CHAPTER 7. STUDY ON AN APPROPRIATE ALTERNATIVE ROUTE

7.1 Introduction

7.1.1 Issues on the Intersections for Study

Koteshwor Intersection is on the southwest side of TIA, in the middle of Kathmandu Valley. It is one of the most congested intersections in the area, as Araniko Highway, a major arterial road connecting the city center of Kathmandu with Bhaktapur District on the east side, meets Ring Road (RR) at this intersection. RR is another major road in the valley, running along the outskirts of the populated area in Kathmandu and Lalitpur Districts. These two roads are overlapped at the section from Koteshwor intersection to Tinkune intersection, which is located at north of Koteshwor intersection with approximately 600m(hereinafter called “Connecting Road”). The locations of these intersections and major arterial roads: RRN, Araniko Highway show in Figure 7.1.1.

Jadibuti Intersection, where Pepsi Cola Road connects with Araniko Highway, is only about 400 m south of the Koteshwor Intersection. The Araniko Highway links to the Singhar Durbar area, which has many public offices, the New Road area, which has many businesses, and the Thamel area, which has many tourism facilities.

Thus, major issues on the Study intersections are following;

- The two busy roads that meet at the Koteshwor Intersection
- The low capacity of the road section and the Connecting Road between the two intersections due to duplication and many conflict points
- The proximity of three busy intersections to each other

Source: JICA Survey Team

Figure 7.1.1 Location Map of the Study Area

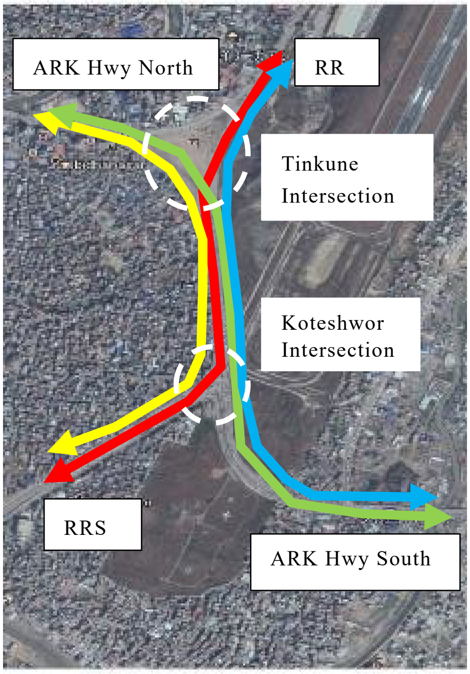
7.1.2 Grade-Separated Structure Direction

The Study on the grade-separated structure shall be conducted in order to improve traffic flow and ease congestion from the Koteshwor Intersection to the Tinkune Intersection through the Connecting Road. Four (4) alternative routes have been identified in the Pre-survey, as shown in Figure 7.1.2. Note that the route north of Koteshwor Intersection is named RRN, and the route southwest is named RRS.

Alternative 1: Direction between RRS and RRN (Red Color Line in Figure 7.1.2)

Alternative 2: Direction between RRS and ARK Hwy North (Yellow Color Line in Figure 7.1.2)

Alternative 3: Direction between RRN and ARK Hwy South (Blue Color Line in Figure 7.1.2)



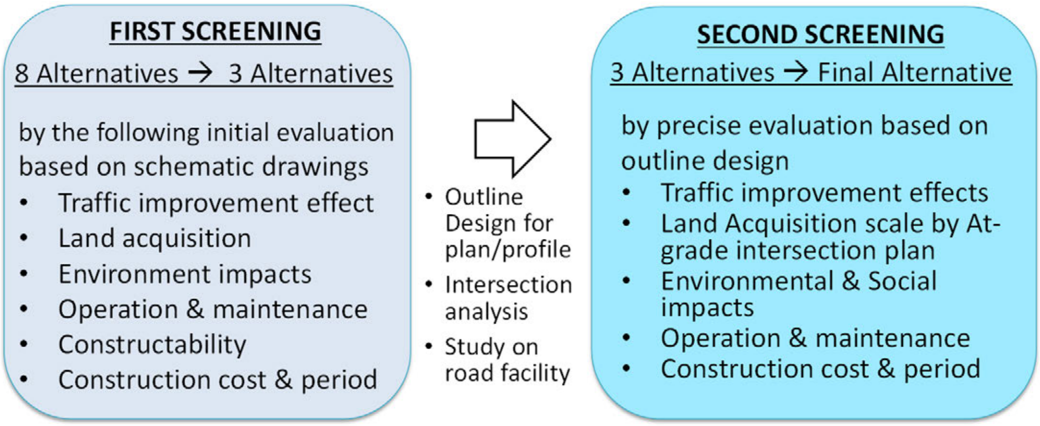
Source: JICA Survey Team

Figure 7.1.2 Alternatives for Grade-Separated Direction

Alternative 4: Direction between ARK Hwy North and ARK Hwy South (Green Color Line in Figure 7.1.2)

7.1.3 Selection Procedure of the Optimal Alternative Route

The selection procedure for the optimal alternative is in Figure 7.1.3.



Source: JICA Survey Team

Figure 7.1.3 Selection Procedure

7.1.4 Available Land for the At-Grade Intersection Improvement

(1) Background

A study on the improvement of the at-grade intersection was carried out from August to November 2022 to determine the optimal alternative route with the following two (2) points:

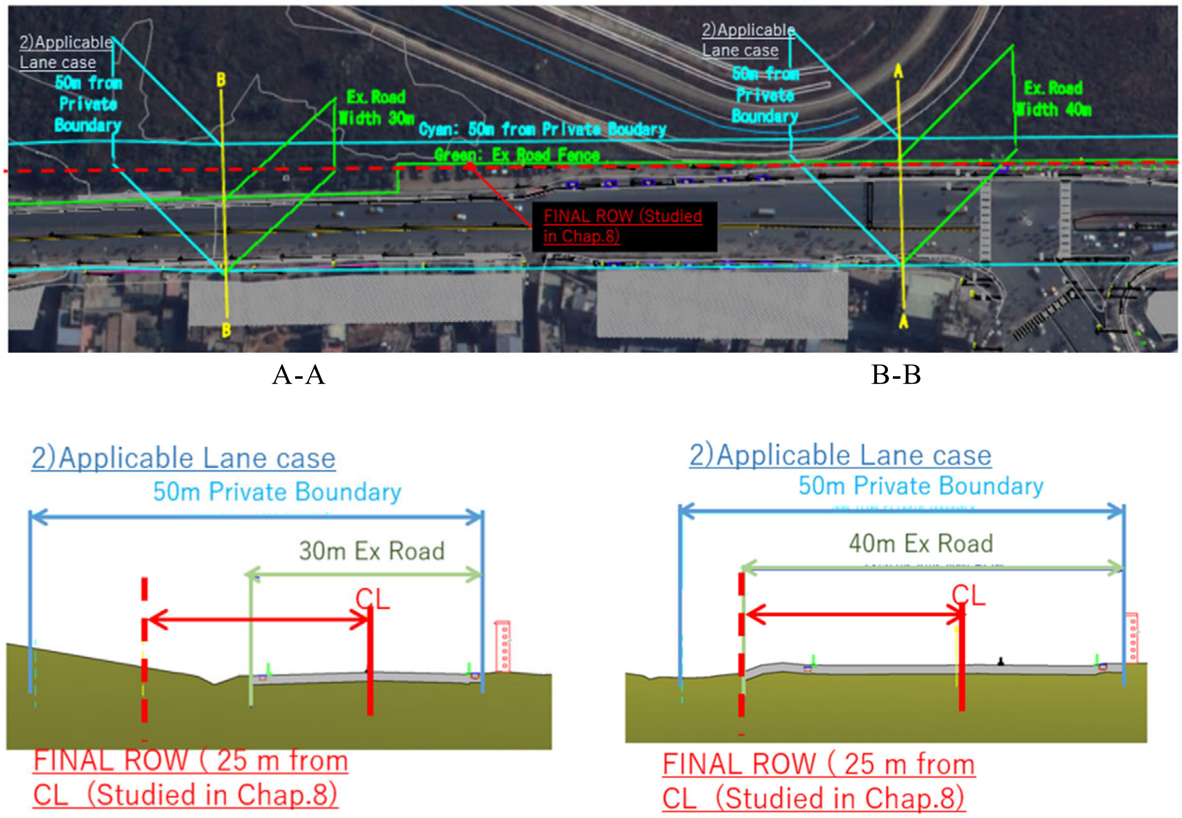
1) Ideal Lane Layout (not limited to ROW)
2) Applicable Lane (within 50m of ROW)

The Connecting Road section between the Tinkune Intersection and Koteshwor Intersection is essential to maximize the improvements from the Project because two major roads overlap at this section despite its narrow road width.

Although the government gazette lists ROW for the RR as 50 m (25 m each from the centerline,) the actual road reserve in the Connecting Road section is approximately 30 - 40 m.

Since the land condition was indeterminate in this stage of alternative study as of December 2022, JST had proposed 2case; i) ideal case securing required lane to meet design LOS with no land constraint, ii) Applicable Lane case assigning lanes within ROW of 50m from private land boundary.

Further communication on the available land for the Project took place in December 2022 among the Office of the Prime Minister and Council of Ministers, MOPIT, and CAAN. These parties wanted to clarify the land available for the Project, concluding that the available land for Project was within ROW (50m width,) excluding the Connecting Road section. For connecting road section, available land is 25m from the centerline of the Araniko Highway to the TIA side, almost to the existing fence of the bus section, as shown in Figure 7.1.4. The available width of Connecting Road is approximately 40m.



Source: JICA Survey Team

Figure 7.1.4 ROW

(2) Assumptions on Available Land for Route Alternative Selection and Outline Design

Assumptions for the alternative route selection are as follows, accounting for the factors above:

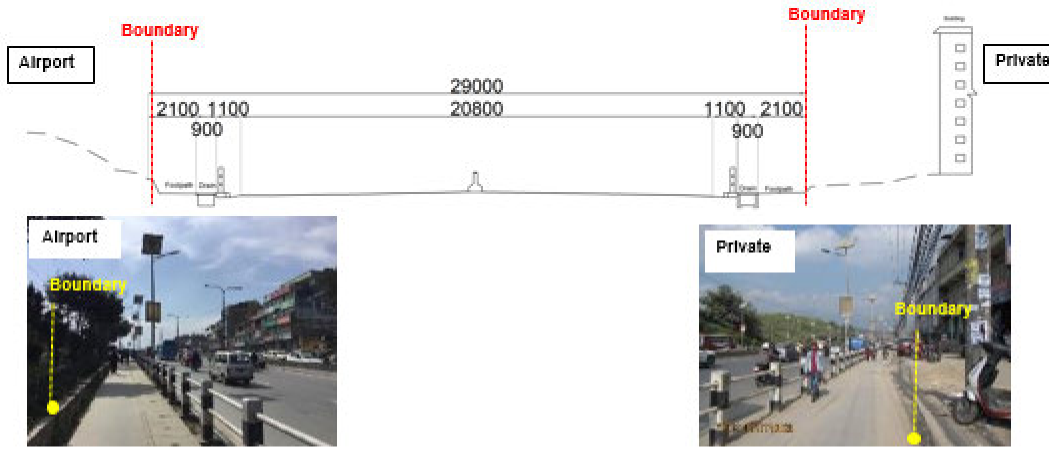
- The First Screening and Second Screening (Final Selection) prepared in Chapter 7 2case are studied; i) ideal case securing required lane to meet design LOS with no land constraint, ii) Applicable Lane case assigning lanes within ROW of 50m from private land boundary.
- For the outline design described in Chapter 8, available land for the Project is set at 25m from the centerline of the Araniko Highway to TIA side, as agreed upon by the related ministries in December 2022.

Although JST proposed the target LOS of D for the Project roads in Chapter 6, the Study result could not achieve its target due to narrower available land for the at-grade road sections near the Koteshwor Intersection. JST recommend increasing the traffic lane numbers to improve LOS when additional land becomes available in the future.

7.1.5 Current Condition of the Study Area as of 2023

(1) Connecting Road Section

The Connecting Road section, an overlapping section between RR and Araniko Highway, is sandwiched by private land with buildings in the west and TIA territory in the east. The narrowest width of the Connecting Road section is approximately 30 m, as shown in Figure 7.1.5.



Source: JICA Survey Team

Figure 7.1.5 Existing Width of Connecting Road Section

(2) Section Near Koteshwor Intersection

The road width near the Koteshwor Intersection is more spacious by approximately 40 m than the Connecting Road section shown in Figure 7.1.6. Bus bays and a track parking station are on the border area with TIA.

Source: JICA Survey Team

Figure 7.1.6 Existing Road Width around the Koteshwor Intersection

(3) Road Section between Koteshwor and Jadibuti Intersection

Although the existing width of the six-lane road section between Koteshwor and Jadibuti Intersections is about 44m, as shown in Figure 7.1.7, widening work added another two lanes to the south, completed in mid-2022.

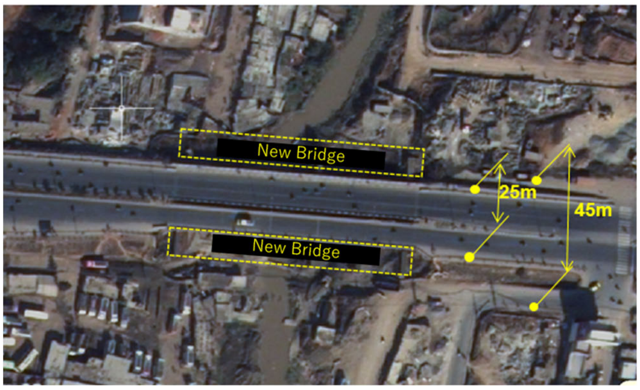
Source: JICA Survey Team

Figure 7.1.7 Road Section between Koteshwor and Jadibuti Intersections

(4) Araniko Highway South

The existing road width of Araniko Highway South is approximately 25 m, with four lanes in both directions.

Araniko Highway has a designated ROW of 45 m, accommodating a maximum of eight lanes. A widening project completed two bridges across the Manohara River in 2022, which increased the lanes from four to eight at the river crossing point. However, construction of the frontage road sections connecting the Manohara River Bridge to the Jadibuti Intersection has not started yet. DOR awaits project progress.

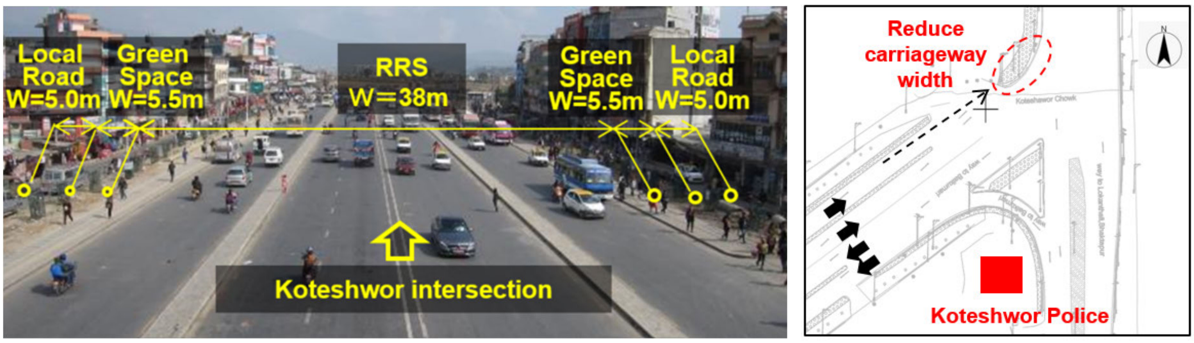


Source: JICA Survey Team

Figure 7.1.8 Existing Road Width of Araniko Highway

(5) Ring Road South

The existing road width of RRS is approximately 38 m, including the medians, local roads, and green spaces on both sides of the main carriageway. The 2018 RRS widening created a four-lane main carriageway, a two-lane frontage road, and a pedestrian bridge funded by China. However, the private land populated by buildings reduces the ROW at the upper west corner of the Koteshwor Intersection, as shown in Figure 7.1.9. The DOR could not acquire this area for the road improvement project undertaken by JICA.



Source: JICA Survey Team

Figure 7.1.9 Existing Width of Ring Road South

(6) Ring Road North

The existing road width of the RRN is approximately 20 m across four lanes. The DOR created a study for widening the RRN. However, the implementation schedule of the Project is still not fixed. Figure 7.1.11 shows the future shape of the RRN.

Source: JICA Survey Team

Figure 7.1.10 Existing Width of Ring Road North

Typical Cross Section of Proposed Road

5.2.3 Design Criteria

The design criteria adopted in the design is shown in Table 5-1.

Table 5-1 : Design Criteria

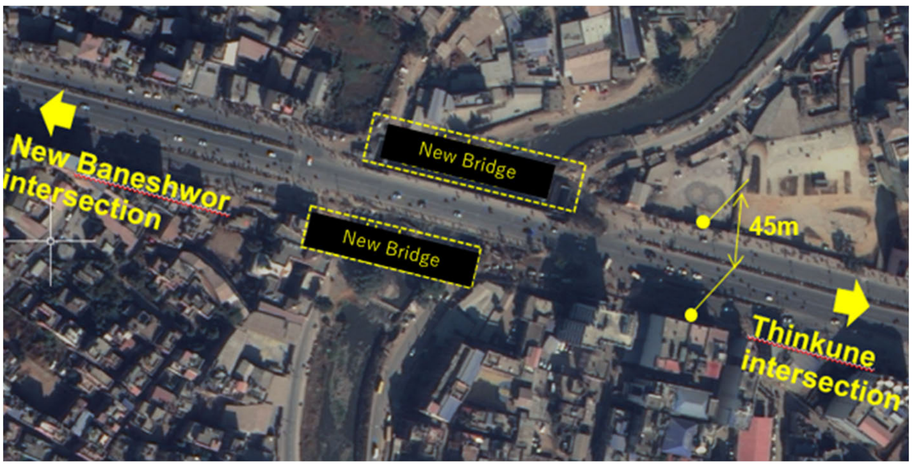
S.N	Design Parameter	Double Lane
1	Design Speed	40 kmph
2	Right of Way	31m (On either side)
3	Carriageway Width	2 x 15.0 m
4	Total Formation Width	62.0 m
5	Median Width	3 m

Source: Detailed Engineering Survey. Design of Road & Report Preparation of Tilganga-Teenkune 8-Lane Ring Road Improvement Project, DOR, November 2019

Figure 7.1.11 Typical Cross-section and Design Criteria of the Widening Project of RRN

(7) Araniko Highway North

Tribhuvan Highway North obtained improvements with a four-lane main carriageway, two-lane frontage roads, and a footpath on two sides, totaling approximately 45m in width. However, the bridge crossing at the Bagmati River remains at four lanes as of June 2023. According to DOR, the construction of additional side bridges with two lanes each is under preparation and will be completed within approximately three years.



Source: JICA Survey Team

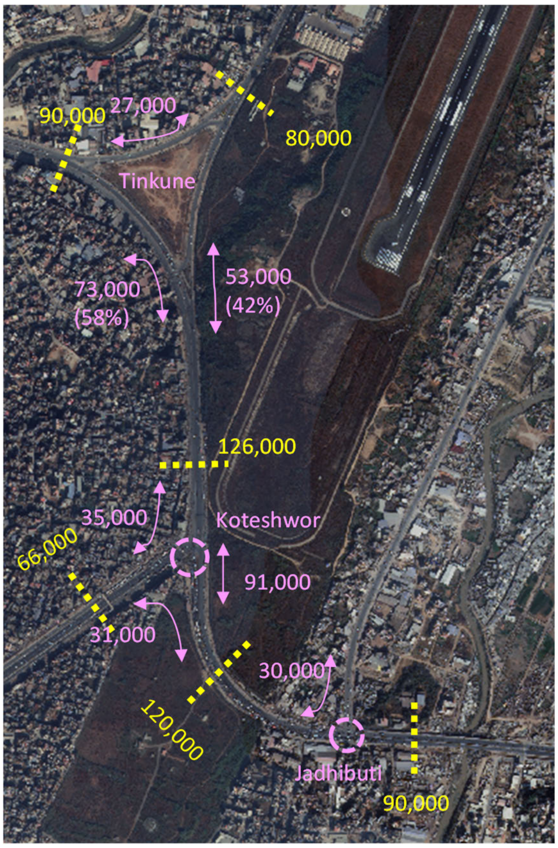
Figure 7.1.12 Existing Width of Araniko Highway North

7.1.6 Current Situation of Project Intersections

(1) Current Traffic Volume

Figure 7.1.13 show current traffic flows at the Project intersections and roads. Observable characteristics of the current traffic flows are:

- Peak hours of 9:00 to 10:00 in the daytime and 17:00 to 18:00 at nighttime
- K-Value (Peak ratio): 10.0%
- D-Value (Traffic volume ratio by direction): 50.6%
- Share of Heavy Vehicles:14.5%
- Motorcycles: 58.8%
- Traffic volume on Araniko Highway South is approximately 90,000 pcu per day.
- Around 30,000 pcu per day passes by Jadibuti Intersection to and from Pepsi Cola Road.
- Traffic volume on RRS is about 66,000 pcu per day.
- Traffic to and from Connecting Road and Araniko Highway South dominates the Koteshwor intersection.
- Traffic volume to and from Araniko Highway North is higher than traffic to and from the RRN (58% vs. 42%) at the Tinkune intersection.



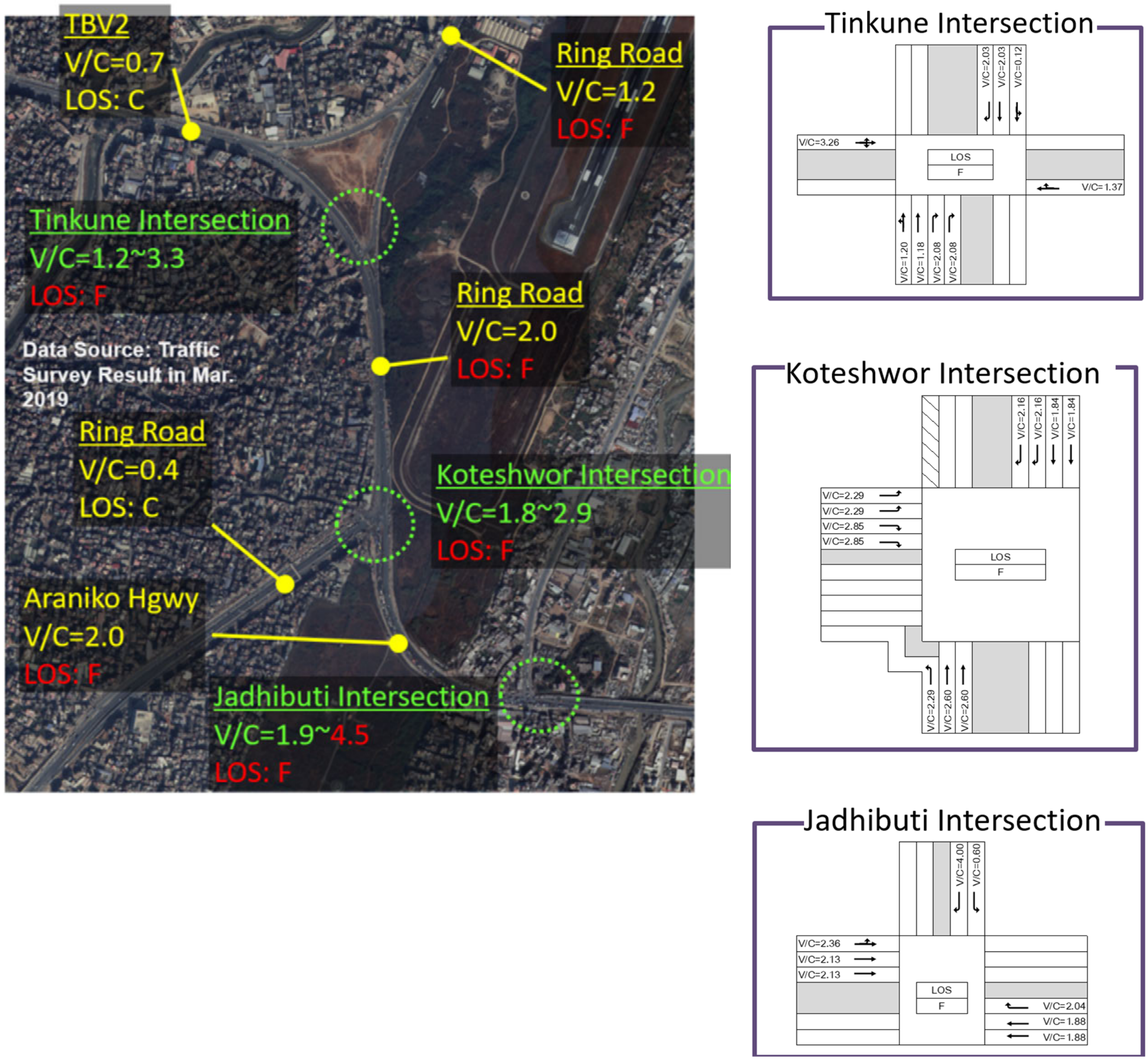
Unit: PCU/day
Source: Traffic Count Survey Result in March 2019
Figure 7.1.13 Current Traffic Volume

The traffic flow analysis in the project area indicates dominant traffic flow to and from Araniko Highway South coming to and from Araniko Highway North.

(2) Traffic Analysis Based on Current Traffic Volume

The current traffic volumes mentioned above necessitate a quantitative evaluation of congestion levels for the Project Road sections and intersections by Volume-to-Capacity Ratio (V/C) and Level of Service (LOS) during the peak hours in Figure 7.1.14. An interpretation of the LOS is in Chapter 6.1.2, and LOS of F means Forced or Breakdown of Traffic Flow, representing the worst service level.

A V/C of more than 1 means traffic volume on the road section exceeds its road capacity, representing saturation.



Source: JICA Survey Team

Figure 7.1.14 Evaluation of Existing Road Segments and Intersections in the Project Area

Here are clarifications and findings from the analysis above:

- Road segments run beyond capacity except for ARK Hwy North and RRS.
- All noted intersections, Tinkune, Koteshwor, and Jadibuti, are also beyond capacity, and their congestion levels are grave.
- V/Cs of the Connecting Road and ARK Hwy are 2.0 or more. Lowering their V/C to less than 1.0 requires double the number of lanes in their road segments.

The findings conclude that applying grade separation to improve road capacity is essential to ease the traffic congestion on the Project roads and intersections.

7.2 Target Intersection Improvement Approach

7.2.1 Target Improvement Area for the Project

Based on the results and recommendations from the JICA 2018-2019 Pre-survey and the traffic analysis results above, the target improvement area for the Project should at least include Tinkune, Koteshwor, and preferably the Jadibuti Intersection. These inclusions are necessary as LOS of F already saturates Jadibuti Intersection F, and it is possible to cover it depending on the alternative route.

7.2.2 Improvement Method by Grade Separation: Single (One-by-One or Continuous Application?)

There are two methods to develop the grade separation methods: One-by-One Improvement by single grade separation or Continuous viaduct over several intersections. To discuss this matter, following two features of the project area should be considered:

- The proximity of the study intersections, which is approximately 400-600 m only, with the second one in a hilly topography along the three Project intersections. The Koteshwor intersection is at its peak.
- The Tinkune and Jadibuti Intersections are at the bottom, with an elevation difference of about 12 m.

Considering the two features of the Project area, the continuous application of grade separation to the Study intersections is more suitable for the following reasons:

- Since the Project intersections are saturated close to each other, improvement by continuous (plural) grade separation through two or three project intersections is desirable. Improving Project intersections one by one will not mitigate traffic congestion and will prevent them from accommodating future traffic volumes due to proximity.
- In case of applying a one by one improvement approach, weaving sections where opportunities to merge and diverge are close between each intersections. A weaving section is generally a black spot in traffic safety. Due to the existing layout of the Project intersections and topographical constraints, the weaving section needs to be provided at a short interval. Therefore, one by one improvement approach cannot recommend for traffic safety.

7.2.3 At-Grade Intersection Type

In this sub-section, the following at-grade intersection types are compared: A signalized intersection and a roundabout. Conclusion is that the Project at-grade intersection must be the signalized type from the results of several studies and analyses below.

(1) Traffic Capacity Aspect

See a general roundabout design guide below, based on statistical data and meeting US guidelines in Roundabouts: An Informational Guide Second Edition (NCHRP Report 672, FHWA). Figure 7.2.1 shows the relationship between traffic volume and the diameter of a roundabout.

The predicted future traffic volumes for the Project intersections reach approximately 70,000 vehicles per day, which does not correspond to any category in Figure 7.2.1. This incongruence means that roundabouts are generally incapable of serving the future traffic needs of the Project intersections.

Roundabouts: An Informational Guide

Exhibit 1-9
Roundabout Category Comparison

Design characteristics of the three roundabout categories.

Design Element	Mini-Roundabout	Single-Lane Roundabout	Multilane Roundabout
Desirable maximum entry design speed	15 to 20 mph (25 to 30 km/h)	20 to 25 mph (30 to 40 km/h)	25 to 30 mph (40 to 50 km/h)
Maximum number of entering lanes per approach	1	1	2+
Typical inscribed circle diameter	45 to 90 ft (13 to 27 m)	90 to 180 ft (27 to 55 m)	150 to 300 ft (46 to 91 m)
Central island treatment	Fully traversable	Raised (may have traversable apron)	Raised (may have traversable apron)
Typical daily service volumes on 4-leg roundabout below which may be expected to operate without requiring a detailed capacity analysis (veh/day)*	Up to approximately 15,000	Up to approximately 25,000	Up to approximately 45,000 for two-lane roundabout

*Operational analysis needed to verify upper limit for specific applications or for roundabouts with more than two lanes or four legs.

Source: Roundabouts: An Informational Guide Second Edition (NCHRP Report 672, FHWA)

Figure 7.2.1 Excerpt from Roundabouts: An Informational Guide

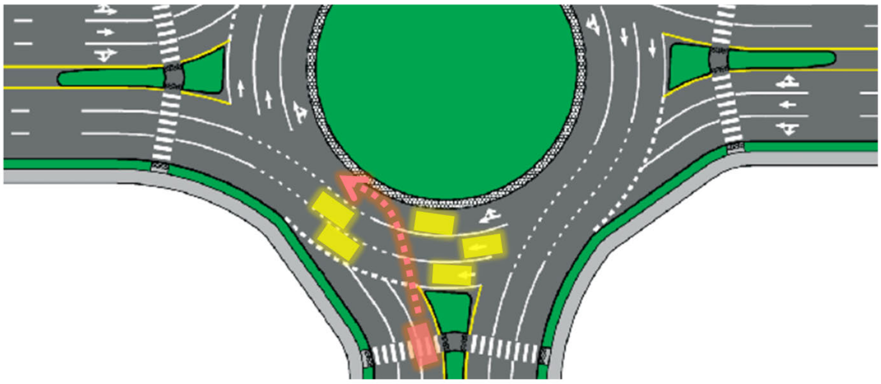
(2) Required Land for the Scale of the Intersection Area

Roundabouts require larger areas than signalized intersections. Since there are several control points and land restrictions along the Project roads, as mentioned in Chapter 6, roundabouts require more land acquisition, which is unrealistic as the Project area is heavily populated.

(3) Traffic Operation and Safety

Basic traffic rules in a roundabout require a driver to get into the correct lane when approaching, turn on indicators when turning, and give way to traffic already inside the roundabout. These rules are only applicable with a measure of traffic safety where the number of circular lanes is two or less as conflict points increase within the roundabout.

Traffic safety drops in roundabouts with three or more circular lanes. For example, when a driver entering the roundabout from the inner lane intends to take a right turn, they must change two lanes fast, as illustrated in Figure 7.2.2. Such maneuvers could result in traffic accidents and congestion.



Source: JICA Survey Team

Figure 7.2.2 Traffic Issues of a Roundabout with 3 Circular Lane

(4) Aspect on Applicability of Improvement Measures

To examine the applicability of a triangle roundabout for the Koteshwor Intersection, which has a shape similar to the Tinkune Intersection, a traffic microscopic simulation was carried out for three (3) options in Figure 7.2.3.

Source: JICA Survey Team

Figure 7.2.3 Three Study Options for Koteshwor Intersection

The study examines three (3) improvement options for the Koteshwor intersection and compares its results based on the two indicators below:

- **The number of trip-completed vehicles**: The number of vehicles entering the network and completing their trip distance
- **Average control delay time**: The difference in the average between the actual travel time and the travel time at ideal conditions (travels completed under desirable speeds)

According to the analysis results in Table 7.2.1, Option 2 of the triangle plan shows the best results among the three considering the two indicators. However, land acquisition from the TIA is mandatory for Option 2 and Option 3, unlike Option 1 (the single intersection). As mentioned in (2) above, acquiring land for permanent road facilities is nearly impossible. Options 2 and 3 are unimplementable at the Koteshwor intersection.

Table 7.2.1 Comparison Results for Koteshwor Options

Indicator	Option-1 (Single intersection)	Option-2 (Triangle plan)	Option-3 (Roundabout plan)
No. trip-completed vehicles (vehicle)	22,899	23,344 (445)	19,395 (-3,504)
Average delay (s)	103	52 (-51)	160 (57)

(xxx): Difference of Option-1
Source: JICA Survey Team

Appendix 5 explains details on the traffic microscopic simulation.

7.2.4 Tinkune Intersection

Land acquisition within the Tinkune Intersection has been a conflict between landowners and the Kathmandu Municipality since 2005. A part of ROW is inside it's the land slated for buying.

Since the land issue in the Tinkune Intersection is sensitive and complicated, DOR requests that an improvement plan for this Project should respect the current shape of the Tinkune Intersection as much as possible.

Improvements to the Tinkune Intersection does not require sizeable changes to its current shape.

7.3 Preliminary Selection of the Alternative Route (First Screening)

7.3.1 Potential Alternative Route

As explained in Chapter 7.1.2, four alternative routes of grade-separated facilities exist for the Project. Eight theoretical alternatives exist since flyover and underpass structures can apply to the grade-separated facility.

However, since there is obstacle limitation for TIA operations, a flyover structure for Alternative 3 and 4 is impossible to apply, as examined in Chapter 6.2. Adding an underpass option for Alternative 3 and 4 was a response to a request from DOR at the Inception Report meeting between JICA and Nepal. It passes through airport land because MOCTCA accepted using TIA land for the Project.

Eight alternatives for preliminary selection are examined:

- Alternative 1-1: RRS-RRN with Flyover
- Alternative 1-2: RRS-RRN with Underpass
- Alternative 2-1: RRS-ARK Hwy North with Flyover

- Alternative 2-2: RRS-ARK Hwy North with Underpass
- Alternative 3-1: ARK Hwy South -RRN using Existing Road with Underpass
- Alternative 3-2: ARK Hwy South -RRN using TIA land with Underpass
- Alternative 4-1: ARK Hwy South - ARK Hwy North using Existing Road with Underpass
- Alternative 4-2: ARK Hwy South – ARK Hwy North using TIA land with Underpass

7.3.2 Issues and Study Policy for Each Alternative

Tables 7.3.1 to 7.3.3 summarize the outlines and issues for each alternative.

Table 7.3.1 Issues and Outline (1/3)

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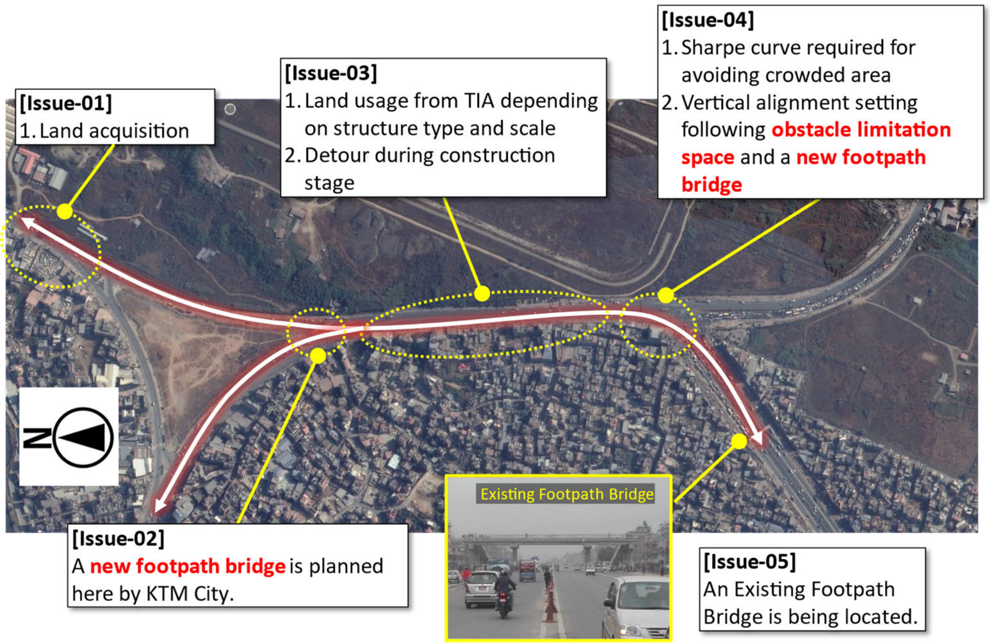

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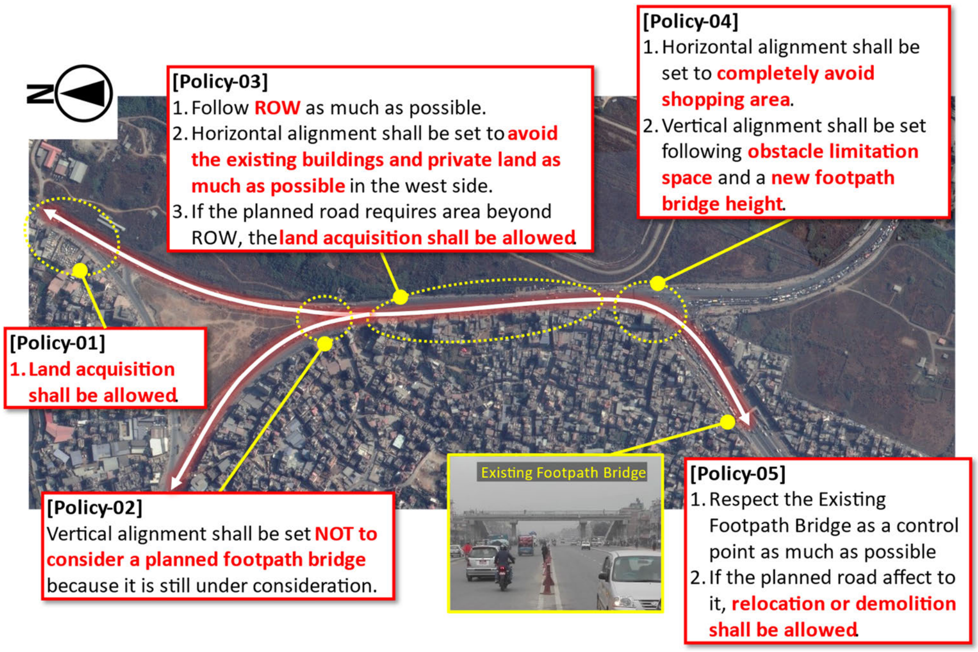

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Source: JICA Survey Team

Table 7.3.2 Issues and Outline (2/3)

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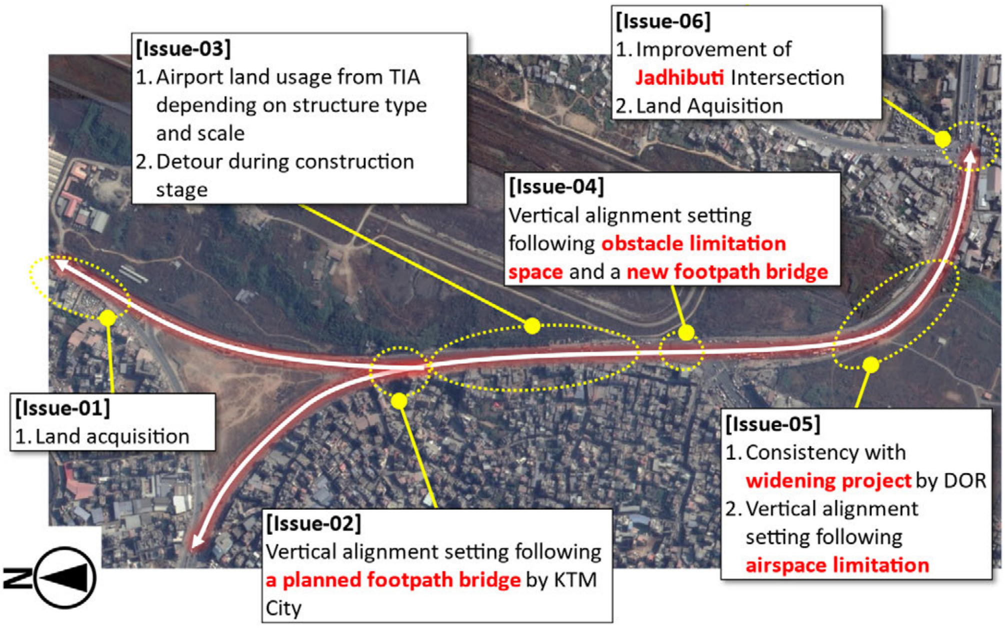
<tr><td>Issues</td><td>
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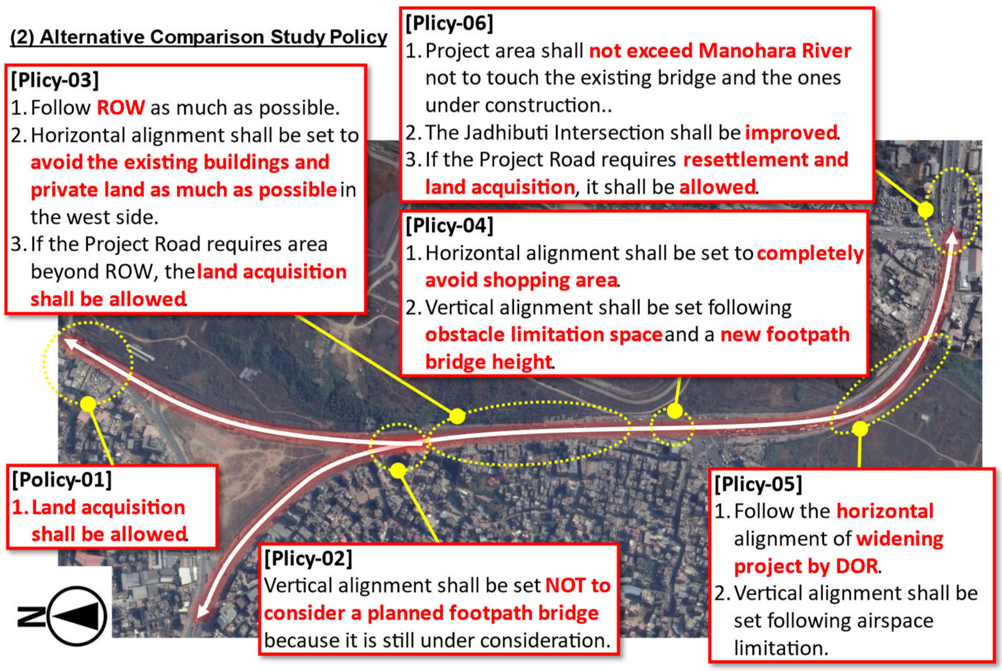
<tr><td>Policy</td><td>
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Source: JICA Survey Team

Table 7.3.3 Issues and Outline (3/3)

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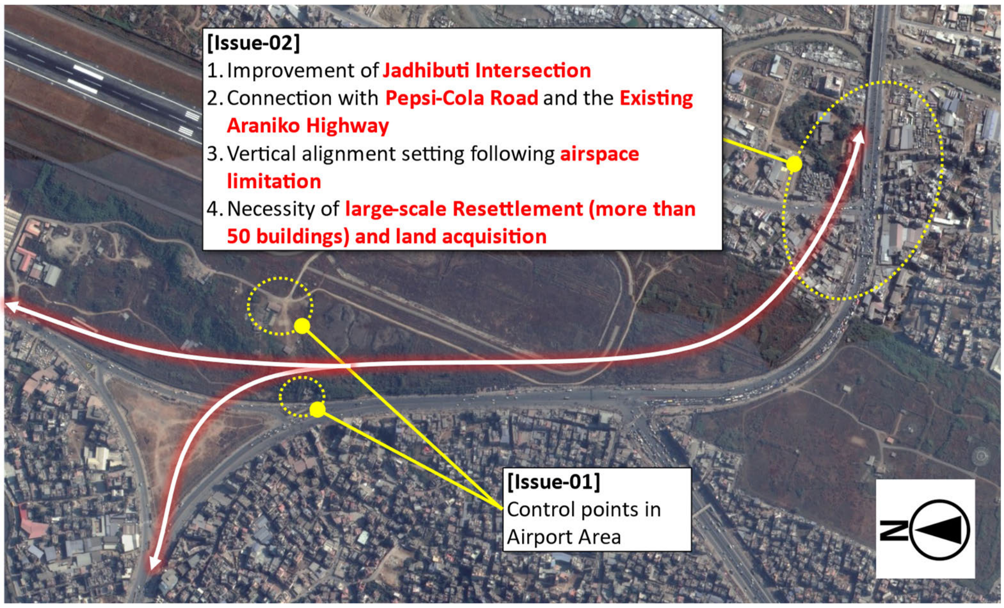
<tr><td>Issues</td><td>
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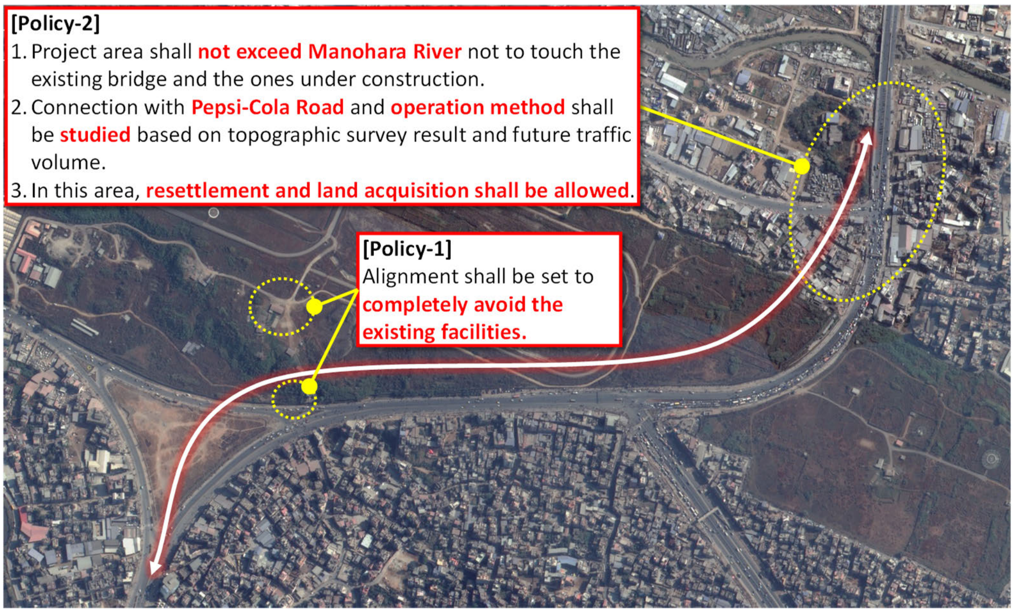
<tr><td>Policy</td><td>
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Source: JICA Survey Team

7.3.3 First Screening for Comparison

(1) Selection Method

First screening for the alternatives shall be made by scoring to the evaluation items and criteria to be explained as follows.

(2) Scoring Criteria

A. Effect of Grade Separation

A-1. Grade Separated Section

Scoring relies on traffic volume in the grade-separated section.

- 3 points: Traffic volume is more than 90,000 pcu/day
- 2 points: Traffic volume is from 80,000 - 90,000pcu/day
- 1 point: Traffic volume is less than 80,000 pcu/day

A-2. At-Grade Section

Scoring relies on the Level of Service of the at-grade section of Connecting Road, between Koteshwor and Tinkune Intersection.

- 3 points: Level of service is more than B
- 2 points: Level of service is C
- 1 point: Level of service is less than D

B. Land Transfer Scale from TIA

Scoring relies on the widening width to accommodate the necessary road facility against the predicted traffic volume in 2033.

- 3 points: No additional land
- 2 points: Additional land width is 5m
- 1 point: Additional land is 10m

C. Resettlement

Scoring is made based on the scale of resettlements.

- 3 points: No resettlement
- 2 points: Minor (Number of affected people is less than 200)
- 1 point: Major (Number of affected people is more than 200)

D. Environmental Impacts

Scoring is made based on the level of noise and vibration by structure type.

- 3 points: No impact (GS structure by only UP)
- 2 points: Minor (GS structure combined by FO & UP)
- 1 point: Major (GS structure with only FO)

E. Operation and Maintenance Burden

Scoring is made based on underpass length, which requires facilities like ventilation, evacuation drainage system, etc.

