CHAPTER 5

EXISTING CONDITION SURVEY

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EXISTING CONDITION SURVEY

5.1 INTRODUCTION

The urban expressway will act as a component of the existing road network and it will not function alone. Therefore, data of ordinary at-grade road network is indispensable when an urban expressway network is formulated. To obtain such data, existing condition survey is implemented. The survey takes into consideration three main existing conditions which are:

- Existing road conditions by undertaken Road Inventory Surveys.
- Existing soil conditions by undertaking Geotechnical Investigations.
- Existing geometric conditions by undertaking Topographical Surveys.

The scope of this Study includes carrying out Feasibility Study for the Expressway Sections E1-2, E2-2 and E3-1 and Pre-Feasibility Study for Sections E1-1, E2-1, E3-2 and E3-3. Theses sections which belong to Expressways E1 (6^{th} of October), E2 (15^{th} of May) and E3 (Autostrad/Salah Salem) are shown in Figure 5.1-1.

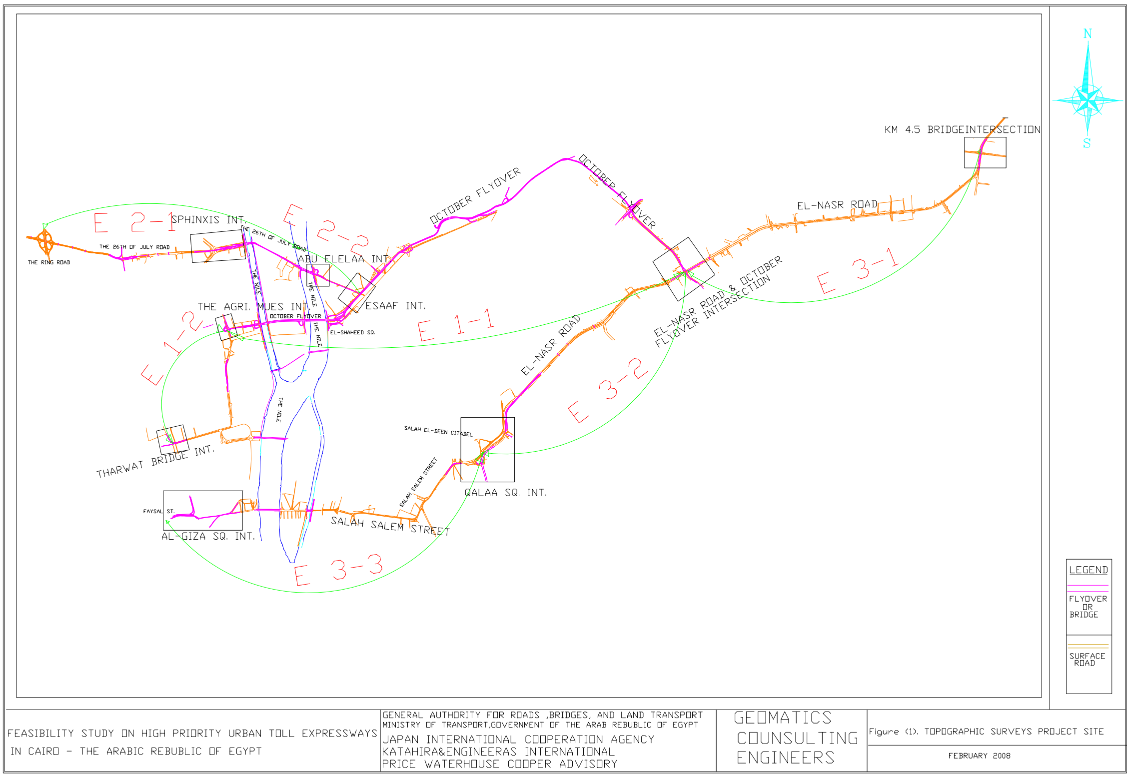


Figure 5.1-1 Expressways under Study

Hereafter and based on the scope of the Study, the objectives, terms of references, tasks and results are described.

5.2 ROAD INVENTORY SURVEY

5.2.1 Adopted Method for Data Collection

The survey covered the following tasks:

1. Topographic Survey for profiles and cross sections at every 200 m and where the layout changes along the existing routes of E1 and E2, as well as the proposed routes E1-2, E2-2, and E3-1 which are under the feasibility study. For the future proposed routes of E3-2 and E3-3, which are under the pre-feasibility study, such inventory data are collected at every 400 m along the route and where layout changes. Land use plans are produced with 1/2,000 scale. Hard and soft copies in AUTOCAD format are delivered.
2. Land Use Survey
3. Pavement Assessment survey

5.2.2 Objective of the Road Inventory Survey

The main objective of the road inventory surveys is to prepare and provide technical information needed to perform the required feasibility study for different components of the project.

5.2.3 The Study Area

The Study covered high priority routes shown in Figure 5.1-1. They include the routes of the following roads segments:

E2-1 and E2-2 (along the 26 of July Road from Esaaf Intersection to the Ring Road Intersection).

E1-1 and E1-2 (along October Flyover from El-Nasr Road Intersection to the Agriculture Museum Intersection, then along the Dokki Street to its intersection with Tharwat Street and along Tharwat Street to Tharwat Bridge).

E3-1, E3-2 and E3-3 (along El-Nasr Road to the Citadel Square, then along Salah Salem street to El-Malek El-saleh Street, and along El-Rawda Street up to Al-Ahram Street).

5.2.4 Performed Road Inventory Survey Activities

To achieve the main objectives of the project, the following tasks have been performed.

(1) Data Collection and Assessment:

Available topographic maps, mainly the 1:5,000 digital topographic maps covering the project area have been collected by the Local Consultant. In addition, the high resolution satellite imageries taken in 2006 are provided to the Local Consultant by the JICA Study Team.

This information has been assessed and their suitability for the project has been evaluated.

Topographic Surveying information and plans prepared in the Topographic Surveys phase of the project were also collected and used.

(2) Reconnaissance Survey

Reconnaissance survey was carried out in order to identify locations and extensions of the different routes included within the study area. This survey was carried out with the aid of updated topographic maps and geo-referenced satellite images.

Performing reconnaissance survey was also very important in the determination of the proper methodology and tools to be implemented.

(3) Field Works and Preparation of Land Use Maps

The 1/2,000 scale topographic plans, prepared by updating available 1/5,000 topographic maps from the QuickBird satellite imageries taken in 2006, were used as base maps for the preparation of the land use plans along the expressway routes included in the Study.

Field survey works were performed in order to define the land use pattern and the number of floors for each individual building along the expressway routes.

Sixteen (16) land use categories were identified and each individual building along the expressway route was classified and assigned to a certain land use category and then identified by a special color on the prepared land use plans.

These land use categories are:

1. Military,
2. Stores,
3. Sport Clubs,

4. Companies & Banks,
5. Hospitals,
6. Hotels & Markets,
7. Residential,
8. Universities,
9. Schools,
10. Government,
11. Mosques,
12. Churches,
13. Cemetery,
14. Parking,
15. Green Area, and
16. Embassy

AutoCAD 2000 was used to process the field works data and to prepare land use plans. Figure 5.2-1 shows an example of the prepared (61) land use plans.

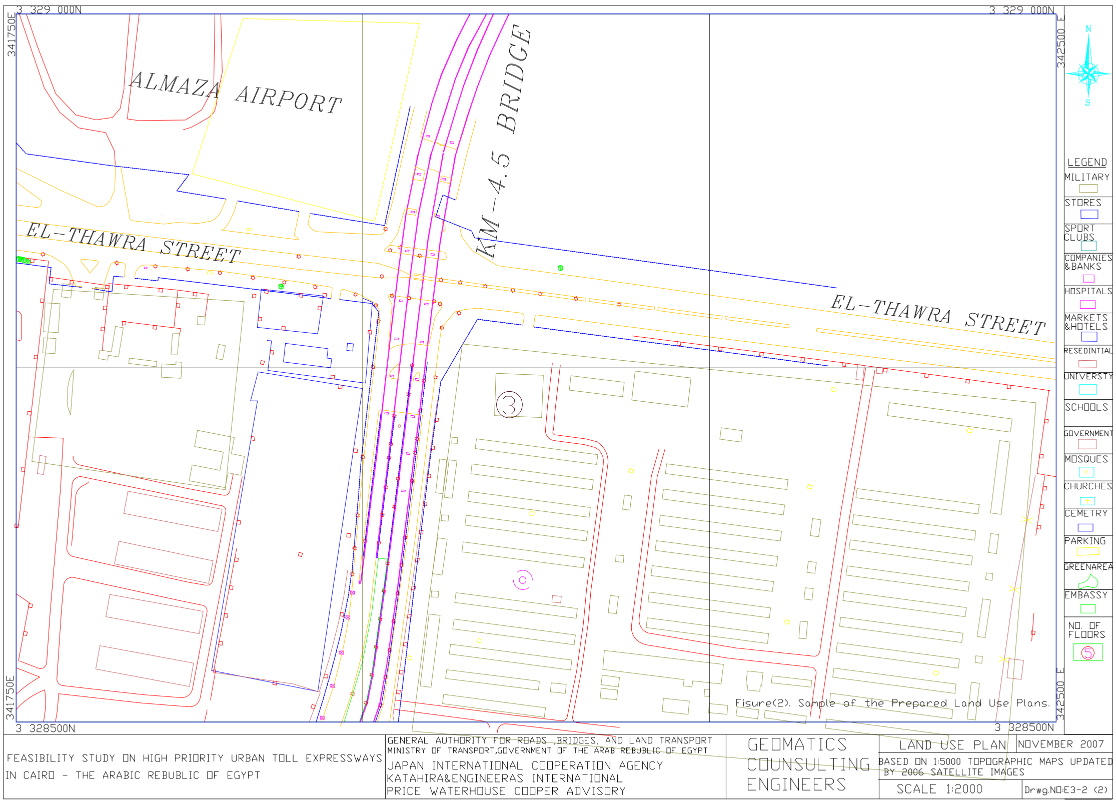


Figure 5.2-1 Sample of the Prepared Land Use Plans

(4) Surveying Field Works and Preparation of Profiles and Cross Sections

Surveying field works were conducted to measure levels and locations of points spaced at

50m distance along center lines of flyovers and roads in the project area.

Total Stations have been used to measure locations and levels of profile points in routes where inter-visibility, between the instrument and target prisms, did exist. Dual frequency Global Positioning Systems (GPS) Receivers were used to supplement Total Stations in very congested segments along the roads corridors.

A set of surveying equipments were used to perform the required field surveying works that include:

- 3 Topcon Total stations 702, 235 and 6002C
- 2 Dual frequency GPS receiver Lieca 300
- 2 Magellan GPS Navigators
- 3 Radio Sets

(5) Preparation of the Profiles and Cross Sections

AutoCAD 2006 and Civil Map software packages were used for processing surveying measurements and for the preparation of the profiles and cross sections. Profiles were produced for the following Roads:

E1-1 and E1-2
E2-1 and E2-2
E3-1, E3-2, and E3-3

Ground Surface profiles were prepared from available elevations data for the following routes:

- Route below October Flyover (Road E1-1),
- Routes below the Flyover Part of Roads E2-1 and E2-2
- Cross sections have been prepared, at 200 m intervals along centerline, for roads E1-1, E2-1, E2-2 and E3-3
- Cross sections, at 400 m interval along center line, were prepared for Roads E3-1 and E3-2

(6) Field Works and Preparation of the Pavement Assessment Report

Roads in the study area were divided into sections and visual inspection of pavement conditions were carried out along these roads. The Pavement Rating method was used to classify pavements conditions in these road sections. Three pavement classes were defined and used to describe pavement conditions in roads within the study area. These pavement categories are: Good Pavement with rating (90-100), Fair Pavements with rating (75-90) and Poor Pavement with rating less than 75.

A Pavement Assessment Report was prepared which contains tables of the assessment results in addition to a number of colored photos show some examples of the pavement conditions.

5.2.5 Results

The following road inventory surveys information was prepared, both in digital and in hard copy (colored copy).

a- Land Use Plans in scale 1:2,000 (61- Sheets- in A3-size).

b- Pavement Assessment Report

c- Plan, Profile and Cross-Sections for the following roads:

1. Existing E1-1 (from El-Nasr Road Intersection to the Agricultural Museum Intersection).
2. Existing E2-1 and E2-2 (from Esaaf Intersection to the Ring Road Intersection).
3. E3-1, E3-2, and E3-3 (from Km 4.5 at Cairo-Suez Road (Flyover Intersection) to Giza Square Intersection).

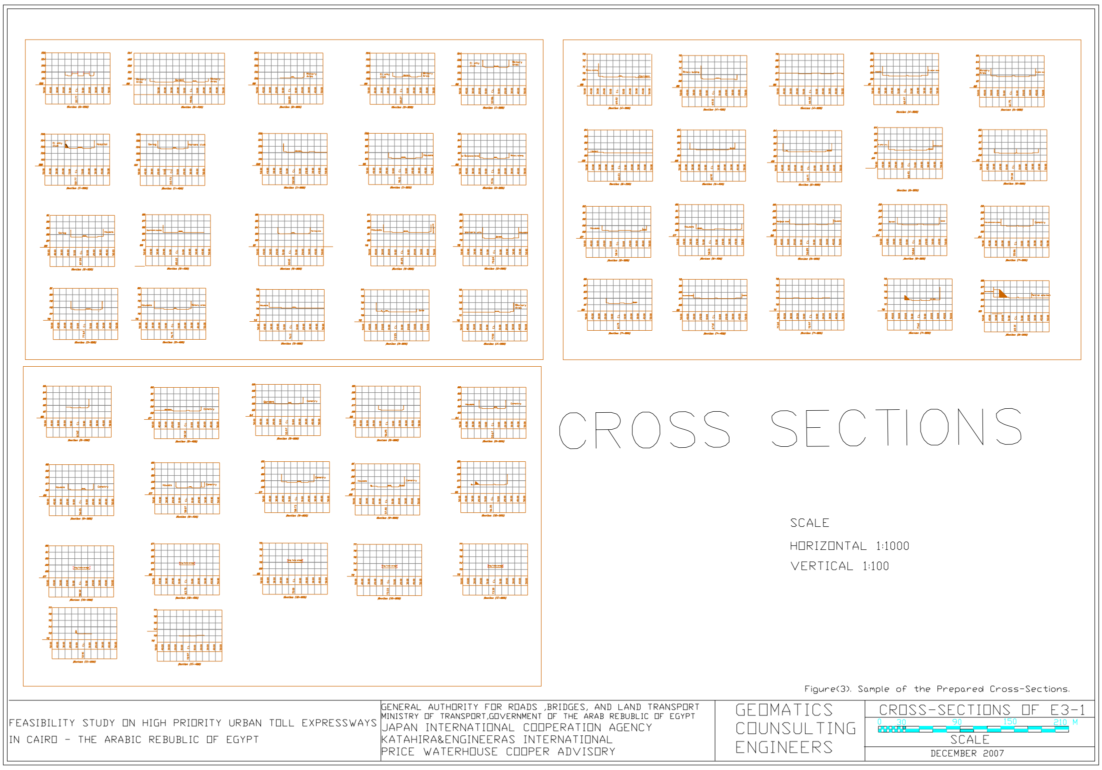


Figure 5.2-2 Sample of the Prepared Road Cross-Sections

d- Plans and Profiles for the Ground levels along the routes of the following roads:

1. Existing E1-1 and E1-2 (from El-Nasr Road Intersection to Tharwat Bridge Intersection), and
2. Existing E2-1 and E2-2 (from Esaaf Intersection to Sphinx Intersection).

Figure 5.2-2 shows an example of the prepared road cross-sections.

The data collected through the road inventory survey have been consisted for check-ups of at-grade street cross-sections produced from satellite imagery, road facilities and structures, pavement conditions, elevations, etc., and outputs include:

1. The Profile and Cross Sections of Road E3-1
2. The Profile and Cross Sections of Road E3-2
3. The Profile and Cross Sections of Road E3-3
4. The Amended Profile for Road E3-3
5. The Profile and Cross Sections of Road E1-1
6. The Profile and Cross Sections of Roads E2-1 and E2-2
7. Ground-Surface Profile for E1-1 and E1-2
8. Ground-Surface Profile for E2-1 and E2-2
9. The Pavement Assessment Survey Report for Roads (E1-1, E1-2, E2-1, E2-2, E3-1, E3-2, and E3-3)
10. The Land-Use Plans along the Roads (E1-1.E1-2, E2-1, E2-2, E3-1, E3-2, and E3-3), (61-Plans). In case of residential areas, the number of building floors are surveyed and shown in drawings since such data will be required during the social environmental assessment of the project. The existing facilities and utilities are also surveyed and assigned on plans. The data about the existing facilities and utilities will be required in case of needs for utility relocation

These data are prepared in both hard copy and in digital forms.

5.3 TOPOGRAPHICAL SURVEY

5.3.1 Adopted Method for Data Collection

The topographical survey is undertaken to update the 1/5,000 topographical maps by utilizing QuickBird satellite imageries taken in 2006 to produce updated topographical plans in 1/2,000 scale.

5.3.2 Objective of the Topographic Survey

The main objective of the topographic surveying is to prepare and provide topographic information needed to perform Road Inventory Surveys and to conduct the required feasibility study for different components of the Study.

5.3.3 The Study Area

The Study covered high priority expressway routes shown in Figure 5.1-1. They include the routes of the following roads segments:

E2-1 and E2-2 (along the 26 of July Road from Esaaf Intersection to the Ring Road Intersection).

E1-1 and E1-2 (along 6th of October Flyover from El-Nasr Road Intersection to the Agriculture Museum Intersection, then along the Dokki Street to its intersection with Tharwat Street and along Tharwat Street to Tharwat Bridge). However, additional route alignment for E1-2 was surveyed in the direction from Agriculture Museum through Shooting Club, Gadh Street to Sudan Street to cover the new proposed Shield Tunnel alignment for E1-2.

E3-1, E3-2 and E3-3 (along El-Nasr Road to the Citadel Square, then along Salah Salem street to El-Malek El-saleh Street, and along El-Rawda Street up to Al-Ahram Street).

5.3.4 Performed Topographic Survey Activities

To achieve the main objectives of the project, the following tasks have been performed.

(1) Data Collection and Assessment

Available topographic maps, mainly the 1:5,000 digital topographic maps covering the project area in addition to the 2006 high resolution Satellite images have been obtained with the aid of JICA Study Team.

This information has been assessed and their suitability for the project has been evaluated.

(2) Reconnaissance Survey

Reconnaissance survey was carried out in order to identify locations and extensions of the different routes and intersections included within the project area. This survey was carried out with the aid of available topographic maps and satellite images. Also, another purpose for the reconnaissance survey was to identify and locate areas where updating for the topographic maps are needed.

Performing reconnaissance survey was also very important in the determination of the proper methodology and tools to be implemented in the topographic survey.

(3) Updating Available Topographic Maps

The available 1:5,000 topographic maps were produced from aerial photographs with 1:20,000 scales in August 1993.

Since that date several of developments have taken place in the project area, in general, and for the routes of the roads included in the project in particular.

So, it was of great importance to update those maps, along the interested routes, by utilizing, relatively, recently acquired high resolution Satellite Images. The 2006 high resolution satellite images acquired by the Quick-bird Satellite System were used to update the 1:5,000 digital topographic maps.

The satellite images were geometrically rectified in order to conform geometrically to the projection system of the 1:5,000 topographic maps.

New developments along the corridors of the specified routes, then, been added, on the screen, to the digital maps.

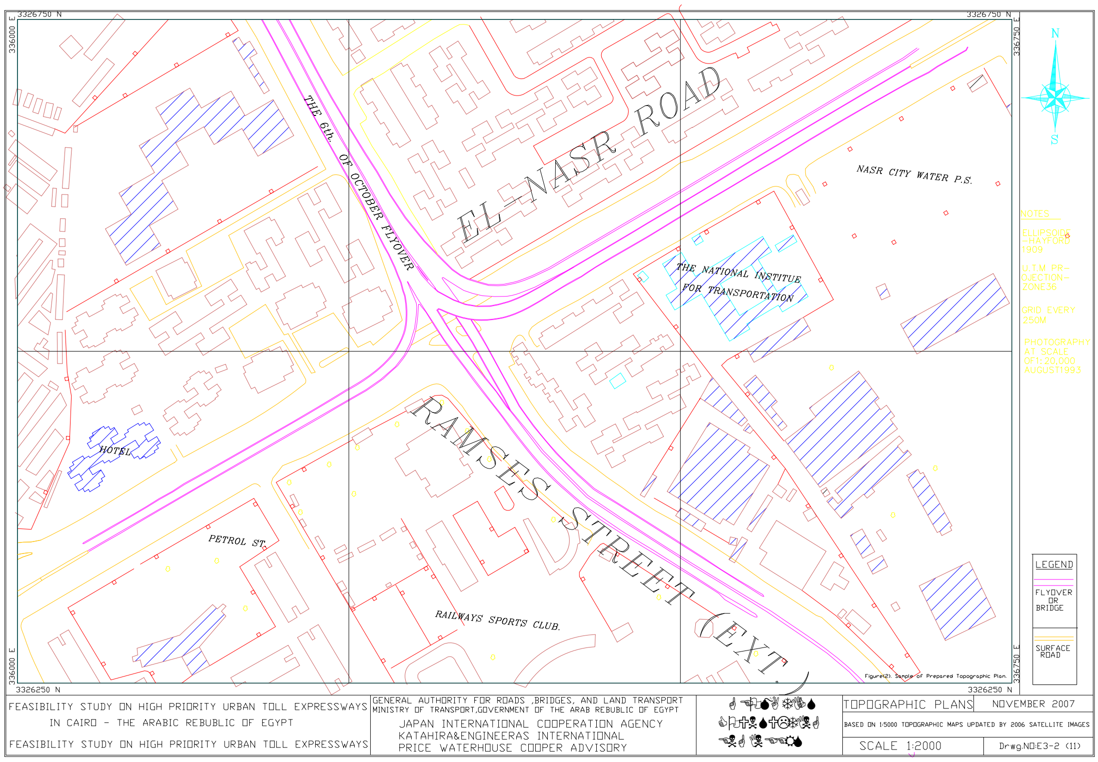


Figure 5.3-1 Sample of the Prepared Topographic Plans

Updated plans with a scale of 1:2,000 were prepared for the corridors of the routes included in the project. A sample of these plans is shown in Figure 5.3-1.

(4) Surveying for Layout Mapping

Field topographic and land surveying was conducted to prepare 1:1,000 scale topographic plans (layouts) for some specified intersections within the project area.

A set of surveying equipments were used to perform the required field surveying works include.

- 3 Topcon Total stations 702, 235 and 6002C
- 2 Dual frequency GPS receiver Lieca 300
- 2 Magellan GPS Navigators.
- 3 Radio sets

(5) Methodology of Topographic and Land Surveying

All topographic features existing in the intersection were surveyed by determining the three-dimensional co-ordinates of each individual features by Total Stations. Dual frequency GPS receivers were used in very congested areas, where inter-visibility between Total Station and Target Prisms is impossible.

These features include, but not limited to, flyovers, bridges, streets edges, kerbs, property lines and on-surface utility networks.

(6) Preparation of the Topographic Plans

AutoCAD-2006 and Civil Map software packages were used for processing surveying measurements and for the preparation of the topographic plans.

For the Updated Topographic maps, 61 updated plans with 1:2,000 scales were produced.

For the Intersections, Topographic plans, showing all existed topographic features and spot elevations, with 1:1,000 scale were produced. A sample plan is show in Figure 5.3-2.

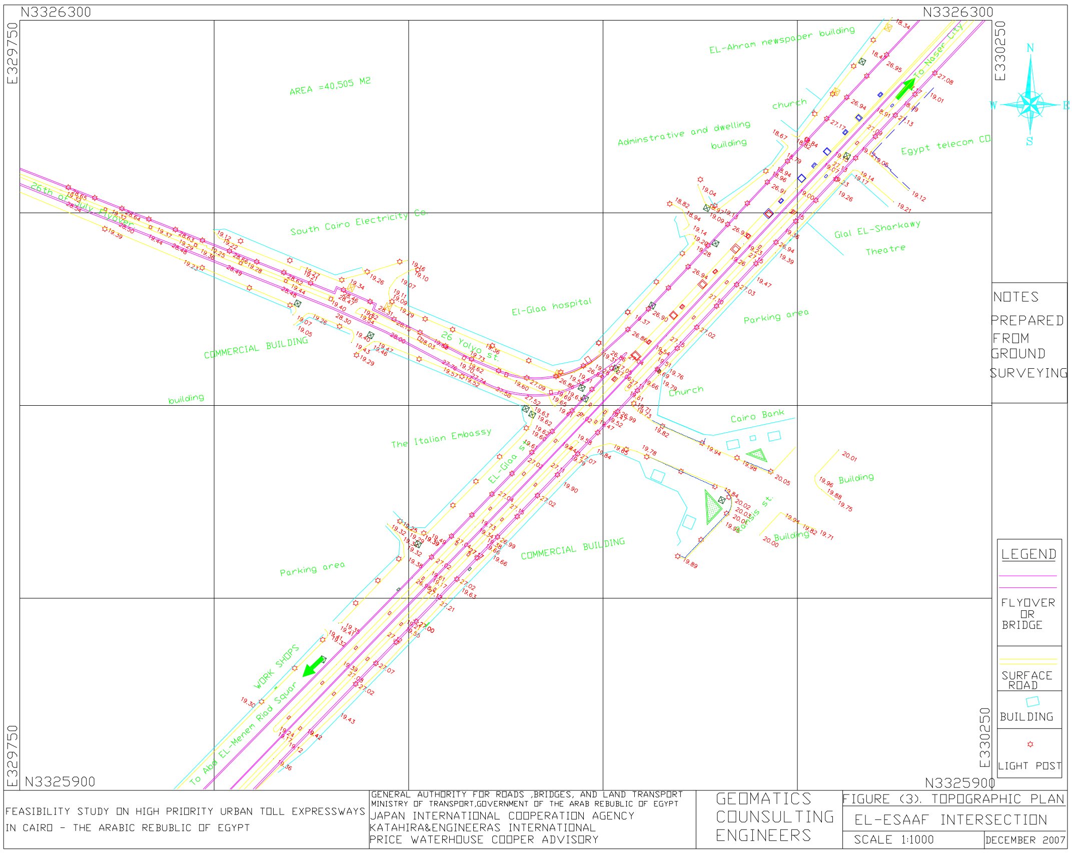


Figure 5.3-2 Sample of the Prepared Intersection Topographic Plans

5.3.5 Results

The following topographic surveying information was prepared, both in digital and in hard copy (colored copy), and submitted:

a- The Updated 1:2,000 scale topographic plans for the routes corridors (61- Sheets).

b- Topographic plans (layout) with scale of 1:1,000 for 9- Intersections which are:

1. Esaaf Intersection
2. Abu Elelaa Intersection
3. Sphinxix Intersection
4. Tharwat Bridge Intersection
5. The Agricultural Museum Intersection
6. Giza Square Intersection
7. Salah El-Deen Citadel Intersection
8. Km (4.5) Bridge Intersection, and
9. El-Nasr Road and October Flyover Intersection.

