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

PROJECT FOR MASTERPLAN ON HIGH STANDARD HIGHWAY NETWORK DEVELOPMENT (PHASE 2)

FINAL REPORT

MAIN TEXT

<VOLUME-2>

JULY 2021

Japan International Cooperation Agency (JICA)

CTI Engineering International Co., Ltd.
Nippon Koei Co., Ltd.
Oriental Consultants Global Co., Ltd.
Nippon Engineering Consultants Co., Ltd.
Metropolitan Expressway Company Limited

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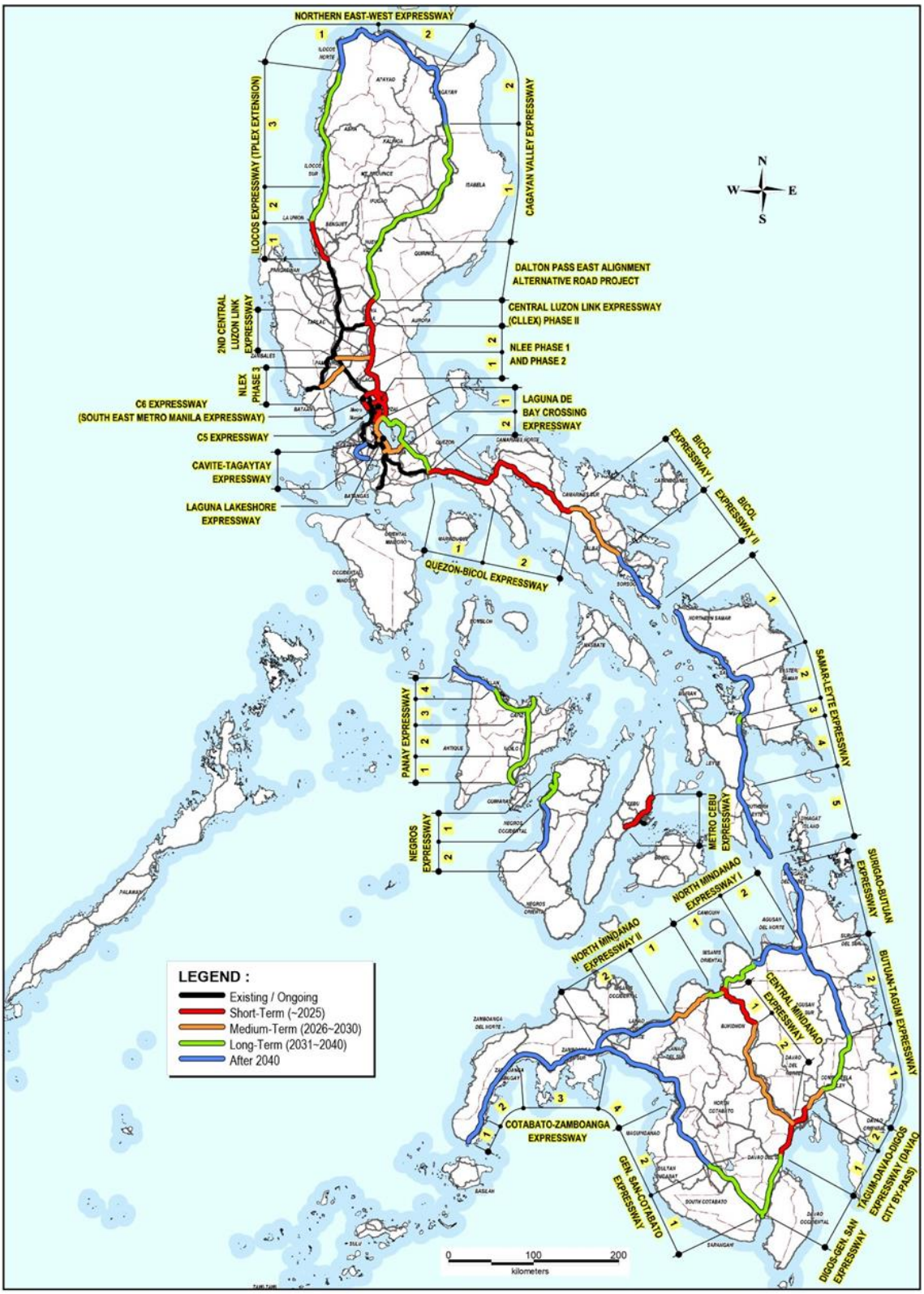
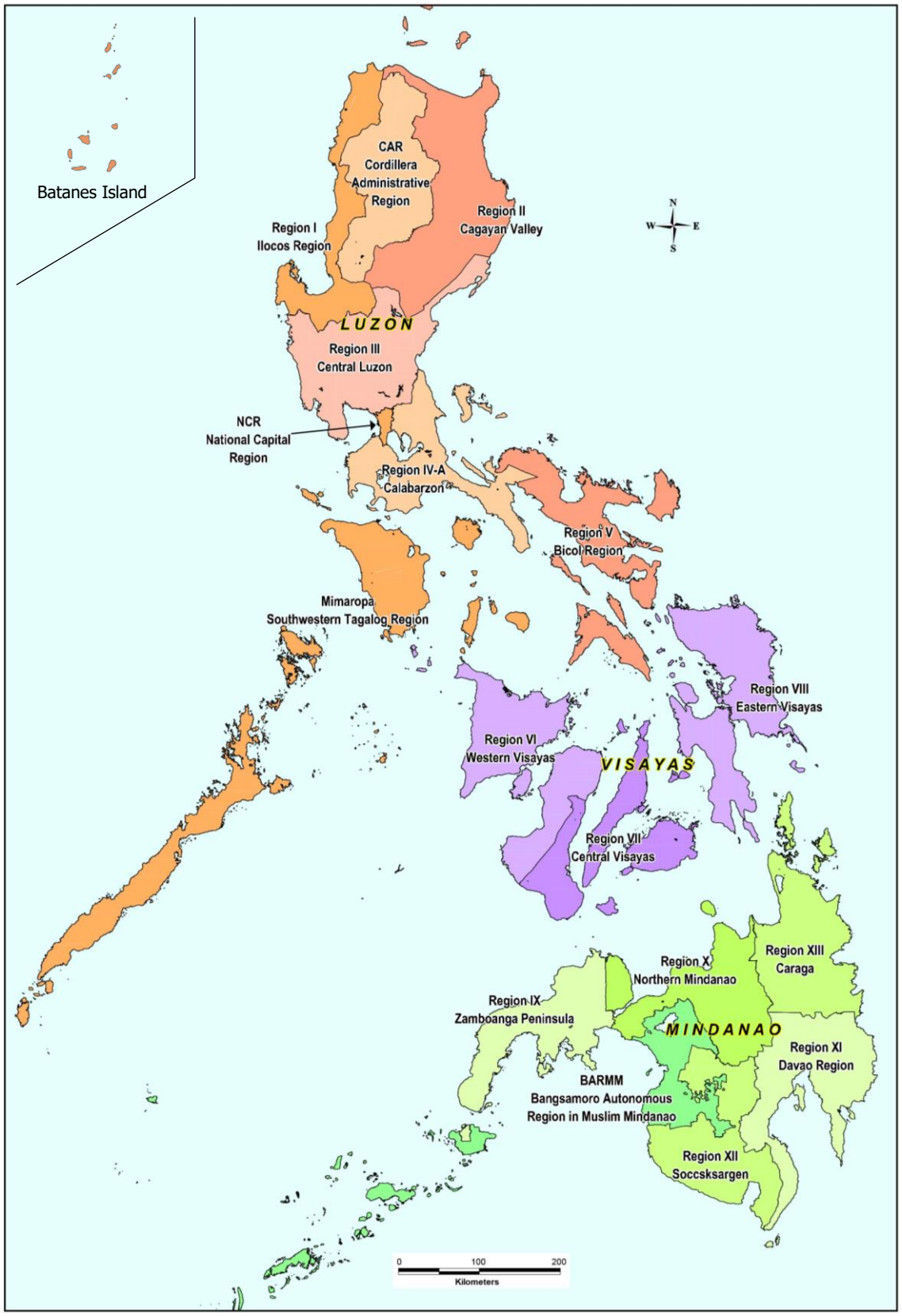
EXCHANGE RATE

March 2020
1Php = 2.1138 Japan Yen
1US$ = 51.0440 Philippine Peso
1US$ = 107.8283 Japan Yen

Central Bank of the Philippine



HSH Network and Implementation Schedule



Region Border

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ACRONYMS AND ABBREVIATIONS

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
ADB	:	Asian Development Bank
ADT	:	Average Daily Traffic
AFF	:	Agriculture, Forestry. and Fisheries
AGF	:	Artificial Ground Freezing
AGR	:	Average Growth Rate
AH 26	:	Asian Highway 26
AHFF	:	Agriculture, Hunting, Forestry and Fishing
ARMM	:	Autonomous Region in Muslim Mindanao
ASEAN	:	Association of Southeast Asian Nations
BARMM	:	Bangsamoro Autonomous Region in Muslim Mindanao
BBEX	:	Bataan-Bulacan Airport Expressway
B/C	:	Benefit/Cost
BCDA	:	Bases Conversion and Development Authority
BCEZ	:	Baguio City Economic Zone
BGTOM	:	Build-Gradual-Transfer-Operate and Maintain
BIMP-EAGA	:	Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area
BLISTT	:	Baguio City-La Trinidad-Itogon-Sablan-Tuba-Tublay
BOT	:	Build-Operate-and-Transfer
BP	:	Base Port
BPO/KPO	:	Business/Knowledge Processing Outsourcing
BPR	:	Bureau of Public Roads (USA)
BQS	:	Bureau of Quality and Safety
BRT	:	Bus Rapid Transit
BSDS	:	Bridge Seismic Design Specifications
BTEX	:	Bulacan-Tarlac Airport Expressway
BTO	:	Build-Transfer-and-Operate
C3EX	:	C-3 Elevated Expressway
CAAP	:	Civil Aviation Authority of the Philippines
CADC	:	Certificate of Ancestral Domain Claim
CADT	:	Certificate of Ancestral Domain Title
CALABARZON	:	Cavite-Laguna-Batangas-Rizal-Quezon (Region IV-A)
CALAX	:	Cavite-Laguna Expressway
CAO	:	Contract-Add-and-Operate
CAPEX	:	Capital Expenditures
CAR	:	Cordillera Administrative Region
CAVITEX	:	Manila-Cavite Expressway
CBD	:	Central Business District
CBR	:	Cost-Benefit Ratio
CCLEX	:	Cebu-Cordova Link Expressway
CCPL	:	Central Cebu Protected Landscape
CCR	:	Cebu Circumferential Road
CCW	:	Centers, Corridors, and Wedges
CDO	:	Cagayan de Oro
CIAC	:	Clark International Airport Corporation
CK	:	Cotabato City-Kidapawan City
CLLEX	:	Central Luzon Link Expressway

CMH	:	Central Mindanao Highway
CLUP	:	Comprehensive Land Use Plan
CNC	:	Certificate of Non-Coverage
CO2	:	Carbon Dioxide
CP	:	Certificate of Precondition
CPA	:	Cebu Port Authority
CPI	:	Consumer Price Index
CRSDF	:	CARAGA Regional Spatial Development Framework
CS	:	Construction Stage
CTBEX	:	Cavite-Tagaytay-Batangas Expressway
CWG	:	Counterpart Working Group
DA	:	Department of Agriculture
DAO	:	DENR Administrative Order
DBM	:	Department of Budget and Management
DBTO	:	Design-Build-Transfer-Operate
DENR	:	Department of Environment and Natural Resources
DEO	:	District Engineering Office
DepEd	:	Department of Education
DF/R	:	Draft Final Report
DGCS	:	Design Guidelines, Criteria, and Standards
DIAA	:	Davao International Airport Authority
DIDP	:	Davao Integrated Development Program
DILG	:	Department of Interior and Local Government
DMM	:	Deep Mixing Method
DO	:	Department Order
DOF	:	Department of Finance
DOST	:	Department of Science and Technology
DOT	:	Develop-Operate-and-Transfer
DOTr	:	Department of Transportation
DPD	:	Development Planning Division
DPMEX	:	Del Pan-Pasig-Marikina Expressway
DPWH	:	Department of Public Works and Highways
DPWH-RBIA	:	Department of Public Works and Highways – Road and Bridge Information Application
DREAM	:	Disaster Risk and Exposure Assessment for Mitigation
DRR-CAA	:	Disaster Risk Reduction-Climate Change Adaptation
DRRM	:	Disaster Risk Reduction and Management
DRSDF	:	Davao Region Spatial Development Framework
DTI	:	Department of Trade and Industry
EAGA	:	East Asian Growth Area
ECA	:	Environmentally Critical Areas
ECC	:	Environmental Compliance Certificate
ECP	:	Environmentally Critical Project
EGWS	:	Electricity, Gas, and Water Supply
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
EIS	:	Environmental Impact Statement
EMB	:	Environmental Management Bureau
EMoP	:	Environmental Monitoring Plan
EMP	:	Environmental Management Plan
ENPV	:	Economic Net Present Value

EO	:	Executive Order
EPZ	:	Export Processing Zone
ESCAP	:	Economic and Social Commission for Asia and the Pacific
ESSD	:	Environmental and Social Safeguards Division
FAME	:	Fishery, Agro-Forestry, Mineral and Ecotourism
FDI	:	Foreign Direct Investments
FI	:	Financial Intermediation
FIRR	:	Financial Internal Rate of Return
FGD	:	Focus Group Discussion
FPIC	:	Free Prior, and Informed Consent
FRIMP	:	Flood Risk Improvement and Management Plan
F/R	:	Final Report
F/S	:	Feasibility Study
Fs	:	Factor of Safety
G2G	:	Government-to-Government
G/A	:	Generation-Attraction
GAA	:	General Appropriations Act
GCR	:	Greater Capital Region
GDP	:	Gross Domestic Product
GFS	:	Government Financing Statistics
GIDA	:	Geographically Isolated and Disadvantaged Areas
GIS	:	Geographic Information System
GNI	:	Gross National Income
GOCC	:	Government-Owned and Controlled Corporation
GOJ	:	Government of Japan
GOP	:	Government of the Philippines
GPS	:	Global Positioning System
GRDP	:	Gross Regional Domestic Product
GRP	:	Government of the Republic of the Philippines
GRPI	:	Groundwater Resource Potential Index
GVA	:	Gross Value Added
GVW	:	Gross Vehicle Weight
HAM	:	Hybrid Annuity Model
HCM	:	Highway Capacity Manual
HSH	:	High Standard Highway
HSH Class-1(IU)	:	Inter-Urban Expressway
HSH Class -1(U)	:	Urban Expressway
HSH Class -2	:	Regional High Standard Highway
HSH Phase 1	:	Study of Master Plan on HSH Network Development Phase 1
HSH Phase 2	:	Study of Master Plan on HSH Network Development Phase 2
HUC	:	Highly Urbanized City
HVDC	:	High Voltage, Direct Current
IBA	:	Important Bird Area
IC	:	Interchange
ICC	:	Investment Coordination Committee
IC/R	:	Inception Report
ICT	:	Information and Communications Technology
IE	:	Industrial Estates
IEC	:	Information, Education, and Communication
IEE	:	Initial Environmental Examination
IEM	:	Integrated Ecosystem Management

IGS	:	Isulan-General Santos
IM4Davao	:	Davao City Infrastructure Development Plan and Capacity Building Project
IMAG	:	Infrastructure Monitoring and Advisory Group
IMF	:	International Monetary Fund
IPA	:	Investment Promoting Agency
IPRA	:	Indigenous Peoples' Rights Act
IRR	:	Implementing Rules and Regulations
IT-BPO	:	Information Technology-Business Processing Outsourcing
IT/R	:	Interim Report
ITT	:	Intermodal Transport Terminal
JCC	:	Joint Coordination Committee
JICA	:	Japan International Cooperation Agency
JPY	:	Japan Yen
JV	:	Joint Venture
KAPP	:	Kilos Abante Programs/Projects
KII	:	Key Informant Interview
KDZ	:	Key Development Zone
LARRIPP	:	Land Acquisition, Resettlement, Rehabilitation and Indigenous Peoples' Policy
LCP	:	League of Cities of the Philippines
LFP	:	Locally Funded Project
LGU	:	Local Government Unit
LMAG	:	Lebak-Maasim-Alabel-Glan
LMP	:	League of Municipalities of the Philippines
LOS	:	Level of Service
LQ	:	Local Quotient
LRFD	:	Load and Resistance Factor Design
LRT	:	Light Rail Transit
LSDF	:	Luzon Spatial Development Framework
LTI	:	Laguna Technopark, Inc.
MBA	:	Maintenance by Administration
MBC	:	Maintenance by Contract
MBIFCCD	:	Manila Bay Integrated Flood Control Coastal Defense and Expressway Project
MC	:	Metropolitan Center
MCA	:	Multi-Criteria Analysis
MCDA	:	Metro Cebu Development Authority
MCDCB	:	Metro Cebu Development and Coordination Board
MCIAA	:	Mactan-Cebu International Airport Authority
MCT	:	Mindanao Container Terminal
MCTEX	:	Manila-Cavite Toll Expressway
MCWD	:	Metropolitan Cebu Water District
MCX	:	Muntinlupa-Cavite Expressway
MEPZ II	:	Mactan Export Processing Zone II
MGB	:	Mines and Geosciences Bureau
MICP	:	Manila International Container Port
MICT	:	Manila International Container Terminal
MIMAROPA	:	Mindoro-Marinduque-Romblon-Palawan (Region IV-B)
MinDA	:	Mindanao Development Authority
MHHW	:	Mean Higher High Water

MLLW	:	Mean Lower Low Water
MMDA	:	Metro Manila Development Authority
MMIS	:	Modified Mercali Intensity Scale
MMSP	:	Metro Manila Subway Project
MMUTIS	:	Metro Manila Urban Transportation Integration Study
M/P	:	Master Plan
MQX	:	Manila-Quezon Expressway
MRT	:	Metro Rail Transit
MRTS	:	Metro Rail Transit System
MSDS	:	Materials Safety Data Sheet
MSEZ	:	Manufacturing Special Economic Zones
MSME	:	Micro, Small and Medium Enterprises
MSS/DF	:	Mindanao Spatial Strategy/ Development Framework
MTEX	:	Manila-Taguig Expressway
MTL	:	Mean Tide Level
MUCEP	:	MMUTIS Update and Capacity Enhancement Project
MVUC	:	Motor Vehicle User's Charge
NAAQGV	:	National Ambient Air Quality Guideline Values
NAIA	:	Ninoy Aquino International Airport
NAIAX	:	NAIA Expressway
NaLUA	:	National Land Use Act
NAMRIA	:	National Mapping and Resource Information Authority
NATM	:	New Austrian Tunneling Method
NCIP	:	National Commission on Indigenous People
NCR	:	National Capital Region
NDRRMC	:	National Disaster Risk Reduction and Management Council, formerly National Disaster Coordinating Council (NDCC)
NEAX	:	North East Airport Expressway
NEDA	:	National Economic and Development Authority
NEXCO	:	Nippon Expressway Company
NFA	:	National Food Authority
NGO	:	Non-Governmental Organization
NHAI	:	National Highway Authority of India
NLEE	:	North Luzon Expressway East
NLEX	:	North Luzon Expressway
NOA	:	Notice of Award
NPFP	:	National Physical Framework Plan
NPR	:	National Primary Road
NPV	:	Net Present Value
NRIMP-I	:	National Roads Improvement and Management Phase I
NRW	:	Non-Revenue Water
NSCR	:	North-South Commuter Railway Project
NSR	:	National Secondary Road
NSS	:	National Spatial Strategy
NTDP	:	National Tourism Development Plan
NTR	:	National Tertiary Road
O&M	:	Operation and Maintenance
OCD-NDCC	:	Office of Civil Defense – National Disaster Coordinating Committee
OCHA	:	Office of the Coordination of Humanitarian Affairs
OD	:	Origin-Destination
ODA	:	Official Development Assistance

OECD	:	Organization for Economic Cooperation and Development
OGCC	:	Office of the Government Corporate Counsel
OGP	:	Other Government Port
OJT	:	On-the-Job Training
OS	:	Operation Stage
OSG	:	Office of the Solicitor General
OTP	:	Other Terminal Port
PA	:	Protected Area
PAD	:	Public Administration and Defense
PAGASA	:	Philippine Atmospheric, Geophysical, and Astronomical Services Administration
PALMANABA	:	Paracelis, Alfonso Lista and Mayoyao in Ifugao and Natonin and Barlig in Mountain Province
PAP	:	Programs, Activities and Projects
PAPs	:	Project Affected Persons
PBAC	:	Prequalification, Bids, and Awards Committee
PCB	:	Palawan Micro-continental Block
PCCP	:	Portland Cement Concrete Pavement
PCS	:	Pre-Construction Stage
PCU	:	Passenger Car Unit
PD	:	Presidential Decree
PD	:	Programming Division
PDD	:	Planning and Design Division
PDP	:	Philippine Development Plan
PDPFP	:	Provincial Development and Physical Framework Plan
PEA	:	Public Estates Authority, now Philippine Reclamation Authority (PRA)
PEGR	:	Philippines-Australia Partnership for Economic Governance Reform
PEIS	:	PHIVOLCS Earthquake Intensity Scale
PEISS	:	Philippine Environmental Impact Statement System
PEZA	:	Philippine Economic Zone Authority
PHP	:	Philippine Peso
PFA	:	Priority Focus Areas
PFD	:	Policy Formulation Division
PFZ	:	Philippine Fault Zone
PG/R	:	Progress Report
PHIVOLCS	:	Philippine Institute of Volcanology and Seismology
PHP	:	Philippine Peso
PIP	:	Public Investment Plan
PIRR	:	Project Internal Rate of Return
PMB	:	Philippine Mobile Belt
PMC	:	Palawan-Mindoro Microcontinent
PMO	:	Project Management Office
PMO-BOT	:	Project Management Office for Build-Operate-Transfer, now Public-Private Partnership Service
PND	:	Police National Database
PNR	:	Philippine National Railways
PP	:	Private Port
PPA	:	Philippine Ports Authority
PPD	:	Project Preparation Division
PPE	:	Personal Protective Equipment

PPMC	:	Poro Point Management Corporation
PPP	:	Public-Private Partnership
PPPC	:	Public-Private Partnership Center
PPPS	:	Public-Private Partnership Service
PREXC	:	Program Expenditure Classification
PS	:	Planning Service
PSA	:	Philippine Statistics Authority
PSCG	:	Pre-Stressed Concrete Girder
PVD	:	Pre-fabricated Vertical Drain
QOL	:	Quality of Life
RA	:	Republic Act
RAP	:	Resettlement Action Plan
RC	:	Regional Center
RC	:	Reinforced Concrete
RCDG	:	Reinforced Concrete Deck Girder
R&D	:	Research and Development
RDC	:	Regional Development Council
RDCOM	:	Regional Development Committee
RDP	:	Regional Development Plan
RERBA	:	Real Estate, Renting, and Business Activity
RIMSS	:	Road Information Management Support System
RO	:	Regional Office
ROLL IT	:	Roads Leveraging Linkages of Industry and Trade
RORO	:	Roll-on / Roll-off
ROW	:	Right-of-Way
ROWA	:	Right-of-Way Acquisition
RPFP	:	Regional Physical Framework Plan
RQD	:	Rock Quality Designation
RROW	:	Road Right-of-Way
RRTS	:	Roll-On-Roll-Off Terminal System
SABATABESA	:	Sabangan-Bauko-Tadian-Besao-Sagada
SAFDZ	:	Strategic Agriculture and Fisheries Development Zones
SBMA	:	Subic Bay Metropolitan Authority
SCADA	:	Supervisory Control and Data Acquisition
SCTEX	:	Subic-Clark-Tarlac Expressway
SD	:	Statistics Division
SEA	:	Strategic Environmental Assessment
SEARCA	:	Southeast Asian Regional Center for Graduate Study and Research in Agriculture
SEZ	:	Special Economic Zone
SHM	:	Stakeholder Meeting
SLEX	:	South Luzon Expressway
SMMSP	:	South Metro Manila Skyway Project
SOCCSKSARGEN	:	South Cotabato, Cotabato, Sultan Kudarat, Sarangani, and General Santos City, or Region XII
SRC	:	Sub-Regional Center
SRNH	:	Strong Republic Nautical Highway
STAR	:	Southern Tagalog Arterial Road
STD	:	Sexually Transmitted Disease
STEP	:	Special Terms for Economic Partnership
STOA	:	Supplemental Toll Operation Agreement

STRADA	:	System for Traffic Demand Analysis
SWP	:	Site Working Procedure
TDA	:	Tourism Development Areas
TDM	:	Traffic Demand Management
TDS	:	Total Dissolved Solids
TEC	:	Traffic Engineering Center
TED	:	Traffic Engineering Division
TEU	:	Twenty-Foot Equivalent Unit
TEZ	:	Tourism Economic Zones
TOC	:	Toll Operations Certificate
TOD	:	Transit Oriented Development
TOR	:	Terms of Reference
TP	:	Terminal Port
TPLEX	:	Tarlac-Pangasinan-La Union Expressway
TR-4	:	Toll Road 4
TRAIN-2	:	Tax Reform for Acceleration and Inclusion
TRB	:	Toll Regulatory Board
TTC	:	Travel Time Cost
TSC	:	Transport, Storage, and Communication
TSP	:	Total Suspended Particles
TSS	:	Total Suspended Solids
TWG	:	Technical Working Group
UMRT	:	Urban Mass Rapid Transit
UNESCAP	:	United Nations Economic and Social Commission for Asia and the Pacific
UPMO	:	Unified Project Management Office
UPMO-RMC1	:	Unified Project Management Office – Roads Management Cluster 1
UPMO-RMC2	:	Unified Project Management Office – Roads Management Cluster 2
USAID	:	United States Agency for International Development
USD	:	United States Dollar
VAT	:	Value Added Tax
VCR	:	Volume Capacity Ratio
VGF	:	Viability Gap Funding
VOC	:	Vehicle Operating Cost
VPA	:	Volunteer Probation Assistance
VSDF	:	Visayas Spatial Development Framework
WACC	:	Weighted Average Cost of Capital
WB	:	World Bank
WTP	:	Willingness-To-Pay

PART F

PRE-FEASIBILITY STUDY

CHAPTER 14

SELECTION OF THE PROJECT FOR PRE-FEASIBILITY STUDY

CHAPTER 14
SELECTION OF THE PROJECT FOR PRE-FEASIBILITY STUDY

14.1 Outline of Candidate Pre-F/S Project

The JICA Study Team studied the prioritization of candidate Pre-F/S project from HSH Network.

As the Feasibility Study of ordinary road/bridge project can be conducted by DPWH, candidate projects for the Pre-F/S were selected among the projects which necessitates the application of an advanced technology, such as long span bridge, long tunnel, earthquake proof, soft ground protection and rapid construction in the urban area, etc.

The purpose of the Pre-F/S in this project is to find candidate projects needing an advanced technology. The main objective is to find the issues to be addressed during the F/S stage by examining the alternatives for the road alignment or bridge type using available and free satellite photos and existing topographic data. In addition, due to the effects of the COVID-19 pandemic, some field surveys could not be fully conducted. The F/S is required for comparison and selection of the alternatives, and detailed planning based on the field survey conducted.

The Pre-F/S candidate projects have not completely matched the prioritization of the Master plan, since the Pre-F/S was conducted for a technology transfer for DPWH utlizing advanced technology.

14.2 First Screening

Initial candidate Pre-F/S projects identified were thirteen (13) projects as shown in **Table 14.2-1** and **Figure 14.2-1.**

Among the thirteen (13) projects, five (5) candidate projects for Pre-F/S were excluded due to no urgency of the project which might be not feasible from the point of future traffic demand. Thus, the remaining eight (8) projects are as shown in **Table 14.2-2** and **Figure 14.2-2** were selected for evaluation.

Table 14.2-1 First Screening of candidate Pre-F/S projects

Area	Project Name	Major Technology	Selected	Remarks
Luzon	1. Laguna de Bay Crossing Highway	Long Bridge crossing Laguna de Bay	○	
	2.Bicol Highway	Long Span Bridge crossing bay		In order to cross the bay, long-span bridge will be necessary under sea depth 20m. Not urgent project due to low traffic located in the southernmost Luzon island.
	3.Marikina-Infanta Highway	Mountain Tunnel		Not urgent project due to less than 1000 daily traffic though its necessary to construct mountain tunnel (1500 m, 2000 m).
	4. NLEX - East Highway	Long Bridge passing large river	○	
	5.Cagayan Valley Highway	Long Bridge passing large river		Not urgent project due to low traffic volume.
Visayas	6. Cebu Circumferential Road	Long Tunnel and High pier bridge	○	
	7. 2nd San Juanico Bridge	Long Span Bridge crossing strait	○	
	8. Naga -Toledo Road	Long Mountain Tunnel	○	

Area	Project Name	Major Technology	Selected	Remarks
Mindanao	9. Central Mindanao Highway	Long Span Bridge with high piers at deep Valley	○	
	10. Tagum-Davao-Digos Exp.(L=102km)	Slope Protection along mountainous area or Bridge along the seashore		Not urgent project due to no traffic congestion along 4-lane widening national road outside of Davao city. Limited advanced technology will be applied.
	11 Mindanao I Exp.(CDO - Gingoog Section)	Slope Protection		After the rough alignment study, advanced technology was not high necessary.
	12. North Mindanao II Exp.(Iligan- CDO Section)	Mountain Tunnel	○	
	13. Agusan del Norte - Butuan City Logistic Highway	Long Span Bridge Soft ground countermeasures	○	

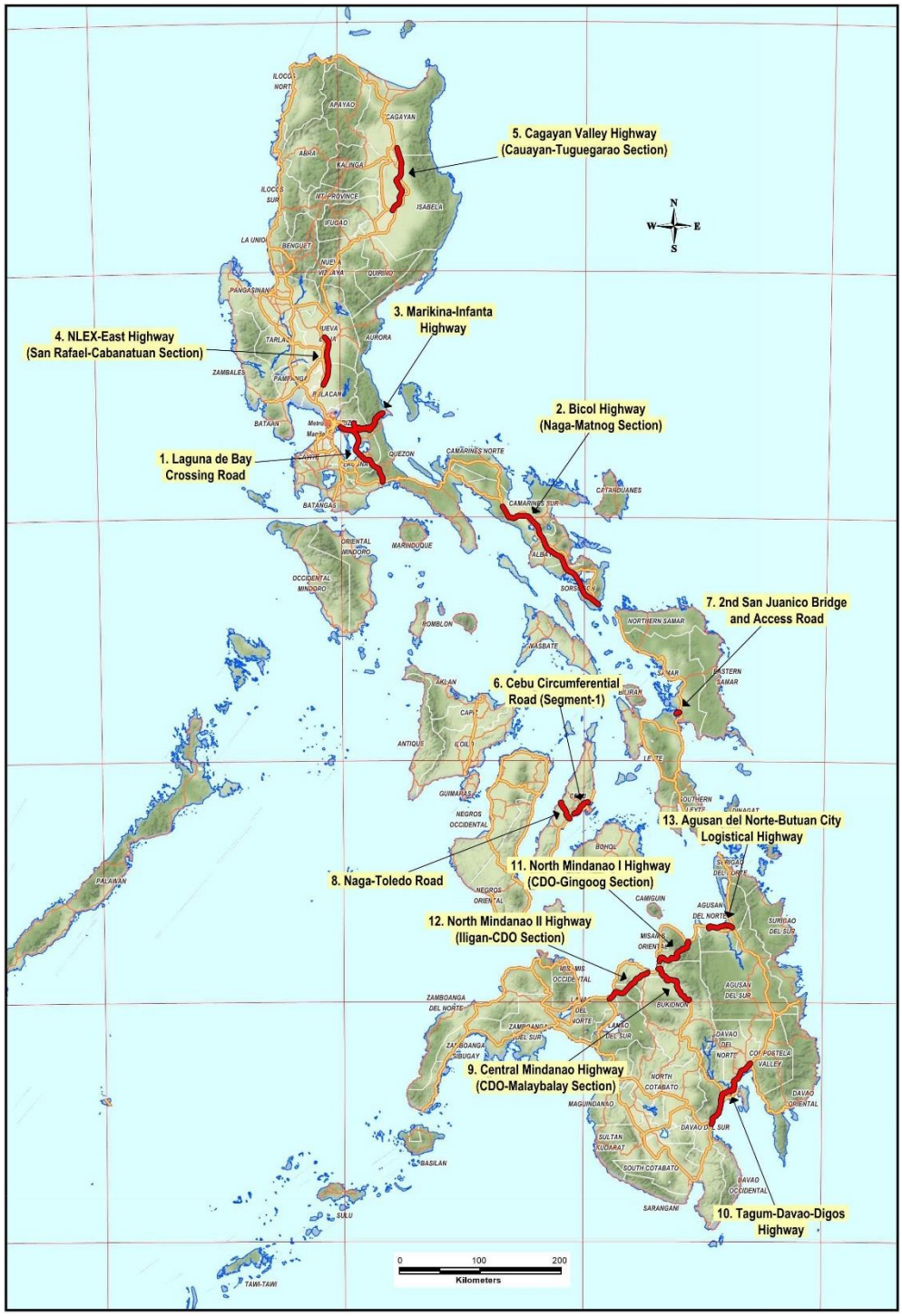


Figure 14.2-1 Location Map of Thirteen (13) Candidate Pre-F/S Projects

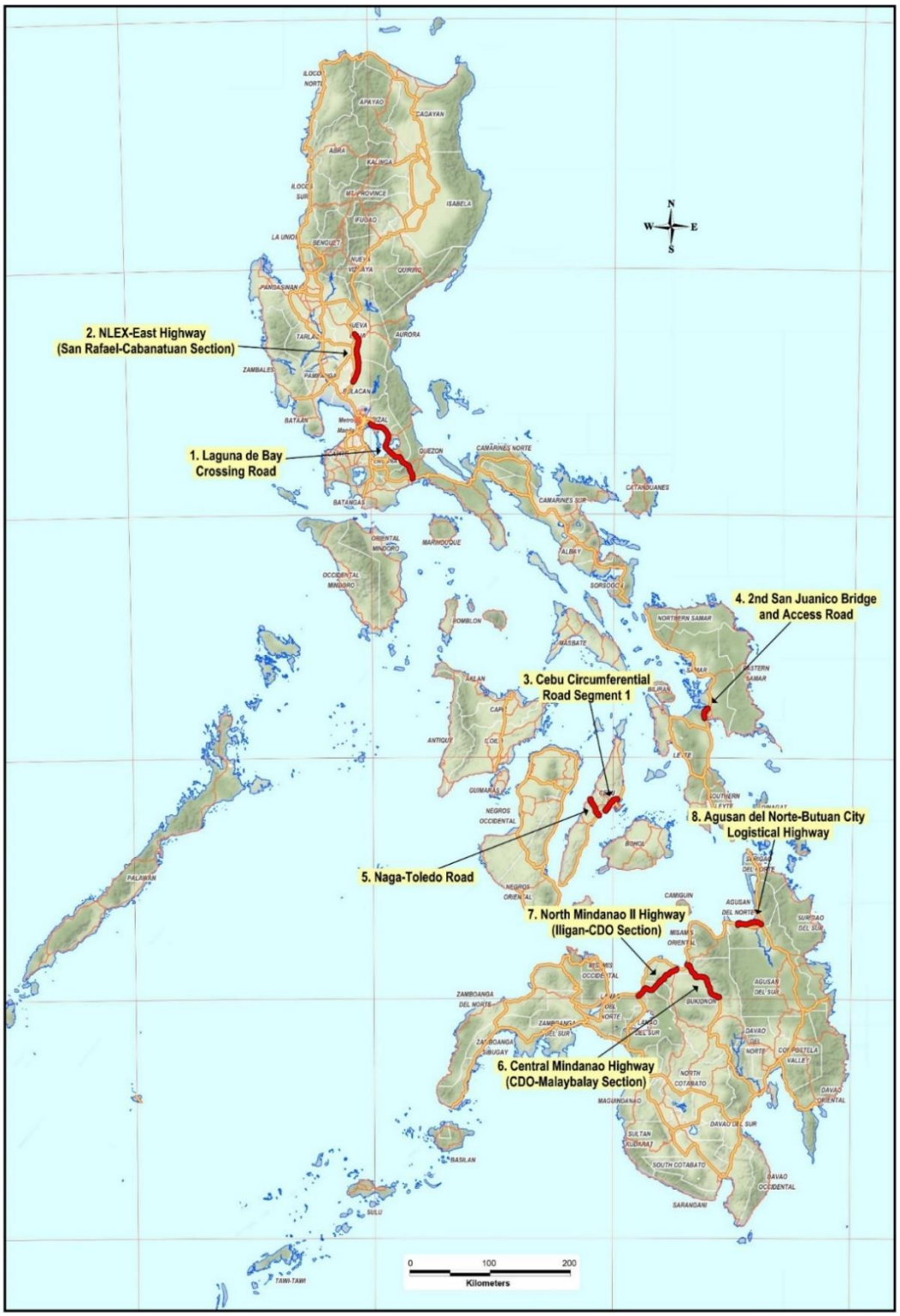


Figure 14.2-2 Location Map of Eight (8) Candidate Pre-F/S Projects

Table 14.2-2 Candidate Pre-F/S by Area

Area	No. of Candidate Pre-F/S
Luzon	2
Visayas	3
Mindanao	3

Source: JICA Study Team

14.3 Second Screening

14.3.1 Evaluation Criteria

The following evaluation criteria were used to prioritize the Candidate Pre-F/S Project.

- Traffic Impact –Traffic Volume
- Economic Impact- EIRR is
- Regional Development Impact
- Resiliency and/or Redundancy
- Environmental and Social Impact
- Advanced Technology

Based on the summation of each evaluation criteria, prioritization was prepared.

Table 14.3-1 Draft Evaluation Criteria for prioritization of candidate Pre-F/S Projects

Criteria	Evaluation
Traffic Impact - Daily Traffic Volume in 2025	Over 20,000 vehicle/day :◎ 10,000-5,000 vehicle/day :○ Less 10,000 vehicle/day :△
Economic Impact - EIRR (%)	Over 20% :◎, 15～20% :○, 10～15% :△, Less 10% :×
Regional Development Impact	[Large Impact] The connection between Metropolitan center or contribute the development of Metropolitan center :◎ [Medium Impact] The connection between Regional center:○ [Less Impact] Other than those above :△
Resiliency and/or Redundancy	[New HSH] Both Resiliency and Redundancy :○, [Upgrade HSH] Only Resiliency :△
Natural Environment Impact	[Less Impact] Total length of crossing (1) forest / trees (2) river /lake (3) seashore / river mouth area along the proposed HSH is below its respective averages of HSH sections. :◎ [Medium Impact] Total length of crossing (1) forest / trees (2) river /lake (3) seashore / river mouth area along the proposed HSH is above its respective averages of HSH sections, at least one parameter. :○ [Large Impact] Total length of crossing (1) forest / trees (2) river /lake (3) seashore / river mouth area along the proposed HSH is above each average of HSH section significantly. : △ ※respective averages (1) 29.5km, (2) 2.9km, (3) 0.4km Use the lowest rating of the three categories
Social environment Impact (Affected building and structures)	[Less Impact] 0~500 :◎ [Medium Impact] 600~1,000 :○ [Large Impact] 1,100 :△
Advanced technology required	Long Span Bridge or Long Tunnel :◎ Other Item such as Iconic Bridge or Steel Bridge:○

Source: JICA Study Team

14.4 Selection Result

Table 14.4-1 shows the outline of the Candidate Pre-F/S Projects. **Table 14.4-2** shows the result of the evaluation.

The following four (4) projects were selected for the conduct of Pre-F/S.

Figure 14.4-1 shows the location map of selected four Pre-F/S projects. The 2nd San Juanico Bridge was selected because the existing San Juanico bridge will necessitate slab reconstruction during the early stage and will be closed for traffic during the reconstruction. The other three projects were selected as Short-term projects in the Master Plan (see Chapter 12).

- Central Mindanao Highway (CDO- Malaybalay)
- Cebu Circumferential Road
- 2nd San Juanico Bridge
- Agusan del Norte - Butuan City Logistic Highway

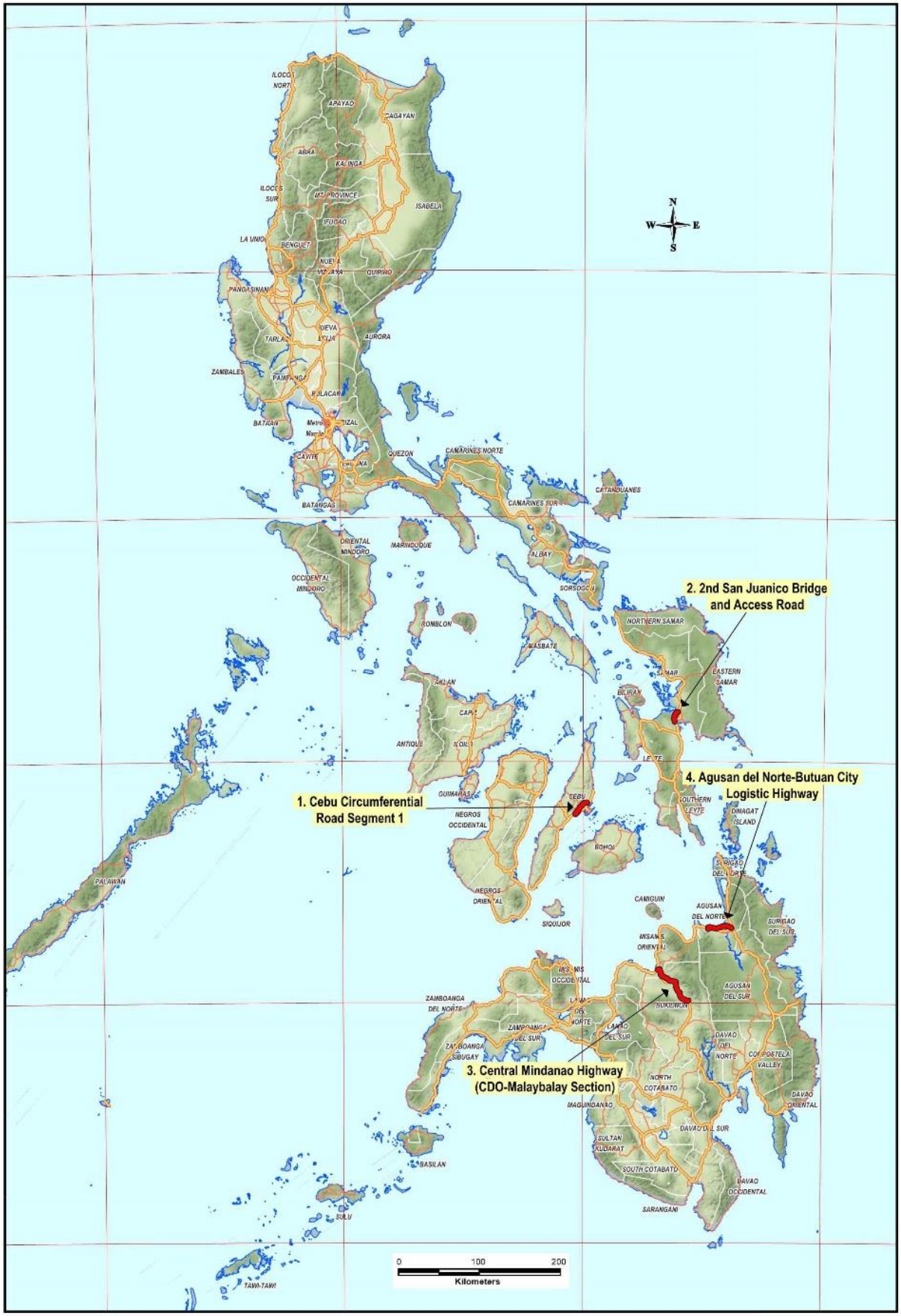
Table 14.4-1 Outline of the Candidate Pre-F/S Project

Area	Project	Section	Length	No. Lane	Remarks
Luzon	1. Laguna de Bay Crossing Highway	Phase-1 (only along Laguna de Bay sec.)	51.2 km	4	✓ To mitigate the traffic congestion near Metro Manila ✓ To improve access from East Metro Manila to Lucena. Present travel time of 4 hr. will be reduced to 1 hr. [assumed travel speed is 100km/h]) ✓ To support development of East Metro Manila ✓ High potential development area in the future ✓ To build a connection with the proposed Laguna Lakeshore Expressway (ADB) ✓ ADB will study the preliminary route after the Laguna Lakeshore Exp. F/S.
	2. NLEX - East Highway	San Rafael – Cabanatuan	61.6 km	4	✓ To mitigate the traffic congestion along Pan Philippine Highway (PPH). ✓ The area is mostly flat, with many rivers and waterways (ref. 29 bridges along PPH parallel section; longest bridge is Gen. Luna Br. 600m). ✓ To connect the end of Plaridel BP and CLLEX Phase-1
Visayas	3. Cebu Circumferential Road	Segment-1	24.5 km	4	✓ The project was initially proposed in the Cebu Transport M/P (JICA). ✓ JST revised the route alignment. Many buildings will still be affected, however (no. of affected buildings is approximately 1,400 based on the satellite map. ROW 60m). ✓ Viaduct/bridges (higher pier or long span bridge) and tunnels will be required.
	4. 2nd San Juanico Bridge	Phase-1 section	9.8 km	2	✓ The existing San Juanico Bridge is a 2-lane bridge (Y1969, 2.16km, truss type). The condition is still good, but repair of defects and continuous maintenance are necessary, especially reconstruction of slab due to damage. ✓ The depth of sea is at 13-18 m (NAMRIA).
	5. Naga -Toledo Road	Tunnel Portion	-	2	✓ To improve the road alignment and provide a short cut route. ✓ Two tunnels will be proposed (1,500m and 3,700 m).
Mindanao	6. Central Mindanao Highway	CDO - Malaybalay	67.1 km	2-4	✓ This proposed route shall pass through Cagayan de Oro City and Davao City ✓ A loop bridge shall be proposed at the Cagayan de Oro side due to its sharp gradient. ✓ The route will also pass through cross deep valleys where long span bridges will be needed.
	7. North Mindanao Highway	CDO - Iligan	65.6 km	4	✓ Travel distance between Cagayan de Oro and Iligan will be shortened from 90 km. to 60 km. and travel time will be reduced from 2 hr. to 45 min. [assumed travel speed is 80 km/h].
	8. Agusan del Norte - Butuan City Logistic Highway	4th Butuan Bridge + Road (Phase-1)	18.5 km	4	✓ Project was proposed by DPWH as one of the candidates for pre-F/S. ✓ IDI(Japan) conducted the preliminary survey for the 4th Butuan Bridge. ✓ The road shall connect Nasipit Port, Masao Port and several SEZs with the AH26.

Table 14.4-2 Evaluation Result of Pre-F/S Project Selection

Area	No	Project Name	Daily Traffic Volume in 2025		EIRR(%)		Regional Development Impact		Resiliency / Redundancy		Natural Evironment Impact		Social Environment Impact		Advanced Technology Requirement		Other Factors		Remarks	Total	
			Daily Volume	Evaluation	%	Evaluation	Impact	Evaluation	Item	Evaluation	Clossing Length of each category (km)	Evaluation	No.of Structure Affected	Evaluation	Item	Evaluation		Evaluation		Evaluation	Results
Luzon	1	Laguna de Bay Crossing Highway	12,400	○	16.0%	○	To contirbute the development of East Metro Manila	◎	New Road	○	①4.0 ②32.7 ③0	△	800	○	Laguna Late Crossing Bridge (L=5600m) and along coastal bridge	◎	ADB plans to conduct FS as Laguna de bay Phase-2	△		◎ 2 ○ 4 △ 2	
	2	NLEX-East Highway (San Rafael - Cabanatuan)	18,500	◎	33.5%	◎	To improve accessibility North Luzon	○	New Road	○	①1.5 ②0.5 ③0	◎	900	○	Long Bridge will be required but not necessary long span bridge	△	High potential as PPP project	△	DPWH will implemtnt as PPP	◎ 3 ○ 3 △ 2	
Visayas	3	Cebu Circumferential Road	32,400	◎	26.8%	◎	Main purpose is to decongest in Metro Cebu.	○	New Road	○	①15.0 ②0.1 ③0	◎	1,400	△	14Bridges/Viaducts（Total 5,330m)、 6 Tunnels （Total 3,600m)	◎	Quite big impact for traffic decongestion in Cebu	◎		◎ **5** ○ 2 △ 1	**Selected**
	4	2nd San Juanico Bridge and access Road	7,300	△	12.0%	△	Inter-island Bridge.	○	New Road & Inter island bridge	◎	①2.1 ②0 ③0.7	○	100	◎	Long Span Bridges (1,000m)	◎	Exsting San Juanico Bridge is necessary to reconstruction of slab due to serious damage.	◎		◎ **4** ○ 2 △ 2	**Selected**
	5	Naga-Toledo Road (Tunnel Section)	7,000	△	15.6%	○	East-West Corridor in the Cebu Island	△	Existing Road	△	①0 ②0 ③0	◎	0	◎	Mountain Tunnels (L=3700m,1500m)	◎	To construct the tunnels is not so much traffic improvement along road.	△		◎ 3 ○ 1 △ 4	
Mindanao	6	Central Mindanao Highway (Cagayan de Oro- Malaybalay Section)	5,300	△	15.4%	○	To improve accessibility between Davao and CDO	◎	New Road	○	①25 ②0 ③0	◎	500	◎	Loop Bridges (Height deference 100m) and two(2) Long Span Bridges	◎	Two Metropolitans in Mindanao will be connected by Expressway.	◎		◎ **5** ○ 2 △ 1	**Selected**
	7	North Mindanao II Highway (Iligan-Cagayan de Oro Section)	11,400	○	25.8%	◎	To improve accessibility between CDO and Iligan	○	New Road	○	①28.9 ②5.3 ③0	○	600	○	Mountain Tunnel= 5,000 m）	◎	It is necessary to consider fully the problems in the peace and order	△		◎ 2 ○ 5 △ 1	
	8	Agusan del Norte - Butuan City Logistical Highway (4th Butuan Bridge)	10,100	○	11.1%	△	It depends the new SEZ development	○	New Road	○	①11.0 ②0.8 ③0	◎	200	◎	3 Span Extradosed Bridge proposed by preliminary Survey	◎	Project will contribute the promotion of new SEZ	◎		◎ **4** ○ 3 △ 1	**Selected**

Source: JICA Study Team



Source: JICA Study Team

Figure 14.4-1 Location Map of Selected Pre-F/S Projects

CHAPTER 15

CENTRAL MINDANAO HIGH STANDARD HIGHWAY (CAGAYAN DE ORO – MALAYBALAY)

CHAPTER 15
CENTRAL MINDANAO HIGH STANDARD HIGHWAY (CAGAYAN DE ORO – MALAYBALAY)

15.1 Introduction

15.1.1 Project Background

At the Japan-Philippines High Level Joint Committee on Infrastructure Development and Economic Cooperation, the implementation of the Pre-Feasibility Study (Pre-F/S) of four (4) projects was decided. This project is one the four (4) projects identified in the said high level meeting. A Pre-F/S is conducted to consider the applicability of advanced construction technology and material.

The Central Mindanao High Standard Highway (CMH) with a total length of 208km is proposed as an important corridor in Mindanao, which connects two (2) Metropolitan Centers (Cagayan de Oro and Davao City). The Cagayan de Oro (CDO) - Malaybalay Section of the Central Mindanao Highway is proposed as a short term (the present to 2025) project in the implementation program for HSH Class-1.

There is a 100-150 m height difference over the 2 km section at the beginning area of the road, which explains the presence of hairpin curves and very steep gradient sections along Sayre Highway. To solve these issues, advanced construction technology for long span and higher pier bridge will be necessary for the CMH.

Table 15.1-1 Outline of Pre-F/S

Name	Central Mindanao High Standard Highway (Cagayan De Oro - Malaybalay Section)
Class	HSH Class-1
Length	67.6 km
Number of Lanes	4 lanes (Initially 2 lanes)
Design Speed	80 km/h

15.1.2 Objectives of the Study

The following items were included in the conduct of the pre-feasibility study:

1) Traffic Demand Forecasting
2) Preliminary Design
3) Project Cost Estimation
4) Economic Analysis
5) Preliminary Environmental and Social Survey

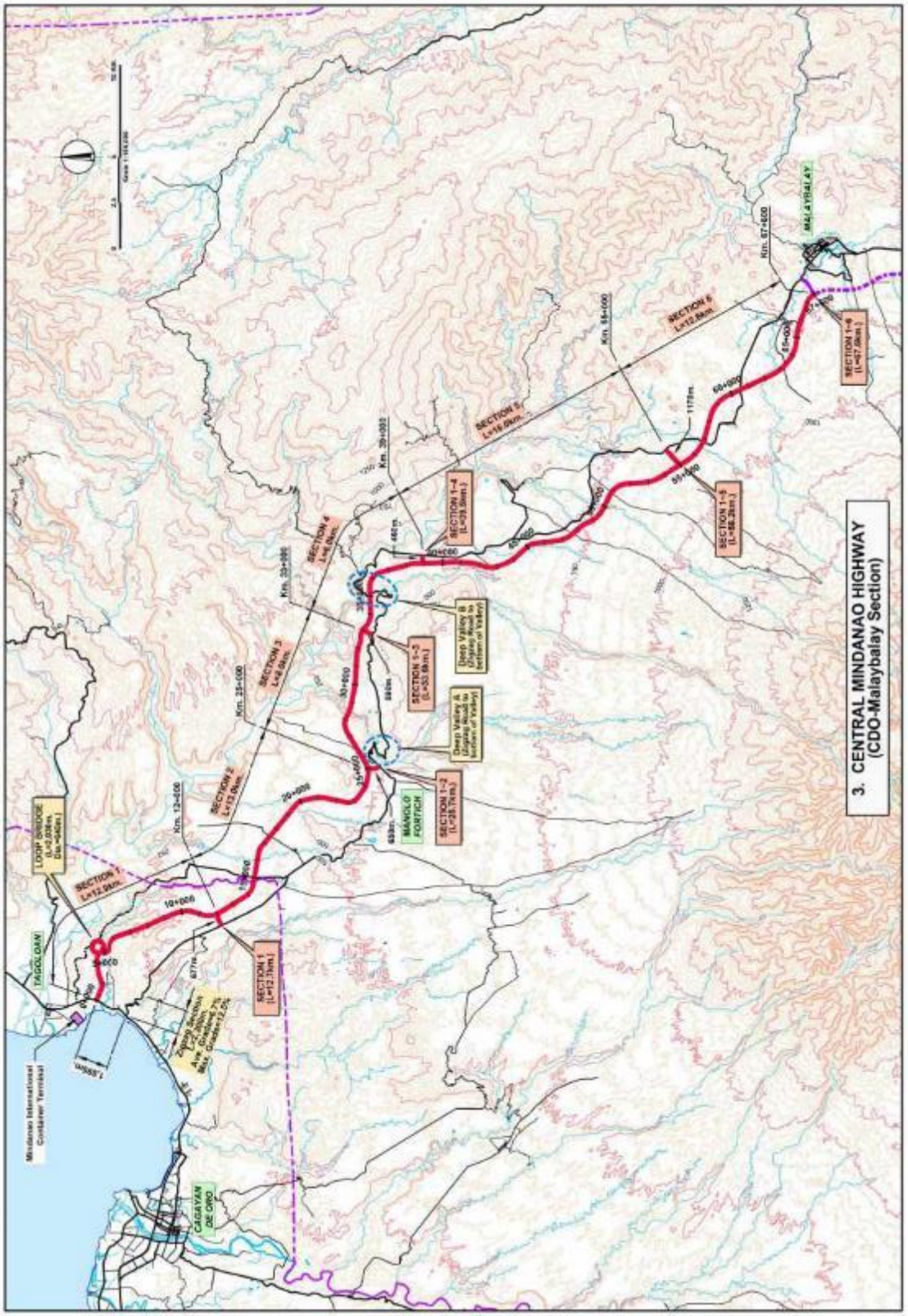


Figure 15.1-1 Project Location Map

Source: JICA Study Team

15.1.3 Justification of the Project

(1) Necessity of CMH

The CMH is envisioned to be the most important transportation corridor in Mindanao, connecting Cagayan de Oro (CDO) and Davao City Metropolitan Centers.

The road will be constructed as a High Standard Highway Class 1 in HSH M/P, and it is expected to greatly contribute to the economic development in Mindanao.

At present, the travel time between CDO and Davao City is about six and a half hours by car. Once the project is realized, the travel time between CDO and Davao City would be significantly reduced to three and a half hours.

(2) Cagayan De Oro ~ Malaybalay Section

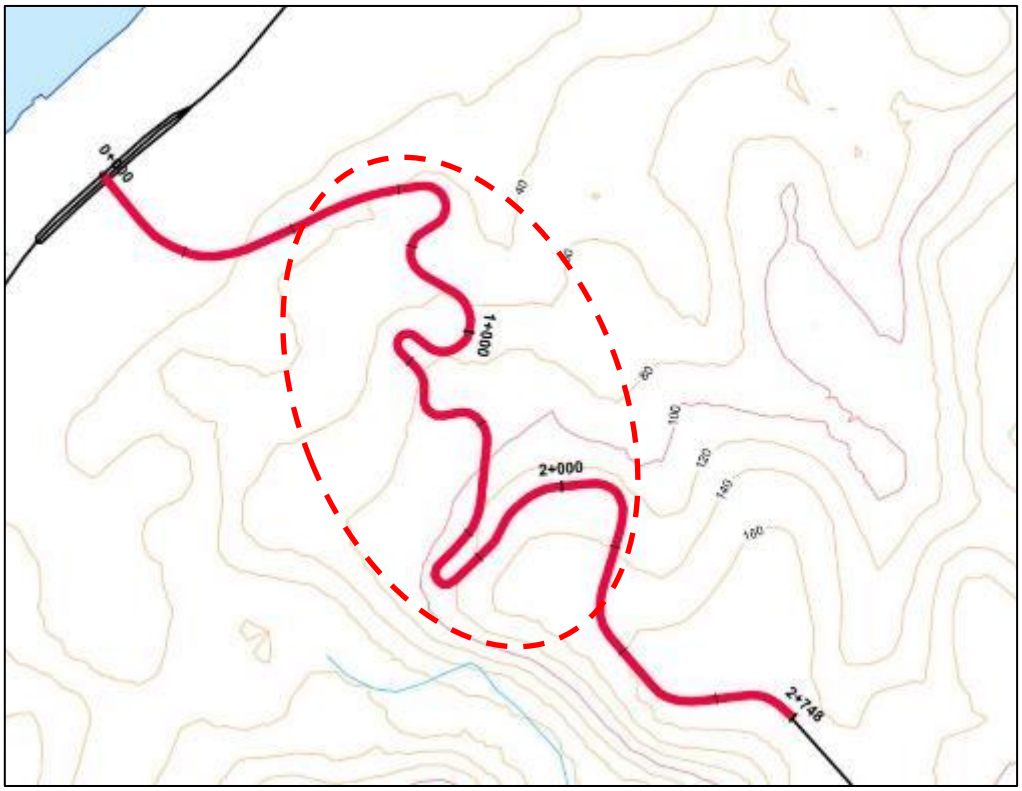
The CDO – Malaybalay section would serve as a gateway for transporting agricultural products as there are large plantations along the road that could potentially boost the local economy.

It is likewise an essential road for residents along the area to access the CDO metropolitan center. However, there are sections with steep slopes (Sayre Highway), which hinder smooth and safe travel of road users.

The existing observed daily traffic volume is approximately 8,000 vehicles/day which is the traffic count survey result in 2019. Future traffic volume in 2040 that pass through this road was estimated to be over 20,000 vehicles/day.

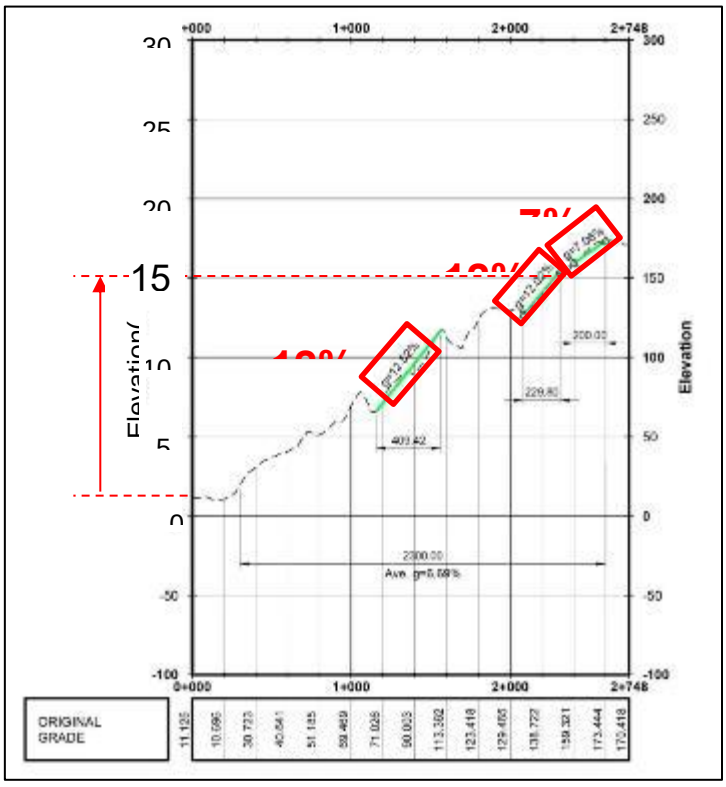
(3) Existing Road Condition (Sayre Highway)

The beginning section of Sayre Highway features zigzag sections which create bottlenecks. These sections hinder smooth transport of vehicles and raises traffic safety concerns. Vehicles, especially large trucks, are forced to drive at a very low speed to ensure safe driving.



Source: JICA Study Team

Figure 15.1-2 Sharp Curve Section of Sayre Highway Alignment



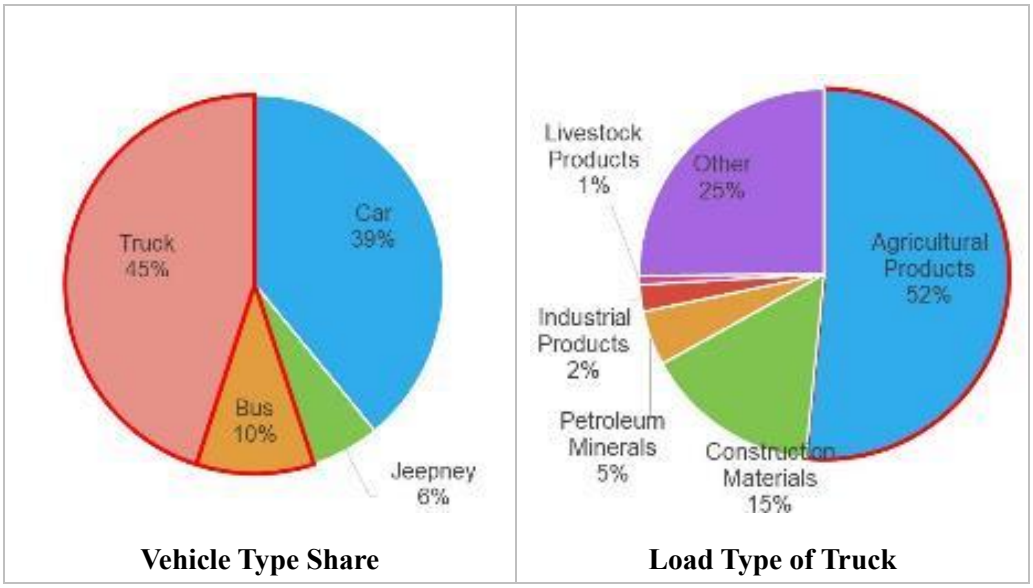
Source: JICA Study Team

Figure 15.1-3 Profile of Sayre Highway Alignment

As shown in **Figure 15.1-2**, the first 2-km section has many existing sharp curves. There is a height difference of about 150 m in the section of about 2km and a continuous gradient of more than 10% along the zigzag section as shown in **Figure 15.1-3**. The assumed design speed is 20km/h for this section on the current alignment.

(4) Traffic Situation at the Zigzag Section

A traffic survey was conducted along the zigzag section of the Sayre Highway. The Annual Average Daily Traffic Volume was 8,080 vehicles. The share of trucks was high at 45%, followed by cars at 39%, as shown in **Figure 15.1-4**. Based on the roadside interview survey, more than half of trucks volume carried "agricultural products". It can be said that this corridor is mainly for agribusiness due to many plantation areas.



Vehicle Type Share **Load Type of Truck**

Source: JICA Study Team

Figure 15.1-4 Traffic Data at the Zigzag Section (2019 Data)

Figure 15.1-5 shows the map of the travel speed survey result. The speed is based on a free flow by sedan car (2019 travel speed survey). Less than 20 km/h was observed at the hairpin section.

Source: JICA Study Team

Figure 15.1-5 Travel Speed Survey Result

(5) Traffic Accident along Sayre Highway

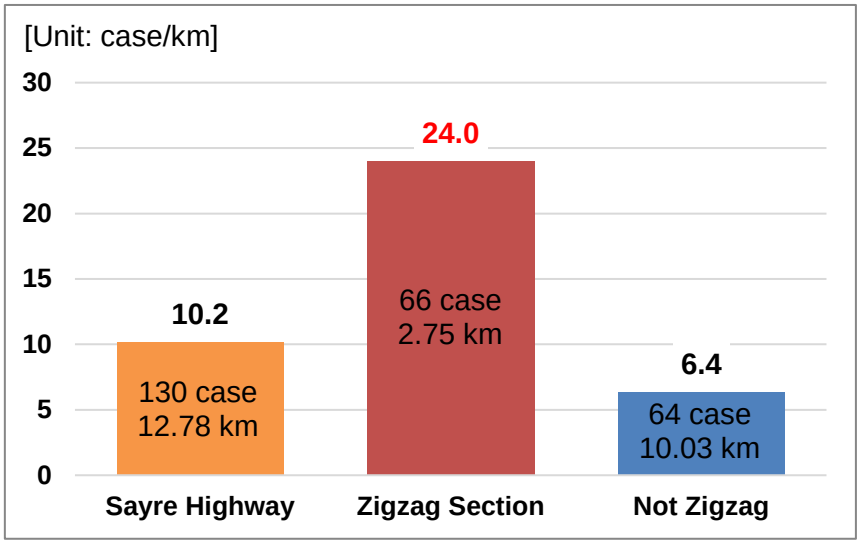
The traffic accident data along Sayre Highway was collected from DPWH Region X and analyzed.

There were a total of 130 recorded traffic accidents over a 15-month period (January 2018 to March 2019), as shown in **Table 15.1-2**. The traffic accident per km along the zigzag section was 24.0, which is about 4 times higher than the rate along the non-zigzag section as illustrated in **Figure 15.1-6**. This rate was observed to be higher than the ordinary road section.

Table 15.1-2 Number of Traffic Accident along Sayre Highway (Jan. 2018 to Mar. 2019)

	Zigzag Section	Not Zigzag	Total
No of Accident (a)	66	64	130
Road Length km(b)	2.75	10.03	12.78
Accident/km(c=a/b)	**24.0**	6.4	10.2

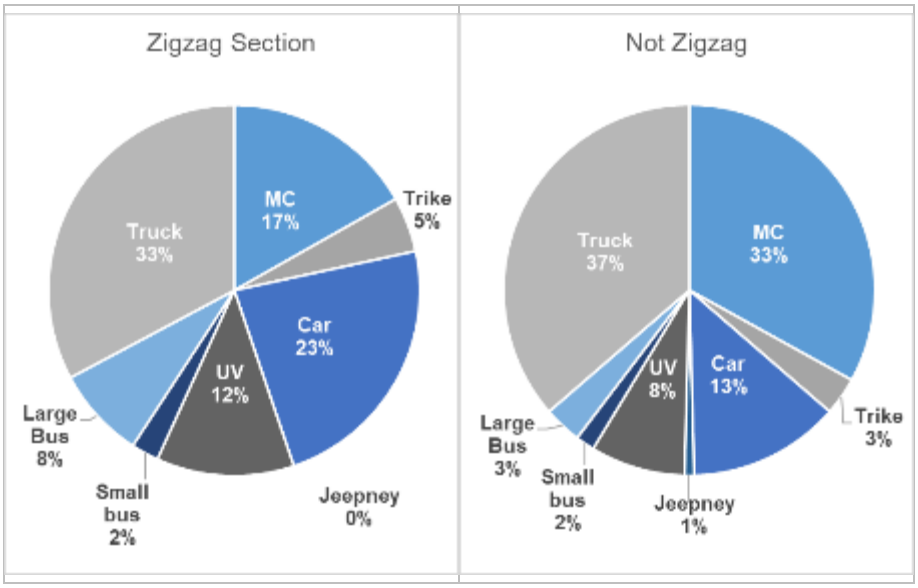
Source: JICA Study Team (original data from DPWH Region X)



Source: JICA Study Team (original data from DPWH Region X)

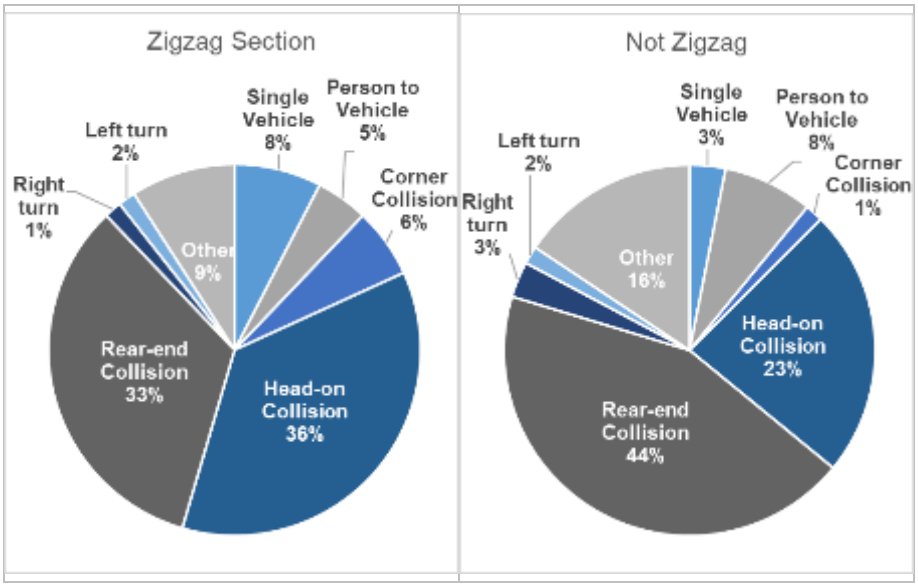
Figure 15.1-6 Traffic Accident per km along Sayre Highway

There is no big difference in percentages between zigzag section and non-zigzag section in terms of vehicle type as illustrated in **Figure 15.1-7**. Trucks comprised 33% to 37% of accidents in both zigzag and non-zigzag sections. The percentages of cause of traffic accidents (**Figure 15.1-8**), however, is different of that in zigzag and non-zigzag sections. The share of "Rear-end Collisions" along the non-zigzag section was very high, whereas "Head on Collision"," Single Vehicle" and "Corner Collisions" along the zigzag section was higher than that of the non-zigzag section. It seems that a specific cause of traffic accident is brought about by the sharp curve section. **Figure 15.1-9** plotted the different causes of traffic accidents along the zigzag section.