- 3 points: No facility (no UP structure)
- 2 points: Minor facility (length of UP is less than 1.0km)
- 1 point: Major facility (UP is more than 1.0km long)

F. Constructability

Scoring is made based on the impact of construction works on the existing traffic situation through restrictions and detours.

- 3 points: GS is constructed within the TIA land (Traffic restriction is necessary only at beginning/end points of GS)
- 2 points: UP is constructed on the existing road. Traffic restriction is necessary on the temporary cover deck section. Beyond it, the road reopens.
- 1 point: FO is constructed on the existing road. Lengthy traffic restriction is necessary when building sub-structures and foundations with cast-in-place concrete.

G. Construction Cost

Scoring relies on estimated costs.

- 3 points:
- 2 points: (Secret)
- 1 point:

H. Construction Period

Scoring relies on construction period estimates.

- 3 points:
- 2 points: (Secret)
- 1 point:

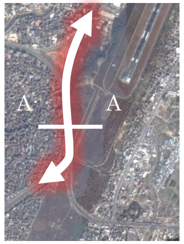
(3) Comparison Result

Table 7.3.4 shows a comparison between the first screening and the alternatives.

The following alternatives move to the next step of the final selection stage:

- Alternative 1-1: RRS-RRN with Flyover
- Alternative 3-2: Araniko Highway South-RRN using TIA land with Underpass
- Alternative 4-2:Araniko Highway South - Araniko Highway North using TIA land with Underpass

Table 7.3.4 Comparison Table on Preliminary Selection

Alternative		Alt-1: RRS-RRN				Alt-2: RRS-ARK Hwy Noth				Alt-3: ARK Hwy South-RRN				Alt-4: ARK Hwy South –ARK Hwy North			
Alt. No.		1-1		1-2		2-1		2-2		3-1		3-2		4-1		4-2	
Plan																	
Type of Structure		Flyover		Underpass		Flyover		Underpass		Underpass &Flyover		Underpass &Flyover (Use of TIA land)		Underpass &Flyover		Underpass &Flyover (Use of TIA land)	
A. Effect of Grade Separation	A-1	GS:81,696[pcu/Day] (LOS:C)			**2**	GS: 66,968 [pcu/Day] (LOS:C)			**1**	GS: 85,089 [pcu/Day] (LOS:C)			**2**	GS: 90,608 [PCU/Day] (LOS:C)			**3**
	A-2	AG:171,198[pcu/Day] (LOS:C)			**2**	AG: 190,132 [pcu/Day] (LOS:D)			**1**	AG: 178,963 [pcu/Day] (LOS:C)			**2**	AG:177,019 ([PCU/Day] (LOS:C)			**2**
B. Land Transfer from TIA[*2]	A-A Section	Approx. 10m	**1**	Approx. 5m	**2**	Approx. 10m	**1**	Approx. 5m	**2**	Approx. 5m	**2**	Approx. 5m	**2**	Approx. 5m	**2**	Approx. 5m	**2**
C. Resettlement		Minor at RRN	**2**	Minor at RRN	**2**	No resettlement	**3**	No resettlement	**3**	Minor at RRN	**2**	Minor at RRN & Jadibuti intersection	**2**	No resettlement	**3**	Minor at Jadibuti intersection	**2**
D. Environmental Impact		Major impact	**1**	No impact	**3**	Major impact	**1**	No impact	**3**	No impact	**3**	Minor impact	**2**	Major impact	**1**	Minor impact	**2**
E. O&M		No UP facility	**3**	Major UP facility	**1**	No UP facility	**3**	Major UP facility	**1**	Major UP facility	**1**	Minor UP facility	**2**	Major UP facility	**1**	Minor UP facility	**2**
F. Constructability		Major impact	**1**	Middle impact	**2**	Major impact	**1**	Middle impact	**2**	Middle impact	**2**	Low impact	**3**	Middle impact	**2**	Low impact	**3**
G. Construction Cost [Mil.USD] [*3]		(Secret)															
H Construction Period																	
Evaluation		Total:18 Points **Recommend**		Total:17 Points		Total:17 Points		Total:16 Points		Total:16 Points		Total:19 Points **Recommend**		Total:16 Points		Total:20 Points **Recommend**	

*1: Traffic Volume is as Year 2033. *2: Required width is from the existing road width of 30m. *3: (XX) is cost ratio to the Alt.1-1
Source: JICA Survey Team

(4) Conclusion and Observation

A. Effect of Grade Separation

Alt-4 has the most sizeable traffic volume at GS, followed by Alt-3 and 1. Alt-2 has the smallest. Thus, Alt-2 is ineffective in easing traffic congestion.

B. Land Transfer from TIA Land

Land transfer from TIA is a requirement for all alternatives. Flyovers in Alt-1-1 and Alt-2-1 require a larger land area (10 m) than the underpass (5 m) since flyovers require median to install substructures.

C. Resettlement

Except for Alt-2, all of the alternatives require resettlement. However, the number of affected people must be less than 200. JICA files the Project under environmental category B.

D. Environmental Impacts

Flyover options along the private land may cause noise and vibration issues. Thus, the underpass option is more advantageous.

E. Operation and Maintenance

Underpass length is highly related to the constructability of additional tunnel facilities such as ventilation, evacuation, and drainage systems. A shorter underpass has the advantage.

F. Constructability

Alt-3-2 and 4-2 are advantageous since significant construction works like excavation and structure installation are implementable within the TIA land. This factor reduces impacts on traffic from restriction periods compared to the other options.

G. Construction Cost

Since a temporary cover deck on the existing road is necessary for underpass construction, the Project cost increases under an option that requires an underpass. Alt-3-2 and 4-2 do not require such temporary measures since they are outside the existing road.

These options require the cofferdam method during construction on TIA land. They also necessitate a long-span steel bridge at the Tinkune and Jadibuti Intersections, making the construction cost for the underpass within TIA land slightly higher than the flyover option.

H. Construction Period

Underpass options require cast-in-place concrete for construction, while a flyover needs pre-cast and prefabricated members. The construction period for any underpass option is lengthier than a flyover option.

7.4 Selection of Optimal Alternative Route (Final Selection)

7.4.1 Number of Lanes Required for Project Roads by Target Year

(1) Objective and Target Analysis Road Section

HCM-based traffic analysis was conducted in the subsequent investigation to select the most optimal option from three alternatives chosen from the initial screening stage described in Section 7.4. This analysis aimed to ascertain the number of lanes required for GS and the Connecting Road section by the target year, as illustrated in Figure 7.4.1.

Source: JICA Study Team

Figure 7.4.1 Analysis Locations

(2) Analysis Conditions

1) Target Level of Service (LOS[1])

As explained in Chapter 6, the proposed target LOS is LOS D, the typical target LOS in traffic analysis in urban areas.

2) Traffic Demands by Target Year

The considered target year for the analysis is 2033, which is assumed to be five years commencing its operation at this stage.

Input traffic volumes on the project roads in peak hour are calculated from future daily traffic volume in both target years using K factors and D factors described in Chapter 6.

3) Development Projects to Consider

During the pre-survey, two future development projects closely associated with the intersection improvement project were identified. These are the Eastern New City Development Project (EDP) initiated by KVDA, currently awaiting government approval, and an urban railway project aimed at connecting Bhaktapur to the center of Kathmandu. The latter was identified as a priority project in the long term during the pre-survey.

JST and DOR have concurred that the EDP will be incorporated into the study by revising the population growth scenario for EDP by the recent government policy outlined in Chapter 4. Conversely, the consideration of the aforementioned urban railway project should be excluded from the analysis, as its conclusion by 2033 is deemed highly impossible.

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[1] LOD of D at intersections describes the situation "Approaching unstable flow (tolerable delay, occasionally wait through more than one signal cycle before proceeding". E is described as "Unstable flow with intolerable delay" and F is "Forced flow with jammed".

4) Analysis Cases

Table 7.4.1 summarizes the analysis cases for Alt-1-1, 3-2, and 4- 2 by road type (at-grade or grade separation) and the analysis conditions in the previous section.

Table 7.4.1 Analysis Cases

Target Year	Case Name	Structure	EDP	Railway Project
2033	Alt-1-1	At grade	Consider	Not Considered
	Alt-3-2	At grade		
	Alt-4-2	At grade		
	Alt-1-1	Grade Separation		
	Alt-3-2	Grade Separation		
	Alt-4-2	Grade Separation		

Source: JICA Survey Team

(3) Analysis Results

Table 7.4.2 shows the analysis results by the target year using the updated traffic demand forecast model described in Chapter 4. Based on the results, no significant differences were observed in the number of lanes and the LOS for each alternative.

Table 7.4.2 Number of Lanes Required and the LOS for the Project Roads (2033)

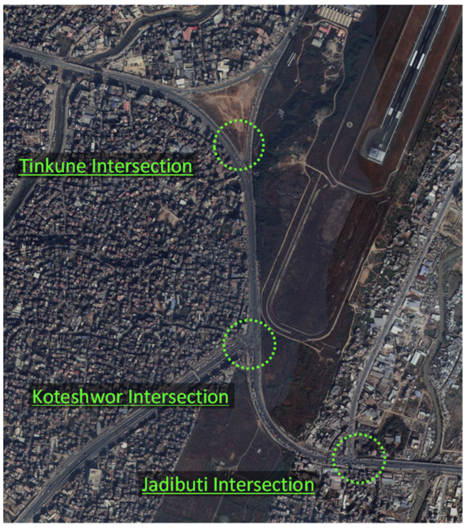
Alternative		Factor**		Daily Traffic Volume (PCU/day)	Peak Hourly Traffic Volume (PCU/h)	No. of Lanes	Volume to Capacity Ratio	Additional Width*		LOS
		K Factor	D Factor							
At Grade	Alt-1-1	0.067	0.51	171,198	5,850	8	0.65	FO	10m	C
								UP	5m	
								UP	5m	
	Alt-3-2	0.067	0.51	178,963	6,115	8	0.68	UP	5m	C
								TIA	5m	
	Alt-4-2	0.067	0.51	177,019	6,049	8	0.67	UP	5m	C
								TIA	5m	
Grade Separation	Alt-1-1	0.067	0.51	81,696	2,792	4	0.62			C
	Alt-3-2	0.067	0.51	85,089	2,907	4	0.65			C
	Alt-4-2	0.067	0.51	90,608	3,096	4	0.69			C

Note:
*Additional width is measured from the edge of the existing road. (30m width). Required width shows in Figure 7.4.1.
** For K and D factors, refer to Section 6.1.6.
*** Difference in the distribution results (Daily Traffic Volume) resulted from the difference in the connecting points between the GS and the at-grade alternative.
Source: JICA Survey Team

7.4.2 Intersection Analysis

(1) Objective and Target Analysis Intersection

The traffic analysis for the project intersections was conducted to determine the necessary lane layout at the entrance of the intersections. This was done to evaluate the LOS for future traffic demand at the project intersection and to determine whether the target LOS, as defined in Chapter 6, can be achieved. This results of this analysis constitutes a crucial element in determining the scale of improvements needed for the at-grade intersections in the project. Three intersections were analysised, which have been experiencing severe traffic congestion and are pivotal for enhancing traffic flow in the Kathmandu Valley.



Source: JICA Survey Team
Figure 7.4.2 Target Analysis Intersections

(2) Analysis Conditions

1) Target Level of Service (LOS)

The target LOS is the same as in Section 7.4.1(2).

2) Traffic Demand as of Target Year

Table 7.4.3 shows the directional traffic demand for Tinkune, Koteshwore, and Jadibuti intersections for the project road in 2033.

Table 7.4.3 Directional Traffic Demand (pcu/h)

Tinkune I/S as of 2033			
pcu/h	Koteshwor	ARK-N	RRN
Koteshwor	0	2007.923	4032.194
ARK-N	1259.667	0	0
RRN	4063.148	1795.935	0

Koteshwor I/S as of 2033			
pcu/h	ARK-N	RRS	ARK-S
ARK-N	0	1,985	3,989
RRS	1,327	0	2,489
ARK-S	3,116	2,229	0

Jadibuti I/S as of 2033			
pcu/h	ARK-S	Koteshwor	PC Road
ARK-S	0	4894.752	237.046
Koteshwor	3557.633	0	885.673
PC Road	473.221	1079.437	0

Source: JICA Survey Team

1) Analysis Cases

Table 7.4.4 summarizes the analysis cases for three target intersections. Note that Alt-1-1 for Jadibuti Intersection is not considered since the route of Alt-1-1 does not affect the intersection.

Table 7.4.4 Analysis Cases

Intersection	Year	Alternative	EDP	Railway Project
Tinkune	2033	Alt-1-1	Considered	Not Considered
		Alt-3-2		
		Alt-4-2		
Koteshwor	2033	Alt-1-1		
		Alt-3-2		
		Alt-4-2		
Jadibuti	2033	Alt-3-2		
		Alt-4-2		

Source: JICA Survey Team

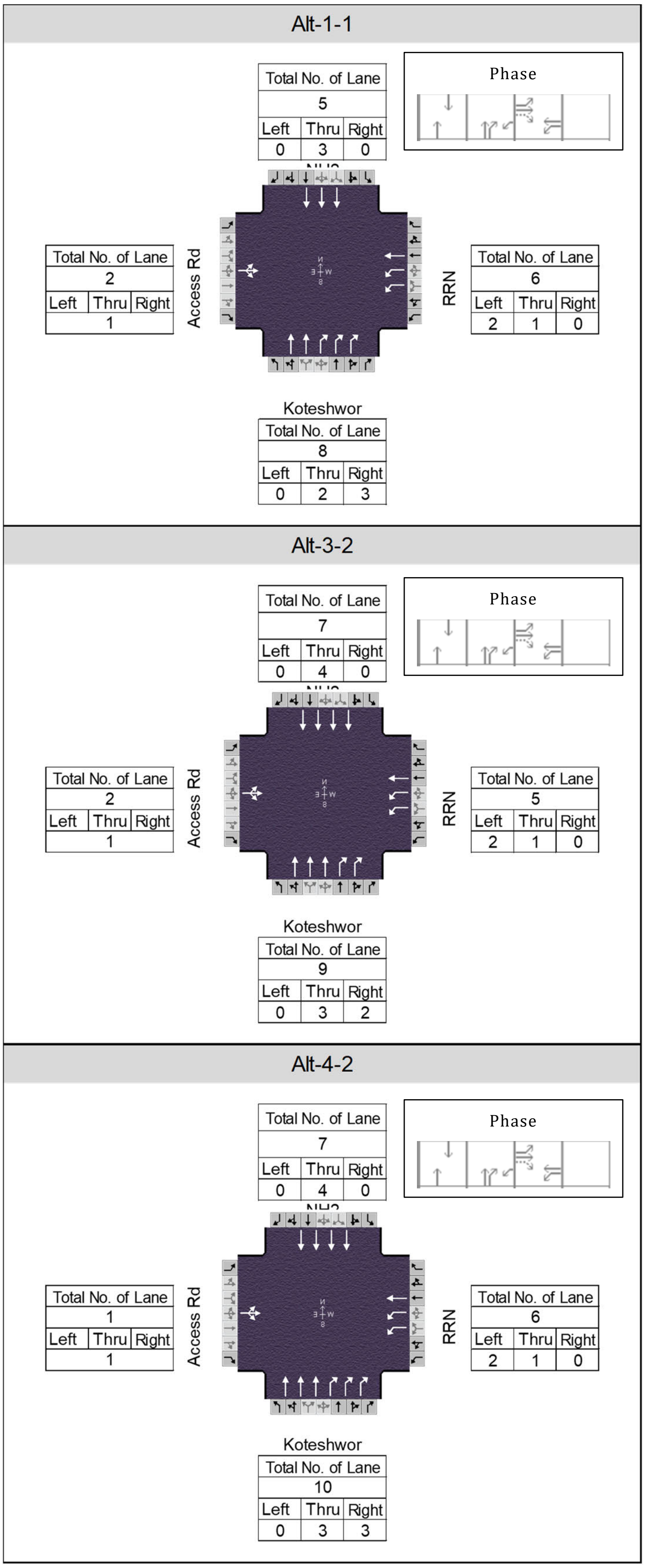
(3) Analysis Results

Figure 7.4.3 illustrates the southern intersecting point at the Tinkune Intersection, where Araniko Highway South diverges into RRN and Araniko Highway North. Note that an access road heading west represents one of the legs of the Tinkune Intersection.

Source: JICA Survey Team

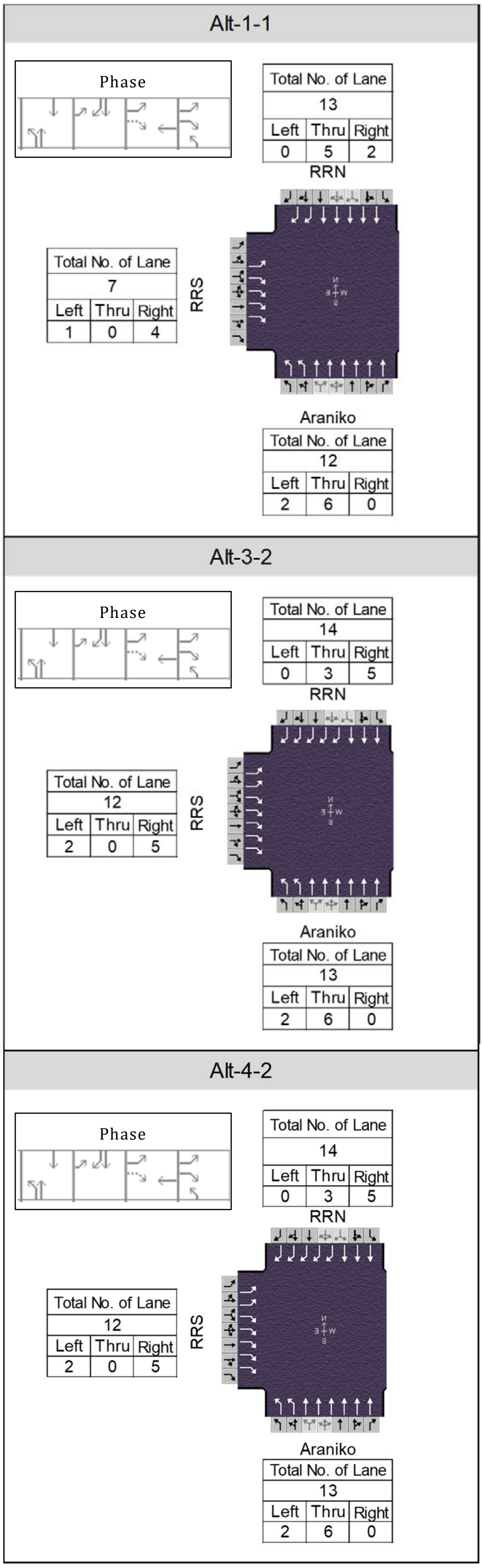
Figure 7.4.3 Target Analysis Point at Tinkune Intersection

Figure 7.4.4 to Figure 7.4.6 present the analysis results, organized by intersection. Values under “Left”, “Thru” and “Right” indicate the number of lanes for entry into the intersection, a crucial factor for calculating the LOS of the intersection. Additionally, the term “Total No. of Lane” refers to the total number of lanes for both entry and at the intersection.



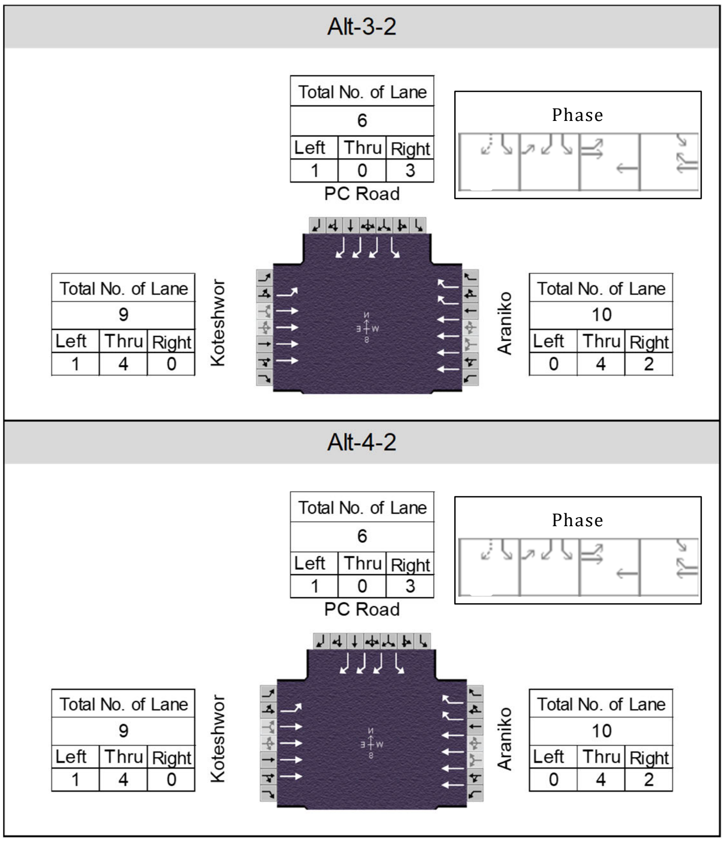
Source: JICA Survey Team

Figure 7.4.4 Required Lane Layout at Tinkune Intersection for Target Year 2033



Source: JICA Survey Team

Figure 7.4.5 Required Lane Layout at Koteshwor Intersection for Target Year 2033



Source: JICA Survey Team

Figure 7.4.6 Required Lane Layout for Jadibuti Intersection for Target Year 2033

(4) Required Number of Lanes in Each Intersection

Table 7.4.5 to Table 7.4.7 summarize the number of lanes by intersection.

Table 7.4.5 Number of Lanes in Tinkune Intersection

Tinkune Intersection	Alt-1-1				Alt-3-2				Alt-4-2			
	ARK N	RNN	Koteshwor	Access Road	ARK N	RNN	Koteshwor	Access Road	ARK N	RNN	Koteshwor	Access Road
Entrance	3	3	5	1	4	3	6	1	4	3	6	1
Exit	2	3	3	1	3	2	4	1	3	3	4	1
Total	5	6	8	2	7	5	10	2	7	6	10	2

Source: JICA Survey Team

Table 7.4.6 Number of Lanes in Koteshwor Intersection

Koteshwor Intersection	Alt-1-1			Alt-3-2			Alt-4-2		
	RRN	ARK S	RRS	RRN	ARK S	RRS	RRN	ARK S	RRS
Entrance	7	8	5	7	8	7	8	8	7
Exit	6	5	2	6	5	5	6	5	5
Total	13	13	7	13	13	12	14	13	12

Source: JICA Survey Team

Table 7.4.7 Number of Lanes in Jadibuti Intersection

Jadibuti Intersection	Alt-3-2			Alt-4-2		
	RRN	ARK S	RRS	RRN	ARK S	RRS
Entrance	4	6	5	4	6	5
Exit	2	4	4	2	4	4
Total	6	10	9	6	10	9

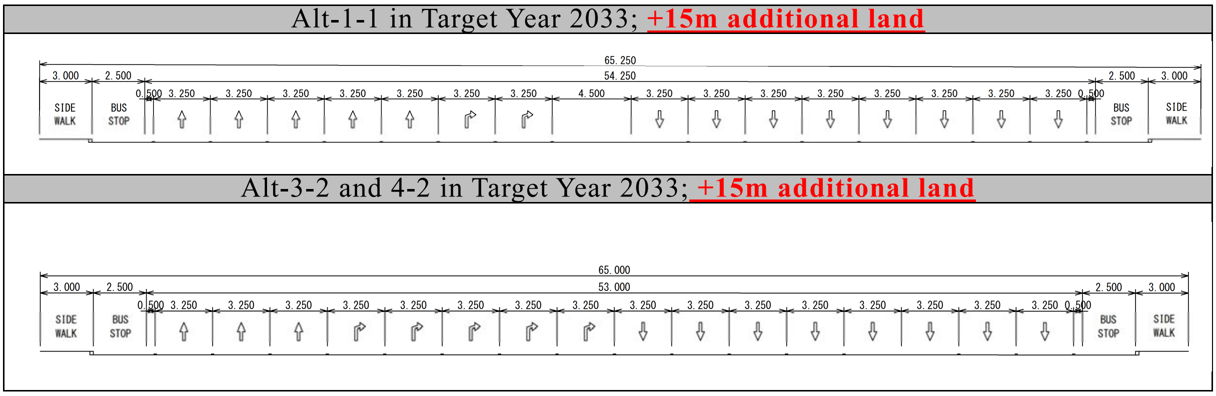
Source: JICA Survey Team

7.4.3 Target Year to Determine the Facility Scale of the Project

(1) Required Land Area to Accommodate Traffic Demand in 2033 at Koteshwor Intersection

Following the guidelines presented in Section 7.4.2, Figure 7.4.7 illustrates the necessary lane layouts to achieve LOS D or higher at the Koteshwor Intersection for each alternative.

Figure 7.4.7 Required Lane Layout in 2033 for LOS D or Higher



Source: JICA Survey Team

(2) Target Year for Determining Project Facility for the Project

During discussions with MOPIT and DOR, the set target year is 2033. This timeframe was decided upon, assuming a period of five years post-project completion (in 2028), for the following reasons:

- **Uncertainty of Eastern New City Development (ENCD) by KVDA**: Future traffic demand at the project intersections would be greatly affected by the progress of ENCD and the population growth trend in the area.
- **Possibility of Other Development Projects**: Traffic movement would change due to other development projects (Outer Ring Road, Urban Railway, New Road connecting the ENC to KTM etc.). The new transportation mode development would significantly change the future traffic volumes at the project intersections.
- **Requires High Investment Cost and Large Land Acquisition**: If the target year is ten years after completion of the project (2038), high investment cost and land acquisition for large areas and large-scale facilities are required.

In addition, JST suggested the Stepwise Development Approach for the project facility by observing the future development progress. The Nepal government agreed to the suggestion. The Stepwise Development Approach aims to develop the necessary facilities to improve the project intersections by stage or phase due to the uncertainty of the progress of ongoing relevant development projects such as the ENCD, Ring Road widening, and Boudha Road.

For the present phase of the project, determining the minimum scale for the grade separated facility at the project intersections involves reducing the target year for future traffic. Additionally, the contents of the next project phase have been identified through an updated and revised traffic demand forecast in the future Transport Master Plan Revision Study.

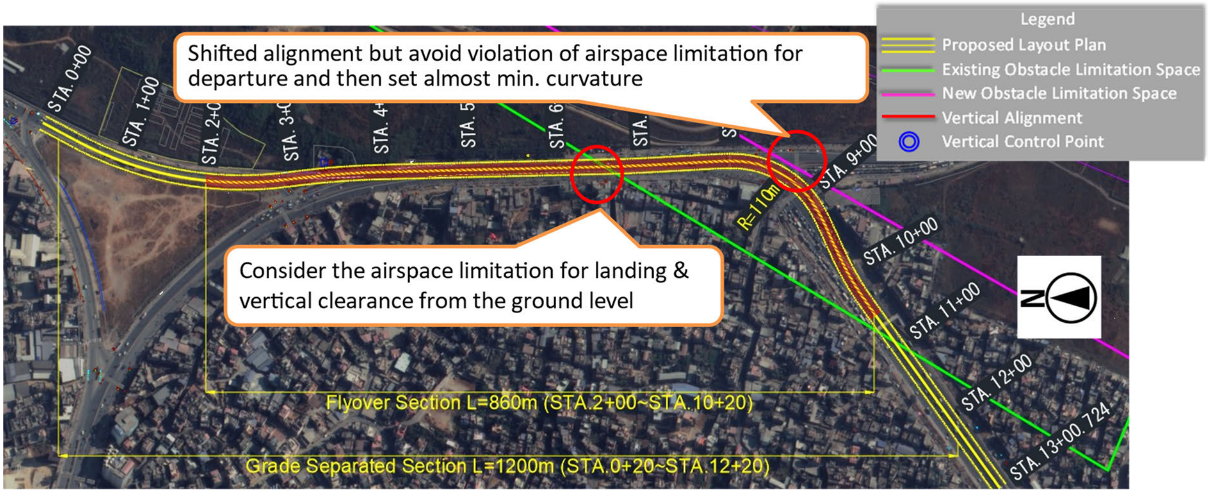
The second phase of the project must include the grade-separated facilities in other routes for the project intersections, the new road connection between the eastern area to the city center, and the introduction of urban railways. Chapter 22, title “Conclusions and Recommendations,” describes further details of this approach.

7.4.4 Road Planning for Grade-Separated Section

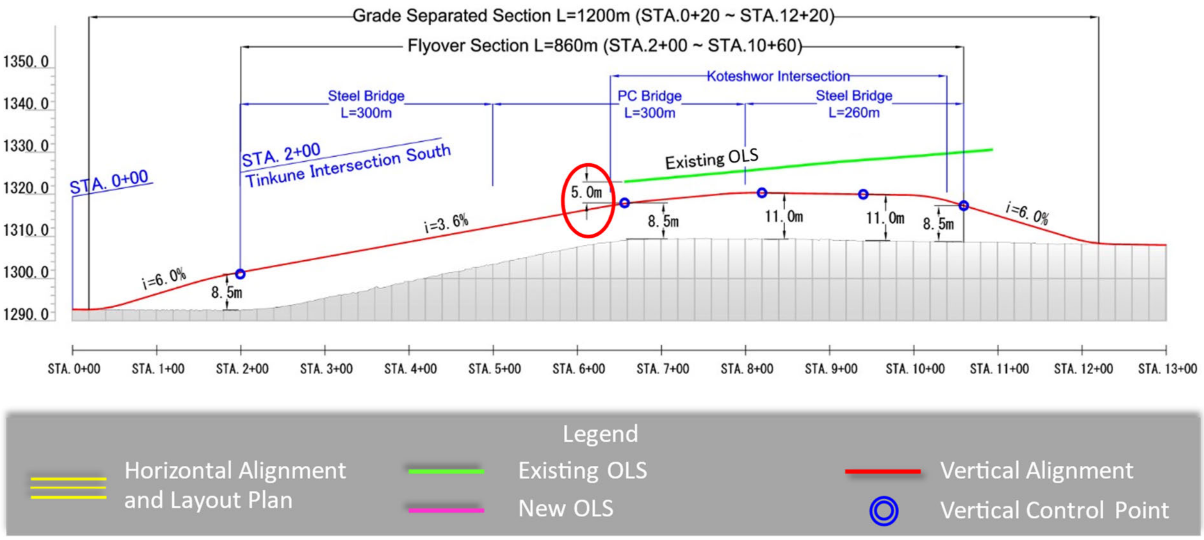
(1) Setting the Horizontal and Vertical Alignments for Alt-1

Figure 7.4.8 illustrates the horizontal and vertical alignments for Alt-1-1, which is approximately 1,200 m-length from RRN to RRS on the existing project roads.

In designing the horizontal alignment, engineers avoid passing through the control points, such as the obstacle limitation space (OLS) for taking-off (pink line in Figure 7.4.8) and private building areas located west. They also consider the vertical clearance fromo the at-grade road section and the airplane landing OLS (green line in Figure 7.4.8) in setting the vertical alignment.



Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.4.8 Horizontal and Vertical Alignments for Alt-1

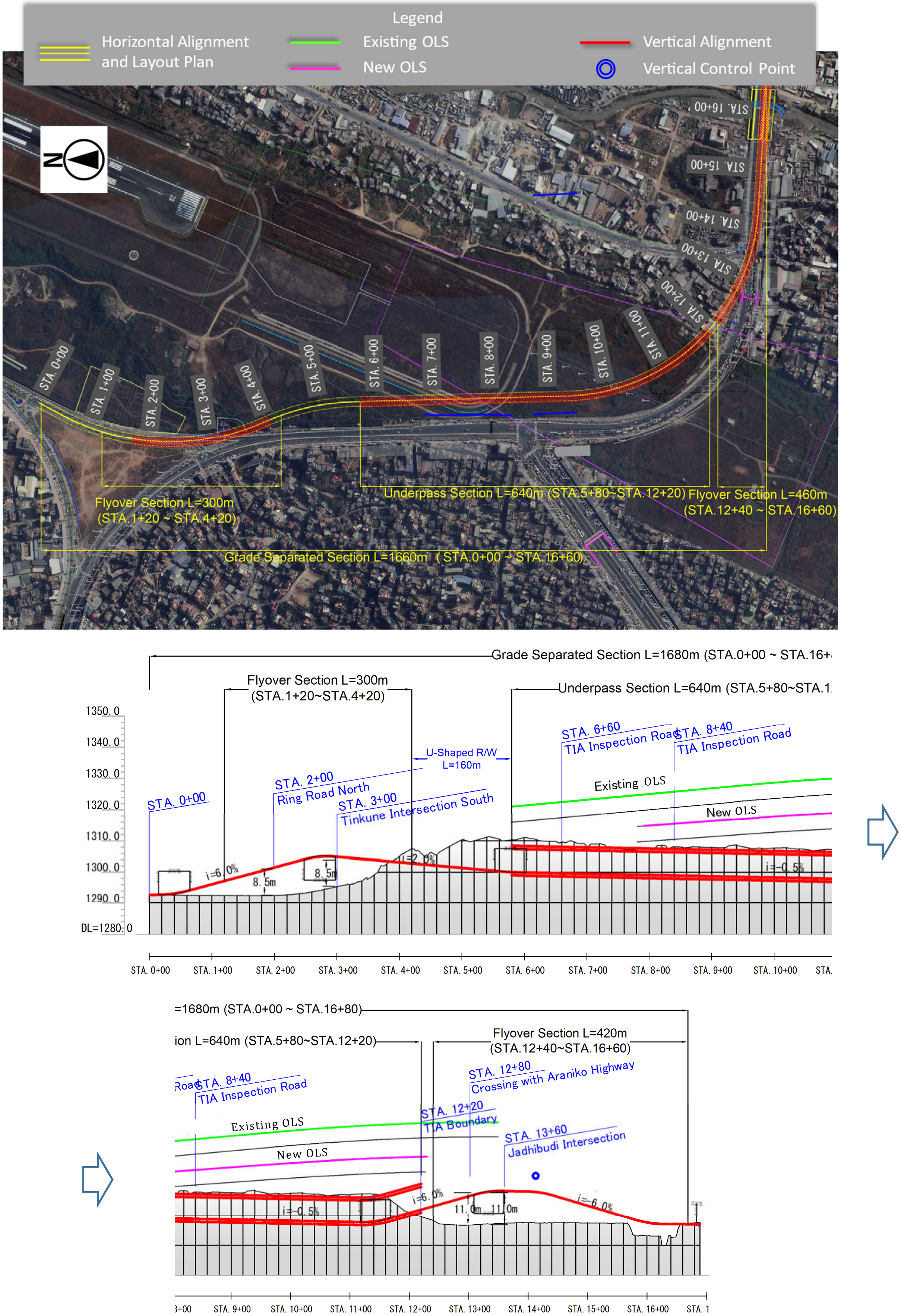
(2) Setting Horizontal and Vertical Alignments for Alt-3-2 (Use of TIA Land)

Figure 7.4.9 presents the horizontal and vertical alignments for Alt-3-2 (use of existing road), which is approximately 1,600 m-length from RRN to Araniko Highway South via TIA land using flyover and underpass structures. Table 7.4.8 lists the considerations in setting the vertical alignment.

Table 7.4.8 Considerations in Setting the Vertical Alignment for Alt-3-2

Section	Station No.	Consideration	Remarks
Flyover Section	STA.1+20 to STA.4+20	● GS overpasses Ring Road at STA.2+00 connecting to UP section in TIA land.	-
Underpass Section	STA.5+80 to STA.12+20	● Minimum vertical grade of 0.5% shall be applied to drain road surface water. ● No minimum earth cover is required at the portal of Jadibuti. In contrast, at least 1m covering is necessary for the remaining section. ● Application of box culvert from the crossing point of obstacle limitation space (STA 9+0) to the end of TIA land (STA.15+40). ● ROW is utilized to the fullest extent possible at Tinkune Intersection.	There is a possibility to apply drainage pumps to drain water inside the tunnel depending on the future detailed topo survey.
Flyover Section	STA.12+40 to STA.16+60	● FO option is selected at the Jadibuti Intersection for several reasons: ➢ Unrealistic for UP under the Manohara River. ➢ In case the tunnel ends before the Manohara River, many roadside buildings is affected due to the widening of new ramp noses. ➢ In case the tunnel ends before Judibuti Intersection, many roadside building is affected due to the widening of a new ramp.	-

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.4.9 Horizontal and Vertical Alignments for Alt-3-2 (Use of TIA Land)

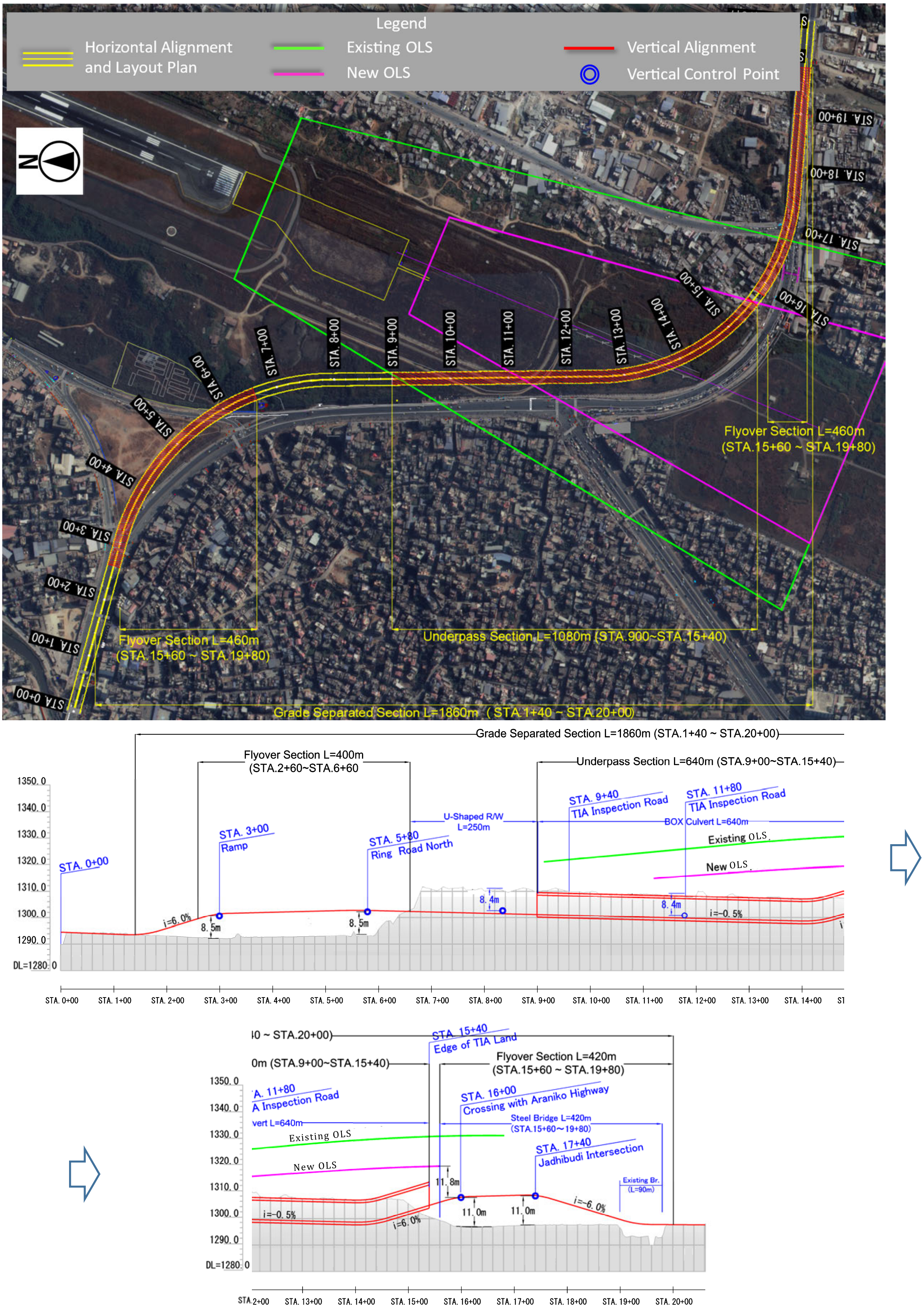
(3) Horizontal and Vertical Alignment Setting for Alt-4-2 (Use of TIA Land)

Figure 7.4.10 illustrates the horizontal and vertical alignments for Alt-4-2 (use of TIA land), which is approximately 1,860 m-length from Araniko Highway North to Araniko Highway South via TIA land using flyover and underpass structures. Table 7.4.9 lists the considerations in setting the vertical alignment.

Table 7.4.9 Consideration in Setting the Vertical Alignment for Alt-4-2 (Use of TIA Land)

Section	Station No.	Consideration	Remarks
Flyover Section	STA.2+60 to STA.6+60	● GS overpasses Ring Road at STA.6+00 for connecting to UP section in TIA land.	-
Underpass Section	STA.3+00 to STA.12+80	● Minimum vertical grade of 0.5% shall be applied to drain road surface water. ● No minimum eart cover is required at the portal of Jadibuti. In contrast, at least 1m covering is necessary for the remaining section. ● Application of box culvert from the crossing point of obstacle limitation space (STA 9+0) to the end of TIA land (STA.15+40). ● ROW is utilized to the fullest extent possible at Tinkune Intersection.	There is a possibility to apply drainage pumps to drain water inside the tunnel depending on the future detailed topo survey.
Flyover Section	STA.15+60 to STA.19+80	● FO option is selected at the Jadibuti Intersection for several reasons: ➢ Unrealistic for UP under the Manohara River. ➢ In case the tunnel ends before the Manohara River, many roadside buildings are affected due to the widening of new ramp noses. ➢ In case the tunnel ends before Judibuti Intersection, many roadside buildings are be affected due to the widening of a new ramp.	-

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.4.10 Horizontal and Vertical Alignments for Alt-4-2 (Use of TIA Land)

7.4.5 Road Planning for At grade Section

(1) Basic Approach

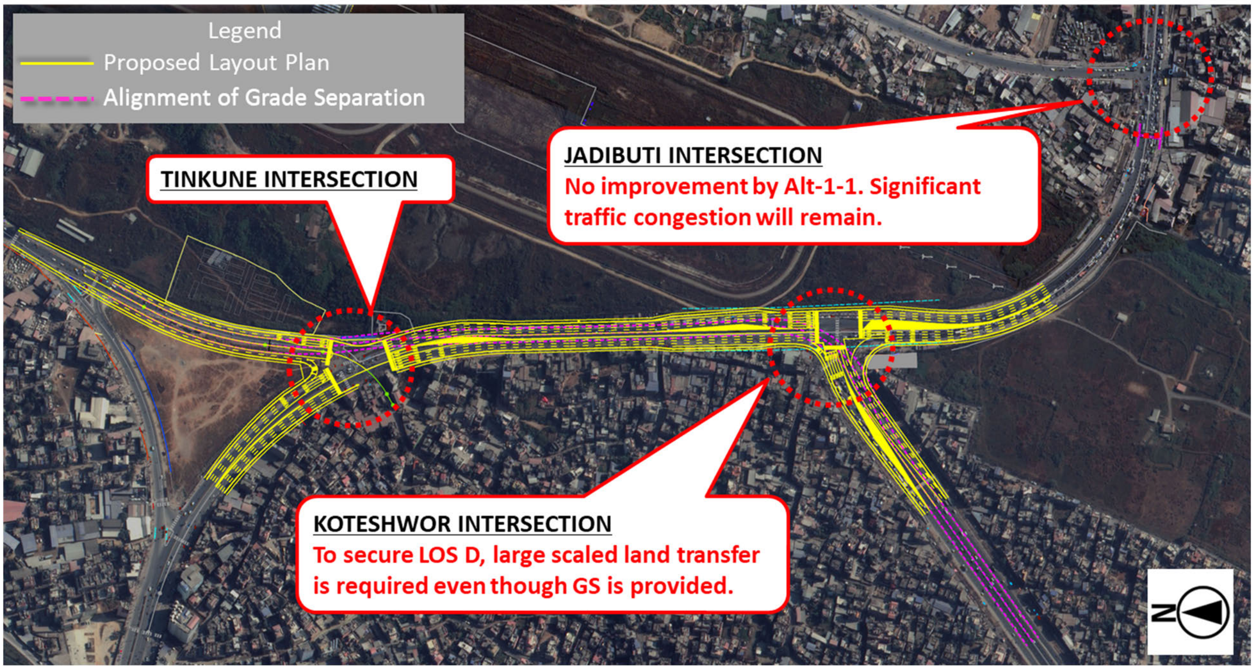
The road alignment within the at-grade section for each alternative should adhere to the existing road. Considering the conditions and policy for control points outlined in Chapter 6, a widening-based improvement was recommended.

The next section described the road plan for each alternative.

(2) Road Plan

1) Alt-1-1

Figure 7.4.11 illustrates the proposed at-grade road plan for Alt-1-1.

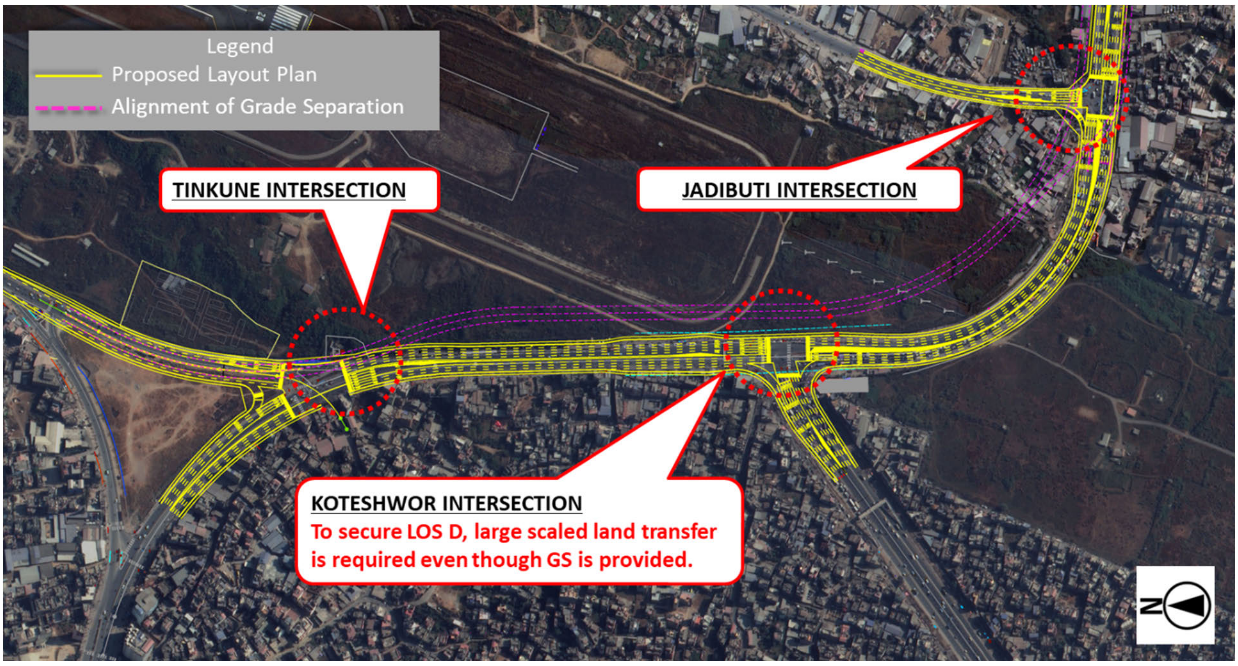


Source: JICA Survey Team

Figure 7.4.11 At-grade Road Plan for Alt-1-1

2) Alt-3-2

Figure 7.4.12 shows the proposed at-grade road plan for Alt-3-2.

