	Required	Required	Required

Source: Wind Resistant Design Manual for Highway Bridges

- **Seismic Resistance**

The site frequently experiences earthquakes. The bridge design will prioritize safety against seismic events using standards to verify and ensure the required safety levels. However, considering the uncertainties inherent in actual structural seismic behavior, designs that incorporate excellent redundancy are highly advantageous. Structures that minimize the impact of inertia forces will be highly evaluated.

- **Ship Collision**

During severe weather events like typhoons, ships may lose control and collide with the approach bridge piers. Such collisions could cause serious damage to the bridge structure. Therefore, structural forms that minimize the risk of ship collisions are highly valued in the evaluation.

3) Workability

The bridge is located in an area prone to earthquakes and typhoons. To ensure safe construction, bridge types will be evaluated in terms of stability during construction.

- **Stability During Construction**

During erection, the bridge structure may experience instability, for example, during cantilever erection of girders. Bridge types with shorter periods of instability will be highly evaluated.

- **Construction Period**

The bridge is expected to be completed as soon as possible, as it will serve as a replacement for the existing SJB during reinforcement work. In order to achieve the benefits of the road improvement, bridge types with shorter construction periods will be highly evaluated.

4) Operation and Maintenance

It is important for the road network to function promptly during emergencies. Bridge types will be evaluated in terms of frequency of required repairs and ease of inspection.

- **Frequency of Repair**

Because the bridge is offshore, extensive construction work may be required, such as the installation of scaffolding.

- **Ease of Inspection**

The ability to reliably and easily ascertain the condition of a bridge is important from the perspective of securing the network in the event of a disaster. Bridge types that require fewer inspection points and provide easy access to these points will be highly evaluated.

5) Landscape

The extended length of the approach bridge raises concerns about potential environmental and landscape impact during construction.

- **Impact on the Surrounding Environment**

The strait, including the proposed bridge location, is home to valuable ecosystems such as mangroves and coral reefs. Structures that minimize impacts on these ecosystems during the approach bridge’s construction are prioritized.

- **Bridge Design**

Structures that present a visually simple and uncluttered appearance for the approach bridge are preferred.

- **Harmony with the Main Bridge**

Given the approach bridge's visual proximity to the main bridge, structural designs that harmonize aesthetically with the main bridge are prioritized.

6) Weight of the Evaluation Items

The weights of the evaluation items are shown in Table 4-51. Cost is set as the most significant factor, with a score distribution of 50 points. Other criteria are allocated five, six, and two points. Driving comfort and smoothness were not included in the evaluation, as they do not make a difference between the alternatives.

(Example of Weighting)
1. Cost: 40-50 points, 2. Structure: 10-15 points, 3. Workability: 10-15 points,
4. Road Performance: 0-5 points, 5. Environmental Impact: 0-5 points, 6. O&M: 20-25 points

Source：Hokuriku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

Figure 4-75 Reference for Weighting

Table 4-51 Weight of Evaluation Items

Category	Evaluation Item	Weighted Score	
1. Cost	1.1) Const. Cost: Life Cycle Cost = Initial cost + Maintenance cost	50	
2. Structure	2.1) Wind Resistance: Typhoons occur frequently at the bridge location. A bridge type that is less likely to cause vibrations is highly rated.	5	15
	2.2) Seismic Resistance: Earthquakes occur frequently at the bridge location. Seismically resistant bridge types are highly rated.	5	
	2.3) Ship Collision: The structure is highly rated for its low risk of collisions with ships that have lost control, such as during typhoons.	5	
3. Workability	3.1) Stability: Structures with high structural stability during construction are rated.	5	15
	3.2) Period: Structural types with short construction periods are highly rated.	5	
	3.3) Const. Yard: Structural types that require a small construction yard are highly rated.	5	
4. O&M	4.1) Frequency and Scale of Repair: Bridge types that require less frequent repairs and small scale of repair are highly rated.	5	10
	4.2) Ease of Inspection: The structural type which requires fewer inspections and allows easy access to the areas of interest is highly rated.	5	
5. Landscape*	5.1) Harmony with the surroundings: The aesthetic harmony of the structure with the surroundings and the existing SJB is highly rated.	6	10
	5.2) Bridge Aesthetics: An excellent design of the bridge itself is highly rated.	2	
	5.3) Harmony with Main Bridge: The aesthetic harmony of the structure with the main bridge is highly rated.	2	
Total Weighted Score		100	

* The assessment of landscape quality incorporates the opinions of experts. (Appendix-I Opinions on the Landscape Design of the SSJB)

Source：JICA Survey Team

The following is a comparison with the evaluation items in the “Guide for Bridge Planning and Bridge Type Selection”, which is used as a reference for bridge type selection.

Table 4-52 Comparison with the Evaluation Items

Evaluation Items in the "Guide for Bridge Planning and Bridge Type Selection”		Response at SSJB
Structural Complementarity (Structural Properties)	Safety and reliability of the structure (whether verified by actual performance, new technology, etc.)	Not applicable since there is no difference in the comparison proposal.
	Seismic performance of structures and restoration after functional failure	Evaluation by (2.2)
	Driving safety (e.g., consideration for crossing over, icy road surfaces, falling snow, etc.)	Not applicable since there is no difference in the comparison proposal.
Reliability and Ease of Maintenance (Maintenance)	Difficulty of repair (damage expected is common, need for alternative paths)	Evaluation by (4.1)
	Environmental conditions (e.g., proximity to overseas lines, effects of anti-freeze, etc.)	recorded in the economics of (1.1)
	Constraints such as crossing property, etc. (construction time constraints for repair, construction yard)	Not applicable since there is no difference in the comparison proposal.
	Reliability and ease of periodic inspection (proximity inspection method, inspection flow line, etc.)	Evaluation by (4.2)
Certainty and Ease of Ensuring Construction Quality (Workability)	Construction time constraints, regulations, and impact	Evaluation by (3.2)
	Whether or not girders, etc. can be transported to the bridge location, the entry road, etc. to the site	Evaluation by (3.3)
	Long and short on-site construction period	Evaluation by (3.2)
	Reliability of general or special construction methods	No special construction methods are used in each proposal.
	Safety during construction	Evaluation by (3.1)
	Impact on completed construction in the case of temporary construction	It is a construction in a completed system.
Harmony with the Surrounding Environment (Environmental)	Noise and vibration during construction and operation	Not applicable because there are no private houses, etc. in the vicinity.
	Impact on valuable species and ecosystems	Evaluation by (5.1)
	Impact on properties with crossings	No intersecting properties.
	The beauty of the bridge and its harmony with the surrounding environment	Evaluated by (5.2) and (5.3)
Economy (Saving Money)	Life cycle cost (initial construction cost + maintenance cost)	Evaluation by (1.1)

Source：JICA Survey Team

(3) Results of Bridge Type Selection for Approach Bridge

As a result of the multi-criteria evaluation, “Alternative 1: AASHTO Girder Bridge (span length: 40 m)”, which has the highest overall score, was selected as the structural type for the approach bridge of the SSJB, although it is slightly inferior in terms of economic efficiency. Table 4-53 and Table 4-54 provide a detailed comparative analysis of the considered alternatives.

Table 4-53 Results of the Bridge Type Selection for Approach Bridge (Samar Island Side)

Samar Side Approach Viaduct: Structural Type Comparison (Bridge Length 525m, Straight Bridge)																							
PROPOSED STRUCTURES				40m-SPAN			60m-SPAN									80m-SPAN							
				ALT 1：AASHTO GIRDER			ALT 2：STEEL I-GIRDER			ALT 3：NARROW STEEL BOX GIRDER			ALT 4：PC BOX GIRDER			ALT 5：NARROW STEEL BOX GIRDER			ALT 6：PC BOX GIRDER				
ITEM		PTS.	ASSESMENT CRITERIA	EVALUATION OF EACH OPTION																			
ECONOMY			INITIAL COST	SUPERSTR.		(1.00)	上部工		(1.72)	上部工		(1.75)	上部工		(1.87)	上部工		(2.21)	上部工		(1.98)		
				SUBSTR.		(2.05)	下部工・基礎		(1.25)	下部工・基礎		(1.25)	下部工・基礎		(1.42)	下部工・基礎		(1.00)	下部工・基礎		(1.32)		
50				TOTAL		(1.00)	＜合計＞		(1.16)	＜合計＞		(1.17)	＜合計＞		(1.27)	＜合計＞		(1.33)	＜合計＞		(1.30)		
			MAINTENANCE COST			(1.03)			(1.02)			(1.04)			(1.00)			(1.06)			(1.04)		
			LIFE CYCLE COST RATIO			(1.00)			(1.12)			(1.13)			(1.20)			(1.25)			(1.23)		
		50	RATIO FROM THE MOST ECONOMICAL TYPE <a/b=50/ratio>	MOST ECONOMICAL		50	2ND MOST ECONOMICAL		44	3RD MOST ECONOMICAL		43	4TH MOST ECONOMICAL		40	5TH MOST ECONOMICAL		37	LEAST ECONOMICAL		38		
STRUCTURAL INTEGRITY	WIND RESISTANCE	5	Since the location is typhoon prone, wind-resistant designs are preferred.	The PC girder's heavy weight provides good wind resistance.	★★★★★		The steel bridge's light weight and low torsional rigidity lead to poor wind resistance.	★★☆☆☆		While lightweight, the steel bridge's box girder design provides high torsional rigidity, resulting in mode rately good wind resistance.	★★★☆☆		The PC girder's heavy weight provides good wind resistance.	★★★★★		This structure offers excellent driving comfort due to the reduced number of expansion joints.	★★★☆☆		The PC girder's heavy weight provides good wind resistance.	★★★★★		
	SEISMIC RESISTANCE	5	Earthquake-resistant bridge designs minimizing component damage are preferred at this seismically active location.	The weight per substructure is the third smallest, resulting in moderately low susceptibility to unforeseen seismic events	★★★★☆	11	This structural design has the lowest weight on each substructure, making it the design least affected by unanticipated earthquakes.	★★★★★	10	This structural design has the second-lowest weight on each substructure, making it a design less affected by unanticipated	★★★★★	11	This structural design has the second-highest weight on each substructure, making it a design more susceptible to damage from	★★☆☆☆	10	This structural design has the third-highest weight on each substructure, making it moderately susceptible to damage from unanticipated	★★★☆☆	10	This structural design has the heaviest weight on each substructure, making it the most vulnerable design to damage from unanticipated	★☆☆☆☆	10	
15	SHIP COLLISION RESISTANCE	5	Bridge designs minimizing damage from uncontrolled vessel collisions, especially during typhoons, are preferred.	Has the highest number of piers compared to other options, leading to an increased risk of ship collisions	★★☆☆☆		This structure has fewer number of piers, resulting to a slightly higher risk of ship collisions.	★★★☆☆		This structure has fewer number of piers, resulting to a slightly higher risk of ship collisions.	★★★☆☆		This structure has fewer number of piers, resulting to a slightly higher risk of ship collisions.	★★★☆☆		This structure has the fewest piers compared to the other options, resulting in the lowest risk of ship collisions	★★★★☆		This structure has the fewest piers compared to the other options, resulting in the lowest risk of ship collisions	★★★★☆		
CONSTRUCTABILITY	CONSTRUCTION STABILITY	5	Structures that maintain high stability during construction, particularly during phases where structural instability is anticipated, are preferred.	Prefabricated girders, erected with specialized equipment, ensure high stability throughout construction.	★★★★☆		Prefabricated girders offer limited torsional rigidity before deck slab installation, posing a stability risk during erection.	★★☆☆☆		Using prefabricated girders supported by specialized equipment during erection ensures high stability throughout construction.	★★★★☆		Adopting cantilever construction method results in an inherently unstable structural state during the construction period.	★★☆☆☆		Using prefabricated girders supported by specialized equipment during erection ensures high stability throughout construction.	★★★★☆		Adopting cantilever construction method results in an inherently unstable structural state during the construction period.	★★☆☆☆		
15	CONSTRUCTION PERIOD	5	Structures offering short construction periods are preferred.	Requiring more substructure units and on-site girder fabrication, this method has the third-longest construction timeline	★★★☆☆	9	This method's moderate substructure needs and quick prefabricated girder installation make it the third-fastest to construct	★★★★☆	9	This method is the second-fastest due to moderate substructure needs and efficient prefabricated girder use	★★★★☆	11	Moderate substructure needs combined with time-consuming on-site concrete pouring make this the slowest method	★☆☆☆☆	5	The fewest substructure units and rapid prefabricated girder installation make this the fastest construction	★★★★★	13	Despite minimal substructure units, on-site concrete pouring makes this the second-slowest construction method	★★☆☆☆	6	
	CONSTRUCTION YARD	5	Structures requiring smaller construction yards are preferred.	Yard needed for girder fabrication and storage. Large concrete plant required for considerable number of substructures.	★★☆☆☆		Yard needed for girder storage. Medium scale concrete plant required for moderate number of substructures.	★★★☆☆		Yard needed for girder storage. Medium scale concrete plant required for moderate number of substructures.	★★★☆☆		Large concrete plant required for superstructure and substructure concrete pouring.	★★☆☆☆		Yard needed for girder storage. Small concrete plant required for limited number of substructures.	★★★★☆		Large concrete plant required for superstructure and substructure concrete pouring.	★★☆☆☆		
MAINTAINABILITY	REPAIR SCOPE & FREQUENCY	5	Structures that minimize the scale and frequency of repairs throughout their service life are preferred.	Main girder section repairs needed every ~30 years. Large exposed area (I-section).	★★★☆☆		Full bridge repainting every ~50 years (long-life paint). Large exposed area (I-section).	★☆☆☆☆		Full bridge repainting every ~50 years (long-life paint). Small exposed area (box girder).	★★☆☆☆		Main girder section repairs needed every ~30 years. Small exposed area (box girder).	★★★★☆		Full bridge repainting every ~50 years (long-life paint). Small exposed area (box girder).	★★☆☆☆		Main girder section repairs needed every ~30 years. Small exposed area (box girder).	★★★★☆		
10	INSPECT ABILITY	5	Structures with minimal number of members requiring inspection are preferred.	Girder inspection easily accessible by bridge inspection vehicle. High number of substructure units and bearings require	★★☆☆☆	5	Girder inspection easily accessible by inspection vehicle. Has fewer members requiring inspection due fewer no. of substructures	★★★☆☆	4	Girder inspection easily accessible by inspection vehicle. Has fewer members requiring inspection due fewer no. of substructures	★★★☆☆	5	Girder inspection easily accessible by inspection vehicle. Has fewer members requiring inspection due fewer no. of substructures	★★★☆☆	7	Girder inspection easily accessible by inspection vehicle. Fewest no. of members requiring inspec tion due to the small qty of	★★★★☆	6	Girder inspection easily accessible by inspection vehicle. Fewest no. of members requiring inspec tion due to the small qty of	★★★★☆	8	
ENVIRONMENTAL & SCENIC	LOCAL ENVIRONMENTAL IMPACT	6	Structures with minimal impact on endangered species and ecosystems are preferred.	High number of substructures, significantly impacting the ecosystem.	★★☆☆☆☆		Moderate number of substructures, resulting in a somewhat low impact on the ecosystem.	★★★★☆☆		Moderate number of substructures, resulting in a somewhat low impact on the ecosystem.	★★★★☆☆		Moderate number of substructures, resulting in a somewhat low impact on the ecosystem.	★★★★☆☆		Low number of substructures, resulting in a low impact on the ecosystem.	★★★★★★		Low number of substructures, resulting in a low impact on the ecosystem.	★★★★★★		
10	BRIDGE STRUCTURE DESIGN	2	Structures offering visual simplicity and elegance, particularly in the approach bridge's overall aesthetic, are preferred.	Lowest girder height. Many substructures, resulting in poor visual permeability and a catastrophically cluttered	★☆	4	Moderately high girder height. Moderate number of substructures, potentially offering good visual	★☆	7	Moderately low girder height. Moderate number of substructures, potentially offering good visual	★★	8	Moderately low girder height. Moderate number of substructures, potentially offering good visual	★★	7	Tall girders. Few substructures, potentially offering good visual permeability.	★☆	9	Tall girders. Few substructures, potentially offering good visual permeability.	★☆	8	
	VISUAL HARMONY WITH MAIN BRIDGE	2	Bridge structures that aesthetically complement the main span are preferred.	Using a different type of prestressed concrete bridge than the main bridge creates a slight visual disharmony	★☆		Matching the main bridge with a steel bridge creates a sense of visual unity.	★★		Matching the main bridge with a steel bridge creates a sense of visual unity.	★★		Using a different type of prestressed concrete bridge than the main bridge creates a slight visual disharmony	★☆		Matching the main bridge with a steel bridge creates a sense of visual unity.	★★		Using a different type of prestressed concrete bridge than the main bridge creates a slight visual disharmony	★☆		
		100				79			74			78			69			75			70		

Source：JICA Survey Team

Table 4-54 Results of the Bridge Type Selection for Approach Bridge (Leyte Island Side)

Leyte Side Approach Viaduct: Structural Type Comparison (Bridge Length 700m, Curved Bridge)																							
PROPOSED STRUCTURES				40m-SPAN			60m-SPAN									80m-SPAN							
				ALT 1: AASHTO GIRDER			ALT 2: STEEL BOX GIRDER			ALT 3: NARROW STEEL BOX GIRDER			ALT 4: PC BOX GIRDER			ALT 5: NARROW STEEL BOX GIRDER			ALT 6: PC BOX GIRDER				
ITEM		PTS.	ASSESMENT CRITERIA	EVALUATION OF EACH OPTION																			
ECONOMY			INITIAL COST	SUPERSTR. 2,970,000千円 (1.00) SUBSTR. 3,070,000千円 (2.13) TOTAL 6,040,000千円 (1.00)			SUPERSTR. 5,730,000千円 (1.93) SUBSTR. 1,880,000千円 (1.31) TOTAL 7,610,000千円 (1.26)			SUPERSTR. 5,190,000千円 (1.75) SUBSTR. 1,880,000千円 (1.31) TOTAL 7,070,000千円 (1.17)			SUPERSTR. 5,570,000千円 (1.88) SUBSTR. 1,990,000千円 (1.38) TOTAL 7,560,000千円 (1.25)			SUPERSTR. 6,570,000千円 (2.21) SUBSTR. 1,440,000千円 (1.00) TOTAL 8,010,000千円 (1.33)			SUPERSTR. 5,896,800千円 (1.99) SUBSTR. 1,900,000千円 (1.32) TOTAL 7,796,800千円 (1.29)		
50			MAINTENANCE COST	2,069,000千円 (1.03)			2,115,000千円 (1.05)			2,115,000千円 (1.05)			2,013,000千円 (1.00)			2,125,000千円 (1.06)			2,122,000千円 (1.05)				
			LIFE CYCLE COST RATIO	8,109,000千円 (1.00)			9,725,000千円 (1.19)			9,185,000千円 (1.13)			9,573,000千円 (1.18)			########## (1.24)			9,918,800千円 (1.22)				
		50	RATIO FROM THE MOST ECONOMICAL TYPE	MOST ECONOMICAL		50	3RD MOST ECONOMICAL		40	2ND MOST ECONOMICAL		43	4TH MOST ECONOMICAL		40	5TH MOST ECONOMICAL		37	LEAST ECONOMICAL		38		
STRUCTURAL INTEGRITY	WIND RESISTANCE	5	Since the location is typhoon prone, wind-resistant designs are preferred.	PC girders' substantial weight provides good wind resistance.	★★★★★		While lightweight, the steel bridge's box girder design provides high torsional rigidity, resulting in mode rately good wind resistance.	★★★☆☆		The steel bridge, though lightweight, offers moder ately good wind resistance due to its torsionally rigid box girder design.	★★★☆☆		The PC girder's heavy weight provides good wind resistance.	★★★★★		Despite its light weight, the steel box girder bridge exhibits moderately good wind stability due to its high torsional rigidity.	★★★☆☆		The PC girder's heavy weight provides good wind resistance.	★★★★★		
15	SEISMIC RESISTANCE	5	Earthquake-resistant bridge designs minimizing component damage are preferred at this seismically active location.	This structure has the third-lowest weight on each substructure, making it a design less affected by unanticipated earthquakes.	★★★★☆	11	The weight per substructure is second-lowest, but its susceptibility to unforeseen seismic events is moderate.	★★★★★	11	This structure minimizes weight per substructure and exhibits relatively low susceptibility to unforeseen seismic events.	★★★★★	11	The weight per substructure is the second highest, making it moderately susceptible to unforeseen seismic events.	★★☆☆☆	10	The weight per substructure is the third highest, leading to moderate susceptibility to unforeseen seismic events.	★★★☆☆	10	This has the heaviest weight per substructure, making it the most vulnerable to unforeseen seismic events.	★☆☆☆☆	10	
	SHIP COLLISION RESISTANCE	5	Bridge designs minimizing damage from uncontrolled vessel collisions, especially during typhoons, are preferred.	Having the highest number of piers among the alternatives, this stucture presents a heightened risk of ship collisions.	★★☆☆☆		This structure has an ave. number of piers, resulting in a slightly elevated risk of ship collisions compared to other options.	★★★☆☆		This structure has an ave. number of piers, resulting in a slightly elevated risk of ship collisions compared to other options.	★★★☆☆		This structure has an ave. number of piers, resulting in a slightly elevated risk of ship collisions compared to other options.	★★★☆☆		This structure has the fewest piers compared to the other options, resulting in the lowest risk of ship collisions.	★★★★☆		This structure has the fewest piers compared to the other options, resulting in the lowest risk of ship collisions.	★★★★☆		
CONSTRUCTABILITY	CONSTRUCTION STABILITY	5	Structures that maintain high stability during construction, particularly during phases where structural instability is anticipated, are preferred.	Prefabricated girders, erected with specialized equipment, ensure high stability throughout construction.	★★★★☆		Using prefabricated girders supported by specialized equipment during erection ensures high stability throughout construction.	★★★★☆		Using prefabricated girders supported by specialized equipment during erection ensures high stability throughout construction.	★★★★☆		Adopting cantilever construction method results in an inherently unstable structural state during the construction period.	★★☆☆☆		Using prefabricated girders supported by specialized equipment during erection ensures high stability throughout construction.	★★★★☆		Adopting cantilever construction method results in an inherently unstable structural state during the construction period.	★★☆☆☆		
15	CONTRUCTION PERIOD	5	Structures offering short construction periods are preferred.	Requiring more substructure units and on-site girder fabrication, this method has the third-longest construction timeline.	★★★☆☆	9	Moderate substructure needs and quick prefab bricated girder installation make this the third-fastest construction method.	★★★★☆	11	This method is the second-fastest due to moderate substructure needs and efficient prefabricated girder use.	★★★★☆	11	Moderate substructure needs combined with time-consuming on-site concrete pouring make this the slowest method.	★☆☆☆☆	5	The fewest substructure units and rapid prefabricated girder installation make this the fastest construction.	★★★★★	13	Despite minimal substructure units, on-site concrete pouring makes this the second-slowest construction method.	★★☆☆☆	6	
	CONSTRUCTION YARD	5	Structures requiring smaller construction yards are preferred.	Yard needed for girder fabrication and storage. Large concrete plant required due to many substructures.	★★☆☆☆		Yard needed for girder storage. Medium scale concrete plant required for moderate number of substructures.	★★★☆☆		Yard needed for girder storage. Medium scale concrete plant required for moderate number of substructures.	★★★☆☆		Large concrete plant required for superstructure and substructure concrete pouring.	★★☆☆☆		Yard needed for girder storage. Small concrete plant required for small number of substructures.	★★★★☆		Large concrete plant required for superstructure and substructure concrete pouring.	★★☆☆☆		
MAINTAINABILITY	REPAIR SCOPE & FREQUENCY	5	Structures that minimize the scale and frequency of repairs throughout their service life are preferred.	Main girder section repairs needed every ~30 years. Large exposed area (I-section).	★★★☆☆		Full bridge repainting every ~50 years (long-life paint). Small exposed area (box girder).	★★☆☆☆		Full bridge repainting every ~50 years (long-life paint). Small exposed area (box girder).	★★☆☆☆		Main girder section repairs needed every ~30 years. Small exposed area (box girder).	★★★★☆		Full bridge repainting every ~50 years (long-life paint). Small exposed area (box girder).	★★☆☆☆		Main girder section repairs needed every ~30 years. Small exposed area (box girder).	★★★★☆		
10	INSPECTABILITY	5	Structures with minimal number of members requiring inspection are preferred.	Girder inspection easily accessible by bridge inspection vehicle. High number of substructure units and bearings require	★★☆☆☆	5	Girder inspection easily accessible by inspection vehicle. Has fewer members requiring inspection due fewer no. of substructures	★★★☆☆	5	Girder inspection easily accessible by inspection vehicle. Has fewer members requiring inspection due fewer no. of substructures	★★★☆☆	5	Girder inspection easily accessible by inspection vehicle. Has fewer members requiring inspection due fewer no. of substructures	★★★☆☆	7	Girder inspection easily accessible by inspection vehicle. Fewest no. of members requiring inspec tion due to the small qty of	★★★★☆	6	Girder inspection easily accessible by inspection vehicle. Fewest no. of members requiring inspec tion due to the small qty of	★★★★☆	8	
ENVIRONMENTAL & SCENIC	HARMONY W/ THE EXISTING BRIDGE & ENVIRONMEN	6	Structures with minimal impact on endangered species and ecosystems are preferred.	High number of substructures, significantly impacting the ecosystem.	★★☆☆ ☆☆		Moderate number of substructures, resulting in a somewhat low impact on the ecosystem.	★★★★ ☆☆		Moderate number of substructures, resulting in a somewhat low impact on the ecosystem.	★★★★ ☆☆		Moderate number of substructures, resulting in a somewhat low impact on the ecosystem.	★★★★ ☆☆		Low number of substructures, resulting in a low impact on the ecosystem.	★★★★ ★★		Low number of substructures, resulting in a low impact on the ecosystem.	★★★★ ★★		
10	BRIDGE STRUCTURE DESIGN	2	Structures offering visual simplicity and elegance, particularly in the approach bridge's overall aesthetic, are preferred.	Lowest girder height. Many substructures, resulting in poor visual permeability and a potentially cluttered	★☆	4	Moderately high girder height. Moderate number of substructures, potentially offering good visual	★★	8	Moderately low girder height. Moderate number of substructures, potentially offering good visual	★★	8	Moderately low girder height. Moderate number of substructures, potentially offering good visual	★★	7	Tall girders. Few substructures, potentially offering good visual permeability.	★☆	9	Tall girders. Few substructures, potentially offering good visual permeability.	★☆	8	
	VISUAL HARMONY WITH MAIN BRIDGE	2	Designs that achieve aesthetic continuity with adjacent structures along the entire 1.5km total span are desirable.	Using a different type of prestressed concrete bridge than the main bridge creates a slight visual	★☆		Matching the main bridge with a steel bridge creates a sense of visual unity.	★★		Matching the main bridge with a steel bridge creates a sense of visual unity.	★★		Using a different type of prestressed concrete bridge than the main bridge creates a slight visual	★☆		Matching the main bridge with a steel bridge creates a sense of visual unity.	★★		Using a different type of prestressed concrete bridge than the main bridge creates a slight visual	★☆		
		100				79			75			78			69			75			70		

Source：JICA Survey Team

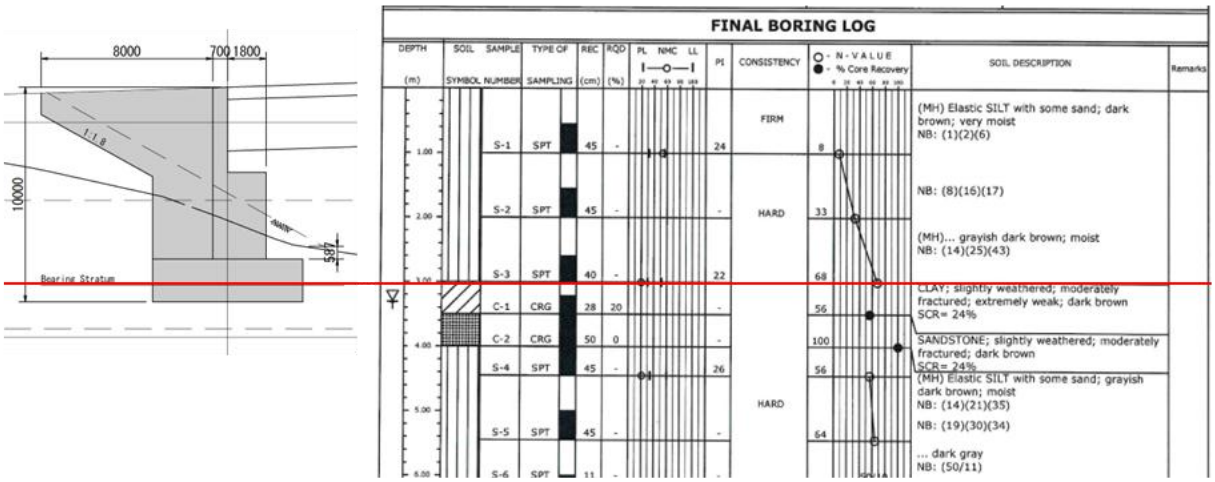
4.5 Bridge Foundation Type Selection

4.5.1 Selection of Abutment Foundation Type for Overland Section

(1) Definition of Bearing Layer

1) A1 Abutment

Geotechnical investigations near the A1 abutment identified a C1 layer (clay, N-value > 50) at about 3.0 m depth. However, using the C1 layer as the bearing stratum for a shallow foundation would place the base above the mean higher high water (MHHW), making it impossible to account for overburden depth that stabilizes against circular slip, thus not satisfying the ultimate bearing capacity check. Therefore, it is not adopted. Instead, the bearing layer will be the C3 layer (bedrock), which allows for higher characteristic values of pile end bearing capacity.

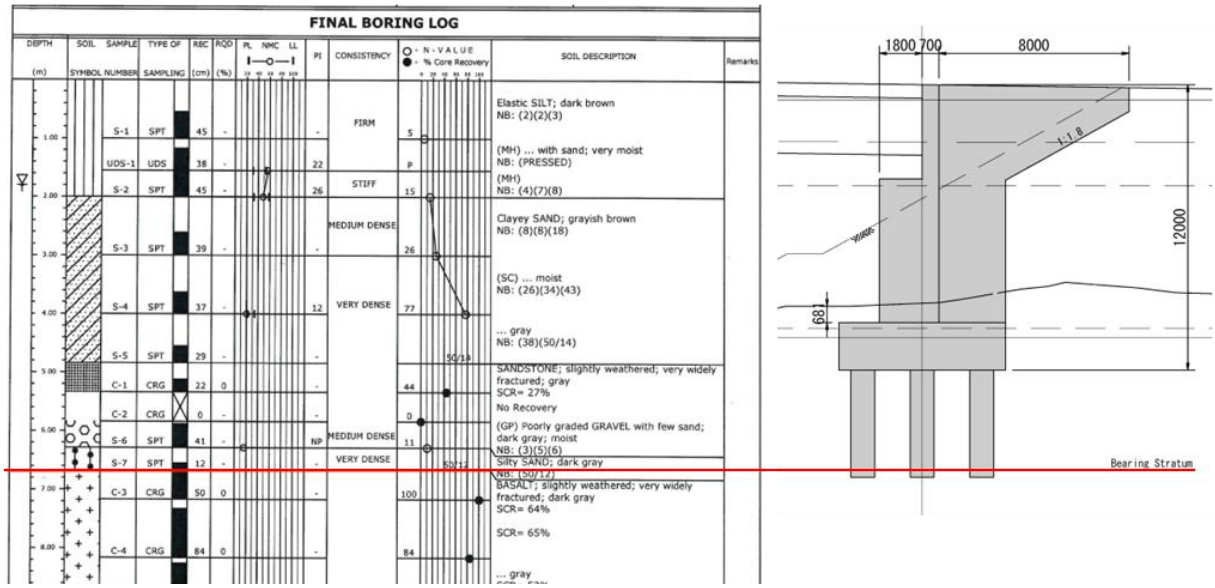


Source：JICA Survey Team

Figure 4-76 Geological Conditions Near A1 Abutment

2) A2 Abutment

Near the A2 abutment, a hard sand layer is found at approximately 4 m depth, but a very soft silty sand layer exists around 6 m. The basalt layer beneath the silty sand is considered suitable as the bearing layer.



Source：JICA Survey Team

Figure 4-77 Geological Conditions near A2 Abutment

(2) Selection of Foundation Type

Based on ground conditions, the following foundation options are identified. However, since there is a limited experience with precast piles in the Philippines, cast-in-place piles (all casing method) are selected for applicability, despite certain limitations.

Table 4-55 Extraction of Proposed Foundation Form - A2 Abutment

APPLICABLE SELECTION CRITERIA
EXTRACTED FOUNDATION TYPES

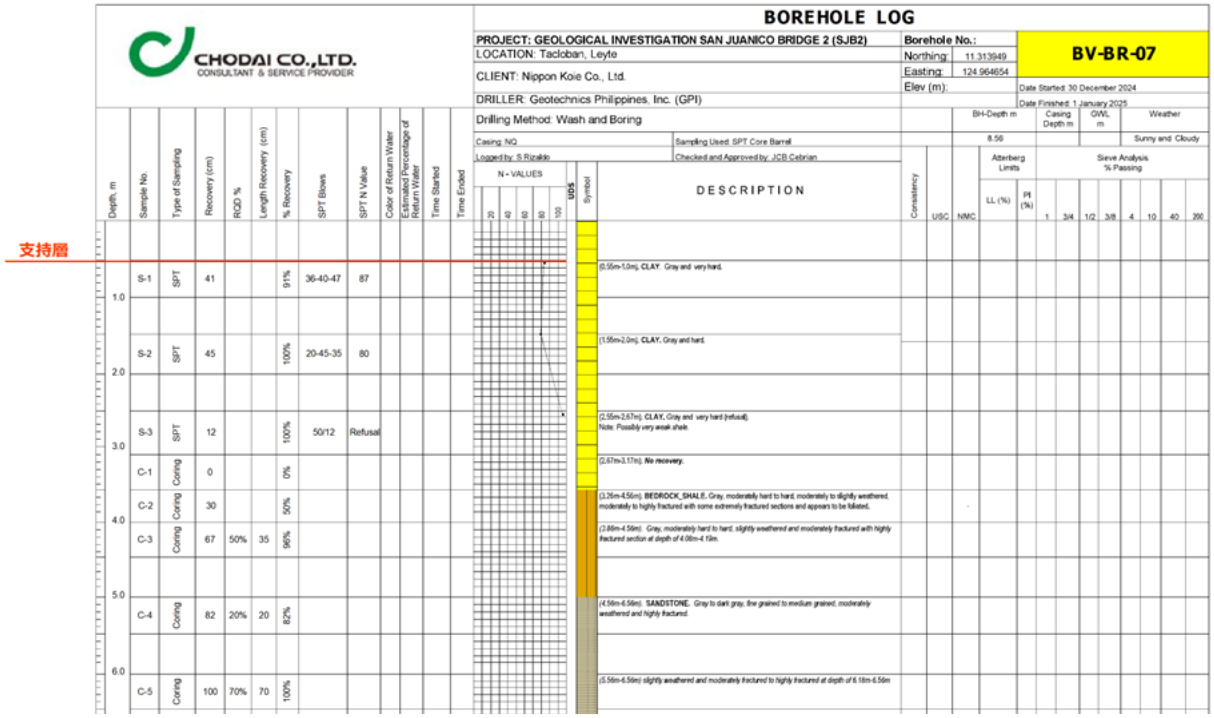
SELECTION CRITERIA \ FOUNDATION TYPE				SPREAD FOOTING	PILE FOUNDATION															DEEP FOUNDATION		CAISSON FOUNDATION		SPSP (DRIVING METHOD)	SECANT PILE WALL FOUND.
					DRIVEN PILE METHOD			BORED PILE METHOD						CEMENT PILE METHOD	STEEL PIPE SOIL	PRE-BORING METHOD	CIP PILE METHOD			ROTARY PILE METHOD	GROUP PILE FOUNDATION	DEEP FOUNDATION ELEMENT	PNEUMATIC CAISSON	OPEN CAISSON		
					PHC・SC PILE	STEEL PIPE PILE		PHC / SC PILE			STEEL PIPE PILE						ALL CASING METHOD	REVERSE (RCD) METHOD	EARTH DRILL METHOD							
						IMPACT DRIVING	VIBRO HAMMER	FINAL HAMMER BLOW	JET GROUTING	CONCRETE PLACING	FINAL HAMMER BLOW	JET GROUTING	CONCRETE PLACING												
SOIL CONDITION	SOIL ABOVE BEARING LAYER	EXTREMELY SOFT LAYER NEAR SURFACE OR MID-LA			○	○	○	○	○	○	○	○	○	○	○	○	×	○	○	○	×	×	○	△	○	○
		EXTREMELY HARD LAYER EXISTS MID-LAYER			△	△	△	○	○	○	○	○	○	○	○	○	△	○	×	○	○	○	○	△	△	○
		GRAVEL	DIAMETER ≧ 50mm		△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			DIAMETER = 50mm～100mm		△	△	○	△	△	△	△	△	△	○	○	△	×	○	○	○	○	○	○	○	△	△
			DIAMETER = 100mm～500mm		×	×	×	×	×	×	×	×	×	×	×	△	×	×	×	○	○	○	△	×	△
		LIQUEFIABLE SOIL			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○			○	○	○	○
	BEARING LAYER	DEPTH	> 5m	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○		×	×	×	×
			5m ～ 15m	△	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	○	○	△	△
			15m ～ 25m	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			25m ～ 40m	×	○	○	○	○	○	○	○	○	○	○	○	○	△	○	△	△	○	○	○	○	○
			40m ～ 60m	×	△	○	○	△	△	△	○	○	○	○	○	△	○	×	○	×	×	△	○	○	○
			≧ 60m	×	×	△	△	×	×	×	×	×	×	△	△	×	△	×	○	×	×	×	△	△	△
		TYPE SOIL	SAND・GRAVEL (N ≧ 30)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			CLAY (N ≧ 20)	○	○	○	○	○	△	×	○	△	×	△	△	○	○	○	△	○	○	△	△	○	○
			SOFT ROCK / TUFF	○	×	○	△	○	△	×	○	△	×	△	△	○	○	○	△	○	○	○	○	○	○
			HARD ROCK	○	×	×	×	×	×	×	×	×	×	×	×	△	△	△	×	○	○	△	×	×	△
		INCONSISTENT DEPTH OF BEARING LAYER (STEEP SLOPE, UNEEN LAYERS)		△	△	△	△	△	△	△	△	△	△	△	△	○	○	○	○	○	○	△	×	○	○
	GROUNDWATER	HIGH GROUNDWATER TABLE (≒GROUND SURFAC		△	○	○	○	○	○	○	○	○	○	○	○	△	△	△	○	△	△	○	○	○	△
		EXTREMELY HIGH GROUNDWATER DISCHARGE		×	○	○	○	○	○	○	○	○	○	△	△	△	△	△	○	×	×	○	○	○	△
		CONFINED AQUIFER, HEAD > 2m ABOVE GROUND		×	○	○	○	×	×	×	×	×	×	×	×	×	×	×	○	×	×	△	△	○	×
		GROUNDWATER VELOCITY ≧ 3m/min		×	○	○	○	○	×	×	○	×	×	×	×	×	×	×	○	×	×	○	△	○	×
TYPE OF PILE SUPPORT		POINT-BEARING / END-BEARING PILE			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○					
		FLOATING / FRICTION PILE			○	○	○	×	×	×	×	×	×	○	×	○	○	○	×							
CONSTRUCTION CONDITIONS	OVER WATER	WATER DEPTH < 5m		△	○	○	○	△	△	△	△	△	△	×	×	×	×	×	○			△	△	○	×
		WATER DEPTH ≧ 5m		×	△	○	○	△	△	△	△	△	△	×	×	×	×	×	○			△	△	○	×
	CONFINED WORKING SPACE			○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	○	○	△	△	×	△
	BATTER PILE CONSTRUCTION				○	○	○	×	×	×	×	×	×	×	×	×	×	○	×						
	HAZARDOUS GAS EFFECT				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	×	×	○	○	○
	SURROUNDINGS	VIBRATION AND NOISE CONTROL MEASURE		○	×	×	△	△	○	○	△	○	○	○	○	○	○	○	○	○	○	○	○	×	○
		ADJACENT STRUCTURE IMPACT		○	×	△	△	△	○	○	△	○	○	○	○	○	○	○	○	△	△	△	△	△	○

○ : HIGLY SUITABLE △ : SUITABLE × : NOT SUITABLE

Source : Some Additions to the Specifications for Highway Bridges

4.5.2 Selection of Foundation Type for Piers in the Marine Section

Geological surveys conducted in the offshore area reveal strong ground conditions near the seafloor surface, with N-values consistently exceeding 80.



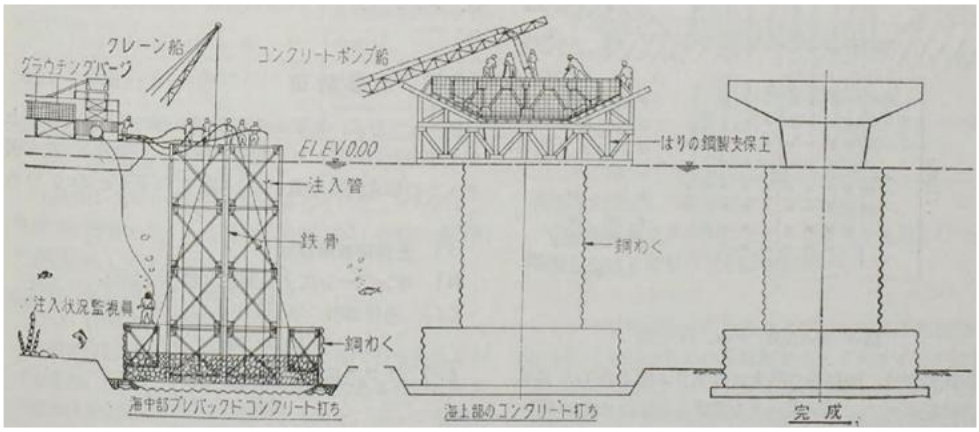
Source：JICA Survey Team

Figure 4-78 Geological Conditions Near P17 Pier

The standard foundation types shown in Table 4-56 are generally difficult to apply given the ground and construction conditions for this bridge.

A proposal to adopt a direct foundation using a temporary barrier was considered; however, this approach proved unfeasible. The water depth reaches 10 meters, necessitating a large temporary barrier. Additionally, the hard surface soil makes placing the earth retaining system challenging.

The existing SJB utilizes a direct foundation constructed with steel frames and pre-compacted concrete; however, this method is applicable only to unreinforced concrete and cannot be adopted in the design due to current standards.



Source：JICA Survey Team

Figure 4-79 Foundation Construction Method for Existing SJB

Table 4-56 Extraction of Proposed Foundation Form - Pier

SELECTION CRITERIA \ FOUNDATION TYPE				SPREAD FOOTING	PILE FOUNDATION																DEEP FOUNDATION		CAISSON FOUNDATION		SPSP (DRIVING METHOD)	SECANT PILE WALL FOUND.
					DRIVEN PILE METHOD			BORED PILE METHOD							CEMENT PILE METHOD	STEEL PIPE SOIL	PRE-BORING METHOD	CIP PILE METHOD			ROTARY PILE METHOD	GROUP PILE FOUNDATION	DEEP FOUNDATION ELEMENT	PNEUMATIC CAISSON	OPEN CAISSON		
					PHC・SC PILE	STEEL PIPE PILE		PHC / SC PILE			STEEL PIPE PILE							ALL CASING METHOD	REVERSE (RCD) METHOD	EARTH DRILL METHOD							
						IMPACT DRIVING	VIBRO HAMMER	FINAL HAMMER BLOW	JET GROUTING	CONCRETE PLACING	FINAL HAMMER BLOW	JET GROUTING	CONCRETE PLACING													
SOIL CONDITION	SOIL ABOVE BEARING LAYER	EXTREMELY SOFT LAYER NEAR SURFACE OR MID-LAY			○	○	○	○	○	○	○	○	○	○	○	○	×	○	○	○	×	×	○	△	○	○
		EXTREMELY HARD LAYER EXISTS MID-LAYEF			△	△	△	○	○	○	○	○	○	○	○	○	△	○	×	○	○	○	○	△	△	○
		GRAVEL	DIAMETER ≧ 50mm		△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			DIAMETER = 50mm～100mm		△	△	○	△	△	△	△	△	△	○	○	△	×	○	○	○	○	○	○	○	△	△
			DIAMETER = 100mm～500mm		×	×	×	×	×	×	×	×	×	×	×	△	×	×	×	○	○	○	△	×	△	
		LIQUEFIABLE SOIL			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○			○	○	○	○
	BEARING LAYER	DEPTH	＞5m	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○		×	×	×	×	
			5m ～ 15m	△	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	○	○	△	△
			15m ～ 25m	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			25m ～ 40m	×	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	△	△	○	○	○	○
			40m ～ 60m	×	△	○	○	△	△	△	○	○	○	○	○	△	○	×	○	×	×	△	○	○	○
			≧ 60m	×	×	△	△	×	×	×	×	×	×	△	△	×	△	×	○	×	×	×	△	△	△
		TYPE SOIL	SAND・GRAVEL (N ≧ 30)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			CLAY (N ≧ 20)	○	○	○	○	○	△	×	○	△	×	△	△	○	○	○	△	○	○	△	△	○	○
			SOFT ROCK / TUFF	○	×	○	△	○	△	×	○	△	×	△	△	○	○	○	△	○	○	○	○	○	○
			HARD ROCK	○	×	×	×	×	×	×	×	×	×	×	×	△	△	△	×	○	○	△	×	×	△
		INCONSISTENT DEPTH OF BEARING LAYER (STEEP SLOPE, UNEEN LAYERS)		△	△	△	△	△	△	△	△	△	△	△	△	○	○	○	○	○	○	△	×	○	○
	GROUND WATER	HIGH GROUNDWATER TABLE (=GROUND SURFACE)		△	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	○	△	△	○	○	○	△
		EXTREMELY HIGH GROUNDWATER DISCHARGI		×	○	○	○	○	○	○	○	○	○	△	△	△	△	△	○	×	×	○	○	○	△
		CONFINED AQUIFER, HEAD > 2m ABOVE GROUND		×	○	○	○	×	×	×	×	×	×	×	×	×	×	×	○	×	×	△	△	○	×
		GROUNDWATER VELOCITY ≧ 3m/min		×	○	○	○	○	×	×	○	×	×	×	×	×	×	×	○	×	×	○	△	○	×
TYPE OF PILE SUPPORT		POINT-BEARING / END-BEARING PILE			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○					
		FLOATING / FRICTION PILE			○	○	○	×	×	×	×	×	×	○	×	○	○	○	×							
CONSTRUCTION CONDITIONS	OVER WATER	WATER DEPTH < 5m		△	○	○	○	△	△	△	△	△	△	×	×	×	×	×	○			△	△	○	×
		WATER DEPTH ≧ 5m		×	△	○	○	△	△	△	△	△	△	×	×	×	×	×	○			△	△	○	×
	CONFINED WORKING SPACE			○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	○	○	△	△	×	△
	BATTER PILE CONSTRUCTION				○	○	○	×	×	×	×	×	×	×	×	×	×	×	○	×						
	HAZARDOUS GAS EFFECT				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	×	×	○	○	○
	SURROUNDINGS	VIBRATION AND NOISE CONTROL MEASURE		○	×	×	△	△	○	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	×	○
		ADJACENT STRUCTURE IMPACT		○	×	△	△	△	○	○	△	○	○	○	○	○	○	○	○	△	△	△	△	△	○

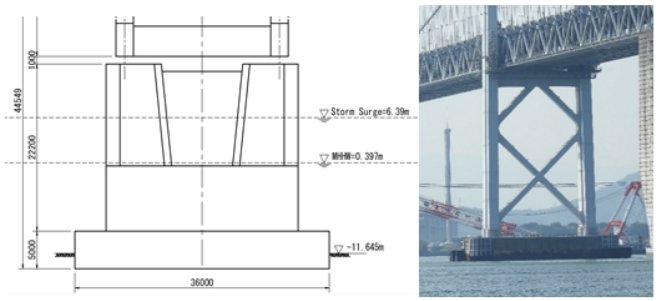
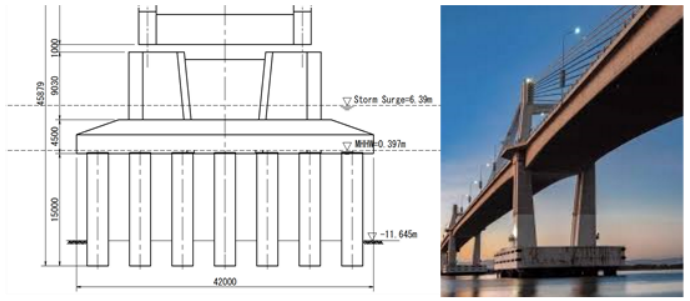
○ : HIGLY SUITABLE △ : SUITABLE × : NOT SUITABLE

Source : Some Additions to the Specifications for Highway Bridges

The Installed Caisson Method and the Multi-pillar Foundation Method, both with proven efficacy in deep-water offshore areas, were evaluated as potential foundation types for the pier locations.

The results of the comparative study of these two methods are shown on the following page. The Multi-pillar Foundation was selected as the foundation type for the piers due to its superior economic efficiency, workability, and resistance to scouring. It should be noted that both methods have confirmed stability.

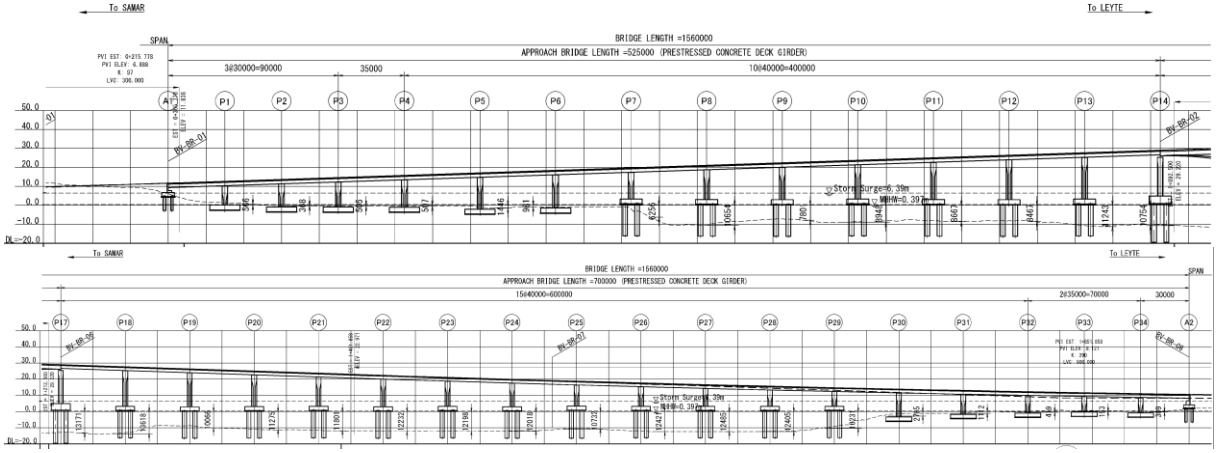
Table 4-57 Study of Foundation Types

ITEM		OPTION 1: CAISSON		OPTION 2: MULTI-COLUMN FOUNDATION	
ILLUSTRATION					
STRUCTURAL OVERVIEW		Large, prefabricated caisson structures are transported over water and sunk into their designated positions. They are then filled with concrete to create a single, unified structure, offering stable support for the bridge. This is known as the caisson foundation structure.		Multiple concrete piles are driven into the seabed, and their heads are connected by a top slab near the water surface. This distributes the load and ensures ground support, creating a multi-column foundation structure.	
STRUCTURE	CHARACTE-RISTICS	Because the footing is constructed directly on the seabed, it experiences minimal inertial forces due to its own weight.	good	Due to the top slab being situated atop protruding piles, the impact of inertial forces caused by its own weight is significant.	fair
	SCOUR RESISTANCE	Since the excavated seabed must support the structure, there are concerns about tilting and settlement of the foundation due to scour. Separate scour countermeasures will be necessary.	fair	Because the piles are embedded a certain depth below the supporting layer, the impact of scour on the foundation is minimal.Because the piles are embedded a certain depth below the supporting layer, the impact of scour on the foundation is minimal.	good
	APPLICA-TIONS	This method has been implemented in Japan, with examples including the Akashi Kaikyō Bridge and the South Bisan-Seto Bridge. However, no applications have been confirmed in the Philippines.	fair	This method has been successfully implemented in Japan, notably on the Oonaruto Bridge. It also boasts a proven track record in the Philippines, with applications on the First, Second, and Third Mactan Bridges. Furthermore, it is the chosen construction method for the New Mactan Bridge.	good
CONSTRUCT-ABILITY	DIFFICULTY	The installation of caissons in straits with strong currents that vary in speed and direction presents significant challenges. Moreover, the placement of large caissons would necessitate the mobilization of large-capacity floating cranes, which are not readily available in the Philippines.	fair	While ensuring pile-driving accuracy at sea can be slightly more demanding, it doesn't pose the same level of difficulty as caisson installation. Additionally, it doesn't require specialized equipment.	good
	PERIOD	Since the caissons are prefabricated on land and then submerged, the on-site construction period is short.	good	Due to the large number of piles that need to be driven, the on-site construction period for this option would be longer compared to option 1.	fair
SHIP COLLISION RESISTANCE		In the event of a collision with a large vessel, there is a risk of the ship's bow directly impacting the bridge pier.	fair	Due to the presence of a large, flat superstructure above the waterline, the risk of a ship's bow directly striking the bridge pier is minimal.	good
AESTHETICS		Because the footing is submerged, a clean and sleek visual appearance can be achieved.	good	The large deck, protruding above the waterline, detracts from the surrounding scenery and diminishes its visual appeal.	fair
ENVIRONMENTAL IMPACT		Extensive seabed excavation raises concerns about potential environmental impacts, particularly on water quality.	fair	The pile construction method is non-dredging, which minimizes environmental impact and promotes environmental sustainability.	good
APPROXIMATE COST RATIO		1.06	fair	1.00	good
EVALUATION				Recommend	

Source：JICA Survey Team

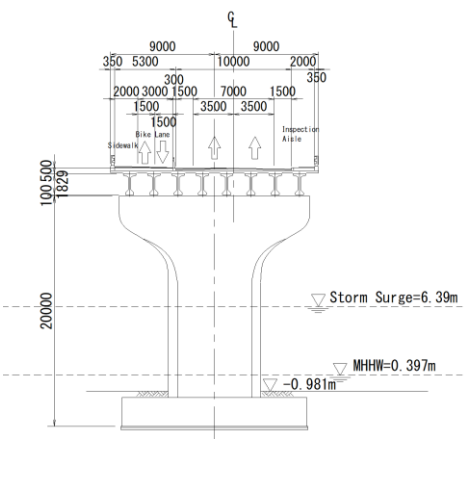
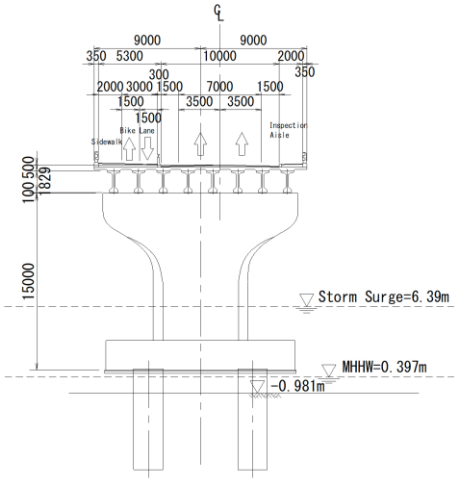
4.5.3 Selection of Foundation Type for Piers in the On-Share Section

Geological survey results indicate that bearing layers are exposed near the surface. Furthermore, since the water depth is shallow, approximately 1.0 m or less, direct foundations are proposed as a comparative alternative. Spread foundations, which offer superior cost-effectiveness and constructability, are selected.



Source：JICA Survey Team

Figure 4-80 Piers in the On-Share Section

ITEM		SPREAD FOUNDATION		MULTI-COLUMN FOUNDATION	
IMAGE					
STRUCTURE	characteristics	good		fair	
	Scour	good		good	
	Precendent	good		good	
WORKABILITY	Difficulty	good		good	
	Work Period	fair		fair	
MAINTENANCE		fair		good	
SHIP COLLISION		good		good	
AESTHETIC		good		fair	
ENVIRONMENT		fair		good	
COST RATIO		1.00	good	1.08	fair
RESULT		Recommend			

Source：JICA Survey Team

5 Natural Condition Survey

5.1 Overview of Survey

Table 5-1 shows the survey items related to natural conditions and their applications as described in this chapter.

Table 5-1 Survey Items of Natural Condition Survey and Way of Utilizing

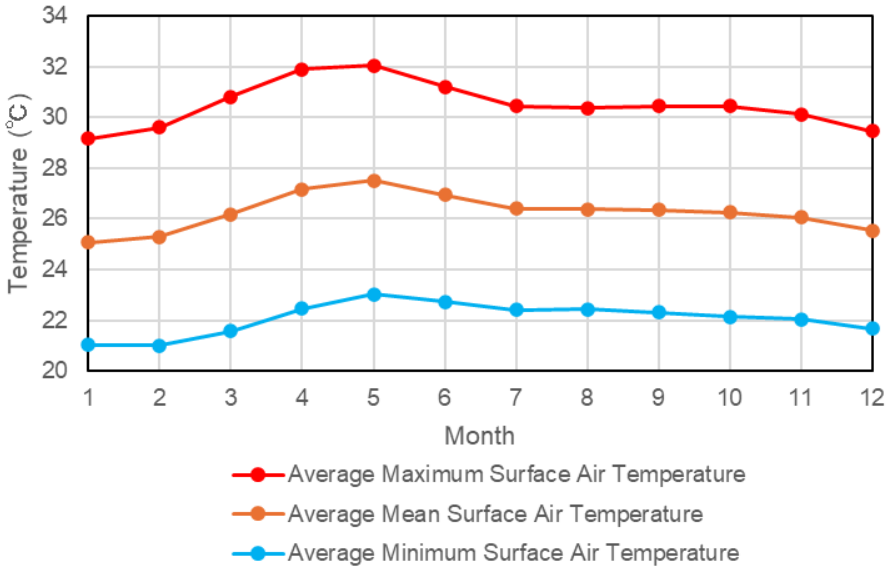
Chap.	Survey Item	Way of Utilizing
5.4.1	Rainfall Intensity	Drainage designs; consideration of unworkable days
5.4.3	Tidal Condition	Profile design (e.g., clearance for main bridge, setting formation height for embankment section)
5.5	Topographic Survey	Confirmation of site boundaries; verification of existing structures within the construction area; basis for calculating cut-and-fill volumes; condition setting for the construction plan; design basis for both permanent and temporary works; specification basis; flow pressure during substructure design; and load settings.
5.6	Geotechnical Investigation	Geological assessment for route selection; basis for selecting foundation types for structures; selection of borrow pits; and verification of subgrade material strength.
5.7	Weather Simulation	Setting design wind speed

Source: JICA Survey Team

5.2 Meteorology

5.2.1 Climate Overview of the Philippines

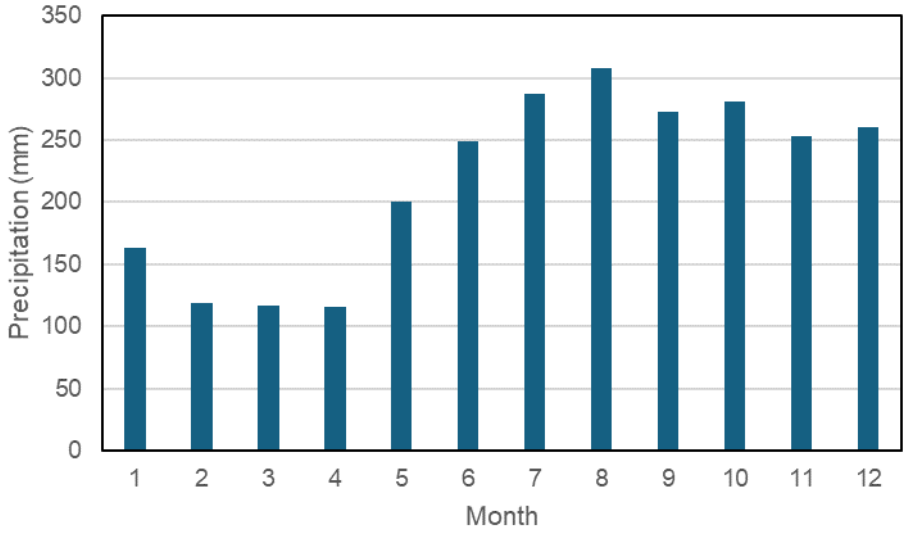
The Philippines, consisting of more than 7,000 islands, has a tropical maritime climate characterized by relatively high temperatures, high humidity, and high rainfall. The country's weather patterns are influenced by the prevailing westerly winds of the southwest monsoon from May to October and the northeast monsoon from November to early May. The average annual temperature is 26.6 °C, with January being the coolest month at 25.5 °C and May the warmest at 28.3 °C. Overall, temperature fluctuation throughout the year is minimal.