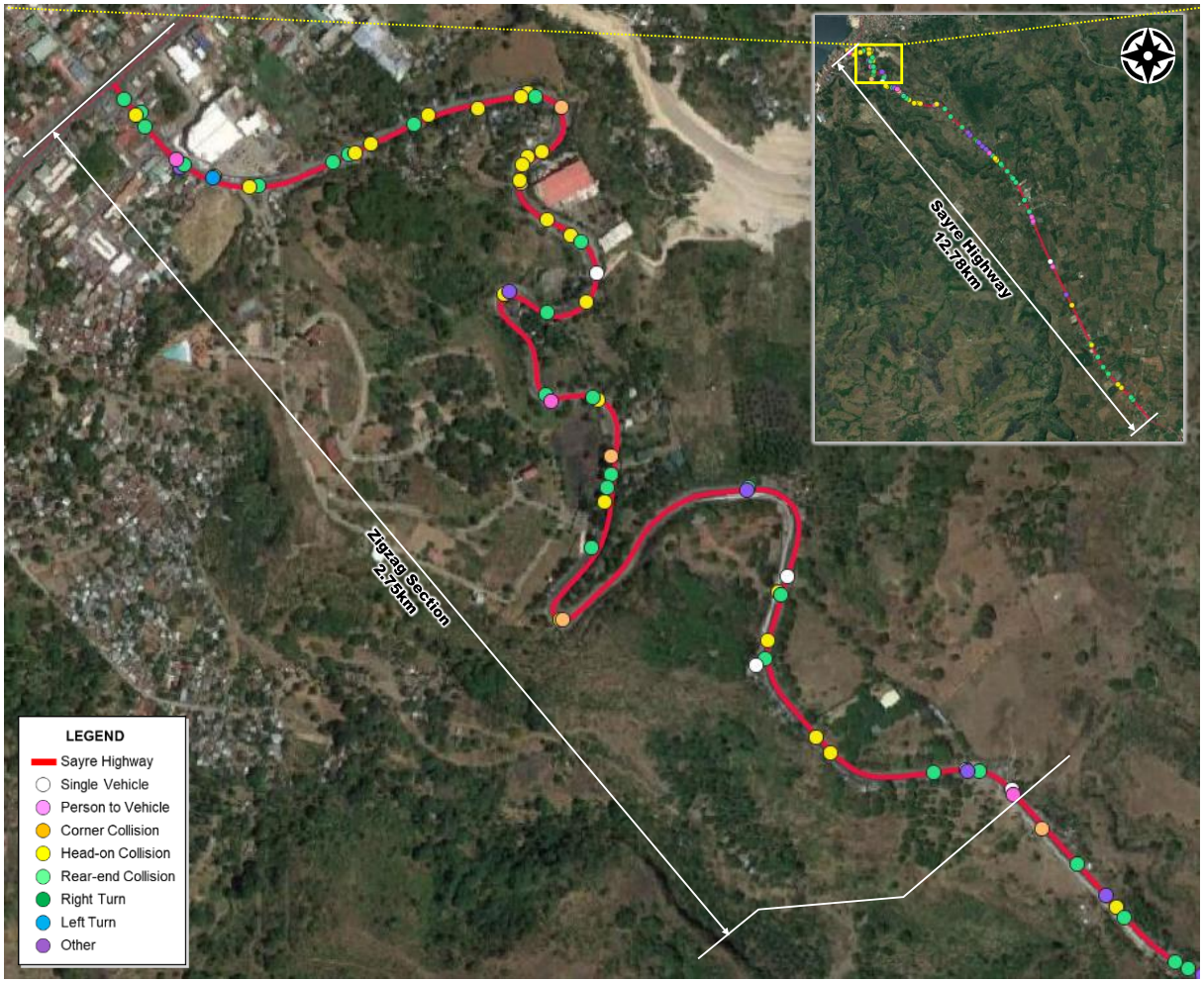
Source: JICA Study Team (original data from DPWH Region X)

Figure 15.1-7 Component Ratio of Traffic Accident by Vehicle Type



Source: JICA Study Team (original data from DPWH Region X)

Figure 15.1-8 Component Ratio of Traffic Accident Causes



Source: JICA Study Team (original data from DPWH Region X)

Figure 15.1-9 Traffic Accident Point in the Zigzag Section

(6) Alae-PHIVIDEC Bypass Road

A new bypass road between Bukidnon and Misamis Oriental was built by the DPWH Region X Office. The new bypass is called the Alae-PHIVIDEC Bypass Road and will serve as an alternate route for motorists coming from Alae, Bukidnon to Tagoloan, Misamis Oriental and vice versa.

As of March 2020, the project is almost completed already except for the new bridge as well as the drainage system that are under construction along the new bypass road.

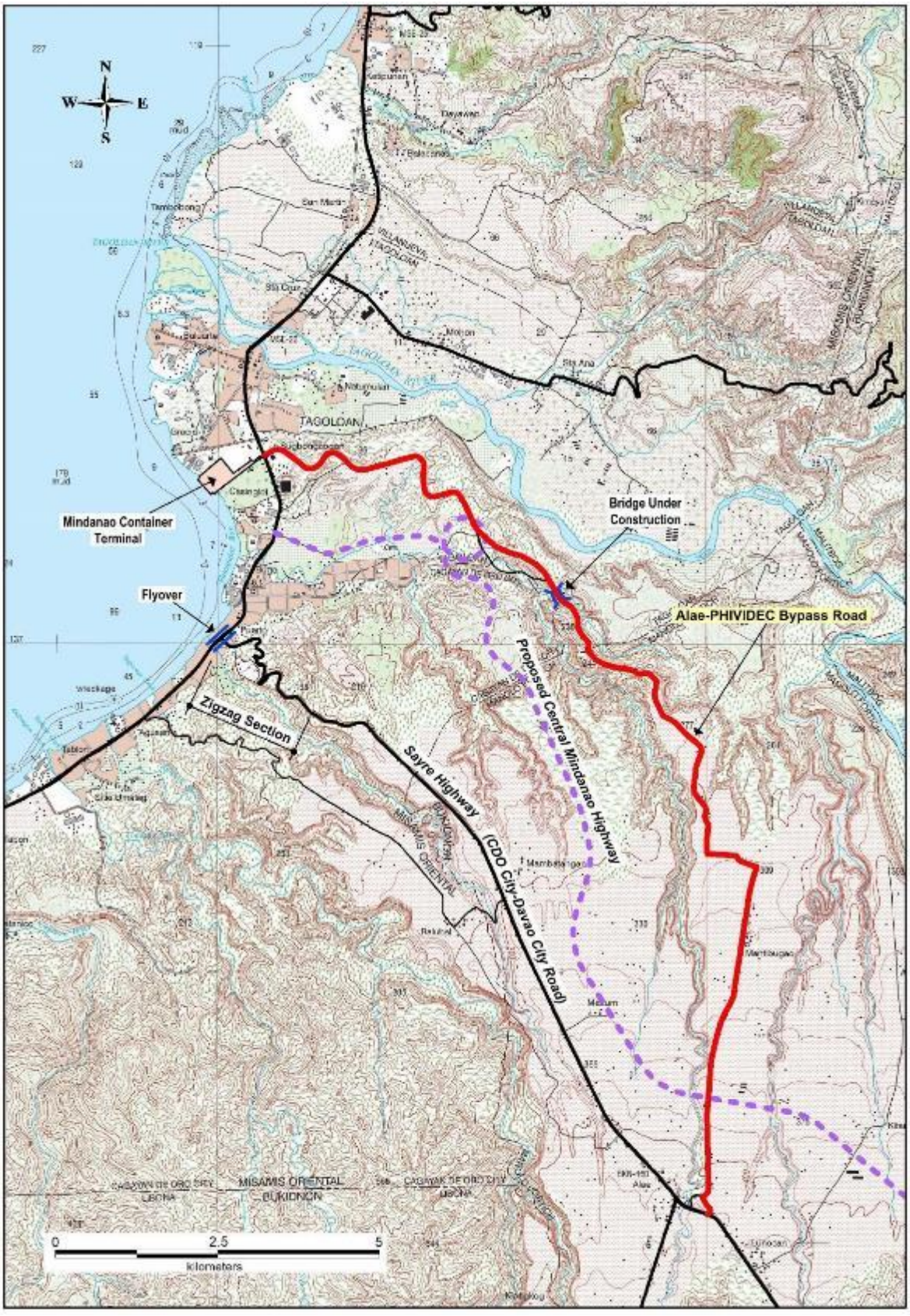
Once completed, the road is expected to divert the traffic along the Sayre Highway in Puerto-Alae Section. In addition, the new bypass road will also serve as an alternate thoroughfare for cargo trucks heading towards Mindanao Container Terminal (MCT) in Tagoloan.

As shown in **Table 15.1-3**, the road geometric element is not so high level such as many steep slope section and sharp curve. Design speed is 20 km/h based on design drawing's grade and curve elements.

Table 15.1-3 Alae-PHIVIDEC Bypass Road

Name	Alae-PHIVIDEC Bypass Road (Bukidnon - Misamis Oriental)
Length	10km (New Road) + 7km (Existing Road)
Number of Lanes	2 lanes
Radius	35m* 2 sections and 100m
Grade	12%*2 sections,10%, 7%
Design Speed	20km/h (based on the design element)

Source: Drawing by DPWH Region X



Source: JICA Study Team

Figure 15.1-10 Location Map of Alae-PHIVIDEC Bypass Road

Under construction Road

High Cut Section

New Bridge with High pier and drainage

New Bridge under construction

High Cut Section after Bridge under construction

Beginning section connect with Mindanao Container Terminal

Source: JICA Study Team

Figure 15.1-11 Alae-PHIVIDEC Bypass Road

15.2 Traffic Demand Forecast

Future traffic demand is forecasted to decide the design daily traffic volume and to obtain basic information for economic analysis of the project. The basic details of the traffic demand forecast are as follows:

Year of traffic demand forecast: 2040

Method of traffic demand forecast:

- ✓ Traffic assignment,
- ✓ Road network: 2040 road network including all proposed HSH class 1 and HSH class2,
- ✓ Link condition of CMH: 4-lane and Toll road
- ✓ OD table: 2040, 4 type vehicles (Car, Jeepney, Bus and Truck).

Future Traffic Volume of CMH under conditions: 4-ane and Toll road is forecasted as shown in **Table 15.2-1**. Based on the traffic demand forecast, the design traffic volume for CMH is around 18,000 vehicle per day, which is around 29,000 pcu per day.

Table 15.2-1 Future Traffic Volume in 2040

Unit: Vehicle/day

Section	2019	2040		
	Existing Road	CMH	Existing Road	Total
Section 1	8,100	17,200	5,800	23,000
Section 2		17,100	5,900	23,000
Section 3		18,100	4,700	22,800
Section 4		18,100	4,600	22,700
Section 5		17,400	4,300	21,700
Section 6		17,500	4,200	21,700

Existing road: Sayre Highway. Alae-PHIVIDEC Bypass Road is not included.
Source: JICA Study Team

Table 15.2-2 Design Volume in 2040

	Traffic Volume (Vehicle/day)	Traffic Volume (PCU)
CMH	18,000	29,000

Source: JICA Study Team

15.3 Preliminary Design

15.3.1 Design Standard

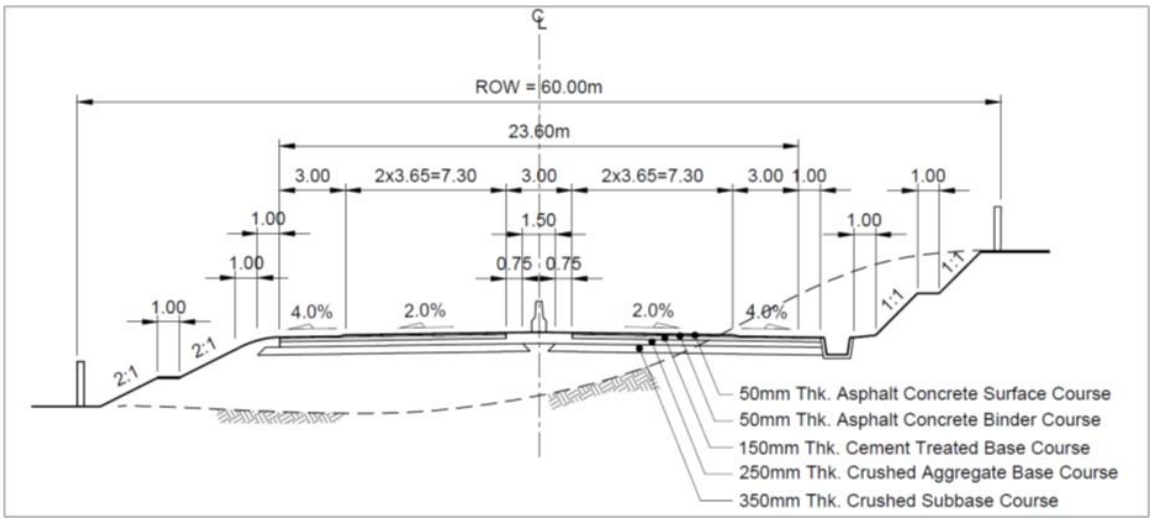
The proposed highway is an Inter-Regional High Standard Highway Class-1. The Geometric Design Criteria to be applied is shown in **Table 15.3-1**.

Table 15.3-1 Geometric Design Criteria

Items		Value
Design Speed		80 km/h
Maximum Grade		4% 5% is applicable (max. length: 600 m)
Radius	Minimum	230 m
	Desirable	280 m
No. of Lanes		2 (initial stage) in case of starting plan 4 (final stage)
Lane width		3.65 m
Medium strip width		3.00 m
Outer shoulder width		3.00 m

Source: JICA Study Team

The typical cross-section to be applied to the project is shown in **Figure 15.3-1**.



Source: JICA Study Team

Figure 15.3-1 Typical Cross-Section of Central Mindanao Highway (4-Lane)

15.3.2 Road Design Including Alternative Study

The project consists of six (6) sections as illustrated in **Figure 15.1-1**. The section is divided by interchanges. Basically, the proposed project will be developed parallel with Sayre Highway. There are three major issues related to the project:

(1) Alignment's Issues

1) Section 1

From the beginning point up to the 2 km mark, there is a 150 m elevation difference. As such, the alignments of Sayre Highway and Alae-PHIVIDEC Bypass Road (under construction) feature very steep slopes. In order to fulfill the HSH Class-1 design standard, the challenge is to determine the alignment that shall be applied in the area.

2) Section 3 and Section 4

There are deep valleys located in section 3 and section 4. Long Span Bridges will be necessary to traverse the deep valleys. This situation will be described in further detail in **Section 15.4**.

As other sections will not be so much different among other alternatives, alternative study was conducted in section 1.

(2) Alternative Alignment

Figure 15.3-2 illustrates the beginning point of the Central Mindanao Highway. The roadside of Butuan-Cagayan de Oro- Iligan Road is already developed and the only available section is along the southern area of the Mindanao Container Terminal ("S (Start)" mark). In addition, some inland communities were already developed into residential areas. The green colored area in the map represents the available area for the project.

Three alternatives were studied, as shown in **Figure 15.3-3**.

- Alternative -1 Loop Bridge alignment - Compact road alignment
- Alternative -2 Many curve sections in order to minimize the steep slope
- Alternative -3 Detour route in order to minimize the steep slope

Each Profile are prepared in **Figure 15.3-4**, **Figure 15.3-5** and **Figure 15.3-6**.

Table 15.3-3 shows the comparison table. Based on the comparison table, Alternative-1 or Alternative-3 is recommended. In view of the workability, Alternative-1 is better than Alternative-3, so road alignment is designed based on Alternative-1.

(3) Road Alignment

The road plan and profile were designed based on the geometric design criteria shown in **Table 15.3-1**. The road alignment is studied utilizing the secondary data of Google satellite map and ASTER GDM v2 Worldwide Elevation Data.

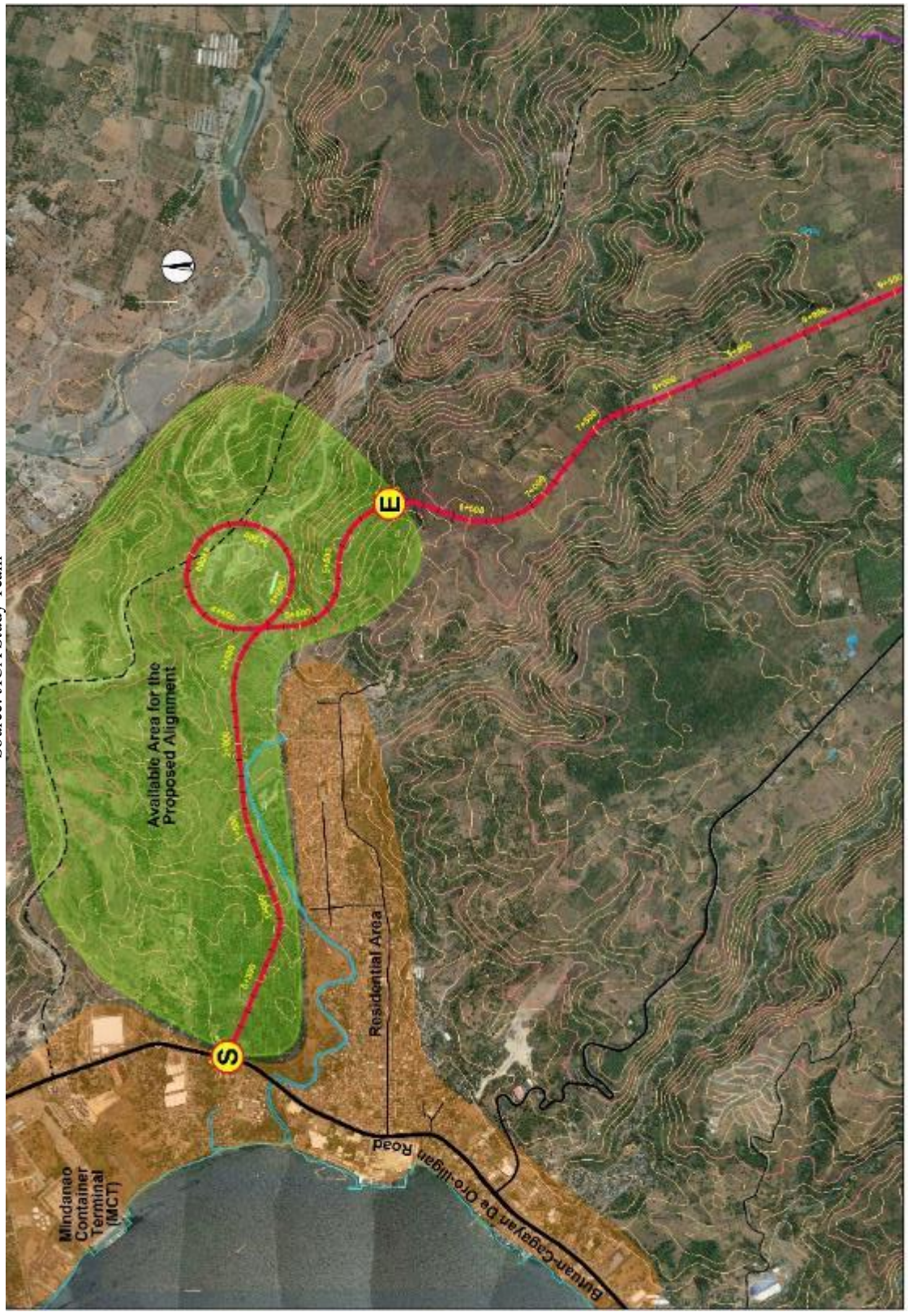
Basically, maximum embankment height and cut height was designed each 10m and 20m. In cases which exceed heights of 10m, viaducts were considered.

The interchange type applied was the trumpet type and all crossing roads were designed as overpass or underpass. **Table 15.3-2** shows the summary of quantity of proposed road alignment.

The plan and profile are shown in **Appendix 15-1**.

Table 15.3-2 Quantity of Road Alignment

	Section-1	Section-2	Section-3	Section-4	Section-5	Section-6	Total
Embankment Section (km)	6.58	11.14	3.96	3.40	11.71	8.65	45.52
High Cut Section(km)	1.84	0.40	2.91	1.04	2.11	2.05	10.35
Bridge(km)	3.74	1.46	1.13	1.08	2.73	1.75	11.88
Total(km)	**12.16**	**13.00**	**7.99**	**5.60**	**16.55**	**12.45**	**67.75**
Overpass (No.)	8	2	3	1	5	9	28
Underpass (No)	11	12	4	2	9	9	47
Interchange (No.)	1	1	1	1	1	1	6



Source: JICA Study Team

Figure 15.3-2 Available Space for the Proposed Alignment (Green Color)

Source: JICA Study Team

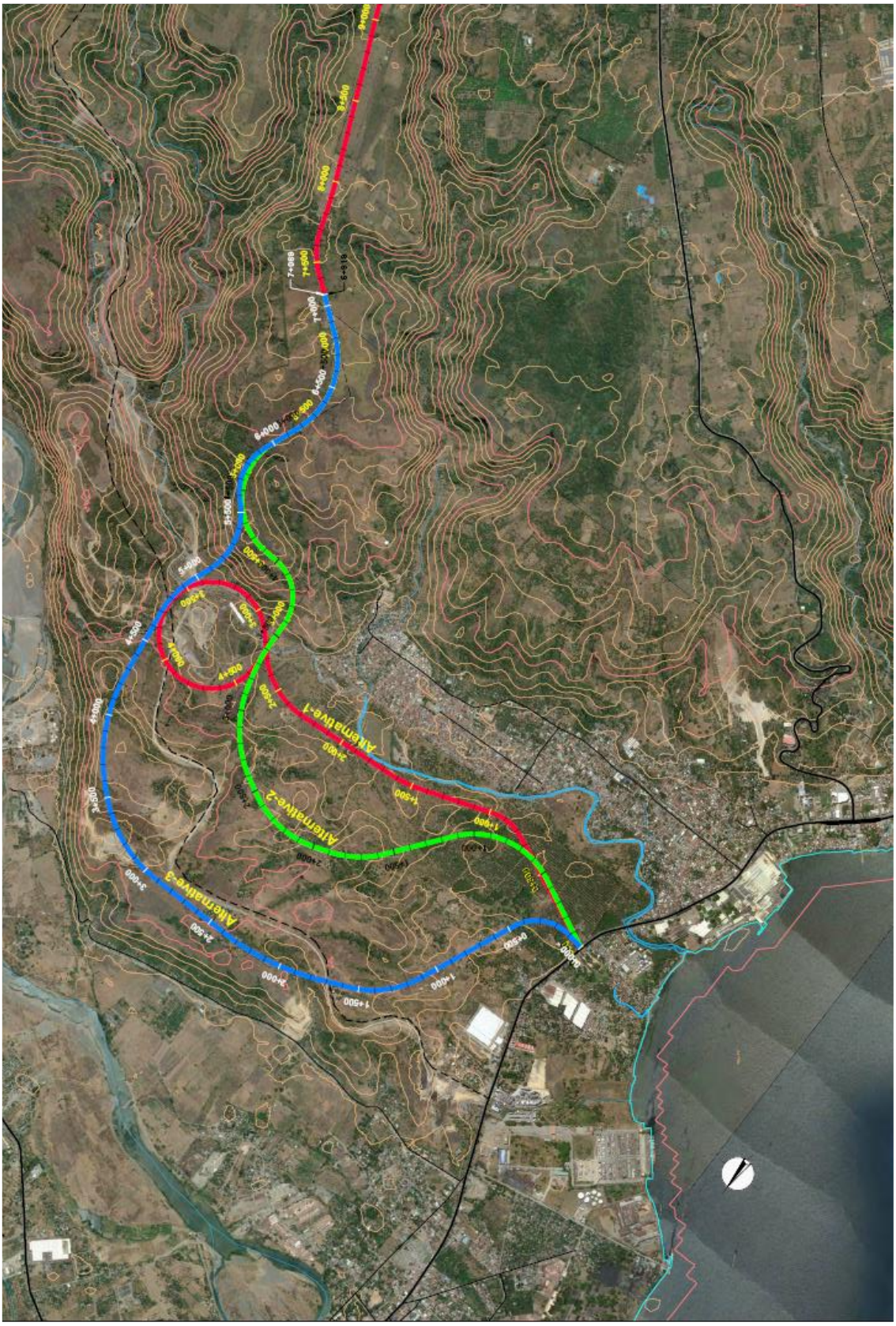


Figure 15.3-3 Alternative Alignments

Source: JICA Study Team

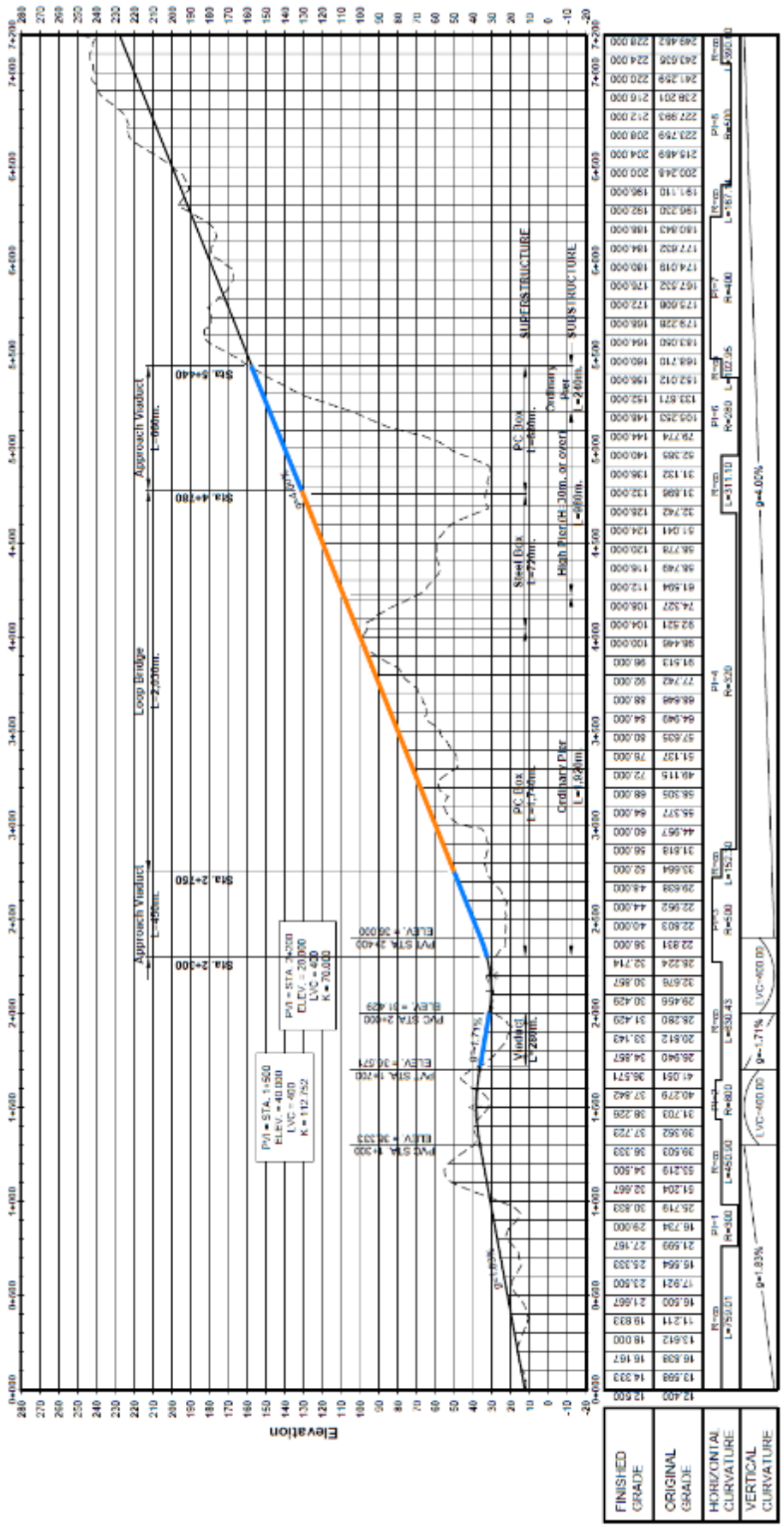


Figure 15.3-4 Profile of Alternative-1

Source: JICA Study Team

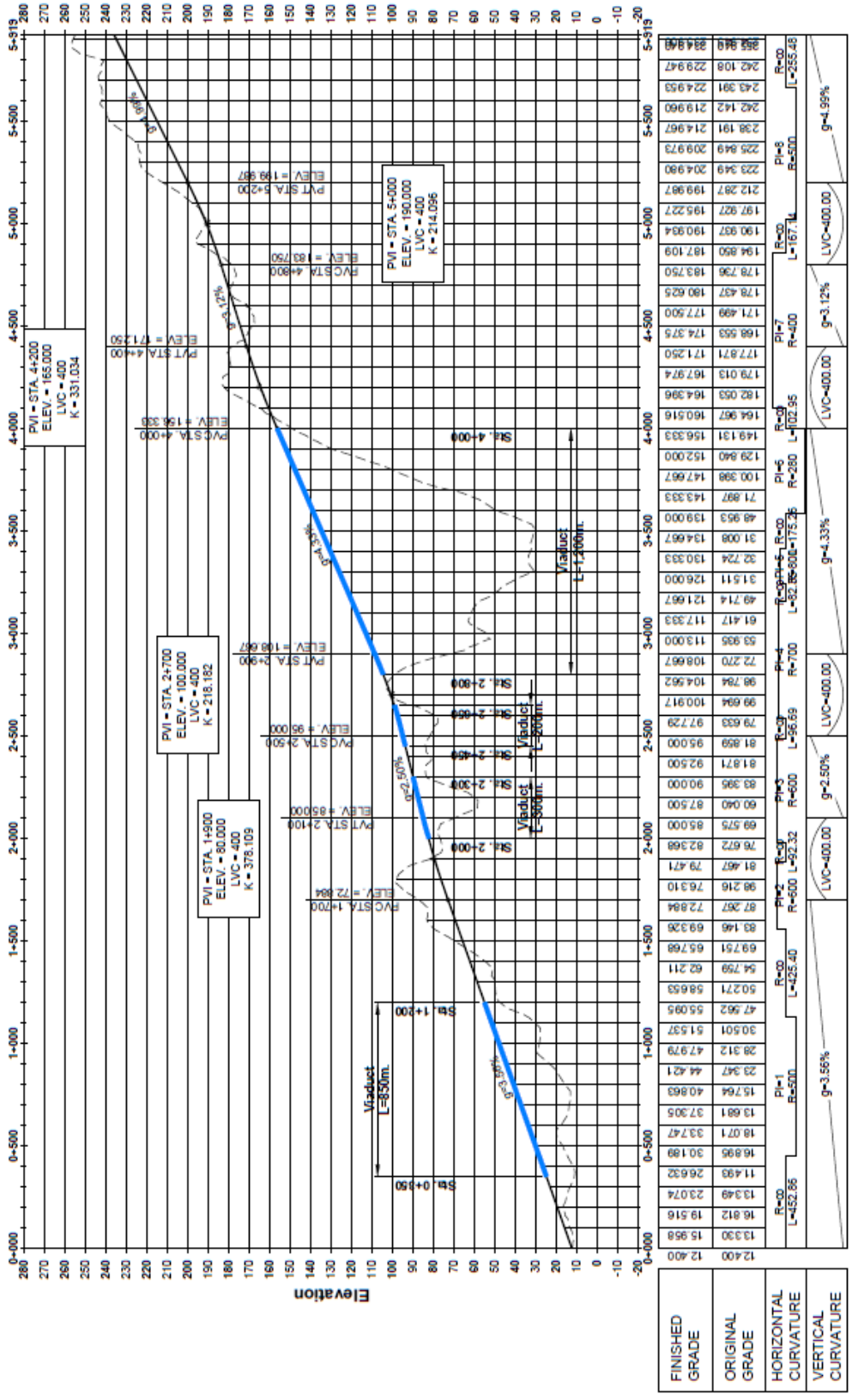


Figure 15.3-5 Profile of Alternative-2

Source: JICA Study Team

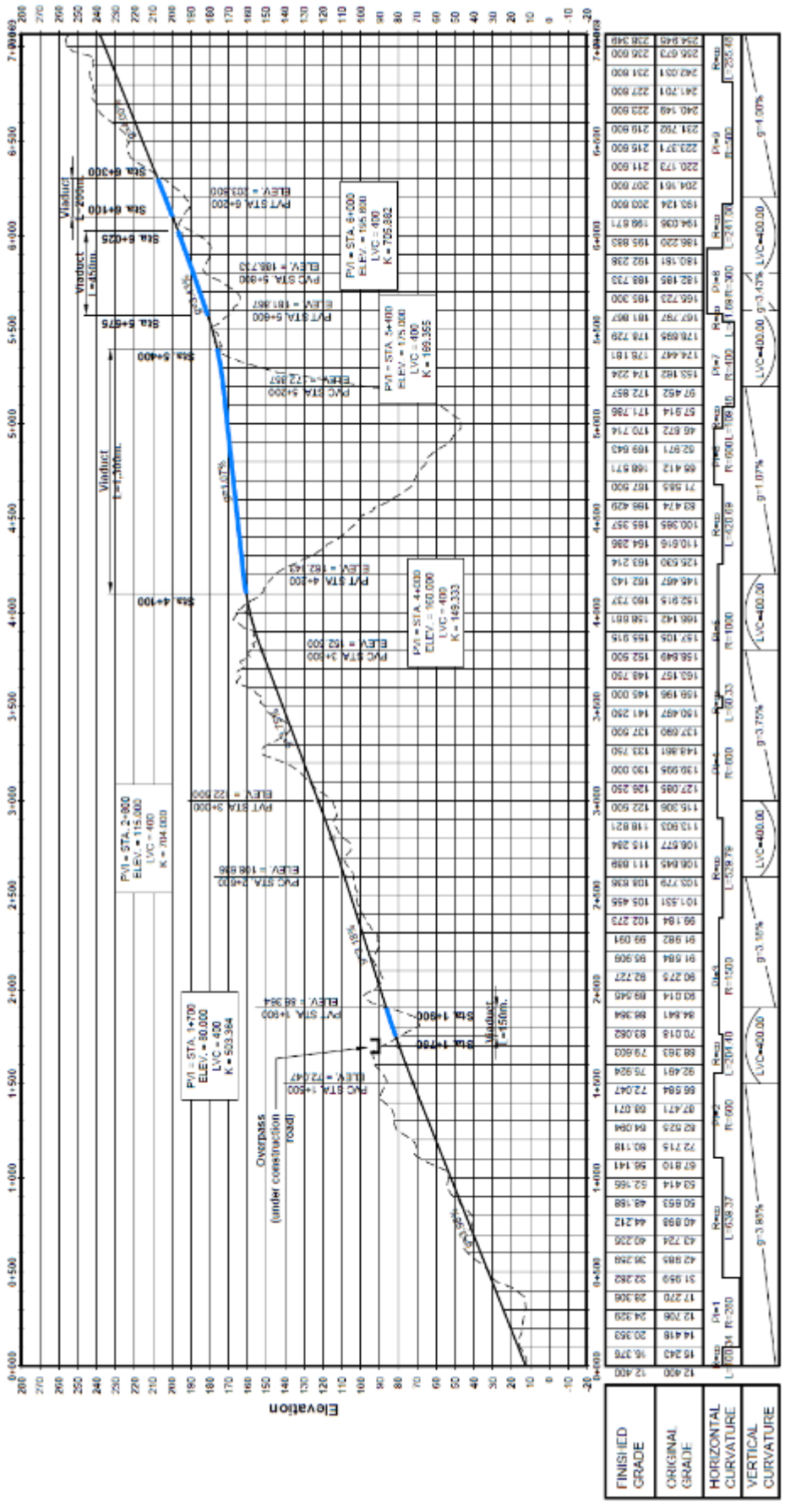


Figure 15.3-6 Profile of Alternative-3

Source: JICA Study Team

Table 15.3-3 Comparative Analysis of Central Mindanao Highway (Cagayan de Oro Section)

Alternative	Alternative-1 （Loop Bridge Plan）	Alternative-2 （Instead of Loop Bridge, apply many curve sections in order to minimize the slope section）	Alternative-3 （Plan which shift to north side to Alternative-1 in order to minimize the slope section）
Length	7.2km	5.9km（1.3km shorter than Alt-1）	7.1km（0.1km shorter than Alt-1）
Max. Gradient	4.0%	5.0%(l=700m), 4.3%(l=1200m)	4.0%
Long Span Bridge Length [Max. Span] Other Bridge Length Total Bridge Length	1,880m (Loop Bridge[60m]) 1,390m（Approach Bridge） **3,270m (1.00)**	1,200m (Truss Type[180m]) 1,350m (Three Bridge) **2,550m (0.78)**	1,300m (Arch Type[300m]) 800m (Three Bridge) **2,100m (0.64)**
Applicable Advanced Construction Technology (Long Span Bridge)	Upper Structure：Narrow box steel girder, Composite floor slab, Corrosion Resistance Steel for Painting Life Span Extension Substructure：High Pier (Hybrid Hollow High Pier, REED System Pier, SPER System Pier) Foundation：Large diameter caisson pile, Geo-Reinforcing Type Caisson Pile, TAKEWARI type earth retaining method	Upper Structure：High performance steel plate, Corrosion Resistance Steel for Painting Life Span Extension Substructure：High Pier (Hybrid Hollow High Pier, REED System Pier, SPER System Pier) Foundation：Large diameter caisson pile, Geo-Reinforcing Type Caisson Pile, TAKEWARI type earth retaining method	
Construction Cost (4lane) - Bridge Section - Road Section - Total	28.0 Billion PHP 1.1 Billion PHP **29.1 Billion PHP** **(1.00)** （○）	28.7 Billion PHP 1.1 Billion PHP **29.8 Billion PHP** **(1.03)** （△）	26.4 Billion PHP 1.6 Billion PHP **28.0 Billion PHP** **(0.96)** （◎）
Construction Cost (2lane) - Bridge Section - Road Section - Total	14.0 Billion PHP 0.8 Billion PHP **14.8 Billion PHP** **(1.00)** （○）	14.4 Billion PHP 0.8 Billion PHP **15.2 Billion PHP** **(1.03)** （△）	13.2 Billion PHP 1.1 Billion PHP **14.3 Billion PHP** **(0.96)** （◎）
Route Alignment (Drivability)	All sections are within 4% gradient and has the most compact alignment. Long curve section (L-=2,030m, R=320m) continues at the loop bridge section and it fully satisfies the design speed of 80km/h. （◎）	It is the steepest slope (5.0%- 4.3%) even though long span bridge section is the shortest. It does not partially satisfy the design speed of 80km/h （△）	All sections are within the 4% gradient, and the horizontal alignment passes a detour around the mountain area, and it fully satisfies the design speed of 80km/h. （◎）
Environmental Consideration	There is no difference among the three alternatives -Environmental condition of each alternative is almost same on the slope and hilly area. Land is used as cultivated and bush area, and there are not so many structures (The number of affected structures is as follows) - Cagayan de Oro Section (all of three alternatives) is over 20 km far from KBA (Key Biodiversity Area) /IBA (Important Bird and Biodiversity Area) and approved area of CADT (Certificates of Ancestral Domain Titles).		
Affected Forest by passing Central Mindanao Highway	4.4 km (○)	3.3 km (◎)	4.6 km (△)
No of Affected Building	34 （○）	27 (◎)	41 (△)
Workability	Best; for the steel girder section, the truck crane bent method and for the PC box section the cantilever overhang erection method will be applied. Both methods are standard erection method. （◎）	Good; application of the cable erection method for truss bridge Cable erection method is unfamiliar in the Philippines. Many bridge parts for truss structures （△）	Better; application of the cable erection method for arch bridge Cable erection method is unfamiliar in the Philippines. Many bridge parts of braced arch rib, but not much for truss structures （○）

Note: Special Bridge Cost was estimated based on the actual cost and construction estimate data in Japan. As a Special Bridge in the Alternative-1 will reduced the cost utilizing procured local firm, material and equipment compared with the other two alternatives. It will be studied further during the F/S for possible cost reduction.

Source: JICA Study Team

15.4 Preliminary Bridge Design

As a result of comparative analysis in the previous section, no significant difference was found between Alternative 1 and Alternative 3. Although the section of best alternative should be considered in the F/S stage, the preliminary bridge design, the cost estimation and the economic analysis etc. from this section will be carried out for Alternative 1 that would be most costly.

15.4.1 Applied Design Standard and Criteria

The following Guidelines, Department Orders (DOs) and Specifications are applied for the bridge design:

1) DPWH Design Guidelines, Criteria and Standards, Volume V 2015 (DGCS)
2) DPWH LRFD Bridge Seismic Design Specifications, 1st Edition 2013 & Interim Revision 2019 (BSDS)
3) AASHTO LRFD Bridge Design Specifications, 8th Edition 2018
4) AASHTO LRFD Bridge Construction Specifications, 3rd Edition 2016
5) Japan Road Association, Specifications for Highway Bridges, Part 1 to Part 5, Nov 2017

15.4.2 Summary of Design Results

Table 15.4-1 shows the summary of Bridge Plans Results.

Table 15.4-1 Summary of Bridge Plan

Special Bridge			
Section	**Type**	**No. of Bridge**	**Total Length (m)**
Section-1	Loop Bridge	1	3,660
Section-3	Steel Bridge	1	660
Section-3	Truss Bridge	1	635
Section-4	Arch Bridge	1	560
Total			5,515
Ordinary Bridge			
Section	**Type**	**No. of Bridge**	**Total Length (m)**
Section-1	PC I-girder	1	80
Section-2	PC I-girder and PC Continuous Rigid-Frame	3	800
Section-3	PC I-girder	2	490
Section-4	Concrete Box girder	1	520
Section-5	PC I-girder and PC Continuous Rigid-Frame	10	2,725
Section-6	PC I-girder	6	1,750
Total		23	6,365

Source: JICA Study Team

15.4.3 Special Bridge

(1) Loop Bridge

The loop bridge section is between Sta. 2+750 and 4+780, configured at the shallow valley and the deep valley where a ridge also exists. In addition, the road alignment has a small curve with a radius of 340m. Therefore, the loop bridge section shall be designed by the following.

The Shallow Valley Section from Sta. 2+750 to 3+900

The depth of the valley on this section is about 20m and is considered shallow. Therefore, the impact from the superstructure to the substructure and the foundation is considered to be small. Even if the superstructure is heavy like a concrete structure, the bridge in this section shall be designed as a general bridge.

Table 15.4-2 Plan of the Shallow Valley Section

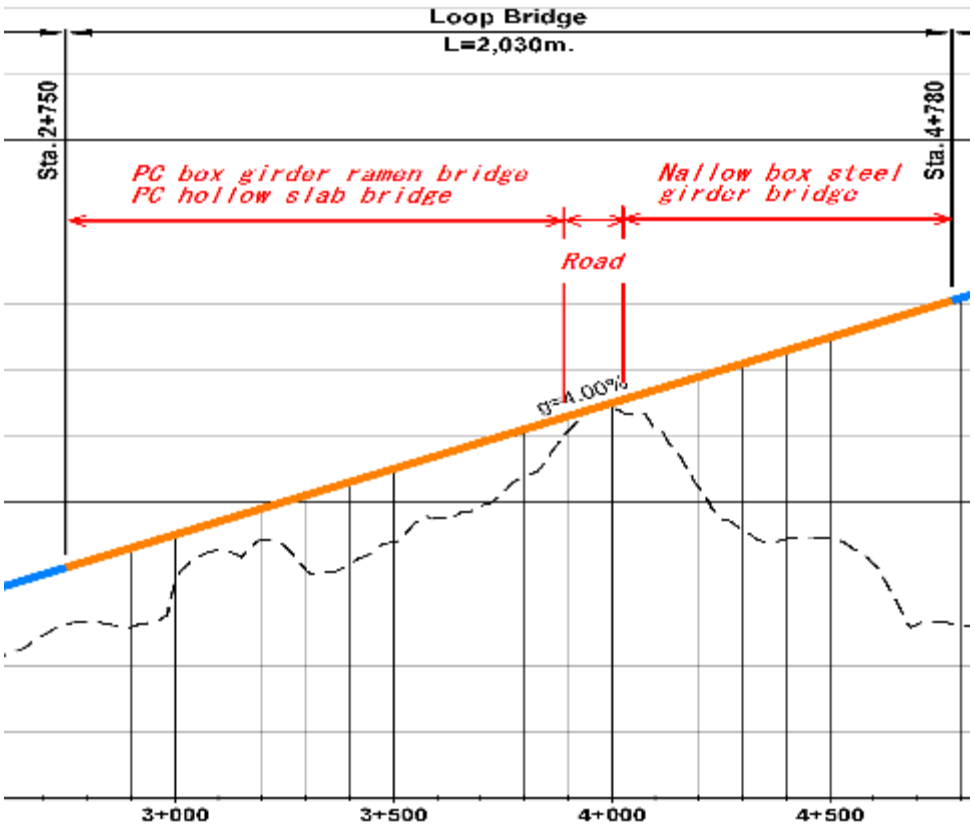
Sta. No	Bridge Type	Depth of Valley (m)
Sta.2+750 - Sta.3+020	PC Box Girder Rigid-Frame Bridge	20m or more
Sta.3+020 - Sta.3+220	PC Hollow Slab Bridge	10m or more
Sta.3+220 - Sta.3+900	PC Box Girder Rigid-Frame Bridge	20m or more

The Ridge Section from Sta. 3+900 to 4+040

This section is configured by both the ridge and some shallow valleys is less than 5m. It shall be designed as the road constructed with excavation and embankment.

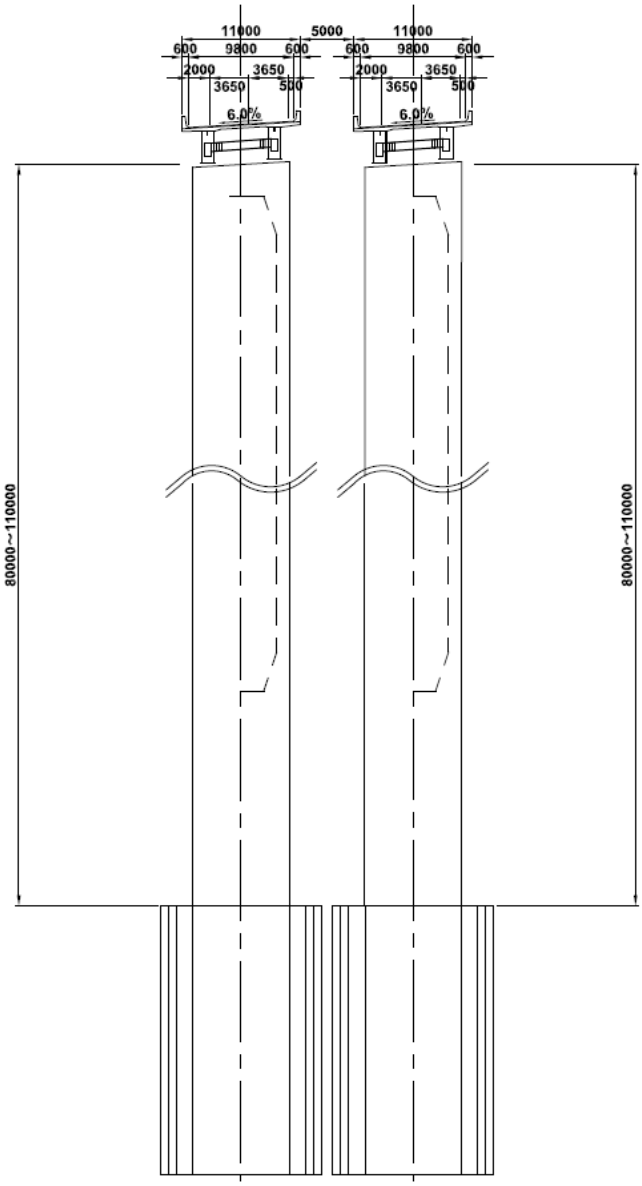
The Deep valley Section from Sta. 4+040 to 4+780

The depth of the valley on this section is about 100m and is considered deep. Since the impact from the superstructure to the substructure and the foundation is considered to be huge, the bridge in this section shall be designed as a steel bridge which has lighter weight. In addition, regarding the steel bridge type, it shall be designed as a narrow box steel girder which has lighter weight and easy maintenance. This bridge type is the latest advanced construction technology. The Structural Classification at the loop section and the Cross Section of the narrow box steel girder is shown in **Figure 15.4-1** and **Figure 15.4-2**.



Source: JICA Study Team

Figure 15.4-1 Profile of Loop Bridge Section



Source: JICA Study Team

Figure 15.4-2 Cross Section of Loop Bridge (Narrow Box Steel Girder and High Pier)

(2) Truss Bridge

The section between Sta. 28+300 and 29+900 has a deep valley, and therefore, a long span bridge shall be designed. One of the candidate super structure is the truss bridge. **Figure 15.4-3** and **Figure 15.4-4** illustrated the side view drawing and Cross Section.

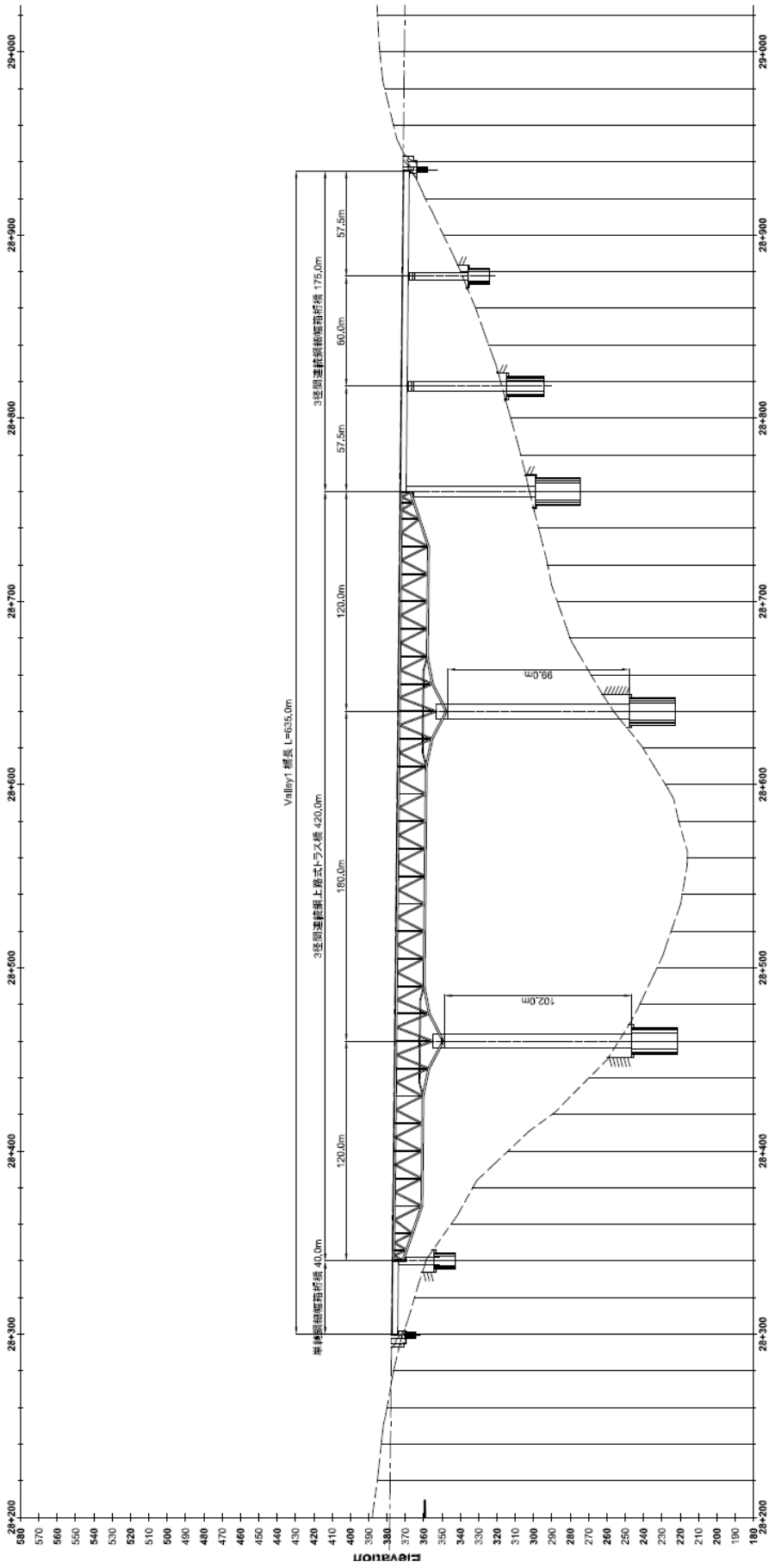
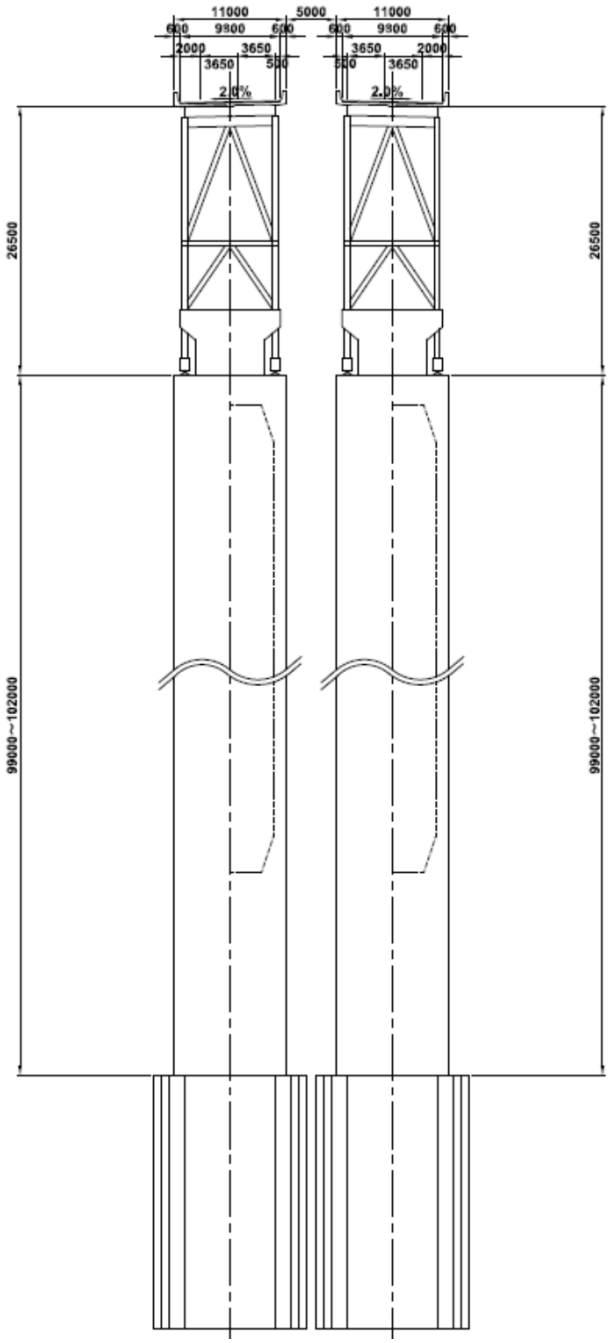


Figure 15.4-3 Side View of Truss Bridge Section

Source: JICA Study Team



Source: JICA Study Team

Figure 15.4-4 Cross Section of Truss Bridge

(3) Arch Bridge

The section between Sta. 34+800 and 35+400 is a deep valley and therefore, a long span bridge shall be designed. One of the candidate super structure is an arch bridge due to its section symmetry. The side view drawing and Cross Section is shown in **Figure 15.4-5** and **Figure 15.4-6**, respectively. Another arch bridge shall be designed between Sta. 31+750 and 32+150.

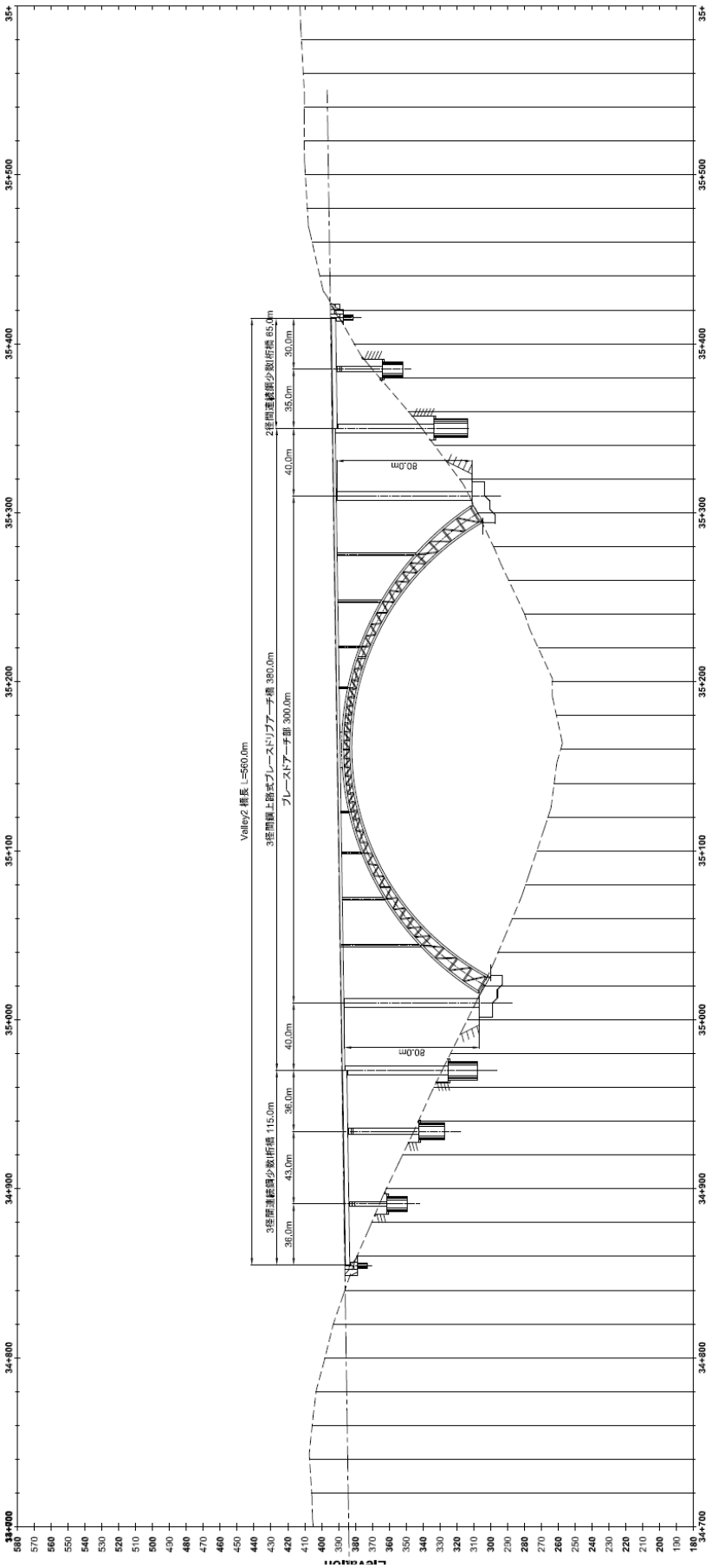
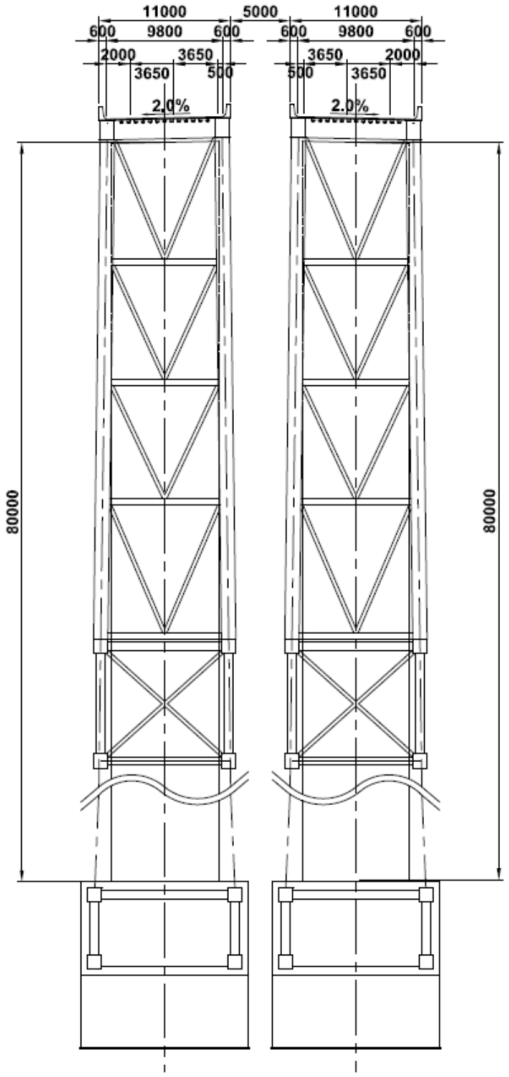


Figure 15.4-5 Side View of Arch Bridge Section

Source: JICA Study Team



Source: JICA Study Team

Figure 15.4-6 Cross Section of Arch Bridge

15.4.4 Ordinary Bridge

The result of the preliminary bridge design is summarized in **Table 15.4-3**.

Table 15.4-3 Bridge Plan Result

No.	Section No.	Sta.	Length(m)	Structure Type	No. of Span	Span Arrangement
1	1	0.9kp	80	PC I-girder	2	2@30+20
2	2	14.7kp	315	PC I-girder	9	9@35
3	2	16.0kp	240	PC Continuous Rigid-Frame	3	3@80
4	2	19.5kp	245	PC I-girder	7	7@35
5	3	30.4kp	280	PC I-girder	8	8@35
6	3	31.3kp	210	PC I-girder	6	6@35
7	4	33.5kp	520	Concrete Box Girder	9	50+7@60+50
8	5	44.5kp	280	PC I-girder	8	8@35
9	5	46.9kp	315	PC I-girder	9	9@35

No.	Section No.	Sta.	Length(m)	Structure Type	No. of Span	Span Arrangement
10	5	48.7kp	385	PC I-girder	11	11@35
11	5	50.0kp	280	PC I-girder	8	8@35
12	5	52.8kp	245	PC I-girder	7	7@35
13	5	53.2kp	245	PC I-girder	7	7@35
14	5	53.6kp	240	PC Continuous Rigid-Frame	3	3@80
15	5	53.9kp	320	PC Continuous Rigid-Frame	4	4@80
16	5	54.4kp	210	PC I-girder	6	6@35
17	5	54.7kp	210	PC I-girder	6	76@35
18	6	55.9kp	140	PC I-girder	4	4@35
19	6	56.2kp	350	PC I-girder	10	10@35
20	6	60.0kp	315	PC I-girder	9	9@35
21	6	62.2kp	70	PC I-girder	2	2@35
22	6	65.1kp	560	PC I-girder	16	16@35
23	6	67.0kp	315	PC I-girder	9	9@35

Source JICA Study Team

15.4.5 Advanced Construction Technology

The following advanced construction technologies are proposed:

Table 15.4-4 Applicable Advanced Construction Technologies for the Project

Advanced Construction Technology	Advantages	Applicability to this project
1) High-performance materials owned by other countries		
(1) High performance steel	Reduced member weight by improving yield strength and labor saving in the manufacturing process by improving welding and processing performance	By reducing the weight of the members and saving labor in the process of manufacturing the curved girder, a reduction in the total cost of the bridge can be expected.
2) Technology that minimizes maintenance		
(1) Weather Resistant Steel	It is a steel material that does not require painting, so maintenance in terms of painting and repainting can be omitted.	The repainting will not be needed, which can reduce bridge maintenance costs.
(2) Corrosion Resistance Steel for Painting Life Span Extension	The repainting cycle can be significantly extended (30 to 70 years), saving labor for maintenance.	The repainting cycle can be extended, and the effect of reducing bridge maintenance costs can be expected.
(3) Composite floor slab	Due to its high durability, it is possible to extend the cycle of the floor slab replacement period and reduce labor costs.	The effect of reducing maintenance costs by extending the floor slab replacement cycle can be expected.
(4) Narrow box steel girder	By reducing the box cross section from using synthetic floor slabs, it is possible to reduce the number of members and save maintenance, labor and weight.	Reduction of maintenance costs by reducing the number of members and reduction of bridge construction costs (initial cost) by reducing weight can be expected.

Advanced Construction Technology	Advantages	Applicability to this project
3) Effective technology in places where terrain conditions are severe (e.g., height differences)		
(1) Pre-fabrication method for piers (3H method and REED method, etc.)	By using H-steel instead of the rebar and using buried formwork of not needing removal, it is possible to save labor costs and construction costs.	Since high piers are installed in the loop, labor saving and cost reduction effects can be expected by using this method.
(2) Large diameter caisson pile (Geo-Reinforcing Type Caisson Pile)	Methods used to reduce terrain alteration and reduce environmental impact	By using it as a foundation for a high pier installed on or near the slope, it is possible to suppress the topographical alteration and reduce the environmental impact.

Source JICA Study Team

15.5 Cost Estimates of the Project

15.5.1 General

Since this is a Pre-Feasibility Study, a rough cost estimate will be applied.

15.5.2 Construction Unit Price

The reference data for the construction unit cost is shown in **Appendix 15-2**.

The cost of Long Span Bridge was estimated based on the Japan's Unit cost.

Table 15.5-1 Construction Unit Cost for Rough Cost Estimate

Structure Type		Unit Cost (mil. PHP/km)	Remarks
Earthwork - Embankment Section	2-lane	182.48	
	4-lane	262.57	
Earthwork - High Cut Section	2-lane	431.76	H=10
	4-lane	494.25	
Bridge - P/S Concrete Girder	2-lane	909.61	
	4-lane	1,739.29	
Bridge - Steel Box	2-lane	1,613.61	
	4-lane	3,342.74	
Interchange		358.04	Trumpet type including toll collection facilities
Overpass	Per bridge	55.56	W=8.5 m
Underpass	Per box culvert	52.10	W=8.5 m

Source: JICA Study Team

15.5.3 Construction Cost for Each Section

The construction cost for each section was roughly estimated in case of 2-lane and 4-lane as shown in **Table 15.5-2** and **Table 15.5-3**.

Table 15.5-2 Construction Cost for 4-lane

Item	Unit	Section-1	Section-2	Section-3	Section-4	Section-5	Section-6	Total
Special Bridge	Million Php	31,808.0	2,471.0	9,196.2	15,374.5	0.0	0.0	58,849.7
Ordinary Bridge	Million Php	139.1	1,391.4	852.3	904.4	4,739.6	3,043.8	11,070.6
Road Cut Sectiton	Million Php	909.4	197.7	1,438.3	514.0	1,042.9	1,013.2	5,115.5
Road Embankment	Million Php	1,727.7	2,925.0	1,038.4	913.7	3,076.0	2,271.2	11,952.0
Overpass(W=8.5m)	Million Php	444.5	111.1	166.7	55.6	277.8	500.1	1,555.8
Underpass(W=8.5m)	Million Php	573.1	625.2	208.4	104.2	468.9	468.9	2,448.5
IC	Million Php	358.0	358.0	358.0	358.0	358.0	358.0	2,148.2
Total	**Million Php**	**35,959.9**	**8,079.4**	**13,258.3**	**18,224.5**	**9,963.1**	**7,655.1**	**93,140.3**
	Mil. Php/km	2,957.2	621.5	1,659.4	3,254.4	602.0	614.9	1,374.8

Source: JICA Study Team

Table 15.5-3 Construction Cost for 2-lane

Item	Unit	Section-1	Section-2	Section-3	Section-4	Section-5	Section-6	Total
Special Bridge	Million Php	15,904.0	2,471.0	4,598.1	7,687.3	0.0	0.0	30,660.3
Ordinary Bridge	Million Php	72.8	727.7	445.7	473.0	2,478.7	1,591.8	5,789.7
Road Cut Sectiton	Million Php	794.4	172.7	1,256.4	449.0	911.0	885.1	4,468.7
Road Embankment	Million Php	1,200.7	2,032.8	721.7	635.0	2,137.8	1,578.5	8,306.5
Overpass(W=8.5m)	Million Php	444.5	111.1	166.7	55.6	277.8	500.1	1,555.8
Underpass(W=8.5m)	Million Php	573.1	625.2	208.4	104.2	468.9	468.9	2,448.5
IC	Million Php	358.0	358.0	358.0	358.0	358.0	358.0	2,148.2
Total	**Million Php**	**19,347.5**	**6,498.5**	**7,755.1**	**9,762.1**	**6,632.2**	**5,382.4**	**55,377.8**
	Mil. Php/km	1,591.1	499.9	970.6	1,743.2	400.7	432.3	817.4

Source: JICA Study Team

15.6 Construction Plan of the Project

1. Construction Planning

Detailed Construction Planning will be finalized during the detailed design stage. Based on the result of the Preliminary Design, the JICA Study Team prepared the preliminary construction plan. The project site is located in the mountainous area in Central Mindanao.

2. Construction Casting Yard

Major construction activities for the project are producing numbers of Steel Box Girders, Steel Truss type bridge and Steel Arch type bridge within the construction yard. These manufactured steel box girder, steel truss bridge and Steel Arch Bridge will be transported to the project construction site timely according to implementation schedule using by ship and land transport. The selection of construction casting yard is in the nearby construction site. The construction casting yard is temporary work station but production activities are large volume to prepare concrete materials by the concrete batch plant and assemble of Steel Bridge. The contractor will select proper location for the construction site and its scale during tender procedure.

3. Construction Method for Erection of Each Bridge

Assembled Steel Bridge will be located near the new bridge construction area. After assembling, each span of steel bridge will be erected following Erection method.

Cable Erection System, Traveler Crane System and Erection Girder System will be used for the very deep valley area with more than 50m dept. Recommended Erection System for each type of Bridge is shown in Table 15.6-1.

Table 15.6-1 Bridge Erection Method for Each Type of Bridges

Bridge Type	Proposed Erection System	Sample Picture
Steel Narrow Box Girder for Loop Bridge (Deep Vallay)	Launching Erection method (Deep Vallay H=90 m)) Bent System with Track Crane (H=20 m)	
Steel Truss Bridge (Deep Valley)	Traveler Crane System	
Steel Arch Bridge (Deep Vallay)	Cable Erection System	
Steel Box Girder Bridge (Viaduct)	Bent System with Track Crane	
PC Continuous Box Girder	Canchlever System	
PC-I Girder Bridge (Viaduct)	Track Crane	

Source: Yahoo Web Site

4. Construction Site and Access Road

The project construction site is in CDO-Malaybalay route in Central Mindanao. Access from the new road construction site and casting yard will be using the existing road or construction of a temporary road might be needed. This temporary road will be used for delivery of construction material to construction site. Casting yard will serve as stockpiling materials such as steel, formworks and scaffoldings for construction of piers and bridge.

5. Construction Schedule

The construction schedule did not take into consideration ROW acquisition-related activities such as demolition and relocation of houses and structures, which means that the construction schedule assumes that ROW acquisition for the Project has been completed and that each section has been cleaned up. Based on the above condition, total construction period for Construction for Central Mindanao Highway (CDO-Malaybalay Section) project will be 26 months for 4 lanes construction and 24 months for 2 lanes construction. Construction Schedule for Central Mindanao Highway (CDO-Malaybalay Section) Project is shown in Table 15.6-2 and Table 15.6-3.

6. Traffic Management and Safety during Construction

Traffic Management during construction for this project would be coordinate with LGU and Police to manage traffic along the site during construction. Each LGU has Traffic control section and this project needs support from them.

Table 15.6-2 Construction Schedule for Central Mindanao Highway (CDO-Malaybalay Section) 4 Lanes

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Mobilization																											
Section-1 L=12.16 km	Clearing and Grubbing																										
	High Cut Section L=1.84 km																										
	Embankment Section L=6.58 km																										
	Drainage																										
	Pavement (Asphalt)																										
	Loop Steel Box Bridge L=3,660 m			Fabrication								Assembling		Painting at Factory		Oversea Transport			Assembling/Erection/Bolting		Painting at site						
	PC-I Girder Bridge L=80 m																										
	Overpass 8 location																										
	Underpass 11 location																										
	Interchange 1 location																										
	Miscellaneous																										
Section-2 L=13.00 km	Clearing and Grubbing																										
	High Cut Section L=0.40 km																										
	Embankment Section L=11.14 km																										
	Drainage																										
	Pavement (Asphalt)																										
	Steel Bridge L=660 m			Fabrication							Assembling		Painting at Factory	Oversea Transport			Assembling/Erection/Bolting		Painting at site								
	PC-I Girder Bridge L=800 m																										
	Overpass 2 location																										
	Underpass 12 location																										
	Interchange 1 location																										
	Miscellaneous																										
Section-3 L=7.99 km	Clearing and Grubbing																										
	High Cut Section L=2.91 km																										
	Embankment Section L=3.96 km																										
	Drainage																										
	Pavement (Asphalt)																										
	Steel Truss Bridge L=635 m			Fabrication							Assembling		Painting at Factory	Oversea Transport			Assembling/Erection/Bolting		Painting at site								
	PC-I Girder Bridge L=490 m																										
	Overpass 3 location																										
	Underpass 4 location																										
	Interchange 1 location																										
	Miscellaneous																										
Section-4 L=5.60 km	Clearing and Grubbing																										
	High Cut Section L=1.04 km																										
	Embank Section L=3.40 km																										
	Drainage																										
	Pavement (Asphalt)																										
	Steel Arch Bridge L=560 m			Fabrication							Assembling		Painting at Factory	Oversea Transport			Assembling/Erection/Bolting		Painting at site								
	PC-Box Girder Bridge L=520 m																										
	Overpass 1 location																										
	Underpass 2 location																										
	Interchange 1 location																										
	Miscellaneous																										
Section-5 L=16.55 km	Clearing and Grubbing																										
	High Cut Section L=11.71 km																										
	Embank Section L=2.11 km																										
	Drainage																										
	Pavement (Asphalt)																										
	PC-I Girder Bridge L=2,730 m																										
	Overpass 5 location																										
	Underpass 9 location																										
	Interchange 1 location																										
	Miscellaneous																										
Section-6 L=12.45 km	Clearing and Grubbing																										
	High Cut Section L=2.05 km																										
	Embank Section L=8.65 km																										
	Drainage																										
	Pavement (Asphalt)																										
	PC-I Girder Bridge L=1,750 m																										
	Overpass 9 location																										
	Underpass 9 location																										
	Interchange 1 location																										
	Miscellaneous																										
Demobilization																											

Source: JICA Study Team

Table 15.6-3 Construction Schedule for Central Mindanao Highway (CDO-Malaybalay Section) 2 Lanes

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Mobilization																									
Section-1 L=12.16 km	Clearing and Grubbing																								
	High Cut Section L=1.84 km																								
	Embankment Section L=6.58 km																								
	Drainage																								
	Pavement (Asphalt)																								
	Loop Steel Box Bridge L=3,660 m			Fabrication							Assembling		Painting at Factory		Oversea Transport			Assembling/Erection/Bolting		Painting at site					
	PC-I Girder Bridge L=80 m																								
	Overpass 8 location																								
	Underpass 11 location																								
	Interchange 1 location																								
	Miscellaneous																								
Section-2 L=13.00 km	Clearing and Grubbing																								
	High Cut Section L=0.40 km																								
	Embankment Section L=11.14 km																								
	Drainage																								
	Pavement (Asphalt)																								
	Steel Bridge L=660 m			Fabrication						Assembling		Painting at Factory	Oversea Transport			Assembling/Erection/Bolting			Painting at site						
	PC-I Girder Bridge L=800 m																								
	Overpass 2 location																								
	Underpass 12 location																								
	Interchange 1 location																								
	Miscellaneous																								
Section-3 L=7.99 km	Clearing and Grubbing																								
	High Cut Section L=2.91 km																								
	Embankment Section L=3.96 km																								
	Drainage																								
	Pavement (Asphalt)																								
	Steel Truss Bridge L=635 m			Fabrication						Assembling		Painting at Factory	Oversea Transport			Assembling/Erection/Bolting			Painting at site						
	PC-I Girder Bridge L=490 m																								
	Overpass 3 location																								
	Underpass 4 location																								
	Interchange 1 location																								
	Miscellaneous																								
Section-4 L=5.60 km	Clearing and Grubbing																								
	High Cut Section L=1.04 km																								
	Embank Section L=3.40 km																								
	Drainage																								
	Pavement (Asphalt)																								
	Steel Arch Bridge L=560 m			Fabrication						Assembling		Painting at Factory	Oversea Transport			Assembling/Erection/Bolting			Painting at site						
	PC-Box Girder Bridge L=520 m																								
	Overpass 1 location																								
	Underpass 2 location																								
	Interchange 1 location																								
	Miscellaneous																								
Section-5 L=16.55 km	Clearing and Grubbing																								
	High Cut Section L=11.71 km																								
	Embank Section L=2.11 km																								
	Drainage																								
	Pavement (Asphalt)																								
	PC-I Girder Bridge L=2,730 m																								
	Overpass 5 location																								
	Underpass 9 location																								
	Interchange 1 location																								
	Miscellaneous																								
Section-6 L=12.45 km	Clearing and Grubbing																								
	High Cut Section L=2.05 km																								
	Embank Section L=8.65 km																								
	Drainage																								
	Pavement (Asphalt)																								
	PC-I Girder Bridge L=1,750 m																								
	Overpass 9 location																								
	Underpass 9 location																								
	Interchange 1 location																								
	Miscellaneous																								
Demobilization																									

Source: JICA Study Team

15.7 Environmental and Social Considerations

The "Pre-Feasibility Study (Pre-F/S) level" is undertaken without confirmed fixed conditions and further study and evaluation shall be implemented during the Feasibility Study (F/S). Therefore, relevant studies in environmental and social considerations of this report are also Pre-F/S level and shall be studied further in the F/S.