5.4 GEOTECHNICAL INVESTIGATIONS

5.4.1 Adopted Method for Data Collection

The geotechnical investigation implemented at 16 locations along the three expressways under this F/S and Pre-F/S. The investigations to be carried out by Egyptian local consultant under the supervision of the JICA Study Team include:

1- Boring Survey about 20 m depth
2- Standard Penetration Tests with rate one sample every 2 m
3- Laboratory and physical tests

The details of the investigations and outputs are presented in Table 5.4-1.

Table 5.4-1 Description of Soil Investigations

<table>
<tr><th colspan="2">Type</th><th colspan="2">Contents</th><th>Outputs</th></tr>
<tr><td colspan="2" rowspan="4">Boring Survey</td><td>- Section E1-2</td><td>- 20m x 3 locations</td><td rowspan="4">- Key Map for Drilling Points
- Soil Boring</td></tr>
<tr><td>- Section E2-2</td><td>- 20m x 3 locations</td></tr>
<tr><td>- Section E3-1</td><td>- 20m x 10 locations</td></tr>
<tr><td colspan="2">- 5m after confirming bearing layer (N-value is 30 or more)
- Boring Depth: 20m in average
- Other sections beside the above, existing data shall be utilized for determination of the conditions</td></tr>
<tr><td colspan="2">Std. Penetration Test</td><td colspan="2">- 1 sample/2m x 20m x 16 locations = 160 samples</td><td rowspan="2">- Summary Sheet for Laboratory Test, and Individual Data Sheets of Physical Test Results</td></tr>
<tr><td>Laboratory Test</td><td>Physical Test</td><td colspan="2">- Unit Volume Weight, Specific Gravity, Liquid Limit, Plastic Limit, Grading Distribution, and Moisture Content Tests</td></tr>
</table>

Source: JICA Study Team

5.4.2 Results

(1) Expressway Section E3-1

Permission to undertaking borings can not be obtained from the Governmental Authority along Al Nasr Road under the Scope of Works for F/S. To overcome this problem, three field borings are undertaken within the land adjacent to Al Nasr Road under the authority of Al Azhar Univeristy and GARBLT after the Study Team and Local Consultant can obtained the permision from those two Governmental Authorities. Two locations are located inside the boundary of Al-Azhr University (BH2 and BH3) and one location is located within the boundary of GARBLT (BH1). Addational four boring data are collected by the Local

Consultant from previous projects (BHs A, B, C and D). Figure 5.4-1 presents the location of boreholes.

Based on the obtained data and the carried out boring investigation, Figure 5.4-2 shows the longitudinal section for Soil Profile along section E3-1. The contents of the Geotechnical Report for E3-1 included the followings:

1. INTRODUCTION

2- GENERAL DESCRIPTION OF THE PROJECT

3. FIELD INVESTIGATION AND TESTING PROGRAM
   - 3.1 Objectives of the Investigation
   - 3.2 Scope of Field Exploration Program
   - 3.3 Standard Penetration Test Procedure

4. LABORATORY TESTING PROGRAM
4.1 Grain Size Analysis
4.2 Atterberg Limits (LL and PL)
4.3 Free Swell Test

5. SUBSURFACE SOIL CONDITIONS
5.1 General Soil Description
5.2 Ground Water

6. Soil Profile

7. CLOSURE

8- APPENDICES.

Appendix A (Site general Layout & Location of Boreholes)
- Figure (1) An aerial photo of the site along the Route E3-1
- Figure (2) A general layout for the site along section E3-1 and location Boreholes

Appendix B (Borelogs &Longitudinal soil Profile)
- Legend of soil Type (Figure 3)
- Borehole Logs (Figure 4 to 10)
- longitudinal Soil Profiles (Figure 11)

Appendix C (Laboratory Tests)
C-1 Grain Size Distribution Curves (Figure 12)
C-2 Atterberg limits (Plasticity chart) (Figure 13)
C-3 Free Swell Test

BH	Location	BH	Location
1	In front of General Authority for Roads, Bridges and Land Transport (hereinafter referred to as "GARBLT".	A	At the end of Al Azhar University fence
2	Inside the fence of Al-Azhar University, At the corner of El-Nasr Road and Al Hay Es Sadas street.	B	At midway between El Tayran street and Abass El Aqqad street (Existing data)
3	Inside the fence of Al-Azhar University, close to the university campus main entrance at El-Nasr road.	C	Near the intersection of El-Nasr Road and Makram Ebid street.
		D	Intersection El-Nasr Road & Hassan Fakhary street.

Figure 5.4-1 Location of Boreholes along Section E3-1

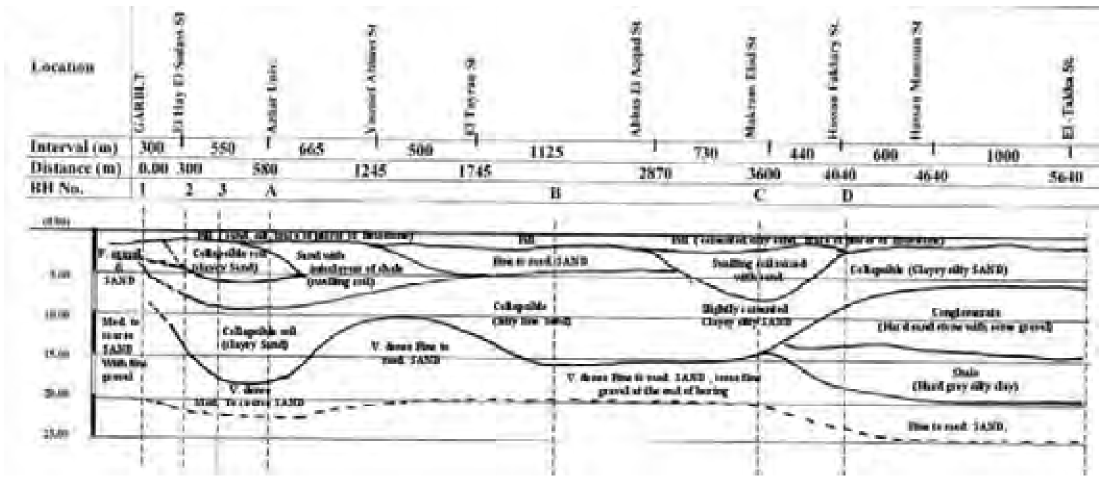


Figure 5.4-2 Longitudinal Section for Soil Profile along Section E3-1

(2) Expressway Section E2-2

At the busy site of this section official permission to carry out the soil boring can not be obtained under the scope of FS Study. The Local Egyptian Consultant can collect previous eight (8) undertaken borehole-log. Five (5) of the obtained borehole logs are located along 26th of July Street and denoted A to E. The other three (3) boreholes are located along Galaa Street and denoted F to H. The location of these boreholes is presented in Figure 5.4-3.

Figure 5.4-4 shows longitudinal section of soil profile along E2-2 Section. The contents of the Geotechnical Report for E2-2 included the same contents mentioned for Section E3-1.

Figure 5.4-3 Location of Boreholes along Section E2-2

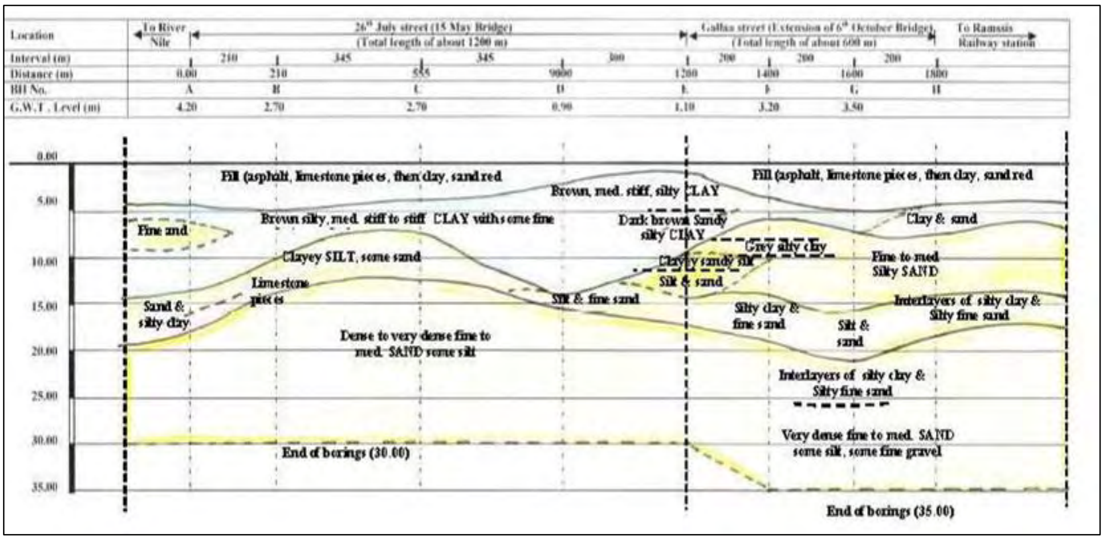


Figure 5.4-4 Longitudinal Section for Soil Profile along Section E2-2

(3) Expressway Section E1-2

This section is located within the boundries of the Agricultural Musiem, Shotting Club, Gadah Street and Sudan Street. JICA Study Team, GARBLT and Egyptian Local Consultant face again the problem to get permision to carry out the requried soil boring tests.

The site of route E1-2 is very congested urban area, and on the other hand, in green areas it was also very difficult to get permissions to do borings. Therefore, the alternative proposal was to get available data of borings previously drilled along the path of Route E1-2

Five borehole logs could be obtained, three along Sudan Street, and denoted as "A, B, C, and the other two boreholes are one at the site of shooting Club, denoted as D, and the other at Mohandisin area. The location of used boreholes at the site is shown in Figure 5.4-6, the ground elevations at the locations of the borings are considered as the top of borehole. The data were analyzed to estimate the soil profile along the proposed section of Route E1-2.

Figure 5.4-5 shows longitudinal section of soil profile along E1-2 Section. The contents of the Geotechnical Report for E1-2 included the same contents mentioned for Section E3-1.

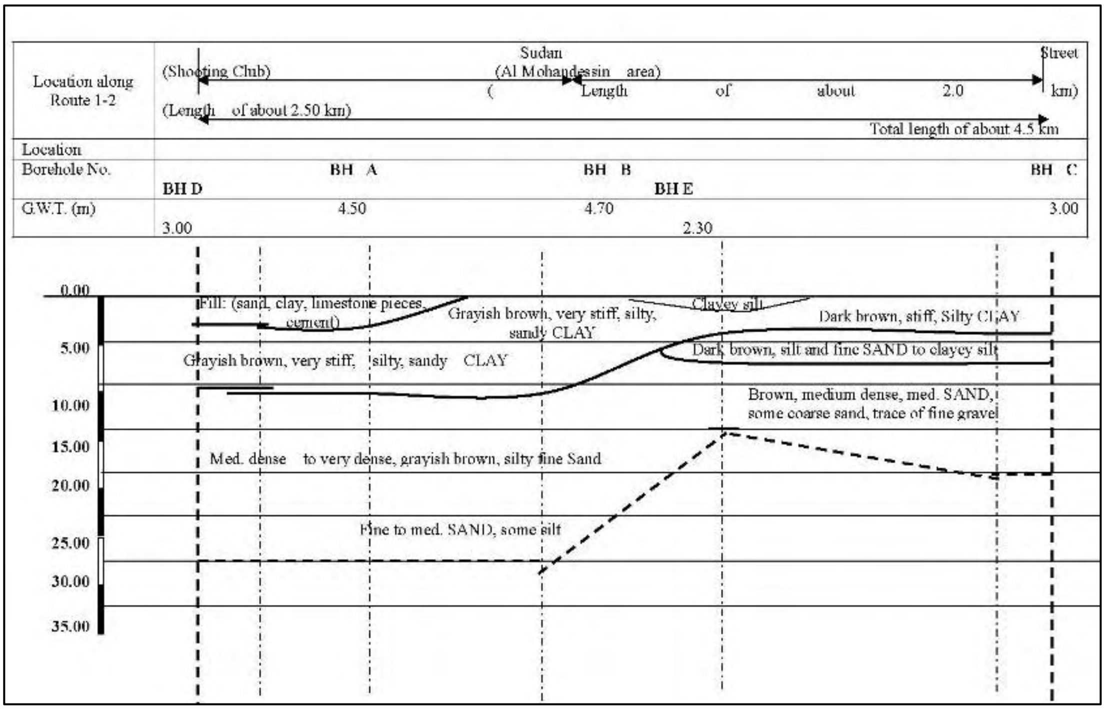


Figure 5.4-5 Longitudinal Section for Soil Profile along Section E1-2

Figure 5.4-6 Location of Boreholes along Section E1-2

CHAPTER 6

ALIGNMENT / CONFIGURATION
OF
HIGH PRIORITY ROUTES

CHAPTER 6

ALIGNMENT / CONFIGURATION OF HIGH PRIORITY ROUTES

6.1 ALIGNMENT/ CONFIGURATION ALTERNATIVES

6.1.1 F/S Corridors

(1) E1-2

E1-2 is proposed to be constructed with 4-lane (2-lane westbound and 2-lane eastbound) structure between western end of existing 6th October Bridge (E1-1) in Dokki near Agricultural Museum and eastern end of E11 in Giza near north-western corner of Cairo University Campus.

E11 has been under construction supervised by Ministry of Housing and Urban Development (MoHUD) as a part of proposed Metropolitan Expressway Networks and it connects between western quadrant of Ring Rd. on the west and al-Sudan St. on the east.

Several alternative alignments are proposed based on the geometrically possibilities along this corridor even though each alternative has some advantages and disadvantages as follows;

<u>Alternative-1</u>

As shown in Figure 6.1-1a, first alternative alignment is proposed along al-Duqqi St. (RoW=36~42m) as first half section and ‘Abd al-Salam ‘Arif St. (RoW=40~45m) as second half section by viaduct type structures. This alignment will be the shortest (approximately 4.4 km) therefore most probably economical among the alternatives; however this alignment has following disadvantages;

- ✓ Requiring demolition of existing on & off ramp/loop at the end of the 6th October Bridge
- ✓ Encroaching into either secondary school or Ministry of Agriculture compound in Dokki at the beginning point of the corridor to accommodate absolute minimum radius of 120m (R120) for design speed of 60 kph
- ✓ Over passing the existing al-Dukki flyover with a length of about 585m
- ✓ Encroaching into either Embassy of Czech Republic compound or Oman Gardens in Giza to accommodate R120 as same criteria as above
- ✓ Over passing in front of Cairo University main campus and its student hostel
- ✓ Almost no room to construct additional viaduct beside the western half of existing flyover crossing al-Sudan St. and ENR/Metro Tracks, where ramps from/to E11 are proposed
- ✓ Conflicting with planning of MoHUD to construct underpasses and underground parking spaces around Oman Gardens which is partially overlapping with this alignment, and their

project is ahead of this project, therefore coordination will be required to accommodate both structures in the same road spaces, and might be suspending their project until further arrangements

Alternative-2

As shown in Figure 6.1-1a, second alternative alignment is proposed along Umm Kalsum (al-Gabalaya) St. (RoW=22m) which runs western bank of Zamalek/Gazira Island and al-Tahrir St. (RoW = 36m), then either al-Sudan St. (RoW=27m) or ENR Track (RoW=42~108m) to avoid disadvantages of Alternative-1 described above by viaduct type structures, however this alignment has also following advantage and disadvantages;

- ✓ Branch off viaducts are necessary to split from existing 6th October Bridge on the Zamalek/ Gazira Island near Gazira Sports Club compound
- ✓ Disturbance to current traffic on the 6th October Bridge will be minimum
- ✓ Over passing both al-Gala' Bridge and al-Gala' Square together with al-Gala' underpass in front of Sheraton Hotel in Dokki is required
- ✓ Metro Line No.2 is running along al-Tahrir St. and its El Dokki Station and El Behoos Station are occupying all underground space of al-Tahrir St. based on the information from NAT
- ✓ Installation of on/off ramps along al-Tahrir St. will be relatively easy
- ✓ Railway Police Station shall be relocated at the connection point with E11
- ✓ Total length required (approximately 6.1 km) is longest among the alternatives.

Alternative-3

As shown in Figure 6.1-1a, third alternative alignment is proposed to connect directly from 'Abd al-Mini'm Riyad Square, where Ramsis St. is ended, via diagonally crossing long-span bridge or submerged tunnel on the River Nile to Zamalek/Gazira Island, and passing through al-Tahrir St., and either al-Giza St. and 'Abd al-Salam 'Arif St. as same as Alternative-1 or continued to al-Tahrir St. and al-Sudan St. as same as Alternative-2 by viaduct type structures. This alignment has following advantages and disadvantages beside the same of the previous two alternatives;

- ✓ Enable to accommodate 6-lane structure with much higher design standards
- ✓ Required long span bridge or submerged tunnel to cross the River Nile and may affect landscape over the Nile
- ✓ Passing over or under the Sa'd Zaghlul Square and running in front of Opera House parallel with Metro Line No.2
- ✓ Encroaching Mosque beside the Giza Police Headquarters near the corner of al-Giza St. and 'Abd al-Salam 'Arif St. in case of southern most route
- ✓ Total length required (approximately 5.6 km) is longer than Alternative-1 and -4, even though slightly shorter than Alternative-2

Alternative-4

As shown in Figure 6.1-1a, forth alternative alignment is proposed to avoid the most of disadvantages of previous three alternatives, however this alignment is probably most expensive than any other alignments since shield and/or open-cut tunnel method is required. Advantages and disadvantages of this alternative are follows;

- ✓ To construct tunnel entrance/exit under the 6th October Bridge along al-Mathaf al-Zira'i St. (RoW=39m) before reaching al-Batal Ahmad 'Abd al-'Aziz St., replacement and/or modification of both substructures and superstructures of the 6th October Bridge is required with a length of approximately 300m
- ✓ Modification or replacement of existing ramps and rerouting of access road from under the bridge to adjacent community park space will be required to accommodate transition ramps along 6th October Bridge
- ✓ Land acquisition will be negligible by passing under the Agricultural Museum and Shooting Club Compounds by shield tunnel, except during the construction to accommodate vertical shaft for the shield boring machines
- ✓ Underground double deck (tandem) tunnels (upper one for eastbound and lower one for westbound) will be required to pass through under Gadda (Jeddah) St. (RoW=12m) in the western side of Dokki area
- ✓ Minimum radius of curve with 100m (R100) for design speed of 50 kph may be required to avoid hitting buildings at the corner of Gadda (Jeddah) St. and al-Sudan St.
- ✓ Land acquisition will be also minimum by utilizing the spaces of Canal and ENR/Metro tracks by separated viaducts to accommodate future bus exclusive lanes from 6th October City proposed by MoHUD and/or E9 (4-lane) above the ENR/Metro tracks
- ✓ Connection ramps from/to E11 will be relatively easily installed by using road and railway track spaces provided with a radius of R90 for design speed of 40 kph based on ramp standard
- ✓ Modification works of on-going E11 ramps, and relocation of railway police station will be required to construct connection ramps between E1-2 and E11
- ✓ Total length required (approximately 4.5 km) is as almost same as Alternative-1 and shorter than Alternative-2 and -3

<u>Alternative-5</u>

As shown in Figure 6.1-1b, fifth alternative alignment is proposed to divert to north along al-Batal Ahmad 'Abd al-'Aziz St. (RoW=36m), and then enter Gam'at al-Dawal al-'Arabiya Avenue (RoW=60m) via Gazirit al'Arab Circle (RoW=36m) by simple viaduct. This alignment also intends to serve for current 15th May Bridge (E2-1) Corridor users. Advantages and disadvantages of this alternative are follows;

- ✓ Demolitions of existing on & off ramp/loop are required at the end of the 6th October Bridge

- ✓ Encroaching into Ministry of Agriculture compound in Dokki at the beginning point of the corridor to accommodate absolute minimum radius of 90m (R90) for design speed of 50 kph
- ✓ Crossing twice Gam'at al-Dawal al-'Arabiya Avenue at both ends of Gazirit al'Arab Circle, and requiring another minimum radius of 90m (R90) at south-eastern end.
- ✓ Provision of On/Off Ramps along Gam'at al-Dawal al-'Arabiya Avenue will be relatively easy
- ✓ Coordination with NAT will be required since Metro No.3 branch line will run under Gam'at al-Dawal al-'Arabiya Avenue
- ✓ Second level structure will be required to overpass existing parallel flyover which connect both sides of ENR Track at the end of Gam'at al-Dawal al-'Arabiya Avenue
- ✓ Relocation of high raised radio tower may be required to install viaduct which cross both al-Sudan St. and ENR Track
- ✓ Coordination with MoHUD will be also required since bus exclusive lane will run along ENR Track Line

Figure 6.1-1 c and d shows alternative cross sections for E1-2. As shown in (a), parallel viaduct is proposed for Alternative-1, 2, 3, and 5 as most typical 2-lane dual carriageway above median of relatively wide arterial roads. As shown in (b), parallel shield tunnel is proposed for Alternative-4 under El Hadaiq St. where RoW is relatively wide. As shown in (c), tandem shield tunnel is proposed for Alternative-4 as well under Gadda Street where RoW is relatively narrow to avoid underground structures of nearby buildings along such street.