Source: Prepared by the JICA Survey Team based on the World Bank Group's "Climate Change Knowledge Portal"

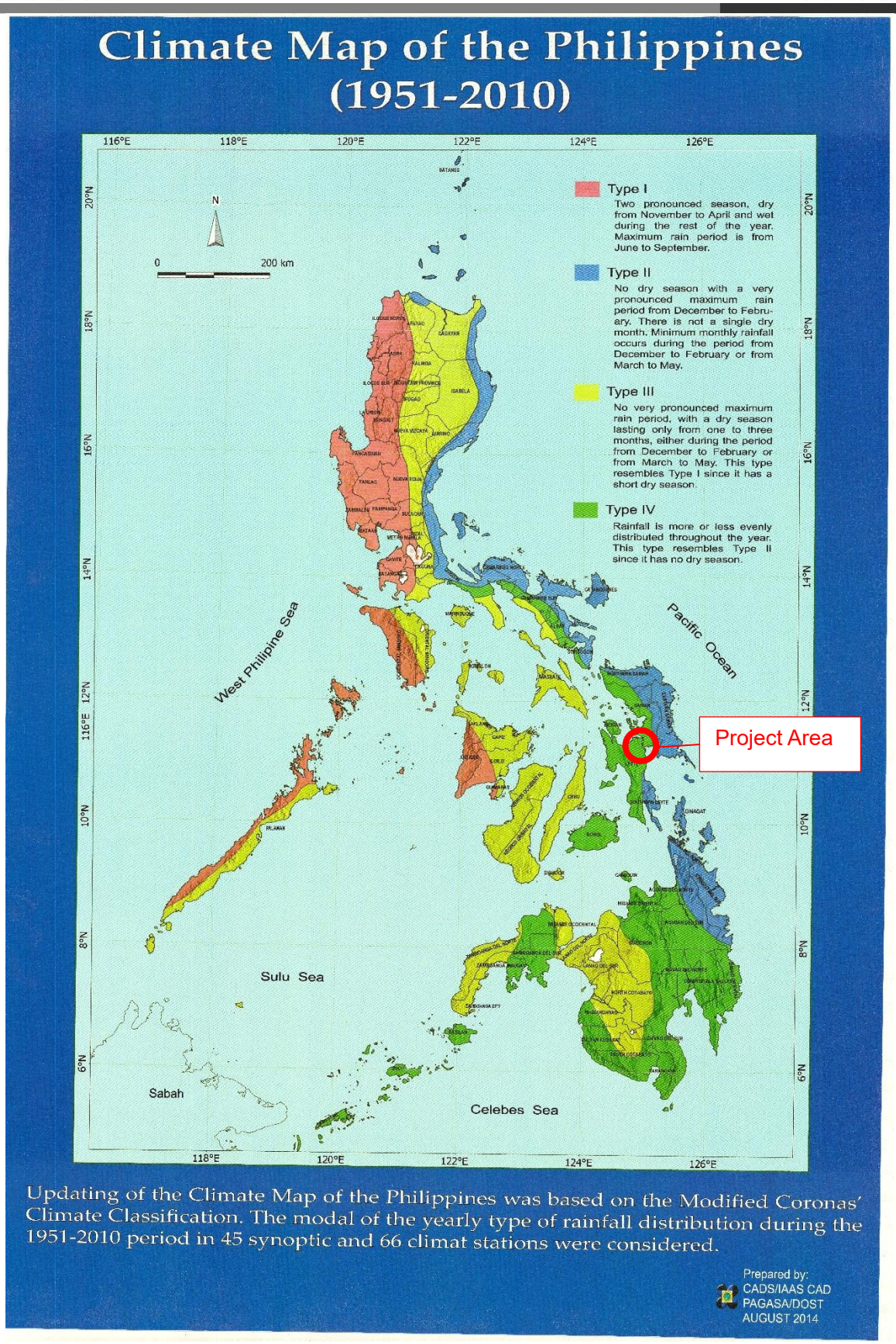
Figure 5-1 Monthly Average Temperature of the Philippines (1991-2020)

Precipitation is a more important climatic factor in the Philippines than temperature. The country's average annual precipitation exceeds 2,500 mm, but it varies widely across regions, ranging from 965 to 4,064 mm per year. Precipitation tends to be relatively higher along the coastline than in the mountains, especially along the east coast, where it reaches 3,000-4,000 mm annually. In the western region, the rainy season coincides with the summer monsoon season from May to November, while the dry season extends from December to April. In contrast, the eastern region receives more rainfall from December to April, experiencing rainfall throughout the year with no definite dry season. Based on these regional rainfall characteristics, the Philippines classifies its climate into four types, as shown in Figure 5-3.



Source: Prepared by the JICA Survey Team based on the World Bank Group's "Climate Change Knowledge Portal"

Figure 5-2 Monthly Average Rainfall of the Philippines (1991-2020)

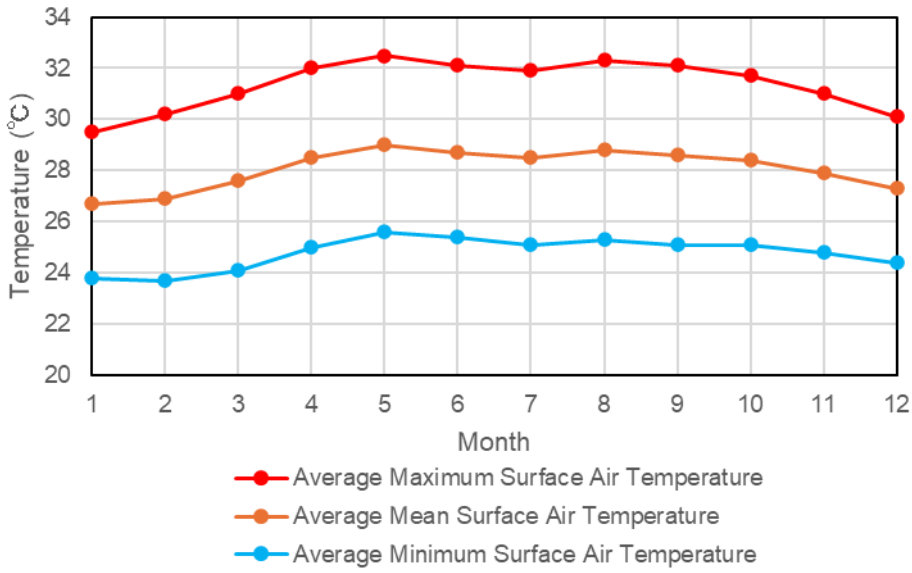


Source: PAGASA

Figure 5-3 Climate Map of the Philippines (Type I - Type IV)

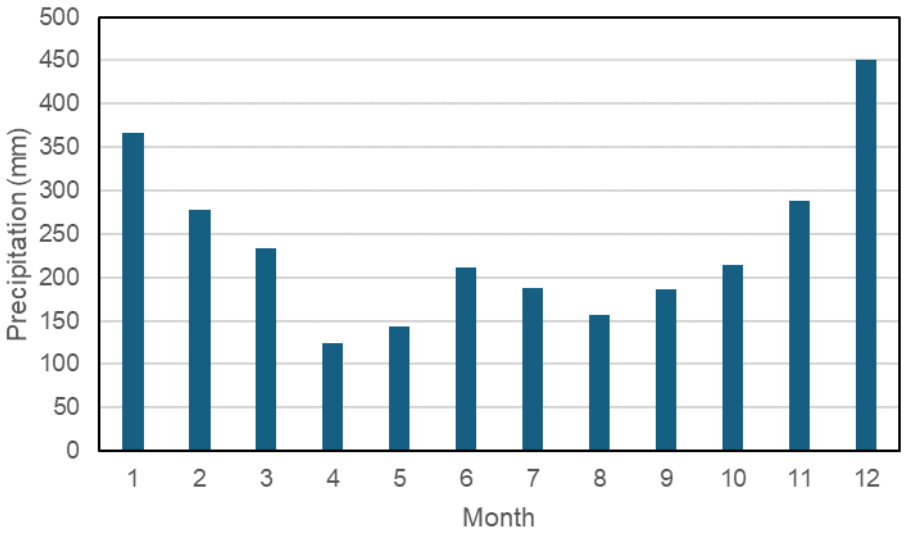
5.2.2 Conditions of the Project Site

The project area is centered on the San Juanico Strait, between the islands of Leyte and Samar in the Eastern Visayas Region. It belongs to Type IV in the aforementioned climatic classification of the Philippines, and is characterized by approximately uniform rainfall throughout the year and no dry season. The average annual temperature at the Tacloban Meteorological Station, which is closest to the project area, is 28.1 °C, which is about 1 to 2 °C higher than the average annual temperature in the Philippines as a whole. The average annual precipitation is 2,840 mm, slightly higher than the national average, but not exceptionally high for the country. The trend is toward a higher average monthly precipitation of 350-450 mm from December to January.



Source: Prepared by the JICA Survey Team based on PAGASA data

Figure 5-4 Monthly Average Temperature of Tacloban (1991-2020)



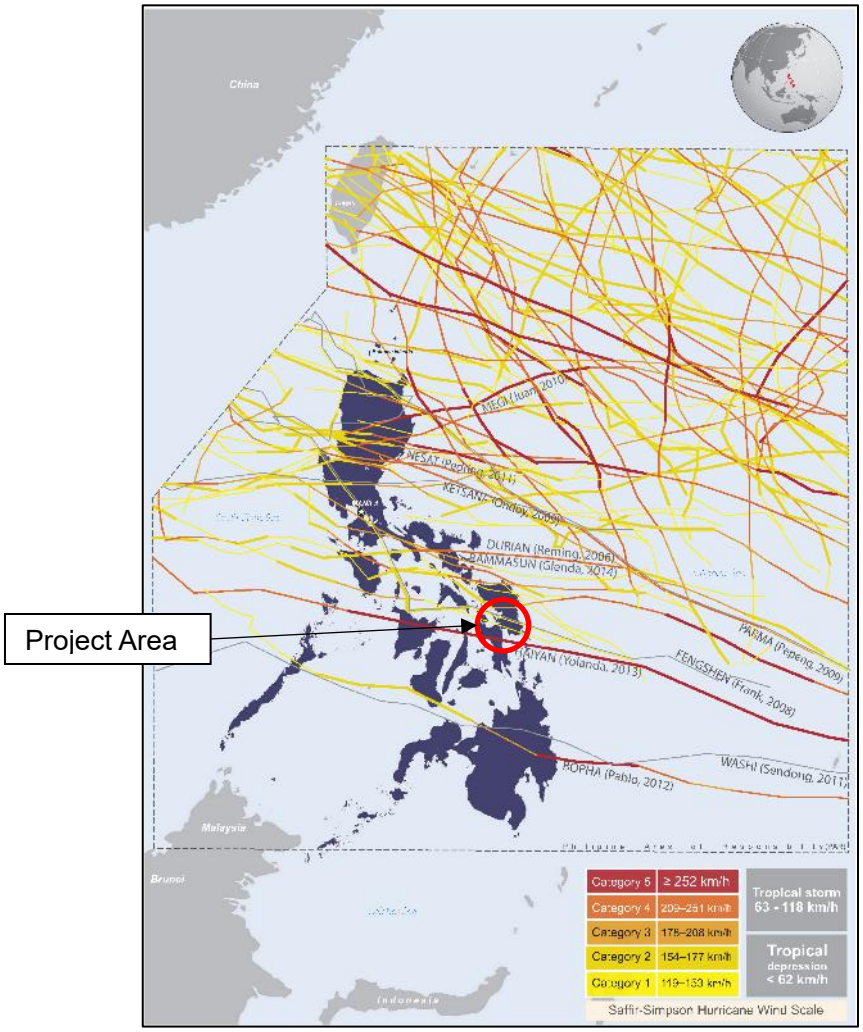
Source: Prepared by the JICA Survey Team based on PAGASA data

Figure 5-5 Monthly Average Rainfall of Tacloban (1991-2020)

5.3 Natural Disaster (Typhoon / Earthquake)

5.3.1 Typhoon

The Philippines is highly prone to typhoon, which is the country's most common and destructive natural disaster. On average, approximately 80 typhoons occur annually in tropical waters, of which about 20 enter Philippine territory and six to nine make landfall. Typhoon Yolanda (Haiyan), which struck in November 2013, passed over the islands of Leyte and Mindoro, causing extensive damage in the project area. Yolanda resulted in approximately 6,300 deaths in the Philippines, and the amount of damage was the worst in the country's recorded history at PhP 95 billion. Numerous housing sites have since been constructed around the project area to relocate victims of Yolanda.



Creation by OHCA (United Nations Office for the Coordination of Humanitarian Affairs)
Source: NDRRMC, DSWD, PAGASA, weather Philippines, PSA, DLG, Typhoon 2017

Figure 5-6 Route Map of Typhoons (2006-2016)

Table 5-2 Major Typhoons in the Philippines: Affected Areas and Damages

No	Name	Dates active	Category	Wind speeds	Pressure	Provinces affected	Damage (PHP)	Deaths	Missing
1	Dading (Winnie)	June 26 - July 3, 1964	Typhoon	185 km/h (115 mph)	970 hPa (28.64 inHg)	Luzon	-	100	-
2	Welming (Emma)	October 31 - November 8, 1967	Super Typhoon	260 km/h (160 mph)	910 hPa (26.87 inHg)	Visayas, Luzon	-	300	64
3	Pitang (Georgia)	September 8 - 14, 1970	Super Typhoon	260 km/h (160 mph)	905 hPa (26.72 inHg)	Luzon	₱1.4 million	95	80
4	Sening (Joan)	October 10 - 18, 1970	Super Typhoon	280 km/h (175 mph)	905 hPa (26.72 inHg)	Luzon, Visayas	₱74 million	768	193
5	Titang (Kate)	October 14 – 25, 1970	Super Typhoon	240 km/h (150 mph)	940 hPa (27.76 inHg)	Mindanao, Visayas	₱50 million	1,551	284
6	Yoling (Patsy)	November 14 – 22, 1970	Super Typhoon	260 km/h (155 mph)	910 hPa (26.87 inHg)	Luzon	₱460 million	611	81
7	Wening (Elaine)	October 23 - November 1, 1974	Typhoon	175 km/h (110 mph)	940 hPa (27.76 inHg)	Luzon	₱21 million	23	-
8	Didang (Olga)	May 10 – 28, 1976	Typhoon	150 km/h (90 mph)	940 hPa (27.76 inHg)	Luzon	₱1.16 billion	374	-
9	Atang (Olive)	April 15 – 26, 1978	Typhoon	150 km/h (90 mph)	955 hPa (28.20 inHg)	Visayas, Luzon	₱24.5 million	111	-
10	Kading (Rita)	October 15–29, 1978	Super Typhoon	220 km/h (140 mph)	880 hPa (25.99 inHg)	Luzon	₱100 million	444	354
11	Nitang (Ike)	August 26 – September 6, 1984	Typhoon	165 km/h (105 mph)	950 hPa (28.05 inHg)	Visayas, danao	₱4.1 billion	3,000	-
12	Undang (Agnes)	October 30 – November 10, 1984	Typhoon	195 km/h (120 mph)	925 hPa (27.32 inHg)	Visayas, Luzon	₱1.9 billion	895	275
13	Katring (Thelma)	July 8 – 30, 1987	Typhoon	185 km/h (125 mph)	890 hPa (26.28 inHg)	Luzon		8	-
14	Herming (Betty)	August 16 – 30, 1987	Super Typhoon	205 km/h (125 mph)	890 hPa (26.28 inHg)	Luzon, Visayas	₱2.07 billion	94	-
15	Sisang (Nina)	November 16 – 30, 1987	Typhoon	165 km/h (105 mph)	930 hPa (27.46 inHg)	Luzon	₱1.12 billion	808	-
16	Unsang (Ruby)	October 20 – 28, 1988	Typhoon	140 km/h (85 mph)	950 hPa (28.05 inHg)	Luzon	₱5.64 billion	157	-
17	Yoning (Skip)	November 3 – 12, 1988	Typhoon	150 km/h (90 mph)	950 hPa (28.05 inHg)	Visayas, Luzon	₱2.77 billion	217	95
18	Ruping (Mike)	November 5 – 18, 1990	Typhoon	185 km/h (115 mph)	915 hPa (27.02 inHg)	Visayas	₱10.8 billion	748	246
19	Uring (Thelma)	November 1 – 8, 1991	Tropical Storm	85 km/h (50 mph)	992 hPa (29.29 inHg)	Visayas	₱1.05 billion	5,956	3,000
20	Monang (Lola)	December 1 – 9, 1993	Typhoon	150 km/h (90 mph)	955 hPa (28.20 inHg)	Visayas	₱1.05 billion	230	0
21	Rosing (Angela)	October 25 – November 7, 1995	Typhoon	215 km/h (130 mph)	910 hPa (26.87 inHg)	Luzon	₱10.8 billion	936	-
22	Iliang (Zeb)	October 7 – 14, 1998	Typhoon	205 km/h (125 mph)	900 hPa (26.58 inHg)	Southern Luzon	₱5.38 billion	46	29
23	Loleng (Babs)	October 15 – 24, 1998	Typhoon	155 km/h (100 mph)	940 hPa (27.38 inHg)	Visayas, Luzon	₱6.79 billion	303	29
24	Gloria (Chataan)	June 27 — July 13, 2002	Typhoon	175 km/h (110 mph)	930 hPa (27.46 inHg)	Luzon	₱39 billion	18	-
25	Harurot (Imbudo)	July 19 — 23, 2003	Typhoon	165 km/h (105 mph)	935 hPa (27.61 inHg)	Luzon	₱35 billion	64	-
26	Unding (Muifa)	November 14 — 21, 2004	Typhoon	150 km/h (90 mph)	950 hPa (28.05 inHg)	Luzon	₱16 billion	68	69
27	Violeta (Merbok)	November 22 — 23, 2004	Tropical Storm	65 km/h (40 mph)	938 hPa (27.70 inHg)	Luzon	₱2.1 billion	31	17
28	Winnie	November 27 — 30, 2004	Tropical Depression	55 km/h (35 mph)	1,000 hPa (29.53 inHg)	Luzon	₱679 million	1,619	713
29	Milenyo (Xangsane)	September 25 — 29, 2006	Typhoon	155 km/h (100 mph)	972 hPa (28.71 inHg)	Luzon, Visayas	₱20 billion	110	79
30	Reming (Durian)	November 28 – December 2, 2006	Typhoon	195 km/h (120 mph)	938 hPa (27.70 inHg)	Luzon, Visayas	₱5.09 billion	1,400	762
31	Cosme (Halong)	May 15 — 19, 2008	Severe tropical Storm	110 km/h (70 mph)	970 hPa (28.64 inHg)	Luzon	₱6.71 billion	51	3
32	Frank (Fengshen)	June 18 — 23, 2008	Typhoon	165 km/h (105 mph)	958 hPa (28.29 inHg)	Luzon, Visayas	₱13.5 billion	1,501	87
33	Ondoy (Ketsana)	September 24 — 27, 2009	Typhoon	130 km/h (80 mph)	980 hPa (28.94 inHg)	Luzon	₱11.2 billion	671	37
34	Pepeng (Parma)	September 30 – October 10, 2009	Typhoon	185 km/h (115 mph)	938 hPa (27.70 inHg)	Visayas, Luzon	₱39.6 billion	465	47
35	Juan (Megi)	October 15 — 20, 2010	Super Typhoon	230 km/h (145 mph)	885 hPa (26.13 inHg)	Luzon	₱8.22 billion	26	4
36	Bebeng (Aere)	May 6 – 10, 2011	Tropical Storm	75 km/h (45 mph)	992 hPa (29.29 inHg)	Luzon, Visayas	₱2.25 billion	35	2
37	Juaning (Nock-ten)	July 24 – 28, 2011	Severe tropical Storm	95 km/h (60 mph)	985 hPa (29.09 inHg)	Visayas, Luzon	₱4.44 billion	77	0
38	Mina (Nanmadol)	August 21 – 29, 2011	Typhoon	185 km/h (115 mph)	925 hPa (27.32 inHg)	Luzon	₱40.9 billion	36	0
39	Pedring (Nesat)	September 24 – 28, 2011	Typhoon	150 km/h (90 mph)	950 hPa (28.05 inHg)	Luzon	₱15.6 billion	85	0
40	Sendong (Washi)	December 14 – 18, 2011	Severe Tropical Storm	95 km/h (60 mph)	992 hPa (29.29 inHg)	Visayas, Mindanao	₱2.07 billion	2,546	181
41	Pablo (Bopha)	December 2 – 9, 2012	Typhoon	185 km/h (115 mph)	930 hPa (27.46 inHg)	Mindanao,	₱42.2 billion	1,901	844
42	Labuyo (Utor)	August 9 – 13, 2013	Typhoon	195 km/h (120 mph)	925 hPa (27.32 inHg)	Luzon	₱1.42 billion	11	3
43	Santi (Nari)	October 8 – 13, 2013	Typhoon	140 km/h (85 mph)	965 hPa (28.50 inHg)	Luzon	₱3.3 billion	15	5
44	Yolanda (Haiyan)	November 6 – 9, 2013	Super Typhoon	230 km/h (145 mph)	895 hPa (26.43 inHg)	Visayas, Mindoro,	₱89.6 billion	6,300	1,081
45	Glenda (Rammasun)	July 13 – 17, 2014	Typhoon	165 km/h (105 mph)	935 hPa (27.61 inHg)	Luzon	₱34.6 billion	106	6
46	Jose (Halong)	August 2–7, 2014	Typhoon	195 km/h (120 mph)	920 hPa (27.17 inHg)	Luzon	₱1.62 billion	2	0
47	Mario (Fung-wong)	September 17 – 21, 2014	Tropical Storm	85 km/h (50 mph)	985 hPa (29.09 inHg)	Luzon	₱3.4 billion	18	4
48	Ruby (Hagupit)	December 3 – 10, 2014	Typhoon	215 km/h (130 mph)	905 hPa (26.72 inHg)	Visayas, Luzon	₱3.35 billion	18	0
49	Seniang (Jangmi)	December 28–31, 2014	Tropical Storm	75 km/h (45 mph)	996 hPa (29.41 inHg)	Visayas, Mindanao	₱1.45 billion	66	6
50	Lando (Koppu)	October 14 – 22, 2015	Typhoon	185 km/h (115 mph)	920 hPa (27.17 inHg)	Luzon	₱14.4 billion	48	83
51	Nona (Melor)	December 9 – 17, 2015	Typhoon	175 km/h (110 mph)	935 hPa (27.61 inHg)	Luzon, Eastern	₱7.04 billion	42	4
52	Karen (Sarika)	October 11 – 16, 2016	Typhoon	175 km/h (110 mph)	935 hPa (27.61 inHg)	Luzon	₱3.86 billion	0	0
53	Lawin (Haima)	October 16 – 21, 2016	Typhoon	215 km/h (130 mph)	900 hPa (26.58 inHg)	Luzon	₱3.74 billion	14	0
54	Nina (Nock-ten)	December 22 – 28, 2016	Typhoon	195 km/h (120 mph)	915 hPa (27.02 inHg)	Luzon	₱6.12 billion	13	21
55	Urduja (Kai-tak)	December 11 – 19, 2017	Tropical Storm	75 km/h (45 mph)	996 hPa (29.41 inHg)	Visayas	₱3.75 billion	11	1
56	Vinta (Tembin)	December 20 – 24, 2017	Typhoon	130 km/h (80 mph)	970 hPa (28.64 inHg)	Visayas, Mindanao	₱2.1 billion	44	14
57	Ompong (Mangkhut)	September 12 – 15, 2018	Typhoon	205 km/h (125 mph)	905 hPa (26.72 inHg)	Luzon	₱33.9 billion	79	2
58	Rosita (Yutu)	October 27 – 31, 2018	Typhoon	215 km/h (130 mph)	900 hPa (26.58 inHg)	Luzon	₱2.9 billion	20	0
59	Usman	December 25 – 29, 2018	Tropical depression	55 km/h (35 mph)	1000 hPa (29.53 inHg)	Visayas, Luzon	₱5.41 billion	28	1
60	Tisoy (Kammuri)	November 24 – December 6, 2019	Typhoon	165 km/h (105 mph)	950 hPa (28.05 inHg)	Luzon, Visayas	₱5.9 billion	12	0
61	Ursula (Phanfone)	December 23 – December 29, 2019	Typhoon	150 km/h (90 mph)	970 hPa (28.64 inHg)	Luzon, Visayas	₱3.44 billion	50	55
62	Ambo (Vongfong)	May 14–17, 2020	Typhoon	155 km/h (100 mph)	960 hPa (28.35 inHg)	Luzon, Visayas	₱1.57 billion	5	2
63	Quinta (Molave)	October 25–26, 2020	Typhoon	165 km/h (105 mph)	940 hPa (27.76 inHg)	Luzon, Mindoro	₱4.22 billion	27	12
64	Rolly (Goni)	October 31 – November 1, 2020	Super Typhoon	220 km/h (140 mph)	905 hPa (26.72 inHg)	Visayas	₱20.0 billion	32	-
65	Ulysses (Vamco)	11-Nov-20	Typhoon	155 km/h (100 mph)	955 hPa (28.20 inHg)	Luzon	₱20.3 billion	98	10
66	Jolina (Conson)	September 6–8, 2021	Severe tropical Storm	95 km/h (60 mph)	992 hPa (29.29 inHg)	Luzon Visayas	₱1.59 billion	19	5
67	Maring (Kompasu)	October 10–11, 2021	Severe tropical Storm	100 km/h (65 mph)	975 hPa (28.79 inHg)	Luzon	₱6.4 billion	43	17
68	Odette (Rai)	December 16–17, 2021	Typhoon	195 km/h (120 mph)	915 hPa (27.02 inHg)	Visayas	₱51.8 billion	410	13
69	Agaton (Megi)	April 9–11, 2022	Tropical Storm	75 km/h (45 mph)	996 hPa (29.41 inHg)	Visayas, Cebu	₱4.72 billion	214	132
70	Karding (Noru)	September 24–26, 2022	Typhoon	175 km/h (110 mph)	940 hPa (27.76 inHg)	Luzon	₱59.8 billion	12	5
71	Paeng (Nalgae)	October 28–30, 2022	Severe tropical Storm	110 km/h (70 mph)	975 hPa (28.79 inHg)	Visayas, Mindanao	₱17.6 billion	160	29

Category	Sustained winds
Supertyphoon (STY)	>220 km/h >119 knots
Typhoon (TY)	118-220 km/h 64-119 knots
Severe tropical storm (STS)	89-117 km/h 48-63 knots
Tropical storm (TS)	62-88 km/h 34-47 knots
Tropical Depression (TD)	<62 km/h <34 knots

Source: Prepared by the JICA Survey Team with information from PAGASA and Japan Meteorological Agency

Table 5-3 Deadliest Typhoons in the Philippines

Rank	Name	Year	Death
1	Haiphong	1881	20,000
2	Yolanda (Haiyan)	2013	6,300
3	Uring (Thelma)	1991	5,936
4	Pablo (Bopha)	2012	1,901
5	Angela	1867	1,800
6	Winnie	2004	1,593
7	October 1897	1897	1,500
8	Nitang (Ike)	1984	1,426
9	Reming (Durian)	2006	1,399
10	Frank (Fengshen)	2008	1,371

Source: JICA Survey Team

Table 5-4 Typhoons Causing the Greatest Damage in the Philippines

Rank	Name	Year	Damage
			PhP
1	Yolanda (Haiyan)	2013	PhP 95.5 billion
2	Odette (Rai)	2021	PhP 51.8 billion
3	Pablo (Bopha)	2012	PhP 43.2 billion
4	Glenda (Rammasun)	2014	PhP 38.6 billion
5	Ompong (Mangkhut)	2018	PhP 33.9 billion
6	Pepeng (Parma)	2009	PhP 27.3 billion
7	Ulysses (Vamco)	2020	PhP 20.2 billion
8	Rolly (Goni)	2020	PhP 20.0 billion
9	Paeng (Nalgae)	2022	PhP 17.6 billion
10	Pedring (Nesat)	2011	PhP 15.6 billion

Source: JICA Survey Team

Table 5-5 shows the recorded maximum wind speeds at the Tacloban Observatory as of 2021. According to this record, the highest wind speed was 223 km/h, observed during Typhoon Nitang on December 21, 1984. Due to damage to the observation equipment caused by Typhoon Yolanda in the project area, the period from November 2013 to June 2014 is considered a data gap, and it is not possible to estimate wind speeds caused by Yolanda based on existing observation records. Therefore, it is necessary to study the wind conditions by analyzing the existing typhoon database and reproducing Yolanda through meteorological simulation.

Table 5-5 Recorded Maximum Wind Speeds at Tacloban Station (as of 2021)

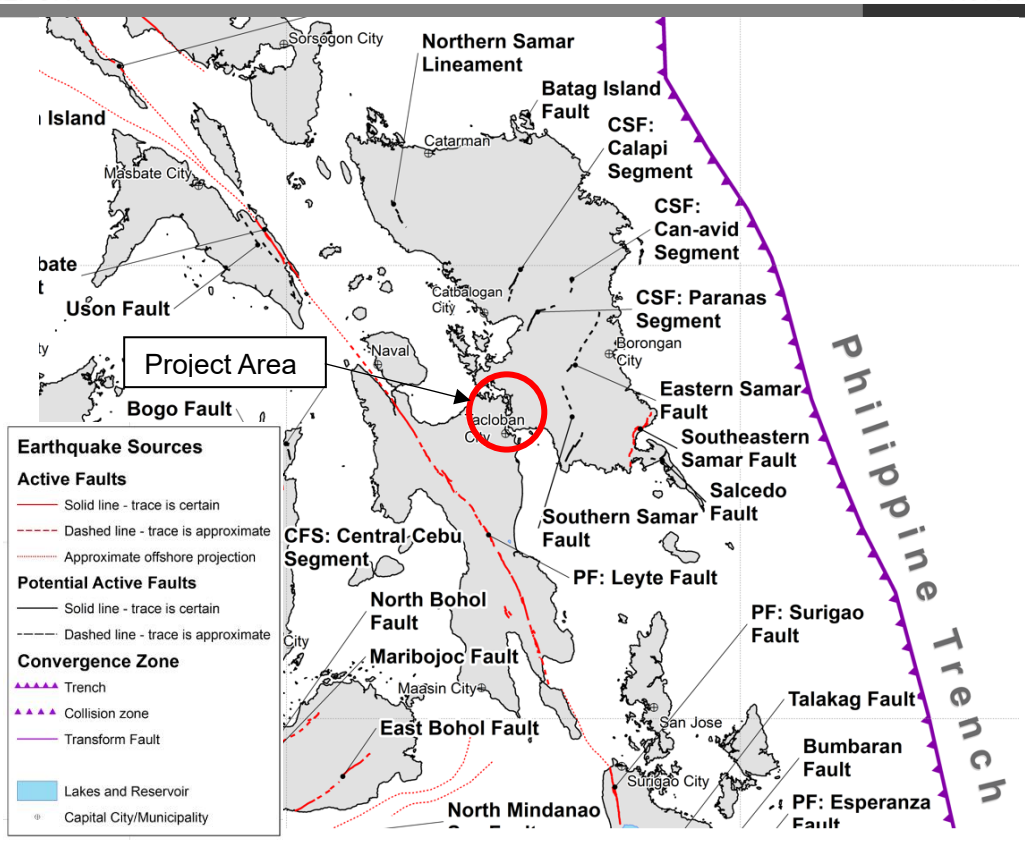
Day (mm-dd-yyyy)	Maximum Wind (3-sec. gust)		Direction
	(m/s)	(km/h)	
01-07-1972	29	104	NNW
02-18-2001	20	72	SE
03-16-2006	27	97	NW
04-15-1979	53	191	NNW
05-15-1966	55	198	SW
06-20-2008	35	126	W
07-14-1971	30	108	WSW
08-08-1968	22	79	WSW
09-06-2021	23	83	SSE
10-26-1952	32	115	W
11-04-1984	62	223	WSW
12-21-1994	43	155	ESE
12-24-2019	43	155	S

Source: PAGASA

5.3.2 Earthquake

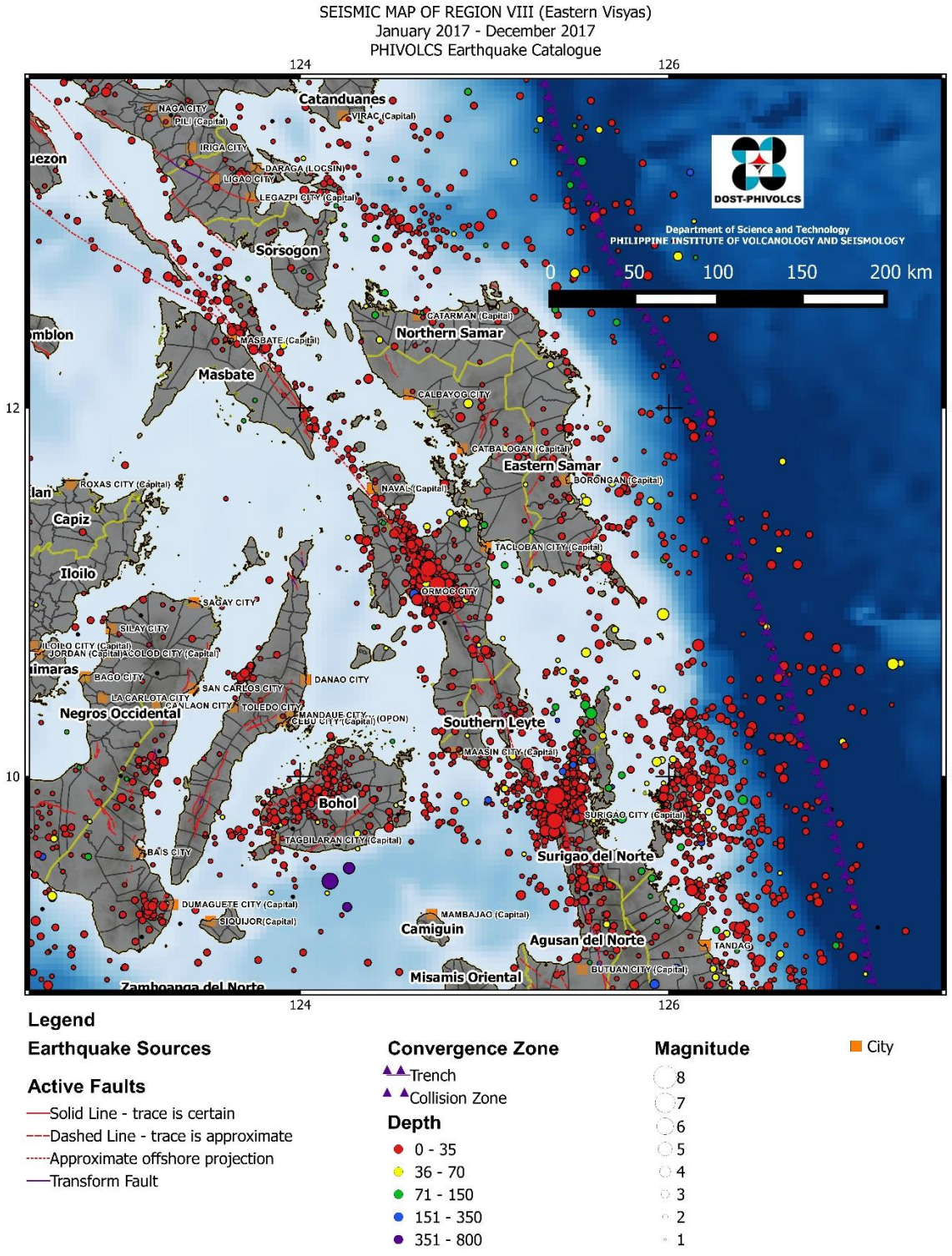
Faults in the vicinity of the project area are shown in Figure 5-7. According to this, two active faults are located near the vicinity of the project area: the Leyte Fault and the Southeast Samar Fault. No faults are present in the San Juanico Channel, which is spanned by the SSJB.

One of the major earthquakes that has occurred in the project area was the 6.5-magnitude Leyte earthquake on July 6, 2017. This earthquake caused at least four deaths and 100 injuries. Figure 5-8 shows the distribution of epicenters in Region VIII during the Leyte earthquake in 2017. The epicenters are mainly concentrated near the Leyte fault. According to the intensity scale defined by the PHIVOLCS, epicenters that are located around the project area are in Ormoc City and Cananga, both with Intensity VII, and Tacloban City with Intensity V. The seismic intensity recorded in Catbalogan, Samar Island, was at intensity IV. Although no active faults have been identified in the San Juanico Strait, it is considered necessary to properly evaluate the effects of earthquake shaking on structures and other factors.



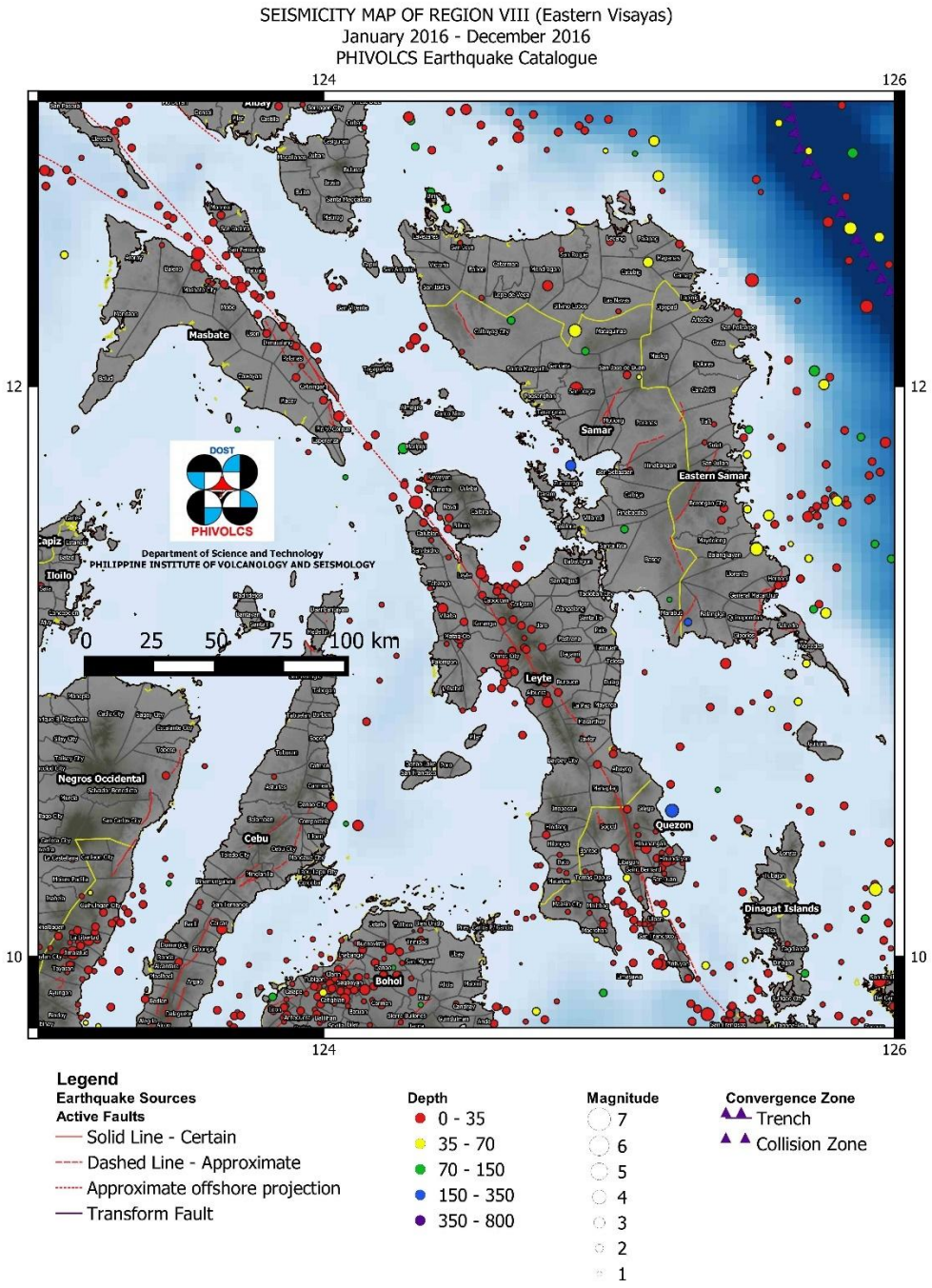
Source: PHIVOLCS. Quoted and elaborated from the source.

Figure 5-7 Faults Around the Project Area



Source: PHIVOLCS

Figure 5-8 Annual Distribution of Epicenters in Region VIII (2017, Year of the Leyte Earthquake)



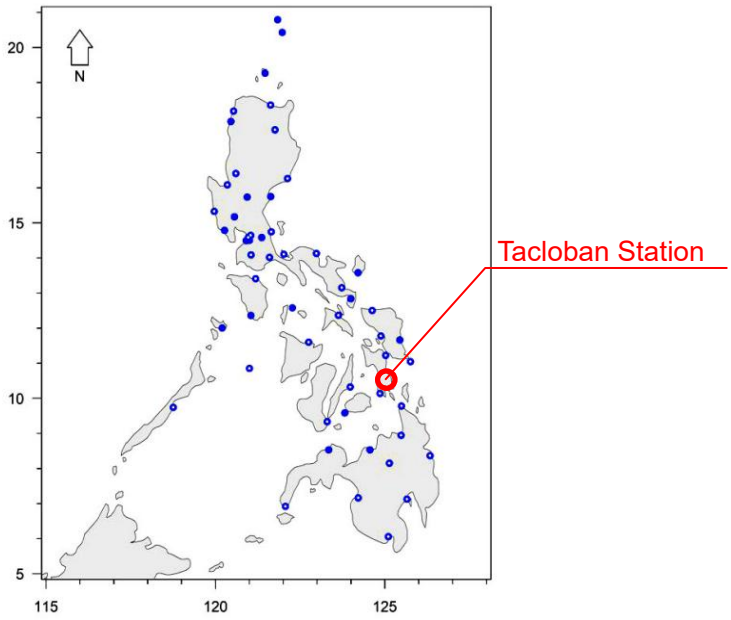
Source: PHIVOLCS

Figure 5-9 Annual Distribution of Epicenters in Region VIII (2016, for Comparative Reference)

5.4 Hydrology / Hydraulics

5.4.1 Rainfall Intensity

Rainfall intensity shall follow the values established by PAGASA. For the project area, the rainfall intensity recorded at the nearest Tacloban Station, shown in Table 5-6 and Figure 5-11, is used.



Source: PAGASA

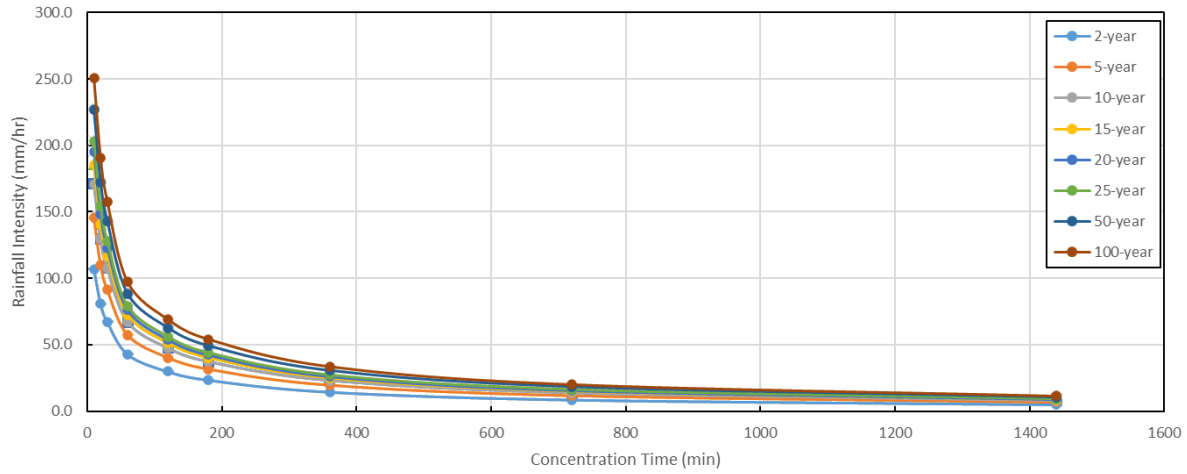
Figure 5-10 Location of PAGASA Climate Observation Station

Table 5-6 Rainfall Intensity (Tacloban Station)

[Unit : mm/hr]

Year	Concentration Time (min.)								
	10	20	30	60	120	180	360	720	1440
2	107.0	80.8	67.1	42.8	29.8	23.5	14.5	8.7	5.0
5	145.6	110.2	91.4	57.4	40.3	31.7	19.6	11.7	6.7
10	171.1	129.6	107.5	67.1	47.3	37.2	23.0	13.7	7.9
15	185.5	140.5	116.5	72.5	51.2	40.2	24.9	14.9	8.5
20	195.5	148.2	122.9	76.3	54.0	42.4	26.3	15.7	8.9
25	203.3	154.1	127.8	79.3	56.1	44.0	27.3	16.3	9.3
50	227.2	172.4	142.8	88.3	62.6	49.1	30.5	18.2	10.3
100	250.9	190.4	157.8	97.3	69.1	54.2	33.6	20.1	11.4

Source: PAGASA



Source: PAGASA

Figure 5-11 Rainfall Intensity-Duration-Frequency Curve

5.4.2 Consideration of Non-workable Days Due to Rainfall

Five years' worth of daily rainfall data is collected from the Tacloban Station, and the number of non-workable days due to rainfall is examined in the construction plan and cost estimation. According to JICA's Supplementary Edition of the Cooperation Preparation Survey, Design and Estimation Manual (Civil Engineering Sector), April 2023 Edition, the standard work suspension coefficient—which accounts for non-working days due to rainfall, holidays, and public holidays—for general construction works is 1.35. Adjustments for rainfall are generally not permitted in principle. At present, it is not clear what conditions other than rainfall would require special adjustments. However, given that the country is frequently affected by typhoons, the work suspension coefficient shall be checked.

Table 5-7 shows the monthly number of non-workable days for the past five years. Non-workable days are defined as days with daily precipitation of 10 mm or more, following the standard value calculation example in the JICA manual. According to this, the five-year average number of non-workable days is 82.2 days, which is more than double the 40 days given as the standard calculation example in the JICA manual.

Table 5-7 Number of Non-workable Days (with Daily Precipitation of 10 mm or more)

Year	Month, Non-Workable Day by Raining (day)												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
2019	3	2	0	2	3	8	4	2	3	5	6	9	47
2020	7	6	2	3	4	11	7	5	7	9	9	7	77
2021	14	12	7	4	9	6	5	4	5	11	9	15	101
2022	8	10	12	13	5	6	6	2	3	13	12	9	99
2023	20	15	9	3	6	5	4	3	4	4	7	7	87
Total	52	45	30	25	27	36	26	16	22	42	43	47	411
Average	10.4	9.0	6.0	5.0	5.4	7.2	5.2	3.2	4.4	8.4	8.6	9.4	82.2

Source: JICA Survey Team based on PAGASA materials

Table 5-8 shows the results of calculating the work stoppage coefficient based on daily precipitation data for the past five years, with reference to the JICA manual. One Sunday off each week is considered, and public holidays are accounted for based on information from the Office of the President of the Philippines (Reference URL: https://www.officialgazette.gov.ph/nationwide-holidays (accessed September 28, 2024)). As a result, the non-working constant based on actual rainfall and holidays over the past five years was 1.63. If this value is taken as positive, adopting the JICA standard value of 1.35 would underestimate the construction period by about 17%, contributing to potential discrepancies with the actual project cost. Therefore, it is considered desirable to use the corrected non-working constant.

Table 5-8 Calculation of Non-working Constant

Item	Unit	Year, Day, Rate					Total, Average
Year of Observation	year	2019	2020	2021	2022	2023	
Calender day	day	365	366	365	365	365	1826
Non-working day (w/o double count)	day	109	132	153	152	143	689
Non-workable day (≥10mm/day)	day	47	77	101	99	87	411
Legal Holiday (Sunday)	day	52	52	52	52	53	261
National Holiday	day	22	18	17	20	21	98
Working day	day	256	234	212	213	222	1137
Rate of working day	—	0.70	0.63	0.58	0.58	0.60	0.62
Non-working constant	—	1.43	1.59	1.72	1.72	1.67	1.63

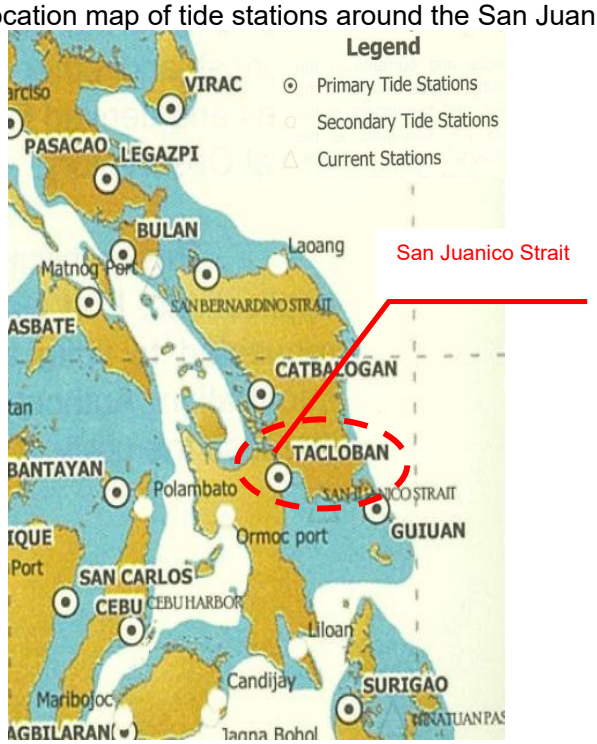
Source: JICA Survey Team

5.4.3 Tidal Conditions

(1) Document Collection

The SSJB, targeted in this project, spans the San Juanico Strait between the Leyte and Samar islands. The primary tidal station located around the San Juanico Strait is only the Tacloban Primary Control Tide Station, and its data are collected and organized by the National Mapping and Resource Information Authority (NAMRIA) of the Philippines.

Figure 5-12 shows the location map of tide stations around the San Juanico Strait.



Source: "Philippines 2024 Tide and Current Tables", NAMRIA, July 2023. Quoted and elaborated from the source.

Figure 5-12 Location Map of Tide Stations Around the San Juanico Strait

In organizing the tidal conditions in the San Juanico Strait, the data collected are summarized in Table 5-9.

Table 5-9 Collected Data on Tidal Levels in the San Juanico Strait

No .	Documents	Contents	Reference
1	Tacloban Tide Station, Average Mean Date of 19 Years (1951-1969)	Mean sea level based on 19 years of observations from 1951-1969 at the Tacloban Primary Tide Station.	NAMRIA
2	Tacloban Tide Station, Monthly and Annual Date (2011-2016, 2018, and 2021)	Information on monthly and annual mean sea level heights at the primary tide stations in Tacloban for the years 2011-2016, 2018 and 2021.	NAMRIA
3	Philippines 2024 Tide and Current Tables	The 2024 edition of the National Tides and Current Forecasts, published annually by NAMRIA	NAMRIA

Source: JICA Survey Team

(2) Data Organization

1) Confirmation of Existing Data

i) Tacloban Tide Station, Average Mean Date of 19 Years (1951-1969)

This document provides the mean sea level organized from 19 years of observations at the Tacloban Primary Control Tide Station. The data meet the requirements for mean sea level as shown in Table 5-10.

Table 5-10 Tacloban Tide Station Average Mean Datum of 19 Years (1951-1969)

[Unit: m]

	MSL	MLLW	MLW	MHW	MHHW
Record	1.548	1.259	1.295	1.765	1.945
Difference from MSL	0	-0.289	-0.253	+0.217	+0.397

Note: “Record” is the elevation from measuring apparatus at Tacloban Tide Station

Source: NAMRIA

MSL – Mean Sea Level
MLLW – Mean Lower Low Water
MLW – Mean Low Water
MHW – Mean High Water
MHHW – Mean Higher High Water

ii) Tacloban Tide Station, Monthly and Annual Date of 2011-2016, 2018, and 2021

Table 5-11 to Table 5-15 show the monthly and annual tidal data recorded in relatively recent years (eight years in total). Although there is a lack of data for each year, the tidal ranges for these years can be confirmed.

Table 5-11 Tacloban Tide Station, Monthly and Annual Datum of 2011-2016, 2018, and 2021 [MSL]

[Unit: m]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
2011							1.70	1.69	1.71	1.69	1.67		1.69
2012							1.55	1.55	1.56	1.45	1.46	1.47	1.51
2013	1.44	1.45	1.50	1.55	1.58					1.57			1.51
2014				1.43		1.45	1.46	1.41					1.44
2015	1.46	1.50	1.51	1.40	1.35								1.44
2016				1.57	1.60	1.66	1.67	1.74	1.70	1.68	1.62	1.61	1.65
2018			1.55	1.55	1.56	1.59	1.60	1.57	1.49			1.45	1.55
2021							1.68	1.67	1.70	1.66	1.61	1.60	1.65

Source: NAMRIA

Table 5-12 Tacloban Tide Station, Monthly and Annual Datum of 2011-2016, 2018, and 2021 [MLLW]

[Unit: m]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
2011							1.41	1.40	1.41	1.40	1.40		1.40
2012							1.28	1.30	1.34	1.23	1.17	1.21	1.25
2013	1.17	1.18	1.25	1.28	1.31					1.31			1.25
2014				1.19		1.19	1.20	1.15					1.18
2015	1.31	1.26	1.25	1.14	1.32	1.11		1.41	1.43	1.36	1.27	1.31	1.29
2016				1.32	1.33	1.41	1.41	1.47	1.41	1.39	1.34	1.34	1.38
2018			1.27	1.25	1.28	1.32	1.33	1.29	1.20			1.17	1.26
2021							1.40	1.39	1.39	1.30	1.31	1.36	1.36

Source: NAMRIA

Table 5-13 Tacloban Tide Station, Monthly and Annual Datum of 2011-2016, 2018, and 2021 [MLW]

[Unit: m]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Mean
2011							1.43	1.42	1.45	1.44	1.44		1.44
2012							1.30	1.32	1.37	1.26	1.21	1.23	1.28
2013	1.20	1.21	1.26	1.32	1.35	1.39				1.34			1.30
2014				1.22		1.21	1.24	1.17					1.21
2015	1.34	1.27	1.28	1.19	1.36	1.17		1.43	1.46	1.40	1.32	1.40	1.33
2016				1.35	1.38	1.43	1.43	1.49	1.44	1.42	1.39	1.38	1.41
2018			1.31	1.29	1.35	1.37	1.37	1.33	1.26			1.26	1.32
2021							1.42	1.42	1.44	1.36	1.36	1.37	1.39

Source: NAMRIA

Table 5-14 Tacloban Tide Station, Monthly and Annual Datum of 2011-2016, 2018, and 2021 [MHW]

[Unit: m]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
2011							1.91	1.92	1.93	1.91	1.88		1.91
2012							1.75	1.76	1.79	1.71	1.65	1.69	1.72
2013	1.64	1.65	1.70	1.76	1.81					1.77			1.72
2014				1.63		1.66	1.66	1.61					1.64
2015	1.78	1.70	1.72	1.61	1.83	1.57		1.86	1.89	1.81	1.77	1.65	1.75
2016				1.79	1.84	1.92	1.94	2nd	1.92	1.94	1.86	1.88	1.90
2018			1.76	1.78	1.75	1.78	1.80	1.80	1.73			1.66	1.76
2021							1.87	1.85	1.92	1.88	1.85	1.92	1.88

Source: NAMRIA

Table 5-15 Tacloban Tide Station, Monthly and Annual Datum of 2011-2016, 2018, and 2021 [MHHW]

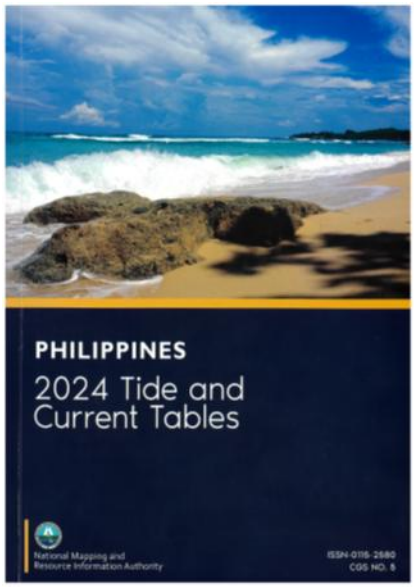
[Unit: m]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
2011							2.08	2.03	2.05	2.06	2.01		1.69
2012							1.93	1.89	1.90	1.86	1.81	1.85	1.51
2013	1.80	1.80	1.83	1.92	1.96					1.90			1.51
2014				1.75		1.83	1.83	1.74					1.44
2015	1.95	1.85	1.83	1.73	1.93	1.73		1.99	2.02	1.95	1.92	1.78	1.44
2016				1.93	1.96	2.01	2.06	2.09	2.06	2.04	2.00	2.01	1.65
2018			1.91	1.93	1.94	1.98	2.00	1.95	1.89			1.85	1.55
2021							2.06	2.05	2.11	1.94	2.04	2.13	1.65

Source: NAMRIA

iii) Philippines 2024 Tide and Current Tables

Figure 5-13 shows the publication summarizing tide and current forecast data, released annually by NAMRIA. The information is organized by date and time for the entire country. This publication serves as a helpful reference for determining the timing and duration of tide and current observations in this study.



Source: “Philippines 2024 Tide and Current Tables”, NAMRIA, July 2023

Figure 5-13 Philippines 2024 Tide and Current Tables

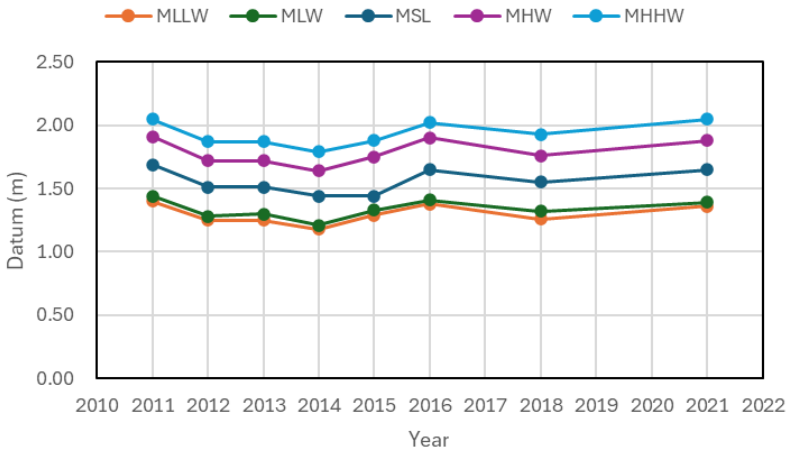
2) Policy for Data Organizations

The basic principle is to use (1) Tacloban Tide Station, Average Mean Datum of 19 Years (1951-1969), which meets the requirements for mean sea level, as the tidal datum for design purposes. However, since this mean sea level is based on observations recorded 50 to 60 years ago, the validity of the data is confirmed using (2) Tacloban Tide Station, Monthly and Annual Datum of 2011-2016, 2018, and 2021. These data are also used as a basis for determining the mean sea level in accordance with the concept of the Intergovernmental Panel on Climate Change (IPCC), considering the response to potential future climate change.

3) Average Sea Level

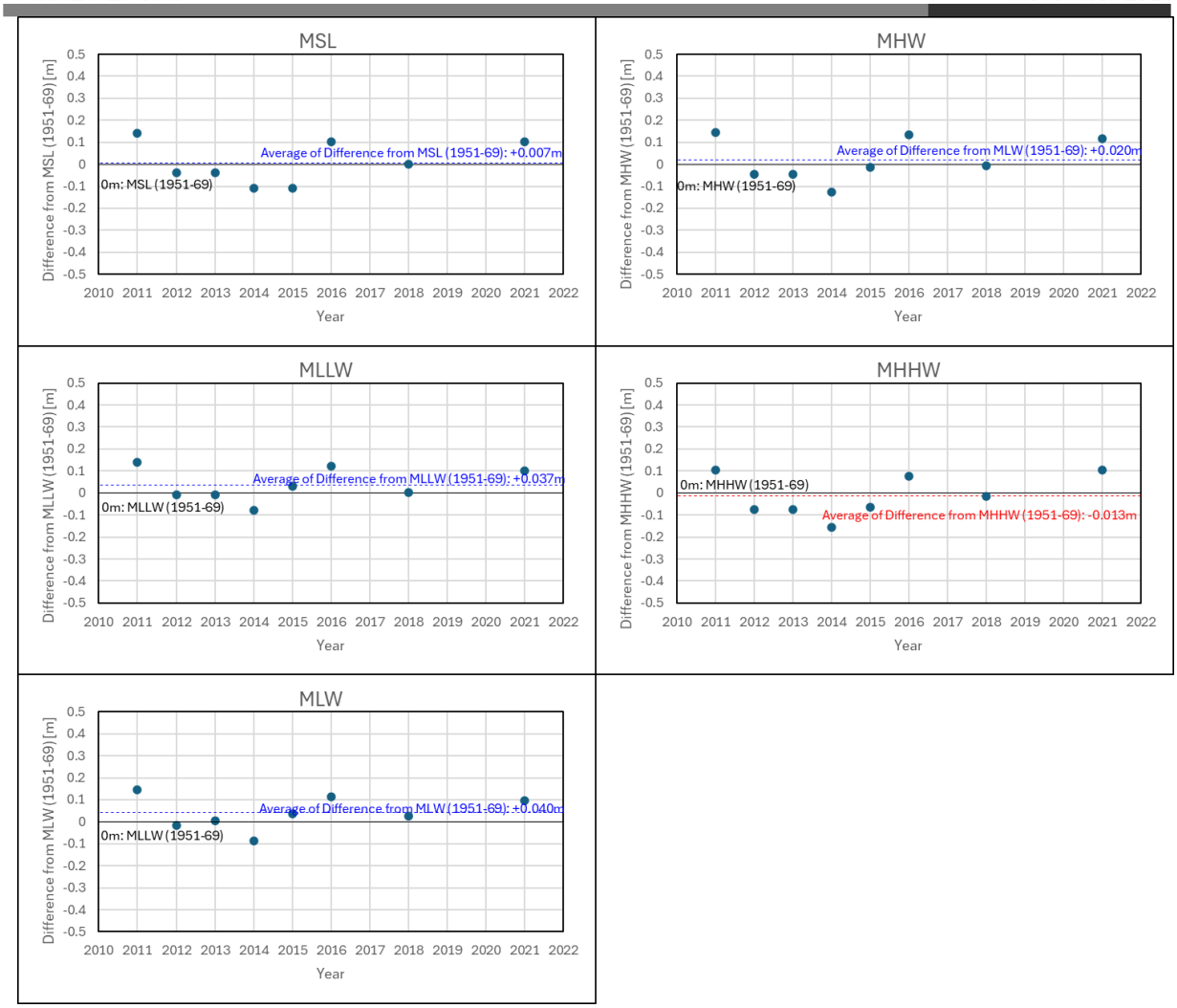
Based on the collected (2) Tacloban Tide Stations, Monthly and Annual Datum of 2011-2016, 2018, and 2021, the trends of annual mean sea level in recent years (2011~2016, 2018, and 2021) are shown in Figure 5-14. Although the analysis covers only a short period of about ten years and thus does not represent the overall trend, the data suggests that the trend appears to be generally flat.

The differences between the annual means and the mean sea level from 1951 to 1969 are shown in Figure 5-15 and Table 5-16, respectively. These differences range from -0.013 m to +0.040 m. While there appears to be a slight upward trend over the past 50 to 60 years, the effect is limited due to the small range of variation. Therefore, the mean sea level for 1951-1969 is still considered accurate today.



Source: JICA Survey Team

Figure 5-14 Recent Average Sea Level (2011-2016, 2018, and 2021)



Source: JICA Survey Team

Figure 5-15 Difference Between Recent Average Sea Level (2011‐2016, 2018, and 2021) and 1951-1969 Average Sea Level

Table 5-16 Difference Between Recent Average Sea Level (2011 to 2016, 2018, and 2021) and 1951-1969 Average Sea Level

YEAR	MSL		MLLW		MLW		MHW		MHHW	
	MEAN	Difference from Base	MEAN	Difference from Base	MEAN	Difference from Base	MEAN	Difference from Base	MEAN	Difference from Base
1951-69 (Base)	1.548	0.000	1.259	0.000	1.295	0.000	1.765	0.000	1.945	0.000
2011	1.690	+0.142	1.400	+0.141	1.440	+0.145	1.910	+0.145	2.050	+0.105
2012	1.510	-0.038	1.250	-0.009	1.280	-0.015	1.720	-0.045	1.870	-0.075
2013	1.510	-0.038	1.250	-0.009	1.300	+0.005	1.720	-0.045	1.870	-0.075
2014	1.440	-0.108	1.180	-0.079	1.210	-0.085	1.640	-0.125	1.790	-0.155
2015	1.440	-0.108	1.290	+0.031	1.330	+0.035	1.750	-0.015	1.880	-0.065
2016	1.650	+0.102	1.380	+0.121	1.410	+0.115	1.900	+0.135	2.020	+0.075
2018	1.550	+0.002	1.260	+0.001	1.320	+0.025	1.760	-0.005	1.930	-0.015
2021	1.650	+0.102	1.360	+0.101	1.390	+0.095	1.880	+0.115	2.050	+0.105
AVERAGE	-	+0.007	-	+0.037	-	+0.040	-	+0.020	-	-0.013

Source: JICA Survey Team

(3) Adjustment to Climate Change

According to the IPCC report, one of the impacts of global climate change is sea level rise, and it is forecasted to rise up to around 2100.