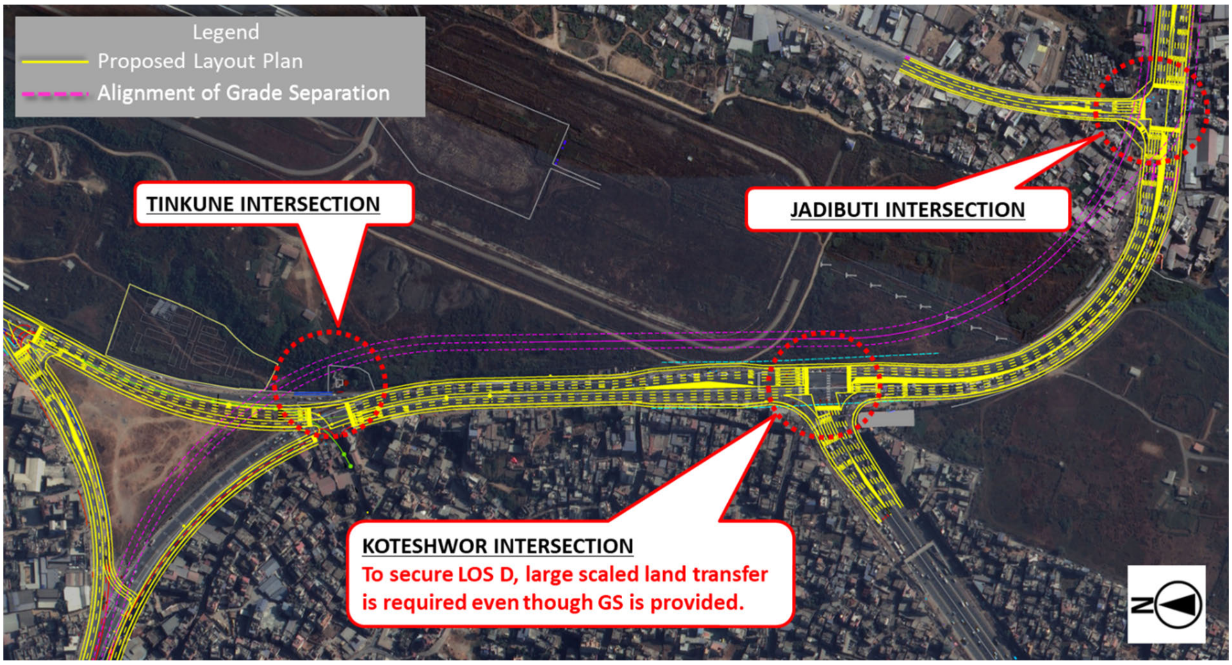


Source: JICA Survey Team

Figure 7.4.12 At-grade Road Plan for Alt-3-2

3) Alt-4-2

Figure 7.4.13 presents the proposed at-grade road plan for Alt-4-2.



Source: JICA Survey Team

Figure 7.4.13 At-grade Road Plan for Alt-4-2

7.4.6 Koteshwor Intersection Improvement Plan

(1) Study on Lane Layout

To ensure that the target LOS for both the intersection and the road segment is LOS D or better required to accommodate the traffic demand projected for 2033, it is imperative to acquire a spacious area (approximately 20 m towards the TIA side from the existing road) as detailed in Chapter 6. Conversely, as previously indicated, only a ROW of 50 m from the private land border at the west end of the Connecting Road section is currently available for the project.

Based on these considerations, an analysis was conducted for two cases: one with an ideal lane layout and the other with a lane layout within the ROW.

The lane layout for the intersection, designed to accommodate the 2033 traffic demand, was planned to minimize control delay[2] and maximize the LOS for each alternative.

(2) Lane Layout of Koteshwor Intersection

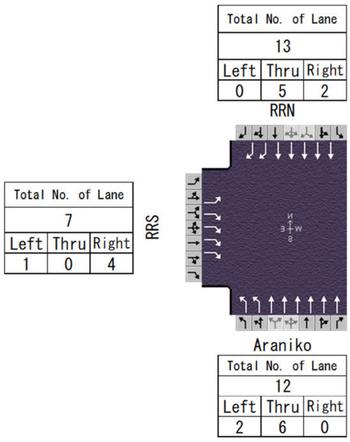
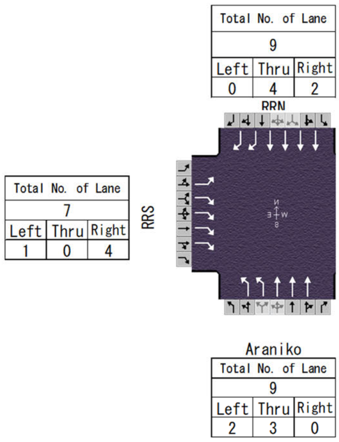
1) Alt-1-1

Table 7.4.10 and Figure 7.4.14 to Figure 7.4.15 presents the analysis result and lane layout plan for Alt 1-1, respectively. In case the piers of the flyover structure are installed at the intersection, the number of lanes increase.

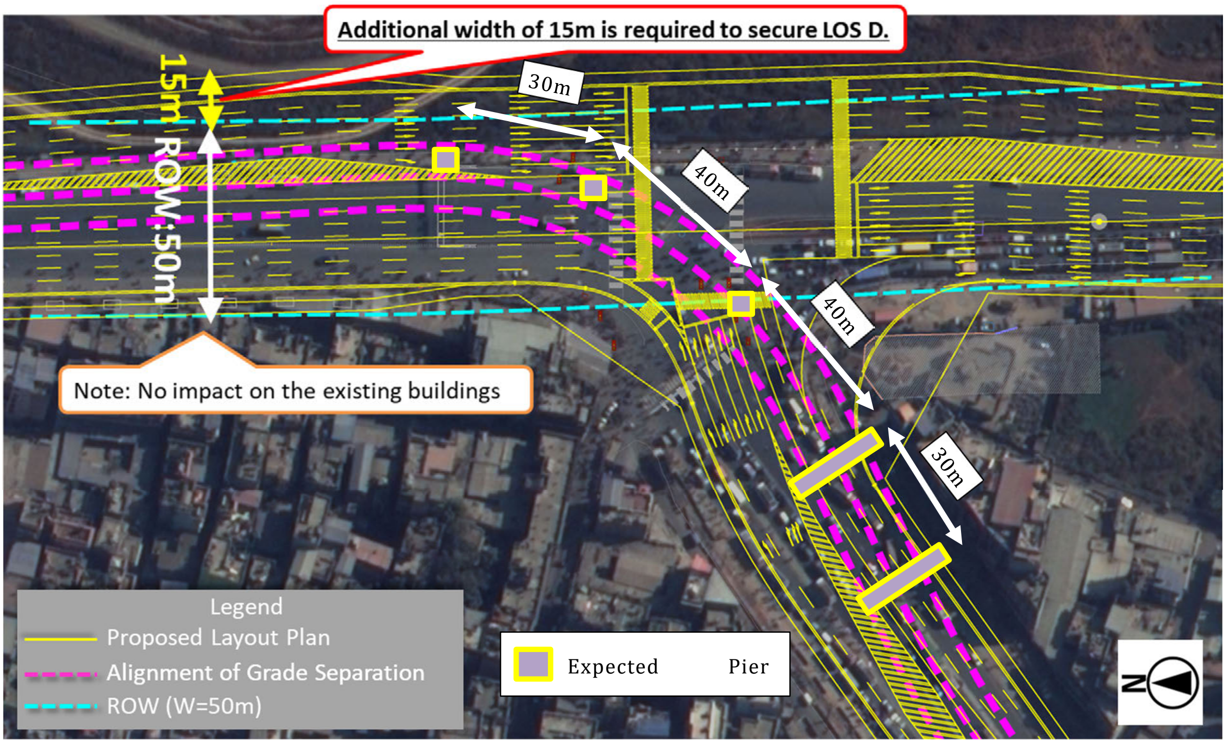
[2] Control delay time: Additional travel time taken for passing through the intersection in consideration of reduction of travel speed or stoppage by traffic control device (eg. traffic signal)

Table 7.4.10 Intersection Analysis Result for Alt-1-1

Lane Layout & LOS for At-grade Koteshwor Intersection (Existing LOS: F, CD:650 sec)

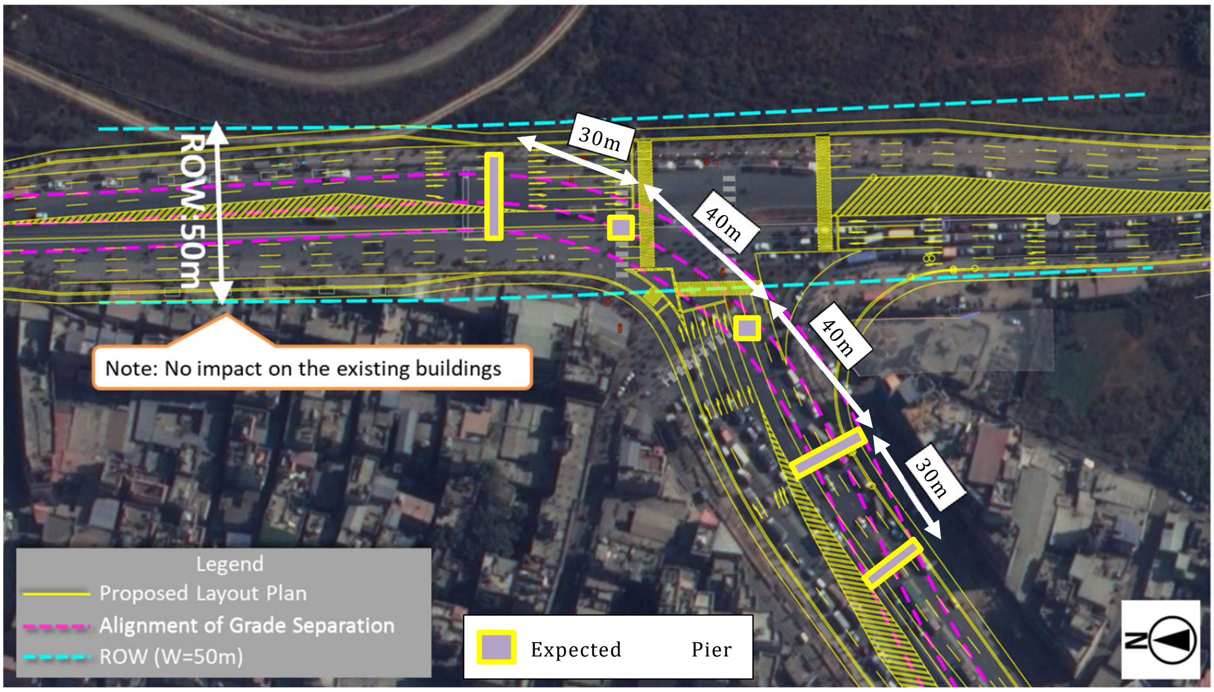
Case	Required Lane Layout	Applicable Lane Layout within ROW:50m
Sketch		
Excess to ROW	Approx. 15m	0
LOS	C	F
Control Delay for Intersection (s/veh)	29.6	181.9

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.4.14 Required Lane Layout Plan for Alt-1-1 (Ideal Case)



Source: JICA Survey Team

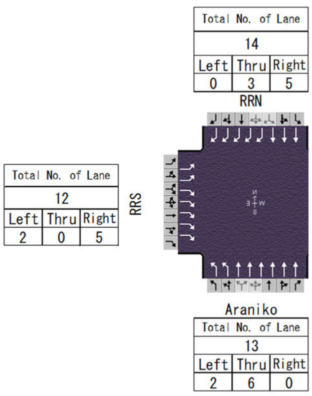
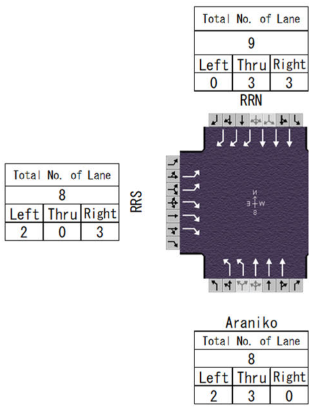
Figure 7.4.15 Lane Layout Plan within the ROW for Alt-1-1

2) Alt-3-2

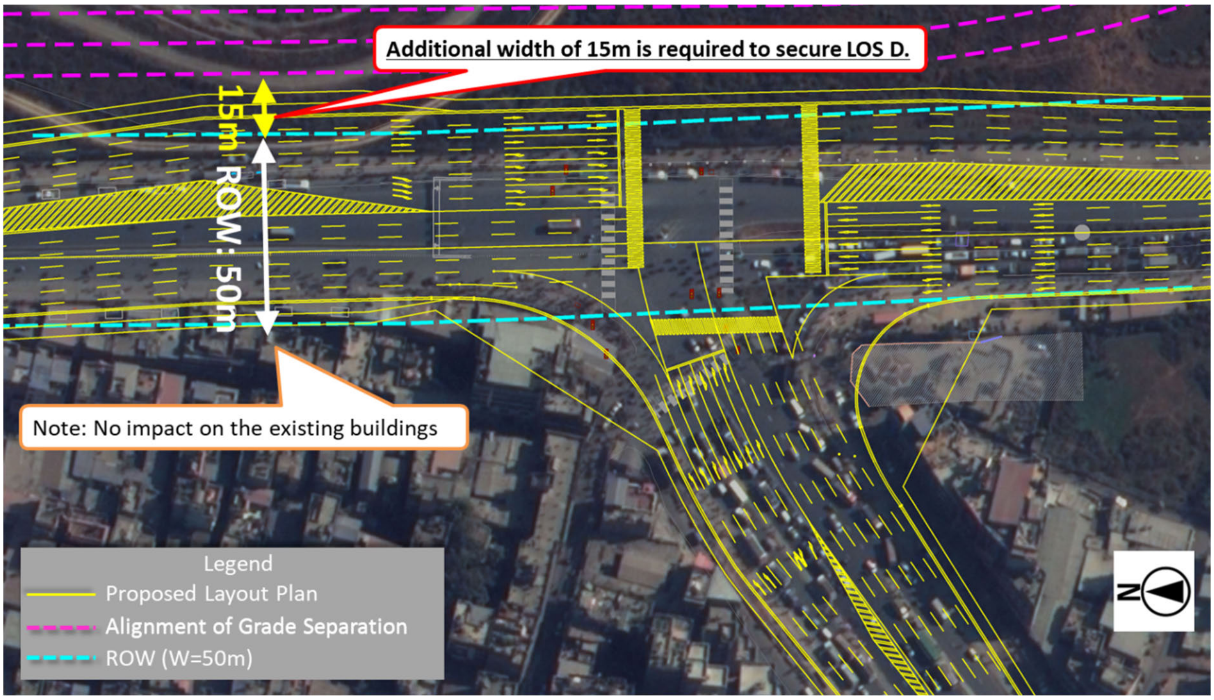
Table 7.4.11 and Figure 7.4.16 to Figure 7.4.17 show the analysis result and lane layout plan for Alt 3-2, respectively.

Table 7.4.11 Intersection Analysis Result for Alt-3-2

Lane Layout & LOS for At-grade Koteshwor Intersection (Existing LOS: F, CD: 650s)

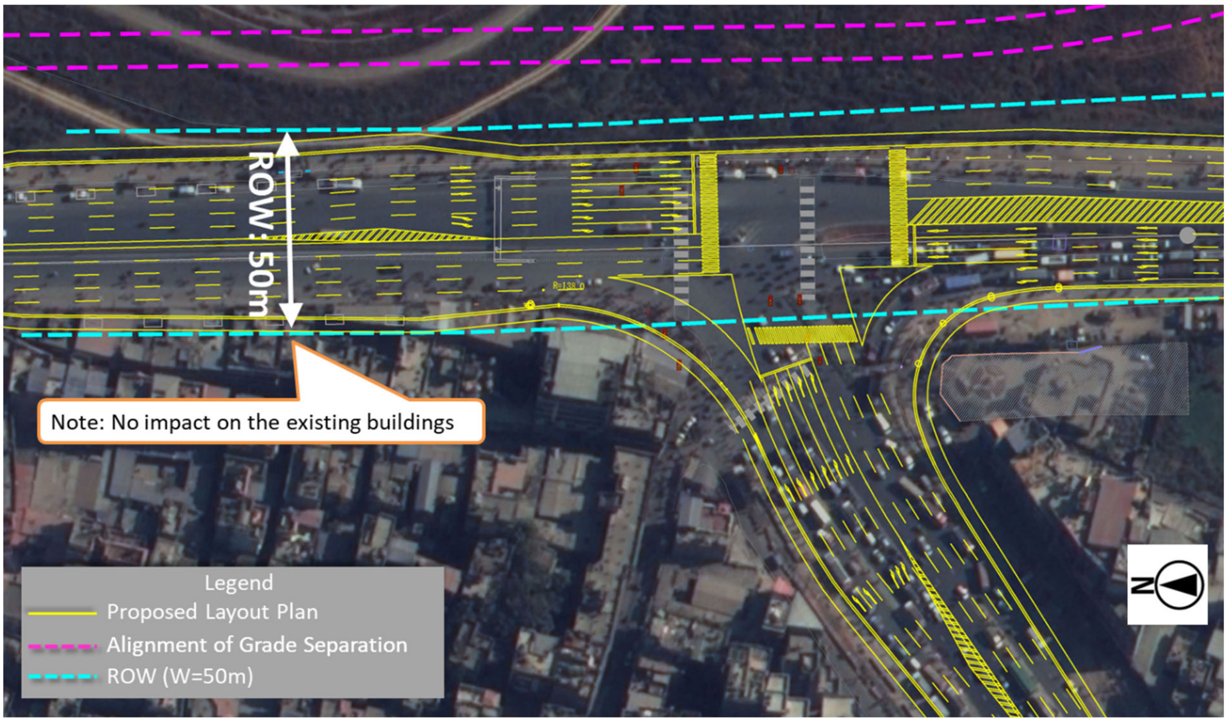
Case	Required Lane Layout	Applicable Lane Layout Within ROW:50m
Sketch		
Excess to ROW	Approx. 15m	0
LOS	D	F
Control Delay for Intersection (s/veh)	35.4	244.5

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.4.16 Required Lane Layout Plan for Alt-3-2



Source: JICA Survey Team

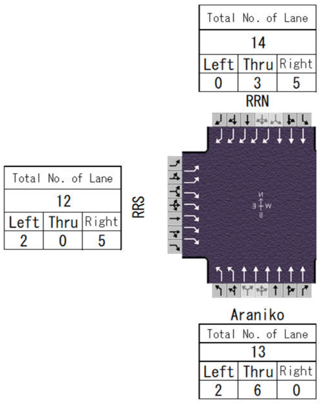
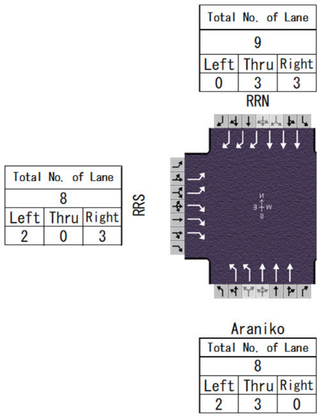
Figure 7.4.17 Lane Layout Plan within the ROW for Alt-3-2

3) Alt-4-2

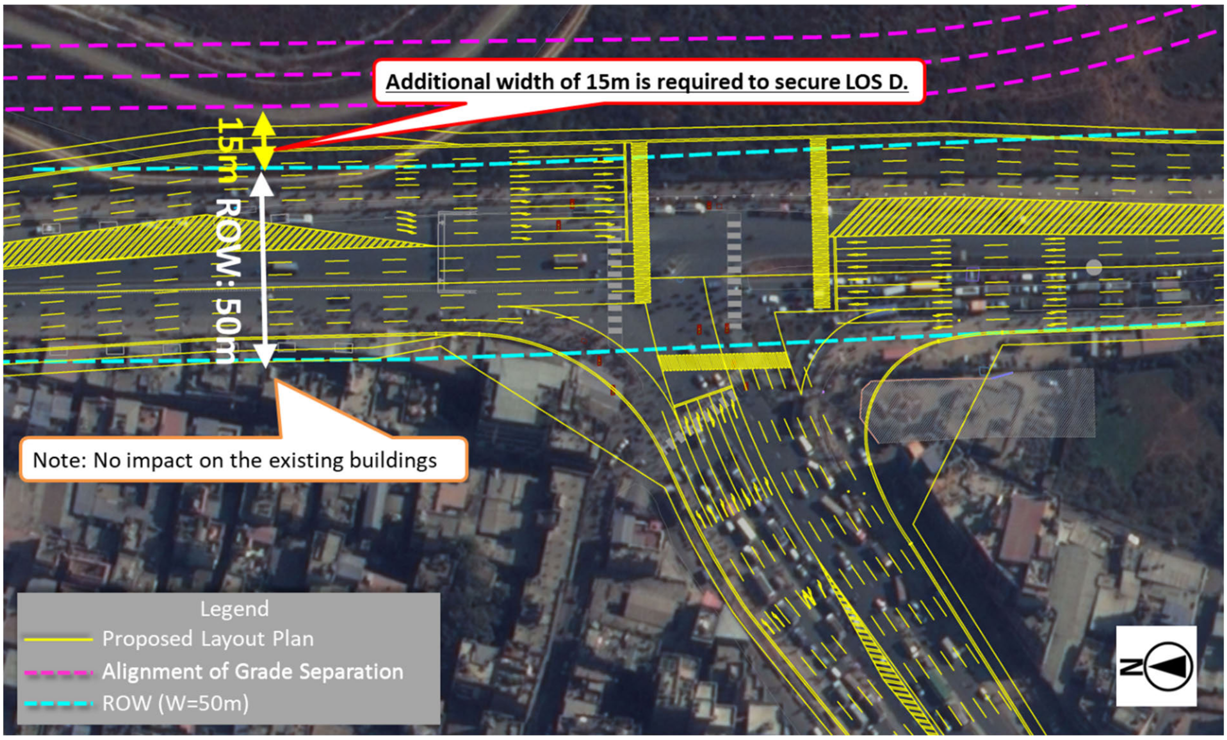
Table 7.5.12 and Figure 7.5 18 to Figure 7.5 19 presents the analysis result and lane layout plan for Alt 4-2, respectively.

Table 7.4.12 Intersection Analysis Result for Alt-4-2

Lane Layout & LOS for At-grade Koteshwor Intersection (Existing LOS: F, CD:650 s)

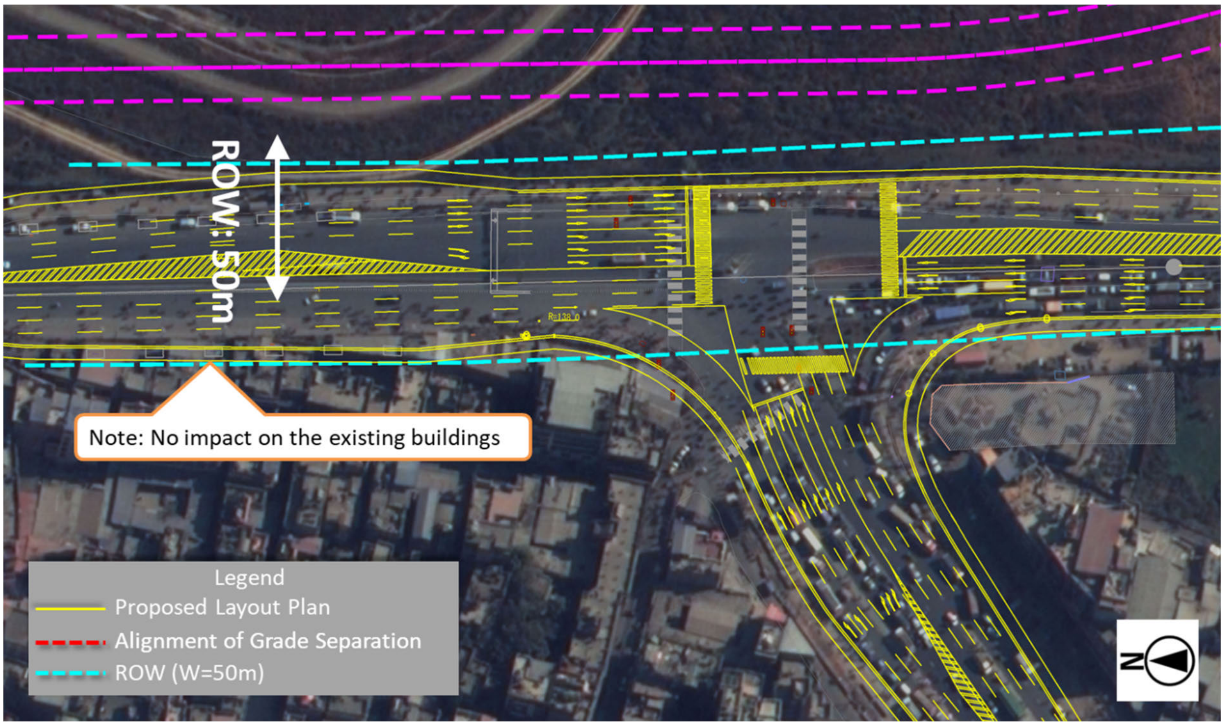
Case	Required Lane Layout	Applicable Lane Layout Within ROW:50m
Sketch		
Excess to ROW	Approx.15m	0
LOS	D	F
Control Delay for Intersection (s/veh)	36.1	245.0

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.4.18 Required Lane Layout Plan for Alt-4-2 (Ideal Case)



Source:JICA Survey Team

Figure 7.4.19 Lane Layout Plan within ROW for Alt-4-2

7.4.7 Tinkune Intersection Improvement Plan

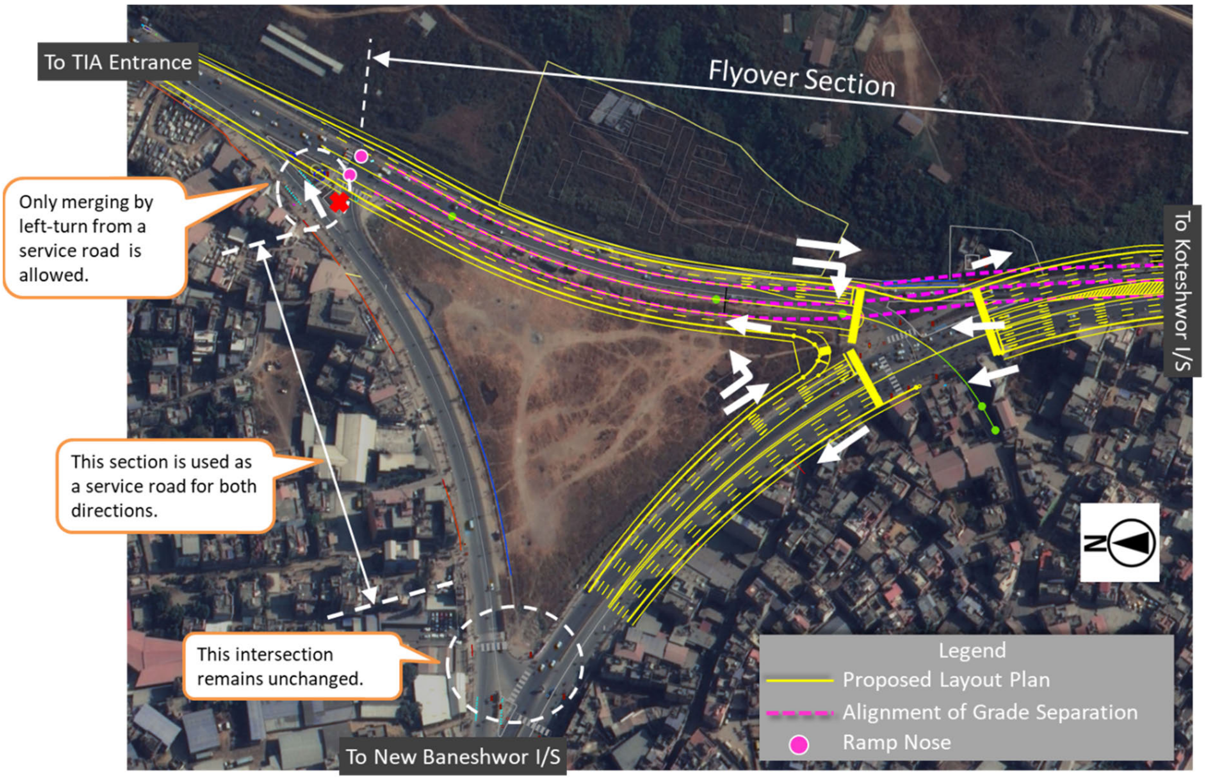
(1) Study on Lane Layout

Same as the Koteshwor Intersection, a lane layout study was conducted for the Tinkune Intersection. Due to less land restriction than the requirements for the Koteshwor and Jadibuti Intersections, they only examined the LOS of the lane layout to pass the required LOS D. Figure 7.4.4 presents the analysis results for the Tinkune Intersection.

(2) Lane Layout of the Tinkune Intersection

1) Alt-1-1

Figure 7.4.20 shows the lane layout plan for Alt 1-1.

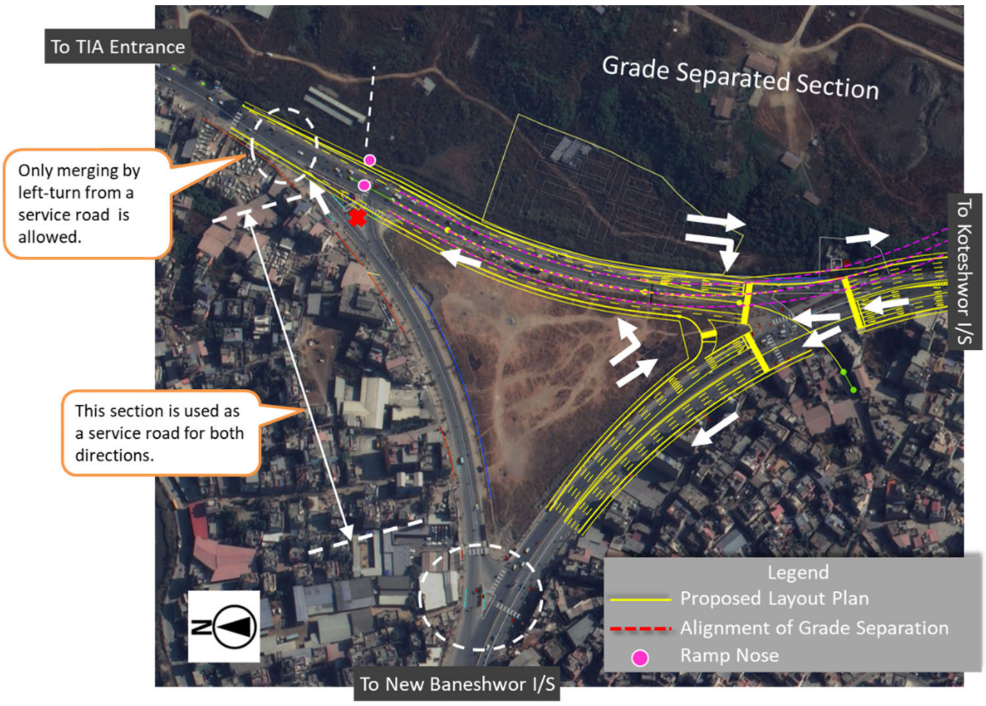


Source: JICA Survey Team

Figure 7.4.20 Required Lane Layout Plan for Alt-1-1

2) Alt-3-2

Figure 7.4.21 shows the lane layout plan for Alt 3-2.

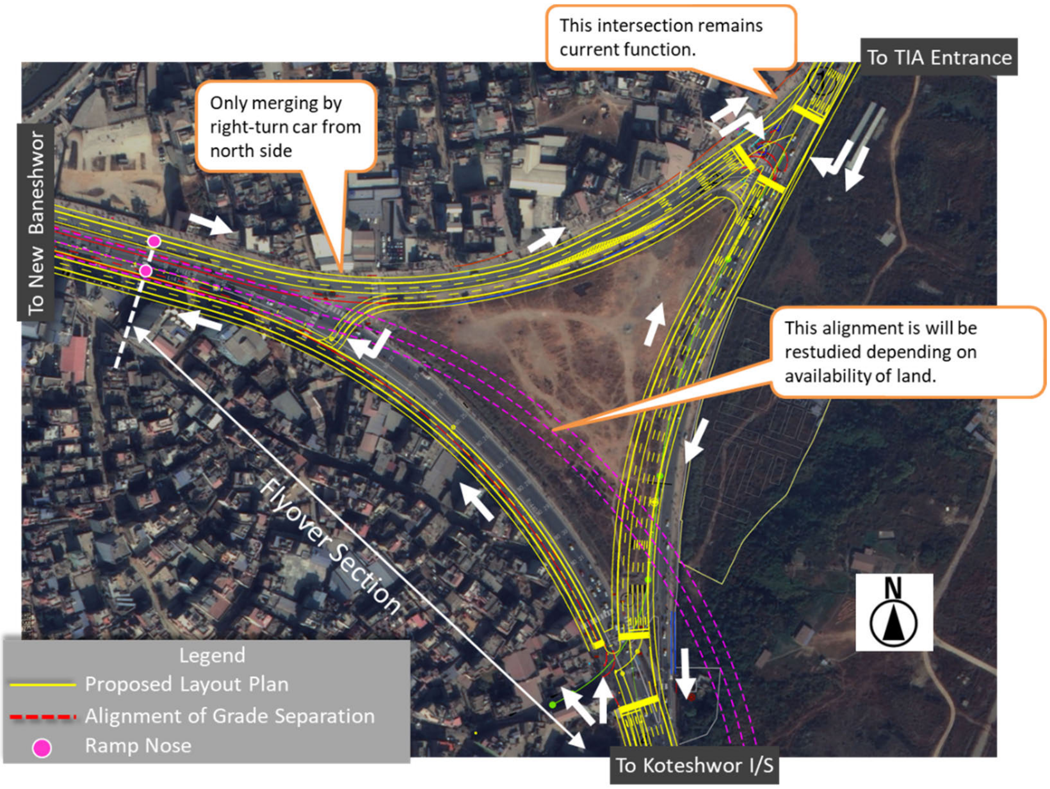


Source: JICA Survey Team

Figure 7.4.21 Required Lane Layout Plan for Alt-3-2

3) Alt-4-2

Figure 7.4.22 shows the lane layout plan for Alt 4-2, the ideal case.



Source: JICA Survey Team

Figure 7.4.22 Required Lane Layout Plan for Alt-4-2

7.4.8 Jadibuti Intersection Improvement Plan

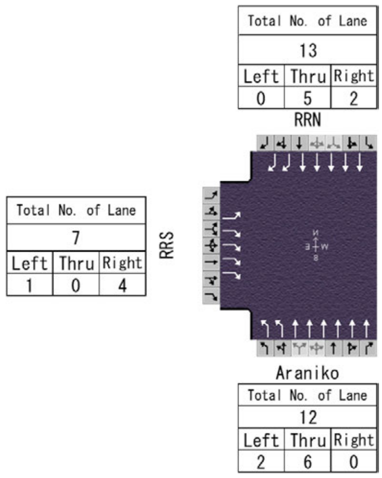
(1) Lane Layout Study

Jadibuti Intersection went under an analysis similar to the Koteshwor Intersection.

(2) Jadibuti Intersection Lane Layout

1) Alt-1-1

Since Alt-1-1 does not pass through the Jadibuti Intersection, its improvement is outside the Project scope. Traffic continues to concentrate on this intersection after the completion of the Alt-1-1 due to its location on Araniko Highway South, which has the highest traffic volume among the Project roads. Figure 7.4.23 shows its required lane layout in 2033, indicating that even after the implementation of Figure 7.4.23. Alt-1-1, the Jadibuti Intersection remains a traffic bottleneck.

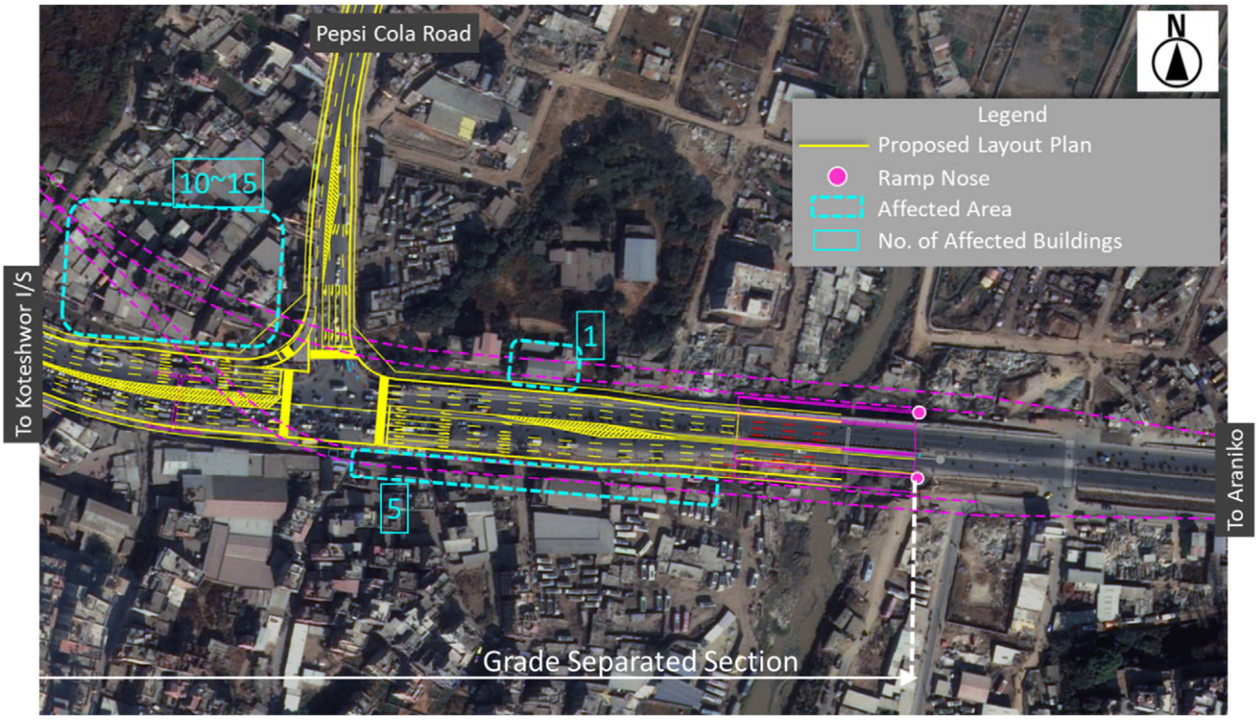


Source: JICA Survey Team

Figure 7.4.23 Required Lane Layout in 2033

2) Alt-3-2

Lane layout plan is in Figure 7.4.24.

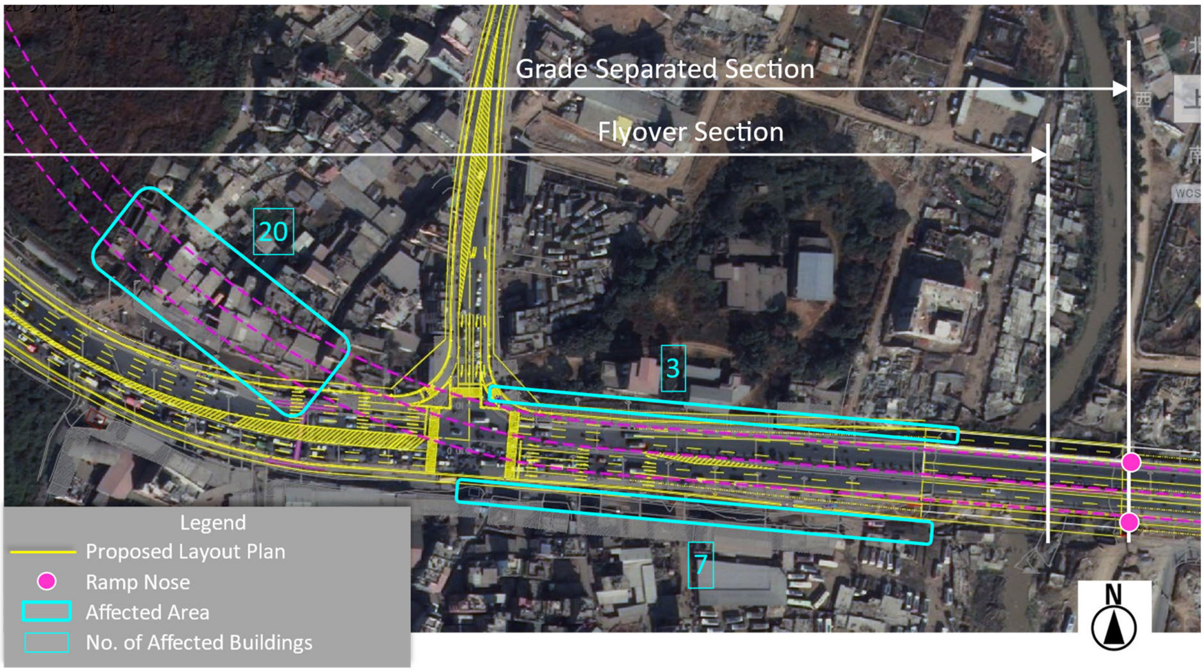


Source: JICA Survey Team

Figure 7.4.24 Required Lane Layout Plan for Alt-3-2

3) Alt-4-2

Lane layout plan is in Figure 7.4.25.



Source: JICA Survey Team

Figure 7.4.25 Required Lane Layout Plan for Alt-4-2

(3) Study on Connection Forms Between GS and Araniko Highway South

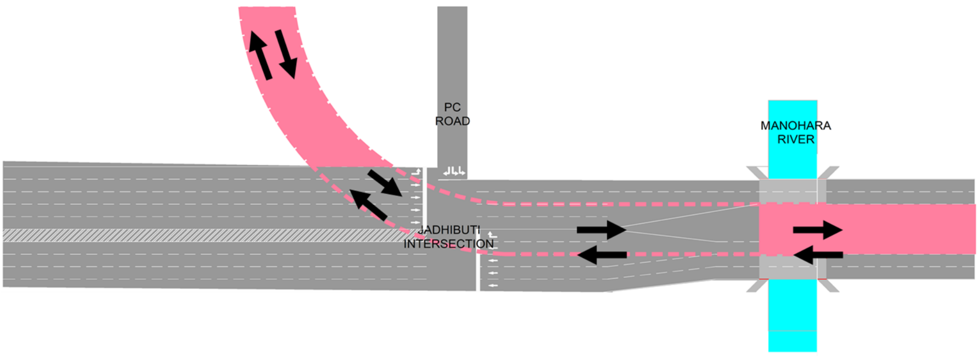
Considering the design conditions and countermeasure policies on the control points mentioned in 6.4.3, the type of connection form and the shape of the Jadibuti intersection were further studied. From the result of the site, social, environmental, and topographic surveys, and discussion with DOR, three improvement options can be considered as a connection form between GS and Araniko Highway South.

- Option-1: Direct Connection to the Center of Araniko Highway South
- Option-2: Separate Connection by Direction with Side Ramps to Araniko Highway South
- Option -3: T-Shaped Connection with Ramps to Araniko Highway South

Explanations for each alternative are below.

1) Option-1: Direct Connection

The outline of Option-1 is in Figure 7.4.26, and its layout plan and profile are in Figure 7.4.27 and Figure 7.4.28. GS directly connects to the center of Araniko Highway South after a flyover crossing. As a result, the GS can connect vehicles before they approach the existing Manohara bridges.

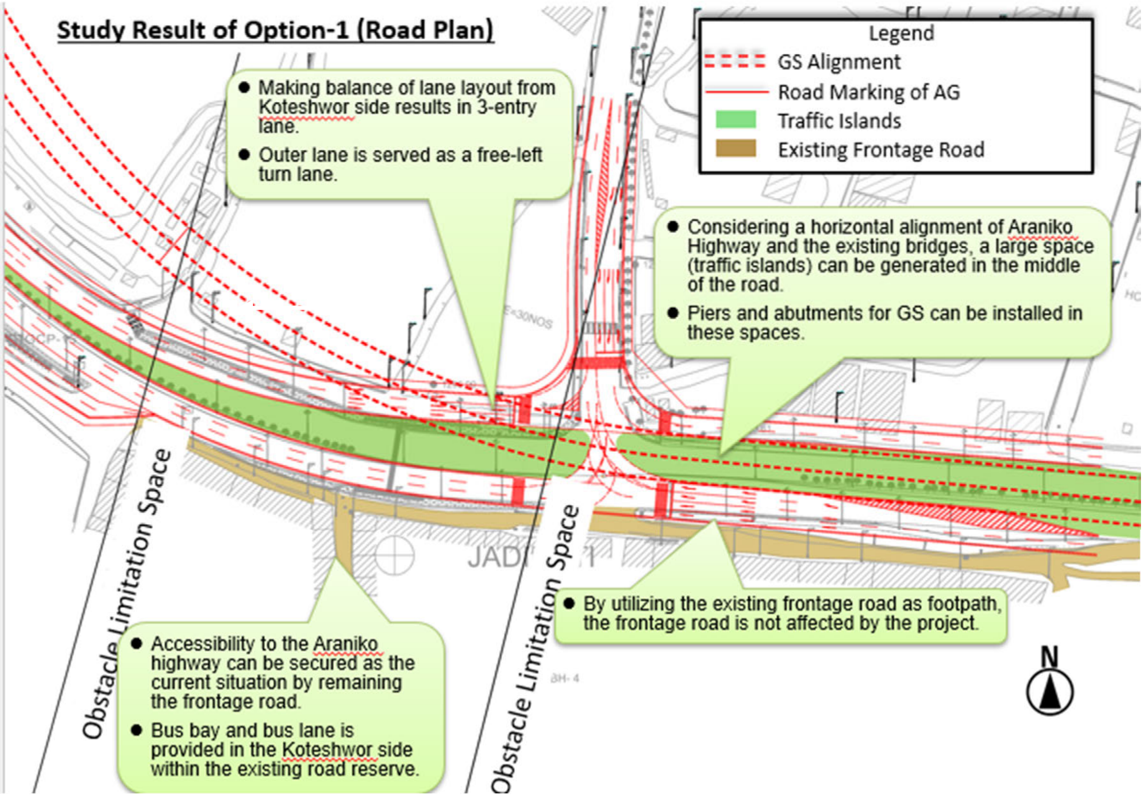


◆ **Option Description**

- **In order to secure smooth traffic flow, Grade Separated Structure is connected directly to the center of Araniko Highway.**
- **The total road width of at-grade road gets wider in the GS Section due to occupation of the road by new bridge piers, so that the existing frontage roads and roadside buildings in the south sides are possible to be affected by the project.**
- **No affection to the future possible widening of Araniko Highway but much disturbance to the traffic during construction.**

Source: JICA Survey Team

Figure 7.4.26 Outline of Option-1 (Direct Connection)



Source: JICA Survey Team

Figure 7.4.27 Proposed Lane Layout of Option-1 (Direct Connection)

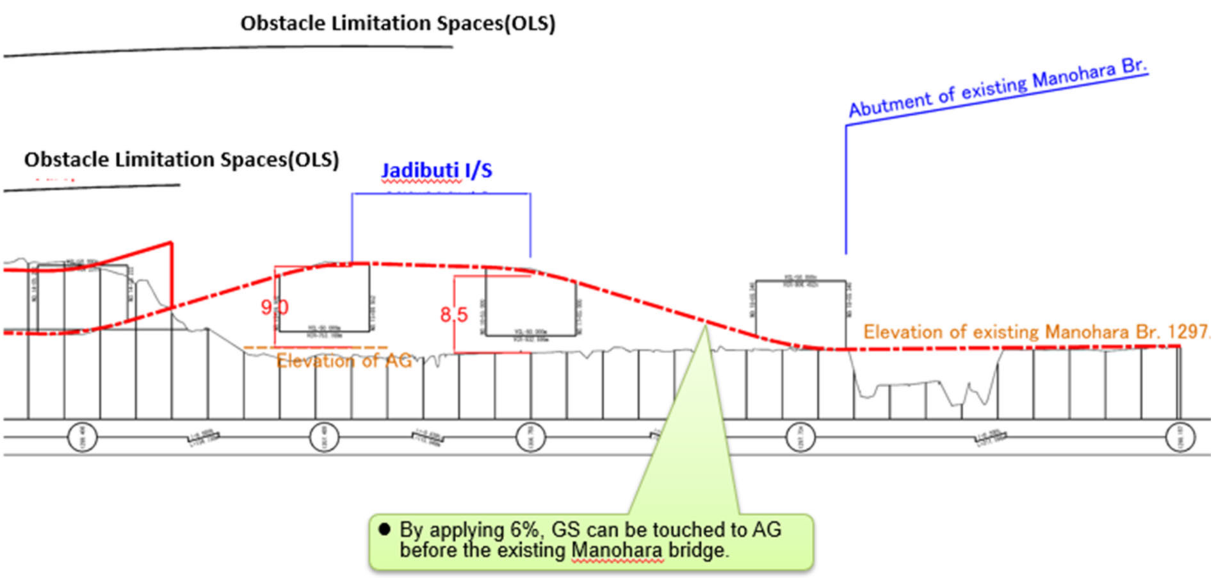
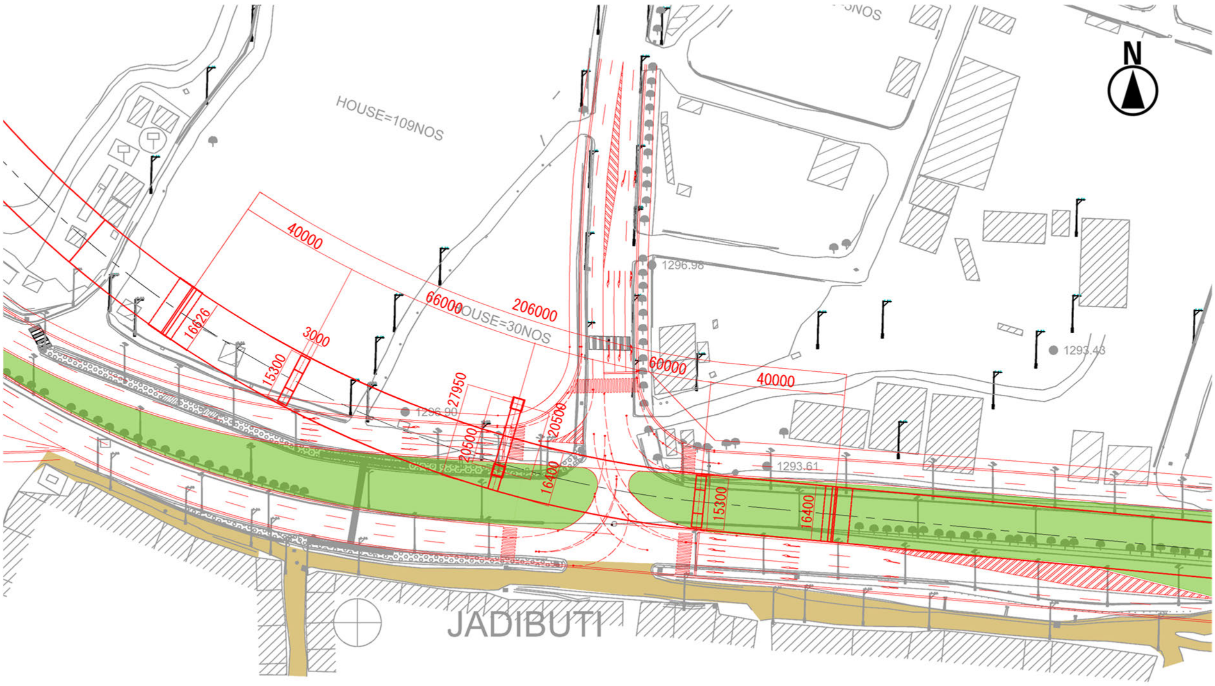


Figure 7.4.28 Proposed Profile of Option-1 (Direct Connection)

Figure 7.4.29 indicates the flyover for Option-1 has an expected span range of 40 - 60m. Building a bridge over the intersection produces no particular issues.