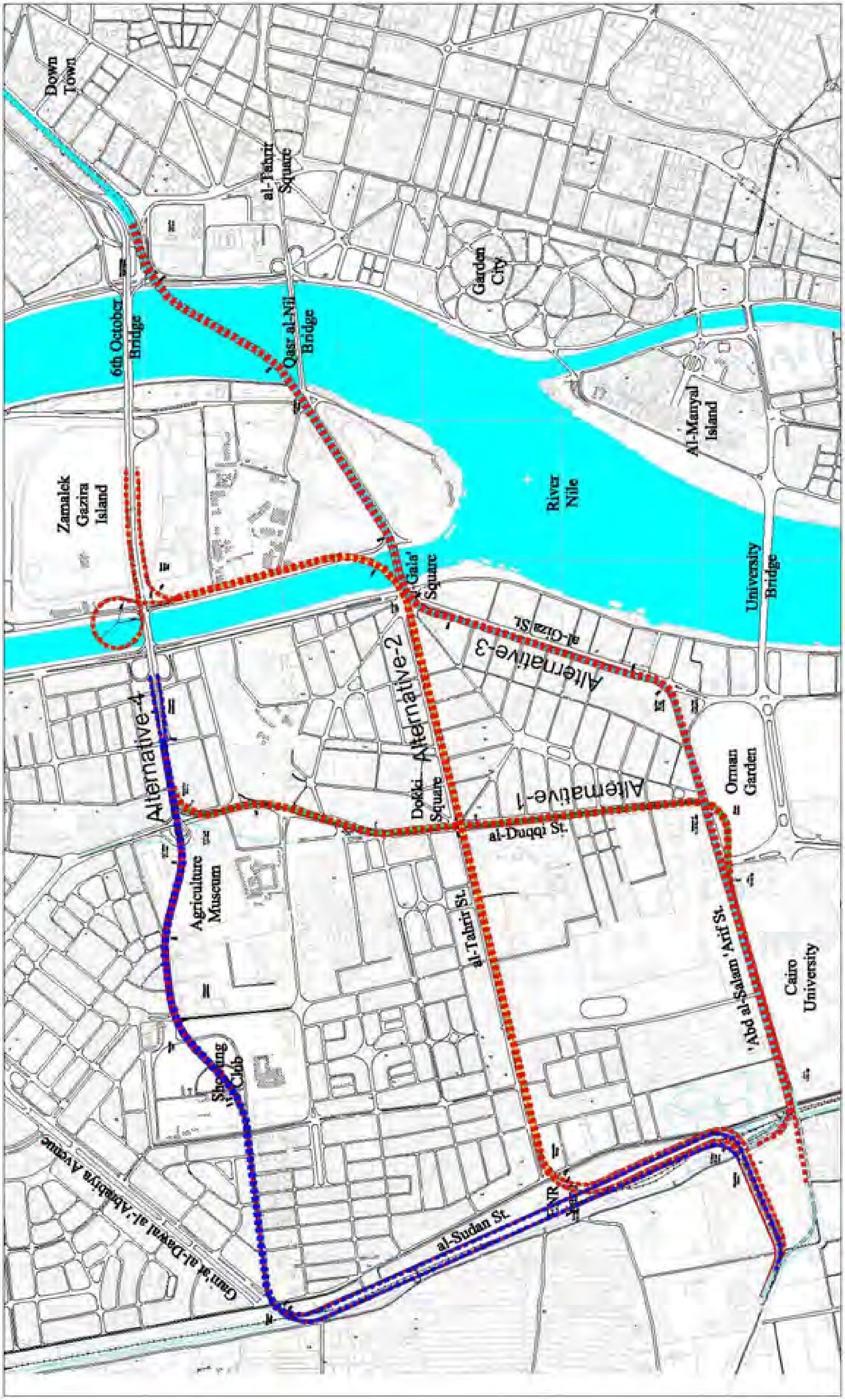


Figure 6.1-1 a Alternative Alignment Plan for E1-2 (Alternative-1, 2, 3, 4)

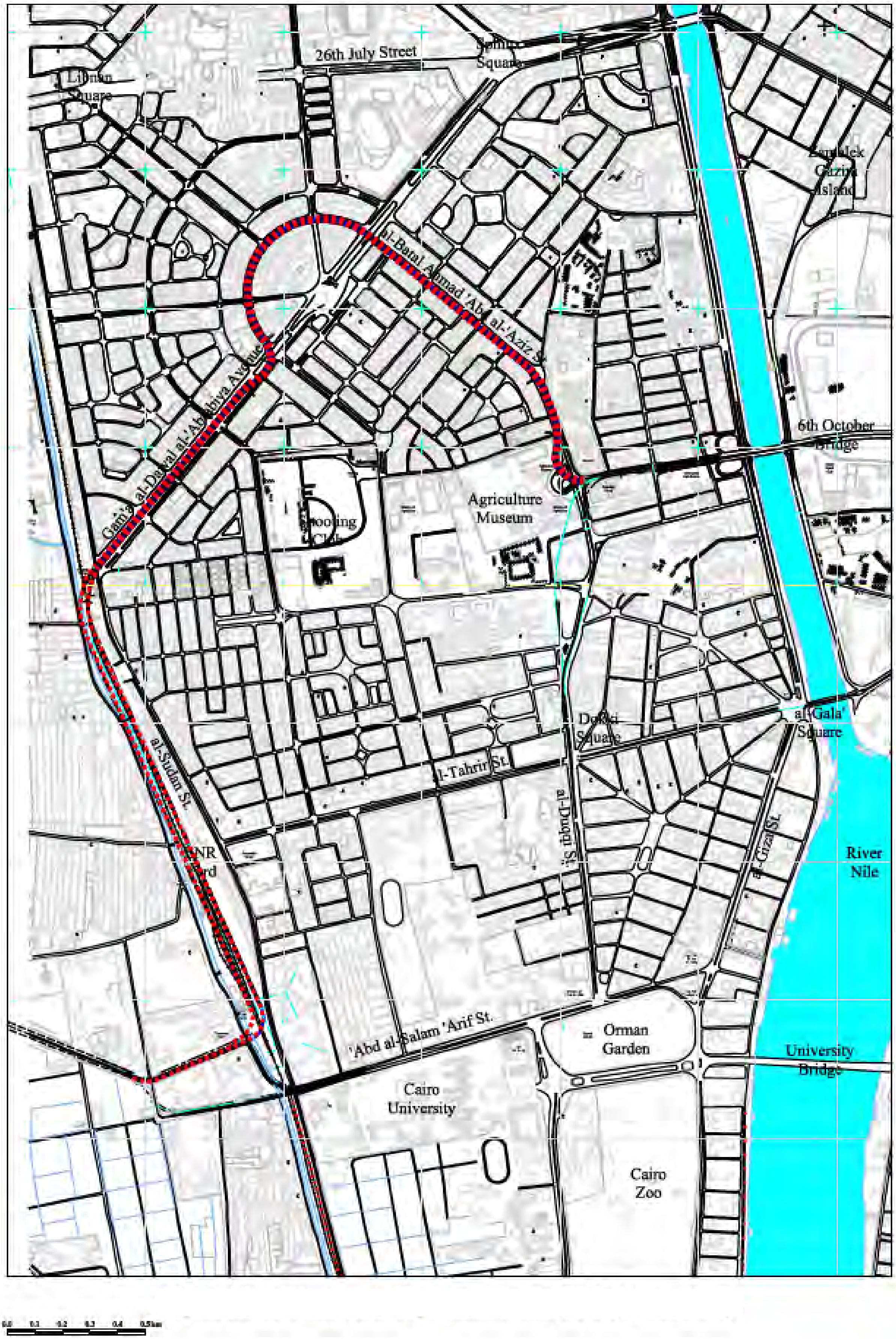
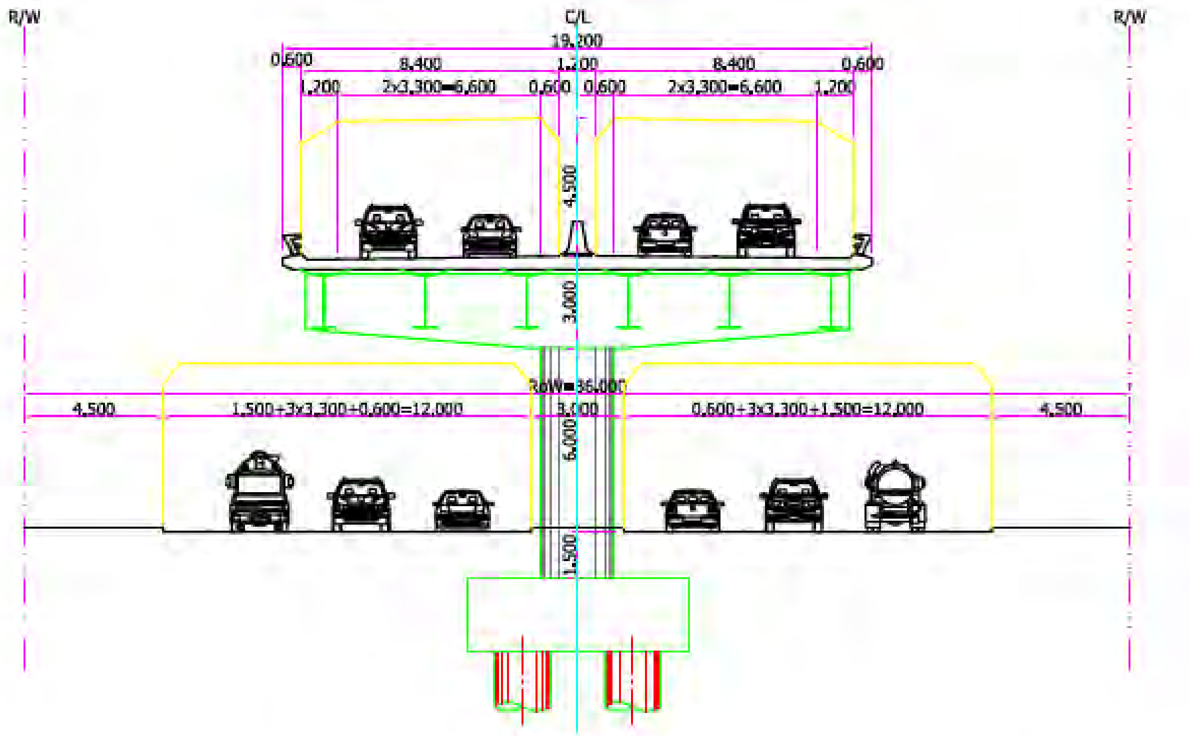
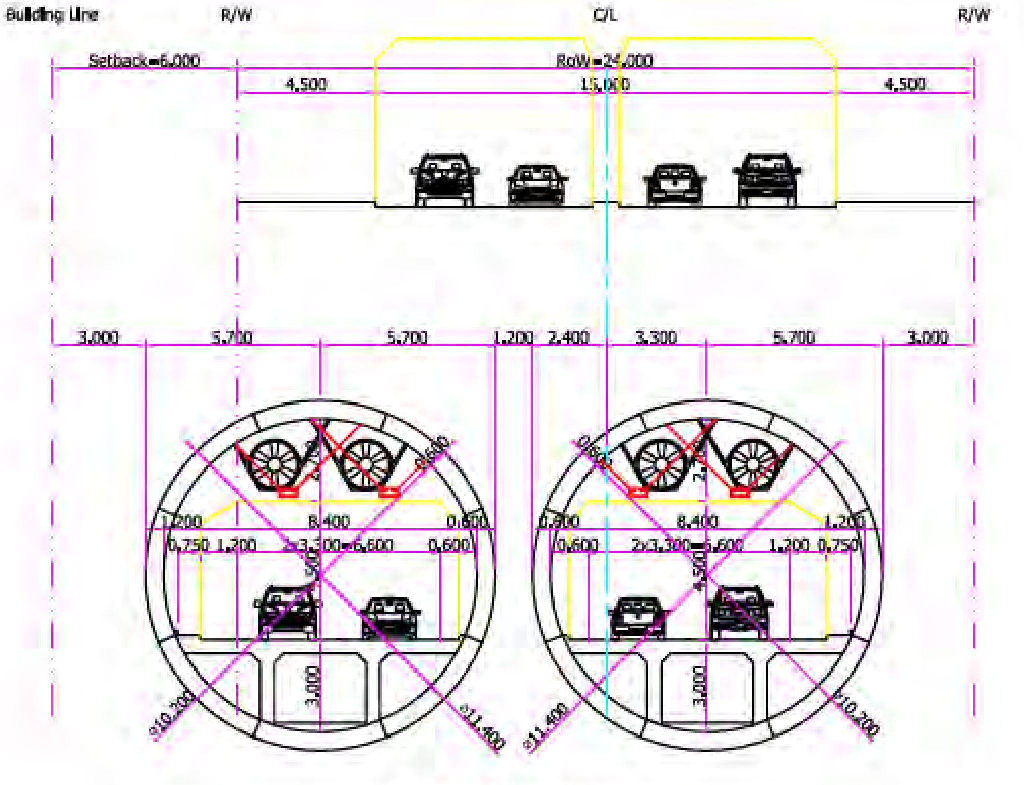


Figure 6.1-1 b Alternative Alignment Plan for E1-2 (Alternative-5)

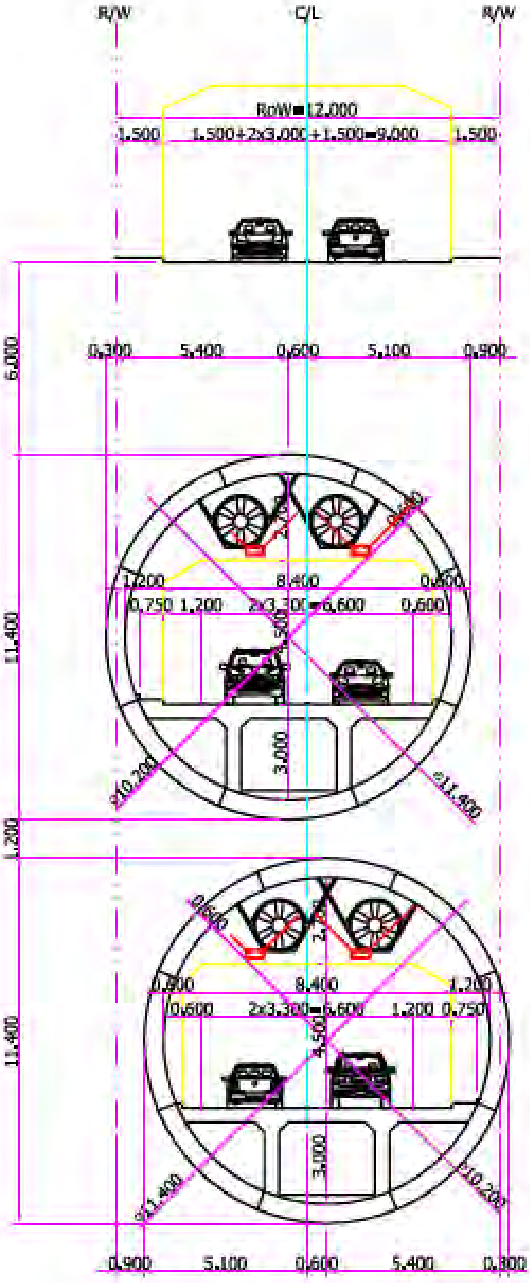


(a) Parallel Viaduct



(b) Parallel Shield Tunnel

Figure 6.1-1 c Alternative Cross Sections for E1-2



(c) Tandem Shield Tunnel

Figure 6.1-1 d Alternative Cross Sections for E1-2

(2) E2-2

As shown in Figure 6.1-2a and -2b, E2-2 is proposed to be constructed between Corniche al-Nil St. and 6th October Bridge (E1-1) above or beside the existing westbound only 15th May Bridge (E2-1) along 26th July St. to handle eastbound traffic from Zamalek and Mohandiseen to Cairo Down Town and Heliopolis or Nasr City.

Only one alignment is available along this corridor due to limited road space available on the eastern bank area of River Nile, even though some structural alternatives are considered as follows;

<u>Alternative-1</u>

Newly proposed eastbound viaduct shall be constructed independently above existing westbound structures without touching existing structures, however following advantages and disadvantages are expected;

- ✓ Diversions of current traffic flow, especially westbound traffic from 6th October Bridge to 15th May Bridge, will be minimized
- ✓ Duration of construction will be minimum, although almost all works shall be taken place direct below and above existing viaduct
- ✓ Vertical limitation of westbound viaduct may be breached, if eastbound viaduct is constructed with straight alignment toward the east from the existing abutment located eastern edge of River Nile crossing and kept maximum grade with 5% for design speed of 60 kph
- ✓ Freedom of proposed underground structure design of Maspero Station for Metro Line No.3 (Phase-3) may be breached by both substructures and foundations of existing westbound viaduct and newly proposed eastbound viaduct

<u>Alternative-2</u>

Newly proposed eastbound viaduct shall be constructed integrated with new westbound viaduct by removing existing westbound structures first, however following advantages and disadvantages are expected;

- ✓ Diversions of current traffic flow, especially westbound traffic from 6th October Bridge to 15th May Bridge is unavoidable
- ✓ Duration of construction will be maximum, due to both demolition works for existing single deck bridge and re-construction works of double deck bridge
- ✓ Violation of vertical limitation below and above existing westbound viaduct with at-grade level street and newly proposed eastbound viaduct will be cancelled
- ✓ Freedom of proposed underground structure design of Maspero Station of Metro No.3 (Phase-3) will be maximized with integrated designs and constructions of both viaducts and subway station all together

Alternative-3

Newly proposed eastbound viaduct shall be constructed partially integrated with new westbound viaduct in western half portion, and partially independent from existing westbound viaduct in eastern half portion, however following advantages and disadvantages are expected;

- ✓ Diversions of current traffic flow, especially westbound traffic from 6th October Bridge to 15th May Bridge is still unavoidable
- ✓ Duration of construction will be intermediate of above two alternatives
- ✓ Violation of vertical limitation below and above existing westbound viaduct with at-grade level street and newly proposed eastbound viaduct will be cancelled
- ✓ Freedom of proposed underground structure design of Maspero Station of Metro No.3 (Phase-3) will be maximized with integrated designs and constructions of both viaducts and subway all together

Alternative-4

Based on H.E. Prime Minister's suggestion, parallel viaduct type configuration is also considered along existing westbound viaduct by acquiring land along 26th July St. for about 1.2ha (280m x 24m plus 380m x 12m) on the northern side of the street to accommodate both newly constructed westbound viaduct and Metro Line No.3 and another space for 1.5ha (100m x 100/200m) at the corner of 26th July St. and Corniche al-Nil St. to accommodate direct loop ramp from 15th May Bridge to World Trade Centre side along Corniche al-Nil St. Beside such large-scale land acquisitions, following advantages and disadvantages are expected;

- ✓ Existing westbound viaduct shall be converted as eastbound viaduct except both ends which shall be replaced with newly constructed structures as follows;
  - † West end of which shall be connected with existing 15th May Bridge eastbound at bridge abutment with newly constructed super structures, and
  - † East end of which shall be replaced with newly constructed connection ramp to 6th October Bridge northbound lane above existing connection ramp from 6th October Bridge southbound lane.
- ✓ Newly constructed westbound viaduct shall be connected with existing connection ramps at both ends as follows;
  - † West end of which shall be re-connected with existing 15th May Bridge westbound by replacing existing last long reverse curve (S-curve) girder with newly constructed super structures, and
  - † East end of which shall be re-connected with connection ramp from 6th October Bridge southbound lane by extending its curved girder.
- ✓ Newly constructed direct loop ramp from 15th May Bridge to Corniche al-Nil St. will provide better accessibility to World Trade Centre side and also reduce eastbound diversion traffic on the 26th July St. under existing viaduct, although this plan requires land acquisition and relocation of historically important mosque which should be conserved

- ✓ Widening of 26th July may provide better natural environmental condition than the other options after opening, although it will induce a lot of outcries from the residents and/or shop owners who have to relocate to the other area and/or loose tenant shipments.
- ✓ Freedom of proposed underground structure design of Maspero Station of Metro No.3 (Phase-3) will be maximized with integral designs and constructions of both viaduct and subway structures all together

Note that eastern end of newly proposed E2-2 will not be able to connect with northeast bound traffic lanes of existing 6th October Bridge directly unless current lane configuration (southwest bound is 4-lane, and northeast bound is 2-lane between ‘Urabi St. and 26th July St.) is modified and the space for connection ramp within existing 6th October Bridge structures is provided due to limited road space along al-Gala St.

Possible option will be connecting this E2-2 eastbound viaduct as ramp to newly proposed eastbound viaduct, which we tentatively named as E1-1 Bypass, along Ramsis St. from ‘Abd al-Mini’m Riyad Square via al-Is’af Square above Nasser Station to ‘Urabi St. above ‘Urabi Station of Metro Line No.1.

This E2-2 Ramp alone or together with above-mentioned E1-1 Bypass will be connected with 6th October Bridge above the intersection of ‘Urabi St. with al-Gala St. together with further widening of 6th October Bridge between ‘Urabi St. and Ramsis Sq. segment, which is still underway by MoHUD and Cairo Governorate.

Or alternatively, E1-1 Bypass will be extendable much further until Ramsis Square or before or after the Railway Repair Yard where new junction with E5 is proposed to accommodate future traffic demands between Cairo Down Town and Northern Cairo.

However, in case of Ramsis Square Rehabilitation Programme is launched near future, 6th October Bridge in front of Ramsis Railway Station will be relocated behind the Station, and above described E1-1 Bypass shall be diverted by passing through ‘Urabi St. toward behind the Station accordingly.

Therefore further detail investigation and study will be required, together with not only Ramsis Square Rehabilitation Programme but also Railway Yard Re-Development Plan, as well as both existing Metro Line No.1 and proposed Metro Line No.3 plans with all concerned public and private entities involved.

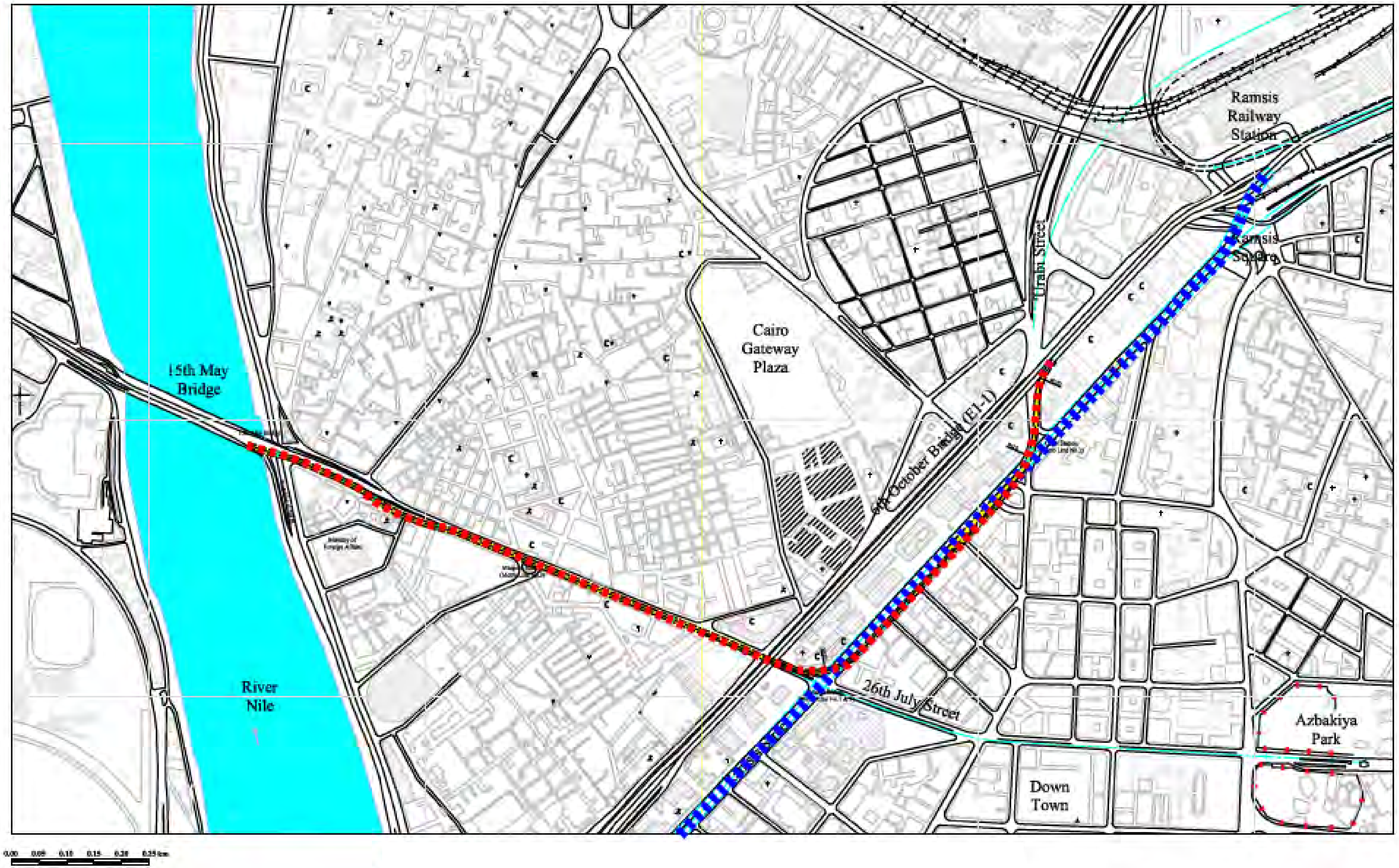


Figure 6.1-2 a Alternative Alignment Plan for E2-2 (Double Deck Type)