In the Sixth Assessment Report (AR6) published in 2021, each scenario is represented by a combination of Shared Socioeconomic Pathways (SSP) and radiative forcing.

In response to the IPCC report, the Philippines has established the criteria, shown in Figure 5-16, as an adjustment to the sea level rise due to climate change. The standard states that a sea level rise of 0.3 m is expected by 2050, which corresponds to a typical design service period of about 50 years. For designs extending to around 2100, it is considered appropriate to expect a rise of about 0.5 m in consideration of uncertainties.

Sea Level Rise

Table 9-1 provides an overview of different sea level rise estimates based on IPCC (2013). In the absence of more up to date information, a sea level rise of 0.3 m might be appropriate for 2050, which would cover a typical design life in the order of 50 years. For design and planning out to 2100, then a potential sea level rise of 0.5 m might be appropriate, given the uncertainty.

The suggested approaches are provided in Table 9-4.

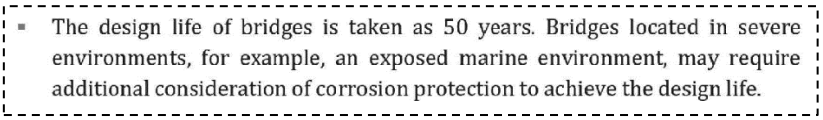
Table 9-4 Suggested Approach for Incorporating Sea Level Rise

Approach	Recommendation
General Approach	Allow for a 0.3 m sea level rise in the design.
Alternative Approach	Determine the likely impacts of a 0.3 m sea level rise. Refer to potential for Planned Upgrade as discussed in Section 9.2.3.

Source: "Design Guidelines, Criteria and Standards: Volume 3-Water Projects Design", DPWH, 2015, P9-6.

Figure 5-16 Adjustment to Sea Level Rise Due to Climate Change as Defined in the DGCS

The design service period of the bridge is set at 50 years in the Philippines, as shown in Figure 5-17; hence, a sea level rise of 0.3 m should be generally expected during this period. The project is anticipated to be completed in 2030 or later, assuming smooth progress.



Source: "Design Guidelines, Criteria and Standards: Volume 3 - Water Projects Design", DPWH, 2015, P4-1.

Figure 5-17 Design Service Period (DGCS)

Considering the sea level rise shown in Table 5-17 and a design service period extending to 2080 or later, this project can be recognized as long-term. Referring to the SSP2-4.5 as the best estimate value, 0.3 m of sea level rise corresponds to a 10% value, which is considered insufficient given the design service period. The 0.5 m value proposed by the DGCS for design and planning until around 2100 represents the median of the best estimates in the IPCC (AR6). Although there is a possibility of an upward swing, the range of possible values tends to be significant in terms of the accuracy of long-term forecast. Therefore, the DGCS proposes 0.5 m as a balanced value between economy and uncertainty.

Accordingly, 0.5 m of sea level rise due to climate change, as proposed by the DGCS for design and planning until around 2100, will be taken into account in the design of this project.

Table 5-17 IPCC(AR6) Climate Change Scenario Forecast Value

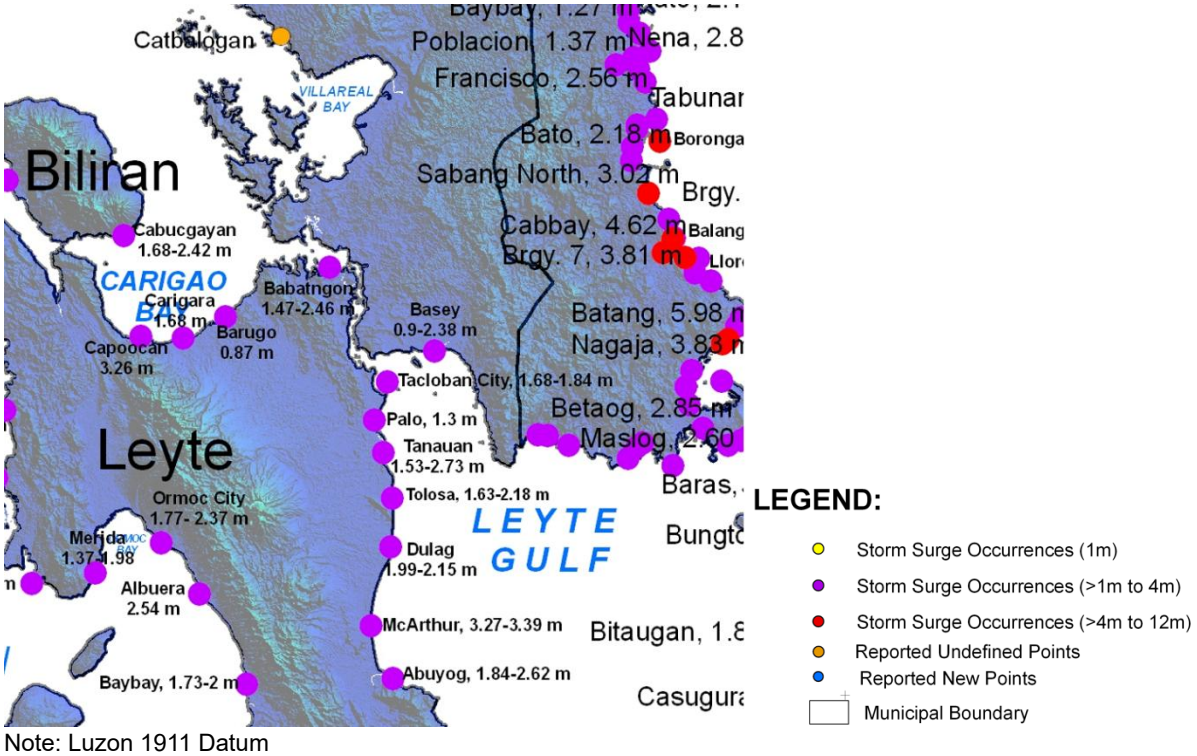
Prediction Period	AR6* Senario	Outline of Senario (Translation from JICA-Climate-FIT (Adaptation)p.21)	Sea Level Rise (Persentile Value)** [m]						
			Median	P25	P75	P10	P90	P5	P95
Near Term (2021-2040)	SSP1-2.6	Introduction of a climate policy that limits the median temperature increase from pre-industrial standards to less than 2℃ under sustainable development. Net-zero CO2 emissions expected in the second half of the 21st century.	0.1	0.1	0.1	0	0.2	0	0.2
Medium Term (2041-2060)	SSP1-2.6		0.2	0.1	0.3	0.1	0.3	0.1	0.3
Long Term (2081-2100)	SSP1-2.6		0.4	0.3	0.6	0.2	0.7	0.2	0.8
Near Term (2021-2040)	SSP2-4.5	Adopted climate policies under middle-of-the-road development, roughly at the upper end of each country's aggregate "Nationally Determined Contribution" (NDC) emissions by 2030. Temperature increase of about 2.7℃ (best estimate) by the end of the 21st century based on pre-industrial levels.	0.1	0.1	0.1	0	0.2	0	0.2
Medium Term (2041-2060)	SSP2-4.5		0.2	0.1	0.3	0.1	0.3	0.1	0.4
Long Term (2081-2100)	SSP2-4.5		**0.5**	0.4	0.7	0.3	0.8	0.2	0.9
Near Term (2021-2040)	SSP3-7.0	Medium to high reference scenario without climate policy under regionally confrontational development. Emissions other than CO2, such as aerosols, are high.	0.1	0.1	0.1	0	0.2	0	0.2
Medium Term (2041-2060)	SSP3-7.0		0.2	0.2	0.3	0.1	0.3	0.1	0.4
Long Term (2081-2100)	SSP3-7.0		0.6	0.5	0.8	0.4	0.9	0.3	1
Near Term (2021-2040)	SSP5-8.5	A high-level reference scenario in which no climate policy is introduced under a fossil fuel dependent development.	0.1	0.1	0.1	0	0.2	0	0.2
Medium Term (2041-2060)	SSP5-8.5		0.3	0.2	0.3	0.1	0.4	0.1	0.4
Long Term (2081-2100)	SSP5-8.5		0.7	0.5	0.9	0.4	1	0.4	1.1

*AR6: 6th Assessment Report
**Based on "IPCC WGI Interactive Atlas: Regional information (Advanced)". No data for SSP1-1.9.
Source: JICA Survey Team, summarized data from IPCC WGI Interactive Atlas, JICA-Climate-FIT (Adaption) etc.

(4) Storm Surge

Past storm surge events in the project area were recorded by PAGASA through interviews with barangays and measurements, rather than through constant instrumental observation. Figure 5-18 presents the storm surge records compiled by PAGASA for the period 1897-2011. The numerical ranges indicate the range of maximum storm surge heights observed during this period. According to this document, a storm surge of 1.68-1.84 m was recorded in Tacloban City, the nearest city to the project area. However, these records do not include data from 2013, when Typhoon Yolanda hit the area. The results of interviews and measurements of the storm surge during Yolanda, obtained separately from PAGASA, are shown in Figure 5-19. The interviews indicate that the storm surge lasted for about two hours, reaching around 6 m near the project area—more than 4 m higher than the pre-Yolanda surge levels. Field interviews conducted by the survey team confirmed that the sea level reach the top of the existing SJB piers—approximately 6 to 7 m—during Typhoon Yolanda in 2013, consistent with the survey results.

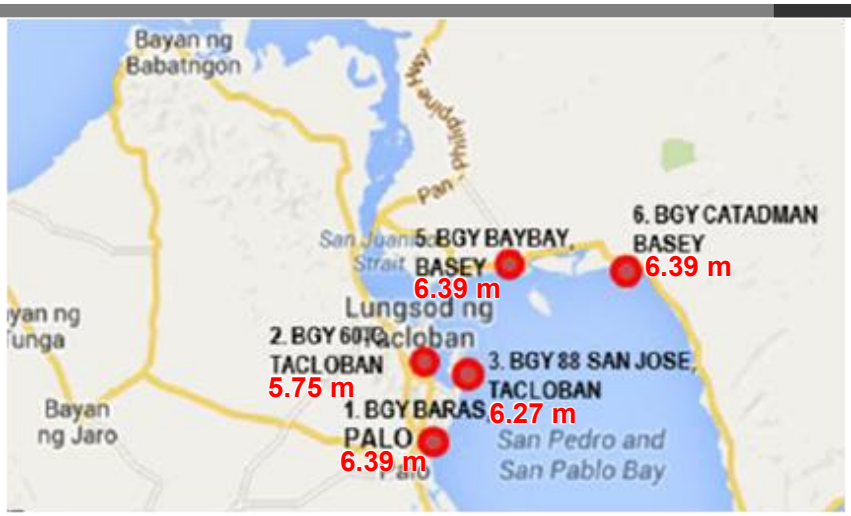
Based on these observations, the highest storm surge condition of 6.39 m, recorded at several points around the project area during Yolanda, is adopted.



Note: Luzon 1911 Datum

Source: PAGASA

Figure 5-18 Storm Surge Record in Project Area (1897-2011)



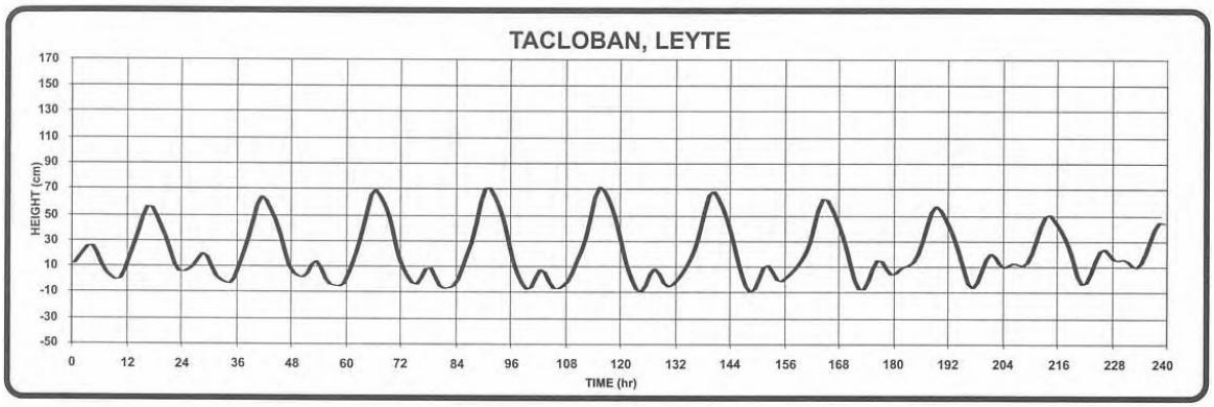
Note: Luzon 1911 Datum

Source: PAGASA

Figure 5-19 Storm Surge Record of Yolanda

(5) Tide

The tidal variation at the Tacloban Primary Tide Control Station is shown in Figure 5-19. The tide ranges approximately 50 -80 cm at its maximum.



Source: "Philippines 2024 Tide and Current Tables", NAMRIA, July 2023

Figure 5-20 Tidal Variation at the Tacloban Primary Tide Control Station

5.5 Topographical Survey

5.5.1 Survey Objectives

The survey shown in Section 1.1.2 was conducted as a topographical survey conducted in two phases: one at the beginning of the survey work and the other after the erection location was determined.

Phase 1: Collection of satellite images and Digital Elevation Model (DEM) data.

Phase 2: A benchmark (BM) was established in the planned construction area, and LiDAR surveying was conducted to create a topographic map and a longitudinal section map. In addition, depth and shallow surveying were conducted to determine the topography of the offshore area.

5.5.2 Survey Items

The following surveys were conducted during the investigation:

(1) Satellite Photogrammetry and DEM Data Collection

DEM data with an accuracy of about 1:5,000 was procured. High-definition satellite photographs were also procured to confirm the number of affected houses and gather other geophysical information.

(2) Reference Point Survey

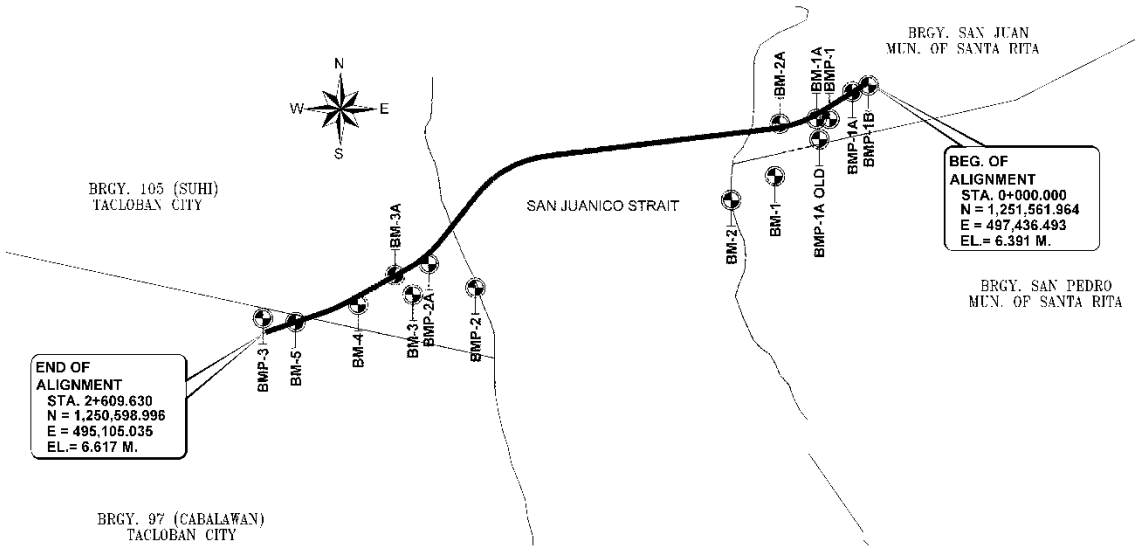
BMs were established within the planned construction area using reference points managed by the NAMRIA.

The following table lists the BMs established in the construction area.

Table 5-18 List of Benchmark Points

STA.	WGS-84			PRS-92			ELEV (MSL)
	LATITUDE	LONGITUDE	EHT	LATITUDE	LONGITUDE	EHT	LEVELING FR.
LY-895	**N11° 17'34.38662"**	**E124° 57'28.80370"**	**67.566**	**N11° 17'38.67073"**	**E124° 57'23.65213"**	**5.560**	4.407
LYT-703	**N11° 21'34.43053"**	**E124° 57'05.39656"**	**66.447**	**N11° 21'38.73208"**	**E124° 57'00.25078"**	**4.621**	
BLLM-28¥SMR-3419	N11° 19'10.43576"	E124° 58'35.92867"	64.088	N11° 19'14.72503"	E124° 58'30.77962"	2.102	
BMP-1	N11° 18'57.93152"	E124° 58'35.68165"	68.557	N11° 19'02.21992"	E124° 58'30.53230"	6.563	5.475
BMP-1A OLD	N11° 18'55.38718"	E124° 58'34.42100"	68.161	N11° 18'59.67543"	E124° 58'29.27158"	6.165	5.130
BMP-1A	N11° 19'01.34761"	E124° 58'38.62001"	69.726	N11° 19'05.63618"	E124° 58'33.47075"	7.732	6.654
BMP-1B	N11° 19'02.17493"	E124° 58'40.66527"	69.709	N11° 19'06.46351"	E124° 58'35.51603"	7.714	6.623
BM-1A	N11° 18'57.93840"	E124° 58'34.04221"	69.612	N11° 19'02.22684"	E124° 58'28.89285"	7.619	6.521
BM-2A	N11° 18'57.33158"	E124° 58'29.32965"	64.343	N11° 19'01.62009"	E124° 58'24.18026"	2.352	1.308
BM-1	N11° 18'50.77606"	E124° 58'28.73761"	65.288	N11° 18'55.06413"	E124° 58'23.58806"	3.293	2.215
BM-2	N11° 18'47.75099"	E124° 58'23.15791"	64.001	N11° 18'52.03897"	E124° 58'18.00827"	2.008	0.942
BMP-2	N11° 18'36.71671"	E124° 57'50.53636"	64.541	N11° 18'41.00469"	E124° 57'45.38637"	2.563	1.484
BMP-2A	N11° 18'39.69880"	E124° 57'44.55064"	67.842	N11° 18'43.98713"	E124° 57'39.40071"	5.869	4.742
BM-3	N11° 18'35.85136"	E124° 57'42.52723"	68.601	N11° 18'40.13947"	E124° 57'37.37719"	6.628	5.499
BM-3A	N11° 18'38.29387"	E124° 57'40.30005"	69.242	N11° 18'42.58220"	E124° 57'35.15007"	7.271	6.179
BM-4	N11° 18'34.60256"	E124° 57'35.56698"	65.340	N11° 18'38.89075"	E124° 57'30.41690"	3.371	2.286
BM-5	N11° 18'32.42355"	E124° 57'27.59681"	68.527	N11° 18'36.71177"	E124° 57'22.44665"	6.561	5.455
BMP-3	N11° 18'32.88896"	E124° 57'23.41194"	70.077	N11° 18'37.17731"	E124° 57'18.26179"	8.115	6.974
C-3B	N11° 18'16.67944"	E124° 59'23.88451"	76.702	N11° 18'20.96378"	E124° 59'18.73428"	14.646	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5-21 Location Map of Installed Benchmark Points

(3) LiDAR Surveying (Drone Surveying)

LiDAR surveying was conducted using a survey drone to improve the accuracy of the topographic maps.

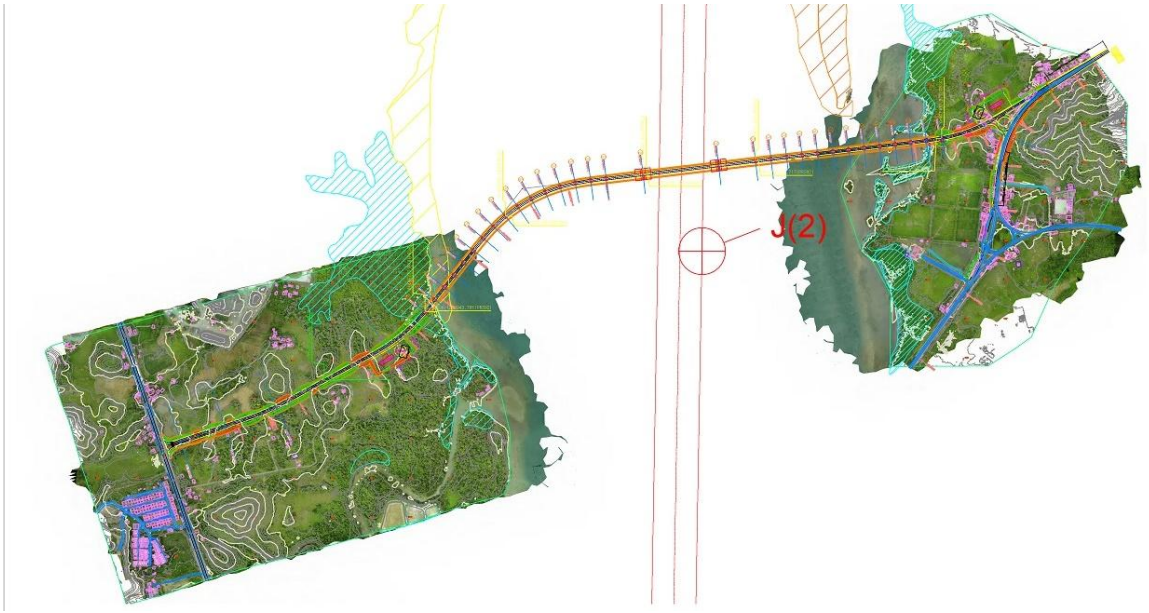


Source: JICA Survey Team

Figure 5-22 Topographic Data from LiDAR Survey (Left: Leyte Side, Right: Samar Side)

(4) Topographic Surveying

Based on the aforementioned BMs, the LiDAR survey results were combined to create topographic maps, and longitudinal and cross-sectional and road centerline survey data were created.

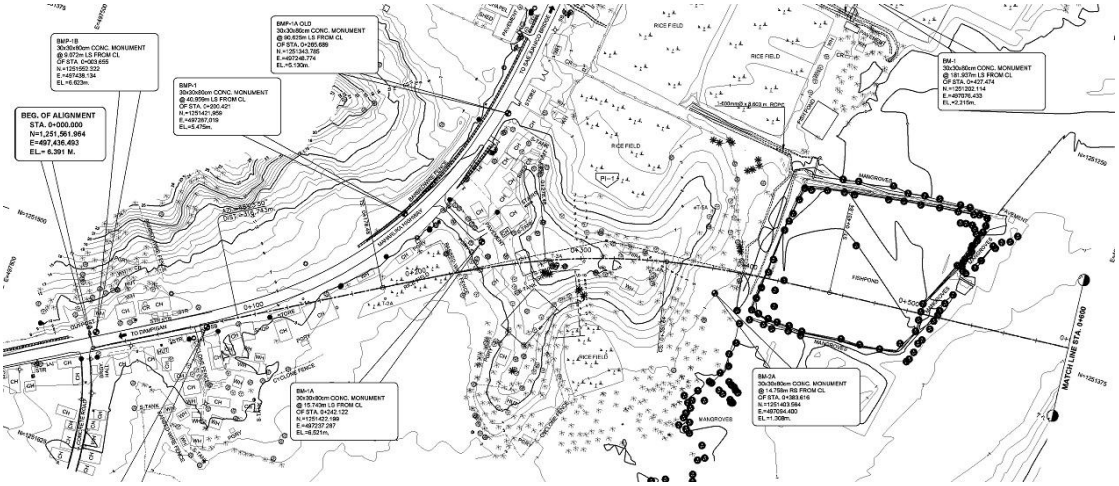


Source: JICA Survey Team

Figure 5-23 Topographic Survey Data Reflecting LiDAR Survey Results

(5) Road Centerline Survey

The road centerlines were placed on the generated topographic survey data to serve as reference for the longitudinal and cross-sectional maps.

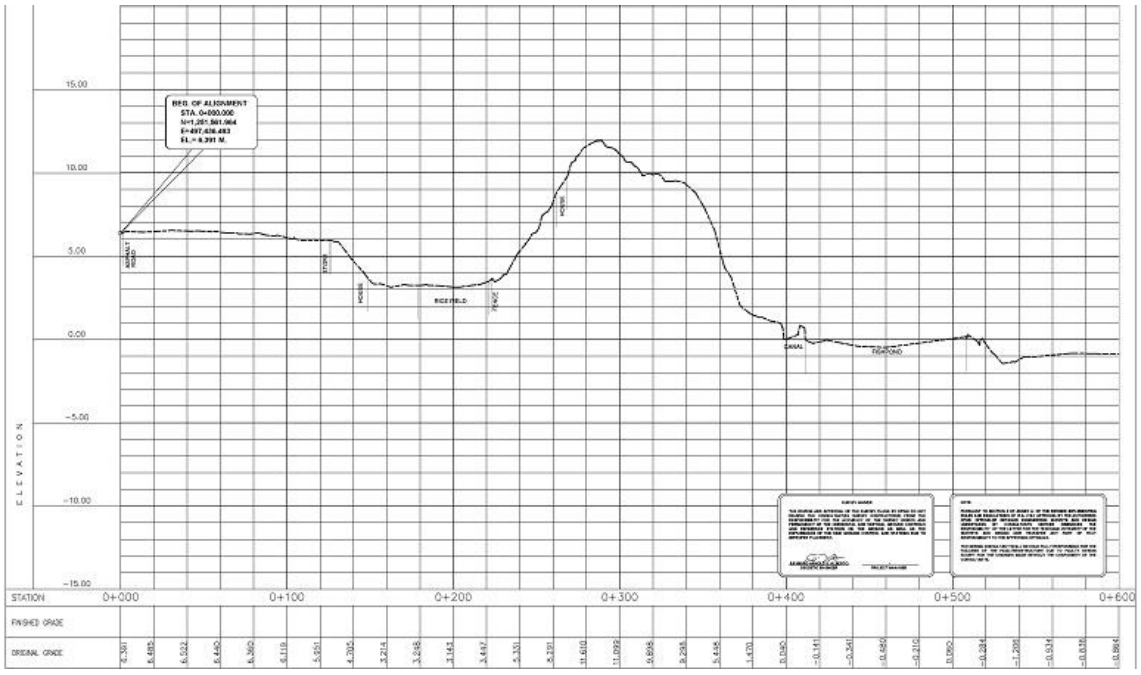


Source: JICA Survey Team

Figure 5-24 Topographic Map Reflecting Results of the Road Centerline Survey (STA0+0 to 0+600)

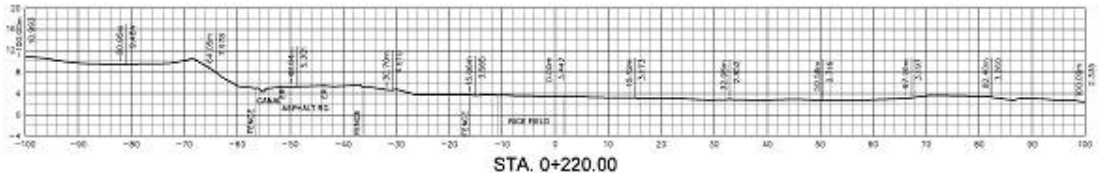
(6) Longitudinal and Transverse Survey

Longitudinal and transect maps were prepared along the road centerline. Transects were made at 20 m intervals, with a width of 100 m on both sides of the road centerline.



Source: JICA Survey Team

Figure 5-25 Longitudinal Section (STA0+0 to 0+600) Based on the Road Centerline Survey Results

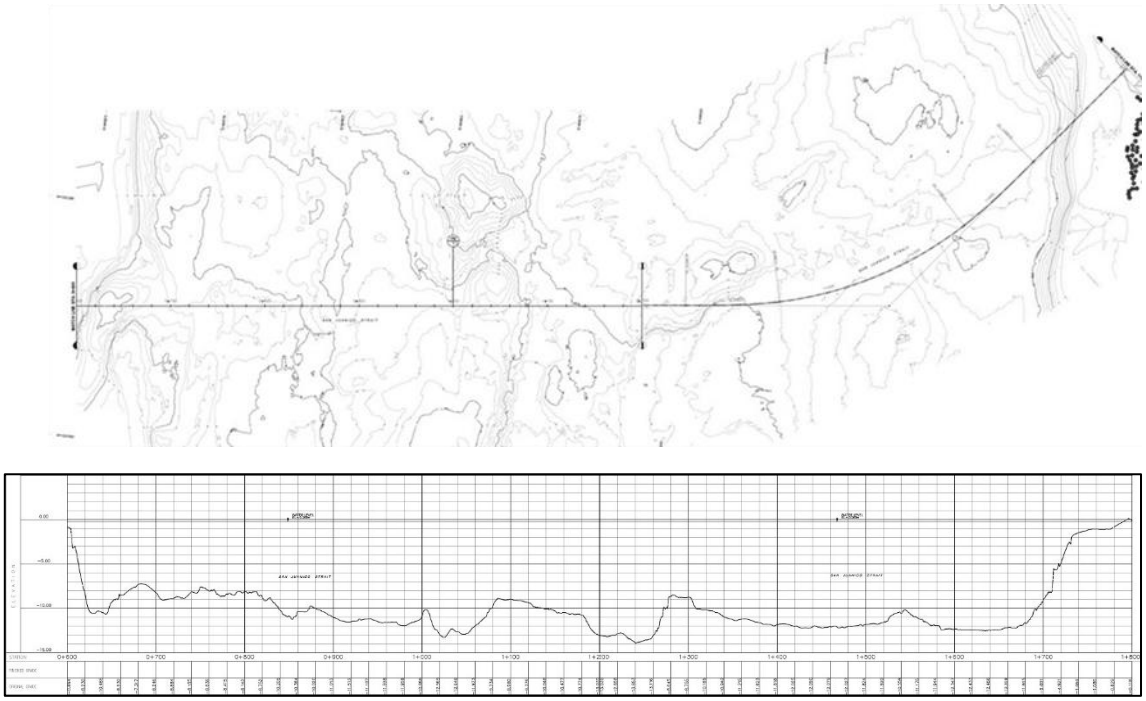


Source: JICA Survey Team

Figure 5-26 Cross Section (STA0+220)

(7) Bathymetry Survey

The bathymetry survey was conducted to confirm the longitudinal and transverse topography of the marine area at the proposed bridge location (C2a-line). A cross-section of the strait, estimated using simplified measurements along the N-line on the north side of the San Juanico Strait (Figure 5-30), showed a maximum depth of over 50 m, but the water depth at the C2a-line, approximately 9 km south of the N-line, was less than 15 m, confirming a significant difference in the topography of the sea areas between the two lines.

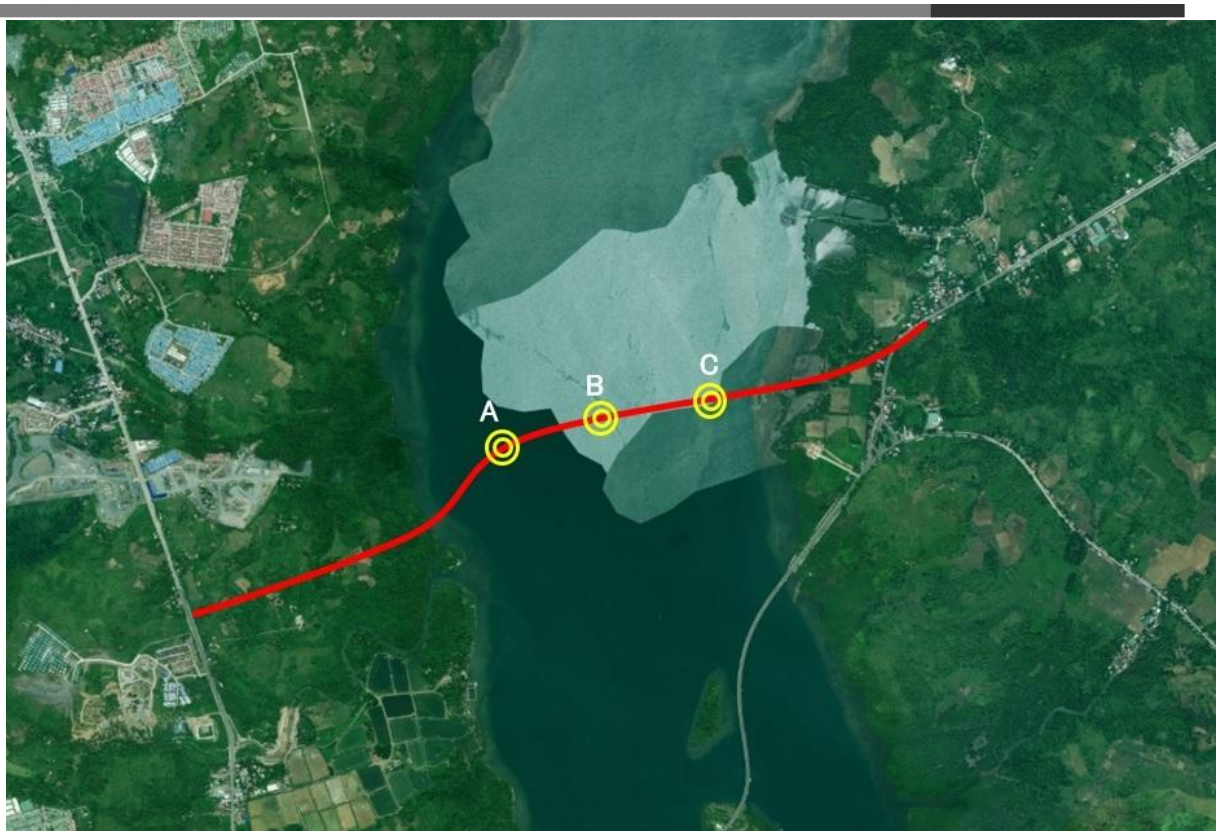


Source: JICA Survey Team

Figure 5-27 Topographic Data of the Sea Area Section from the Bathymetry Survey (Left: Samar Side, Right: Leyte Side)

(8) Measurement of Tidal Velocity

Tidal current velocity measurements were conducted at three points along the planned bridge route. The survey was conducted from October 24 to November 1, 2024.



Source: JICA Survey Team

Figure 5-28 Tidal Current Velocity Measurement Points

The measurements indicated a maximum current velocity of 1.29 m/s at Survey Point B, near the center of the channel along the proposed bridge route. This result is similar with measurements obtained by DPWH during the same period.

Table 5-19 Tidal Current (Maximum) Velocity Measurement Results (Unit: m/s)

	Tidal velocity in the upper layer	Tidal velocity in the middle layer	Tidal velocity in the lower layer
A	0.81	0.78	0.75
B	1.29	1.18	1.12
C	1.25	1.26	1.25

Source: JICA Survey Team

5.6 Geological Survey

5.6.1 Survey Objectives

In order to design the foundations of bridges, the geological survey was divided into two phases:
Phase-I: Investigation to select the bridge location; and
Phase-II: Investigation to determine the geological conditions at the proposed bridge location after the route was determined.

Phase I Survey: Based on the results of previous surveys, field investigations, and borehole investigations of the existing SJB, a new borehole investigation was conducted at the proposed bridge site, which was assumed to have relatively favorable ground conditions.

Phase II Survey: A detailed geological investigation was conducted at the proposed bridge site to determine the bridge's foundation type and specifications, assess whether measures against poor ground were necessary, and appropriately reflect the results into the design and construction cost.

5.6.2 Survey Contents

The contents of the geotechnical survey are described below.

(1) Phase Ⅰ Survey

Borehole surveys were conducted to understand the geological conditions at the proposed bridge locations, using the N-line as the northern route and the C2a-line as the route near the existing SJB, as planned in the JICA Report (2021).

The coordinates of the survey points are shown below.

For the naming of borehole survey points: BH-No. is used for the N-line, BR-No. (Bridge) for bridge sections on the C2a-line, and EW-No. (Earthwork) for earthwork sections.

Table 5-20 List of Phase I Survey Points

Coordinates of Borehole Survey datum: PRS92

No	Line	Borehole-No	x (N)	y (E)	Station	Location	E.L. (m)
1	N	BH-01	1259803.940	497673.384		Offshore	-9.500
2	N	BH-02	1259784.111	497985.403		Offshore	-6.000
3	C2a	BR-02	1251328.610	496599.279	0+885	Offshore	-10.500
4	C2a	BR-03	1251298.858	496532.320	0+955	Offshore	-11.600

Note: ※E.L data for the N-Line were measured at the time of the survey, while the C2a-Line was based on the bathymetry survey data.

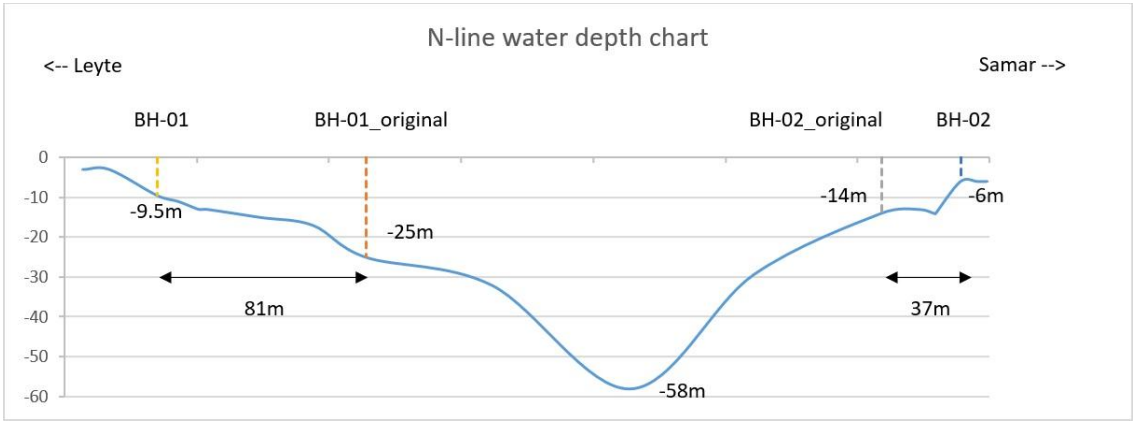
Source: JICA Survey Team

Because of the water depth and strong tidal currents in the N-line, the survey was shifted to a safer location with a stable slope on both banks.



Source: JICA Survey Team

Figure 5-29 Phase I Survey N-line Planned Survey Location and Shifted Survey Points (Marked with ○)



Source: JICA Survey Team

Figure 5-30 N-line Survey Location and Shifted Survey Points (Straits Crossing Overview Map)

(2) Phase II Survey (Borehole Survey)

The detailed geological survey was carried out to examine the bridge foundation type, specifications, and the necessity for countermeasures against weak ground at the planned bridge construction points identified in the Phase I Survey, and to appropriately reflect the results into the design and construction cost.

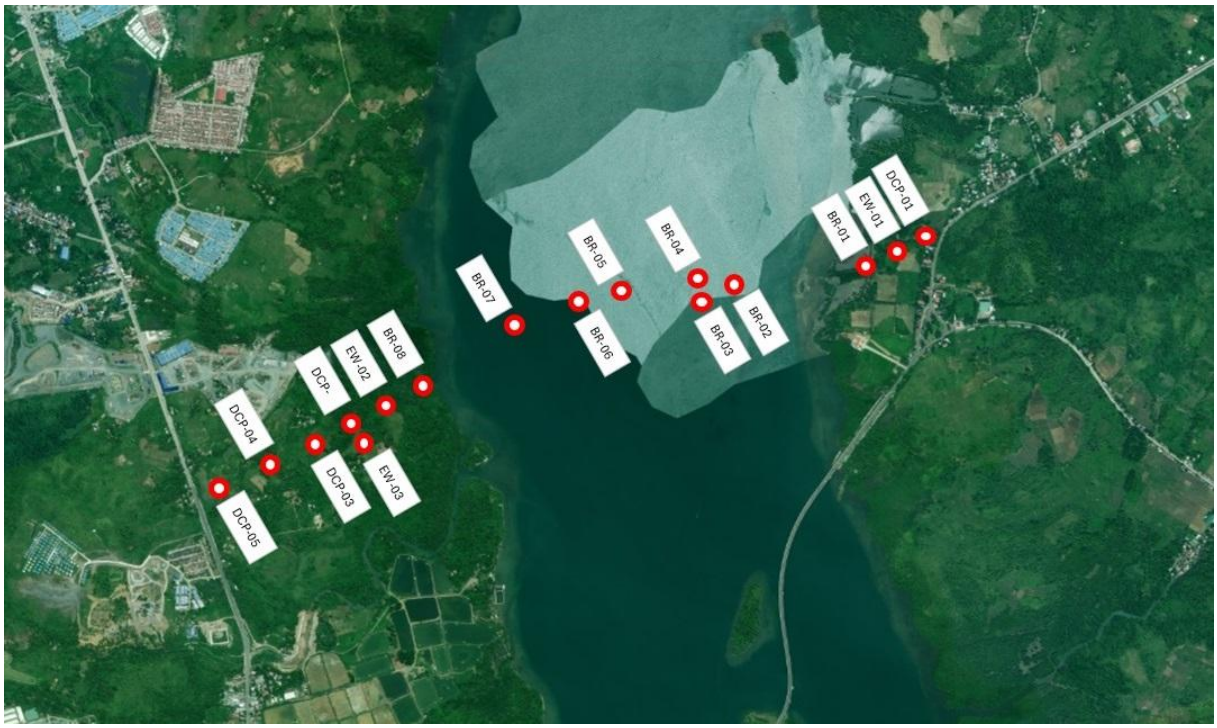
For the naming of borehole survey points, bridge sections are designated as BR-No. (Bridge), and earthwork sections are designated as EW-No (Earthwork).

Table 5-21 List of Phase II Survey Sites

Coordinates of Borehole Survey datum: PRS92

No	Line	Borehole-No	x (N)	y (E)	Station	Location	E.L. (m)
5	C2a	EW-01	1251419.033	497195.878	0+280	Onshore	11.610
6	C2a	BR-01	1251393.698	497120.136	0+360	Onshore	5.448
7	C2a	BR-04	1251356.556	496532.548	0+955	Offshore	-11.600
8	C2a	BR-05	1251297.367	496336.128	1+150	Offshore	-10.500
9	C2a	BR-06	1251289.114	496266.616	1+220	Offshore	-12.858
10	C2a	BR-07	1251189.910	495983.772	1+525	Offshore	-11.500
11	C2a	BR-08	1250892.102	495725.411	1+920	Onshore	1.450
12	C2a	EW-02	1250846.163	495660.044	2+000	Onshore	1.265
13	C2a	EW-03	1250760.616	495586.314	2+420	Onshore	6.525

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5-31 Location of C2a-line Borehole Surveys in Phase I and Phase II Surveys

For safety reasons, the survey locations at BR-04 and BR-06 on the C2a-line were shifted 19 m perpendicular to the bridge axis and 20 m toward the center of the channel, respectively, for BR-04 and BR-06.



Source: JICA Survey Team

Figure 5-32 Phase II Survey C2a-line Planned Survey Location and Shifted Survey Points (BR-04 and BR-06)

The survey was conducted at a location 39 m from the EW-03 on the C2a-line, as agreement with the landowner could not be reached.



Source: JICA Survey Team

Figure 5-33 Phase II C2a-line Planned Survey Location and Shifted Survey Point (EW-03)

(3) Phase II Survey (DCPT Survey)

Dynamic Cone Penetration Test (DCPT) surveys were conducted at the following locations to evaluate soil quality in the onshore area of the C2a-line.

Table 5-22 List of Phase II DCPT Survey Sites

Coordinates of DCPT datum: PRS92

No.	Line	DCPT-No.	x	y	Station	Location
1	C2a	DCP-01	497266.1311	1251457.194	0+200	BP ～ EW-01
2	C2a	DCP-02	495568.1816	1250795.318	2+105	EW-02 ～ EW-03
3	C2a	DCP-03	495476.0157	1250745.014	2+210	
4	C2a	DCP-04	495383.0712	1250696.21	2+315	
5	C2a	DCP-05	495161.5468	1250618.031	2+550	EW-03 ～ EP

Source: JICA Survey Team

5.6.3 Results of Survey

(1) Boring Results

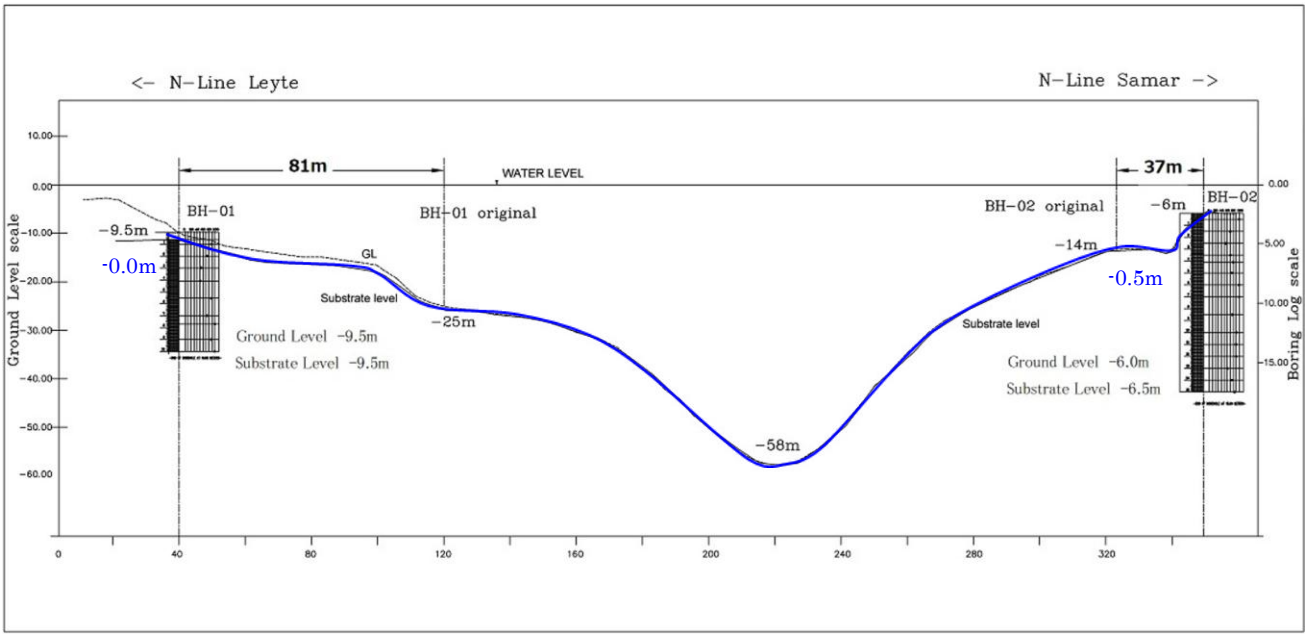
Boring was conducted on the N-line and C2a-line, which serves as comparison targets for the alternative routes. The excavation depth was determined based on the depth at which either (i) it was possible to confirm that the soil layer has an N-value of 50 or higher, or (ii) that the rock layer was sufficiently thick (5 m or more) to serve as a support layer for road structures.

N-line: Rock layer confirmed from the seabed. Excavation depth: 10.0–15.0 m.

C2a-line (Land Section): Soil layers with an N-value of 50 or higher, or rock layers, were confirmed at depths of 2–4 m from the ground surface. Drilling depth: 7.0–11.7 m.

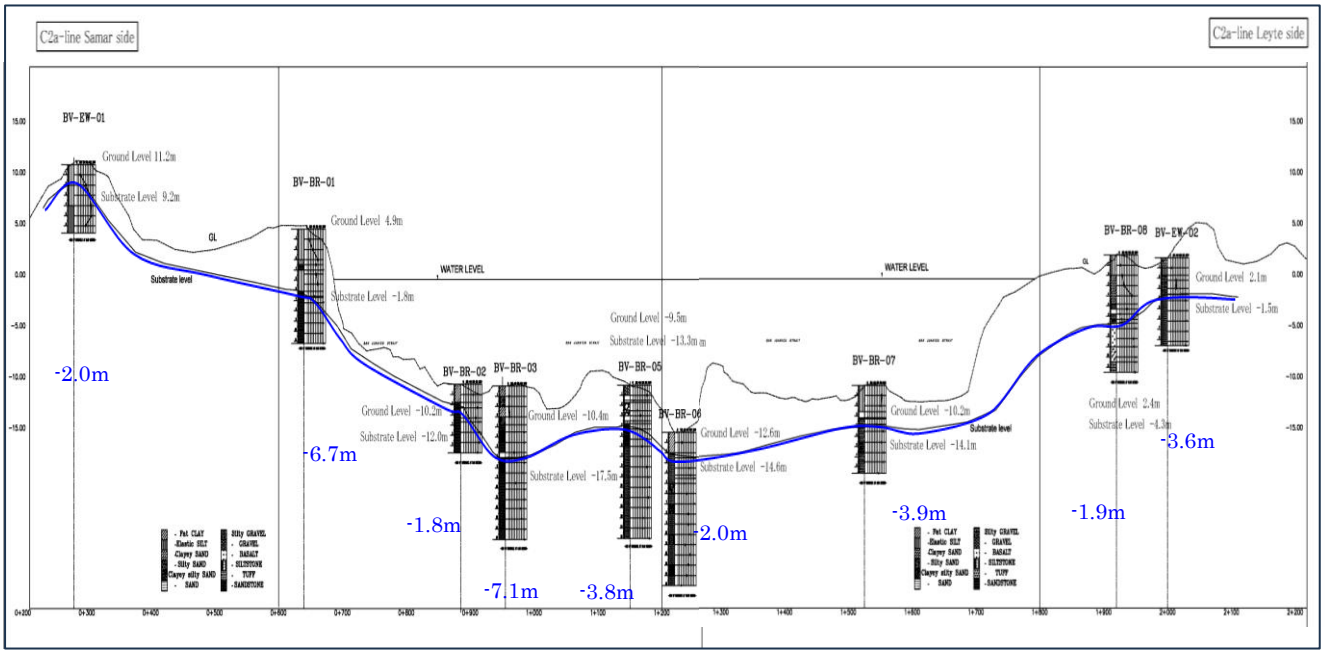
C2a-line (Marine Section): Rock layers were confirmed at depths of 2–4 m from the seabed. Drilling depth: 6.7–15.0 m.

The stratigraphic map and soil properties of the survey sites are outlined below. Columnar diagrams and test result tables are attached separately.



Source: JICA Survey Team

Figure 5-34 N-line Substrate Layer



Source: JICA Survey Team

Figure 5-35 C2a-line Substrate Layer

Table 5-23 Summary List of Borehole Survey Results

Overview of Borehole Survey（Phase-Ⅰ）

No	Line	Borehole-No	Survey depth	Notes
1	N	BH-01	10.00 m	Sandstone was observed at depths below GL-0.6m
2	N	BH-02	15.00 m	Sandstone was observed from the surface to depth
3	C2a	BR-02	6.70 m	Sandstone was observed at depths below GL-1.8m.
4	C2a	BR-03	15.00 m	Depth below GL-3.5m is composed of alternating beds of sandstone, mudstone.

Overview of Borehole Survey（Phase-Ⅱ）

No	Line	Borehole-No	Survey depth	Notes
5	C2a	EW-01	6.69 m	Wet sandy silt, N-value >56 at GL-2m, groundwater level GL-2.9m
6	C2a	BR-01	11.21 m	Wet sandy silt, N-value >68 observed near GL-3m, sandstone observed below GL-6.1m, groundwater level GL-3.3m
7	C2a	BR-04	15.00 m	Shallow layer is clay, gravel, and sandstone from GL-7.6m
8	C2a	BR-05	15.00 m	Sand, gravel, and clay were observed in the shallow layer, and sandstone was observed at depths below GL-4.6m
9	C2a	BR-06	15.00 m	Sandstone was observed from GL-2m, gravel and clayey soil from GL-5m to 6m, and sandstone from GL-6.0m down.
10	C2a	BR-07	8.60 m	Shale was observed from GL-3.5m, sandstone from GL-4.5m to 6.5m, and shale at depths below GL-6.5m
11	C2a	BR-08	11.50 m	Sand and sandstone alternating with clay; basalt identified at depths below GL-6.5m; groundwater level GL-1.8m
12	C2a	EW-02	8.65 m	Sandy silt (wet) at the surface, sandstone was observed at depths below GL-3.6m, groundwater table is near the surface
13	C2a	EW-03	10.00 m	Shallow layer was sandy clay mixed with sand, sandstone was observed at depths below GL-4.8m

Source: JICA Survey Team

Table 5-24 Summary List of DCPT Results

Overview of Dynamic Cone Penetration Test（Phase-Ⅱ）

No	Side	DCPT-No	Notes
1	Samar	DCPT-1	Bearing pressure was confirmed at GL-1.7m to 1.8m.
2	Leyte	DCPT-2	Bearing pressure was confirmed at GL-1.8m.
3	Leyte	DCPT-3	Bearing pressure was confirmed at GL-1.3m.
4	Leyte	DCPT-4	Bearing pressure was confirmed at GL-1.9m to 2.0m.
5	Leyte	DCPT-5	Bearing pressure was confirmed at GL-1.0m.

Source: JICA Survey Team

(2) Results of In-hole Horizontal Load Tests

In order to understand the deformation characteristics of the ground, in-hole horizontal load tests were conducted at five locations in the C2a-line bridge section. The test locations (depths) were selected among the rock layers assumed to be the supporting layer, taking into consideration the degree of weathering and fragmentation. The boreholes tested and their corresponding results are as follows:

Table 5-25 Summary of Borehole Horizontal Load Test Results (Modulus of Deformation)

Borehole No.	Depth(GL.m)	Deformation coefficient(MPa)	Note
BR-01	8.5~9.5	360.63	Sand stone:sizeM
BR-02	3.28~3.68	123.83	Sand stone:sizeL
BR-03	7.5~8.5	564.41	Sand stone:sizeS
BR-05	9.0~10.0	34.3	Sand stone:sizeL
BR-08	6.5~7.5	365.42	Basalt:sizeM

Source: JICA Survey Team

(3) Dynamic Cone Penetration Test Results

As part of the geological survey for preparatory research, boring was conducted at several representative locations within the planned section. In addition to boring, dynamic cone penetration tests were conducted in the land section (road construction section) to obtain a relatively simple understanding of the ground conditions. The results showed that sufficient bearing capacity was obtained at depths of 1–2 m below the ground surface at all locations.

(4) Laboratory Test Results

Samples collected from boring were sent to the testing laboratory of the survey company in Quezon City, Metro Manila for various laboratory tests. The test items and corresponding results (list) are as follows:

- Physical Tests: Moisture content, plasticity and liquidity limit, particle size distribution
- Strength Tests: Uniaxial compression (rock), triaxial compression (clay)
- Fill Material Tests: Compaction, California Bearing Ratio (CBR) (samples collected from the soil quarry)

Table 5-26 Summary of Soil Test Results

Borehole No	Depth (m)	Moisture content(%)	Plasticity index(%)	Particle size distribution(mm)／(%)				Uniaxial strength(MPa)	Adhesion(kPa)	Shear angle(°)
				4.75	0.85	0.25	0.075			
C2a-Line										
EW-01	0.55~6.00	21~34	13~24	100	98~99	57~89	52~72			
BR-01	0.55-4.45	20~53	22~26	100	98~99	83~91	72~74			
	3.00~3.50							0.43*1		
	6.11~9.21							4.32~4.93		
BR-02	0.55~1.78	33~35	39~41	92~99	86~93	82~91	76~86			
	3.68~6.34							6.70~15.9		
BR-03	0.55~7.09	32~47	18~41	68~97	63~95	40~87	20~84			
	9.86~13.39							10.5~12.4		
BR-04	0.55~6.55	23~26	39~43	79~99	79~99	77~98	75~98			
	10.00~13.5							2.94~4.66		
BR-05	0.55~3.78	41~43	21	95~99	89~97	7~96	63~95			
	4.58~14.29							10.4~15.4	3.0E3*2	54*2
BR-06	0.55~1.95	21~28	39~40	81~96	77~93	74~91	73~89			
	6.40~12.90							2.10~3.99	2.2E3*2	53*2
BR-07	0.55~2.00	19~20	28~29	100	97~98	90~96	70~72			
	3.86~6.56							2.38~6.14		
BR-08	1.00~4.00	20~56	12~22	100	92~99	45~79	36~64		20.96	4
	9.00~11.50							2.43~3.58		
EW-02	0.55~3.00	18~59	18~21	96~100	78~92	33~67	21~56		22.69	2
	3.65~8.65							9.71~10.3		
EW-03	0.55~4.80	12~52	9~42	97~100	75~99	41~95	25~90	0.01	80.72	5
	8.55~9.00							23.29		
N-Line										
BH-01	0.55~0.60	15	-	97	92	65	45			
	0.88~9.50							2.07~4.41		
BH-02	No sample									
	0.85~14.28							3.49~4.62	2.6E3*2	55

*1) Viscous soil test results, *2) Rock test results

Source: JICA Survey Team

Table 5-27 Summary of Soil Test Results (2)

Borrow Pit	Compaction test		CBR		
	Maximum dry density(g/cc)	Optimal moisture content(%)	95%dry density	100%dry density	Expansion ratio(%)
TP-1,Aquino Valley(Leyte)	1.825	16	25.55	28.53	0.37
TP-2,Mountain Valley(Samar)	1.873	14.65	29.2	32.64	0.131

Source: JICA Survey Team

5.7 Wind Simulation

5.7.1 Purpose of Conducting Wind Simulation

The target area and its surrounding areas are frequently hit by typhoons, making wind-resistant design essential for long bridges. However, wind speed data from Tacloban Airport is recorded only at intervals of three hours. Moreover, the anemometer broke down when Super Typhoon Yolanda approached, and no data could be obtained for the following six months. As a result, the data is both insufficient and unreliable. Therefore, this study aims to conduct wind simulations to more accurately grasp the wind loads (including those during typhoons) acting on the designed bridges and to improve the accuracy of the outline design.

5.7.2 Selection of Wind Simulation Model

After comparing the three wind analysis models listed below, Model 2: Wind Analysis Using the Microclimate Analysis System for Complex Terrain (MASCOT) Model was selected. This method accounts for the undulating topography of the San Juanico Strait, ensures sufficient accuracy at the preparatory survey stage, and is capable of analyzing local wind speeds at a relatively low cost.

Table 5-26 Wind Simulation Models and Their Overview

Model	Overview	Level of Analysis	Cost
Model 1: Wind Analysis Using an Empirical Typhoon Model	Uses the Myers equation and similar methods to assume concentric wind conditions around a typhoon and analyze changes in wind conditions as the typhoon moves. The calculations are relatively easily. However, terrain undulations are not taken into account, and the image only distinguishes between sea and land on flat terrain.	Simple (No consideration of terrain; flat surface)	Inexpensive (Comparison base: 1.0)
Model 2: Wind Analysis Using the MASCOT Model (with Topographical Effects)	Builds on the results of Method 1 to analyze wind conditions using the MASCOT model. This method accounts the effects of topographical relief and enables the assessment of changes in wind speed due to topographical relief. It is suitable for analyzing local wind speeds.	Medium (Terrain consideration; three-dimensional)	Moderate (Approx. 1.5 times)
Model 3: Wind Analysis Using the WRF Model	Uses the Weather Research and Forecasting (WRF) method to analyze the wind conditions during typhoon periods. This method accounts for effects of terrain and vertical changes in wind speed. However, mesh size is limited, and analyzing local wind speed requires time and computational costs.	High (Terrain consideration; three-dimensional and time-series analysis possible)	Very expensive (Approx. 3.0 times)

Source: JICA Survey Team

5.7.3 Wind Simulation Implementation Flow

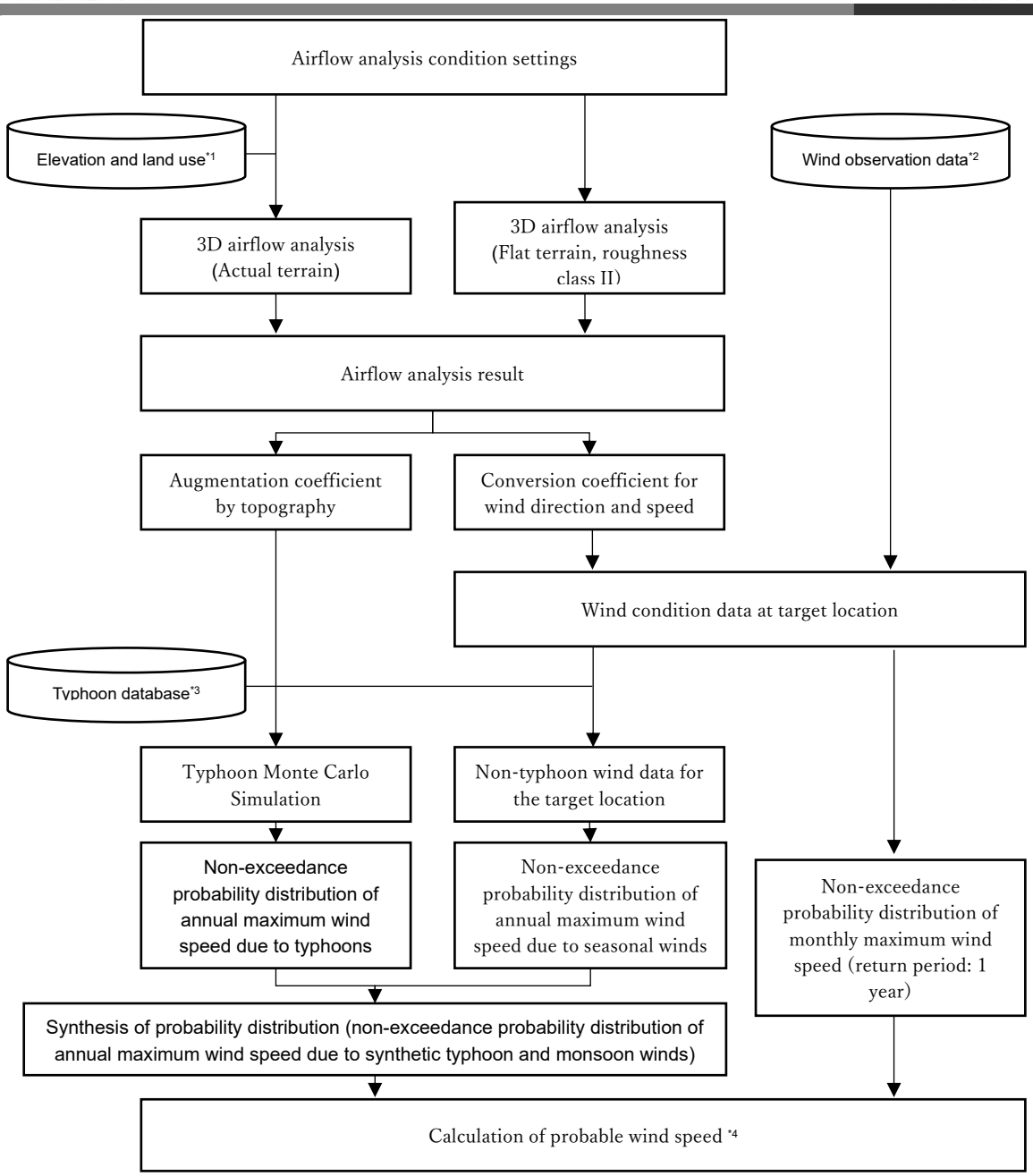
The flow chart of this operation is shown in Figure 5-36.