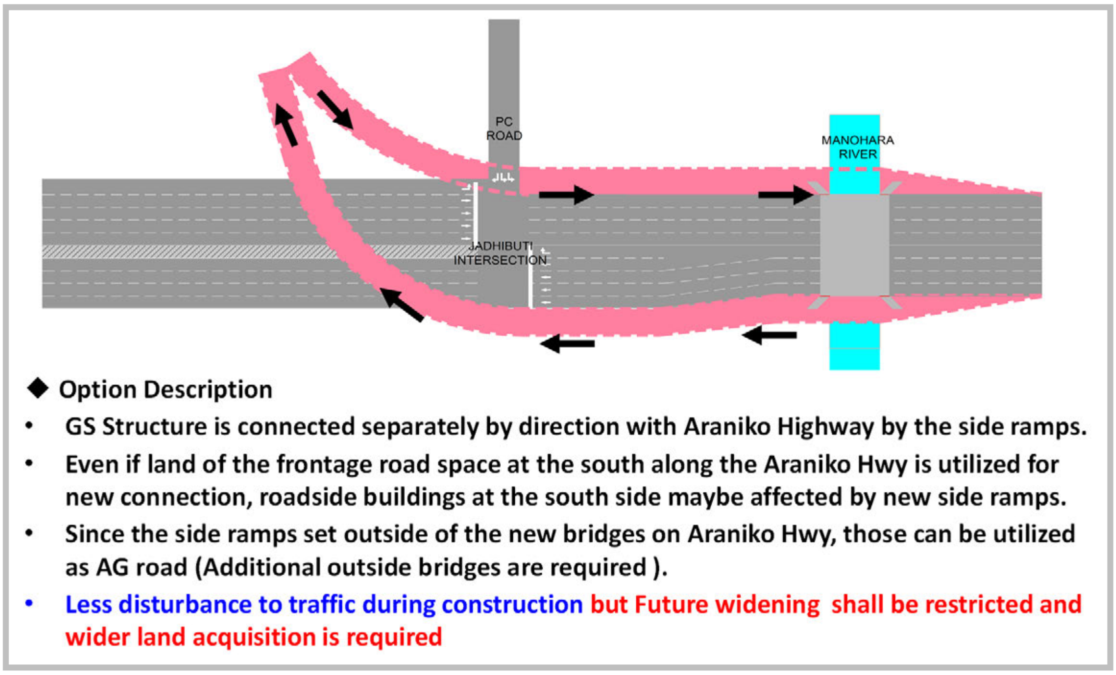
Source: JICA Survey Team

Figure 7.4.29 Proposed Structure Layout of Option-1 (Direct Connection)

2) Option-2: Separate Connection by Direction with Side Ramps

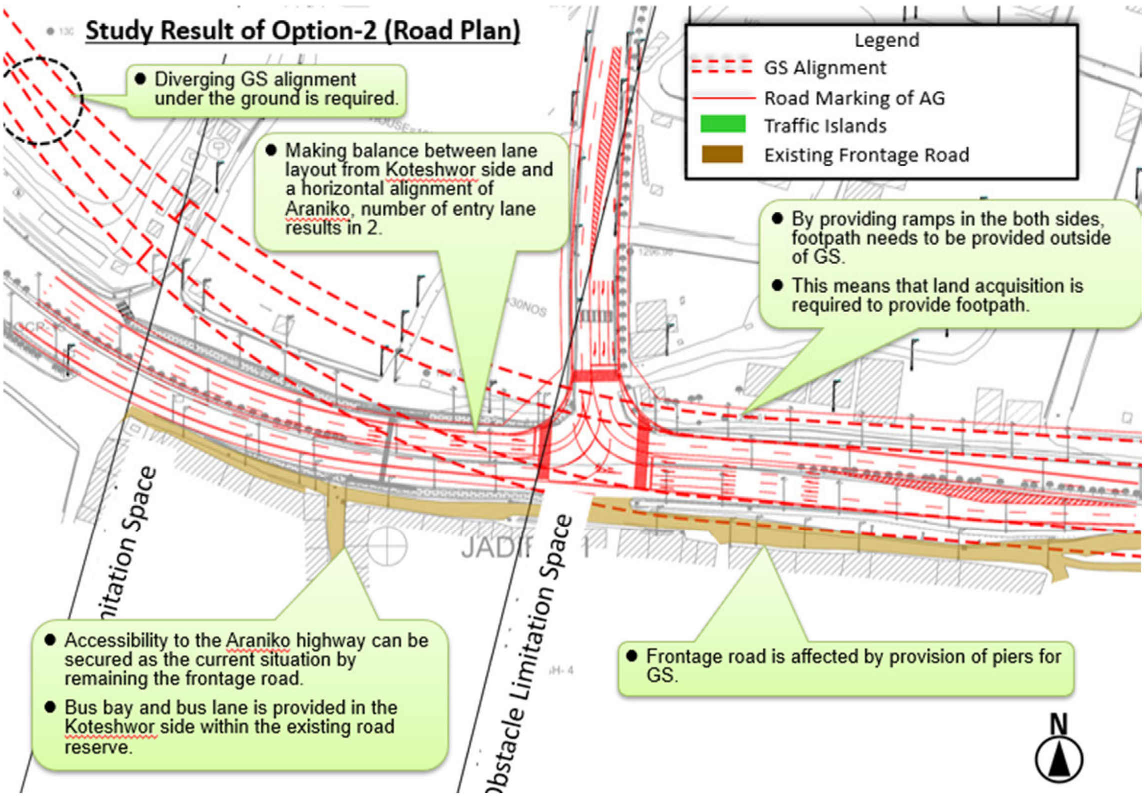
The outline of Option-2 is in Figure 7.4.30 and its layout plan and profile are in Figure 7.4.31 to Figure 7.4.33. The study finds GS can offer a connection before vehicles approach the existing Manohara bridges.

GS connects separately with the outer edges of the Araniko Highway South side ramps through a flyover crossing over the intersection. This option requires the replacement of the existing bridges and the relocation of approximately 30 buildings/houses.



Source: JICA Survey Team

Figure 7.4.30 Outline of Option-2 (Separate Connection by Direction with Side Ramps)



Source: JICA Survey Team

Figure 7.4.31 Proposed Lane Layout of Option-2 (Separate Connection by Direction with Side Ramps)

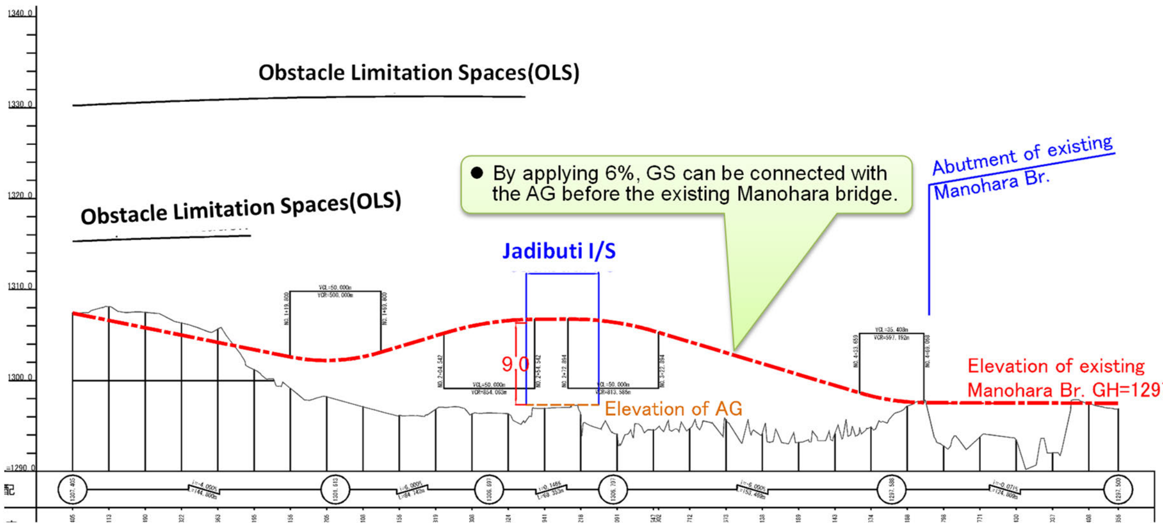


Figure 7.4.32 Proposed North Ramp's Profile of Option-2 (Separate Connection by Direction with Side Ramps)

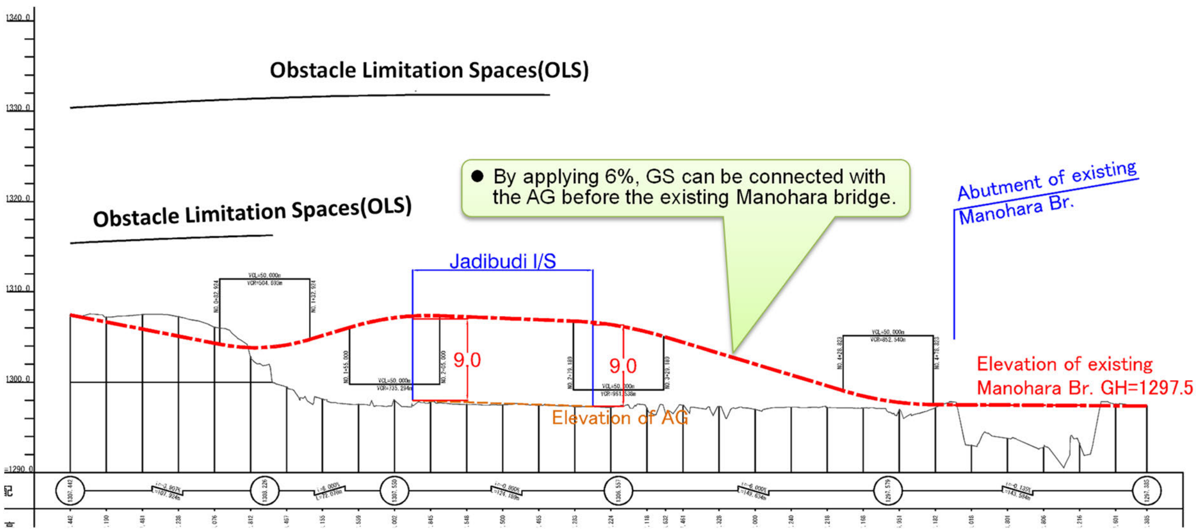
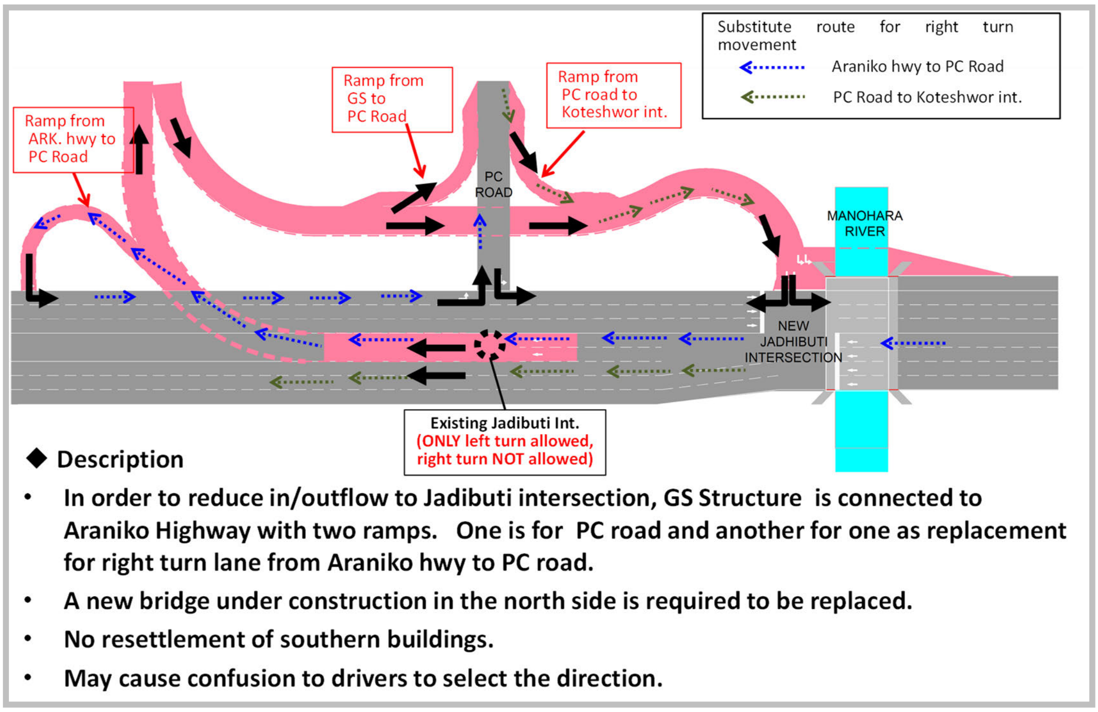


Figure 7.4.33 Proposed South Ramp's Profile of Option-2 (Separate Connection by Direction with Side Ramps)

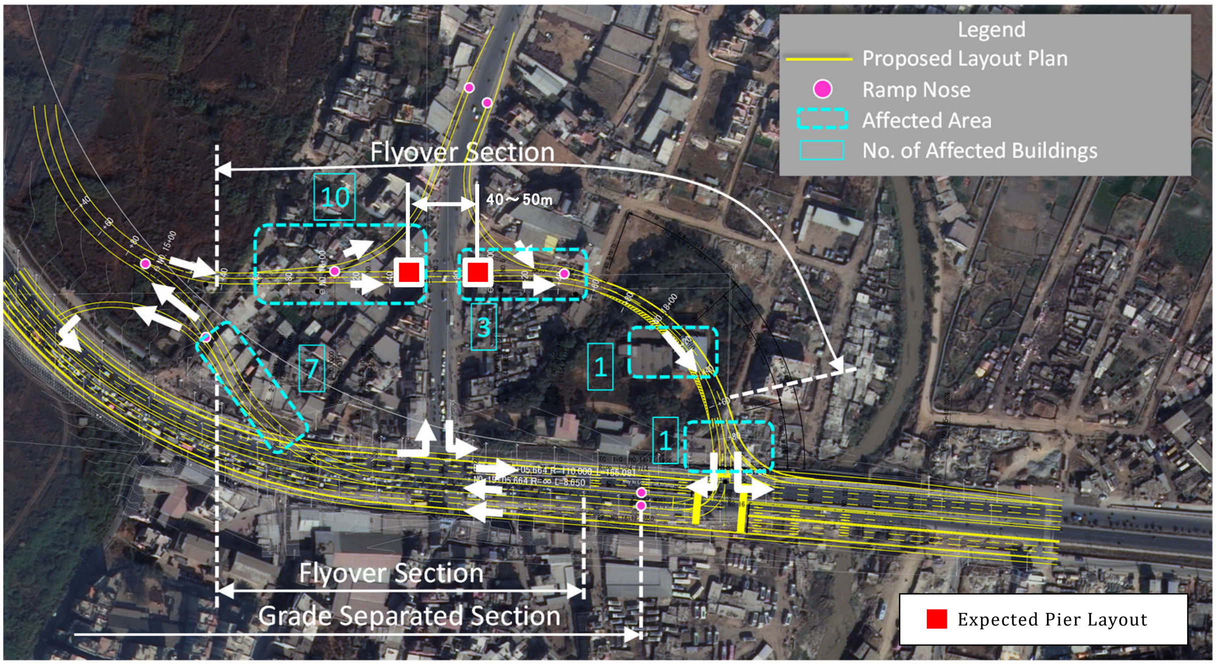
3) Option-3: T-Shaped Connection with Ramps

The outline of Option-3 is in Figure 7.4.34 and its layout plan is in Figure 7.4.35. Option-3 connects GS with the Araniko Highway South through a T-shaped structure, as shown in Figure 7.4.35. Since DOR and JST agreed that this option would confuse drivers, further plan and profile were not prepared.



Source: JICA Survey Team

Figure 7.4.34 Outline of Option-3 (T-Shaped Connection with Ramps)



Source: JICA Survey Team

Figure 7.4.35 Proposed Lane Layout of Option-3 (T-Shaped Connection with Ramps)

4) Comparison of Options

Table 7.4.13 summarizes the evaluation of each option. Option-1 receives priority over the other options as it leaves no impact on the existing bridges and a reduced impact on traffic flow during construction.

Chapter 6 mentions two conditions set after the submission date of the Interim Report in December 2022, which renders Option-1 the only feasible choice.

1) Use of TIA land is allowed only for Grade-separated sections. (Option-3 is not feasible for this reason.)

2) Construction must avoid impacting buildings/houses located south of the intersection. (Option-2 is also not feasible for this reason.)

Table 7.4.13 Summary of Comparison of Each Option

Items	Opt-1: Direct Connection	Opt-2: Separate Connection	Opt-3: T-Shape Connection
Traffic Operation	**Good (3)**	**Fair (2)**	**Poor (1)**
	Simple traffic flow and a smooth connection from the GS section	Simple traffic flow	Complicated traffic flow from Araniko Hwy to PC road
Impacts on the Existing Bridge	**Good (3)**	**Good (3)**	**Poor (1)**
	No impact but requires close observation during construction.	No impact but requires close observation during construction.	Requires replacing an existing bridge on the north side.
Impacts on houses/buildings	**Poor (1)**	**Poor (1)**	**Fair (2)**
	Approximately 30 houses	Approximately 30 houses	Approximately 20 houses
Traffic Safety	**Fair (2)**	**Poor (1)**	**Fair (2)**
	Large intersection with new traffic islands for FO on the road center, optimized for pedestrians	Large intersection	Compact intersection
Easiness of pier installation for FO	**Poor (1)**	**Poor (1)**	**Fair (2)**
	Requires a long span of approximately 60 m at crossing the intersection	Requires a long span of approximately 60 m at crossing the intersection	Requires a long span of approximately 50 m at the Pepsi cola crossings, but is shorter than other options in aggregate
Cost (including land acquisition and compensation one)	**Fair (2)**	**Fair (2)**	**Poor (1)**
	1.0	**1.0**	**1.5**
Recommendation	**Recommended** **Total Score: 12**	**Total Score: 10**	**Total Score: 9**

Source: JICA Survey Team

7.4.9 Tunnel Facilities Required for Each Alternative

(1) Introduction

Since the expected length of the underpass for each alternative exceeds 200 m, their safety facilities should be installed.

A road tunnel is a closed space for vehicles and users. It requires several safety features to create a secure interior, such as a ventilation system, evacuating effluent gas generated from cars, and other facilities that function in case of fire or car accidents.

A study of tunnel facilities for Alt 4-2 is in Chapter 10. The safety facilities for Alt 3-2 are same as Alt 4-2 since the main design conditions, such as traffic volume and tunnel length, are similar for both alternatives.

(2) Ventilation System

As described in Chapter 10, ventilation systems is unnecessary.

(3) Safety Facilities

Study the required safety facilities for the underpass tunnel section compliant with the Specification of Safety Facilities for Road Tunnel (Japanese Road Association, Sep. 2019). The specification stipulates the classification of tunnel sections by length and traffic volume to determine the necessary safety facilities.

Chapter 10 shows the following required facilities from the study:

- Emergency Phone
- Alarm Pushbutton
- VMS outside Tunnel
- Fire Extinguisher
- Fire Hydrant
- Escape Route Sign

7.4.10 Structure Planning

(1) Alt-1: RRN-RRS with Flyover

The structure planning requires Alt-1 to feature a 560 m steel narrow box girder and a 300 m PC girder section, with 340 m of earth section, totaling 1,200m of grade separation length.

The flyover for Alt-1 passing over Tinkune and Koteshwor Intersections consists of combined continuous steel and PC girders. A steel narrow box girder with composite deck slabs is necessary across the Tinkune and Koteshwor Intersections where long spans are required.

A PC girder 30 m in span length is applied to any section with no specific span length requirement, as it is the most economical option.

Where vertical road clearance is limited, special structure is applied such as a rigid connection between girders and pier heads. The structural features are in Table 7.4.14

(2) Alt-3-2 (use TIA Land): RRN-Araniko Highway South with Underpass & Flyover

The structure planning for both underpass and flyover sections requires Alt-3-2 to have a 640 m section with box culverts, 160 m of U-shaped retaining walls, 720 m of bridge structure, and a 160 m earth structure, creating a 1,680 m grade-separated facility.

1) Underpass Structures

This underpass shall be installed within the TIA land. For the underpass structure, box culverts and U-shaped retaining walls are basically applied. The height of the inner space is assumed to be 5m as minimum clearance. Earth cover thickness is 2m based on the requirement from CAAN. The structural features are shown in Table 7.4.15

2) Flyover Structure

A flyover is planned for the road sections connecting the underpass section in TIA land with both the Tinkune (RRN) and Jadibudi Intersections. The applicable superstructure types are the same as Alt-1, which requires a steel narrow box girder at the intersection where the longer span is required and a PC girder for the remaining sections where no span limitation exists. The structural features are in Table 7.4.14. Further details on the construction method are in Table 7.4.17.

(3) Alt-4-2 (use TIA Land): Araniko Highway North - Araniko Highway South with Underpass & Flyover

As a result of the structure planning of both underpass and flyover sections, Alt-4-2 comprises 640 m section with box culverts, 240 m section with U-shape retaining walls, 820 m section with bridge structure, and 160 m section of the earth structure, totaling 1,860m of grade separation length.

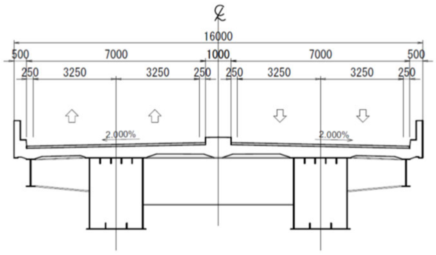
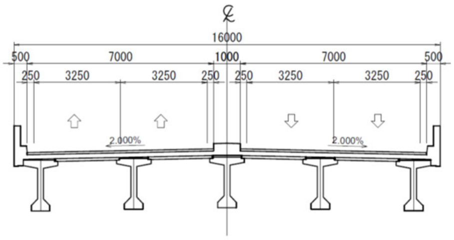
1) Underpass Structure

In the Alt-4-2 route, the underpass is applied to the road section passing through the TIA territory. The applicable structures are the same as Alt-3-2. Section 7.4.10 discusses the details of construction methods.

2) Flyover Structure

The planned location of the flyover is at the road sections connecting from the underpass section in TIA land with both Tinkune Intersection West (ARK Hwy N) and Jadibudi Intersection. The applicable structures are the same as Alt-1and Alt-3-2. Table 7.4.14 shows the structural features of the flyover. Table 7.4.19 discusses the details of construction methods.

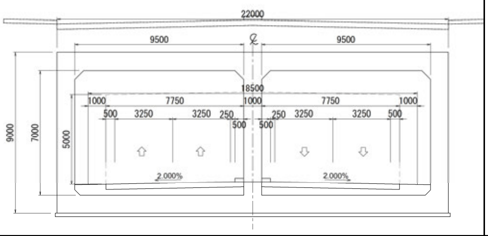
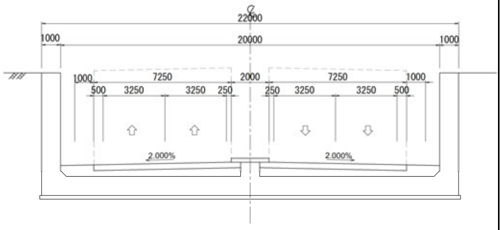
Table 7.4.14 Structural Features of Flyover

	Narrow Steel Box Girder	PC-T Girder
Overview		
Applicability & Features	- Intersections with long spans - Viaducts under special conditions - High cost - Expectation of technology transfer	- Viaducts with no design constraints - Most economical & common usage
Applied Sites & Length*	Alt-1: 300m (T) + 260m (K) =560m Alt-3-2: 180m (T) + 180m (J) =360m Alt-4-2: 180m (T) + 180m (J) =360m	Alt-1: 300m Alt-3-2: 120m (T) + 180m (J) =360m Alt-4-2: 220m (T) + 180m (J) =460m
Span(Max)*	70m	30m
Construction Method	Track Crane Bent Erection	Track Crane Erection

*Design assumptions

Note: Structural types and specifications may change through further study.
Sites to apply (Intersection): Tinkune (T), Koteshwor (K), Jadibudi (J)
Source: JICA Survey Team

Table 7.4.15 Structural Features of Underpass

	Box Culvert	U-shaped Retaining Wall
Overview		
Applied Sites	- At section under obstacle limitation space	- At section with no constraints of obstacle limitation space
Length Inner Height*	640m for Alt-3-2 and Alt-4-2 (5m+2m*)	160m for Alt-3-2, 240m for Alt-4-2 -
Construction Method	- Open cut - Earth retaining wall (in case of restrictions on land use)	- Open cut - Earth retaining wall (in case of restrictions on land use)

*Additional inner space for smoke exhaust equipment shall be studied in the next stage
Note: Structural types and specifications may be changed through further study.
Source: JICA Survey Team

(4) Advanced Technology Applicable to the Project

1) Introduction

Koteshwor, Tinkune and Jadibudi Intersections are along very congested project roads in urban areas of the Kathmandu Valley. Moreover, the road section from Koteshwor Intersection to Jadibudi Intersection is restricted from any activities that could violate obstacle limitation spaces from TIA. Considering such circumstances, it is worth seeking the applicability of advanced technologies, which can minimize negative social impacts during construction and enable construction works properly under the limited vertical work space.

The advanced technologies described in this sub-chapter can reduce the construction period and workspace on the existing road and significantly lessen harmful substances such as noise and air pollution, vibration, and polluted sludge from excavation sites.

Since the structure types for the project are mainly the flyover and the underpass, advanced technologies focus on construction techniques for both structural options, as shown in Table 7.4.16.

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Table 7.4.16 List of Applicable Advanced Technologies

Type	Name of Technology	Pros	Cons	Feature
Flyover	Steel Narrow Box Girder	-Labor saving technology can reduce the fabrication period of girders	-Periodic repaining due to usage of steel members	Narrow width and thicker flange width of the box girder to reduce the number of longitudinal ribs, omit lateral ribs and floor framing using longer deck slab like composite deck slab. small pieces for girder fabrication for shorter construction period
	Composite Deck Slab	- High durability compared with RC deck slab - Possible to open existing traffic under the deck slab after installation of bottom steel plate	- N/A	New deck slab type with high durability and is safe for construction, especially, underneath the deck slab. This can also be applied to steel girders.
	PC Well	- Possible to construct very narrow space	- Construction cost becomes higher.	New type of foundation which can be constructed in a narrow space and can utilize a smaller size of foundation since no pile cap is required.
	Steel Pipe Socket Connection Method	- Possible to reduce construction period	- N/A	New connection method between steel pier column and pile cap/pile by omitting the anchor frame, enabling this method to achieve shorter construction time with possible application to a PC well foundation.
Underpass	Application of Temporary Platform	- Construction cost is cheaper than none-open cut method.	- Adverse impact in existing traffic, especially during installation of temporary platform at night.	Temporary platform is installed above open-cut area of box culvert and is used for detour road. Construction work of box culvert is carried out under temporary platform. Mobilization and demobilization of material and equipment are done at night.
	Installation Equipment for Diaphragm Wall under Limited Clearance	- Possible to construct diaphragm wall under limited vertical clearance	- Availability of equipment is limited.	New construction equipment for diaphragm wall which can be constructed under limited vertical clearance, is applicable in the area under obstacle limitation space by TIA.

Source: JICA Survey Team

2) Outlines of Advanced Technologies

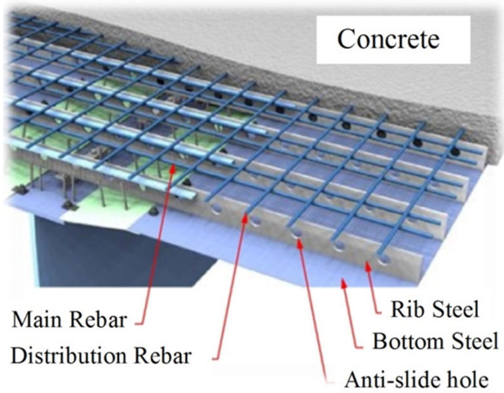
A. Steel Narrow Box Girder

A steel narrow box girder is the latest technology in latest Japan, achieving further labor saving and rationality of its structure by applying narrower box width and thicker flange width to reduce the number of longitudinal ribs and omit lateral ribs. In addition, floor framing is omitted using longer deck slab like composite deck slab.

B. Composite Deck Slab

Composite deck slab is a new innovation with steel and concrete materials. The bottom of the composite deck slab is covered by steel plate reinforced by T or I shaped steel. Concrete is poured after the installation of the bottom steel.

Concrete deck slab is more durable than conventional RC deck slabs and can achieve quick construction results. The initial installation of the steel plate eliminates the risk of wet concrete leakage during construction, preventing any disruption to traffic flow below the deck slab. Figure 7.4.36 shows a sketch of the composite deck slab.



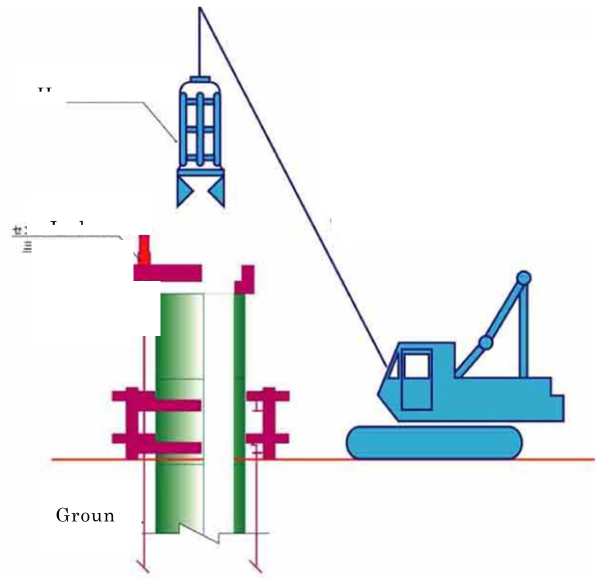
Source: Website of New Technology Information

Figure 7.4.36 Composite Deck Slab

C. PC Well

A PC well foundation comprises precast concrete cylinders, either circular or oval in shape. After placement at the site, each precast concrete cylinder is connected to the adjacent one using a post-tension method. Following the placement and connection of the precast concrete blocks, excavation work is undertaken, and they are compressed into the ground.

This technique is particularly effective, especially within a city, as it allows for the construction of large-diameter pile (up to 8 meter-diameter), capable of bearing the entire load with only this type of large-diameter pile.



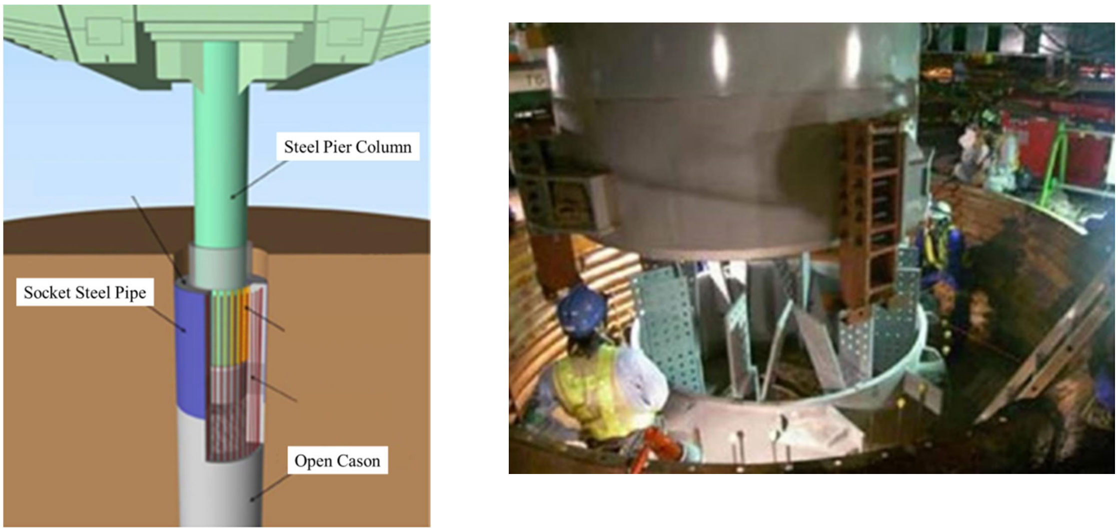
Source: Website of Nippon Hume Corporation Ltd.

Source: Website of Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism

Figure 7.4.37 Sketch and Photograph of PC Well

D. Steel Pipe Socket Connection Method

The steel pipe socket connection method is a jointing technique of inserting a steel column into a steel pipe socket, constructed at the top of the foundation and filling it with concrete. It is possible to reduce the construction period because it can omit the pile cap and anchor frame used in the conventional method.



Source: Investigation Report by MLIT named "solidification construction by quick construction method for Kosaka intersection"

Figure 7.4.38 Sketch and Photograph of Steel Pipe Socket Connection Method

E. Application of Temporary Platform/Road Deck Slab

The construction of a box culvert underground requires a temporary platform to secure a space for a temporary road. As a temporary platform above the structure covers the box culvert, most construction work for the width reduction of the temporary road and under the temporary platform occurs nighttime.

Source: Website of Hazama Ando Corporation

Figure 7.4.39 Photograph of Temporary Platform

F. Installation of Machinery for the Diaphragm Wall under Limited Clearance

This machinery shall be applied to excavate grounds for diaphragm wall under the limited upper clearance. It works on a large scale, and the height of the equipment is more than 20 m, enabling the construction of diaphragm walls under the upper clearance of about 5 m in contrast to the conventional equipment for diaphragm wall excavation.

Source: Website of Low Space Construction Association

Figure 7.4.40 Photograph of Installation Equipment of Diaphragm Wall under Limited Clearance

7.4.11 Construction Planning

(1) Alt-1: RRN-RRS with Flyover

The expected foundation type for this alternative is cast-in-place concrete piles using the earth drill method. The substructure is constructed during the daytime while controlling traffic on the existing project roads. The superstructure is erected by a truck crane at nighttime while controlling or closing the traffic on the project roads for safety reasons. Table 7.4.17 lists the methods and conditions for the construction of the substructure and superstructure.

Table 7.4.17 Construction Methods and Conditions for Flyover Structure

		Remaining Section	Intersections
Substructure	Foundation	Earth Drill Method *Daytime construction with traffic restriction*	Earth Drill Method *Daytime construction with traffic restriction*
	Abutment/ Pier	Construct a temporary cofferdam using steel sheet pile *Daytime construction with traffic restriction*	Construct a temporary cofferdam using steel sheet pile *Daytime construction with traffic restriction*
Superstructure	Steel/PC	Track Crane Erection Method *Nighttime erection with traffic restriction*	Track Crane Bent Erection Method *Fully closed at night*
Superstructure (under the Obstacle Limitation Space)	Steel/PC	Track Crane Erection Method *Nighttime erection with traffic restriction*	Track Crane Bent Erection Method *Fully closed at night with restriction of airplane schedule*

Source: JICA Survey Team

(2) Alt-3-2 (use TIA Land): RRN-Araniko Highway South with Underpass & Flyover

1) Underpass Structure

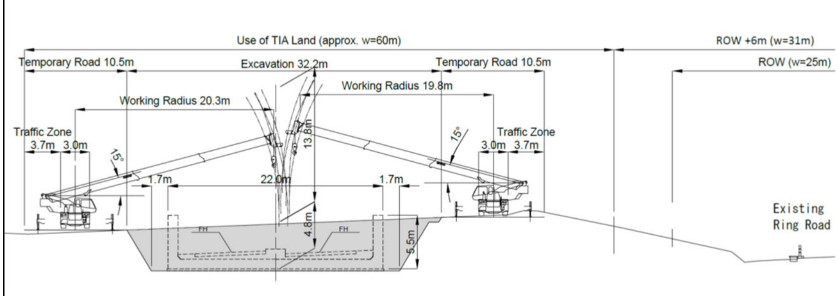
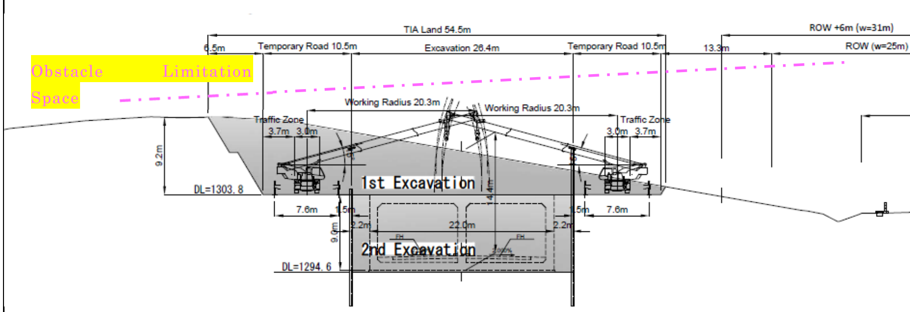
As a result of discussions with CAAN, under the obstacle limitation space within the TIA territory, a tunnel with box culverts is to be applied to minimize the impact on the airport operation using an earth retaining wall (ER).

For the remaining sections, designers assume a U-shaped retaining wall using the open-cut excavation (OC) method, known for its cost-effectiveness. Figure 7.4.41 and Table 7.4.18illustrate the OC and ER areas and construction methods for the underpass.

NOTE: The sections of OC/ER may change depending on the further study.
Source: JICA Survey Team

Figure 7.4.41 Open-Cut (OC) and Earth Retaining Wall (ER) Area

Table 7.4.18 Construction Methods for the Underpass

Method-1: Open Cut	
Section-1 Connection of UP and FO (Tinkune intersection side) 	Applied for 1) Shallow excavation 2) No horizontal obstacles 3) No restriction of land use 4) No restriction when using crane
Method-2: Earth Retaining Wall	
Section-2 Under the Obstacle Limitation Space 	Applied for 1) Deep excavation 2) With horizontal obstacles 3) With restriction of land use 4) With restriction when using crane

Source: JICA Survey Team

2) Flyover Structure

The construction planning for the flyover section in Alt-3-2 is the same as in Alt-1. Table 7.4.19 summarizes the construction methods conditions for the flyover.

Table 7.4.19 Construction Methods and Conditions for the Flyover

Airspace Limitation		**Remaining Section**	**Intersections**
Sub Structure	Foundation	Earth Drill Method *Daytime construction with traffic restriction*	Earth Drill Method *Daytime construction with traffic restriction*
	Abutment/ Pier	Construct a temporary cofferdam using steel sheet pile *Daytime construction with traffic restriction*	Construct a temporary cofferdam using steel sheet pile *Daytime construction with traffic restriction*
Super-structure	Steel/PC	Track Crane Erection Method *Nighttime erection with traffic restriction*	Track Crane Bent Erection Method *Fully closed at night*

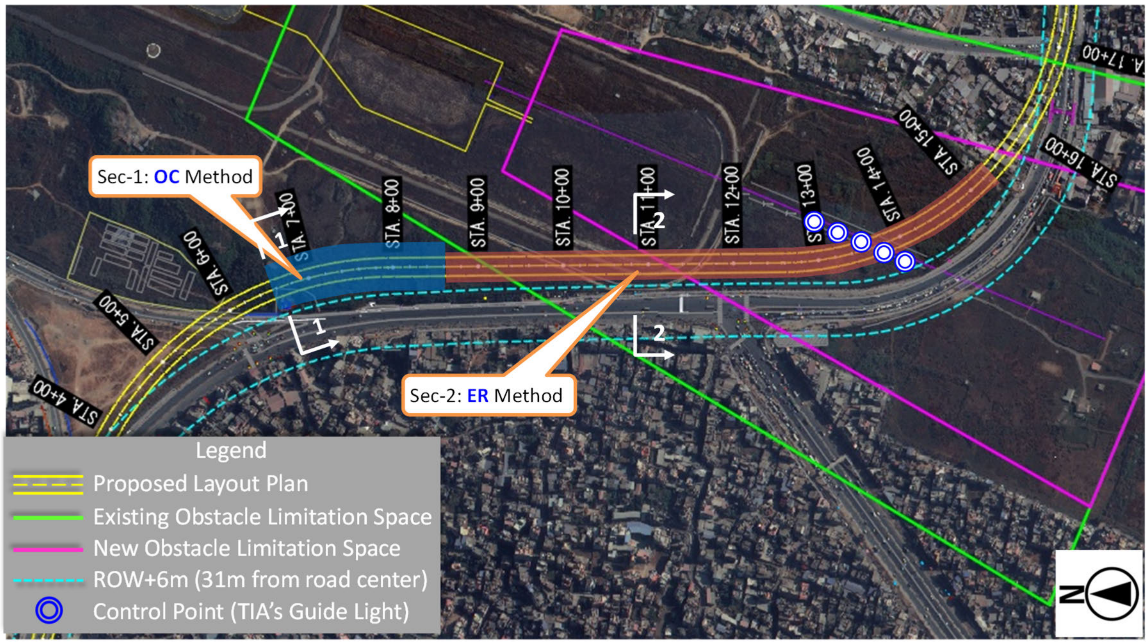
Source: JICA Survey Team

(3) Alt-4-2 (use TIA Land): Araniko Highway North-Araniko Highway South with Underpass & Flyover

1) Underpass Structure

The construction planning for the underpass sections in Alt-4-2 is the same as in Alt-3-2.

Figure 7.4.42 and Table 7.4.18 illustrate the OC and ER areas and construction methods for the underpass.



NOTE: The sections of OC/ER may change depending on the further study.
Source: JICA Survey Team

Figure 7.4.42 Open Cut (OC) and Earth Retaining Wall (ER) Area

2) Flyover Structure

The construction planning for the flyover sections in Alt-4-2 is the same as in Alt-3-2.

Table 7.4.19 summarizes the construction methods and conditions.

7.4.12 Construction Schedule

(1) Alt-1: RRN-RRS with Flyover

Figure 7.4.43 shows the construction schedule for Alt-1 on the conditions of daytime construction for foundation and substructure, and nighttime erection of the superstructure. Consequently, the anticipated timeline for completion is about (Secret).

(2) Alt-3-2 (use TIA Land): RRN- Araniko Highway with Underpass & Flyover

Figure 7.4.44 presents the construction schedule for Alt-3-2, considering daytime construction for the foundation and substructure and nighttime erection of the superstructure for the flyover section. Daytime construction is scheduled under the obstacle limitation space, while nighttime construction is for the underpass section. Consequently, the anticipated timeline for completion is (Secret) .

(3) Alt-4-2 (use TIA Land): NH2- Araniko Highway with Underpass & Flyover

Figure 7.4.45 shows the construction schedule for Alt-4-2. The construction conditions and scale are almost the same as for Alt-3-2, and the set construction period is (Secret) .

(Secret)

Figure 7.4.43 Construction Schedule for Alt-1

(Secret)

Figure 7.4.44 Construction Schedule for Alt-3-2

(Secret)

Figure 7.4.45 Construction Schedule for Alt-4-2

7.4.13 Comparison Study for Final Selection

(1) Policy on Selection Method

The final selection of alternatives for the Project is made based on the evaluation of six significant items in a scoring system. A maximum of 10 points was given to each evaluation item, resulting in 60 points for a full mark. The alternative with the highest score was the best choice.

Evaluation items include the following:

1. Effect of Grade Separation
2. Structure
3. Operation and Maintenance Demands
4. Environmental and Social Impacts
5. Constructability
6. Construction Cost.

Each evaluation item has sub-evaluation aspects described in the following chapter.

Find detailed explanations for the scoring system below.

(2) Criteria for Pointing System

A) Effects of Grade Separation

The Effects of Grade Separation are evaluated based on how much the Project roads and intersections improve from their existing congestion.

The traffic volume was assessed by the grade-separated portion and evaluate LOS improvement for the at-grade intersection. In addition, study was conducted for the sensitivity of the revised traffic demand forecast to project implementation to learn the risks of lowering traffic volumes on the Project roads as described in Chapter 4, Restudy of Traffic Demand Forecast.

A)-1 Effect of Grade Separation (Max. 4 points)

The points were allocated by the traffic volume in 2033 on the GS portion of each Project alternative.

- 4 points: 85,000 PCU/day or more
- 2 points: More than 80,000 PCU/day but less than 85,000 PCU/day
- 0 point: 80,000 PCU/day or less

A)-2 At Koteshwor Intersection (Max. 2 points)

The points were allocated by allot points based on realized LOS after improvement.

- 2 points: D or more
- 1 point: E
- 0 point: F

A)-3 At Jadhibuti Intersection (Max. 2 points)

The points were allocated based on realized LOS after improvement.

- 2 points: D or more
- 1 point: E
- 0 point: F

A)-4 Sensitivity of Traffic Demand Forecast on Project Roads (Max. 2 points)

Lowering the revised traffic demand forecast on RRN and Connecting Road is possible if delays occur in the future widening of both Boudha Road and RRN. In this scenario, traffic diversion is necessary, reducing future traffic flow.

- 2 points: Low
- 0 point: High

B) Structure

The Evaluation of the Structural Aspect features three sub-items: "Impacts on TIA operation" "Structural Specialty" which evaluates the necessary additional structures for alternatives, and "Technology Transfer" which gauges the applicability of the latest technology to each option.

B)-1 Impacts on TIA operation (Max. 6 points)

The points were allocated based on how much each alternative causes adverse impacts through constructing Project facilities in limited space.

- 6 points: No temporary or permanent impacts
- 3 points: Construction works produce temporary impacts on airport operation0 points: Construction permanently impacts airport operation, with the Project facility creating psychological fear among pilots.

B)-2 Structural Specialty (Max. 2 points)

The points were allocated based on whether only conventional structures are necessary. When an alternative requires unique structures, future maintenance issues become extensive, lowering its score.

- 2 points: Only conventional structures are necessary, with no need for special considerations.
- 0 points: Some obstacles exist, such as girder height or small foundation size.

B)-3 Technology Transfer (Max. 2 points)

The points were allocated based on the applicability of the latest technology to alternatives.

The more latest technologies are applicable to an alternative, the higher it scores.

- 2 points: Three items or more
- 1 points: One or more items
- 0 point : No items

C) Operation (necessary facilities) and Maintenance Burden

The Nepali operation and maintenance burden depends on the necessity of ancillary facilities for each alternative. Various ancillary facilities are evaluated, including lighting and noise barrier systems, permanent mechanical pumping systems for road surface drainage, ventilation systems, and safety facilities for tunnel sections.

C)-1 Maintenance for Main Structure (Max. 5 point)

The points were allocated based on how much maintenance Nepal shoulders to preserve the main structure, like a flyover or underpass, for the alternatives. A steel structure requires periodic surface repainting, while concrete does not require intervention as often.

- 5 points: Minimum maintenance burden
- 3 points: Repainting for a short steel bridge
- 1 point: Repainting for a long steel bridge

C)-2 Necessity of Additional Road Facilities (Max. 5 points)

The points were allocated nbased on whether safety facilities are necessary in the tunnel section of the alternatives in the previous sub-chapter.

- 5 points: No safety facilities are required
- 3 points: Minor facilities are necessary for emergencies.
- 1 point: Significant facilities such as ventilation and drainage pumping systems are necessary.

D) Construction: Constructability

The constructability of each alternative were evaluated by the sub-items in Work Limitation by Obstacle Limitation Space, Impacts on the Existing Traffic During the Construction, and Construction Period sections.

D)-1 Work limitation by obstacle limitation space/operation (Max. 2 points)

The points were allocated depending on the work limitations from limited space to operate

- 2 points: No work limitation expected.
- 1 point: Minor work limitation expected.
- 0 points: Severe work limitation expected.