15.7.1 Project Component and Impacts on Environment

CMH with a total length of 208km is proposed as an important corridor in Mindanao. This will connect two (2) Metropolitan Centers (Cagayan de Oro City and Davao City). The Cagayan de Oro (CDO) - Malaybalay Section of Central Mindanao Highway is selected as high priority section. The proposed project outline based on the survey with a map of the target area is elaborated in **Section 15.1**. Project component which will cause adverse impact is found during road construction as shown in **Section 15.3** and **Section 15.4**.

This Pre-F/S is carried out without fixed conditions such as associated projects by other proponents, relevant activities including soil borrow pits, quarry pits, construction roads, camp yards, pre-acquired land for the project among others. Hence further confirmation shall be implemented during the F/S. As far as the Pre-F/S in this master plan survey is concerned, implementation timing is not decided, and other specific plans or reasonably defined developments are not found. Therefore, the survey focuses on direct impact caused by the project during the Pre-F/S stage, and the possibility of cumulative impact will be considered during the F/S.

In order to conduct initial environmental and social environmental impact assessment at Pre-F/S, LGUs in and around the proposed project area are selected as the study area. The Project will traverse six (6) LGUs shown in the table below.

Table 15.7-1 LGUs in the Proposed Project Area

Island	Region	Province	Municipality/ City	Barangays	Length of the Project
Mindanao	Region X: Northern Mindanao	Misamis Oriental	Municipality of Tagoloan	Natumolan, Casinglot	68 km
			Cagayan de Oro City	Bugo, Puerto	
		Bukidnon	Municipality of Manolo Fortich	Alae, Dalirig, Diclum, Lingion, Lunocan, Maluko, Mambatangan, Mantibugao, Santo Nino, Tankulan (Pob.)	
			Municipality of Sumilao	Kisolon, San Vicente	
			Municipality of Impasug-ong	Capitan Bayong, Cawayan, Impalutao, La Fortuna, Poblacion	
			City of Malaybalay	Dalwangan, Kalasungay, Patpat (Lapu-lapu), Barangay10	
Total		2	6	25	68 km

Source: JICA Study Team

Since the proposed alignment will traverse many existing community roads and rivers, the project components include bridges, underpass/over pass roads and box culverts to avoid intersecting with the existing roads and water flow as shown in **Table 15.7-2.**

Table 15.7-2 Proposed Road Structures

Situation	Proposed Road Structure		Number of Structures
Cross points of proposed road and river /valley	Bridge	Loop Bridge	1
		Long span Bridge at deep valley	3
		Ordinary Bridge for the river or lowlands	23
Cross points of proposed road and existing Road	Underpass/over pass roads or Box Culvert		75

Source: JICA Study Team

15.7.2 Baseline of Environmental and Social Conditions

The following descriptions are collected information on pollution, natural environment, reserved areas of natural protection and cultural heritages, land use, areas of indigenous people, and social conditions of land acquisition and involuntary resettlement.

(1) Socio-Economic Conditions

1) Population

Based on the 2015 statistical survey, population status of the project-related municipalities/cites are as shown in **Table 15.7-3**.

Table 15.7-3 Population of the Proposed Project Area

Municipality/ City	Area (km^2)	Population	Population Density (Person/km^2)
Municipality of Tagoloan	69.7	13,253	190
Cagayan de Oro City	412.8	675,950	1,637
Municipality of Manolo Fortich	413.6	100,210	242
Municipality of Sumilao	197.0	27,660	140
Municipality of Impasug-ong	1051.2	47,859	46
City of Malaybalay	969.2	174,625	180

Source: Source: Philippine Statistics Authority, Various Census Reports 2015

2) Education Opportunity

According to the 2018 Regional Social & Economic Trends (RSET) of the Philippine Statistics Authority (PSA), about thirty (30) elementary schools were added to the total number of elementary schools in the region X in 2017-2018 bringing the total to 2,624 elementary schools, of which 2,624 are government owned and 520 are owned by private institutions. In 2017-2018, 26 secondary schools were added to region's total number of secondary schools bringing the current total to 733 secondary schools. This is comprised of 427 public schools and 306 private schools. There was a total of 103 tertiary schools in the region in 2017-2018, of which 62.1% are privately owned. The total number of public elementary teachers increased by 6.37% in 2017-2018. About 0.6% increase in the number of secondary teachers was also reported in 2017-2018. Enrolment in elementary schools in Northern Mindanao reached 673,894 in 2017-2018, which was around a 3.73% decrease from the previous school year's figure of 699,992.

On the other hand, enrolment in junior high schools recorded an increase in 2017-2018. The number of enrollees increased by 76.1% from 334,706 in 2016-2017 to 589,529 in 2017-2018.

3) Health Status

The number of government and private hospitals and their bed capacity is show in **Table 15.7-4.**

Table 15.7-4 Number of Government and Private Hospitals and Bed Capacity (2012)

Province/City		Number of Hospitals	Hospital Classification				Authorized Bed Capacity
			Level I (Primary)	Level II (Secondary)	Level III (Tertiary Non-Teaching)	Level IV (Tertiary Teaching)	
Misamis Oriental	Government	7	3	4			160
	Private	2	1		1		65
Bukidnon	Government	8	5	2	1		249
	Private	11	5	5	1		352
Cagayan de Oro City	Government	3		2		1	500
	Private	11	1	4	5	1	917
Malaybalay City	Government	1			1		150
	Private	5	2	3			209

Source: Regional Social & Economic Trends (RSET) of the Philippine Statistics Authority (PSA), 2018

(2) Pollution Items

1) Air Quality

The results of air quality monitoring in 2018 at two locations around the Taoloan Municipality indicated that the tested parameters for air quality (TSP, SO_2, NO_2 and PM10) were within the prescribed guidelines of National Ambient Air Quality Guideline Values (NAAQGV) of the DENR, as shown in **Table 15.7-5.**

Table 15.7-5 Ambient Air Quality Results along Tagoloan River

Parameters	DENR-NAAQGV DAO 2000-081	WHO Air Quality guidelines	Station 1	Station 2
TSP	230	-	94.8	34.6
SO_2	180	20 µg/m^3 (1-hour mean)	4.13	3.49
NO_2	150	200µg/m^3 (1-hour mean)	1.34	2.01
PM10	150	50µg/m^3 (24-hour mean)	62.4	26.5

Source: Annual Monitoring Report No. 3 of the Flood Risk Management Project for Tagoloan River DPWH 2018

2) Water Quality

All water quality parameters tested in Tagoloan River at two stations were within the prescribed environmental guideline value for the Class A water (Public Water Supply Class II) except for oil and grease and surfactants, as shown in **Table 15.7-6**. The concentration oil and grease measurements in downstream of Tagoloan River were above the prescribed guideline value for Class A water. Surfactant level in the water in the downstream station exceeded the threshold level set in the guideline values for the Class A waters. This can be due to the domestic activities, specifically washing of clothes.

Table 15.7-6 Water Quality Results in Tagoloan River

Parameters	Unit	DAO 2016-08 Class A	IFC EHS guidelines/WHO Guideline	Upstream	Downstream
pH	-	6.5-8.5	6-9	7.7	7.8
Temperature	degrees Celsius	25-30	-	25.4	25.4
Oil and Grease	mg/L	1	10	1	2
Total Dissolved Solids (TDS)	mg/L	-	-	113	336.6
Total Suspended Solids (TSS)	mg/L	50	50	36	30
Color	TCU	50	-	5	5
Cyanide (CN-)	mg/L	0.07	0.07	<0.05	<0.05
Chemical Oxygen Demand (COD)	mg/L	-	125	11	9
Biochemical Oxygen Demand (BOD)	mg/L	3	30	3	1
Surfactants	mg/L	0.2	-	<0.01	30
Phosphate as Phosphorus	mg/L	0.5	0.01	0.19	0.24
Nitrate	mg/L	7	50	0.1	<0.05
Dissolved Oxygen	mg/L	5 (minimum)	-	6.9	7.2
Total Coliform	MPN/100mL	-	-	92,000	35,000
Salinity	mg/L	-	-	0.162	0.381
Arsenic (As)	mg/L	0.01	0.01	<0.01	<0.01
Cadmium (Cd)	mg/L	0.003	0.003	<0.003	<0.003
Lead (Pb)	mg/L	0.01	0.01	<0.01	<0.01
Total Mercury (T-Hg)	mg/L	0.001	0.006	<0.001	<0.001
Hexavalent chromium (Cr+6)	mg/L	0.01	0.05	<0.01	<0.01

Source: Annual Monitoring Report No. 3 of the Flood Risk Management Project for Tagoloan River DPWH 2018

3) Waste

Under the RA 9003, collection, transport and disposal of solid wastes are the responsibilities of the local government units (LGUs). At present, most LGUs administer their own collection systems or contract out this service to private contractors.

In Cagayan de Oro City, domestic Solid Waste and similar businesses are mainly collected by a Private Company hired by the City named Basura Atbp., Inc. (BAI) which collects about 2/3 of the total waste deposited in the dumpsite (2011). Other haulers also take part of the waste collection for those areas that are not covered by the private collector. The total volume of waste collected during 2011 amounted to 272,826 m^3, equivalent to approximately 71,480 t (estimated to be just 64% of waste generated). With the increase in population, the volume of waste being generated will also increase. The collected waste is taken to the existing dumpsite which is about twenty five years old, located in Upper Dagong, Bgy. Carmen. The Carmen dumpsite has almost been filled to capacity. It is necessary to transfer waste disposal activities to an appropriate engineered Sanitary Landfill (SLF) in a new area. A new site has been identified by the City in Barangay Pagatpat for the new SLF. (Source: Pre-Feasibility Study on Wastewater, Watershed & Solid Waste Management Cagayan de Oro City, Philippines, 2013).

4) Soil Contamination

There is no existing monitoring point and report concerned about the soil contamination issues in and around the CMH project site.

5) Noise and Vibration

Based on the noise level results in 2018 at two locations around the Tagoloan Municipality, both stations were beyond the guideline value for Class A area (Residential area) which can be attributed to the noise from passing vehicles and appliances from nearby residential area. The result is shown in **Table 15.7-7**.

Table 15.7-7 Ambient Noise Quality Results along Tagoloan River

Time of sampling	NPCC 1908-02 Class A standards	IFC EHS guidelines	Station 1	Station 2
Morning 05:00-09:00	50	45/55	53.6	58.6
Daytime 09:00-18:00	55	55	55.8	61.3
Evening 18:00-22:00	50	55	52.6	59.6
Nighttime 22:00-05:00	45	45	51.2	56.8

Note Environmental, Health, and Safety (EHS) Guidelines, Day Time 7:00-22:00, Nighttime 22:00-07:00

Source: Annual Monitoring Report No. 3 of the Flood Risk Management Project for Tagoloan River DPWH 2018 PD 984; National Pollution Control Commission (NPCC) Memorandum Circular No. 002 Series of 1980 Section 78

6) Ground Subsidence

A small portion of highly productive aquifer composed of alluvial deposits are found near the mouth of the river in the town of Tagoloan, Misamis Oriental. Both shallow and deep wells within this area can be expected to have high discharges. Outstanding ground subsidence due to groundwater and other kinds of activities have not been observed or reported so far.

7) Offensive Odor

There is no existing monitoring point and report concerned about the offensive odor issues in and around the CMH project site.

(3) Natural Environment

1) Protected Area

"The revised procedural manual for DENR Administrative Order (DAO) 2003-30: Implementing Rules and Regulations (IRR) for the Philippine Environmental Impact Statement (EIS) System" specifies 12 Environmental Critical Areas (ECAs) categories, as listed in **Table 15.7-8**. Protected Area declared by National laws or local ordinances is one of ECA category. ECA as defined is an area considered environmentally sensitive wherein the magnitude or impacts are easily recognized if proposed projects are built, developed, or implemented in it. It is expected that the project area is within four (4) ECA categories namely:

[No.6] Areas hard-hit by natural calamities (high Susceptibility to landslide);

[No.7] Critical Slope (>50%or>27°)

[No.8] Prime Agricultural Lands, and;

[No.10] Water bodies for domestic and wildlife/fishery support

Regarding the issue of Ancestral Lands, the representative of the NCIP in Manolo Fortich mentioned that there are potential CADT/ CADCs along the alignment of the project. The possible overlap of the project area with the CADTs shall be confirmed by NCIP within the screening process of PEISS.

Table 15.7-8 Environmentally Critical Areas (ECAs) within or near the Project Site

No.	ECA Category	ECA within the proposed project	Remarks
1	Protected Areas (declared by National laws or local ordinances)	None	The nearest protected area (Mt. Kitanglad Range Natural Park) from the proposed project is approximately 8 km. (see **Figure 15.7-1)**
2	Aesthetic Potential Tourist Spots	None	Not applicable
3	Wildlife Habitat	None	The nearest protected area (Mt. Kitanglad Range Natural Park) from the Project is approximately 8 km. The Project is outside of the boundaries of Mt. Tago which is considered an important bird area. The nearest boundary of Mt. Tago is approximately 1 km from the Project alignment. (see **Figure 15.7-2**)
4	Unique Historic, Archaeological, Geological Site	None	Camp Kasisang is the nearest Historical site in the proposed alignment, which is located in Malaybalay, Bukidnon (approx. 4-5km from proposed project).
5	Ancestral Lands	To be confirmed	Several CADTs in Region 10 are found near Project area. (see **Figure 15.7-7**) The positional relationship between CADTs and the project area shall be confirmed by NCIP within the screening process of PEISS
6	Hard-Hit by Natural Calamities	✓	Low to High Susceptibility to landslide (see **Figure 15.7-4** and **Figure 15.7-5**)
7	Critical Slope (>50%or>27°)	✓	Some parts of the proposed project are within the 50% and above slope.
8	Prime Agricultural Lands	✓	The proposed road will traverse agricultural lands
9	Recharge Areas of Aquifers	None	Not applicable
10	Water Bodies (for domestic use, or support wildlife/fishery)	✓	The proposed CMH will traverse three (3) rivers and their watershed area including tributary streams at approximately 10 points in reference to the satellite map. (see **Figure 15.7-3**)
11	Mangrove Areas	None	Not applicable
12	Coral Reefs	None	Macajalar Bay is approximately 0.6km away from the proposed alignment. The nearest coral reef is approximately 7 km away from the proposed project.

Source: JICA Study Team

According to the Protected Areas of the Philippines administered by the Department of Environment and Natural Resources' Biodiversity Management Bureau under the National Integrated Protected Areas System (NIPAS) Act of 199, six (6) proclaimed areas are found in Misamis Oriental and Bukidnon Provinces, based on the lists of NIPAS, as shown in **Table 15.7-9** and **Figure 15.7-1.**

The proposed highway project will be planned to avoid the identified protected areas. The nearest protected area in the proposed highway project is Mount Kitanglad Range Natural Park (approximately 8km).

Table 15.7-9 Protected Areas found in Misamis Oriental and Bukidnon Provinces

NIPAS Classification	No.	Location		Declaration [Year/Area]	Approximate distance (in km) from the Proposed CMH
		Misamis Oriental	Bukidnon		
Natural Parks	1	Mount Balatukan Range		Declared as a protected area through Proclamation No. 1249 in 2007 [84.23 km^2]	31
	2		Mount Kalatungan Range	Declared as a Protected Area through Presidential Proclamation No. 305 in 2000 [212.5 km^2]	26-27
	3		Mount Kitanglad Range	Declared as Protected Area through RA No. 8978 in 2000, as ASEAN Heritage Park in 2009 [312.35 km^2]	8
Protected Landscape and Seascapes	4	Initao–Libertad	-	Declared as a protected landscape and Seascape through Proclamation No. 260, s. in 2002 [13.00 km^2]	48-50
	5	Mimbilisan		Reestablished as a Protected Landscape under the National Integrated Protected Areas System by enactment of Proclamation No.134, 1999 [0.66 km^2]	48-50
Watershed Forest Reserves	6	Mahugunao	-	Declared as a protected area under the National Integrated Protected Areas System by enactment of Proclamation No. 470, 1932 [1.36 km^2]	10

Source: NIPAS, 2013

Source: Based on the Protected Area map by geoportal PH, JICA Study Team overlaid the proposed project alignment.

Figure 15.7-1 Protected Areas in Misamis Oriental and Bukidnon Provinces

2) Ecosystem

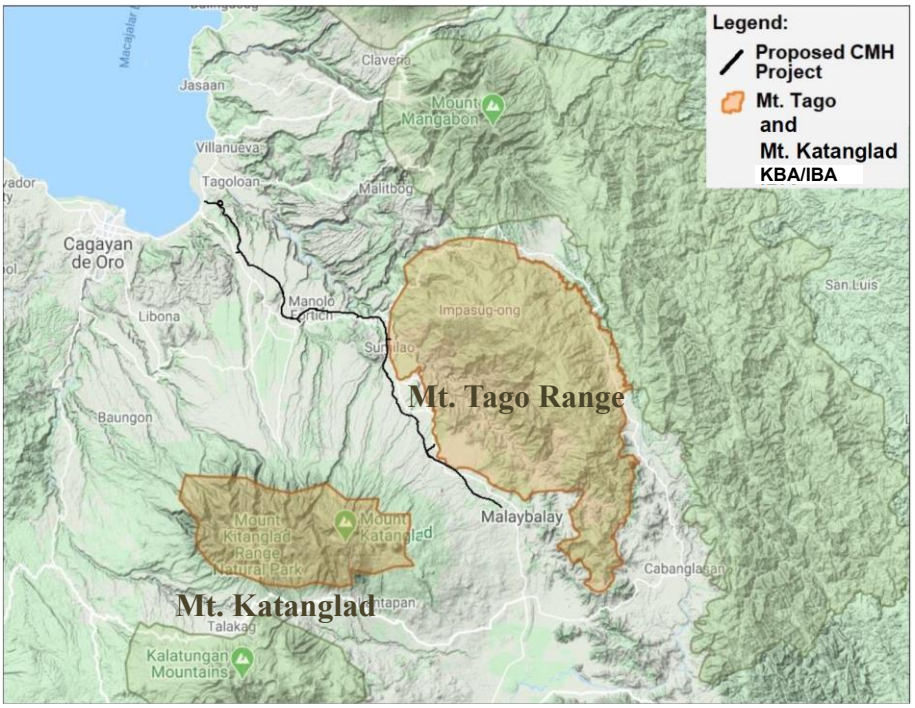
Manolo Fortich has been declared as the Philippine Eagle Sanctuary in Northern Mindanao. In addition, the dense forests of Tuminugan Nature Sanctuary are also home to a diverse range of wildlife, including over 70 endemics and migratory birds. (Source: Regional Social and Economic Trends 2018, Philippine Statistics Authority Regional Statistical Services Office X)

Two Key Biodiversity Area (KBA)/Important Bird Areas (IBAs), Mount Tago Range and Mount Katanglad, are found near the project area, as shown in **Figure 15.7-2**. Based on the boundary map from Bird Life International, the proposed CMH project is outside of the boundaries of Mt. Tago. Philippine Eagle (IUCN category: Critically Endangered) are found in the two KBAs/IBAs, as shown in **Table 15.7-10.**

Table 15.7-10 Outline of KBA/IBAs

Name of IBA	Key Biodiversity
Mount Tago Range Area: 29,062 ha Altitude : 0-2112 m	The Mt Tago range is ornithologically very poorly known, although there is a recent report of Philippine Eagle from nearby. It is likely that many of the threatened and restricted-range species of the Mindanao and Eastern Visayas Endemic Bird Area occur there, and the avifauna may prove to be similar to that of nearby Mt Kitanglad.
Mount Katanglad Area: 31,297 ha Altitude : 700-2938 m	Mt. Kitanglad supports substantial populations of many montane forest specialists, including several which are only known from the higher mountains on Mindanao, such as Mindanao Lorikeet, Mindanao Racquet-tail, Mindanao Scops-owl, Slaty-backed Jungle-flycatcher, Red-eared Parrotfinch and Apo Myna. It is one of only three sites where the poorly known Whitehead's Swiftlet has been recorded. There is also an important population of Philippine Eagle in this IBA. Two subspecies of birds are only recorded from these mountains, Island Thrush Turdus poliocephalus katanglad and Mountain Leaf-warbler Phylloscopus trivirgatus flavostriatus. Many lowland forest species were recorded in the Mt Kitanglad range in the past, but the lowland forests around the base of the mountains have now been almost entirely cleared. Non-bird biodiversity: The known mammal fauna consists of 58 species, including two new species of small non-volant mammals, a shrew-mouse Crunomys suncoides and a moss-mouse Tarsomys sp., discovered in the park in 1993. Other important mammals in the park include Binau or Philippine Brown Deer Cervus mariannus, Baboy Kalasanon or Bearded Pig Sus barbatus, Talibungkok or Mindanao gymnure Podogymnura truei, Unggoy or Long-tailed Macaque Macaca fascicularis, Salumbakutin or Mindanao Tree Shrew Urogale everetti, Kagwang or Philippine Lemur Cynocephalus volans, Tambalingan or Philippine Pygmy Squirrel Exilisciurus concinnus, Kalukag / Kalugit or Mindanao Flying Squirrel Petinomys crinitus and rare bats such as the endemic Mindanao Pygmy Fruit Bat Alionycteris paucidentata, which is known only from Mt Kitanglad. The area is rich in gymnosperms and tree ferns, and more than 300 species of flora used by the indigenous people for herbal medicine, including “ali” Drimys piperita, “kappa-kapa tree” Medinilla magnifica, and the pitcher plant Nepenthes truncata in the montane forest.

Source: Bird life International



Source: Based on the IBA map published by Bird Life International, JICA Study Team overlaid the proposed project alignment.

Figure 15.7-2 KBA/IBA Distribution Map in the Study Area

Table 15.7-11 Fauna and Flora reported Species in KBA/IBA

Taxonomic Group	Common name	Scientific name	Current IUCN Red List Category*
Fauna			
Mount Tago Range			
Bird	Philippine Eagle	*Pithecophaga jefferyi*	CR
Bird	White-cheeked Bullfinch	*Pyrrhula leucogenis*	LC
Amphibians	Tagibo Wart Frog	*Limnonectes diuatus*	VU
Amphibians	Spiny Indonesian Treefrog	*Nyctixalus spinosus*	LC
Amphibians	MIndanao Bush Frog	*Philautus leitensis*	LC
Amphibians		*Philautus poecilius*	LC
Amphibians	Smooth-skinned Tree Frog**	*Philautus worcesteri*	LC
Mount Kitanglad			
Bird	Philippine Duck	*Anas luzonica*	VU
Bird	Dark-eared Brown-dove	*Phapitreron brunneiceps*	VU
Bird	Spotted Imperial-pigeon	*Ducula carola*	VU
Bird	Philippine Spinetail	*Mearnsia picina*	NT
Bird	Whitehead's Swiftlet	*Aerodramus whiteheadi*	DD
Bird	Giant Scops-owl	*Otus gurneyi*	VU
Bird	Mindanao Highland Scops-owl	*Otus mirus*	NT
Bird	Philippine Eagle-owl	*Bubo philippensis*	VU
Bird	Philippine Eagle	*Pithecophaga jefferyi*	CR
Bird	South Philippine Hawk-eagle	*Nisaetus pinskeri*	EN

Taxonomic Group	Common name	Scientific name	Current IUCN Red List Category*
Bird	Writhed Hornbill	*Rhabdotorrhinus leucocephalus*	NT
Bird	Penelopides affinis /Mindanao Hornbill**	*Penelopides affinis*	LC
Bird	Blue-capped Kingfisher	*Actenoides hombroni*	VU
Bird	Mindanao Lorikeet	*Trichoglossus johnstoniae*	NT
Bird	Mindanao Racquet-tail	*Prioniturus waterstradti*	NT
Bird	Mindanao Wattled Broadbill	*Sarcophanops steerii*	VU
Bird	McGregor's Cuckooshrike	*Malindangia mcgregori*	LC
Bird	Black-and-cinnamon Fantail	*Rhipidura nigrocinnamomea*	LC
Bird	Mountain Shrike	*Lanius validirostris*	NT
Bird	Micromacronus leytensis/ Visayan Miniature Babbler**	*Micromacronus leytensis*	DD
Bird	Black-headed Tailorbird	*Orthotomus nigriceps*	LC
Bird	Long-tailed Grasshopper-warbler	*Locustella caudata*	LC
Bird	Hypsipetes everetti/ Yellowish bulbul**	*Hypsipetes everetti*	LC
Bird	Rufous-headed Tailorbird	*Phyllergates heterolaemus*	LC
Bird	Mindanao White-eye	*Heleia goodfellowi*	LC
Bird	Stachyris plateni/ Mindanao Pygmy babbler	*Stachyris plateni*	NT
Bird	Bagobo Babbler	*Leonardina woodi*	LC
Bird	Striated Wren-babbler Ptilocichla	*Ptilocichla mindanensis*	LC
Bird	Apo Myna	*Goodfellowia miranda*	NT
Bird	Slaty-backed Jungle-flycatcher	*Vauriella goodfellowi*	NT
Bird	Philippine Leafbird	*Chloropsis flavipennis*	VU
Bird	Whiskered Flowerpecker	*Dicaeum proprium*	LC
Bird	Olive-capped Flowerpecker	*Dicaeum nigrilore*	LC
Bird	Dicaeum anthonyi/ Yellow-crowned Flowerpecker**	*Dicaeum anthonyi*	NT
Bird	Grey-hooded Sunbird	*Aethopyga primigenia*	LC
Bird	Apo Sunbird	*Aethopyga boltoni*	LC
Bird	Red-eared Parrotfinch	*Erythrura coloria*	LC
Bird	Cinnamon Ibon	*Hypocryptadius cinnamomeus*	LC
Bird	White-cheeked Bullfinch	*Pyrrhula leucogenis*	LC
Bird	Chrysocorythus estherae/ Mountain Serin**	*Chrysocorythus estherae*	LC
Mammal	Shrew-Mouse /Katanglad Shrew Mouse**	*Crunomys suncoides*	DD
Mammal	Binau or Philippine Brown Deer	*Cervus mariannus*	VU
Mammal	Baboy Kalasanon or Bearded Pig	*Sus barbatus*	VU
Mammal	Talibungkok or Mindanao gymnure	*Podogymnura truei*	LC
Mammal	Unggoy or Long-tailed Macaque / Nicobar Crab-eating Macaque**	*Macaca fascicularis*	VU

Taxonomic Group	Common name	Scientific name	Current IUCN Red List Category*
Mammal	Salumbakutin or Mindanao Tree Shrew	*Urogale everetti*	LC
Mammal	Kagwang or Philippine Lemur	*Cynocephalus Volans*	LC
Mammal	Tambalingan or Philippine Pygmy Squirrel	*Exilisciurus concinnus*	LC
Mammal	Kalukag / Kalugit or Mindanao Flying Squirrel	*Petinomys crinitus*	LC
Mammal	Mindanao Pygmy Fruit Bat	*Alionycteris paucidentata*	LC
Flora			
Katmon		*Dillenia philippinensis*	NT
White Lauan		*Shorea contorta*	LC
Red Lauan		*Shorea negrosensis*	LC
Bagtikan		*Parashorea malaanonan*	LC

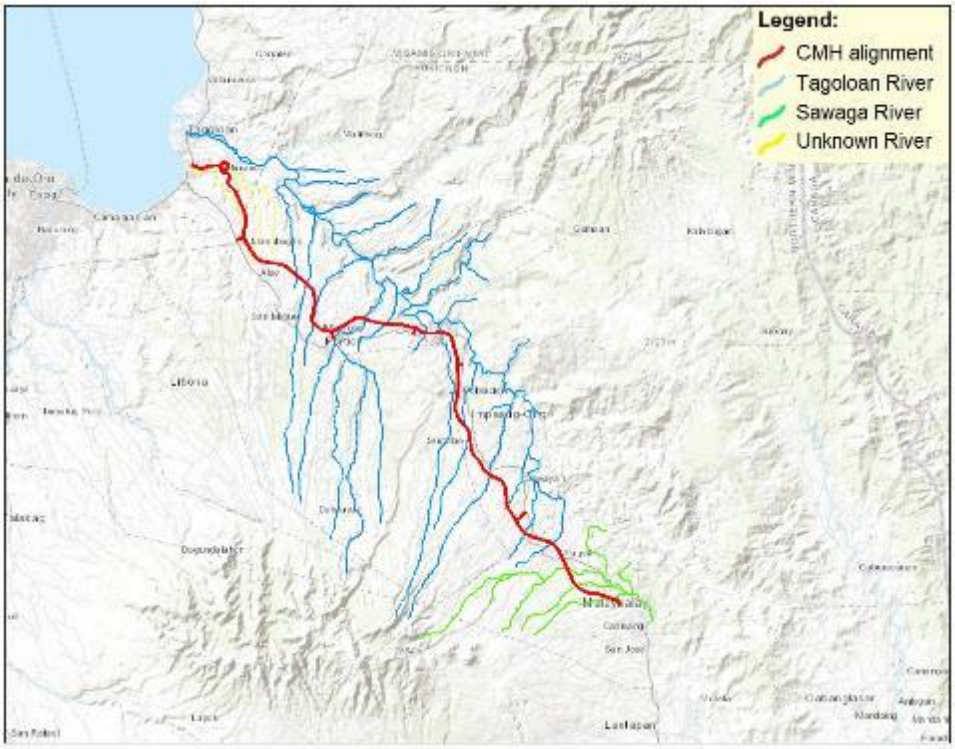
* Current IUCN Red List Category（Accessed the website on 10 March 2021 https://www.iucnredlist.org/）
CR：Critically Endangered, EN：Endangered, VU：Vulnerable, NT：Near Threatened, LC：Least Concern and DD：Data Deficient

** Common name in reference to IUCN

Source：Bird Life International, Key Biodiversity Areas、IUCN Red List

3) Hydrology

The proposed CMH project will be traverse three (3) rivers (Tagoloan River, Sawaga River and Unknown River) and their watershed area including their tributary streams. Tagoloan River is the 13th largest river system in the Philippines with a total length of 106 km. The Sawaga River has a total length of about 64.5 km. However, Sawaga River is not navigable, but it provides a significant contribution to the economy of Malaybalay as a source for irrigation. **Figure 15.7-3** shows the river network reflecting the proposed project.



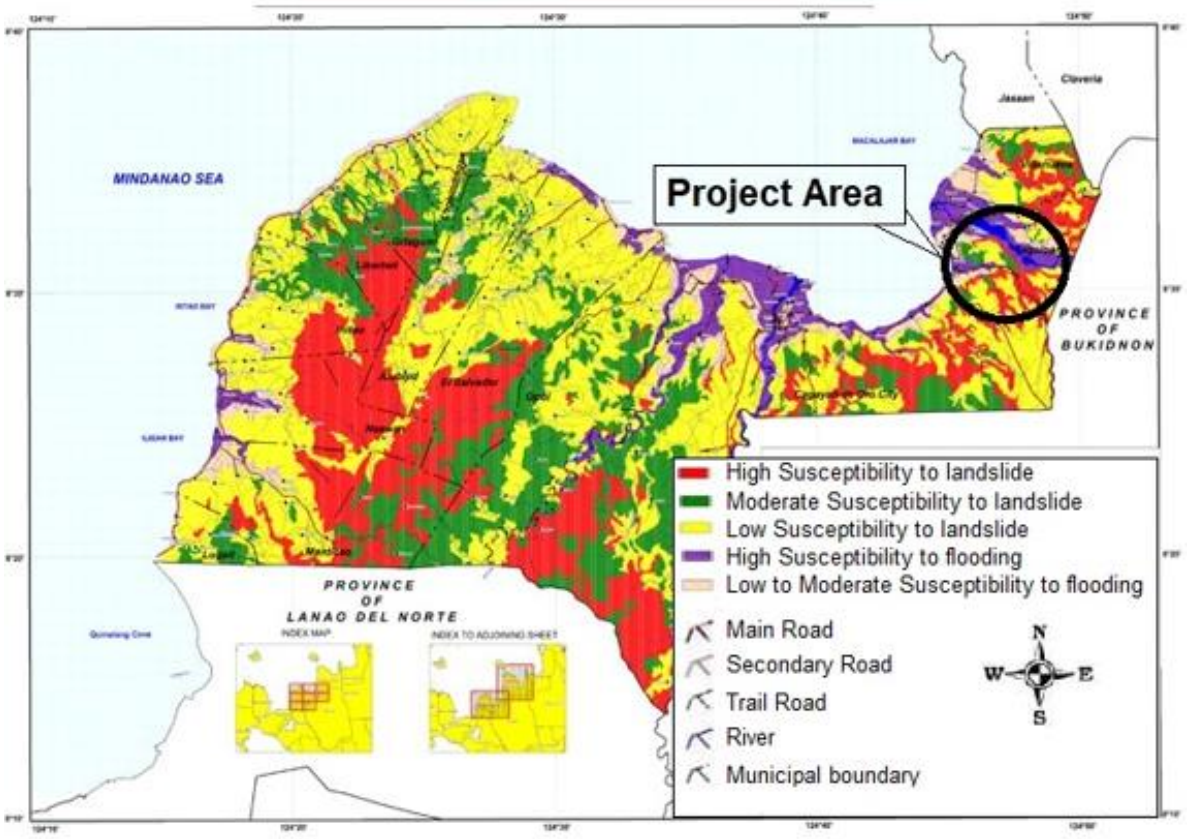
Source: JICA Study Team

Figure 15.7-3 River Network Map in the Study Area

4) Topography and Geology

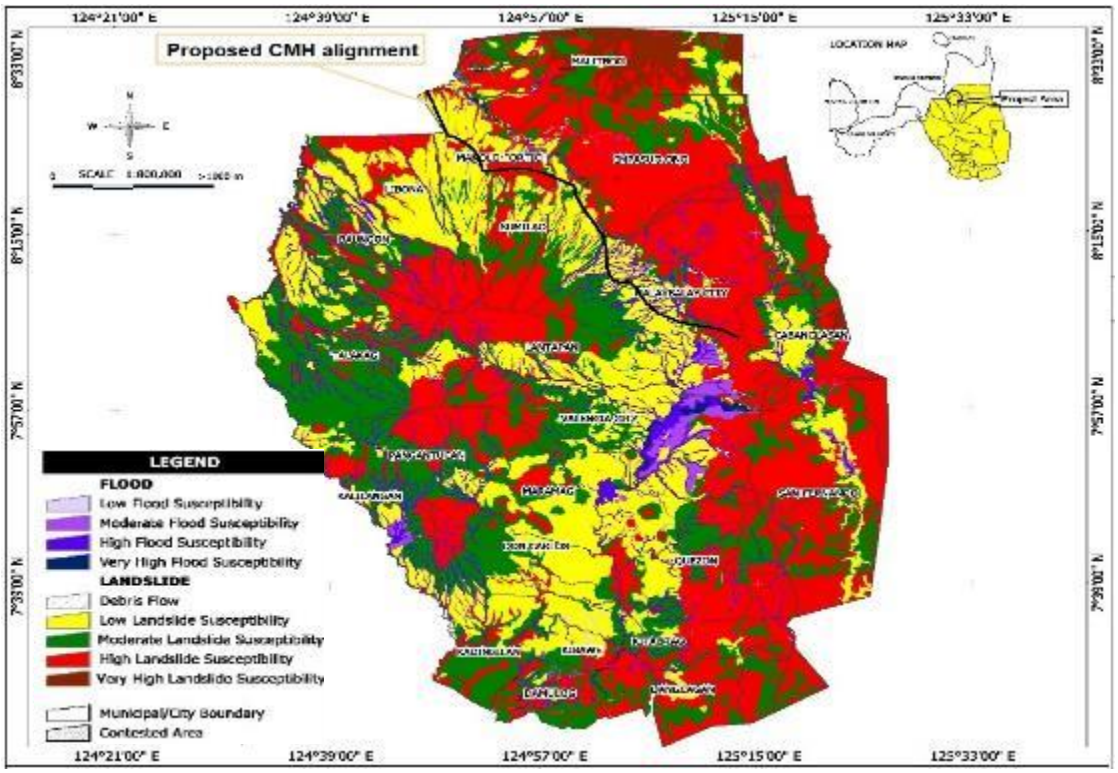
The slopes are categorized into five slope categories depending on the slope steepness such as 0-8%, 8-18%, 30-50% and 50% and above by DENR and NAMRIA. In Tagoloan and Manolo Fortich area, some parts of the proposed project are within the 50% and above slope. These slope areas are high susceptibility to landslide. (**Figure 15.7-4** and **Figure 15.7-5)**

Soil in Misamis Oriental is consist of three types of soil which includes sandy, loam and clay. In addition, soil in Bukidnon is generally categorize as adtuyan clay which composed of reddish brown to yellow red clay loam and well-drained. (**Figure 15.7-6**)



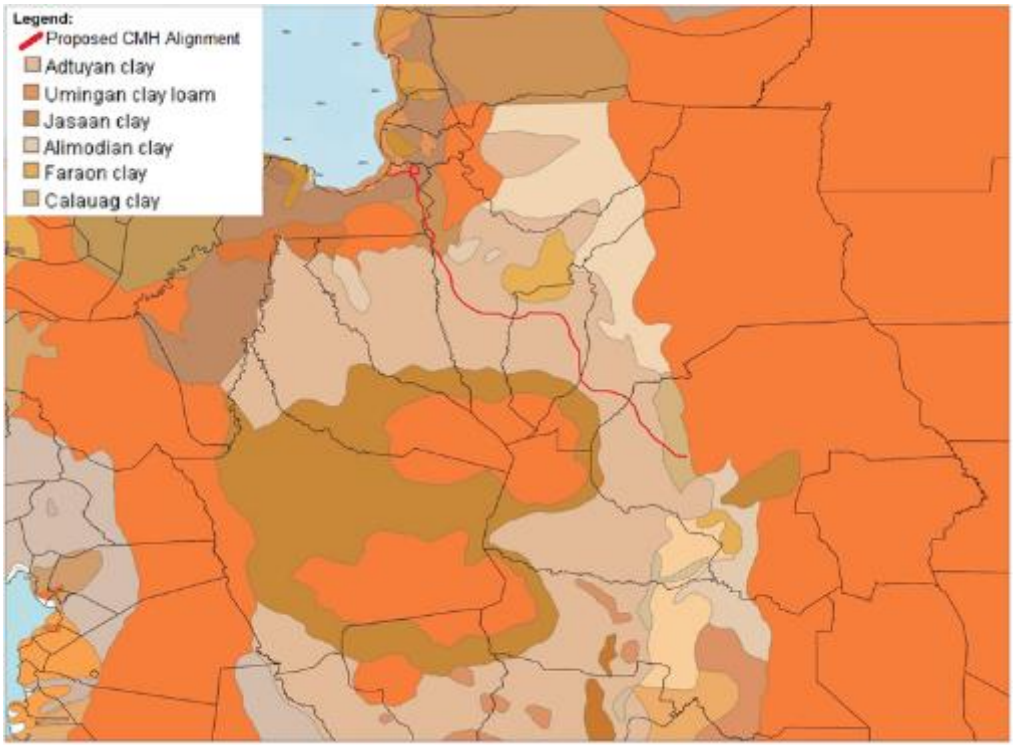
Source: Base on the s Flood and Landslide Susceptibility Map prepared by Mines and Geosciences Bureau (MGB), JICA Study Team overlaid the proposed project alignment

Figure 15.7-4 Flood and Landslide Susceptibility MAP in the Misamis Oriental



Source: Base on the s Flood and Landslide Susceptibility Map prepared by Mines and Geosciences Bureau (MGB), JICA Study Team overlaid the proposed project alignment

Figure 15.7-5 Flood and Landslide Susceptibility in the Province of Bukidnon



Source: geoportal PH

Figure 15.7-6 Soil type in the Study Area

(4) Social Environment

1) Land Acquisition and Resettlement

There have been many experiences of land acquisition and resettlement in and around the project areas including projects under the safeguard policies of Asian Development Bank (ADB) and JICA's Environmental and Social Considerations. Procedures of land acquisition and resettlement follows the country's system (Philippines).

2) Poverty

According to the 2018 Regional Social & Economic Trends (RSET) of the Philippine Statistics Authority (PSA), poverty situation in Region 10 has improved as poverty incidence among families decreased in 2015 at 30.3% from 32.8% in 2012. The said improvement was attributed to the decrease of poverty incidences in all provinces except Bukidnon. On the other hand, farmers remained to be the poorest sector in the region, with poverty incidence of 54.0%.

3) Ethnic Minority and Indigenous People

28 Certificate of Ancestral Domain Titles (CADT) are approved in Region 10, as of December 2019, in accordance with the national distribution maps of CADTs provided by the National Commission on Indigenous Peoples (NCIP). Based on the list of approved CADT's and identified ancestral domain area by NCIP, there are four (4) approved CADT's in Malaybalay City which the proposed CMH alignment is located (**Figure 15.7-7**). These CADT's are issued to the Bukidnon, Higaonon, Pulangiyen and Tagoloanon Indigenous People (IPs).

Source: Based on the Philippine Map showing the approved CADTs on-process CADTs &Identified Ancestral Domain Areas, as of December 2019 prepare by NCIP, JICA Study Team overlaid the proposed project alignment and CADTs on the Google Earth.

Figure 15.7-7 CADT Distribution Maps in the Study Area

4) Local Economy such as Employment and Livelihood

According to the 2018 Regional Social & Economic Trends (RSET) of the Philippine Statistics Authority (PSA), the economy of the region 10 is predominantly services-based with a share of 43.4 percent, followed by Industry with 35.0 percent share and Agriculture, Hunting, Forestry and Fishing with a share of 21.6 percent.

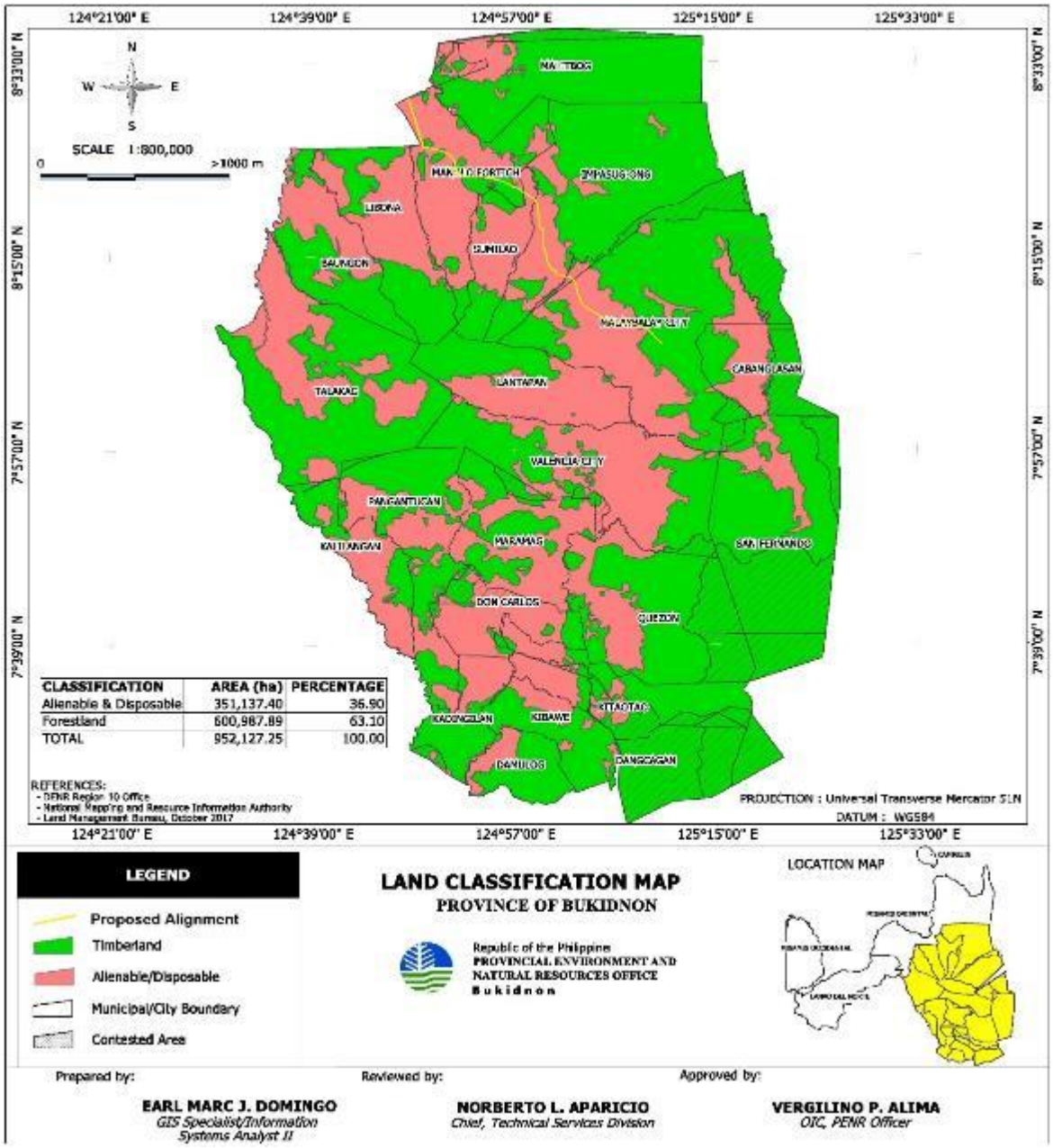
5) Land use and Usage of Local Resources

Figure 15.7-8 and **Figure 15.7-9** present land classification of Bukidnon and Misamis Oriental respectively.

There is more forestland area than alienable and disposable land in Bukidnon. Forestland area covers 63.77% of the total land area of Bukidnon. Bukidnon, hence, has the biggest forestland area in the whole region which has a share of 61.8% of the total forestland area in Region 10.

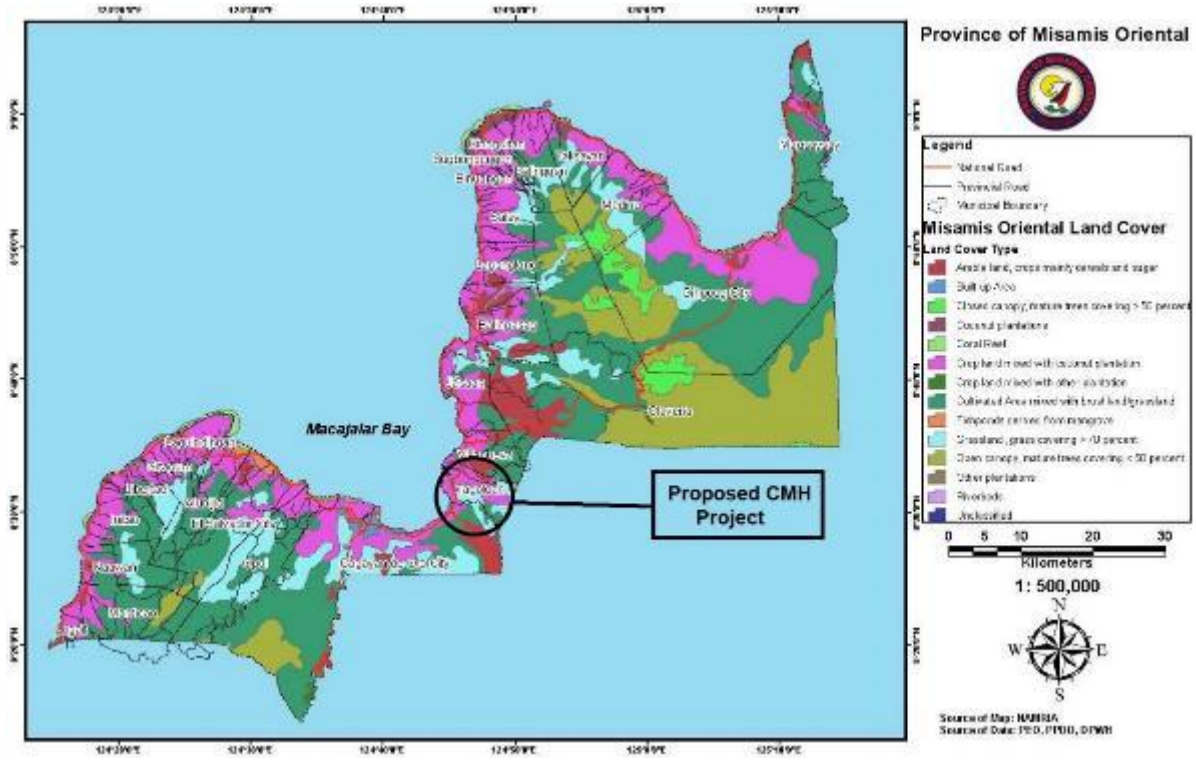
Manolo Fortich dubbed as the Home of the First Pineapple Plantation in the Far East is one of the thriving municipalities of the Province of Bukidnon with a total land area of 47,868.21 hectares. 39% of the Municipality is classified as forest area while 61% of land is classified as alienable and disposable.

The proposed CMH alignment in Bukidnon side will traverse in alienable/disposal forestland while in Misamis Oriental side it will traverse in crop land (mixed with coconut plantation), cultivated area (mixed with brushland/grassland) and grass land.



Source:PENRO Bilidnon

Figure 15.7-8 Land Use Classification of Bukidnon



Source: NAMRIA

Figure 15.7-9 Land Use Classification of Misamis Oriental

6) Water Usage

As of 2017, 59.26% of the potential irrigable area in Region 10 has been developed for irrigation purposes. A total of 68,859,484 cubic meters were consumed by the region and water district, and there were 258,279 water service connections in the whole region.

7) Existing Social Infrastructures and Services

In 2017, Region 10 has a total of 1,959.570 km road length, 68.82% were concrete roads, 22.40% were asphalted roads, and 8.13% were gravel. Also, in the same year, there are a total of 393 national bridges in the region.

8) Social Institution such as Socially Related Capital and Decision-making Organizations

There is different level of local government entities such as municipality, barangay, village, etc. as social institution. Also, there are different kinds of public and private organizations in the field of specific industry/occupation, gender, NGO, etc.

9) Cultural Heritage

Camp Kasisang is the nearest historical site in the proposed alignment, which is located in Malaybalay, Bukidnon (approximately 4-5km), as shown in **Figure 15.7-10**.

10) Children's Rights

Child labor cases in Philippines are commonly reported and it may occur in the survey area. Children's rights in the survey area maybe related to poverty.

Source: JST

Figure 15.7-10 Unique Historic, Archaeological, Geological Site

11) Infectious Diseases such as HIV/AIDS

Nothing particular as social baseline conditions of the survey areas. However, HIV/AIDS cases in Philippines are usually connected to prostitution workers and it may be common in the survey area.

According to the 2018 Regional Social & Economic Trends (RSET) of the Philippine Statistics Authority (PSA) and the Department of Health (DOH), the top killer disease in Region 10 in 2017 is cardiovascular disease with a rate of 93 cases per 100,000 population. Pneumonia being the second highest with a rate of about 69 cases per 100,000 population. On the other hand, the leading cause of morbidity in the region is respiratory problem with a kill rate of 4,790 persons for every 100,000 population. Followed by Disease Hypertension and wounds with rates of 1,130 and 566 per 100,000 population, respectively.

In 2017, DOH recorded a total of 106,106 children who were fully immunized which was lower by 4.72 than the number of fully immunized children in 2016.

(5) Others

1) Transboundary Impact and Climate Change

There are internationally common recognitions on transboundary impact and climate change such as greenhouse effect gas emission in industry, transportation, and other relevant sectors in the survey areas.

15.7.3 Legal and Institutional Framework of Environmental and Social Considerations

Laws and Regulations related to environmental and social issues in the Philippines are summarized in Chapter 13 (Strategic Environmental Assessment) of this report. Based on both legal frameworks in Philippines and the JICA Guidelines for Environmental and Social Considerations, April 2010 (hereinafter, "JICA Environmental Guidelines"), Categorization of CMH is estimated as follows.

(1) Categorization of EIA in line with PEISS

Environmental Compliance Certificate (ECC) will be acquired as a requirement by the DENR before the project implementation. The proposed project is considered as ECA project because it will traverse areas which are hard-hit by natural calamities, areas with water bodies which are used for domestic and wildlife/fishery support, and areas with critical slope.

In addition, based on the project threshold for coverage screening and categorization, the proposed 68 km new road construction project falls under Category A which is required to secure an ECC. An Environmental Impact Statement (EIS) Report shall be prepared and submitted to DENR-EMB for evaluation. Public consultation and baseline social and environmental studies are required to be conducted within the affected areas as requirements in the preparation of EIS report.

(2) Categorization of the Project in accordance with the JICA Environmental Guidelines

Category A defined by the JICA Guidelines for Environmental and Social Considerations, April 2010 (hereinafter, "JICA Environmental Guidelines") generally includes i) projects in sensitive sectors, ii) projects that have characteristics that are liable to cause adverse environmental impact, and iii) projects located in or around environmental sensitive areas. Moreover, a project causing large-scale involuntary resettlement and or a project area inhabited by indigenous people are classified under Category A. Projects are classified as Category B if potential adverse impacts on the environment and society are less adverse than those in Category A.

Based on the above guidelines, the Project is seemed to be classified as Category A by JICA because the project is considered as a large-scale road and bridges project, large scale involuntary resettlement, project area habited by ingenious people under the JICA Environmental Guidelines. The categorization shall be reviewed during feasibility study based on the detail data namely the number of affected persons and the boundaries of the Ancestral Domain Areas.

15.7.4 Alternative Comparison

Discussion of alternative comparison for CMH is described in **Section 15.3.2** of this chapter.

15.7.5 Scoping and ToR for Environmental and Social Considerations Surveys

(1) Scoping

Scoping means choosing alternatives for analysis, a range of significant and potentially significant impacts, and study methods. ✓ mark is applied for environmental items which will be affected by the project or cannot be decided without additional surveys. Scoping is executed for different phases of pre-construction/construction and operation in each environmental item. Items without ✓in both two phases are not the target of following survey and evaluation if there are enough reasons that the items will not be affected by the project. Following table shows the result of scoping of CMH.

Table 15.7-12 Result of Scoping of CMH

No	Item	Selection Status		Reasons for Selection
		PCS/ CS	OS	
1	Air Quality	✓	✓	[CS] Construction vehicles may cause air pollution temporally. [OS] Negative impact on air quality is expected due to exhaust gas from vehicles.
2	Water Quality	✓	✓	[CS] Construction activities (such as cutting/filling works with surface erosion), construction vehicles, camp yards may cause water pollution through drainage water. [OS] Drainage from road structure may cause water pollution in water bodies along the road.
3	Waste	✓		[CS] Construction waste including concrete, asphalt, cut trees and soil may be generated through construction activities. [OS] No serious impacts are expected, because there is no plan of service / parking area which generate waste.
4	Soil Contamination	✓		[CS] There is a possibility of soil contaminant by oil leakage from construction vehicles and distribution of existing polluted soil generated by the project. [OS] Operation of roads may not cause soil contamination both directly and indirectly.
5	Noise and Vibration	✓	✓	[CS] Construction vehicles may cause noise and vibration temporally. [OS] Ambient noise and vibration along CMH may cause negative impact on sensitive receivers such as residential area, school, and hospital.
6	Ground Subsidence	✓	✓	[CS/OS] Landfilling may cause ground subsidence in the case of soft soil and other specific conditions.
7	Offensive Odor	✓		[CS] There is a possibility of offensive odor by construction activities. [OS] Operation of roads may not cause offensive odor both directly and indirectly.
8	Bottom Sediment	✓		[CS] There is a possibility of impact on the river bottom sediment by leaked oil from construction vehicles and flown soil caused by earthwork. [OS] Operation of roads may not cause bottom sediment both directly and indirectly.
9	Protected Area	✓	✓	[CS/OS] The project may cause impact to protected areas nearby.
10	Ecosystem	✓	✓	[CS/OS] The project may cause impact such as tree-cutting activities on ecosystem including indicator species along the project site. Additionally, there is a possibility that the change of the surrounding atmosphere environment, such air quality, noise/vibration and lighting, and would influence the surrounding ecosystem.
11	Hydrology	✓	✓	[CS/OS] There is a possibility of changes to hydrology because the project across some rivers.
12	Topography and Geology	✓		[CS] Topography might change by land cutting in the valley. There are possibilities of land slide and soil erosion due to slope cutting and/or land filling works. [OS] Operation of roads may not cause geographical and topographical changes both directly and indirectly.

No	Item	Selection Status		Reasons for Selection
		PCS/ CS	OS	
13	Land Acquisition and Resettlement	✓		[PCS] Land acquisition and resettlement with more than hundreds are required to secure land for road and other facilities/structures of CMH. [CS/OS] No additional resettlement is expected.
14	Poverty	✓		[PCS/CS] Vulnerable groups including poor households may be targets of resettlement. Some of them may get or lose their livelihood during construction phase. [OS] No additional impact on poverty groups.
15	Ethnic Minority and Indigenous People	✓	✓	[PCS/CS/OS] Ethnic minority and/or indigenous people may live along the project area.
16	Local Economy such as Employment and Livelihood	✓		[CS] Employment opportunity can be created due to the project construction. On the other hand, construction activities may cause temporal inconvenience such as access hinderance to the local economy. Employment and livelihood of project affected households are also affected by resettlement activities. [OS] No additional impact is expected during operation stage.
17	Land Use and Usage of Local Resources	✓	✓	[CS] Loss of farmland and forests for new roads are expected. Land and local resources such as trees of project affected households are also affected by resettlement activities. [OS] CMH may pause some negative impact on land use such as development of forest areas and using of water resources.
18	Water Usage	✓	✓	[CS] There is a possibility of unexpected discharge of ground water due to the bridge construction. Also, river water may be affected by earthworks. Water usage of the affected area may be affected by resettlement activities. [OS] Operation of roads may cause impact on water usage both directly and indirectly.
19	Existing Social Infrastructure and Services	✓		[PCS/CS] Existing social infrastructure may be affected by land acquisition and construction. [OS] Highway may bring positive impact on exiting road networks around the area.
20	Social Institutions such as Socially Related Capital and Decision-making Organizations	✓		[CS] There is a possibility of the temporary physical community division by construction. [OS] No additional impact is expected.
21	Misdistribution of Benefit and Damage			Misdistribution of benefit and damage caused by the road construction is not expected.
22	Local Conflicts of Interest		✓	[CS] No serious impacts are expected. [OS] Community separation by newly constructed highway may cause conflicts of interest.
23	Cultural Heritage			No serious impacts are expected because there are no outstanding cultural heritages around the area.
24	Landscape	✓		[CS] There is a possibility of disturbance of landscape by the road structures especially bridges. [OS] Operation of roads may not cause impact on landscape both directly and indirectly.
25	Gender	✓		[CS] Women may be affected when they commute to working places during the construction period. There might be gaps on working conditions such as wage between men and women when local employment is considered.

No	Item	Selection Status		Reasons for Selection
		PCS/ CS	OS	
				[OS] Improved access by the project may cause positive impact on gender.
26	Children's Right	✓		[CS] There is a possibility of occurrence of child labor [OS] Due to the improvement of traffic congestion of existing road, traveling time to school and hospital will become faster and safer.
27	Infectious Diseases such as HIV/AIDS	✓		[CS] Infectious diseases are possible to be spread due to inflow of construction workers. [OS] Operation of roads may not cause impact on infectious diseases both directly and indirectly.
28	Labor Environment including Safety	✓		[CS] Due to construction activities, labor environment may be affected. [OS] Operation of roads may not cause impact on labor environment diseases both directly and indirectly.
29	Accident	✓	✓	[CS] Traffic accident related to construction vehicles and accident in construction sites are expected. [OS] Traffic accident may increase due to increased traffic volume.
30	Transboundary Impact and Climate Change	✓	✓	[CS] [OS] Greenhouse Effect Gasses may increase due to construction machinery / vehicles and newly generated traffic.

Note: Project stage: PCS: Pre-construction stage, CS: Construction stage, OS: Operation stage
Source: JICA Study Team

(2) ToR for Environmental and Social Considerations Surveys

Based on the scoping results in the previous section, terms of references (ToR) for surveys of necessary environmental items are developed to determine project induced impacts. Possible impact to be caused by the project implementation will be evaluated qualitatively based on existing secondary data, interview with concerned parties and examining project design. **Table 15.7-13** shows the ToR for environmental and social considerations survey.

The potential environmental and social impact due to the implementation of the project was assessed qualitatively in considerations of the project design and collected baseline condition of the project site.

Table 15.7-13 ToR for Surveys of Environmental and Social Considerations

No.	Item	Survey Item	Survey Method
1	Air Quality	(1) Relevant standards on Environment (Domestic, Japanese, WHO's, etc.) (2) Status of air quality items	(1) Existing material (2) Secondary data/information from past projects nearby (3) Qualitative evaluation based on expected traffic volume and construction vehicles
2	Water Quality	(1) Relevant standards on Environment (Domestic, Japanese, WHO's, etc.) (2) Status of water quality items	(1) Existing material (2) Secondary data/information from past projects nearby (3) Qualitative evaluation based on expected construction methods
3	Waste	(1) Waste management process	(1) Secondary data/information from past projects nearby (2) Qualitative evaluation based on

No.	Item	Survey Item	Survey Method
			expected construction methods and facilities
4	Soil Contamination	(1) Protection method against oil leakage	(1) Confirmation on implementation plan of construction vehicles (2) Qualitative evaluation based on expected construction methods
5	Noise and Vibration	(1) Relevant standards on Environment (Domestic, Japanese, WHO's, etc.) (2) Status of water noise and vibration	(1) Existing material (2) Secondary data/information from past projects nearby (3) Qualitative evaluation based on expected traffic volume and construction vehicles
6	Ground Subsidence	(1) Soil conditions	(1) Past study around the area (2) Qualitative evaluation based on expected construction methods
7	Offensive Odor	(1) Possible events causing odor	(1) Collection of necessary information on construction method (2) Qualitative evaluation based on expected construction methods
8	Bottom Sediment	(1) Construction method causing sedimentation	(1) Collection of necessary information on construction method (2) Qualitative evaluation based on expected construction methods
9	Protected Areas	(1) Situation of registration (2) Outline of the protected areas	(1) Relevant laws and regulations (2) Past study around the area (3) Qualitative evaluation based on expected construction methods
10	Ecosystem	(1) Situation of general ecosystem (2) IUCN listed species and endemic species	(1) Past field surveys on occurrences of fauna and flora (2) IUCN and DENR Website etc. (3) Qualitative evaluation based on expected construction methods
11	Hydrology	(1) Situation of surface water such as river and lake (2) Impact during construction	(1) Past field surveys (2) Confirmation of construction methods (3) Qualitative evaluation based on expected construction methods
12	Topography and Geology	(1) Construction method causing changes of topography and geology	(1) Collection of necessary information on construction method (2) Qualitative evaluation based on expected construction methods
13	Land Acquisition and Resettlement	(1) Size of impact (area, structure, etc.) (2) Compensation policy	(1) Aerial photos, design, etc. (2) Existing surveys including resettlement action plan (RAP) (3) Qualitative evaluation based on expected project effects
14	Poverty	(1) Distribution of poverty groups	(1) Existing surveys and Statistics (2) Qualitative evaluation based on expected project effects
15	Ethnic Minority and Indigenous People	(1) Distribution of ethnic minority and indigenous people	(1) Existing surveys and Statistics (2) Qualitative evaluation based on expected project effects
16	Local Economy such as Employment and Livelihood	(1) Local economic status	(1) Existing surveys and Statistics (2) Qualitative evaluation based on expected project effects

No.	Item	Survey Item	Survey Method
17	Land Use and Usage of Local Resources	(1) Land use status	(1) Existing surveys and existing maps (2) Qualitative evaluation based on expected project effects
18	Water Usage	(1) Water usage status in rivers and other resources (2) Impact during construction	(1) Existing surveys and literature material (2) Confirmation of construction methods (3) Qualitative evaluation based on expected impact on water use
19	Existing Social Infrastructure and Services	(1) Distribution of residential areas, school, hospital, and etc.	(1) Existing surveys and literature material (2) Qualitative evaluation based on expected project effects
20	Social Institutions such as Socially Related Capital and Decision-making Organizations	(1) Social institutions and possible impact	(1) Existing surveys and literature material (2) Qualitative evaluation based on expected project effects
21	Local Conflicts of Interest	(1) Expected conflicts	(1) Project design and distribution of interest (2) Qualitative evaluation based on expected project effects
22	Landscape	(1) Scenic areas	(1) Existing surveys and literature material (2) Qualitative evaluation based on expected structures and topographical changes
23	Gender	(1) Impact on gender	(1) Existing surveys and literature material (2) Qualitative evaluation based on expected project effects
24	Children's Right	(1) General situation/possibility of child labor	(1) Existing surveys and literature material (2) Qualitative evaluation based on expected project effects
25	Infectious Diseases such as HIV/AIDS	(1) General situation/possibility of infectious diseases	(1) Existing surveys and literature material (2) Qualitative evaluation based on expected project effects
26	Labor Environment including Safety	(1) General situation/possibility of labor environment	(1) Existing surveys and literature material (2) Qualitative evaluation based on expected project effects
27	Accident	(1) Expected increases of accident	(1) Existing surveys and literature material (2) Qualitative evaluation based on expected project effects
28	Transboundary Impact and Climate Change	(1) Elements related to cross boundary impacts, cumulative impacts, and climate change	(1) Collect information based on highway construction and management (2) Qualitative evaluation based on expected project effects

Source: JICA Study Team

15.7.6 Results of Surveys

(1) Air Quality

There are residential areas (Bugo, Sumilao, and Malaybalay) along the proposed alignment. In general, the large-scale project will require many heavy construction vehicles/ equipment.

[Construction Stage]

Air quality around the construction areas and relevant locations will be degraded due to exhaust gas from construction machineries and vehicles. Also, earthworks may generate particulate matters such as PM_{10} and $PM_{2.5}$. In addition to construction vehicles, the exhaust gas will be generated from local traffic congestion around the construction yard due to the temporary traffic restriction. Level of air pollution may depend on locations, therefore, further monitoring (baseline) surveys are required during F/S.

[Operation stage]

Increased traffic may cause air pollution along the road on typical elements such as NO_2, SO_2, CO and particulate matters. In some sections, unpaved road will be improved, and particulate matters may decrease as a result. It may cause higher level of pollution on specific elements such as SO_2 and NO_2 which might be under domestic standard as baseline data. Level of air pollution may depend on locations, therefore further monitoring (baseline) surveys with forecasting analysis are required during F/S.

(2) Water Quality

The Project will traverse about 10 rivers. The project area is located in the area of water bodies for domestic defined as the ECA (**Table 15.7-8**)

[Construction Stage]

Water quality around the construction areas and relevant locations including camp yards, borrowing pit and other earthwork area will be degraded if wastewater is discharged inadequately, especially oil leakage from consecution machineries. Earth works also cause turbid water to the surrounding environment. Level of water pollution may depend on locations, therefore, further monitoring (baseline) surveys are required during F/S.

[Operation stage]

There is no construction plan of service areas which may discharge domestic wastewater, therefore, severe water pollution may not occur during the operational phase.

(3) Waste

The Project will include soil excavation, cutting land and land filling activities. Trees are found within the project area.

[Construction Stage]

Construction waste which is generated by the project will be excavated soil, and cut trees, etc. Also, domestic waste from labor camp yards is expected.

(4) Soil Contamination

The Project will include soil excavation, cutting land, and land filling activities and construction of bridges piers along 68 km.

[Construction Stage]

Wastewater from construction areas cause soil contamination, if wastewater is not treated appropriately. Furthermore, there is a possibility of soil contamination due to the unexpected leakage/ mishandling of oil and other chemicals, in the all earthwork area including the main road area and borrowing pit, etc. In case that on-site soil had already polluted, Dumping soils also have possibility of soil contamination when they are dumped other places.

(5) Noise and Vibration

There are residential areas (Bugo, Sumilao, and Malaybalay) along the proposed alignment. In general, the large-scale project will require many heavy construction vehicles/ equipment.

[Construction Stage]

Construction machineries and vehicles may cause certain level of noise and vibration around the construction area. Background noise level along the planned alignment is not so high because most of the area is rural regions. Level of noise and vibration may depend on locations, therefore, further monitoring (baseline) surveys are required during F/S.

[Operation stage]

Due to increased vehicles and attracted new demand of traffic, some areas may exceed national standard in the future. Level of noise and vibration may depend on locations, therefore, further monitoring (baseline) surveys are required during F/S.

(6) Ground Subsidence

The Project will include soil excavation, cutting land, and land filling activities and construction of bridges piers along 68km. Soil in Misamis Oriental is consist of three types of soil which includes sandy, loam and clay. In addition, soil in Bukidnon is generally categorize as adtuyan clay.

[Construction Stage and Operation stage]

Basically, there might be no activities which can cause significant ground subsidence, since large amount of water (groundwater) use caused ground subsidence are not expected at this moment. Based on literature survey on legally designated areas, the distribution of soft soil areas is not found. However, the amount of water use and source during construction, and detail geographic mechanism and hydrology conditions are not found from literature survey. The detail investigation based on actual project sites are required during F/S.

(7) Offensive Odor

Large scale project will require many workers and prepare the labors camp in general.

[Construction Stage]

As long as appropriate waste management and equipment maintenance are implemented, sever offensive odor cases are not expected. However, construction camp yards may cause offensive odor from its domestic waste and wastewater.

(8) Bottom Sediment

The Project will traverse about 10 rivers. Working in the river might be occurred.

[Construction Stage]

River crossing points may be affected on bottom sediment by construction activities. Earth works and other works inside rivers can cause direct sedimentation as well as turbid water. In case that crossing river bottom sediment had already polluted, dumping soils in the riverbed also have possibility of soil contamination when they are dumped other places.

(9) Protected Area

The nearest protected area (Mt. Kitanglad Range Natural Park) is approximately 8 km away from the proposed project.

[Construction Stage and Operation stage]

Bukidnon already has two protected areas: Mt. Kitanglad Range Natural Park declared through Republic Act 8978 and Mt. Kalatungan Range Natural Park through Presidential Proclamation No. 305. Based on literature survey on legally designated areas, CMH project may not affect any project areas directly at this moment. On the other hand, in addition to two existing protected areas, six (6) mountain ranges are in the process of application for protected area at this moment. The actual boundary including buffer zone of protected area and the status of new proposed protected area shall be confirmed through the confirmation of relevant agencies based on the fixed alignment of CMH during F/S.

(10) Ecosystem

Land use along the proposed alignment is used as arable land and forest land. Trees in the project area will be cut due to the road development in general. The nearest boundary of IBA named Mt. Tago range is approximately 1 km from the project alignment.

[Construction Stage and Operation Stage]

The project will be designed along the existing highway, traverse forest, agricultural cultivated area near IBA and include several bridges at the crossing rivers and valleys. Construction activities and existence of road structures may have impact (such as damage of trees and vegetation, loss of nest/feeding area/breeding area, and migration inhibition, division of the habitation area, road killing, noise/vibration due to the new traffic flow, etc.) on surrounding ecosystem along the project alignment. Further information and field surveys on birds and other key species confirmed in and around project site should be discussed during F/S. To understand information of habitat and kye species based on actual project sites, further monitoring (baseline) surveys are required during F/S.