Probable wind speeds are calculated using a typhoon Monte Carlo simulation and the Measure-Correlate-Predict (MCP) method. The MCP method predicts wind speeds at a target location using wind observation data from nearby locations. In these calculations, the frequency and strength of typhoons, seasonal winds, as well as the effects of surrounding topography are taken into account.

In the typhoon Monte Carlo simulation, parameters representing the atmospheric pressure field and the probability distribution of the annual number of typhoons occurring are calculated using historical typhoon observation data. Based on these probability distributions, virtual typhoons are randomly generated. Upper-atmosphere winds are then calculated from the pressure field of each generated virtual typhoon. Surface winds are determined applying an altitude correction coefficient, to account for the roughness of the earth's surface, and an average wind speed augmentation coefficient, to account for topography. These calculations are used to determine the annual maximum wind speed. The wind speed augmentation coefficient due to terrain is calculated from the ratio of wind speed obtained through airflow analysis on flat terrain to that calculated on actual terrain. Finally, the annual maximum wind speeds are sorted in ascending order, and the probability distribution of non-exceedance of annual maximum wind speeds caused by typhoons is derived.

The MCP method converts non-typhoon wind speed and direction data observed at nearby observation points into corresponding values at the target site. This conversion uses wind speed and direction coefficients derived from airflow analysis. The annual maximum wind speed is then extracted from the wind speed at the target location, and the non-exceedance probability distribution of annual maximum wind speeds due to the seasonal winds is derived.

Finally, by multiplying the two probability distributions, the non-exceedance probability distribution of the annual maximum wind speed due to the combined wind of the typhoon and monsoon is calculated, and the probable wind speed corresponding to each return period is obtained.



*1 Topographic data is taken from SRTM-3 data provided by the National Aeronautics and Space Administration (NASA), and land use data is taken from USGS_30s data provided by the United States Geological Survey (USGS).

*2 Wind observation data will be taken from wind direction and speed data observed at the Tacloban Observatory near the construction site from 1951 to 2023.

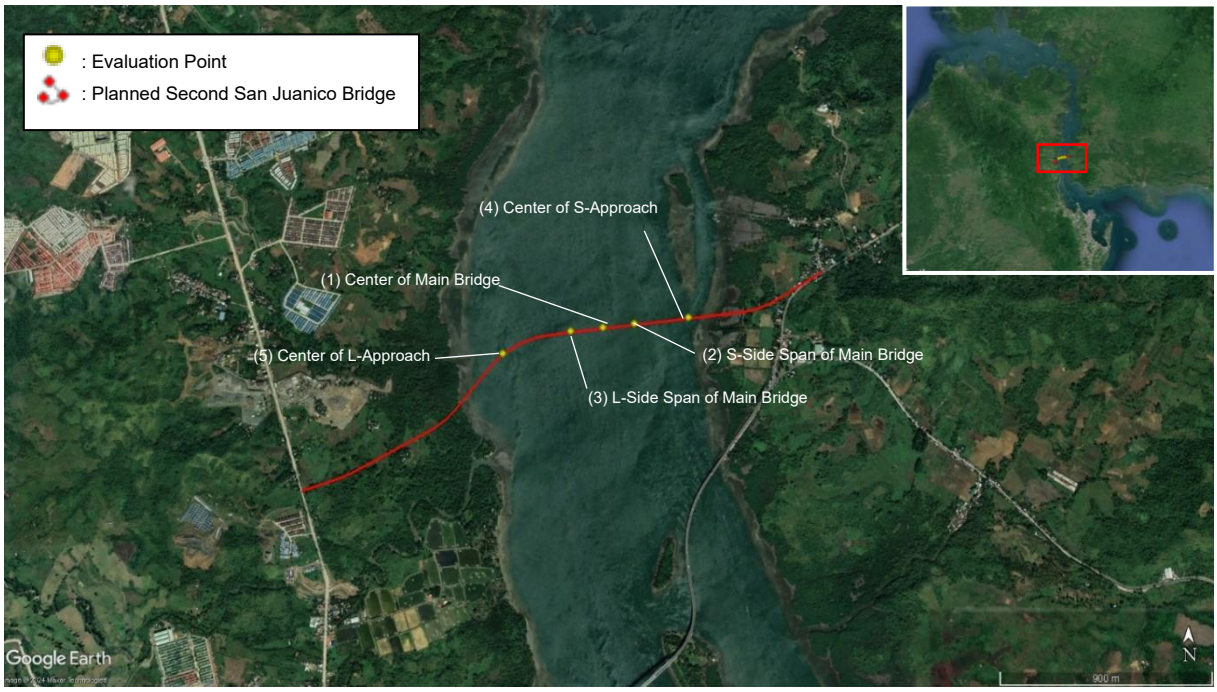
*3 The typhoon database will use data from a total of 44 years, including the period from 1977 to 2007 that is standardly included in MASCOT, as well as data from 2008 to 2021.

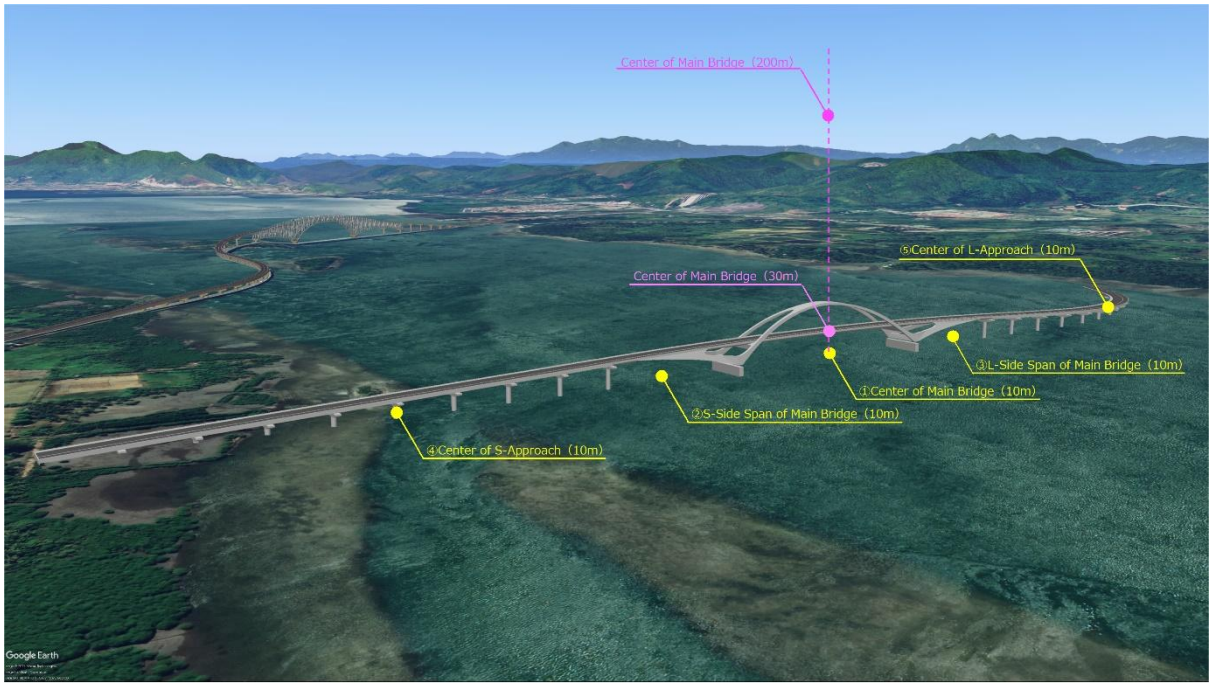
*4 Calculate the probable wind speed for a given recurrence period based on the 10-minute average wind speed.
Source: JICA Survey Team

Figure 5-36 Flow of Wind Simulation

5.7.4 Evaluation Point

The locations of the evaluation points and the calculated altitude information are shown in Figure 5-37 and Table 5-27. Evaluations will be conducted at three altitudes (10, 30, and 200 m) only at the center of the main bridge span, and at an altitude of 10 m at the other four locations.





Source: JICA Survey Team

Figure 5-37 Schematic Diagram of the Evaluation Site

Table 5-27 Latitude, Longitude, and Altitude of Evaluation Points on the SSJB

Evaluation Point	Latitude	Longitude	Altitude [m]
(1) Center of Main Bridge	11° 18′ 54.18"	124° 58′ 07.57"	10,30,200
(2) S-Side Span of Main Bridge	11° 18′ 54.76"	124° 58′ 12.25"	10
(3) L-Side Span of Main Bridge	11° 18′ 53.64"	124° 58′ 02.75"	10
(4) Center of S-Approach	11° 18′ 55.69"	124° 58′ 20.35"	10
(5) Center of L-Approach	11° 18′ 50.33"	124° 57′ 52.70"	10

Source: JICA Survey Team

5.7.5 Summary of Wind Speed Observation Data Used in the Analysis at Tacloban

In this analysis, observational data collected in Tacloban, near the evaluation site, from January 2014 to December 2023 will be used. An overview of the wind observation data is shown in Table 5-28. Wind observations have been conducted for 73 years, from 1951 to 2023, although the observation station was relocated due to the effects of Typhoon Yolanda in November 2013. The observation altitude is 10 m above ground level, and 10-minute average wind speed and direction observed every three hours are recorded. The time series of observed wind condition data is shown in Figure 5-39. At 6:00 UTC on December 18, 2019, a strong wind event with a wind speed of 40 m/s was recorded, as shown in the red frame in the figure. During the same period, Typhoon 201929 passed through; however, it was confirmed that this event occurred before the typhoon formed (see Section 5.6.6). Before and after the event, strong wind remained below 5 m/s, but they increased and decreased rapidly during the occurrence. This is considered an unnatural phenomenon, likely caused by abnormal readings from the observation equipment. Therefore, in this analysis, the event was removed as an outlier. The non-exceedance probability distribution of the annual maximum wind speed due to monsoons and the non-exceedance probability distribution of the monthly maximum wind speed were derived.



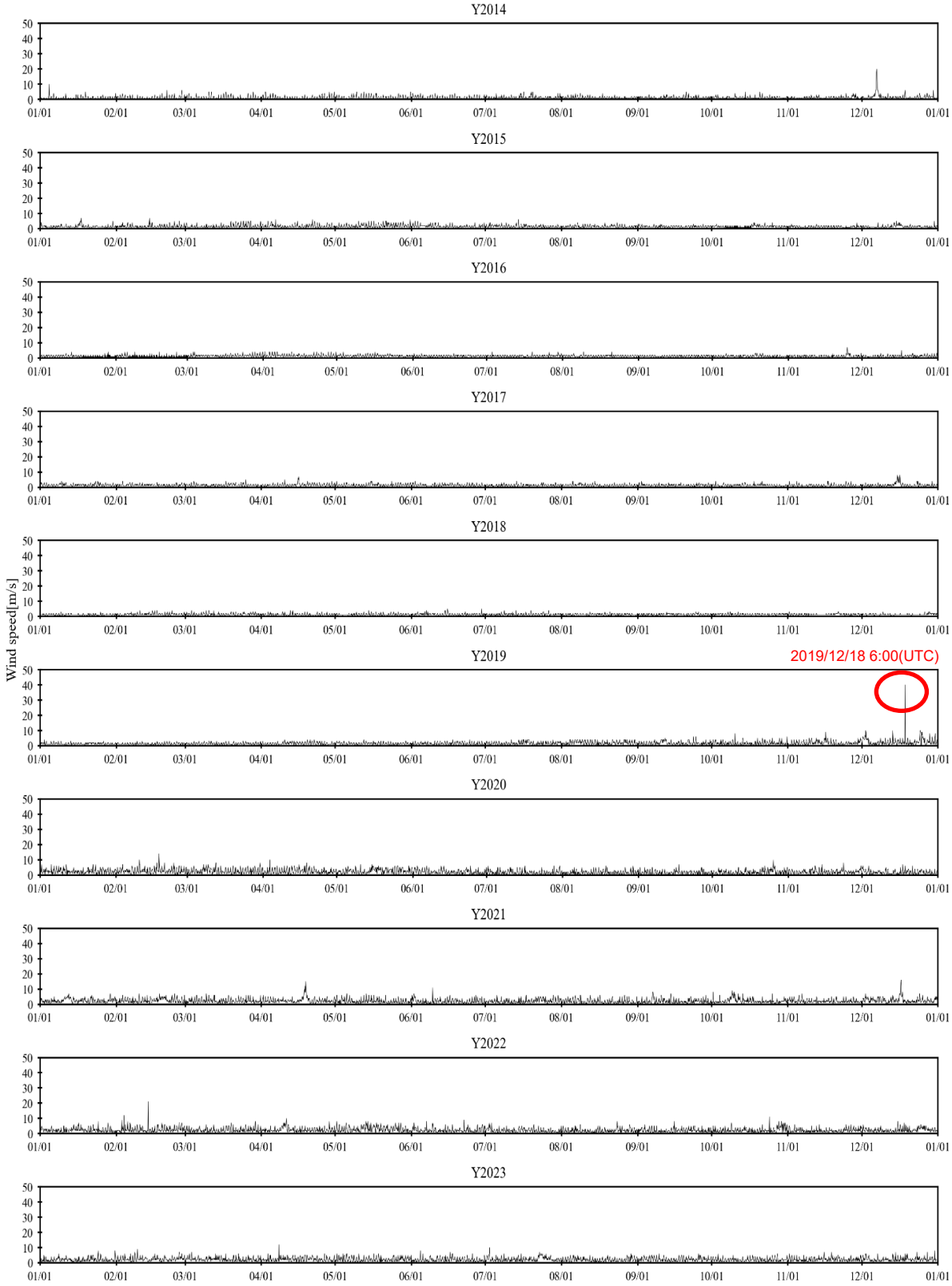
Source: JICA Survey Team

Figure 5-38 Positional Relationship Between Evaluation Point and Wind Observation Point

Table 5-28 Summary of Wind Observation Data

Item		Explanation	Remarks
Period		1951-2023	
Location Information	Before Typhoon Yolanda	Latitude: 11 degrees 13 minutes 31.98 seconds Longitude: 125 degrees 1 minute 30.00 seconds	Observations from 1951 – November 2013
	After Typhoon Yolanda	Latitude: 11 degrees 14 minutes 36.53 seconds Longitude: 125 degrees 0 minutes 28.22 seconds	2014 – Present
Elevation		2.7m	
Observation Altitude		10 m above ground level	
Element		10-minute average wind speed 10-minute average wind direction	Observations every three hours

Source: JICA Survey Team

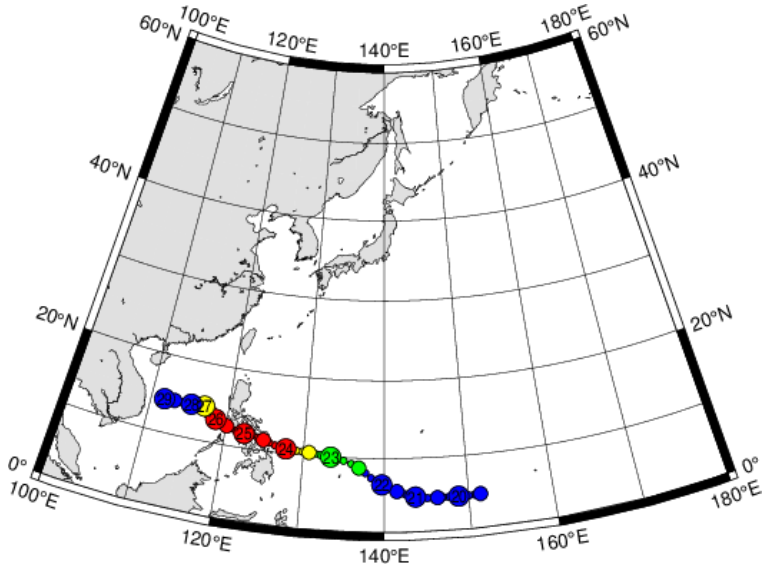


Source: JICA Survey Team

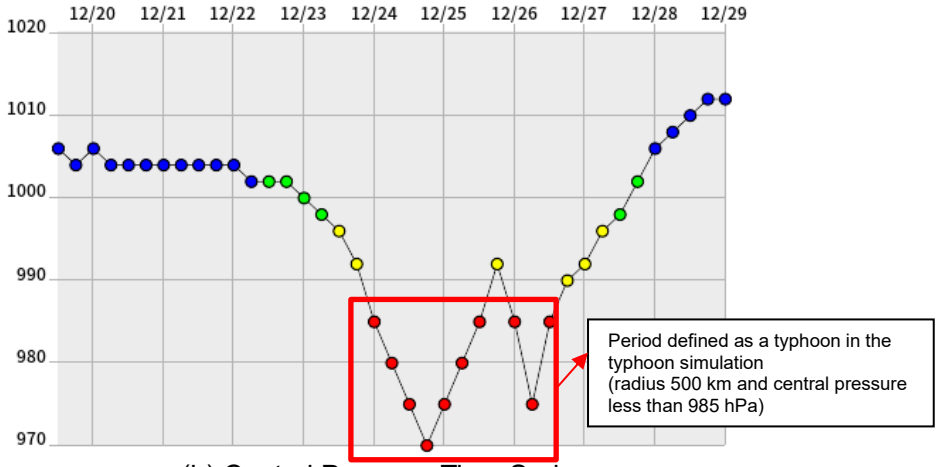
Figure 5-39 Wind Observation Data Time Series (2014-2023)

5.7.6 Strong Wind Event Observation Data at 6:00 UTC on December 18, 2019 (Reference)

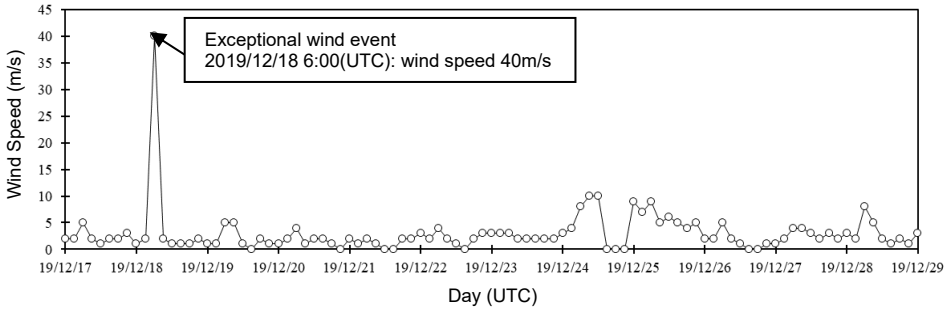
Tacloban observation data recorded a strong wind event with a wind speed of 40 m/s at 6:00 UTC on December 18, 2019. To identify potential causes of this event, Typhoon No. 201929, which passed through the Philippines during the same period, was examined. Figure 5-40 shows the typhoon track information and central pressure time series of Typhoon 201929, as well as a comparison with the Tacloban observation data. Typhoon 201929 formed at 12:00 UTC on December 22, 2019, and dissipated at 00:00 UTC on December 28, 2019. In the typhoon simulation, a typhoon is defined as one within a 500 km radius of the evaluation point and has a central pressure of 985 hPa or less. Under this definition, the typhoon period was from 00:00 UTC on December 24, 2019 to 9:00 UTC on December 25, 2019. Therefore, the strong wind event that occurred at 6:00 UTC on December 18, 2019 is determined to have been caused by a monsoon, and it was not included in the typhoon. Consequently, in the present analysis, this event was excluded, and the non-exceedance probability distribution of annual maximum wind speeds associated with the monsoon was constructed based on the remaining data.



(a) Typhoon Track



(b) Central Pressure Time Series



(c) Tacloban Observation Data (10 m above ground level)

Source: JICA Survey Team

Figure 5-40 Comparison of Track Information and Central Pressure Time Series of Typhoon 201929 with Tacloban Observation Data

5.7.7 Consideration of Analysis Methods

Considering the state of existing data, a comparative study was conducted on the following three methods for calculating probable wind speeds in setting the design wind speed for bridges, as shown in Table 5-29. As a result of this comparison, Method 3—combining the Typhoon Monte Carlo Simulation (MCS) and Measure-Correlate-Predict (MCP) methods—was adopted.

(1) Study Using Typhoon MCS (Method 1)

A typhoon MCS was performed using the typhoon database implemented in MASCOT Offshore to create a non-exceedance probability distribution during typhoon conditions and to calculate the probable wind speed.

(2) Study Using the MCP Method (Method 2)

First, the wind speed ratio by direction between the Tacloban observation station and the SSJB was calculated from the airflow analysis results using MASCOT Basic. The long-term observation data from Tacloban were then converted to equivalent data at the bridge location. Next, the converted time series was separated into typhoon and non-typhoon periods using a typhoon database. The annual and monthly maximum wind speeds for each cause were calculated, and non-exceedance probability distributions were created. Finally, the typhoon and non-typhoon probability distributions were synthesized to create a mixed climate non-probability distribution, thereby obtaining the probable wind speed.

(3) Study Using Typhoon MCS+MCP Method (Method 3)

For probable wind speeds with return periods other than one year, the non-exceedance probability distribution during typhoons was obtained from (1), a study using the typhoon Monte Carlo Simulation, while the distribution during non-typhoon periods was obtained from (2), a study using the MCP method. The probability distribution of non-exceedance during typhoons and non-typhoons is calculated for the one-year return period wind speed using the MCP method.

Table 5-29 Consideration of Analysis Method

	Method 1 Typhoon MCS	Method 2 MCP Method	Method 3 Typhoon MCS+MCP Method [Recruitment]
Analysis of Typhoon Formation	○	×	○
Consideration of Non-typhoon Causes	×	○	○
1-year Probabilistic Wind Speed Calculation	×	○	○
Comprehensive Evaluation	△ The analysis of typhoon formation factors is generally good, but it is not possible to take into account non-typhoon formation factors or calculate one-year probabilistic wind speeds.	△ Since the maximum wind speed during the typhoon is not captured, it is possible that the calculated probable wind speed is an underestimate.	◎ By combining the typhoon MCS and MCP methods, it is possible to calculate the probable wind speeds of typhoon and non-typhoon causes.

Source: JICA Survey Team

5.7.8 Airflow Analysis

The conditions and results of the topography, roughness data, and airflow analysis used in the nonlinear wind forecast model MASCOT are shown below.

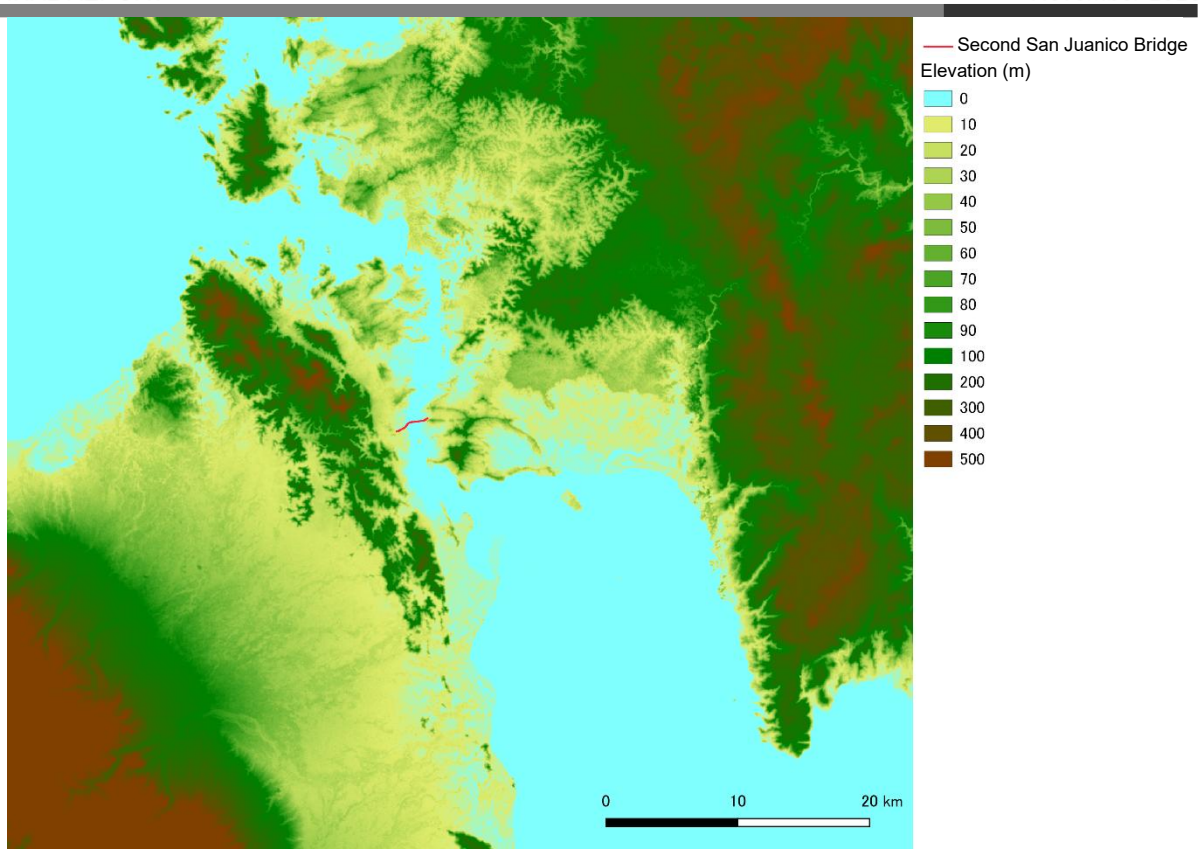
(1) Topographical Data

The topographical data were obtained from the NASA Shuttle Radar Topography Mission (SRTM-3) dataset provided by the National Aeronautics and Space Administration. An overview of the topographical data used is shown in Table 5-30, and the generated topographical data are illustrated in Figure 5-41.

Table 5-30 Overview of Topographical Data

Item	SRTM-3
Data Source	Space Shuttle Radar
Creation and Distribution Organization	NASA/USGS
Distribution Start Year	2003～
Data Acquisition Period	11 Days (2000)
Pixel Spacing	90 m
DEM Coverage	60 degrees north to 56 degrees south
Form	Free
Data Format	HGT format

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5-41 Elevation Distribution Map (SRTM-3)

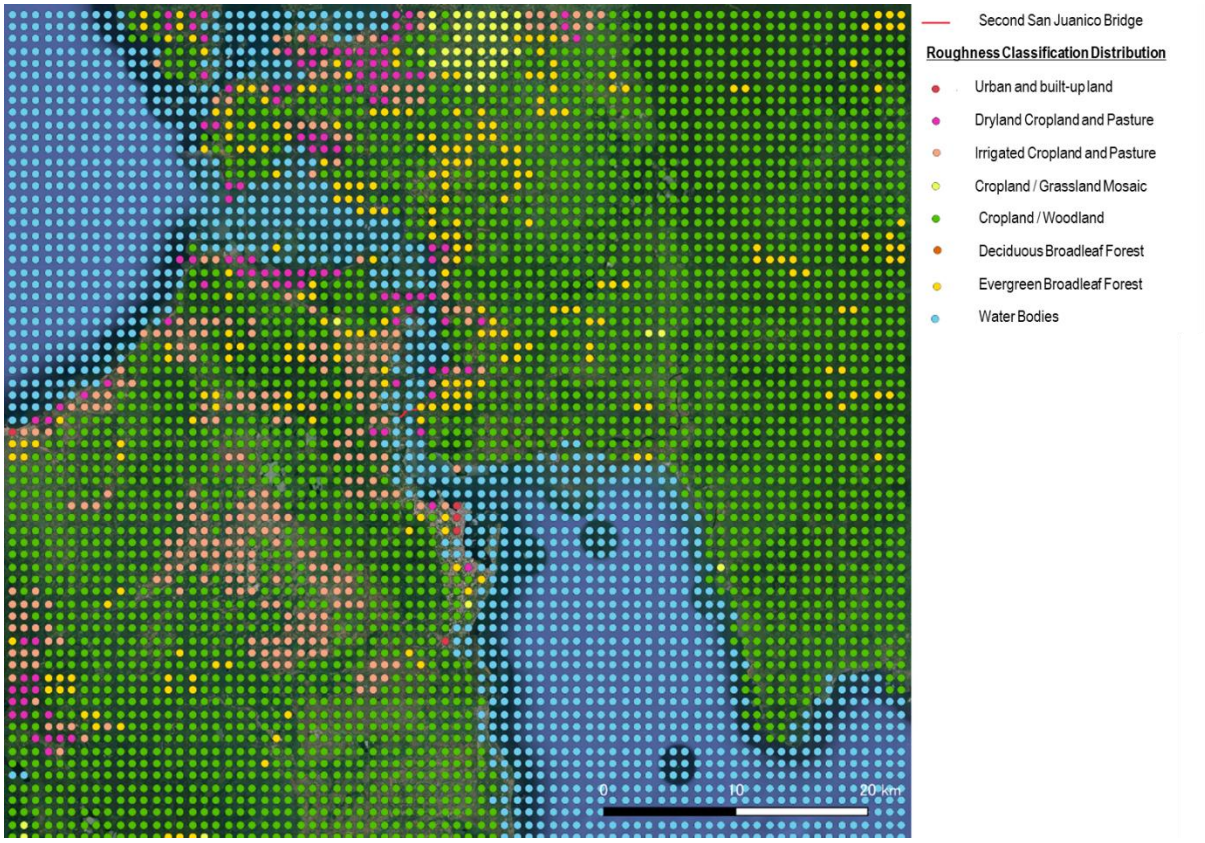
(2) Roughness Data

The roughness data were taken from the USGS_30s dataset provided by the US Geological Survey. An overview of the dataset is shown in Table 5-31, and a distribution map of land use classifications according to USGS-30s is shown in Figure 5-42. The site is comprised primarily of agricultural land, forest, and pastureland, with some urban areas nearby. However, since the USGS_30s has a coarse resolution of 900 m and cannot properly reproduce local land use in some areas, it was checked and corrected using aerial photographs to ensure that the roughness length values are appropriate.

Table 5-31 Summary of Roughness Data

Item	USGS_30s
Creation and Distribution Organization	United States Geological Survey (USGS)
Distribution Start Year	1996
Data Acquisition Period	11 Days (2000)
Pixel Spacing	900 m
DEM Coverage	Global
Form	Free
Data Format	NetCDF Format
Land Use Classification	24 Divisions

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5-42 Land Use Distribution Map (USGS-30s)

Table 5-32 Land Use Classification and Roughness Length Conversion Table (USGS_30s)

No.	Land Use Classification	Explanation	Roughness Length (m)
1	Urban and Built-up Land	Cities and Developed Areas	0.5
2	Dryland Cropland and Pasture	Dryland Cropland and Pasture	0.05
3	Irrigated Cropland and Pasture	Irrigated Farmland and Pastures	0.02
4	Mixed Dryland / Irrigated Cropland and Pasture	Mixed of Dry and Irrigated Farmland and Pastures	0.05
5	Cropland / Grassland Mosaic	Mosaic of Farmland / Grassland	0.05
6	Cropland / Woodland Mosaic	Farmland / Forest	0.2
7	Grassland	Grassland	0.1
8	Shrubland	Shrubland	0.01
9	Mixed Shrubland / Grassland	Mixed of Shrubs and Grasslands	0.01
10	Savanna	Savannah	0.15
11	Deciduous Broadleaf Forest	Deciduous Broadleaf Forest	0.5
12	Deciduous Needleleaf Forest	Deciduous Coniferous Forest	0.5
13	Evergreen Broadleaf Forest	Evergreen Broadleaf Forest	0.5
14	Evergreen Needleleaf Forest	Evergreen Coniferous Forest	0.5
15	Mixed Forest	Mixed Forest	0.2
16	Water Bodies	Water Bodies	0.0001
17	Herbaceous Wetland	Herbaceous Wetlands	0.2
18	Wooded Wetland	Lignified Swamp	0.4
19	Barren or Sparsely Vegetated	Barren Soil or Sparse Vegetation	0.01
20	Herbaceous Tundra	Herbaceous Tundra	0.1
21	Wooded Tundra	Woody Tundra	0.3
22	Mixed Ground Tundra	Mixed Grassland Tundra	0.15
23	Bare Tundra	Bare Tundra	0.05
24	Snow or Ice	Snow or Ice	0.001

Source: JICA Survey Team

(3) Airflow Analysis Conditions

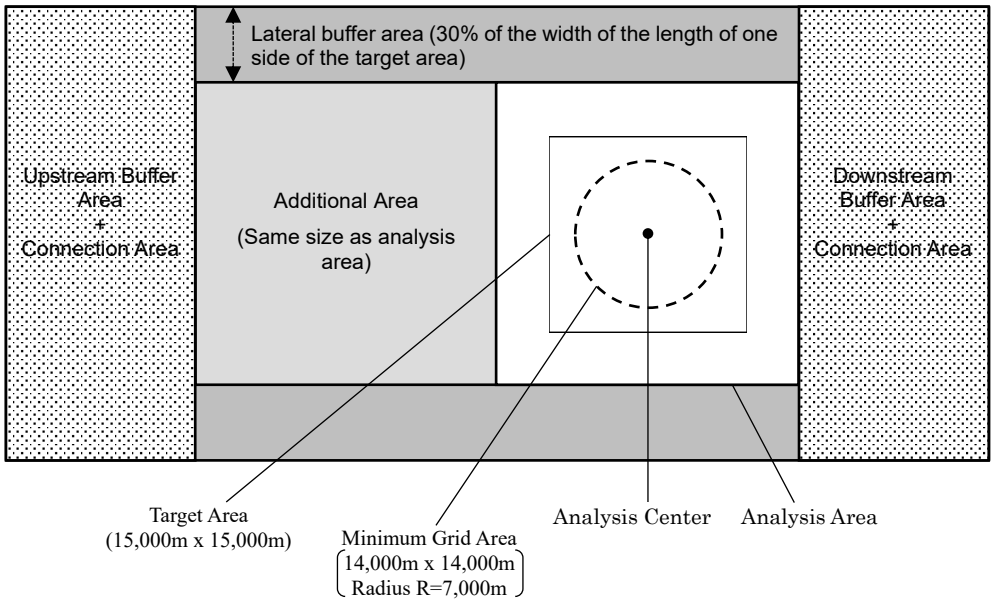
The conditions used in the airflow analysis are listed in Table 5-33.

The target area was set as a square with each side measuring 15,000 m, with the analysis center located approximately at the midpoint between the evaluation point on the SSJB and the wind observation point. The analysis range included the evaluation point, the wind observation station, and the surrounding areas. The analysis area was defined as a square inscribed within a circumscribing circle. An additional area equivalent to the analysis area was set upstream, and a buffer zone was established around both. The elevations of the inflow and outflow areas were set to 0 m, and a connecting area was modeled to smoothly connect the upstream and downstream buffer zones. A non-uniform grid was used for the computational grid in order to improve computational accuracy by refining the grid spacing near the analysis point. The surface roughness classification was set to roughness Classification II. A conceptual diagram of the analysis area is shown in Figure 5-43, the analysis mesh diagram is shown in Figure 5-44, the distribution of roughness lengths and contour lines is illustrated in Figure 5-45, and an example of the analysis area is provided in Figure 5-46.

Table 5-33 Airflow Analysis Conditions

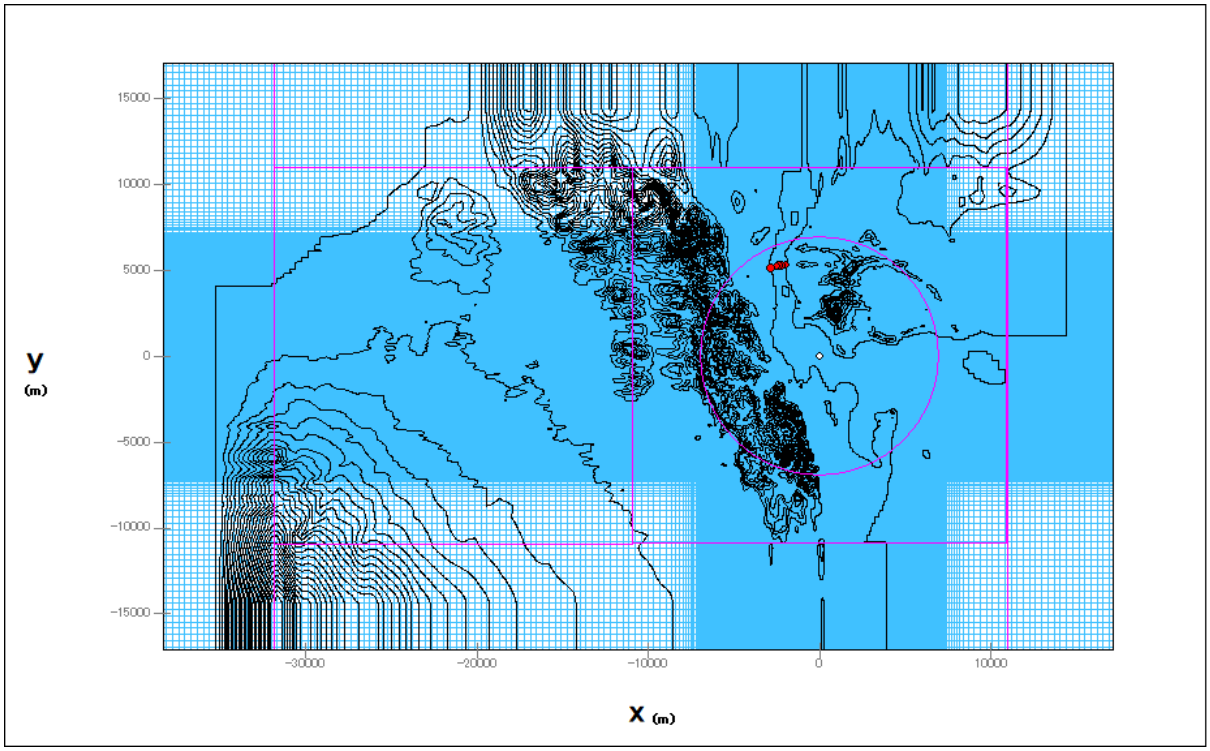
Item		Setting Value
Calculation Range	Latitude and longitude of the center of the target area	11 degrees 16 minutes 3.46 seconds 124 degrees 59 minutes 25.96 seconds
	Size of the target area in the east-west direction	15,000m
	Size of the target area in the north-south direction	15,000m
	Height in the target area	10,000m
Calculated Wind Direction	Calculation target wind direction	16 wind directions (22.5 pitch, 0°:N, 337.5°:NNW)
Lattice Spacing	Minimum horizontal mesh spacing	45m
	Maximum horizontal mesh spacing	360m
	Horizontal grid expansion rate	1.15
	Minimum horizontal mesh extent	7,000m
	Minimum vertical mesh spacing	5m
	Vertical grating elongation rate	1.20
	Upstream and downstream buffer areas	0.3 times
	Side cushioning area	0.3 times
	Additional Area	1.0x
	Total number of analysis grid points	445 × 386 × 34 = 5,840,180
Altitude and Roughness Related Data	Elevation data	SRTM-3 90m mesh
	Roughness data	USGS 900m mesh
Connection Area		Yes
Surface Roughness Classification for Flat Terrain $P(\theta)$		II

Source: JICA Survey Team



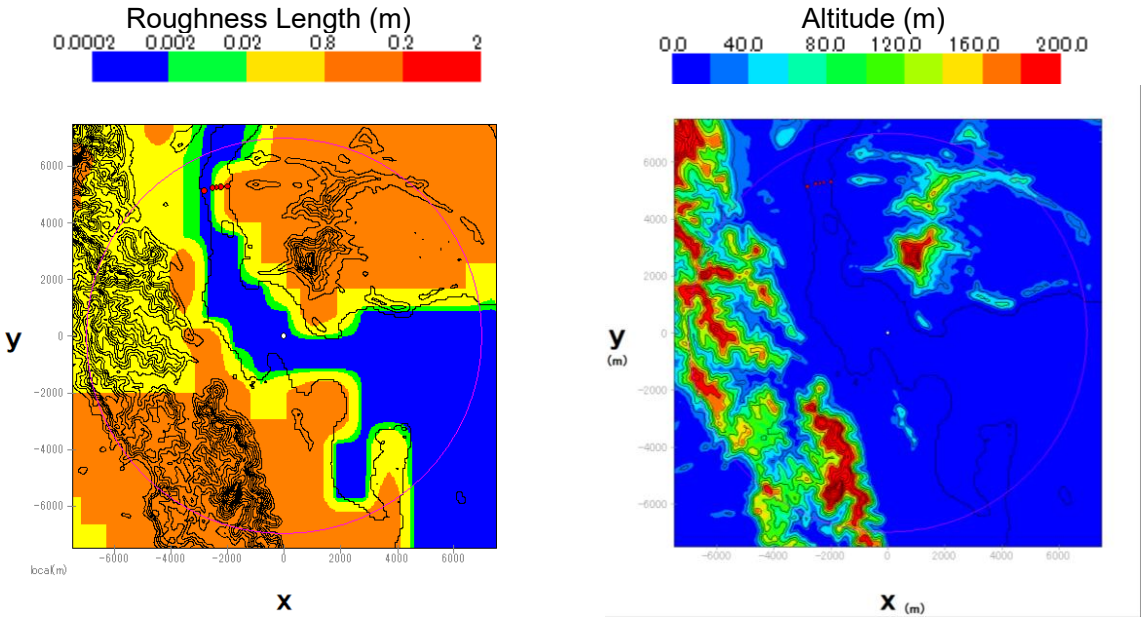
Source: JICA Survey Team

Figure 5-43 Conceptual Diagram of Analysis Area



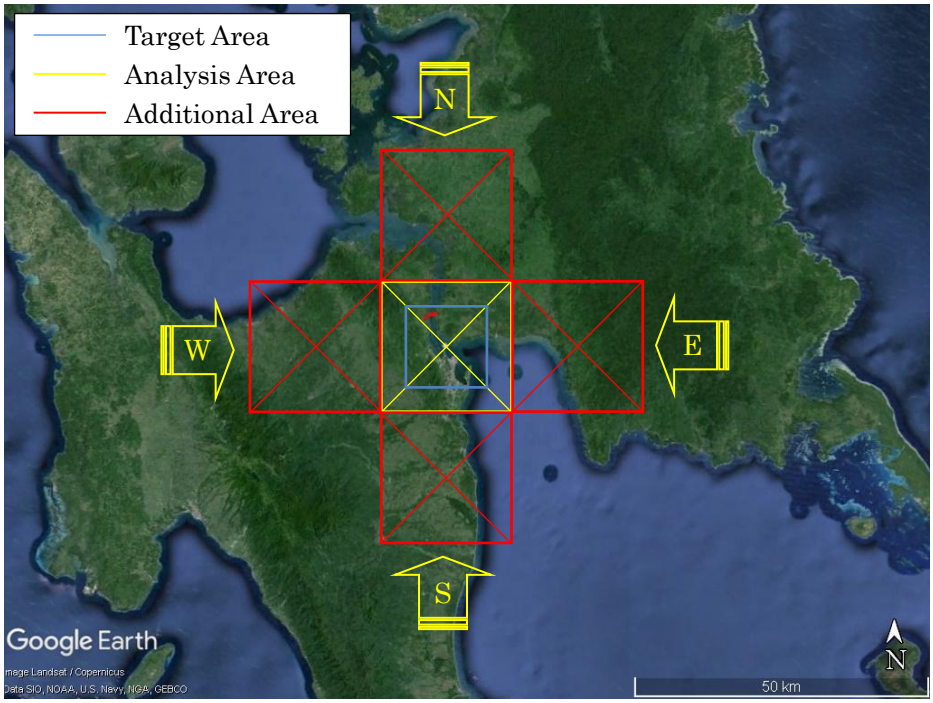
Source: JICA Survey Team

Figure 5-44 Analysis Mesh Diagram (Including Buffer Area, Wind Direction 270°)



Source: JICA Survey Team

Figure 5-45 Distribution of Roughness Length and Contour Lines



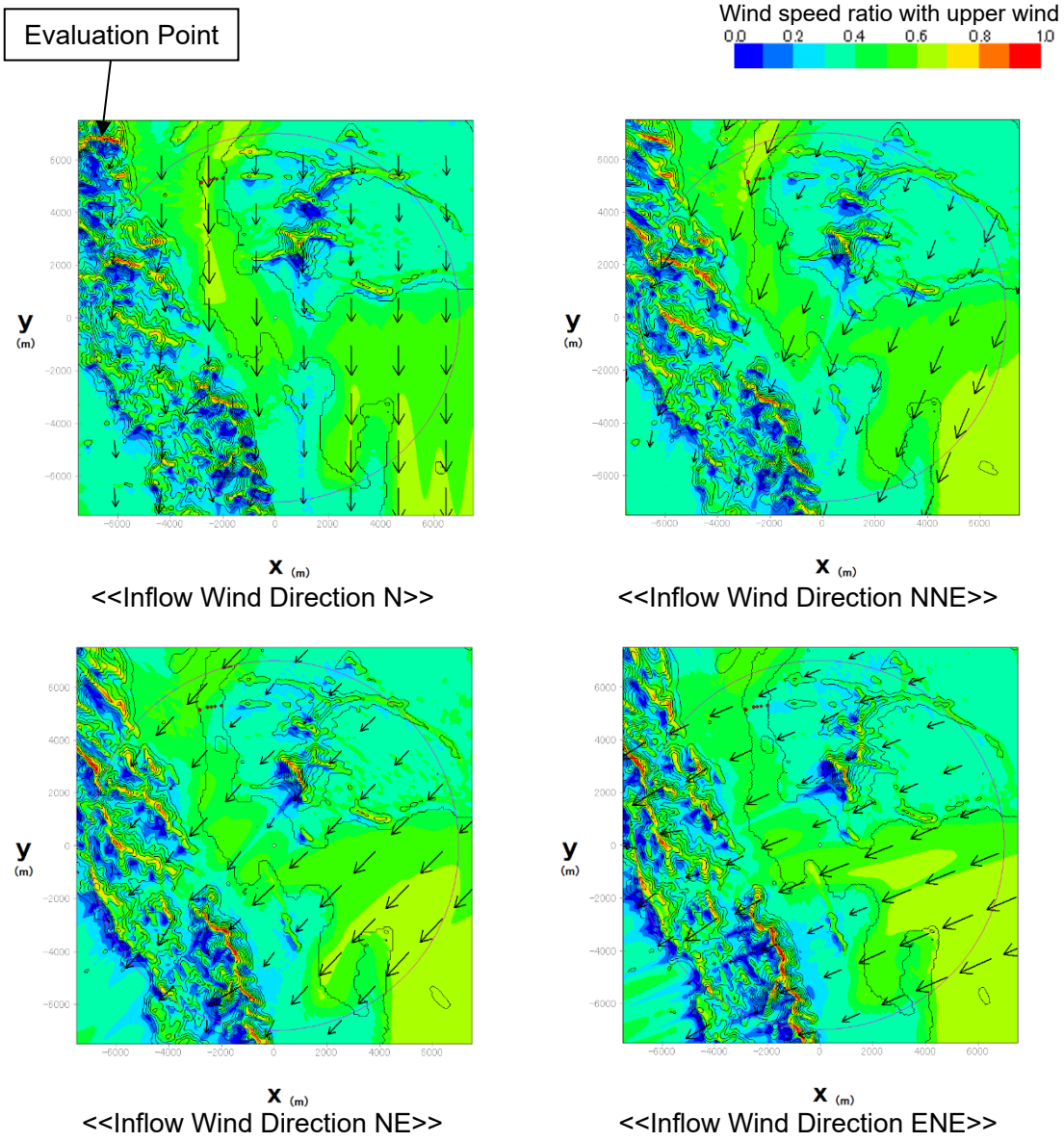
Source: JICA Survey Team

Figure 5-46 Analysis Area (Inlet Wind Direction: N, E, S, W)

(4) Airflow Analysis Results

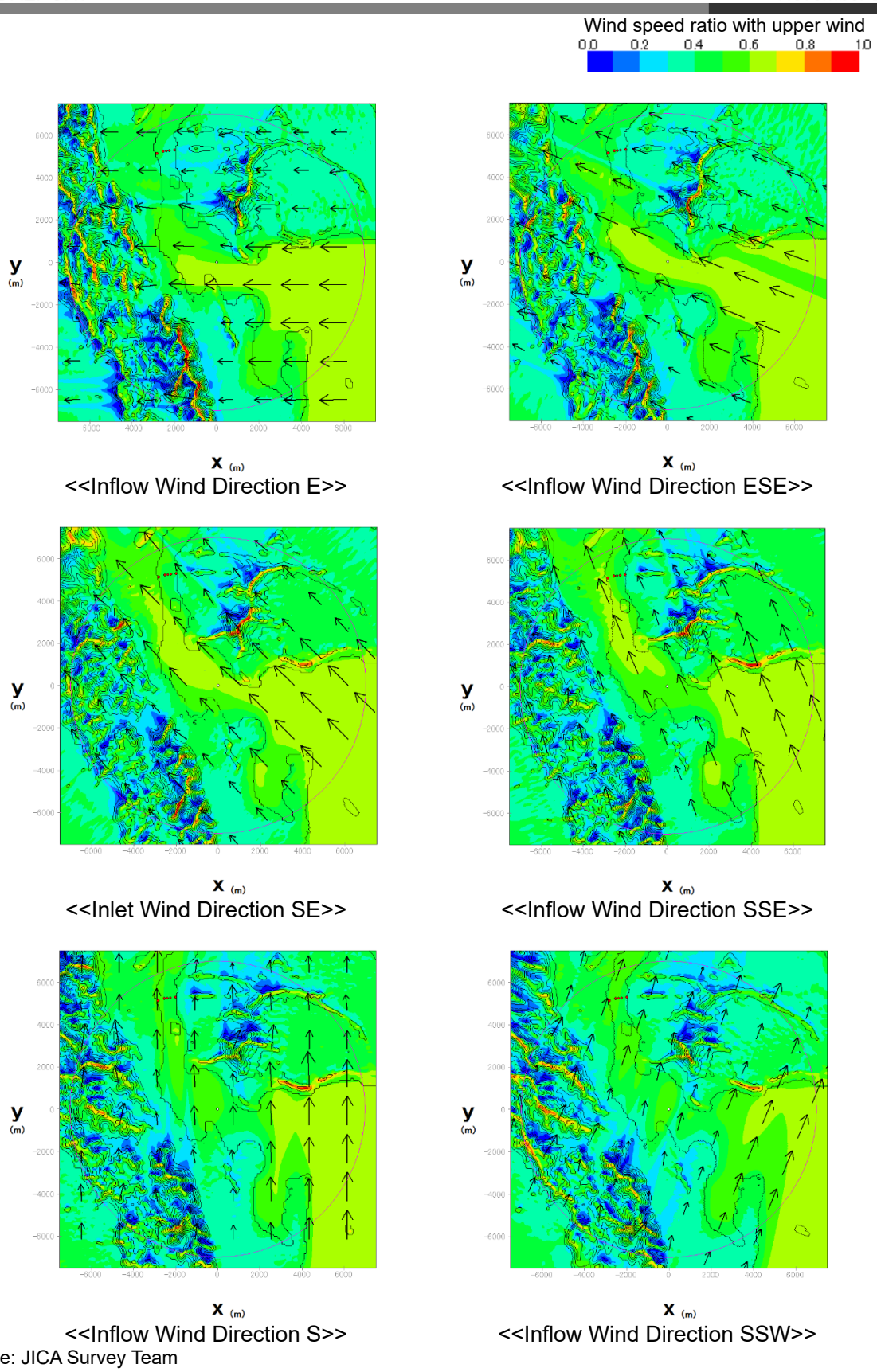
Figure 5-47, Figure 5-48, and Figure 5-49 show the planar wind speed ratio distribution maps obtained from the airflow analysis. Table 5-34 presents the calculated indices representing the vertical distribution of wind speed at each evaluation point. Figure 5-50 Acceleration Factor of

Average Wind Speed Due to Terrainillustrates the average wind speed augmentation coefficient due to topography. The planar distribution represents the contour of wind speed within a plane 8.00 m above the ground surface, which is close to a height of 10 m. The points indicated by red circles correspond to the points to be evaluated. This distribution shows that various changes in wind conditions occur depending on the topography and surface roughness. It can also be seen that the vertical distribution of wind speed varies on the location and wind direction. In particular, at (4) Center of S-Approach, there is a large difference in wind speed between low and high altitudes when the wind comes from the east (E direction). This variation is attributed to the presence of a small hill, about 60 m high, upstream, which reduces wind speeds at low altitudes.



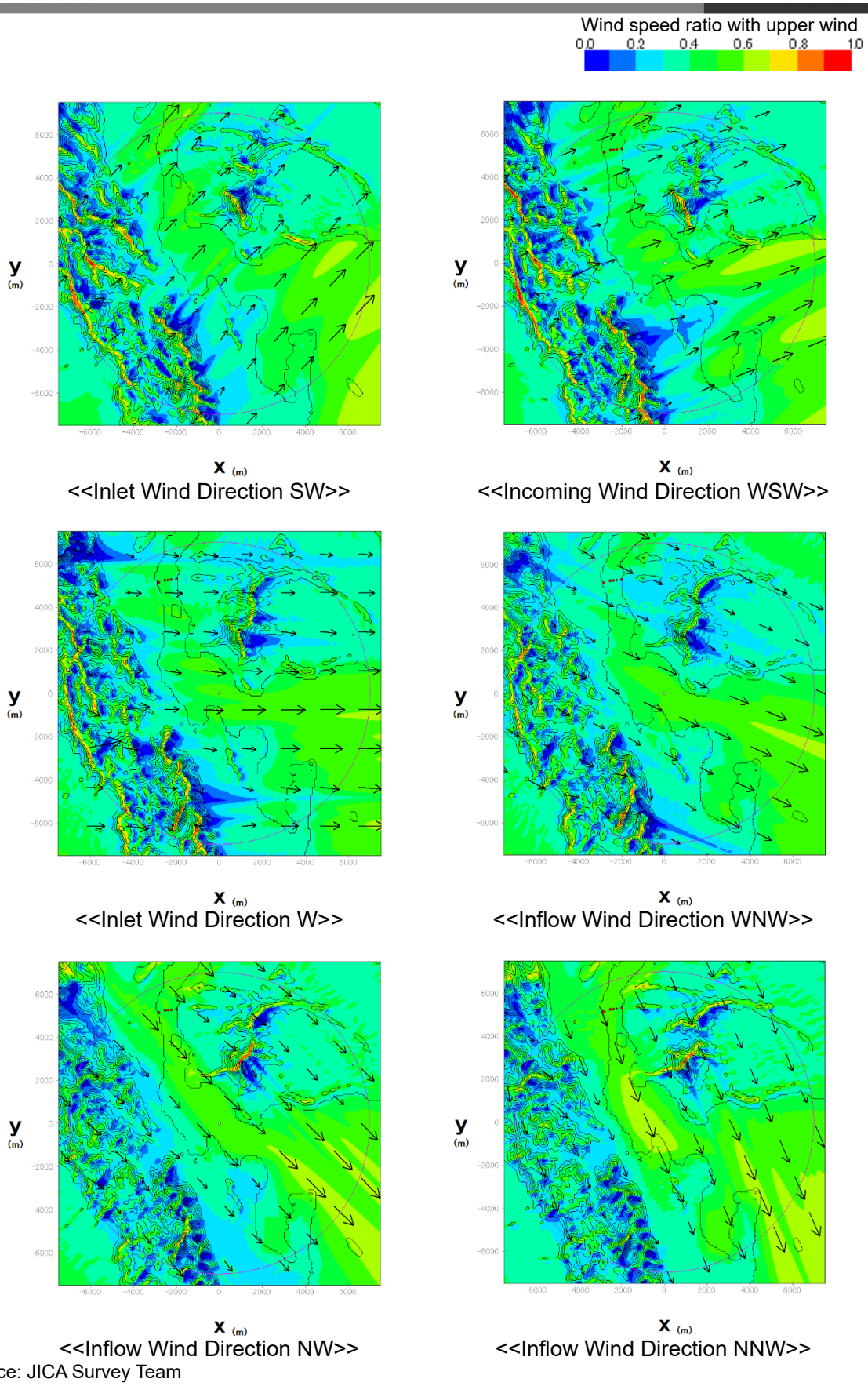
Source: JICA Survey Team

Figure 5-47 Plane Distribution of Wind Speed Within the Analysis Domain (Ground Surface Height: 8.00 m)



Source: JICA Survey Team

Figure 5-48 Plane Distribution of Wind Speed Within the Analysis Domain (Ground Surface Height: 8.00 m)



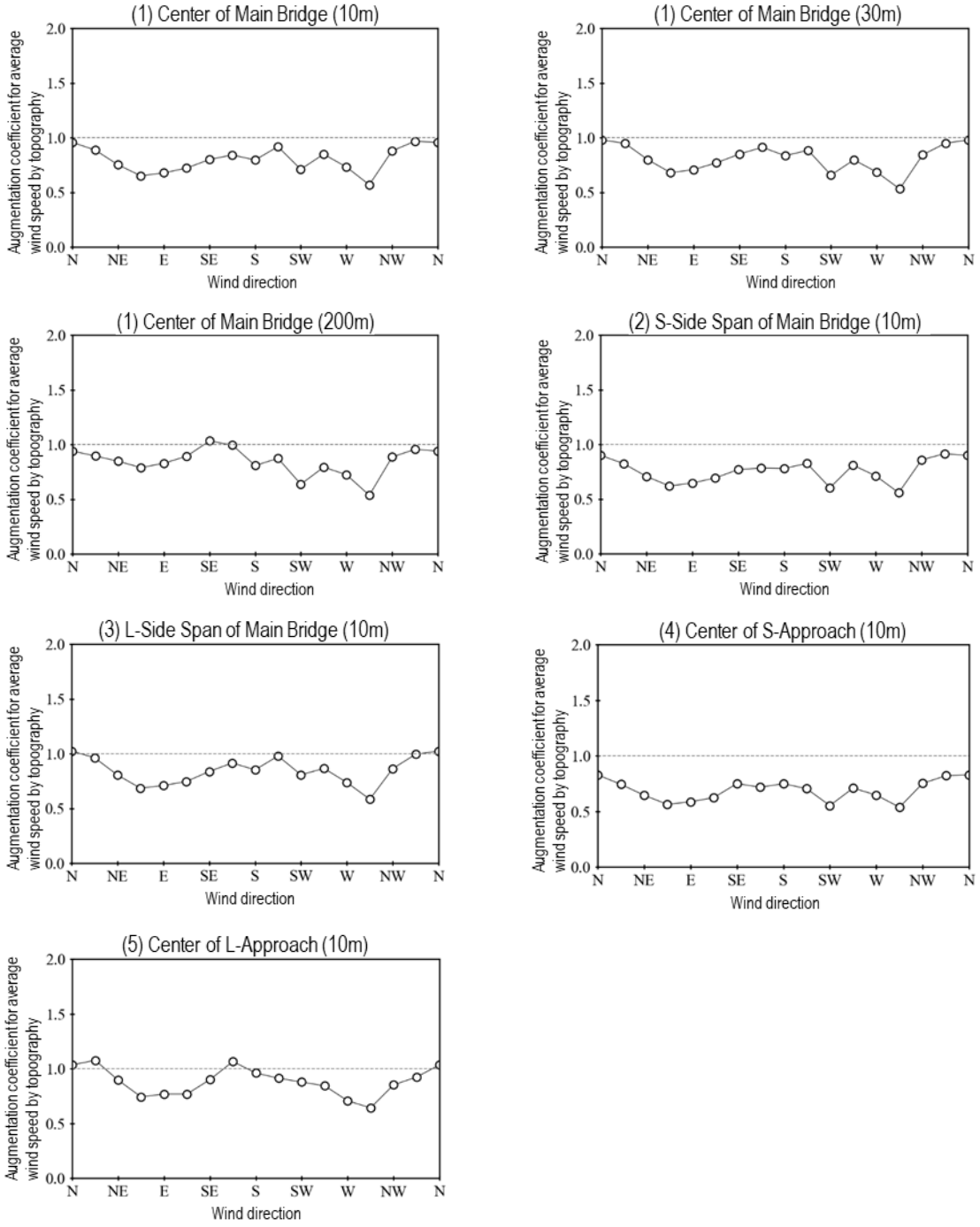
Source: JICA Survey Team

Figure 5-49 Plane Distribution of Wind Speed Within the Analysis Domain (Ground Surface Height: 8.00 m)

Table 5-34 List of Indices to be Identified

Evaluation Point	Wind Direction															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
(1) Center of Main Bridge	0.123	0.130	0.170	0.196	0.199	0.202	0.218	0.185	0.133	0.115	0.096	0.110	0.130	0.113	0.136	0.128
(2) S-Side Span of Main Bridge	0.142	0.151	0.187	0.212	0.215	0.217	0.230	0.209	0.148	0.143	0.134	0.119	0.139	0.118	0.151	0.146
(3) L-Side Span of Main Bridge	0.103	0.107	0.150	0.180	0.184	0.188	0.201	0.157	0.113	0.096	0.081	0.109	0.129	0.112	0.132	0.117
(4) Center of S-Approach	0.168	0.184	0.213	0.244	0.247	0.250	0.237	0.240	0.184	0.187	0.168	0.149	0.169	0.138	0.195	0.178
(5) Center of L-Approach	0.100	0.078	0.116	0.153	0.154	0.167	0.176	0.106	0.086	0.105	0.095	0.120	0.142	0.112	0.136	0.133

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5-50 Acceleration Factor of Average Wind Speed Due to Terrain

5.7.9 Typhoon Monte Carlo Simulation

(1) Typhoon Monte Carlo Simulation Analysis Conditions

Table 5-35 shows the analysis conditions for the Typhoon Monte Carlo Simulation.