D)-2 Impacts on existing traffic during construction (Max. 3 points)

The points were allocated based on the degree of adverse impacts on the existing traffic during construction.

- 3 points: No impact on existing traffic
- 2 points: Limited impact on existing traffic
- 1 point: Large-scale impact on existing traffic

D)-3 Construction period (Max. 5 points)

The points were allocated based on the expected construction period.

-
- (Secret)
-

E) Environmental and Social Impacts by the Project

The environmental and social impacts of the Project were evaluated, such as the scale of resettlement and noise and vibration caused by vehicles passing through the new facility.

A flyover generates noise and vibration from passing vehicles, particularly on steel bridges. However, concrete walls surround an underpass section, producing low vibration and noise.

E)-1 Social impact: Resettlement (Max. 5 points)

The points were allocated based on the scale of resettlement for the Project facility.

- 5 points: No resettlement required.
- 3 points: Resettlement affects less than 50 houses (<200 PSP)
- 1 point: Resettlement affects more than 50 houses (>200 PSP)

E-2) Environmental impact: noise and vibration (Max. 5 points)

The points were allocated based on adverse environmental impacts, such as noise and vibration generated by running vehicles on the flyover section.

- 5 points: No environmental impact.
- 3 points: Few adverse effects on the environment
- 1 point: Extensive adverse effects on the surroundings

F) Construction cost

Since "Construction Cost" is the most importance factor to determine in any infrastructure project, it is independently dealt with in this evaluation. In general, an underpass option for the intersection improvement tends to require the higher cost than one for a flyover option in urban area because of a shorter construction period and its complicated work procedure.

The points were allocated based on the amount of construction cost estimated on other project examples.

- 10 points : estimated construction cost is most economical alternative.
- 5 points : estimated construction cost is less than 40% higher than most economical alternative.
- 3 points : estimated construction cost is more than 40% higher than economical alternative.

(3) Comparisons Result

Table 7.4.20 and Table 7.4.21 show a summary and detailed comparison on the optimal alternative selection for the project. Results indicate that Alt-4-2 has scored the highest with 38 points among the three alternatives, followed by Alt-3-2 with 37 points.

Table 7.4.20 Comparison Table on Secondary Selection (Summary)

		Alt-1		Alt-3-2 (use TIA Land)		Alt-4 (use TIA Land)	
Effect of GS	Effect of GS	2	4	3	7	4	10
	LOS at Koteshwor IS	2		2		2	
	LOS at Jadibuti IS	0		2		2	
	Sensitivity of TDF	0		0		2	
Structure	Impacts on TIA operation	0	1	3	7	3	7
	Structural Specialty	0		2		2	
	Technology Transfer	1		2		2	
O & M	Main Structure	1	6	3	6	3	6
	Additional Facility	5		3		3	
Const.	Work Limitation	0	6	1	6	1	6
	Impacts on Existing Traffic	1		2		2	
	Construction Period	5		3		3	
Env. and Social	Social Impact	5	6	3	6	3	6
	Environmental Impact	1		3		3	
Construction Cost		10		5		3	
Evaluation		33/60		37/60		38/60 Recommended	

Source: JICA Survey Team

Table 7.4.21 Comparison Table on Secondary Selection (Detail)

		Alternative 1			Alternative 3-2 (via TIA land)			Alternative 4-2 (via TIA land)		
Sketch										
Description	Route	Ring Road South (RRS) – Ring Road North (RRN) on the existing road			Araniko Highway (ARK Hwy) – RRN via TIA land			Araniko Highway (ARK Hwy) – NH2 via TIA land		
	Length and Type of Structure	**Total Length**: 1,200m **Structure type**: Flyover: PC-I girder = 300m, steel box girder = 560m, Earth Sec. = 340m			**Total Length**: 1,680m **Structure type**: Underpass: box culvert = 640m, U-shaped wall =160m Flyover: steel girder = 280m, PC-I girder = 440m, Earth Sec =160m			Total Length: 1,860m Structure type: Underpass: box culvert = 640m, U-shaped wall = 250m Flyover: steel girder = 280m, PC-I girder = 520m, Earth Sec. = 170m		
	Pasted Experience in Nepal	Many PC girder bridges but no steel box girder bridge			One underpass structure and no steel box girder bridge			One underpass structure and no steel box girder bridge		
A. Traffic Improve (10)	Effect of GS(4)	GS: 81,696 [pcu/day]	2	4	GS: 84,160 [pcu/day]	3	7	GS: 88,486 [pcu/day]	4	1
	LOS at KS IS(2)	LOS: C, Delay Time: 29.6[s/veh.]	2		LOS: D, Delay Time: 35.4 [s/veh.]	2		LOS: D, Delay Time: 36.1 [s/veh.]	2	
	LOS at JB IS(2)	LOS: F, Delay Time: 509.9 [s/veh.] (due to no improvement)	0		LOS: C, Delay Time: 27.2 [s/veh.]	2		LOS: C, Delay Time: 22.7 [s/veh.]	2	
	Risk of TDF(2)	Large impact caused by delay in RRN and Bouda Rd. improvement	0		Large impact caused by delay in RRN and Bouda Rd. improvement	0		Small impact caused by delay in RRN & Bouda Rd. improvement	2	
B. Structure (10)	Impacts on TIA operation(6)	Permanent disturbance of operation for flyover construction even without penetration to OLS due to psychological fear of pilots	0	1	Temporary operation disturbance during underpass construction works in TIA teritory	3	7	Temporary operation disturbance during underpass construction works in TIA teritory	3	7
	Structural Specialty(2)	Rigid connection between girder & pier head is required because of the height restriction from OLS.	0		No specific consideration in box culvert and bridge structures	2		No specific consideration in box culvert and bridge structures	2	
	Technology Transfer (2)	Steel narrow box girder with composite deck slab Foundation type under narrow working space: steel rotation pile, PC well.	1		Steel narrow box girder with composite deck slab Foundation type at narrow space: steel rotation pile, PC well Diaphragm wall construction machine under height restriction	2		Steel narrow box girder with composite deck slab Foundation type at narrow space: steel rotation pile, PC well Diaphragm wall construction machine under height restriction	2	
C. O&M (10)	Main Structure(5)	Repainting of steel bridge	1	6	Repainting of steel bridge but length is shorter than that of Alt-1	3	6	Repainting of steel bridge but length is shorter than that of Alt-1	3	6
	Add.Facility(5)	No specific facility	5		Minor facilities for emergency activity	3		Minor facilities for emergency activity	3	
D. Construction (10)	Work limitation by OLS/ope.(2)	Girder erection considering of flight schedule (h = approx. 14 m).	0	6	Sheet pile or concrete slab installation for temporary retaining wall considering flight schedule, or usage of special equipment applicable under the height limit (h = approx. 8 m).	1	6	Sheet pile or concrete slab installation for temporary retaining wall considering flight schedule, or usage of special equipment applicable under the height limit (h = approx.6 m).	1	6
	Impacts on Existing Traffic during Construction(3)	Traffic restriction during foundation work. Girder erection work during night time with restriction of existing traffic.	1		Limited impact on traffic due to most underpass within TIA land. Some impacts of flyover works; restriction of existing traffic for substructure construction and during superstructure erection at night.	2		Limited impact on traffic due to most underpass within TIA land. Some impacts of flyover works; restriction of existing traffic for substructure construction and during the superstructure erection at night.	2	
	Construction Period (5)	(Secret)								
E. Env & S(10)	Social Impacts: resettlement (5)	No resettlement	5	6	Approximately 20 houses in Jadibuti Intersection	3	6	Approximately 20 houses in Jadibuti Intersection	3	6
	Env. Impacts: Noise & vibration(5)	Noise and vibration from flyover.	1		Reduced existing surface noise and vibration due to traffic ,Little noise and vibration impact due to new facilities	3		Reduced existing surface noise and vibration due to traffic ,Little noise and vibration impacts due to new facilities	3	
F:.Constrcution Cost (10)		(Secret)								
Evaluation Result		33/60			**37/60**			38/60 **Recommendable**		

Remarks: i) Evaluation Method: Relative comparison system by 6 major items, including 15 sub-items
ii) Present Service Level of the PJ Intersection: a) Koteshwor: **F, CD: 650 sec/veh**, b) Jadibudi:**F, CD: 352sec/veh**

The main points of the comparison among three alternatives are summarized as follows:

1. Effect of Grade Separation

Alt-4-2 can accommodate the highest traffic volume at the GS section, followed by Alt-3-2, then Alt-1. The at-grade intersection at Koteshwor can secure an LOS C or LOD D but requires an additional 15 m of land from TIA land for all alternatives. At the Jadibudi Intersection, Alt-1 cannot improve the traffic congestion, while Alt-3-2 & 4-2 can improve traffic by installing a GS facility.

The traffic flow between Araniko Highway North and Araniko Highway South is significant even in 2033. However, since the revised traffic demand forecast has the sensitivity depending on progress of the RRN & Boudha Rd widening works, traffic from RRN probably decreases, if such projects delays. Therefore, the GS route between Araniko Highway North and Araniko Highway South can secure more of the improvement effect by GS facility.

2. Structure

Alt-1 with flyover causes permanent impacts on TIA operation with psychological fears at landing. Instead, Alt-3-2 and 4-2 only cause temporary impact on TIA operation during construction due to underpass works within TIA territory.

Because of the obstacle limitation space, Alt-1 needs to apply a rigid connection between steel girders and pier heads. Regarding the technology transfer, a steel narrow box girder with a composed deck supported by a pre-cast concrete well applies to the flyover structure for all alternatives. In addition, the diaphragm wall construction machine under height limit can apply to Alt-3-2 and 4-2.

3. Operation and Maintenance Burden

Whereas Alt-3-2 and Alt-4-2 may require evacuation and a smoke exhaust facility, Alt-1 needs only lighting and noise barriers.

4. Construction and Construction Period: Constructability

All alternatives need to work under the restriction of the obstacle limitation space in some way, but Alt-3-2 and Alt-4-2 are severer than Alt-1. However, since both mostly run inside the TIA Land, it can minimize adverse effects on the existing traffic during construction.

Whereas all underpass structures are casted-in-place concrete, the flyover option can apply to pre-cast members. Therefore, construction period for the underpass option becomes longer.

5. Environmental and Social Impacts

Alt-3-2 and Alt-4-2 require a small scale of resettlement at the Jadibuti Intersection. Although they may cause a low noise level and vibration from the GS facility, reduced traffic volume from at-grade roads can lessen noise and vibrations in the existing road conditions. However, because of traffic concentration at the same cross-section (at-grade and GS at the second level), noise and vibration from Alt-1 becomes higher than the existing road conditions.

6. Construction Cost

Due to longer use of the GS facility, Alt-4-2 requires the highest cost than Alt-3-2. Because of the shortest route and application of flyover structure, Alt-1 is the most economical.

7.5 Conclusion

In summary, the underpass alternatives like Alt-4-2 and Alt-3-2 have much higher point in the effect of grade separation. On the one hand, the flyover alternative of Alt-1 has advantages in lower construction cost and shorter construction period. However, Alt-4-2 reduced common disadvantages of underpass alternatives, such as adverse impacts to the existing traffic and TIA operation during construction, and small-scale operation and maintenance burden due to less re-painting of steel bridges. These advantages make Alt4-2 be almost equal in the whole evaluation. Note that the effect of grade separation is the most prominent reason for selection.

In conclusion, Alt-4-2, which runs from Araniko Highway North to Araniko Highway South via TIA land with a combination of the underpass and flyover structures, is highly recommended for intersection improvement among the three alternatives.

CHAPTER 8. OUTLINE DESIGN OF ROADS AND INTERSECTIONS

8.1 Outline Design of Grade-separated Roads

8.1.1 Alignment Study of Grade-Separated Section

(1) Background

Chapter 7 selects Alt-4-2 as the appropriate alternative route for the Project. This section outlines a detailed study of the Alt-4-2 after JST found alignment issues. As illustrated in Figure 8.1.1 and summarized in Table 8.1.1, the viability of the three alternatives depends on land availability.

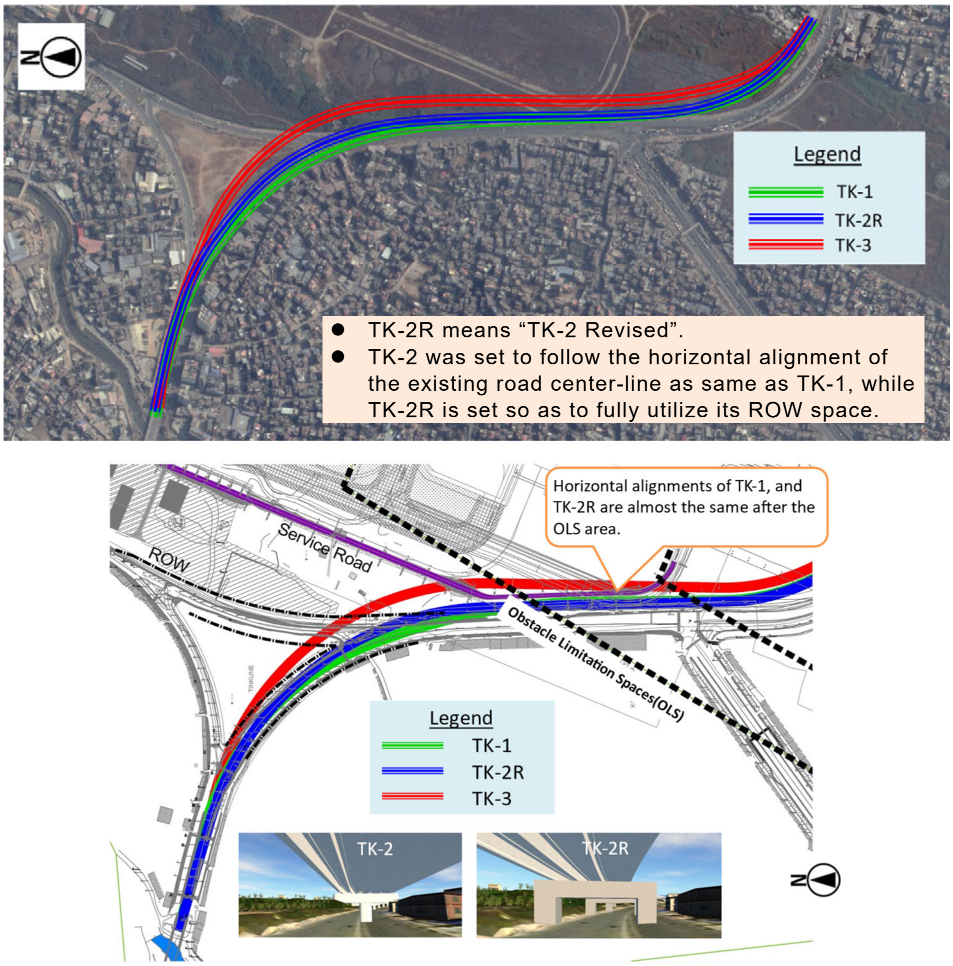


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Figure 8.1.1 GS Alignment Alternatives from Tinkune IS to Koteshwor IS

Table 8.1.1 Summary of Comparison of Each Alternative

ID	Horizontal Control Point	Vertical Control Point
TK-1	● Must be inside the existing road reserve ● Must avoid the service road in TIA	● No violation in OLS of TIA
TK-2R	● Must be within Ex.ROW (22.5m from the existing road center) ● Must avoid the service road in TIA	● No violation in OLSs of TIA
TK-3	● No land control near Tinkune IS ● Must fulfill CAAN's requirements under OLS, namely the structure type, and lack of visible car movements ● No disturbance to traffic on the existing road during construction	● No violation in OLS of TIA ● Meets the elevation requirement relative to the service road in TIA

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Table 8.1.2 shows a discussion record on the alignment setting for Alt-4-2 with DOR and CAAN.

Table 8.1.2 Discussion Record on Alignment Setting

- Originally, JST proposed TK-3, considering the ease of construction within TIA land to secure acceptance from CAAN.
- DOR requested to shift the alignment to TK-1, avoiding land disputes within the Tinkune IS area and reducing the utilization of TIA land.
- JST found that TK-1 cannot meet the requirements from CAAN due to the exposure of box culverts above the ground level under the OLS area.
- Then, JST further studied the alignment options to fulfill the requirements from CAAN and DOR and found TK-2R.
- However, as a result of further study, JST found that TK-2R had some issues with constructability, which will increase costs and prolong the construction period.

(2) Comparison of GS Alignment Alternatives from Tinkune IS to Koteshwor IS

1) TK-1: Set Inside the Existing Road Reserve

The plan, profile, and 3D image of TK-1 and its features are in Figure 8.1.2 to Figure 8.1.4.

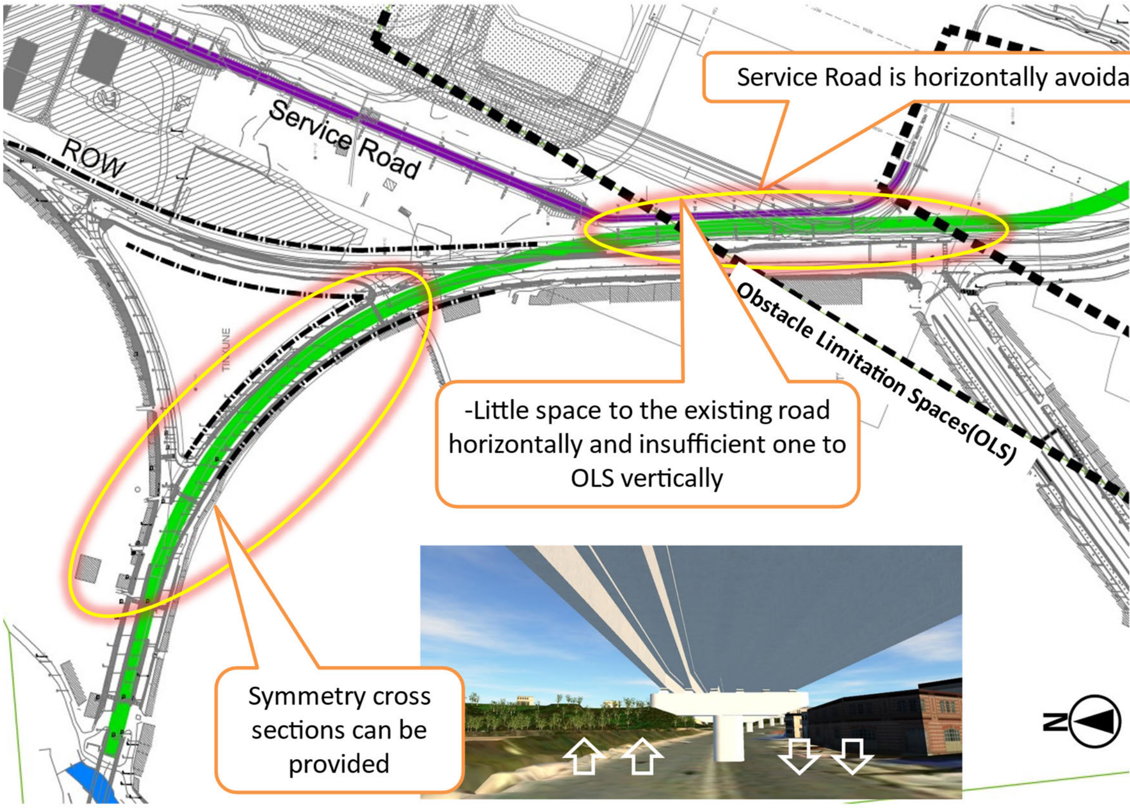

Figure 8.1.2 Plan of TK-1

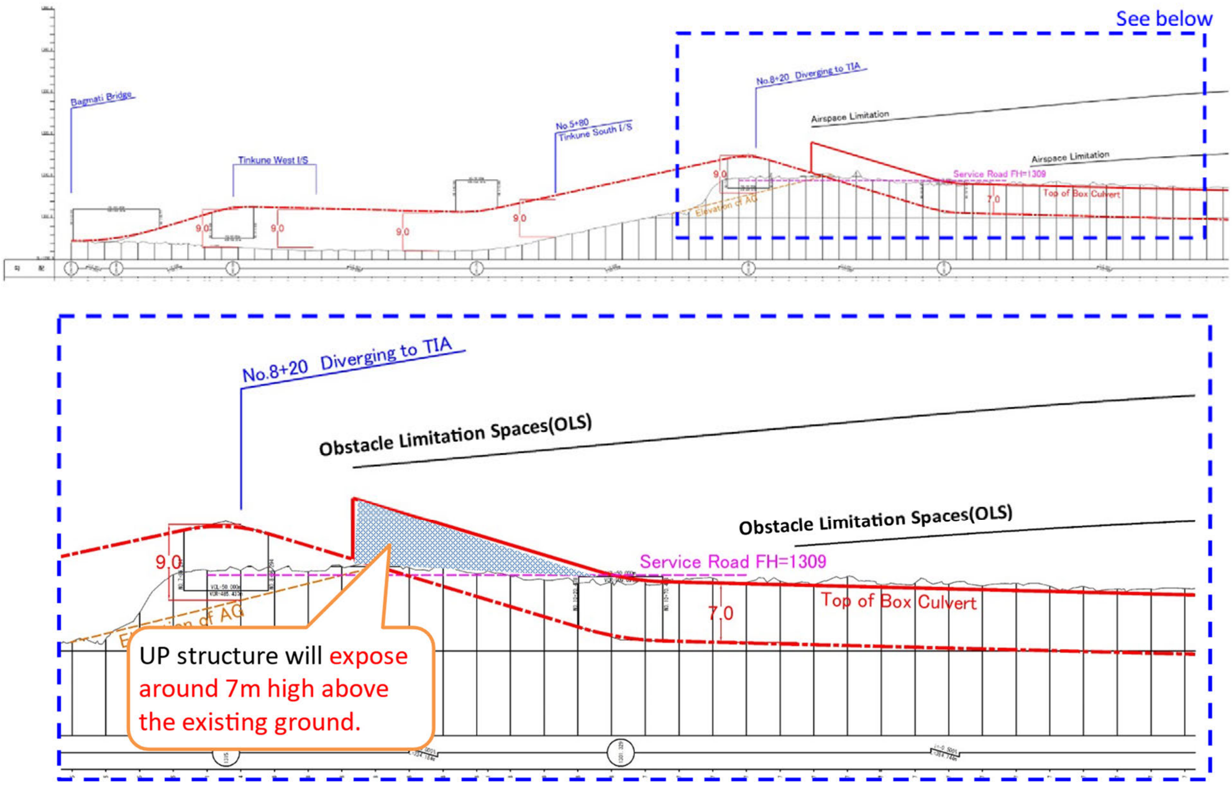

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Figure 8.1.3 Profile of TK-1

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Figure 8.1.4 3D image of TK-1

Figure 8.1.5 shows an alternative of TK-1 that does not expose the structure by applying a U-shaped wall. However, pilots will see the vehicle movement from above, which would violate CAAN's requirement. Thus, TK-1 cannot be an appropriate alternative alignment for Alt-4-2.

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Figure 8.1.5 3D image of TK-1R

2) TK-2R: Set it within Existing-ROW space (22.5 m from the road center)

The plan, profile, and 3D image of TK-2R and its features are in Figure 8.1.6 to Figure 8.1.8. As mentioned above, TK-2R can prevent the exposure of the GS structure to spaces above TIA land by using the Existing ROW space, 22.5 m from the existing road center, as shown in Figures 8.1.7 and 8.1.8. JST also confirms no traffic operation issues on the at-grade Project roads, as mentioned in Future 8.1.6.

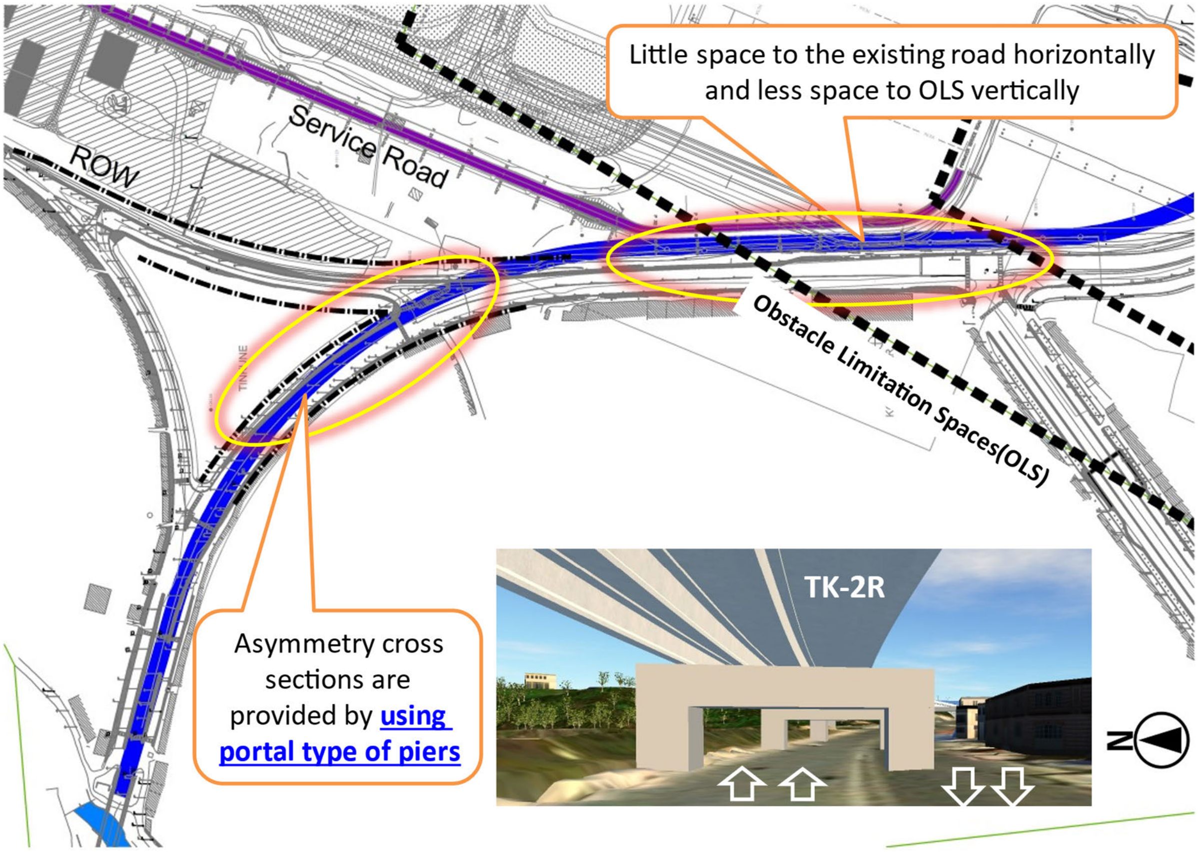

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Figure 8.1.6 Plan of TK-2R

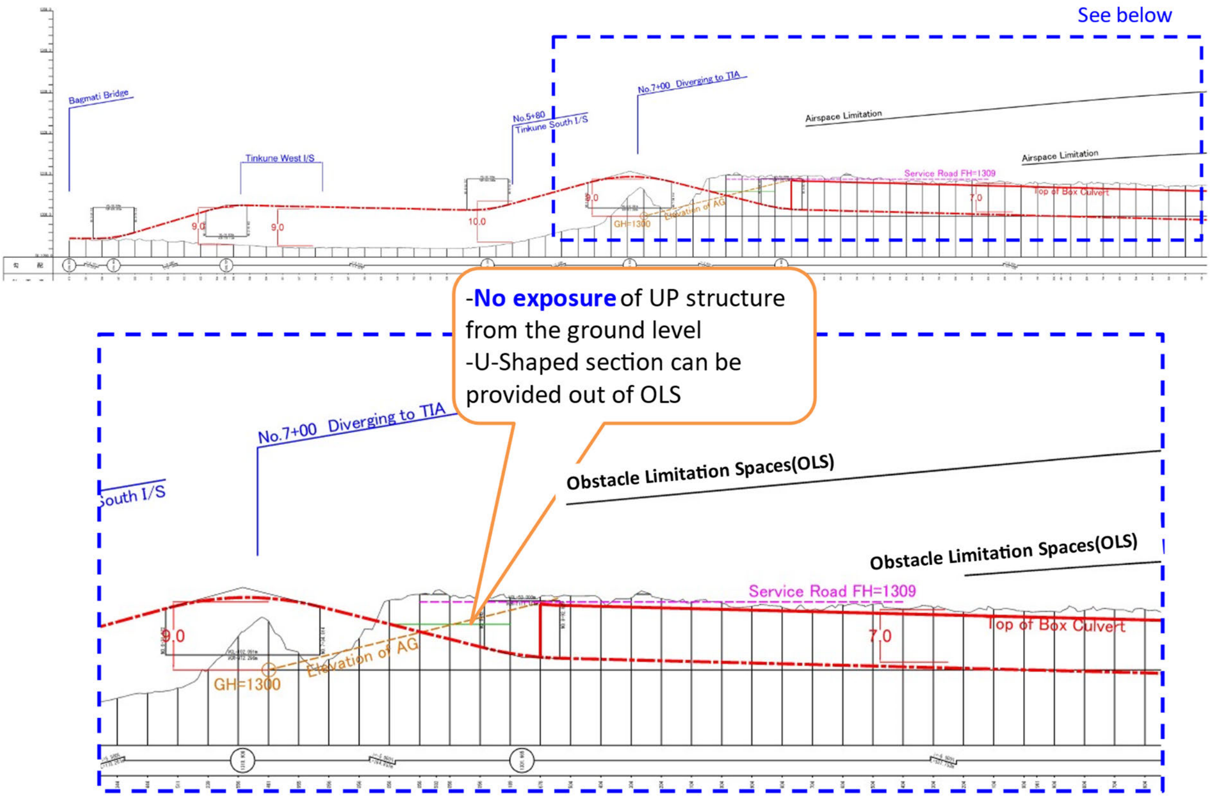

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Figure 8.1.7 Profile of TK-2R

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Figure 8.1.8 3D image of TK-2R

The structural layout of the flyover is shown along the south ramp of Tinkune IS in Figure 8.1.9. It utilizes steel and PC girders for the flyover. The former applies to intersection crossing areas that require a lengthier span and the latter to the remaining section for lower construction costs.

Due to a sharp-angled crossing over the Tinkune south IS, An imbalanced span arrangement is required for steel bridge sections such as 50m+64m and 50m+45m+40m, increasing flyover costs.

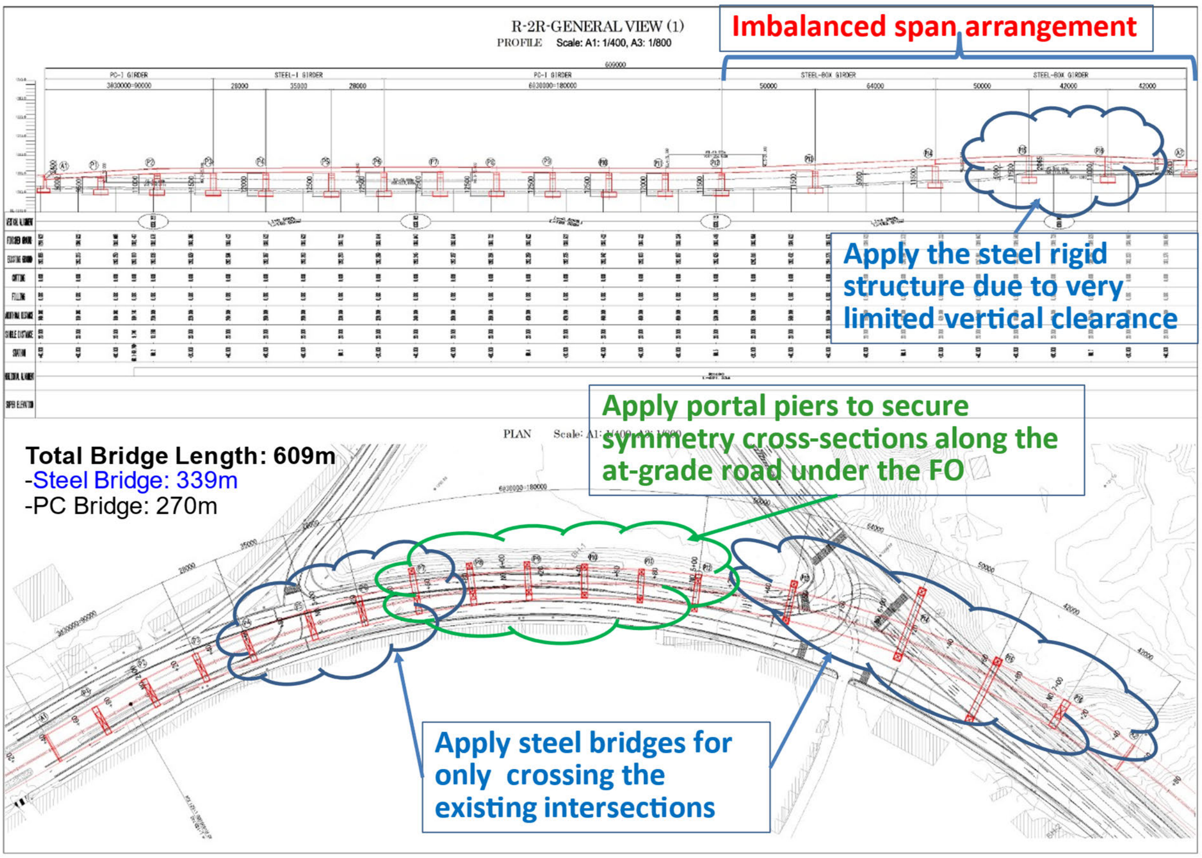

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Figure 8.1.9 Structural Layout of TK-2R

The construction plan of TK-2R is in Figure 8.1.10 to Figure 8.1.16. JST divides the underpass section of TK-2R into five sub-sections, each with unique applicable construction methods and conditions, such as a requirement to occupy the existing road space for a construction yard, vertical height limitations during construction due to OLS for either landing or taking off. Take-off causes tighter restrictions for construction works.

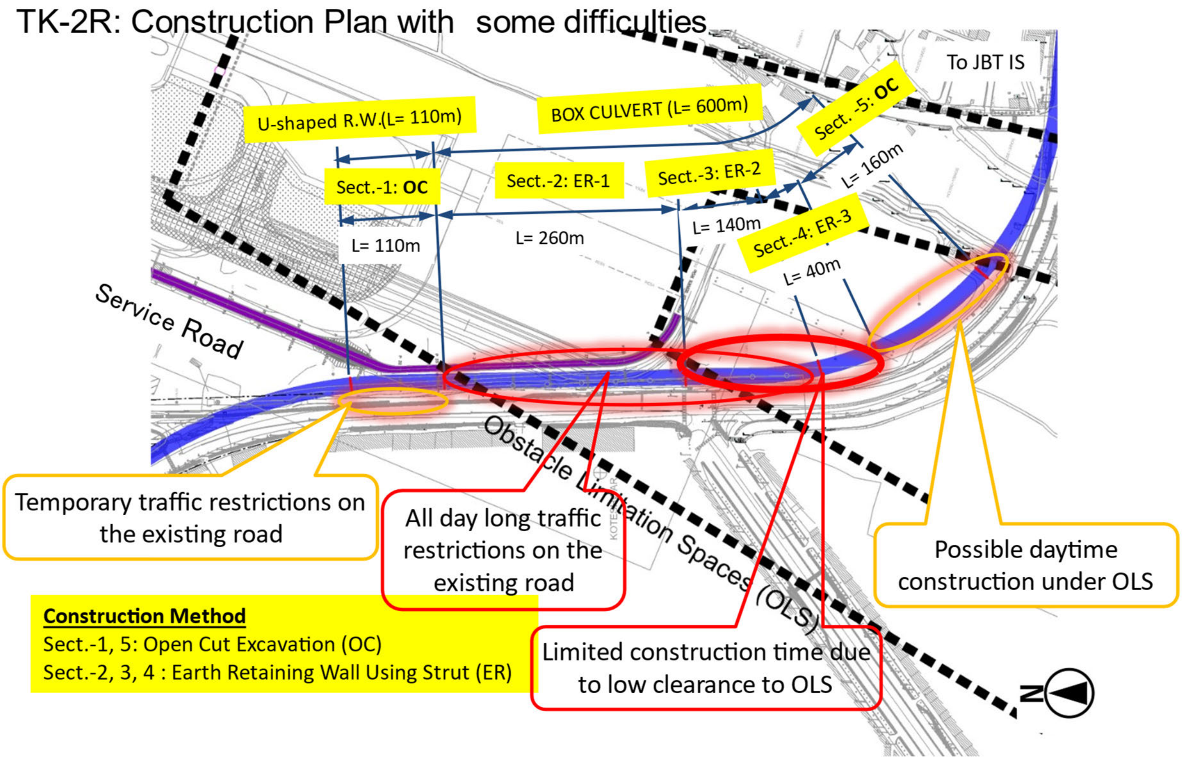

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Figure 8.1.10 Construction Plan of TK-2R

Figure 8.1.11 shows the construction conditions and method for Section-1.

Section-1 can use an open-cut method as it is outside the OLS area and has almost no existing road occupation. It provides sufficient space between the Project structure and the existing road.

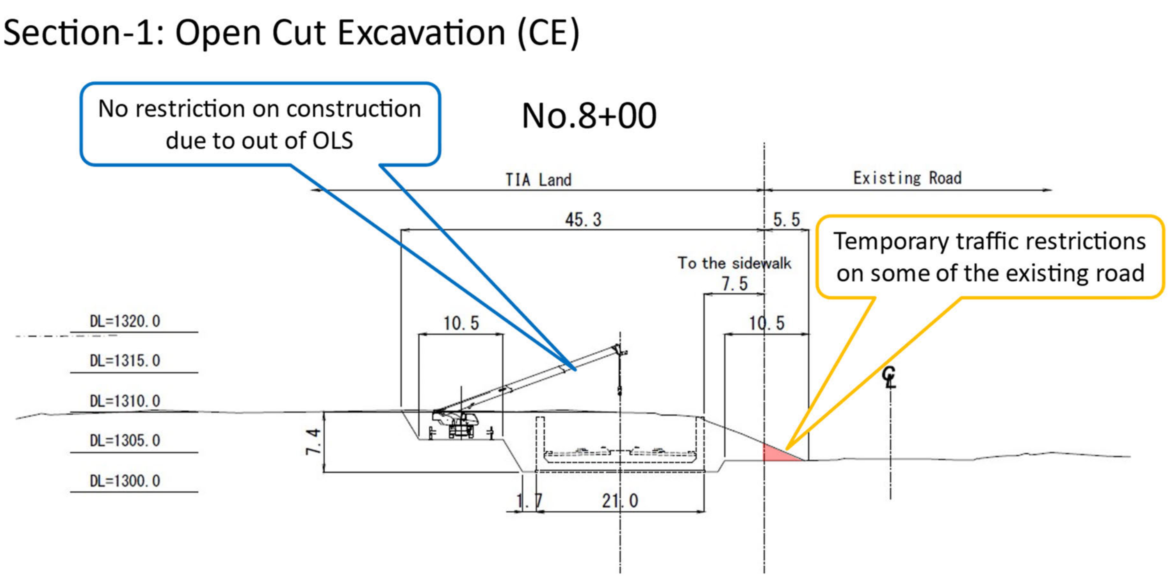

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Figure 8.1.11 Construction Plan at Section-1 of TK-2R

Figure 8.1.12 describes the construction conditions and method for Section-2. This section requires a temporary earth retaining wall of steel-sheet piles with struts as the existing road features a narrower space, making the open-cut method inapplicable.

In addition, construction works will occupy two lanes on the existing road, which will cause further traffic congestion on the existing road. Although this section falls into the area OLS reserved for landing, there is still sufficient vertical height for crane works, which enables the contractor to do daytime work.

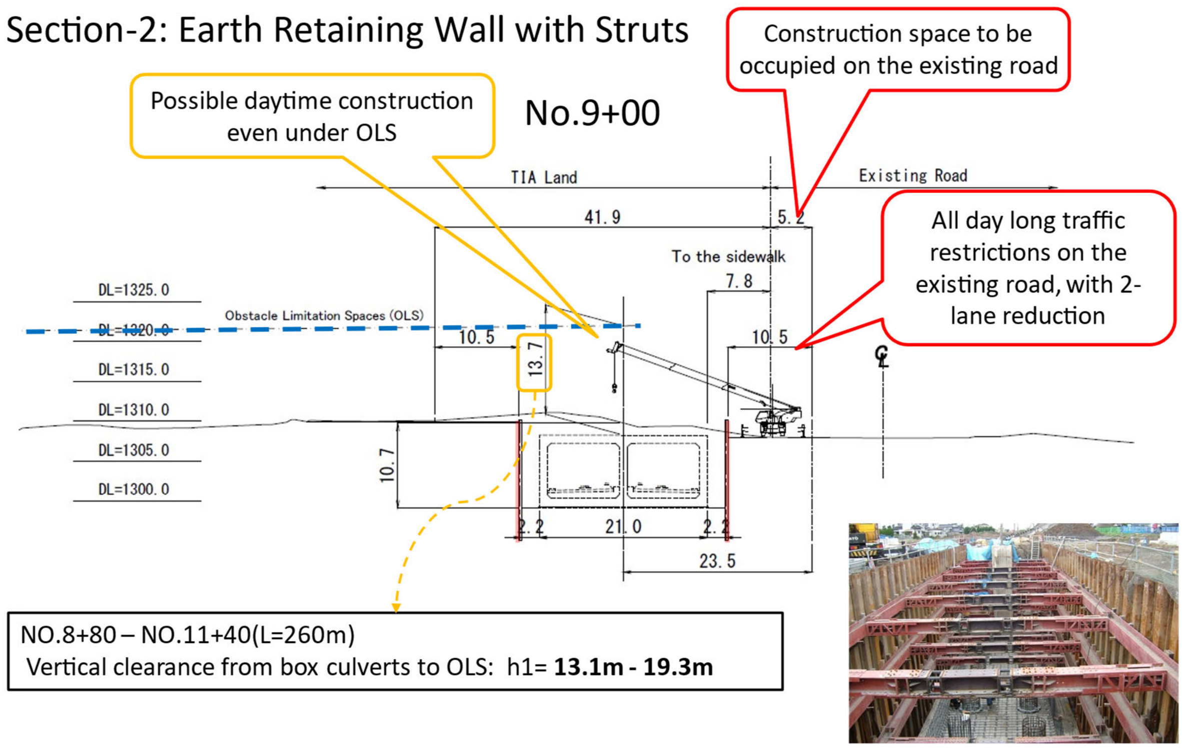

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Figure 8.1.12 Construction Plan at Section-2 of TK-2R

Figure 8.1.13 describes the construction conditions and method for Section-3, which has the most restrictive construction conditions. This section requires temporary earth retaining walls of steel-sheet piles with struts due to the narrow space on the existing road, rendering the open-cut method inapplicable.

In addition, occupying two lanes on the existing road is necessary, causing further traffic congestion. Since this section falls into the area reserved by OLS for airplane take-off, vertical clearance is insufficient for crane works. Contractors must work at night when the airport is closed, causing lengthier construction time and higher costs.

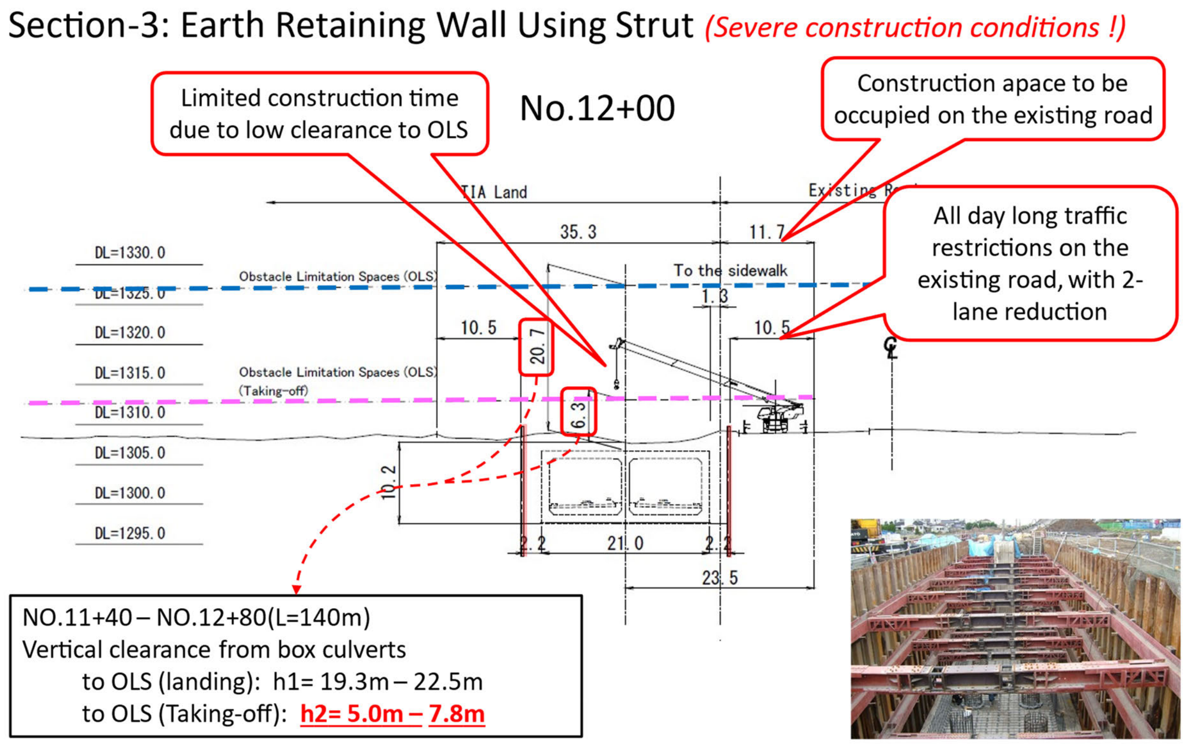

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Figure 8.1.13 Construction Plan at Section-3 of TK-2R

Figure 8.1.14 describes the construction conditions and method for Section-4, which features slightly better working conditions due to the distance of the alignment from the existing road and the take-off point. This section requires temporary earth retaining walls of steel-sheet piles with struts as it still offers insufficient horizontal space relative to the existing road, rendering the open-cut method inapplicable.

In addition, construction requires occupying the footpath on the existing road, which may cause pedestrian control issues. Since this section falls into the area under OLS for take-off, it offers insufficient vertical clearance for crane works. Nearly all work must be completed at night when the airport is closed, prolonging construction period and exacerbating costs.

Section-4: Earth Retaining Wall with Struts

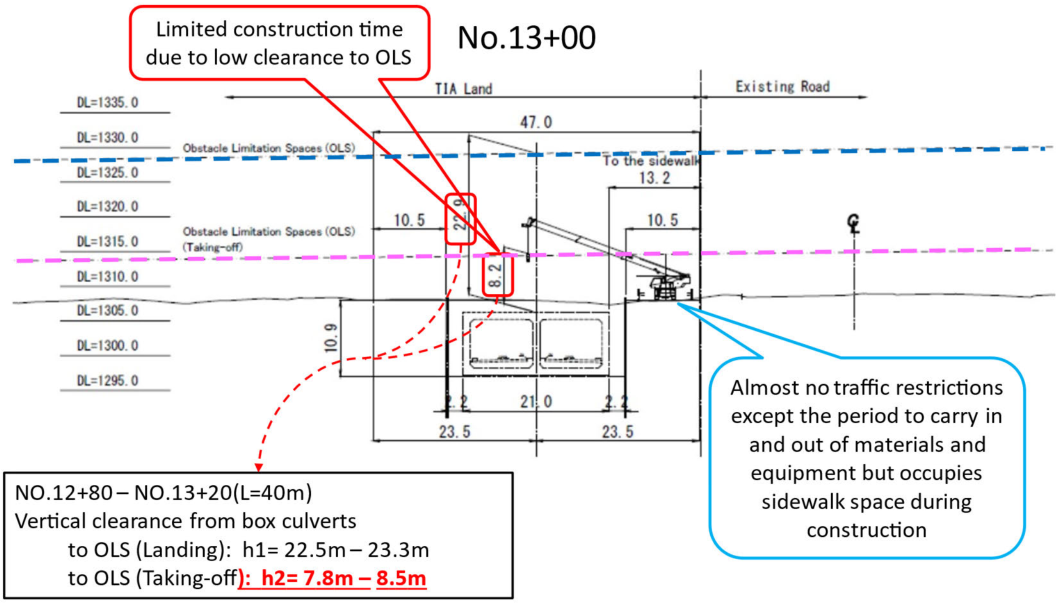

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Figure 8.1.14 Construction Plan at Section-4 of TK-2R

Figure 8.1.15 indicates the construction conditions and method for Section-5. This section is identical to Section-1.

The open-cut method is applicable as it offers sufficient space between the Project structure and the existing road. In addition, construction does not affect traffic as the alignment shifts away from the existing road.