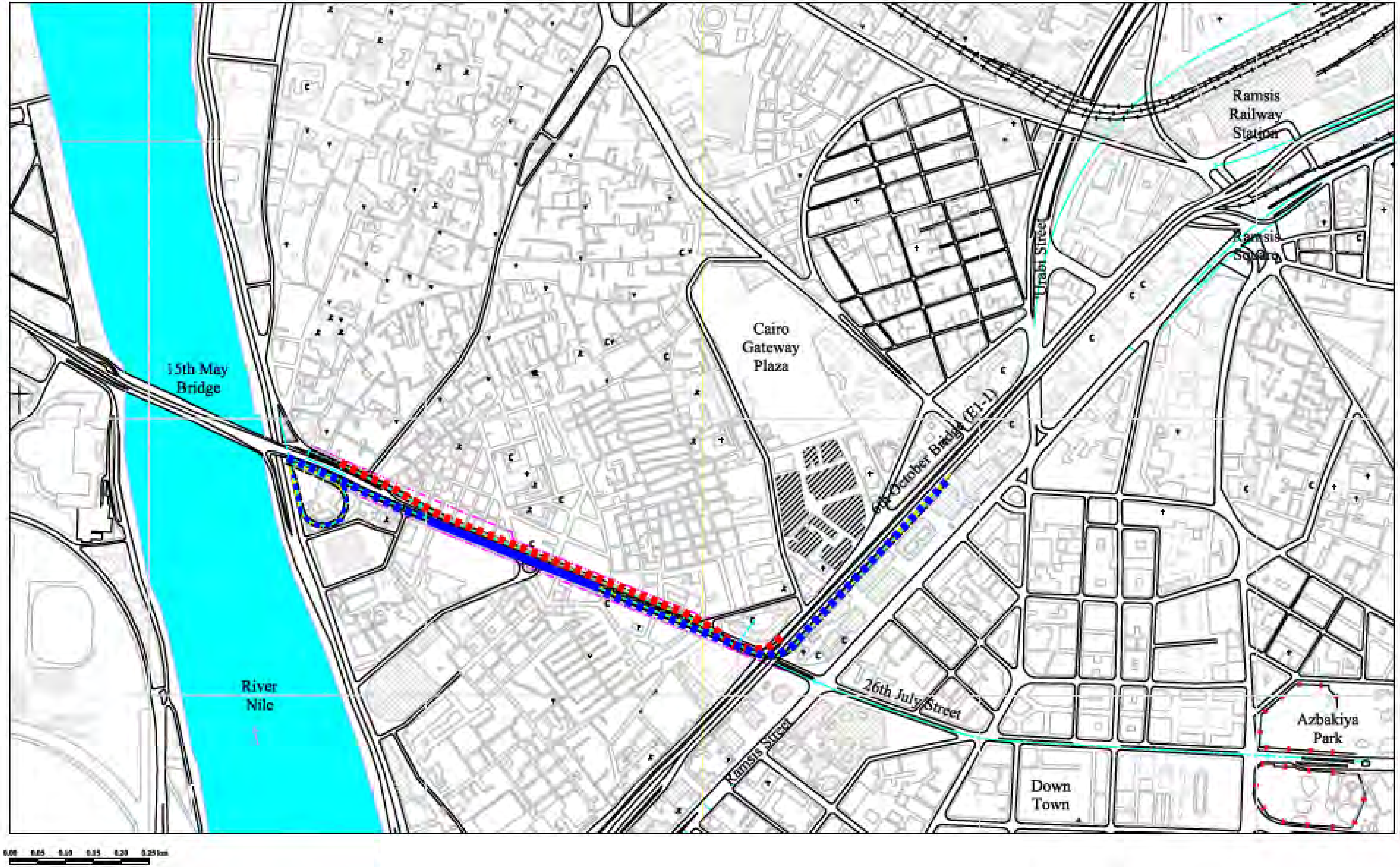
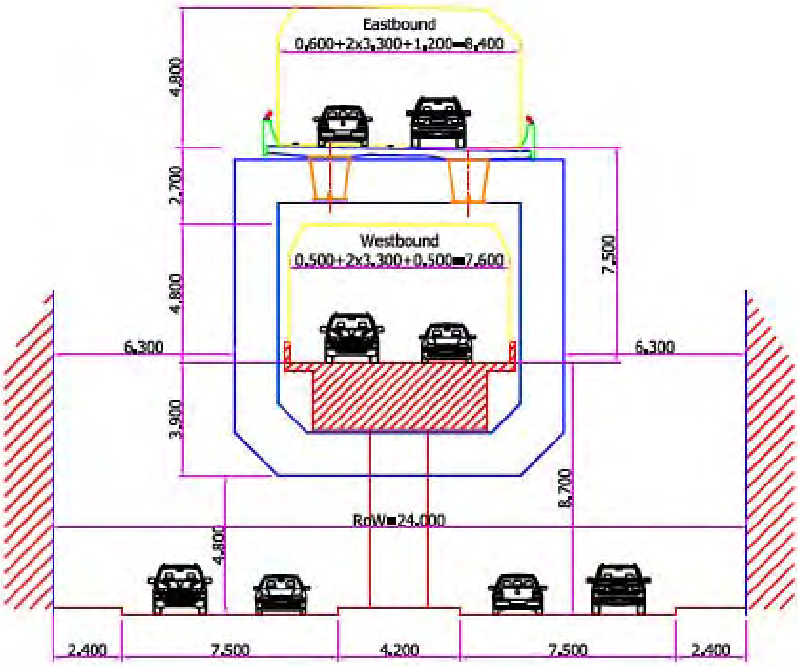
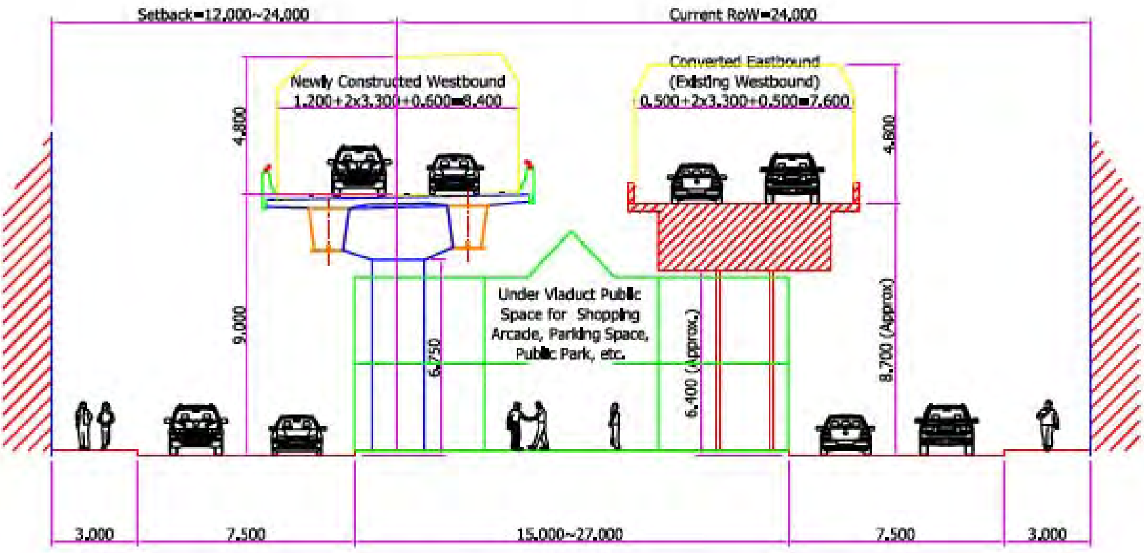


Figure 6.1-2 b Alternative Alignment Plan for E2-2 (Parallel Deck Type)



Double Deck Type Configuration w/o Land Acquisition



Parallel Deck Type Configuration w/ Land Acquisition

Figure 6.1-2 c Proposed Cross Section for E2-2

(3) E3-1

As shown in Figure 6.1-3a, E3-1 is proposed to be constructed between Suez Desert Rd. on the east and junction with 6th October Bridge (E1-1) on the west along Autostrade (Tariq al-Nasr) Rd. with 6-lane structure to accommodate future traffic demand between middle and eastern part of GCR as well as Nasr City itself.

Beginning point of E3-1 will be connected with proposed E4 and E6, and ending point shall be connected with 6th October Bridge (E1-1) as well as proposed E3-2 and E12 of Metropolitan Expressway Networks in the future.

Only one route is available on this corridor, however following alternative configurations are considered;

<u>Alternative-1</u>
As shown in Figure 6.1-3b (top), first possible configuration is viaduct type from economical aspects; however this type of structure may have following disadvantages in this corridor;

- ✓ Both sides of Autostrade (Tariq al-Nasr) Rd. are historically properties of Ministry of Defence (MoD), and after transfer of ownership of some plots and/or buildings to private sectors, still MoD installations are situated along the route, therefore viaduct type structure is not favoured by MoD due to security reason
- ✓ Especially viaduct is not recommended in front of “Unknown Soldiers Monument” due to historical background in Egypt.

<u>Alternative-2</u>
As shown in Figure 6.1-3b (middle), second possible configuration is depressed type to meet MoD requirements described in previous alternative. MoD also requested that even depressed type is their favoured configuration; this depressed type should be closed within the “Unknown Soldiers Monument” segment due to security reason and memorial parade purpose. However this type of structure may have following disadvantages;

- ✓ In case of connection with viaduct section, relatively long transition section with 400~500m for each direction is required, therefore accessibility of at-grade level may be hampered
- ✓ Open section above depressed section may become hazardous point for road users (at-grade level and expressway), general public, as well as government bodies, in case of traffic accidents and/or sabotage acts, if no prevention measures are provided
- ✓ Other underpass projects planned by Cairo Governorate and/or MoHUD for El Fangary St. and Super Tram along Yussef Abbas St. may conflict with this depressed expressway each other due to use of B1 level.

Alternative-3

As shown in Figure 6.1-3b (bottom), last possible configuration is at-grade type; however this option has following disadvantages beside the lowest construction cost, except the cost for land aquisitions;

- ✓ Accessibility between both sides of the corridor along El Nasr Road is completely restricted, unless otherwise connection bridge/overpass and/or tunnel/underpass for both motorized and non-motorized traffic are provided
- ✓ Capacity of at-grade level road would be drastically hampered, unless otherwise widening of RoW with at least 60m wide and provision of extra lanes as well as left turn and/or U-turn bridges or underpasses are implemented

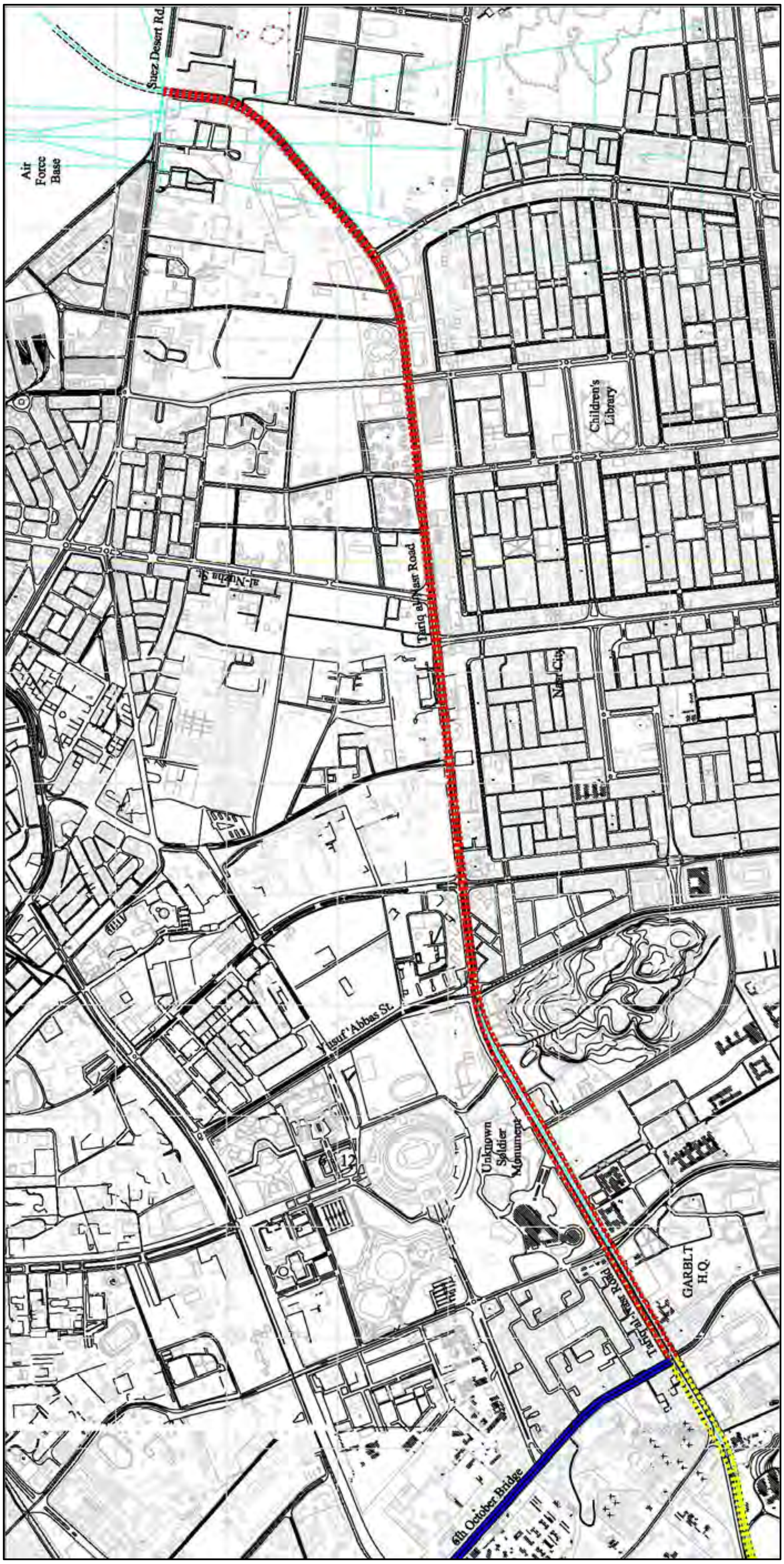
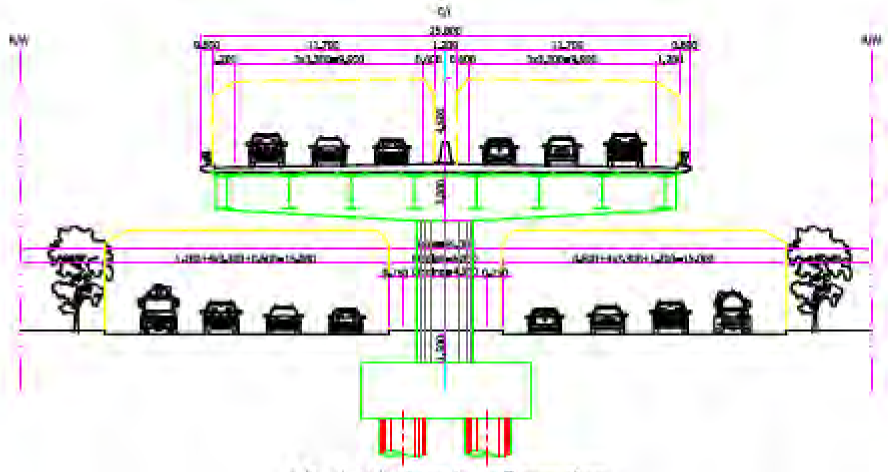
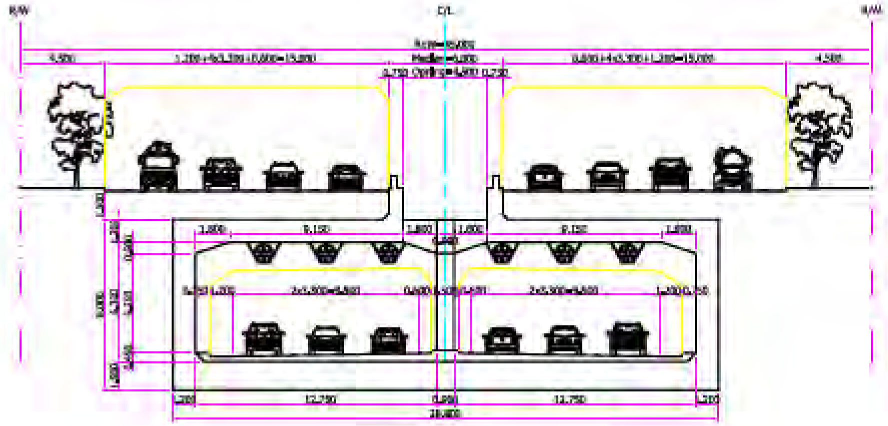


Figure 6.1-3 a Proposed Alignment Plan for E3-1



Alt.-1 Viaduct Configuration



Alt.-2 Depressed Tunnel Configuration

Alt.-3 At-Grade Configureation

Figure 6.1-3 b Proposed Alternative Cross Section for E3-1

6.1.2 Pre-F/S Corridors

(1) E3-2

As shown in Figure 6.1-4a and -4b, E3-2 is proposed to be constructed as extension of E3-1 between junction with 6th October Bridge (E1-1) on the east and Salah Salim St. near the Citadel on the west along Autostrade (Tariq al-Nasr) Rd. with 6-lane (3-lane for westbound, and 3-lane for eastbound) structure.

Beginning point of E3-2 shall be connected with 6th October Bridge (E1-1) and E3-1 as well as proposed E12 and ending point shall be connected with proposed E3-3 and E10 of Metropolitan Expressway Networks in the future.

Only one route is available on this corridor, however following alternative arrangements of viaduct are considered;

<u>Alternative-1</u>

As shown in Figure 6.1-4c (top), first possible option is to construct viaduct along median of Autostrade (Tariq al-Nasr) Rd.. This option has following advantage and disadvantage;

- ✓ During the construction stage, centre side lanes are closed to accommodate spaces for civil works such as foundation works and/or pier/cantilever/girder election works; therefore traffic flow of at-grade level along Autostrade (Tariq al-Nasr) Rd. is affected most of time
- ✓ In case of provision of on/off ramps between at-grade level road and expressway, such ramps are relatively easy to attach without changing vertical and horizontal alignment of expressway

<u>Alternative-2</u>

As shown in Figure 6.1-4c (middle), second possible option is to construct viaduct above cargo railway track which runs parallel with Autostrade (Tariq al-Nasr) Rd.. This option has following advantage and disadvantage;

- ✓ During the construction stage, cargo train operation may be affected to accept civil works such as foundation works and/or pier/cantilever/girder election works; however disturbance to traffic flow of at-grade level along Autostrade (Tariq al-Nasr) Rd. is minimized without special care
- ✓ In case of provision of on/off ramp between at-grade level road and expressway, such ramps are relatively difficult to attach since crossing both at-grade level road and expressway and railway are required

Alternative-3

As shown in Figure 6.1-4c (bottom), third possible option is to construct viaduct between cargo railway track and Autostrade (Tariq al-Nasr) Rd.. This option has following advantage and disadvantage;

- ✓ During the construction stage, both cargo train operation and eastbound traffic flow of at-grade level may be affected slightly to accept civil works such as foundation works and/or pier/cantilever/girder election works; however disturbance to at-grade level traffic flow along Autostrade (Tariq al-Nasr) Rd. and cargo train operation are most likely minimized with special care.
- ✓ In case of provision of on/off ramp between at-grade level road and expressway, such ramps are relatively difficult to attach since crossing both at-grade level road and expressway or railway are required

In any alternative cases, southwestern end segment of the E3-2 alignment has to trespass a part of Northern Cemetery by passing through north side of existing Autostrade (Tariq al-Nasr) Rd. viaduct (6-lane) which overpasses ENR Cargo Track.

Therefore E3-2 last end segment will be passing through above ENR Cargo Track between Salah Salim St. located north-western most and Autostrade (Tariq al-Nasr) Rd. located south-eastern most at saddle-shaped geographical features between Citadel and Muqattam Hill.

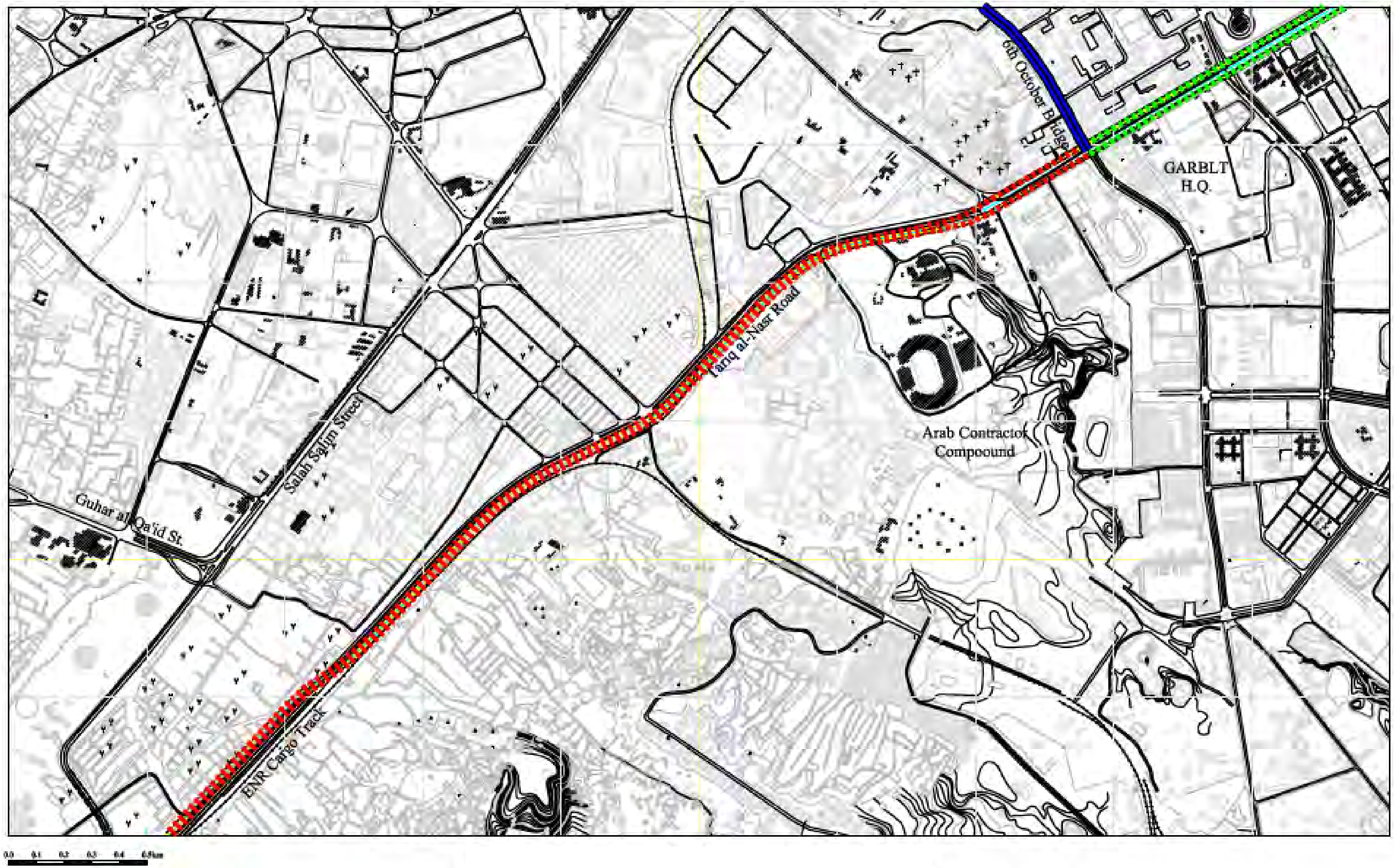
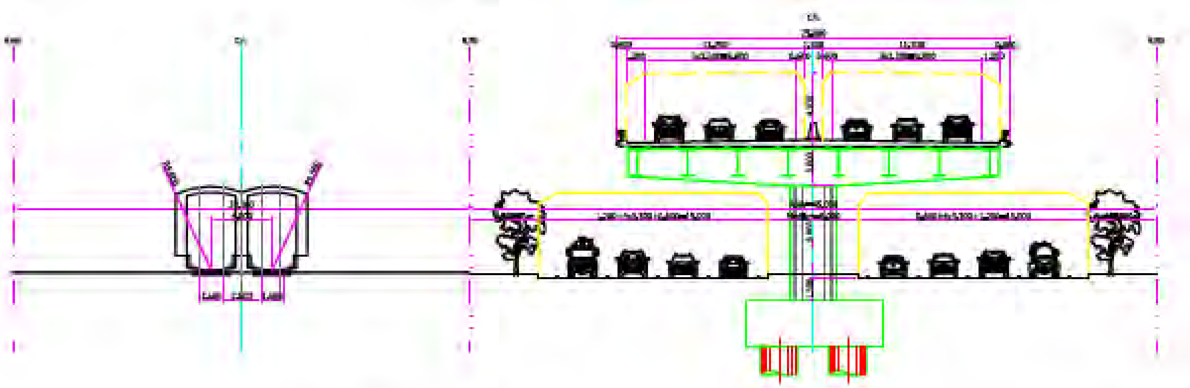
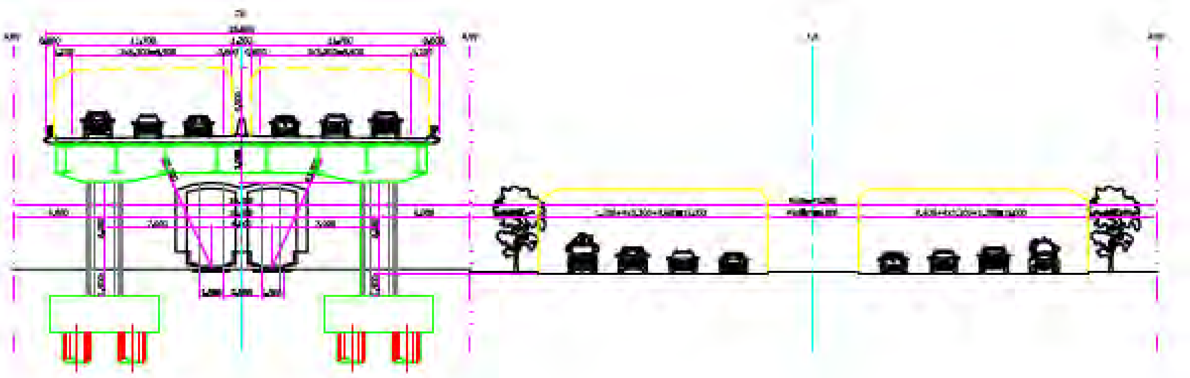


Figure 6.1-4 a   Proposed Alignment Plan for E3-2 (1)

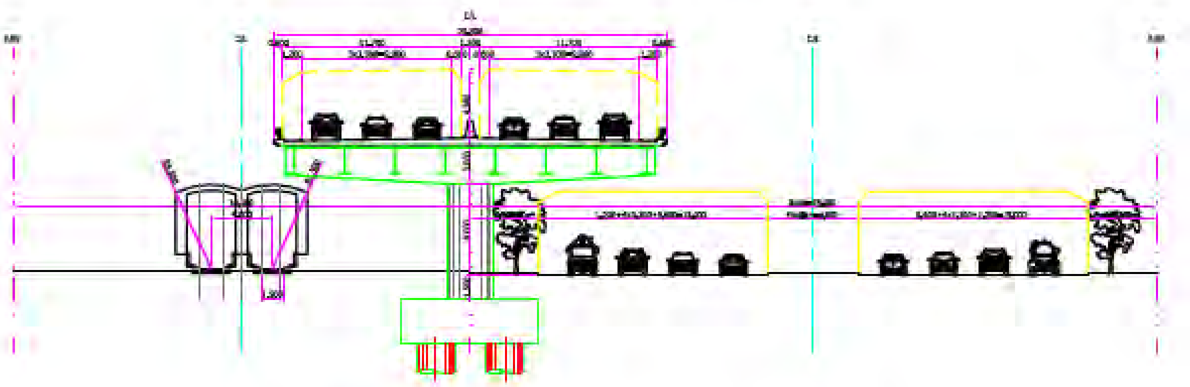
Figure 6.1-4 b Proposed Alignment Plan for E3-2 (2)



Alt.-1 Above Roadway Configureation



Alt.-2 Above Railway Configuration



Alt.-3 Mid of Roadway & Railway Configuration

Figure 6.1-4 c Proposed Alternative Cross Section for E3-2

(2) E3-3

As shown in Figure 6.1-5a, -5b, and -5c, E3-3 is proposed to be constructed as extension of E3-2 between Autostrade (Tariq al-Nasr) Rd. near Citadel on the east and Giza Square on the west along Salah Salim St. with 6-lane (3-lane for westbound, and 3-lane for eastbound) structure.