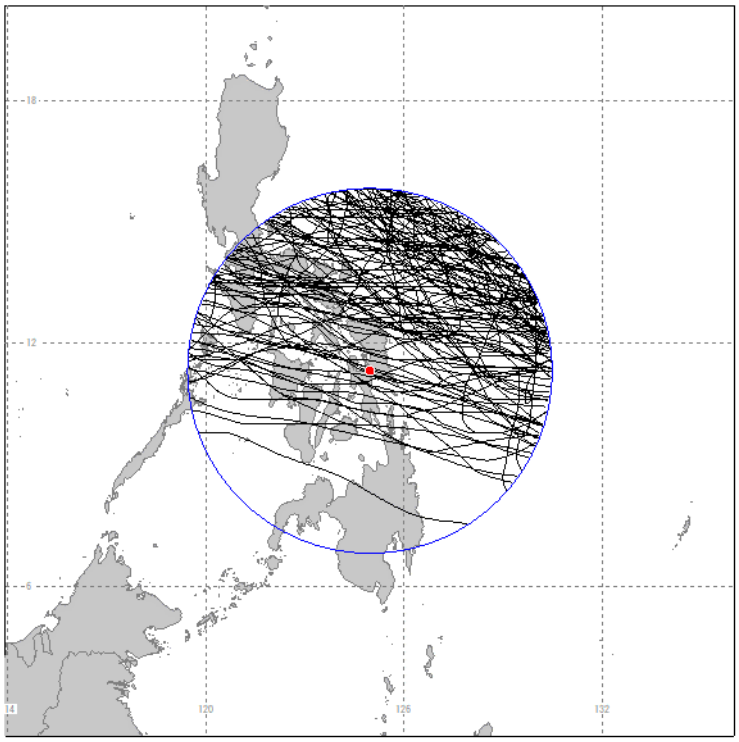
According to these analysis conditions, past typhoons with a radius of 500 km from the target point and a central pressure of 985 hPa or less were extracted. The typhoon tracks are shown in Figure 5-51. For each typhoon, the parameters at the time it was closest to the target location were extracted and modeled using the distribution function shown in the analysis conditions. In addition, a Monte Carlo Simulation was used to generate virtual typhoons over a period of 10,000 years based on the modeled probability distributions.

Based on each typhoon parameter of the hypothetical typhoon, the upper-atmosphere winds were calculated using a typhoon model, and a non-exceedance probability distribution of the annual maximum wind speed was created. Figure 5-52 presents this distribution together with observed values from the typhoon database. The red circles indicate observed values, while the solid line represents the annual maximum wind speed obtained from the simulation. According to this, the annual maximum wind speed for the hypothetical typhoon is lower than the observed value, indicating an underestimation. Therefore, the uncertainties associated with the number of analysis years and the number of years of atmospheric pressure observations when estimating the non-exceedance probability of the annual maximum wind speed were estimated and examined using Gumbel's Theory. Figure 5-52 also shows the values accounting for these uncertainties, indicated by black dashed lines. It can be seen that by taking uncertainty into account, the observed values are largely encompassed. Accordingly, in this analysis, uncertainty was incorporated into the non-exceedance probability distribution of the annual maximum wind speed due to typhoons, and the probabilistic wind speed was subsequently evaluated.

Table 5-35 List of Analysis Conditions

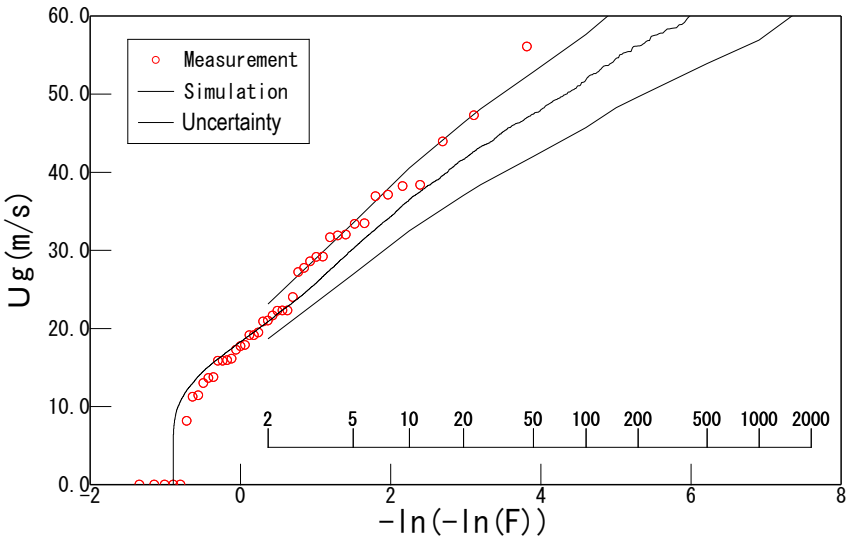
Item			Value
Basic Settings	Typhoon parameter extraction coordinates		Each evaluation point
	Radius from the target point (km)		500.0
	Central pressure (hPa)		985
	Database target period		1977-2021
Identification of Typhoon Parameters and Typhoon Genesis Parameters	Distribution Functions	Central pressure drop	Mixture probability distribution function
		Maximum gyroscopic radius	Mixture probability distribution function
		Speed	Mixture probability distribution function
		Direction	Standard normal distribution function
		Closest distance	Quadratic functions
		Average annual incidence	Poisson distribution function
	Limit Value when a Hypothetical Typhoon Occurs	Closest approach distance (km)	300.0 (upper limit)
		Central pressure drop (hPa)	28.0 (lower limit)
		Maximum gyroscopic radius (km)	8.3 (lower limit)
		Travel speed (m/s)	3.6 (lower limit)
	Whether correlation between parameters is taken into account		Yes
	Application of modified orthogonal transformation method		Yes
	Simulation period (years)		10,000
Wind Speed Forecast Parameters	Vertical distribution model		Engineering model
	Consideration of elevation distribution		Yes
	Averaging time correction		Yes
		constant	0.1
		Standard deviation of mean wind speed (m/s)	0.0
	Whether or not uncertainty is taken into account		Yes

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5-51 Typhoon Track Map

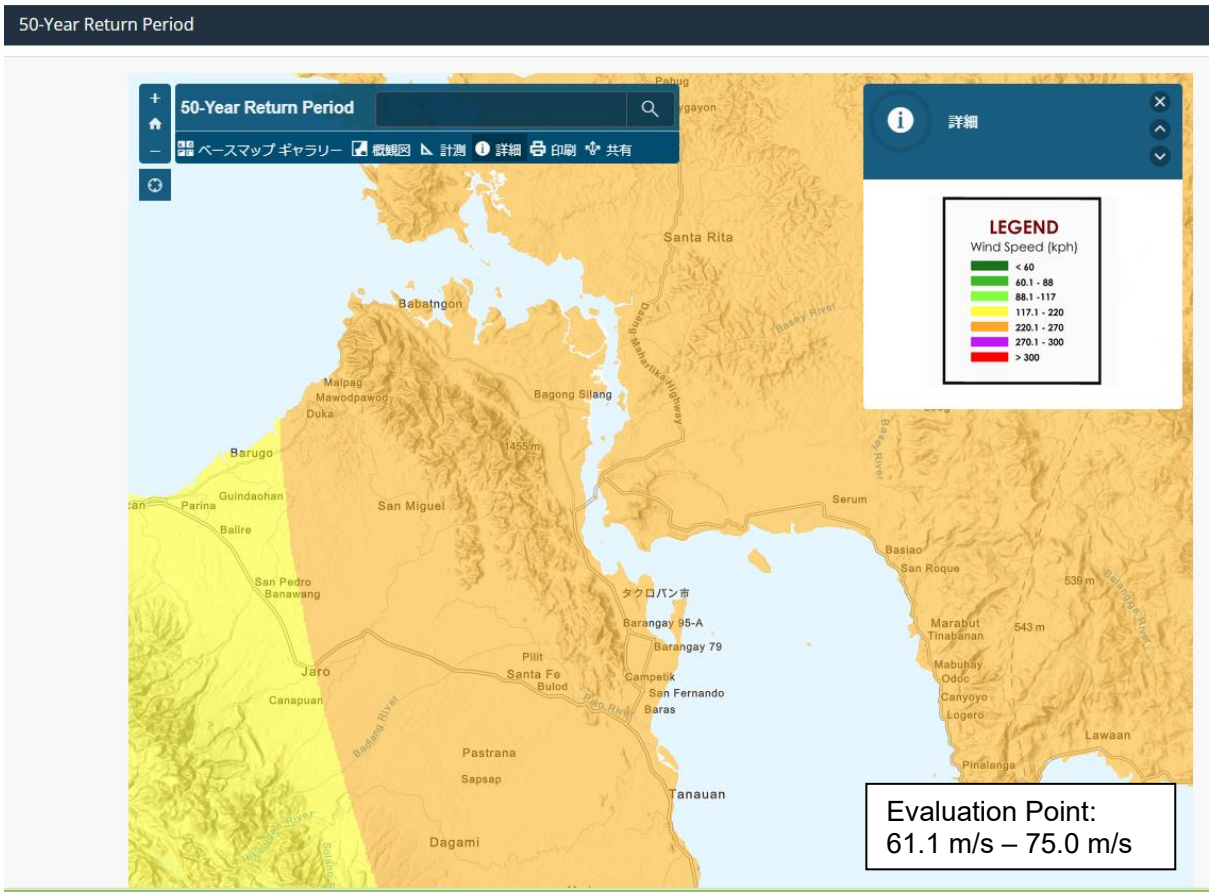


Source: JICA Survey Team

Figure 5-52 Comparison of Upper Air Winds Between Analytical and Observed Values

(2) Verification of Typhoon Monte Carlo Simulation and Calculation of Wind Gust Rate

Figure 5-53 shows a wind map of the expected 50-year maximum instantaneous wind speed at 10 m height over flat terrain, provided by the PAGASA. According to this map, wind speeds in the range of 61.1 m/s - 75.0 m/s are expected to occur in the vicinity of the evaluation site as the 50-year recurrence expectation of the maximum instantaneous wind speed at 10 m height over flat terrain. These values were compared with the results of the Typhoon Monte Carlo Simulation to verify the accuracy and to calculate the wind gust rate.

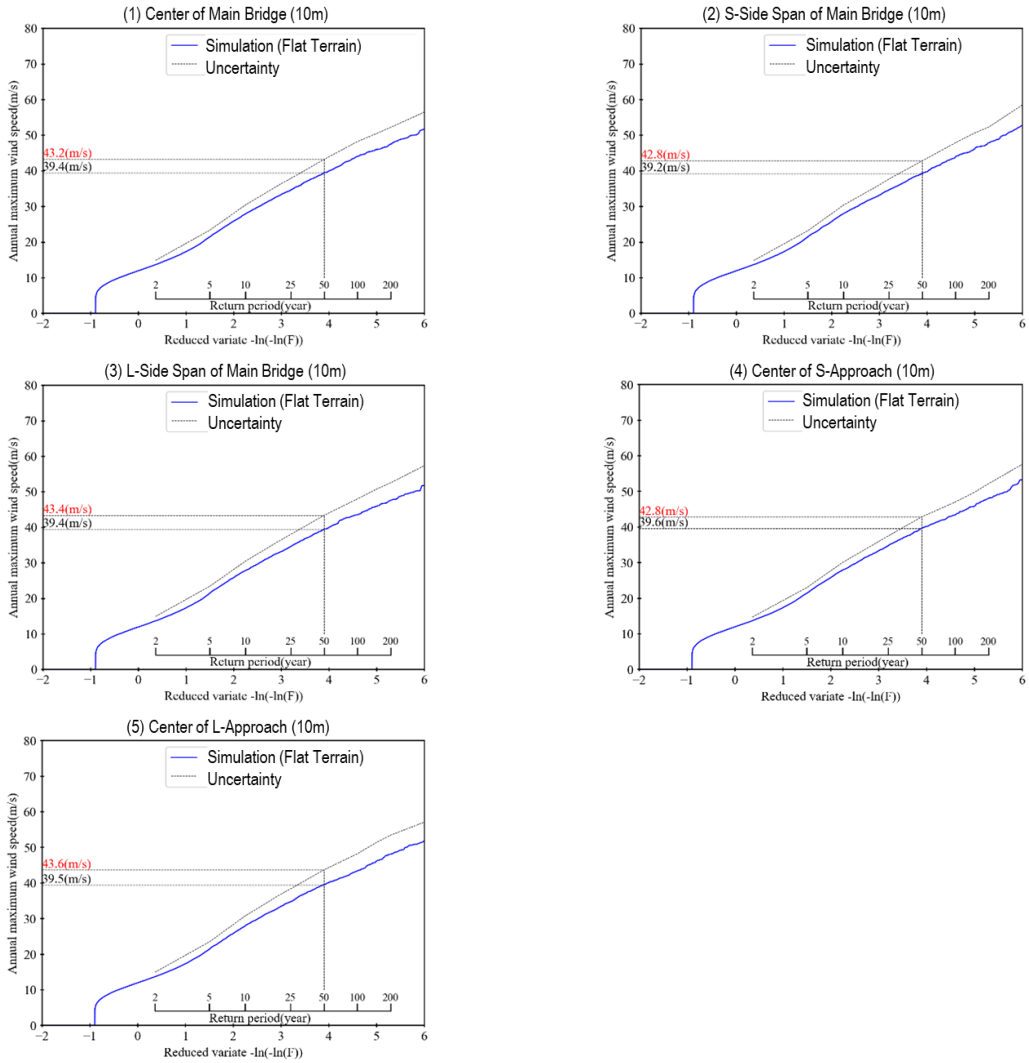


Source: PAGASA

Figure 5-53 Wind Condition Map of Maximum Instantaneous Wind Speed Over Flat Terrain (Height: 10 m)

(3) Calculation of Expected 50-year Recurrence of 10-minute Average Wind Speed on Flat Terrain

Figure 5-54 shows the probability distribution of non-exceedance of the annual maximum wind speed on flat terrain obtained from the typhoon simulation. The 50-year recurrence expectation for the 10-minute average wind speed on flat terrain at each site, U_h^{flat}, ranges from 42.8 to 43.6 m/s.



Source: JICA Survey Team

Figure 5-54 Non-exceedance Probability Distribution of Annual Maximum Wind Speed on Flat Terrain

Table 5-36 Expected 50-year Recurrence of 10-minute Average Wind Speed on Flat Terrain Obtained by Typhoon Simulation

Evaluation Location	Altitude	50-year Recurrence Expectation U_h^{flat} [m/s]
(1) Center of Main Bridge Span	10m	43.2
(2) S-Side Span of Main Bridge		42.8
(3) L-Side Span of Main Bridge		43.4
(4) Center of S-Approach		42.8
(5) Center of L-Approach		43.6

Source: JICA Survey Team

(4) Calculating Maximum Instantaneous Wind Speed Due to Wind on Flat Terrain

The maximum instantaneous wind speed, V_{e50}^{flat}, on flat terrain was calculated using the following formula, in accordance with the Guidelines for the Design of Wind Power Generation Equipment Support Structures (2010):

$$V_{e50}^{flat} = G_f U_h^{flat} \tag{5.1}$$

$$G_f = 1 + 3.5 I_{h1} \tag{5.2}$$

Where, G_f is the wind gust factor, and I_{h1} is the windward component of the turbulence intensity for the design wind speed at hub height. I_{h1} can be calculated using the following formula:

$$I_{h1} = E_{tI} I_P \tag{5.3}$$

where I_P is the turbulence intensity in flat terrain at the calculation altitude, and E_{tI} is the correction factor for the turbulence intensity due to terrain. I_P is calculated according to the following formula depending on the surface roughness classification:

$$I_p = \begin{cases} 0.1\left(\frac{H_h}{Z_G}\right)^{-\alpha-0.05} & Z_b < H_h \le Z_G \\ 0.1\left(\frac{Z_b}{Z_G}\right)^{-\alpha-0.05} & H_h \le Z_b \end{cases} \tag{5.4}$$

where H_h is the calculation height (m), and Z_b, Z_G, α are parameters indicating the vertical distribution of wind speed, which are determined according to the ground surface roughness classification in Table 6.5. In this report, the roughness classification used to calculate the gust rate was set as Classification I, taking into account the surrounding topographical conditions.

Table 5-37 Parameters for Determining Altitude Correction Factor for Mean Wind Speed

Roughness Classification	I	II	III	IV
Z_b	5	5	5	10
Z_G	250	350	450	550
α	0.10	0.15	0.20	0.27

Source: JICA Survey Team

The correction factor for turbulence intensity due to topography E_{tI} is calculated using the following formula:

$$E_{tI} = \max(E_{tS}(\theta_d)/E'_{tV}(\theta_d), 1) \tag{5.5}$$

where E_{tV} is the coefficient for increasing the average wind speed due to the terrain, and E_{tS} is the correction coefficient for fluctuating wind speed due to the terrain. It is calculated using the following formula, based on the results of airflow analysis for different wind directions over actual terrain and flat terrain:

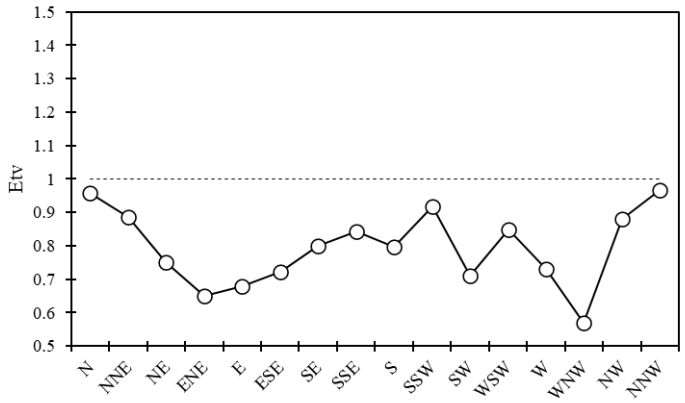
$$E_{tV} = \max(E'_{tV}(\theta_d), 1), E'_{tV} = \max_{\theta}\left(\frac{U(x, y, H_h, \theta)}{U^P(x, y, H_h)}\right) \tag{5.6}$$

$$E_{ts}(\theta_d) = \frac{\sigma_u(x, y, H_h, \theta_d)}{\sigma_u^P(x, y, H_h)} \quad (5.7)$$

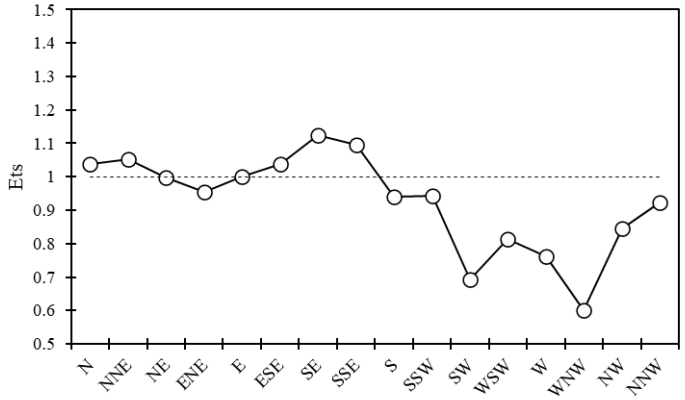
where, $U(x, y, H_h, \theta)$ is the average wind speed in the wind direction θ at the calculation height of the evaluation point H_h on the actual terrain obtained by airflow analysis, and $U^P(x, y, H_h)$ is the average wind speed at the calculation height obtained from airflow analysis on flat terrain with ground surface roughness classification P. In addition, the wind direction θ_d to be inspected is the one with the largest increase coefficient for average wind speed by direction. $\sigma_u(x, y, H_h, \theta_d)$ is the standard deviation of the wind direction θ_d fluctuation wind speed at the calculation height H_h on the actual terrain, and $\sigma_u^P(x, y, H_h)$ is the standard deviation of wind direction fluctuation wind speed at the calculation height H_h on flat terrain.

(5) Calculation Results of Wind Gust Rate

In this report, the gust factor, Gf, was calculated using the representative point at an altitude of 10 m at (1) Center of Main Bridge. The average wind speed enhancement factor and the fluctuating wind speed correction factor due to terrain are shown in Figure 5-55, and the calculation results of the gust factor, Gf, are shown in Table 5-38. The direction in which the terrain-dependent mean wind speed enhancement factor, Etv, is NNW, and the calculated gust factor is 1.567.



(a) Topographical Enhancement Factor for Average Wind Speed



(b) Correction Factor for Wind Speed Fluctuation Due to Terrain
Source: JICA Survey Team

Figure 5-55 Acceleration Coefficient for Average Wind Speed and Correction Coefficient for Fluctuating Wind Speed Due to Terrain ((1) Center of Main Bridge, 10 m Height)

Table 5-38 Calculation Results of Gust Factor, Gf ((1) Center of Main Bridge, 10 m Height)

Wind Direction	Etv	Ets	EtI	IP	Ih	Gf
N	0.957	1.038	1.085	0.162	0.176	1.616
NNE	0.887	1.051	1.185	0.162	0.192	1.672
NE	0.752	0.998	1.327	0.162	0.215	1.753
ENE	0.651	0.954	1.465	0.162	0.237	1.830
E	0.678	1.001	1.476	0.162	0.239	1.837
ESE	0.722	1.039	1.439	0.162	0.233	1.816
SE	0.800	1.124	1.405	0.162	0.228	1.798
SSE	0.842	1.095	1.300	0.162	0.211	1.739
S	0.796	0.941	1.182	0.162	0.191	1.669
SSW	0.918	0.942	1.026	0.162	0.166	1.581
SW	0.711	0.692	0.973	0.162	0.162	1.567
W.S.W.	0.849	0.815	0.960	0.162	0.162	1.567
W	0.732	0.761	1.040	0.162	0.168	1.588
WNW	0.569	0.602	1.058	0.162	0.171	1.599
N.W.	0.880	0.846	0.961	0.162	0.162	1.567
N.N.W.	0.967	0.922	0.953	0.162	0.162	1.567

*Hatching indicates the wind direction where the topographical average wind speed premium coefficient Etv is the largest (wind direction to be examined).

Source: JICA Survey Team

(6) Verification Results of Typhoon Monte Carlo Simulation

The maximum instantaneous wind speed on flat terrain was calculated using the calculated gust rate, and the results are compared with the 50-year recurrence expectation value of the maximum instantaneous wind speed on flat terrain from the PAGASA wind resource map, as shown in Table 5-39. The calculated maximum instantaneous wind speed ranges from 67.1 to 68.3 m/s, which falls within the PAGASA wind resource map range of 61.1–75.0 m/s.

Table 5-39 Comparison of Maximum Instantaneous Wind Speeds Due to Winds on Flat Terrain with PAGASA Wind Condition Map

Evaluation Location	Altitude [m]	Winds Over Flat Terrain Obtained by Typhoon Simulation			Verification 61.1 to 75.0 [m/s]
		50-year Recurrence Expectation U_h^{flat} [m/s]	Wind Gust Rate Gf	Maximum Instantaneous Wind Speed V_{e50}^{flat}[m/s] $V_{e50}^{flat} = G_f U_h^{flat}$	
(1) Center of Main Bridge	10m	43.2	1.567	67.7	○
(2) S-Side Span of Main Bridge		42.8		67.1	○
(3) L-Side Span of Main Bridge		43.4		68.0	○
(4) Center of S-Approach		42.8		67.1	○
(5) Center of L-Approach		43.6		68.3	○

Source: JICA Survey Team

5.7.10 Probability Wind Speed Evaluation

(1) Conversion of Observation Points to Target Points Using the MCP Method

To convert from an observation point to a target point using the MCP method, the average wind speeds, u^{CFD}, at both the reference and forecast target points—obtained from airflow analysis (Computational Fluid Dynamics)—are used to calculate the average wind speed ratio between the reference and forecast target point using the following formula:

$$\hat{u}_{rp,i} = u_{p,i}^{CFD}(x_p, y_p, z_p)/\mathrm{u}_{r,i}^{CFD}(x_r, y_r, z_r) \tag{5.8}$$

Here, $\hat{u}$ is the wind speed ratio between the reference point and the forecast point, x, y are the horizontal coordinates, and z is the height. The subscripts $i, r, p, and\ rp$ indicate the inflow wind direction, the reference point, the forecast target point, and the relationship between the reference point and forecast target points, respectively.

Next, the wind speed ratio for an arbitrary wind direction observed at the reference point is calculated by linear interpolation as follows:

$$S_{rp} = \hat{u}_{rp,i} + a(\hat{u}_{rp,i+1} - \hat{u}_{rp,i}) \tag{5.9}$$

Here, i and $i+1$ are the inflow wind directions at the reference point, which are initially unknown and are determined from the wind direction at the reference point as follows:

$$\theta_{r,j} \in (\bar{\theta}_{r,j}, \bar{\theta}_{r,j+1}) \tag{5.10}$$

where, $\bar{\theta}_{r,j}$ and $\bar{\theta}_{r,j+1}$ are the wind directions at the reference point relative to the inflow wind direction, i and $i+1$.

On the other hand, the proportionality coefficient is assumed to be constant regardless of location and a is calculated from the wind direction at the reference location using the following formula:

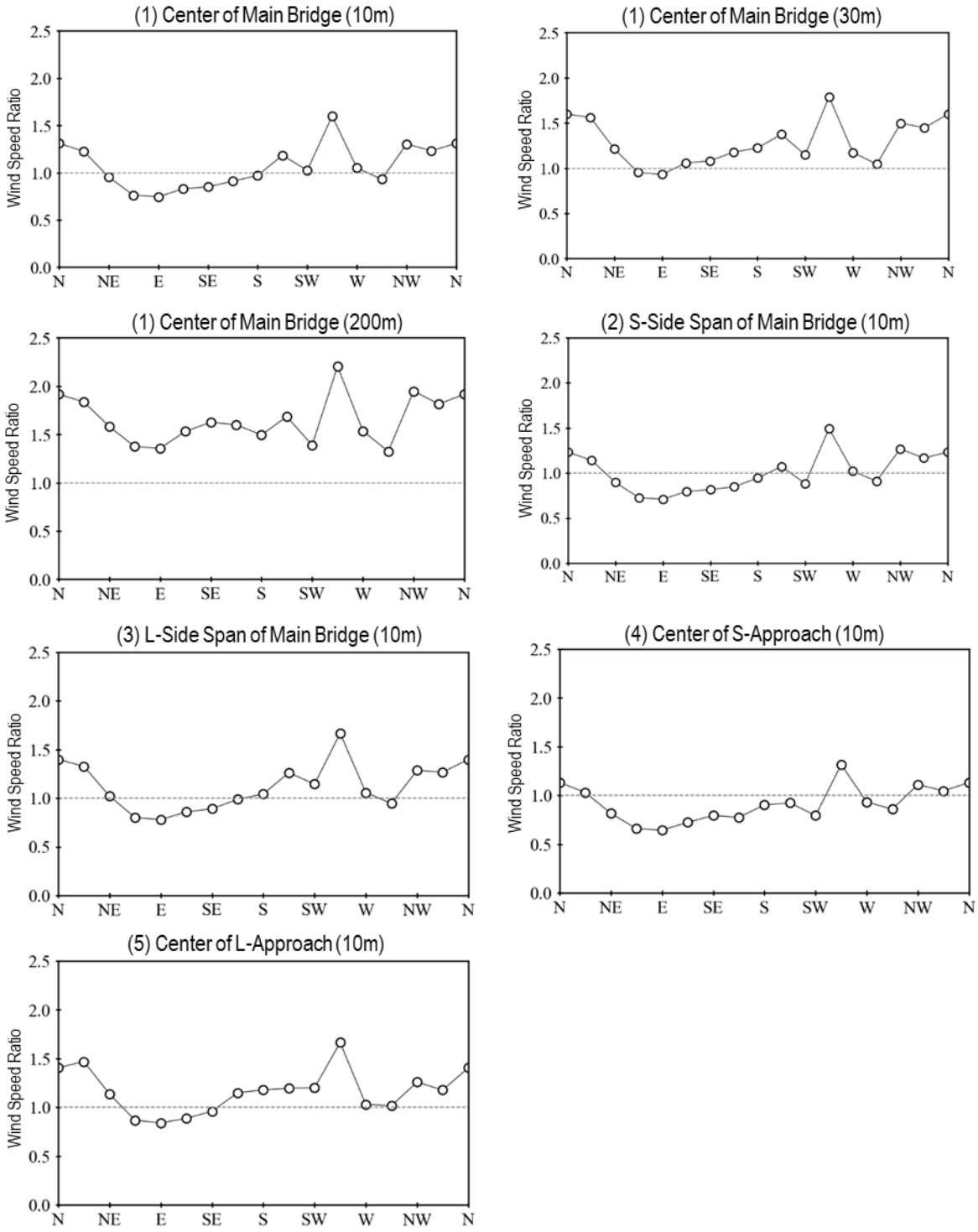
$$a = \frac{\theta_{r,j}^{obs} - \bar{\theta}_{r,j}}{\bar{\theta}_{r,j+1} - \bar{\theta}_{r,j}} \tag{5.11}$$

Finally, the wind speed at the target point is calculated by multiplying the observed wind speed by the calculated wind speed ratio using the following formula:

$$u_{p,j}^{pred} = S_{rp} \times u_{r,j}^{obs} \tag{5.12}$$

Here, the subscript obs represents the observation record, and j represents the observation time.

In this report, the reference point r is located at the 10 m altitude at the Tacloban Observatory, and the prediction points, p, are the evaluation points on the SSJB. The wind speed ratios used to convert from the reference point to each forecast point are shown in Figure 5-56.



Source: JICA Survey Team

Figure 5-56 Wind Speed Ratio Used to Convert from the Reference Point to Each Forecast Point

(2) Assessment of Extreme Wind Speeds Due to Monsoons

When calculating the probability distribution from the time series of wind speeds converted for the target location, the annual maximum wind speed is extracted for each year, excluding typhoons, and the values are then sorted in ascending order. The non-exceedance probability distribution of the annual maximum wind speed is expressed by the following equation, according to Gumbel Theory:

$$F(u_i) = \frac{i}{N+1} \tag{5.13}$$

where u_i is the annual maximum wind speed of ith. The scaling variable y_i is expressed by the following formula:

$$y_i = -\ln\left(-\ln\left(F(u_i)\right)\right) \tag{5.14}$$

It is well known that the annual maximum wind speed due to monsoons follows a Gumbel distribution. If the non-exceedance probability distribution, F, follows the Gumbel distribution, the expected annual maximum wind speed, u_E, due to the monsoon can be expressed by the following equation using the method of moments:

$$u_E = V + \sigma_P(y - \gamma)/(\pi/\sqrt{6}) \tag{5.15}$$

where V and σ_P are the mean and standard deviation of the annual maximum wind speed obtained from wind observation data, respectively; γ is Euler's constant (0.57722), and y is a scaling variable. In addition, the relationship between the return period, R, and the non-exceedance probability distribution, $F(u)$, is expressed by the following equation:

$$F(u) = 1 - \frac{1}{R} \tag{5.16}$$

(3) Evaluation of Extreme Wind Speeds Due to Typhoons

When deriving a probability distribution from a Typhoon Monte Carlo Simulation, the Gumbel distribution cannot be used directly as some years have an annual maximum wind speed of 0 m/s. Therefore, the probability distribution for years with an annual maximum wind speed of 0 m/s is expressed as F_{zero}, while a modified Gumbel distribution, shown as F_{nozero}, is used for other years, as shown in the following equation:

$$F_T(u) = F_{zero} + F_{nozero} \tag{5.17}$$

If the number of simulation years is n and n_0, which is the annual maximum wind speed due to typhoons, is 0 m/s, then F_{zero} can be expressed by the following equation:

$$F_{zero} = \frac{n_0}{n} \tag{5.18}$$

In addition, the annual maximum wind speed in years other than 0 m/s follows a Gumbel distribution, $G(u)$. F_{nozero} is expressed by the following equation:

$$F_{nozero} = \frac{n - n_0}{n} \times G(u) \tag{5.19}$$

The annual maximum wind speed, u_T, and the modified normalized variable, y', due to typhoons are expressed as follows:

$$u_T = V + \sigma_P(y' \quad - \gamma)/(\pi/\sqrt{6}) \tag{5.20}$$

Here, V and σ_P are the mean and standard deviation of the annual maximum wind speed, excluding the annual maximum wind speed of 0 m/s, respectively. This modified Gumbel distribution coincides with the Gumbel distribution when $n_0 = 0$.

(4) Evaluation of Extreme Wind Speeds Taking Into Account Typhoons and Seasonal Winds

It is necessary to evaluate the probability distribution separately for strong winds due to typhoons and monsoons, and then synthesize them. Assuming that the annual maximum wind speed due to monsoons and that due to typhoons are independent phenomena, the mixed probability distribution $F_C(u_C)$, which combines non-exceedance probability of the annual maximum wind speed due to monsoons, $F_E(u_E)$, and that due to typhoons, $F_T(u_T)$, can be evaluated using the following equation:

$$F_C(u_C) = F_E(u_E) \times F_T(u_T) \tag{5.21}$$

(5) Evaluation of Extreme Wind Speeds with a Return Period of 1 Year

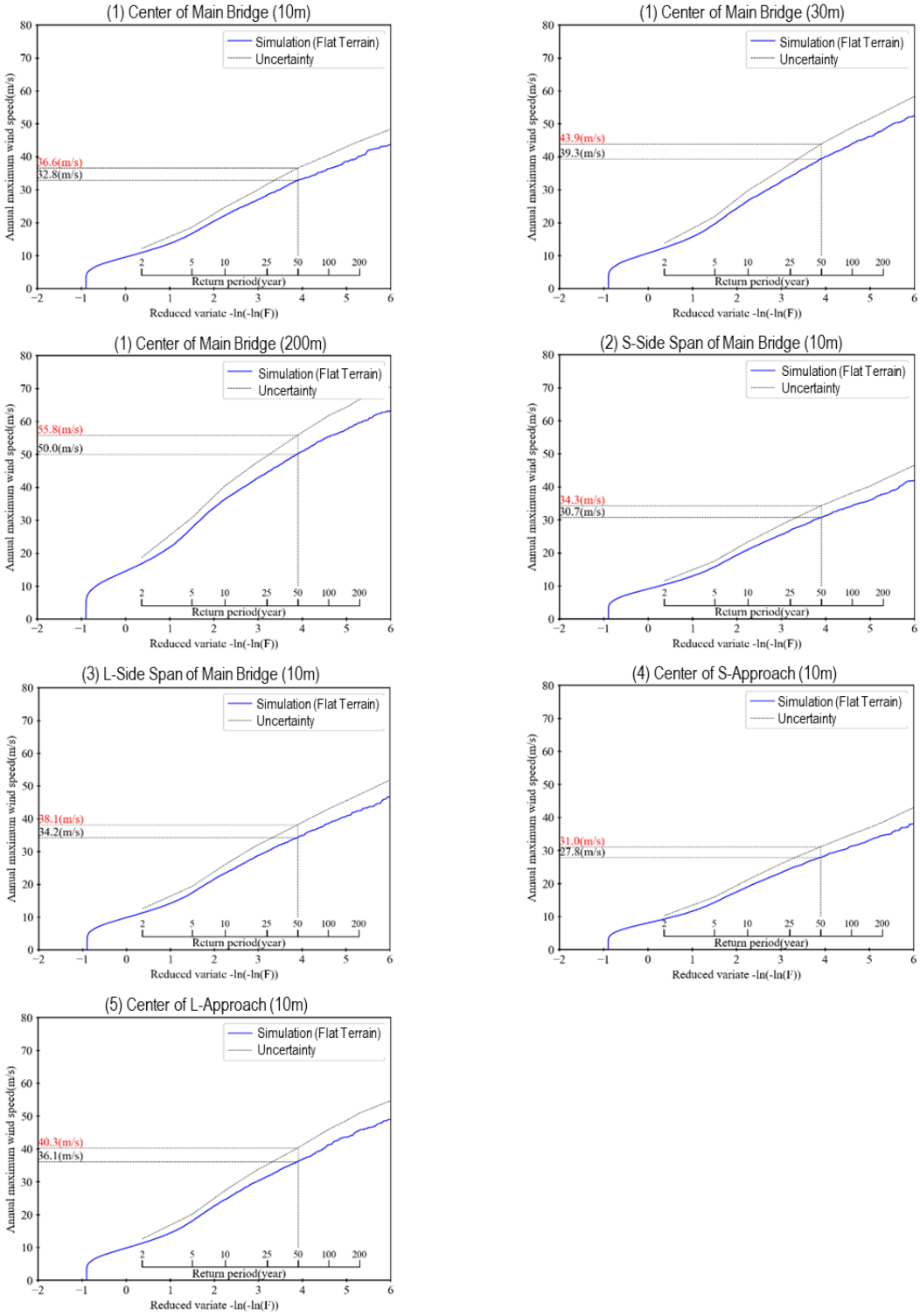
Extreme wind speeds with a recurrence period of 1 year cannot be calculated using the probability distribution based on the annual maximum wind speed described above. Therefore, the monthly maximum wind speeds are extracted from the time series data of wind speeds converted for the target location, sorted in ascending order, and expressed using the Gumbel distribution according to equation (5.13) to calculate the extreme wind speed with a return period of 1 year.

5.7.11 Probability Wind Speed Evaluation Results

The non-exceedance probability distributions of annual maximum wind speeds due to typhoons, seasonal winds, and composite winds are shown, along with the calculated probable wind speeds for each return period.

(1) Non-exceedance Probability Distribution of Annual Maximum Wind Speed Due to Typhoons

Figure 5-57 shows the non-exceedance probability distribution of the annual maximum wind speed due to typhoons at each evaluation point. The dashed line in the figure represents the 50-year recurrence expectation, accounting for uncertainty.

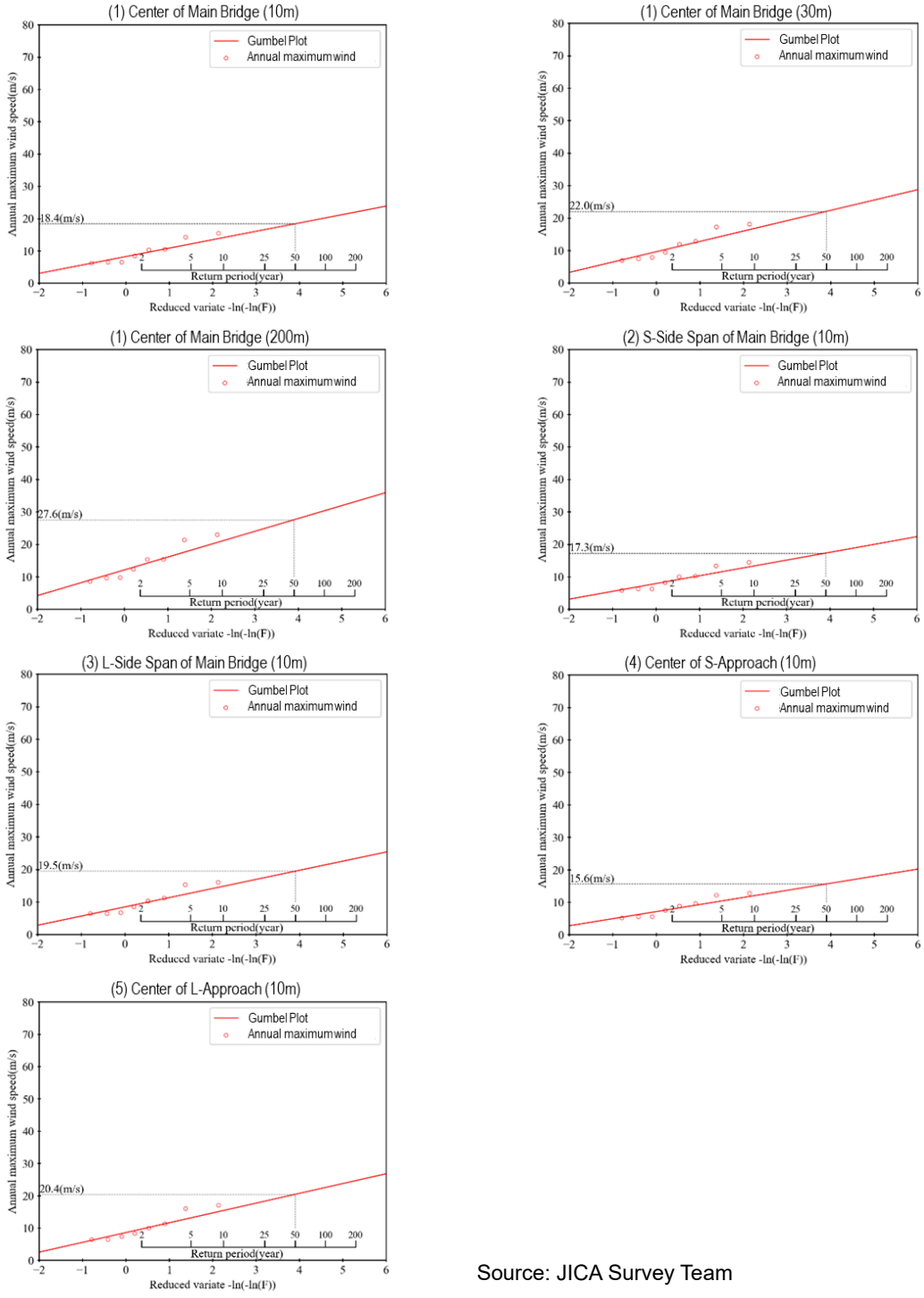


Source: JICA Survey Team

Figure 5-57 Non-exceedance Probability Distribution of Annual Maximum Wind Speed Due to Typhoons

(2) Non-exceedance Probability Distribution of Annual Maximum Wind Speed Due to Monsoon

Figure 5-58 shows the non-exceedance probability distribution of the annual maximum wind speed due to seasonal winds at each evaluation point. The dashed line in the figure represents the 50-year recurrence expectation, while the plot represents the annual maximum wind speed caused by monsoons.

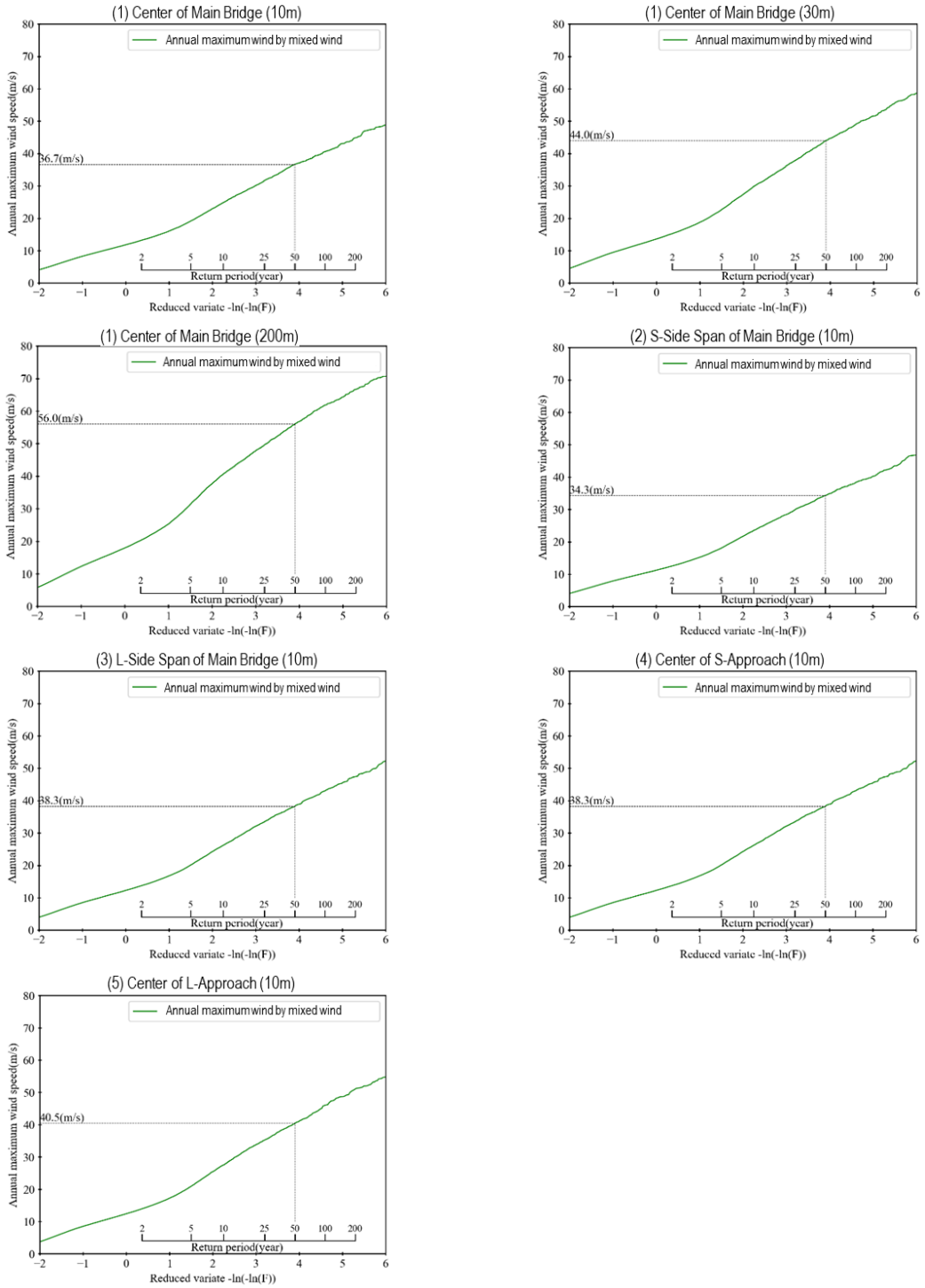


Source: JICA Survey Team

Figure 5-58 Non-exceedance Probability Distribution of Annual Maximum Wind Speed Due to Monsoon

(3) Non-exceedance Probability Distribution of Annual Maximum Wind Speed Due to Combined Typhoon and Monsoon Winds

Figure 5-59 shows the non-exceedance probability distribution of the annual maximum wind speed due to the combined effects of typhoons and seasonal winds at each evaluation point. The dashed line in the figure represents the 50-year recurrence expectation.

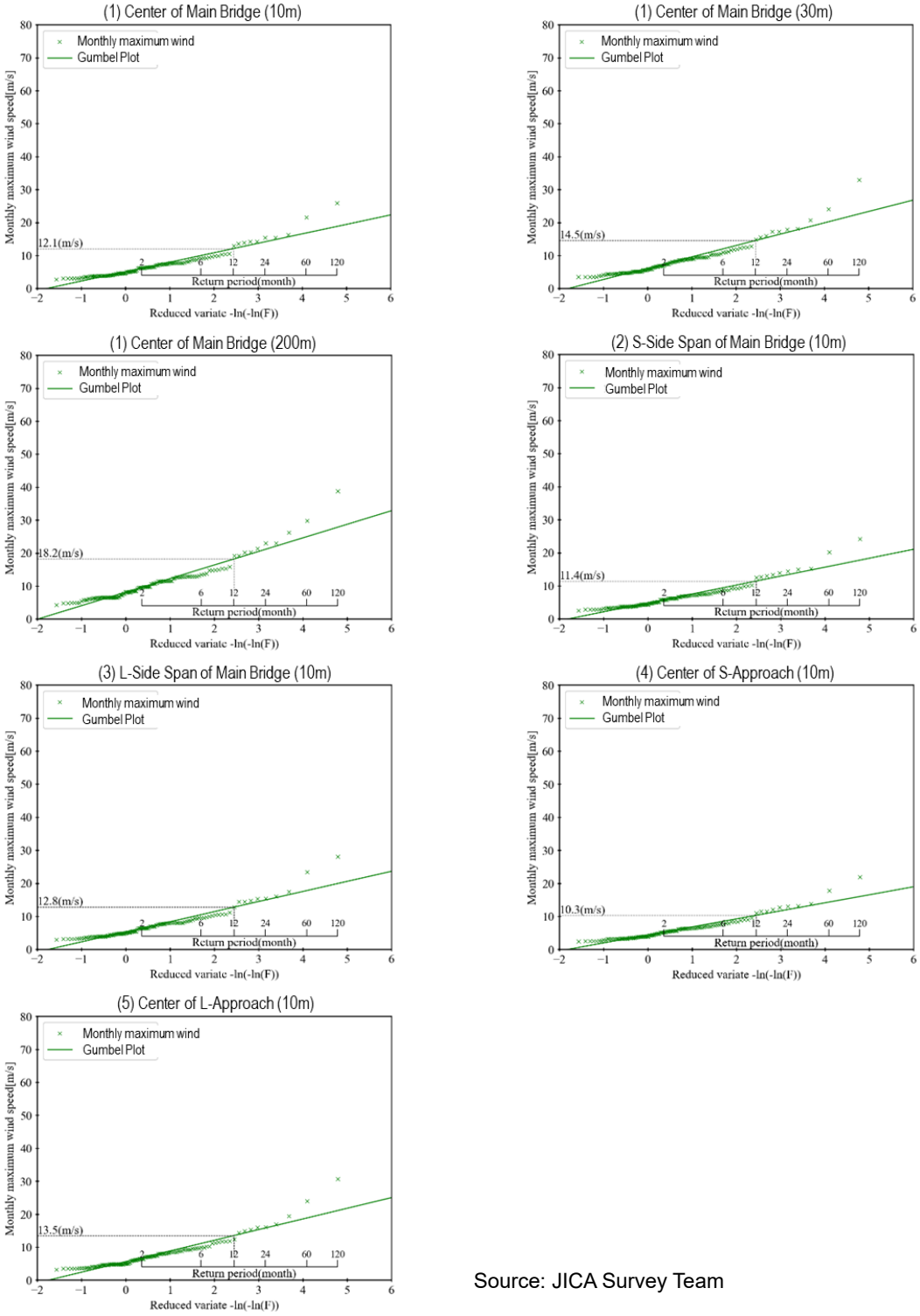


Source: JICA Survey Team

Figure 5-59 Non-exceedance Probability Distribution of Annual Maximum Wind Speed Due to Synthetic Wind

(4) Non-exceedance Probability Distribution by Monthly Maximum Wind Speed

The non-exceedance probability distribution of the monthly maximum wind speed at each evaluation point is shown in Figure 5-60. The dashed line in the figure represents the expected one-year recurrence value, while the plot represents the monthly maximum wind speed.



Source: JICA Survey Team

Figure 5-60 Non-exceedance Probability Distribution of Monthly Maximum Wind Speed

(5) Probability Wind Speed Calculation Results

The probable wind speed calculation results for each evaluation location are shown in Table 5-40.

Focusing on the 100-year return period, (1) Center of Main Bridge (200 m) recorded the highest wind speed at 61.9 [m/s], while (4) Center of S-Approach recorded the lowest at 34.9 [m/s]. Similar trends are observed for other return periods. Additionally, when comparing the 10 m height at each point, it can be seen that (5) Center of L-Approach recorded the highest value, and the wind speed decreases towards the east.

The 10-minute average wind speed listed in this table is adopted as the design wind speed.

Table 5-40 Probability Wind Speed Calculation Results (10-min. Average)

Evaluation Location	Altitude [m]	Return Period [Years]							
		1	10	25	50	100	150	200	700
(1) Center of Main Bridge	10	12.1	24.8	31.6	36.7	40.6	43.1	44.9	51.4
	30	14.5	29.9	37.9	44.0	49.2	51.6	54.1	61.4
	200	18.2	40.5	49.5	56.0	61.9	64.4	66.7	74.4
(2) S-Side Span of Main Bridge	10	11.4	23.5	29.9	34.3	38.3	40.3	42.2	49.1
(3) L-Side Span of Main Bridge	10	12.8	26.2	33.4	38.3	43.0	45.6	47.4	55.4
(4) Center of S-Approach	10	10.3	21.1	27.1	31.1	34.9	37.0	38.6	45.6
(5) Center of L-Approach	10	13.5	27.5	35.2	40.5	46.0	48.7	51.2	60.3

Source: JICA Survey Team

6 Traffic Demand Forecast

6.1 Traffic Count Survey

6.1.1 Purpose of the Survey

The purpose of the survey is to understand the traffic situation in the target area. Existing traffic data was collected, and a traffic count survey was conducted to provide basic data necessary for the traffic demand forecast.

6.1.2 Survey Items・Survey Method

Traffic count survey was conducted through a local sub-contractor. The details of the survey are shown in items (1) through (4) below.

① Traffic Count

The traffic count survey was conducted in two sessions:

- First traffic count survey: Two weekdays (Monday, November 20, and Tuesday, November 21, 2023), and one weekend/holiday (Saturday, November 25, 2023), for a total of three days.
- Second traffic count survey: Two weekdays (Monday, March 4, and Tuesday, March 5th, 2024) and one weekend/holiday (Saturday, March 9th, 2024), for a total of three days.

② Time Zone

The survey hours are assumed to be the 24-hour period shown in Table 6-1.

③ Traffic Count Method

The traffic count survey was conducted by manual counting. Results were aggregated by vehicle type, direction, and time of day. The classification for vehicle types follows the method for the High Standard Highway Master Plan (HSH M/P) shown in Table 6-2.

Table 6-1 Outline of Traffic Count Survey

Classification		Length of Survey (hours)	Survey Time Zone	Count Method	Number of Locations
Traffic Count Survey	1st time: (2 weekdays + 1 holiday (3 total))	24	6:00 a.m.–6:00 a.m. the next day	Manual Traffic Count (by vehicle type/direction/time of day)	1st time: 4（A1, B1, B2, C1）
	2nd time: (2 weekdays + 1 holiday (3 total))				2nd time: 2（B1, B2）

Source: JICA Survey Team

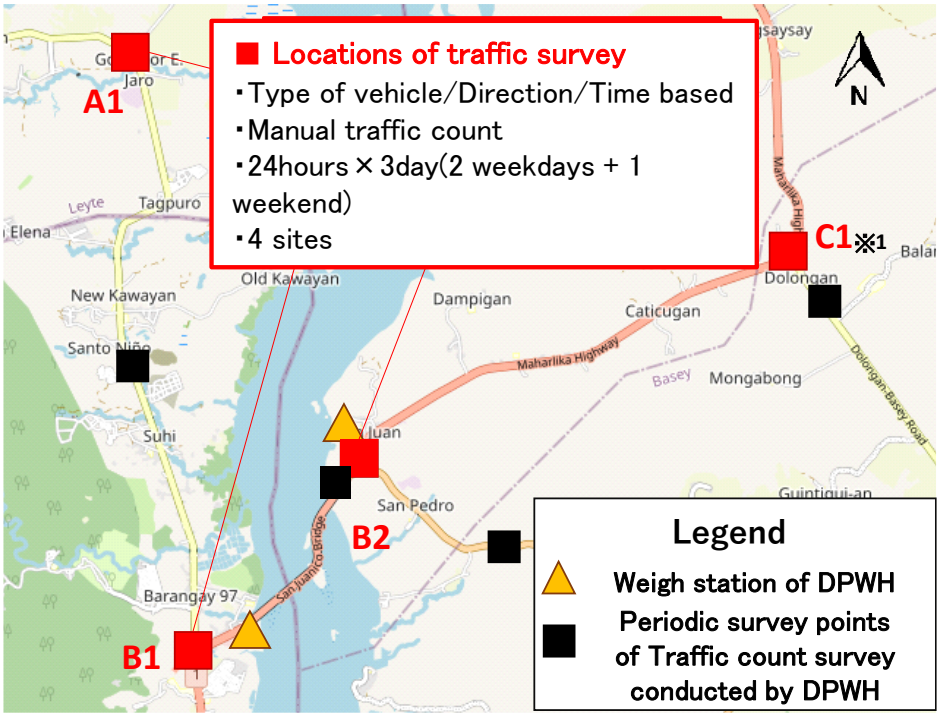
Table 6-2 Classification of Vehicle Types

Model Classification (12 Types)
1: Motorcycle, 2: Tricycle, 3: Passenger Car, 4: Taxi, 5: Jeepney, 6: HOV (High Occupancy Vehicle), 7: Small Bus, 8: Large Bus, 9: Light Truck, 10: Truck (2 axles), 11: Truck (3 axles), and 12: Trailer.

Source: JICA Survey Team

④ Survey Location

The survey locations shown in Figure 6-1 are assumed for the purpose of providing basic data on future traffic volume and project effect indicators. The number of survey locations will be determined based on the results of the field survey. The first traffic count survey was conducted at four locations (A1, B1, B2, and C1), and the second traffic count survey was conducted at two locations (B1 and B2).



※1 ：C1 only counted traffic entering in the direction of the San Juanico Bridge.

Source: JICA Survey Team

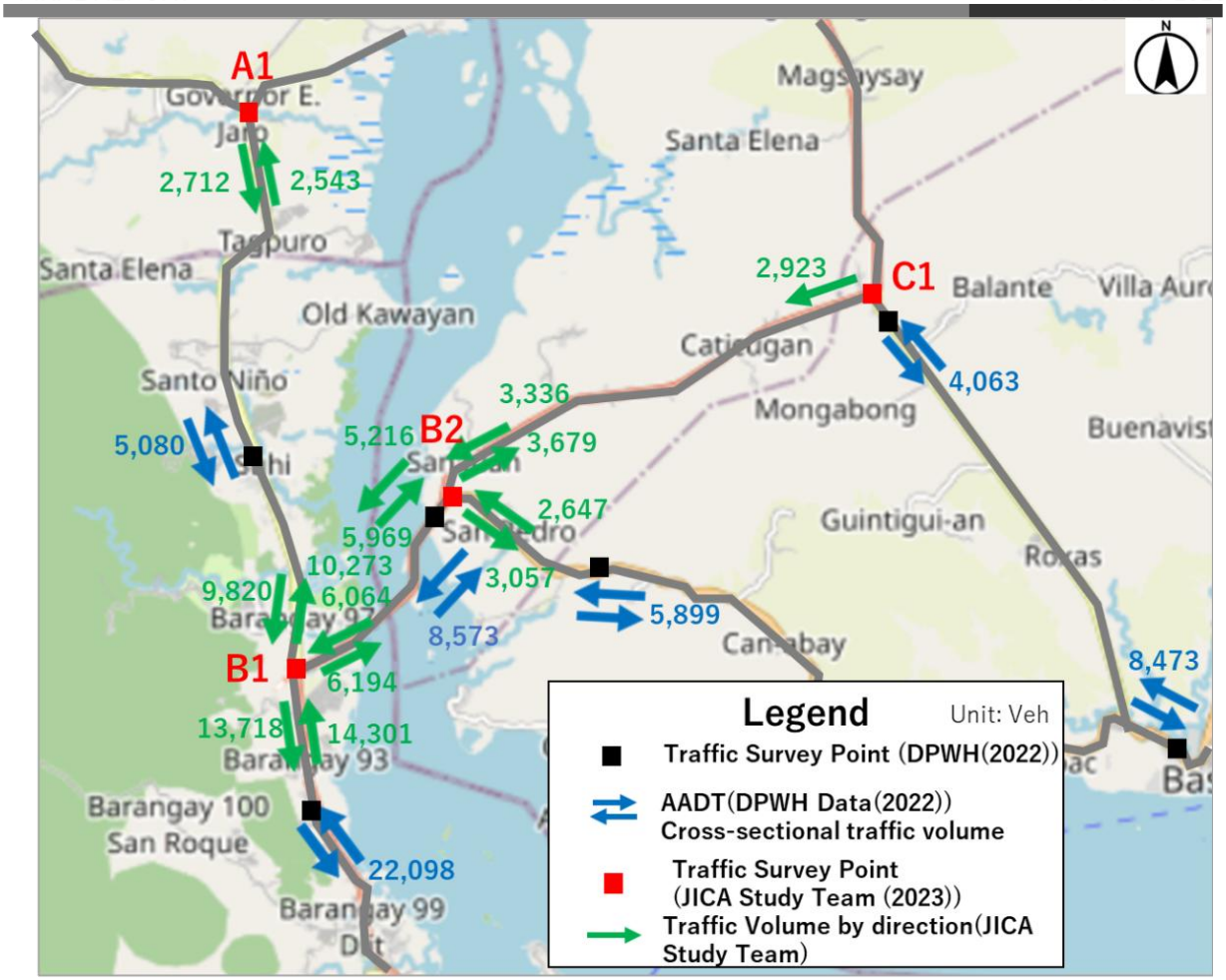
Figure 6-1 Locations of the Traffic Count Survey

6.1.3 Survey Result

(1) Traffic Volume Survey Results for 2023

1) Traffic Volume by Direction and Cross-sectional Volume

The annual average daily traffic volume (cross-sectional traffic volumes) for 2022, as reported by the Department of Public Works and Highways (DPWH), as well as the results of traffic volumes by directions from the traffic count survey conducted in this study are shown in the following table. The cross-sectional traffic volume of the existing SJB exceeds 10,000 vehicles per day, indicating its high level of use.