(11) Hydrology

The Project will traverse about 10 rivers.

[Construction Stage]

Bridge construction work inside river such as piers for bridges may cause hydrological changes.

[Operation stage]

Structures inside river such as piers and foundation block for bridges may cause water flow changes.

(12) Topography and Geology

The Project will include soil excavation, cutting land and land filling activities. The project area is located in the area of high susceptibility to landslide and critical slope area defined as the ECA (**Table 15.7-8**)

[Construction stage]

Cut and fill works for road construction may change topography and geology. To estimate size, location and impact, further design and related surveys on geology and topography are required in following phases such as F/S. There are possibilities of land slide and soil erosion due to slope cutting and/or land filling works. Following table and figures show observation results of general situation of topography with information of structures and typical photos.

Table 15.7-14 and **Figure 15.7-11** present the outline of site condition along the proposed project. A site visit was conducted in Municipality of Tagoloan, Province of Misamis Oriental and Municipalities of Manolo Fortich and Malaybalay, Province of Bukidnon on February 13, 2020.

Table 15.7-14 Site Observations

Location (from south to north)	Observations
A: Barangay of Sumpong, Malaybalay	The proposed alignment will be crossed in sugarcane farm and unknown road.
B: Barangay of Kibenton, Impasug Ong	Corn farm, few structures and vegetation will be affected by the proposed CMH alignment
C: Barangay of San Viciente, Sumilao	Few house structures and vegetation will be traverse by the alignment on both sides.
D: Barangay of Poblacion, Sumilao	The proposed alignment will traverse in corn farm, structure and few vegetation.
E: Sayre Highway, Barangay of Dalirig, Manolo Fortich	The proposed alignment will cross in few structures, vegetation and hilly area.
F: Sayre Highway, Barangay of Tankulan, Manolo Fortich	Structure and few vegetation will be affected by the proposed alignment.
G: Barangay of Lunocan, Manolo Fortich	The proposed alignment will traverse in unknown road and few vegetation on both sides.
H: Sayre Highway, Barangay of Puetro, Cagayan de Oro	Few vegetation will be affected by the proposed alignment.
I: Barangay of Puetro, Cagayan de Oro	The alignment will be crossed in existing road and few vegetation on both sides.
J: Barangay of Bugo, Cagayan de Oro	The alignment will cross in existing road and few vegetation on both sides.
K: Barangay of Natumolan, Tagoloan	Few vegetation and existing road will be affected by the alignment.
L: Barangay of Casinglot, Tagoloan	The alignment will traverse in coconut farm.

Note: Stations (A-L) in this table are shown in **Figure 15.7-11.**
Source: JICA Study Team

Figure 15.7-11 Proposed Project Site Map

Source: JICA Study Team

(13) Land Acquisition and Resettlement

There are residential areas (Bugo, Sumilao, and Malaybalay) along the proposed alignment.

[Pre-Construction Stage]

Based on rough counting survey by using satellite photos, approximately 170 structures may be affected by the project. Presumed form of impact is physical relocation, partial slice of structure, loss of secondary assets such as gate, fruit trees, as well as private land ownership. Exact size and characteristics of land acquisition and resettlement require further survey such as socio-economic survey, census, inventory of loss, etc. to develop resettlement action plan (RAP) in following phases such as F/S.

(14) Poverty

[Pre-Construction and Construction Stage]

Based on statistical situation elaborated in the part of baseline data, there might be poverty groups in the project sites. Some households including informal settlers family (ISF) may become direct project affected household (PAH) and some may be affected their secondary properties such as crops and/or their livelihood. On the other hand, they will have opportunities to obtain new income through construction activities. Exact size and characteristics of impact on poverty requires further survey such as socio-economic survey, census, inventory of loss, etc. to develop resettlement action plan (RAP) and EIA/EIS in following phases such as F/S.

(15) Ethnic Minority and Indigenous People

The mountain ranges in the Bukidnon is used as the homeland of the indigenous peoples (IPs). Several CADTs in Region 10 are found near Project area.

[Pre-Construction and Construction, Construction, and Operation Stage]

Based on the list of approved CADT's and identified ancestral domain area by NCIP as of December 2019, there are four (4) approved CADT's in Malaybalay City. In addition, the one (1) CADT application in Bukidnon is on process. Even there is not observed exact existing of ethnic minority along the project site, there are possibility of their communities and/or living.

To confirm current status and the actual boundary of ancestral domain area, communication with relevant authorities and further field surveys such as RAP related surveys and literature examination are required in following phases such as F/S.

In case that the possibility of impact (e.g. involuntary resettlement, direct land acquisition of ancestral domain, communication disturbance, damage of livelihood, etc.) on the IPs is estimated, the impact and necessary mitigation measures shall be studied during F/S through the communication with NCIP in consideration of on-site ancestral domain condition.

(16) Local Economy such as Employment and Livelihood

[Construction Stage]

Employment opportunity can be created by construction activities and local economy will be improved temporally. On the other hand, overall construction activities and traffic restriction would affect local economy activities including venders and shop owner to some extent temporary inconvenience due to disturbance in smooth operation of commercial/public transportation. Resettlement also may cause lost or degradation of local economy through changes of their livelihood and employment situation.

(17) Land Use and Usage of Local Resources

Current land use along the proposed alignment is mostly used as cultivated land and/or bare land. The project area is located in the prime agricultural land defined as the ECA (**Table 15.7-8**).

[Construction Stage]

Outline of land use along the project alignment is shown in **Table 15.7-15**. Basically, the project alignment is planned along the existing Sayre Highway in parallel. Based on roughly interpretation of satellite photo, the land use along the proposed alignment are used almost as cultivated area / farm/ bare area. The residential areas along or near the proposed alignment are found i) at Bugo, City of Cagayan de Oro, which is southside of the starting point of the Project, ii) at Sumilao municipality of Bukidnon Province along Sayre Highway, and iii) at Malaybalay residential area, which is the end point of the Project. Land Use of ROW will be changed to road structures.

Table 15.7-15 Land Use along the Project Site

Land use classification	Distribution Rate
Cultivated area/ Farm/ Bare area	85.3%
Forest/Trees/Palm	11.4%
Residence / Infrastructures	2.0%
River	1.3%

Source: JICA Study Team

[Operation Stage]

As secondary impact of the project, development along the project area may cause adverse impact on land use and local resources such as forestry and water.

(18) Water Usage

[Construction and Operation]

Though water source during construction is not decided at this moment, water use permission in line with regulation shall be approved from relevant agencies prior to the construction to avoid conflict with water users. The amount of water use and source in and around project site during construction and operation shall be studied during the feasibility study.

(19) Existing Social Infrastructure and Services

The proposed alignment will cross many existing community roads and rivers. The Project components include bridges, underpass/over pass roads and box culvert to avoid intercepting the existing transportation.

[Pre-Construction and Construction Stage]

CMH may traverse existing social infrastructures in the rural areas such as roads, telecommunication lines, electricity networks, and water supply networks. These existing infrastructures are target of relocation during pre-construction and construction stages. Both private and public owners of these infrastructures will be affected, and some services may be degraded due to construction.

[Operation Stage]

There is a possibility of physical community diversion in case a new road traverses in a community.

(20) Social Institutions such as Socially Related Capital and Decision-making Organizations

[Construction Stage]

Construction may cause division of communities along the road temporally. Therefore, there are some potential of impact on social institutions in terms of accessibility.

(21) Local Conflicts of Interest

[Operation Stage]

New alignment of road may hinder existing access between residents and social services in case that no measures are considered to solve these issues. It may cause a kind of conflict among local communities.

(22) Landscape

Current land use along the proposed alignment is mostly used as cultivated land and/or bare land. The Project will include soil excavation, cutting land and land filling activities and construction of bridges piers.

[Construction Stage]

Cut and fill works may cause change of landscape. However, it is difficult to determine location and degree of changes without further designs. So, continuous discussion and assessment is required in following phases such as F/S.

(23) Gender

There are residential areas (Bugo, Sumilao, and Malaybalay) along the proposed alignment.

[Construction Stage]

Women as commuter or daily working for their families may be affected by the construction activities. On the other hand, project can provide opportunities of works and commercial in the area and it may bring positive impact on gender balance. However, there might be gaps on working conditions such as wage between men and women when local employment is considered.

[Operation Stage]

Improvement of accessibility by the project may bring positive impact on gender issues, especially women's business opportunities, socio-economic activities and daily works for their family.

(24) Children's Right

Large scale project will require many workers in general.

[Construction Stage]

There are possibilities of child labor in construction yard and related activities.

[Operation Stage]

Improvement of accessibility by the project may bring positive impact on children's right, especially their school life.

(25) Infectious Diseases such as HIV/AIDS

Large scale project will require many workers and prepare the labors camp in general.

[Construction Stage]

Construction workers coming from outside the community / island may cause HIV/AIDS cases during construction time.

(26) Labor Environment including Safety

Large scale project will require many workers and prepare the labors camp in general. The Project will include soil excavation, cutting land and land filling activities and construction of bridges piers.

[Construction Stage]

Accident and inappropriate occupational condition during the construction may cause negative impact on labor environment and occupational safety as well as health.

(27) Accident

The Project is large scale development. There are residential areas (Bugo, Sumilao, and Malaybalay) along the proposed alignment.

[Construction Stage]

Traffic accident due to construction vehicles may occur without appropriate measures and education.

[Operation Stage]

Traffic accident due to increased traffic may occur along the road and vicinity connecting to the project section.

(28) Transboundary Impact and Climate Change

Land use along the proposed alignment is used as arable land and forest land. Trees in the project area will be cut due to the road development in general.

[Construction Stage]

Greenhouse effect gas is increase by operation of machineries and vehicles in the construction sites, though the construction period is limited. Trees in the project area will be cut due to the road development in general. The survey of estimation of cutting tree area based on actual project sites are required during F/S.

[Operation Stage]

Increased traffic based on newly created demands may produce much greenhouse effect gas.

15.7.7 Impact Assessment

(1) Preliminary Impact Assessment

The result of potential negative environmental and social impact assessment at pre-F/S is shown in the following table. In consideration of survey results, the impacts were evaluated qualitatively in each of the three stages separately, namely: pre-construction stage [PCS], construction stage [CS], and operation stage [OS]. The impacts of pollution, natural environment, and social environment were classified as A to D in accordance with the following criteria, assuming no specific measures toward the impacts are taken:

A: Significant Negative Impact　　A+: Significant Positive Impact

B: Some Negative Impact　　B+: Some Positive Impact

C: Impacts are not clear, need more investigation

D: No impacts or impacts are negligible, no further study required

N/A：Impact assessment isn't conducted because the item was categorized into D in scoping phase.

Table 15.7-16 Result of ESIA at Pre-F/S

No	Item	Assessment at Scoping		Assessment Result based on surveys		Reasons for Assessment
		PCS /CS	OS	PCS/ CS	OS	
1	Air Quality	✓	✓	B-	B+/-	[CS] In consideration of current residential land use, temporary negative impacts are expected on air quality due to exhaust gas and dust generated from construction activities. The exhaust gas will be generated from construction machines, equipment, and traffic congestion around the construction yard due to the temporary traffic restriction. And dust will be generated by earth work including foundation excavation for piers, transporting of earth-and-sand, etc. [OS] Ambient air quality along existing road is already impacted by current traffic exhaust gas. Since it is expected that traffic flow will be smoother by shifting vehicles from existing road to new highway, air quality along the road will be improved. On the other hand, there is a possibility of increasing of vehicles. In that case, air quality along the road might get worse than the current condition. To clarify the baseline condition including current traffic emission, air quality monitoring will be conducted during F/S.
2	Water Quality	✓	✓	B-	D	[CS] The project area is located in the area of water bodies for domestic defined as the ECA, since the Project will traverse about 10 rivers. Turbid water may be generated from excavation areas due to surface run-off. Improper stockpiling of construction materials could affect the water quality of nearby bodies of water bodies. Furthermore, there is a possibility of inadequate treatment and/or mishandling of wastewater, suspended matter, waste oil, and other chemicals, in the all earthwork area including the main road area and borrowing pit, etc.. Additionally, domestic wastewater may be discharged from the labor camp. [OS] No serious impacts are expected, because there is no plan of service / parking area.
3	Waste	✓		B-	N/A	[CS] Construction waste including waste soil, asphalt mass and cutting trees are expected at the construction site. Additionally, domestic waste (garbage) may be generated from the labor camp, if any.
4	Soil Contamination	✓		B-	N/A	[CS] There is a possibility of soil contaminant by wastewater from piling construction/excavation process, if wastewater is discharged without adequate treatment and/or miss handing. Furthermore, there is a possibility of soil contamination due to the unexpected leakage/ mishandling of oil and other chemicals, in the all earthwork area including the main road area and borrowing pit, etc.. Dumping soil and muck also can cause soil contamination if they have specific chemicals.
5	Noise and Vibration	✓	✓	B-	B+/ -	[CS] In consideration of current land use temporary negative impacts are expected on ambient noise due to higher noise generated from construction machines and equipment. [OS] Ambient noise and vibration along existing road is already impacted by current vehicle traveling. Though it is expected that traffic flow is smooth by shifting from existing road to new highway, noise and vibration level might increase because of the increase in traffic and travelling speed of vehicles. To clarify the baseline condition including current traffic impact, ambient noise survey and vibration monitoring will be conducted along the proposed alignment during F/S.
6	Ground Subsidence	✓	✓	B-	B-	[CS/OS] The construction activities will include pumping up the groundwater and some extent of impact will be estimated due to the large-scale excavation work. Though the extent of impact is unknown at this moment, to clarify the baseline condition of geographic mechanism including ground water level and geological test shall be conducted along the proposed alignment during the feasibility study, because there is no detail amount of ground water and geographical test data, and no decided proposed ROW.

No	Item	Assessment at Scoping		Assessment Result based on surveys		Reasons for Assessment
		PCS /CS	OS	PCS/ CS	OS	
7	Offensive Odor	✓		B-	N/A	[CS] There are no direct project-related activities that can generate offensive odor due to the general road construction, however impact of construction basecamp operations may have temporary impact.
8	Bottom Sediment	✓		B-	N/A	[CS] There is a possibility of impact on the river bottom sediment by flown soil caused by earthwork in the river, depending on the construction methodology. In case that crossing river bottom sediment had already polluted, dumping soils in the riverbed also have possibility of soil contamination when they are dumped other places.
9	Protected Area	✓	✓	B-	B-	Basically, no impacts are expected at this moment, since the nearest protected area is approximately 8km far from the project area. To clear the relation between the project and PAs, the boundary and buffer zone of Protected Area and the status of proposed new protected areas shall be confirmed with DENR in the F/S.
10	Ecosystem	✓	✓	B-	B-	[CS/OS] The project will be designed along the existing highway, traverse forest, agricultural cultivated area near IBA and include several bridges at the crossing rivers and valleys. Though there are no reserved forest and IBA within the project area ate this moment, most of existing trees within ROW will be cut down or replanted depending on the final design and construction process. Construction activities and existence of road structures may have some impact (such as damage of trees and vegetation, loss of nest/feeding area/breeding area, and migration inhibition, division of the habitation area, road killing, air pollution and noise/vibration due to the new traffic flow, lighting etc.) on surrounding ecosystem along the project alignment. To clear the impact on the biodiversity, flora and fauna field survey, tree inventory survey, confirmation of the boundary of IBA, and communication with ecologist shall be conducted during the feasibility survey
11	Hydrology	✓	✓	B-	B-	[CS/OS] There is a possibility of disturbance of water flow by construction of bridge pier in the river and preventing /changing water flow by concrete structures.
12	Topography and Geology	✓		B-	N/A	[CS] The project area is located in the area of high susceptibility to landslide and critical slope area defined as the ECA. Topography might change by land cutting in the valley. There is a possibility of land slide and topsoil erosion in the construction site during rainy season (May-October).
13	Land Acquisition and Resettlement	✓		A- /B-	N/A	[PCS] It is expected that about 170 existing structures including houses are affected due to the implementation of the Project, in accordance with the satellite image interpretation. To clear the project affected people, their assets and compensation, identification of landowner, socio-economic survey, inventory survey and market value survey for preparation of the Resettlement Action Plan including rehabilitation of livelihood shall be conducted during the feasibility survey.
14	Poverty	✓		B+/ -	N/A	[PCS/CS] The project may bring positive impact on local economy through construction activities and rural development. Some poor groups may be negatively affected by the project if their properties are acquired and/or their livelihood is lost by the project.
15	Ethnic Minority and Indigenous People	✓	✓	B-	B-	[CS/OS] The representative of the NCIP in Manolo Fortich mentioned that there are potential CADT/ CADCs along the alignment of the project. The location and relation between CADTs and the Project site shall be verified through the feasibility study.
16	Local Economy such as	✓		B+/ -	N/A	[CS] Employment opportunity can be created due to the project construction. On the other hand, overall construction activities and traffic restriction would affect local economy activities including venders and shop owner to some

No	Item	Assessment at Scoping		Assessment Result based on surveys		Reasons for Assessment
		PCS /CS	OS	PCS/ CS	OS	
	Employment and Livelihood					extent temporary inconvenience due to disturbance in smooth operation of commercial/public transportation. Employment and livelihood of project affected households are also affected by resettlement activities.
17	Land Use and Usage of Local Resources	✓	✓	B-	B+/ -	[CS] The project area is located in the prime agricultural land defined as the ECA. Loss of farmland and forests for new roads are expected and land use may be changed along the road. Land and local resources such as trees of project affected households are also affected by resettlement activities. [OS] Effective use of lands and local resources due to high accessibility are expected. At the same time, project-indued development may affect local resources adversely.
18	Water Usage	✓	✓	B-	B-	[CS/OS] To clarify the baseline condition of underground water use around the project area, inventory survey for wells shall be conducted during the feasibility study. Though water source during construction is not decided at this moment, water use permission in line with regulation shall be approved from relevant agencies prior to the construction to avoid conflict with water users. The amount of water use and source in and around project site during construction and operation shall be studied during the feasibility study. Water usage of project affected households are also affected by resettlement activities.
19	Existing Social Infrastructure and Services	✓		B-	B-	[PCS/CS] There are many existing utilities (transmission lines, telecom lines, water lines, etc.) along the existing road. These infrastructures shall be protected and/or diverted before construction work. Inconvenient access to services due to traffic congestion by work vehicles. [OS] There is a possibility of physical community diversion in case a new road traverses in a community.
20	Social Institutions such as Socially Related Capital and Decision-making Organizations	✓		B-	N/A	[CS] There is a possibility of the temporary physical community division by construction yard during construction.
21	Local Conflicts of Interest		✓	N/A	B-	[OS] New alignment may separate access of existing communities and their interest may cause local conflicts without any measures.
22	Landscape	✓		B-	N/A	[CS] There is a possibility of disturbance of landscape by the road structures especially bridges, since current landscape is regional and rich in nature.
23	Gender	✓		B+/ B-	N/A	[CS]: Temporary inconvenience to residents, commuters, and pedestrians because of construction activities is expected. On the one hand, the Project can provide additional employment opportunities during this phase, which women can take advantage of. However, there might be gaps on working conditions such as wage between men and women when local employment is considered.
24	Children's Right	✓		B-	N/A	[CS] There is a possibility of occurrence of child labor

No	Item	Assessment at Scoping		Assessment Result based on surveys		Reasons for Assessment
		PCS /CS	OS	PCS/ CS	OS	
25	Infectious Diseases such as HIV/AIDS	✓		B-	N/A	[CS] Infectious diseases such as STDs are possible to be spread due to inflow of construction workers. Furthermore, alteration to the ground by cutting, soil excavation and land filling may lead to the creation of habitats for mosquitos that possibly transmit dengue fever.
26	Labor Environment including Safety	✓		B-	N/A	[CS] Accident and harm to health for workers in the construction area for bridge section; however, it will be secured in accordance with the domestic laws and regulations during construction.
27	Accident	✓	✓	B-	B+/ -	[CS] Construction vehicles may use existing local road near residential areas, thus the number of traffic accident may increase. There is a possibility for local people to enter the construction area. [OS] It is expected that the road safety on the ground level will be improved due to the improvement of the current traffic congestion by shifting from existing road to new elevated highway. On the other hand, risks of traffic accidents on the new road are expected due to the increase in travelling speed and the number of vehicles. To clarify the baseline condition including current traffic emission, air quality, noise and vibrations monitoring will be conducted during the feasibility study.
28	Transboundary Impact and Climate Change	✓	✓	B-	B-	[CS] Tree cutting due to the development of road may cause to decrease the greenhouse gas absorption, but the level is still unknown. [OS] Increase of Greenhouse Effect Gas is anticipated but the level is still unknown

Note: Project stage:

PCS: Pre-construction stage, CS: Construction stage, OS: Operation stage

Impact:

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

D: No impact is expected.

N/A: Impact assessment isn't conducted because the items was not checked ✓in scoping phase.

Source: JICA Study Team

15.7.8 Mitigation Measures

Mitigation measures should be feasible and practical. **Table 15.7-17** shows mitigation measures for the identified impact of the project during construction and operation phases.

Table 15.7-17 Mitigation Measures

No.	Items (Impacts)	Proposed Mitigation Measures	Implementing Organization	Responsible Organization	Cost (Php)
Construction Stage					
1	Air Quality	- Water sprinkling to reduce particulate matter - Routine / periodic maintenance and washing of construction machineries and vehicles to minimize air pollutants -Announcement of construction work to surround resident - In the event of complaint from resident, review the additional mitigation measures including the construction schedule or location of heavy vehicles through the communication with local people	Contractor	DPWH	TBD
2	Water Quality	- Installing sedimentation tank to reduce discharged turbid water - Cover exposed earth especially before heavy rains are expected. - Installing septic tanks for origin of polluted water such as camp yard - Appropriate wastewater treatment such as connecting drainage system to existing sewage systems	Contractor	DPWH	TBD
3	Waste	-Prepare detailed waste management program in consideration with LGU's waste management system - Education on waste treatment for workers - Separation of hazardous waste and bring out to appropriate treatment facilities - 3Rs promotion to reduce waste	Contractor	DPWH	TBD
4	Soil Contamination	- Necessary laboratory test to identify contaminated soil and mock for special cares - Find feasible treatment facilities or filling area in earlier stage of the project such as F/S	Contractor	DPWH	TBD
5	Noise and Vibration	- To avoid disturbance of daily life, construction time shall be set within day time, especially residential areas. - Apply low-noise and vibration machineries as much as possible nearby -Provide the temporary noise barrier and/or fence around the construction yard near residential area, if necessary -Announcement of construction work to surround resident - In the event of complaint from resident, review the additional mitigation measures including the construction schedule or location of heavy vehicles through the communication with local people	Contractor	DPWH	TBD
6	Ground Subsidence	- Avoid extraction of ground water for construction - Applying replacement methods for soft soil areas based on further studies and discussion in F/S. - Monitoring to identify early symptoms of subsidence	Contractor	DPWH	TBD
7	Offensive Odor	- Education and instruction of rules in camp yards to keep good hygiene	Contractor	DPWH	TBD

No.	Items (Impacts)	Proposed Mitigation Measures	Implementing Organization	Responsible Organization	Cost (Php)
8	Bottom Sediment	- Installing sedimentation tank to reduce discharged turbid water	Contractor	DPWH	TBD
9	Protected Area	-Clarify the boundary and buffers zone and core zone of protected area. -Communicate with DENR appropriately, and conduct the mitigation measures in line with the advice from relevant agencies	Contractor	DPWH / DENR	TBD
10	Ecosystem	- Avoid tree cutting to reduce impact on habitat -Relocation/replant of trees - Consider construction season and time if specific rare species' breeding points / nests / important feeding ground are confirmed in the affected areas. -Conduct awareness campaign to all relevant construction workers about the careful consideration for ecosystem -Adoption of lower noise and vibration construction method and machines - Adoption of adequate pass route, based on the field survey, estimated impact and advices from biological expert, if necessary	Contractor	DPWH / DENR	TBD
11	Hydrology	- Avoid large amount of extraction of ground water	Contractor	DPWH	TBD
12	Topography and Geology	- Slope protection is required after cutting slopes especially in the period of rainy season	Contractor	DPWH	TBD
13	Land Acquisition and Resettlement	- Alignment discussion should be carefully done during F/S study to avoid and minimize resettlement - Appropriate RAP must be prepared consistent with domestic and development partner's policies.	Consultant, Contractor, DPWH, LGUs, NHA	DPWH	TBD
14	Poverty	- Appropriate RAP must be prepared consistent with domestic and development partner's policies.	Consultant, Contractor, DPWH, LGUs, NHA	DPWH	TBD
15	Ethnic Minority and Indigenous People	- Appropriate RAP must be prepared consistent with domestic and development partner's policies. - If there are indigenous people in and around the project areas, Indigenous People Plan (IPP) must be prepared with cares	Consultant, Contractor, DPWH, LGUs, NHA	DPWH	TBD
16	Local Economy such as Employment and Livelihood	- Appropriate RAP must be prepared consistent with domestic and development partner's policies with assistance for business disturbances.	Consultant, Contractor, DPWH, LGUs, NHA	DPWH	TBD
17	Land Use and Usage of Local Resources	- Appropriate RAP must be prepared consistent with domestic and development partner's policies.	LGUs	LGUs	TBD
18	Water Usage	- Avoid large amount of extraction of ground water	Contractor	DPWH	TBD
19	Existing Social Infrastructure and Services	- Appropriate / agreed compensation for owners of infrastructures to recover, divert, and replace. - Road-crossing measures such as over path / under path should be considered for possible community diversion cases.	DPWH, LGUs	DPWH	TBD
20	Social Institutions such as Socially Related Capital and Decision-making Organizations	- Detour for securing reasonable accessibility to social institutions	Contractor	DPWH	TBD
21	Landscape	- Minimize cutting trees and slopes - Consider earth color for temporal works and fences	Contractor	DPWH	TBD

No.	Items (Impacts)	Proposed Mitigation Measures	Implementing Organization	Responsible Organization	Cost (Php)
		- Installation of slope seeding / planting to recover construction areas			
22	Gender	- Positive employment of women for light works in construction activities such as cleaning with fair salary and other conditions - Prepare toilet and dressing spaces for women workers - Education on gender equality for workers	Contractor	DPWH	TBD
23	Children's Right	- Restrict child labor (workers under 14 years old) in contract with punishment - Report list of workers with their age information	Contractor	DPWH	TBD
24	Infectious Diseases such as HIV/AIDS	- Education on infectious diseases for workers	Contractor	DPWH	TBD
25	Labor Environment including Safety	- Education on occupational safety for workers - Safety patrol - Sign boards	Contractor	DPWH	TBD
26	Accident	- Periodic maintenance of machineries and vehicles - Sign boards - Employ enough number of traffic guards	Contractor	DPWH	TBD
27	Transboundary Impact and Climate Change	- Periodic maintenance of machineries and vehicles - Recommendation of idling stop activities	Contractor	DPWH	TBD
Operational Stage					
1	Air Quality	- Strengthening of vehicle inspection	DPWH	DPWH	TBD
2	Noise and Vibration	- Noise barriers if the level significantly exceeds the standard - Restriction of maximum speed	DPWH	DPWH	TBD
3	Ground Subsidence	- Periodic observation of level changes	DPWH	DPWH	TBD
4	Protected Area	-Communicate with DENR appropriately, and conduct the mitigation measures in line with the advice from relevant agencies	DPWH	DPWH	TBD
5	Ecosystem	- Periodic observation of flora and fauna	DPWH	DPWH	TBD
6	Hydrology	- Avoid large amount of extraction of ground water - Periodic observation of water flow / level	DPWH	DPWH	TBD
7	Ethnic Minority and Indigenous People	- If there are indigenous people in and around the project areas, Indigenous People Plan (IPP) must be prepared with cares.	DPWH, LGUs	DPWH	TBD
8	Land Use and Usage of Local Resources	- Controlled rural development under legal framework and masterplans by LGUs	LGUs	LGUs	TBD
9	Water Usage	- Avoid large amount of extraction of ground water - Periodic observation of water flow / level	DPWH, LGUs	DPWH	TBD
10	Local Conflicts of Interest	- Design box culvert or any other crossing structure to secure accessibility	DPWH, LGUs	DPWH	TBD
11	Accident	- Sign boards - Traffic violation crackdown by police - Road safety education at schools and other appropriate facilities	DPWH, LGUs, Police	DPWH	TBD
12	Transboundary Impact and Climate Change	- Strengthening of vehicle inspection	DPWH	DPWH	TBD
Total Cost					TBD

Source: JICA Study Team

15.7.9 Monitoring Plan

Table 15.7-18 presents general/typical proposed Environmental Monitoring Plan (EMoP) for mitigating the negative impacts. EMoP and EIA shall be studied further during the Feasibility Study.

Table 15.7-18 Monitoring Plan

No	Environmental Item	Items	Location	Frequency	Responsible agent	Supervisor	Cost (Php)
Construction Stage							
1	Air Quality	PM10, PM2.5, SO_2, CO, NO_2	Construction sites, major access routes to the construction sites	Once a month	Contractor	DPWH	TBD
2	Water Quality	BOD5, COD, Oil and Grease, pH, Total Coliform, Total Nitrogen, Total Phosphorous, Total suspended solids, Turbidity, Arsenic, Iron, Sulphate	Rivers, drainages, camp yards, wells, springs	Once every three-month	Contractor	DPWH	TBD
3	Waste	Types and amount of waste	Temporal waste storage	Once every three-month	Contractor	DPWH	TBD
4	Soil Contamination	Soil quality test in accordance with the baseline survey and existing land use, Monitoring accident, maintenance record of machineries and vehicles, site observation	Construction sites and camp yards	Once a month	Contractor	DPWH	TBD
5	Noise and Vibration	Sound level and vibration.	Construction sites, major access routes to the construction sites	Once a month	Contractor	DPWH	TBD
6	Ground Subsidence	Visible observation on markers and gauges	Surrounding structures of construction sites	Once a week	Contractor	DPWH	TBD
7	Offensive Odor	Types and amount of waste, other specific cases such as oil leakage	Temporal waste storage	Once every three-month	Contractor	DPWH	TBD
8	Bottom Sediment	Visible observation of rivers and drainage from construction sites	Construction sites and rivers	Once every three-month	Contractor	DPWH	TBD
9	Protected Area	Visible observation of mitigation measurements Field confirmation by experts	Construction sites and surrounding areas	Once a year	Contractor	DPWH	TBD
10	Ecosystem	Visible observation of mitigation measurements Field confirmation by experts	Construction sites and surrounding areas	Once a year	Contractor	DPWH	TBD
11	Hydrology	Visible observation, interview, measurement of water volume	River, spring, well, etc.	Once every three-month	Contractor	DPWH	TBD
12	Topography and Geology	Visible observation, reviewing of cut and fill plan, tree cutting plan with certification	Forest, hilly areas	Once every three-month	Contractor	DPWH	TBD
13	Land Acquisition and Resettlement	Internal / External monitoring report defined in RAP, grievance records	Project Areas	Following RAP	LGUs, NHA, other relevant bodies	DPWH	TBD

No	Environmental Item	Items	Location	Frequency	Responsible agent	Supervisor	Cost (Php)
14	Poverty	Internal / External monitoring report defined in RAP, grievance records	Project Areas	Following RAP	LGUs, NHA, other relevant bodies	DPWH	TBD
15	Ethnic Minority and Indigenous People	Internal / External monitoring report defined in RAP, grievance records, IPP, if any	Project Areas	Following RAP and IPP	LGUs, NHA, other relevant bodies	DPWH	TBD
16	Local Economy such as Employment and Livelihood	Internal / External monitoring report defined in RAP, grievance records, income restoration program (IRP)	Project Areas	Following RAP, IRP	LGUs, NHA, other relevant bodies	DPWH	TBD
17	Land Use and Usage of Local Resources	Construction plan including lease land, grievance records	Project Areas	Once every three-month	Contractor	DPWH	TBD
18	Water Usage	Water volume, visible observation, interview, grievance records	Water usage areas	Once a month	Contractor	DPWH	TBD
19	Existing Social Infrastructure and Services	Visible observation, interview, grievance records	Project Areas	Once every three-month	Contractor	DPWH	TBD
20	Social Institutions such as Socially Related Capital and Decision-making Organizations	Visible observation, interview, grievance records	Project Areas	Once every three-month	Contractor	DPWH	TBD
21	Landscape	Visible observation, interview, grievance records	Project Areas	Once every three-month	Contractor	DPWH	TBD
22	Gender	Visible observation, interview, grievance records, list of construction worker, record of education, number of facilities for women in construction site and camp yard	Project Areas	Once a month	Contractor	DPWH	TBD
23	Children's Right	Visible observation, interview, grievance records, list of construction worker, record of education	Construction sites	Once a month	Contractor	DPWH	TBD
24	Infectious Diseases such as HIV/AIDS	Visible observation, interview, grievance records, record of education	Construction sites	Once a month	Contractor	DPWH	TBD
25	Labor Environment including Safety	Visible observation, interview, grievance records, record of education, record of safety patrol, sign boards	Construction sites	Once a month	Contractor	DPWH	TBD
26	Accident	Record of accident, record of education, sign boards	Construction sites and surrounding areas	Once a month, on demand	Contractor	DPWH	TBD
27	Transboundary Impact and Climate Change	Record of maintenance of machinery and vehicles, sign boards	Construction sites	Once a year	Contractor	DPWH	TBD
Operational Stage							
1	Air Quality	PM10, PM2.5, SO2, CO, NO2	Residential area, junctions, long bridges, etc.	Once a year	Regional Office (RO) - DPWH	DPWH	TBD
2	Noise and Vibration	Sound level and vibration.	Junctions, long bridges and residential areas	Once a year	RO	DPWH	TBD
3	Ground Subsidence	Visible observation on markers and gauges	Surrounding structures of construction sites	Once a year	RO	DPWH	TBD

No	Environmental Item	Items	Location	Frequency	Responsible agent	Supervisor	Cost (Php)
4	Protected Area	Visible observation of mitigation measurements by experts	Construction sites and surrounding areas	Once a year	Contractor	DPWH	TBD
5	Ecosystem	Periodical monitoring of affected biodiversity condition	Construction sites and surrounding areas	Once a year	Contractor	DPWH	TBD
6	Hydrology	Visible observation, interview, measurement of water volume	River, spring, well, etc.	Once a year	RO	DPWH	TBD
7	Ethnic Minority and Indigenous People	Interview, observation, socio-economic survey, if needed	Project Areas	Once a year	RO	DPWH	TBD
8	Land Use and Usage of Local Resources	Regional development plan, visible observation	Project Areas	Once a year	LGUs	DPWH	TBD
9	Water Usage	Water volume, visible observation, interview, grievance records	Water usage areas	Once a year	RO	DPWH	TBD
10	Local Conflicts of Interest	Interview, observation	Project Areas	Once a year	LGUs	DPWH	TBD
11	Accident	Record of accident, record of education, sign boards	Project road and surrounding areas	Once a year	RO	DPWH	TBD
12	Transboundary Impact and Climate Change	Record of maintenance of machinery and vehicles, sign boards	Project road and surrounding areas	Once a year	RO	DPWH	TBD

Source: JICA Study Team

15.7.10 Implementation Structure

Implementation structure for CMH will be established based on the country's legal frameworks with reporting/discussion channels to investors/development partners. Based on the existing project institutional plan such as Cebu-Mactan Bridge Construction Project under JICA's cooperation, **Figure 15.7-12** and **Figure 15.7-13** shows rough implementation structure of environmental and social considerations of the project.

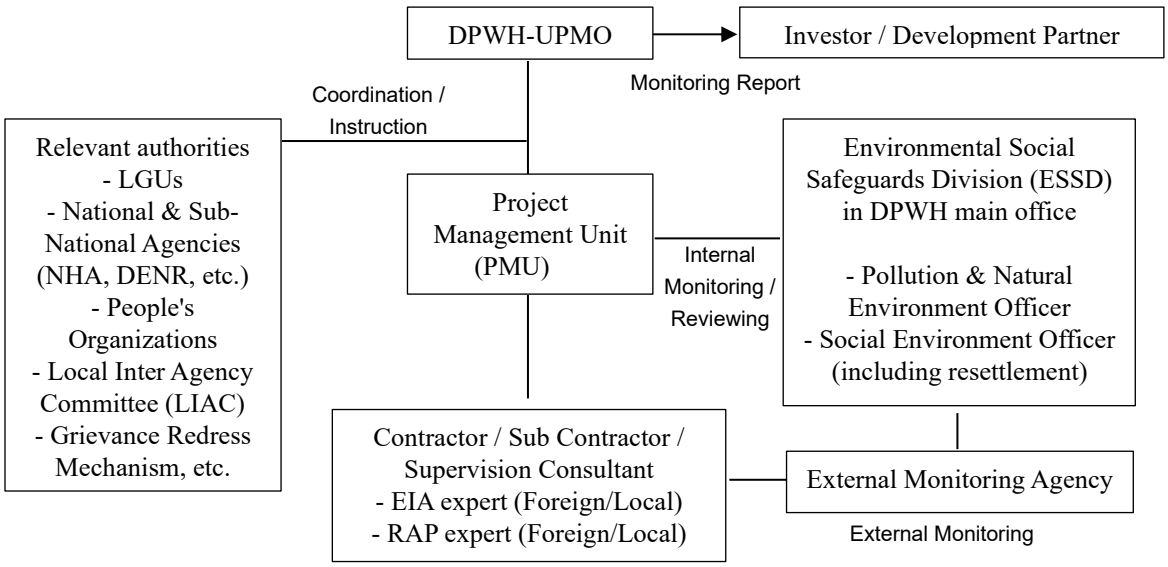


Figure 15.7-12 Implementation Structure of Environmental and Social Considerations during Construction Stage

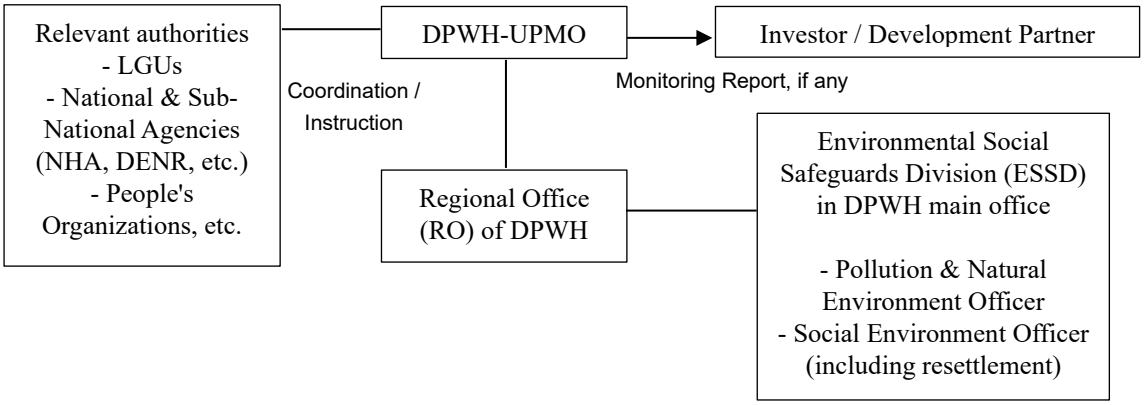


Figure 15.7-13 Implementation Structure of Environmental and Social Considerations during Operation Stage

15.7.11 Public Consultation

(1) Key Informant Interview (KII)

On 03 February 2020, a key informant interview (KII) was conducted at the Regional Office of DENR, NCIP Region 10 and at the municipalities of Tagoloan and Municipality of Manolo Fortich. The agenda is to brief the stakeholders about the project including its environmental and social aspects, as well as to ask their perception on the said project. The team interviewed representatives from the DENR, NCIP Region 10 and the Municipal Mayors and Municipal Engineers of the affected areas.

Based on the KII results, the following were the concerns and opinions of the people about the proposed project:

- The officials of the Municipality of Tagoloan support the project and they find it feasible since it will decongest the traffic going to Cagayan de Oro;
- There is an existing road construction named as Alae-PHIVIDEC Bypass along the Municipality of Manolo Fortich that will traverse the proposed project;
- Both DENR and NCIP Region 10 requested for the coordinates and an endorsement letter from DPWH to gather information on the alignment of the proposed project.

The officials of the two (2) municipalities believed that the project will increase their economic development.

NCIP Region 10

DENR Region 10

Mayor and Municipal Engineer of Tagoloan

(2) Focus Group Discussion (FGD)

The summary of FGD for CMH is shown in **Table 15.7-19**. Focus Group Discussion (FGD) activities were conducted in the Municipality of Manolo Fortich and Municipality of Tagoloan with the aim of eliciting their issues and concerns (**Table 15.7-20**) regarding the proposed CMH. Participants showed concerns on specific topics such as gender, social and environmental aspects. The Team from the project side replied that their comment and concerns are to be reflected into the on-going survey and the succeding F/S. The activity tackled issues on environment, social aspect, economy, and gender sensitivity.

The participants were asked about their positive and negative perceptions regarding the proposed Project. The result of the FGD shows that the majority of the stakeholders support the project, both in Manolo Fortich and Tagoloan. On the other hand, apprehensions about relocation of the possible affected structures and agricultural lands were expressed during the discussion as they feared that some of the owners will be relocated.

One of the attendees in the Manolo Fortich FGD expressed her concern on potential impact of the project on ancestral lands. She suggested to the Team to visit the procedure of getting a Certificate of Precondition (CP) following the Free and Prior Informed Consent (FPIC) through the NCIP.

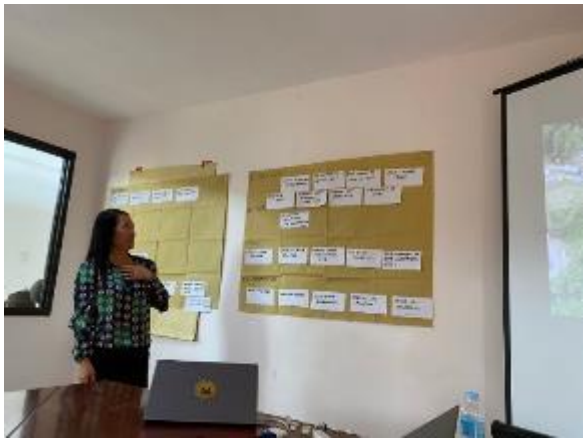
Table 15.7-19 Summary of FGDs

Items	Manolo Fortich	Tagoloan
Venue	Conference Room, Manolo Fortich Municipal Hall	Conference Room, Tagoloan Municipal Hall
Time & Date	Time 9:55 AM – 11:42 AM Date 13 February 2020	Time 1:50 PM – 3:00 PM Date 13 February 2020
Participants	17 persons - Municipal Mayor -DPWH District Officers -DENR-BMB Region X -DENR-EMB Region X -Local LGUs	11persons -Different heads of the municipal departments -DENR-EMB Region X
Agenda	1. Presentation of the project outline 2.Presentation of the general impact of Project 3.Group Discussion 4.Presentation by group 5.Question and Answer session	

Source: JICA Study Team

Table 15.7-20 Issues and Concerns

Given Fields	Issues / Concerns from Participants
Economic	・ The project will make transportation faster, provide easy access, save travel time, and increase investors. ・ the project will entail an easier transport of agricultural products such as banana and pineapple, influx of settlements in beside the road but this will be controlled, conversion of agriculture lands to industrial lands, will cut down travel time that will result to greater amount of economic profit. The highway must be converted into green highway by developing vegetation.
Gender	・ The gender of the people must be identified, and this can be done while researching for the land owners. ・ The project must be gender inclusive and income generating.
Social	・ There should be an acquisition of cadastral maps, research on the land owners of the affected properties, and identification of ancestral domains. There should also be parcellary surveys to determine the affected lots and land valuation. ・ A negative impact will be the displacement of locals and farmers. ・ The IPs must also be identified, and the locals must be prioritized in the provision of job opportunities. ・ This will promote peace and order through the cutting of and will lessen road accidents.
Environmental	・ Tree inventory and public consultation must be conducted as well as landslide susceptibility studies as it is identified to be prone to landslide. ・ There will be water and air pollution, diminish in forest cover, solid waste issues ・ the ECC conditions shall are followed.



Ms. Judith Dinsag from the Office of the Mayor (Municipality of Manolo Fortich) giving her perception on the project impacts

Consultant Team giving general impacts of the project which was used as guide of the participants from Manolo Fortich

Consultant explaining the things to be done during the FGD

The participants of the FGD in the Municipality of Tagoloan

(3) Stakeholders Meeting (SHM)

Stakeholders meeting (SHM) during the Pre-F/S was conducted on 24 February 2021. The SHM was held via online taking into account the impact of COVID-19. For those who were not able to access to the internet, the venues on the sites where people could participate to the Zoom meeting were arranged.

A total 87 participants (male 47 and female 40) for morning time and at total of 89 participants (male 51 and female 38) for afternoon time including affected barangay people (resident, barangay caption) and representatives of Central/Regional/Local Government officers joined the meeting. The agenda was to present the project description including the proposed alignment, alternatives, outline of legal framework regarding environmental and social considerations, and potential environmental and social impact due to the project implementation. The detailed program of SHM is described in **Section 13.8.4**. **Table 15.7-21** shows the summary of comments, questions and suggestions raised in the open forum. Some of the reactions of the residents are positive for their local economy and accessibility, and they are looking forward on this Project. The major concerns of participants were the compensation for affected people and properties due to the project, the affected trees, and the prone to landslide. DPWH and the JICA study team principally replied that their comment and concerns are to be reflected into the following F/S and would be studied further through coordination with LGUs. Regarding the resettlement issues, DPWH explained the policy about the

resettlement action plan (ROW Action Plan of DPWH) and the detail survey for resettlement would be conducted in the following F/S.

Table 15.7-21 Opinions and Answers at the Open Forum of SHM

No.	Comment, Questions and Suggestion	Answers
1	Comment and Question We would like to ask if it is possible that the presentations and discussion be translated to local dialect so that the people will fully understand the project, and the proper coordination be conducted before the start of any activity or survey. (Brgy. Captain of Barangay Maluko)	The request is noted. The study still on the Pre-Feasibility Stage. When the final alignment will be finalized, the LGUs will be informed and DPWH will conduct a series of coordination and consultations in the next stages of the project. Also, the DPWH will conduct a study to identify if there are affected Indigenous Peoples (IPs) or Ethnic Groups in the area. Based on the initial coordination to NCIP region X, there are some IP's affected by the project. In addition, the team will ensure that during the survey, they will hire a local people as a translator to ensure that the local people will thoroughly understand the project. (JICA Study Team)
2	Question Who will be liable for paying the damages cause by the project? (Brgy. Councilor of Barangay Mambatangan)	The DPWH is the liable entity for any compensation for damages caused by the project including the land, crops, house or structure. (JICA Study Team)
3	Question What is the plan of the DPWH regarding the affected trees? (Representative of Municipal Environment and Natural Resources Office (MENRO), Tagoloan)	After the alignment is finalized the DPWH will conduct a tree cutting inventory together with MENRO and DENR. For every 1 tree to be cut, there will be a replacement of 50-100 seedlings. Aside from the Trees, we also need to consider the Key Biodiversity Area that will be affected in the sensitive areas. (JICA Study Team)
4	Question How much is the compensation of the affected land? (Local people from Barangay Kagawad, Manolo Fortich)	The DPWH will have a different discussion about the compensation. DPWH will conduct a series of consultation to discuss the details of the project (JICA Study Team)
5	Comment We request the DPWH and the Study Team to implement the project as soon as possible as it is good. Our LGU is looking forward to this project as it will be of big help in terms of transportation to the local people. (Local people from Barangay Kagawad, Manolo Fortich)	The Central Mindanao Highway Project is a priority project amongst the other proposed road projects of the Government. (JICA Study Team)
6	Question (To all participants) What are the positive and negative impact of the project in the community? (JICA Study Team)	The project is a good development project which helps in transporting our agricultural products (pineapple and corn) and it will provide more access especially to our hidden tourist spots. It will also provide faster response to crimes and will improve peace and order especially in case of emergency because there is an inaccessible area in Manolo Fortich. (Brgy. Captain in the Manolo Fortich/Male)
7	Question (To all participants) Do you have any suggestions regarding the indigenous people and environmental considerations in the hilly area of Bukidnon? (JICA Study Team)	We are not in the position to answer the questions regarding IPs whether they are willing to adapt the project. (Brgy. Captain in the Manolo Fortich/Male)

No.	Comment, Questions and Suggestion	Answers
8	Question The case of Impasug-ong where 82% of the land area is under the category of Timberland. How will the project handle those affected people without title? (Local people from Tagoloan)	If the lots have been proven that it is under the Ancestral Domain, CAD-T or CAD-C, it has a separate process of acquisition. It will undergo a Free Prior Informed Consent (FPIC). The DPWH will be coordinating to NCIP and the IPs will be providing their consent. And still, they will receive the compensation equivalent to that of their land. The reason why we have this kind of consultation is to discuss the issues detail by detail, and all of the affected lots or people that will be need compensation. This kind of discussion or consultation is a requirement and it is the people's right to be compensated and paid. Furthermore, DPWH will not implement the project if the issues and concerns are not yet addressed satisfactorily. DPWH will prepare a ROW Action Plan*, where details on the number of families, structures, livelihood and compensation to the affected people will be indicated in this plan. (DPWH-ESSD/JICA Study Team)
9	Question We want to know the process regarding the claiming of the payment for ROW. (Local people from Impasug-ong/Male)	DWPH will follow the RA 1072 or Right of Way Act. (DPWH-ESSD)
10	Comment The proposed alignment is prone to accident including landslide. (Local people from Barangay 10, City of Malaybalay)	During this stage, all the concerns especially the risk of natural disaster will be considered. The team will carefully design the road considering natural disasters, especially landslide. More detailed and important inputs are needed. The other stakeholders meeting will be held during the Feasibility Study Stage and will focus on this matter. In addition, HSH is designed taking natural disaster into consideration. If the existing national highway will be destroyed due to natural disaster, the proposed HSH will be a detour in Central Mindanao. (JICA Study Team)
11	Question (To all participants) Do you have any opinions about the project?	The project will be a big help for them. Our concern is that the affected lot/structure owners are still not yet informed. (Brgy. Captain of Barangay Kasulangay)
12	Comment There is a project being implemented but the affected lot/structure owners were still not yet informed about the project. We request DPWH to inform them at least 30 days before the implementation of the project. Question What is the meaning of GAD and RAP. (Brgy. Captain of Barangay Kasulangay)	This will not be the last consultation with the affected LGUs and barangays. There will be a series of consultation to discuss during the consultation the total number of structures and compensation to the affected families. Aside from the ROW Acquisition Plan, there are many processes to comply including the acquisition of ECC. During the ECC application, another public consultation will be conducted to present the assessment of the environment. GAD is Gender Assessment Development. This discussion will focus on the men, women, elderly, youth, indigenous people, etc. While RAP is Right of Way Action Plan*. It will focus on the process of paying and compensation to the affected lots and structures. All the

No.	Comment, Questions and Suggestion	Answers
		studies and consultations need to be conducted by the DPWH to ensure a better implementation of this project. (DPWH-ESSD/JICA Study Team)

Note: During the meeting, "Right-of-Way Action Plan" under the DPWH ROW Acquisition Manual (2017) is* presented *as the same meaning of "Resettlement Action Plan (RAP) " under the JICA guidelines for environmental and social* considerations *(2010).*

Source: JICA Study Team

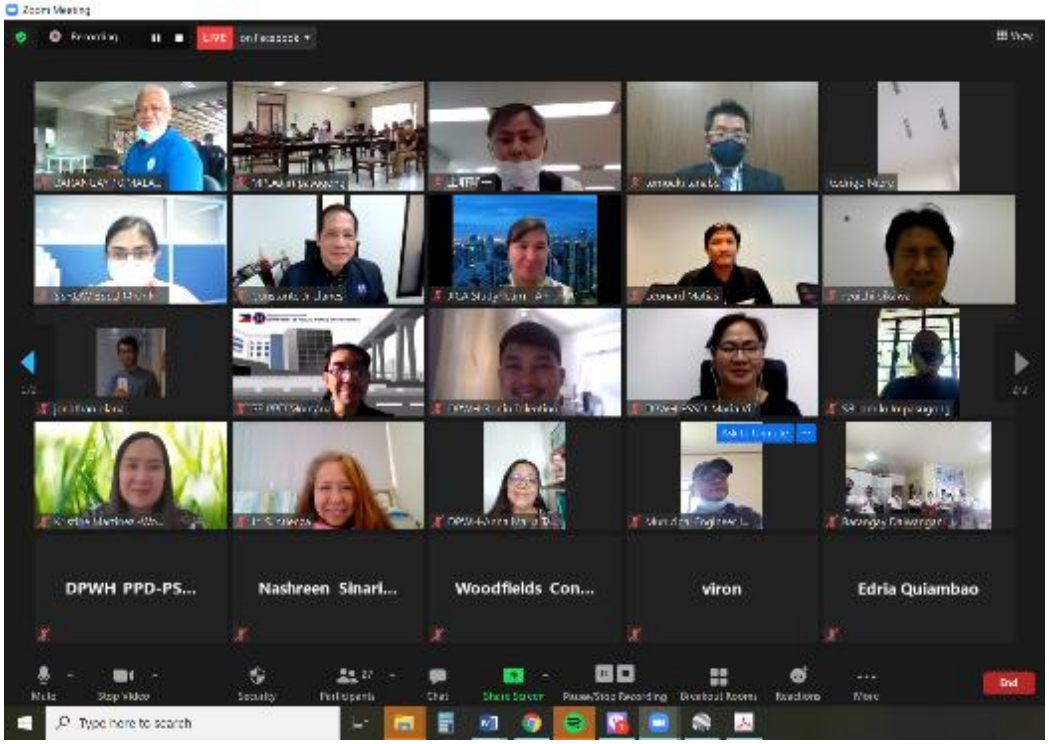


Figure 15.7-14 On-line Zoom Meeting

Malaybalay City **Impasug-ong**

Figure 15.7-15 Participants from Local Venue

15.8 Land Acquisition and Resettlement

The actual conditions during this Pre-F/S cannot determine the project's actual impact on land acquisition and resettlement. Therefore, discussions in this chapter is based on rough estimation and have to be studied further during the F/S.

15.8.1 Requirement of Land Acquisition and Resettlement

The project requires land acquisition and resettlement to construct the road.

15.8.2 Legal Frameworks on Land Acquisition and Resettlement

Laws and Regulations related to environmental and social issues in the Philippines are summarized in the **Chapter 13** of this report. The chapter also includes JICA's policy and gap analysis.

(1) JICA's Policy on Resettlement

Following is JICA's policy on resettlement (as a reference).

The key principle of JICA policies on involuntary resettlement is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

II. When, after such an examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected.

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

IV. Compensation must be based on the full replacement cost[1] as much as possible.

V. Compensation and other kinds of assistance must be provided prior to displacement.

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.

IX. e and accessible grievance mechanisms must be established for the affected people and their communities.

[1] Description of "replacement cost" is as follows.

Land	Agricultural Land	The pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes.
	Land in Urban Areas	The pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes.
Structure	Houses and Other Structures	The market cost of the materials to build a replacement structure with an area and quality similar or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, plus the cost of any registration and transfer taxes.

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principle based on World Bank OP 4.12 is as follows.

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

XI. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

XIII. Provide support for the transition period (between displacement and livelihood restoration.

XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

XV. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

In addition to the above core principles on the JICA policy, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc.

(2) Policy for Land Acquisition and Resettlement of the Project

Following is draft policy on land acquisition and resettlement of the project.

I. The Government of Philippines will use the Project Resettlement Policy (the Project Policy) for the Central Mindanao Highway Road Project (Temporal) specifically because existing national laws and regulations have not been designed to address involuntary resettlement according to international practice, including JICA's policy. The Project Policy is aimed at filling-in any gaps in what local laws and regulations cannot provide in order to help ensure that PAPs are able to rehabilitate themselves to at least their pre-project condition. This section discusses the principles of the Project Policy and the entitlements of the PAPs based on the type and degree of their losses. Where there are gaps between the Philippines legal framework for resettlement and JICA's Policy on Involuntary Resettlement, practicable mutually agreeable approaches will be designed consistent with Government practices and JICA's Policy.

II. Land acquisition and involuntary resettlement will be avoided where feasible, or minimized, by identifying possible alternative project designs that have the least adverse impact on the communities in the project area.

III. Where displacement of households is unavoidable, all PAPs (including communities) losing assets, livelihoods or resources will be fully compensated and assisted so that they can improve, or at least restore, their former economic and social conditions.

IV. Compensation and rehabilitation support will be provided to any PAPs, that is, any person or household or business which on account of project implementation would have his, her or their:

- Standard of living adversely affected;
- Right, title or interest in any house, interest in, or right to use, any land (including premises, agricultural and grazing land, commercial properties, tenancy, or right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or possessed, temporarily or permanently;

- Income earning opportunities, business, occupation, work or place of residence or habitat adversely affected temporarily or permanently; or
- Social and cultural activities and relationships affected or any other losses that may be identified during the process of resettlement planning.

V. All affected people will be eligible for compensation and rehabilitation assistance, irrespective of tenure status, social or economic standing and any such factors that may discriminate against achievement of the objectives outlined above. Lack of legal rights to the assets lost or adversely affected tenure status and social or economic status will not bar the PAPs from entitlements to such compensation and rehabilitation measures or resettlement objectives. All PAPs residing, working, doing business and/or cultivating land within the project impacted areas as of the date of the latest census and inventory of lost assets(IOL), are entitled to compensation for their lost assets (land and/or non-land assets), at replacement cost, if available and restoration of incomes and businesses, and will be provided with rehabilitation measures sufficient to assist them to improve or at least maintain their pre-project living standards, income-earning capacity and production levels.

VI. PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living. The minimum size of remaining land and structures will be agreed during the resettlement planning process.

VII. People temporarily affected are to be considered PAPs and resettlement plans address the issue of temporary acquisition.

VIII. Where a host community is affected by the development of a resettlement site in that community, the host community shall be involved in any resettlement planning and decision-making. All attempts shall be made to minimize the adverse impacts of resettlement upon host communities.

IX. The resettlement plans will be designed in accordance with Philippines' Domestic Resettlement Policies and JICA's Policy on Involuntary Resettlement.

X. The Resettlement Plan will be translated into local languages and disclosed for the reference of PAPs as well as other interested groups.

XI. Payment for land and/or non-land assets will be based on the principle of replacement cost.

XII. Compensation for PAPs dependent on agricultural activities will be land-based wherever possible. Land-based strategies may include provision of replacement land, ensuring greater security of tenure, and upgrading livelihoods of people without legal land titles. If replacement land is not available, other strategies may be built around opportunities for re-training, skill development, wage employment, or self-employment, including access to credit. Solely cash compensation will be avoided as an option if possible, as this may not address losses that are not easily quantified, such as access to services and traditional rights, and may eventually lead to those populations being worse off than without the project.

XIII. Replacement lands, if the preferred option of PAPs, should be within the immediate vicinity of the affected lands wherever possible and be of comparable productive capacity and potential . As a second option, sites should be identified that minimize the social disruption of those affected; such lands should also have access to services and facilities similar to those available in the lands affected.

XIV. Resettlement assistance will be provided not only for immediate loss, but also for a transition period needed to restore livelihood and standards of living of PAPs. Such support could take the form of short-term jobs, subsistence support, salary maintenance, or similar arrangements.

XV. The resettlement plan must consider the needs of those most vulnerable to the adverse impacts of resettlement (including the poor, those without legal title to land, ethnic minorities, women, children, elderly and disabled) and ensure they are considered in resettlement planning and mitigation measures identified. Assistance should be provided to help them improve their socio-economic status.

XVI. PAPs will be involved in the process of developing and implementing resettlement plans.

XVII. PAPs and their communities will be consulted about the project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible be involved in the decisions that are made concerning their resettlement.

XVIII. Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition (including compensation and income restoration measures) within the agreed implementation period. The funds for all resettlement activities will come from the Government.

XIX. Displacement does not occur before provision of compensation and of other assistance required for relocation. Sufficient civic infrastructure must be provided in resettlement site prior to relocation. Acquisition of assets, payment of compensation, and the resettlement and start of the livelihood rehabilitation activities of PAPs, will be completed prior to any construction activities, except when a court of law orders so in expropriation cases. (Livelihood restoration measures must also be in place but not necessarily completed prior to construction activities, as these may be ongoing activities.)

XX. Organization and administrative arrangements for the effective preparation and implementation of the resettlement plan will be identified and in place prior to the commencement of the process; this will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and rehabilitation activities.

XXI. Appropriate reporting (including auditing and redress functions), monitoring and evaluation mechanisms, will be identified and set in place as part of the resettlement management system. An external monitoring group will be hired by the project and will evaluate the resettlement process and final outcome. Such groups may include qualified NGOs, research institutions or universities.

Cut-off-date of Eligibility

The cut-off-date of eligibility refers to the date prior to which the occupation or use of the project area makes residents/users of the same eligible to be categorized as PAPs and be eligible to Project entitlements. In the Project, Cut-off-date will be declared during F/S phase.

Principle of Replacement Cost

All compensation for land and non-land assets owned by households/shop owners who meet the cut-off-date will be based on the principle of replacement cost. Replacement cost is the amount calculated before displacement which is needed to replace an affected asset without depreciation and without deduction for taxes and/or costs of transaction. Further discussion will be implemented during resettlement action plan (RAP) development.

15.8.3 Size and Areas of Land Acquisition and Resettlement

CMH requires land acquisition and resettlement for construction of approximately 68km road section as well as 6 interchanges. Rough estimation of necessary land acquisition areas and roughly counted affected structures are shown in **Table 15.8-1**.

Table 15.8-1 Rough Estimation of Land Acquisition and Resettlement of CMH

Component	Approx. Length	Number	Land acquisition	Affected Structures	Remarks
1. Road and Bridge Sections	68 km	-	408 ha	170	Estimation with fixed width of 60 m
2. Interchange	-	6	30 ha		Estimation with fixed area of 5 ha per one interchange
Total	-	-	4 38 ha	170	

Source: JICA Study Team

15.8.4 Policies of Compensation and Assistance

Entitlement matrix as a policy of compensation and assistance for land acquisition and resettlement should be further discussed and elaborated in RAP which will be developed in the succeeding phases of the study. This Pre-F/S assumed possible form of impacts with practical mitigation measures. **Table 15.8-2** shows inititial entitlement matrix of the project.

Table 15.8-2 Temporal Entitlement Matrix

Type of Loss	Application	Entitled Persons	Entitlement
1. Land			
Classified as Agricultural, Residential, Commercial, or Institutional	Severely Affected	PAFs with Original Certificate of Title (OCT), Transfer Certificate of the Title (TCT) or Tax Declaration (TD) showing 30 or more years of continuous possession (Tax Declaration may be legalized to full title)	• Cash Compensation for loss of entire land based on the current market value free of taxes. • Transaction costs (e.g. administrative charges and registration or title fees) . • If feasible, land for land will be provided in terms of a new parcel of land of equivalent value or productivity, at a location acceptable to PAFs • Rehabilitation Assistance in the form of Skills Training equivalent to PhP 15,000 per family, if the present means of livelihood is no longer viable and the affected family will have to engage in a new income activity.
		Holders of Certificates of Land Ownership Award (CLOA) Granted under the Comprehensive Agrarian Reform Act	• Cash Compensation for loss of entire land at the current market value free of taxes. • Transaction costs (e.g. administrative charges and registration or title fees) • If feasible, land for land will be provided in terms of a new parcel of land of equivalent value or productivity, at a location acceptable to PAF's. • Rehabilitation Assistance in the form of Skills Training equivalent to Php. 15,000 per family, if the present means of livelihood is no longer viable and the affected family will have to engage in a new income activity.
		Holders of Free or Homesteads Patents and CLOA under CA 141	No compensation for land up to 20 m width if patent was granted prior to 1975 or up to 60 m width for patents granted thereafter, but compensation on land improvement only. For area in excess of government lien, same as PAPs with OCT
		PAP's without OCT, TCT or Tax Declaration	• Compensation on land improvement only
		Holders of Free or Homesteads Patents and CLOA under Public Land's Act	• Compensation on land improvements only • Disturbance compensation equivalent to five times the average of the gross harvest for the past 5 years but not less than PhP 15,000
		Lessees of Agricultural Land	• Disturbance compensation equivalent to 5 times the average gross harvest during the last 5 years contrary to the statement of only 3 years but not less than PhP 15,000
		Agricultural Tenant/Settlers/ Occupants	• Financial assistance equivalent to the average gross harvest for the last 3 years but not less than PhP 15,000 per hectare

Type of Loss	Application	Entitled Persons	Entitlement
	Marginally Affected	PAF with TCT or TD (Tax declaration may be legalized to full title)	• Cash compensation for affected land at the current market value of land free of taxes • Transaction costs (e.g. administrative charges and registration or title fees)
		Holders of CLOA granted under the Comprehensive Agrarian Reform Act	
		Holders of Free or Homesteads Patents CLOA under CA 141 Public Lands Act	• Compensation on land improvements only
2. Structure			
(1) Residential	Severely Affected	Owners with or without TCT or TD (Tax Declaration may be legalized to full title)	• Cash compensation for the entire structure at 100 % Replacement Cost (compliant with RA 10752) including transaction costs without deduction for depreciation or salvaged materials. • Inconvenience Allowance in the amount of Php 10,000 for relocation and new construction • Transportation Assistance
		Homeless, landless, underprivileged, informal occupants of public land, except professional squatters and squatting Syndicates) as defined in RA 7279	• If qualified, apply for housing in LGU or NHA Resettlement sites • Transportation Assistance to transfer to Resettlement Site or return to original province
	Marginally Affected	Owners with or without TCT or TD (Tax Declaration may be legalized to full title)	• Cash compensation for affected portion of the structure at 100 % replacement cost
	Severely Affected	Renters and Rent-Free Occupants of Dwelling Structures	• Provide sufficient time (i.e. at least 3 months) for moving • If renters or rent-free occupants of dwelling structures do not own any real property whether in the urban or rural areas as defined in RA 7279, may apply for housing in LGU or NHA Resettlement Sites only if they are qualified.
(2) Commercial	Severely Affected	Owners with or without TCT or TD (Tax Declaration may be legalized to full title)	• Cash compensation for the entire structure at 100 % Replacement Cost compliant with RA 10752) including transaction costs without deduction for depreciation or salvaged materials. • Transportation Assistance
	Marginally Affected	Owners with or without TCT or TD (Tax Declaration may be legalized to full title)	• Cash compensation for affected portion of the structure at 100 % Replacement Cost
(3) Industrial	Severely affected	Owners with or without TCT or TD (Tax Declaration may be legalized to full title)	• Cash compensation for the entire structure at 100% Replacement Cost compliant with RA 10752) including transaction costs without deduction for depreciation or salvaged materials. • Transportation Assistance
	Marginally affected	Owners with or without TCT or TD (Tax Declaration may be legalized to full title)	• Cash compensation for affected portion of the structure at 100% Replacement Cost

Type of Loss	Application	Entitled Persons	Entitlement
3. Commercial Activity			
(1) Business	Severely Affected	Business Owner	• Rehabilitation assistance in the form of livelihood and skills training • Administrative support to apply capital for small business in cooperation with concerned LGUs • Income Rehabilitation Assistance for the period to the stoppage of business according to business/ income level based on tax record, income statement and/or business permit for small scale business commercial establishments only if business owners continue their business at the remaining area or another area. Appropriateness of the period of business stoppage shall be validated with concerned parties.
	Marginally Affected	Business owners	• Income Rehabilitation Assistance for the period to the stoppage of business according to business/ income level based on tax record, income statement and/or business permit for small scale business commercial establishments only if business owners continue their business at the remaining area or another area. Appropriateness of the period of business stoppage shall be validated with concerned parties.
		Employees in displaced establishments and lose jobs for reasons of reasonably attributable to the damages caused by the project	• Rehabilitation assistance in the form of livelihood and skills training • One month or longer prior notice to the establishments • Priority in employment during construction and operation stage of projects • Rehabilitation assistance in the form of skill trainings and other development activities
4. Improvements			
(1) Other Non-Dwelling Structures	Severely or Marginally Affected	PAFs with or without TCT or TD	• Cash Compensation for the affected improvements at 100% Replacement Cost
5. Crops, Trees, Perennials			
	Severely or Marginally Affected	Owners of crops, trees, perennials	• Cash Compensation for crops, trees, and perennials in full replacement cost[1]
6. Graves			
		Owners of graves	• Compensate for the transfer/relocation cost of graves in coordination with LGUs and relevant Government Agencies. • Ensure observance of practices/beliefs.
7. Vulnerable Households			
(1) Additional Support to Nos. 1 to 6 above		Households with poor, solo households, households headed by elderly (over 60 years old) or a disabled person	• Cash allowance if it is justified as necessary • Administrative support for applying respective governmental social welfare program based on household conditions in cooperation with concerned LGUs • Provide priority for jobs related to the project based on capability of PAFs

Type of Loss	Application	Entitled Persons	Entitlement
			• Rehabilitation assistance in the form of skill trainings and other development activities
		Homeless, landless, underprivileged, informal occupants of public land, except professional squatters and squatting Syndicates) as defined in RA 7279	• If qualified, apply for housing in LGU or NHA Resettlement sites • Transportation Assistance to transfer to Resettlement Site or return to original province
8. Loss of Community or Public Structures			
	Severely or marginally affected	Community or public structure owners/ administrators	• Cash Compensation for entire or affected portion of the structure at 100% Replacement Cost.

According to World Bank OP 4.12, the replacement cost for fruit and trees are defined below:

For fruit: Where markets exist, the value of a tree of a specified age and use can be used to determine compensation rates. Where markets do not exist, surrogate values must be determined. For timber trees, the value of a tree equals that of the lumber. For fruit or fodder trees, the value is equal to the cumulative value of the fruit crop for its productive life (and any timber value). If replacement trees are provided, good practice indicates that compensation be based on the value of the harvests lost until the replacement trees come into full production (typically, 7‐10 years). In the case of immature trees, a less costly alternative may be to directly supply seedlings as a replacement and provide compensation for the resulting delay in reaching fruit-bearing capacity.

For crops: When arrangements cannot be made to allow for harvest, the market value for lost cash crops is paid. In some countries the value of the harvest is determined by the average market value of crops for the previous three years. Whatever the multiplier, if food supplies are sold in the area enough cash compensation is paid to purchase equivalent supplies, taking into account the possibility of price increases caused by heightened demand from DPs. In areas of predominantly subsistence production, good practice recommends that in-kind compensation be made for subsistence crops.

Source: JICA Study Team

15.8.5 Grievance Redress Mechanism

Grievance Redress Mechanism (GRM) is an indispensable part of RAP and defined in the LARRIPP (2017). Usually, a responsible body called Grievance Redress Committee is organized to manage GRM appropriately. Generally, Resettlement Implementation Committee (RIC) and LIAC (Local Inter-Agency Committee) that consist of LGUs and other relevant authorities play a role of GRC in Philippines. Also, ESSD in DPWH functions as internal monitoring agency to monitor and follow up GRM. GRM for CMH shall be discussed further in following phases such as F/S when RAP is developed.

As a reference, outlines of GRM in the case of "RAP from Cebu-Mactan Bridge Project (2019)" is summarized as follows.

- RIC's responsibilities is to receive and record the voices, complaints opinions and suggestions provided by the PAPs, except complaints and grievances that specifically pertain to the valuation of affected assets since such will be decided upon by the proper courts, and to address them as the first stage of the decision-making body.

- If the response to the complaint is deemed inadequate in the view of the PAPs, they may elevate their grievance to the ROW Task Force that consists of higher-level officials of DPWH Central Office before resorting the case finally to the court. Under this project, grievances from the PAPs would be handled in the following manner.

- Grievance shall be filed by the PAP with the RIC who will act within 15 days upon receipt, except complaints and grievances that specifically pertain to the valuation of affected assets, since such will be decided upon by the proper courts.

- If no understanding or amicable solution can be reached, or if the PAP does not receive a response from the RIC within 15 days of registry of the complaint, he or she can appeal to the

ROW Task Force, which should act on the complaint or grievance within 15 days from the day of its filing

- If the PAP is not satisfied with the decision made by the ROW Task Force, he/she, as a last resort, can submit the complaint to any court of law PAPs shall be exempted from all administrative and legal fees incurred pursuant to the grievance redress procedures as is guaranteed under LARRIPP (2007). All complaints received in writing (or written when received verbally) from the PAPs will be documented and shall be acted upon immediately

15.8.6 Implementation Structures

Implementation structure for CMH will be established based on the country's legal frameworks with reporting/discussion channels to investors/development partners. Based on existing project institutional plan such as Cebu-Mactan Bridge Construction Project under JICA's cooperation, **Figure 15.8-1** and **Figure 15.8-2** shows rough implementation structure of environmental and social considerations of the project.