Beginning point of E3-3 shall be connected with E3-2 as well as proposed E10 and ending point shall be connected with proposed E8 of Metropolitan Expressway Networks in the future.

Initially, only one route is proposed on this corridor along narrow Salah Salim St. (RoW=24~30m) in front of Aqueduct, however in the course of the Study, MoHUD has revealed that they have plan to re-route Salah Salim St. behind the Aqueduct in the southern part of Cemetery between Citadel and Tariq Magra al-‘Uyum St., together with construction of connection underpass between Tariq Magra al-‘Uyum St. and re-routed Salah Salim St..

Considering such re-routing project of major corridor, E3-3 alignment should be also re-arranged in accordance with their plan. Under such conditions, following alternative arrangements of viaduct are considered;

<u>Alternative-1</u>

As shown in Figure 6.1-5d (top), first possible option is double deck type viaduct; to be able to meet narrower RoW condition like Salah Salim St., although required minimum RoW for this type will be at least 24m to accommodate upper deck supporting piers and to meet Egyptian Fire Defence Law which restricting to keep at least 5m clearance between building surface and viaduct.

- ✓ Construction cost will be more than the single deck type (Alternative-2)
- ✓ Installation of on/off ramp is relatively difficult, even additional RoW is available, since upper deck supporting piers become obstructions for lower deck ramp, and upper deck ramp require much longer approach path between deck and ground

<u>Alternative-2</u>

As shown in Figure 6.1-5d (bottom), second possible option is standard single deck type viaduct as same type as E3-2, although width of Salah Salim St. is narrower than which of Autostrade (Tariq al-Nasr) Rd., therefore application of this type of structure will be limited and only possible to install with Salah Salim St. re-routing plan. This option has following advantage and disadvantage;

- ✓ Construction cost will be less than the double deck type (Alternative-1)
- ✓ At least 36m wide right of way (RoW) required to install this type of structure, since each

direction of structure is at least 12m wide

- ✓ Installation of on/off ramp is relatively easy, if additional RoW is available

Alternative-3

Third possible option is combination of above-described two alternatives.

Since eastern side of the E3-3 section has still room to select any type of viaduct, once GoE decided to acquire land between Citadel and Ein El-Seera area in the Southern Cemetery and segment of Salah Salim St. in Ein El-Seera area is associated with wide green belt space on its south side.

On the other hand, western side of the E3-3 section has almost no room to select but double deck type, unless large-scale land acquisition is taken place where the land-use is already urbanised in the east bank of River Nile, Al-Manyal Island, and west bank of River Nile toward the Giza Square, and it will be almost impossible to implement such re-development projects within the expressway project time frame.

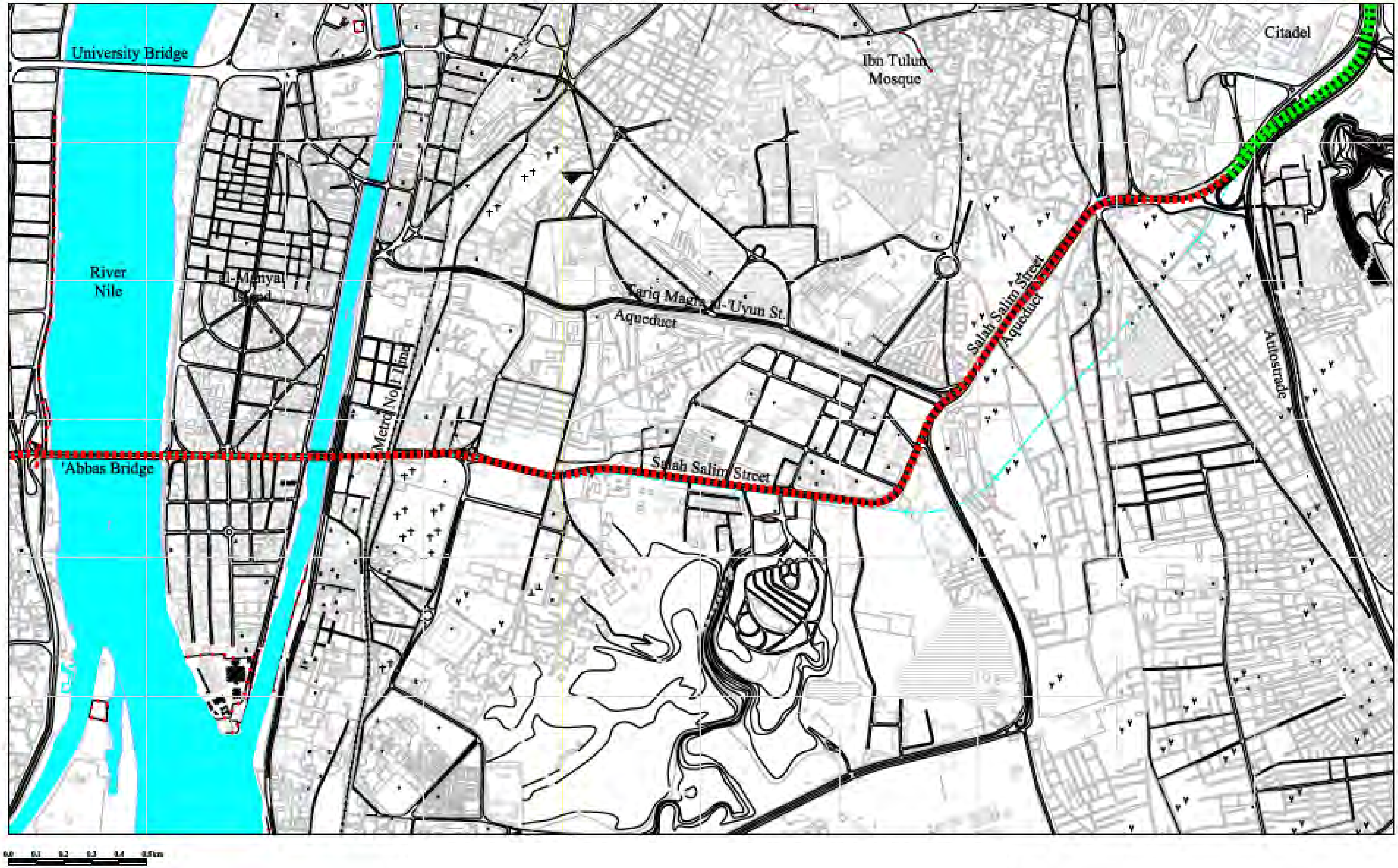


Figure 6.1-5 a   Proposed Alignment Plan for E3-3 (1.1)

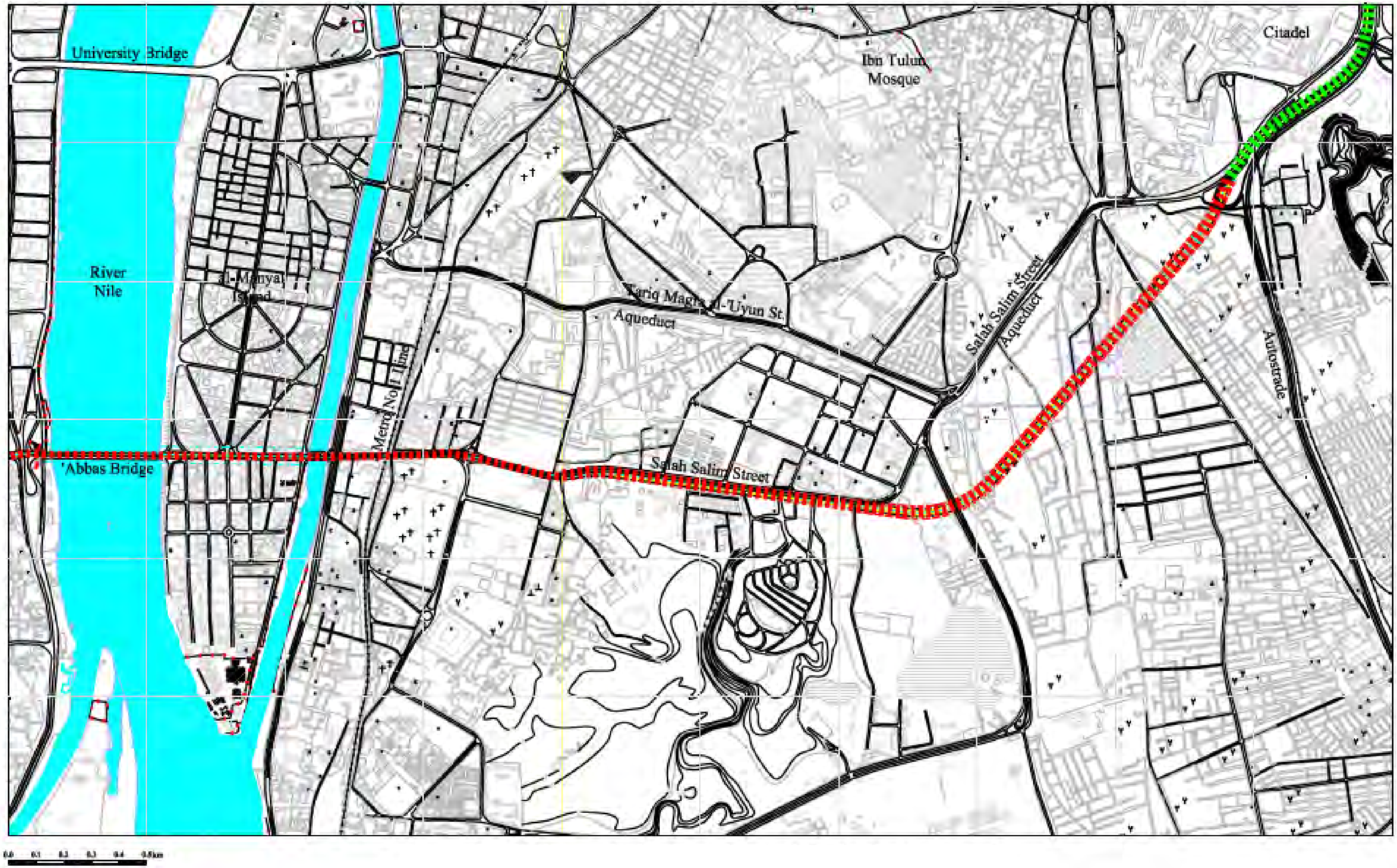


Figure 6.1-5 b   Proposed Alignment Plan for E3-3 (1.2)

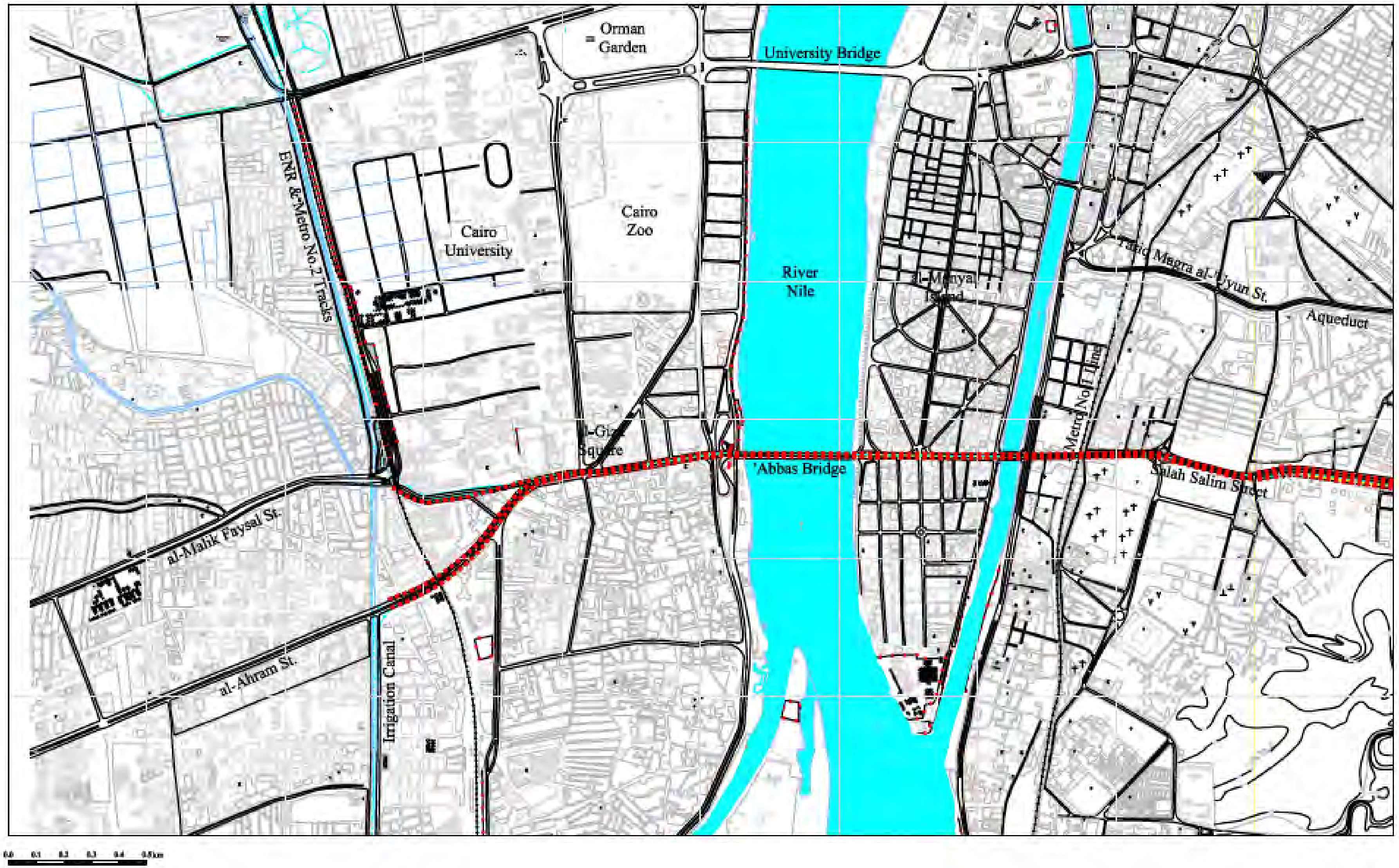
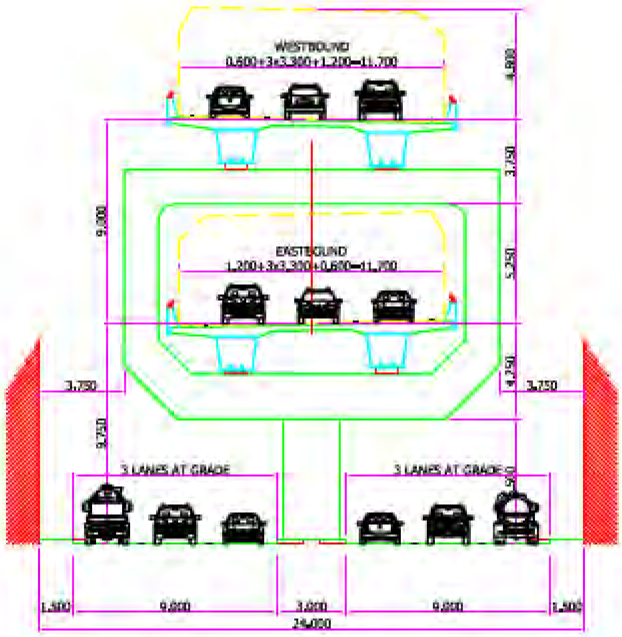
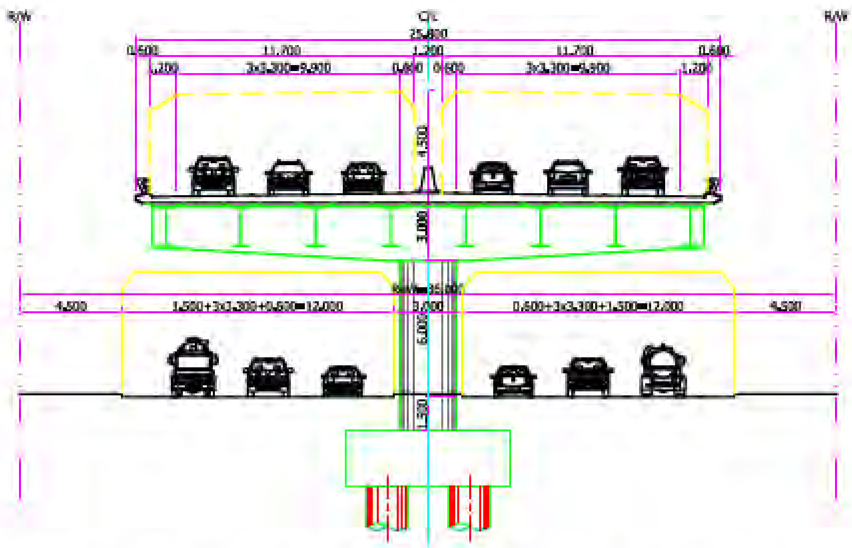


Figure 6.1-5 c Proposed Alignment Plan for E3-3 (2)



Alt.-1 Double Deck Configuration for Narrow Street (RoW=30m or Narrower)



Alt.-2 Single Deck Configuration for Wide Street (RoW=36m or Wider)

Figure 6.1-5 d Proposed Alignment Cross Section for E3-3

6.2 Evaluation Criteria

Following ten (10) general criteria are introduced to evaluate the alternatives each other and select the optimum alignment and/or route among the corridors;

Length

When route choice is concerned, length of route becomes an important factor to evaluate the alternatives in terms of construction cost directly.

Configuration

When different type of configuration (viaduct, underground, or at-grade) is concerned, type of configuration becomes an important factor to evaluate the alternatives in terms of construction cost as well.

Geometric

Horizontal and vertical alignment of the expressway is an important factor to provide a proper level of service. In the initial evaluation, only number of horizontal curvature with limited speed (less than 60 km/hr) shall be applied.

Land Acquisitions

Necessity of land acquisition and its magnitude shall be one of the most important factors to judge whether the alignment is acceptable or not by the citizens and government in terms of both cost and sensitivity.

Accessibility

During and after the construction, new expressway may become an obstruction of the community to split one into two in case of particular type of structure, such as at-grade type, unless otherwise mitigation measures are provided.

Traffic Diversion

During and after the construction, some existing traffic flow may have to divert to the other route to avoid traffic jam and/or due to limited accessibility to the expressway and/or at-grade level road networks.

Public Utilities

Due to construction of new expressway, some major public utility lines might be relocated, and if the magnitude of relocation of subject public utilities becomes large scale, it will increase the construction cost as well.

Landscape

In some historical conservation area, change of landscape becomes more important factor than economical aspects.

Environmental Impact

In some sections, current environmental situation may be affected by new expressway in terms of nuisances, such as noise, vibration, air pollution, etc.

Other Infrastructures

In some sections, beside the public utilities mentioned above, public transport (ENR, Metro, or Tram), and irrigation (River and Canal) facilities as well as other public purpose facilities (public buildings, airport, park, green belt, etc.) may be affected by new expressway.

As shown in Table 6.2-1, within the each criterion, 3-level scores (1, 3, 5) are provided to differentiate the alternatives each other. If single scoring is difficult, average score and/or middle score either 2 or 4 will be applied. And sum of scores of each criterion will be an overall evaluation score of the alternatives, unless otherwise any other considerations are applied.

Table 6.2-1 Evaluation Criteria and Scores

Score	1	3	5
Length	Long	Intermediate	Short
Configuration	Underground	Viaduct	At-Grade
Geometric (m)	< R120	R120 - R240	> R240
Land Acquisitions (ha)	> 1.0	0.1 - 1.0	< 0.1
Community Accessibility	Fully Limited	Partially Limited	Non Limited
Traffic Diversion ('000 pcu/day)	> 10	5 - 10	< 5
Public Utilities	Large	Intermediate	Small
Landscape	Reserved	Partially Reserved	Urbanized
Environmental Impact	Large	Intermediate	Small
Other Infrastructures	Large	Intermediate	Small

6.3 Comparative Analysis

As shown in following Table 6.3-1~5, alternative alignments and/or configurations are assessed based on the evaluation criteria set forth in the previous section through the various discussions between the Study Team and the Counterpart Team during the course of the Study, as well as with the Steering Committee Members in the 2nd Steering Committee Meeting held on late November 2008 at GARBLT.

Note that these comparative analyses are provisional and very simple without weighing each criterion, therefore further discussions will be needed based on the facts we have found so far and/or any other factors which we have not recognized yet. Although we may have to consider all alternatives in terms of not only technical, economical, and financial points of views, but also environmental and social points of view as well, even after various independent meetings and discussions with other relevant ministries and authorities or entities, such as Ministry of Housing and Urban Development, Ministry of Defence, Ministry of Culture, Ministry of Water Resources and Irrigation, Ministry of Agriculture, Ministry of Investment, Ministry of Finance, Cairo Governorate, Giza Governorate, National Authority for Tunnels, Egyptian National Railways, and so on.

Table 6.3-1 Simplified Comparative Analysis for E1-2

Alternatives	Alternative-1 (via al-Duqqi St.)		Alternative-2 (via al-Tahrir St.)		Alternative-3 (via al-Giza St.)		Alternative-4 (via al-Sawra St.)		Alternative-5 (via al-Arabiya St.)	
Length (km)	Relatively Short (4.4)	4	Relatively Long (6.1)	2	Intermediate (5.1)	3	Relatively Short (4.5)	4	Intermediate (5.3)	3
Configuration	Viaduct	3	Viaduct	3	Viaduct & Long Span Bridge	2	Tunnel & Viaduct	1	Viaduct	3
Geometric (m) [Radius and Number of Curves]	R120 x 2 (2) R360 x 1 (5) R300 x 1 (5) R600 x 1 (5)	4	R240 x 1 (3) R150/180 x 1 (3) R90 x 1-Ramp (3)	3	R360 x 2 (5) R180 x 1 (3) R120 x 1 (2)	4	R360 x 4 (5) R120/150 x 1 (2) R90 x 1-Ramp (3)	3	R90 x 2 (1) R240 x 3 (3) R270 x 1 (4) R360 x 1 (5) R90 x 1-Ramp (3)	3
Land Acquisitions (ha)	Secondary School or Ministry of Agriculture	1	Railway Police Office	4	Mosque beside Giza Police HQ	3	Railway Police Office	4	Agriculture Museum, Railway Police Office	2
Community Accessibility	Partially Limited	3	Partially Limited	3	Partially Limited	3	Almost Not Limited	4	Partially Limited	3
Traffic Diversion ('000 pcu/day)	al-Duqqi	1	al-Tahrir	3	al-Giza	3	6th Ocotober, Al-Masthaf al-Zira'i	2	Al-Batal Ahmad Al-Alamiya	1
Public Utilities	Relatively Large	2	Relatively Large	2	Relatively Large	2	Relatively Small	4	Relatively Large	2
Landscape	Oman Garden	1	Nile River (Channel)	3	Nile River (Main) Opera House	2	Agriculture Museum Shooting Club	4	Agriculture Museum	3
Environmental Impact	Cairo University	2	Gazira Sports Club	3	Cairo University	2	Al-Sawra Square	2	Mohandiseen	2
Other Infrastructures	Dokki Flyover (585m)	3	Metro No.2 ENR	1	Metro No.2	3	Metro No.2 & 3 Extension, ENR Irrigation Canal	2	Metro No.2 & 3 Extension, ENR, Irrigation Canal	2
Overall Score		24		27		27		30		24

Table 6.3-2 Simplified Comparative Analysis for E2-2

Alternatives	Alternative-1 (Additional)		Alternative-2 (Replacement)		Alternative-3 (Combination)		Alternative-4 (Parallel Deck)	
Length (km)	1.8 km (1.0 km / 26 July St. and 0.8 km / Ramsis St.)	4	1.8 km (1.0 km / 26 July St. and 0.8 km / Ramsis St.)	4	1.8 km (1.0 km / 26 July St. and 0.8 km / Ramsis St.)	4	1.8 km (1.0 km / 26 July St. and 0.8 km / Ramsis St.)	4
Configuration	Viaduct (Double)	3	Viaduct (Double)	1	Viaduct (Double)	2	Viaduct (Parallel)	4
Geometric (m) [Radius and Number of Curves]	R120 x 1	2	R120 x 1	2	R120 x 1	2	R120 x 1	2
Land Acquisitions (ha)	(Museum)	3	Nil	5	Nil	5	Very Large Scale	1
Community Accessibility	Partially Limited	3	Partially Limited	3	Partially Limited	3	Partially Limited	3
Traffic Diversion (‘000 pcu/day)	26th July St. (eastbound)	3	26th July St. (both)	1	26th July St. (both)	2	26th July St. (Westbound)	3
Public Utilities	Intermediate	3	Intermediate	3	Intermediate	3	Relatively Less	4
Landscape	Ramsis St.	3	Ramsis St.	3	Ramsis St.	3	Ramsis St.	3
Environmental Impact	Relatively Large	2	Relatively Large	2	Relatively Large	2	Large	1
Other Infrastructures	Metro No.1 & No.3	1	Metro No.1 & No.3	3	Metro No.1 & No.3	3	Metro No.1 & No.3	3
Overall Score		27		27		29		28

Table 6.3-3 Simplified Comparative Analysis for E3-1

Alternatives	Alternative-1 (Viaduct)		Alternative-2 (Depressed)		Alternative-3 (At-Grade)	
Length (km)	Relatively Long (6.5)	2	Relatively Long (6.5)	2	Relatively Long (6.5)	2
Configuration	Viaduct (Parallel-6)	3	Depressed (Paralell-6)	3	At-Grade (Parallel-6)	5
Geometric (m) [Radius and Number of Curves]	R450 x 1 R900 x 2	5	R450 x 1 R900 x 2	5	R450 x 1 R900 x 2	5
Land Acquisitions (ha)	Nil	5	Nil	5	7.5m x 2 x where RoW=45m	1
Community Accessibility	Partially Limited	3	Non Limited	5	Full Limited	1
Traffic Diversion ('000 pcu/day)	Autostrade	3	Autostrade	2	Autostrade	1
Public Utilities	Intermediate	3	Relatively Large	2	Relatively Small	4
Landscape	Very Affected	1	Not Affected	5	Affected	3
Environmental Impact	Intermediate	3	Small	5	Large	1
Other Infrastructures	Tram	3	Tram	3	Tram	3
Overall Score		32		38		27

Table 6.3-4 Simplified Comparative Analysis for E3-2

Alternatives	Alternative-1 (above Roadway)		Alternative-2 (above Railway)		Alternative-3 (between Roadway and Railway)	
Length (km)	Relatively Long (6.5)	2	Relatively Long (6.5)	2	Relatively Long (6.5)	2
Configuration	Single Pier Viaduct (Parallel-6)	3	Double Pier Viaduct (Parallel-6)	2	Single Pier Viaduct (Parallel-6)	3
Geometric (m) [Radius and Number of Curves]	R600 x 3, R900 x 1, R1050 x 2, R300 x1, and R330 x 1	5	R600 x 3, R900 x 1, R750 x 2, R300 x1, and R330 x 1	3	R600 x 3, R900 x 3, R300 x1, and R330 x 1	4
Land Acquisitions (ha)	Arab Contractor	3	Arab Contractor	3	Arab Contractor	3
Community Accessibility	Partially Limited	3	Partially Limited	3	Partially Limited	3
Traffic Diversion ('000 pcu/day)	Autostrade	1	Cargo Train	3	Autostrade Cargo Train	2
Public Utilities	Large	1	Small	5	Intermediate	3
Landscape	Slightly Affected	3	Slightly Affected	3	Slightly Affected	3
Environmental Impact	Intermediate	3	Intermediate	3	Small	5
Other Infrastructures	n/a	5	ENR	3	ENR	4
Overall Score		29		30		32

Table 6.3-5 Simplified Comparative Analysis for E3-3

Alternatives	Alternative-1 (Single Deck)		Alternative-2 (Double Deck)		Alternative-3 (Combination)	
Length (km)	Intermediate (6.5)	3	Intermediate (6.5)	3	Intermediate (6.5)	3
Configuration	Viaduct (Parallel-6) w/ Suspension Bridge	4	Viaduct (Double-6) w/ Suspension Bridge	2	Viaduct (Parallel-6 & Double-6) w/ Suspension Bridge	3
Geometric (m) [Radius and Number of Curves]	R480 x 2, R360 x 5, R240 x 1, R600 x 1	4	R360 x 8, R180 x 1, R120 x 1, R240 x 1, R600 x 1	3	R480 x 2, R360 x 5, R240 x 1, R600 x 1	4
Land Acquisitions (ha)	Large	1	Small	5	Intermediate	3
Community Accessibility	Partially Limited	3	Partially Limited	3	Partially Limited	3
Traffic Diversion (‘000 pcu/day)	Salah Salim St.	3	Salah Salim St.	3	Salah Salim St.	4
Public Utilities	Relatively Large	2	Large	1	Intermediate	3
Landscape	Affected	2	Very Affected	1	Partially Affected	3
Environmental Impact	Intermediate	3	Very Large	1	Relatively Large	2
Other Infrastructures	Metro No.1 & No.4	3	Metro No.1 & No.4	3	Metro No.1 & No.4	3
Overall Score		28		25		31

6.4 OPTIMUM ALIGNMENT / ROUTE / CONFIGURATION

6.4.1 F/S Corridors

(1) E1-2

Based on the simplified comparative analysis in previous section as well as discussions with GoE officials in the course of the Study and its Second Steering Committee Meeting held in late November 2007, Alternative-4 (Tunnel) is recommended for E1-2 corridor.