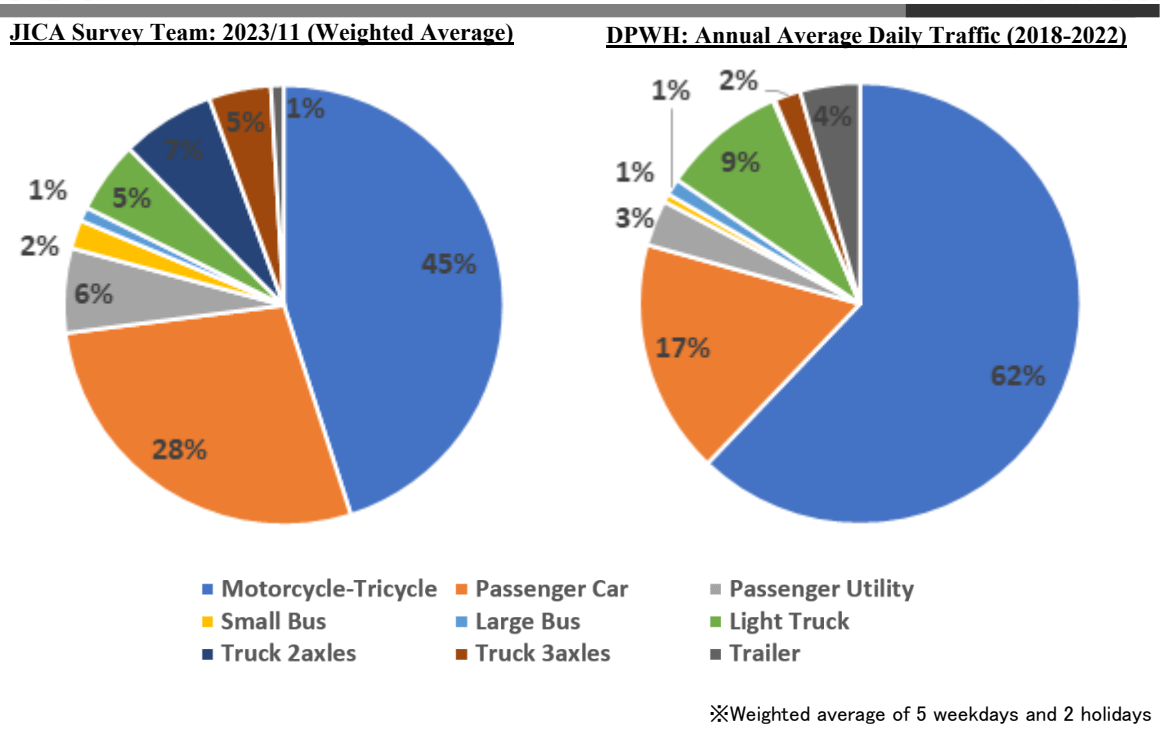


*The results of the traffic count survey in 2023 are the daily traffic volume (weighted average) assuming five days/week on weekdays and two days/week on weekends.
Source: Prepared by the JICA Survey Team based on data provided by the DPWH

Figure 6-2 Annual Average Daily Traffic（2022）and Results of Traffic Count Survey（2023）

2) Variation in Traffic Volume

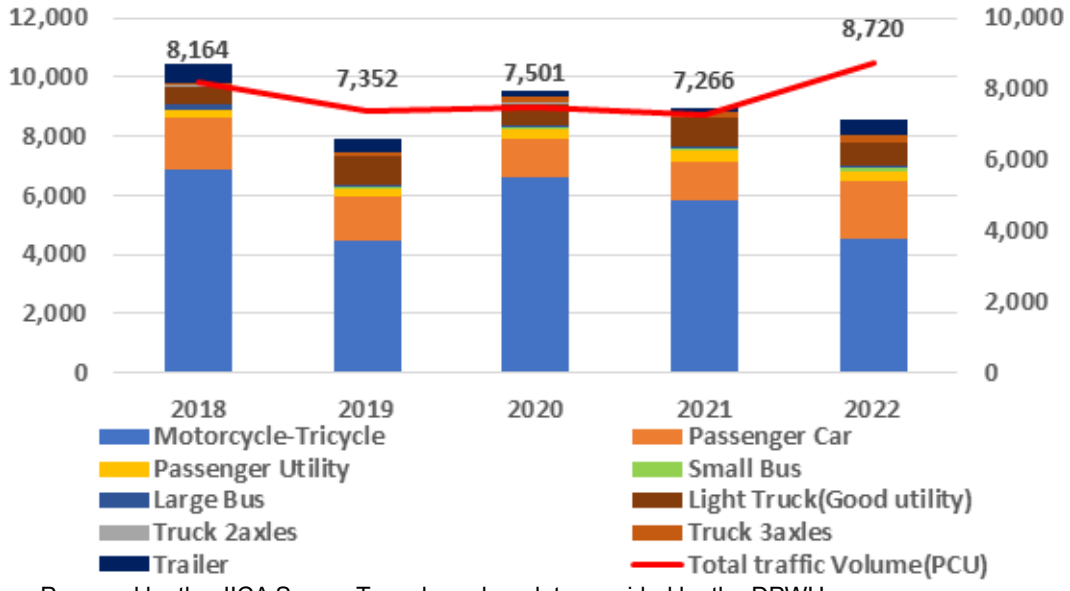
The JICA Survey Team compared the composition by vehicle type between the traffic count survey conducted in November 2023 and the traffic count survey conducted by the DPWH (average for 2018–2022) at the existing SJB. In both survey locations, motorcycle-tricycle and passenger cars accounted for about three-fourths of the total traffic. However, the DPWH survey results showed that the percentage of motorcycle-tricycle exceeds 60%, while the survey results from the JICA Survey Team showed around 45%.



Source: JICA Survey Team

Figure 6-3 Comparison of Vehicle Type Ratio

Trends of annual average daily traffic at the existing SJB from 2018 to 2022, as counted by the DPWH, showed that traffic volumes varied from year to year of the survey. It also showed slight variability in the percentage of traffic volume by vehicle type. In this area, the results of the traffic count survey tend to fluctuate due to seasonal variations and other factors. To better understand the impact of the seasonal variations mentioned above, additional traffic volume surveys were decided to be conducted at points B1 and B2, located at both ends of the existing SJB.



Source: Prepared by the JICA Survey Team based on data provided by the DPWH

Figure 6-4 Trends of Average Daily Traffic Volume at existing SJB (DPWH: 2018–2022)

To account for the effects of the seasonal variations described above, additional traffic count surveys were conducted at sites B1 and B2 on March 4 (Monday), March 5 (Tuesday), and March 9 (Saturday), 2024, during the dry season (two weekdays and one holiday). The survey methodology was the same as that used in the first survey.

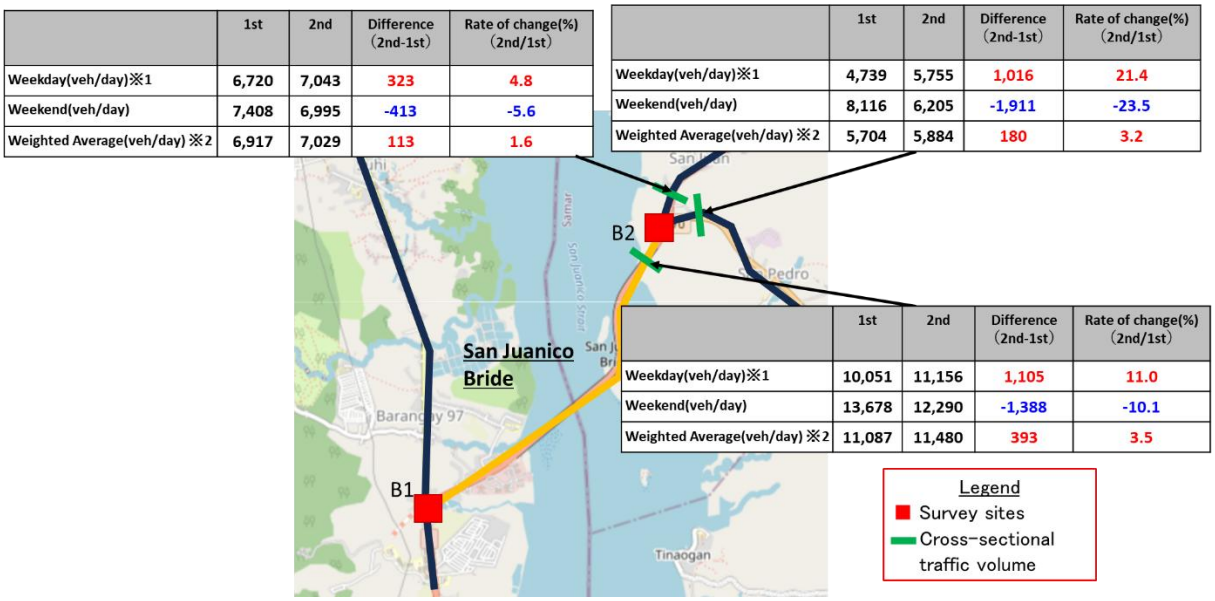
(2) Verification of Seasonal Traffic Volume Fluctuations

The cross-sectional traffic volume, traffic volume by hours, and vehicle type composition ratio of the traffic volume from the first survey conducted by the JICA Survey Team in November 2023, and the second survey conducted in March 2024, are shown in Figures 6-5 to 6-9.

At site B2, there was a tendency for traffic volume to increase on weekdays and decrease on holidays in March 2024 compared in November 2023. However, there was no significant change in the daily traffic volume (weighted average) when weekdays were five days per week and holidays were two days per week. Similarly, comparing the traffic volume by hours at the southwest cross section of B2, there was no significant change in the peak time on both weekdays and holidays.

In terms of vehicle type composition, there was no significant change on weekdays. On holidays, however, there was a tendency for the ratio of large vehicles to be higher at night in March 2024 compared in November 2023. Although there were differences in the traffic volume and vehicle type composition ratio for weekdays and holidays, it was confirmed that the daily traffic volume did not change significantly when weekdays were five days per week and holidays were two days per week.

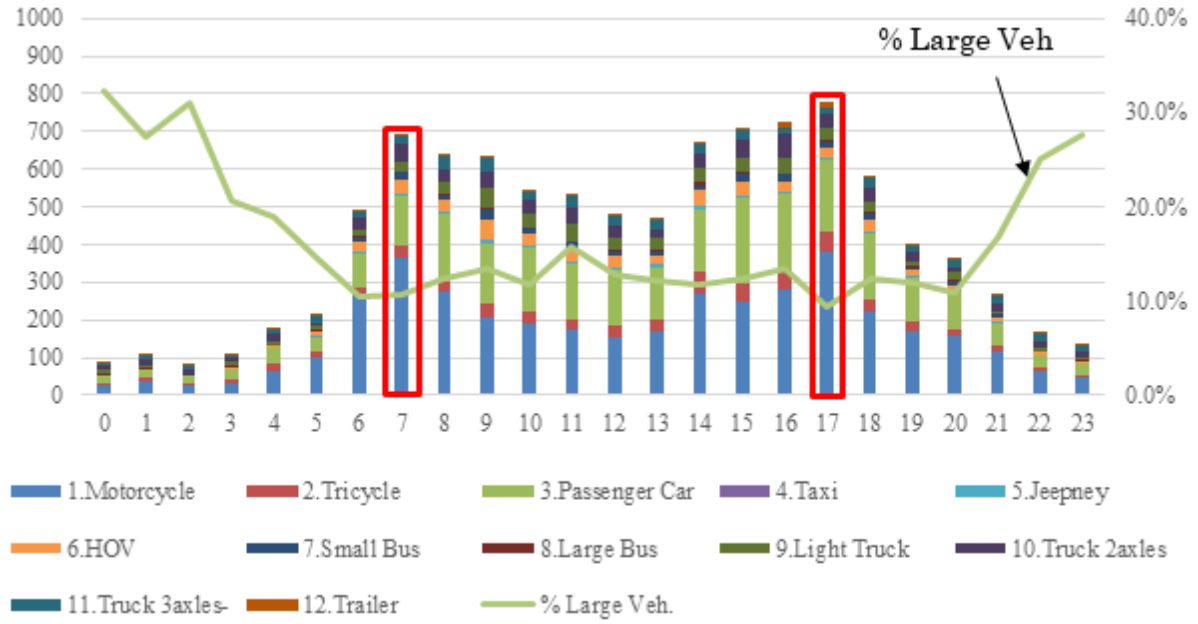
The next section shows the average traffic volume for November 2023 and March 2024.



※1 Average for two weekdays
※2 Weighted average of 5 weekdays and 2 holidays

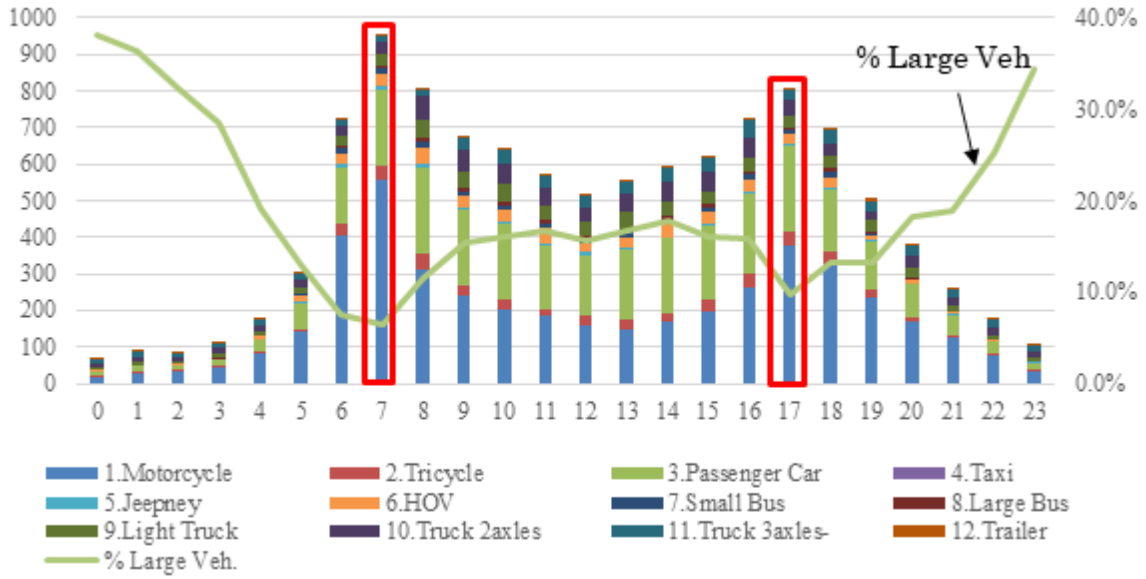
Source: JICA Survey Team

Figure 6-5 Comparison of Cross-sectional Traffic Volume



※Large Vehicle: Large Bus、Truck (2 axles)、Truck (3 axles)、Trailer
Source: JICA Survey Team

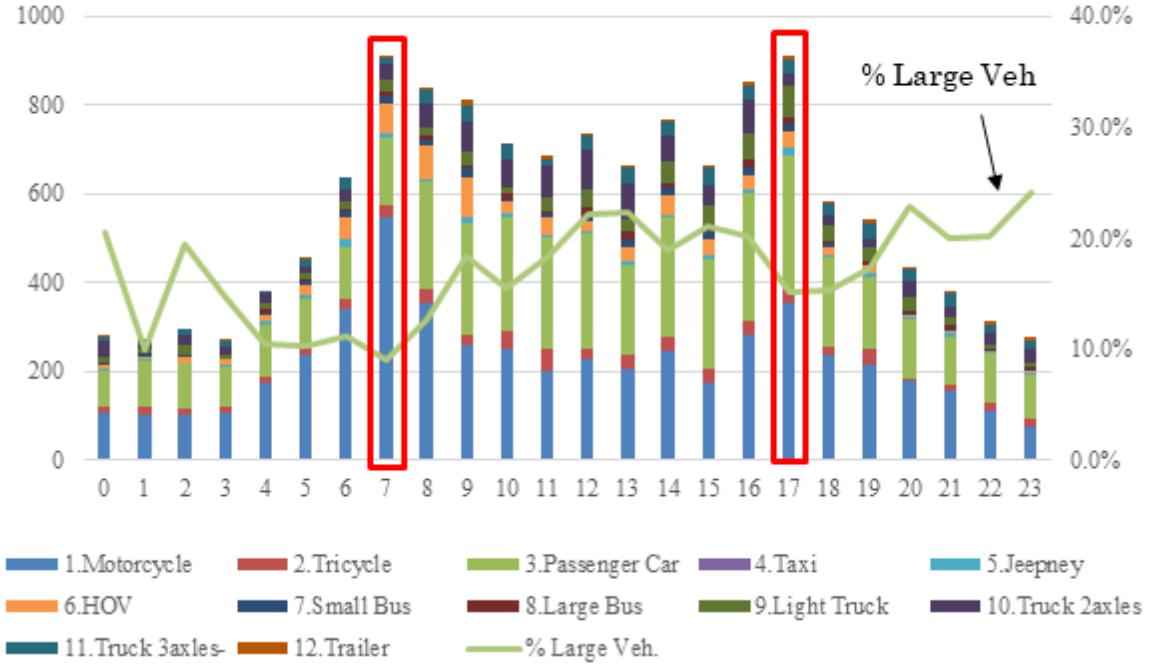
Figure 6-6 Traffic Volume by Time of Day and Composition by Vehicle Type (Average for two weekdays in November 2023)



※Large Vehicle: Large Bus、Truck (2 axles)、Truck (3 axles)、Trailer

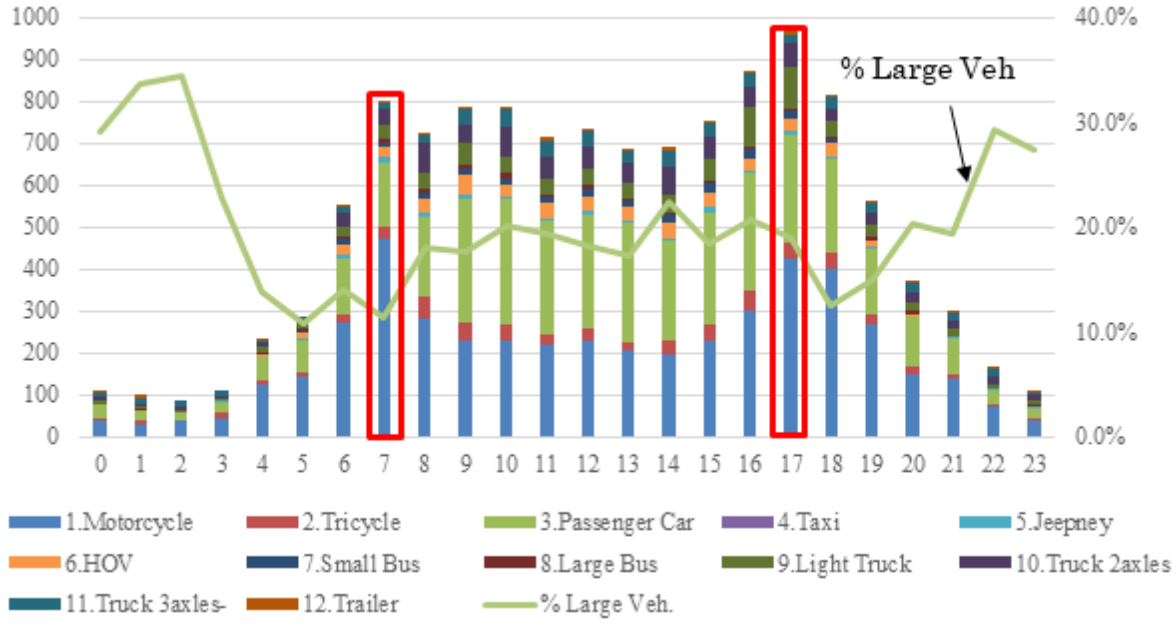
Source: JICA Survey Team

Figure 6-7 Traffic Volume by Time of Day and Composition by Vehicle Type (Average for two weekdays in March 2024)



※Large Vehicle: Large Bus、Truck (2 axles)、Truck (3 axles)、Trailer
Source: JICA Survey Team

Figure 6-8 Traffic Volume by Time of Day and Composition by Vehicle Type (One holiday in November 2023)



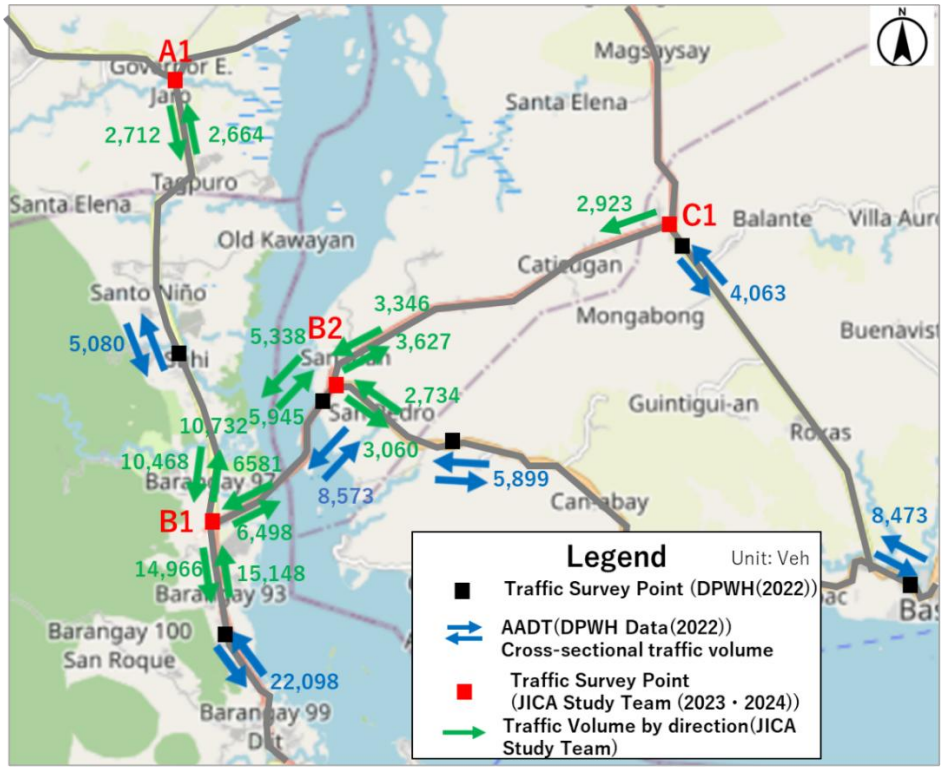
※Large Vehicle: Large Bus、Truck (2 axles)、Truck (3 axles)、Trailer
Source: JICA Survey Team

Figure 6-9 Traffic Volume by Time of Day and Composition by Vehicle Type (One holiday in March 2024)

(3) Average Traffic Volume for 2023 and 2024

1) Traffic Volume by Direction and Cross-sectional Volume

Figure 6-10 shows the annual average daily traffic volume (cross-sectional traffic volume) by direction in 2022 conducted by the DPWH around the existing SJB, alongside the average traffic volume (by direction) based on the results of the traffic volume survey conducted in this study in 2023 and 2024. Future traffic demand forecasts will be made based on this average daily traffic volume.



*The results of traffic count survey in 2023 are the daily traffic volume (weighted average) assuming five days/week on weekdays and two days/week on weekends.
Source: Prepared by the JICA Survey Team based on data provided by the DPWH

Figure 6-10 Annual Average Daily Traffic（2022）and Results of Traffic Count Survey（2023, 2024）

2) Traffic Volume and Vehicle Type Composition by Hours

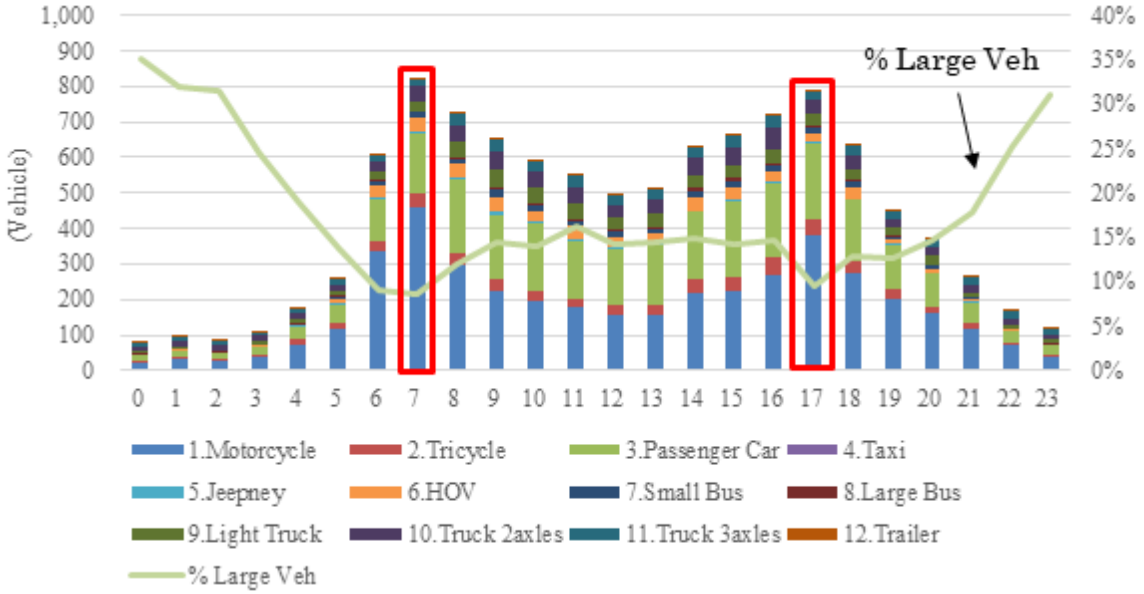
The traffic volume by hours and the vehicle type breakdown ratio—averaged from the results of the traffic volume surveys conducted in this study for 2023 and 2024—are shown in Figure 6-11 and Figure 6-12.

Traffic volumes were generally higher on holidays than on weekdays. This may be partly attributed to the region's large Catholic population, with increased demand for travel to churches for worship on holidays.

In terms of traffic volume by time of day, the peak hours for both weekdays and holidays are from 7:00 to 8:00 am and from 5:00 to 6:00 pm.

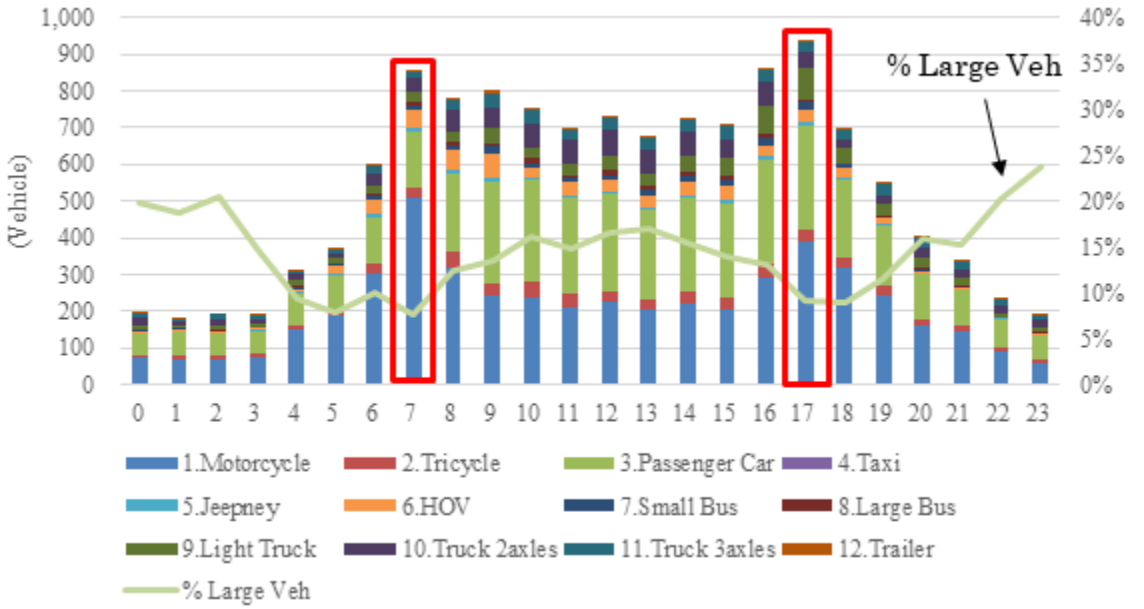
In terms of composition by vehicle type, motorcycles accounted for the highest percentage on both weekdays and holidays (40.3% on weekdays and 38.4% on holidays), followed by private cars

(26.2% on weekdays and 31.1% on holidays) and 2-axle trucks (6.8% on weekdays and 7.1% on holidays). The ratio of large vehicles was higher at night on weekdays, while on holidays, there was no significant difference in volume between morning and evening counts.



※Large Vehicle: Large Bus、Truck (2 axles)、Truck (3 axles)、Trailer
Source: JICA Survey Team

Figure 6-11 Traffic Volume by Time of Day and Composition by Vehicle Type (Average for four weekdays)



※Large Vehicle: Large Bus、Truck (2 axles)、Truck (3 axles)、Trailer
Source: JICA Survey Team

Figure 6-12 Traffic Volume by Time of Day and Composition by Vehicle Type (Average of two holiday days)

6.2 Traffic Demand Forecast

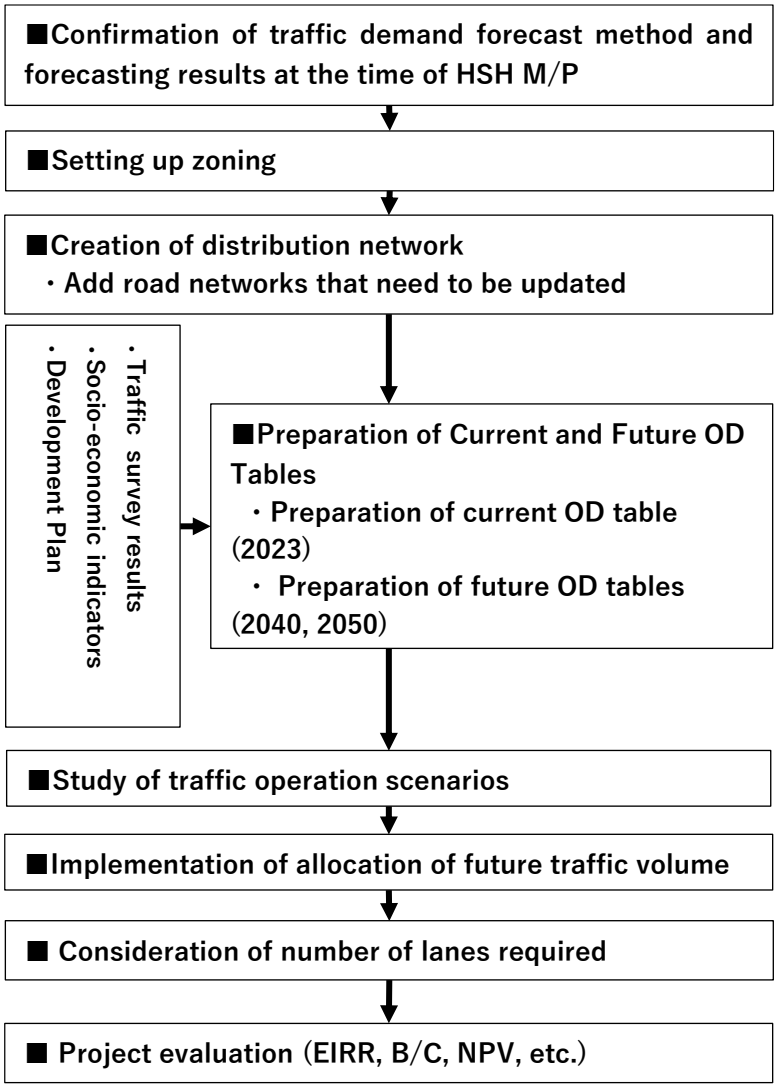
6.2.1 Outline of the Survey

The JICA Survey Team will review the adequacy of the future traffic volumes forecasted in the HSH M/P considering the results of the traffic count survey and the latest economic indicators. Then, the current and future origin-destination (OD) tables, road network data, and related inputs will be updated to forecast traffic demand.

6.2.2 Survey Method

The process follows the basic conditions and methods of the HSH M/P and utilizes existing data such as the road network provided by JICA. Information on road network around the target area necessary for updating network data will be collected from field surveys and implementing agencies.

The JICA Survey Team will forecast the future traffic volume with and without the construction of the SSJB.



Source：JICA Survey Team

Figure 6-13 Flow of Traffic Demand Forecast

① Review the traffic demand forecasting method and results at the time of the HSH M/P.

② Define the zoning for this study and update the network data for the SSJB and surrounding roads.
③ Update the current OD table (2023) for this study using the OD table from 2019 in step ① and the growth rate based on the inflation of traffic volume. Use this estimated OD table to allocate and confirm the current traffic volume in the target section.
④ Adjust the results of the allocation in step ③ using the results of the screen line survey (bridge cross section) conducted in this study.
⑤ Confirm with the implementing agency whether there are any new development plans in the vicinity of the subject area and, if applicable, reflect these in the OD as an increase in generation/concentration.
⑥ Prepare a future OD table using step ⑤ and the growth rate of traffic volume.
⑦ Consider traffic operation scenarios and allocate future traffic volumes to the network.
⑧ Based on the results of step ⑦, determine the design traffic volume and conduct the project evaluation.

6.2.3 Pre-conditions of Traffic Demand Forecast

The table below shows the pre-conditions of the traffic demand forecast.

Table 6-3 Pre-conditions of the Traffic Demand Forecast

Item	Contents
Target Area	Leyte Island and Samar Island
Zoning	20 zones
Target Year for the Traffic Demand Forecast	Base year：2023 Target year：2040 and 2050
Classification of Vehicle	**Vehicle Model** / **Passenger Car Equivalent*1** Car: individual car and taxi / 1.0 Jeepney / 1.5 Bus: HOV, mini-bus, and large bus / 2.0 Truck: all types of trucks and trailers / 2.5 Motorcycle: motorcycle and tricycle / 0.5
Network	All Expressways All National Primary Roads All National Secondary Roads Major Tertiary National Roads and Major Urban Roads

∗1 Compliant with DPWH PCEF standards

Source: JICA Survey Team

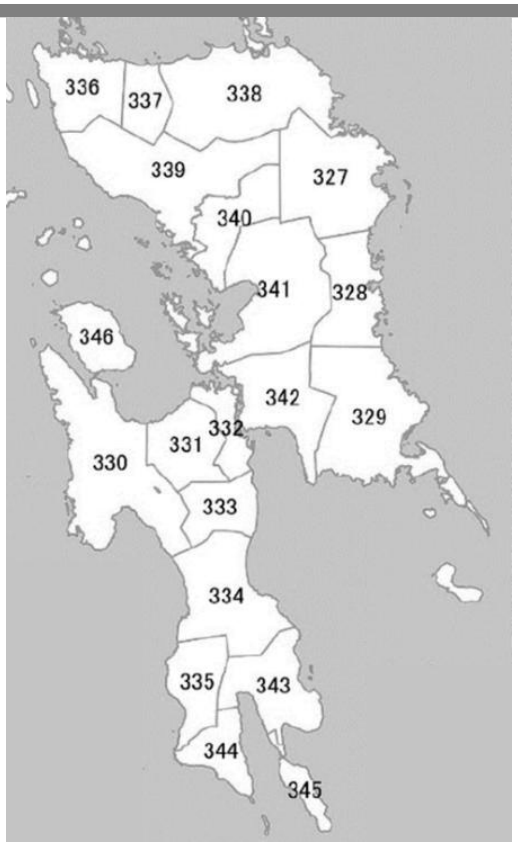
(1) Zoning

At the time of the HSH M/P, zoning was targeted in the entire country of the Philippines. However, the area affected by traffic due to the SSJB is limited to the Leyte and Samar islands only. In this study, the target area was narrowed down, and the number of zones was set to 20, as shown in the table below.

Table 6-4 Zoning System for the Traffic Demand Forecast

No.	Island	Zone No.	City/Municipality	Province	Region
1	Leyte	330	Albuera, Calubian, Capoocan, Isabel, Kananga, Leyte, Matag-Ob, Merida, Ormoc City, Palompon, San Isidro, Tabango, and Villaba	Leyte	Region VIII
2	Leyte	331	Alangalang, Barugo, Carigara, Jaro, Pastrana, San Miguel, and Tunga	Leyte	Region VIII
3	Leyte	332	Babatngon, Palo, Santa Fe, and Tacloban City (Capital)	Leyte	Region VIII
4	Leyte	333	Burauen, Dagami, Dulag, Julita, Tabontabon, Tanauan, and Tolosa	Leyte	Region VIII
5	Leyte	334	Abuyog, City of Baybay, Javier (Bugho), La Paz, Macarthur, Mahaplag, and Mayorga	Leyte	Region VIII
6	Leyte	335	Bato, Hilongos, Hindang, Inopacan, and Matalom	Leyte	Region VIII
7	Leyte	343	Anahawan, Bontoc, Hinunangan, Hinundayan, Libagon, Saint Bernard, San Juan (Cabalian), Silago, and Sogod	Southern Leyte	Region VIII
8	Leyte	344	City of Maasin (Capital), Limasawa, Macrohon, Malitbog, Padre Burgos, and Tomas Oppus	Southern Leyte	Region VIII
9	Leyte	345	Liloan, Pintuyan, San Francisco, and San Ricardo	Southern Leyte	Region VIII
10	Leyte	346	Almeria, Biliran, Cabucgayan, Caibiran, Culaba, Kawayan, Maripipi, and Naval (Capital)	Biliran	Region VIII
11	Samar	327	Arteche, Can-Avid, Dolores, Jipapad, Maslog, Oras, and San Policarpo	Eastern Samar	Region VIII
12	Samar	328	City of Borongan (Capital), San Julian, Sulat, and Taft	Eastern Samar	Region VIII
13	Samar	329	Balangiga, Balangkayan, General Macarthur, Giporlos, Guiuan, Hernani, Lawaan, Llorente, Maydolong, Mercedes, Quinapondan, and Salcedo	Eastern Samar	Region VIII
14	Samar	336	Allen, Biri, Bobon, Capul, Lavezares, Rosario, San Antonio, San Isidro, San Jose, San Vicente, and Victoria	Northern Samar	Region VIII
15	Samar	337	Catarman (Capital) and Lope De Vega	Northern Samar	Region VIII
16	Samar	338	Catubig, Gamay, Laoang, Lapinig, Las Navas, Mapanas, Mondragon, Palapag, Pambujan, San Roque, and Silvino Lobos	Northern Samar	Region VIII
17	Samar	339	Almagro, Calbayog City, Gandara, Matuguinao, Pagsanghan, Santa Margarita, Santo Niño, Tagapul- An, and Tarangnan	Samar (Western Samar)	Region VIII
18	Samar	340	City of Catbalogan (Capital), San Jorge, and San Jose De Buan	Samar (Western Samar)	Region VIII
19	Samar	341	Calbiga, Daram, Hinabangan, Jiabong, Motiong, Paranas (Wright), Pinabacdao, San Sebastian, Talalora, Villareal, and Zumarraga	Samar (Western Samar)	Region VIII
20	Samar	342	Basey, Marabut, and Santa Rita	Samar (Western Samar)	Region VIII

Source：Project for Masterplan on High Standard Highway Network Development (Phase 2)



Source：Project for Masterplan on High Standard Highway Network Development (Phase 2)

Figure 6-14 Zoning System

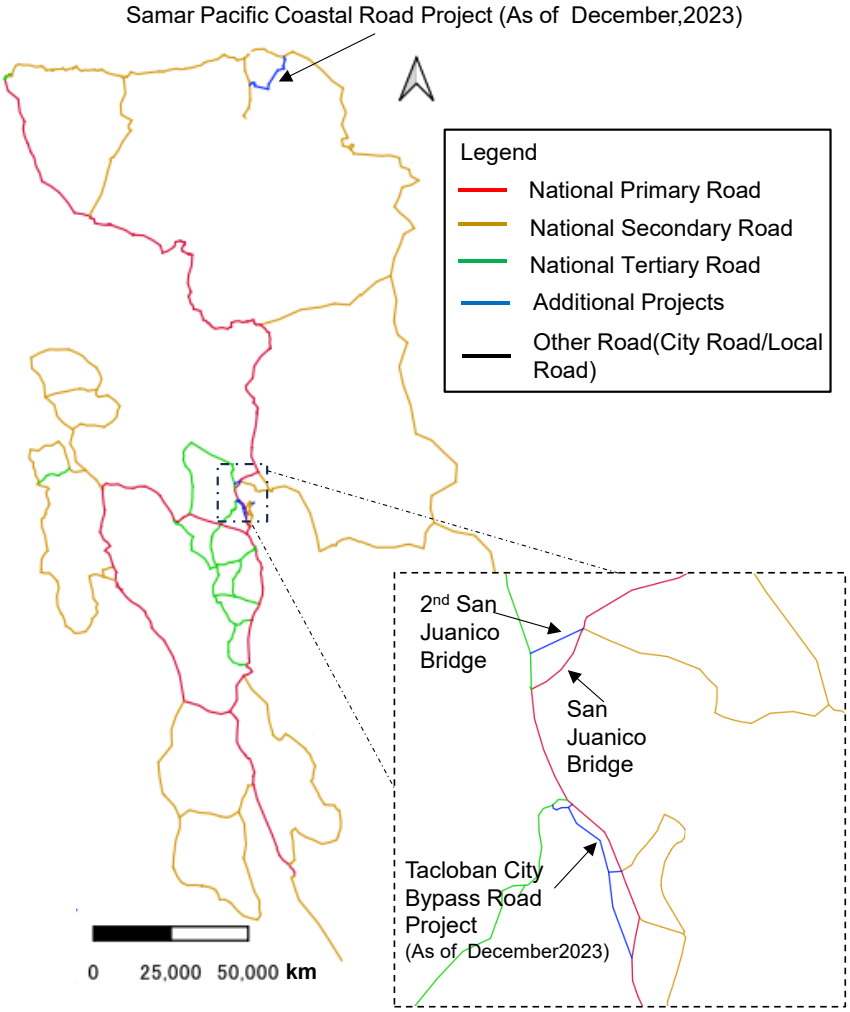
(2) Road Network for Traffic Assignment

For the traffic assignment, the road network from the HSH M/P was updated to reflect the road projects planned and under implementation in Leyte and Samar. The details are presented in Table 6-6, while the configurations of the present and future road networks are illustrated in Figure 6-15 and Figure 6-16. In addition, the parameters applied in the assignment are summarized in Table 6-7.

Table 6-5 Road Network for Traffic Assignment

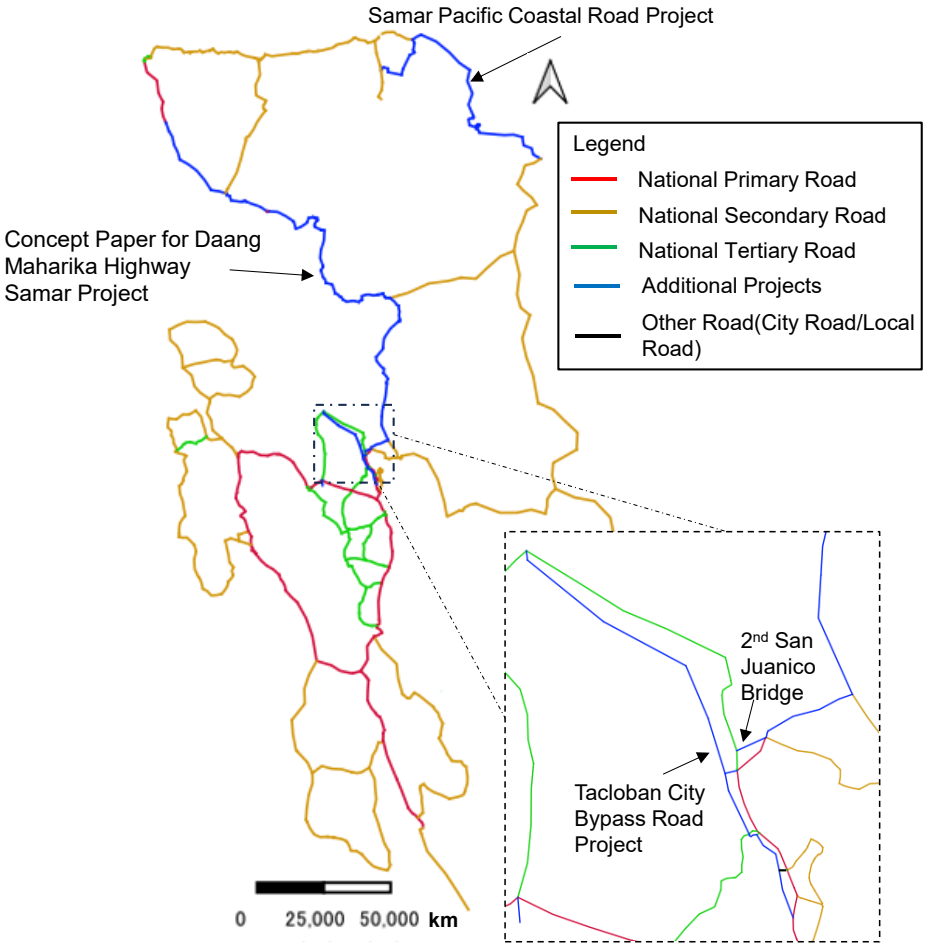
Item	Main Survey
Road Classification	・All Expressways ・All National Primary Roads ・All National Secondary Roads ・Major Tertiary National Roads and Major Urban Roads
Added Road Projects	・Tacloban City Bypass Road Project （6 lanes, reflected in 2040 and 2050） ・Samar Pacific Coastal Road Project （2 lanes, reflected in 2040 and 2050） ・Concept Paper for Daang Maharlika Highway Samar （4 lanes, reflected in 2040 and 2050）

Source：JICA Survey Team



Source：JICA Survey Team

Figure 6-15 Road Network for the Present Traffic Assignment（2023）



Source：JICA Survey Team

Figure 6-16 Road Network for the Future Traffic Assignment（2040 and 2050）

Table 6-6 Link Cost

Type	Road Class	Topography	Lane	Free flow velocity (km/h)	Road Capacity (PCU/day)
1	HSH Class1 (Expressway)	Plain	10	100	200,000
2			8	100	160,000
3			6	100	120,000
4			4	100	80,000
5	HSH Class1 (Urban Area)	Plain	6	80	120,000
6			4	80	80,000
7	HSH Class 2 (Access Controlled National Road)	Plain	6	60	72,000
8			4	60	48,000
9			2	60	24,000
10	National Road (Primary)	Plain	8	50	96,000
11			6	50	72,000
12			5	50	60,000
13			4	50	48,000
14			2	40	10,000
15	National Road (Secondary)	Plain	6	40	60,000
16			4	40	40,000
17			2	30	8,000
18	National Road (Tertiary)	Plain	6	40	48,000
19			4	40	32,000
20			2	30	6,000
21	HSH Class1	Mountainous	6	80	84,000
22			4	80	56,000
23	HSH Class 2	Mountainous	4	60	48,000
24			2	50	24,000
25	National Road (Primary)	Mountainous	8	40	67,200
26			6	40	50,400
27			4	40	33,600
28			2	30	7,000
29	National Road (Secondary)	Mountainous	6	30	42,000
30			4	30	28,000
31			2	20	5,600
32	National Road (Tertiary)	Mountainous	4	30	22,400
33			2	20	4,200
34	Ferry	-	-	5	1,000

Source: Project for Masterplan on High Standard Highway Network Development (Phase 2)

(3) Preparation of Current and Future OD Tables

1) Preparation of Current OD Table

The current OD table (2023) for this study was estimated based on the OD table in 2019 prepared for the HSH M/P. The effects of seasonal variations have not yet been reflected in the traffic demand forecast.

① Add Motorcycle to the OD Table

In the HSH M/P, motorcycles were not included as only four vehicle types—car, jeepney, bus, and truck—were considered. However, as shown in the table below, motorcycles account for 20% of the total traffic volume and therefore should be included in the demand forecast. In this study, motorcycles have been added as a vehicle type where the updated OD was estimated.

Since the OD matrix for motorcycles was not created in the HSH M/P, the OD matrix for cars was duplicated and used as the OD matrix for motorcycles. The traffic volumes and vehicle type ratios at the existing SJB in 2023 are summarized in Table 6-8 below

Table 6-7 Traffic Volume and Ratio of Vehicle Type at existing SJB (2023)

	Car	Jeepney	Bus	Truck	Motorcycle※	Total
Traffic Volume (PCU)	3,186	180	1,711	5,184	2,524	12,500
%	24.9%	1.4%	13.4%	40.5%	19.07	100%

※Tricycle included

Source: JICA Survey Team

② Estimation of the Current OD Table (2023)

The following procedure was used to estimate and validate the current OD table (2023) for this study:

I. The current OD table (2019) created by the HSH M/P and the annual growth rate of traffic volume (3.98%) shown in the figure below were used to estimate the current OD table (2023) for this study. The estimated OD table was also used for the current assignment. The JICA Survey Team reviewed the results of pre-correction assignment on the existing SJB tables. Consistent with the HSH M/P, a user equilibrium assignment method was adopted for traffic assignment.

Table 6-8 Annual Growth Rate of Traffic Volume（HSH M/P）

Traffic Growth	NCR	CAR	Region I	Region II	Region III	Region IV-A	Region V	Region VI	Region VII	Region IX	Region X	Region XI	Region XII	Region XIII	Total (w/o NCR)
2018-2030 (%)	1.79	4.07	2.75	5.54	5.10	3.97	2.73	3.54	4.00	3.39	2.66	4.79	4.59	2.38	3.97
2030-2040 (%)	1.67	3.15	2.56	3.61	5.55	5.35	2.25	2.47	4.81	2.89	2.69	5.49	3.13	2.62	3.99
2018-2040 (%)	1.73	1.73	2.67	4.66	4.66	4.60	2.51	3.06	4.36	3.16	2.68	5.10	3.93	2.49	3.98
2040/2018	1.46	2.20	1.78	2.72	2.72	2.69	1.73	1.94	2.56	1.98	1.79	2.99	2.33	1.72	2.36

Source：Project for Masterplan on High Standard Highway Network Development (Phase 2)

II. The existing OD table (2019) did not include internal traffic volumes, only interzonal traffic volumes. Since the existing SJB is located between zones (see Figure 6-7), the traffic volumes on the existing SJB do not include internal traffic volumes. To address this, the OD table was calibrated by comparing the results of pre-correction assignment with the observed 2023 traffic volume (②) at one location on the existing SJB, as obtained in this study.

III. Using the OD table calibrated in Step II, future traffic assignment (③) was performed. By comparing the traffic assignment results with the observed traffic volume, the accuracy of the current reproduction assignment results was confirmed. The accuracy of current reproduction was confirmed to be 2.3% overall and 6.7% or less for each vehicle type. The OD table, whose accuracy was confirmed, was finalized as the current OD (2023). The validation results are summarized in Table 6-10.

Table 6-9 Validation Results for Current OD

No.	Car Model	① Assignment Results (Pre-Correction)	② Traffic Count Survey Results	③ Assignment Results (Post-Correction)	Accuracy (%) (①/③)
		Traffic Volume (PCU/day)	Traffic Volume (PCU/day)	Traffic Volume (PCU/day)	
1	Car	3,868	3,186	3,217	99.0%
2	Jeepney	545	180	195	92.3%
3	Bus	235	1,711	1,732	98.8%
4	Truck	1,735	5,184	5,250	98.7%
5	Motorcycle	3,868	2,524	2,545	99.2%
Total		11,427	12,785	12,660	98.8%

Source：JICA Survey Team

2) Future OD Tables（2040 and 2050）

When examining the vehicle type ratios of generated traffic volumes for regions excluding the Manila Metropolitan Area (as estimated in the HSH M/P), the changes in vehicle type composition ratios between 2019 and 2040 were small: a 3% increase for passenger cars and jeepneys, a 1% increase for buses, and a 0% change for trucks. Therefore, when creating the future OD tables, it was confirmed that the composition ratio of each vehicle type in the future will basically not change.

Based on the above considerations, the finalized current OD table (2023) was multiplied by the annual growth rate of traffic volume shown in the table below (as estimated in the HSH M/P) to create the future OD tables for 2040 and 2050.

Table 6-10 Generated Traffic Volume Excluding the Manila Metropolitan Area

Unit: 1,000 veh.

Area	Year	Car	Jeepney	Bus	Truck	Total
Generated traffic volume excluding the Manila Metropolitan Area	2019	1,478,415	312,838	146,723	279,558	2,217,534
		67%	14%	7%	13%	100%
	2040	3,507,914	546,205	326,495	656,447	5,037,061
		70%	11%	6%	13%	100%
	2040/2019	2.37	1.75	2.23	2.35	2.27

Source：Project for Masterplan on High Standard Highway Network Development (Phase 2)

Table 6-11 Annual Growth Rate of Traffic Volume

	Annual Growth Rate of Traffic Volume (%)
2023–2050	3.98

Source：Project for Masterplan on High Standard Highway Network Development (Phase 2)

Table 6-12 Generated Traffic in 2040 and 2050

PCU/day

Area	Year	Car	Jeepney	Bus	Truck	Motorcycle	Total
Region Ⅷ	2023	9,400	400	3,800	7,500	7,400	28,500
		33.0%	1.4%	13.3%	26.3%	26.0%	100.0%
	2040	18,100	800	7,300	14,500	14,300	55,000
		32.9%	1.5%	13.3%	26.4%	26.0%	100.0%
	2050	26,800	1,200	10,800	21,400	21,200	81,400
		32.9%	1.5%	13.3%	26.3%	26.0%	100.0%

Source：JICA Survey Team

3) Induced Traffic Volume Due to Development

① Babatngon Port

The future traffic volume of Babatngon Port, which is planned as a new port on Leyte Island, was reviewed using materials provided by the Philippine government.

According to a report by the Philippine Ports Authority (PPA), Babatngon Port is not assumed to handle containers and is expected to accommodate about 5% of the cargo volume currently handled by Tacloban Port, Leyte Island's main port.

The figure below shows the estimated cargo volume based on the above conditions. The growth rate of cargo volume until 2028 is shown in three cases. In the case with the highest growth rate, the port is expected to handle approximately 31,000 tons of cargo annually in 2028, equivalent to about 122 tons per day (excluding holidays). Assuming 10-ton trucks are used for transport, this translates to a traffic volume of roughly 12 vehicles per day. As the current scale of the project will have an extremely limited impact on the surrounding road network in the future, it has been decided that this project will not be considered in the traffic demand forecasts.

Year	LOW FORECAST			MEDIUM FORECAST			HIGH FORECAST		
	Inbound Cargo	Outbound Cargo	Total Cargo Volume	Inbound Cargo	Outbound Cargo	Total Cargo Volume	Inbound Cargo	Outbound Cargo	Total Cargo Volume
2003	16,584	5,784	22,368	16,584	5,784	22,368	16,584	5,784	22,368
2004	16,601	6,073	22,674	16,833	5,871	22,704	16,91	5,900	22,815
2005	16,617	6,377	22,994	17,085	5,959	23,044	17,254	6,018	23,272
2006	16,634	6,696	23,330	17,342	6,048	23,390	17,599	6,138	23,737
2007	16,650	7,031	23,681	17,602	6,139	23,741	17,951	6,261	24,212
2008	16,667	7,382	24,049	17,866	6,231	24,097	18,310	6,386	24,696
2009	16,684	7,751	24,435	18,134	6,325	24,458	18,676	6,514	25,190
2010	16,767	7,790	24,557	18,315	6,388	24,703	18,956	6,612	25,568
2011	16,851	7,829	24,680	18,498	6,452	24,950	19,241	6,711	25,952
2012	16,935	7,868	24,804	18,683	6,516	25,199	19,529	6,811	26,341
2013	17,020	7,908	24,928	18,870	6,581	25,451	19,822	6,914	26,736
2014	17,105	7,947	25,052	19,059	6,647	25,706	20,120	7,017	27,137
2015	17,191	7,987	25,177	19,249	6,714	25,963	20,422	7,123	27,544
2016	17,199	7,991	25,190	19,346	6,747	26,093	20,626	7,194	27,820
2017	17,208	7,995	25,203	19,442	6,781	26,223	20,832	7,266	28,098
2018	17,216	7,999	25,215	19,539	6,815	26,354	21,040	7,338	28,378
2019	17,225	8,003	25,228	19,637	6,849	26,486	21,251	7,412	28,663
2020	17,234	8,007	25,240	19,735	6,883	26,618	21,463	7,486	28,949
2021	17,242	8,011	25,253	19,834	6,917	26,751	21,678	7,561	29,239
2022	17,251	8,015	25,266	19,933	6,952	26,885	21,895	7,636	29,531
2023	17,259	8,019	25,278	20,033	6,987	27,020	22,114	7,713	29,826
2024	17,268	8,023	25,291	20,133	7,022	27,155	22,335	7,790	30,125
2025	17,277	8,027	25,304	20,234	7,057	27,291	22,558	7,868	30,426
2026	17,285	8,031	25,316	20,335	7,092	27,427	22,784	7,946	30,730
2027	17,294	8,035	25,329	20,437	7,128	27,564	23,011	8,026	31,037
2028	17,303	8,039	25,342	20,539	7,164	27,702	23,242	8,106	31,348

Source：Final Report of the Consultancy Services for the Formulation of Master Plans and Conduct of Feasibility Studies for PMO-Tacloban and PMO-Tagbilaran in the Post District of Visayas (Package 1), Philippine Ports Authority (PPA)

Figure 6-17 Estimated Cargo Volume Handled by Babatngon Port

② Catbalogan Airport

The amount of traffic that will be induced by Catbalogan Airport, which is being planned as a new airport on Samar Island, was reviewed based on materials provided by the Philippine government.

According to the feasibility study (FS) report, it is assumed that the number of passengers at Catbalogan Airport will be in the same class (Principal Class II) as nearby airports such as Calbayog and Catarman.

The number of passengers estimated based on the above conditions is shown in the figure below. Expected passenger numbers are capped at approximately 390,000 per year as they are limited by the targeted annual terminal capacity based on the current scope of the project. This corresponds to roughly 1,100 people per day, indicating that the induced traffic volume will be relatively modest.

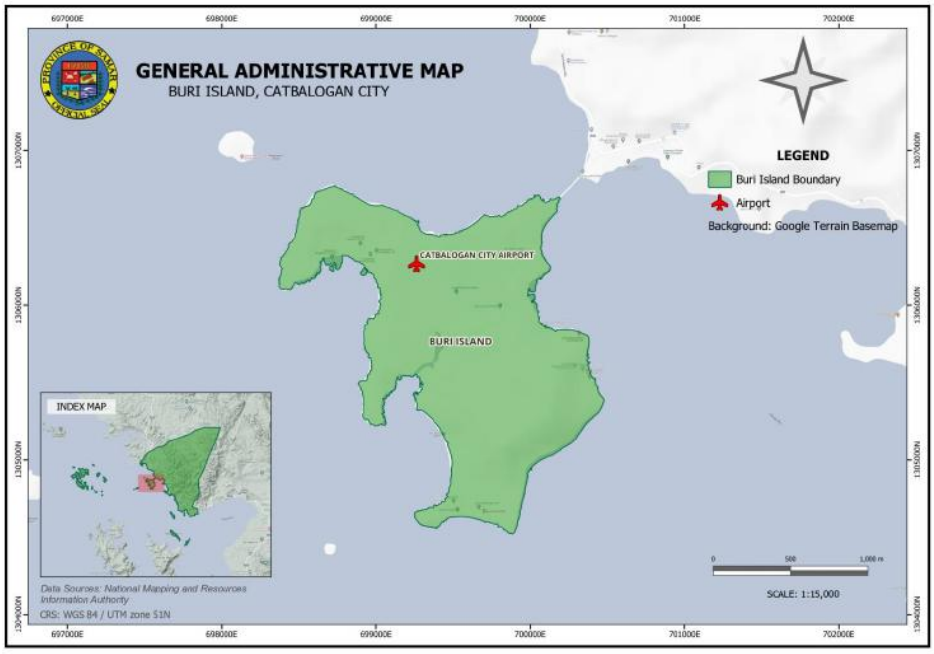
Table 4-7 Projected Ridership, 2023-2051

	2023	2028	2033	2038	2043	2048	2051
Total Airport Demand (Unrestricted)	479,409	818,288	1,396,710	2,175,191	2,347,754	2,534,006	2,652,777
Effective Passenger Traffic, Annual	238,467	391,361	391,361	391,361	391,361	391,361	391,361

Source：Feasibility Study for the Catbalogan Airport Development Project

Figure 6-18 Catbalogan Airport Passenger Number

Catbalogan Airport is located in Catbalogan City, the main commercial, trade, educational, financial, and political center of Samar Island. However, given the presence of Tacloban Airport on Leyte Island and the fact that the Catbalogan Airport is also targeting domestic passengers, it is assumed that there will be a limited number of passengers passing through the Catbalogan Airport on their way to the island of Leyte. Therefore, the impact of the development of this airport on the traffic volume between Leyte Island and Samar Island is limited. It was then decided not to take it into account in the demand forecast.



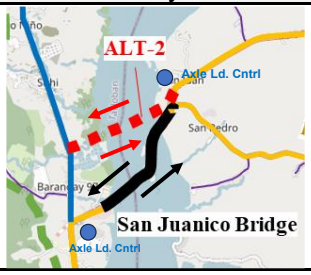
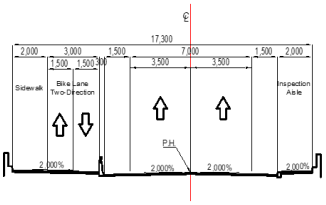
Source：Feasibility Study for the Catbalogan Airport Development Project

Figure 6-19 Catbalogan Airport Location Map

(4) Scenario for Traffic Operations

Multiple scenarios for traffic operations were considered based on the construction of the SSJB in the vicinity of the existing SJB.

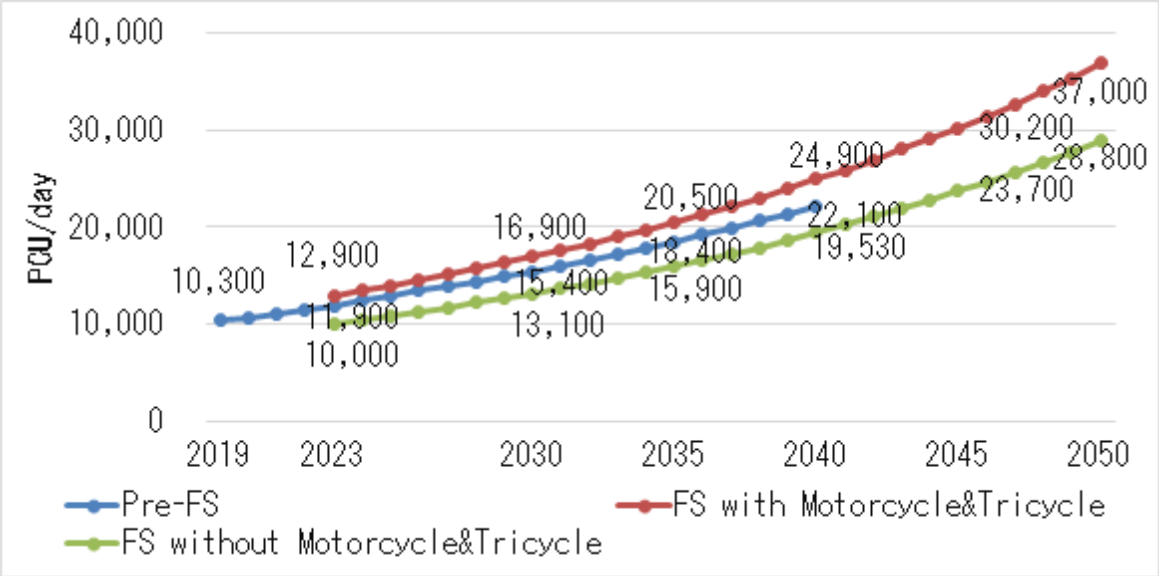
Table 6-13 Traffic Operations

	One-Way Traffic	Two-Way Traffic	Bicycle Lane
Image			
Number of Lanes	SSJB：2 / 4 lanes in one direction (both sides). Existing SJB: 2 lanes in one direction (both sides).	SSJB：one lane in one direction (one direction). Existing SJB：one lane in one direction (one direction).	SSJB：bicycle lane
Advantages of Traffic Operations	It is safer than two-way operation and has a higher speed limit. When either bridge is closed for maintenance or due to an accident, traffic operations need to be modified.	Drivers can choose their route according to their destination. If one of the bridges is closed, there is no need to change traffic operations. The speed limit is generally advisable to keep low because of the possibility of head-on collisions.	The installation of a bike lane on the SSJB will improve convenience for residents and promote tourism. Economic internal rate of return (EIRR) declines due to increased costs.

Source：JICA Survey Team

6.2.4 Results of Traffic Demand Forecast

According to the results of the traffic demand forecast, the traffic volume between Leyte and Samar is shown in the figure below (24,900 PCU/day in 2040 and 37,000 PCU/day in 2050).



Source: JICA Survey Team

Figure 6-20 Future Traffic Between Leyte and Samar

The future traffic volumes allocated to the existing SJB and the SSJB when operated in one-way traffic are shown in the table below.