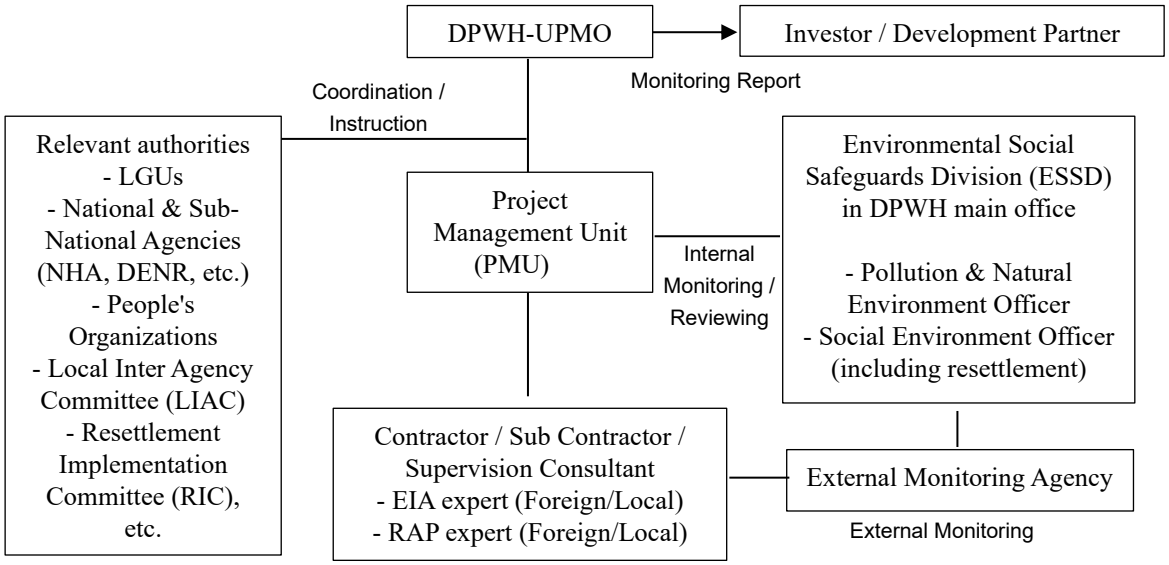


Figure 15.8-1 Implementation Structure of Environmental and Social Considerations during Construction Stage

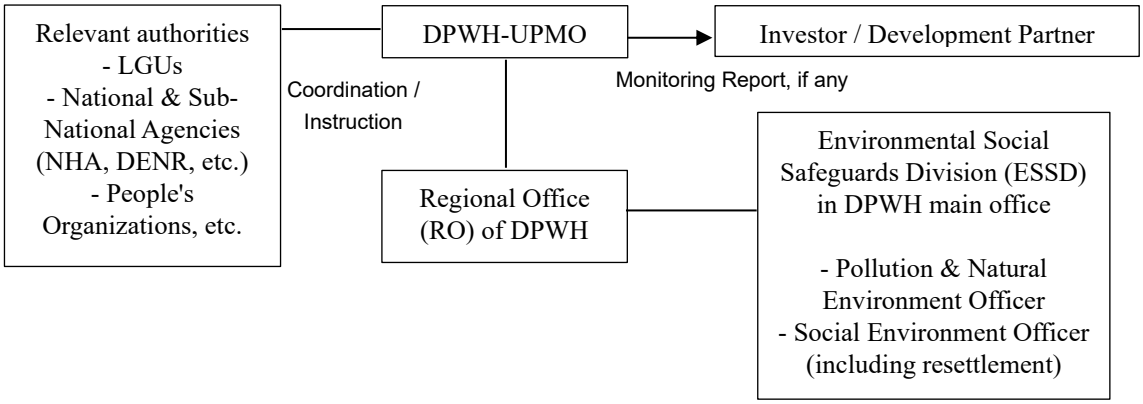


Figure 15.8-2 Implementation Structure of Environmental and Social Considerations during Construction Stage

15.8.7 Implementation Schedule

Implementation schedule cannot be firmed up during this Pre-F/S stage. However, it is roughly estimated that land clearance requires at least two years after RAP is authorized. During that time, final parcellary survey with census are required to determine eligible PAPs and other preparation and processes such as negotiation, payment, preparation of relocation sites, among others. These processes will be discussed in the RAP based on the size of impact.

15.8.8 Cost and Budget

Cost and budget for land acquisition and resettlement shall be calculated based on the results of the RAP related field surveys such as census survey, parcellary survey, replacement cost survey among other during the F/S. The rough estimate cost for 438 ha of land and 170 households with unit price of 100 USD (equal to 5,000 Php) per sqm and 5,000 USD (equal to 250,000 Php) per structure is estimated at 438,000,000 USD for land acquisition and 850,000 USD for structures (Total is around 439 million USD). This rough calculation is not accurate because of uncertain unit price and other factors which could not be determine during this Pre-F/S stage.

15.8.9 Monitoring by Implementing Agency and Monitoring Forms

Contents of internal and external monitoring shall be discussed during RAP development. Monitoring forms will be developed during this stage.

15.8.10 Public Consultations

Public consultations for actual project affected persons (PAPs) will be implemented during the F/S where development of RAP report is one of the outputs.

15.9 Economic Evaluation of the Project

Economic validity of the project was evaluated by economic benefits and costs "With" and "Without" the projects. EIRR are calculated by using economic benefits and economic costs. Economic benefits are estimated by calculating unit VOC, TTC and the demand forecast in **Section 15.2**. Assumptions of economic evaluation are shown in **Table 15.9-1.**

Table 15.9-1 Assumptions of Economic Evaluation

Items	Assumptions	Remarks
Social Discount Rate	10%	
Project Period	2022-2057	2022-2027: Detailed Design (D/D), Right of Way (ROW) Acquisition, and Civil Work 2028-2057: Operation (30 years)
Price Level Year	2020	Inflation is not considered.
Physical Contingency	10%	1) 10% of Construction Cost 2) 10% of Consulting Service Cost

Source: Department of Finance and National Economic and Development Authority (NEDA) (2016) "Revisions on ICC Guidelines and Procedures Updated Social Discount Rate for the Philippines" for discount rate, NEDA (2004) "ICC PROJECT EVALUATION PROCEDURES AND GUIDELINES" for physical contingency.

15.9.1 Economic Cost for the Project

Economic cost includes construction cost, ROW cost, consulting service cost, administration cost and O&M cost of the projects. VAT (12%) was deducted from financial cost of the project. Economic evaluation for CMH was carried out for two cases: 4 lane, toll road case, 2 lane, non-toll road case.

(1) Initial Cost

Financial cost and converted economic cost are shown in **Table 15.9-2** and **Table 15.9-3**.

Table 15.9-2 Financial Cost

Unit: million PHP

Case	Construction cost	ROW Cost	Consulting Service (D/D)	Consulting Service (C/S)	Administration Cost	Total
4 Lane	93,140	466	2,794	4,657	3,334	104,391
2 Lane	55,378	277	1,661	2,769	1,982	62,067

Source: JICA Study Team

Table 15.9-3 Converted to Economic Cost

Unit: million PHP

Case	Construction cost	ROW Cost	Consulting Service (D/D)	Consulting Service (C/S)	Administration Cost	Total
4 Lane	83,161	433	2,495	4,158	2,977	93,224
2 Lane	49,444	258	1,483	2,472	1,770	55,427

Source: JICA Study Team

(2) O&M Cost

O&M costs is set at 1% of construction cost in this Pre-F/S. It is estimated at 831.6 million pesos/year for 4 lanes, 494.4 million pesos/year for 2 lanes, respectively.

15.9.2 Economic Benefit of the Project

Economic benefits were calculated by measuring "Saving of TTC and VOC" since they are measurable in monetary value. JICA study team estimated Unit TTC and VOC in 2020, which are explained in **Section 12.4**. The economic benefit of the projects is shown in **Table 15.9-4**. The result shows the analysis result of whole section of CMH. Here, two cases were analyzed: 4 lane, toll road case, 2 lane, non-toll road case.

Table 15.9-4 Economic Benefit of the Projects

Unit: million PHP

Economic Benefit (TTC+VOC Saving)		
Cases	**2028**	**2040**
4-Lane, toll road case	18,803	35,994
2-Lane, non-toll road case	14,463	27,687

Source: JICA Study Team

15.9.3 Results of Economic Evaluation

(1) Results of Base Case

The following economic indicators: EIRR, B/C and ENPV of the project were calculated. Calculation formula and remarks of them are explained in **Section 12.4**. Results of economic evaluation are shown in **Table 15.9-5**. Results of EIRR for two cases is exceeded.

Table 15.9-5 Results of Economic Evaluation

Indicators of Economic Analysis			
Cases	**EIRR (%)**	**B/C**	**ENPV (million PHP)**
4-Lane, toll road case	18.6%	2.27	82,630
2-Lane, non-toll road case	22.0%	2.92	74,652

Source: JICA Study Team

Table 15.9-6 Result of EIRR for CMH (CDO-Malaybalay Section) by Section

Case	4-Lane, toll road case	2-Lane, non-toll road case
Section 1	15.0%	15.8%
Section 1+2	14.6%	15.9%
Section 1+2+3	19.8%	23.0%
Section 1+2+3+4	19.3%	23.5%
Section 1+2+3+4+5	19.0%	22.8%
Total (Section 1+2+3+4+5+6)	18.6%	22.0%

Source: JICA Study Team

Table 15.9-7 Comparison of EIRR for Alternatives of Section 1

Case	Alt 1 (Loop Bridge)	Alt 2	Alt 3
4-Lane, toll road case	15.0%	14.9%	15.3%
2-Lane, non-toll road case	16.6%	16.2%	17.0%

Source: JICA Study Team

(2) Sensitivity Analysis

Sensitivity analysis of EIRR regarding the economic cost and the economic benefit is conducted. Results of sensitivity analysis of economic evaluation are shown in **Table 15.9-8** and **Table 15.9-9**. If the benefit is minus 10% with the base case and plus 10% of the cost and the benefit is base case with plus 10% of cost, EIRR is higher than 10%. Therefore, the project is feasible in all cases.

Table 15.9-8 Sensitivity Analysis of EIRR for 4 Lane

EIRR		Cost		
		-10%	**Base Case**	**+10%**
Benefit	**-10%**	18.4%	17.3%	16.2%
	Base Case	19.8%	**18.6%**	17.5%
	+10%	21.1%	19.8%	18.7%

Source: JICA Study Team

Table 15.9-9 Sensitivity Analysis of EIRR for 2 Lane

EIRR		Cost		
		-10%	**Base Case**	**+10%**
Benefit	**-10%**	21.9%	20.5%	19.4%
	Base Case	23.4%	**22.0%**	20.8%
	+10%	24.9%	23.4%	22.1%

Source: JICA Study Team

15.10 Conclusion and Recommendation

In this Pre-F/S, the initial alignment was studied based on available free satellite map and topographic data. The proposed alignment was selected based on the lowest construction cost and as much as possible with least negative social and environmental impact.

In particular, the alignment avoided the mountain tunnels, minimizes the long span bridge length crossing valleys, avoided areas of the indigenous people, protected areas and important bird areas.

The proposed alignment during this Pre-F/S is not a conclusive alignment since it is based on the secondary data with low accuracy (both the topographical data and environmental data). It is necessary to carefully select the optimum alignment by comparing alternatives based on a more accurate field survey data during the F/S stage.

15.10.1 Recommendation on Section 1

Regarding the Section 1, since the present road networks such as the Sayre Highway and the Alae-PHIVIDEC Bypass Road have many hair pin curves and steep slope sections, the design speed of these roads is just 20km/h. The zigzag section of Sayre Highway has a very slow travel speed and occurrence of road crashes is high. Since good connection between the two Metropolitans (CDO City and Davao City) is essential, a high standard highway for this corridor is of a highest priority amongst the projects. Results of alternative study of the beginning 2km section, either Alternative-1 or Alternative-3 is recommended. Since there is no significant difference between Alternative-1 and Alternative-3, it is necessary to conduct a detailed comparative study between the two alignments during the F/S stage to come up with the alignment. Discussion with the DPWH and other related stakeholders should be factored in in selecting the best alignment.

During the F/S, the following items shall be considered for the comparative study:

Evaluation Items	To be considered for evaluation
Cost	The bridge cost must be studied carefully with due consideration of construction method, especially during erection method at the hilly area. Cost reduction should be highly considered.
Route Alignment	To study further the optimum alignment to minimize the bridge cost (to minimize the long span length).
Bridge Type	Determine the span length considering a balanced superstructure and substructure. To study the foundation type at the slope area.
Construction Plan	To consider the difficulty of curve bridge erection in the hilly area, the erection of a long span bridge in Loop bridge and in the deep valley with over 100m high pier construction. The highest pier of the bridge in Japan is about 125 m (Washimi bridge, Tokai-Hokuriku Expressway). For the construction of a high pier bridge, the appropriate construction method considering influence due to earthquake or wind and cost-effective method should be considered. Appropriate crossing design and construction method between new planned road and existing road should be considered.
Construction Period	Based on the above conditions, construction period will be calculated and will be included as one of the evaluation criteria.
Others	Balance between the Cost vs. Environmental Impact aspect. (Example: in order to reduce the cost, high embankment/cut section instead of bridge section will be applied. In that case, there will be negative impact for the environment such as slope failure or landslide)

15.10.2 Recommendation of the study on route Selection and Phasing Development during the F/S stage

In year 2040, the future traffic volume of CMH will be 18,000 vehicle per day. Thus, a four-lane highway will be necessary. Based on the preliminary economic analysis, the EIRR in case of 4-lane toll road is 18.6%; and in case of a 2-lane non-toll road, the EIRR is 22.0%, both cases passed the 10% NEDA requirement. Based on the EIRR, it is desirable to construct a 2-lane road during the initial stage. This will be studied further during the F/S stage.

The Pre-F/S was conducted utilizing secondary data such as an available free satellite map data. In order to improve the accuracy of the design and construction cost, a topographic survey (aerial photography or ground topo survey) and geotechnical survey at the proposed bridge sites shall be conducted during the F/S stage. Based on the proposed surveys, adequate road and bridge plan and design shall be implemented.

It is necessary to study the staging plan as well. This may include study of initial 2-lane construction and construction of sections 1 and 2 only if the budget is limited. It is also necessary to thoroughly study either the road will be designed for toll road or not. Likewise, there is a need to study the operation and maintenance structure of the project during the F/S stage.

15.10.3 Environmental and Social Considerations

During the F/S stage, a detailed survey and analysis of environmental and social considerations should be carried out with more accurate project design to understand the following impacts:

(1) General Issues

- Based on the project threshold for coverage screening and categorization, CMH falls under Category A which is required to secure an Environmental Compliance Certificate (ECC). An Environmental Impact Statement (EIS) Report shall be prepared and submitted to DENR-EMB for evaluation during the F/S stage.
- F/S and RAP shall refer issues and concerns from FGDs and SHMs in **Table 15.7-20** and **Table 15.7-21** to develop their contents.
- Alternative discussion shall be done again to avoid protected areas, areas inhabited by indigenous peoples, and KBA/IBA (sensitive areas from development impact based on JICA's Guidelines for Environmental and Social Considerations) as many as possible.
- Additionally, the condition of crossing rivers shall be considered into the alternative discussion, since the proposed route will cross the river at many points.
- Confirmation of construction methodology and necessary machinery and vehicles.
- Confirmation of soil borrow pit, quarry, waste dumping site, etc.
- Necessary budget for mitigation and monitoring
- Confirmation of specific role and responsibility for mitigation, monitoring, and resettlement implementation
- Stakeholder Meetings and Public Consultations as F/S level

(2) Pollution Control

- Measurement of necessary items on air, water, noise and vibration, soil quality, ground condition (possibility of soft ground, and groundwater level) etc., at appropriate locations in appropriate seasons (e.g. dry and wet season)
- Review of results of assessment based on relevant surveys such as topographical and geological survey

- Regarding impact on ambient air quality and noise due to the operation of new highway, the road traffic impact shall be estimated quantitatively by using mathematical emission model. The result shall be compared with National and International Environmental Quality Standards. Depending on the evaluation, necessary mitigation measurement must be proposed to satisfy with the standards.

(3) Natural Environment

- CMH will pass through near the Mount Tago Range (KBA/IBA) and some new proposed protected areas. The proposed alignment will not hit these areas, but the actual boundary of IBA and Protected Area and status of proposed protected area should be confirmed with DENR during the F/S stage.
- Field surveys for fauna and flora at appropriate locations in appropriate seasons (e.g. dry and wet season) to identify the important points (nest, feeding area, breeding area) for fauna.
- Impact assessment on ecosystem including threatened species of IUCN Red list and endemic species.
- Impact on the ecosystem due to cutting trees in the project area.

(4) Social Environment

- CMH will pass through near some Certificate of Ancestral Domain Titles (CADTs). In addition, the one (1) CADT application in Bukidnon is on process. The proposed alignment will not hit these areas at this moment, but the actual boundary of CADTs and status of CADT application should be confirmed with NCIP during F/S stage.
- In case that the possibility of impact on the IPs is estimated, the impact and necessary mitigation measures shall be studied during F/S through the communication with NCIP in consideration of on-site ancestral domain condition.
- RAP-related surveys including Census, Socio-Economic Survey, Inventory of Loss, Replacement Cost Survey, and etc.
- Confirmation of status of vulnerable people including poor people and illegal resident around the project area
- Confirmation of status of ethnic minority and/or indigenous people
- Confirmation of public/social facilities around the project sites
- Impact on the existing water resources and water usage by resident due to the interception/changing of groundwater flow caused by the construction of road structures including soft ground treatment or liquefaction measures.
- Surveys finding traffic-vulnerable people and relevant facilities including schools shall be implemented during F/S phase and road safety education might be considered as one of the mitigation measures of accidents.
- In case that livelihood of PAPs is likely to be affected based on socioeconomic survey and stakeholder meetings during F/S and/or monitoring processes during implementation, appropriate compensation and livelihood restoration program to PAPs shall be provided based on RAP.
- Land price along the project sites may increase after the completion of each project area. Therefore, actual unit prices for compensation shall be determined based on replacement cost surveys which reflect transaction prices of PAP’s properties in and around the project areas so that PAPs can recover and keep their living environment.

- Further study of traffic volume, traffic characteristics, business along the existing road are required to determine indirect impacts including economic impact and necessity of mitigation measures due to bypass function by the new highway in F/S.
- Project-induced impact on business along existing road bypassed by the planned highway shall be discussed in the items of "Poverty" or "Local Economy such as Employment and Livelihood". In addition, appropriate mitigation measures shall be proposed if any such impact is expected based on the results from stakeholder meetings and any other surveys.
- JICA asks the project proponents to consider following conditions. In case that impact is expected on existing roads bypassed by the highway, relevant households and/or business bodies should be involved in public participation processes such as stakeholder meetings, and socioeconomic survey shall be implemented, if necessary.

CHAPTER 16

CEBU CIRCUMFERENTIAL ROAD

CHAPTER 16
CEBU CIRCUMFERENTIAL ROAD

16.1 Outline of the Project

As the second-largest metropolitan city in the Philippines, the development of Metro Cebu is extremely fast. Metro Cebu consists of seven (7) cities and six (6) municipalities, as shown in **Figure 16.1-1**. The population of Metro Cebu is expected to increase from 3.2 million in 2020 to 5.0 million in 2050 due to rapid rate of urbanization. However, only limited transport investments have been made so far, consisting mostly of modifications of the existing infrastructure, such as road widening and construction of flyovers.

Recently, the Cebu–Cordova Link Expressway (construction started from March 2017) has begun construction, while, the proposed 4th Cebu-Mactan Bridge has already been approved in January 2020 and expected to start implementation soon (see **Figure 16.3-1**).

Although these projects will contribute to ease the traffic between Cebu City/Mandaue City and Lapu-Lapu City, these will not bring significant impact on traffic decongestion in Cebu and Mandaue metropolis.

As illustrated in **Figure 16.1-2**, Metro Cebu has a longitudinal coastal topography, where only two (2) major corridors connect south-north traffic. Under this condition, DPWH conducted the Business Case Study for the Cebu Circumferential Road, which was divided into three (3) segments (see **Table 16.1-1** and **Figure 16.1-2**). Among these segments, the JICA Study Team (JST) conducted a Pre-F/S for Segment-1. Since this road section is located in a hilly area, in order to achieve high standard highway criteria, advanced technology for long mountain tunnel and high pier bridge will be adopted for the whole section. It is proposed as a short term (present~2025) project in the implementation program for HSH Class-1.

Table 16.1-1 Cebu South Coastal Road – Cebu Circumferential Road Segment by DPWH F/S Study

Segment	Station point	Length(km)
Segment-3	Naga City - Minglanilla/Talisay Bdry.	17.15
Segment-1	Minglanilla/Talisay Bdry. – Cebu City - Mandaue / Consolacion Bdry.	26.80
Segment-2	Mandaue / Consolacion Bdry.- Danao City	29.80
Total		73.75

Source: Feasibility and Business Case Studies for the Cebu South Coastal Road – Cebu Circumferential Road.

Figure 16.1-1 Metro Cebu Area

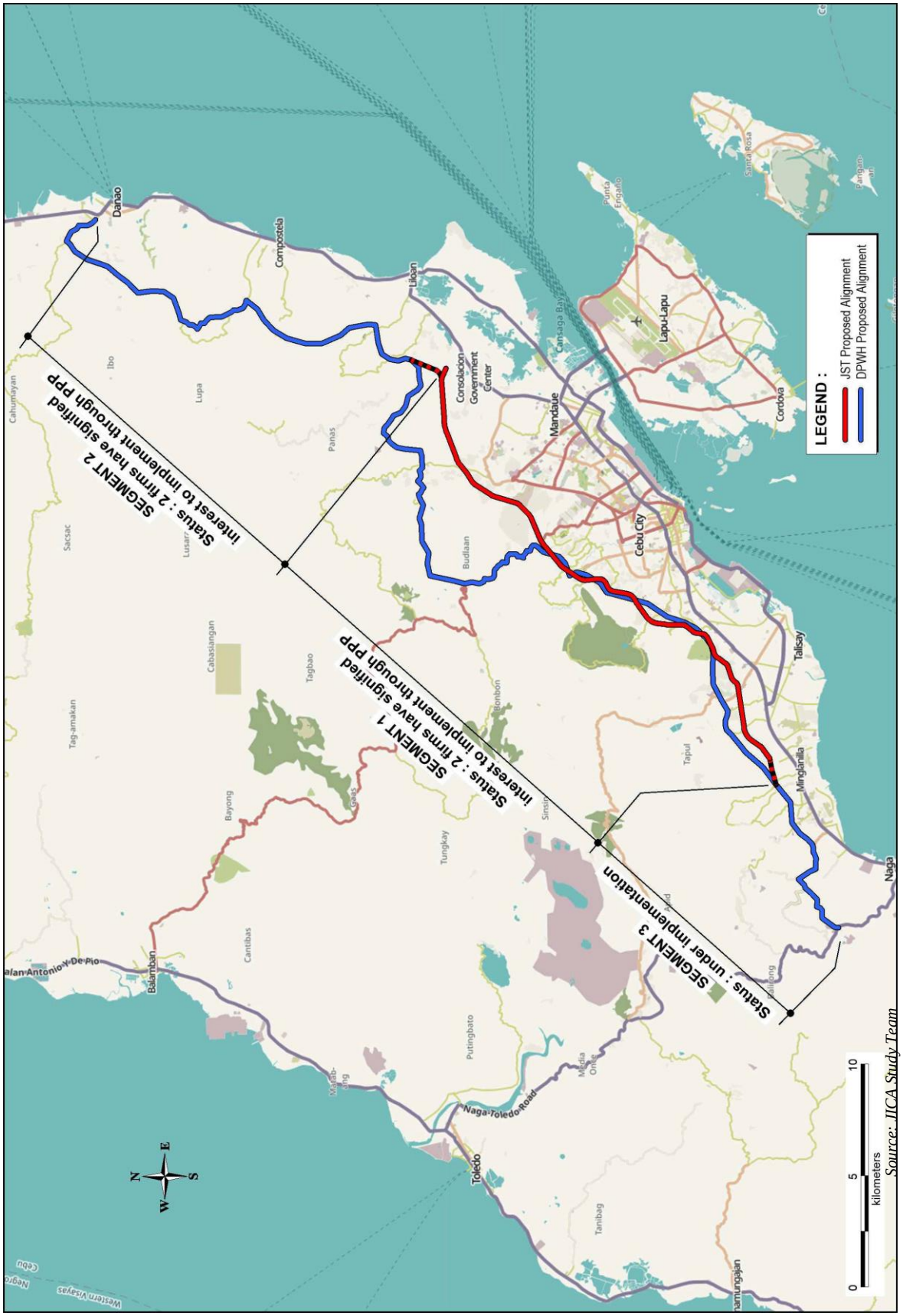


Figure 16.1-2 Location Map of Cebu Circumferential Road

16.2 Justification of the Project

16.2.1 Necessity of Cebu Circumferential Road

- Cebu Circumferential Road (CCR) will have a role of a bypass road that passes through the congested Cebu Urban Area.
- Traffic decongestion of the Metro Cebu Area will certainly contribute to the economic enhancement of the metropolis.

16.2.2 Traffic Situation in Cebu Urban Area

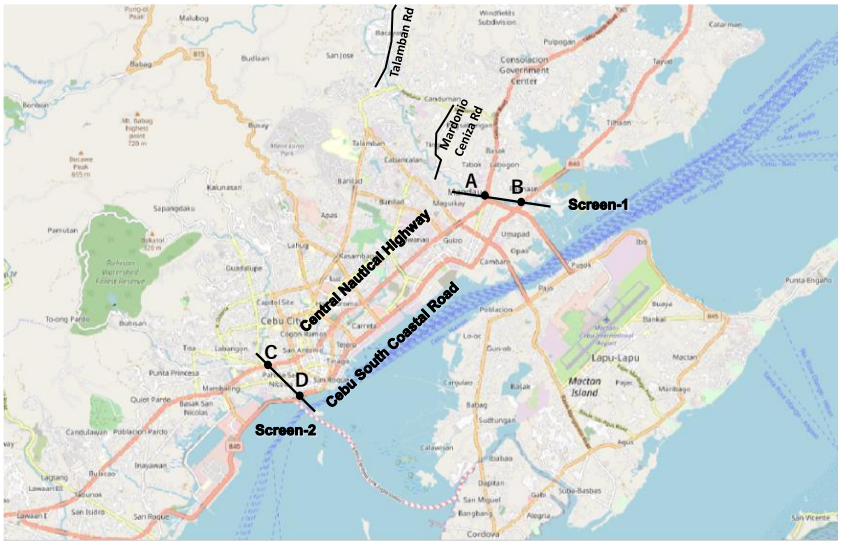
There are two main roads along the east-west direction, the Central Nautical Highway and Cebu South Coastal Road. The traffic volumes in 2018 and locations of these roads are shown in **Table 16.2-1** and **Figure 16.2-1**.

The highest Volume to Capacity Ratio (V/C) is at Central Nautical Highway East (Station A, Screen-1). The traffic volume is 47,000 veh./day and V/C is 0.98. while the V/C of Cebu South Coastal Road West section (Station D, Screen-2) is 0.83. But the V/C is expected to become more than 1.0 in the near future and traffic congestion will be evident soon.

Table 16.2-1 Traffic Volume and V/C at Screen-1 and Screen-2 (Year 2018)

Screen	Sta	Road Name	Capacity (a) (Vehicle/day)	Traffic Volume (b) (Vehicle/day)	V/C (= b / a)
1	A	Central Nautical Highway East	48,000	47,000	0.98
	B	Cebu South Coastal Road East	40,000	19,000	0.47
	Total			-	-
2	C	Central Nautical Highway West	72,000	43,800	0.61
	D	Cebu South Coastal Road West	40,000	33,200	0.83
	Total			-	-

Source: JICA Study Team



Source: JICA Study Team

Figure 16.2-1 Location of Screen and Survey Station in Cebu Urban Area

Figure 16.2-2 to **Figure 16.2-5** show the traffic projection and road capacity of each station. Growth rate for traffic volume is set at approximately 2.0 % per year based on the socio-economic indicators, such as population growth. For the result of projected traffic volume and road capacity, the Central Nautical Highway East section (Station A, Screen-1) and the Cebu South Coastal Road West section (Station D, Screen-2) will be over capacitated by 2020 and 2028, respectively.

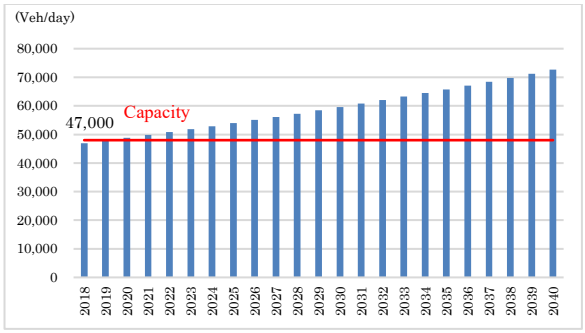


Figure 16.2-2 Traffic Volume Station A

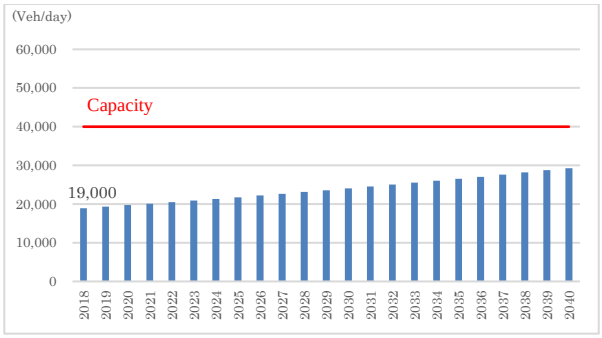


Figure 16.2-3 Traffic Volume Station B

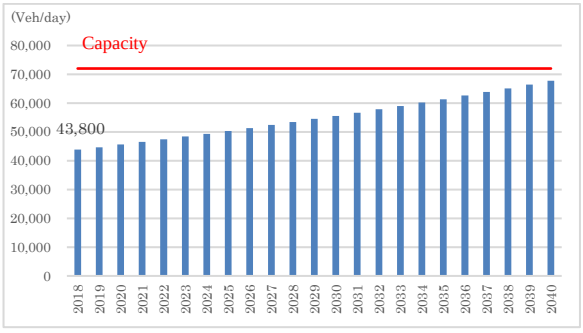


Figure 16.2-4 Traffic Volume Station C

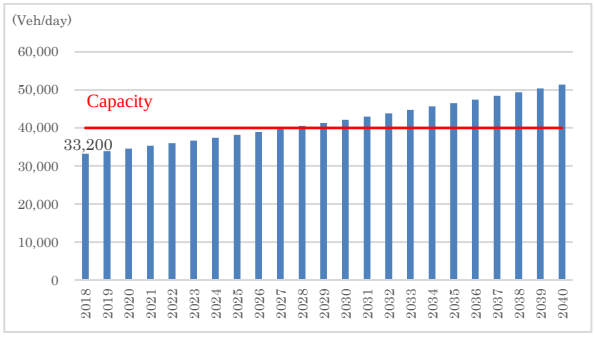
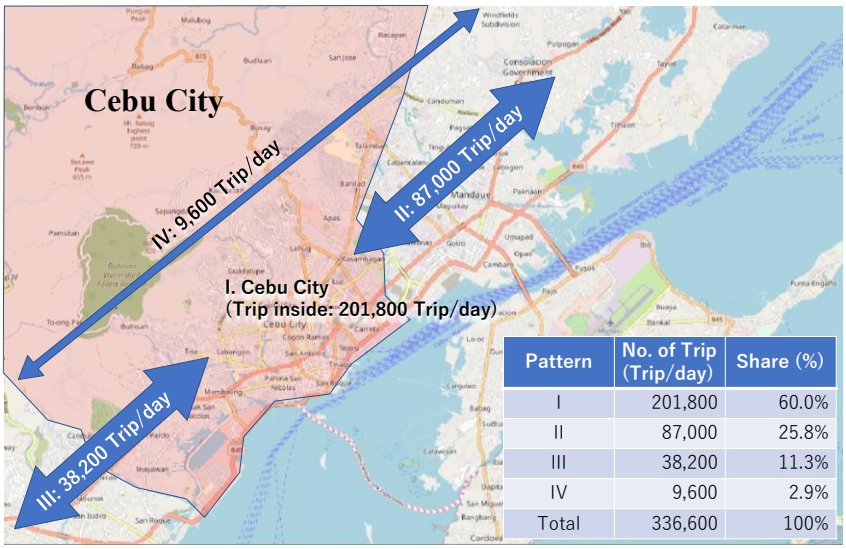


Figure 16.2-5 Traffic Volume Station D

Source: JICA Study Team

16.2.3 Present Traffic Pattern in Cebu City

Figure 16.2-6 shows the present trip pattern in Cebu City. Sixty percent (60.0%) of total trip in Cebu City is intra-city (within the city) movement, while the remaining 37.1% of the total trip flows inter-city (inside and outside of Cebu City) and 2.9% are passing through movement (flows from one end to another end of Cebu City). Through traffic will be shifted to CCR. And in order to attract traffic along CCR, it is important to plan-out carefully how traffic would be attracted to shift from inter-city flow to CCR. The layout of interchange should be planned near the major roads for easier access.



Pattern	No. of Trip (Trip/day)	Share (%)
I	201,800	60.0%
II	87,000	25.8%
III	38,200	11.3%
IV	9,600	2.9%
Total	336,600	100%

Source: JICA Study Team

Figure 16.2-6 Present Trip Pattern in Cebu City

16.3 Transport Demand Forecast for the Project

16.3.1 Basic Idea of Traffic Demand Forecast

Future traffic demand forecast is used to decide on the design of the daily traffic volume and to obtain basic information for economic analysis of the project. The basic idea of traffic demand forecast is as follows:

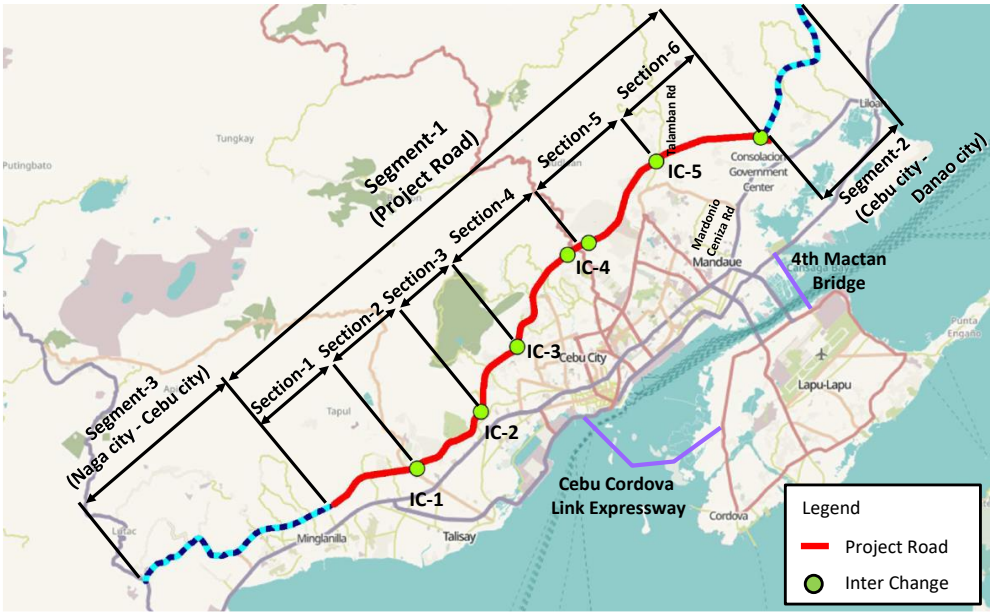
Year of traffic demand forecast: 2040,

Method of traffic demand forecast:

- ✓ Traffic assignment: User Equilibrium Assignment
- ✓ Link condition: 4-lane road, toll road for CCR and 2040 road network (Cebu Cordova Link Expressway and 4th Mactan Bridge)
- ✓ OD table: 2040, 4-types of vehicles (Car, Jeepney, Bus and Truck)
- ✓ Toll rate applied as the same as M/P case. Jeepneys are prohibited to use CCR.

The consideration for development of before and after section of project road (Segment-1) is shown in the figure below. As the construction of Segment-3 is under implementation, it will be completed before the start of project road (Segment-1). The construction of Segment-2 was proposed under the PPP scheme and its implementation schedule has not yet been finalized. Hence, the future traffic volume in 2040 for the two cases are estimated numbers.

Case-1: Development of Segment-1 (Project Road) and Segment-3 (Naga City - Cebu City)
Case-2: Development of All Segments (Segment-1, 2 (Cebu City - Danao City), 3)



Source: JICA Study Team

Figure 16.3-1 Project Road with Other Road Segments

16.3.2 Future Traffic Volume

The estimated future traffic volume by sections is shown in **Table 16.3-1** and **Table 16.3-2**. The traffic volume of CCR in 2040 was estimated in range from 11,900 veh/day to 37,400 veh/day in Case-1, and from 22,900 veh/day to 37,700 veh/day in Case-2, respectively.

The traffic volume will increase from section-4 to section-6 by constructing segment-2 which connects the northeastern part of Cebu Island.

Based on the estimated future traffic volumes, it is necessary to construct initially a 4-lane due to excess of 2-lane capacity (10,000 vehicle/day).

Table 16.3-1 Future Traffic Volume CCR in Case-1

Unit: Vehicle/day

Year	Section-1	Section-2	Section-3	Section-4	Section-5	Section-6
2030	30,700	27,300	27,100	17,800	17,800	9,800
2035	33,900	30,200	29,900	19,700	19,700	10,800
2040	37,400	33,300	33,100	21,700	21,700	11,900

Note: Traffic volume in year 2030 and 2035 were estimated by approx. 2.0 % per year based on the average traffic growth in the Cebu City.
Source: JICA Study Team

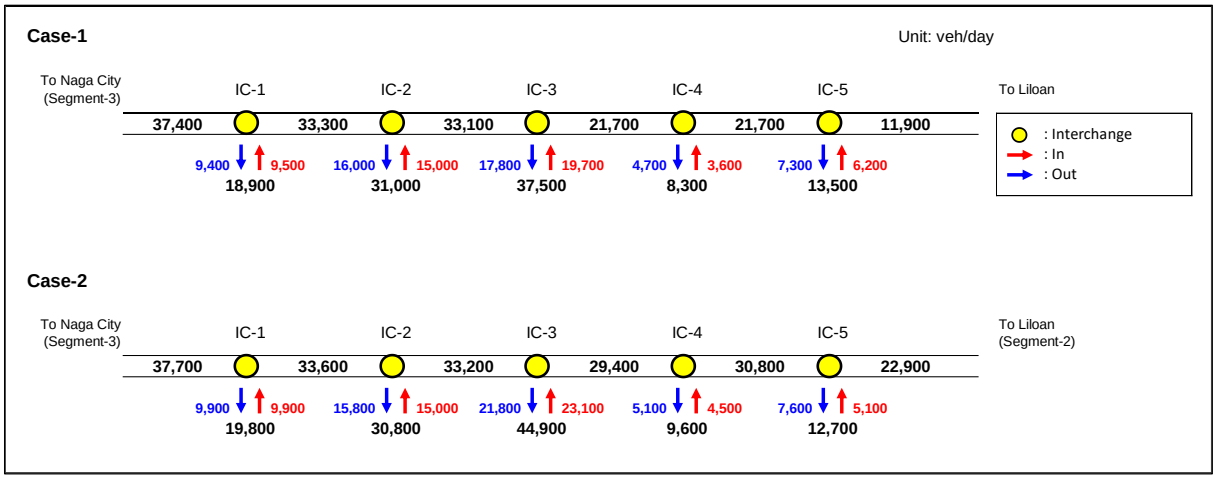
Table 16.3-2 Future Traffic Volume CCR in Case-2

Unit: Vehicle/day

Year	Section-1	Section-2	Section-3	Section-4	Section-5	Section-6
2030	30,900	27,500	27,200	24,200	25,300	18,800
2035	34,100	30,400	30,100	26,700	27,900	20,800
2040	37,700	33,600	33,200	29,400	30,800	22,900

Note: Traffic volume in year 2030 and 2035 were estimated by approx. 2.0 % per year based on the average traffic growth in the Cebu City.
Source: JICA Study Team

Traffic volume of Interchange of 2 and 3(IC-2 and IC-3) are expected high as illustrated in **Figure 16.3-2**, since inter-city trips (inside and outside of Cebu City) may enter or exit from them.



Source: JICA Study Team

Figure 16.3-2 Interchange Traffic Volume in 2040 for Case-1 and Case-2

16.3.3 Project Effect

(1) Traffic Diversion to CCR, V/C and Travel Speed Savings

Tables and figures below show traffic diversion, V/C and travel speed savings in 2040 and is compared at typical screen. The effects of CCR development are shown below;

< Case-1 >

- Traffic volume of CCR Section-4 was estimated at 21,700 veh/day. Diverted traffic from Central Nautical Highway East, Talamban Road and Mardonia Ceniza Road were calculated at 7,600 veh/day (12%), 9,700 veh./day (35%) and 3,400 veh./day (43%), respectively. The traffic volume of Talamban Rd and Mardonio Ceniza Road which are in mountainous areas will be diverted to CCR.
- V/C of Central Nautical Highway is increased from 1.48 to 1.32, thus, traffic congestion in the urban area will be improved. And, V/C of Talamban Road and Mardonio Ceniza Road will drastically decrease by over 0.5, respectively.
- Travel speed along Talamban Road in Without Case was estimated to be less than 10 km/h, but in With Case, travel speed will increase to 10 km/h or more.

< Case-2 >

- Traffic volume of CCR Section-4 was estimated at 29,400 veh./day. Diverted traffic from Central Nautical Highway East, Cebu South Coastal Road East, Talamban Road and Mardonio Ceniza Road were calculated at 15,400 veh./day (24%), 5,900 veh./day (52%), 7,300 veh./day (25%) and 600 veh./day (7%), respectively. The traffic volume of Central Nautical Highway and Cebu South Coastal Road will be diverted to CCR for further development of Segment-2 (Cebu City-Danao City).
- V/C of Central Nautical Highway and Cebu South Coastal Road is decreased from 1.64 to 1.32, from 0.43 to 0.32, respectively. And, V/C of Talamban Road is likewise decreased. Much traffic are diverted to CCR, which contributes to the traffic decongestion. And, travel speed at Central Nautical Highway and Talamban Road is increased by 7.5 km/h and 4.5 km/h in order to develop the CCR.
- It is expected to further improve the traffic congestion in Cebu Urban Area by the development of segment-2 compared with Case-1.

Table 16.3-3 Comparison of Traffic Volume and V/C in Cebu Urban Area in Case-1

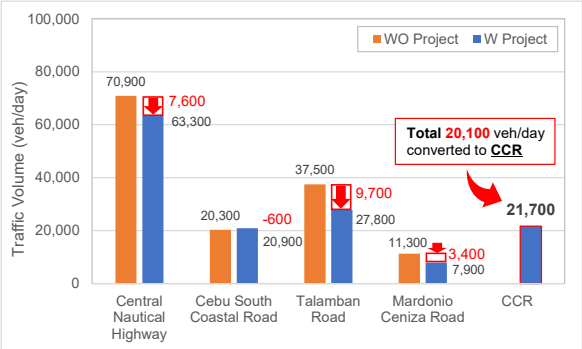
Road Name	Traffic Volume (veh./day) in Year 2040			V/C			Travel Speed (km/h)		
	W Project	WO Project	W-WO	W	WO	W-WO	W	WO	W-WO
Central Nautical Highway East	63,300 (100%)	70,900 (112%)	-7,600 (-12%)	1.32	1.48	-0.16	34.8	30.9	3.9
Cebu South Coastal Road East	20,900 (100%)	20,300 (97%)	600 (3%)	0.52	0.51	0.01	38.5	38.5	-0.1
Talamban Road (Mountainous Area)	27,800 (100%)	37,500 (135%)	-9,700 (-35%)	1.96	2.64	-0.68	12.9	6.6	6.3
Mardonio Ceniza Road (Mountainous Area)	7,900 (100%)	11,300 (143%)	-3,400 (-43%)	1.32	1.89	-0.57	20.7	14.9	5.7
CCR (Section-4)	21,700 (100%)	-	21,700 (100%)	0.39	-	-	76.7	0.0	-
Total	141,600	140,000	1,600	-	-	-	-	-	-

Source: JICA Study Team

Table 16.3-4 Comparison of Traffic Volume and V/C in Cebu Urban Area in Case-2

Road Name	Traffic Volume (veh./day) in Year 2040			V/C			Travel speed (km/h)		
	W Project	WO Project	W-WO	W	WO	W-WO	W	WO	W-WO
Central Nautical Highway East	63,300 (100%)	78,700 (124%)	-15,400 (-24%)	1.32	1.64	-0.32	34.7	27.2	7.5
Cebu South Coastal Road East	11,300 (100%)	17,200 (152%)	-5,900 (-52%)	0.28	0.43	-0.15	39.7	39.1	0.6
Talamban Road (Mountainous Area)	29,400 (100%)	36,700 (125%)	-7,300 (-25%)	2.07	2.58	-0.51	11.3	6.8	4.5
Mardonio Ceniza Road (Mountainous Area)	8,400 (100%)	9,000 (107%)	-600 (-7%)	1.40	1.51	-0.10	19.8	18.0	1.8
CCR (Section-4)	29,400 (100%)	-	29,400 (100%)	0.53	-	-	76.7	0.0	-
Total	141,800	141,600	200	-	-	-	-	-	-

Source: JICA Study Team



Source: JICA Study Team

Figure 16.3-3 Comparison of Traffic Volume in Case-1

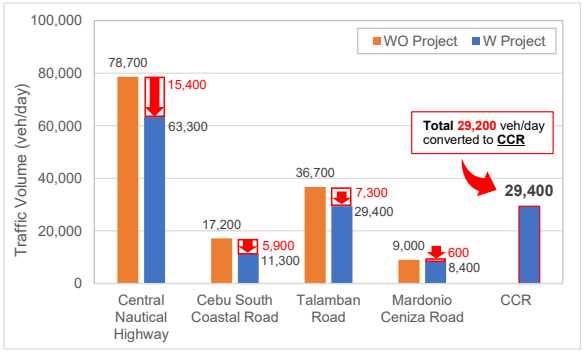


Figure 16.3-4 Comparison of Traffic Volume in Case-2

(2) Comparison of V/C in Cebu Urban Area

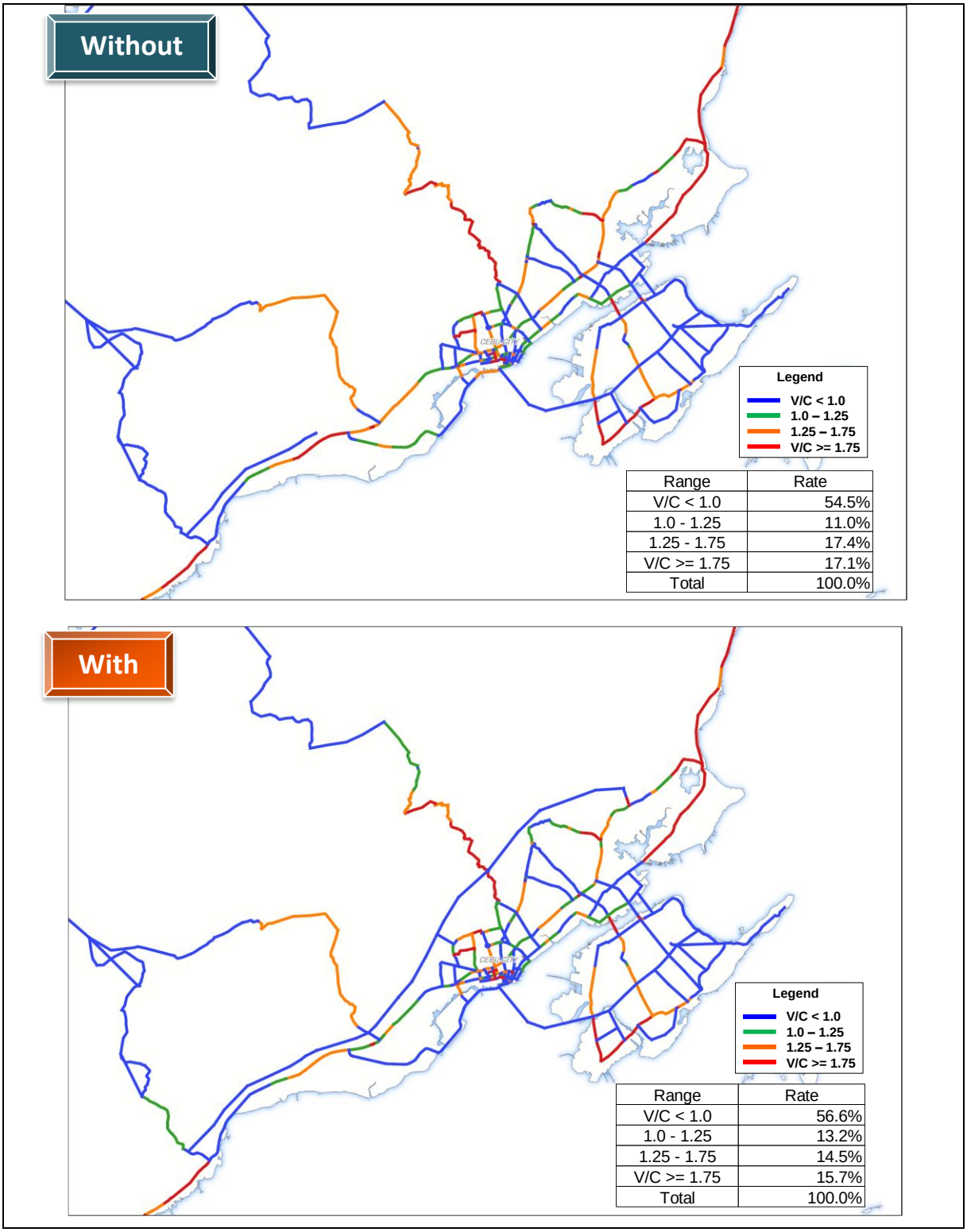
Figure 16.3-5 and **Figure 16.3-6** show the comparison between "with case" and "without case" for V/C in Cebu urban area. The effects of CCR development are shown below;

<Case-1>

- V/C rate for ranges 1.25-1.75 and over 1.75 in "without case" was estimated at 17.4% and 17.1%, respectively.
- V/C rate for ranges 1.25-1.75 and over 1.75 in "with case" was estimated at 14.5% and 15.7% and increase the rate due to the development of the CCR.
- Traffic congestion along the westside of Cebu Urban Area will be improved, but V/C on east side national road will be still over 1.25.

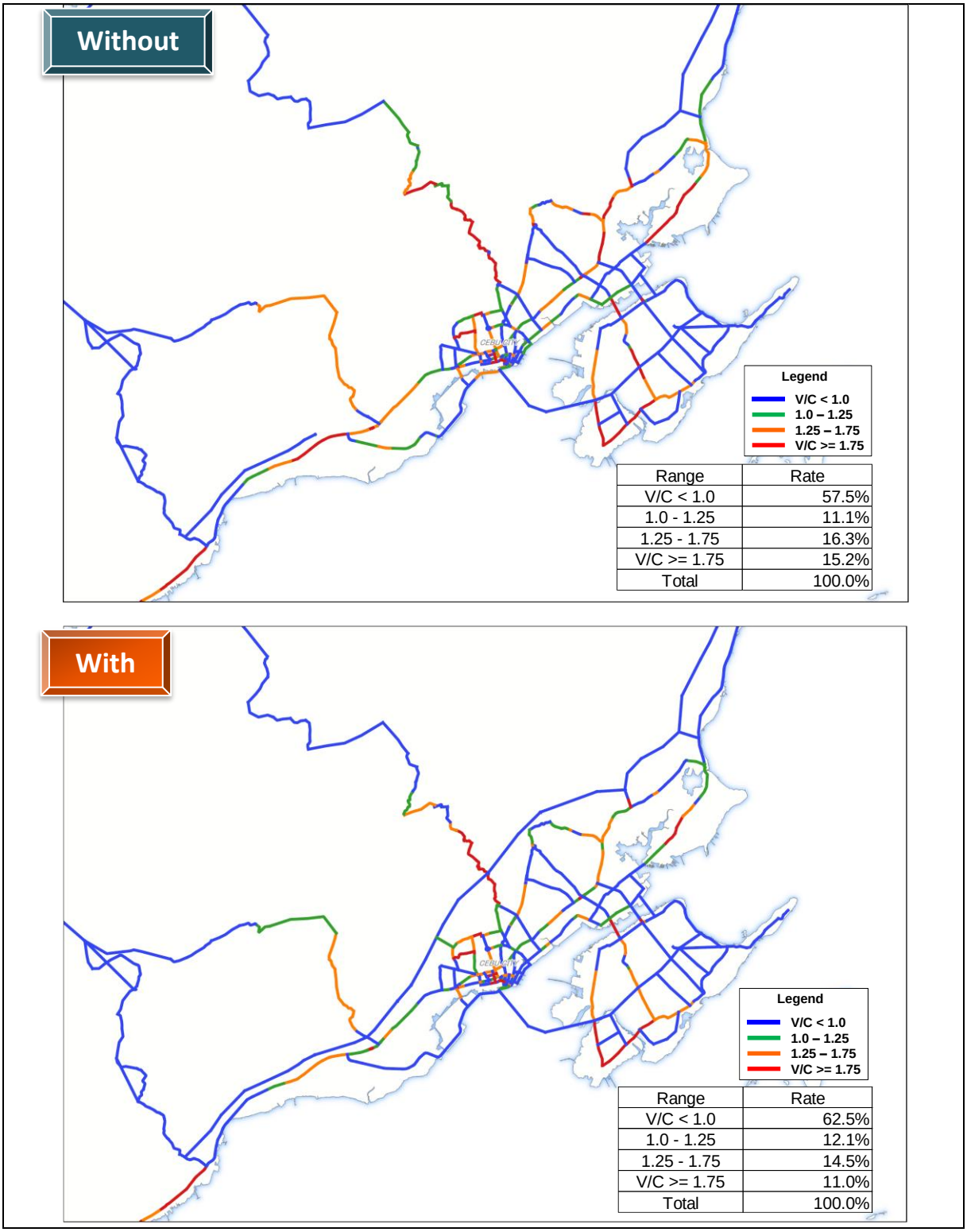
<Case-2>

- V/C rate for ranges 1.25-1.75 and over 1.75 in "without case" was estimated at 16.3% and 15.2%, respectively.
- V/C rate for ranges 1.25-1.75 and over 1.75 in "with case" was estimated at 14.5% and 11.0%. Especially, V/C for over 1.75 was decreased further due to the development of the CCR.
- Based on the development of the CCR segment-2, V/C rate for less than 1.00 will be higher than Case-1.



Source: JICA Study Team

Figure 16.3-5 V/C Comparison in Case-1



Source: JICA Study Team

Figure 16.3-6 V/C Comparison in Case-2

(3) Reduction of Total Vehicle Kilometer and Total Travel Time, Improvement of Travel Speed

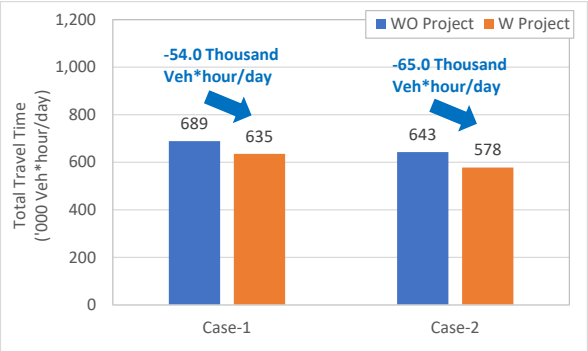
Reduction of Total vehicle- kilometer and travel time and improvement of travel speed for CCR in Case-1 and Case-2 are shown in the table and figures below.

- Reduction of total vehicle- kilometer and travel time saving were estimated at 73,000 veh.*km/day, 54,000 veh.*hour/day in Case-1 and 102,000 veh.*km/day, 65,000 veh.*hour/day in Case-2, respectively.
- Travel speed of without project and with project were estimated at 18.6 km/h and 17.2 km/h in Case-1 and at 19.6 km/h and 17.7 km/h in Case-2. Each case was increased from 1.4 km/h and 1.9 km/h.
- Thus, total vehicle- kilometer and total travel time will be reduced, travel speed will be increased by the development of CCR. Result of Case-2 is remarkable.
-

Table 16.3-5 Reduction of Total Vehicle- Kilometer and Total Travel Time, Improvement of Travel Speed in Year 2040

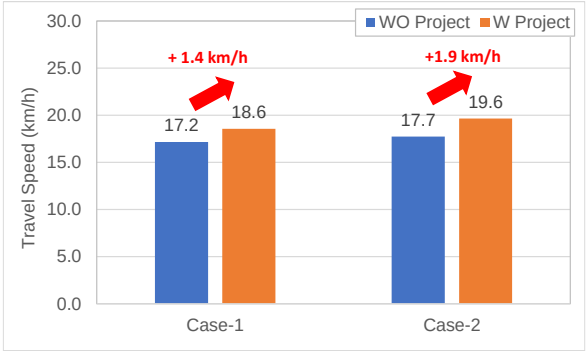
Items		WO Project	W Project	WO - W
Case 1	Vehicle-km (veh.*km/day)	11,700,000	11,627,000	73,000
	Vehicle-Hour (veh.*hour/day)	689,000	635,000	54,000
	Speed (km/h)	17.2	18.6	-1.4
Case 2	Vehicle-km (veh.*km/day)	11,276,000	11,174,000	102,000
	Vehicle-Hour (veh.*hour/day)	643,000	578,000	65,000
	Speed (km/h)	17.7	19.6	-1.9

Note: Evaluation area is set as Cebu Urban Area
Source: JICA Study Team



Source: JICA Study Team

Figure 16.3-7 Reduction of Total Travel Time

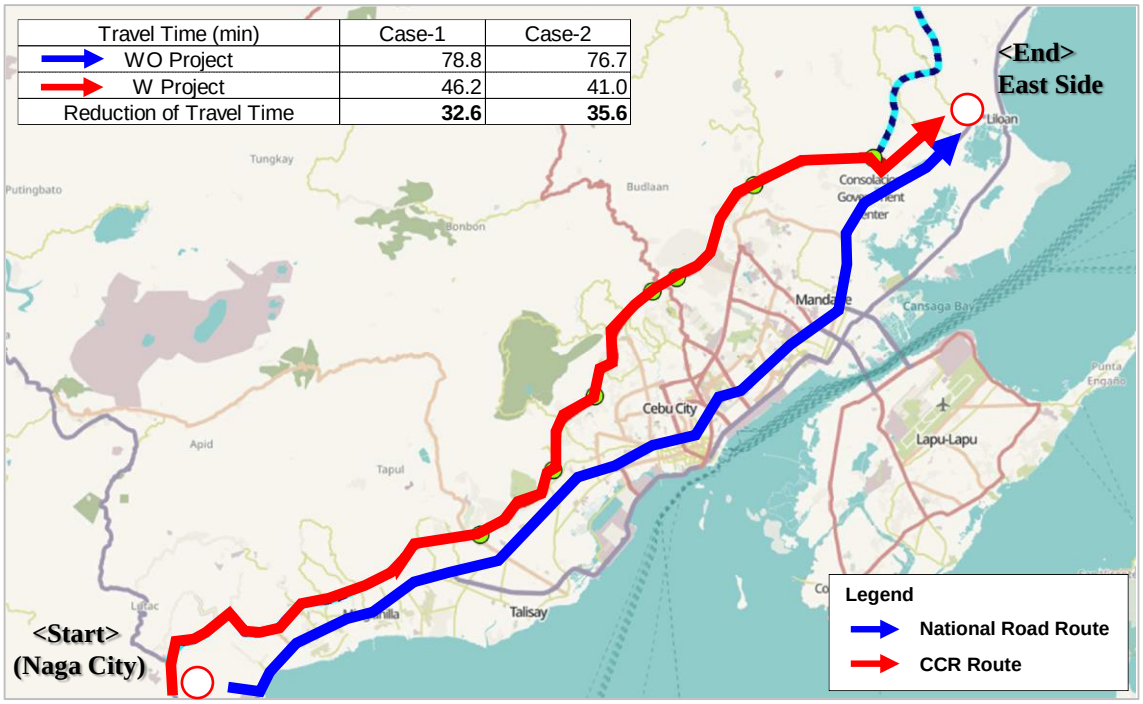


Source: JICA Study Team

Figure 16.3-8 Improvement of Travel Speed

(4) Reduction of Travel Time

Reduction of travel time from Naga City to East Side of Cebu Urban Area is shown in **Figure 16.3-9**. Based on result of traffic demand forecast, reduction of travel time of Case-1 and Case-2 was estimated at approximately 33min and 36min, respectively. It is possible to pass through smoothly from west side to east side of Cebu Urban Area with the development of the CCR.



Source: JICA Study Team

Figure 16.3-9 Reduction of Travel Time in Year 2040

16.4 Preliminary Design

16.4.1 Design Standard

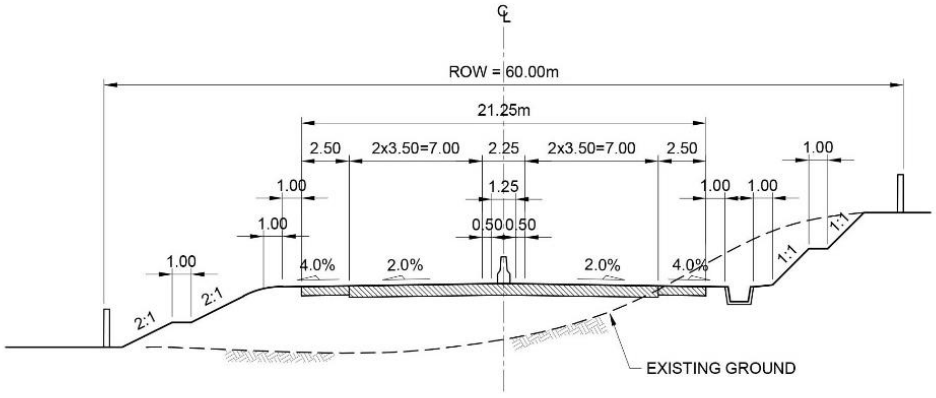
The proposed Highway is an Inter-City High Standard Highway Class-1. The Geometric Design Criteria to be applied are shown in **Table 16.4-1**.

Table 16.4-1 Geometric Design Criteria

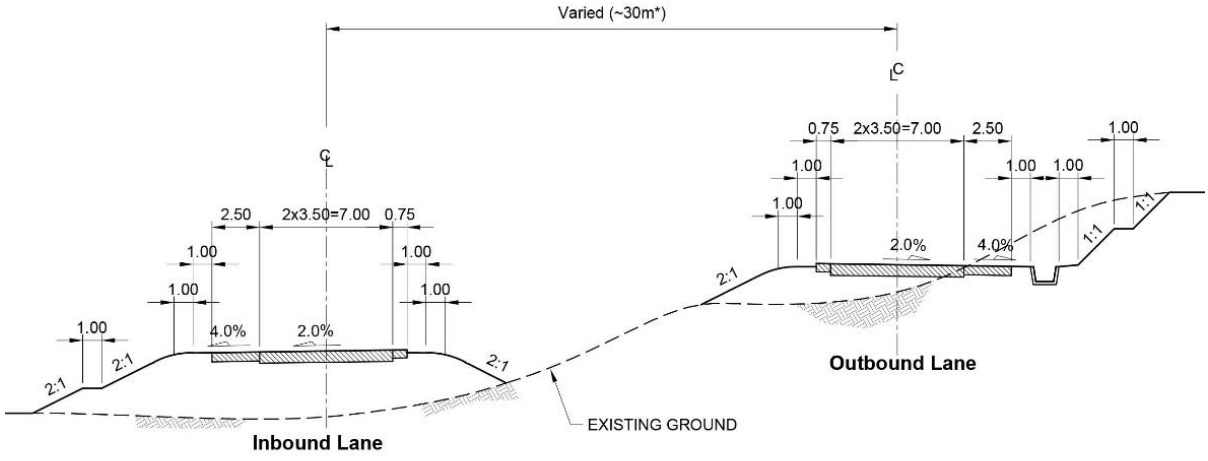
Items		Value
Design Speed		60 km/h
Maximum Grade		5% 6% (l = 500 m)
Radius	Minimum	120 m
	Desirable	150 m
No. of Lanes		4
Lane width		3.50 m
Medium strip width		2.25 m
Outer shoulder width		2.50 m

Source: JICA Study Team

Typical Cross Section to be applied to the project is shown in **Figure 16.4-1**.



Typical Cross-Section of Road Section (4-Lane)



* ***The maximum mutual separation distance of the road section neighboring the tunnel section depends on the mutual separation distance of the tunnel.***

Source: JICA Study Team

Figure 16.4-1 Typical Cross-Section of Cebu Circumferential Road (4-Lane)

16.4.2 Road Design Including Alternative Study

Based on the proposed alignment of JICA Metro Cebu Urban Transport Masterplan, the following four alternative alignments were prepared and studied.

Table 16.4-2 Outline of the Four Alternatives

Alignment	Features
Alignment A	Inland Alignment compared with Alignment B
Alignment A (dash)	Same plan as Alignment A (To minimize the number of affected buildings, two long mountain tunnel was applied. The profile is indicated as orange color dot line in **Figure 16.4-3**)
Alignment B	Improvement of alignment based on the Metro Cebu Urban Transport Masterplan
Alignment C	The plan in Alignment B is moved a little closer to Cebu City

Source: JICA Study Team

Table 16.4-3 Comparison Table of the Four Alternatives

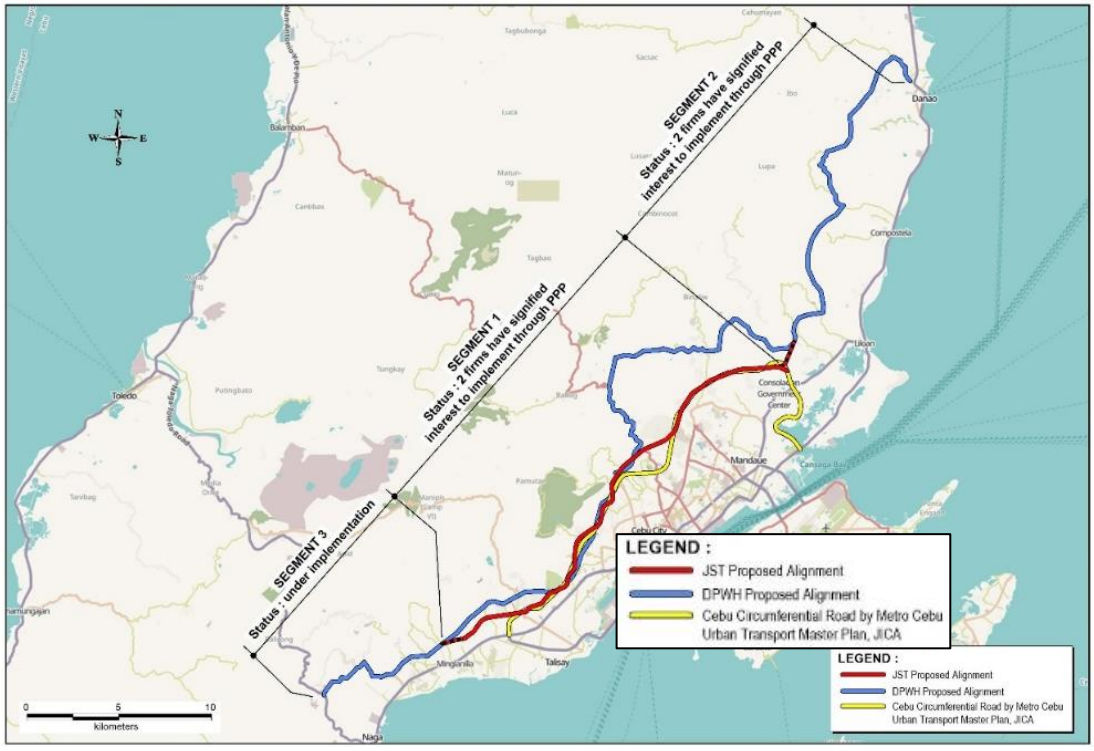
	Alignment A	Alignment A (dash)	Alignment B	Alignment C
Length	23.5 km	23.5 km	24.6 km	22.4 km
1)Route	Due to mountainous area, there are three critical vertical sections (grade: over 6 %). These sections do not satisfy the design speed of 60 km/h. (△)	In order to satisfy the design speed of 60 km/h, long mountain tunnels were applied. (○)	Due to hilly area, some critical vertical sections exist, however, these sections satisfy the design speed of 60 km/h. (○)	Compared with other two alternatives, vertical alignment is not critical. Shortest road length among the alternatives. (◎)
2)Structures (Bridge and Tunnel)	It is necessary to construct high-pier bridges and tunnel sections. Highest pier for bridge is 170 m, project implementation would be difficult with the use of the present technology. (△)	In order to achieve a high standard highway, it is necessary to construct long mountain tunnels. With the present technology, this is implementable. (○)	In order to achieve a high standard highway, it is necessary to construct many high-pier bridges and mountain tunnels. But highest pier is 40 m and the longest tunnel is 1,700 m. With the present technology, this is implementable. (○)	In order to achieve a high standard highway, it is necessary to construct many bridges and mountain tunnels. (○)
3)Environmental and Social Considerations	Relatively rich natural habitats are along the alignment and a large number of trees to be cut is required. Impacts on hydrology, topography and other items are also most severe among the options. (×)	Long mountain tunnel was applied in order to lessen the impact on hydrology, topography, and other items compared with Alignment A. (○)	Some sections are close to forest / hilly areas where natural environment is easily affected. Such impact is middle/mild among the options. (△)	Some sections are close to forest / hilly areas where natural environment is easily affected. Such impact is relatively low among the options. (○)
4)No. of affected structures * Social Impact	1123 (○) Cases Impact on land acquisition and resettlement is relatively low.	812(◎) Cases Impact on land acquisition and resettlement is the lowest.	1,200 (○) Cases Impact on land acquisition and resettlement is relatively low.	3,120 (×) Cases Alignment C is diverted from alignment B and moved a little closer to Cebu City, the number of affected structures increased by over 2.6 times.
5)Project cost rate (Construction cost +	1.28(○) Construction cost will be higher than Alignment B	1.46(△) Project cost is the highest due to long tunnel.	1.00(◎) Since both construction cost and ROW	1.14(○) Although construction cost will be cheapest,

	Alignment A	Alignment A (dash)	Alignment B	Alignment C
ROW acquisition cost)			acquisition cost are middle among the options, project cost is the cheapest among 4 options	ROW cost will be highest due to many affected residential areas
6)Future Traffic (2040)	19,700 vehicle/day (0.73) (△) Two interchanges/ ramps are difficult to construct due to deep ravine which requires long column lengths	19,700 vehicle/day (0.73) (△) Two interchanges/ramps are difficult to construct due to deep ravine which requires long column lengths	25,300 vehicle/day (0.94) (○)	26,800 vehicle/day (1.00) (◎) Alignment is the nearest to residential areas among the 4 options
Evaluation	○ **2,** △ **4**	◎ **1,**○ **3,**△ **2**	◎ **1,**○ **5** **Recommended** Firstly, civil design (alignment) shows more advantages than Alignment A based on topographical conditions and fulfill design speed. Secondly, social impact of land acquisition and resettlement is lower than Alignment C. Thirdly, Project cost and traffic impact is better than Alignment A dash. As a result, as the intermediate option between Alignment A, A dash and C, Alignment B is recommended.	◎ **2,**○ **3,** △ **1**

Note1: ◎: very good, ○: good, △ No good
Note2: see **Figure 16.4-3** the plan and profile of the three alternatives.
Note3: No. of affected structures along each main highway was counted from the satellite image map. The affected structures along the interchange were not counted.
Note4: Approximate construction cost and ROW cost were estimated. Construction cost was estimated based on the road/bridge and tunnel section and unit price per km. ROW cost was estimated with the assumption of residential area and agri based and the affected buildings. As the project cost was roughly estimated, project cost ratio was indicated for comparison purposes only.
Note5: Future traffic volume is the average section volume by traffic assignment model.
Source: JICA Study Team

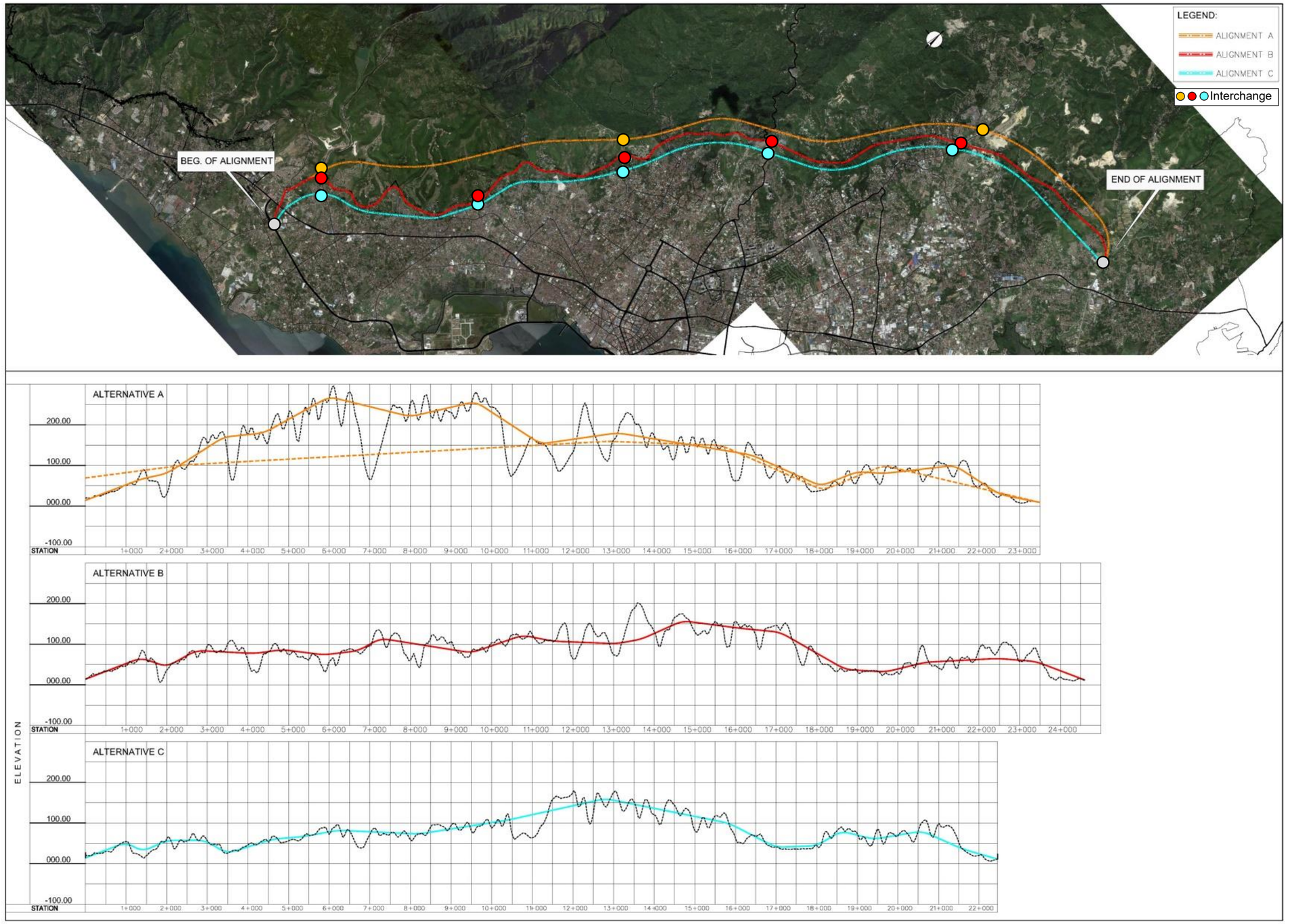
Based on the Comparison Table, Alignment A does not satisfy the design criteria and a difficult technology will be necessary to develop the high standard highway. Although Alignment A(dash) is among the preferred candidates due to the minimal number of affected buildings and natural environmental impact, but applying long mountain tunnel sections, the project cost will be the highest and the traffic is not attracted due to limited number of interchanges. Alignment C has many affected building/structures compared with other Alignments. So, Alignment B is recommended for the Project and road alignment shall be designed based on Alignment B. In addition, comprehensive study for specific route based on the Central Cebu Protected Landscape will be reviewed in the F/S and modified if necessary.
The beginning point was adjusted to connect with the DPWH Segment 3 alignment (see **Figure 16.1-2**).
Figure 16.4-2 illustrates the JST proposed alignment and the Cebu Urban Transport Masterplan alignment used as reference.