However there are several technical and financial difficulties to implement this scheme in spite of its advantages, such as less utility relocation, minimum land acquisition, less environmental and social impact, and less landscape disturbance.

The largest obstruction of this scheme is its cost as shown in Chapter 11 Preliminary Cost Estimation, which indicated that unit cost for shield tunnel is more than quadruple, and even still more than triple of which of viaduct scheme if including relocation cost of underground public utilities for viaduct foundation. In other words, if we have any choices and even length of viaduct is three times longer than which of shield tunnel, still viaduct is economical than shield tunnel.

Therefore, to take and implement this alternative, GoE should have very strong willingness for the sake of minimizing land acquisitions, landscape disturbance, and environmental and social negative impacts, and further more to shoulder the construction cost which should not be beard by only road users and/or citizens as toll and/or tax, unless it is more than their benefit level.

Issues of revenue and toll level as well as economical and financial viabilities shall be discussed in Chapter 12 Toll Road Legislation and Chapter 13 PPP Implementation.

Besides the above mentioned difficulties, following conditions shall be taken into account further more during the detail design stage and its preparation stage from now on.

Option-1; 6th October Bridge Modification (1)
Starting point of the tunnel will be under the existing 6th October Bridge along al-Mathaf al-Zira'i St. (RoW=39m~30m) before reaching al-Batal Ahmad ‘Abd al-‘Aziz St.

Section between al-Batal Ahmad ‘Abd al-‘Aziz St. and Dr. Muhammad Shahin St. of al-Mathaf al-Zira'i St. is narrower than the other section, therefore road tunnel and its transition section should be completed before reaching Dr. Muhammad Shahin St. to provide accessibility to the properties facing al-Mathaf al-Zira'i St.

To do so, existing on/off ramps located east side of Dr. Muhammad Shahin St. shall be removed and replaced with much steeper but wider ramps, together with depressed transition structure under the 6th October Bridge.

And at-grade level access roads (westbound in the north of off-ramp and eastbound in the north of on-ramp and under the bridge) shall be modified as follows;

- ✓ Westbound shall be narrowed from 6m to 4.5m or less
- ✓ Eastbound shall be relocated into adjacent community park with library facility

Other options are also available to avoid this kind of complicated modification of existing bridge and ramp structures with local open space acquisition.

However they also have some advantages and disadvantages as follows;

<u>Option-2; Shifting Transition Section toward East in Zamalek / Gazira Island</u>
This option will cancel negative factors of former option indicated above, although tunnel section becomes longer and require crossing Little Nile by submerged or shield tunnel, therefore it will increase the cost further more.

In addition, underpinning of existing 6th October Bridge will be still necessary despite the facts that narrowing access roads and encroaching Community Park will not be necessary.

<u>Option-3; Shifting Transition Section toward West beyond the Existing Loop Ramp</u>
This option will cancel negative factors of previous two options indicated above, although demolition of existing loop ramp will induce the termination of left-turn traffic movement from westbound flow on the 6th October Bridge to southbound flow on al-Batal Ahmad 'Abd al-'Aziz St. as well as same left-turn traffic movement from the southbound traffic flow on the street to eastbound traffic flow on the bridge.

Therefore, to revive those traffic movements within the vicinity of existing loop ramp, one possible option is to let those traffic movements use nearest U-turn bays located both north and south sides of the bridge along said major arterial, and let them make U-turn after and/or before using the other ramps from/to the bridge which remain as they are.

<u>Alternatively, by providing new strait ramps beside the tunnel transition section inside the Agricultural Museum Compound, and let those traffic movements to divert all the way along both streets running north and south sides of the MoA compound, then rejoin the said major arterial at right angle.</u>

Option-4; 6th October Bridge Modification (2)

This option will be an absolute resolution over the other three options, although some major civil works are required. This will have very major advantage as urban toll expressways since former three options will not be able to separate expressway traffic from the local traffic on the 6th October Bridge.

This is because of its configuration. All former three configurations require sharing of road space on the "6th October Bridge" with local and expressway traffic all together; and they have to breech common traffic rule as inner lanes for fast track (expressway traffic) and outer lanes for slow track (local traffic), by providing expressway connection ramps outer side, except option-3.

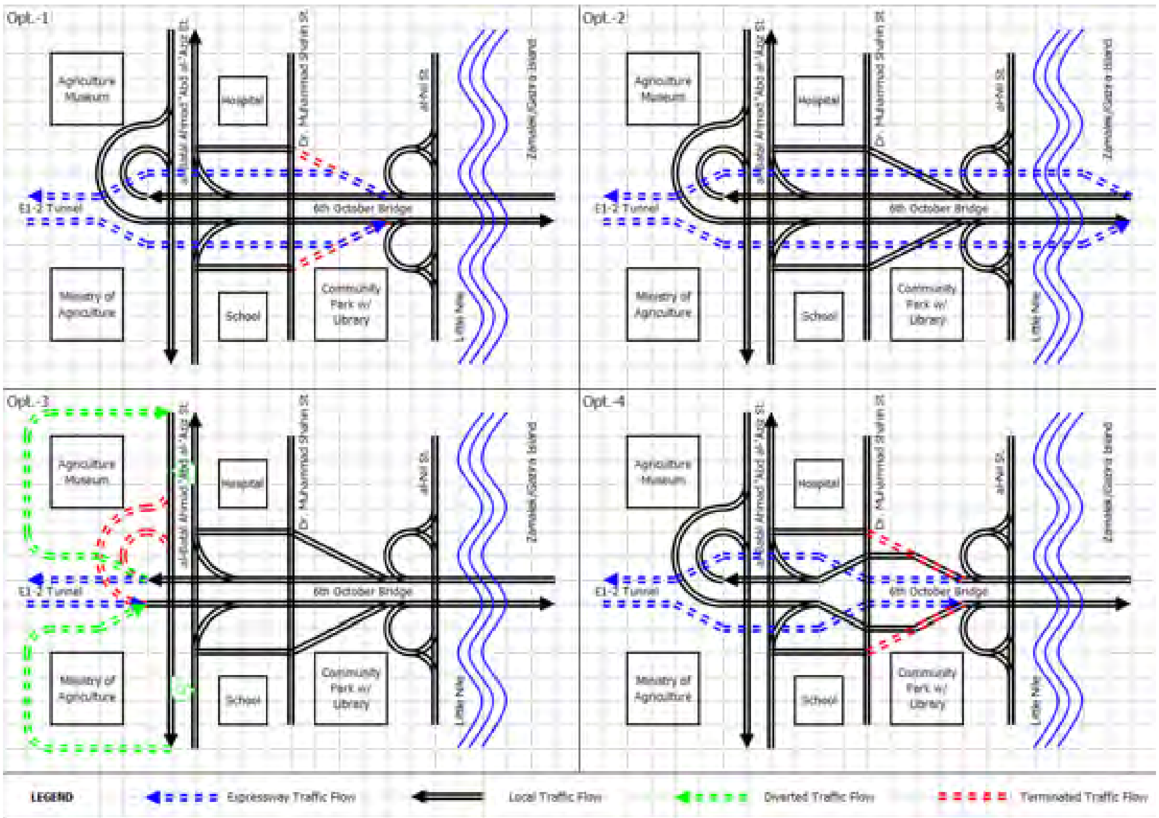


Figure 6.4-1 Schematic Conceptual Plans of Transition Section for E1-2 Tunnel

Major civil works are consisted of followings steps;

- ✓ 1st Step; Close existing parallel on/off ramps along "6th October Bridge" between loop ramps from/to al-Nil St. and Dr. Muhammad Shahin St.
- ✓ 2nd Step; Construct split viaducts along "6th October Bridge" above closed parallel on/off ramps and re-connect both east and west ends to the Bridge
- ✓ 3rd Step; Demolish "6th October Bridge" about same section above
- ✓ 4th Step; Construct transition ramp toward the tunnel section under "6th October Bridge" remaining between Dr. Muhammad Shahin St. and al-Batal Ahmad 'Abd

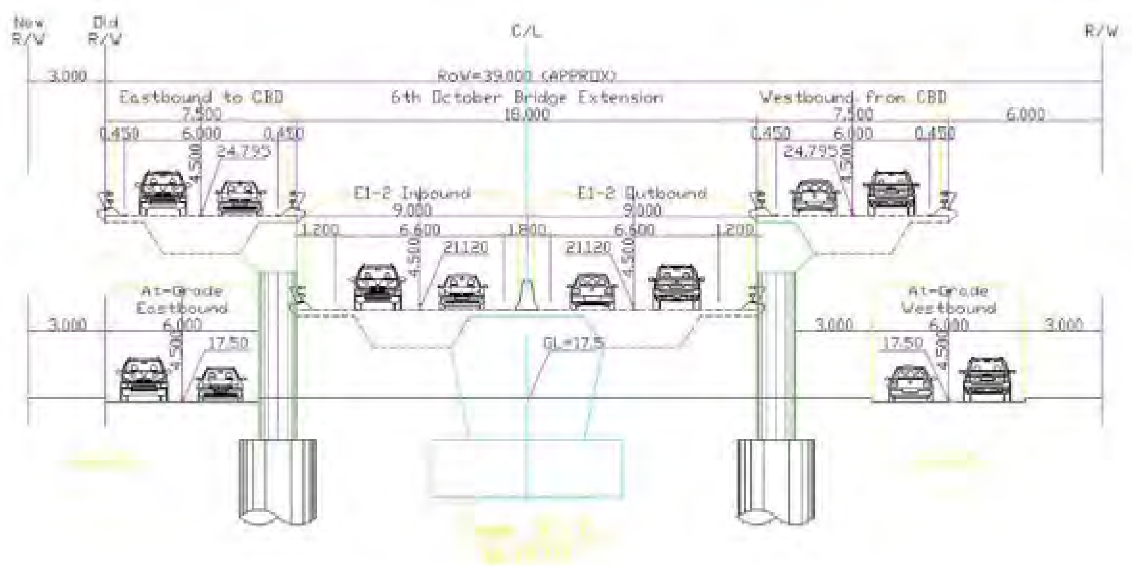


Figure 6.4-2 Conceptual Cross Section for E1-2 Transition Segment

<u>Agricultural Museum & al-Sawra St.</u>

Under Agricultural Museum Compound and al-Sawra St., parallel twin shield tunnel is proposed.

This type of tunnel does not require open-cutting from the ground surface, except vertical shaft to launch and/or retrieve the shield machine.

Tunnel alignment is arranged to avoid running directly under the old buildings in the Agricultural Museum Compound, based on the information from Ministry of Agriculture that those buildings are about 200 years old, and should be conserved.

Therefore the alignment is making reverse curve toward al-Sawra St. in the said compound.

Also, due to width of each tunnel and room between two structures, at least 27~30m wide space is required, and width of al-Sawra St. is around 24m, as a result centre line of twin tunnel shall be off set 3m toward the south along the street, to avoid foundation of mid/high raised buildings standing north side of the street.

<u>Shooting Club Compound & Gadda (Jeddah) St.</u>

Under Shooting Club Compound, tunnel alignment will make the other reverse curve and westbound tunnel shall change its depth much deeper to enter almost direct below of eastbound tunnel to pass through much narrower Gadda (Jeddah) St. (RoW=12m) with tandem twin configuration to avoid foundations of mid/high raised buildings standing both sides of the street.

Ventilation Shaft

Tunnel length will be 1.5km each, and traffic volume for each direction will be more than 30 thousand pcu per day in 2027, therefore somewhere in the middle and/or both sides of the tunnel section, ventilation shafts will be needed.

Possible location of ventilation shaft will be either inside Agricultural Museum or Shooting Club Compound where the tunnel will run directly under the compound, and relatively wide open space is available.

Alternatively, al-Sawra Square and/or median green-belt located just south of the square along Dr. Mishil Bakhum will be suitable for installation of such ventilation shaft, if both of above candidates are not suitable.

Although, installation of ventilation shaft in the square or median will require lateral underground shaft and further environmental impact assessment, since location of the square is not directly above the tunnel, and a lot of residential buildings are standing already around the square.

The other option for installing ventilation shafts is utilizing shield machine launching/retrieving shafts at both ends of the tunnels by converting them as ventilation shafts after tunnel constructions and de-assembling of shield machine have done.

Minimum Curve Radius at the Corner of al-Sudan St. and Gadda (Jeddah) St.

To avoid touching foundation of the buildings at the corner of the two streets and the other building standing between al-Sudan St. and ENR Track just south of high raised Radio Tower, curve radius of 100m (R100) is required.

Although, R100 is only acceptable for design speed of 50 kph with 6% super elevation, therefore, if design speed of 60 kph is desired, at least R120 with 10%, preferably R150 with 6% is recommended for minimum curve radius.

To install R150 or R120 in this particular corner, land acquisition might be necessary, since even tunnel will pass at least 6m deep from the ground surface, foundation depth and/or influence to the building(s) are not be certain yet.

Widening of Tunnel at Tight Curve Segments

Further more, such tight curves require widening of inner spaces to maintain enough sight distance. This sight distance is set as 75m (required to full stop in case of obstruction and/or breakdown vehicle on same lane ahead) for design speed of 60kph.

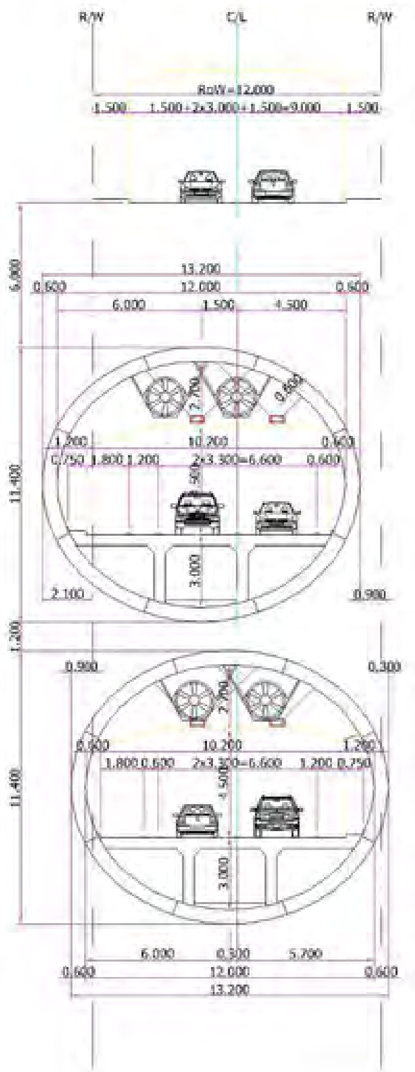


Figure 6.4-3 Conceptual Cross Section for E1-2 Shield Tunnel Widening

In the tunnel, inner side wall blocks this sight distance in smaller radius of curve such as R120 and R150 which we are intending to install at above-mentioned location.

Formula to obtain approximate side clearance to maintain above sight distance along the curved segment is;

E = D^2/8R

Where,

E; Side Clearance between Centre of Inner Lane and Inner Wall,

D; Sight Distance, and

R; Curve Radius

In case of in-bound tunnel, if R120 is applied, E = 5.85m (= 75^2/8/120) is required.

Although we have wider shoulder of 1.2m and catwalk with extra space for another 1.2m on the right hand side (inner side of curve and outer side of way), so total width between Centre of Inner Lane and Inner Wall becomes 4.05m (= 3.3/2+1.2+1.2). Therefore we do need to widen tunnel about 1.80m (= 5.85m - 4.05m).

In case of out-bound tunnel, if R150 is applied, E = 4.65m (=75^2/8/150) is required. And we have narrower shoulder of 0.6m with extra space for another 0.6m on the left hand side (inner side of curve and inner side of way), so total width between Centre of Inner Lane and Inner Wall becomes 2.85m (= 3.3/2+0.6+0.6), therefore we need to widen tunnel about 1.80m (= 4.65m - 2.85m) as well.

<u>Transition Section along ENR Track and Irrigation Canal</u>

Transition from tunnel to viaduct or visa versa requires relatively long length about 450m to 500m without vertical curve section. RoW of ENR around this and northern section is about 18~24m wide and 4 tracks are running currently.

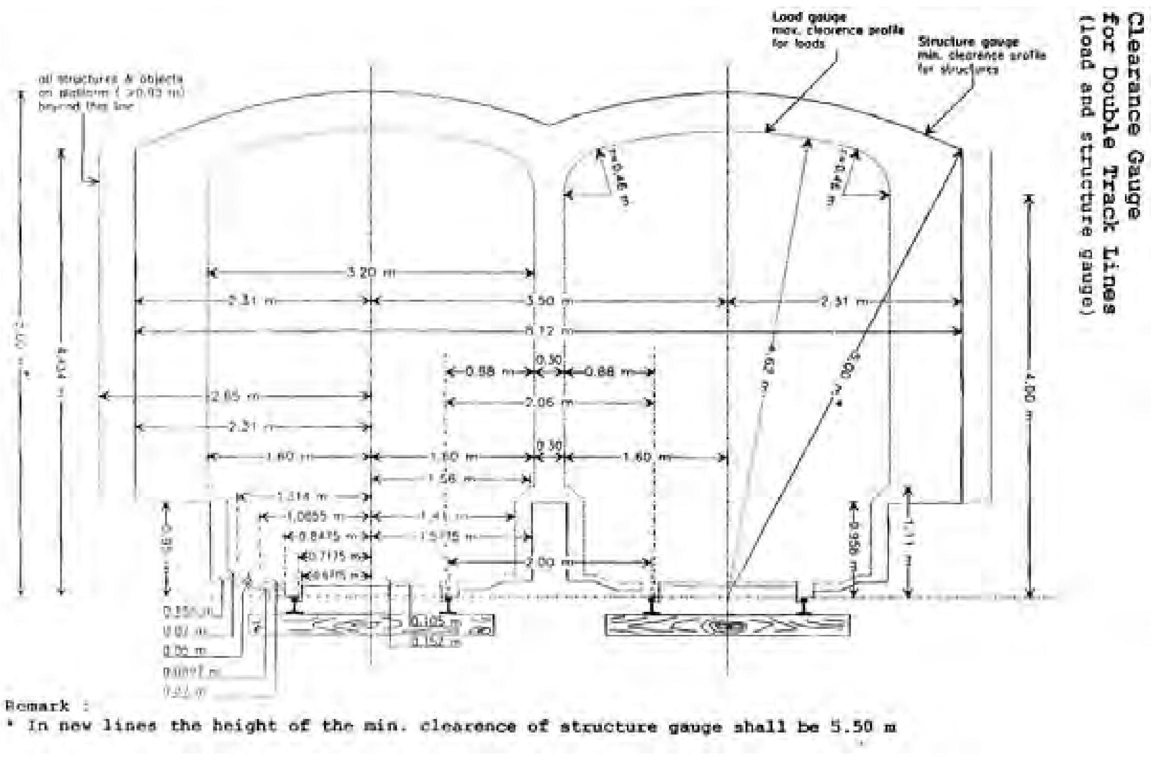


Figure 6.4-4 ENR Clearance Gauge

On the other hand, southern section after this point, RoW of ENR is gradually widened and number of tracks is also increased toward the ENR station and engine and/or cargo train yard with workshop. Width of this southern section is varied from 32m to more than 100m

Applying ENR Clearance Gauge, minimum track centre spacing is 3.5m for existing and 4.0m for new lines based on the information from ENR. Therefore, for example, to accommodate 4 tracks without any extra room, at least 15.8m or 17.3m (= 2.65 + 3 x 3.50 or 4.00 + 2.65) open space above ground is required according to the existing or new line requirements.

In addition, about 12~15m wide irrigation canal is running parallel between ENR Track and the other local street on the west, and this irrigation canal was covered partially, and now underway to cover whole section by joint project between Giza Governorate and Ministry of Water Resources & Irrigation in cooperation with the Government of Germany.

Transition section of E1-2 shall be spitted to utilize available spaces, one on the east and the other on the west of ENR Track. Therefore, some realignment works will be necessary for both ENR and Irrigation Canal to accommodate 10~12m wide each transition section structures together with future E9 viaduct substructures beside or between them.

Realignment and/or partial removal of ENR Tracks will be arranged within current ENR RoW. On the other hand, realignment of Irrigation Canal will be arranged by utilizing underground space of the parallel running local street on the west, if necessary.