Table 6-14 Future Traffic Volumes of Existing SJB and SSJB

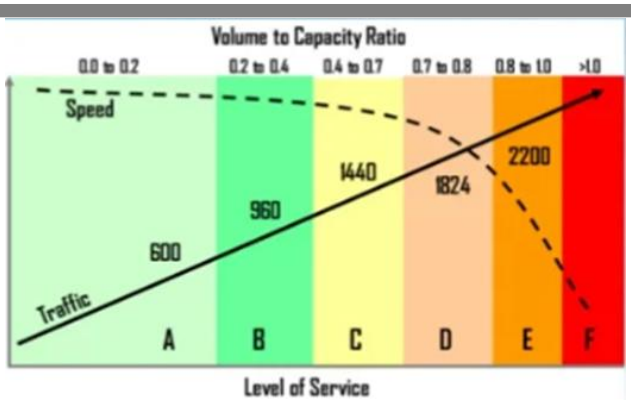
Year	Pre-FS					FS				
	Total	SSJB		Existing SJB		Total	SSJB		Existing SJB	
	(PCU/day)	PCU/day	%	PCU/day	%	(PCU/day)	PCU/day	%	PCU/day	%
2019	10,300	-	-	10,300	100	-	-		-	
2023	11,900	-	-	11,900	100	12,900	-		12,900	100
2030	15,400	6,600	43	8,800	57	16,900	7,800	46	9,100	54
2035	18,400	7,900	43	10,500	57	20,500	9,400	46	11,100	54
2040	22,100	12,600	57	9,500	43	24,900	11,500	46	13,400	54
2045	-	-	-	-	-	30,200	13,900	46	16,300	54
2050	-	-	-	-	-	37,000	17,200	46	19,800	54

Source: JICA Survey Team

6.2.5 Examination of Required Number of Lanes

The traffic capacity ratio (traffic volume/traffic capacity) was calculated using the future traffic volumes estimated by the JICA Survey Team and the traffic capacity of the existing highway. The required number of lanes was then validated based on the Level of Service (LOS) concept. In addition, traffic volumes were evaluated assuming a ±20% variation to account for demand uncertainty.

The LOS concept is summarized as follows. For rural highways, Level C is considered the target level.



Source: Highway Capacity Manual

Figure 6-21 Relationship Between LOS Traffic Capacity Ratio and Travel Speed

Table 6-15 LOS Standards

V/C	Traffic status by level
< 0.2	A: Free flow.
< 0.4	B: Moderately free flow. LOS A speed is maintained, but maneuverability within the flow of traffic is slightly limited.
< 0.7	C: Steady flow, free flow or near-free flow. Target LOS for rural highways.
< 0.8	D: Approaching an unstable flow. This situation is a busy shopping district on weekdays or an urban highway during rush hours.
< 1.0	E: Flow is unstable and near the maximum capacity. Any accident will result in significant delays.

Source: Highway Capacity Manual

Traffic capacity is set for existing highways based on the Highway Capacity Manual.

$$C_D = C_B \times f_{lw} \times f_{rs} \times f_{pv} \times f_{los} \times \frac{N}{2} \times \frac{100}{K} \times \frac{100}{D}$$

C_D : Daily capacity （pcu/day）
C_B : Basic capacity （pcu/hour）
f_{lw} : Adjustmet factor for the lane width
f_{rs} : Adjustment factor for the roadside condition
f_{pv} : Adjustment factor the pavement condition
f_{los} : Adjustment factor for the level of service
N : Number of lanes in both directions
K : $Propotion\ of\ daily\ capacity\ in\ the\ peak\ direction$ (%)
D : Proportion of peak hour traffic in the peak direction （%）
V_{max} : Maximum speed （km/h）
V_B : Basic speed （km/h）
S_r : Speed reduction rate （%）

Using the above formula, the traffic capacity of the two lanes was set at 31,400 PCU/day.

Table 6-16 Traffic Capacity Settings

	Lane	Q_{max}	LOS					
	N	(pcu/day)	A	B	C	D	E	F
❶	2	31,400	6,280	15,700	21,980	26,690	31,400	-
❷	2	34,800	6,960	17,400	24,360	29,580	34,800	-

※❶Two-way traffic:40 km/h、❷One-way traffic：60 km/h

Source: JICA Survey Team

The results of the evaluation with the future traffic volumes allocated to the existing and new bridges and the traffic capacity set based on the LOS are shown below. Since the traffic capacity differs for two-way and one-way traffic due to the difference in speed limits, the traffic operation scenarios are evaluated separately.

(1) Two-Way Traffic

Without Case (without the SSJB improvement): Traffic capacity is exceeded by 2050 in both the base case and the +20% case, while congestion is severe in the -20% case.

With Case (with SSJB improvement): In all scenarios except the +20% case, the LOS in 2050 will be B or C. Even in the +20% case, it stays at D.

(2) One-Way Traffic

Without Case (no SSJB maintenance): Same as for the two-way traffic.

With Case (with SSJB improvement): In all cases, the LOS in 2050 will be B or C.

Based on the abovementioned, it is considered that the two lanes of the existing SJB and the SSJB can cover the future traffic volume until 2050.

Table 6-17 Evaluation by LOS (Two-Way Traffic)

	WITHOUT			WITH					
Year	Existing SJB			Existing SJB			SSJB		
	Base	+20%	-20%	Base	+20%	-20%	Base	+20%	-20%
2023	12,900			12,900					
2030	16,900	20,280	13,520	9,000	10,800	7,200	7,900	9,480	6,320
2040	24,900	29,880	19,920	13,200	15,840	10,560	11,700	14,040	9,360
2050	37,000	44,400	29,600	19,500	23,400	15,600	17,500	21,000	14,000

Source: JICA Survey Team

Table 6-18 Evaluation by LOS (One-Way Traffic)

	WITHOUT			WITH					
Year	Existing SJB			Existing SJB			SSJB		
	Base	+20%	-20%	Base	+20%	-20%	Base	+20%	-20%
2023	12,900			12,900					
2030	16,900	20,280	13,520	9,100	10,920	7,280	7,800	9,360	6,240
2040	24,900	29,880	19,920	13,400	16,080	10,720	11,500	13,800	9,200
2050	37,000	44,400	29,600	19,800	23,760	15,840	17,200	20,640	13,760

Source: JICA Survey Team

6.3 Axle Load Survey

6.3.1 Purpose of Survey

Axial load data of overloaded vehicles was obtained and used as reference information for operation and maintenance of the project as shown in Table 6-19.

Table 6-19 Utilization Policy of Axial Load Data

Items	Outline
Operation and Maintenance	To obtain the quantity and frequency of overloaded vehicles and to examine the organizational structure.
Existing SJB Investigation/Evaluation	Since the overloaded vehicles cause damage to the existing SJB floor plates, this information will be used as reference for damage assessment.

Source: JICA Survey Team

6.3.2 Survey Items

The survey items and outline are shown in Table 6-20.

Table 6-20 Outline of Axle Load Survey

Survey Items	Outline
Data Collection of Axle Load	Collection of existing axle load survey results.

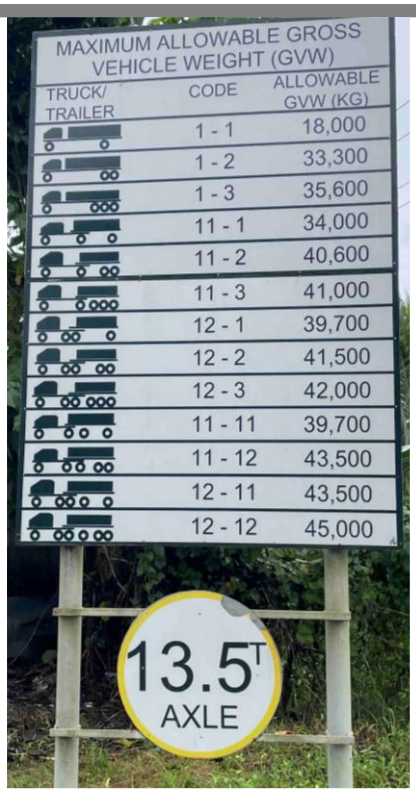
Source: JICA Survey Team

6.3.3 Survey Method

Axle load surveys are being conducted by the DPWH at the locations shown in Figure 6-1. The survey team collected data from weigh stations on both sides of the existing SJB.

6.3.4 Survey Result

Daily axial weight measurement results from September 2023 to January 2024 were obtained from DPWH Region VIII. The measurement targeted 13 types of trucks and trailers, as shown in Figure 6-22, and approximately 87% of total transit traffic was measured based on actual results. The criterion for overloaded vehicles is 13.5 tons per axis if it is a shaft weight, and the Gross Vehicle Weight (GVW) is determined according to the number of axles.



Source: JICA Survey Team

Figure 6-22 Notice Board of Allowable Weight Located Near Weigh Stations

Table 6-21 shows the measurement results by measurement station and month. Starting from the left side, the items in the table are: the measured month, the number of units measured, the type of overload (shaft weight only, gross weight only, and both shaft weight and gross weight), the total excess weight (tons) in shaft weight, the total number of excess axle weight, the total excess weight (tons) in gross weight, and the number of vehicles that passed through without measurement (units).

Table 6-21 Result of Axle Load Survey

Leyte									
Month/Year	Weighed Trucks	No. of Overloaded Trucks				Sum of Excess Load Per Axle (tons)	No. of Overloaded Axles	Sum of Excess Load Per GVW (tons)	No. of Trucks passing (traffic count)
	No.	Type of Violation			Total (a)+(b)				
		Axle only	GVW only (a)	both (b)					
Sep-23	1,652	0	7	15	22	51.43	23	110.04	254
Oct-23	1,548	0	5	18	23	74.18	29	226.07	275
Nov-23	1,625	1	4	19	23	73.92	34	158.01	187
Dec-23	1,729	0	2	9	11	5.53	3	88.92	259
Jan-24	1,715	1	4	16	20	49.13	27	74.98	322
Total	**8,269**		**22**	**77**	**99**	**254.19**	**116**	**658.02**	**1297**

Samar									
Month/Year	Weighed Trucks	No. of Overloaded Trucks				Sum of Excess Load Per Axle (tons)	No. of Overloaded Axles	Sum of Excess Load Per GVW (tons)	No. of Trucks passing (traffic count)
	No.	Type of Violation			Total (a)+(b)				
		Axle only	GVW only (a)	both (b)					
Sep-23	1,549	3	9	9	18	26.9	18	100.64	221
Oct-23	1,547	0	7	9	16	10.21	13	71.94	221
Nov-23	1,550	1	6	13	19	21.12	17	98.24	166
Dec-23	1,386	3	3	7	10	21.34	12	27.27	273
Jan-24	1,429	1	1	11	12	30.35	18	41.94	221
Total	**7,461**		**26**	**49**	**75**	**109.92**	**78**	**340.03**	**1102**

Ground Total	**15,730**		**48**	**126**	**174**	**364.11**	**194**	**998.05**	**2399**

Source: Prepared by the JICA Survey Team based on the data from DPWH Region VIII

From these data, an analysis was performed, and the results are summarized as shown in Table 6-22. The ratio of overloaded vehicles to the total number of overloaded vehicles is approximately 1.2% on the Leyte side and 1.0% on the Samar side. The average excess weight exceeding the allowable value of 13.5 tons per axis is 2.19 tons/axis on the Leyte side and 1.41 tons on the Samar side. Similarly, the average excess gross vehicle weight is 6.65 tons/unit on the Leyte side and 4.53 tons/unit on the Samar side, which is larger on the Leyte side as well as the axle weight.

Table 6-22 Analysis of Axle Load Survey Record

Leyte			
Month/Year	Ratio of Excess Load Trucks	Average Excess Load by Axle (tons)	Average Excess Load by GVW (tons)
Sep-23	1.3%	2.24	5.00
Oct-23	1.5%	2.56	9.83
Nov-23	1.4%	2.17	6.87
Dec-23	0.6%	1.84	8.08
Jan-24	1.2%	1.82	3.75
Total	**1.2%**	**2.19**	**6.65**

Samar			
Month/Year	Ratio of Excess Load Trucks	Average Excess Load by Axle (tons)	Average Excess Load by GVW (tons)
Sep-23	1.2%	1.49	5.59
Oct-23	1.0%	0.79	4.50
Nov-23	1.2%	1.24	5.17
Dec-23	0.7%	1.78	2.73
Jan-24	0.8%	1.69	3.50
Total	**1.0%**	**1.41**	**4.53**

Ground Total	**1.1%**	1.88	5.74

Source: Prepared by the JICA Survey Team based on data from DPWH Region VIII

Regarding the actual handling and operation of overloaded vehicles, DPWH RO VIII reported that vehicles exceeding the weight limit are still permitted to pass through the existing SJB after the collection of fines for overloading. These fines will be paid to the Land Transportation Franchising and Regulatory Board (LTFRB) under the Department of Transportation (DOTr).

In addition, the cargo type of the overloaded vehicles is also recorded, and the top five items by weigh stations are shown in Table 6-23 for reference. Many vehicles from Leyte to Samar are overloaded with stone, cement, and other similar materials. Common to both the stations are vegetables, chemical products, and metal products.

Table 6-23 Type of Cargo of Overloaded Vehicles

Rank	Leyte		Samar	
	Type of Cargo	Units	Type of Cargo	Units
1st	Articles of stone, plaster, cement, asbestos, and ceramic products.	40	Vegetable products.	21
2nd	Products of the chemical or allied industries.	17	Vehicles, aircraft, vessels, and associated transport equipment.	17
3rd	Vegetable products.	13	Works of art, collectors' pieces, and antiques.	12
4th	Wood and articles of wood, wood charcoal, cork, and articles of cork.	11	Base metals and articles of base metal.	10
5th	Base metals and articles of base metal.	7	Products of the chemical or allied industries.	6

Source: Prepared by the JICA Survey Team based on data from DPWH Region VIII

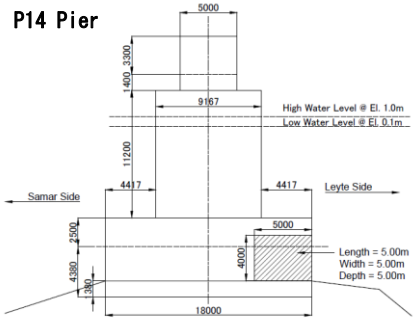
7 Survey of Present Condition of San Juanico Bridge

7.1 Past Inspection Results and Repair Works

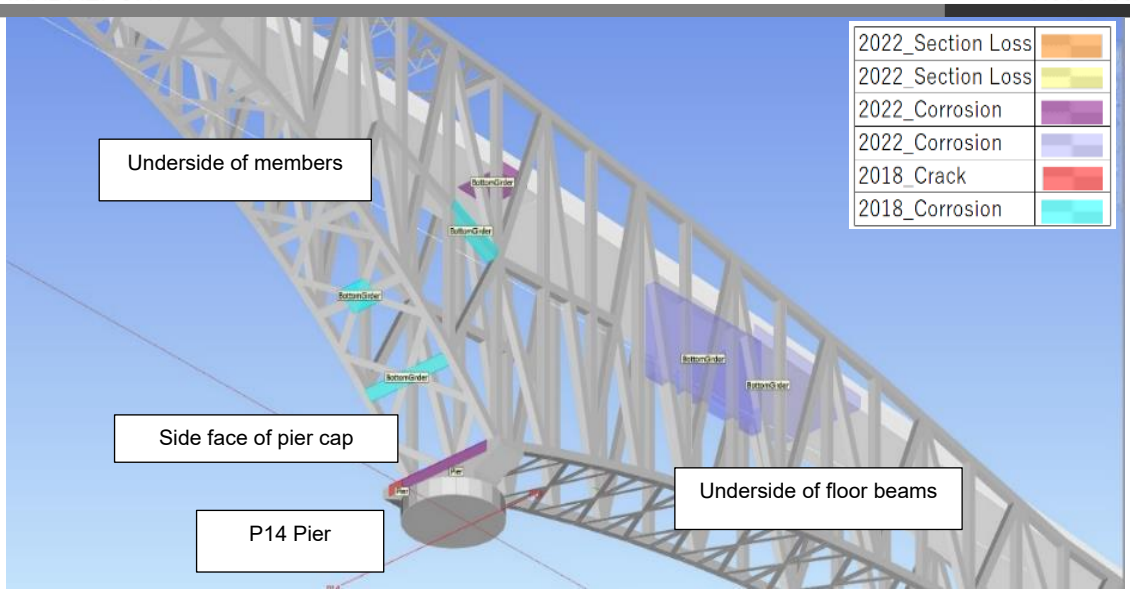
7.1.1 Past Inspection Results

The observations and findings from the inspections on the existing SJB, conducted in 2018 and 2022, are outlined in Table 7-1. Locations of some defects detected by visual inspection are shown in Figure 7-1, using a 3D model.

Table 7-1 Outlines of Past Inspections

Inspection	November 2018 (Project on Improvement of Quality Management for Highway and Bridge Construction and Maintenance, Phase 3)	May 2022 (DPWH Maintenance Office) July 2022 (DPWH HQ)
Inspection Method ＊Note	**Inspection with an Aerial Drone** ＊Appropriate for inspection of entire structure but less suitable for bearings and narrow spaces such as the inside of a truss.	**Visual Inspection, Compression Strength Test of Concrete, Diving Survey** ＊Applicable for inspections of narrow spaces if accessible.
Major Findings	Corrosion of steel members (i.e. gusset plates and joints), deformation of steel parts, and various cracks on the surface of RC piers were observed.	Defects on deck slabs and around bearings, corrosion of steel, and localized distortion of inner stiffener of main girder were found and investigated through visual inspection and compression strength tests. Abnormalities were found at footings of underwater piers through a diving survey.
Photo/ Illustration		

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7-1 Visualization of Defects Found

The report of the inspection conducted by the DPWH, *OCULAR INSPECTION & VALIDATION REPORT SAN JUANICO BRIDGE,* on May 27, 2022, accounts for some major defects, as shown in Table 7-2. Among these defects or findings are as follows:

1. Section losses of steel members found in many portions of the bridges.
2. Compression strength tests, using concrete core samples of 52 mm diameter collected from 16 random locations of the deck slab, indicated insufficient strength to meet the design strength (excluding the test results for samples from three locations).
3. Large-scale defects or abnormalities at two underwater footings of the main truss bridge.

While none of these defects are seen to prompt restrictions on safe passage, recommendation of concrete deck slab replacement after the completion of the SSJB was still brought about (in connection with item 2 above). On the other hand, further detailed visual inspection and survey by qualified competent experts are suggestively necessary for item 3.

The DPWH RO VIII has acquired for extensive Inspection Services for the existing SJB in 2024, which shall include visual inspection, non-destructive tests (NDT), preparation of as-found drawings, assessment of load carrying capacity based on as-found dimensions, assessment of structural soundness, scope and size of necessary repair works, cost estimate of repair works, and preparation of contract documents, among others.

Table 7-2 Outline of Inspection Results by the DPWH

Component	Major Defects
Truss Bridge	- Section loss of members due to corrosion. - Distorted members.
Box Girder	- Section loss of lower flanges due to corrosion.
Plate Girder	- Section loss of lower flanges and web plates due to corrosion. - Deformed members.
Deck Slab	- Indication of water leakage from deck slab. - Weaker strength of some tested samples of RC deck slab than design strength. - Peeled-off CFRP sheets.
Bearing	- Missing steel cover plates for bearings. - Deterioration of protective coating. - Vegetation growth.
Restrainer	- Corrosion with some section losses.
Pavement	- Corrugation and deformation.
Railing	- Damaged railings between Spans 17–20.
Coating	- Rusting and peeled-off paints.
Underwater Pier	- Abnormalities (i.e. voids and cavitation) between footing and seabed at P14 and P15 Piers.
Others	- Excessive vibration between Spans 10–12.

Source: JICA Survey Team

Table 7-3 Outline of Inspection Services Recently Acquired by RO VIII

Objectives	The Consulting Services aims to completely improve the existing condition of the bridges, load carrying capacities, and resistance to disastrous seismic activities. The Services shall cover for the structural assessment and design work for rehabilitation and retrofitting of the existing SJB.
Scope of Work	・Field investigations and surveys to obtain actual data of existing structures necessary to perform the technical studies and detailed engineering. ・NDTs for determination of size, dimensions, and spacing of bars as well as concrete compression strength. ・Underwater exploration for the detailed assessment of the existing foundations. ・Soil exploration for reference in the structural modeling and in the design of foundation retrofit. ・Overall detailed analysis / assessment of the existing SJB and determination of the most suitable rehabilitation and retrofitting schemes. ・Detailed engineering design plans of the recommended rehabilitation and retrofitting works for the whole bridge structure. ・Quantity estimate and corresponding detailed unit price analysis (DUPA) and program of works (POW) for the rehabilitation and retrofitting works.
Other	Contract Period: 300 days, Approved Budget: PhP 96.5 million.

Source: JICA Survey Team, Modified from TOR for the Consultancy Services, DPWH

7.1.2 History of Rehabilitation

The existing SJB, with its more than 50 years of existence, had already undergone several rehabilitation works since its completion in 1973. As shown in Table 7-4, past repair works include retrofitting of piers, repair of concrete deck slab by placing Carbon Fiber-Reinforcing Plastics (CRFP) sheets on the undersurface of the slab, replacement of the original high-strength bolts, repair and replacement of expansion joints, and repair of asphalt pavement. The bridge superstructures were also over-coated in 2018, changing its then-reddish appearance to its now aluminum surface color.

Despite these collected information, the JICA Survey Team has still noted the failure in obtaining complete records or documentations of past rehabilitations and retrofitting conducted for the bridge. This is due to several technical and engineering documents, including the original as-built drawings, being reported as lost and damaged in severe typhoons. Thus, recounting the history of repair works may not be perfected with such difficulties. The major rehabilitation and repair works carried out on the existing SJB are summarized in the table below.

Table 7-4 Major History of Rehabilitation

No.	Date	Contents of Repair
1	July, 1973	Opening of San Juanico Bridge (Marcos Bridge)
2	1996	Retrofitting of piers
3	2000	Repair of deck slab
4	September, 2002	Collision by a barge into the P35 pier (Samar side)
5	October, 2002	Yield of steel frame of the P35 pier
6	2004	Repair of pavement
7	November, 2013	Damage by Super Typhoon Haiyan
8	2014	Rehabilitation of deck and piers
9	2018	Over coating with whitish paint
10	March, 2021	Repair/replacement of expansion joints (Spans 21-24)
11	December, 2021	Retrofitting (Phase 1), Replacement with F11T high-strength bolts
12	November, 2022	Retrofitting (Phase 2), Replacement with F11T high-strength bolts
13	October, 2022	Completion of the illumination facility
14	2022	Partial reconstruction of the deck slab (Span 41)

Source: JICA Survey Team

7.1.3 Review of Vehicle Restrictions and Repair Works

During the implementation of this project, DPWH imposed a traffic restriction limiting vehicles passing over the existing SJB to a maximum of 3 tons. The review results of the DPWH-issued "Load Rating Analysis" report—which serves as the basis for this restriction, as well as concerns regarding the ongoing reinforcement works—are attached in the Appendix-C4.

7.2 Inspection Results of the Superstructure

7.2.1 Purpose of Inspection

Considering that the existing SJB is not only a historical landmark in the region but also an important tourist attraction—being named as the nation’s first longest bridge for a significant period of time—DPWH intends to prolong the use and lifespan of the bridge, even after the completion of the SSJB.

The inspection conducted by the JICA Survey Team aimed to identify the possible defects and appropriate response of repair or rehabilitation, and subsequently coordinate these findings with related authorities and appeal for further detailed inspections.



Source: JICA Survey Team

Figure 7-2 Distant View of the existing SJB (Truss Bridge)

7.2.2 Extent of Survey

Contents of the survey are summarized in Table 7-5.

Table 7-5 Outline of Survey

Contents	Major Activity
(1) Review of past reports of inspections and rehabilitation	Study of inspection reports made by JICA's *Project on Improvement of Quality Management for Highway and Bridge Construction and Maintenance* and by the DPWH.
(2) Selection of inspection points	Selection of appropriate inspection areas based on the study results of item (1).
(3) Inspection of superstructures	Visual inspection using temporary scaffolding to observe the extension and severity of corrosion. Inspected structures：one span each of Leyte and Samar Island side of the approach bridges, truss members located around P14 and P15 piers, and floor beams of central part of center span of the truss bridge.
(4) Inspection of piers	Underwater inspection of six piers (four piers of truss bridge and two piers of approach bridges).
(5) Assessment of necessity of detailed inspection and rehabilitation	Assessment of necessity of further detailed inspection and rehabilitation based on inspection results

Source: JICA Survey Team

7.2.3 Survey Method

(1) Selection of Inspection Areas

Due to the limited access to areas of the existing SJB, the visual inspection work had to focus on the defect-prone locations of the structures. The inspection areas were selected based on the mapping model shown in Figure 7-1.

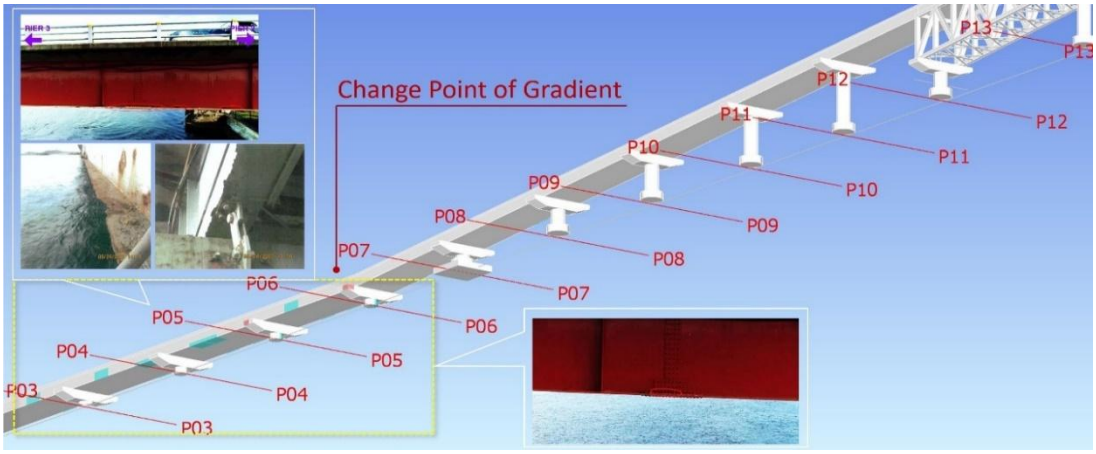
One location valid for this inspection is where water ponding frequently occurs. For the truss bridge, this location is around the bearings, lower chord members at the central part of the center span (due to their level-alignment in the longitudinal direction), and floor beams of the center span (see Figure 7-3). Due to the complicated structural member arrangement in trusses—especially at gusset plate connections—the joints tend to easily trap rainwater, and proper application of protective coating is generally difficult.



Source: JICA Survey Team

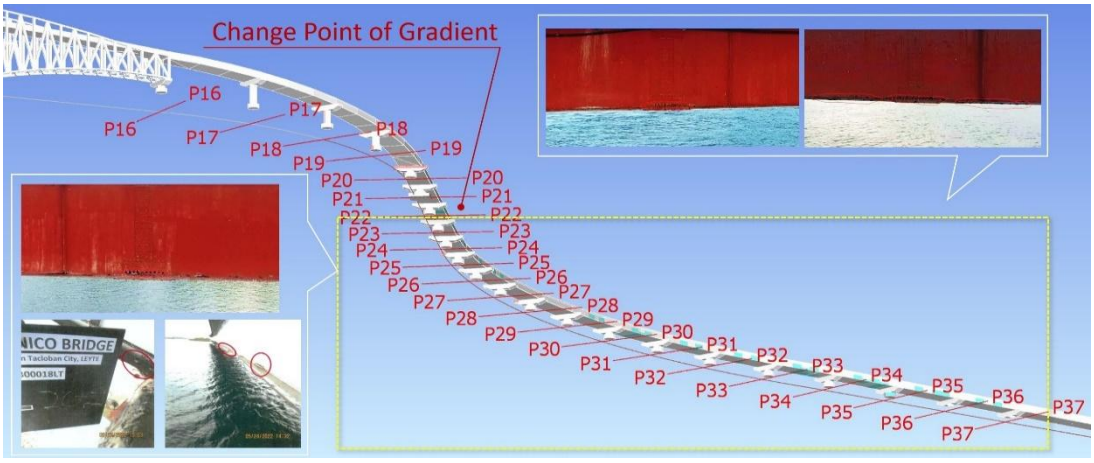
Figure 7-3 Portions with Noticeable Defects in the Truss Bridge

For the approach bridges, the inspection covered each span of the steel box girder and steel plate girder bridges. Considering that the bearings tend to generally show defects, several bearings of the approach bridges were inspected.



Source: JICA Survey Team

Figure 7-4 Portions with Noticeable Defects (Leyte Side Approach Bridges)



Source: JICA Survey Team

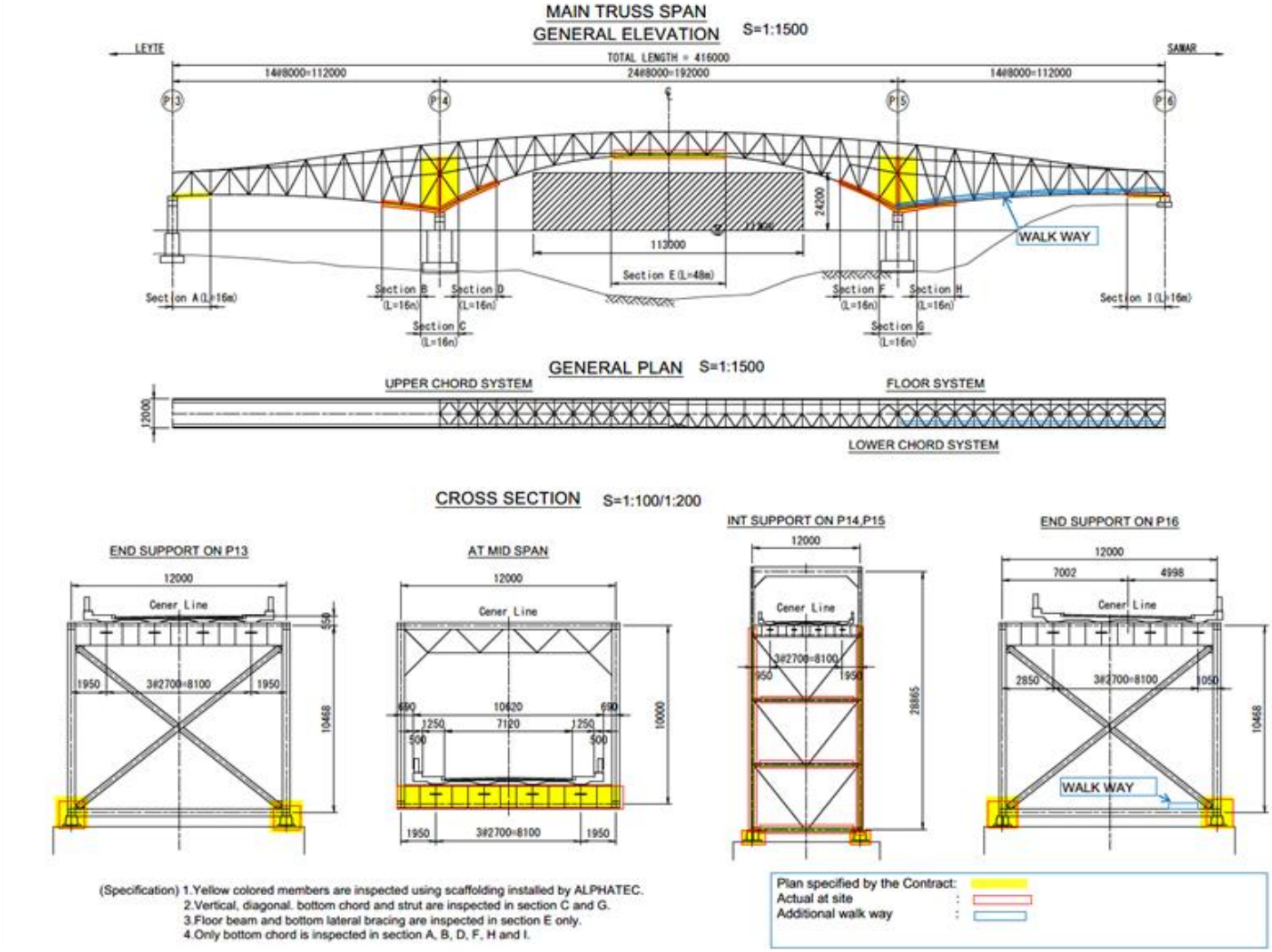
Figure 7-5 Portions with Noticeable Defects (Samar Side Approach Bridges)

P14 and P15 were carefully inspected because of the serious damages observed in these piers based on the previous inspection reports by the DPWH conducted in May, July 2022. Other several piers of both the truss and approach bridges were also inspected in the same manner.

(2) Close-up Visual Inspection

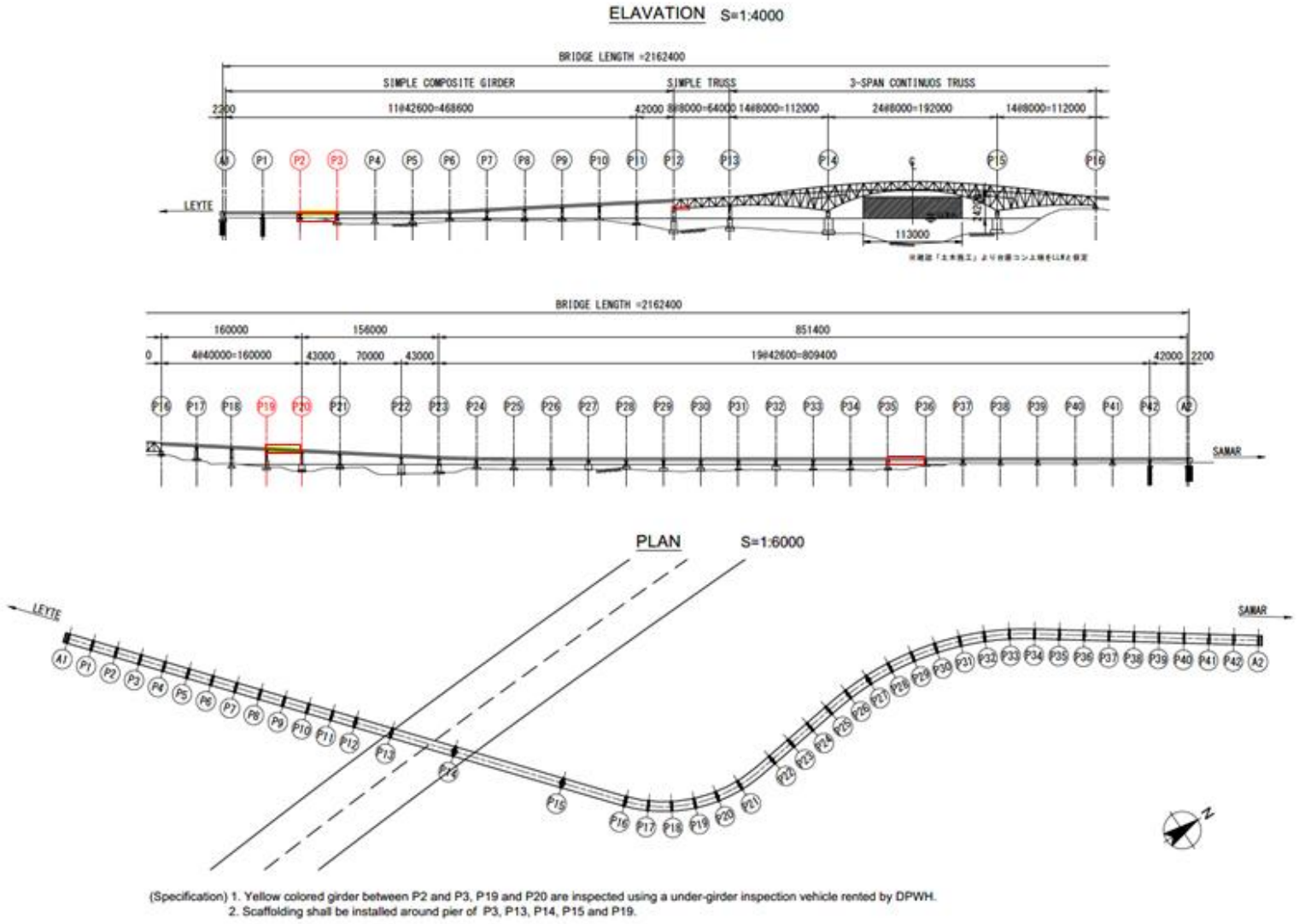
Temporary scaffoldings were installed and utilized for the inspection of members of the truss bridge, whereas the inspection of the approach bridges was conducted using a bridge inspection vehicle (BIV) provided by the DPWH. The BIV conveys personnel to a close-up visual inspection of the underside of the girders by its extending telescopic articulated platform. Truss members located high above the road surface were inspected using binoculars.

The scaffoldings were set up in the areas of the truss marked in red and blue, as shown in Figure 7-6. Inspected areas of the approach bridges were spans of P2 to P3, P19 to P20, and P35 to P36, as indicated in red in Figure 7-7. Six bearings of P3, P13, P14, P15, P19, and P35 were inspected.



Source: JICA Survey Team

Figure 7-6 Range of Visual Inspection for Truss



Source: JICA Survey Team

Figure 7-7 Range of Visual Inspection for Approach Bridges

(3) Rating of Damage

The detected damages during inspection were classified or rated in accordance with the provisions from the DPWH bridge inspection manuals (see Table 7-6 and Table 7-7) and the Japanese bridge inspection manual (see Table 7-8). These manuals in particular are the following:

① Bridge Management System Bridge Inspection Manual, August 22, 2007 (DPWH);
② Bridge Inspection Manual for Steel Truss Bridge 2014 (DPWH);
③ Road Bridge Periodic Inspection Manual 2019, Road Bureau, MLIT, Japan.

Table 7-6 Rating of Damage According to the DPWH Manual

Condition Rating	Description
Good	No damage
Fair	With minor damage(s) not affecting the stability of the structure
Poor	With deteriorating damage(s) which should be repaired as a preventive action
Bad	With severe damage(s) that affects stability of bridge or that has possibility to harm public

Source: Bridge Management System Bridge Inspection Manual, August 22, 2007 (DPWH)

Table 7-7 Bridge Condition Rating of the DPWH Manual ①

BRIDGE ELEMENT		SPAN	BRIDGE ATTTRIBUTE	DECK (1/2)
MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT		
		TYPE OF DAMAGE	CONDITION	
CONCRETE Deck Slab	0 - Good	1 Cracking	Hairline crack or no crack	
		2 Spalling Scaling Disintegration	Affected area is <= 150mm wide in any direction, or depth is less than 25mm	
		3 Delamination	Delaminated area measuring <=150mm in any direction	
		4 Rebar exposure/corrosion	No damage	
		5 Honeycomb	Affected area is <= 150mm wide in any direction	
		6 Water leakage	Not visible	
	1 - Fair	1 Cracking	<= 0.3mm, 1 direction, spacing > 500mm	
		2 Spalling Scaling Disintegration	Affected area is > 150mm to <= 300mm wide in any direction. or depth is 25mm to 50mm	
		3 Delamination	Delaminated area measuring >=150mm to <=300mm wide in any direction	
		4 Rebar exposure/corrosion	Main rebar exposed is <=500mm wide, corroded ot flaking only	
		5 Honeycomb	Affected area is > 150mm to <= 300mm wide in any direction	
		6 Water leakage	Water leak in 1 spot has an area of <= 200mm wide	
	2 - Poor	1 Cracking	> 0.3mm to <= 1.0mm, 2 directions, spacing is <500mm to >= 200mm	
		2 Spalling Scaling Disintegration	Affected area is > 300mm to <= 600mm wide in any direction, or depth is 50mm to 100mm	
		3 Delamination	Delaminated area measuring >300mm to <=600mm in any direction	
		4 Rebar exposure/corrosion	Main rebar exposed is >1500mm to <=1000mm wide, corroded	
		5 Honeycomb	Affected area is >300mm to <= 600mm wide in any direction	
		6 Water leakage	Water leak in 1 spot has an area of > 200mm to <= 500mm wide	
	3 - Bad	1 Cracking	> 1.0mm, 2 directions, spacing is < 200mm	
		2 Spalling Scaling Disintegration	Affected area is > 600mm wide in any direction, or depth is more than 100mm	
		3 Delamination	Delaminated area measuring >600mm in any direction	
		4 Rebar exposure/corrosion	Main rebar exposed is >1000mm wide and corroded	
		5 Honeycomb	Affected area is >600mm wide in any direction	
		6 Water leakage	Water leak in 1 spot has an area of > 500mm wide	

Source: Bridge Management System Bridge Inspection Manual, August 22, 2007 (DPWH)

Table 7-8 Bridge Condition Rating Criteria of MLIT Japan

Member	Damage	No.	Rating	Photograph	Remark
Steel Member	Corrosion	1	Fair		Corrosion in local area. If it is left without repaire, the corrosion expands to extend that it has a serios impact.
		2	Poor		Serious corrosion in wide area and thickness reduction of steel plate.
		3	Bad		Reduction of thickness of steel plate at supporting point.
	Cracking	4	Fair		Though growth of crack does not make the main member disrupt, the crack may growth in the future.
		5	Poor		Further growth of crack makes the main member disrupt.
		6	Bad		Serious corrosion is found in wide area and thickness reduction of steel plate is observed.
Bearing		7	Fair		Coating damage and corrosion on bearing . Peeled concrete cover of pedestal at small area.
		8	Poor		Strictly rusty on Almost all parts ofbearing and reduction of element.
		9	Bad		Strict cross section defect of bearing and support member

Source: Road Bridge Periodic Inspection Manual 2019, Ministry of Land, Infrastructure and Transport, Road Bureau, Japan

7.2.4 Materials and Equipment for Inspection

Shown in Figure 7-8 are the temporary scaffoldings installed for the inspection of the truss bridge, and the BIV used for the inspection of the approach bridges.













Source: JICA Survey Team

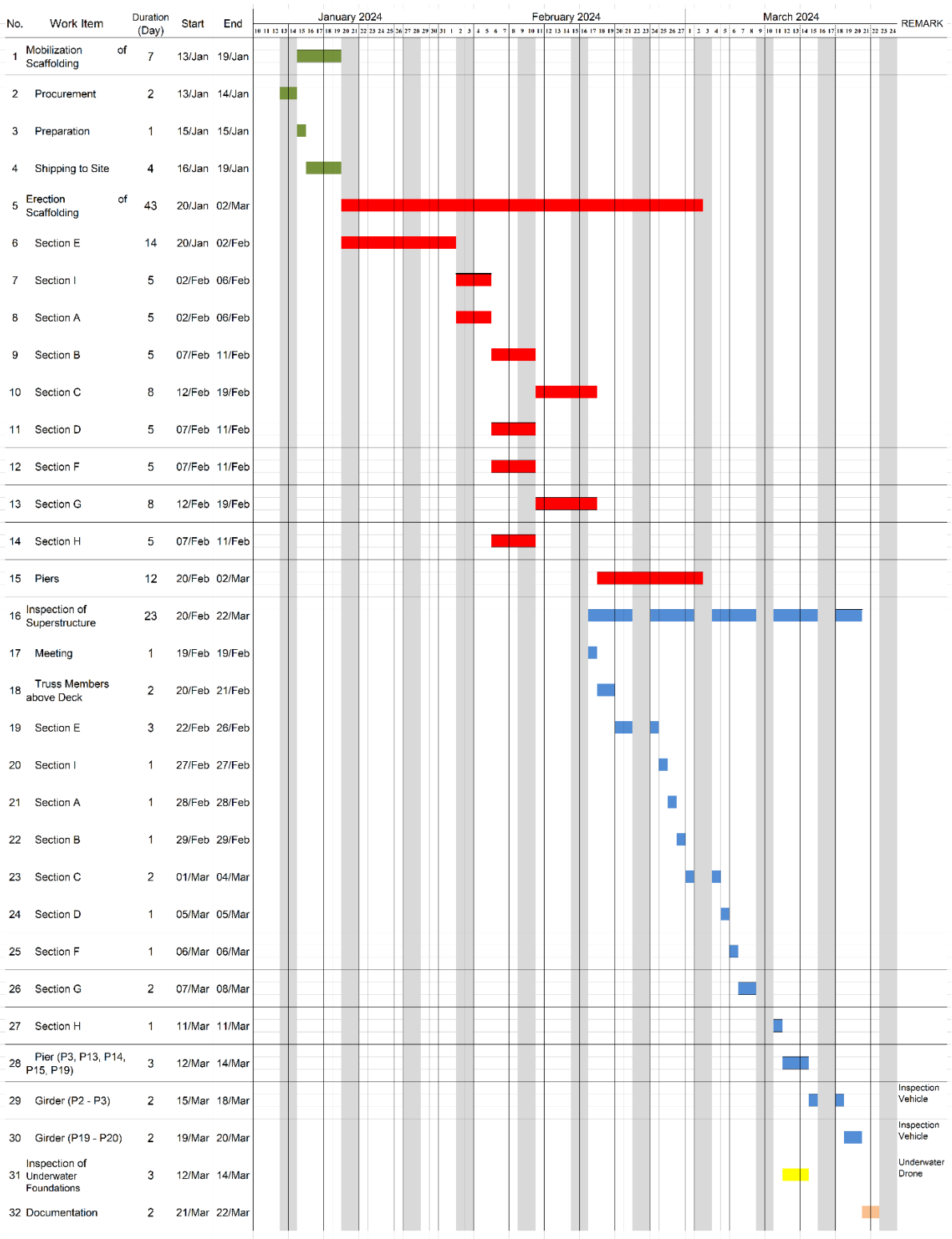
Figure 7-8 Situation of the Temporary Scaffolding and a BIV

7.2.5 Work Schedule for Inspection

Actual procedure and work items for inspection were performed as indicated in the following work schedule, including procurement of scaffolding and installation at site, counting to a total duration of 70 days.

Table 7-9 Work Schedule of Inspection Work

No.	Work Item	Duration (Day)	Start	End	REMARK
1	Mobilization of Scaffolding	7	13/Jan	19/Jan	
2	Procurement	2	13/Jan	14/Jan	
3	Preparation	1	15/Jan	15/Jan	
4	Shipping to Site	4	16/Jan	19/Jan	
5	Erection of Scaffolding	43	20/Jan	02/Mar	
6	Section E	14	20/Jan	02/Feb	
7	Section I	5	02/Feb	06/Feb	
8	Section A	5	02/Feb	06/Feb	
9	Section B	5	07/Feb	11/Feb	
10	Section C	8	12/Feb	19/Feb	
11	Section D	5	07/Feb	11/Feb	
12	Section F	5	07/Feb	11/Feb	
13	Section G	8	12/Feb	19/Feb	
14	Section H	5	07/Feb	11/Feb	
15	Piers	12	20/Feb	02/Mar	
16	Inspection of Superstructure	23	20/Feb	22/Mar	
17	Meeting	1	19/Feb	19/Feb	
18	Truss Members above Deck	2	20/Feb	21/Feb	
19	Section E	3	22/Feb	26/Feb	
20	Section I	1	27/Feb	27/Feb	
21	Section A	1	28/Feb	28/Feb	
22	Section B	1	29/Feb	29/Feb	
23	Section C	2	01/Mar	04/Mar	
24	Section D	1	05/Mar	05/Mar	
25	Section F	1	06/Mar	06/Mar	
26	Section G	2	07/Mar	08/Mar	
27	Section H	1	11/Mar	11/Mar	
28	Pier (P3, P13, P14, P15, P19)	3	12/Mar	14/Mar	
29	Girder (P2 - P3)	2	15/Mar	18/Mar	Inspection Vehicle
30	Girder (P19 - P20)	2	19/Mar	20/Mar	Inspection Vehicle
31	Inspection of Underwater Foundations	3	12/Mar	14/Mar	Underwater Drone
32	Documentation	2	21/Mar	22/Mar	



Source: JICA Survey Team

7.2.6 Inspection Results

(1) Inspected Members and Portions

The following members and portions of the truss bridge and approach bridges were inspected:

① Asphalt pavement and expansion joints of the entire bridge section.

② Truss members above and under the deck within a visible range.

③ Truss members in Section E (L = 48.0m) which are marked in red and visible members from the temporary walkway marked in blue in the side span of P15 and P16 as shown inFigure 7-6.

④ The bearings on P12, P14, P15, and P16 piers of the truss bridge and P2, P3, P19, P20, and P35 piers of the approach bridges.

(2) Inspection Results

1) Technical Assessment Results

The condition of the existing SJB is rated as "Poor", indicating the presence of damage that requires preventive repair. While the current partial visual inspection did not reveal any severe damage that could cause the immediate collapse of the bridge, early measures are necessary because this is the only important bridge connecting Leyte and Samar islands. Significant section loss was found on the upper surface of the bottom chord of the truss bridge, the upper flange of the cross beam's bottom flange, and part of the approach span's bottom flange near girder ends. These conditions could compromise the functionality of the road bridge. Therefore, it is recommended to promptly conduct a detailed visual inspection of the entire truss and approach bridges.

In addition, damage due to rust on the side plates of the bottom chord at the main span of the truss bridge could lead to future cracking and should be repaired immediately. Moreover, heavily damaged areas on the lower flanges of the truss cross beams and at the end support parts of the approach bridge must be urgently repaired. The main damages found in this inspection are summarized below in Table 7-10 in terms of load-bearing capacity and durability performance:

Table 7-10 Evaluation of Inspected Damage

No.	Observed Damage	Estimated Cause	Estimating Progress	Role of Component	Assessment of Structural Stability	Reference Diaphragm
1	Rust on the top surface of the central lower chord of the truss bridge	It is estimated that the cause was rainwater accumulating on the top surface of the lower chord.	Since the structure does not allow for drainage, it is expected that the rust will continue to progress.	As the main structural member of the truss bridge, it is an important member that supports the entire dead load and live load.	If the rust continues to progress and an opening appears at the corner of the lower chord cross section, the strength will decrease, causing it to break and potentially causing the bridge to collapse, so it is determined that immediate repairs are necessary.	Figure 7-9
2	Severe corrosion of the bottom flange of the cross beam of the truss bridge	The cause cannot be determined, and bird droppings cannot be ruled out as a possible cause.	Since it is not painted, it is assumed that rust is progressing.	As part of the floor structure, the RC deck is an important component that supports the live load.	If the rust continues to progress, the cross beams may break, making it unable to support the live load and causing the RC deck to collapse, so it is determined that immediate repairs are necessary.	Figure 7-10
3	Water retention at truss node	It is estimated that the cause was that the drainage holes in nodes were clogged with debris, preventing rainwater from draining.	It is estimated that the water will continue to stagnate as it will not be drained.	As a load concentration point of the truss chord, it plays an important role in resisting the overall dead load, live load, and earthquake load.	It is determined that immediate repairs are necessary as the stagnation of water in the truss joints could cause rust to progress, resulting in a lack of strength and the structure collapsing.	Figure 7-11
4	Corrosion of truss bridge bearings	It is believed that the cause of the rust was due to the lack of repainting, and that the bearings were washed away by seawater during a typhoon.	It is assumed that the corrosion protection function has already been lost and rust will continue to progress.	It is an important component that supports the entire truss bridge.	If the rust continues to progress, it is predicted that the bearing will no longer function properly, so it is deemed necessary to carry out repairs immediately.	Figure 7-12 Figure 7-13
5	Damage to RC deck of truss bridge	It is believed to be due to long-term live load.	It is assumed that there is no rapid progression of damage.	It is an important component that supports live loads.	Since the underside has also been reinforced with chemical fiber reinforcing sheets, it is determined that no immediate repairs are necessary, and regular inspections will continue in the future.	Figure 7-14
6	Opening of the plate girder lower flange web	It is estimated that this is due to bird droppings causing the rust to progress.	It is assumed that rust will continue to progress as the corrosion prevention function has already been lost.	As a main girder member, it is an important component that mainly transmits shear forces.	The main girder web is an important component that supports dead load, live load, and seismic force. During an earthquake, compressive stress acts on the lower flange of the main girder, causing local buckling at the opening, which may lead to collapse. Therefore, it is determined that immediate repair is necessary.	Figure 7-15
7	Corrosion of the box girder bottom flange and rust on the bearing	It is estimated that the cause was rust caused by rainwater entering the end of the girder.	It is assumed that rust will continue to progress as the structure has not been repainted and there are no measures in place to prevent rainwater from entering through the expansion joint.	It is an important component that supports the dead load, live load, and seismic forces of the main girder.	Since the support point is an important component that transmits dead load, live load, and seismic force to the substructure, it is determined that immediate repair is necessary.	Figure 7-16
8	Corrosion of the lower flange of the plate girder	It is estimated that the rust progressed due to rainwater entering the ends of the girders.	It is assumed that rust will continue to progress as the structure has not been repainted and there are no measures in place to prevent rainwater from entering through the expansion joint.	The ends of the main girders are important components that transmit loads to the supports.	Since the support point is an important component that transmits dead load, live load, and seismic force to the substructure, it is determined that immediate repair is necessary.	Figure 7-17（Left）
9	Vertical stiffener bending	The cause cannot be determined.	Live loads may cause progressive bending.	Main girder web shear buckling prevention member	If bending progresses due to live loads and seismic loads and rigidity rapidly decreases, the main girder web may buckle and the bridge may collapse, so it is determined that immediate repairs are determined.	Figure 7-17（Right）
10	Corrosion of the rivets on the lower flange of the plate girder	It is believed that the rust has progressed due to improper repainting.	It is assumed that rust will progress because the corrosion prevention function has been impaired.	As the main girder, it is an important component that transmits dead load and live load.	The on-site connection of the main girder is an important component that supports dead load, live load, and seismic force, and therefore it is determined that immediate repair is necessary.	Figure 7-18（Left）
11	Lower flange web opening	It is estimated that the rust is caused by bird droppings.	It is assumed that rust will progress because the corrosion prevention function has been impaired.	As the main girder, it is an important component that transmits dead load and live load.	The main girder web is an important component that supports dead load, live load, and seismic force. During an earthquake, compressive stress acts on the lower flange of the main girder, causing local buckling at the opening, which may lead to collapse. Therefore, it is determined that immediate repair is necessary.	Figure 7-18（Right）
12	Chemical fiber reinforcement sheet peeling off from the underside of the deck	The cause cannot be determined.	Since no rainwater has been observed to seep in from the underside of the deck, it is estimated that rapid spalling will not occur in the future.	It is an important component that reinforces the RC deck and transfers live loads.	It is determined that immediate repairs are necessary to prevent damage to the deck due to live load.	Figure 7-19
13	Opening due to corrosion of the curb of the expansion joint	It is believed that the cause was rust on the expansion joint due to rainwater.	Since the corrosion prevention function has already been lost, it is estimated that the openings caused by rust will continue to expand.	It is an important component that supports the live load at the cross section of the girder and prevents rainwater from entering the end of the girder.	It is determined that the opening needs to be sealed immediately as it is the cause of damage to the end of the girder that has already occurred.	Figure 7-20

Source: JICA Survey Team

2) Major Site Photos

① Corrosion of Side Plate and Bottom Plate of the Truss Bridge's Bottom Chord

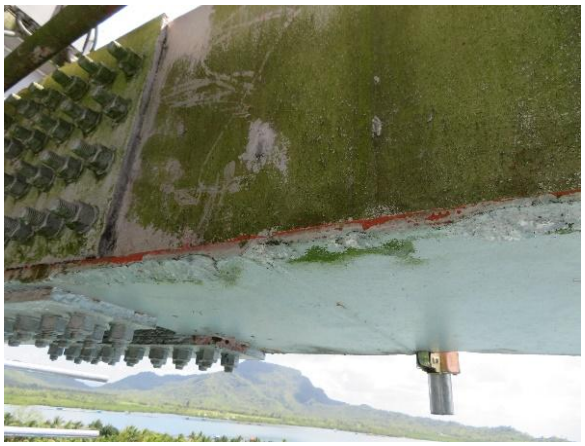
Section loss due to corrosion was observed at the corners of the side and bottom plates of the bottom chord (see Figure 7-9). The probable causes are the nearly horizontal alignment of the bottom chord along the bridge axis and the protrusion of the side plate above the top plate of the

bottom chord, which prevented drainage of rainwater for prolonged periods combined with the clogging of drainage holes at truss joints by debris. The sharp corners of the section loss may concentrate stresses and lead to cracks; thus, immediate repair is required.

Inspection of hand holes at the field splices revealed no rust stains, but some bird-nesting materials were found.



Corroded upper edge of the side plate



Corroded edge of the bottom plate



Corroded edge of the side plate, Strut over P15

Source: JICA Survey Team

Figure 7-9 Section Loss of Lower Chord by Corrosion

② Section Loss due to Corrosion on the Upper Surface of the Cross Beam Bottom Flange of the Truss Bridge

Severe section loss due to corrosion was discovered at two locations on the upper surface of the cross beam bottom flange in the truss bridge. Ultrasonic thickness measurements revealed that compared to the original design plate thickness of 24.0 mm, the remaining thickness at the corroded sections was approximately 6.0 mm. If corrosion progresses further, there is a risk of a cross beam fracture; therefore, early repairs are required. Since corrosion was observed only at these two locations and not on other cross beams, the cause of corrosion has not been identified at this time. However, it is possible that water leakage from cracks in the deck slab accumulated on the flange and contributed to the damage (see Figure 7-10).

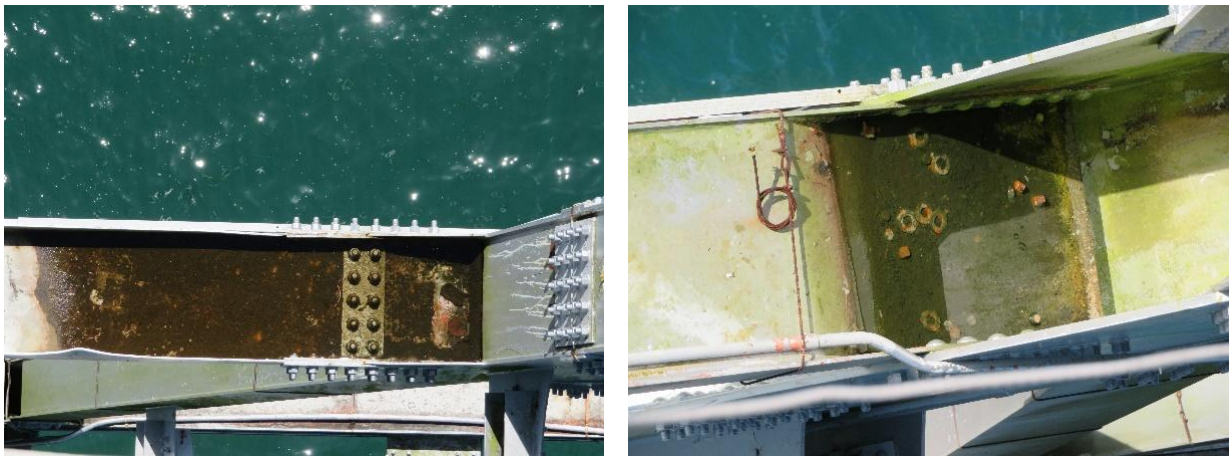


Source: JICA Survey Team

Figure 7-10 Deep Corrosion at the Lower Flange of the Floor Beam

③ Water Accumulation at the Truss Joints

Rainwater accumulation was observed at the truss joints (see Figure 7-11). The cause is presumed to be either the absence of drainage holes at the joints or blockage of existing drainage holes by debris. Since standing water accelerates corrosion of steel members, it is necessary to promptly install drainage holes in the gusset plates.



Source: JICA Survey Team

Figure 7-11 Accumulation of Water at Node of the Middle Chord

④ Bearing Damage

At Pier P16, bearings for both the truss bridge and the approach bridge were installed. The bearings on the approach bridge are densely covered with moss, but no major damage—such as separation of the bearing cap from the base—was observed.

Additionally, the cover plate of the intermediate support bearing on the truss bridge was found to have fallen off due to rust, exposing the internal rollers (see Figure 7-13). The rack and pinion inside the bearing could not be inspected. It is recommended to remove the cover plate for inspection of these components during detailed inspections.

If continued use of this truss bridge is intended in the future, it will likely be necessary to replace all bearings with new ones in the near future.




Source: JICA Survey Team

Figure 7-12 Bearing of the Truss Bridge (Right) and the Approach Bridge (Left) at P16

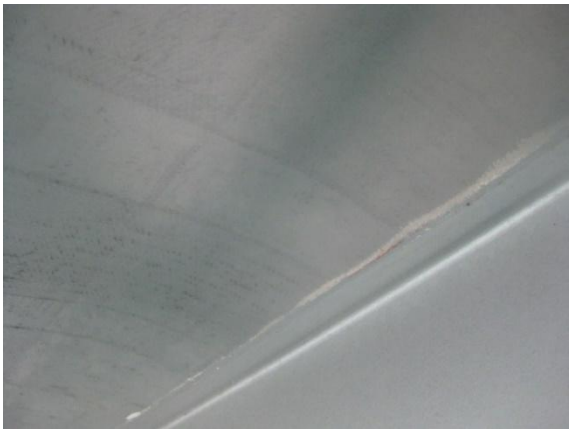



Source: JICA Survey Team

Figure 7-13 Bearing of the Truss Bridge (Left) and the Lost Cover Plate (Right)

⑤ Damage to the Deck Slab

The underside of the deck slab is reinforced with a chemical fiber sheet (CFRP sheet), and no water leakage from the underside was observed. However, on the overhanging portions of the deck slab, which are not reinforced with CFRP sheets, small cracks and moss growth were observed. No major cracks or significant water leakage at these locations were found (see Figure 7-15).




Source: JICA Survey Team

Figure 7-14 Bottom of the Deck Reinforced with and without Chemical Fiber Sheet

⑥ Damage of Approach Bridge (Leyte Side)

Damage to the approach bridge tends to be more prevalent in areas where the road surface is low, suggesting a strong influence from seawater spray. These low-lying sections are also inhabited by many birds, indicating that bird droppings around their nests may also contribute to the damage. Severe corrosion has been observed on the web of the steel plate girder near the lower flange, and an opening in the web at the bottom flange of the steel girder has been detected. The opening on the web at the midspan (left of Figure 7-16) occurs in an area dominated by bending stresses, so the decrease in stiffness due to the opening is presumed to be small. However, the openings on the web near the support (right of Figure 7-15) are subjected to compressive stress, where there is a risk of local buckling occurring at the opening. Therefore, prompt repairs are necessary.



Source: JICA Survey Team

Figure 7-15 Perforated Web Plate (Left) and Corrosion between Connection Plates (Right)



Source: JICA Survey Team

Figure 7-16 Corroded Lower Flange of the Box Girder (Left) and Damage around the Bearing (Right)

⑦ Damage to the Approach Bridge (Samar Side)

Similar to the Leyte side, several damages are observed in areas where the road surface is lower. Near the bearings, sections of the lower flange have been found to be half missing due to corrosion.

In addition, deformations have been observed in some vertical stiffeners. The locations of the missing lower flange sections and the deformed stiffeners do not coincide. The deformed vertical stiffeners are not located at bearing positions, and no shear buckling has been observed in the main girder web. At present, it is difficult to determine the cause of bending in the vertical stiffeners; therefore, further detailed investigation is recommended during the next close inspection.

Corrosion-induced openings have been observed in the kerbstone part of the expansion joint. It is believed that rainwater flowing through these openings is causing corrosion at the girder ends and bearings; thus, repair of the openings is considered necessary. Furthermore, partial peeling of the chemical fiber reinforcement sheet applied to the deck slab has been observed (see Figure 7-18 to 7-21).