Section-5: Open Cut Excavation

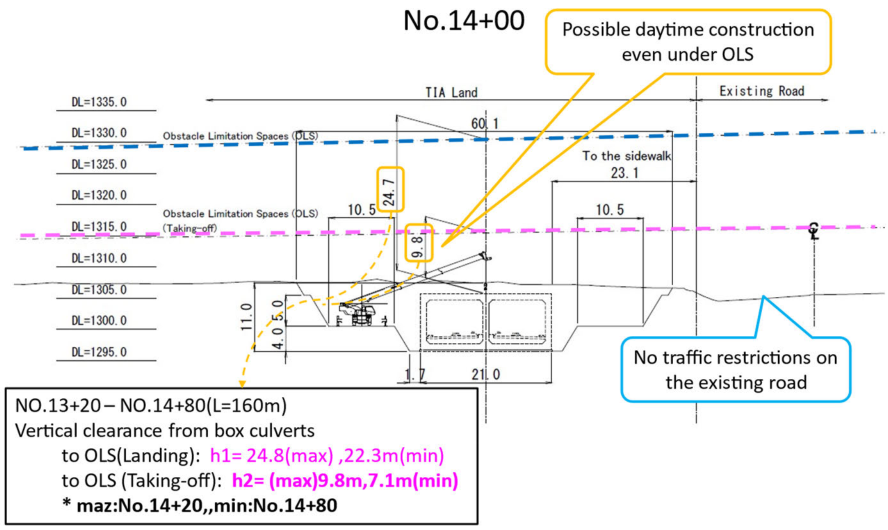

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Figure 8.1.15 Construction Plan at Section-5 of TK-2R

Figure 8.1.16 summarizes traffic restrictions on the existing road during construction. 400m-long sections comprising Sections-2 and 3 require all-day traffic restrictions as construction will use the footpath and two lanes.

The 40m long section on Section-4 only requires the footpath space as a construction yard.

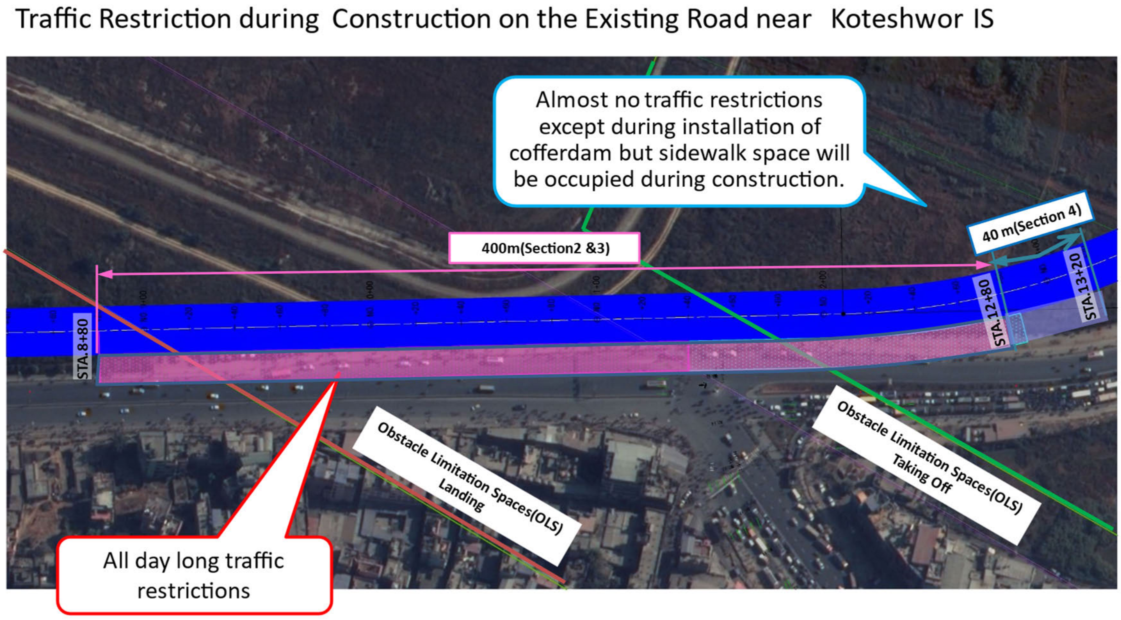

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Figure 8.1.16 Traffic Restriction during Construction

3) TK-3: No Land Control (GS alignment runs beyond ROW at Tinkune inner land.)

The plan, profile, and 3D image of TK-3 and its features are in Figure 8.1.17 to Figure 8.1.19. As mentioned above, this alignment resolves traffic restrictions on the existing road and the severe construction conditions with the open-cut method. Furthermore, TK-3 can also avoid influencing future airport development, construction of which has just started. It will still fulfill the requirements from CAAN for the structure type under OLS.

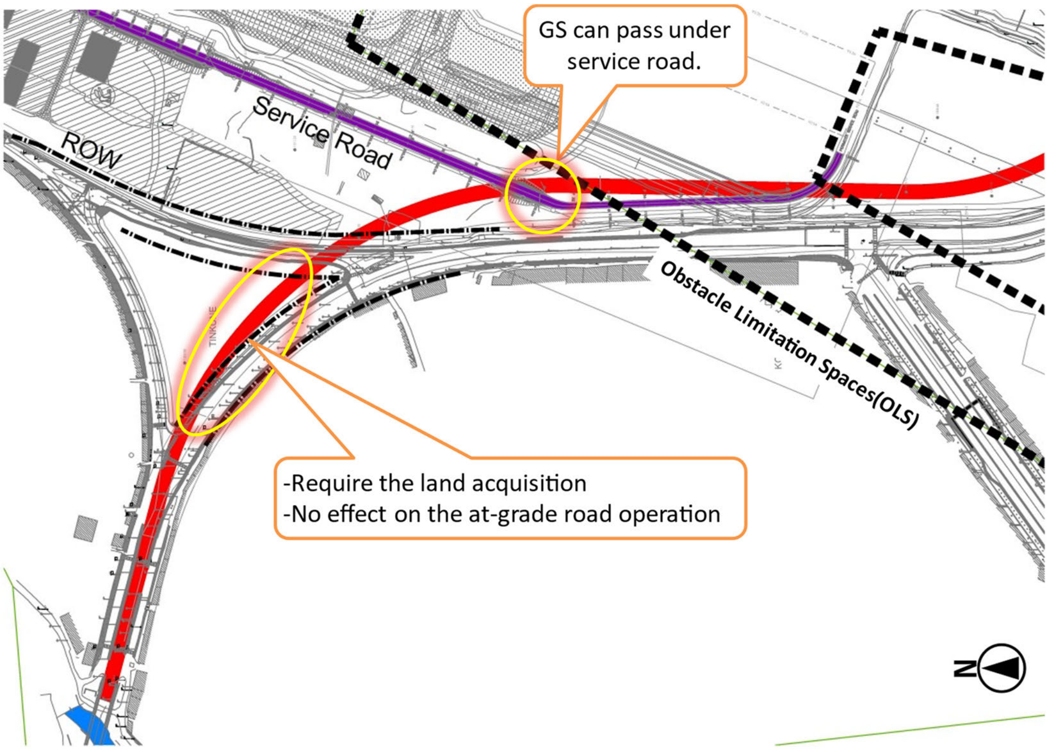

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Figure 8.1.17 Plan of TK-3

As shown in Figure 8.1.18, TK-3 does not expose the Project structure to OLS. Also, it will pass under the planned Service Road

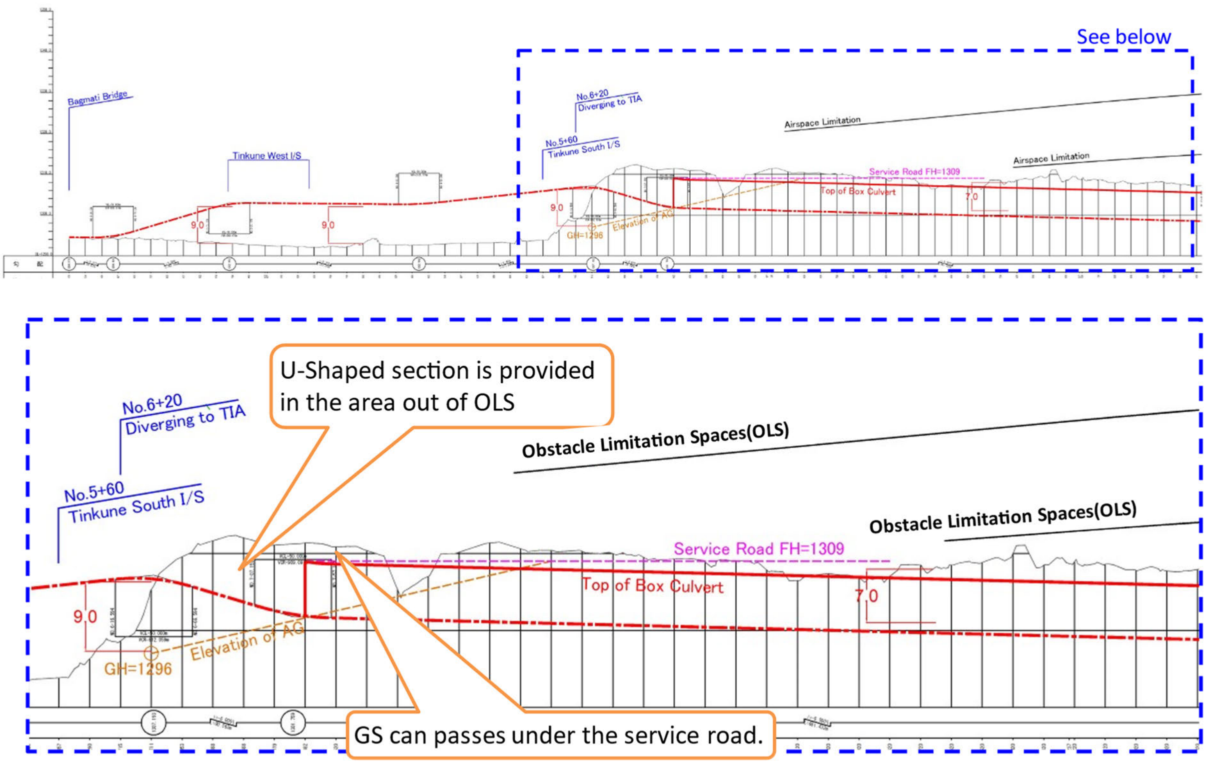

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Figure 8.1.18 Profile of TK-3

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Figure 8.1.19 3D Image of TK-3

Figure 8.1.20 shows the structural layout of TK-3. It shows the flyover plan along the Tinkune IS. The bridge type, steel girder, and PC girder will create the flyover. The former applies to the area crossing over the intersections, which requires a lengthier span, and the latter applies to the remaining section to reduce flyover cost.

With a gentler angle for crossing over the Tinkune south IS than TK-2R, TK-3 provides a well-balanced span arrangement for the steel bridge section, such as 40m+70m+55m and 40m+50m+40m, which can reduce flyover cost.

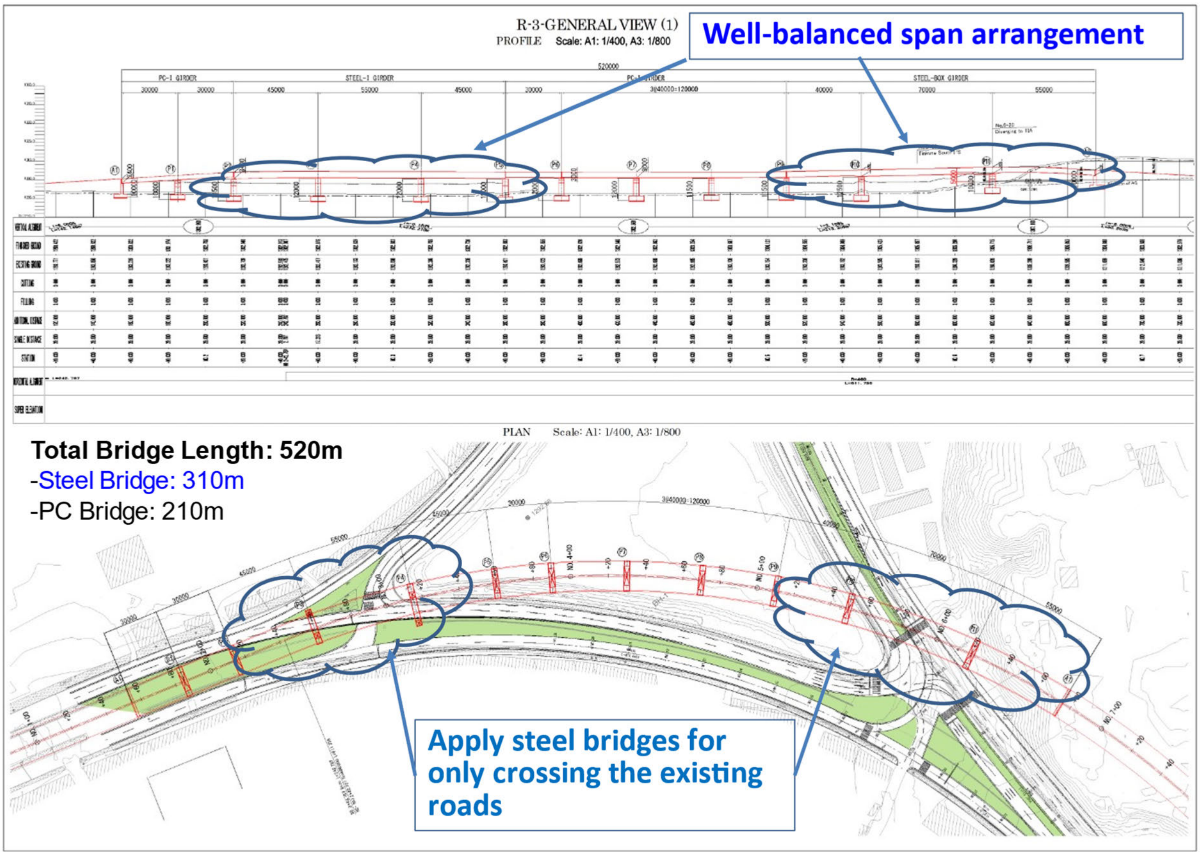

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Figure 8.1.20 Structure Layout of TK-2R

Figure 8.1.21 shows the construction plan for TK-3. It displays the applied structures for the underpass section and construction conditions for all other sections.

The alignment of TK-3 prevents traffic restrictions on the existing road from daytime construction, even under OLS, because it utilizes the open-cut method for all sections.

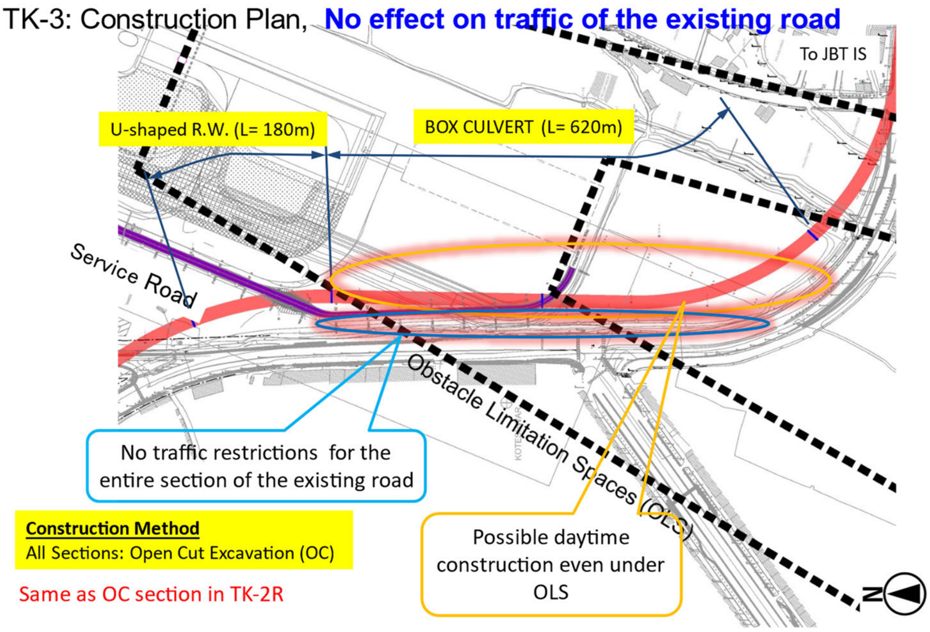

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Figure 8.1.21 Construction Plan of TK-3

4) Comparison of Alignment Alternatives for Alt-4-2

Table 8.1.3 shows the comparison results of three alignment alternatives for Alt-4-2. JST strongly recommended TK-3 as the most appropriate alignment for Alt-4-2 for the following reasons:

1. Lower construction cost
2. Shorter construction period
3. No traffic disturbance on the existing road during construction, even if Nepal has to tackle and solve the land issues within the Tinkune IS area.

Although Nepal side agree this idea, long time is required to solve the land issue within Tinkune IS. Therefore, t further study was focus on TK-2R If the land issue will be solved, then route will switch to TK-2R.

Table 8.1.3 Comparison Table

Comparison Item	TK-1	TK-2R	TK-3
Alignment Setting around Tinkune IS	Set along the existing road reserve	Set within the ROW space of the Tinkune Ramp road	Passes through the Tinkune inner land, requiring land acquisition
New Service Road of TIA	Plan and profile are unaffected	Plan and profile are unaffected	Affected during construction but can be restored later
Profile of GS structure: **to follow the CAANs requirements**	UP exposure above the TIA ground surface, requiring the application of a U-shaped wall	No exposure of UP above the TIA ground surface	No exposure of UP above the TIA ground surface
Features of UP &FO structure	BC:600m+U:100m FO: similar to 2R	BC:600m+U:110m FO: 609m **with a partially imbalanced span arrangement**	BC:620m+U:180m FO:520m **with a well-balanced span arrangement**
Construction Method of UP	- Requires steel sheet pile cofferdam along the extension road. - Difficulty of works due to narrow vertical clearance under OLS	- Requires steel sheet pile cofferdam along extension road - Difficulty of works due to narrow vertical clearance under OLS	The open excavation method is applicable.
Construction Method of Structures (FO)	Requires workspace for piers on the extension road	Require workspace for piers on the extension road	No special consideration for land acquisition
Traffic Operation of Ex. road during construction	Two-lane reduction of the extension road between KS and TK ISs	Two-lane reduction of the extension road between KS and TK ISs	Requires no traffic control for the extension road between KS IS and TK IS
Construction Cost	(Secret)		
Construction Schedule	-	**64 months**	**46 months**
Evaluation		**○(Implementable if land acquisition for TK-3 is unsuccessful)**	◎

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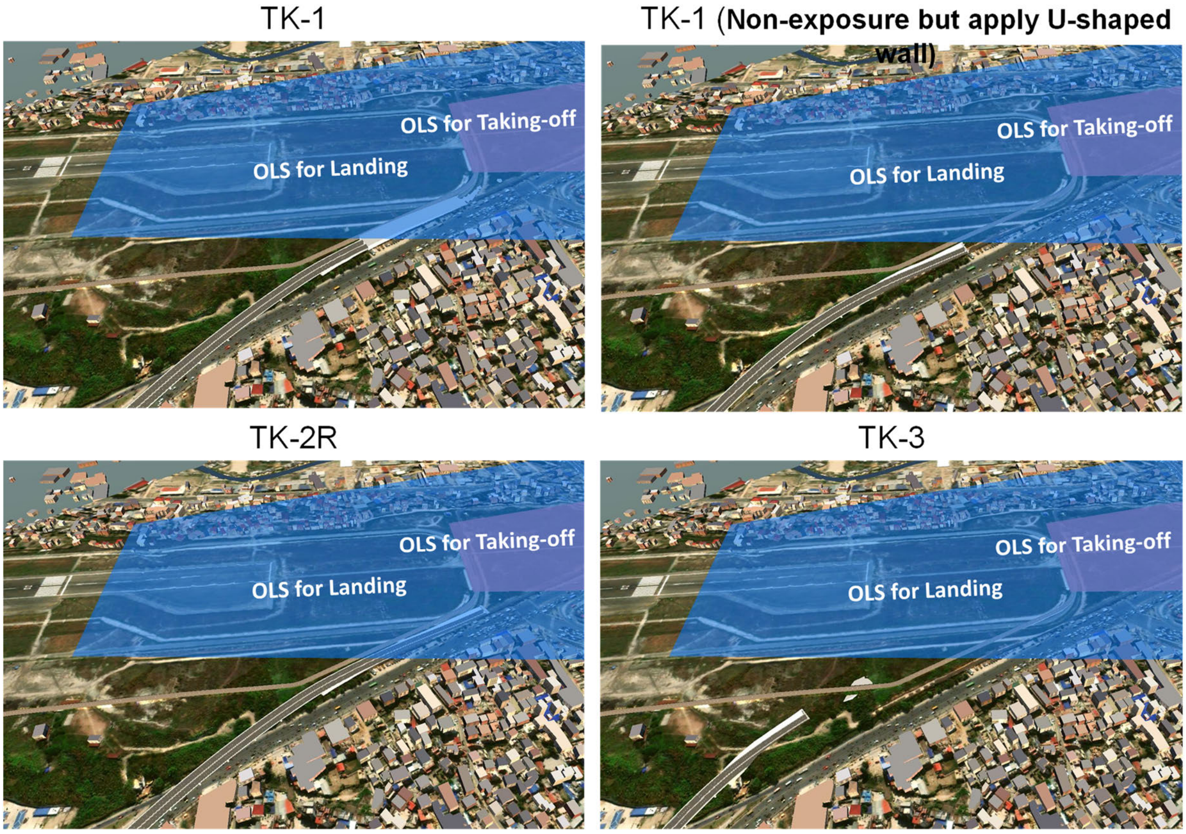

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Figure 8.1.22 3D Image by Alternative

(3) Conclusion

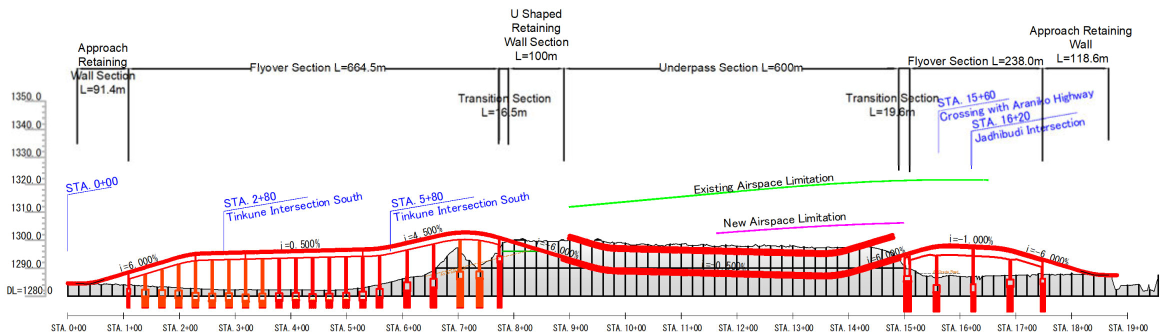
Through the discussion between Nepal and Japanese, an agreement exists were Nepal will explore the possibility of settling land issues within the Tinkune IS by the end of August 2023 while JST proceeds with the outline design based on TK-2R, along with construction planning and cost estimating.

8.1.2 Plan and Profile

According to the design conditions in Chapter 6, the plan for the GS section of the Project follows the images in Figure 8.1.23.

8.1.3 Typical Cross Section

See 8.2.3.



Source; JICA Survey Team

Figure 8.1.23 Proposed Plan for GS section of the Project Roads

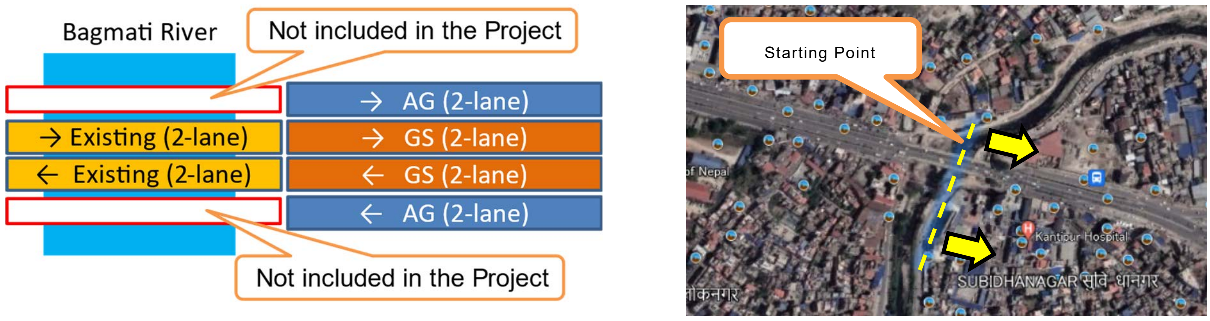
8.2 Outline Design of At-grade Roads (AG)

8.2.1 Project Area

(1) Starting Point

From the outline design of the grade-separated (GS) road section around the Tinkune Intersection mentioned for the project in Section 8.1, the GS section will connect to the Araniko Highway North before crossing the Bagmati River Bridge.

At present, new outer bridge crossing Bagmati river is under construction. DOR will complite the new outer bridges within three years. The At-grade (AG) road section of the project plan to connect to new outer bridges so that it is not be included in the project scope, as illustrated in Figures 8.2.1. The starting point of the project roads is on the east side of the existing Bagmati River Bridge.



Source; JICA Survey Team

Figure 8.2.1 Project Scope

Since the new outer bridges at the Bagmati River Bridge are essential for the project to ensure traffic connectivity with the AG section to be provided by the project, JST discussed with the DOR by presenting Figure 8.2.2 on its importance before the completion of the project.

In addition to the bridge construction, a weaving section for channelization between vehicles running on the grade separation and ones on the at-grade road is necessary on the western side of the Bagmati River Bridge. During the detail design stage, an additional topographic survey and design of the weaving section are required.

Source; JICA Survey Team

Figure 8.2.2 Importance of the New Outer Bridges of Bagmati River Bridge

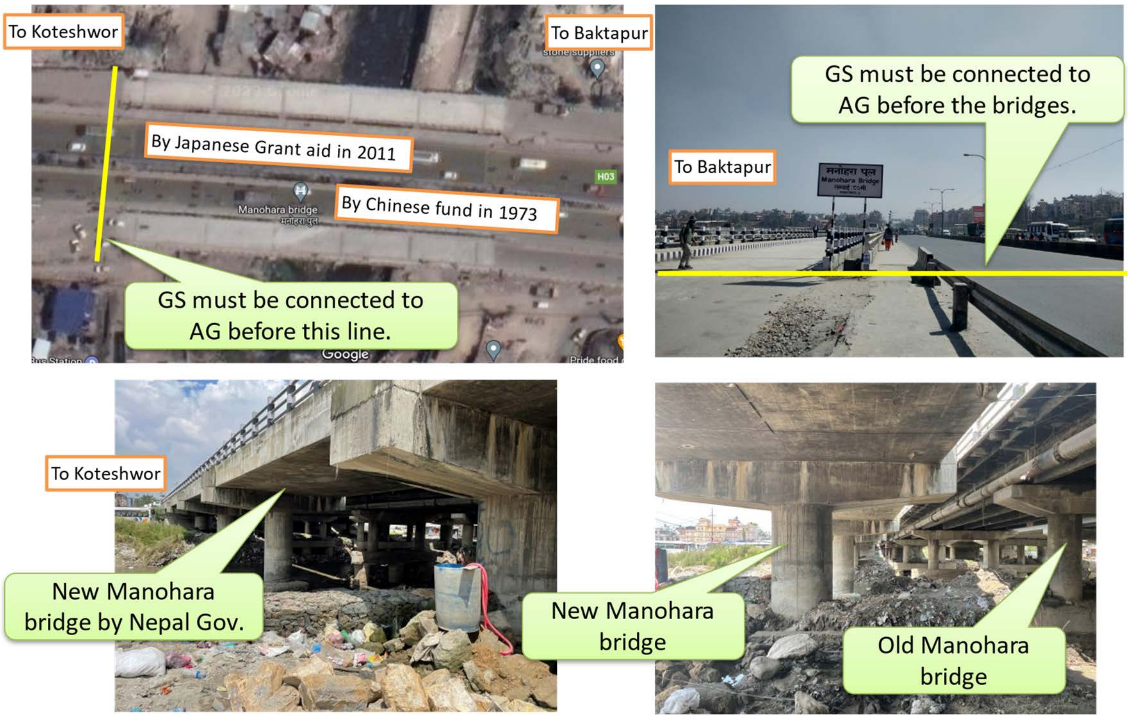
(2) End Point

Following a discussion with the DOR regarding the project road plan at the Jadibuti Intersection side, an agreement was settled to ensure that there would be no adverse impacts on the existing bridges across the Manohara River, as explained in the planning concept in Figure 8.2.2. It is important to note that JST confirmed the feasibility of avoiding impact on the existing bridges after a study of the project road profile.

Consequently, the end point of the project will be positioned prior to the existing Manohara River Bridges, as shown in Figure 8.2.3.

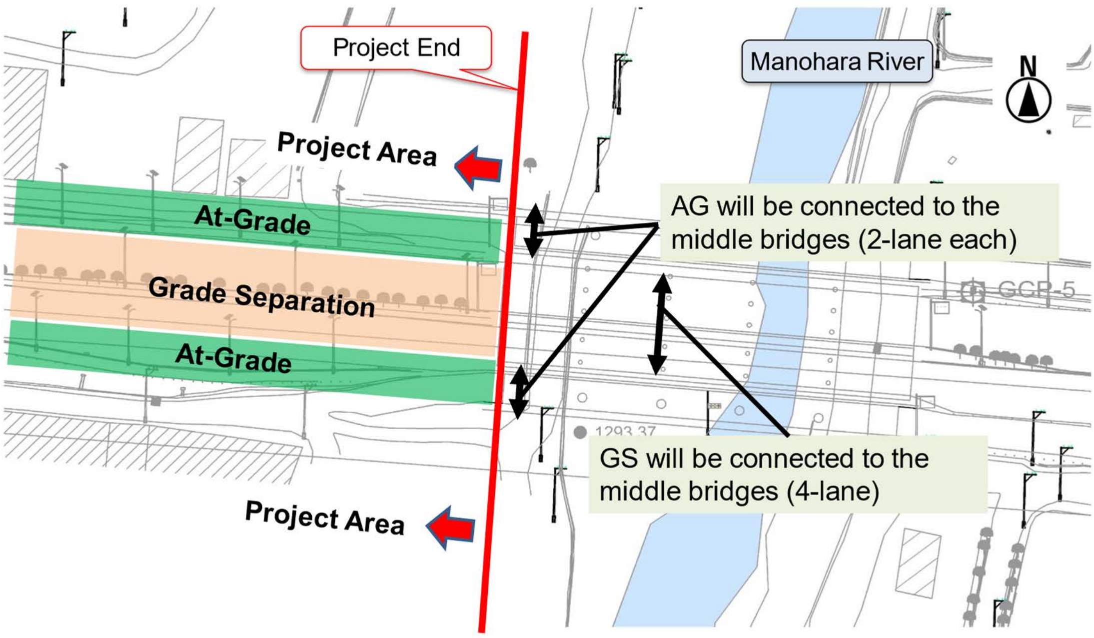
Additionally, a weaving section for channeling traffic between vehicles on the grade separation and those on the at-grade road is necessary on the western side of the Bagmati River Bridge.

During the detailed design stage, it is crucial to conduct an additional topographic survey and design of the weaving section.



Source; JICA Survey Team

Figure 8.2.3 Planning Concept (Impact on the existing bridges shall be avoided.)



Source; JICA Survey Team

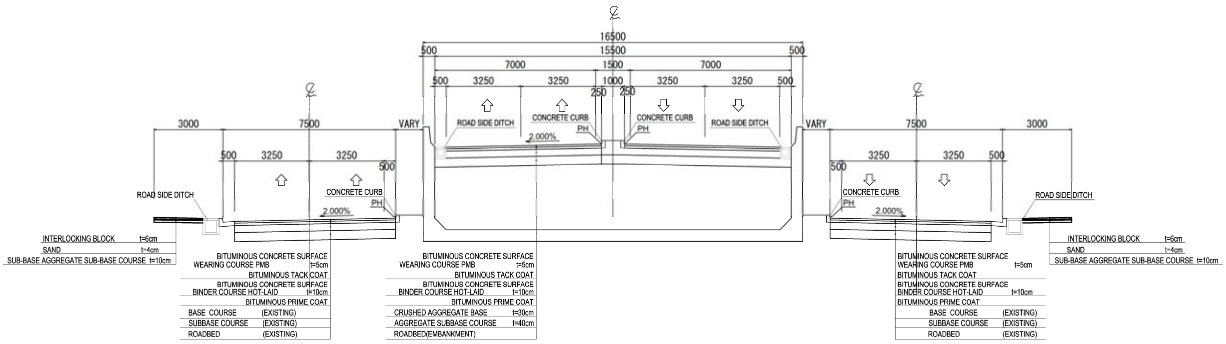
Figure 8.2.4 Project End Point

8.2.2 Plan and Profile

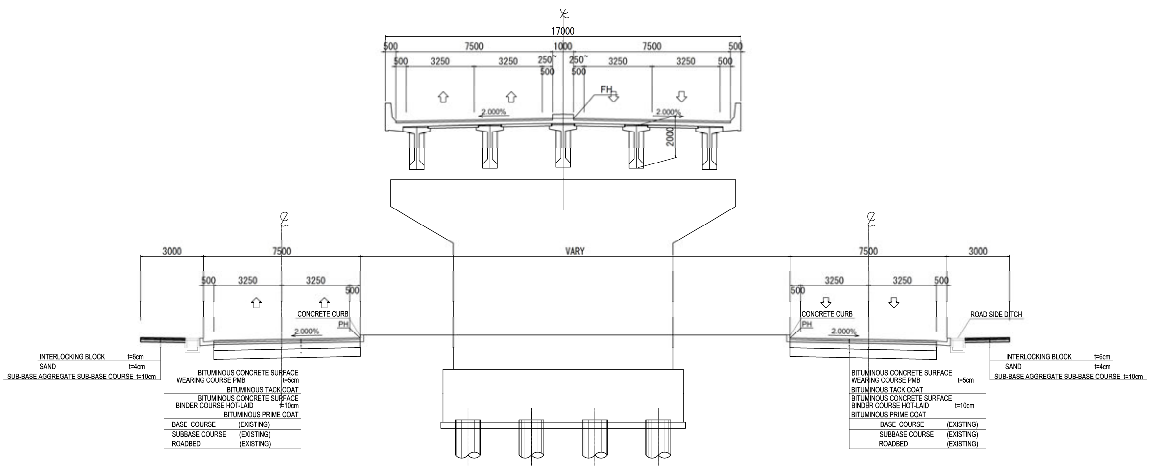
Since accessibility to the roadside by the AG road section is secured along the project road, the profile of the AG section shall remain unchanged from the existing one.

8.2.3 Typical Cross-Section

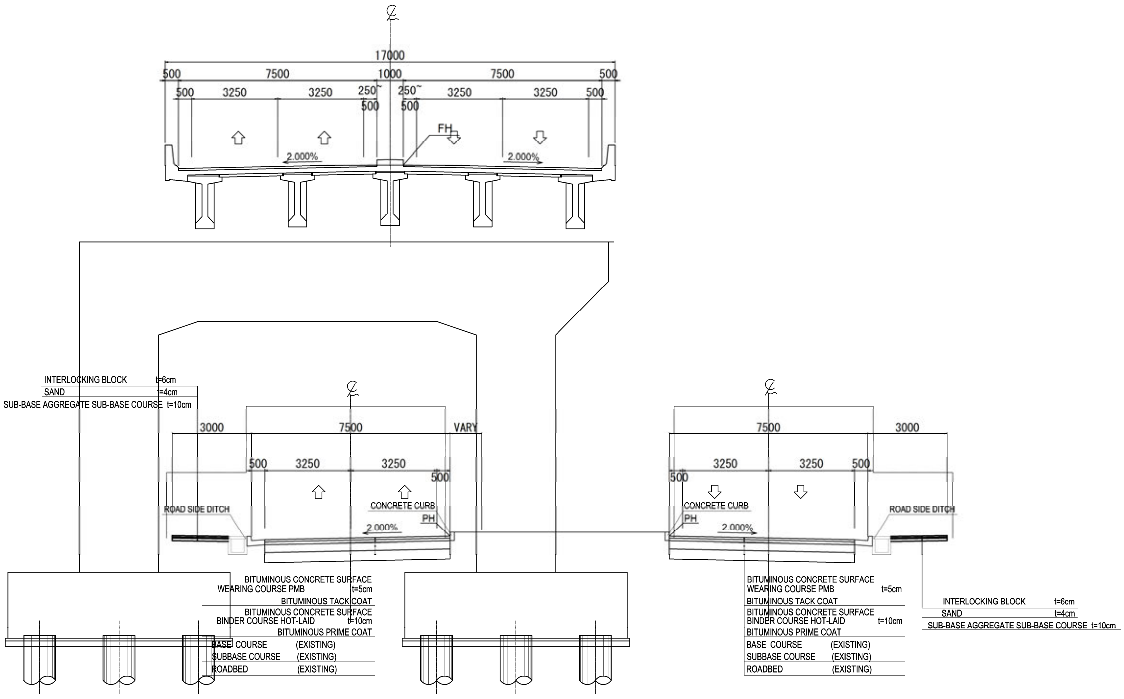
According to the design conditions in Chapter 6, the proposed typical cross sections for the project roads are presented by road section in Figure 8.2.5. Note that 3.25 m of the carriageway width is applied to all typical cross-sections of the project roads, considering the design speed and ROW limitation.



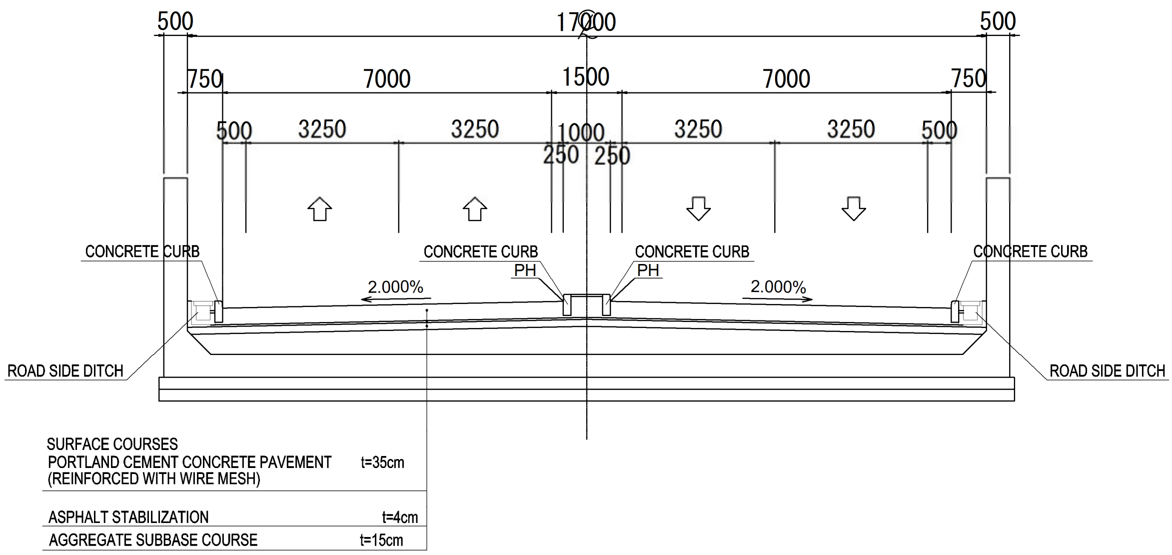
(1) Bridge Approach Section



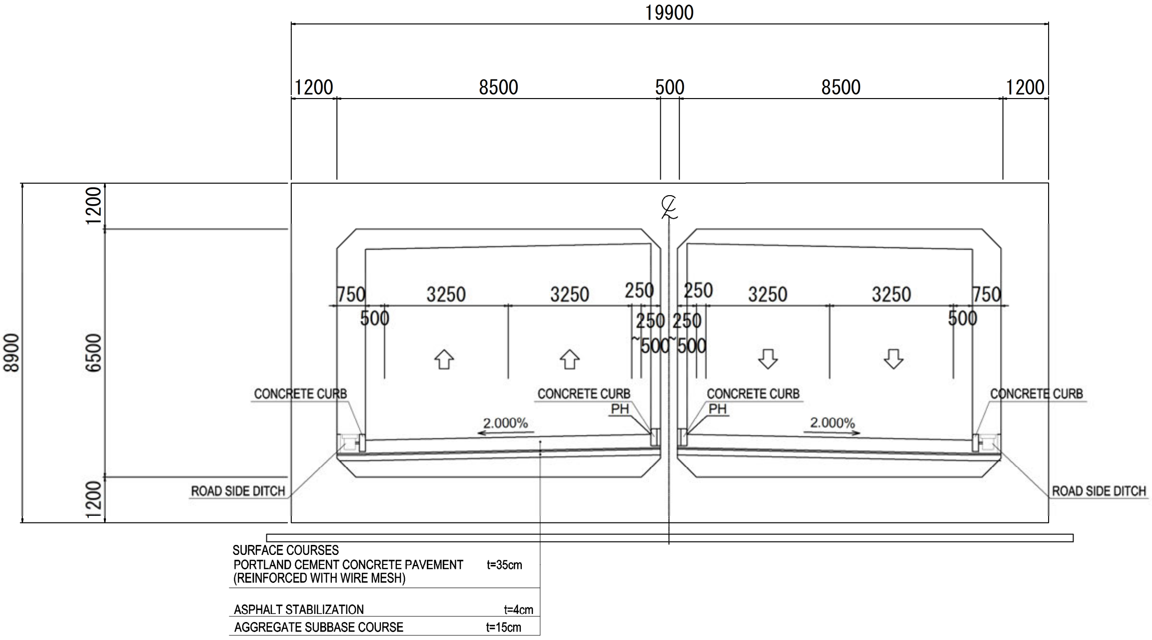
(2) Bridge Section with Single Pier



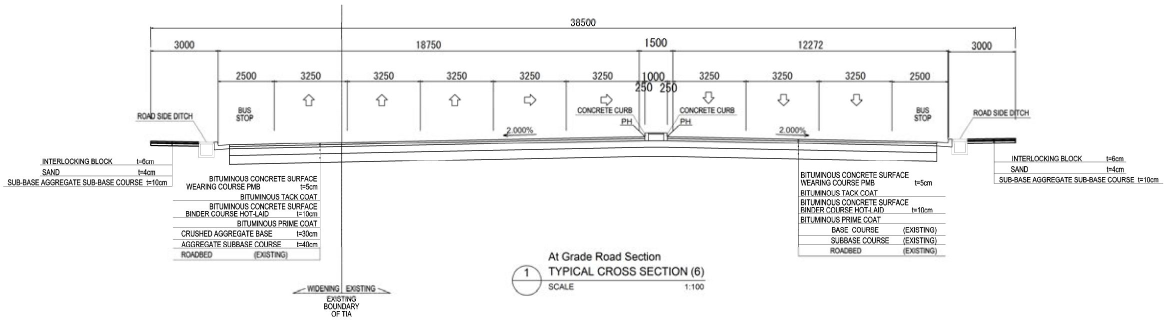
(3) Bridge Section with Portal Pier



(4) Transition Section (U-shaped Retaining Wall) Between Bridges and Box Culvert



(5) Box Culvert Section



(6) At-Grade Section

Source; JICA Survey Team

Figure 8.2.5 Proposed Typical Cross-Sections for Project Roads

8.2.4 Pavement Design for Project Roads

(1) Pavement Type

Table 8.2.1 summarizes the pavement type for the project roads as discussed with the DOR.

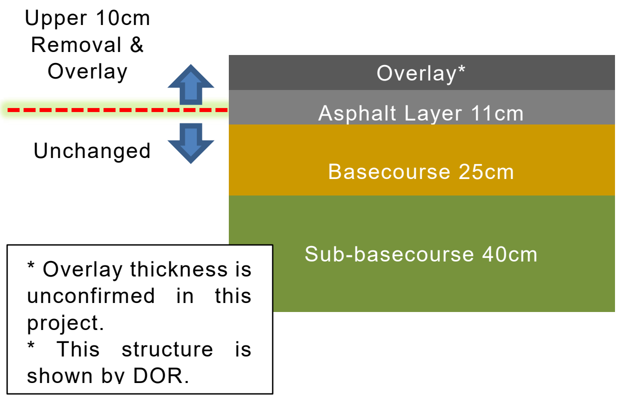
Table 8.2.1 Applied Pavement Type

Open Road	Bridge	Box Culvert	Footpath
			
Asphalt Concrete		Cement Concrete	Interlocking

Source; JICA Survey Team

(2) Project Scope for Pavement Works

During the site reconnaissance of the pavement conditions on the project roads by JST, it was verified that the pavement of the AG section remains in good condition. There are no pot holes or significant cracks, and the base course is presumed to be highly compacted, which suggests it has sufficient design CBR for the traffic load experienced to date. Consequently, the pavement structure for the AG road sections will undergo a 10 cm asphalt concrete overlay on the existing pavement after removal of the top asphalt layer, as detailed in Figure 8.2.6.



Source; JICA Survey Team

Figure 8.2.6 Scope of Pavement Work

(3) Pavement Structure for the New Road Section

When determining the pavement structure for the new road section of the AG roads within the project roads, the choice of pavement structure will be based on the future traffic volume and the pavement design code provided in Table 8.2.2.

Table 8.2.2 Proposed Pavement Structure

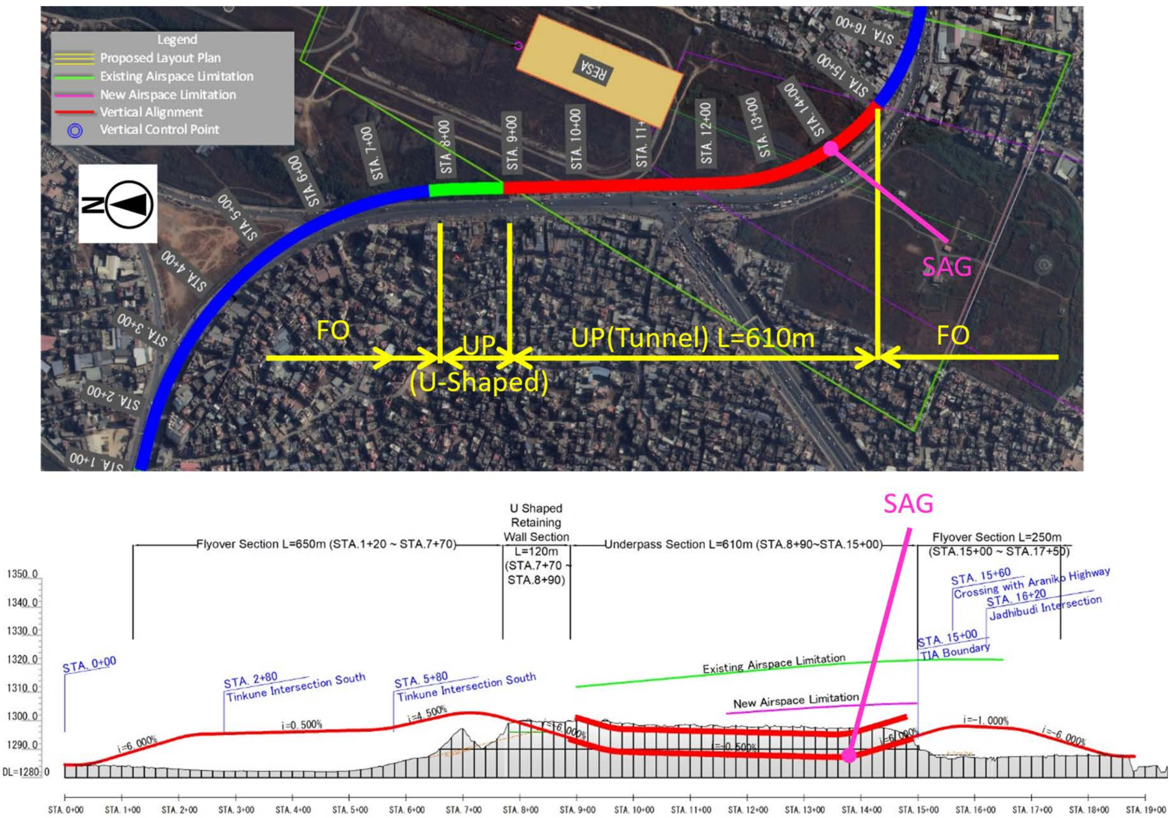
Type	Asphalt Concrete (Overlapped section on the existing pavement)		Asphalt Concrete (New section)		Cement Concrete	
Structure	Wearing Course	5cm	Wearing Course	5cm	Top Slab	35cm
	Binder Course	10cm	Binder Course	10cm	Asphalt Stabilization	4cm
	Basecourse	Utilize the existing basecourse	Basecourse	25cm	Basecourse	15cm
	Sub-basecourse	Utilize the existing sub-basecourse	Sub-basecourse	40cm		

Source; JICA Survey Team

8.2.5 Drainage System

(1) Grade Separated Road Section

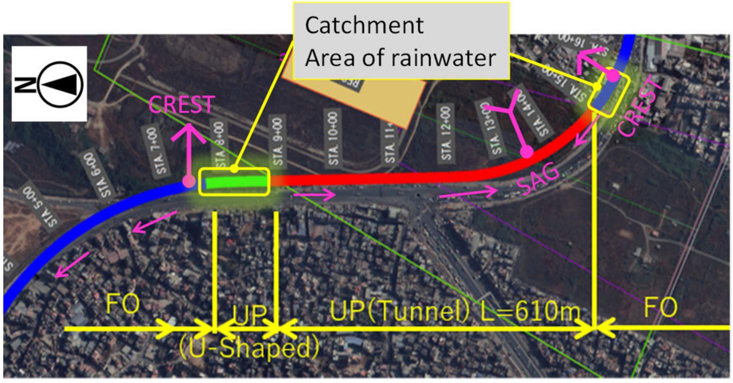
With the aim of facilitating future maintenance for the GS road section, a no-drainage pump system (natural flow) is necessary. However, a sag-point will be located within the underpass road section to meet the CAAN's requirement, as illustrated in Figure 8.2.7. Given these conditions, the following drainage system is planned.