Necessity of Cebu Circumferential Road in the Cebu Urban Transport Masterplan
Cebu Circumferential road was proposed as outer diversion road connecting the coastal road with the central area of Metro Cebu that always experiences serious traffic congestion. It was proposed as short-term project (2019-2023) and a 4-lane highway.



Source: JICA Study Team

Figure 16.4-2 Proposed Alignment and Cebu Urban Transport Alignment


LEGEND:
ALIGNMENT A
ALIGNMENT B
ALIGNMENT C
Interchange
BEG. OF ALIGNMENT
END OF ALIGNMENT
ALTERNATIVE A
ALTERNATIVE B
ALTERNATIVE C
ELEVATION
200.00
100.00
000.00
-100.00
STATION
1+000
2+000
3+000
4+000
5+000
6+000
7+000
8+000
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10+000
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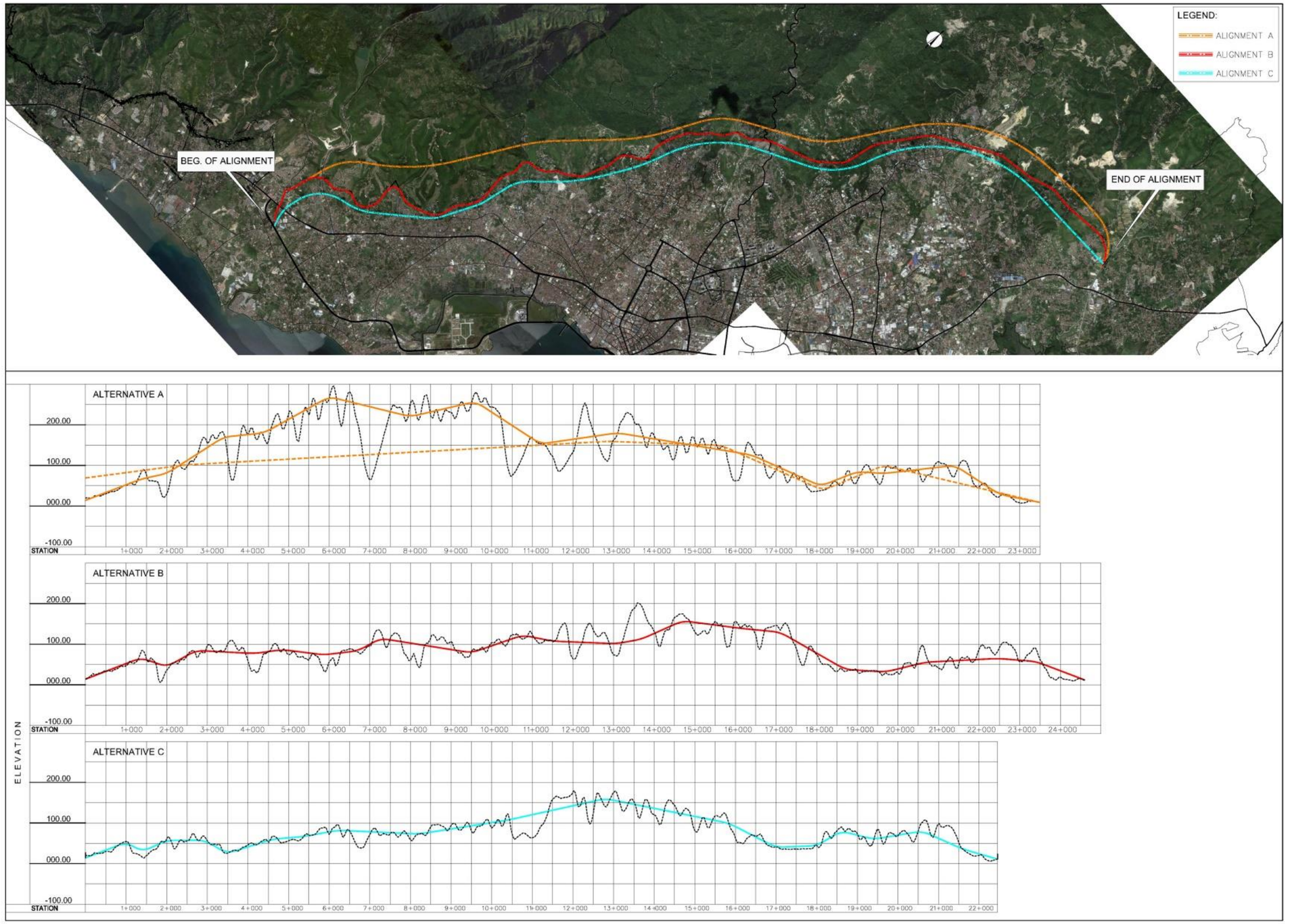
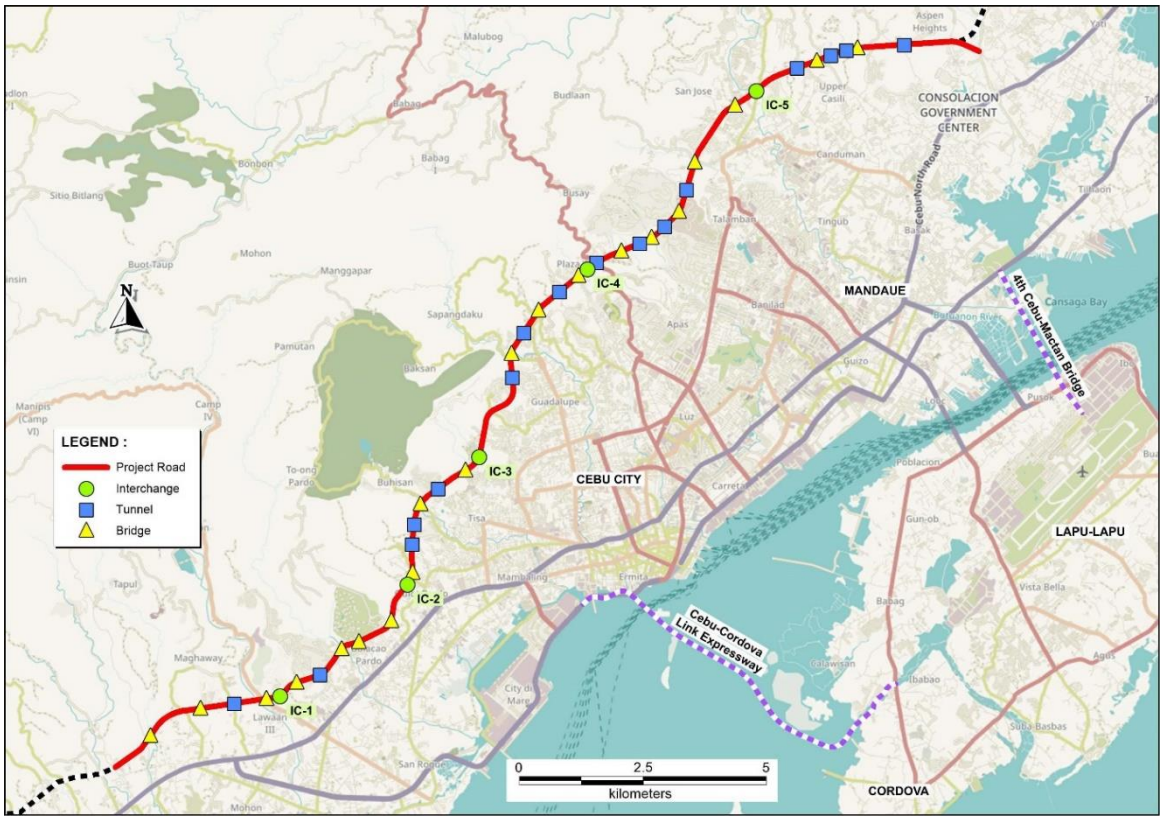


Source: JICA Study Team

Figure 16.4-3 Plan and Profile of the Three Alternatives

Figure 16.4-4 shows the proposed Cebu Circumferential Road Alignment.



Source: JICA Study Team

Figure 16.4-4 Proposed Alignment of CCR

The road plan and profile were designed based on the geometric design criteria shown in **Table 16.4-1**. The road alignment is studied utilizing the secondary data from google satellite map and Shuttle Radar Topography Mission (SRTM Plus Version 3.0).

Basically, maximum embankment height and cut height was designed each at10 m and 20 m. In case of over 10 m height, viaduct was planned instead.

Different interchange types were applied at intersections and all road crossings were designed as an overpass or underpass. **Table 16.4-4** shows the summary of quantities of proposed road alignment.

Table 16.4-4 Quantities of Road Alignment

Component	Unit	Quantity	Remarks
1. Embankment Section	Km	2.27	
2. High Cut Section	Km	4.68	
3. Tunnel	Km	10.12 16 tunnels (32 tubes)	See Section16.5
4. Bridge	Km	7.49 20 bridges	See Section16.6
Total (1+2+3+4)	**Km**	**24.56**	
Underpass	No.	5	
Overpass	No.	5	
Interchange	No.	5	See Section 16.4.4

Preliminary drawing of the plan and profile are shown in **Appendix-16-1**.

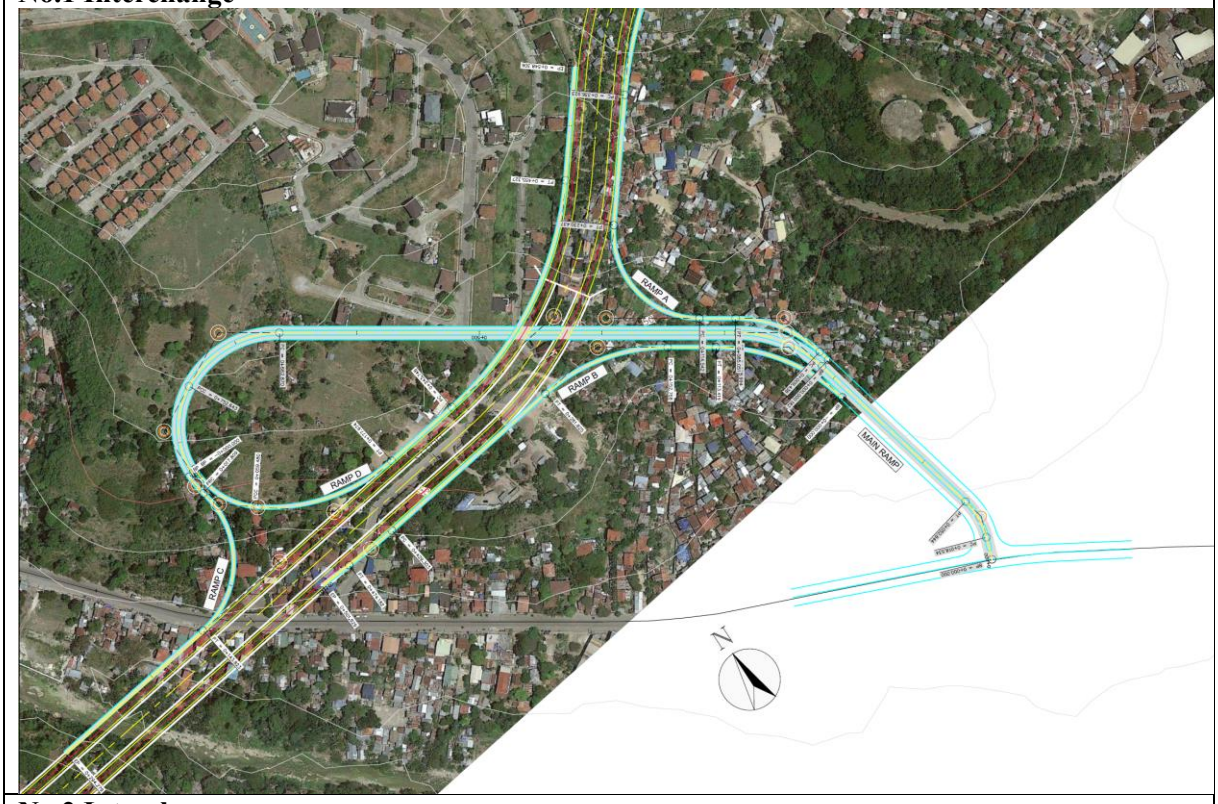
16.4.3 Proposed Layout of Interchange

Although diamond-type interchanges are much more economical in the use of materials and land compared with other interchange designs, however, diamond-type intersections are not implementable for this particular project, hence, the following interchange types are proposed to connect with the ordinary roads.

Table 16.4-5 List of Proposed Interchange

Interchange	Type	Sta.	Remarks
No.1	Trumpet type	2+900 - 3+400	Connect to "Cebu-Toledo Wharf Rd"
No.2	Y-interchange	6+500 - 7+000	Connect to "E Sabellano Street"
No.3	Y-interchange	9+700 - 10+400	Connect to "Salvador Street"
No.4	partial cloverleaf interchange	14+350 – 15+600	Two separate interchange type Connect to "Cebu Transcentral Hwy"
No.5	Trumpet type	19+500 – 19+900	Connect to "Talamban Rd"

No.1 Interchange

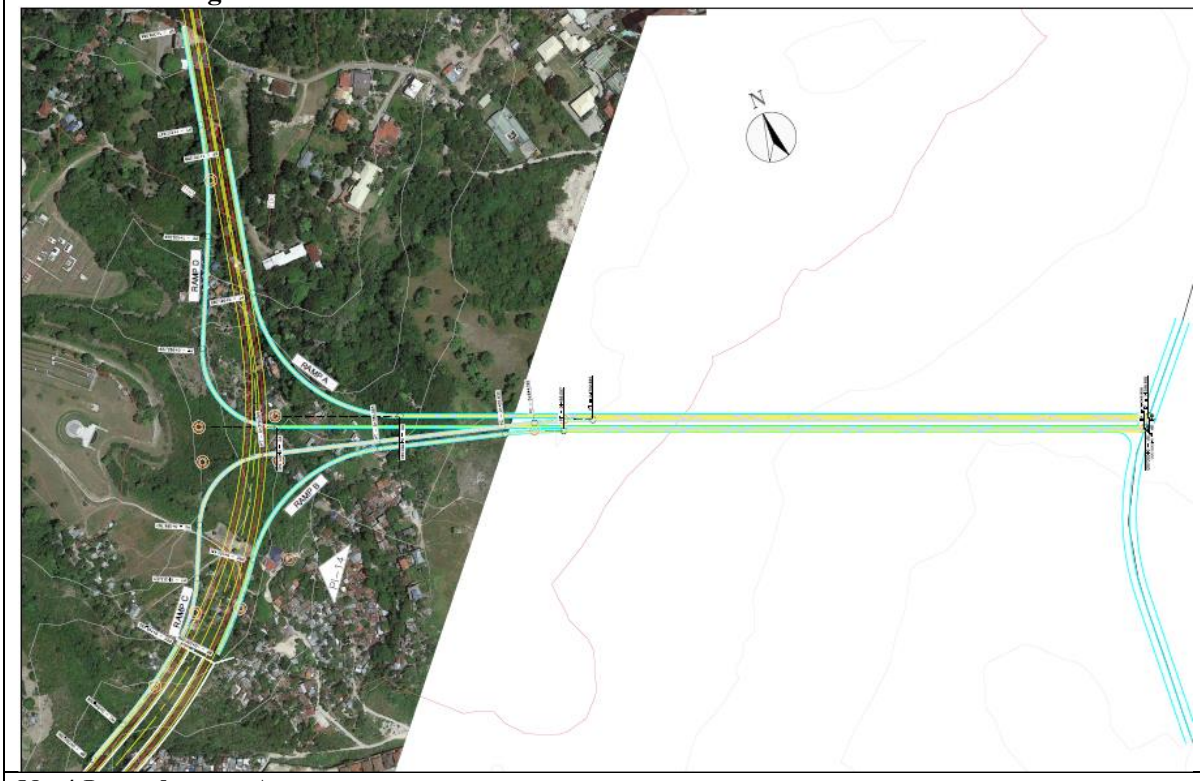


No.2 Interchange

Source: JICA Study Team

Figure 16.4-5 Interchange Plan (1/3)

No.3 Interchange



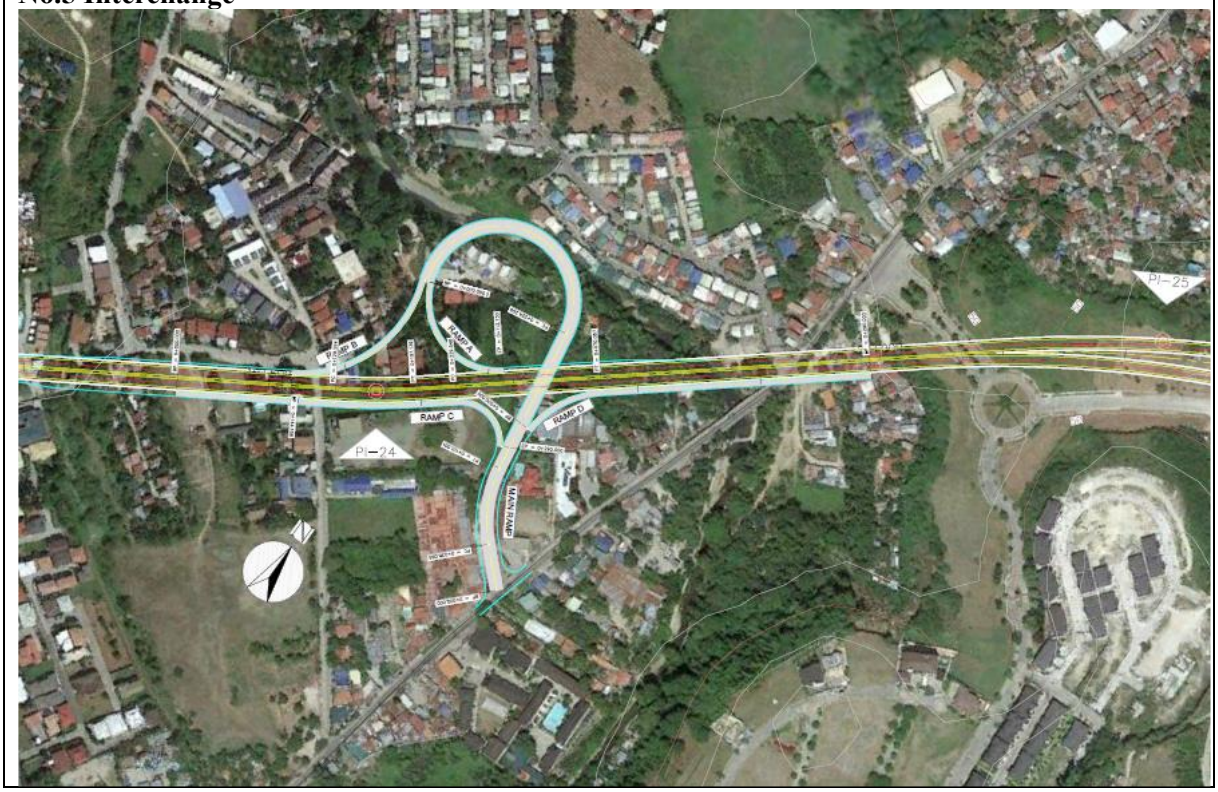
No.4 Interchange -A

Source: JICA Study Team

Figure 16.4-6 Interchange Plan (2/3)

No.4 Interchange -B

No.5 Interchange



Source: JICA Study Team

Figure 16.4-7 Interchange Plan (3/3)

16.5 Tunnel Design

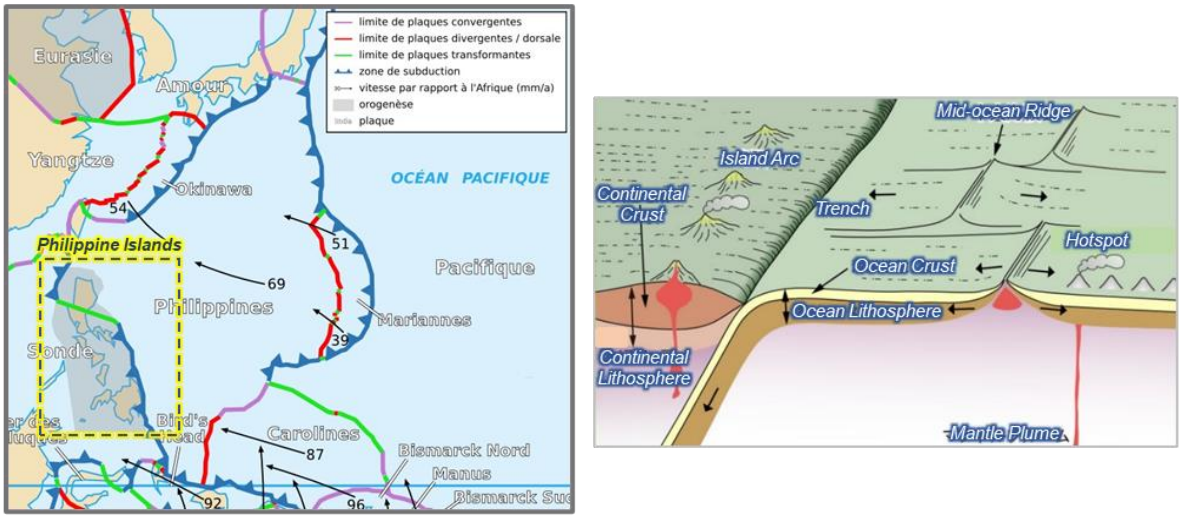
16.5.1 Geology, Geo-Technical and Hydrological Condition

16.5.1.1 Geological Characteristics of the Philippines

The Philippine Islands form part of the island arc that extends from the Philippines in Southeast Asia to Indonesia, and connects to Japan archipelago through Taiwan in the north (see **Figure 16.5-1**). The Japan archipelago is also part of an island arc that extends from the Kuril Islands to the northeast and the Ryukyu Islands towards Taiwan to the southwest.

An island arc is an arched archipelago with a trench at its front edge and a marginal sea behind it. In addition, the island arc is characterized by the development of Quaternary volcanoes and deep seismic zone that deepens from near the trench to the marginal sea.

The Philippine Islands are distributed in the northwest-southeast direction, parallel to the Philippine Trench in the east. In the Philippine Trench, the Philippine Sea Plate is subducting into the Eurasian Plate. For this reason, throughout the Quaternary, the present topography and geology is formed with high uplift and erosion rates.



a) Plates around the Philippine Islands **b) Relationship between Island Arc and Sea Floor Spreading**

Source: Geoinformation Sharing Infrastructure for East and Southeast Asia

Figure 16.5-1 Geological Characteristics of the Philippines

16.5.1.2 Topography Characteristics

(1) Cebu Island

Cebu Island is a long and narrow island that extends 225 km from north to south, and the width from east to west is about 20 km. Topographically, the central part of the island is mountainous, decreasing in height toward the coast and transitioning from mountainous to hills, and hills to plains. Cebu Island's highest peak is Mount Osmena at an altitude of 1,000 m located in the southern part of the island.

The Philippine Islands are arranged in the northwest-southeast direction, but the major axis of Cebu Island is northeast-southwest, and the main ridgelines and valley lines (so-called lineaments) of the mountains area have also northeast-southwest directions. In addition, Negros Island has volcanoes that are characteristic of the island arc, while Cebu Island does not.

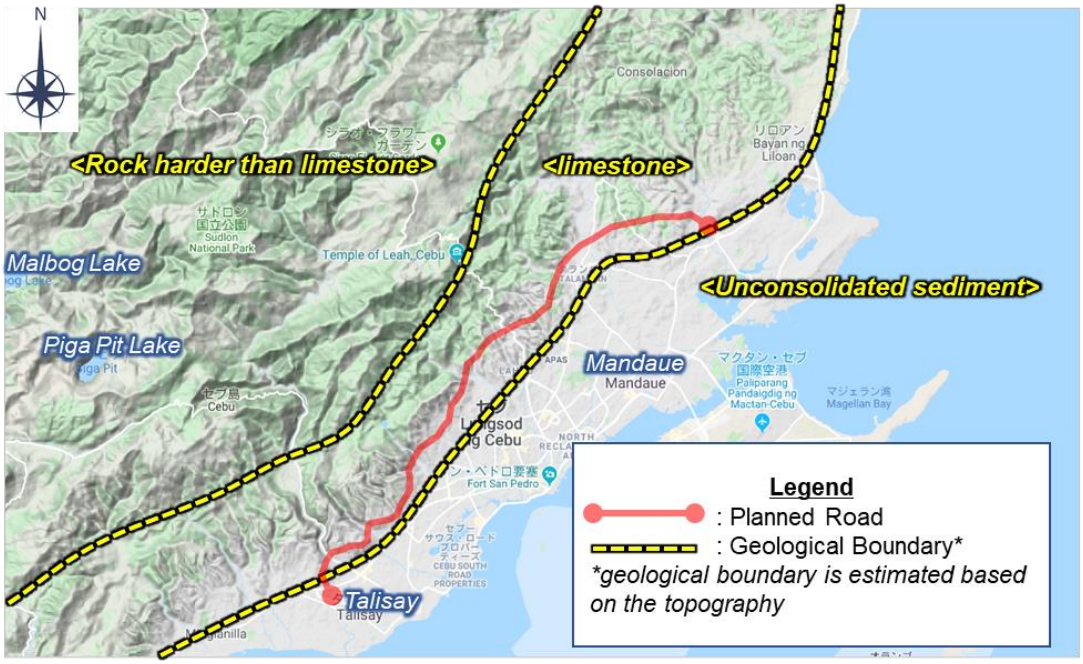
This point is important in considering the formation of Cebu Island from the viewpoint of structural geology. Although a detailed explanation is not included in this report, the Philippine Islands are islands that were formed by uplifting due to the compression of the crust, and it is considered that the northeast-southwest faulting played a major role in the uplift.

(2) Topography of the Planned Road

The planned road alignment is located near the boundary between the hilly area and the plain area (see **Figure 16.5-2**). As mentioned in the previous section, northeast-southwest lineaments are conspicuous in the mountainous area. On the other hand, rivers flowing from the hills run northwest to southeast (in harmony with decreasing altitude) toward the sea.

Therefore, it is estimated that the hills and the mountains have different geology (the mountains have a solid ground and the hills have a relatively soft ground). From the geographical conditions, it is estimated that the hilly area around the coast is formed by the uplift of an old coral reef and is composed of limestone, as similar to Okinawa, Japan. Also, from the shape of the boundaries between the hills and the plains, it is estimated that this lowland was formed by burial with sand and mud supplied from mountains and hills as the sea level rose after the last glacial period.

On the other hand, Lakes such as Malbog Lake and Piga Pit Lake are distributed in the west mountains. Lake Malbog is the reservoir of the Malbog Dam and Lake Piga Pit is the site of the open pit mine. According to the regional geological map, quartz diorite is distributed around Lake Piga Pit. Therefore, the porphyry copper deposit formed by the intrusion of quartz diorite may have been mined at this mine.



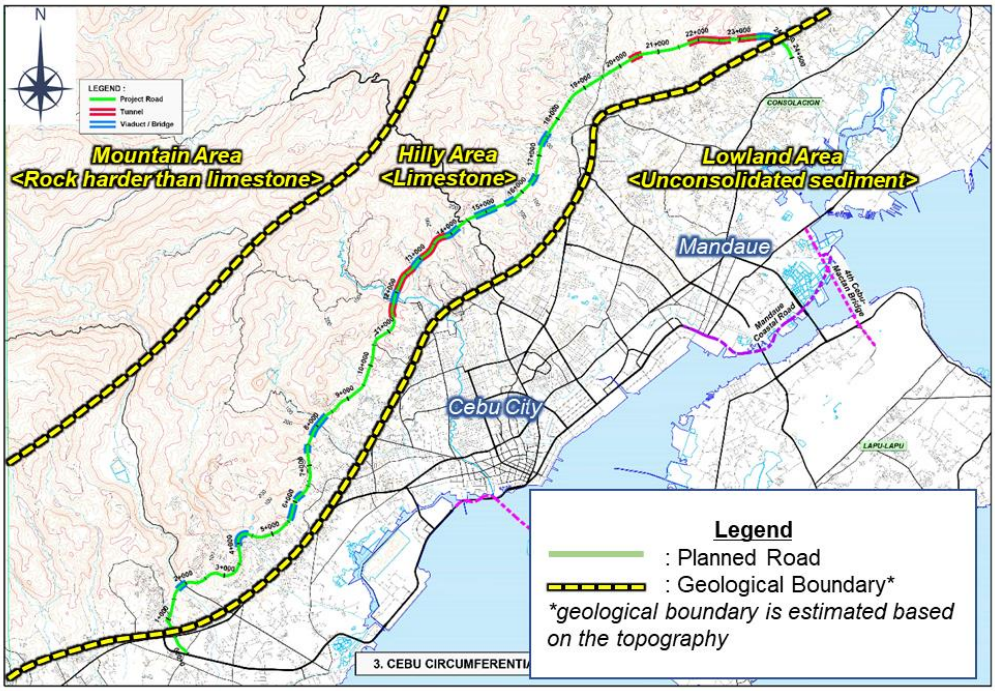
Source: Geoinformation Sharing Infrastructure for East and Southeast Asia

Figure 16.5-2 Wide Area Topography of the Planned Road

Next, take a closer look at the terrain around the planned road (see **Figure 16.5-3**). The hilly area is rich in undulations and is considered to reflect the characteristics of limestone.

Limestone is generally not so hard, it is mainly composed of calcite (calcium carbonate), it is easily eroded by rainwater and acidic groundwater, and one characteristic is that it is easy to form terrain with fine undulating.

Since there are no clear lineaments or landslide topography around the planned road, it is estimated that the limestone has a relatively massive bedrock.



Source: JICA Study Team

Figure 16.5-3 Geology of the Planned Road Estimated from the Topography

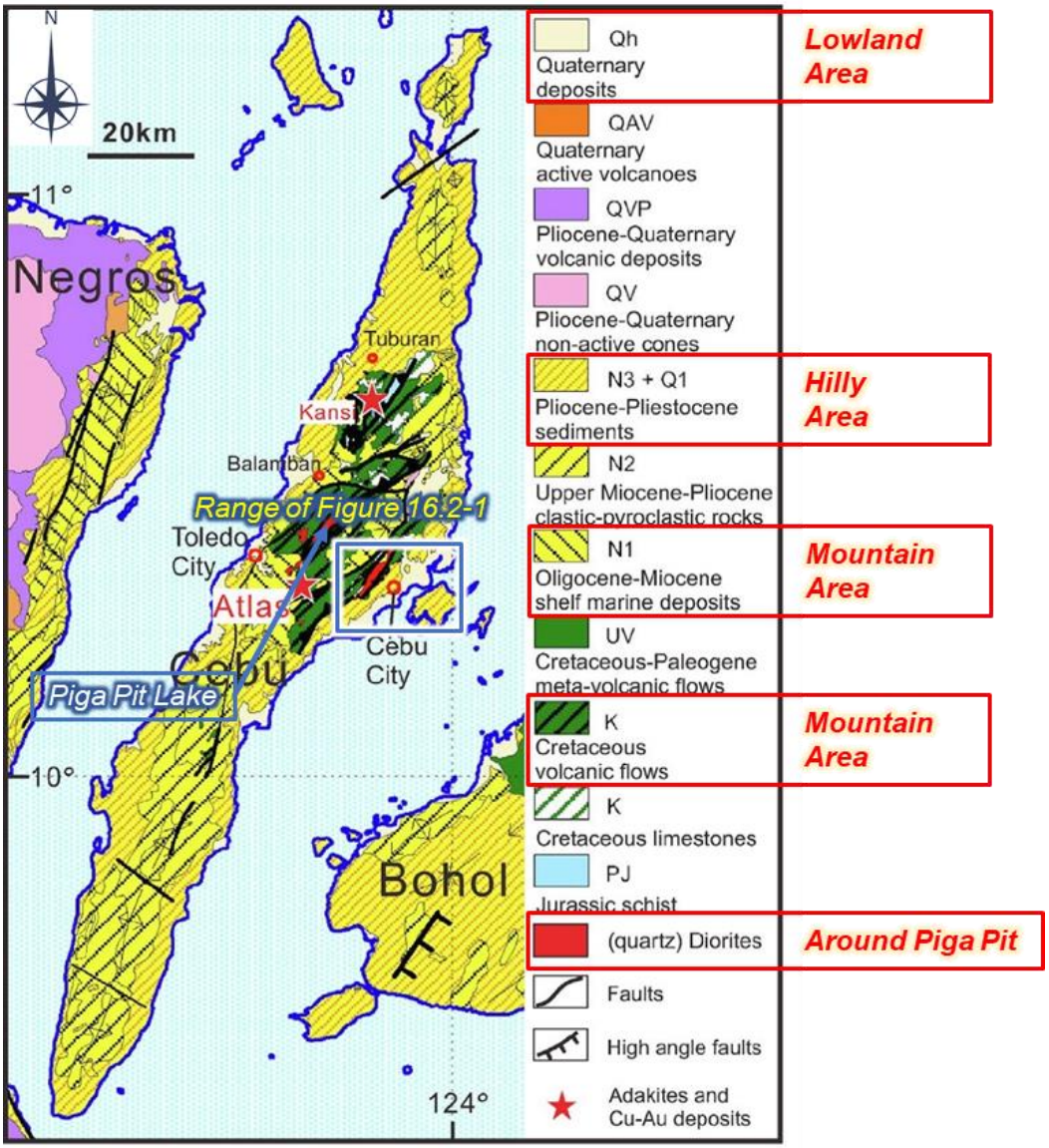
(3) Geology and Geological Structure

Figure 16.5-4 shows the geological map of Cebu Island. According to this geological map, the lowlands near the coast are classified as Quaternary sediments (Qh), and the hilly geology is classified as Neogene Pliocene to Quaternary Pleistocene sedimentary rocks (N3 + Q1). According to another geological map (see **Figure 16.5-5**), this sedimentary rock is labeled as limestone.

The geology of the mountains consists of Cretaceous volcanic rocks (K) and Paleogene-Oligocene to Neogene Miocene sedimentary rocks (N1). These are harder than limestone, and their geological boundaries roughly match the geological boundaries estimated from the topographic map in **Figure 16.5-3**.

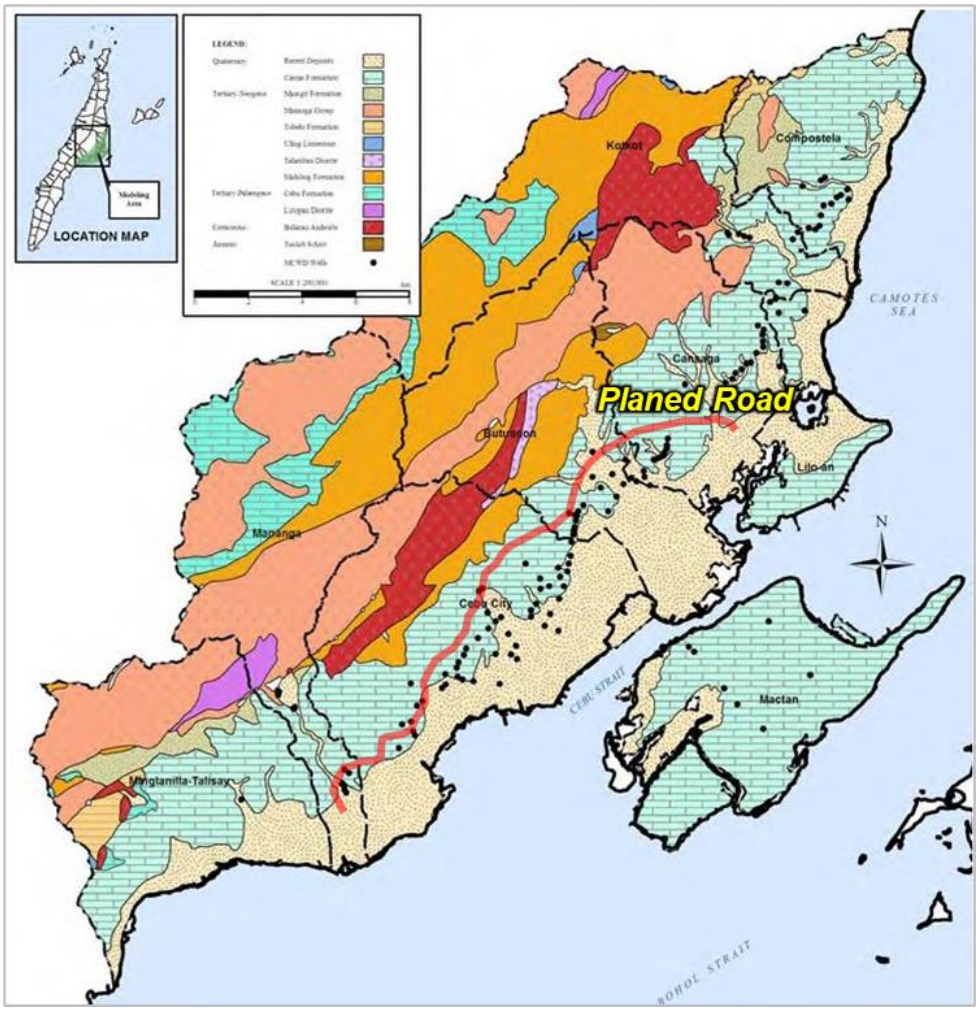
According to reference ”The study for improvement of water supply and sanitation in Metro Cebu in the Republic of the Philippines, Final Report, JICA, August 2010”, etc., the geology of the planned tunnel is all limestone (limestone) called Carcar Formation formed in the Neogene Pliocene to Quaternary Pleistocene (see **Figure 16.5-5** and **Figure 16.5-6**).

According to reference “Clay mineralogical study of the Plio-Pleistocene Carcar formation and the quaternary alluvium in Consolacion-Liloan, Cebu province, Philippines Rep. Fac. Sci., Kagoshima Univ, 2003”, it is reported that this limestone is rich in smectite. Since hydrothermal alteration is considered as one of the smectite formation mechanisms, the Carcar formation might be partially hydrothermally altered. This is a consideration in geological surveys for tunnels.



Source: After GeoMapApp (http://www.geomapapp.org) and Aurelio and Peña (2010)

Figure 16.5-4 Geology of Cebu Island



Source: The study for improvement of water supply and sanitation in Metro Cebu in the republic of the Philippines Final Report, JICA, August 2010

Figure 16.5-5 Geological Map around the Planned Road

Stratigraphy				Geologic Nomenclature in Cebu Area		
Group	System	Series	Time	Southern Part	Central Part	Northern Part
Cenozoic	Quaternary	Holocene	0.011	Recent Formation: Qal		
		Pleistocene	2.000	Carcar Formation (un-conformity): CaF		
	Tertiary – Neogene	Pliocene	5.200			
		Miocene			Maingit Formation: MG	
				Toledo Formation	Uling Limestone	Talamban Diorite
			25.000	Malubog Formation: MbF		
	Tertiary – Palaeogene	Oligocene		Cebu Formation: CF		
			38.000	Lutak Hill Formation		
		Eocene	55.000	Lutopan Diorite: LD		
		Paleocene	65.000			
Mesozoic	Cretaceous		143.000	Cansi Meta-Volcanic	Pandan Formation	
	Jurassic		212.000	Tunlob Schist		

Time: a time scale ago in million years

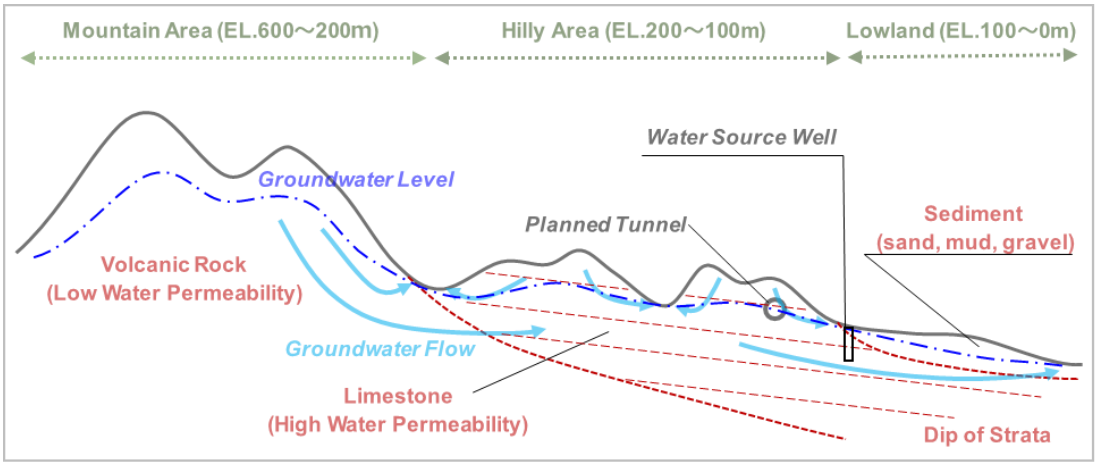
Source: The study for improvement of water supply and sanitation in Metro Cebu in the republic of the Philippines Final Report, JICA, August 2010

Figure 16.5-6 Geological Stratigraphy Around the Planned Road

(4) Geology and Geological Structure

According to the above geological composition, it can be seen that the Cretaceous volcanic rocks stratigraphically form the base of the island, and the Paleogene-Neogene-Quaternary sedimentary rocks are successively formed on the seafloor, and these bedrocks are uplifted and covered with unconsolidated deposit.

Since the geological map shows some northeast-southwest faults, the strikes of the strata are considered to be in harmony with this. Moreover, since no clear lineaments are found at the boundary between the volcanic rocks and the limestone, it is estimated that the strata are almost horizontal to gentle slope (see **Figure 16.5-7**).



Source: JICA Study Team

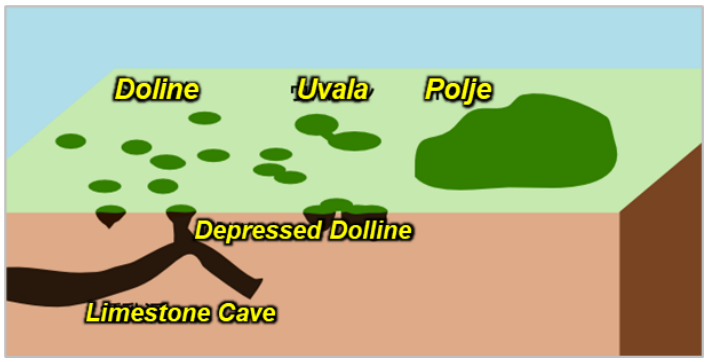
Figure 16.5-7 Schematic Geological Cross Section near the Planned Road

(5) Engineering Characteristics of Limestone

Limestone is one of the carbonates rocks whose main component is carbonate, and is mainly composed of calcite (CaCO3). Carbonate rocks are not widely distributed in Japan, but they are estimated to be so wide that they occupy one-fifth of the sedimentary rocks that make up the crust.

Limestone is eroded by rainwater (acidic water) and forms cavities known as Karst landform (Doline, Uvala, etc.). Limestone is practically used as a raw material for cement and stone. At construction sites in the limestone area, unexpected situations such as collapse, and sudden spring water may occur.

There is a large variation in the physical properties of limestone as rock pieces (intact rocks). For example, the Ryukyu limestone formed in the Quaternary Pleistocene (5 to 1.8 million years ago) has a dry density of about 1.7 to 2.3 g/cm3 and a uniaxial compressive strength of about 2 to 60 MPa. Regarding the water permeability, limestones in Okinawa and Cebu Island, which are composed of coral remains, are relatively porous, and the rock pieces themselves also have relatively high-water permeability.



Source: http://geo.skygrass.net/note/geo/karst.html

Figure 16.5-8 Karst Landforms Peculiar to Limestone Area

16.5.2 Design Standards

Japan is one of the most experienced countries in the world in the field of tunneling. The geology and geotechnical condition of the Philippines is similar to that of Japan. Therefore, the study on tunnel planning under this Project is based upon the experiences in Japan and the design of the tunnel is based on the DPWH and Japanese Standards listed in **Table 16.5-1**. These standards in Japan are applied to all the highway tunnels and national road tunnels in Japan, and most of them have been constructed by New Austrian Tunneling Method (NATM), which is a standard construction method of mountain tunnels in the world. This method is applicable also in the case of the tunnels planned for Cebu circumferential road as some part (geologically and topographically) of the road is mountainous and hilly area.

Table 16.5-1 List of Applied Japanese Standards for Tunnel Design

Standard	Issue	Year
Design Guidelines, Criteria & Standards, Volume 4, Highway Design	DPWH	2015
Standard Specifications for Tunneling-2016: Mountain Tunnel	Japan Society of Civil Engineers	2016
Road Tunnel Technical Standards for Tunnel Structure	Japan Road Association	2003
Road Tunnel Technical Standards for Tunnel Ventilation	Japan Road Association	2008
Traffic Capacity for Road	Japan Road Association	1984
Commentary on Road Structure Ordinance	Japan Road Association	2015
Road Tunnel Technical Standards for Emergency Facilities	Japan Road Association	2001
Maintenance Guideline for Road Tunnel (Structure)	Japan Road Association	2015
Maintenance Guidelines for Road Tunnel (Facilities)	Japan Road Association	2016
Design Standard for Telecommunication Facilities (Electric)	Association of Electricity and Telecommunication Engineering for Land and Infrastructure	2017
Installation Standard for Road Lighting Facilities	Japan Tunneling Association	2006
Observation/Measurement Guideline for Road Tunnel	Japan Tunneling Association	2009
Design Guideline -Part3- and -Part4-	Nippon Expressway Research Institute Company (NEXCO)	2016
Road Tunnel Safety Construction Guideline	Japan Road Association	1996

16.5.3 Design Condition

(1) Road Classification and Design Speed

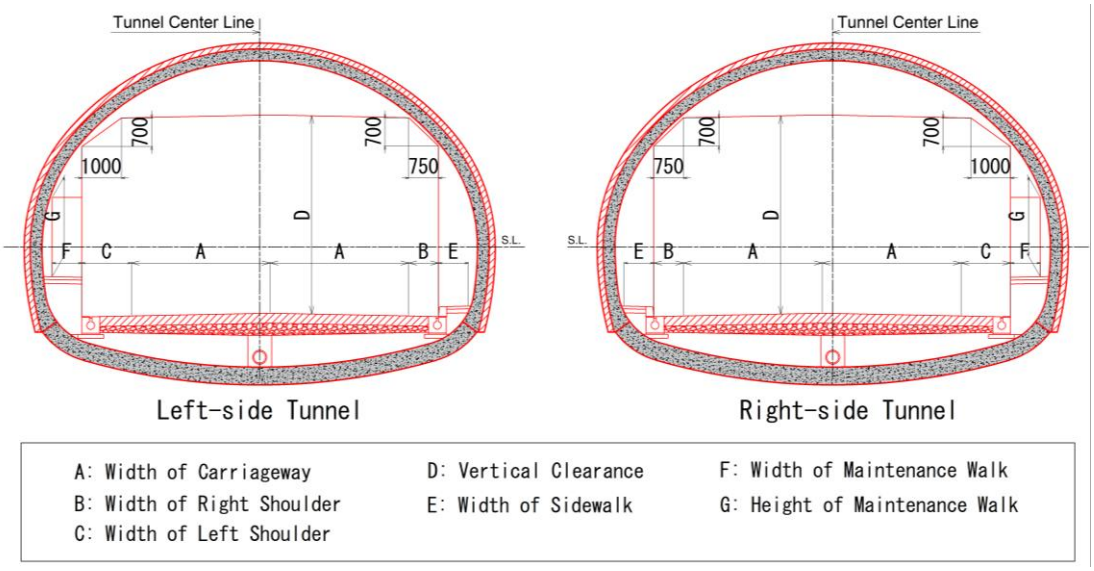
Due to the mountainous to hilly topography of the area, the expressway design speed applied was 60 kph (minimum).

(2) Geometric Condition

The geometric conditions in **Table 16.5-2** will apply for the design works of the tunnel. Also, the geometric structure conditions such as necessary space for installation of facilities and the types of maintenance walk to set the tunnel standard cross-section are set with reference to a DPWH standard and the common practice of the Japanese tunnel of the same scale as this tunnel.

Table 16.5-2 Geometric Condition (Tunnel Design)

Items	Description	Standards
Design Speed	60 km/h	—
Number of Tunnel Tube	2 tube tunnels	—
Width of Carriageway	3.50 m	JP Standard (Class 2-1)
Width of Right Shoulder	0.75 m	JP Standard (Class 2-1)
Width of Left Shoulder	1.25 m	JP Standard (Class 2-1)
Vertical Clearance	5.00 m	DGCS Vol.4 2015, P3-81
Width of Sidewalk	0.50 m	DGCS Vol.4 2015, P3-81
Width of Maintenance Walk	0.75 m	JP Standard
Height of Maintenance Walk	2.00 m	JP Standard



Source: JICA Study Team

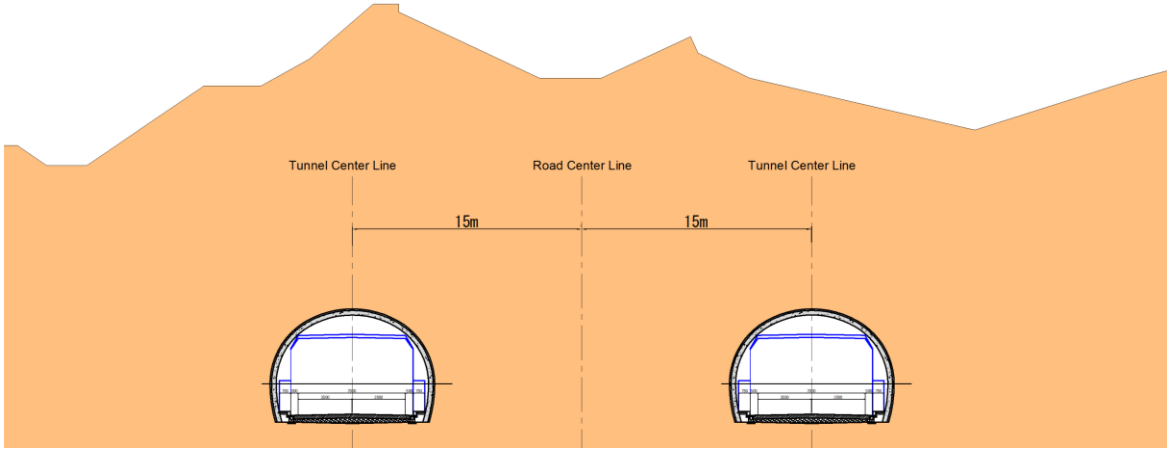
Figure 16.5-9 Tunnel Geometric Conditions

(3) Mutual Separation Distance of Each Tunnel

In cases where new tunnel or other structures are to be constructed near an existing tunnel, it is generally designed with due consideration to the effect of deformation and stress exerted on the existing tunnel.

The traffic demand forecast conducted in this Study indicates that the 4-lane is required. Therefore, the tunnel section must also be planned to accommodate four lanes. When the number of lanes to be provided for each direction exceeds 2 lanes, fundamentally, a twin tunnel is applied from the viewpoint of workability and stability of tunnel structure. This Study also plans to provide a twin tunnel, one tunnel for each direction and the two tunnels will have a mutual separation distance (distance between the centerline of two tunnels) of 30 m as shown in **Figure 16.5-10** based on the Design Guidelines -Part 3 in consideration of the effect of deformation and stress by neighboring construction.

Structural behavior will vary significantly, depending on factors such as the extent of neighboring construction, overburden, ground condition, existing tunnel structures, the construction method and construction sequence. The main effect of neighboring construction is that the tunnel is feared to suffer deformation at the lateral side of the neighboring construction, further loosening of ground surrounding the tunnel, and increase of loads acting on supports and the lining. Therefore, it is necessary to study in detail and decide an appropriate mutual separation distance in the feasibility study and detailed design stage. Based on these conditions, detailed plan of the tunnel approach road and environmental consideration around the tunnel shall also be prepared.



Source: JICA Study Team (refer to Design Guideline -Part3-)

Figure 16.5-10 Mutual Separation Distance of Tunnels

16.5.4 Rock Classification Method and Standard Support Patterns of the Tunnel

In this Pre-F/S, the geological survey such as the elastic wave exploration was not conducted. Therefore, major geology around the site was estimated as limestone based on the secondary data. In addition, the tunnel support patterns were proposed based on the tunnel overburden and the rock class estimated from the secondary data.

Based on the site reconnaissance and the bibliographic survey in the Study, the ground level of tunnel section is classified with reference to the index shown in **Table 16.5-3**. Also, the support patterns for the tunneling shown in **Table 16.5-4** are applied based on that ground levels.

Tunnel support types in the Study are mainly classified into three (3) types, CII, DI and DIII. based on the results of the site reconnaissance and the bibliographic survey.

Type CII applies where the overburden is over 2D (D=tunnel excavation width: 12 m) and rock mass appear to be relatively stable. Type DI applies where the overburden is over 1.5D and rock mass appear to be relatively sheared or weathered. Type DIII applies where the overburden is less than 1.5D such as tunnel portal area.

Rock classification and support pattern for the tunnels are shown in **Table 16.5-3**.

Table 16.5-3 Rock Mass Classification System

Rock class	Condition of rock mass	RQD	Stability of face	Convergence
B	Rock is fresh and hard. Discontinuous planes are stable and the possibility of loosening due to tunnel excavation is very small.	60 to 90	The strength is significantly higher than the expected load and only occasional local spalling of rock fragment may occur.	Convergence of tunnels is negligible.
CI	Rock is partly weathered or altered. Discontinuous planes are generally relatively stable	20 to 70	The strength is higher than the expected load and the loosening is expected to be local.	Convergence of tunnels is usually within the elastic range.
C II	Rock is partly weathered or altered and fractured.	20 to 70	Strength is not significantly higher than the expected load, but is sufficient to limit the elastic deformation. Rock chunks along slippery discontinuous planes tend to spall.	Convergence stops to increase before the tunnel face has advanced a distance of 2 D, where D is the tunnel diameter. Convergence of tunnels does not exceed 50 mm.
D I	Rock is significantly weathered and softened or sheared.	< 20	Partial plastic displacement and elastic deformation could occur. Or even if the strength is high enough to limit the elastic deformation, significant loosening of ground along slippery discontinuous planes could occur.	Where the strength is small and the invert concrete is not placed at an early stage, the convergence could reach 30 to 60 mm and does not stop to increase even if the tunnel face has advanced more than 2 D
D II	Rock is completely weathered and partly softened to soil, or heavily sheared.	< 20	The strength is low compared to the expected load and large plastic deformation as well as elastic displacement could occur. In addition to the low strength, significant loosening of ground along slippery discontinuous planes and large displacement could occur.	Convergence of tunnels could reach as far as to 60 to 200 mm and does not stop to increase even if the tunnel face has advanced more than 2 D, if the invert concrete is not placed at an early stage
DIII	It is tunnel portal section where the overburden is around 1.0 D to 2.0D.	—	It is difficult to form the ground arch due to a thin overburden.	—
E	Ground such as faults, fractured zones and large talus deposit.	—	Squeezing occurs and generates occasional collapse in face area.	Large deformation could reach to 400mm.

Notes: RQD (Rock Quality Designation): Indicator of degree of rock crack. The total length of rod-like cores of more than 10 cm included in the boring core length 1.0 m is indicated by percentage.
Gray color: Rock class assumed in the Project

Source: JICA Project Team (refer to Design Guideline -Part3-)

Table 16.5-4 Standard Support Patterns for Two-Lane Tunnels

Ground class	Support pattern	Cut per adva-nce (m)	Rock bolts				Shotcrete	Steel rib			Lining thickness (cm)		Allowable deformation (cm)	Excavation method
			Length (m)	Spacing		Construc-tion range	Thickne-ss (cm)	Upper half size	Lower half size	Install-ation Interval (m)	Arch & wall	Invert		
				Periph-eral (m)	Longitu-dinal (m)									
B	B	2.0	3.0	1.5	2.0	Upper half 120°	5	-	-	-	30	0	0	Full face with micro bench or top heading cut
C I	C I	1.5	3.0	1.5	1.5	Upper half	10	-	-	-	30	(40)	0	
C II	C II-a	1.2	3.0	1.5	1.2	Upper and lower halves	10	-	-	-	30	(40)	0	
	C II-b							H125	-	1.2				
D I	D I-a	1.0	3.0	1.2	1.0	Upper and lower halves	15	H125	H125	1.0	30	45	0	
	D I-b	1.0	4.0							1.0				
D II	D II	1.0 or less	4.0	1.2	1.0 or less	Upper and lower halves	20	H150	H150	1.0 or less	30	50	10	

Notes: The support patterns are divided into a and b as shown below.

a: Standard support pattern generally used for all rock types

b: Support pattern used in the initial design only when the tunnel excavation is expected to result in a larger displacement in clay stone, black schist, mudstone, shale, tuff, or other rock types.

Note that the values in ( ) for the invert are applied to tertiary mudstone, tuff, serpentinite, and other ground rocks, weathered crystalline schist, and sulfuric soil.

Source: Road Tunnel Technical Standards for Tunnel Structure

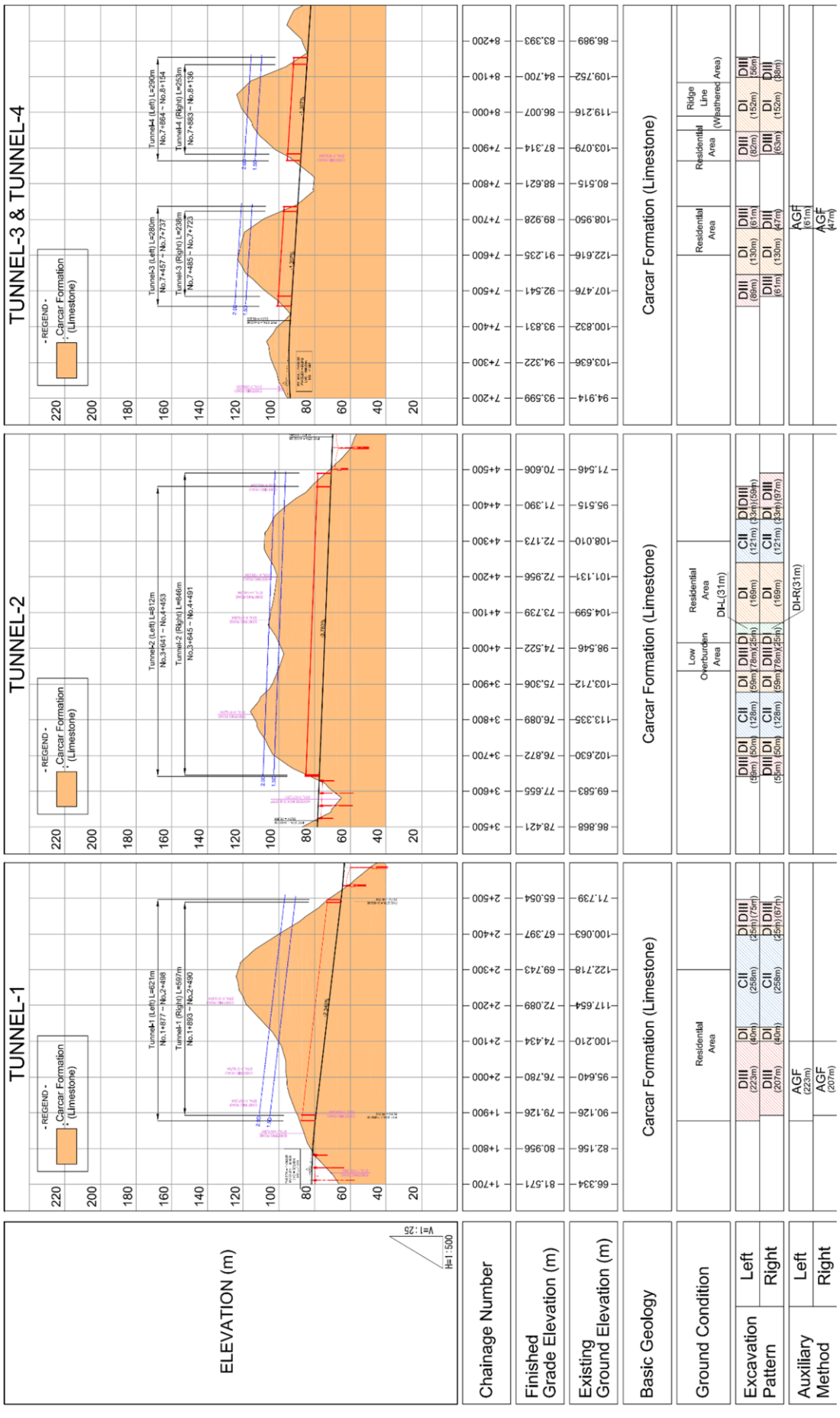
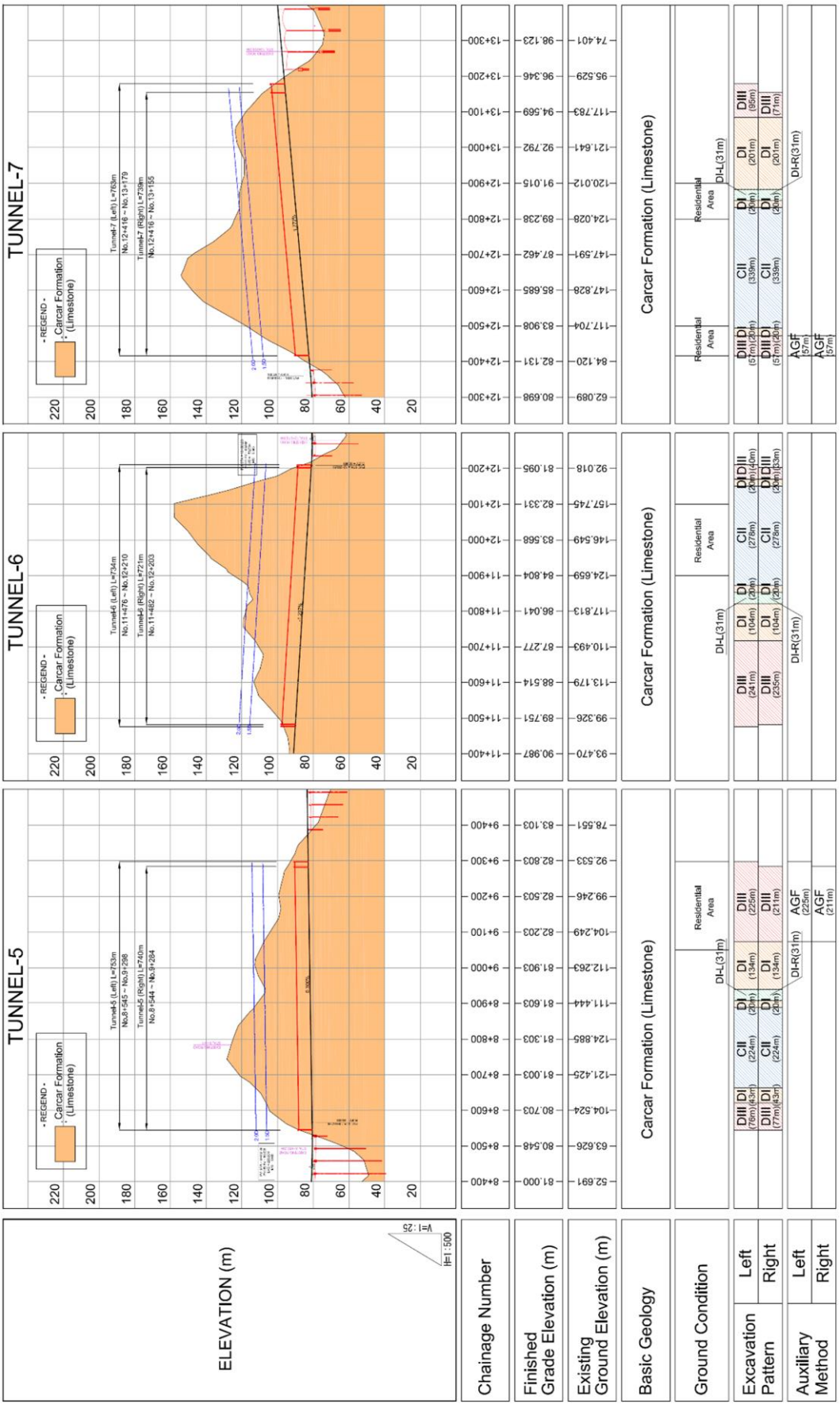


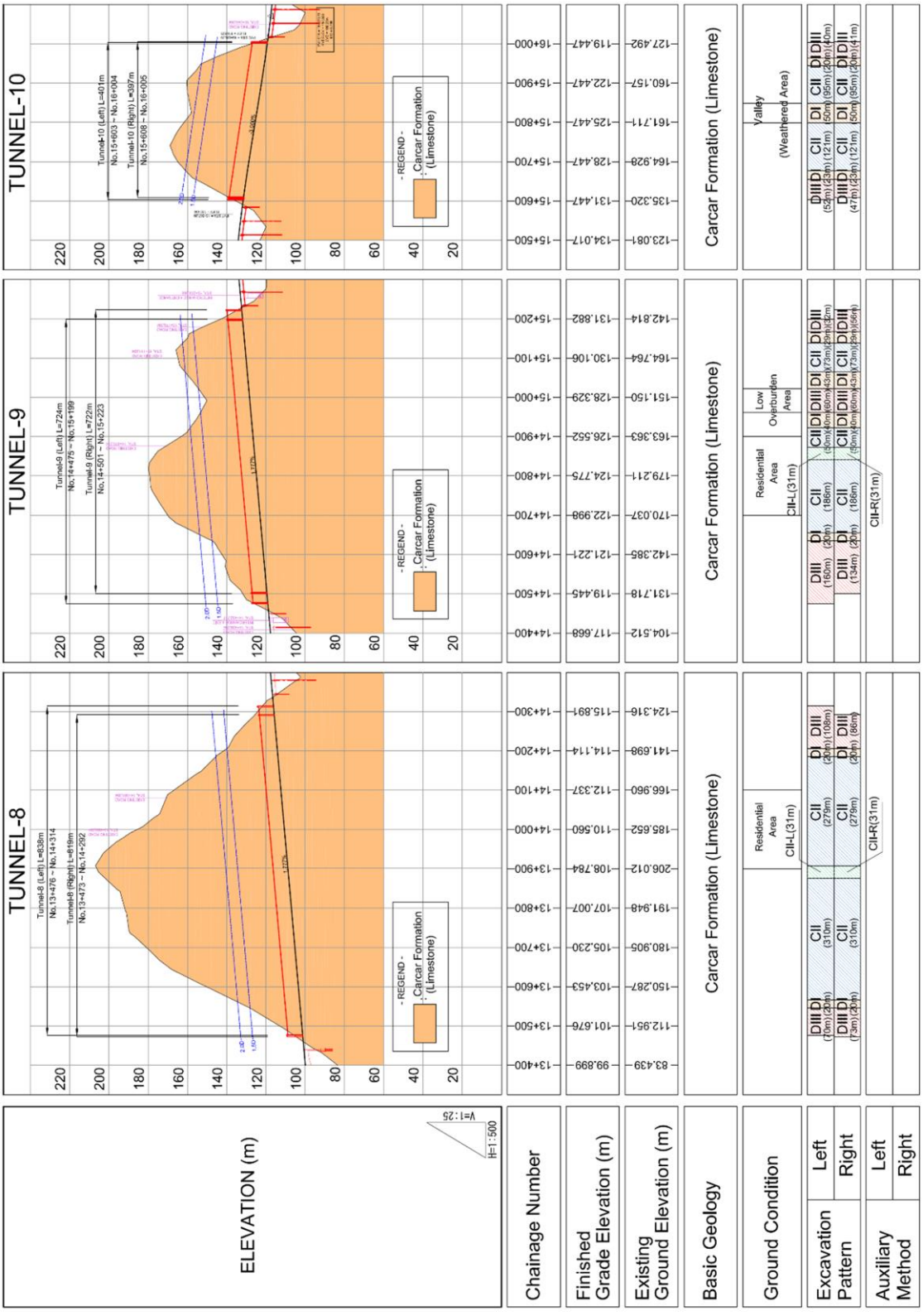
Figure 16.5-11 Geological Profile (1/5)

Source: JICA Study Team



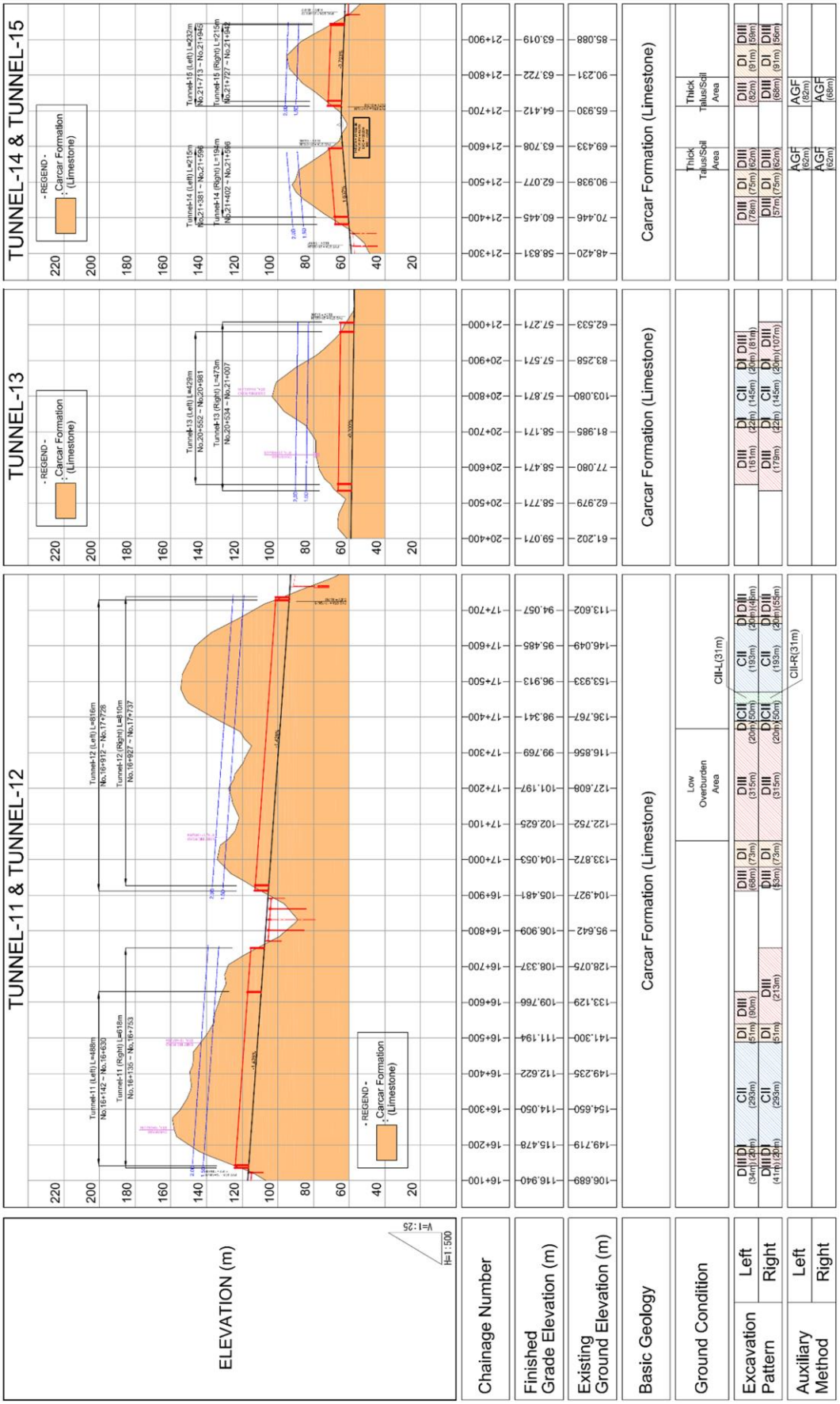
Source: JICA Study Team

Figure 16.5-12 Geological Profile (2/5)



Source: JICA Study Team

Figure 16.5-13 Geological Profile (3/5)



Source: JICA Study Team

Figure 16.5-14 Geological Profile (4/5)

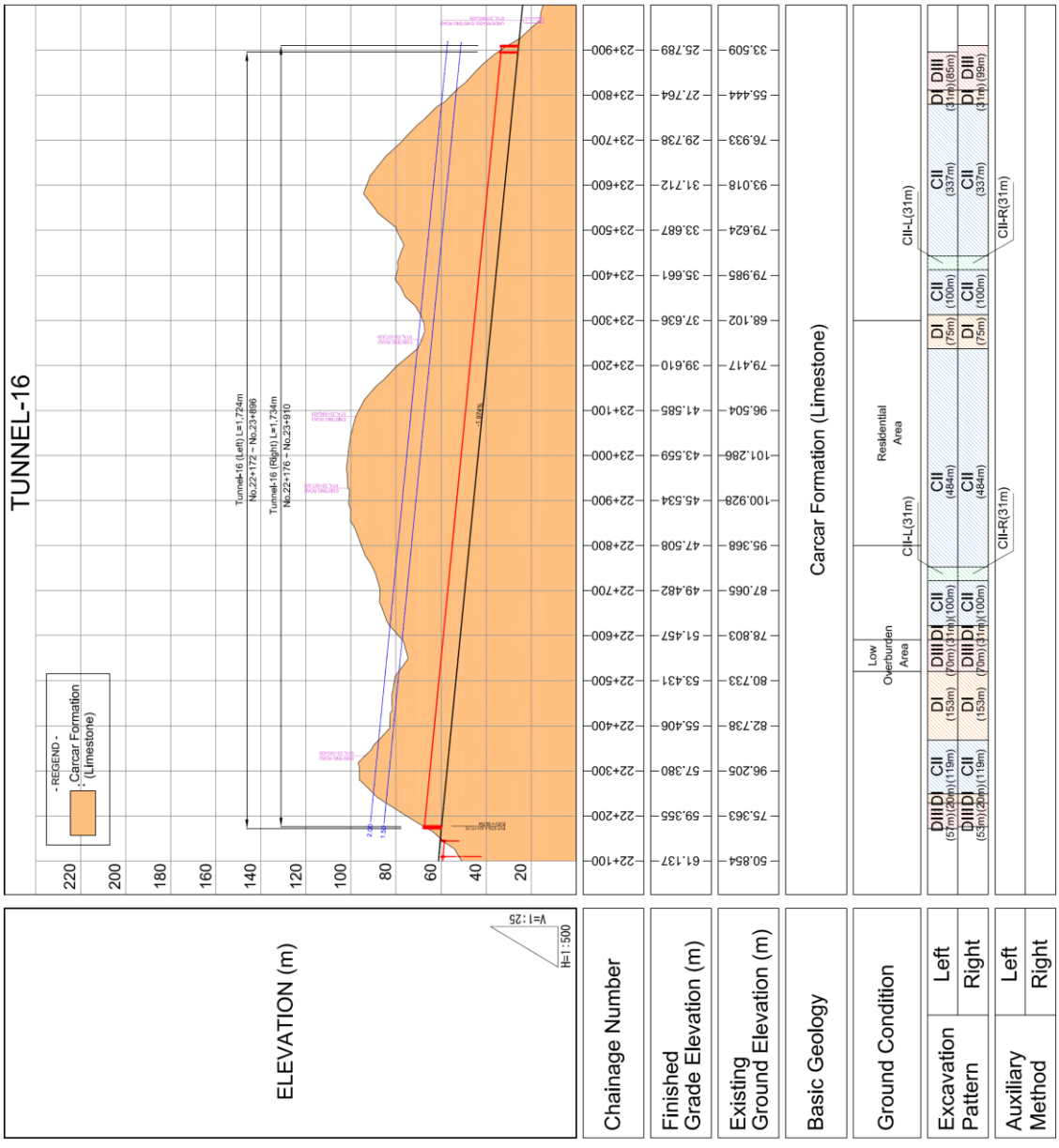
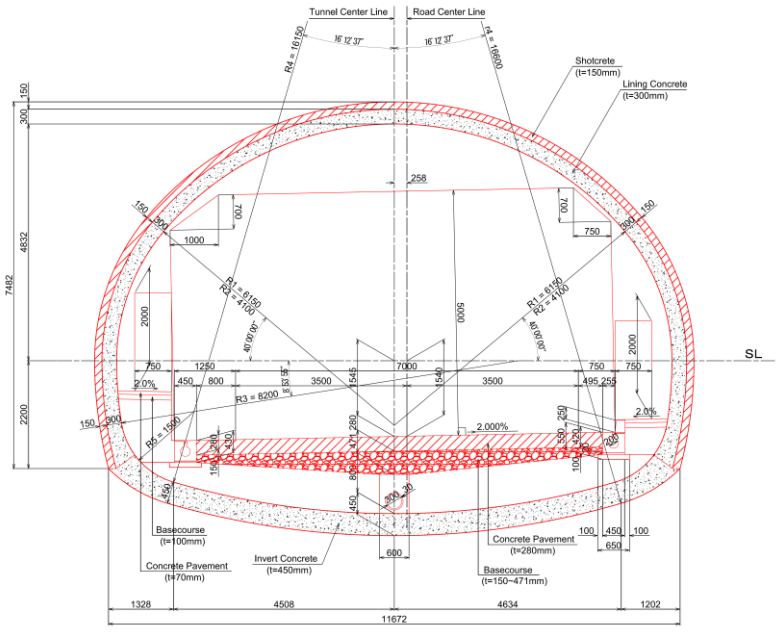


Figure 16.5-15 Geological Profile (5/5)

Source: JICA Study Team

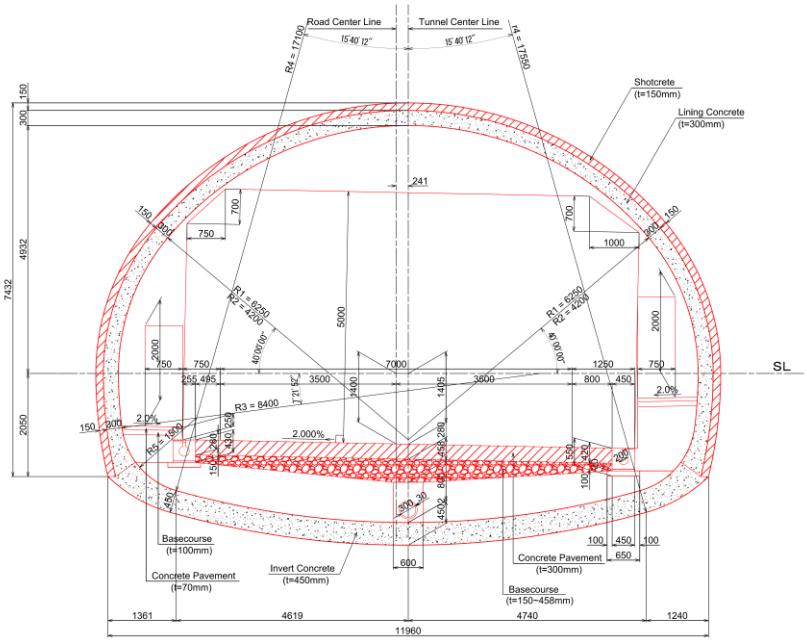
16.5.5 Tunnel Cross-Section

Tunnel cross-sections are designed such that they meet the geometric requirements shown in **Table 16.5-2** and allow to minimize the cross-section area. The smallest cross-sections of left-side tunnel and right-side tunnel are of different sizes, which are determined using repeated calculation method. Typical cross sections of both are shown in **Figure 16.5-16** and **Figure 16.5-17**.