Source: JICA Survey Team

Figure 7-17 Severely Corroded Lower Flange (Left) and Deformed Vertical Stiffener (Right)



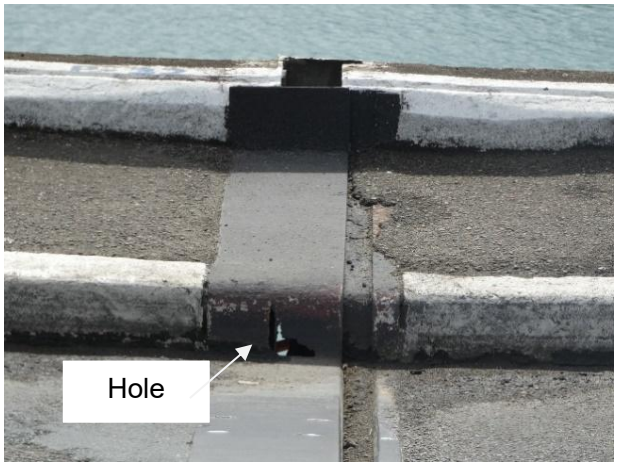
Source: JICA Survey Team

Figure 7-18 Corroded Splice Plates (Left) and Perforated Web Plate (Right)



Source: JICA Survey Team

Figure 7-19 Peel-off of Chemical Fiber Sheet on the Bottom of the Deck

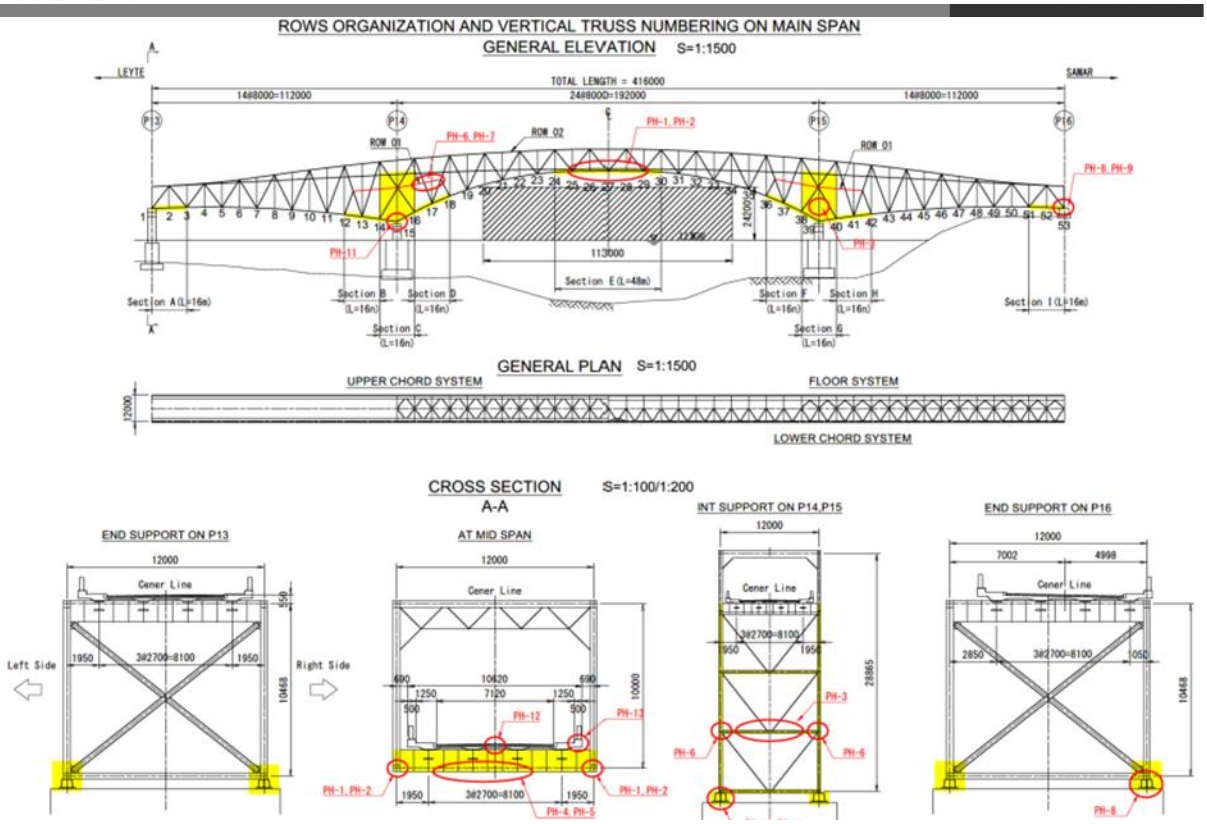


Source: JICA Survey Team

Figure 7-20 Hole of Steel Plate of Expansion Joint due to Corrosion

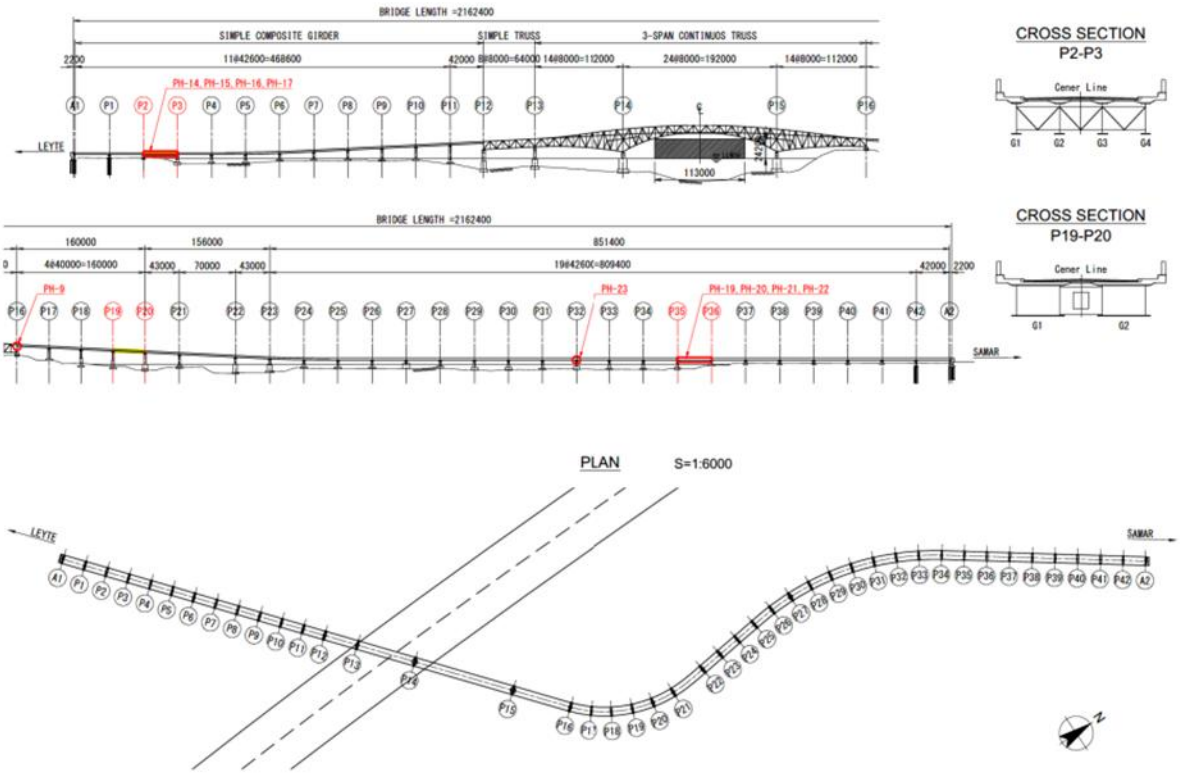
3) Location of Major Damage

The location of the observed major damages are shown in Figure 7- 21.



Source: JICA Survey Team

Figure 7-21 Location Map of Observed Damage of the Truss Bridge



Source: JICA Survey Team

Figure 7-22 Location Map of Observed Damage of Approach Bridge

4) Classification of Members with Cross-sectional Loss

In Table 7-11, members with confirmed cross-sectional loss are classified into tension and compression members as a reference for determining the priority of future repairs.

It is evaluated that compression members are more important than tension members because a compression member can fail suddenly due to buckling.

Table 7-11 Classification of Section Loss in Existing SJB

Member with Section Loss	Role of Member	Compression or Tension	Repair Priority	Figure	Remarks
Bottom chord at the midspan of the truss bridge	Main member in the entire system	Tension	High	Figure 7-10	Fracture could lead to the collapse of the entire truss bridge.
Bottom flange of cross beam in the truss bridge	Floor member	Tension	High	Figure 7-11	Fracture of a cross beam could result in the collapse of the roadway.
Opening in the web at the lower flange side near the midspan of the approach bridge	Main member in the entire system	Tension	Low	Figure 7-16 (left)	As the web opening is small, the increase in bending stress due to the reduction in main girder sectional rigidity is considered to be minor.
Bottom flange near the support of the approach bridge	Stiffener at the Bearing	Tension	High	Figure 7-18 (left)	The buckling resistance of the bearing stiffeners and webs near the support is considered to be reduced.
Bottom flange of the steel box girder in the approach bridge	Main member in the entire system	Tension	Low	Figure 7-17 (left)	Since this is near the support, the stress in the bottom flange is considered to be small.

Source: JICA Survey Team

7.3 Inspection of Underwater Piers

7.3.1 Purpose of Inspection

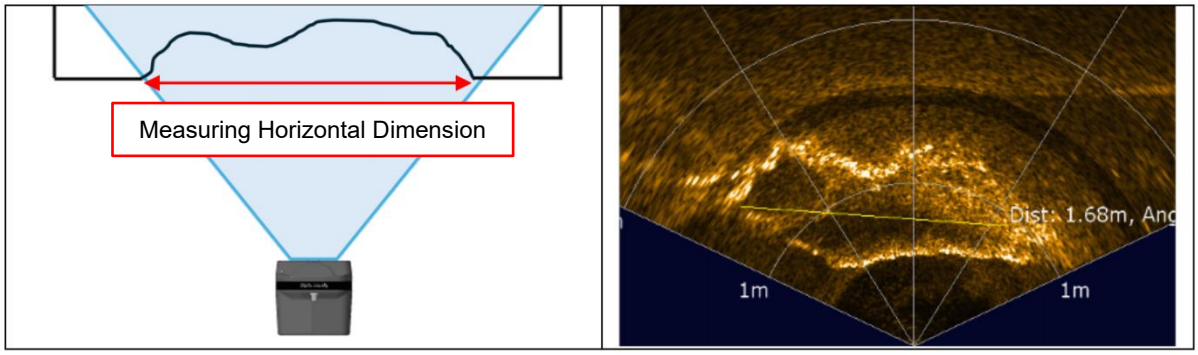
As reported in Sub-clause 7.1.1 from the underwater inspection conducted in 2022, partial damage and scouring were observed at the footings of the underwater foundations. Because such abnormalities could lead to instability of the entire bridge structure, it is necessary to verify the situation of the underwater piers to study for necessary countermeasures.

7.3.2 Method of Inspection

The underwater inspection was conducted using underwater drones equipped with optical cameras to measure the approximate dimensions of gaps or voids found between the footings and the seabed. To minimize the effects of poor visibility in the water and strong currents that disturb the control over the underwater drones, the inspection schedule was planned to be carried out during slack tide.

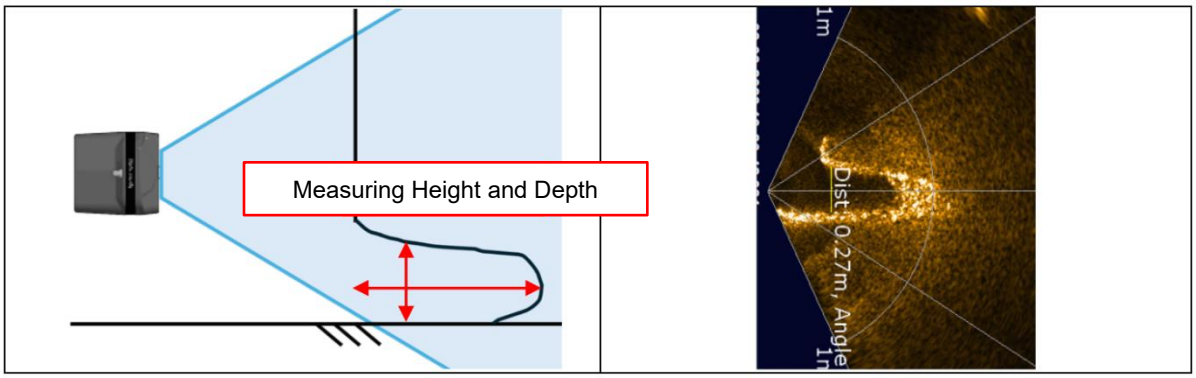
The inspection proceeded with an underwater drone, equipped with a camera and a 2D imaging sonar, to check the condition around the target piers. While moving around the piers in a horizontal position, the drone took acoustic images of the lower part of the piers at regular intervals. Any abnormalities found were captured through acoustic imaging. By obtaining images in both horizontal and vertical directions, the dimensions of both directions were measured. Some of the acoustic images taken at the site are shown in Figure 7-21 and Figure 7-22.

Prime specifications of the used underwater drones are shown in Figure 7-23.



Source: JICA Survey Team

Figure 7-21 Measuring Horizontal Dimension by Sonar (Left) and Acoustic Imaging (Right)



Source: JICA Survey Team

Figure 7-22 Measuring Vertical and Depth Dimensions by Sonar (Left) and Acoustic Imaging (Right)

DRONE-1

	Dimensions	383mmx331mmx158mm
	Weight	5.0kg
	Maximum Speed	3 knots (1.5m/sec)
	Maximum Operating Depth	150m
	Accuracy of Positioning	±1.0cm
	Maximum Workable Time	4 hours
	Working Temperature	-10℃ to 60℃

DRONE-2

	Dimensions	430mmx345mmx170mm
	Weight	5.1kg
	Movement speed	3 knots (1.5m/sec)
	Maximum Operating Depth	100m
	Accuracy of Positioning	±1.0cm
	Maximum Workable Time	4 hours
	Working Temperature	-10℃ to 50℃

IMAGING SONAR

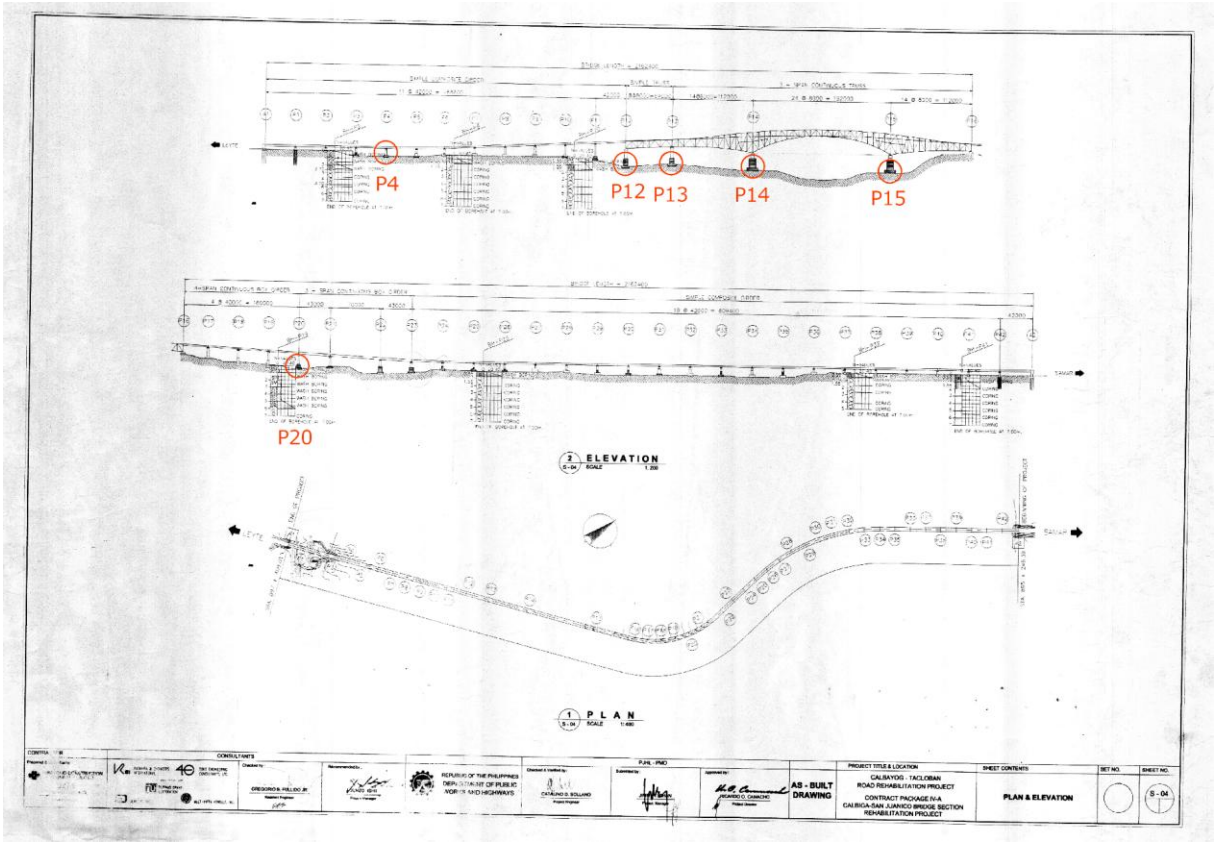
	Sound Frequency	750kHz/1.2kHz
	Maximum Measurement Range	120m/40m
	Resolution	4mm/2.5mm
	Unit of Measurement	0.01mm
	Horizontal Angle	130°/130°
	Vertical Angle	20°/20°
	Working Temperature	-10℃ to 35℃

Source: https://www.jun-techno.com/

Figure 7-23 Specifications of Underwater Drones and 2D Imaging Sonar

7.3.3 Inspected Piers

The underwater inspection using underwater drones was conducted at six piers in total: Piers P12, P13, P14, and P15 of the main truss bridge (and a single-span truss bridge), as well as Piers P4 and P20 of the approach bridges.



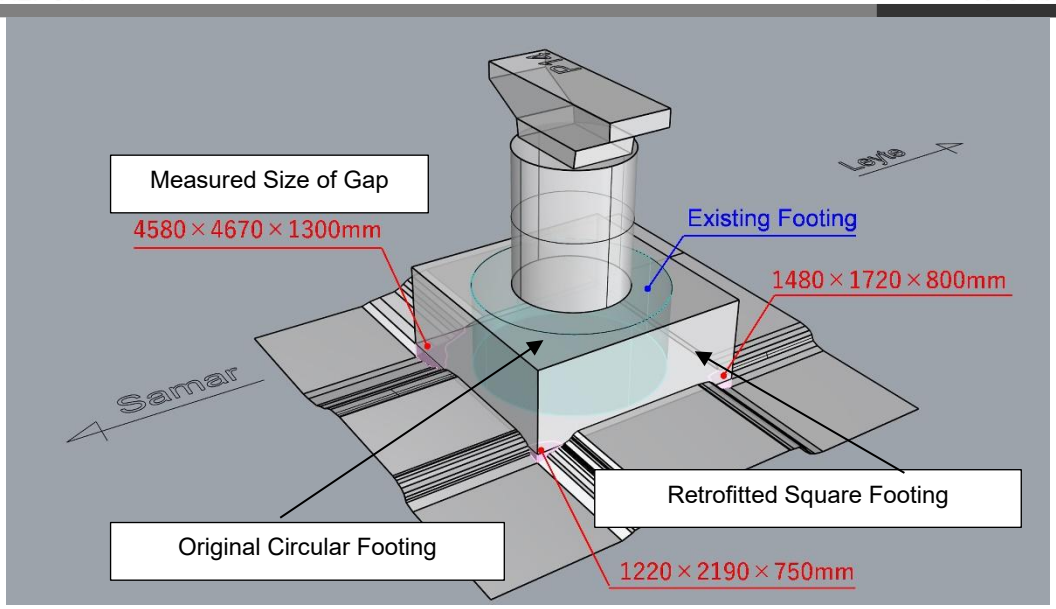
Source: JICA Survey Team

Figure 7-24 Piers of Underwater Inspection

7.3.4 Results of Inspection

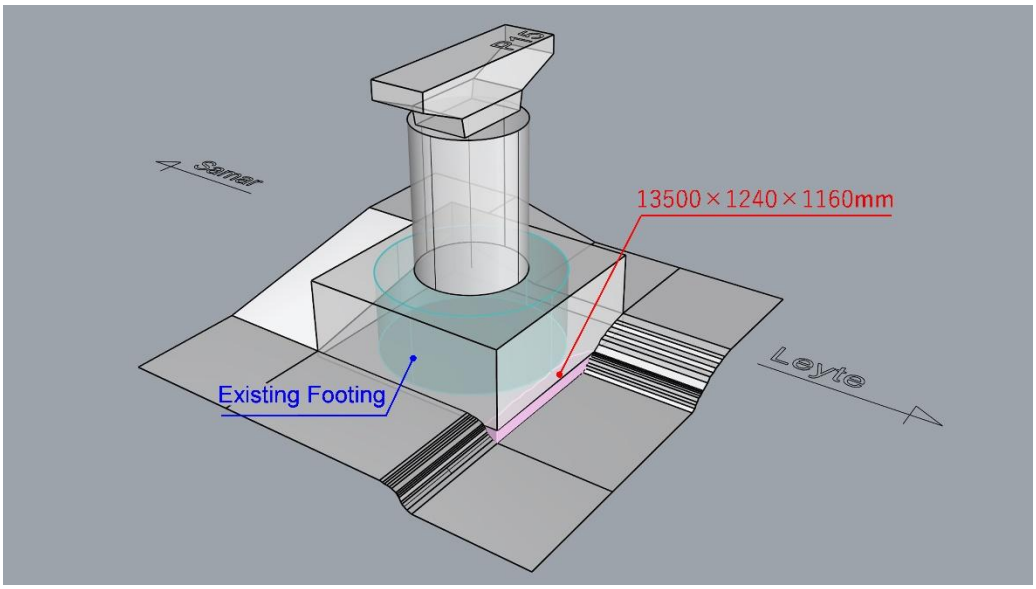
Some partial gaps or voids were detected between the contact surfaces of the retrofitted spread footing and the seabed at piers P14 and P15, which are located in deeper water at the central span of the truss bridge. On the other hand, no gaps were found in the other four piers included in the inspection.

Although the report of the underwater (diving) inspection conducted in 2022 reported damage to the body of the P14 spread footing, no findings of such were confirmed by the underwater (drone) inspection. The partial gaps or voids surveyed by underwater drones are shown in Figure 7-25 and Figure 7-26.



Source: JICA Survey Team

Figure 7-25 Result of the Underwater Survey at P14



Source: JICA Survey Team

Figure 7-26 Result of the Underwater Survey at P15

7.3.5 Impact of Gaps at the Base of the Foundation

(1) Evaluation Method

Gaps between contact surfaces of footings and seabed were found, specifically at three corners of the square spread footing of Pier P14 and along one bottom edge of the footing of Pier P15. To evaluate the influence of these abnormalities on the stability of these piers, a static stability calculation was carried out. Moreover, due to the larger extent of gaps found at Pier P14 compared to Pier P15, the P14 footing was selected as the subject for calculation.

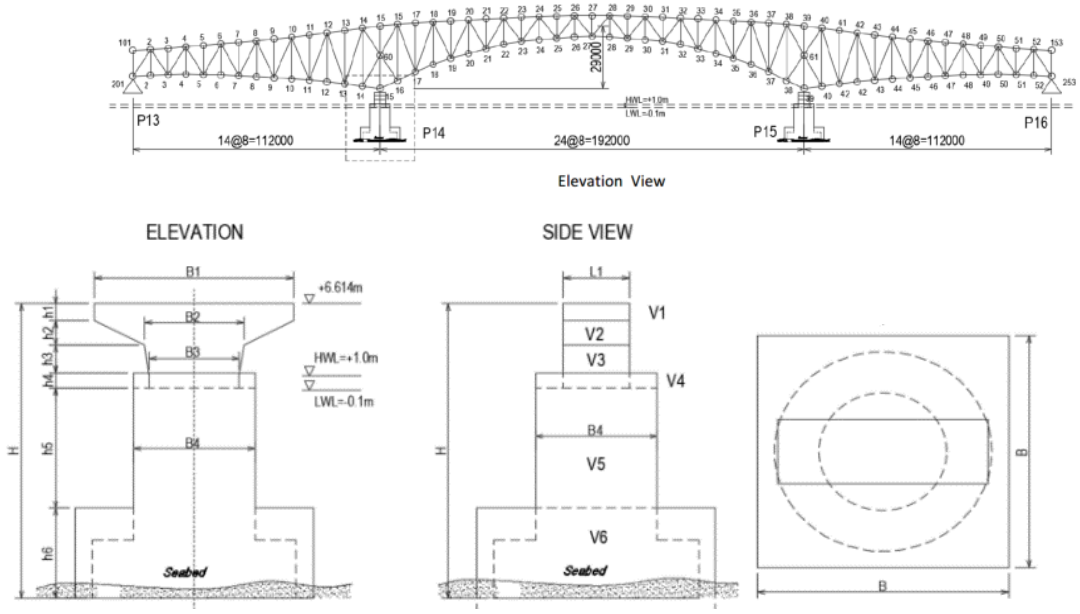
A horizontal earthquake coefficient of K_h = 0.20 was assumed in the calculation to evaluate the impact of abnormality by comparing the calculated results. Therefore, the appropriateness of the calculated figures by the assumed earthquake was not judged. The measured horizontal areas of

the three corners of Pier P14 totals to about 15 m^2; however, the calculation simplified these areas into one concentrated rectangular gap of 31.92 m^2 set at one corner.

According to the technical report on the *Construction of San Juanico Bridge* (Civil Engineering Construction Magazine, Japan, January 1973), horizontal earthquake coefficient K_h = 0.10 and vertical earthquake coefficient K_v = 0.05 were applied in the project. Same coefficients were also mentioned in the *Ocular Inspection & Validation Report on San Juanico Bridge* (DPWH Region VIII, 2022).

(2) Dimensions of P14 Footing

The truss bridge consists of two planes of main trusses spaced 12 m apart. Originally, Pier P14 was designed and constructed with a circular spread footing for a circular column topped with the beam that acts as the support for the bearings of the truss bridge. This original circular footing (15 m in diameter and 4.5 m in height) was later retrofitted into a larger square footing, along with the reinforcement of the top part of the column with additional concrete body. After these modifications, P14 footing now horizontally spans at 18 m width at four sides, with a 7 m height. Comparatively, the base area of the footing was increased to 1.83 times that of the original circular footing.



P14 (Original in dotted line) Plan view of footing

Source: JICA Survey Team

Figure 7-27 Dimensions of Pier P14

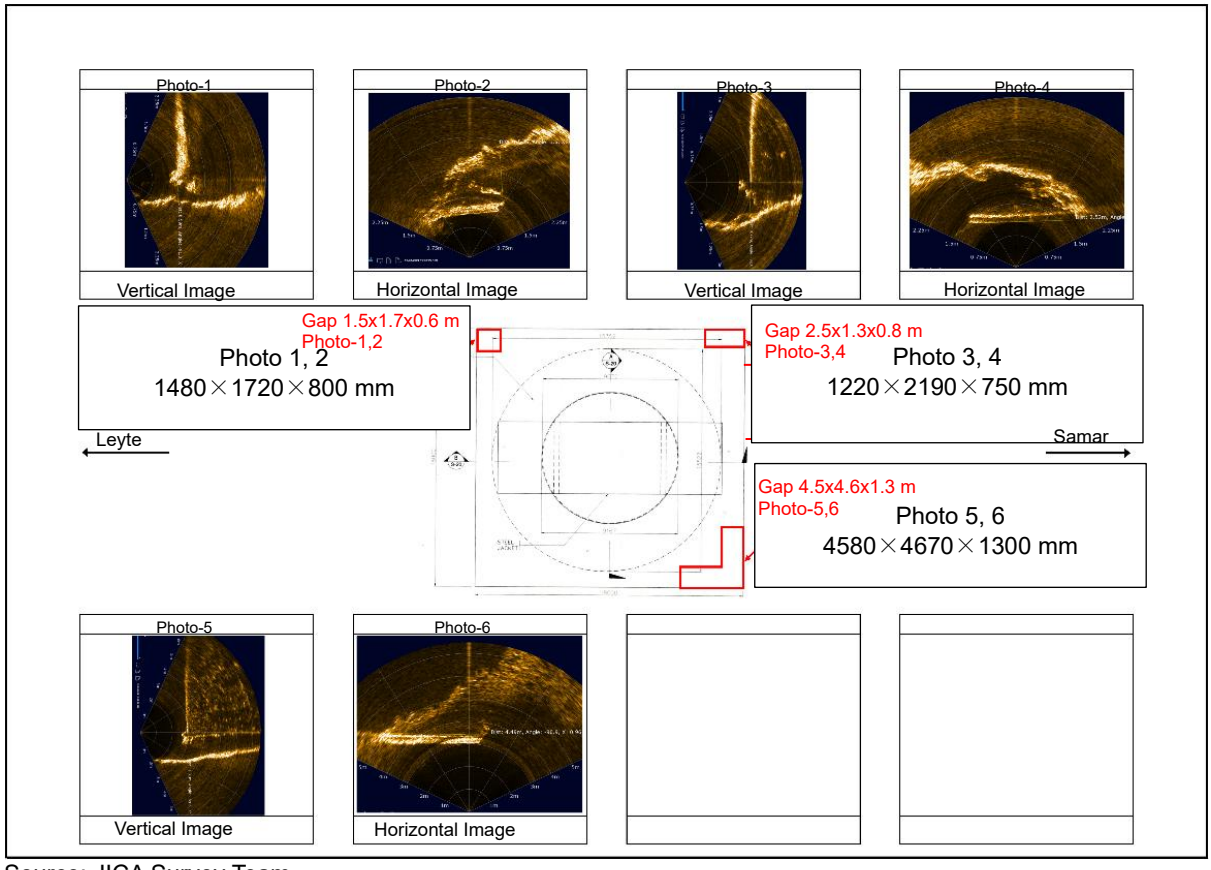
(3) Gaps Between Footing and Seabed

The inspection of Pier P14 by underwater drones detected the gaps or voids between the contact surfaces of its square footing and the seabed, particularly at its three corners. The size of the biggest void measured approximately 4.5 m in terms of horizontal span and 1.3 m in terms of height from the seabed, while the other two smaller voids measured 0.8 m and 0.75 m, respectively.

The exact causes of these gaps or voids remain uncertain. According to construction reports published in Japanese engineering magazines, the bearing seabed of the footing consisted of sandstone, silty rock, shale, and their conglomerates. Based on the compressive strength of the seabed, which was estimated at 50 to 100 kgf/cm^2, the possibility of large-scale scouring was considered low.

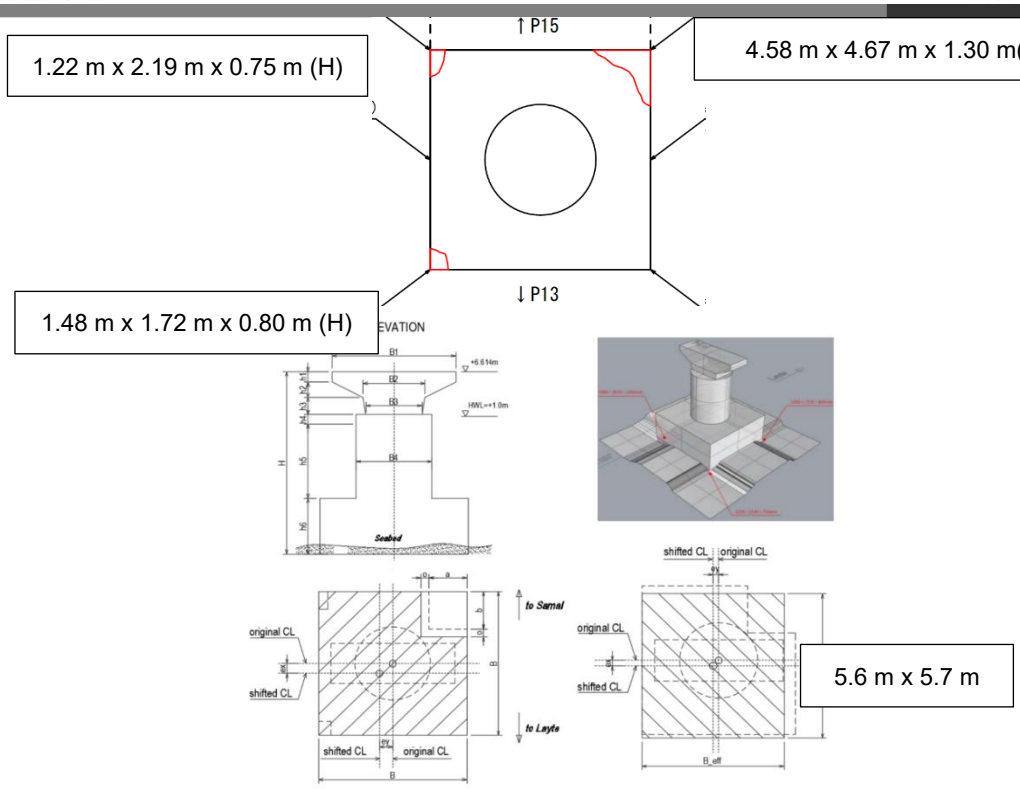
Given the above accounts, the closest possible cause that could explain these gaps or cavitations was from the retrofitting works, likely during the handling or disposal of the excavated bedding materials.

For the sake of a conservative evaluation of the influence of the gaps to the structure's stability, a simplification of the model was made. The 14.68 m^2 total area of the actual gaps at three corners—which is 4.5% of footing size—was theoretically concentrated into one gap at a corner. The simplified unattached area of 31.92 m^2 (9.9% of entire footing size), more than double the actual area, was used for calculation.



Source: JICA Survey Team

Figure 7-28 Gap or Void of Footing at P14 Pier



Source: JICA Survey Team

Figure 7-29 Model of Gap or Void for Calculation (P14 Pier)

(4) Results of Stability Calculation

Results of the static stability calculation are shown in Table 7-12. Parameters from three cases—the original structure, the retrofitted structure, and the present structure with gaps or voids found under the footing—are presented for comparative analysis. Because the earthquake coefficient used in the retrofitted project was not known, the horizontal coefficient was assumed as K_h = 0.20 for the calculation of retrofitted structure and present structure, while K_h = 0.10 was used for the calculation of the original structure.

Table 7-12 Calculated Stability of P14

Case	Earthquake	Overturning	Sliding	Bearing Capacity
Original Structure	K_h = 0.10	0.77 (≦1.00)	4.30 (≧1.00)	1.40 (≦1.50 MPa)
Retrofitted Structure	K_h =0.20	0.66 (≦1.00)	4.10 (≧1.00)	0.73 (≦0.90 MPa)
With Voids under Footing	K_h = 0.20	0.87 (≦1.00)	4.10 (≧1.00)	0.76 (≦0.90 MPa)

Source: JICA Survey Team

The results confirm that the original structure of Pier P14 satisfied static stability requirements against overturning, sliding, and bearing capacity of seabed under K_h = 0.10. As the footing size and base area were increased greatly by the retrofitting works, the structure secures stability with K_h = 0.20, which is twice the reported original coefficient. Although the present structure expresses slight deterioration from overturning and bearing capacity affected by the smaller bearing area of the footing, the structure maintains sufficient stability. Considering the results of static stability

calculations, the impact of the gaps or voids found under the footing is therefore considered insignificant.

(5) Repair of Gaps or Cavities

The gaps or voids found through underwater inspection were identified to be confined in the limited spots of the footing, and the effect of such abnormalities to the stability of the piers is not significant. However, considering a prolonged service life for the existing SJB, it is important to prevent further progression of risk from these gaps in the future. Repair works to fill and close the gaps and voids found in the footings are recommended.

7.4 Consideration of Utilization Methods for Existing SJB and Service Life Assessment

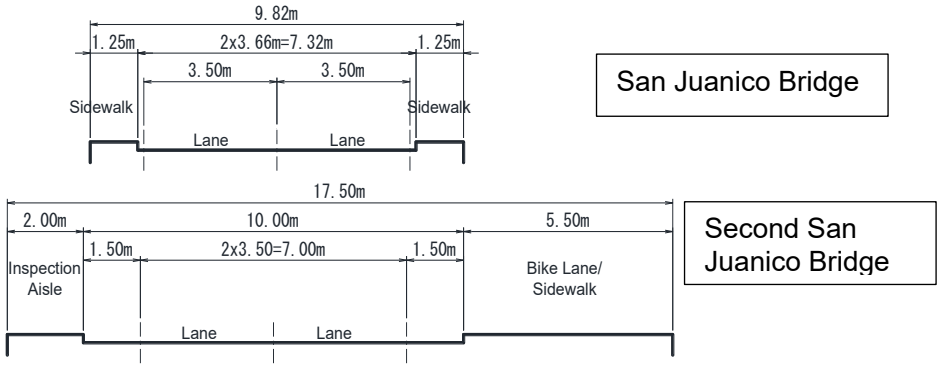
Upon completion of the SSJB, it is expected that the new and existing SJB will each serve a one-way two-lane route (1x2). However, since the repair works for the existing SJB are anticipated to be more comprehensive, specialized, and time-consuming, the SSJB should tentatively operate with a two-way route scheme, similar to the present bridge. The existing SJB will be closed for repair upon the completion of the SSJB.

The design specifications applied to the existing SJB are different from the current design specifications, given the time difference since its completion. The comparison and transition of design vehicle and carriageway width are shown in Figure 7-30 and Table 7-14. Normally, the signs of maximum axle weight of 13.5 tons are posted at the bridge.

Table 7-13 Transition of Traffic Operation

Stage	Traffic Flow	
① Present	San Juanico Br	2-way operation 1-lane traffic
② Completion	2nd SJ Bridge	2-way operation 1-lane traffic
Closure	San Juanico Br	Inspection/Rehabilitation
③ Pararell operation	2nd SJ Bridge	1-way operation 2-lane in each direction
	San Juanico Br	

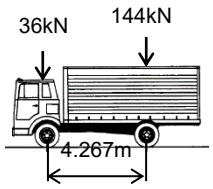
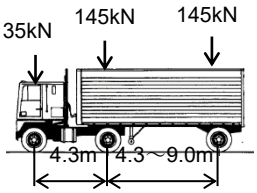
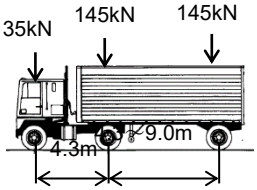
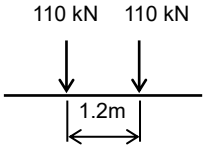
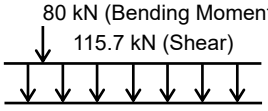
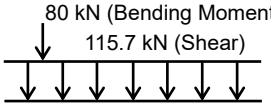
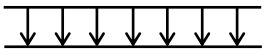
Source: JICA Survey Team



Source: JICA Survey Team

Figure 7-30 Comparison of Carriageways

Table 7-14 Comparison of Design Standards

Variation	Construction Stage (1970)	Retrofitting Stage (1996)	Present Version
Design Standard	AASHTO Standard Specifications for Highway Bridges, 10th Edition	AASHTO Standard Specifications for Highway Bridges, 15th Edition	AASHTO LRFD Bridge Design Specifications, 8th Edition
Method	Allowable Stress Design (ASD)	ASD/ Load and Resistance Factor Design (LRFD)	LRFD
Vehicle Load	H20 (M18)	HS20	HL-93
Combination	Design Truck or Design Lane Load	Design Truck or Design Lane Load	Design Truck（or Design Tandem） and Design Lane Load
Design Truck	 Total weight 180 kN	 Total weight 325 kN	 Total weight 325 kN
Design Tandem			 Total weight 220 kN
Design Lane Load	Knife edge load 80 kN (Bending Moment) 115.7 kN (Shear)  Uniform 9.4 kN/m Distributed on 3.0 m width	Knife edge load 80 kN (Bending Moment) 115.7 kN (Shear)  Uniform 9.4 kN/m Distributed on 3.0 m width	 Uniform 9.3 kN/m Distributed on 3.0 m width

Source: JICA Survey Team

Table 7-15 Allowable Vehicle Weight

Code	Truck/Trailer	Description	G.Weight (kgf)
1-1	Truck	2 axles	18,000
1-2	Truck	1 front axle/tandem rear axle, 3 axles	33,300
1-3	Truck	1 front axle/tandem rear axle, 4 axles	35,600
11-1	Truck-Semitrailer	2 axles at motor vehicle/1 axle at trailer	34,000
11-2	Truck-Semitrailer	2 axles at motor vehicle/2 axle at trailer	40,600
11-3	Truck-Semitrailer	2 axles at motor vehicle/3 axle at trailer	41,000
12-1	Truck-Semitrailer	3 axles at motor vehicle/1 axle at trailer	39,700
12-2	Truck-Semitrailer	3 axles at motor vehicle/2 axle at trailer	41,500
12-3	Truck-Semitrailer	3 axles at motor vehicle/3 axle at trailer	42,000
11-11	Truck-Trailer	2 axles at motor vehicle/2 axle at trailer	39,700
11-12	Truck-Trailer	2 axles at motor vehicle/3 axle at trailer	43,500
12-11	Truck-Trailer	3 axles at motor vehicle/2 axle at trailer	43,500
12-12	Truck-Trailer	3 axles at motor vehicle/3 axle at trailer	45,000

Source: JICA Survey Team

This project involves partial visual inspection of the existing SJB, but no survey has been conducted to determine the capacity of the entire bridge. While it is difficult to accurately determine how many years the existing SJB will last, it is proposed that a detailed inspection of the entire bridge should be carried out in the next stage to determine the state of deterioration, the content and scope of necessary repairs, and its soundness. Regarding future use of this bridge, it is realistic to continue using it within the load limit set within its load-bearing capacity, while making appropriate repairs through continued maintenance, including regular inspections.

7.5 Further Detailed Inspection

7.5.1 Purpose of Detailed Inspection

Visual inspection was conducted by the JICA Survey Team at selected areas of the existing SJB, per access limitations. Findings from the inspection include defects and damages that are necessary to be repaired or retrofitted such as in the locations of lower chords of the center span of the truss bridge, web plates and lower flanges of the steel plate girders, bearing supports, and expansion joints. It was also confirmed that gaps or voids exist between the contact surfaces of the footings of piers P14 and P15 and the seabed. The past inspection report pointed out that compression strength of samples collected from concrete deck slab did not satisfy the design strength.

This visual inspection also revealed damages that required immediate repair. It is recommended that detailed inspection be conducted in the near future to cover the entire bridge sections, and to assess the soundness of the bridges (excluding the areas where the inspection was done by the JICA Survey Team), to locate the portions that need repair, and to study the corresponding suitable repair methods. The DPWH has been conducting the detailed inspection through Consulting Services for the Conduct of Feasibility Study for Structural and Foundation Analysis and Investigation on the Rehabilitation/Repair of the existing SJB. Because the scope of these consulting services includes the inspection of substructures and foundations, the scope recommended by the JICA Survey Team is limited to the detailed inspection of the superstructures.

7.5.2 Contents of Detailed Inspection

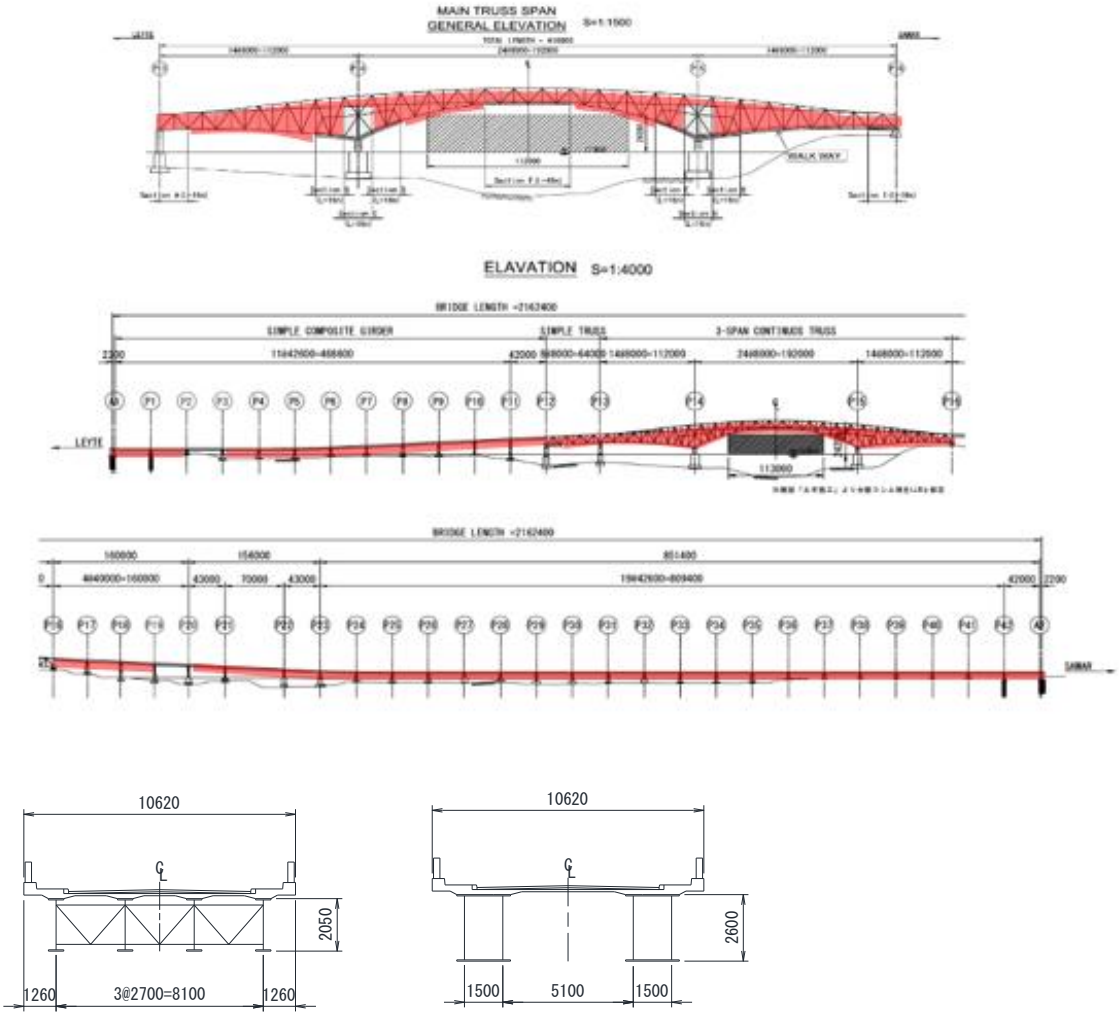
The target sections for detailed inspection should cover the entire length of the truss bridge and approach bridges, except where visual inspection has already been undertaken. Among the components to be inspected are the deck slabs, walkways, bearing supports, expansion joints, and restrainers.

The detailed inspection shall require a close visual inspection supported by measuring devices—such as measuring tapes and calipers—for checking and obtaining precise data and record on the extent of corrosion-induced holes, thickness of steel plates, and other relevant conditions.

Major dimensions—such as bridge length, span length, and other important sizes—shall be measured again and recorded. The daily change of temperature and the movement at expansion

joints will be monitored and measured. The situation of underside surface of the concrete deck slab will be checked by partially removing the attached CFRP sheets. The deflection of the deck slabs will be measured using a dynamic loading test machine.

To assess the soundness of the bridge structures, static loading tests and natural frequency tests are planned in addition to visual inspection. It is desirable to add the measurements of stress fluctuation of the lower chords of the center span of the truss bridge.



Source: JICA Survey Team

Figure 7-31 Areas of Detailed Inspection

7.5.3 Experiment of Repair Method

The inspection carried out by the JICA Survey Team identified significant section loss in the lower chords of the truss bridge, as well as in the web and lower flange plates of the steel plate girders. To repair these damages, it is inevitable to consider application of field welding and high-strength bolts to restore the original capacities of the structures.

Accordingly, necessary information such as the following will be collected on-site for assessment of the appropriate repair methods to be applied: 1) sampling of steel plates and testing of steel grade through chemical components analysis, 2) testing of coating system and paint types, and 3) experimental repair of damaged steel members.

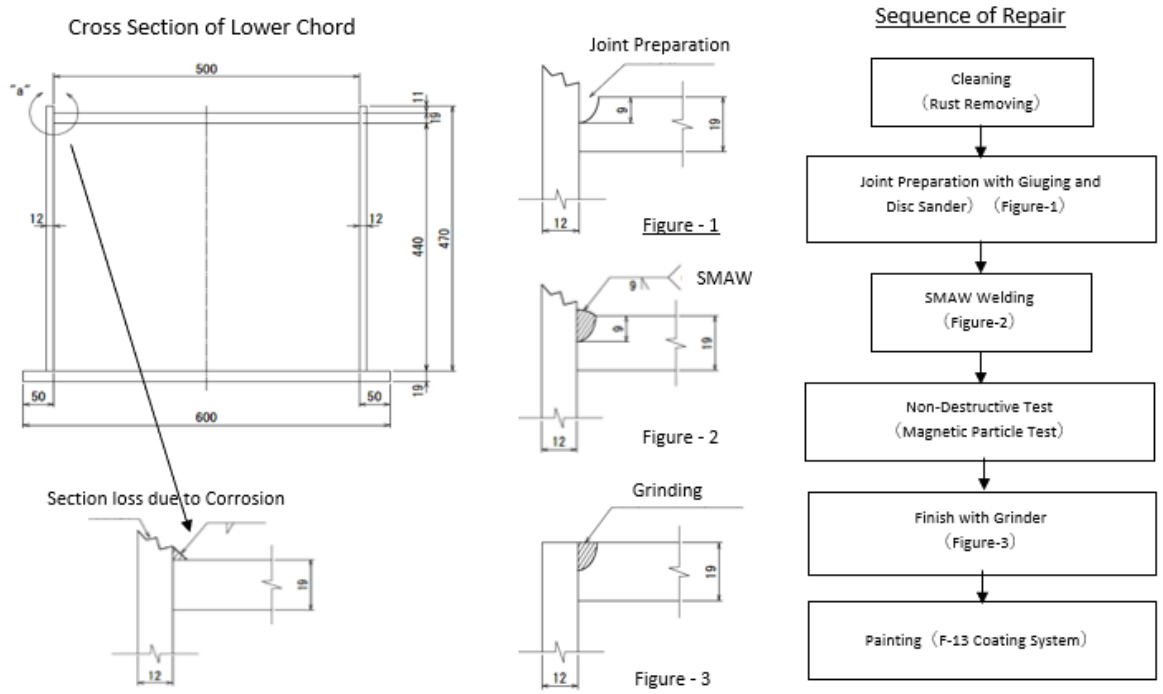
7.6 Typical Repair Methods

Specific repair methods will be determined and applied accordingly based on the results of the detailed inspection. Meanwhile, this section will consider typical repair methods applicable to the damages identified in the earlier discussions, for a tentative estimate of the schedule for the repair works.

7.6.1 Repairing Lower Chord of Truss Bridge

To relieve the stress concentration at the fillet weld locations on the upper part of the bottom chord in the center span of the truss bridge, and to prevent rainwater from accumulating on the upper flange, sharp corroded areas of the side plates over the entire length of the horizontally arranged bottom chord will be removed. After removing the coating within 150 mm from each side of the weld line, the affected area will be beveled and repaired by partial penetration welding. To match the height of the upper surface of the upper flange, the upper portion of the weld metal and the protruding part of the web caused by field welding will be ground flat with a grinder. Furthermore, any unevenness at the edge of the bottom steel plate due to corrosion shall be smoothly finished with a grinder. An overview of the repair method is illustrated in the following diagram.

In addition, in order to ensure weldability, it is necessary to conduct a component analysis of the steel plate of the existing SJB in advance to select the appropriate welding materials, and to perform preliminary welding procedure tests.



SMAW: Shield Metal Arc Welding

Source: JICA Survey Team

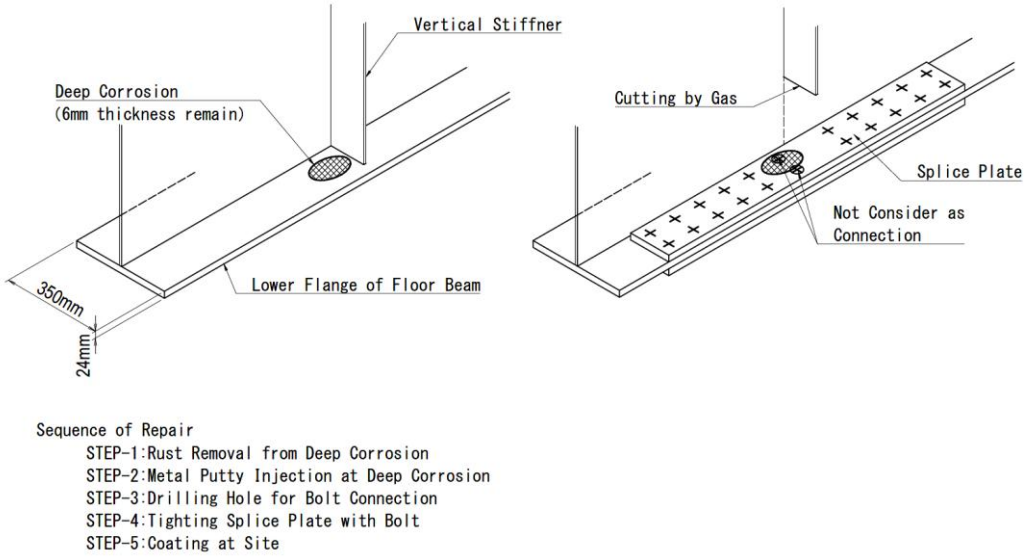
Figure 7-32 Repair Method of Lower Chord by Field Welding

7.6.2 Repairing Steel Girder

The damaged areas of the lower flanges and web plates where part of the original cross section of the steel plates has been lost and the areas where the original plate thickness has been greatly reduced will be repaired by increasing the cross-sectional area with additional splice plates fastened with high-strength bolts on both sides of the damaged plate. If new splice plates cannot be installed due to insufficient working space with the existing vertical stiffeners, the bottom part of the vertical stiffener would be cut.

The coating on the friction surfaces of the splice plates should be removed and cleaned so that the splice plates bear the stress. The overview of the repair method for the cross beam is shown in Figure 7-33.

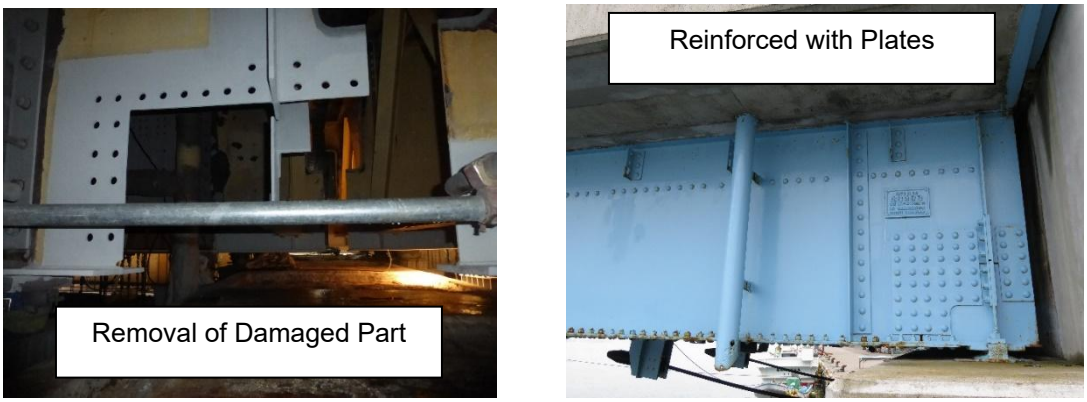
The damaged area of the longitudinal section of the steel girder near the bearing support should be cut and compensated with new splice plates fastened by high-strength bolts as shown in Figure 7-34. In addition, repairing the lower flange near the support and the hole of the web plate requires partial removal of the damaged area. However, since the support reaction force is acting, the repair work requires the release of the support reaction force. To do this repair work, it is thought that jacking up the end sway bracing or jacking up the girder with vent installed in front of the support will be necessary.



Sequence of Repair
STEP-1:Rust Removal from Deep Corrosion
STEP-2:Metal Putty Injection at Deep Corrosion
STEP-3:Drilling Hole for Bolt Connection
STEP-4:Tighting Splice Plate with Bolt
STEP-5:Coating at Site

Source: JICA Survey Team

Figure 7-33 Repair of Lower Flange with Splice Plates



Source: JICA Survey Team

Figure 7-34 Example of Repairing Girder Section with New Splice Plates

7.6.3 Repair of Concrete Deck Slab

Although the bottom surface of the existing SJB's RC deck slab has been reinforced with chemical fiber sheets, more than 50 years have passed since its construction. Therefore, based on the results of the detailed inspection, it will be necessary to consider either repairing and retaining the existing slab or replacing it with a new deck slab. At that time, the selection of the slab type should be based on how many more years the existing SJB is planned to be used after the construction of the SSJB.

7.6.4 Repainting

The existing SJB, once repaired, will be in use for many years to come. The original coating, which has been in place for over 50 years since construction, has deteriorated and is considered in need of repainting. The extent and the coating system for the repainting will be determined by

the findings of the detailed inspection. However, based on the results of this partial visual inspection, it is presumed that the previous recoating work did not remove the old coating or properly treat the steel surface. Therefore, it is judged that a complete repainting will be necessary after the repair work on the existing SJB is completed.

7.6.5 Precautions when Removing Old Coatings

With reference to the paint system generally applied at the time, due to the insufficient information or records on the coating system and paint specification adopted during the construction of the existing SJB, it is assumed that a lead-based paint system was applied for the existing coatings. Compliance with the notice from the Japanese Ministry of Health, Labor and Welfare, which targets on "*Preventing health problems for workers involved in peeling or scrapping off paint containing harmful substances such as lead*", is required, along with the following relevant laws and regulations in Japan:

1) Industrial Safety and Health Act "*Special Chemical Substances Hazard Prevention Regulations*"
2) Industrial Safety and Health Act "*Organic Solvent Poisoning Regulations*";
3) Industrial Safety and Health Act "*Lead Poisoning Preventing Regulations*";
4) Industrial Safety and Health Act "*Dust Hazard Preventing Law*";
5) Law Concerning Special Measures for Promoting Proper Treatment of Polychlorinated Biphenyl Waste;
6) Selection and Use of Chemical Protective Gloves; and
7) Prevention of Industrial Accidents when removing paint using a paint remover.

Therefore, the chemical substances listed in Table 7-17 should be first measured before the old paint on the existing SJB is removed.

Table 7-16 Industrial Safety and Health Act Standard (Content Test)

Substance	Tolerance
Lead	No detection
Chromium	1% or less
Polychlorinated biphenyls (PCB)	1% or less
Coal tar	5% or less

Source: JICA Survey Team

Table 7-17 Standards for Specially Controlled Industrial Waste (Dissolution Test)

Substance	Tolerance
Lead	0.3 mg/l or less
Chromium	1.5 mg/l or less
Polychlorinated biphenyls (PCB)	0.003 mg/l or less
Coal tar	—

Source: JICA Survey Team

Anyone removing lead paint in the working area must wear a protective mask, protective gloves, protective glasses, protective clothing, and shoe covers. After the daily work, all the protective equipment must be removed in the designated changing area on-site to reduce the release of lead into the environment. The protective equipment and changing area are shown in Figure 7-35.



Toxic gas mask with electric fan, Protective clothing, Shoes cover, Protective gloves, Changing area

Source: JICA Survey Team

Figure 7-35 Protective Equipment

7.7 Proposal for Detailed Inspection Schedule

7.7.1 Schedule of Detailed Inspection

Based on the results of the partial inspection, the condition of the existing SJB is classified as being at the stage where early repairs are required, so it is recommended that a full detailed inspection be carried out as soon as possible. Depending on the results of the detailed inspection, it is deemed effective to plan repairs by dividing them into repair work that should be carried out early and large-scale repair work to be carried out after the construction of the SSJB. The actual repair method will be planned depending on the results of the detailed inspection.

Depending on the results of the detailed inspection, repair work may become large-scale and take a long time, so it is proposed that the detailed inspection and the repair design based on the detailed inspection be carried out at the time of detailed design of the SSJB as part of the consultant's scope. The proposed schedule for detailed inspections is shown in Table 7-18.

Key points to note for the detailed inspection include the need to outsource the tests of steel grades and coating types used in the truss bridge and approach bridges to specialized contractors. Additionally, for the non-contact areas between the footing undersides of piers P14 and P15 and the seabed surface confirmed during this survey, repair design will be based on the results obtained using underwater drones. The scope and method of the repair will be reviewed within the repair work contract, including the possibility of further detailed investigation using divers etc.

7.7.2 Schedule of Repair

Depending on the extent of the repairs, it is expected that the repairs will be large-scale, including reinforcement of steel girders with backing plates, repainting, extensive renewal of the deck plates, repair or replacement of bearings, renewal of expansion joints, etc.

Because the existing SJB crosses the channel, considering the need to transport and store on-site the materials and equipment needed for repairs, it would be more reasonable to close the traffic of the existing SJB and begin repairs after the completion of the SSJB, in order to ensure safety

and work quality. However, damages that require immediate repairs must be carried out without waiting for the completion of the SSJB.

The detailed scope and content of the repair work will be determined based on the results of the detailed inspections to be conducted in the future, so it is difficult to provide an actual schedule at this time.

As shown in Table 7-14, design standards have changed since the time of construction of the existing SJB. Therefore, when preparing a repair plan, it is necessary to consider the condition of the superstructure and substructure of the existing SJB and make a realistic and rational judgment on the extent and scope of repairs. For example, it is necessary to consider the appropriate repair content, considering the extent to which the current state should be preserved, the extent to which repairs should be made to keep the same capacity as when the existing SJB was constructed, or the extent to which overall reinforcement should be made to meet the current design standard.

Furthermore, if the concrete deck is replaced, the current deck will need to be removed, and the cost and duration of the repair work will vary greatly depending on the scope of the repair. The scope of the repair will be determined based on the results of the detailed inspections in the future, but here we show a proposed schedule assuming that only the deck of the truss bridge will be replaced with new one.

Table 7-18 Draft Schedule of Detailed Inspection and Repair

Item	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	Remark
Operation of the existing bridge			2 Directional Operation						One-way 2-lane		
Operation of the 2nd bridge						2 Directional Operation			One-way 2-lane		
Detailed design of the 2nd bridge		Preparation of									
Detailed inspection of the entire existing bridge											
Design of partial repair work of the existing bridge											
Design of repair work of the existing bridge											
Partial repair work of the existing bridge											
Construction of the 2nd bridge											
Repair work of the entire existing bridge											

Source: JICA Survey Team