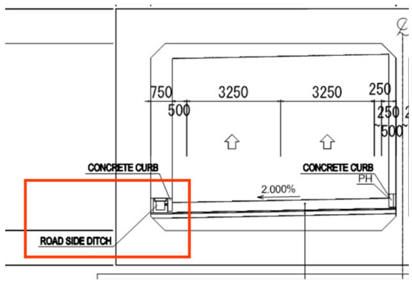


Source; JICA Survey Team

Figure 8.2.7 Plan and Profile of the GS Road Section

The rainwater flows inside the tunnel from the catchment area, as shown in Figure 8.2.8. A roadside ditch is necessary to lead the rainwater to the sag point. Figure 8.2.8 illustrates the water flow direction for the roadside ditch in the UP road section.

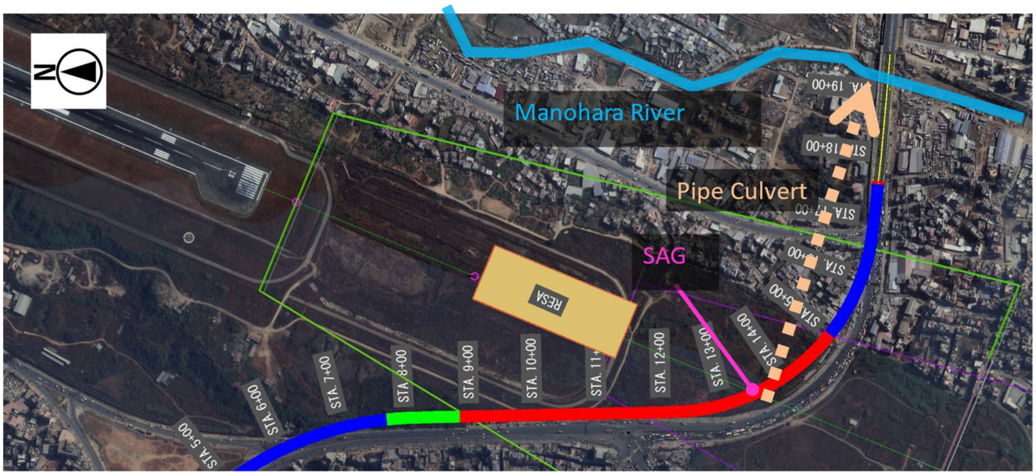




Source; JICA Survey Team

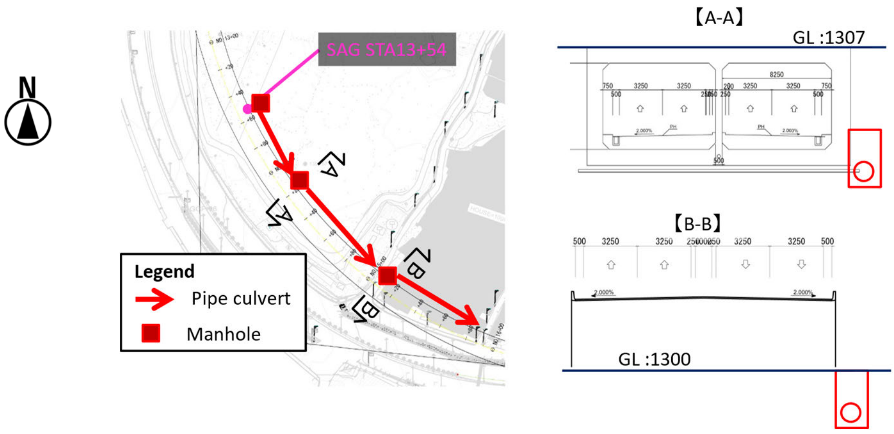
Figure 8.2.8 Water Flow Direction and Roadside Ditch

Manholes and pipe culverts are planned, as shown in Figure 8.2.9, to drain the rainwater from the sag point to the Manohara River, as illustrated in Figure 8.2.10. The maintenance of the drainage facility should be considered during the detailed design stage, such as the diameter of the pipe culvert, to secure the constant flow of the rainwater though pipe culverts.



Source; JICA Survey Team

Figure 8.2.9 Drainage Route from Sag Point



Source; JICA Survey Team

Figure 8.2.10 Drainage System from the Sag Point in the UP Section

(2) At-Grade Road Section

The drainage system in the AG road section will remain unchanged, as there will be no alteration to the road profile. At the Koteshwor Intersection, where the highest point in the AG road section is, surface water will be directed to the Bagmati River on the northern side and the Manohara River in the southern side, respectively. Drainage facilities will be installed beneath the footpath due to land constraints following the existing configuration, as illustrated in Figure 8.2.11.

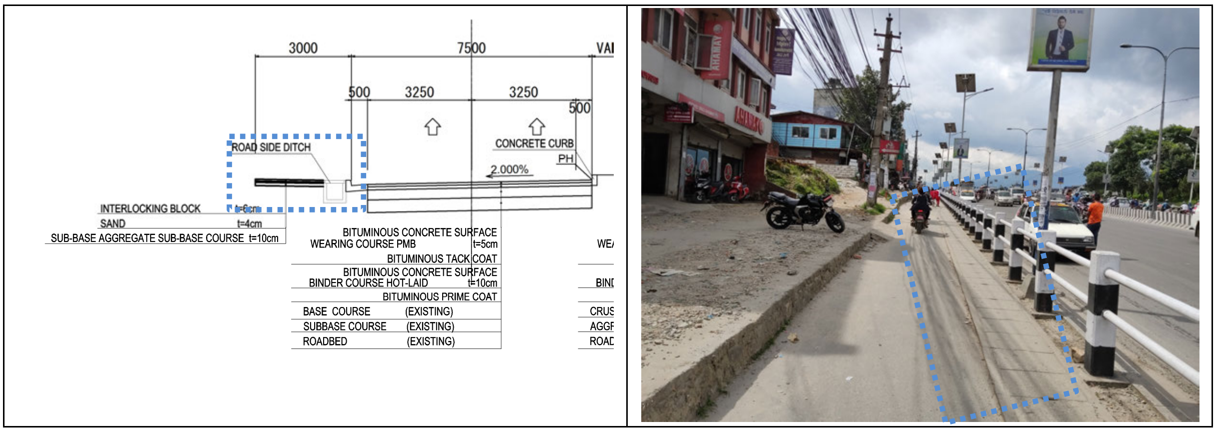


Figure 8.2.11 Drainage System in At-Grade Section

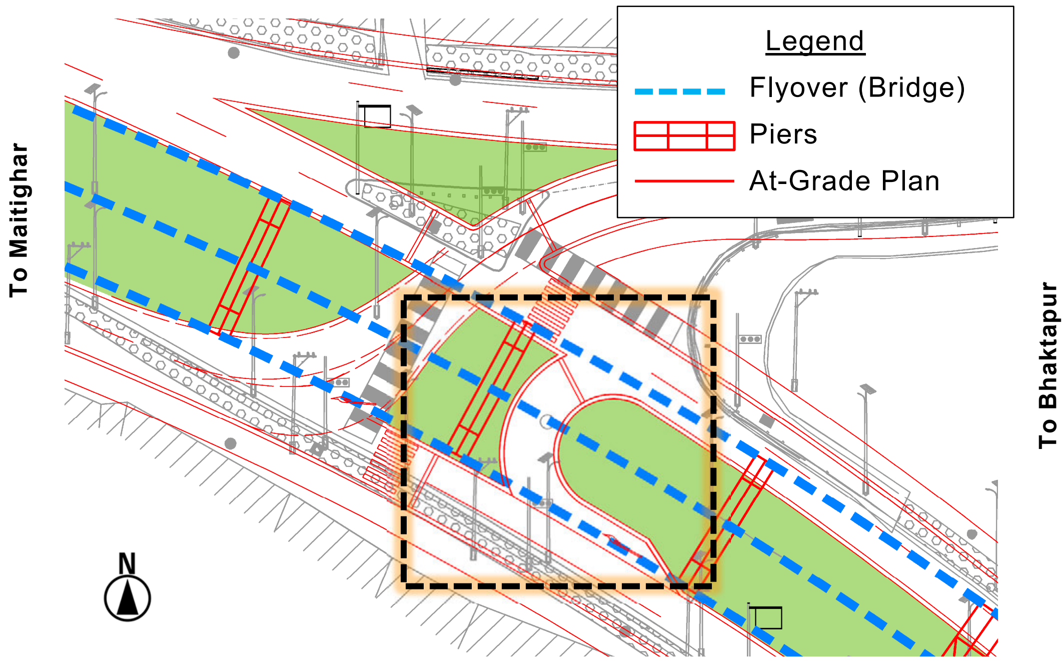
8.2.6 U-Turn Lane

(1) Purpose for Provision

A U-turn lane is essential at both Tinkune Intersection and Jadibuti Intersection. Figure 8.2.12 and Figure 8.2.13 show the proposed U-turn lane locations, respectively. The U-turn lane at Tinkune Intersection, shown in Figure 8.2.13, shall be utilized mainly for the vehicles from access road to the Tinkune South Intersection and the car users along the western ramp road of the Tinkune Intersection who would like to head towards the Koteshwor Intersection.

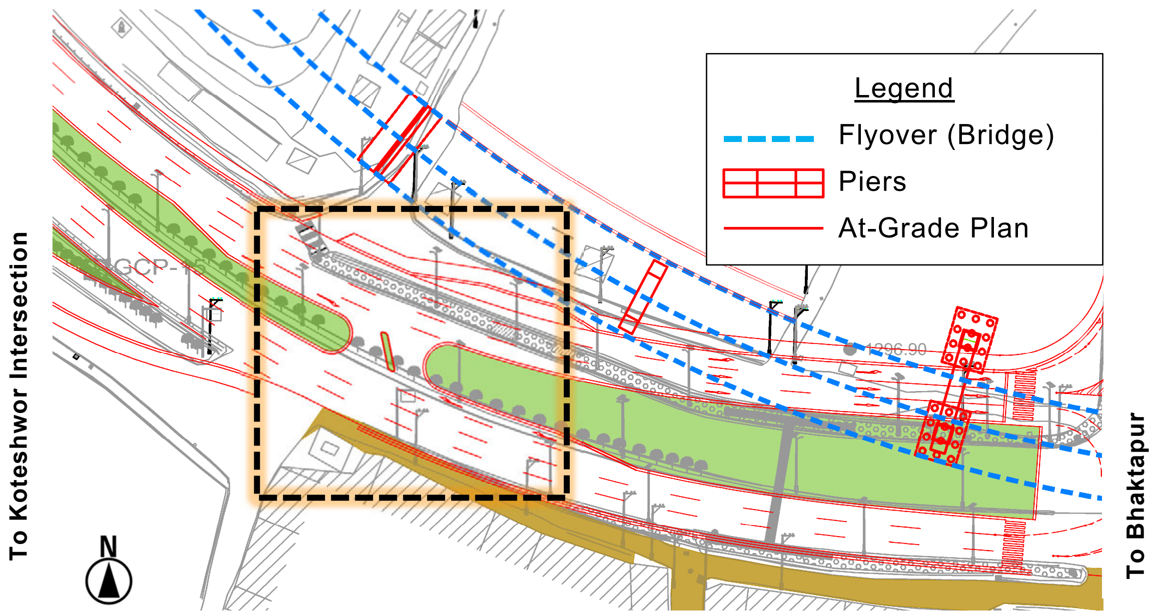
On the one hand, the U-turn lane at the Jadibuti Intersection shall be utilized for the car users along the southern side of Jadibuti Intersection who would like to head towards Bhaktapur and the ones who would like to access the south side of the Jadibuti Intersection from Koteshwor Intersection to avoid the U-turn or left turn at the Jadibuti Intersection.

(2) Proposed Location



Source; JICA Survey Team

Figure 8.2.12 Near Tinkune Intersection in the West



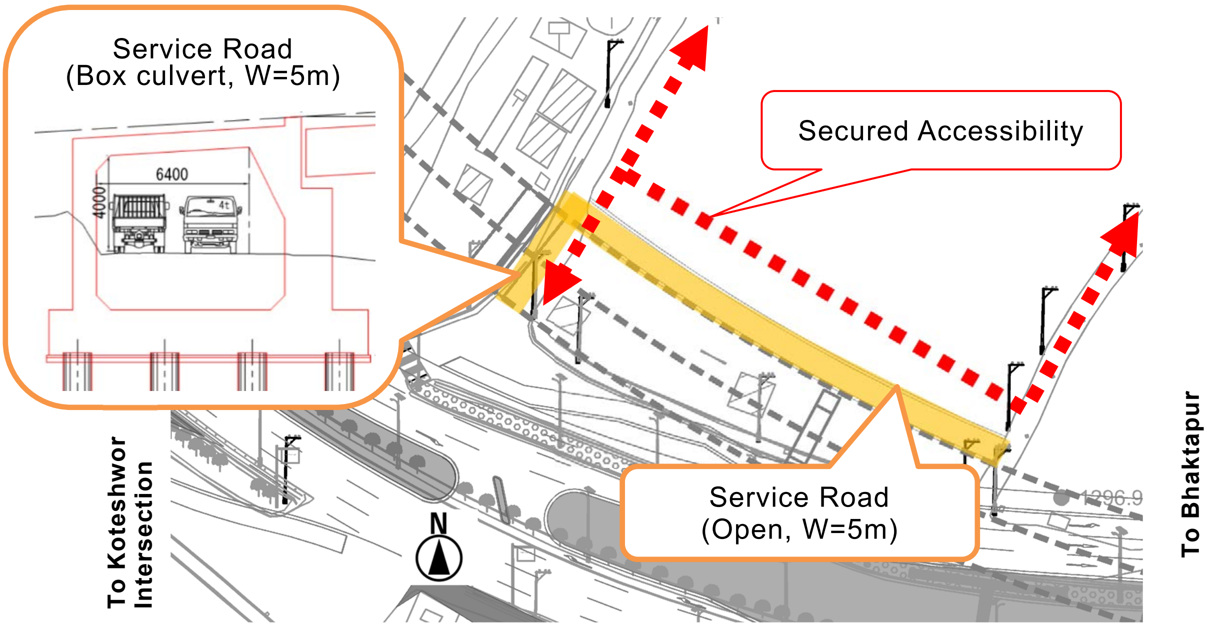
Source; JICA Survey Team

Figure 8.2.13 Near Jadibuti Intersection in the West

8.2.7 Service Road

(1) New Provision

A service road is necessary between the existing highway at the north-west section of the AG road near the Jadibuti IS to secure the accessibility of residents, as shown in Figure 8.2.14. For the access road to Araniko Highway from the north side, the provision of a box culvert is proposed by combining the abutment of the flyover, as shown in Figure 8.2.14.



Source; JICA Survey Team

Figure 8.2.14 Proposed Service Road

The vertical clearance for underpass (box culvert) section is approximately 4 m. A height restriction barrier (Figure 8.2.15) is provided at the entrance on both sides to avoid heavy vehicles and damage to the abutment.

Figure 8.2.15 Height Restriction Barrier

Source; JICA Survey Team

Figure 8.2.16 Existing Frontage Road

(2) Rehabilitation of Existing Frontage Road

As mentioned in Section 8.4, the existing frontage road south of the Jadibuti Intersection, as shown in Figure 8.2.16, will be a service road after the project. Since this road is an access road from/to roadside facilities, surface rehabilitation (5 cm removing and repaving) shall be made so as not to change the road profile.

8.2.8 Road Ancillaries

(1) Streetlights

Streetlights are necessary for the entire stretch of the project roads. in accordance with the agreement with the DOR, the new streetlights shall be an electric type (not solar power type), considering their maintenance. Table 8.2.3 outlines the specific lighting arrangements and details. The streetlight layout study is during the detailed design stage through discussion with traffic police.

Table 8.2.3 Proposed Details for Streetlights

Section	Open Road		At-grade Intersection	Bridge	U-Shaped Retaining Wall	Box Culvert
Pole Height	10 – 12m					See Chapter 10
Interval	30 to 40 m					
Location	On Median	On Footpath	On Footpath and Median	On Side Wall	On Median	
Type of Lighting Fixture	Double Arm	Single Arm	Single Arm and Double Arm	Single Arm	Double Arm	

Source; JICA Survey Team

(2) Traffic Signals (Traffic Light)

Traffic signals will be used to control major intersections on the project roads, as described in Section 8.3. During the detailed design stage, additional discussions with the traffic police will be necessary to determine their specific placement.

(3) Traffic Signs (Regulatory Signs)

Table 8.2.4 describes the expected installation of traffic signs. During the detailed design stage, additional discussions with the traffic police will be necessary to determine their specific placement.

Table 8.2.4 Proposed Traffic Signs

Location	At-grade section	Grade-separated section	Ramps	Before at-grade intersection	Pedestrian Crossing	Diverging / Merging Point	Before bridge and underpass section
Traffic Signs							

Source; JICA Survey Team

(4) Railings

Figure 8.2.17 shows the installation of railings along the footpath for pedestrian and traffic safety, similar to the existing ones.

(5) Cushion Drums and Blinker Lights

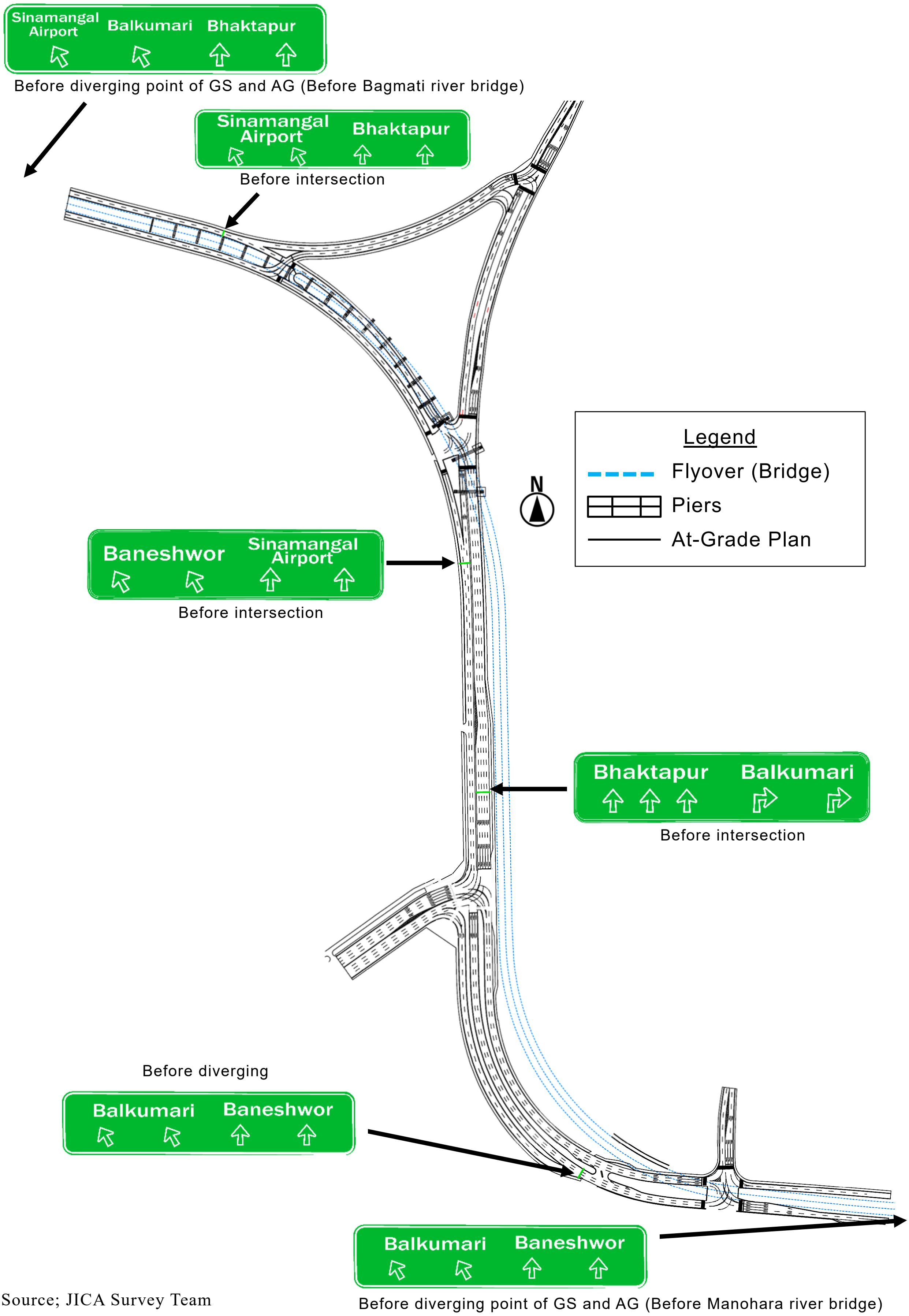
Cushion drums and blinker lights shall be installed at the ramp terminals and diverging points to avoid crushing to the median, as shown in Figure 8.2.18.

Source; JICA Survey Team
Figure 8.2.17 Existing Railings

Source; JICA Survey Team
Figure 8.2.18 Cushion Drums

(6) Information / Guide Signs

Information signs in the form of gate-type installations, will be implemented for the AG section to guide drivers in selecting the correct travel route. Figure 8.2.19 shows the proposed layout of information signs in the project area for reference to enhance the further discussion on the position and number of information/guide signs during the detailed design stage.



Source; JICA Survey Team

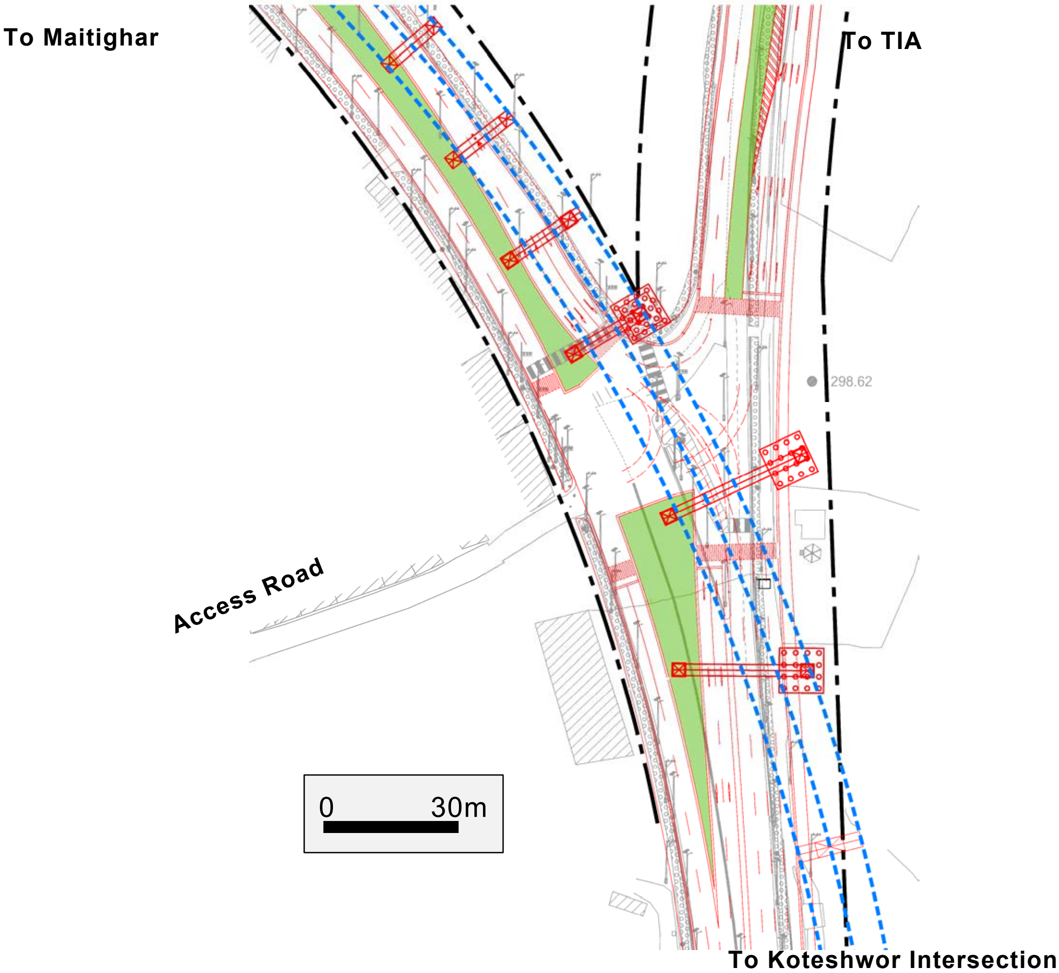
Figure 8.2.19 Proposed Information Signs

8.3 Outline Design of Tinkune Intersection

8.3.1 Improvement Plan

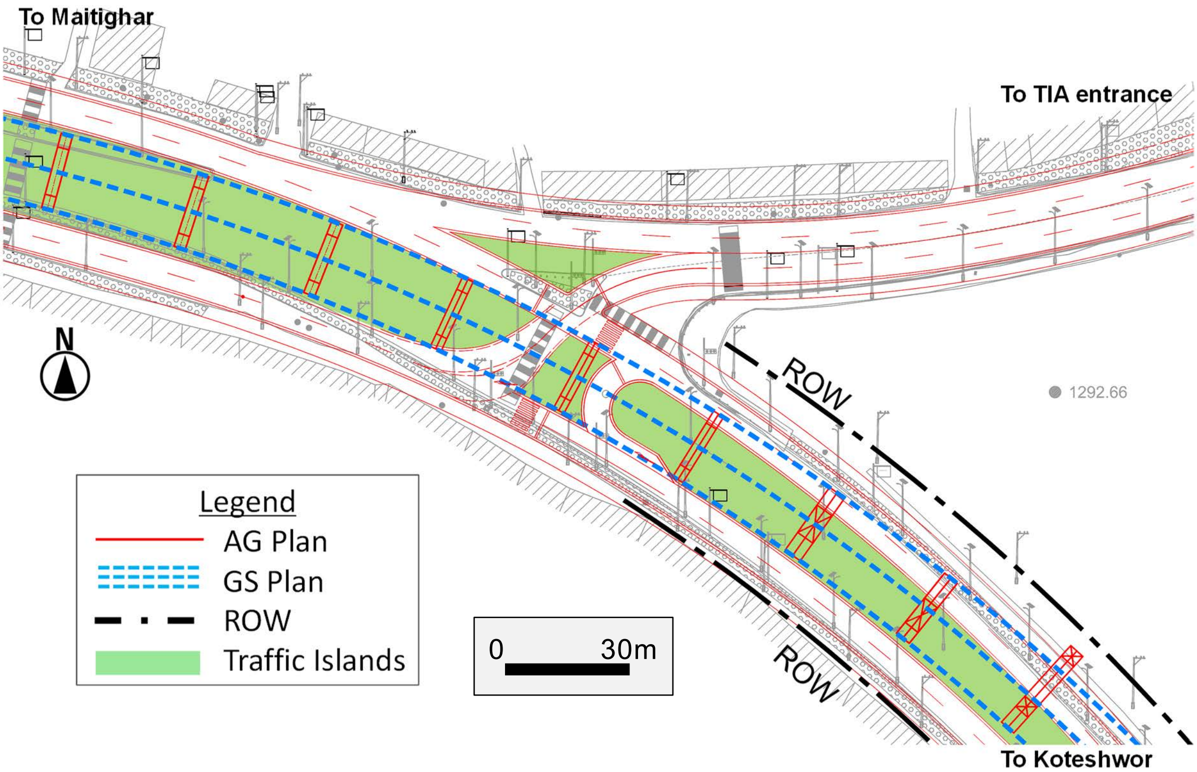
(1) Plan

Figure 8.3.1 to Figure 8.3.3 present the proposed improvement plans for the at-grade (AG) roads at Tinkune Intersection. Following a lane layout study, it was possible to harmonize the number of lanes for three intersections (east, north, and south). On the other hand, due to the diagonal alignment of flyover structures for the GS road section over the center of the intersection, there is a requirement for installation and construction space for piers. Furthermore, as explained later, a significant change in the major traffic direction will be introduced at the intersection. The intersection configurations consider these technical issues and ensures the retention of at least the existing number of lanes or more. It is important to note that JST has designed the intersection so that vehicles entering from the access road from the west can only make left turns, thereby reducing the risk of collisions with other vehicles within the intersection. A U-turn lane is also provided for vehicles from the access road before Tinkune Intersection West.



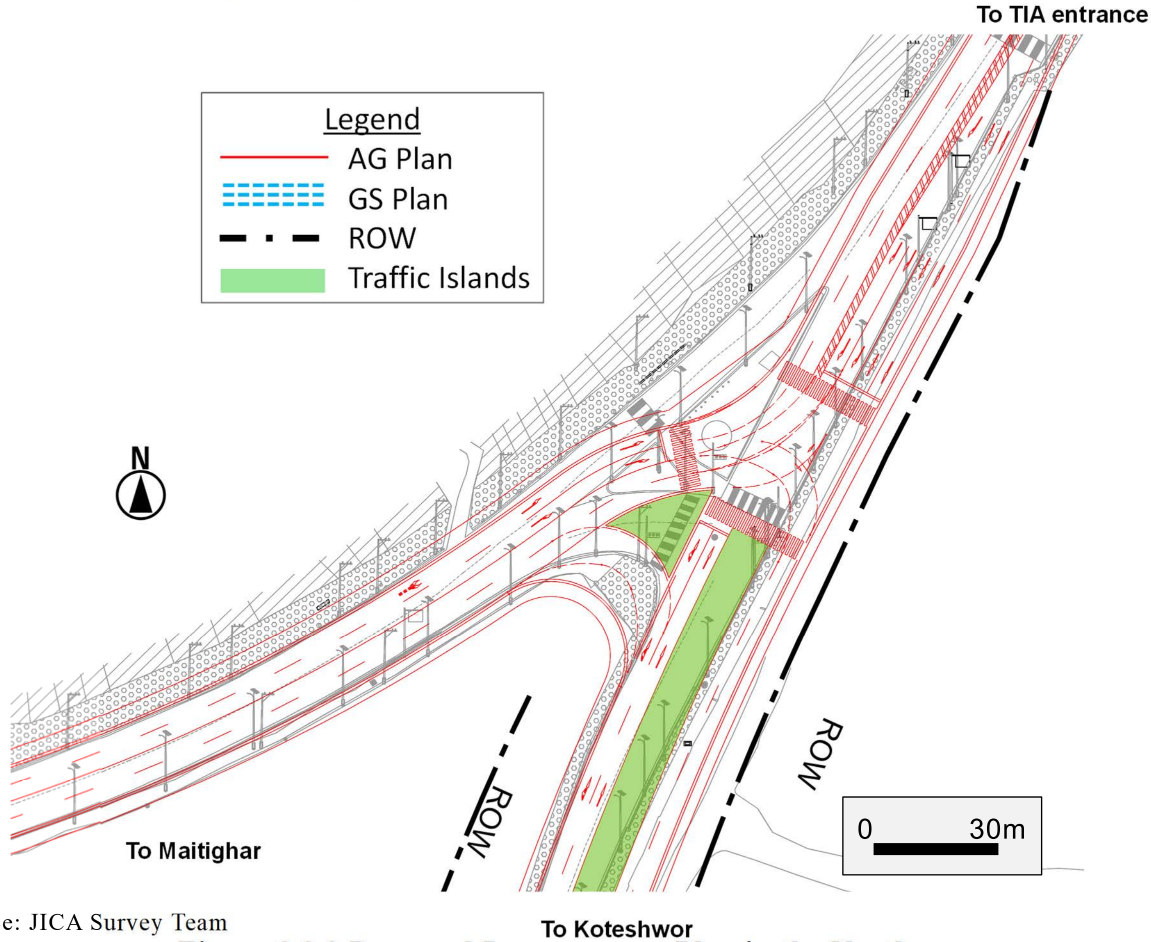
Source: JICA Survey Team

Figure 8.3.1 Proposed Improvement Plan in the South Vertex of the Intersection



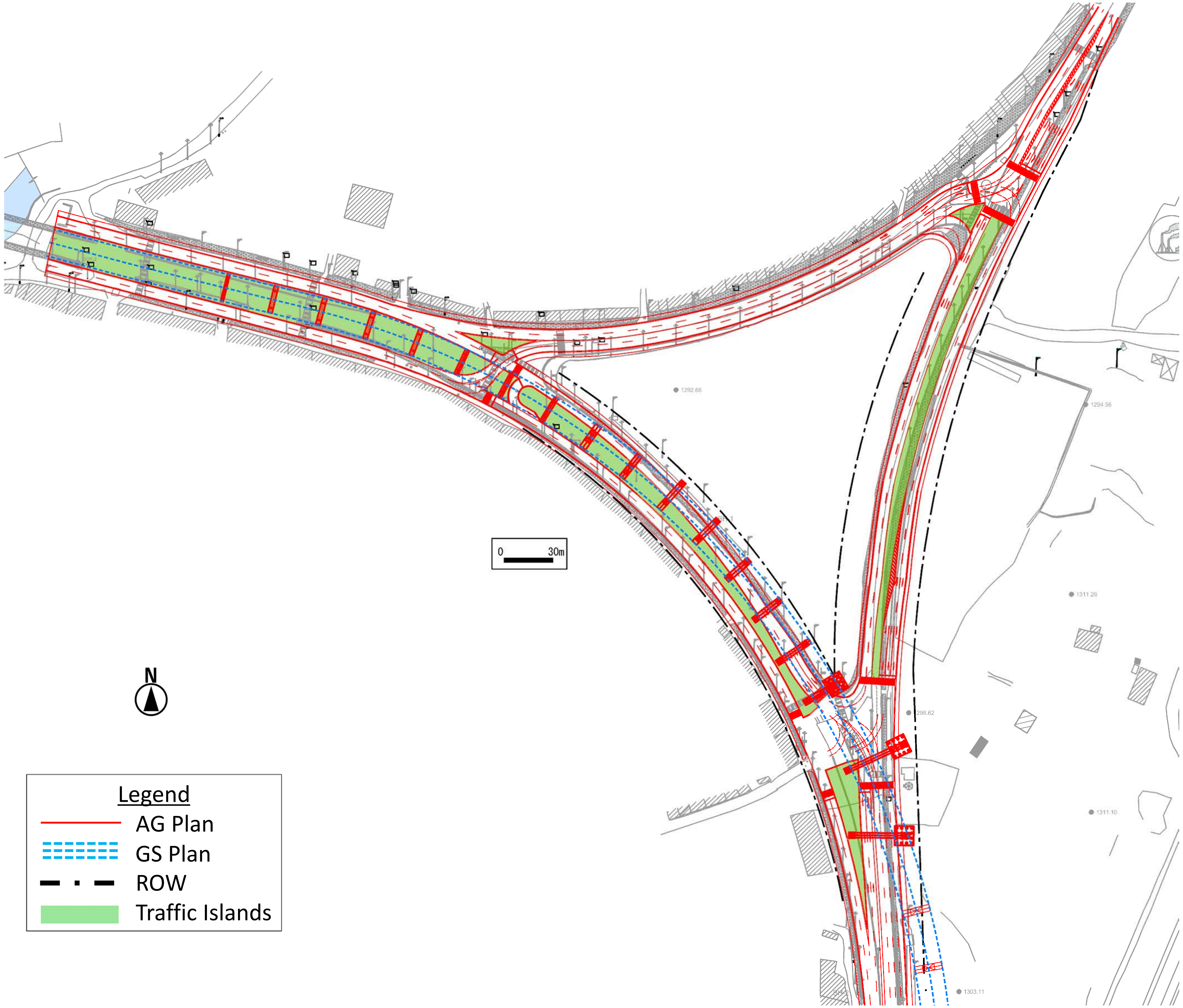
Source: JICA Survey Team

Figure 8.3.2 Proposed Improvement Plan in the West Vertex of the Intersection



Source: JICA Survey Team

Figure 8.3.3 Proposed Improvement Plan in the North

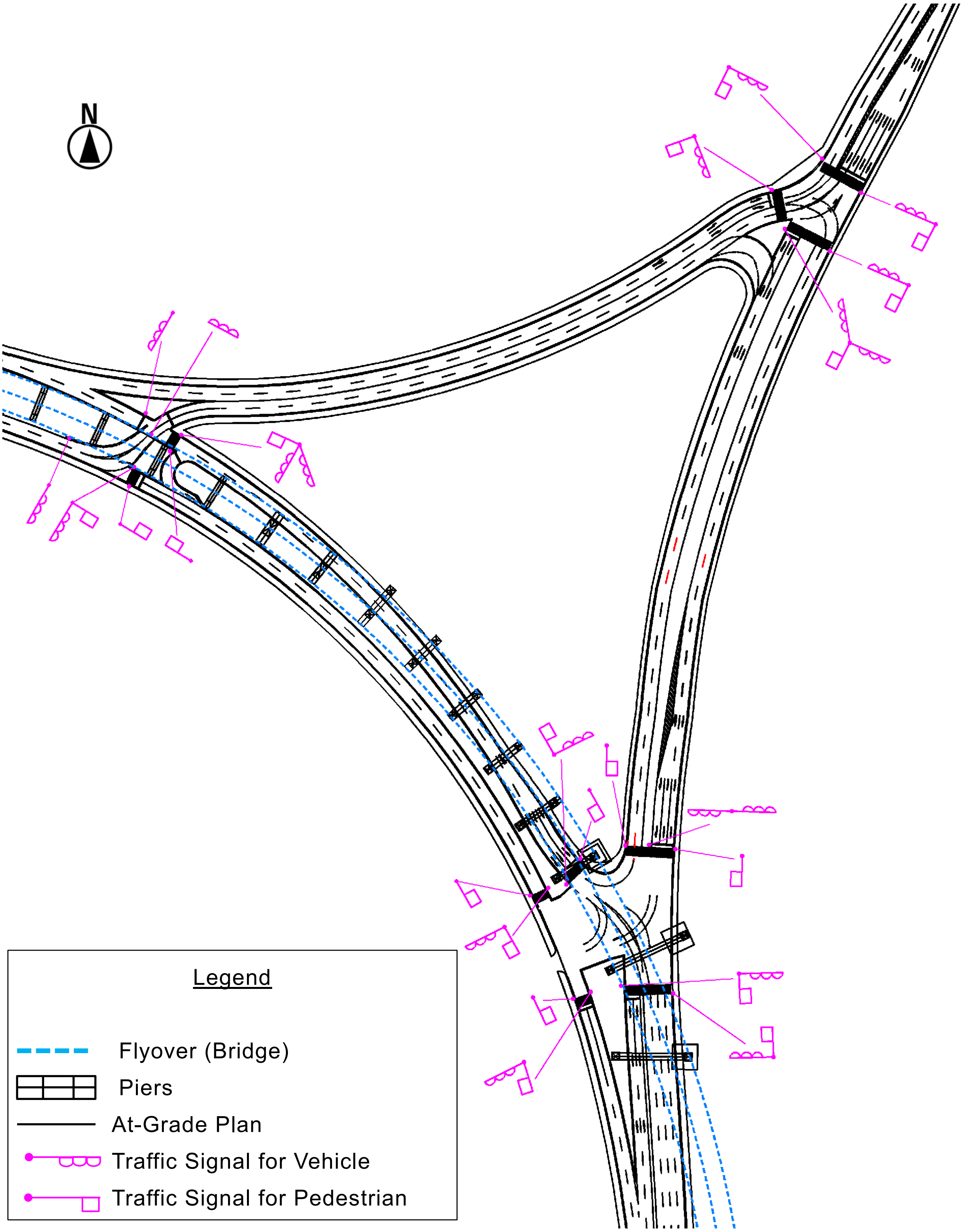


Source: JICA Survey Team

Figure 8.3.4 Proposed Improvement Plan

(2) Traffic Signal Layout

Figure 8.3.5 presents the proposed traffic signal layout at the Tinkune Intersection.

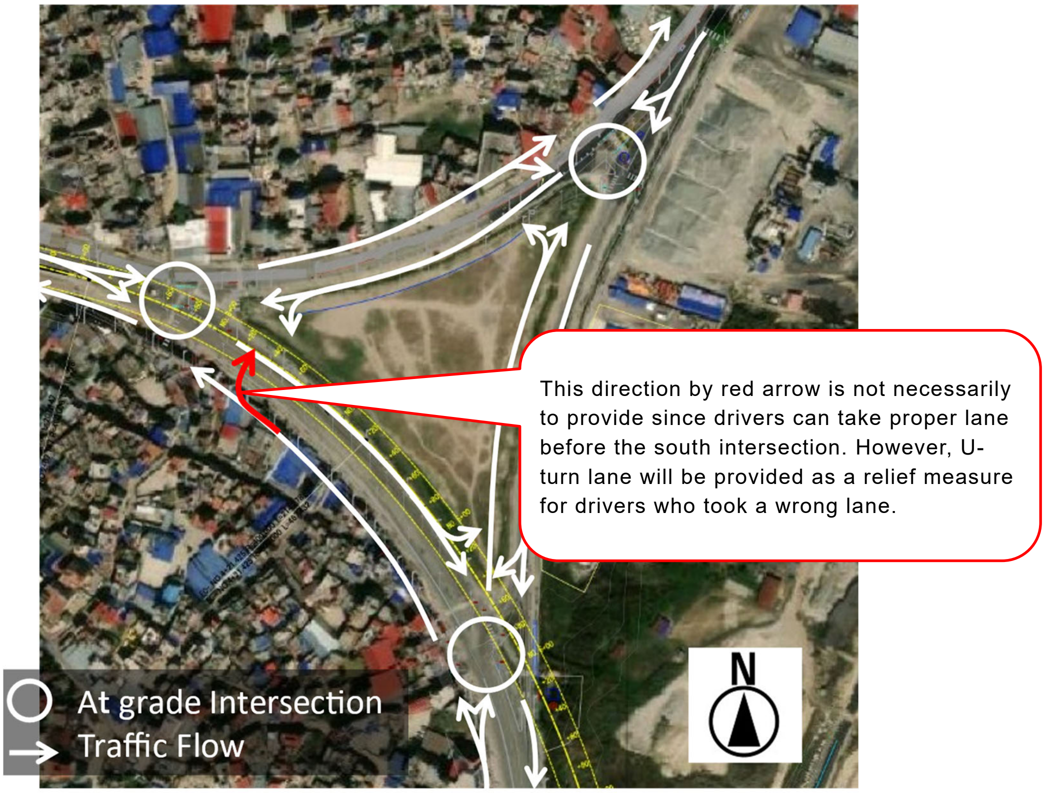


Source: JICA Survey Team

Figure 8.3.5 Proposed Traffic Signal Layout at the Tinkune Intersection

8.3.2 Design Concept

The design concept for the Tinkune Intersection is that "Current traffic control operation, which both directions are passable on all ramps of the intersection, shall remain unchanged" as a result of the discussion with DOR as explained in Figure 8.3.6



Source: JICA Survey Team

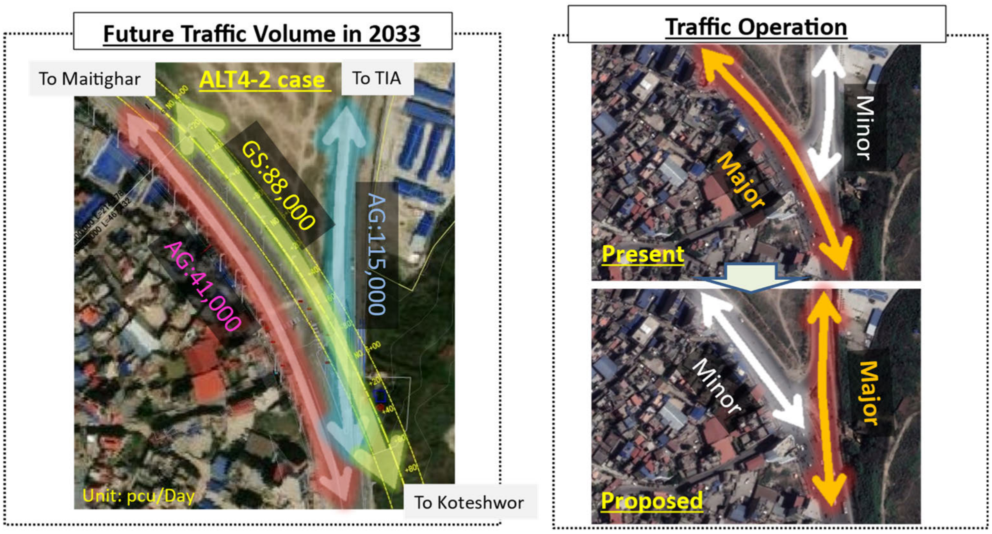
Figure 8.3.6 Current Traffic Operation

8.3.3 Traffic Operation Plan

(1) Changing Major Traffic Direction

According to traffic demand forecast described in chapter 7, traffic volume at the at-grade roads between RRN and Araniko Highway South becomes more than that of Araniko Highway North and Araniko Highway South once the grade-separated road section opens. Therefore, the major traffic direction shall be changed as described in Figure 8.3.7, connecting RRN with Araniko Highway directly in order to maximize the intersection capacity.

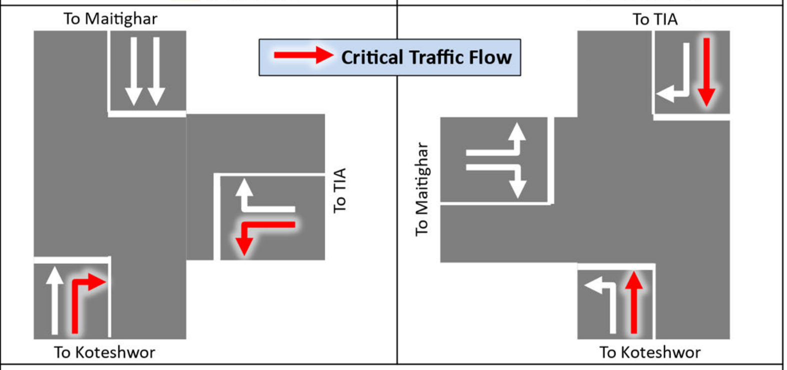
By changing the major traffic direction from the minor direction, much traffic volume can be accommodated during the green time of the signal phase, as explained in Table 8.3.1.



Source: JICA Survey Team

Figure 8.3.7 Proposed Traffic Operation Plan

Table 8.3.1 Comparison of Present and Proposed Traffic Operations

Type	Present Traffic Operation	Proposed Traffic Operation
Sketch		
Lane Layout		
Observation	● By assigning a critical traffic flow to the **Thru-lane**, much traffic volume can be accommodated during green time of the signal phase. ● Due to this, size of the intersection could be smaller.	

Source: JICA Survey Team

(2) Pedestrian Operation

Pedestrian bridges will not be required at the intersection for the following reasons:

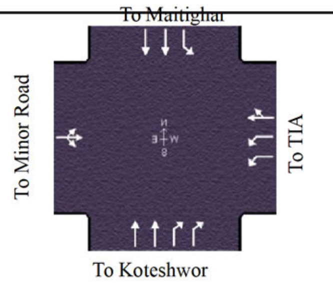
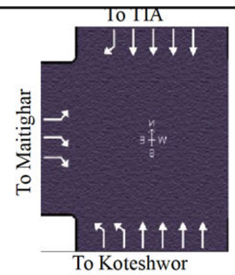
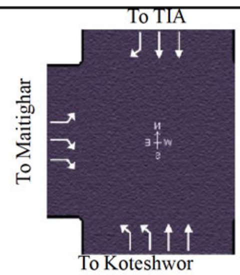
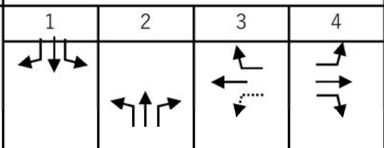
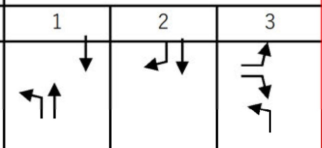
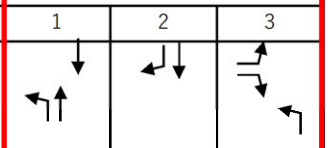
- A flyover structure exists for vehicles above the intersection, preventing physical conflicts.
- Traffic signals at the intersections are planned to ensure the safety of pedestrians crossing the AG roads.