Source: JICA Study Team

Figure 16.5-16 Typical Cross-Section (Left Side Tunnel: DI-b)



Source: JICA Study Team

Figure 16.5-17 Typical Cross-Section (Right Side Tunnel: DI-b)

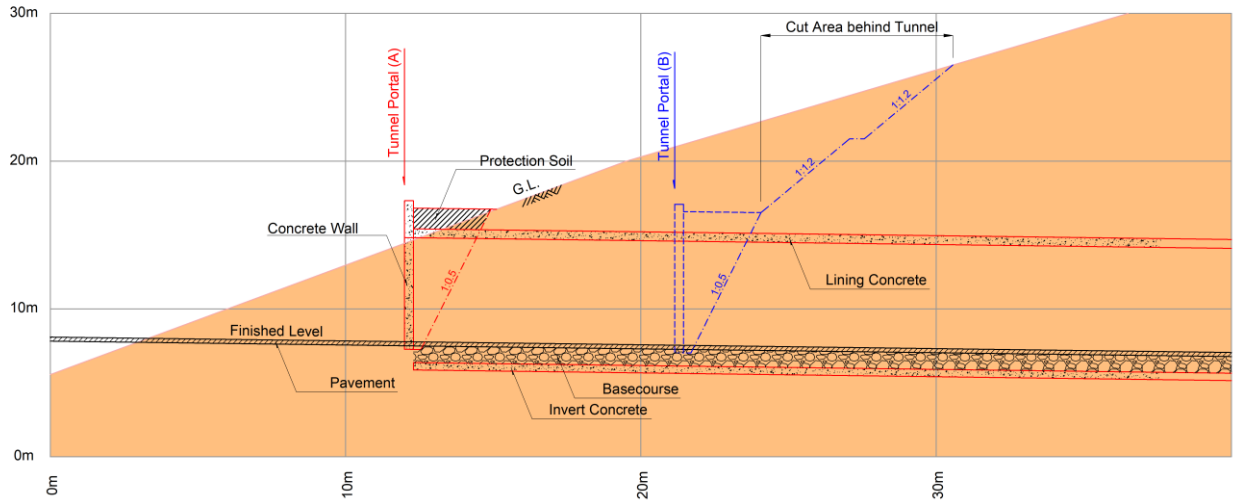
16.5.6 Tunnel cross Design of Tunnel Portal

Location of tunnel portals should be designed in consideration of stability of the slope behind the tunnel, natural and social environment around the tunnel portals. Tunnel portals in this Study are determined taking these issues into consideration.

Also, mutual separation distance of both tunnel is applied to 30m based on **Figure 16.5-10**. If the mutual separation distance should be applied to less than 30 m due to constraints related to land acquisition, it is necessary to consider the adoption of Binocular-shaped tunnel at the feasibility study or detailed design stage.

Since detailed geological survey has not been carried out at the Project, the tunnel portal locations are determined at a position where the effect of natural and social environment is small and there is no cut slope behind the tunnel as shown in "Tunnel Portal (A)" of **Figure 16.5-18**.

Location of tunnel portals and tunnel plan are shown in **Table 16.5-5** and .**Figure 16.5-19** to **Figure 16.5-21**.



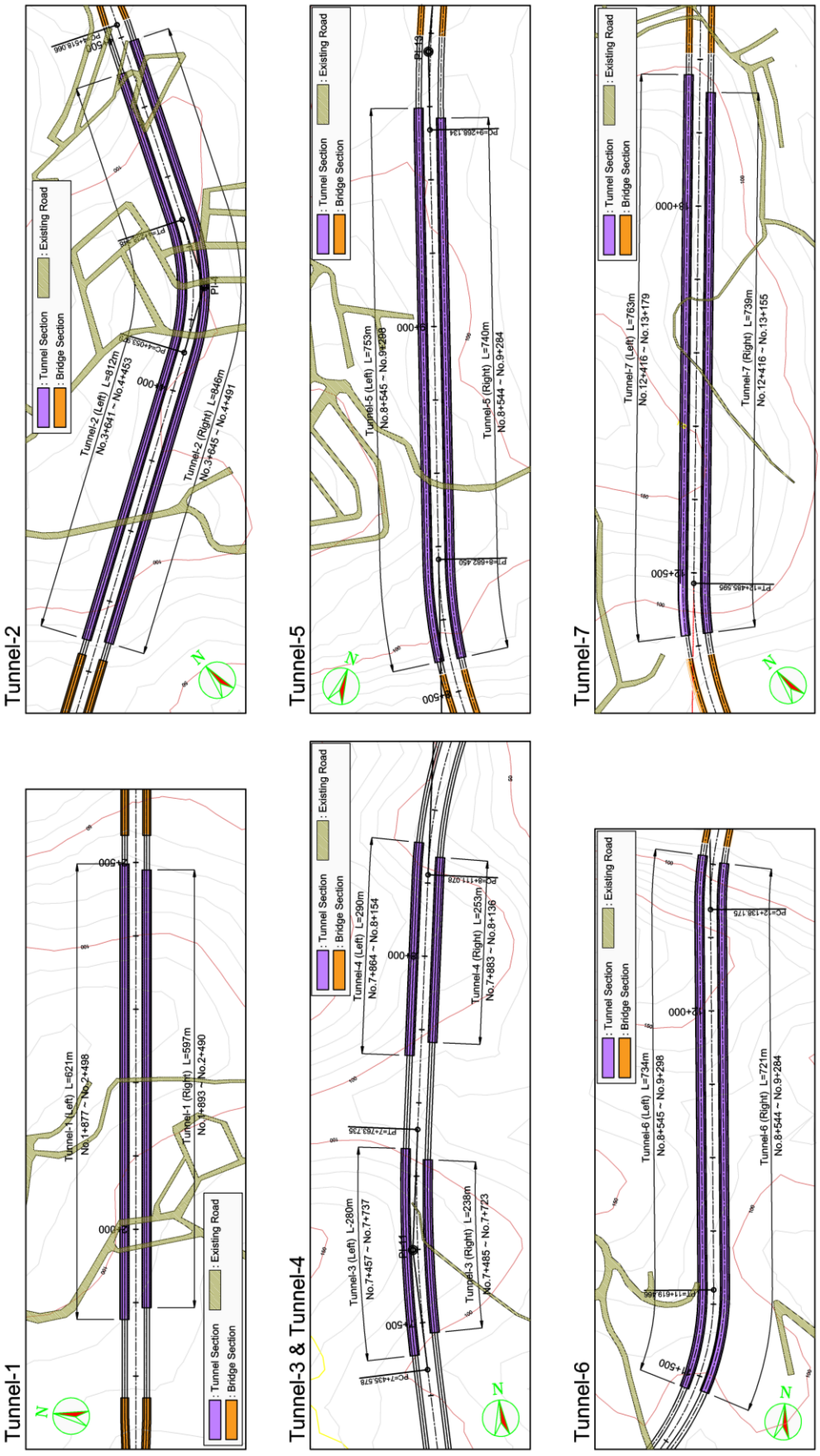
Source: JICA Study Team

Figure 16.5-18 Tunnel Portal Position

Table 16.5-5 Location of Tunnel Portals

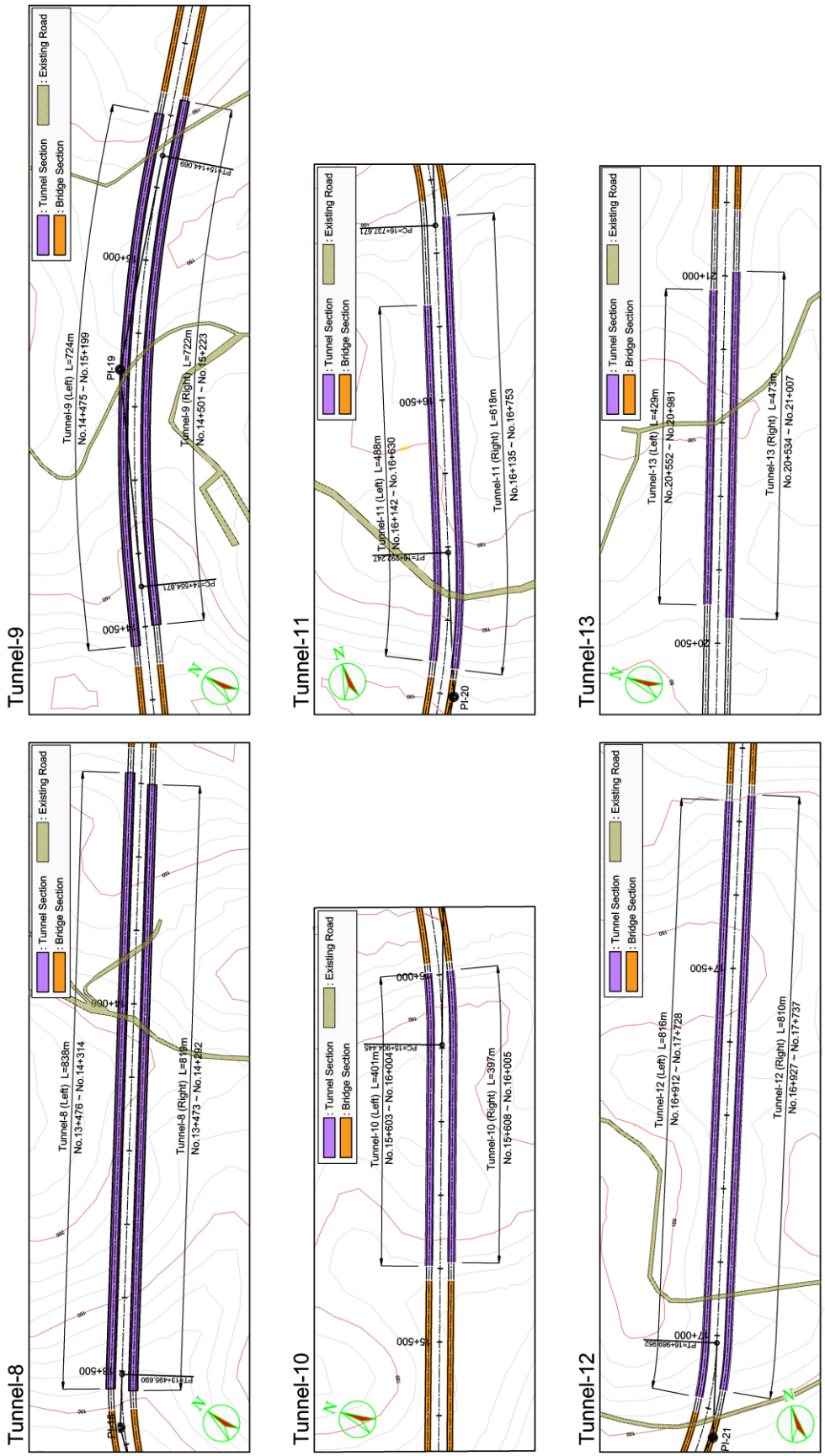
Tunnels		Portal (Sta.)		Length (m)	Super-Elevation	Gradient
		Start	End			
Tunnel-1	Left	1+877	2+498	621	-2.0%	-2.35%
	Right	1+893	2+490	597	-2.0%	-2.35%
Tunnel-2	Left	3+641	4+453	812	-5.9 ~ -2.0%	-0.78%
	Right	3+645	4+491	846	-2.0 ~ +5.9%	-0.78%
Tunnel-3	Left	7+457	7+737	280	-2.0%	-1.31%
	Right	7+485	7+723	238	-2.0%	-1.31%
Tunnel-4	Left	7+864	8+154	290	-2.0 ~ +4.0%	-1.31%
	Right	7+883	8+136	253	-4.0 ~ -2.0%	-1.31%
Tunnel-5	Left	8+545	9+298	753	-2.0 ~ +4.0%	+0.30%
	Right	8+544	9+284	740	-4.0 ~ -2.0%	+0.30%
Tunnel-6	Left	11+476	12+210	734	-5.6 ~ +4.8%	-1.24%
	Right	11+482	12+203	721	-4.8 ~ +5.6%	-1.24%
Tunnel-7	Left	12+416	13+179	763	-2.0 ~ +4.8%	+1.78%
	Right	12+416	13+155	739	-4.8 ~ -2.0%	+1.78%
Tunnel-8	Left	13+476	14+314	838	-2.0 ~ +4.8%	+1.78%
	Right	13+473	14+292	819	-4.8 ~ -2.0%	+1.78%
Tunnel-9	Left	14+475	15+199	724	-2.0%	+1.78%
	Right	14+501	15+223	722	-2.0%	+1.78%
Tunnel-10	Left	15+603	16+004	401	-3.1 ~ -2.0%	-3.00%
	Right	15+608	16+005	397	-2.0 ~ +3.1%	-3.00%
Tunnel-11	Left	16+142	16+630	488	-3.1 ~ -2.0%	-1.43%
	Right	16+135	16+753	618	-2.0 ~ +3.1%	-1.43%
Tunnel-12	Left	16+912	17+728	816	-4.8 ~ -3.6%	-1.43%
	Right	16+927	17+737	810	-3.6 ~ +4.6%	-1.43%
Tunnel-13	Left	20+552	20+981	429	-2.0%	-0.30%
	Right	20+534	21+007	473	-2.0%	-0.30%
Tunnel-14	Left	21+381	21+596	215	-2.0%	+1.63%
	Right	21+402	21+596	194	-2.0%	+1.63%
Tunnel-15	Left	21+713	21+945	232	-2.0%	-0.70%
	Right	21+727	21+942	215	-2.0%	-0.70%
Tunnel-16	Left	22+172	23+896	1,724	-2.0%	-1.97%
	Right	22+176	23+910	1,734	-2.0%	-1.97%

Source: JICA Study Team



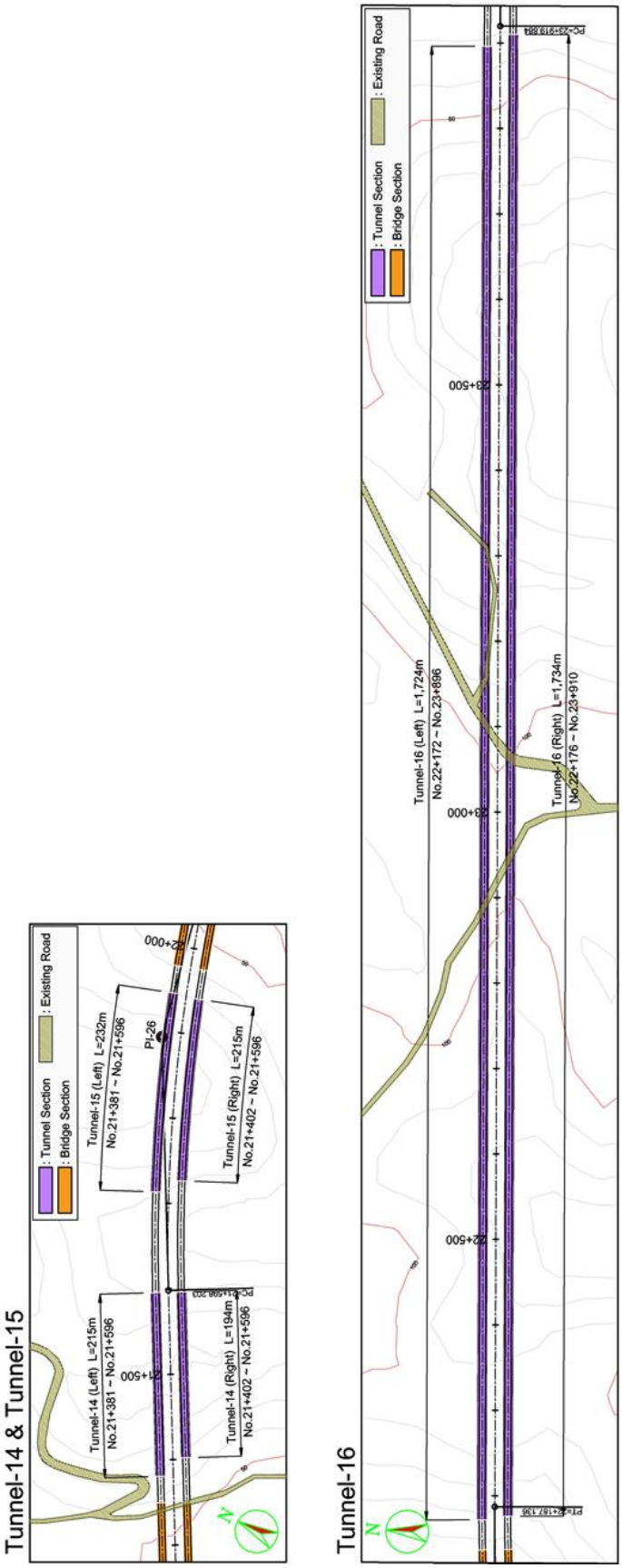
Source: JICA Study Team

Figure 16.5-19 Tunnel Plan (1/3)



Source: JICA Study Team

Figure 16.5-20 Tunnel Plan (2/3)



Source: JICA Study Team

Figure 16.5-21 Tunnel Plan (3/3)

16.5.7 Tunneling Method

16.5.7.1 Excavation Method of Tunneling

(1) Method of Tunneling

There are two excavation methods of tunneling, namely: (1) drill & blasting (D&B) and (2) mechanical excavation. The D&B method is generally applied in hard rock mass, while mechanical excavation is generally applied in middle hard rock mass and soft rock mass.

Geology of the tunnel in the project is assumed to consist mainly of middle hard rock or soft rock and is generally classified as poor rock mass (qu < 50 MPa). For this type of rock mass, the Japanese standards for tunnel structure recommends mechanical excavation using Road-Header, the picture of which is shown in **Figure 16.5-22**. Therefore, mechanical excavation by Road-Header is recommended in the project.

Mechanical excavation using Road-Header (Power 200 kw) has a great merit when it comes to excavating soft rock or hard rock of poor nature, where many planes of discontinuities develop. Over breaks are less than using D&B method, support patterns are lighter and the rock mass surrounding the tunnel remains more intact after excavation than D&B. However, when the rock mass is very hard and intact, it cannot excavate the rock mass economically and necessitates a bigger more powerful machine (Power 300kw or 350 kw). Further, when the rock mass becomes even harder (qu>100 MPa), economical excavation becomes impossible. In such case, D&B is inevitable.

Source:
https://www.kyb-ksm.co.jp/products/construction_machinery/construction_machinery-0019.html
https://www.kyb-ksm.co.jp/products/construction_machinery/construction_machinery-0017.html

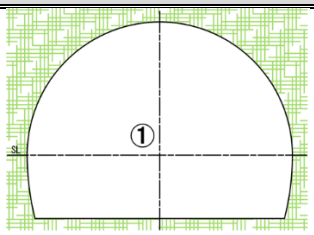
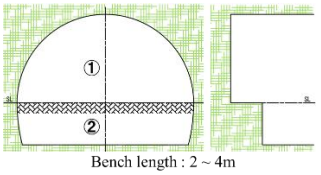
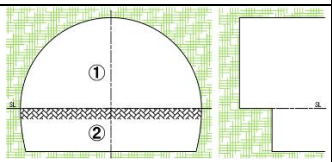
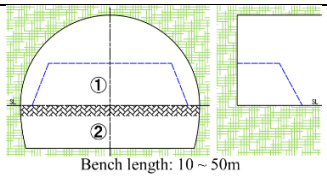
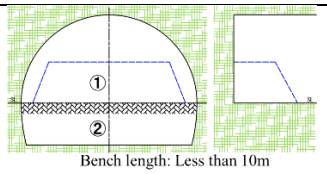
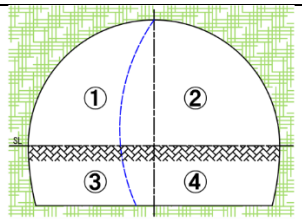
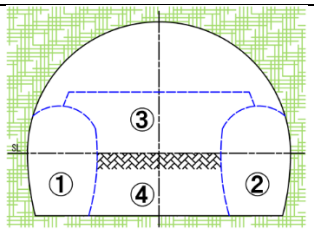
Figure 16.5-22 Road-Header as Tunneling Machine

(2) Standard Excavation Method

Tunnel excavation method is classified as shown in **Table 16.5-6**. Depending upon the geotechnical condition, excavation face area is sometimes divided into sections and when geotechnical condition is of extremely poor, center diaphragm method or side drift method are employed.

Based on the geological characteristics and area of tunnel cross section of tunnels, the bench cut method is recommended. However, the excavation method should be selected carefully at the feasibility study and detailed design stage based on the results of geological survey.

Table 16.5-6 Classification and Characteristics of Standard Excavation Method

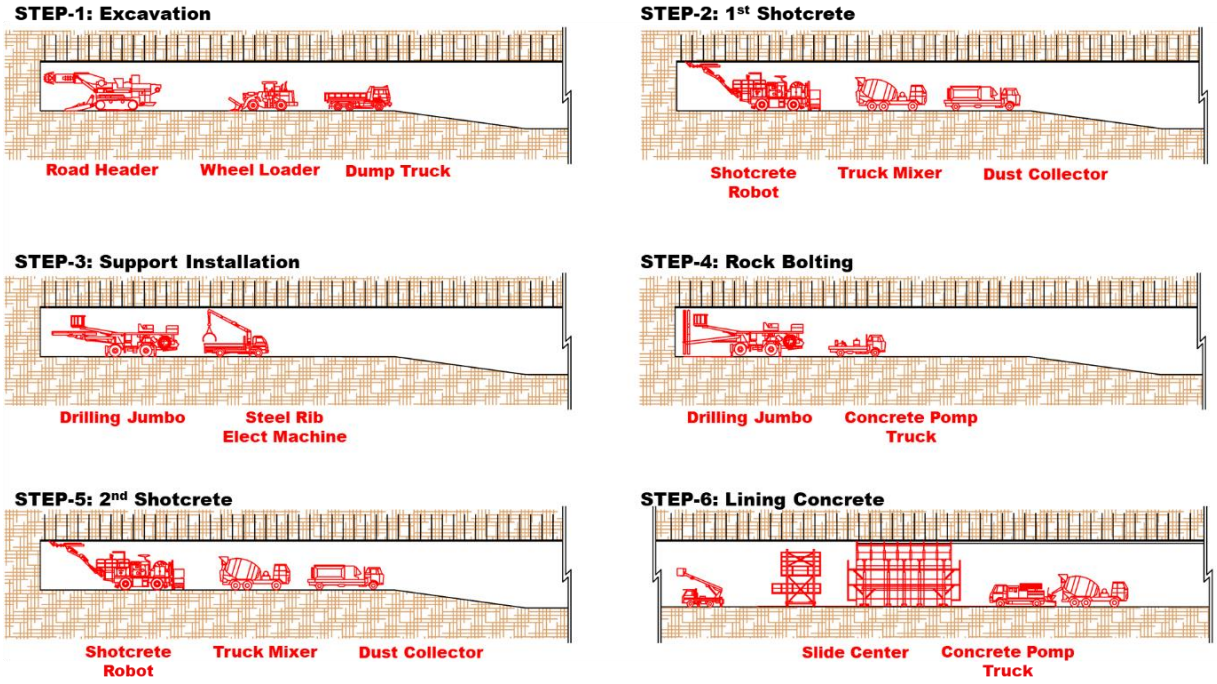
Excavation Method		Division of Section of Heading	Applicable Ground Condition	Advantages	Disadvantages
Full Face Method			Common excavation method for small section tunnel Very stable ground for large section tunnel (A=30m^2) Unfit for good grounds interspersed with poor ground that may require the change of the excavation method	Labor saving by mechanized construction Construction Management including safety control is easy because of the single-face excavation.	Full tunnel length cannot necessarily be excavated by full face alone. Changing of excavation method will be adopted as required. Fragment rocks from the top of the tunnel may fall down with increased energy & additional safety measure are required.
Full Face Method with Auxiliary Bench Cut		 Bench length : 2 ~ 4m	Comparatively stable ground, but difficult using the Full-Face Method. Full-face excavation is made difficult during construction. Presence of some poor ground in fairly good ground.	Labor saving due to mechanized construction. Construction management including safety control is easy because of the single-face excavation.	Difficult to switch to other excavation method when the face does not stand up.
Bench Cut Method	Long Bench Cut	 Bench length: more than 50m	Ground is fairly stable, but Full-face excavation is difficult.	Alternate excavation of top heading and lower bench reduces equipment and manpower needs.	Alternate excavation system elongates the construction period.
	Short Bench Cut	 Bench length: 10 ~ 50m	Applicable to various ground such as softly ground, swelling ground, and medium to hard rock ground. (The most fundamental and popular method.)	Adaptable to change in the ground condition.	Parallel excavation makes difficult the balancing of cycle time for top heading and bench.
	Mini Bench Cut	 Bench length: Less than 10m	Deformation control of the excavated inner section is more urgently required than in the case of the Short Bench Cut. Squeezing ground that require an early closure of the excavated section	Easy to make early closure of the invert.	Parallel excavation makes difficult the balancing of cycle time for top heading and bench.
Center Diaphragm Method		 One method is to provide a diaphragm only to the top heading, while the other is to provide both a top heading and a bench.	Ground of shallow overburden where ground surface settlement is required to be kept at a minimum. Comparatively poor ground condition for a large section tunnel.	Face stability is secured by dividing into small sections. Ground Surface settlement can be significantly reduced. Divided sections of heading are larger than those used in the Side Drift Method, and larger machines can be used.	Displacement or settlement during the removal of the diaphragm shall be checked. Time for diaphragm removal is added to the construction period. The adoption of a special auxiliary method in the tunnel is difficult.
Side Drift Method			Bearing capacity of the ground is not sufficient for adopting the Bench Cut Method. Ground of shallow overburden where ground surface settlement is required to be kept at a minimum.	Ground surface settlement can be reduced. Temporary diaphragms can be more easily removed than those of center diaphragm method.	Small machines have to be used for drift excavation.

Sources: JICA Project Team (refer to Standard Specifications for Tunneling-2016: Mountain Tunnel)

16.5.7.2 Sequence of Tunneling and Temporary Facilities for Tunnel Construction

It is recommended that the tunnel excavation be performed with an uphill gradient from a portal with lower altitude to drain construction wastewater and spring water outside of the tunnel naturally.

The sequence of tunnel excavation is shown in **Figure 16.5-23**. Both tunnels (left-side and right-side tunnel) can be excavated simultaneously depending upon the geological condition and construction period restriction.



Source: JICA Study Team

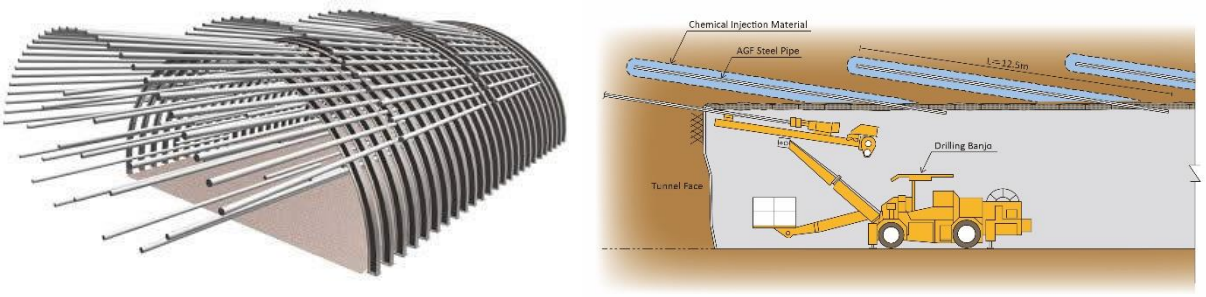
Figure 16.5-23 Sequence of Mechanical Excavation

16.5.8 Auxiliary Method

Some of the auxiliary methods are designed in the support patterns such as fore-porling and fore-piling likely umbrella (see **Figure 16.5-24**) in accordance with geological condition and tunnel surrounding environment, such as very poor ground, fault zones and neighboring construction with important structures.

Since some of the tunnel portals cross within residential areas, it is necessary to suppress the subsidence of the existing road and houses caused by tunnel excavation. Also, since some of tunnels encounter thin overburden section, it is necessary to ensure the stability of the tunnel face and ground arch. Therefore, a long span fore-piling method is applied to these areas.

Long span fore-piling method is divided into widening type and non-widening type. Widening type is a method of expanding the face and inserting the steel pipe from between the tunnel supports. The non-widening type is a method of inserting a steel pipe from between tunnel supports without expanding the face. Since it plans to be applied at thin overburden section, it is desirable to avoid the application of the widened type which makes the overburden thinner. Therefore, it is recommended to apply non-widening type in the tunnel.



Source: Technical Document of AGF Method -6th revised edition- (Right), JICA Project Team (Left)

Figure 16.5-24 Long Span Fore-Piling in Difficult Ground (Non-Widening Type)

16.5.9 Temporary Facilities and Equipment Necessary for Tunnel Construction

Major temporary facilities consist of drainage water treatment plant for drainage water from the tunnel, concrete batching plant for shotcrete and lining concrete, diesel generators for electric supply, ventilation fan and dust collector to keep inside the tunnel clean and temporary houses for office and labor camps and so on. These facilities for tunnel excavation will be planned in a portal where tunnel excavation starts.

At the feasibility study or detailed design stage, the detailed layout of the temporary facilities and detailed tunnel construction plan will be planned in consideration of the result of the tunnel excavation plan, road construction plan and influence on the noise caused by the construction.

16.5.10 Facilities Necessary for Tunnel

16.5.10.1 General

Table 16.5-7 lists the general facilities to be installed in road tunnels (inside and outside) for securing safe and smooth traffic flow. They are selected in consideration of several factors such as traffic volume, tunnel length, tunnel cross section area, etc.

Table 16.5-7 General Facilities to be Installed Tunnel

Facilities		Equipment
Tunnel Ventilation	Tunnel Inside	Jet Fan/ CO meter/ VI meter/ AV meter
	Tunnel Outside	Local Control Panel
Tunnel Lighting	Tunnel Inside	Interior Lighting/ Entrance Lighting/ Emergency Lighting
	Tunnel Outside	Local control panel, etc.
Emergency Facilities	Tunnel Inside	Emergency Telephone/ Push Button Alarm/ Fire Detector/ Fire Extinguisher/ Fire Hydrant/ Guide Board, Hydrant/ CCTV Camera, etc.
	Tunnel Outside	Local Control Panel/ Water Supply Pump/ Water Tank/ Pump Panel/ Emergency Information Board, etc.
Other Facilities	Tunnel Inside	-
	Tunnel Outside	Electrical Room/ Management Office/ Power supply system/ Back-up Generator, etc.

Source: JICA Study Team

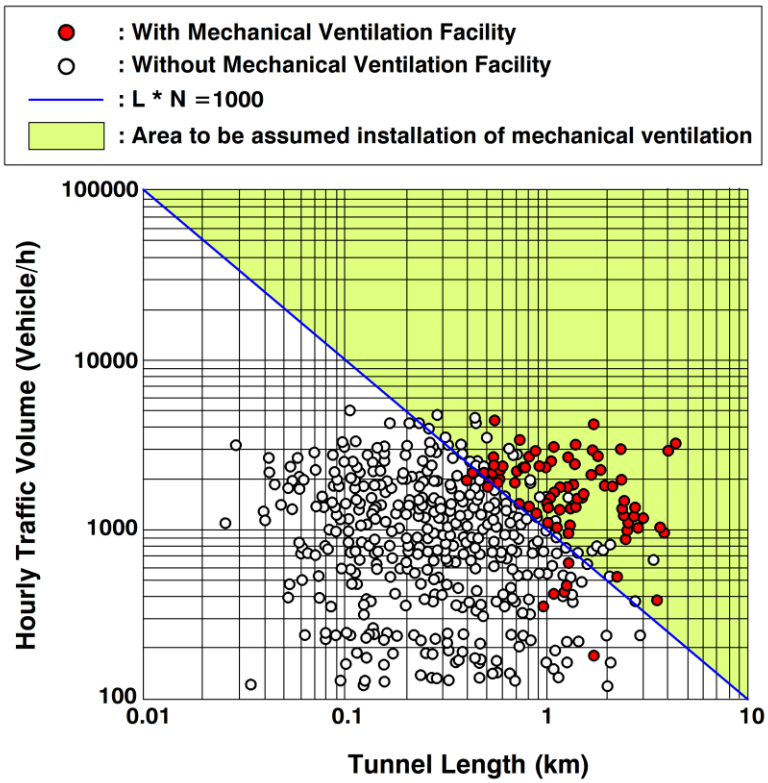
16.5.10.2 Ventilation Facilities

(1) General

Ventilation in the tunnel forcibly discharges harmful substances discharged by the vehicle to tunnel outside and secures safety and comfortability for driving inside the tunnel by keeping the concentration of harmful substances in the tunnel below the control standards. And also, it is important to provide better environment for the superintendents that undertake the tunnel maintenance work.

The necessity of tunnel ventilation and the detailed specification of ventilation equipment are considered based on various elements such as tunnel cross-section, tunnel length and traffic volume in the tunnel. In case ventilation volume inside the tunnel by natural wind is not enough to meet safe and comfortable condition inside the tunnel, mechanical ventilation system must be necessary.

Tunnel ventilation is designed by Road Tunnel Technical Standards for Tunnel Ventilation (2008). In the standard, the index for necessity of mechanical ventilation equipment inside tunnel such as Jet Fan is defined as shown in **Figure 16.5-25**. This index is made based on the actual data of mountain tunnels in Japan, and it is one guide to judge the necessity of mechanical ventilation, and the mechanical facility is not necessary for all tunnels according to that as shown in **Table 16.5-8**. The necessity of mechanical ventilation inside tunnel should be examined using numerical calculation at the feasibility study or detailed design stage which finalize detailed conditions.



Source: *Prepared with reference to "Road Tunnel Technical Standards for Tunnel Ventilation" by JICA Study Team*

Figure 16.5-25 Actual Data of Japan Tunnels for Ventilation Facility

Table 16.5-8 Necessity of Tunnel Ventilation

Tunnels		Tunnel Length (km) [L]	Hourly Traffic Volume (vehicles/hour) [N]	L×N	Necessity (with or without)
Tunnel-1	Left	0.621	770	479	Without
	Right	0.597	770	460	Without
Tunnel-2	Left	0.812	713	579	Without
	Right	0.846	713	603	Without
Tunnel-3	Left	0.280	707	198	Without
	Right	0.238	707	168	Without
Tunnel-4	Left	0.290	707	204	Without
	Right	0.253	707	179	Without
Tunnel-5	Left	0.753	707	532	Without
	Right	0.740	707	523	Without
Tunnel-6	Left	0.734	621	456	Without
	Right	0.721	621	448	Without
Tunnel-7	Left	0.763	621	474	Without
	Right	0.739	621	459	Without
Tunnel-8	Left	0.838	621	520	Without
	Right	0.819	621	508	Without
Tunnel-9	Left	0.724	646	468	Without
	Right	0.722	646	467	Without
Tunnel-10	Left	0.401	646	259	Without
	Right	0.397	646	257	Without
Tunnel-11	Left	0.488	646	315	Without
	Right	0.618	646	399	Without
Tunnel-12	Left	0.816	646	527	Without
	Right	0.810	646	524	Without
Tunnel-13	Left	0.429	474	203	Without
	Right	0.473	474	224	Without
Tunnel-14	Left	0.215	474	102	Without
	Right	0.194	474	92	Without
Tunnel-15	Left	0.232	474	110	Without
	Right	0.215	474	102	Without
Tunnel-16	Left	1.724	474	818	Without
	Right	1.734	474	822	Without

Source: JICA Study Team

16.5.10.3 Tunnel Lighting Facilities

Lighting inside the tunnel is very important to secure traffic safety. Tunnel lighting is composed of Primary Lighting, Entrance Lighting and Emergency Lighting (in case of power cut). Detailed layout and the specification are considered based on the following factors.

- High efficiency with long life
- Accommodating against high temperature, durability, and humidity
- Appropriate luminescent color
- High luminous flux to meet the required high lighting level
- Easy maintenance
- Low running cost

In recent years, LED lighting which meets the following factors is used as tunnel lighting in many countries including Japan.

The detailed specification and layout of tunnel lighting should be examined by numerical calculation in consideration of several factors, such as tunnel length, width, pavement type, etc. at the feasibility study or detailed design stage.

(1) Interior Lighting

Basic lighting is installed at regular intervals over the entire length of the tunnel to provide the necessary brightness for the drivers so that they can see the obstacles ahead under constant speed.

(2) Entrance Lighting

Entrance lighting is installed to adjust the difference between outdoor brightness and brightness in the tunnel. Therefore, it is necessary to set the luminance so that the influence of luminance can be mitigated when the driver enters the tunnel.

(3) Emergency Lighting during Power Failure

In case of a sudden loss of power, emergency lighting is required to prevent visual obscuration for the drivers already running in the tunnel. Power shall be supplied from the UPS immediately as uninterruptible power source, and subsequently it shall be connected to the back-up generator.

(4) Lighting outside the Tunnel Entrance

The street lamp at the exit of tunnel shall be installed adequately to guide the drivers coming up from the tunnel, especially in nighttime. No street lamp at the exit road may cause the constriction of the visual field of drivers and may lead to the accidents.

16.5.10.4 Tunnel Emergency Equipment/Facilities

(1) General

Tunnel emergency equipment and facilities are to support the information transmission to road users and road administrator, evacuation, self-extinguishment, and fire fighter activities when accidents or disasters occur inside the tunnel.

(2) Classification of Tunnel and Installation of Emergency Facilities

In Japanese Standard shown, necessary installation facilities of tunnel are decided by tunnel classification shown in **Table 16.5-9**.

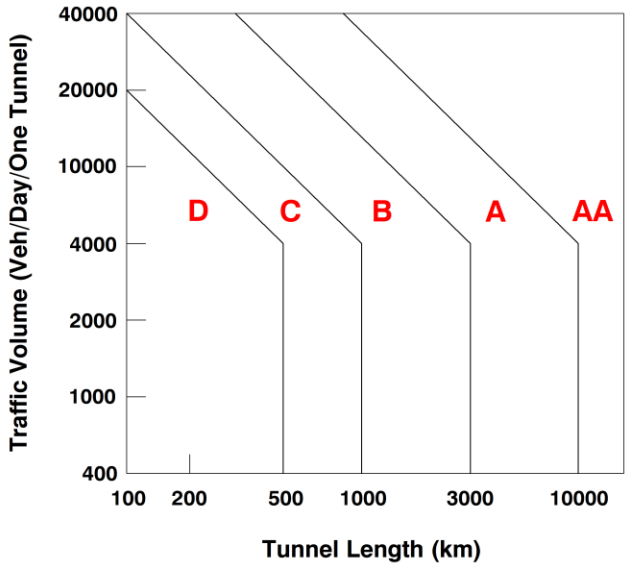
Also, tunnel classification is classified as Class-AA, Class-A, Class-B, Class-C and Class-D according to traffic volume inside the tunnel and tunnel length as shown in **Figure 16.5-26**. According to this table, the higher the tunnel classification, it is necessary to install various emergency equipment.

Table 16.5-9 Installation Standard of Emergency Facilities

Facilities \ Classification of Tunnel		AA	A	B	C	D	Remarks
Information and Alarm Facility	Emergency Telephone	○	○	○	○		
	Push Button Alarm	○	○	○	○		
	Fire Detector	○	△				To be provided in Class A tunnel with ventilation system or water sprinkler system.
	Emergency Information Board	○	○	○	○		Information board at tunnel entrance
Fire Fighting Facility	Fire Extinguisher	○	○	○			
	Fire Hydrant	○	○				
Evacuation Guide Facility	Guide Board	○	○	○			
	Smoke Removal System or Evacuation Route	○	△				Ventilation system shall be used for smoke removal. Evacuation tunnel shall be provided for Class A tunnel. 3000m or more in length, bidirectional traffic and longitudinal ventilation system.
Other Emergency Facility	Hydrant	○	△				To be provided in Class A tunnel with fire hydrant.
	Radio Communication Support System	○	△				To be provided in Class A tunnel 3000m or more in length. Required and recommended for tunnel operation and maintenance.
	Radio Re-broadcast System or Loud Speaker System	○	△				To be provided in Class A tunnel 3000m or more in length. Class A tunnel with evacuation passage.
	Water Sprinkler System	○	△				To be provided in Class A tunnel 3000 m or more in length.
	Monitor System	○	△				To be provided in Class A tunnel with water sprinkler system.

Note : ○ : Mandatory (standard) △ : Recommended

Source: Prepared with reference to "Road Tunnel Technical Standards for Emergency Facilities" by JICA Study Team



Source: Prepared with reference to "Road Tunnel Technical Standards for Emergency Facilities" by JICA Study Team

Figure 16.5-26 Classification of Tunnel

(3) Type of Emergency Facilities

The outline of each emergency facility is as follows. Installation intervals described below are based on Road Tunnel Technical Standards for Emergency Facilities.

1） Emergency Telephone

Provision of Emergency Telephones as shown in **Photo 16.5-1** are planned at both entrances to notify the tunnel administrator about any accidents or disasters. These phones should be placed at intervals of 200 m in the tunnel.

Emergency Telephone on wall

Emergency Telephone at Entrance

Emergency Telephone Box

Source:
https://radiate.jp/20130421/higashi-fushimi/
https://blogs.yahoo.co.jp/biwako_1164/59547680.html
https://travel.watch.impress.co.jp/img/trw/docs/1049/821/html/12.jpg.html

Photo 16.5-1 Emergency Telephone Types

2） Push Button Alarm

Provision of Push button alarm system as shown in **Photo 16.5-2** are planned to be set at 1.2 to 1.5 m above road surface and at intervals of 50 m to notify the tunnel administrator of any accident or disaster. This alarm system will connect with the emergency telephone and firefighting system.

Push Button Alarm
with Fire Extinguisher & Fire Hydrant

Push Button Alarm

Source:
https://car.watch.impress.co.jp/img/car/docs/685/703/html/049.jpg.html
https://www.iwasaki.co.jp/projects/examples/detail.php?EID=t34&cat=3

Photo 16.5-2 Push Button Alarm Types

3） Fire Detector

Fire Detector shown in **Photo 16.5-3** reacts to the smoke generated by the fire in the tunnel and detects the fire accident in the tunnel. It is planned at intervals of 50 m inside the tunnel. In many cases, it functions as a switch for activating the emergency information board, firefighting facilities and the ventilation facility with the reaction of the fire detector.

Source:
http://nexcokiyomi.hida-ch.com/index_7.html
http://www.pref.akita.jp/chuodo/new/newimg/h19.05.31new.html

Photo 16.5-3 Fire Detector

4) Emergency Information Board

Emergency alarm system as shown in **Photo 16.5-4** sends accidents and disaster information to road users by visual signals (alarm display) or audible alarms.

It is necessary to have adequate communication function to inform the road users of the disaster and accident situation in the tunnel and it is installed in an appropriate place not to interfere with fire extinguishing activity and evacuation activities by road users.

Emergency Information Board

Control Panel

Source: http://kitanihon-t.com/results/
http://www.iwate-shinkodenki.com/case/case25.html

Photo 16.5-4 Emergency Information Board

5) Fire Extinguishers

Fire extinguishers are shown in **Photo 16.5-5**. They are utilized for self-firefighting by the road users and are placed at intervals of 50 m.

Source:http://www.pref.yamanashi.jp/kanjo/kanri/manriki.html
https://car.watch.impress.co.jp/docs/news/688076.html

Photo 16.5-5 Fire Extinguisher

6) Fire Hydrants

Fire hydrants are as shown in **Photo 16.5-6**. They are utilized for self-firefighting by the road users and are placed at every 200 m interval. At the same time, the hydrant for supporting

firefighting activities may be installed. In that case, the fire hydrant and the hydrant will be installed at same place.

Source:http://asahisetsubi.co.jp/construction/463/
http://photozou.jp/photo/show/629359/116028160

Photo 16.5-6 Fire Hydrant

7） Guide Boards

Guide boards shown in **Photo 16.5-7** are illuminated signs to inform the location of Tunnel portal to road users. Guide boards are to be set at intervals of 200 m.

Source: https://www.iwasaki.co.jp/projects/examples/detail.php?EID=rhi07&cat=1
http://www.pref.yamanashi.jp/kanjo/kanri/manriki.html

Photo 16.5-7 Guide Boards

8） Smoke Removal System and Evacuation Route

The tunnel ventilation system is placed for the purpose of both smoke removal and tunnel ventilation. Jet fan will act to extract smoke in the event of fire in the tunnel.

Evacuation route facilities include evacuation tunnel, evacuation connection tunnel and evacuation portal and they are provided to evacuate users of the tunnel to a safe place when emergency happens. Smoke removal system and evacuation route are shown in **Photo 16.5-8**.

The tunnel is operated by two tube tunnels, which is the route of evacuation to escape towards the tunnel portal or adjacent tunnel in case of fire. Therefore, the evacuation connection tunnel is installed instead of the evacuation tunnel.

Smoke Removal System (Jet Fan)

Evacuation Route (Evacuation Connection Tunnel)

Source: http://www.hanshin-exp.co.jp/company/skill/library/tech/post.html
https://radiate.jp/20081213/kitakan_opening_tochigi-ibaragi/

Photo 16.5-8 Smoke Removal System and Evacuation Route

9）Hydrant at Tunnel Portal

Hydrant at tunnel portal as shown in **Photo 16.5-9** are placed at both tunnel portals to support the firefighting activity in the event of fire.

Source:http://daikitihanayama.web.fc2.com/2004Touring/yasya/Re/y3.html
http://www.pref.yamanashi.jp/kanjo/kanri/manriki.html

Photo 16.5-9 Hydrant

10）Wireless Radio System

Coaxial cable as shown in **Photo 16.5-10** are to be placed under the tunnel lighting system or the tunnel center wall to allow tunnel staff, firefighters and police officers to use radios in emergency cases.

Source: https://car.watch.impress.co.jp/img/car/docs/685/703/html/048.jpg.html

Photo 16.5-10 Wireless Radio System

11）Radio Re-Broadcasting System and Loud Speaker System

Radio re-broadcasting system secures radio broadcast in the tunnel by using lead antenna at tunnel entrance. When an emergency occurs in the tunnel, the system shall be used to transmit emergency information radio signals to car users in the tunnel. In addition, the loud speaker system transmits the information on accident situation and evacuation instructions to tunnel users through radio broadcasting with speakers installed in the tunnel. Radio re-broadcasting and loudspeaker systems are shown in **Photo 16.5-11**.

Guide Wire for AM Radio

AM Aerial Wire

Loud Speaker System

Source: https://travel.watch.impress.co.jp/img/trw/docs/1048/548/html/53.jpg.html

Photo 16.5-11 Radio Re-Broadcasting System and Loud Speaker System

12） Monitor System

The monitor system (CCTV Camera) like the one shown in **Photo 16.5-12** is designed based on the tunnel plan and profile, focal length of cameras, and the size of objectives. The cameras will be installed at tunnel wall at 150-200 m intervals. Also, they shall be installed at the emergency parking bays.

Source: http://www.densetsu-ndd.co.jp/construction/construction-329/

Photo 16.5-12 Monitoring System

(4) Installed Emergency Facilities

Classes of tunnels and necessary emergency facilities are presented in **Table 16.5-10** and **Table 16.5-11**.

Table 16.5-10 Tunnel Class

Tunnels	Traffic Volume (Vehicles/day)	Left		Right	
		Length (km)	Length (km)	length	Class
Tunnel-1	18,491	0.621	B	0.597	B
Tunnel-2	17,121	0.812	A	0.846	A
Tunnel-3	16,959	0.280	B	0.238	B
Tunnel-4	16,959	0.290	B	0.253	B
Tunnel-5	16,959	0.753	A	0.74	A
Tunnel-6	14,897	0.734	B	0.721	B
Tunnel-7	14,897	0.763	B	0.739	B
Tunnel-8	14,897	0.838	A	0.819	A
Tunnel-9	15,511	0.724	B	0.722	B
Tunnel-10	15,511	0.401	B	0.397	B
Tunnel-11	15,511	0.488	B	0.618	B
Tunnel-12	15,511	0.816	A	0.81	A
Tunnel-13	11,380	0.429	B	0.473	B
Tunnel-14	11,380	0.215	C	0.194	C
Tunnel-15	11,380	0.232	C	0.215	C
Tunnel-16	11,380	1.724	A	1.734	A

Table 16.5-11 Necessary Emergency Facilities

Tunnels		No. of Facilities							
		A	B	C	F	E	F	G	H
Tunnel-1	Left	4	13	13	2	13		4	
	Right	3	12	12	2	12		3	
Tunnel-2	Left	5	17	17	2	17	17	5	5
	Right	5	17	17	2	17	17	5	5
Tunnel-3	Left	2	6	6	2	6		2	
	Right	2	5	5	2	5		2	
Tunnel-4	Left	2	6	6	2	6		2	
	Right	2	6	6	2	6		2	
Tunnel-5	Left	4	16	16	2	16	16	4	4
	Right	4	15	15	2	15	15	4	4
Tunnel-6	Left	4	15	15	2	15		4	
	Right	4	15	15	2	15		4	
Tunnel-7	Left	4	16	16	2	16		4	
	Right	4	15	15	2	15		4	
Tunnel-8	Left	5	17	17	2	17	17	5	5
	Right	5	17	17	2	17	17	5	5
Tunnel-9	Left	4	15	15	2	15		4	
	Right	4	15	15	2	15		4	
Tunnel-10	Left	3	9	9	2	9		3	
	Right	2	8	8	2	8		2	
Tunnel-11	Left	3	10	10	2	10		3	
	Right	4	13	13	2	13		4	
Tunnel-12	Left	5	17	17	2	17	17	5	5
	Right	5	17	17	2	17	17	5	5
Tunnel-13	Left	3	9	9	2	9		3	
	Right	3	10	10	2	10		3	
Tunnel-14	Left	2	5	5	2				
	Right	1	4	4	2				
Tunnel-15	Left	2	5	5	2				
	Right	2	5	5	2				
Tunnel-16	Left	9	35	35	2	35	35	9	9
	Right	9	35	35	2	35	35	9	9

A: Emergency Telephone **B: Push Button Alarm** **C: Fire Detector** **D: Emergency Information Board**
E: Fire Extinguisher **F: Fire Hydrant** **G: Guide Board** **H: Hydrant**

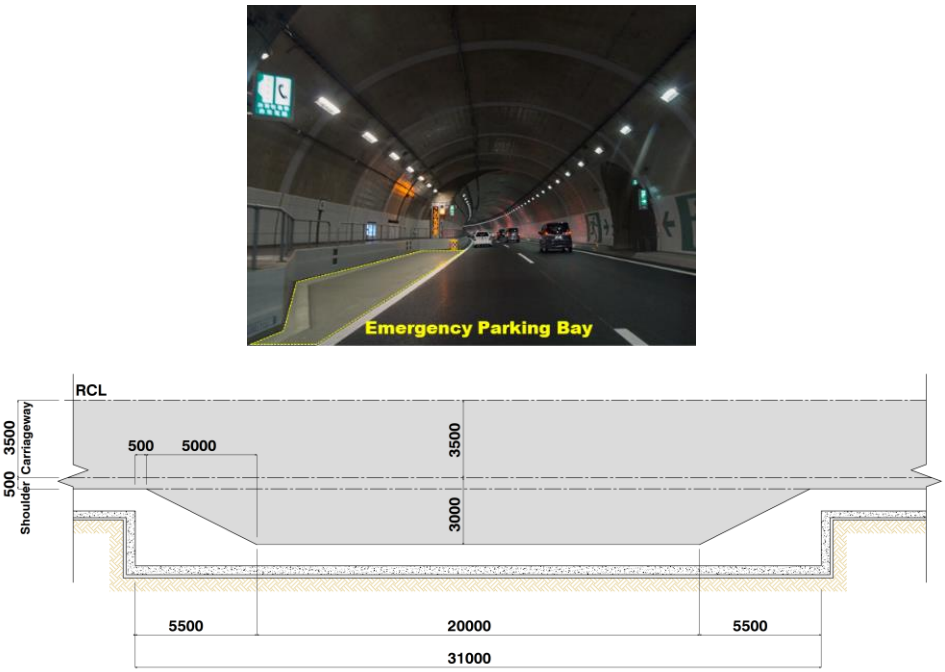
16.5.10.5 Other Facilities

(1) Emergency Parking Bay

Emergency parking bay is a facility that ensures a safe and smooth traffic flow inside the tunnel by providing a parking space for mechanically malfunctioned vehicles.

Based on the Design Guidelines Part 4 issued by Nippon Expressway Research Institute Company (NEXCO), emergency parking bay shown in **Figure 16.5-27** is provided in the tunnel at intervals of about 750 m. Proposed number of emergency parking bays for tunnels is shown in **Table 16.5-12**.

As for the location and number of the emergency parking bays, it is necessary to sufficiently discuss and consider the necessity of this facility during the feasibility study or detailed design stage.



Source:
JICA Study Team (Layout of Emergency Parking Bay)
https://radiate.jp/20140628/sagami_open/ (Photo)

Figure 16.5-27 Emergency Parking Bay

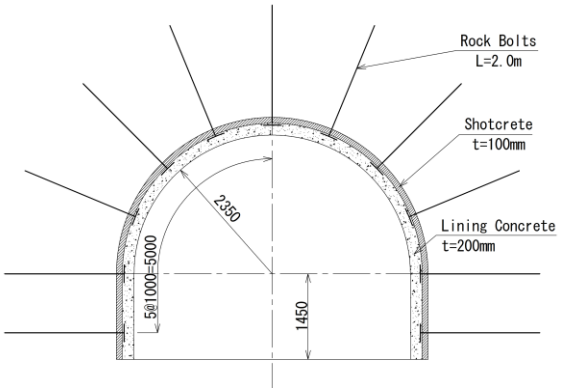
Table 16.5-12 No. of Emergency Parking Bays and Evacuation Connection Tunnels

Tunnels	No. of Emergency Parking Bays		No. of Evacuation Connection Tunnel
	Left-side	Right-side	
Tunnel-1	0	0	0
Tunnel-2	1	1	1
Tunnel-3	0	0	0
Tunnel-4	0	0	0
Tunnel-5	1	1	1
Tunnel-6	1	1	1
Tunnel-7	1	1	1
Tunnel-8	1	1	1
Tunnel-9	1	1	1
Tunnel-10	0	0	0
Tunnel-11	0	0	0
Tunnel-12	1	1	1
Tunnel-13	0	0	0
Tunnel-14	0	0	0
Tunnel-15	0	0	0
Tunnel-16	2	2	2

(2) Evacuation Connection Tunnel

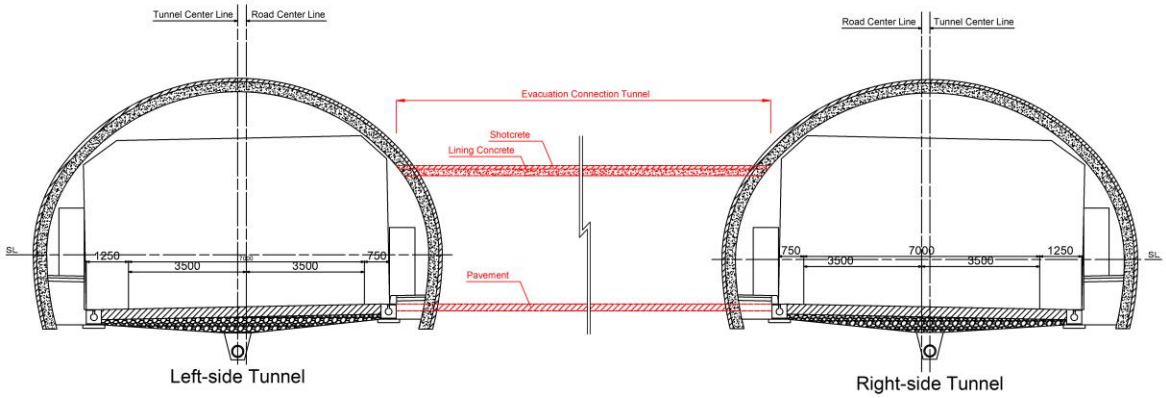
Evacuation connection tunnel shown in **Figure 16.5-28** and **Figure 16.5-29** is an evacuation route connecting between the inbound tunnel and the outbound tunnel or main tunnel and evacuation tunnel. According to the Road Tunnel Technical Standard for Tunnel Structure, they are installed at intervals of about 700-800 m in many cases in Japan. Proposed number of evacuation connection tunnel is shown in **Table 16.5-12**.

As for the location and installation number of the evacuation connection tunnel, it is necessary to sufficiently discuss and consider the necessity of this facility during the conduct of the feasibility study or detailed design.



Source:
JICA Study Team (Cross-section)

Figure 16.5-28 Evacuation Connection Tunnel Cross-Section



Source: JICA Study Team (Cross-section)

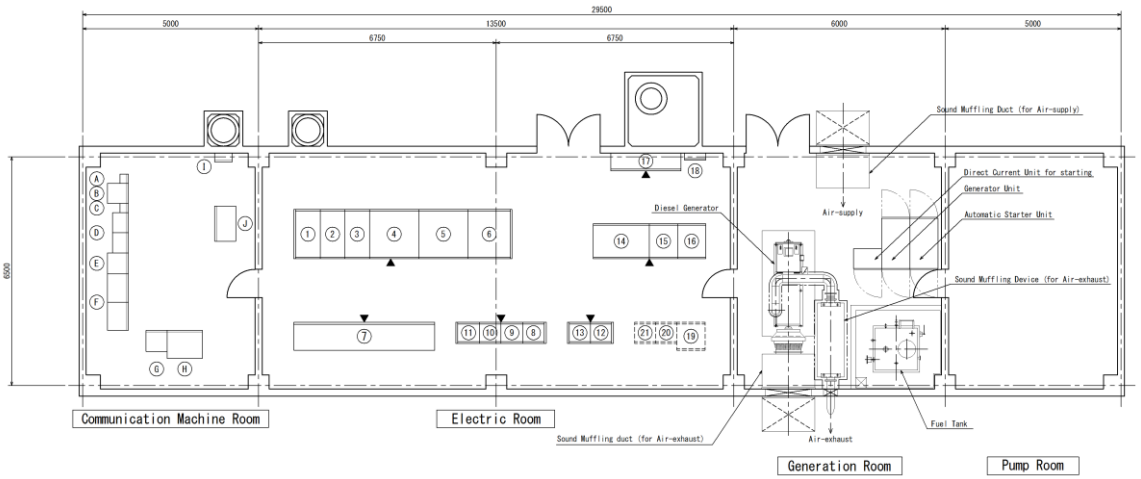
Figure 16.5-29 Evacuation Connection Tunnel Overview

(3) Tunnel Management Office and Electric Room

Description of the tunnel management office and the electric room are shown in **Table 16.5-13**.

Table 16.5-13 Description of Tunnel Management Office and Electric Room

Facility	Description	
Tunnel Management Office	Area	1,030 m^2 (Office) + 1,500 m^2 (Parking Space) = 2,530 m^2
	Proposed Location	1 place near any class-A tunnel
	Function	✓ Administration building for maintenance staff and toll-collection related staff to carry out the tunnel operation and monitoring ✓ Parking area of tunnel maintenance vehicles and emergency vehicles
	Facilities	✓ Administration Office Space ✓ Stock Room for Equipment ✓ Traffic Control & Monitoring Center (including rest space for patrol team, machine room for control system etc.) ✓ Other (Reception, Meeting Room, Toilet etc.) ✓ Parking space
Electric Room	Office Area	200 m^2 (Electric Room) + 500m^2 (Maintenance Space) + 225 m^2 (Receiving Facility Space) = 925 m^2 (Sample layout of electric room is referred to **Figure 16.5-30**)
	Proposed Location	5 places for class-A tunnels (Tunnel-2, 5, 8, 12, 16) (Refer to **Figure 16.5-31**)
	Function	✓ Primary receiving facility for the tunnel (class-A tunnel) ✓ Installation room for control device of tunnel emergency facilities
	Facilities	✓ Communication Machine Room ✓ Electric Room for Control Device ✓ Generation Room ✓ Pump Room



Legend

Mark	Item
Ⓐ	Police Radio
Ⓑ	Shared Device
Ⓒ	Management Radio
Ⓓ	Radio Re-broadcast (AM・FM)
Ⓔ	Remote Monitoring/Control Device
Ⓕ	ＩＴＶ
Ⓖ	Monitoring/Control Dvice
Ⓗ	Receiver Unit
Ⓘ	Splice and Connector box
Ⓙ	ＶＤＦ

Mark	Item
①	Power Receiving Unit
②	Power Compensator Unit for Power Failure
③	Power/Lighting Transformer Unit
④	Power Transformer Unit
⑤	Lighting Transformer Unit
⑥	Transformer Unit
⑦	Power Compensator Unit for Power Failure
⑧	Lighting Control Unit
⑨	No.1 Lighting Control Center
⑩	No.2 Lighting Control Center
⑪	No.3 Lighting Control Center
⑫	No.1 Ventilation Control Center
⑬	No.2 Ventilation Control Center
⑭	Inverter Unit
⑮	Battery Charger Unit
⑯	Storage Battery Unit
⑰	Low-voltage Switching Unit
⑱	Earth Terminal Unit
⑲	Ventilation Control Unit
⑳	Ventilation Measurement Unit
㉑	Traffic Volume Processing Device

Source: JICA Study Team

Figure 16.5-30 Layout of Electric Room (Proposed)

Source: JICA Study Team

Figure 16.5-31 Location Map of Electric Room and Management Office (Proposed)

16.5.11 Tunnel Construction Schedule

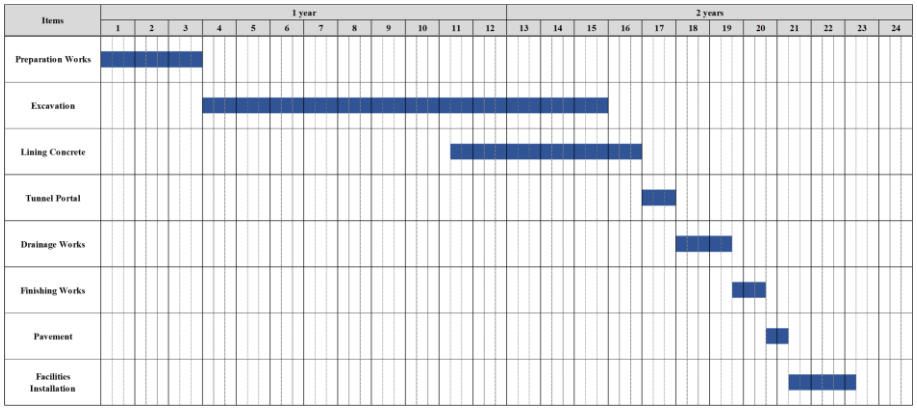
Tunnel construction schedule is estimated based on tunnel construction experiences in Japan equivalent to the tunnel cross section area planned in this Project. Pre-conditions for estimation are shown in **Table 16.5-14**, and the construction schedule of each tunnel is shown in **Figure 16.5-32** to **Figure 16.5-40**.

The construction schedule is planned out on the assumption that all tunnel sections will be constructed in parallel position. At the F/S stage, it is desirable to review the construction period taking into consideration the construction process, contractor's capacity and constraint of tunnel construction equipment.