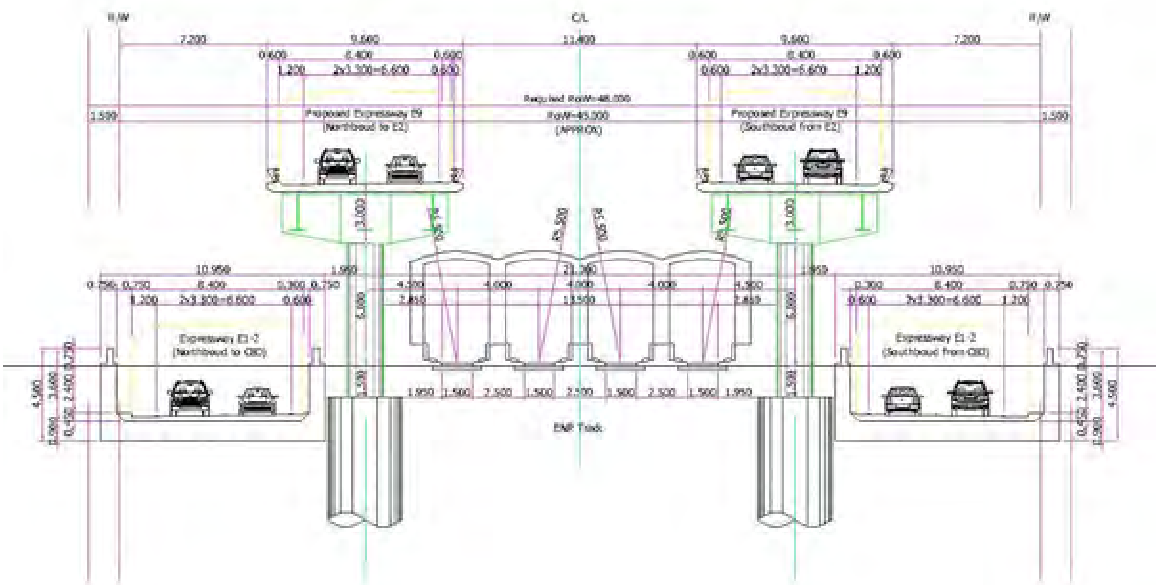


Figure 6.4-5 a   Conceptual Cross Section for E1-2/E8/E9 above ENR Track (1)

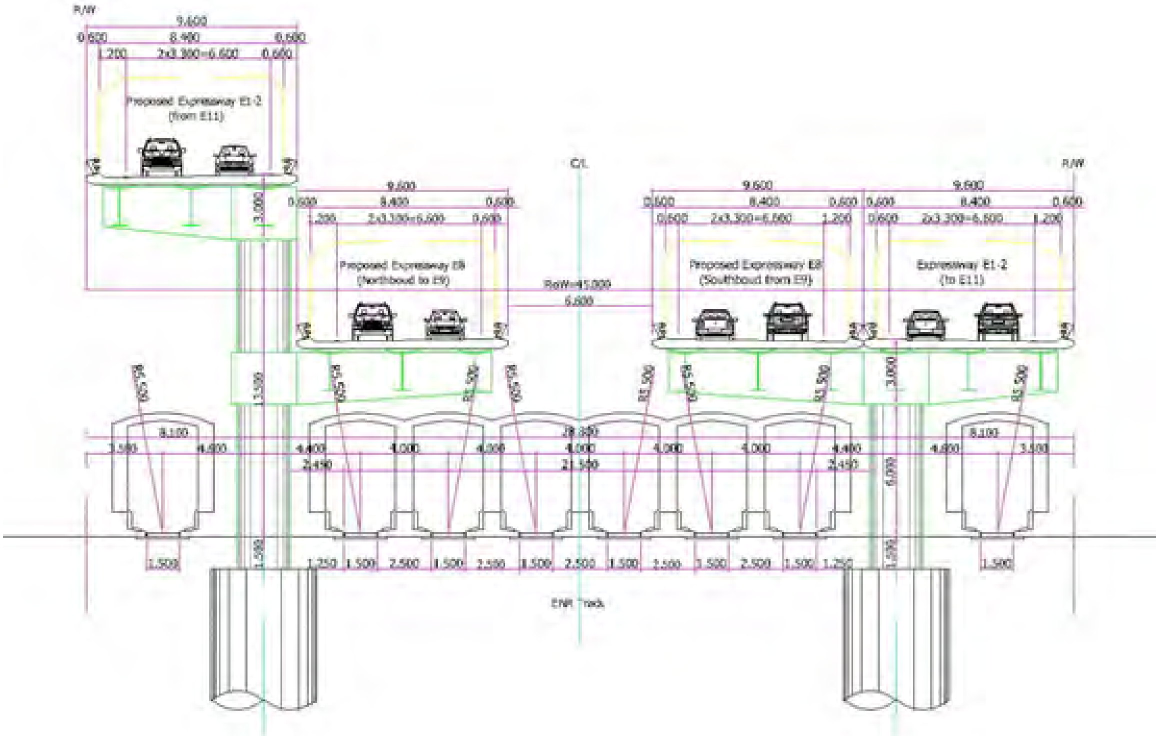


Figure 6.4-5 b Conceptual Cross Section for E1-2/E8/E9 above ENR Track (2)

(2) E2-2

Based on the simplified comparative analysis in previous section, Alternative-3 (Combination) is recommended for E2-2 corridor.

To implement this scheme, following conditions shall be taken into account further more during the detail design stage and its preparation stage from now on.

<u>Metro No.3 Line and its Maspero Station</u>

National Authority for Tunnel (NAT) has been planning to construct Metro Line No.3 along same corridor under its Phase-3 stage after completion of on-going Phase-1 and Phase-2 stage which connect between Attaba in Cairo Downtown and Salah Salim in Heliopolis.

To construct E2-2 viaduct above proposed Maspero Station, E2-2 substructure should be integrated with Maspero Station structures, and its construction cost shall be shared between NAT and MEA although both authorities are under the same umbrella of Ministry of Transport. Therefore it is expected that such technical and financial coordination will be implemented without so much complexities.

<u>Nuisance Evaluation</u>

Width of double deck structure is around 9 m and width of 26 July St. is 24 m in average and narrowest section is only 20 m wide. Therefore minimum clearance of 5 m will be provided for both sides of the viaduct with middle raised buildings along the street, and which is cleared Egyptian Fire Defence Law requirement at least.

However, for residents and shop owners as well as road users, negative impacts by nuisances, such as noise, vibration, and air pollutants, will be expected.

Therefore, evaluating aforementioned negative impacts, simplified nuisance simulation shall be presented in the course of the Study.

Traffic Diversion Programme

Before and during the construction of E2-2 viaduct together with Maspero Station of Metro Line No.3, traffic using existing 15th May Bridge (Westbound) and 26 July St. shall be diverted to other corridors since width of road space is limited and traffic demand between Cairo and Zamalek or Mohandiseen is currently approximately 128 thousand pcu per day, and it will be 137 thousand in 2017, and 189 thousand in 2022, if no project is implemented.

Extension above Ramsis St.

To connect E2-2 with 6th October Bridge, construction of 2-lane viaduct with approximately 875m is required above Ramsis St. where Metro Line No.1 and its Nasser and Orabi stations are situated.

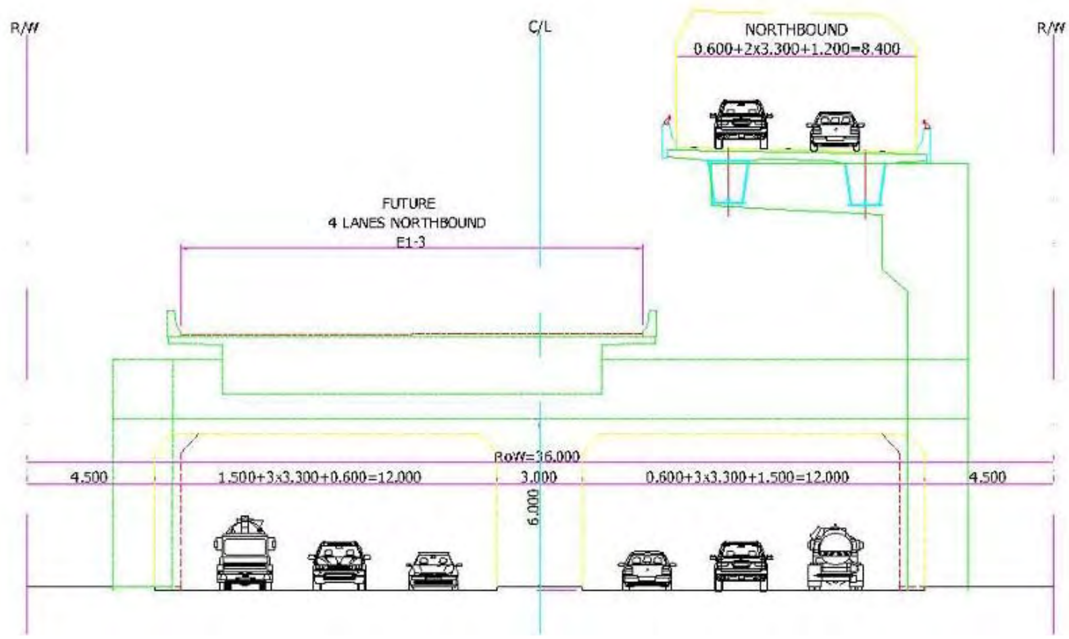


Figure 6.4-6 Conceptual Cross Section for E2-2 Extension and E1-1 Bypass

Further more, to accommodate future traffic demand along 6th October Bridge between River Nile crossing and future junctions with E5 and E7, construction of parallel viaduct with at least 3- or 4-lane above Ramsis St. (tentatively called as E1-1 Bypass) will be necessary.

Therefore again, coordination works between NAT and MEA will be essential.

<u>Main Stream Toll Plaza</u>

Due to limited road space along E2-2 corridor and its irregular configurations, tolling facility is not installable at east side of River Nile. Alternative location of installing such tolling facility is found on the west side of River Nile in Mohandiseen, such as above Sphinx Square. Figure 6.4-5 shows such tolling facility to cover both in and outbound traffic at once by constructing wide viaducts along existing one.

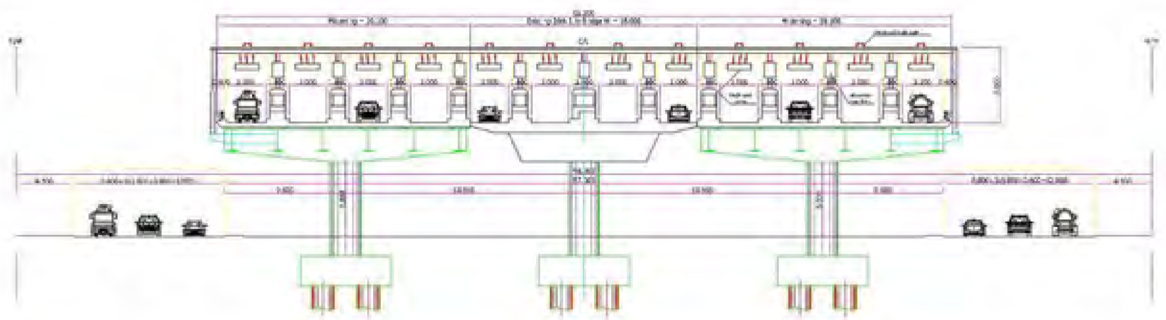


Figure 6.4-7 Conceptual Cross Section for Main Stream Toll Plaza

(3) E3-1

Based on the simplified comparative analysis in previous section, Alternative-2 (Depressed) is recommended for E3-1 corridor.

To implement this scheme, following conditions shall be taken into account further more during the detail design stage and its preparation stage from now on.

<u>Underground Public Utilities</u>

Underground public utility relocation plan shall be provided prior to the construction, and implemented smoothly by GoE with its own expenses in very early stage of the project. Especially coordination with large scale sewer main pipe under Nasr Rd. should be essential since it will not be possible to relocate, therefore very detail underground investigation works shall be necessarily to confirm its depth and location whether it will affect to E3-1 depressed structures or not, much precisely.

<u>Traffic Control and Management</u>

Traffic control and management along Nasr Rd. will be essential especially during the underground public utility relocation and following construction period which will be continuing at least 5 years by section by section.

Most congesting spots (black spots) along this corridor are observed at every intersections and

U-turn bays where prohibition of left turn from main carriageway as well as crossing from collector roads is implemented.

This type of traffic control methods is basically very practical, since no manual control by police officer nor automatic signal control is required, if traffic volume is limited such as night time and/or off-peak hours.

However, during the peak hours in the daytime, this type of traffic control would not be so efficient since diverting traffic, which is not necessarily to remain main carriageway, has to share the road space with other through traffic until they find the way out or in.

That is why current condition is already chaotic, especially at aforementioned black spots during the peak hours. Furthermore, illegal on-street parking behaviours by vehicle users and residents induce these already chaotic conditions further worse in spite of traffic police officers' efforts every day and night.

Therefore, first of all, all illegal parking vehicles shall be removed from the road space to keep enough room for through traffic as well as construction works, and then if necessary, allowing left turn at the designated intersection with automatic signal control shall be implemented not only before and during, but also after the construction of the expressways, since some U-turn bays will be closed due to depressed expressway presence.

And comprehensive traffic control system should be introduced as well to offer much more smooth traffic flow along the at-grade level corridor to accommodate much more local traffic demands in the same but limited road space in the near future.

Land Acquisition

Despite the all efforts to minimize the land acquisition, some lands along the corridor might be acquired to accommodate on/off ramps and toll booth for expressway, or extra right, left, and U-turn bays for at-grade level at once in same sections.

However it will be avoidable by following counter measures;

- ✓ Minimize the facilities required in the particular one section and relocate them to other section where room is still available first.
- ✓ Re-adjusting requirements of width of each lane and/or number of lanes for both expressway and at-grade levels based on the micro traffic simulation, which is out of scope in this F/S Study.
- ✓ Introducing traffic demand control scheme, such as staggered working time concept, licence number plate control, congestion tax scheme, etc. to distribute and/or reduce the

peak hour traffic demands

- ✓ Provision of more off-street parking spaces along the corridor or inside the Nasr City to completely eliminate illegal on-street parking which reduces the capacity of the roads
- ✓ Provision of grade separation for crossing collector roads under or above expressway

6.4.2 Pre-F/S Corridors

(1) E3-2

Based on the simplified comparative analysis in previous section, Alternative-2 (Middle) is recommended for E3-2 corridor.

To implement this scheme, following conditions shall be taken into account further more during the detail design stage and its preparation stage from now on.

Arab Contractor Compound

As transition between depressed and viaduct sections, land acquisition about 30m wide and 500m long along the segment out side of right of way, in this case south of Nasr Rd., is required.

Fortunately, due to ground level change (toward the west, it goes down) slope of this transition would be only 3%, and in front of Arab Contractor Compound, embankment is situated between property wall line and road space with about 30m wide and 500m long.

However, some minor modification would be necessary to set back their approach pass toward the hill westward to slightly south side to accommodate transition structures of expressway.

ENR Cargo Track

After the transition section, centre line of viaduct shall pass just between Tariq al-Nasr (Autostrade) Rd. and ENR Cargo Railway Track, both of which run parallel until the road over passing railway. Therefore, disturbance to general vehicle traffic and railway operation shall be minimized.

During and after the construction of expressway, informal encroachment inside ENR railway property line along Autostrade (Tariq al-Nasr) Rd. shall be eliminated. And, if necessarily, re-allocation of space under the elected viaduct space for nearby neighbourhood’s further activities and/or parking space with proper charge or public activity spaces without charge are recommended, if ENR side has no plan to convert their single track to double track and/or commuter lines.

Land Acquisition in the Cemetery

To accommodate expressway viaduct along Tariq al-Nasr (Autostrade) Rd. viaduct at its north side along westbound (at-grade level) street, 15m wide land acquisition will be required inside the Northern Cemetery.

Furthermore, in case of closure of existing bridge which connect Salah Salim St. and Muqattam Hills, to accommodate direct connection ramp between Autostrade Rd. and Salah Salim St., additional land acquisition will be necessary along Salah Salim St. between junction with Tariq al-Nasr Rd. (at-grade level) and overpass on Qarafet Bab el-Wazir St. in the Northern Cemetery as well.

Citadel

To stay as low profile as possible, new expressway superstructure shall be installed horizontally and vertically between Salah Salim St. and Autostrade Rd. to minimize landscape disturbance to/from the nearby Citadel, one of main world cultural heritages in Cairo.

Therefore, new expressway shall run most likely in line with and above ENR cargo railway track alignment between both merging and separation points of aforementioned two major arterials which run in front of Citadel where terrain forms saddle like shape.

Connection with Muqattam Hills

Based on the aforementioned concept, closure of existing bridge which connects Salah Salim St. and Muqattam Hills is required. In this case, traffic between Muqattam Hills and Salah Salim St. will be accessible from only Autostrade Rd. Therefore, following two types of operations shall be considered;

- ✓ Parallel running section of Autostrade Rd. and Salah Salim St. in front of Citadel may be modified to one-directional operation as follows;
  - † Autostrade Rd. shall be converted as northeast bound only
  - † Salah Salim St. shall be converted as southwest bound only
  - † U-turn ramps shall be installed both sides of the one-directional operation segment, one is in the northeast corner with newly constructed off-ramp under Autostrade Rd., and the other is in the southeast corner by converting existing off-ramp from Autostrade Rd. to Salah Salim St. as on-ramp from Salah Salim St. to Autostrade Rd.
  - † Direct connection ramps shall be also installed both sides of the one-directional operation segment, one is in the northeast corner to connect from Autostrade Rd. to Salah Salim St. by crossing under the E3-2 and ENR railway track, and the other is in the southwest corner to connect from Salah Salim St. to Autostrade Rd. by crossing under the existing U-turn ramp.
- ✓ Traffic Signal may be installed at intersection of Autostrade Rd. and Access Road to

Muqattam Hills, although it might induce following diversions;

- † Traffic from Muqattam Hills to Salah Salim St. shall tern left at this newly signalized intersection on the Autostrade Rd., then enter U-turn ramp located west of this segment then U-turn again for westbound or go-straight for eastbound along Salah Salim St.
- † Traffic from Salah Salim St. to Muqattam Hills shall divert to Autostrade Rd. before entering this segment then enter Access Road at newly signalized intersection on Autostrade Rd.

Figure 6.4-8 Conceptual Traffic Diversion Plan in front of Citadel

(2) E3-3

Based on the simplified comparative analysis in previous section, Alternative-3 (Combination) is recommended for E3-3 corridor.

To implement this scheme, following conditions shall be taken into account further more during the detail design stage and its preparation stage from now on.

<u>El-Saiyida Aisha Bridge</u>

This steel girder overpass was constructed by Military Engineering Corps, and closed every night to prevent endless overrun accidents due to too acute curve. Once Salah Salim St. is realigned behind the Aqueduct, this overpass bridge shall be dismantled and square under the bridge shall be modified to meet surrounding landscapes.

Aqueduct

MoHUD together with Ministry of Culture and Cairo Governorate have been planning to reroute Salah Salim St. between Citadel and intersection near Fort Nugues where another world heritage Aqueduct running parallel with Salah Salim St. to inside the Southern Cemetery area located south of Salah Salim St. and Aqueduct.

Therefore, in line with Salah Salim St. Rerouting Plan, E3-3 shall be shifted to new Salah Salim St. alignment which pass about 300m behind (south-eastern side of) the Aqueduct to avoid construction of double deck type viaduct above currently narrow Salah Salim St. and just in front of Aqueduct.

In this case, E3-3 viaduct shall be single deck parallel type, and Salah Salim St. realignment plan shall be integrated with E3-3 project in terms of land acquisition in the Southern Cemetery with right of way of at least 36m, preferably 45~60m, to accommodate both E3-3 and New Salah Salim St..

Single Deck with On/Off Ramps

Section between Citadel and intersection with Abu el-Saud St., together with aforementioned Salah Salim St. Rerouting Plan, single deck parallel type viaduct shall be installed along Salah Salim St. Furthermore, by utilizing current green belt area which located south side of Salah Salim St. for about 1km, both or one-directional on/off ramps along Salah Salim St. or alternatively diamond-type interchange at intersection of realigned Salah Salim St. with Ain el-Sira St. shall be installed to provide accessibility to/from Ain el-Sira and/or Coptic Cairo areas.

Double Deck

Section between intersection with Abu el-Saud St. and Giza Square via El-Roda Island, where Salah Salim St. width becomes narrower, double deck type viaduct shall be installed. This double deck viaduct shall overpass Metro No.1 Line above underpass and el-Corniche St. Therefore, special shape sub structure (tri-leg) is required to support super structure. In addition, overpass along el-Corniche St. will be dismantled and replaced by underpass to maintain low profile for E3-3.

El-Manyal (El-Roda) Island

In El-Manyal (El-Roda) Island, set back plan has been proposed by Cairo Governorate to widened El-Roda St. both sides or one side. Width of double deck structure is around 12m and width of El-Road St. is currently 24m, therefore minimum clearance of 6m is provided for both sides of E3-3 with middle raised buildings along the street with current condition, and which clear the Egyptian Fire Defence Law requirement.

However, for road users as well as onlookers, such set back plan will be welcome in terms of much better landscape and environment, and from the point of view of expressway project, it is also welcome to reduce negative impact from nuisances, such as noise, vibration, and air pollutants which may be increased without widening of at-grade level street.

On the other hand, for residents and shop owners who may have to resettle into the other location inside or outside of the Island, it is matter of their life and it is not so easy from their social point of view.

For former environmental negative impacts, simplified nuisance simulation shall be presented in the course of the Study.

However, for latter social negative impacts, as the first principle, resettlement action plan should be prepared in the course of the set-back project proposed by Cairo Governorate.

Nile Bridge

El-Giza (‘Abbas) Bridge which crosses River Nile is 8-lane wide 5-span concrete box-beam bridge with approximately 30m wide and 360m long. To cross River Nile above El-Giza (‘Abbas) Bridge, special type of structure will be required. Detail shall be discussed in Chapter 8 Structure Design.

Giza Square

Currently Giza Square is covered by very wide eastbound-only flyover with multi legs (3-in [al-Malik Faisal St., al-Haram St., and Salah Salim St.] and 3-out [Gami’it al-Qahira St., Murad St., and al-Haram St.]) configuration.

E3-3 shall pass over this wide flyover at 2nd level for eastbound and 3rd level for westbound. To do so, large-scale portal type substructures are required to support both 2nd and 3rd deck superstructures above existing flyover. And in case of Metro Line No. 4 project along Pyramid St. and Salah Salim St. is launched near future to connect 6th October City with Metro Line No.1, this E3-3 project shall be integrated with underground subway structures.

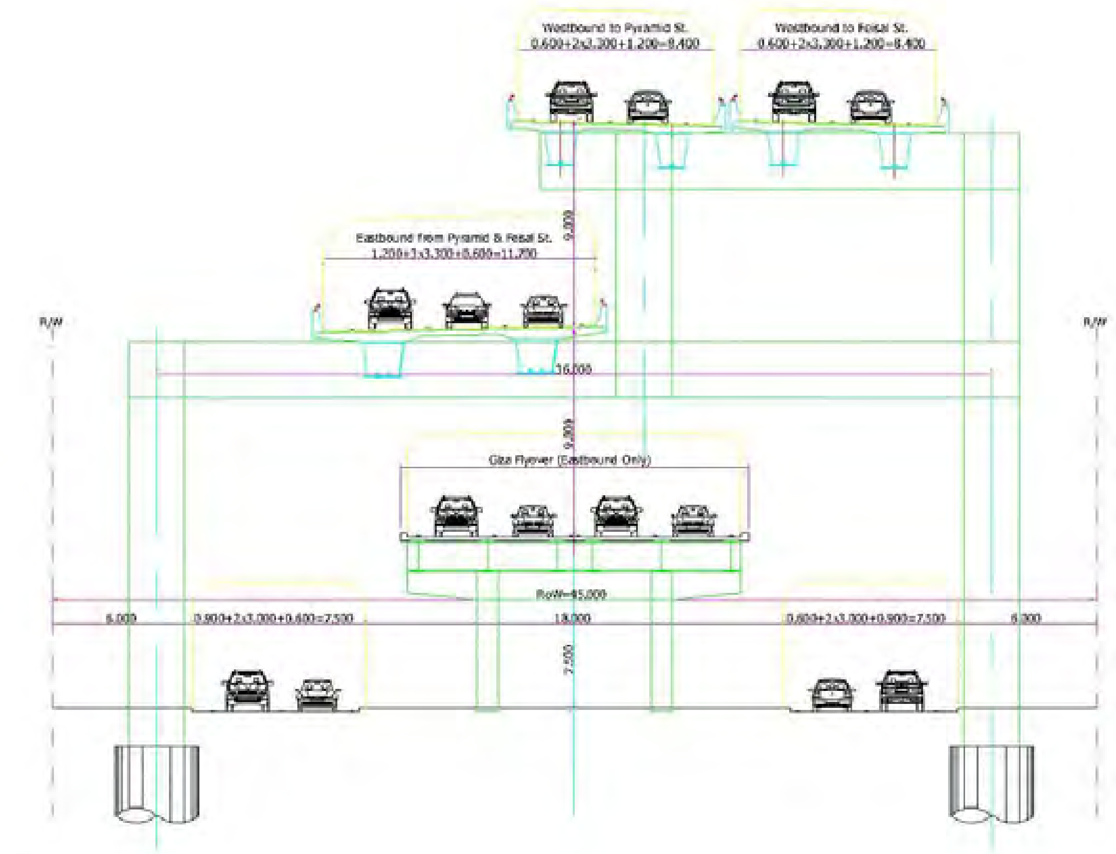


Figure 6.4-9 Conceptual Cross Section at Giza Square

6.5 INTEGRATION WITH FUTURE EXPRESSWAYS

6.5.1 F/S Corridors

(1) E1-2 with E9

Weaving Section

Based on the CREATS, E9 shall be developed between 26th July (E2) corridor and Saft al-Laben (E11) along ENR Track Line in the future, and now E1-2 is joining from east and running same alignment of E9 above and/or beside the ENR. Therefore, reserving the space for future E9 development shall be taken into account from now on.

As descried in previous Chapter 4 High Priority Routes, demand on the E9 northern section between E2 and E1-2 will be 31 thousand pcu, and demand on the E1-2 between E9 and 6th October Bridge (E1-1) will be 59 thousand pcu per day in 2027 with full network case.

In addition, demand on the E1-2/E9 section between northern E9 and E11 will be 89 thousand pcu before and 74 thousand pcu after on/off ramps respectively. And demand on the E11 will be 80 thousand pcu, then demand on the E8-2 section between E11 and E3-3 will be over 100 thousand pcu per day in the same case.

Taking into consideration that capacity of expressway is set as 1.5 thousand pcu per hour per lane, and peak hour ratio is around 7~8% against daytime 12-hr traffic, and 24/12-hr ratio is 1.60 based on the traffic survey results, each one-lane of expressway will be able to handle at least 30 thousand pcu per day.

Although, if traffic demand reached this capacity, travel speed will be drastically reduced, hence Level of Service (LoS) will not be achievable with such full capacity condition as shown in Chapter 9. Therefore, some allowances are usually adapted to determine the number of lanes required.

For example, E11 is now under construction with 6-lane double deck viaduct with demand of 80 thousand pcu per day. Which means that demand will be about 44% (=80/6/30) of its full capacity in 2027, and enough LoS will be provided in this case.