If the DOR can acquire the land up to the boundaries of all legal Right-of-Way (ROW) along all ramps of the intersection in the future, adding additional traffic lanes can expand the capacity of the Tinkune Intersection. Accordingly, the proposed shape can be considered as the tentative shape at present. In the future, when the permanent shape is determined, the study of the need for footpath bridges at the intersection, considering the traffic volumes.

8.3.4 Level of Service

Table 8.3.2 shows Level of Service (LOS) of Tinkune (South) Intersection by condition. Even though LOS is F due to the land constraint mentioned above, by the intersection improvement in this project, approximately 60% of the control delay, similar to the waiting time at the entry lane, is expected to be reduced.

Table 8.3.2 Level of Service of Tinkune (South) Intersection

Status	Existing (As of 2020)	Required (LOS: D or above)	Outline Design (Applied)
Lane Layout			
Phasing (Controlled →, Free ⋯▶)			
Control Delay	412 sec / veh	39 sec / veh	177 sec / veh
LOS	F	D	F

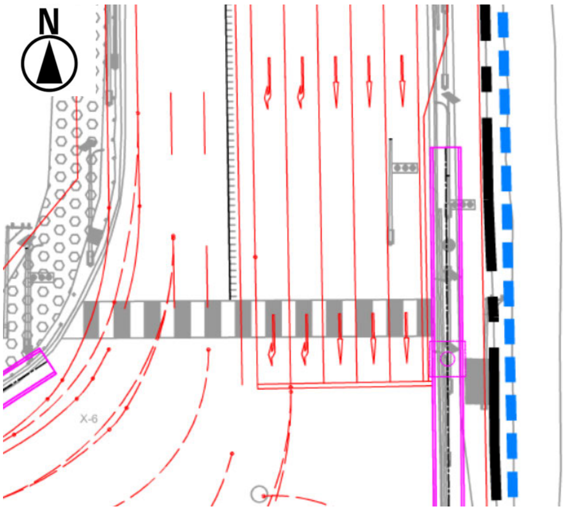
Source: JICA Survey Team

8.4 Outline Design of Koteshwor Intersection

8.4.1 Improvement Plan

(1) Plan

The improvement concept of the Koteshwor Intersection is to maximize the number of lanes within the available right-of-way (ROW) of approximately 40 m. A bus bay strip and a 3-meter footpath are also provided on the outer carriageways, considering the existing usage. As a result of these provisions, eight lanes are the total design lane within the remaining width. Considering the flow of traffic, the entry lane from Araniko Highway North to the Koteshwor Intersection will consists of five lanes, with two lanes for right turns toward the west (to RRS) and three lanes for through traffic towards the south (to Jadibuti). From entering the Araniko Highway South, three lanes are secured, respectively, as illustrated in Figure 8.4.1.

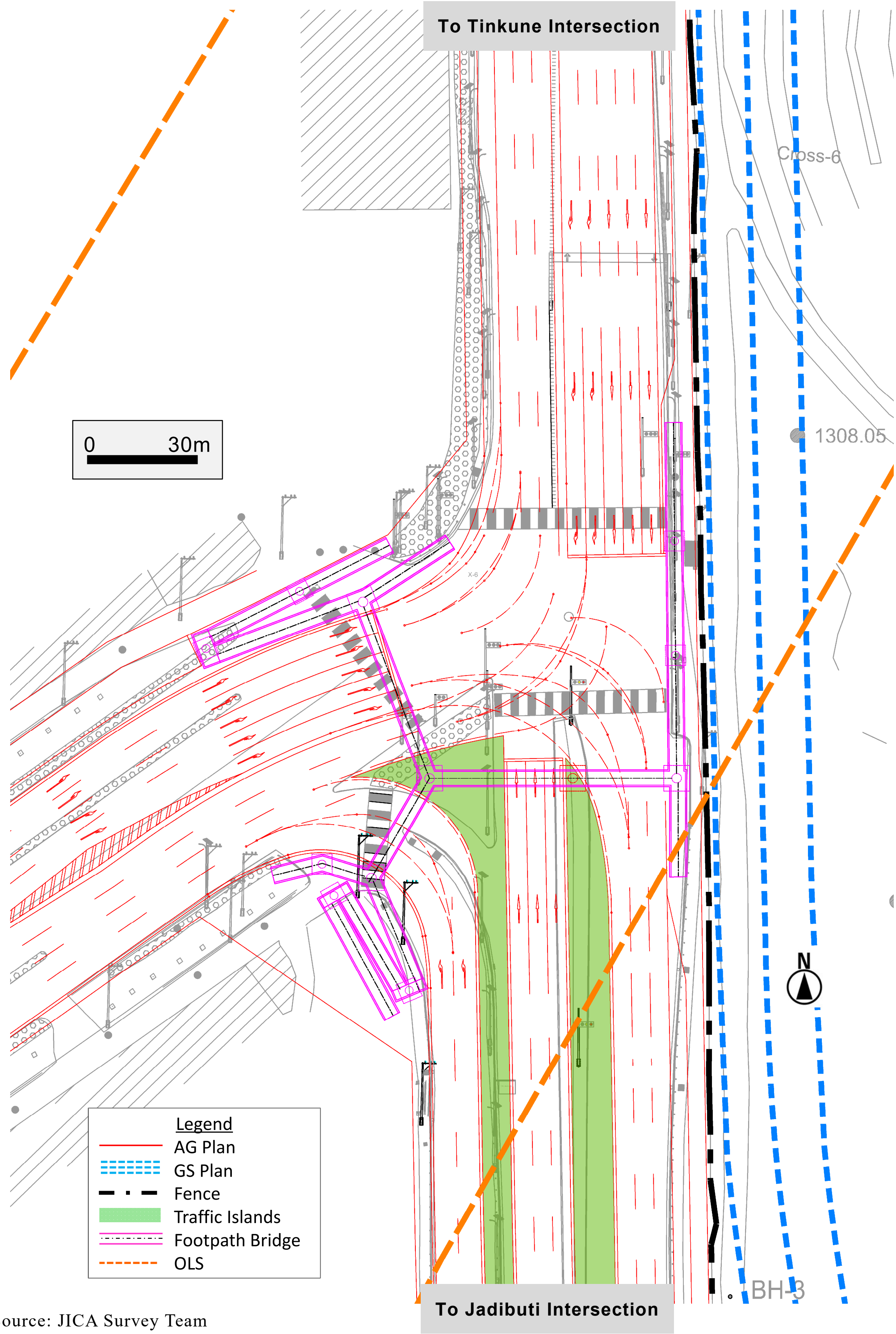


Source; JICA Survey Team

Figure 8.4.1 Entry Lane Layout in the ARK-N Side

On the other hand, many pedestrians cross Araniko Highway from the east (bus-bay side) to the west, a factor that causes traffic congestion since the distributed allowable time that vehicles can move gets shorter due to distribution for pedestrian road crossing time. The proposed footpath bridge aims to mitigate traffic congestion and avoid traffic accident risks by removing physical conflict points between vehicles and pedestrians.

The width of the footpath bridge is based on the survey of pedestrians at the intersection during the detailed design stage.

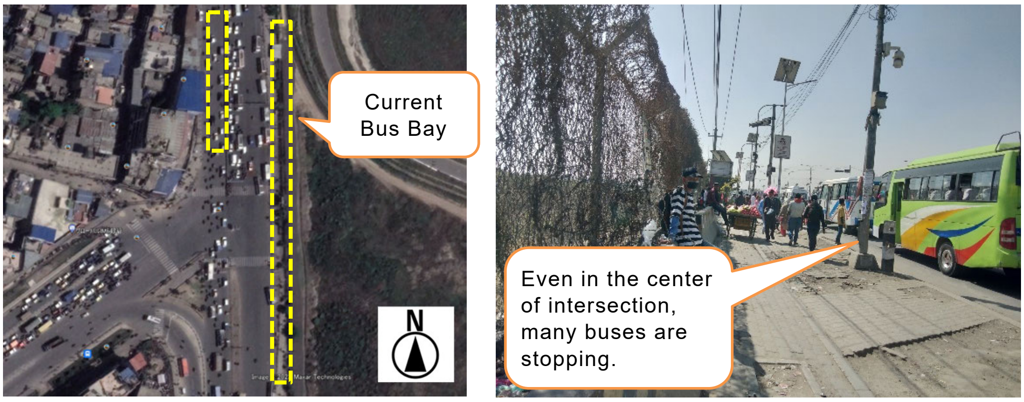


Source: JICA Survey Team

Figure 8.4.2 Proposed Improvement Plan at Koteshwor Intersection

(2) Bus Bay Layout

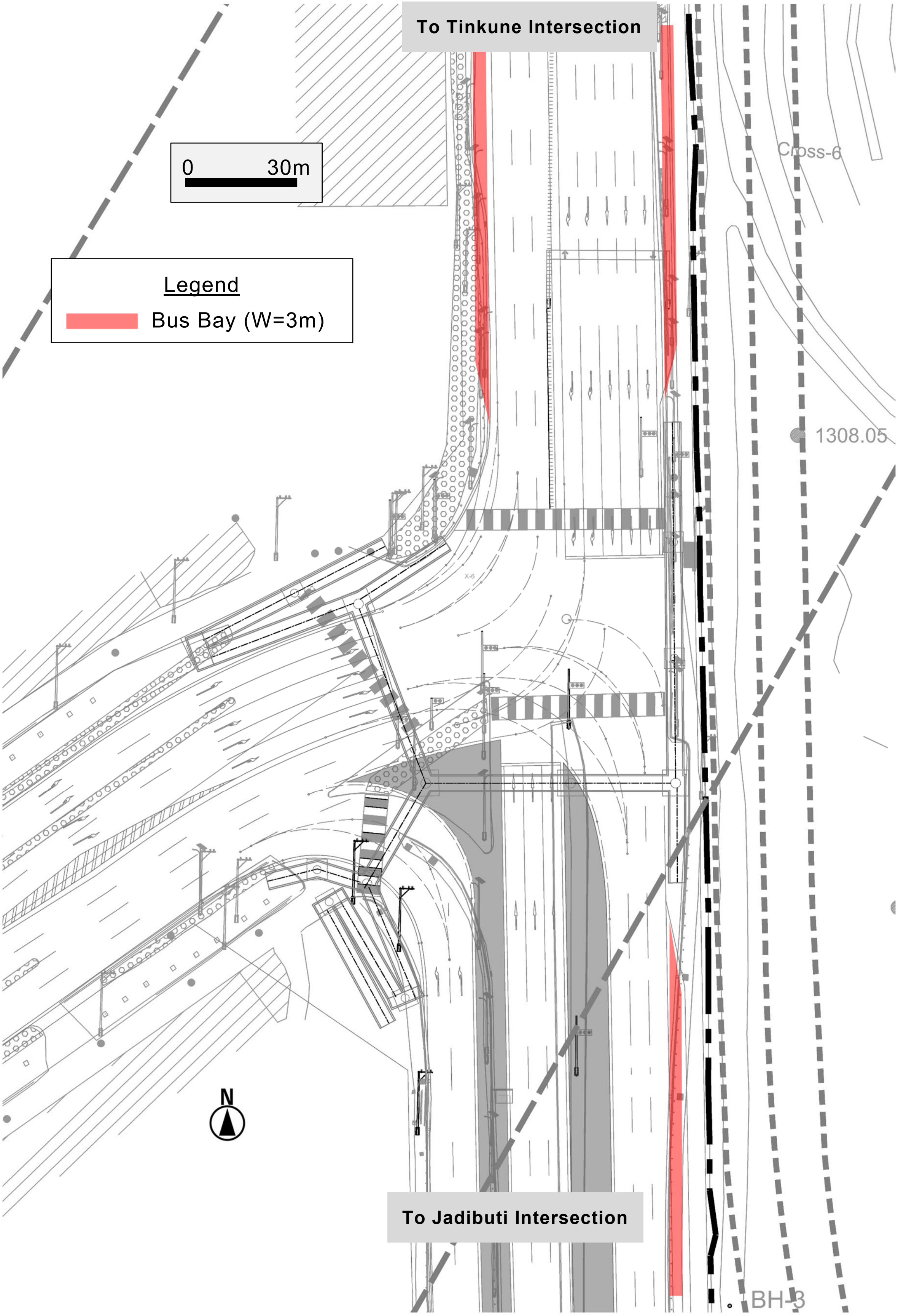
The existing bus bays are located in the center of the intersection, as shown in Figure 8.4.3. This placement results in buses obstructing the AG road, leading to occasional double-lined parking and traffic congestion at the intersection.



Source; JICA Survey Team

Figure 8.4.3 Current Bus Bays

Considering both securing current useability and mitigating traffic congestion, a new proposed bus bay layout is presented in Figure 8.4.4. This layout positions the bus bays separately to prevent buses from stopping within the intersection. The specific location of these bus bays should be thoroughly discussed among relevant organizations, including the DOR, traffic police, and bus operators, during the detailed design stage.

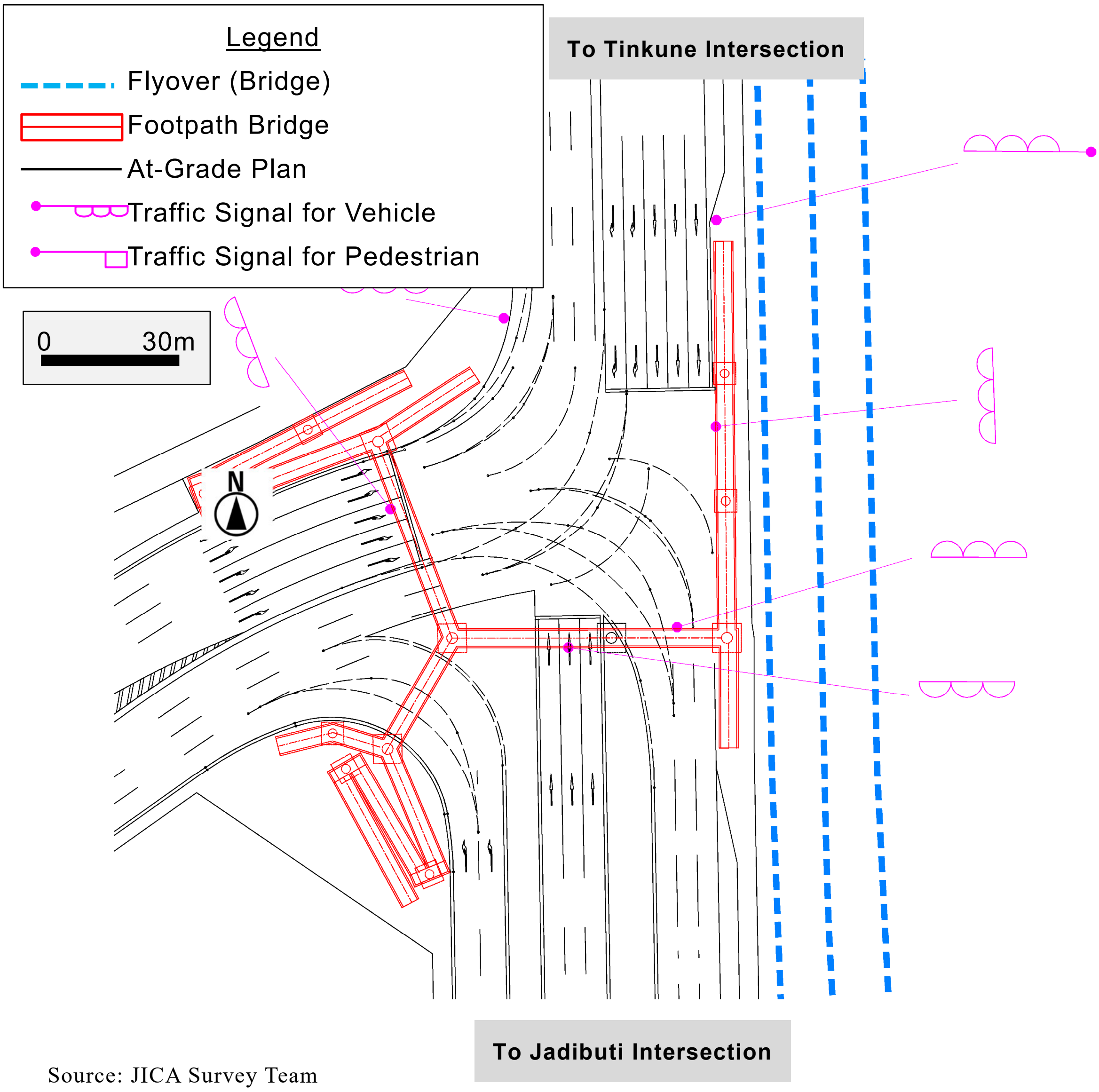


Source: JICA Survey Team

Figure 8.4.4 Proposed Bus Bay Layout at Koteshwor Intersection

(3) Traffic Signal Layout

Figure 8.4.5 presents the proposed traffic signal layout at the Koteshwor Intersection.



Source: JICA Survey Team

Figure 8.4.5 Proposed Traffic Signal Layout at Koteshwor Intersection

8.4.2 Available Land for Improvement

According to the land availability for the project, as mentioned in Chapter 6 and 7, the Koteshwor Intersection shall be designed as large as possible in its capacity within available lands, which are 25 m away from the center of the Araniko Highway to both sides on the Connecting Road section. The existing fences installed at present almost indicate the border of land available for the project, as shown in Figure 8.4.6.

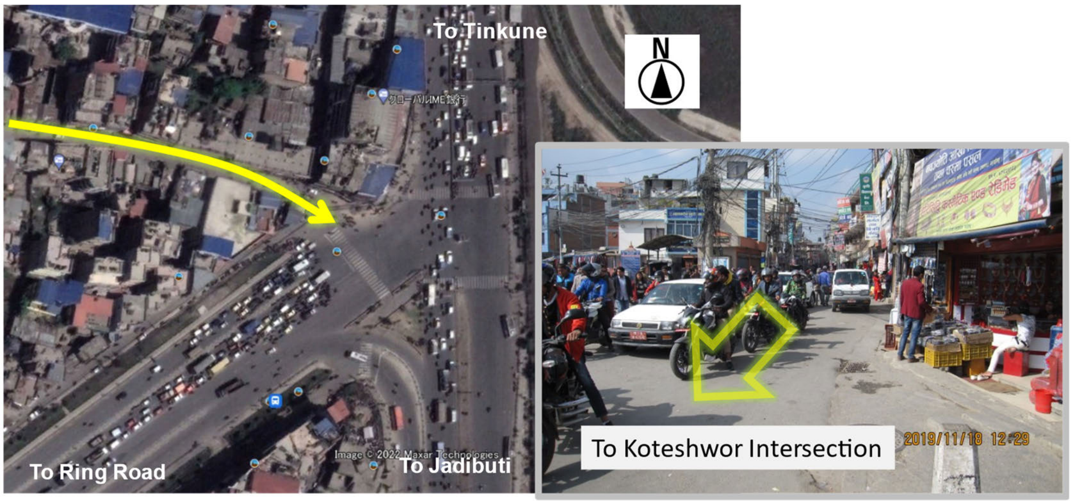
Source: JICA Survey Team

Figure 8.4.6 Existing Fence

8.4.3 Traffic Operation Plan

(1) Traffic Control of Residential Road

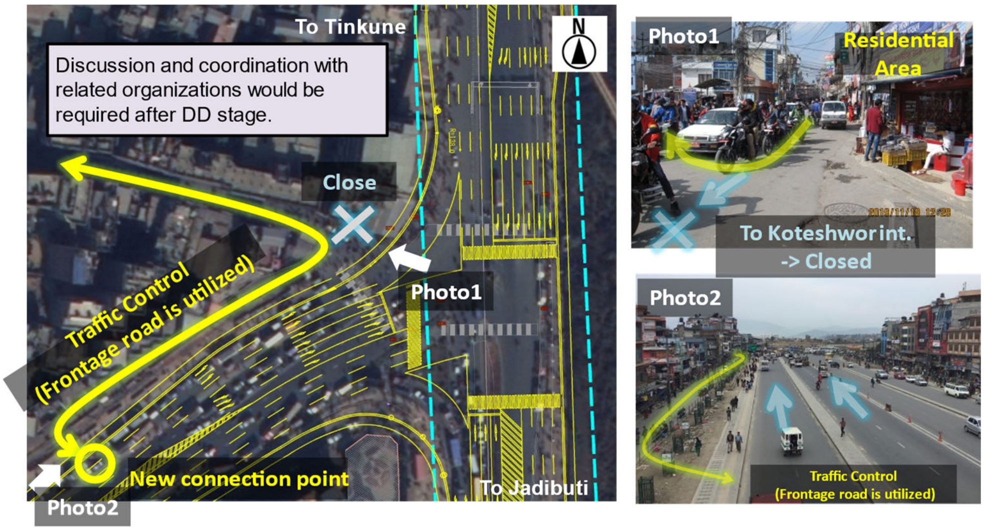
By observation, a residential road connecting with Koteshwor Intersection, as shown in Figure 8.4.7, results to further traffic congestion within the intersection. It is a bottleneck of smooth traffic flow from the viewpoint of traffic safety.



Source: JICA Survey Team

Figure 8.4.7 Current Situation of Connecting of a Residential Road

If the road is directly connected to the Koteshwor Intersection, it would result in a traffic demand that exceeds the capacity of the intersection since the green time for the main is reduced when assigning green time for the minor road. The proposal to close the current direct access to the intersection and reroute the traffic to the existing frontage road of RR South, as illustrated in Figure 8.4.8, aims to maximize the capacity of the intersection. The application of this operation needs to be studied and discussed with the related organizations/communities during the detailed design stage.

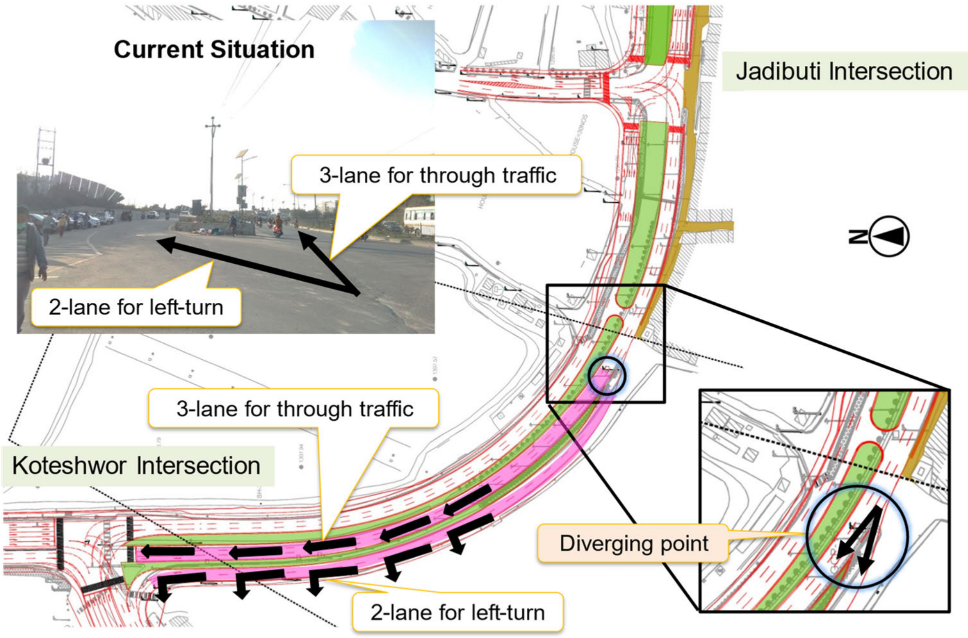


Source: JICA Survey Team

Figure 8.4.8 Proposed Traffic Operation

(2) Exclusive Left-Turn Lane for Traffic on the Road Section from the Jadibuti IS

Similar to the current traffic operation along the road section between Jadibuti Intersection and Koteshwor Intersection, dedicated left-turn lanes will be provided at the Koteshwor Intersection, as illustrated in Figure 8.4.9.



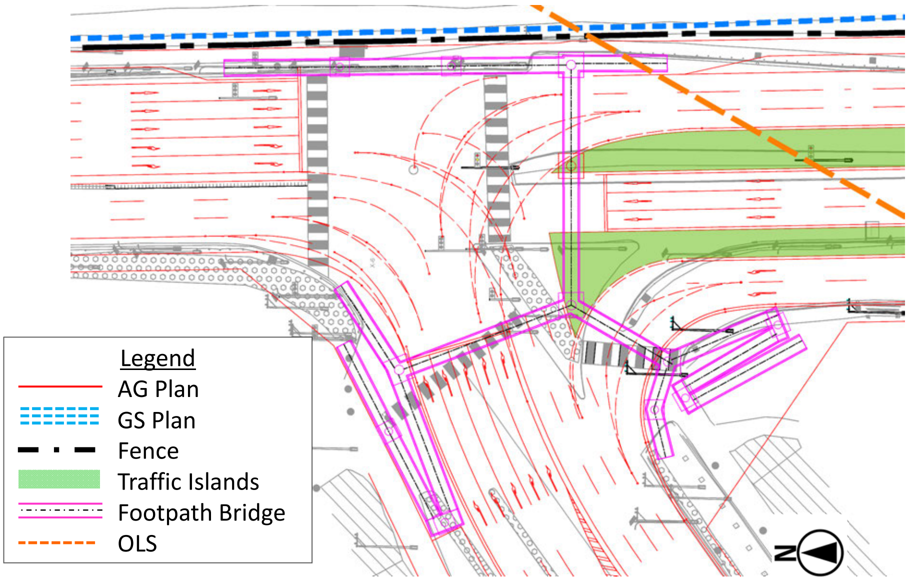
Source: JICA Survey Team

Figure 8.4.9 Proposed Exclusive Left-Turn Lane

(3) Pedestrian Operation

A line of an OLS passes slightly outside the intersection, as shown in Figure 8.4.10. Installation of a footpath bridge is proposed at the preliminary design stage to ensure safe crossing of pedestrians and to prevent conflicts between vehicles and pedestrians at the intersection.

However, further discussion will be necessary to determine its necessity during the detailed design stage and if required, approval from CAAN is needed.



Source: JICA Survey Team

Figure 8.4.10 Obstacle Limitation Space at the Koteshwor Intersection

To accommodate transportation-disadvantaged individuals, a slope with 12% grade, as shown Figure 8.4.11, will be provided in addition to the steps.

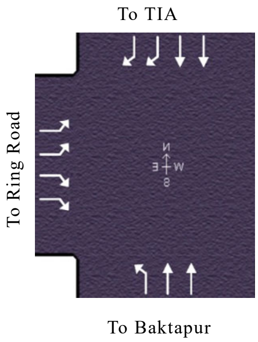
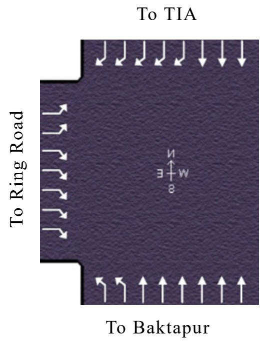
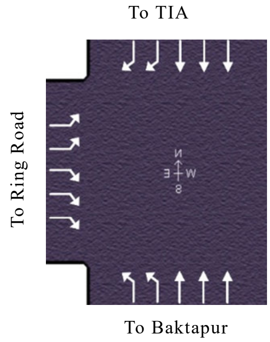
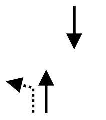
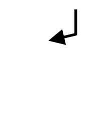
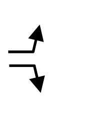
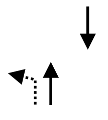
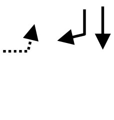
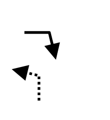
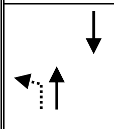
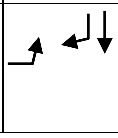
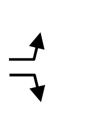
Source: JICA Survey Team

Figure 8.4.11 Image of Footpath Bridge

8.4.4 Level of Service

Table 8.4.1 shows the Level of Service (LOS) of the Koteshwor Intersection according to its current status. Despite the land constraints mentioned earlier resulting in a LOS of F, the intersection’s improvement within the project is expected to reduce approximately 50% of the control delay, comparable to the waiting time at the entry lane.

Table 8.4.1 Level of Service of Koteshwor Intersection

Status	Existing (As of 2020)			Required (LOS: D or above)			**Outline Design (Applied)**		
Entry Lane Layout									
Phasing	1	2	3	1	2	3	1	2	3
→ Controlled ⋯→ Free									
Control Delay	650 sec / veh			36 sec / veh			**347 sec / veh**		
LOS	F			D			**F**		

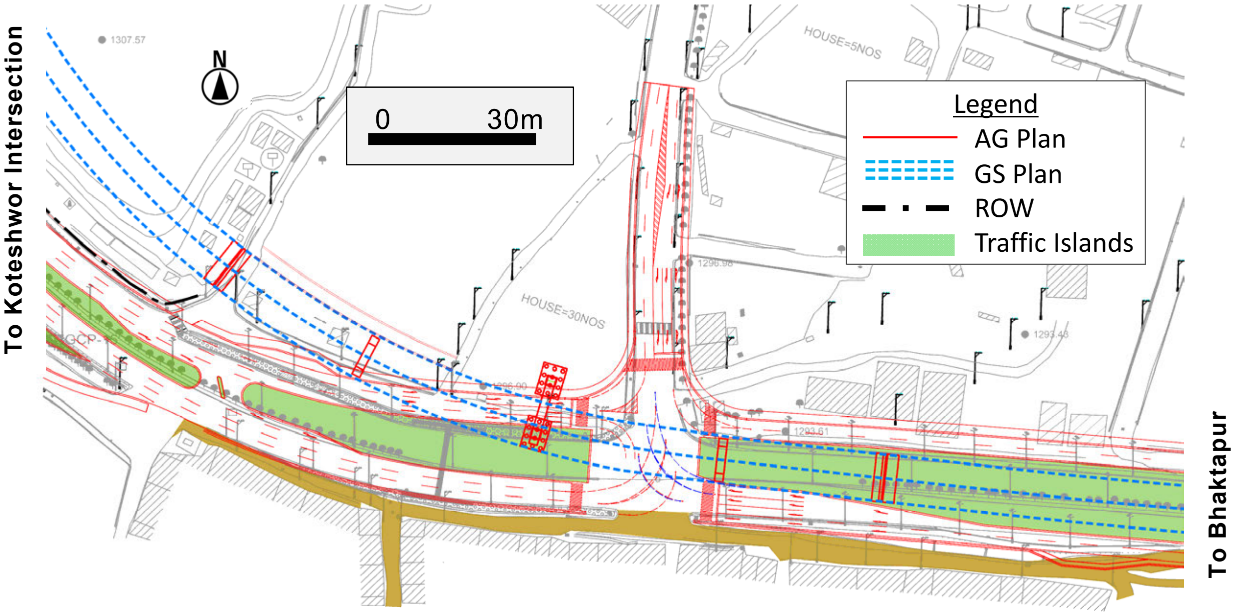
8.5 Outline Design of Jadibuti Intersection

8.5.1 Improvement Plan

(1) Plan

Following the improvement policy mentioned in Chapter 7, the lane layout at the intersection is planned. Entry lanes from the Koteshwor Intersection side are the main focus, including the alignment of the existing Manohara outer bridges that must not be affected. In addition, since the direct connection option of the GS road is selected, spaces for a pier and an abutment of the FO structures are required.

Considering such requirements, Figure 8.5.1 presents the improvement plan at the AG portion for the Jadibuti Intersection.

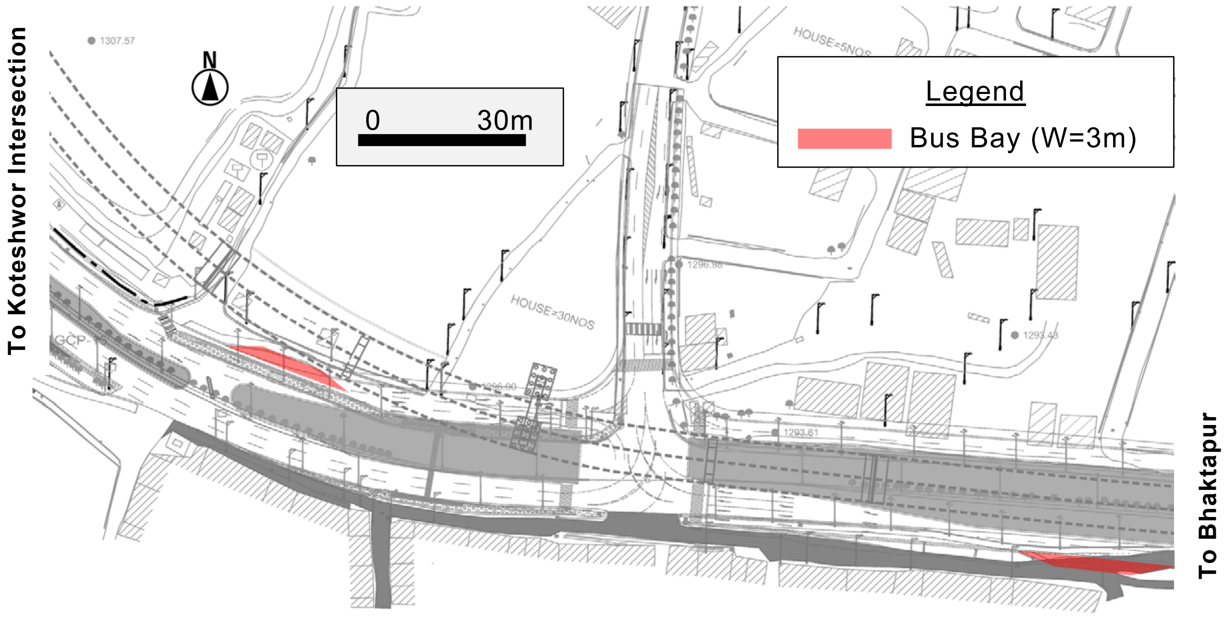


Source: JICA Survey Team

Figure 8.5.1 Proposed Improvement Plan of Jadibuti Intersection

(2) Bus Bay Layout

Figure 8.5.2 presents the proposed bus bays.

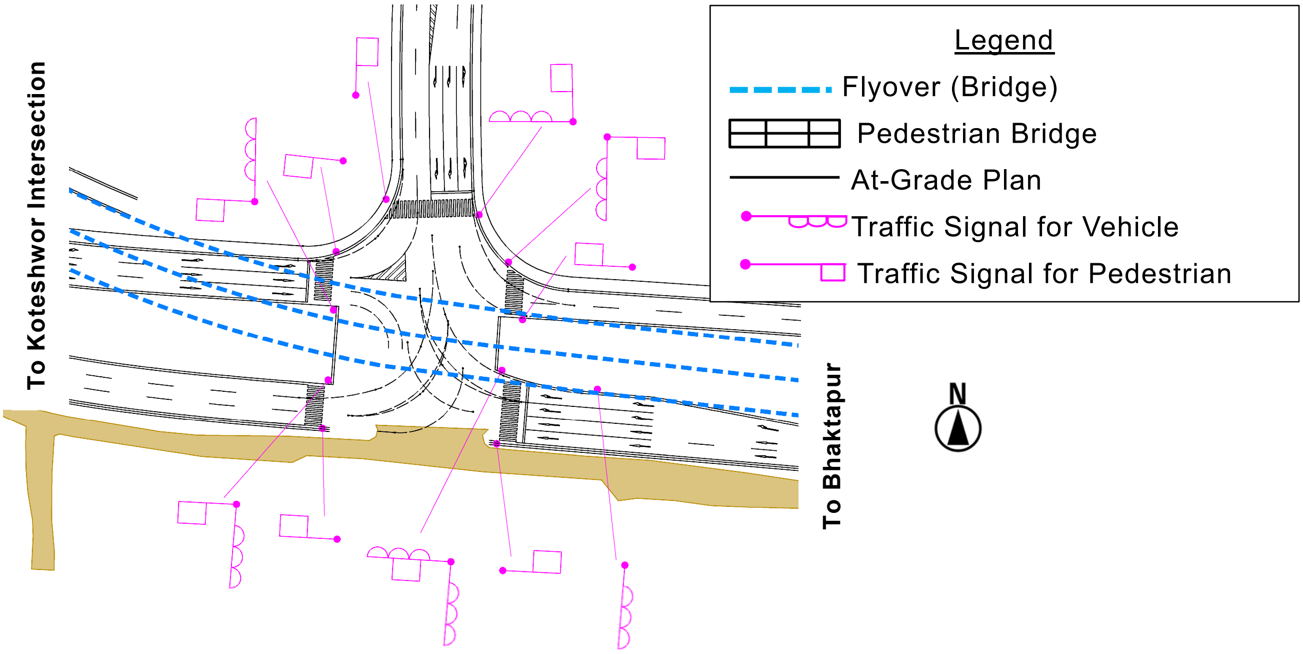


Source: JICA Survey Team

Figure 8.5.2 Proposed Bus Bay Layout at Jadibuti Intersection

(3) Traffic Signal Layout

Figure 8.5.3 shows the proposed traffic signal layout at Jadibuti Intersection.



Source: JICA Survey Team

Figure 8.5.3 Proposed Traffic Signal Layout at Jadibuti Intersection

8.5.2 Design Concepts for Improvement

(1) Design Concept: Minimum Impact on the Existing Frontage Road and Buildings

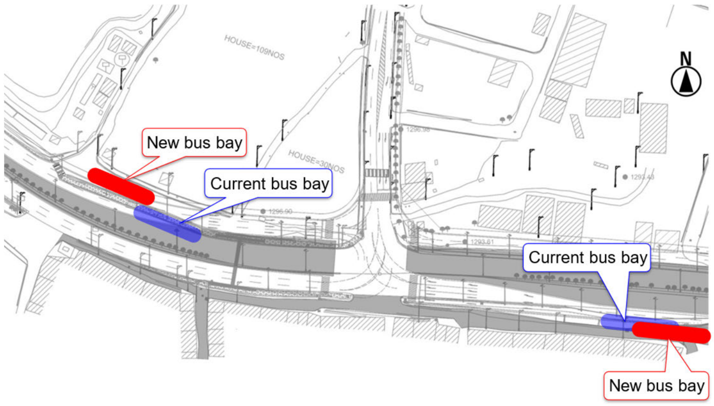
The design concept incorporated minimizing the impacts on the existing buildings and frontage road to the south of the intersection, as illustrated in Figure 8.5.4

Source: JICA Survey Team

Figure 8.5.4 Present Conditions of the Existing Frontage Road and Buildings

(2) Relocation of Bus Bays

Bus bays shall be relocated at the locations nearby the current ones, as shown in Figure 8.5.5.



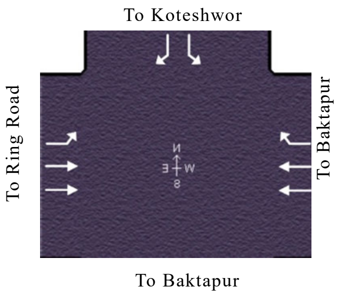
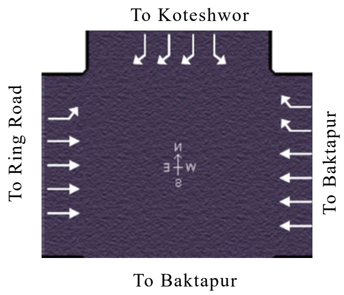
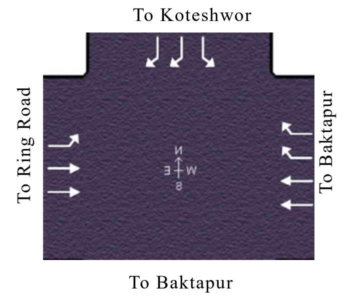
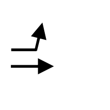
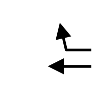
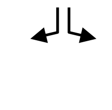
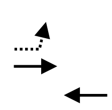
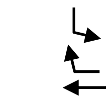
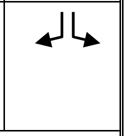
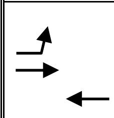
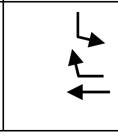
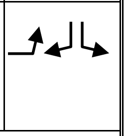
Source: JICA Survey Team

Figure 8.5.5 Relocation of Bus Bays

8.5.3 Level of Service

Table 8.5.1 shows the Level of Service (LOS) of the Jadibuti Intersection according to its current status. Despite the land constraints mentioned earlier in a LOS of F, the intersection improvement within the project is expected to reduce approximately 60% of the control delay, comparable to the waiting time at the entry lane.

Table 8.5.1 Level of Service of Jadibuti Intersection

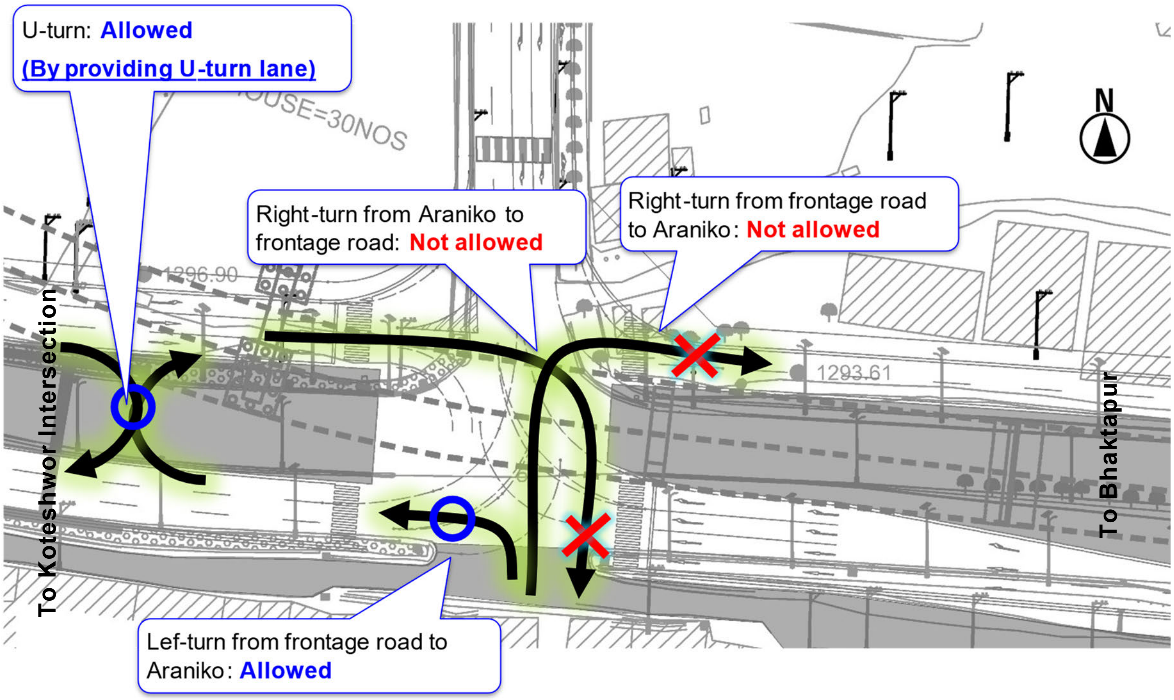
Status	Existing (As of 2020)			Required (LOS : D or above)			**Outline Design (Applied)**		
Entry Lane Layout									
Phasing	1	2	3	1	2	3	1	2	3
Controlled Free									
Control Delay	577 sec / veh			36 sec / veh			**223 sec / veh**		
LOS	F			D			**F**		

Source: JICA Survey Team

8.5.4 Traffic Operation Plan

(1) Traffic Control of Frontage Road

Considering traffic safety and the intersection capacity, it is recommended to apply the following traffic control/operation shown in Figure 8.5.6 to avoid traffic accidents between vehicles or vehicles and pedestrians.



Source: JICA Survey Team

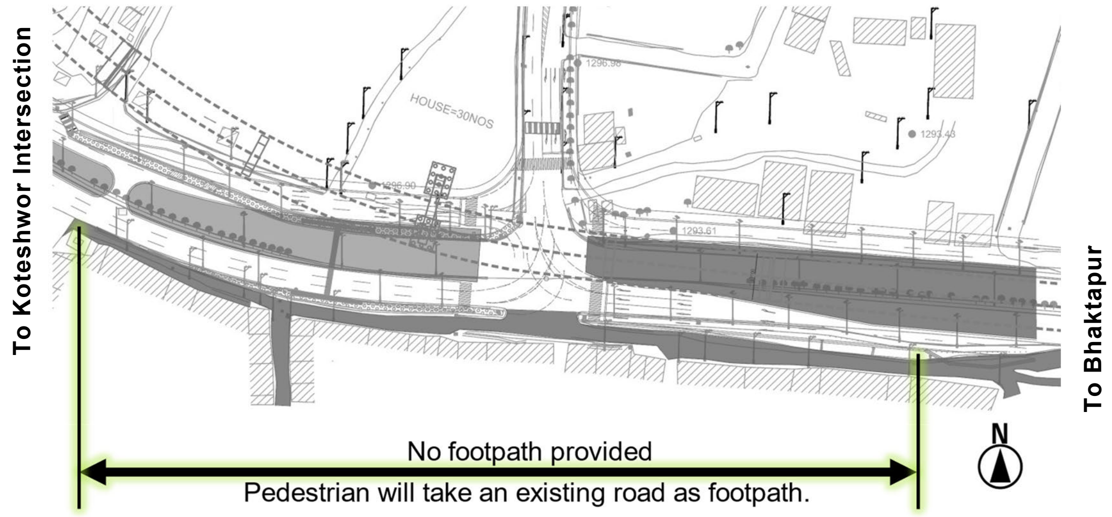
Figure 8.5.6 Proposed Traffic Control

(2) Pedestrian Operation

Footpath bridges will not be required at the intersection for the following reasons:

- There is a flyover structure for the GS road across the intersection (no physical conflict will occur).
- Pedestrians can cross the AG roads safely with the installation of traffic signals.

Since the existing frontage road at the south of the intersection is almost not affected by the project facilities, the road can be utilized as a footpath as it is. Therefore, the footpath will not be provided south of the intersection, as indicated in Figure 8.5.7.



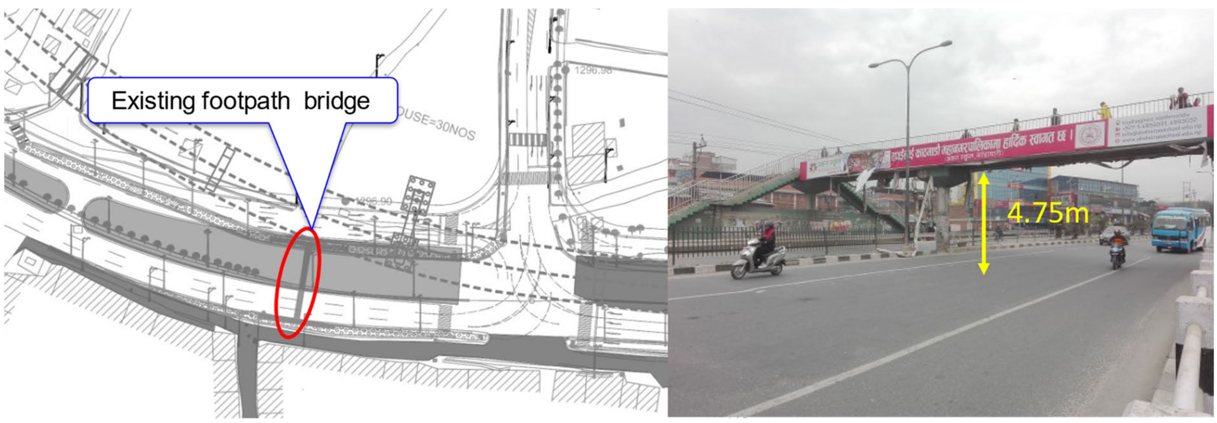
Source: JICA Survey Team

Figure 8.5.7 Proposed Pedestrian Control

8.5.5 Removal of Existing Footpath Bridge

The existing footpath bridge will be removed due to its current overhead clearance (4.75 m) falling short of the minimum requirement (5 m) specified in the Nepal Standards, as shown in Figure 8.5.8. Furthermore, the bridge cannot accommodate the new width of the project roads at this location.

Additionally, the GS facility improvements (highlighted in dark color) created new traffic islands. These islands can be utilized by pedestrians who need to wait for a signal change, ensuring the safe crossing to the project roads. The pedestrian operation facilities, including the required area of traffic island in the road center, will be determined through discussions based on a pedestrian survey at the intersection during the detailed design stage involving relevant organizations such as the DOR, traffic police, and nearby residents.



Source: JICA Survey Team

Figure 8.5.8 Existing Footpath Bridge

8.5.6 Control Rooms for Tunnel Emergency Facilities

Control rooms for tunnel emergency facilities will be provided to utilize the space under the flyover structures. Access to the rooms will be secured by the box culvert, as shown in Section 8.2.7 (1).

Chapter 10 discusses a more detailed plan for the tunnel emergency facilities.