Table 16.5-14 Pre-condition of Tunnel Construction Schedule

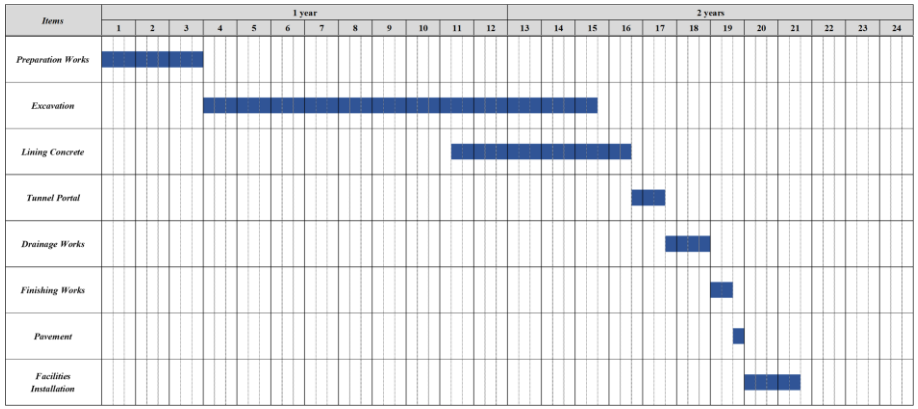
Items		Unit	Speed
Preparation Works		months	3.0
Excavation	CII	m/month	64.0
	DI	m/month	64.0
	DIII	m/month	57.0
	DIII-P	m/month	42.0
	CII-L, CII-R	m/month	47.0
	DI-L, DI-R	m/month	47.0
Lining Concrete		m/month	109.7
Tunnel Portal		month	1.0
Drainage Works		m/month	400.0
Finishing Works		month	1.0
Pavement		m/month	1000.0
Facilities Installation		month	2.0

Tunnel-1 (Left)



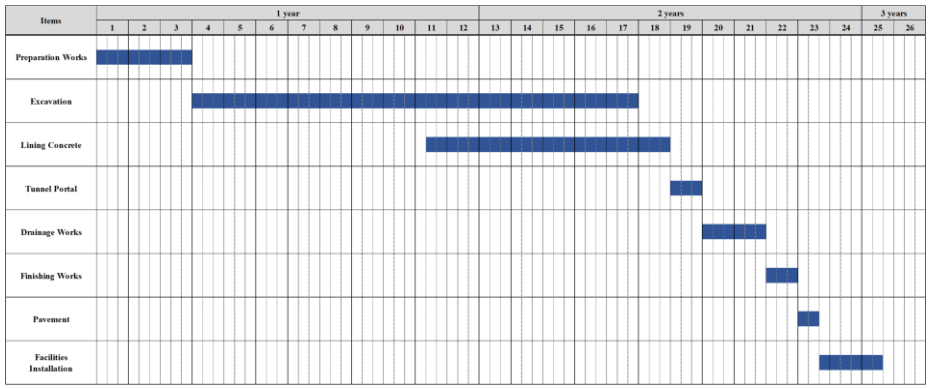
L=621m Construction Period:22.4months

Tunnel-1 (Right)



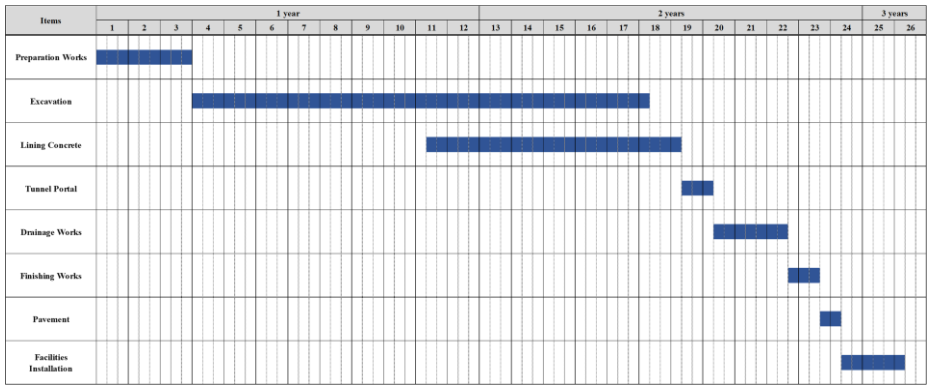
L=597m Construction Period:21.8months

Tunnel-2 (Left)



L=812m Construction Period:24.6months

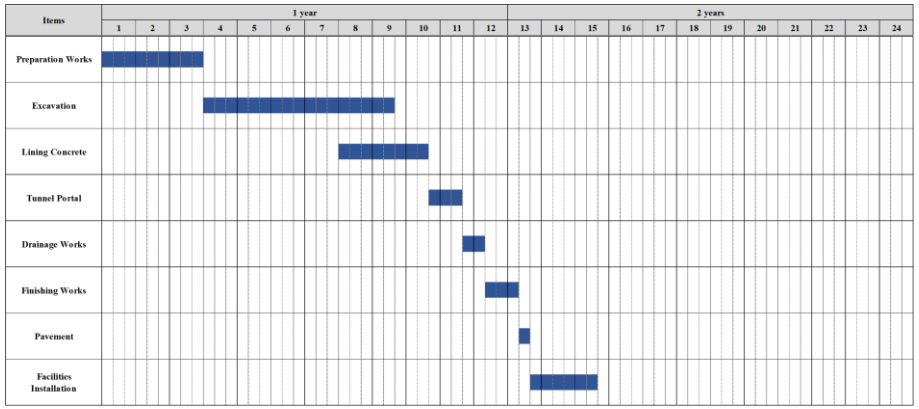
Tunnel-2 (Right)



L=846m Construction Period:25.4months

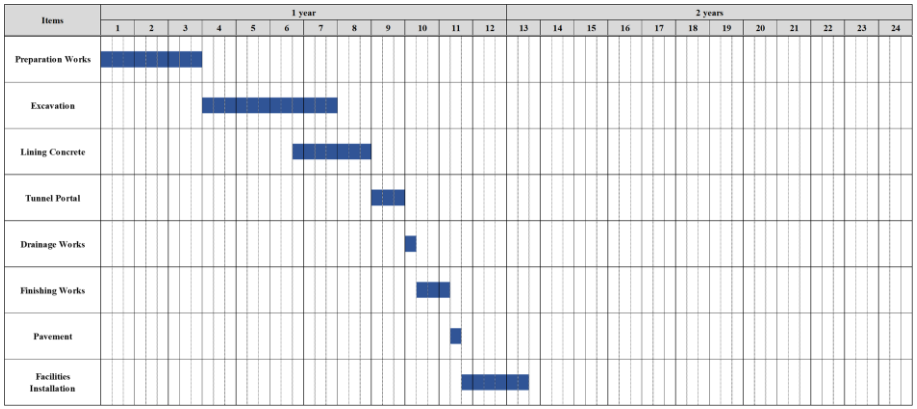
Figure 16.5-32 Construction Schedule Bar Chart (1/9)

Tunnel-3 (Left)



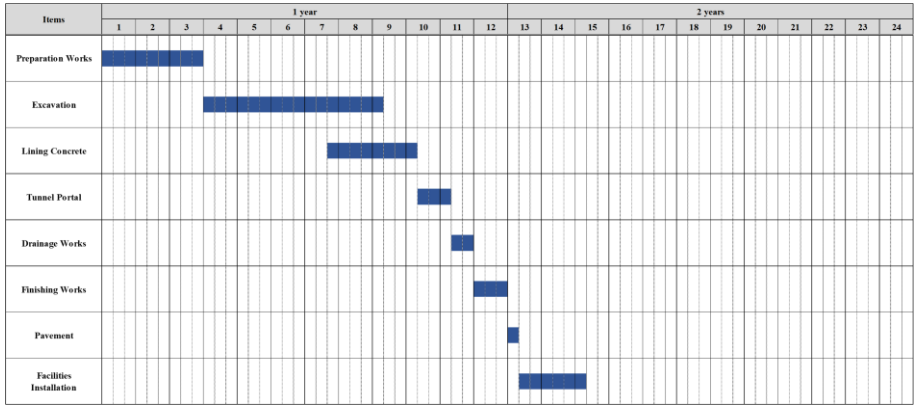
L=280m Construction Period:14.6months

Tunnel-3 (Right)



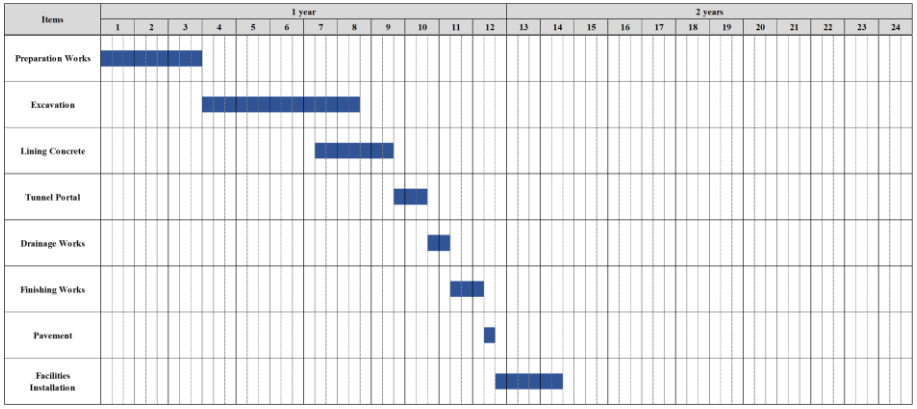
L=238m Construction Period:13.6months

Tunnel-4 (Left)



L=290m Construction Period:14.4months

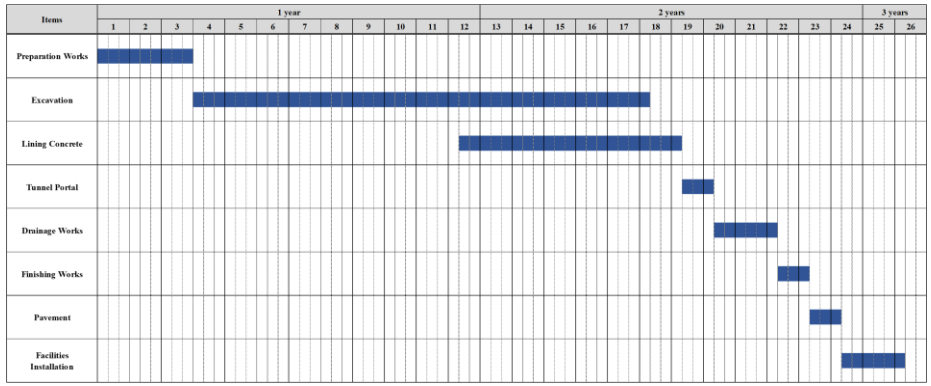
Tunnel-4 (Right)



L=253m Construction Period:13.6months

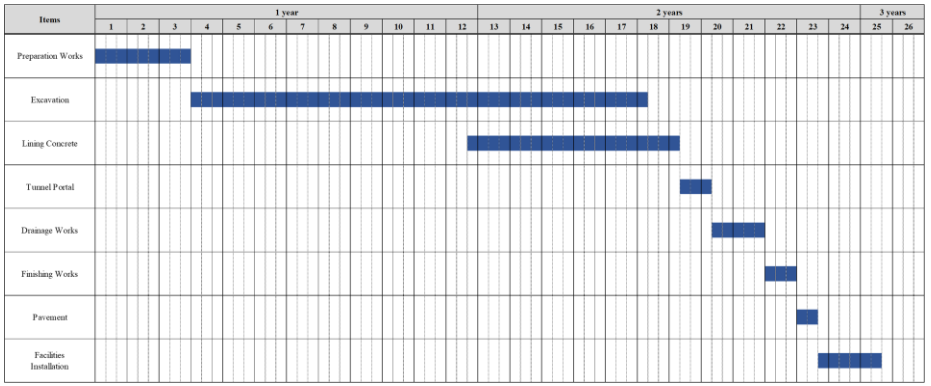
Figure 16.5-33 Construction Schedule Bar Chart (2/9)

Tunnel-5 (Left)



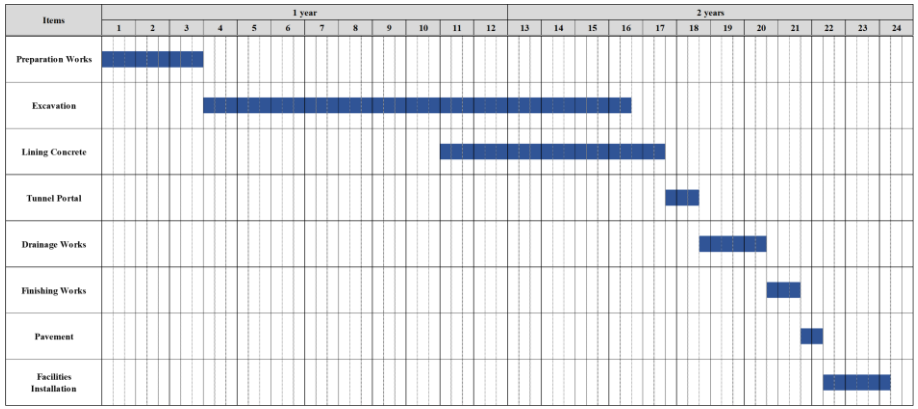
L=753m Construction Period:25.1months

Tunnel-5 (Right)



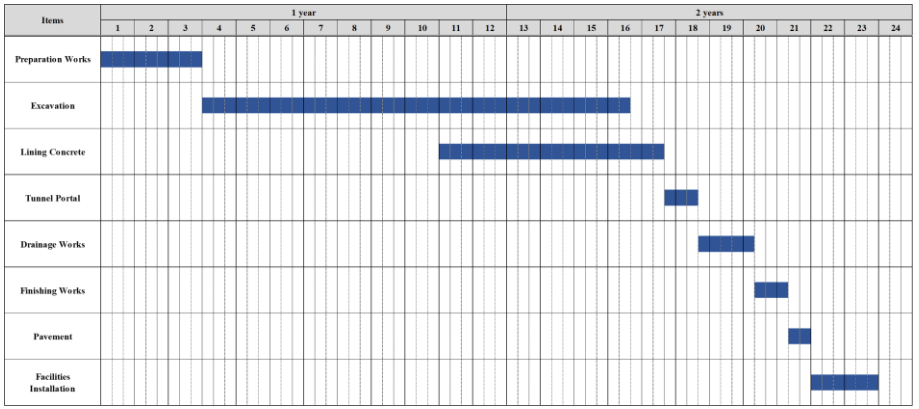
L=740m Construction Period:24.7months

Tunnel-6 (Left)



L=734m Construction Period:23.3months

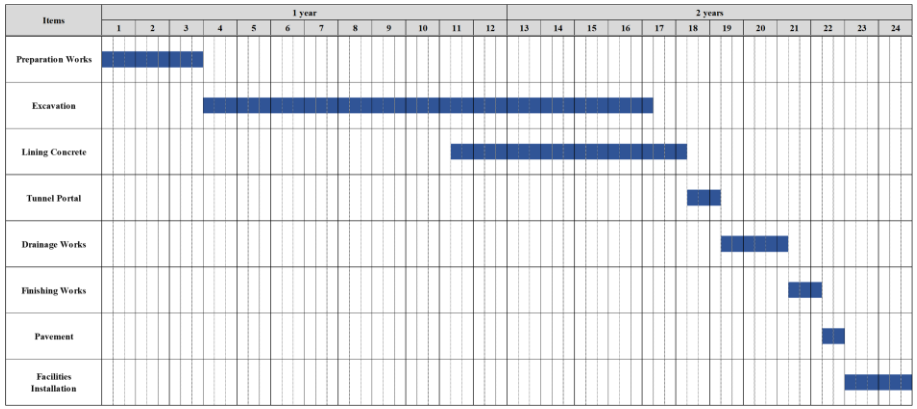
Tunnel-6 (Right)



L=721m Construction Period:23.0months

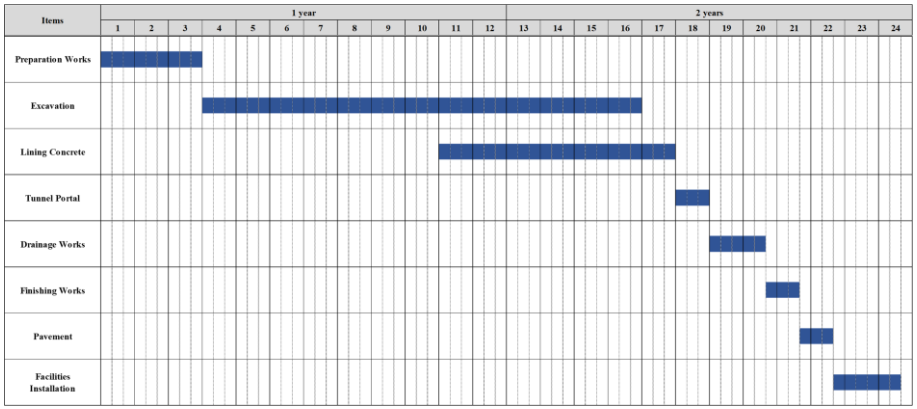
Figure 16.5-34 Construction Schedule Bar Chart (3/9)

Tunnel-7 (Left)



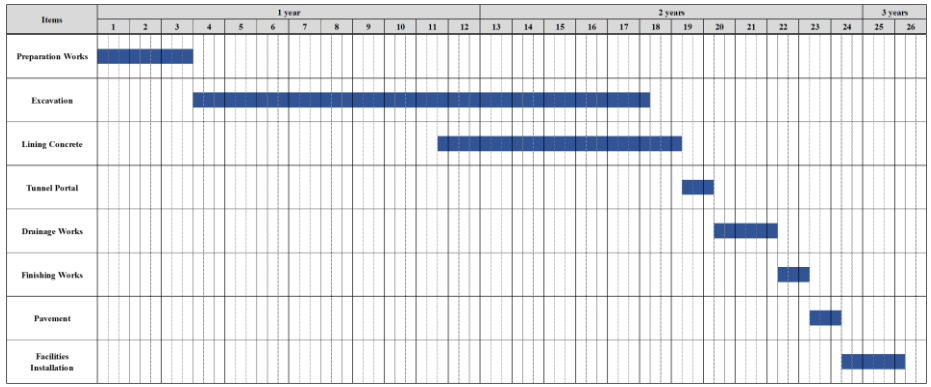
L=763m Construction Period:24.0months

Tunnel-7 (Right)



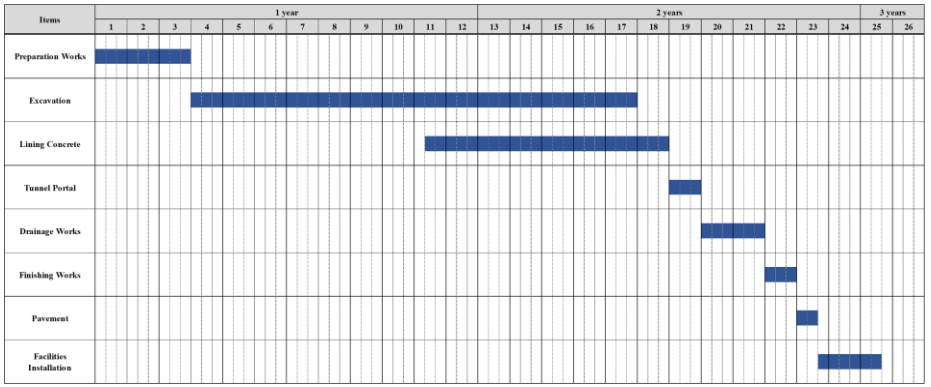
L=739m Construction Period:23.5months

Tunnel-8 (Left)



L=838m Construction Period:25.1months

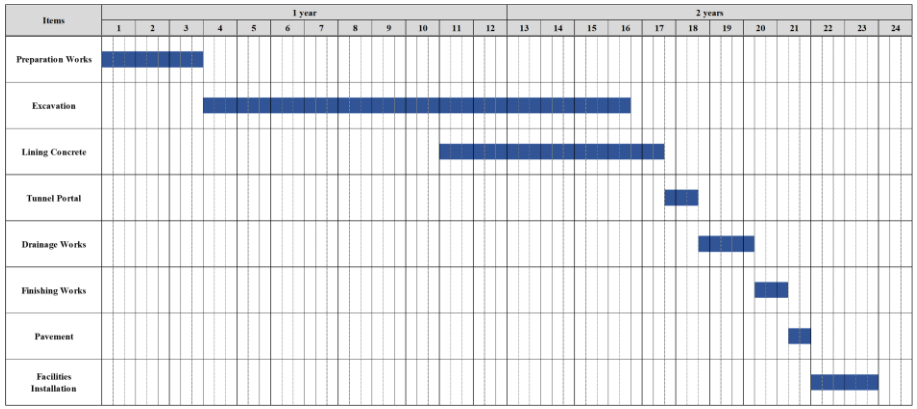
Tunnel-8 (Right)



L=819m Construction Period:24.7months

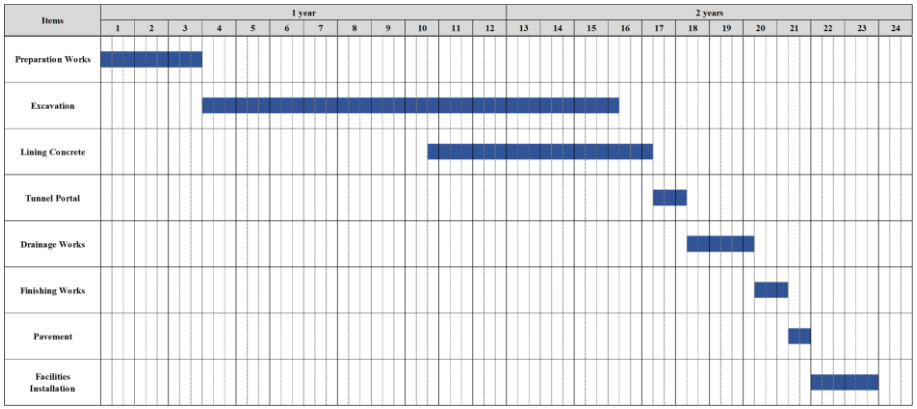
Figure 16.5-35 Construction Schedule Bar Chart (4/9)

Tunnel-9 (Left)



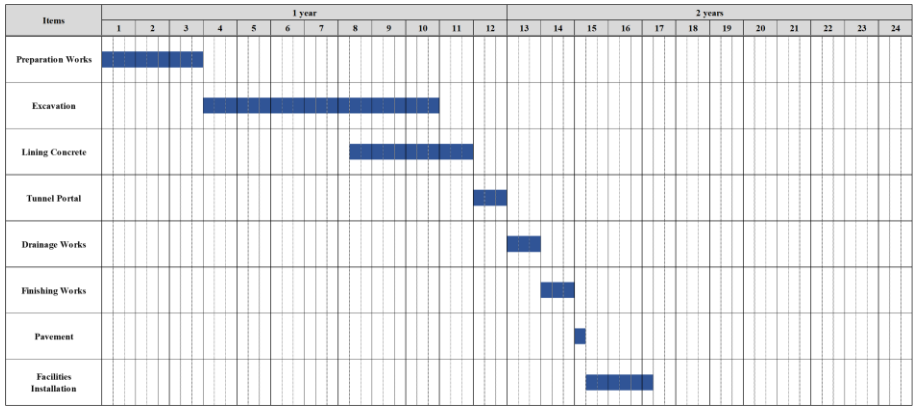
L=724m Construction Period:23.0months

Tunnel-9 (Right)



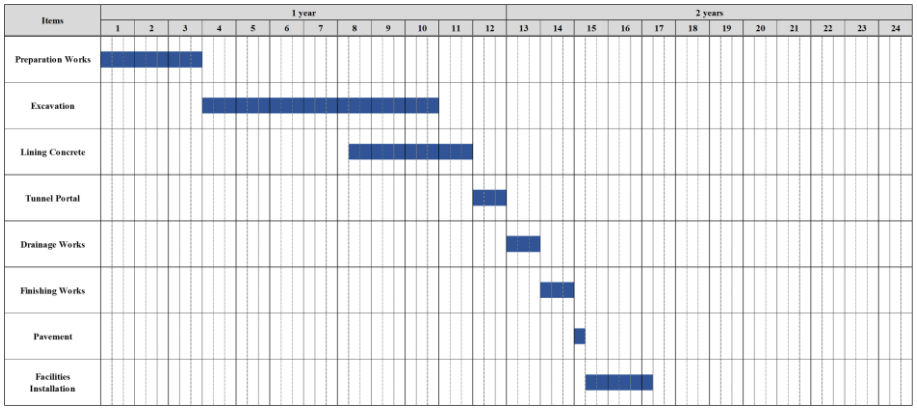
L=722m Construction Period: 23.0months

Tunnel-10 (Left)



L=401m Construction Period:16.4months

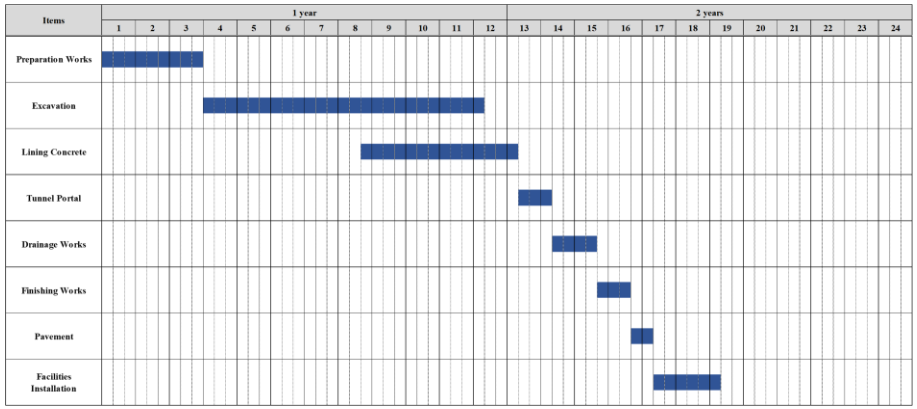
Tunnel-10 (Right)



L=397m Construction Period:16.3months

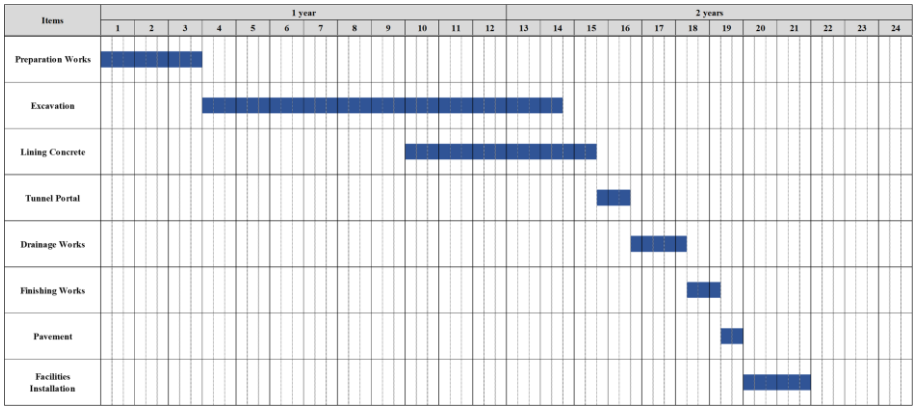
Figure 16.5-36 Construction Schedule Bar Chart (5/9)

Tunnel-11 (Left)



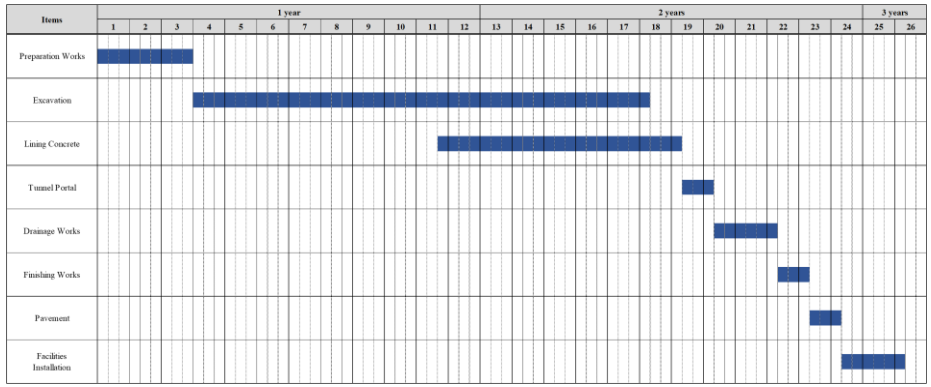
L=488m Construction Period:18.1months

Tunnel-11 (Right)



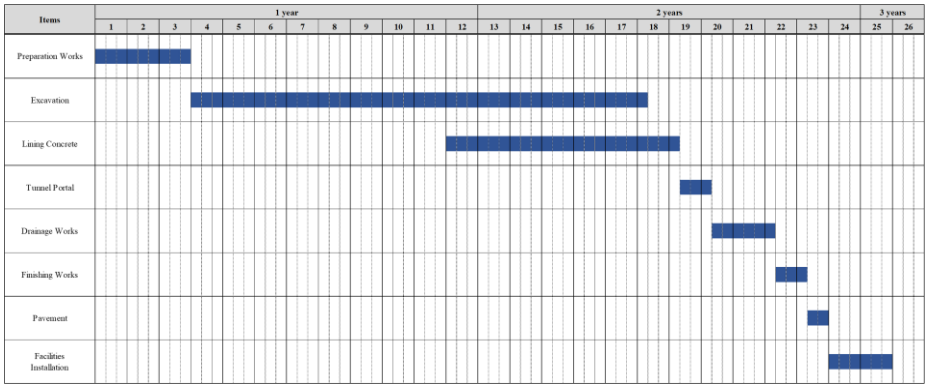
L=618m Construction Period: 20.9months

Tunnel-12 (Left)



L=816m Construction Period:25.2months

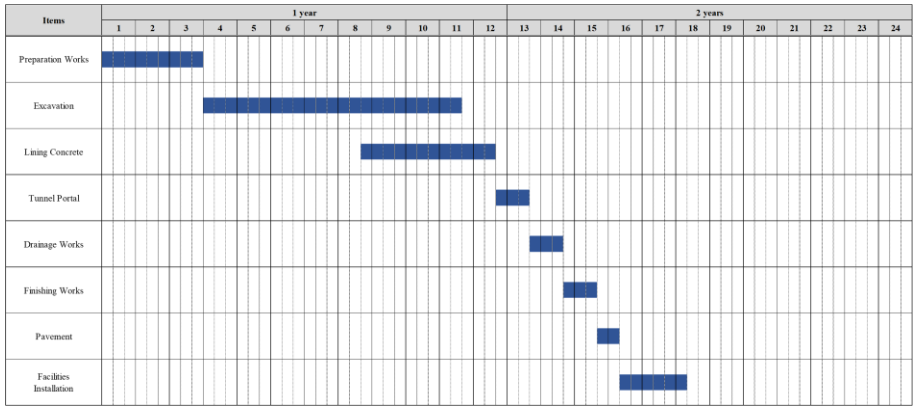
Tunnel-12 (Right)



L=810m Construction Period:25.0months

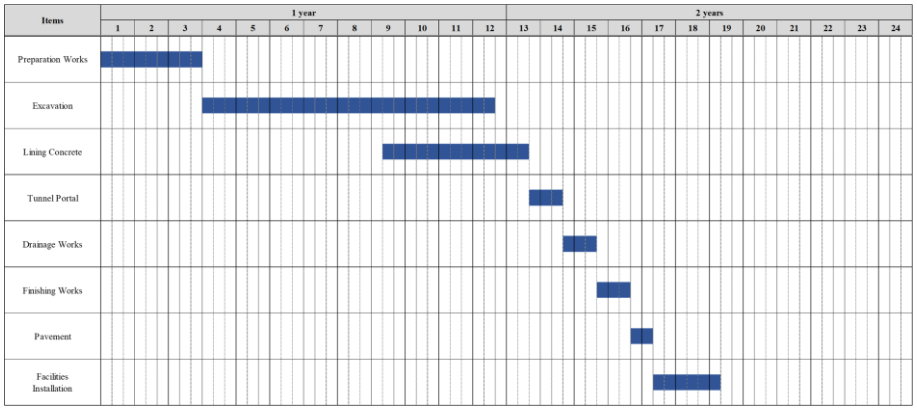
Figure 16.5-37 Construction Schedule Bar Chart (6/9)

Tunnel-13 (Left)



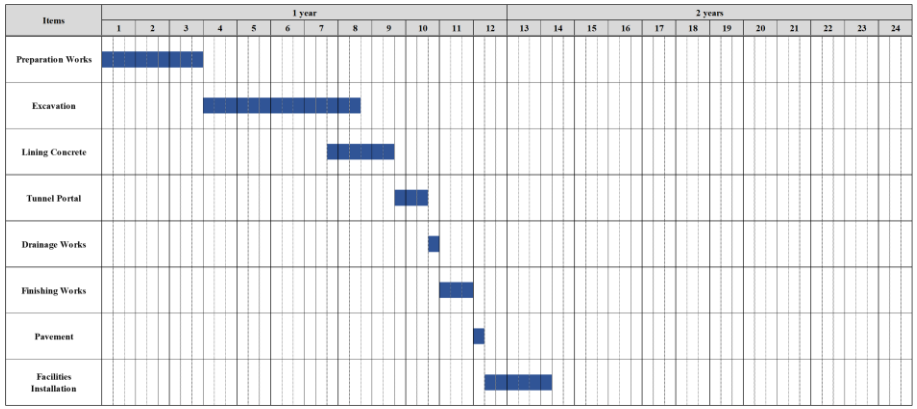
L=429m Construction Period:17.2months

Tunnel-13 (Right)



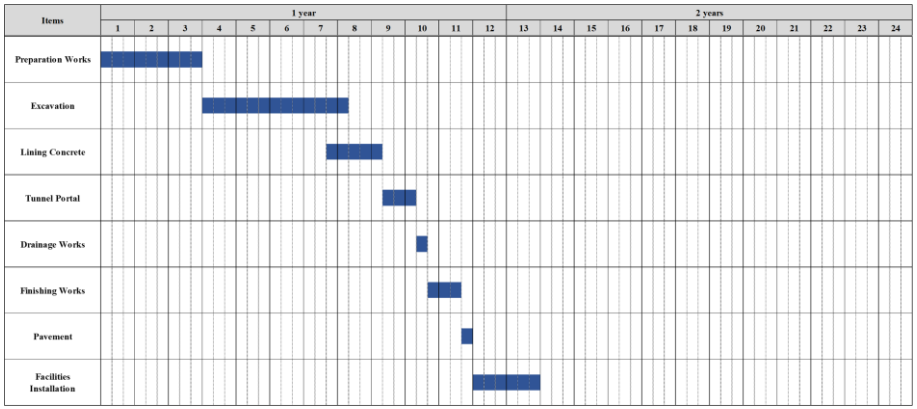
L=473m Construction Period: 18.1months

Tunnel-14 (Left)



L=215m Construction Period:13.3months

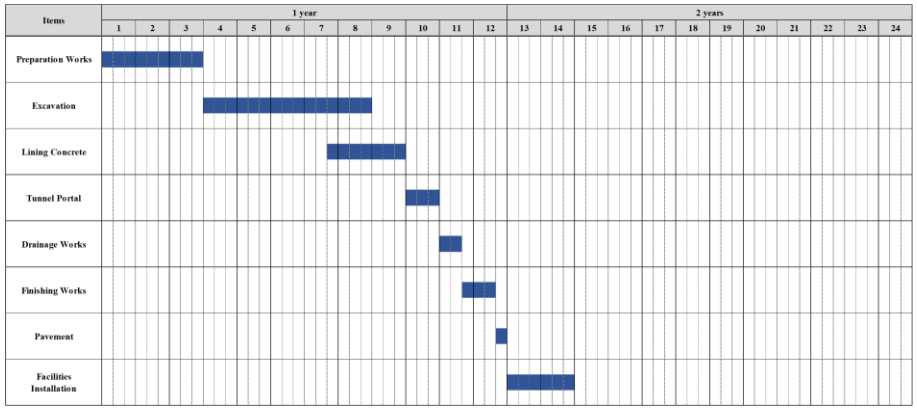
Tunnel-14 (Right)



L=194m Construction Period:12.9months

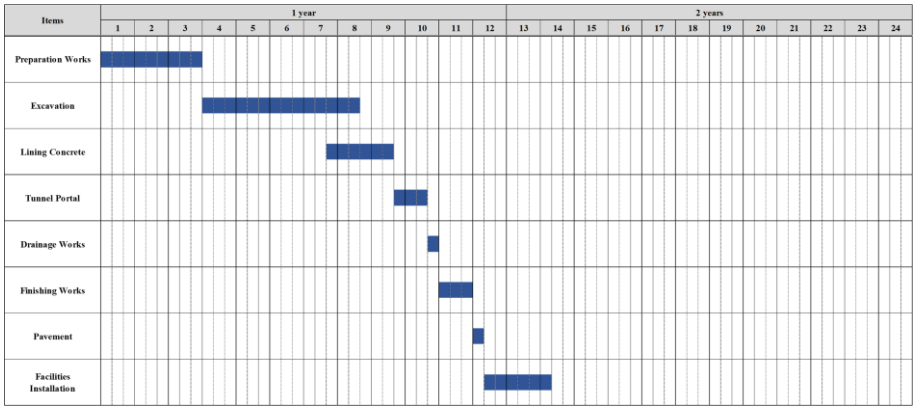
Figure 16.5-38 Construction Schedule Bar Chart (7/9)

Tunnel-15 (Left)



L=232m Construction Period:13.8months

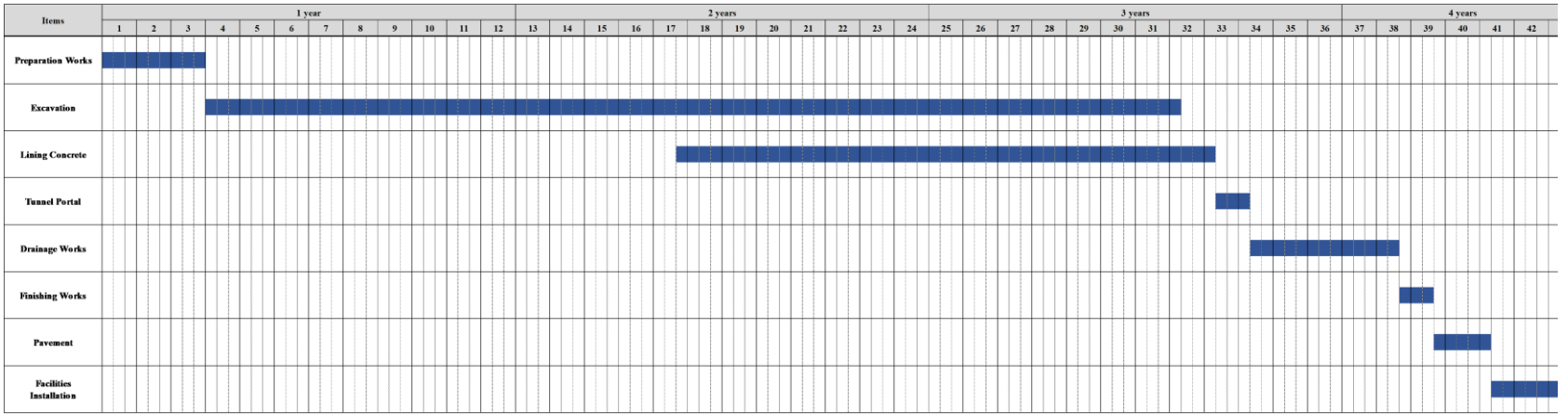
Tunnel-15 (Right)



L=215m Construction Period: 13.3months

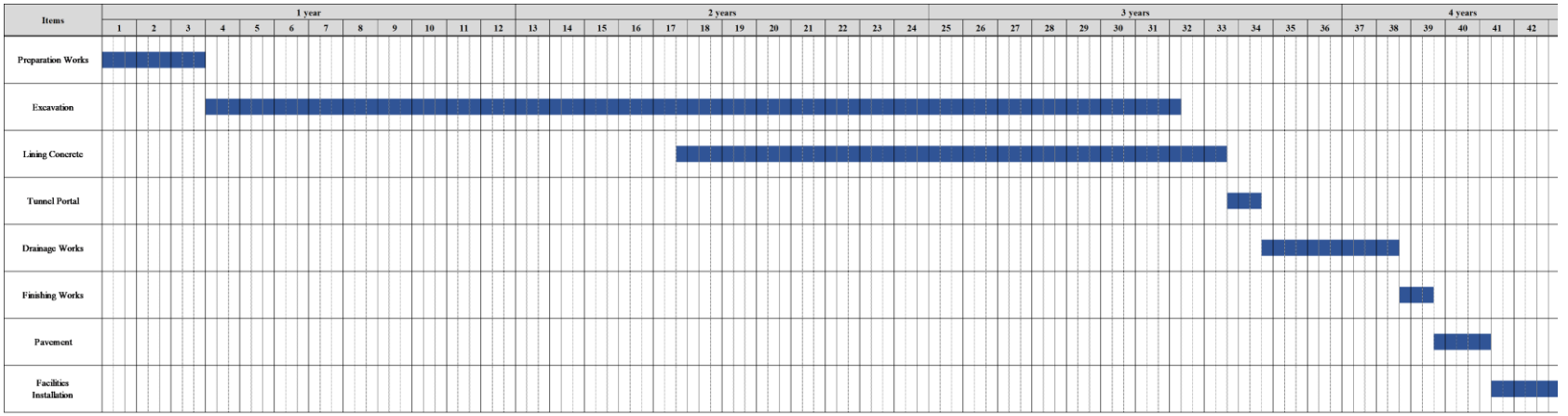
Figure 16.5-39 Construction Schedule Bar Chart (8/9)

Tunnel-16 (Left)



L=429m Construction Period:17.2months

Tunnel-16 (Right)



L=215m Construction Period:13.3months

Figure 16.5-40 Construction Schedule Bar Chart (9/9)

16.5.12 Tunnel Operation and Maintenance

16.5.12.1 General

It is extremely important that tunnel facilities (equipment) be properly maintained to ensure efficiency and safety inside the tunnel. Traffic management is also necessary in the prevention and handling of accidents, as well as in assisting in the evacuation of tunnel users and minimize damages due to incidents/accidents inside the tunnel.

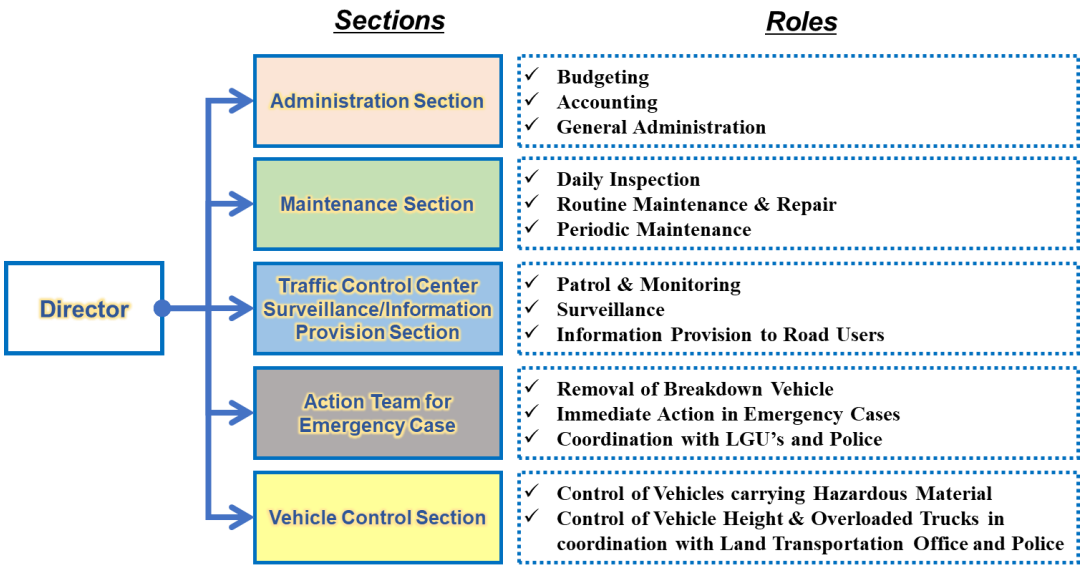
For safety operation inside tunnel, tunnel O&M activities consisting of inspection and maintenance of tunnel structures and facilities, monitoring of traffic movement, traffic accident, fire incident, immediate actions against incidents, vehicle control, etc. are carefully planned out. Since these O&M activities include different aspects from those of ordinary roads, establishment of a special organization: 'Tunnel Management Office' is necessary.

Major tunnel O&M activities are classified as follows:

- ✓ Inspection
- ✓ Maintenance; tunnel structure and facilities
- ✓ Monitoring of traffic movement, traffic accident, fire incident, etc.
- ✓ Immediate actions when some incidents are found or reported
- ✓ Vehicle Control (vehicles carrying hazardous materials, vehicle height, and overloaded trucks)

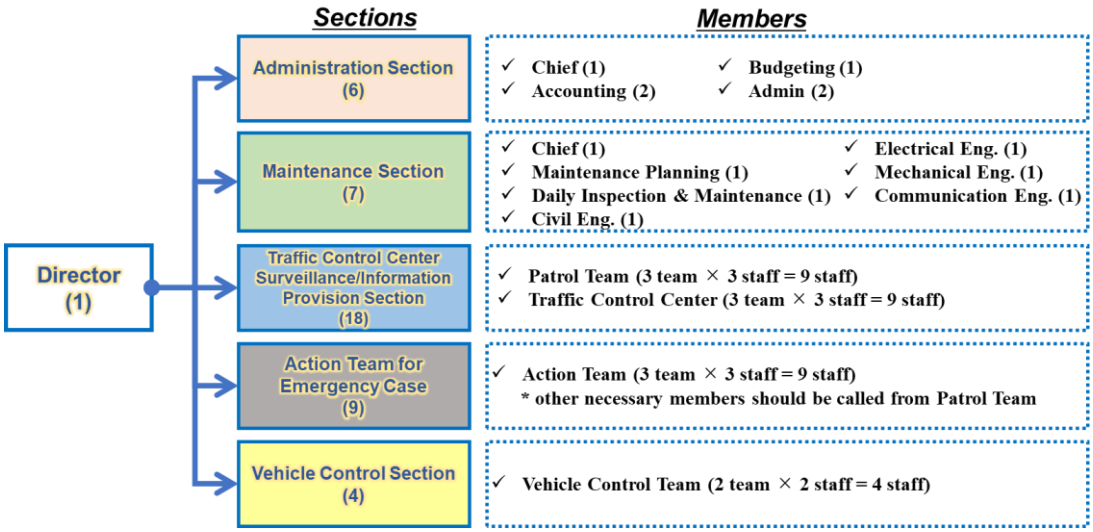
16.5.12.2 Tunnel O&M Organization

In order to assure safe operation inside the tunnel and to save road users' lives in case of critical incidents, a tunnel management office should be stablished. The proposed structure of the tunnel management office is shown in **Figure 16.5-41**. Proposed number of staff for the tunnel management office is fifty (50), comprising of one (1) Director, six (6) Chiefs and forty three (43) staff as shown in **Figure 16.5-42**.



Source: JICA Study Team

Figure 16.5-41 Proposed Organization of Tunnel Management Office



Source: JICA Study Team

Figure 16.5-42 Estimated Staff Requirements

16.5.12.3 Tunnel Inspection

Tunnel inspection should be undertaken daily by an inspection team, and the following items should be checked. Inspection items for civil work components and electrical/communication facilities are shown in **Table 16.5-15**.

- ✓ Facilities inside the tunnel such as lighting facility, jet fans, etc. are properly functioning.
- ✓ Cleanliness of the tunnel wall, road surface, facilities, etc.
- ✓ Any cracks on concrete lining and pavement, water seepage from concrete lining, etc.
- ✓ Drainage facility (no clogging, etc.)
- ✓ Deformation of the tunnel arch.
- ✓ Any other problems.

Table 16.5-15 Tunnel Inspection Items

Component			Inspection Items
Civil work Component	Pavement		(1) Surface roughness, (2) Cracks, (3) Joint failure, (4) Heaving, (5) Pumping, (6) Local settlement
	Tunnel Structure	Tunnel Portal	(1) Cracks, (2) Drainage, Water Flow, (3) Any deformation, (4) Slope condition
		Lining	(1) Cracks, (2) Leakage of water, (3) Free Lime, (4) Delamination, (5) Difference at a joint
		Interior Wall	(1) Damage, (2) Damages to the accessories
		Drainage	(1) Clogging, (2) Damage
Electrical/ Mechanical/ Communication Component	Jet Fans		Abnormal noise, vibration, cable connection and voltage. Interlocking with visibility index (VI) sensors and carbon dioxide (CO_2) sensors
	Lighting Facilities		Intensity of illumination. As for distribution board, checking abnormal heating, looseness and breaking of wire etc. by visual check and check with measuring instrument.
	Power receiving and distribution equipment and standby generator		Appearance (dirt, damage), looseness, breaking of wire, oil leakage, pipe damage, abnormal noise and vibration etc. by visual check and check with measuring instrument.

Component		Inspection Items
	Information collection and provision equipment	Performance, communication and appearance (dirt, damage) of each equipment. Facility/equipment which also defined as information collection and provision should be inspected.
	Emergency Equipment	Performance and appearance (dirt, damage) of each equipment. As for signal receiving and control board, abnormal noise and heating etc. are checked by visual check etc.

16.5.12.4 Tunnel Maintenance

Routine maintenance activities are summarized in **Table 16.5-16**. Routine maintenance should be implemented based on the findings of inspection and regular requirements.

Table 16.5-16 Tunnel Maintenance Activities

Component			Routine Maintenance Activity
Civil work Component	Pavement		(1) Crack sealing, (2) Joint repair, (3) repair of heaving, pumping and local settlement (4) Road surface cleaning
	Tunnel Portion	Tunnel Portal	(1) Crack sealing, (2) Cleaning of drainage facilities, (3) Repair of Slope protection work
		Lining	(1) Lining cleaning, (2) Crack sealing, (3) Water leakage prevention, (4) Reinforcement work for the cavity at the back of lining, (5) Joint repair, (6) Delamination repair
		Interior Wall	(1) Wall cleaning
		Drainage	(1) Drainage cleaning
Electrical/ Mechanical/ Communication Component	Jet Fans		(1) Cleaning, (2) Replacement of aged jet fan
	Lighting Facilities		(1) Cleaning, (2) Replacement of aged lighting facility
	All kinds of Signboards		(1) Cleaning, (2) Replacement of aged facility
	Fire Hydrant, Fire Detector, Fire Extinguisher, etc.		(1) Cleaning, (2) Functioning or not, (3) Replacement of aged facility
	CCTV, Emergency Equipment in Traffic Control		(1) Functioning or not, (2) Replacement of aged facility
	Other Equipment such as CO_2 sensor, Visibility Index Sensor		(1) Functioning or not, (2) Replacement of aged facility
	Standby Generator		(1) Functioning or not, (2) Fuel Amount, (3) Replacement of aged facility

16.5.12.5 Monitoring Traffic Movement, Traffic Accident, Fire Incidents, etc.

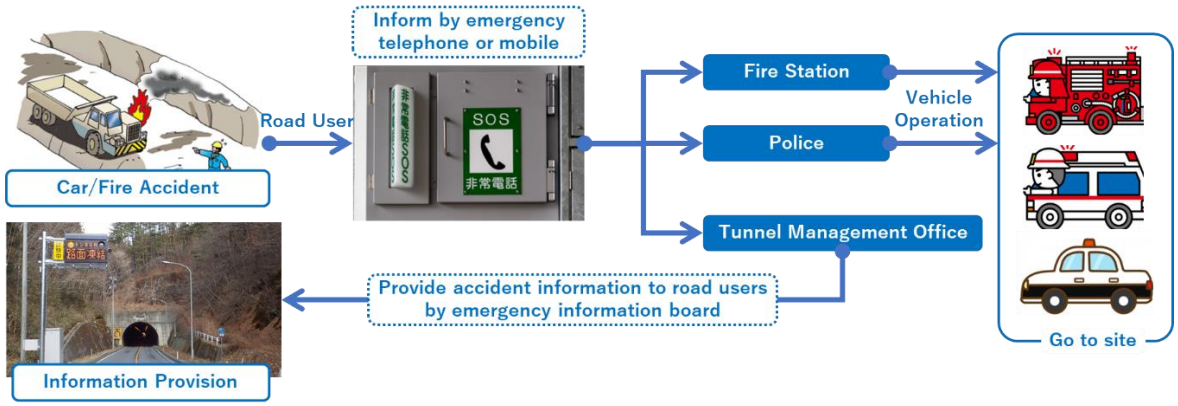
This work should be undertaken for 24-hours a day for 365 days a year. Traffic movements are monitored through CCTV and are reported by a patrol group and road users. Information from reporting shall be compiled at a traffic control center of the Tunnel Management Office, and necessary actions should be quickly considered and informed to proper agencies and the action team. Monitoring will be focused on reckless driving, overtaking, over speeding, stopped (stalled) or parked vehicles, vehicle breakdown, obstacles dropped from vehicles, car accident and fire accident. Information collected shall be properly recorded, and necessary information should be provided to road users through an emergency information board or a loudspeaker. Monitoring is quite important to assure safe operation of a tunnel and to protect road users' lives. Emergency actions should be made in accordance with the instructions of the head of the monitoring team.

16.5.12.6 Immediate Actions When Some Incidents are Found or Reported

The head of the monitoring team needs to take immediate decisions on what to do when some incidents are found or reported from road users including whether it is imminent to inform the Action Team, Fire Department and/or Police. Major possible incidents that can be anticipated inside a tunnel are as follows:

- ✓ Traffic accidents
- ✓ Fire break out
- ✓ Vehicle breakdown
- ✓ Objects fallen from vehicles
- ✓ Parked/stopped (stalled) vehicles

Actions to be taken during emergency cases are illustrated in **Figure 16.5-43**.



Source: JICA study team

Figure 16.5-43 Tunnel Emergency Actions

16.5.12.7 Vehicle Control

The following vehicles should not be allowed to use the tunnel, thus these vehicles should be controlled before entering the tunnel;

- ✓ Motorbikes – high incidence of traffic accident
- ✓ Vehicles carrying hazardous materials – when these get an accident or fire, it will be disastrous to people and tunnel facilities
- ✓ Overloaded trucks – high risk of vehicle breakdown
- ✓ Vehicles of which height is higher than the limit (5 m) – these will damage jet fans and other facilities.

16.5.12.8 Equipment Needed for Tunnel O&M

Table 16.5-17 shows the equipment needed for tunnel O&M.

Table 16.5-17 Tunnel O&M Equipment

Equipment		No. of Unit
Maintenance Work	Road Sweeper	1
	Wall Cleaning Vehicle	1
	Water Supply Equipment for Cleaning	1
	Aerial Work Platform	1
	Station Wagon	1
	Inspection Machinery and Tools	1 set

Equipment		No. of Unit
Traffic Monitoring and Information Provision	Tunnel Monitoring Facilities	1 set
	Patrol Car	2
	Traffic Control Devices	1 set
Emergency Case	Towing Vehicle	2
	Air Jack	2
	Truck for Transport of Air Jack	2
	Fire Truck	2
	Ambulance Car	2
Vehicle Control	Weight Scale (Mat Type)	2
	Height Restricting Device (Gate Type)	2

16.5.12.9 Tunnel O&M Cost Estimation

Tunnel O&M cost is shown in **Table 16.5-18**.

Table 16.5-18 Tunnel O&M Cost

Items		Cost (PhP Million /Year)
Tunnel Management Office	Staff Cost	21.9
	Office Running Cost	1.1
Electricity Cost	Tunnel Lighting	42.1
	Emergency Facilities	58.9
	Electric Room	15.8
Maintenance Work/ Parts Replacement		7.2
Total		**147.0**

16.6 Preliminary Bridge Design

16.6.1 Applicable Bridge Standards

The following are the applicable codes, specifications and references for the bridge design:

1) DPWH Design Guidelines, Criteria and Standards Volume V, 2015 (DGCS)
2) DPWH LRFD Bridge Seismic Design Specifications, 1st Edition, 2013 & Interim Revision 2019 (BSDS)
3) AASHTO LRFD Bridge Design Specifications 8th Edition, 2018
4) AASHTO LRFD Bridge Construction Specifications 3rd Edition, 2016
5) Specifications for Highway Bridges 2017, Japan Road Association

16.6.2 Summary of Design Results

Figure 16.6-1 shows the summary of Bridge Plans.

Table 16.6-1 Summary of Bridges

	Number of bridges		Total Length (m)	
	Integrated Section	**Separate Section**	**Integrated Section**	**Separate Section**
PC Hollow Slab	---	1	---	330
PSCG – AASHTO Girder	5	18	1,340	3,785
PC Box Girder	3	4	730	815
Steel Narrow Box Girder	1	---	280	---
Steel Truss Girder	---	1	---	210
Subtotal	9	24	2,350	5,140
Total		**33**		**7,490**

Source JICA Study Team

Table 16.6-2 Summary of Preliminary Design Results

No	Bridge Name	A1 (Sta.)	A2 (Sta.)	L (m)	Type of Bridge	Integrated/ Separated	Nos. of Span	Span Arrangement (m)
1	Br-1-1	0 + 5	0 + 225	220	PC Box	Integrated	4	45 + 65 + 65 + 45
2	Br-1-2	0 + 225	0 + 585	360	PSCG	Integrated	9	9 x 40
3	Br-2	1 + 290	1 + 770	480	PSCG	Separated	12	12 x 40
4	Br-3-1	2 + 537	2 + 887	350	PC Box	Separated	6	45 + 65 + 65 + 65 + 65 + 45
5	Br-3-2	2 + 887	3 + 7	120	PSCG	Separated	3	40 + 40 + 40
6	Br-3-3	3 + 7	3 + 337	330	PC Hollow	Separated	11	11 x 30
7	Br-4	3 + 530	3 + 620	90	PSCG	Separated	3	30 + 30 + 30
8	Br-5-1	4 + 521	4 + 721	200	PSCG	Separated	5	40 + 40 + 40 + 40 + 40
9	Br-5-2	4 + 721	4 + 981	260	PC Box	Integrated	5	40 + 60 + 60 + 60 + 40
10	Br-6	5 + 80	5 + 220	140	PSCG	Integrated	4	30 + 40 + 40 + 30
11	Br-7	5 + 790	6 + 40	250	PC Box	Integrated	5	50 + 50 + 50 + 50 + 50
12	Br-8-1	6 + 884	7 + 34	150	PC Box	Separated	3	50 + 50 + 50
13	Br-8-2	7 + 34	7 + 174	140	PSCG	Separated	4	30 + 40 + 40 + 30
14	Br-9	8 + 318	8 + 528	210	S-Truss	Separated	6	60 + 90 + 60
15	Br-10	9 + 396	9 + 756	360	PSCG	Separated	9	9 x 40
16	Br-11	12 + 226	12 + 386	160	PC Box	Separated	3	45 + 70 + 45
17	Br-12	13 + 208	13 + 448	240	PSCG	Separated	6	40 + 40 + 40 + 40 + 40 + 40
18	Br-13	14 + 348	14 + 448	100	PSCG	Separated	3	30 + 40 + 30
19	Br-14-1	15 + 229	15 + 384	155	PC Box	Separated	3	45 + 65 + 45
20	Br-14-2	15 + 384	15 + 584	200	PSCG	Separated	5	40 + 40 + 40 + 40 + 40
21	Br-15	16 + 16	16 + 121	105	PSCG	Separated	3	35 + 35 + 35
22	Br-16	16 + 772	16 + 892	120	PSCG	Separated	3	40 + 40 + 40
23	Br-17	17 + 750	18 + 10	260	PSCG	Separated	7	30 + 40 + 40 + 40 + 40 + 40 + 30
24	Br-18-1	18 + 212	18 + 972	760	PSCG	Separated	19	19 x 40
25	Br-18-2	18 + 972	19 + 112	140	PSCG	Integrated	4	35 + 35 + 35 + 35
26	Br-18-3	19 + 112	19 + 552	440	PSCG	Integrated	11	11 x 40
27	Br-18-4	19 + 552	19 + 692	140	PSCG	Integrated	4	35 + 35 + 35 + 35
28	Br-18-5	19 + 692	19 + 812	120	PSCG	Integrated	3	40 + 40 + 40
29	Br-18-6	19 + 812	20 + 92	280	S-Girder	Integrated	4	70 + 70 + 70 + 70
30	Br-18-7	20 + 92	20 + 182	90	PSCG	Separated	3	30 + 30 + 30
31	Br-18-8	20 + 182	20 + 382	200	PSCG	Separated	5	40 + 40 + 40 + 40 + 40
32	Br-19	21 + 190	21 + 350	160	PSCG	Separated	4	40 + 40 + 40 + 40
33	Br-20	21 + 977	22 + 137	160	PSCG	Separated	4	40 + 40 + 40 + 40

Source JICA Study Team

16.6.3 Design Condition

16.6.3.1 Used Topographic Maps and Geotechnical Data

The topographic and geotechnical data used in this study are shown below.

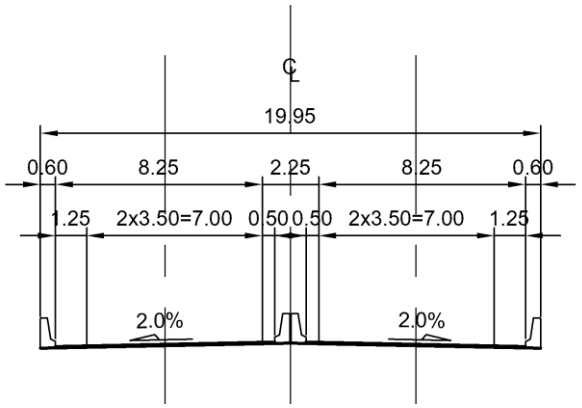
(1) Topographic Data

At this stage, existing topographic data could not be obtained. For this reason, the topographic data used were from contour maps converted from Geographic Information System (GIS) data.

(2) Geotechnical Data

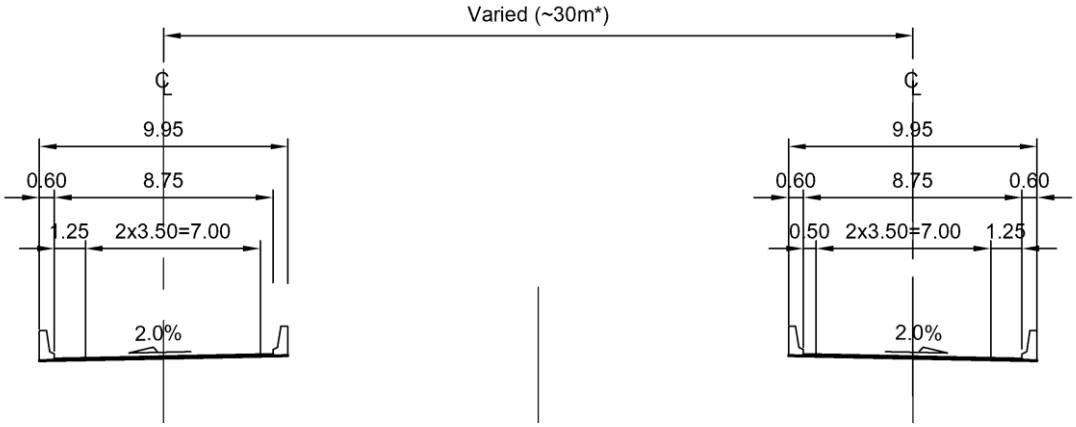
At this stage, existing geological data could not be obtained.

16.6.3.2 Typical Cross Section for Bridge



Source JICA Study Team

Figure 16.6-1 Typical Cross Section at Integrated Section



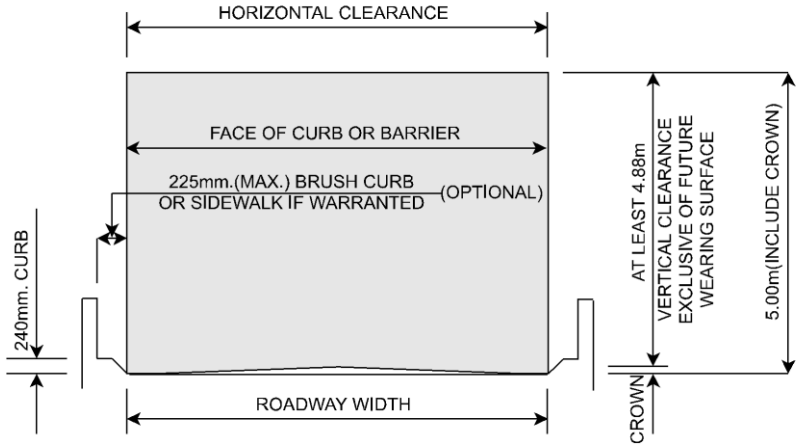
Source JICA Study Team

Figure 16.6-2 Typical Cross Section at Separated Section

16.6.3.3 Clearances

(1) Highway

According to DGCS, the minimum vertical clearance for bridges is 4.88 m, hence, the bridge vertical clearance for this project is determined at 5.0 m.



Source JICA Study Team

Figure 16.6-3 Bridge Clearance (Source: DGCS)

(2) Overpass/ Underpass

The clearance of Overpass / Underpass that intersects the mainline is the same as in **Figure 16.6-3**.

16.6.3.4 Crossing Elements

Tables below present the lists of crossing elements at different stations.

Table 16.6-3 List of Crossing Elements (1/3: Sta 0+000 – 6+800)

No	Station	Element	Skew (deg.)		Original Width (mm)	Projected Width (mm)	Related Structure	
1	0 + 160	Road	R	55	3500	6000		
2	0 + 300	River		0	4000	4000		
3	0 + 420	Road		0	3000	3000	Br1	
4	0 + 485	Road	R	30	6000	7000		
5	0 + 535	Road	L	30	2000	2000		
6	1 + 145	Road	L	65	5000		OV1	
7	1 + 335	Balley	L	15				
8	1 + 470	Balley		0				
9	1 + 585	Road	R	20	2500	3000	Br2	
10	1 + 625	Road	R	15	7500	8000		
11	1 + 725	Road	R	45	7000	10000		
12	2 + 670	River	L	30	20000	23000		
13	2 + 800	Road	L	50	13500	21000	Br3	
14	3 + 30	Road	L	15	7000	7000		
15	3 + 135	Ramp	L	30	18000	21000		
16	3 + 575	Road	L	15	1000	1000		
17	3 + 580	Balley	L	20			Br4	
18	3 + 615	Road		0	1000	1000		
19	4 + 670	Road		0	6000	6000		
20	4 + 780	Road	L	15	3500	4000	Br5	
21	4 + 790	River	L	20	6000	6000		

OV: Overpass, UP: Underpass

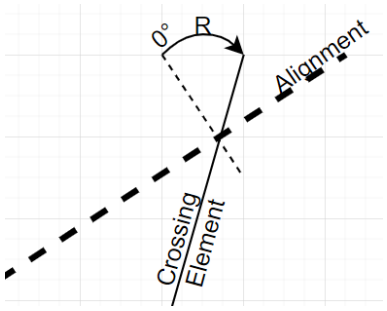
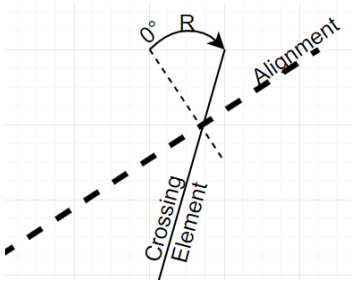


Table 16.6-4 List of Crossing Elements (2/3: Sta 6+800 – 17+000)

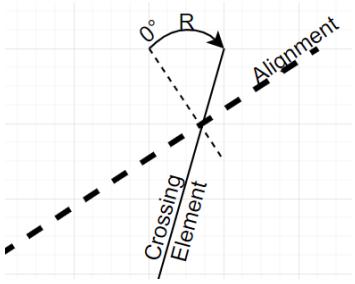
No	Station			Element	Skew	(deg.)	Original Width (mm)	Projected Width (mm)	Related Structure	
22	5	+	170	Road		0	5000	5000	Br6	
23	5	+	220	Road	L	30	5000	6000		Relocate
24	5	+	875	Road	R	30	7000	8000	Br7	
25	5	+	900	Balley	R	30				
26	6	+	405	Road	L	25	1000	1000	UP1	
27	6	+	765	Ramp	L	10	11000	11000	UP2	
28	6	+	950	Road	R	20	7000	7000	Br8	
29	7	+	20	Road	R	25	3000	3000		
30	8	+	470	Balley	R	40			Br9	
31	8	+	490	Road	R	30	5000	6000		
32	9	+	580	Balley	L	60			Br10	
33	9	+	630	Balley	R	50				
34	9	+	660	Balley	R	30				
35	9	+	950	Ramp	L	25	3500	4000	UP3	
36	9	+	980	Ramp	R	10	3500	4000	UP4	
37	10	+	375	Road	R	50	3500	5000	OV2	
38	10	+	910	Road		0	10500	11000	OV3	
39	12	+	265	Road		0	5000	5000	Br11	
40	12	+	295	River	L	55	6500	11000		Relocate
41	12	+	360	River		0	6500	7000		Relocate
42	13	+	270	Road	L	15	5500	6000	Br12	Relocate
43	13	+	375	River	R	30	3000	3000		
44	14	+	390	River	R	35	3000	4000	Br13	
45	14	+	395	Road	R	40	3500	5000		
46	14	+	430	Ramp	R	35	7000	9000		
47	14	+	265	Ramp	L	25	3500	4000	Br14	
48	14	+	275	Balley	L	60				
49	14	+	335	Balley	L	15				
50	14	+	540	Balley		0				
51	16	+	40	Road		0	5000	5000	Br15	
52	16	+	80	River		0	3000	3000		



OV: Overpass, UP: Underpass

Table 16.6-5 List of Crossing Elements (3/3: Sta 17+000 – 24+000)

No	Station			Element	Skew	(deg.)	Original Width (mm)	Projected Width (mm)	Related Structure	
53	16	+	825	Balley	L	25			Br16	
54	16	+	885	Road	L	30	6000	7000		
55	17	+	825	Road		0	3000	3000	Br17	
56	17	+	890	River	R	30	8500	10000		
57	17	+	915	Road		0	6000	6000		
58	17	+	950	Road	R	15	6000	6000		Relocate
59	17	+	990	Road	L	15	6000	6000		Relocate
60	18	+	65	Road	L	25	6000	7000	OV4	
61	18	+	260	Road	L	40	6000	8000	Br18	
62	18	+	640	Road	L	35	6000	7000		
63	18	+	700	Road		0	6000	6000		
64	18	+	740	Road		0	6000	6000		
65	18	+	960	Road	L	30	5000	6000		
66	19	+	95	Road	R	20	5000	5000		
67	19	+	295	Road	R	25	5000	6000		
68	19	+	360	Road	R	50	6000	9000		Relocate
69	19	+	375	Road	L	25	3000	3000		Relocate
70	19	+	540	Road		0	7000	7000		
71	19	+	825	Ramp	L	40	12000	16000		
72	19	+	855	River	L	45	12000	17000		
73	19	+	925	Road	L	30	11000	13000		Relocate
74	19	+	930	Road	R	40	12000	16000		
75	20	+	70	Entrance	L	40	20000	26000		
76	20	+	355	Road	R	15	5000	5000		
77	21	+	80	Road	L	75	3000	12000	Br19	Relocate
78	21	+	270	Balley	L	35				
79	21	+	345	Road	L	15	5500	6000		
80	22	+	65	Balley	R	20			Br20	
81	23	+	960	Road		0	7000	7000	UP5	



OV: Overpass, UP: Underpass

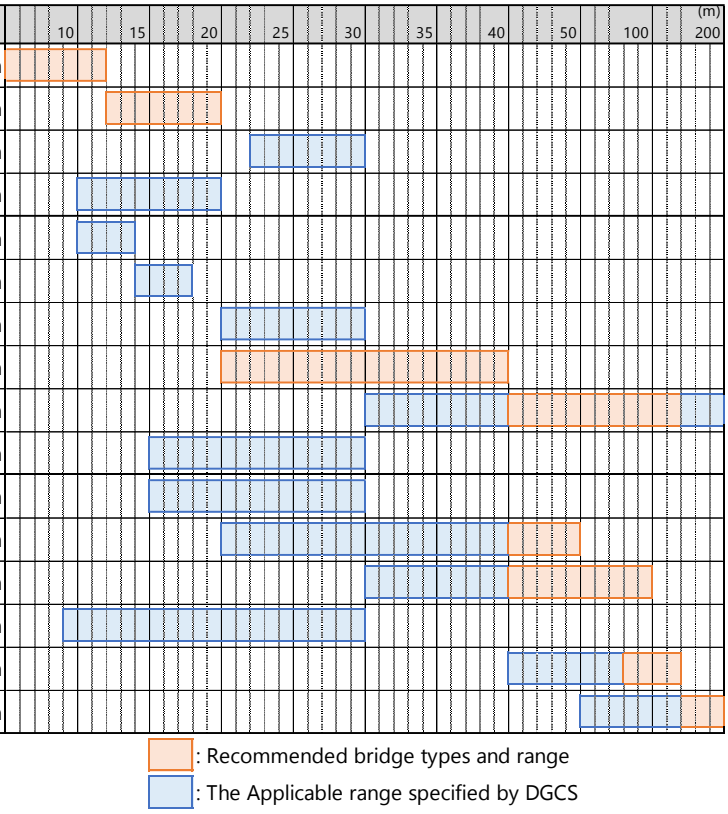
16.6.4 Preliminary Design for Bridges

(1) Extraction of the Alternative of the Superstructure

Since the main bridge covers almost the entire area of the strait, the approach bridge will be only on land and shallow water. At the approach bridge part, there is no intersecting structure and the road alignment is almost straight, hence, the generally applied PSCG is adopted.

Table 16.6-6 Applicable Span for Each Bridge Type

Materials	Type of Bridge	Range
RC	Precaset Slab, Flat Slab	6- 12m
	Concrete Deck Girder (RCDG)	13- 20m
	Box Girder	22- 30m
	Hollow Slab Bridge	10- 20m
PC	Channel beams	11- 14m
	Tee beams	15- 18m
	I-beams	21- 30m
	AASHTO girder (PSCG)	20- 40m
	Box girders	30-200m
	Hollow (voided) slab	15- 30m
Steel	I-beams	15- 30m
	Plate girder	20- 50m
	Box girder	30-100m
	Bailey bridge	9- 30m
	Truss	40-130m
	Arch	50-400m



(2) Substructure and Foundation Type

The substructure is a RC structure. For the foundation, the Sinso-caisson of the large diameter foundation piles shall be used and the pile length is assumed to be 10 m.