In addition, although E1-2 is proposed as 4-lane tunnel/viaduct due to limitation of space, and its demand will be still about a half of its full capacity (=59/4/30), therefore enough LoS will be provided along tunnel section as well.

On the other hand, demand of E9 northern section will be about one quarter (0.25 = 31/4/30) of its full capacity, therefore more than enough LoS will be provided once this section constructed as 4-lane viaduct.

Now, what is the requirement of this particular section where E1-2 and E9 are running parallel and weaving each other and split again toward E11 and E8-2? To do so, based on above LoS level, tentatively we have set the volume capacity ratio (VCR) as 0.50, although it is not absolute value to determine the number of lane, and depends on the other constrain, such as physical, economical, environmental, and social point of view, section by section.

Demand of this weaving section indicated that 74 thousand pcu per day in 2027, therefore, to provide proper LoS, 4-lane will be not enough (4.9 = 74/30/0.50), even no loss of capacity is considered, since this section becomes weaving section in the future, and usually such weaving section capacity will drop somehow due to complexity of each driver’s manoeuvre.

Considering 10~20% loss of capacity at this particular weaving section, at least 6-lane (6.2 = 74/30/0.80/0.50), or 8-lane, if possible, shall be kept to maintain better LoS. And also it is recommendable that future E8-2 segment beyond the junction with E11 shall be at least 6-lane (6.9 = 104/30/0.5), and connection ramps from/to E11 shall be 2 lane each (1.8 = 33/30/1.20/0.5) by increasing capacity as 120% for also better LoS.

Main Stream Toll Plaza Installation

Further more, main stream toll plaza installation should be considered at this section as well, since this section become strategic location to handle traffic from/to western part of GCR from now on, and there is no space on E11 nor E1-2 to install such tolling facility on the main carriageway, except on-ramp tolling facility. All traffic coming from and/or going to E1-2, E11, and E9 or E8 in the future must pass this particular section, when road users wish to continue their travel between CBD and western part of GCR.

In this case, using 74 thousand pcu per day as demand of this section, about 10 booths (9.8 = 74/10/0.75) is required to handle both directional traffics at once, considering capacity of each booth becomes one-third of ordinal traffic lane, and allow VCR as 0.75, instead of 0.50.

Each one booth requires at least 4.8m (=3.0m for lane plus 1.8m for booth), therefore, to accommodate 10 booths, minimum required width of toll plaza becomes 48m wide.

Although, there is possibility to toll only from either in-bound or out-bound traffic, and letting opposite direction traffic pass freely, therefore, required number of booths becomes also a half of them as 5, and 3 or 4 normal lanes for opposite direction traffic are provided.

In this case, required section width becomes at least 36 or 39m (=5 x 4.80 for booth plus 3 or

4 x 3.30 for opposite lane plus 1.80 for shoulders) instead of 24 or 30m for normal 6 or 8-lane configuration.

Even so, later case does not have any allowance by opening extra booths based on the peak hour demand, since inbound demand is basically higher during the morning, and outbound demand is higher during the evening.

Former case, there is allowance to use more than 5 booths for either in-bound or out-bound traffic by switching centre located some booths as revisable booths. This kind of practice is widely introduced in other countries, such as United States and Japan where main stream toll plaza is installed.

Fortunately, along this particular section, ENR property is wide enough to accommodate such very wide facility above railway track without acquiring any land, and that is very big asset for the Government of Egypt, although some re-alignment or termination of railway tracks will be required to accommodate substructures of the said facilities together with other main expressway carriageway.

(2) E1-2 with E11 & E8

To connect E1-2 with E11 or in case of E8 provision in near future, another pair of connection ramps is required between E8 and E11. Unfortunately, E11 is planned and started its construction without considering such future connections with the other MEA Networks, although only considering connections with al-Sudan St. and ‘Abd al-Salam ‘Arif St. Therefore, late comer may have to do something based on the pre-fixed situations.

There are basically two options, both of which have advantages and disadvantages as follows;

- ✓ Direct Ramps;
  All connection ramps shall be provided by shortest way between E11 with E1-2 and future E8, according to each traffic movement; therefore multi storey superstructures are required within limited land space.

  For example, out-bound from E1-2 to E11 will be 1st Level as same as E11 and E1-2, but in-bound from E11 to E1-2 must over pass others as 3nd Level, since there is a ramp from E11 to local streets and E1-2/E9 should be connected with E8 as Level-2 to cross existing flyover above ENR Track.

  When considering E8 connection with E11, south-bound from E11 to E8 will be 1st Level, but west-bound from E8 to E11 must over pass all the others as 4th Level, since all other level from ground to 3rd are already occupied.

As mentioned in previous section, Railway Police Station building (5-storeys) also shall be relocated somewhere near place, or reconstructed under the E1-2 viaduct, since connection ramp from E1-2 to E11 will pass just same location of the police station building with 1st Level.

And all multi storey superstructure works will be taken place above not only ENR but also Metro Line No. 2, therefore extreme care shall be taken.

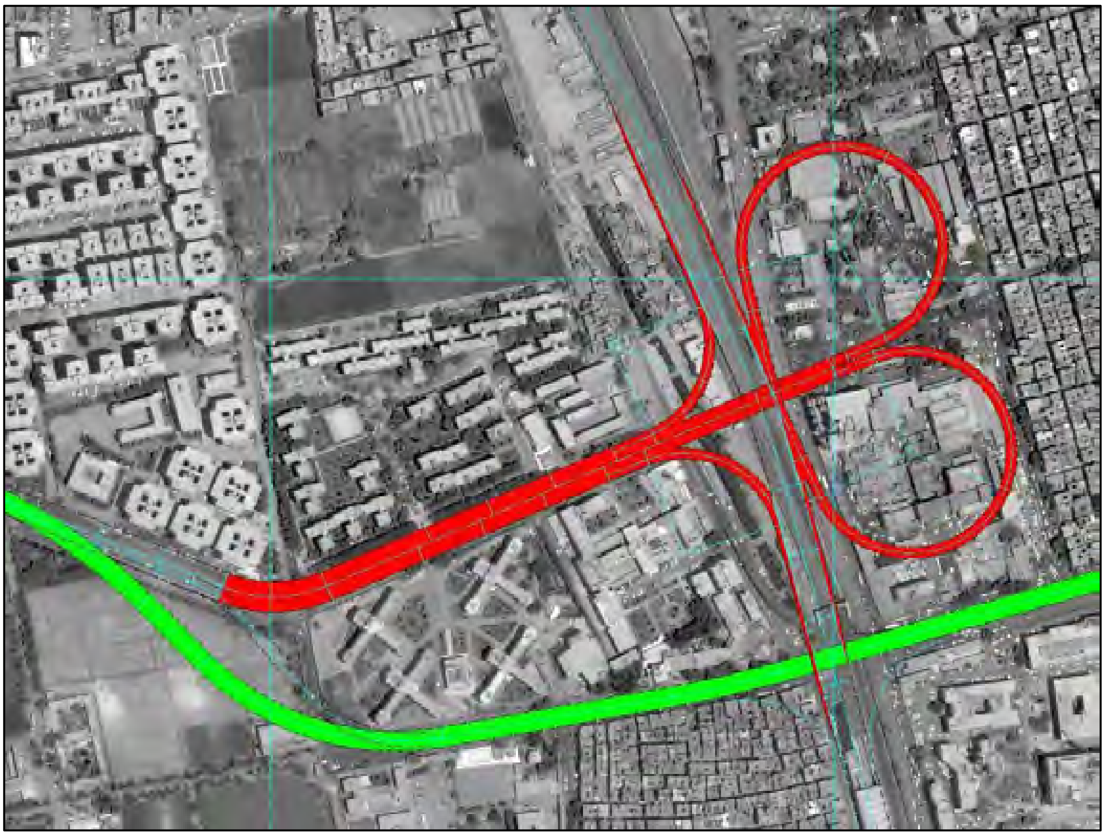


Figure 6.5-1 Conceptual Layout Plan for E11 with E1-2 & E8 Jct. (Loop Ramp)

- ✓ Loop Ramps;

  All connection ramps shall be provided either shortest ways or longest way to avoid installation of multi-storey super-structures above ENR Track and Metro Line, although utilization of currently abandoned factory space located northeast quadrant (corner between al-Sudan St. and ‘Abd al-Salam ‘Arif St. in front of Cairo University) is required.

(3) E1-1 Bypass Extension with E5

As all users on 6th October Bridge are well experiencing that said elevated road is always jammed at the particular point in front of the Ramsis Square and Ramsis Station for both in and outbound traffic. This is typical bottle neck point on the expressway network, since 2-lane main carriageway is merging with 2-lane on-ramp without proper length of acceleration lane or much wider down stream side carriageway for inbound lanes.

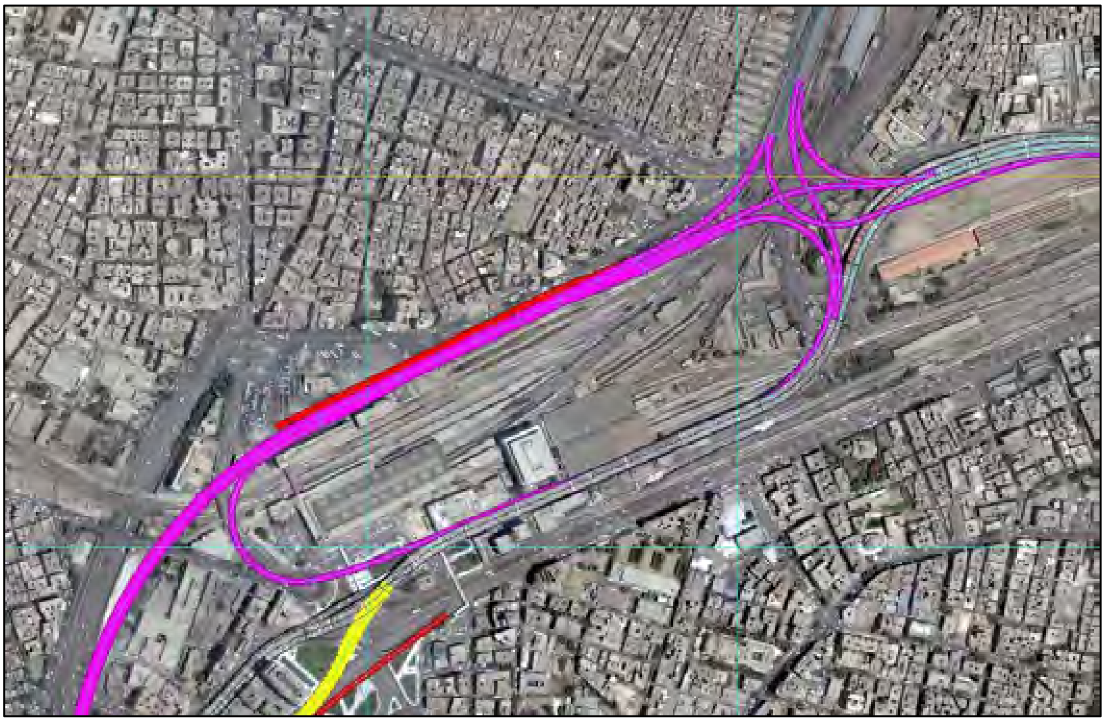


Figure 6.5-2 a Conceptual Layout Plan for E1-1 Bypass Extension with E5 Jct. (1)
(Extension above Urabi St. Case)

Figure 6.5-2 b Conceptual Layout Plan for E1-1 Bypass Extension with E5 Jct. (2)
(Extension above Ramsis St. Case)

And for outbound lanes, one building corner entering inside the side barriers of curved segment and becomes obstruction of keeping enough site distance along this segment.

MoHUD has been stretching widening section of said bridge between Cairo Gateway Plaza off-ramp and Ramsis Railway Station on-ramp above al-Gala St. from off-ramp side, however that work is still underway and it will take some more time to complete such widening works for whole segment.

In the near future, E5 will be connected with Alexandria Agriculture Road at Ring Road. And its southern end will be at Cairo Down Town. Section between E5 junction and Nile River crossing on the E1-1 (6th October Bridge) will have to handle much more traffic demand than current one.

To handle such heavy traffic demand, above mentioned widening works will not be enough that is why E1-1 Bypass along Ramsis St. is proposed together with E2-2 extension.

In addition, to handle heavy traffic demand between Ramsis Square and E5 Junction, further extension of E1-1 Bypass along Urabi St. or Ramsis St. will be necessarily.

Figure 6.5-2a and 2b shows such concept plans for E1-1 Bypass Extension with E5 Junction around Ramsis Railway Station and ENR Cargo Yard.

(4) E3-1 with E4 & E6

Obstacle Limitation Surface

Eastern end segment of proposed E4 and western end segment of E6 should be depressed since it will cross under the approach and/or departure path of nearby air force base runway 36/18 (R/W Length = 1875-m or 6150-ft) which is located at north-western quadrant of intersection of Autostrade (Tariq al-Nasr) Rd. with Suez Desert Rd..

This is based on the regulations for the protection of airspace in the vicinity of airfield established by a set of imaginary obstacle limitation surface. In addition, both south-western and south-eastern quadrants are also occupied by the MoD facilities, therefore north-eastern quadrant will be only available plot to construct proposed junction for E4 and E6 with E3-1.

However junction superstructures and supplemental facilities such as lighting fixtures, traffic signboards, traffic surveillance and control system should be strictly controlled by the same regulations for the protection of airspace, since even this quadrant is located within a radius of 3000m from the air force base and under its horizontal surface (45m above ground level) which is part of aforementioned imaginary obstacle limitation surface of the airfield.

Figure 6.5-3 Conceptual Layout Plan for E3-1 with E4 & E6 Jct.

<u>MoD Facilities</u>

Connecting ramps between E4 eastbound to E3-1 southbound as well as E3-1 northbound to E6 eastbound are most likely to pass inside MoD facilities located south-western and south-eastern quadrants of subject intersection. Due to depressed configuration of E4 and E6 at this segment, former connecting ramp also becomes depressed or tunnel type. And later connecting ramp may become either depressed or elevated type based on the requirements by MoD.

(5) E1-1 with E3-1

Connection of 6th October Bridge (E1-1) with E3-1 has been also reviewed by both horizontal and vertical geometrical points of view as well as following assumptions;

- ✓ Existing on/off ramps of 6th October Bridge should not be demolished to keep current traffic flow pattern between Autostrade (Tariq al-Nasr) Rd. and 6th October Bridge
- ✓ Disturbance of traffic flow of at-grade level on Autostrade (Tariq al-Nasr) Rd. should be minimized

In this regard, existing on/off ramps of E1-1 is simply connected with depressed section of E3-1 through transition section from/to ground level to/from B1 level. Although this application may disturb current direct traffic movement from 6th October Bridge to Azhar University Campus in Nasr City, there is other ways to reach this area by using the other southbound off ramp of 6th October Bridge, therefore this installation of transition segment should not be critical.

(6) E3-1 with E12

Connection of E3-1 with E12 will be the same location of junction for E1-1 with E3-1 & E3-2, if E12 alignment comes along extension of 6^{th} October Bridge in front of GARBLT Headquarter compound.

In such case, connection between 6^{th} October Bridge and E12 will be most probably either 1^{st} level or 4^{th} level to avoid existing 2^{nd} and 3^{rd} level on/off ramps, although connections between E12 and E3-1 or E3-2 may become problematic, unless some modification works are applied into existing and/or proposed on/off ramps to/from 6^{th} October Bridge.

6.5.2 Pre-F/S Corridors

(1) E1-1 with E3-2

Connection of 6^{th} October Bridge (E1-1) with E3-2 is not considered at this moment due to less traffic demand between these two segments, although it is still possible to connect both by modifying existing off ramp from E1-1 southbound to Autostrade westbound and adding on-ramp from Autostrade eastbound to E1-1 northbound as same manner as ramps between E1-1 and E3-1, by modifying one of the piers which obstructing construction of said on-ramp.

(2) E3-2 with E10

To connect E3-2 with proposed E10 which most likely run along Autostrade between Ring Rd. and Citadel, there is no space to construct such massive junction above ground level in front of Citadel.

Possible solution to construct such junction is shifting E10 alignment slightly toward west along El-Mowasla / El-Sekka El-Hadeed St. and connect E3-2 and E10 each other by standard T-junction with or without loops, although it will require further land acquisition around this junction.

(3) E3-2 with E13 or E14

To connect E3-2 with E13 (Azhar Tunnel Extension) or E14 (El-Qalaa Tunnel) is still very provisional, since alignments and priorities of those new links are not determined yet. Even though, in case of such new links become more realistic, location of those junctions are most likely around intersection of El-Nasr Rd. with Mostafa El-Khazendar St. for E13, and the same location of junction of E3-2 with E10 for E14.

In case of such new junctions for E13 or E14 or both are required, further land acquisitions in either northern cemetery or southern cemetery or both will be necessarily.

(4) E3-3 with E8

To connect E3-3 with proposed E8 which most likely run along irrigation canal where cover-up project has been underway by Giza Governorate and Ministry of Water Resources & Irrigation in cooperation with the Government of Germany, complicated two pairs of connection ramps shall be provided.

One pair shall be installed northward along ENR & Metro Track above Faisal Overpass, and the other pair shall be installed southward along al-Haram St. and the Canal after crossing ENR & Metro Track near Giza Railway Station.

Both cases, at least three level structures will be required to cross over existing flyovers or proposed on/off ramps for E3-3 as well as Metro Line No.2 and ENR.

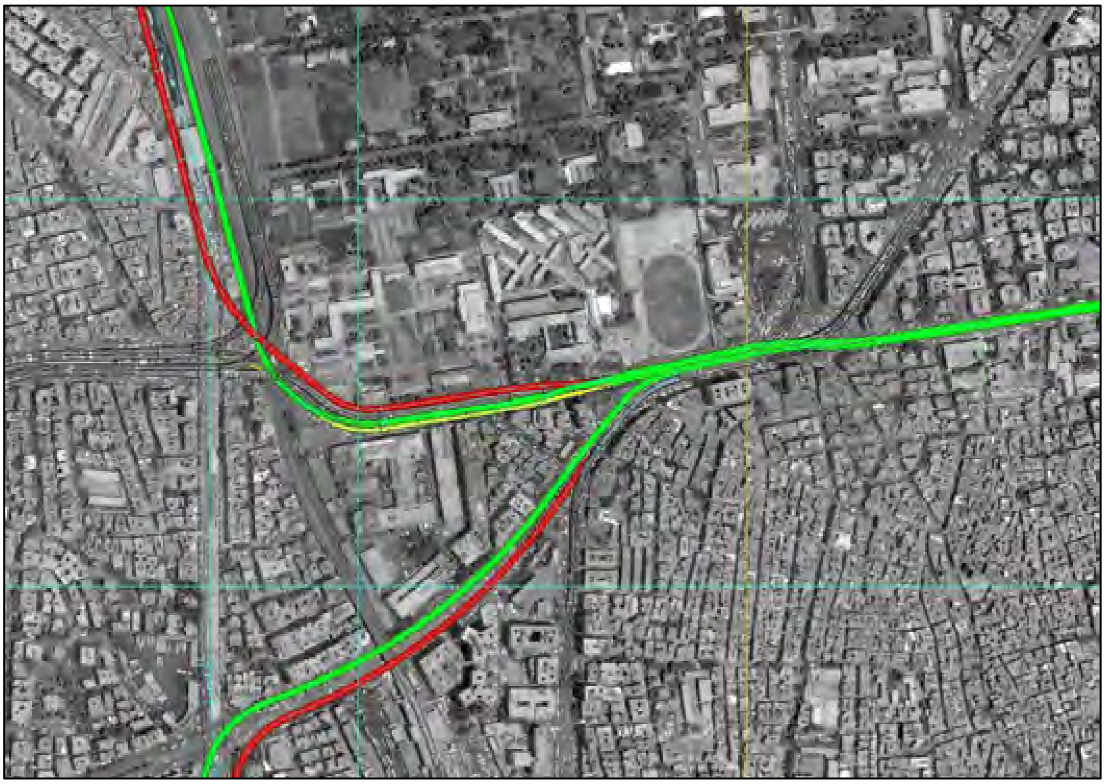


Figure 6.5-4 Conceptual Layout Plan for E3-3 with E8 Junctions

CHAPTER 7

PRELIMINARY GEOMETRIC DESIGN

CHAPTER 7

PRELIMINARY GEOMETRIC DESIGN

7.1 DESIGN STANDARDS

7.1.1 Geometric Design Standards

Urban expressway's primary function is to transport large volumes of traffic with faster speeds. Therefore, Design Speed of an urban expressway should be as high as possible under the prevailing land restriction within the busy land uses of urbanized areas. In case of urban expressways which pass through highly urbanized and development areas, higher design standards usually require more lands to be acquired, which results in not only high project costs but also difficult and prolonged implementation.

Since the geometric design standards for urban expressways in Egypt is not clearly defined yet, the standards adoptable to this Study are established based on available Egyptian and international well known ones such as a Policy on Geometric Design of Highways and Streets, AASHTO, 2004 and Japanese Design Standards, 2004. Due to limited available lands in the heavily urbanized Japanese cities, the Japanese Standard is considered very reasonable to be adopted in the busy areas of Greater Cairo that has similar conditions.

The major factors of geometric design standards that affect project cost, land acquisition and construction methods are:

- Design Speed,
- Lane Width, and
- Shoulder Width.

These three (3) fundamental design elements are deeply investigated and then assessed with the Steering Committee Members. Finally, the Standards shown hereafter are recommended.

(1) Design Speeds

Two different design speeds (Class A and Class B) are recommended based on the proposed alignments and location of the expressways.

<u>Class A: Expressway E3 (E3-1, E3-2 and E3-3)</u>

For expressway E3 (E3-1 to E3-3), higher design standards than other expressways E1-2 and E2-2 are considered due to the following findings:

- Expressway E3 will be in future linked with an intercity expressways (E6 and E11) that will have high design speeds of 80 km per hour or higher.

- To reduce traffic burden of El Nasr Road, expressway E3 (E3-1, E3-2 and E3-3) should be planned with high design standards so that traffic will be attracted to this new expressway.

- To strengthen accessibility among new urban communities located in East and West wings of GCR, by less travel time due to its higher travel speed than which of at-grade level due to its lower travel speed.

Therefore, design speed of 60 km per hour is recommended as appropriate speed design for expressway E3 (E3-1, E3-2 and E3-3).

<u>Class B: Expressways E1-2 and E2-2</u>

Expressways E1-2 and E2-2 are located at the Down town area where extensive land acquisition will be quite difficult and expensive. Therefore, an expressway alignment should be selected to fully utilize existing public available land spaces. It is recommended also to utilize as much as possible the existing viaducts, existing at-grade major roads, exiting railway tracks if possible, existing canals or even construction under ground. Alignment under this concept may restrict and control expressway design elements specially design speed to some extent.

Thus, design speed of 50 kph is considered to be most appropriate for Expressways E1-2 and E2-2. However, from point of view of expressway function, design speed of 60 kph is considered as far as possible during design stage and 50 kph is considered as the minimum acceptable value in case of natural restrain which design speed of 60 kph cannot be achieved.

(2) Lane Width

Internationally, the standard lane width is 3m (10ft) minimum and 3.6m (12ft) maximum. Large width of the traffic lane will increase the construction cost especially in case of viaducts and tunnels. Small width will decrease traffic lane capacity and reduce vehicle traveling speeds. Therefore, it is very important to find out the optimum traffic lane width. In the previous studies, Master Plan and PPP Study, 3.6m is applied based on the review of Egyptian Standards. However, 3.6m in the Egyptian Standard is practical for inter-urban roads such as Alexandria Desert Road which design speed is 80 kph or higher and the Study Team prefers to adopt more reliable lane width to reduce the expected high construction cost in urbanized area.

After consultation with the Steering Committee members the Lane width 3.30 m is recommended to be adapted for the design of expressways under this Study.

This lane width has been found to be the most optimum value taken into consideration the effect of the lane width on the construction cost especially within highly urbanized areas. Furthermore, present road users driving practices show that wide lane width encourage them to occupy one lane with more than one vehicle that can severely affects the traffic safety on the expressway.

(3) Outer Shoulder Width

Traffic demand for expressways in Grater Cairo is high, thus all traffic lanes will be in use for the most of time in a day. Where shoulder width is not sufficient, a broken down vehicle may disrupt traffic on not only the occupied lane but all lanes in the direction of occupied lane.

The ratio of old vehicle models in the fleet of vehicle in Egypt seems to be high and it is expected that a rate of vehicle breakdown on an expressway may be high due to these obsolete vehicles which are in use in Grater Cairo. Traffic jams over existing viaducts due to broken down vehicles can be recognized in Cairo and especially during Summer time due to overheating of motors of aged vehicles.

Providing the outer shoulder can mitigate the effect due to stopping of broken down vehicles. Therefore, it is recommended to construct not only 1.20m outer shoulder but also emergency parking bay/escape shelter at certain intervals in case of highly urbanized areas should be provided.

(4) Geometric Design Standards and Cross Section

The other elements of geometric design standard are thoroughly investigated based on the recommended two design speed classes which are Class A for 60 km/hr and Class B for 50 km/hr.

Elements of geometric design standard for expressway, interchange, acceleration/deceleration lane and on/off ramp are presented in Table 7.1-1, Table 7.1-2, Table 7.1-3 and Table 7.1-4, respectively.

Taking the above mentioned standard design elements into consideration, the recommended standard cross-sections are presented in Figure 7.1-1.

Table 7.1-1 Geometric Design Standards for an Urban Expressway

Description	Unit	Class A E3-1/2/3	Class B E1-2 & E2-2
Design Speed	kph	60	50
Lane Width	m	3.3	3.3
Shoulder Width (outer)	m	1.2	1.2
Shoulder Width (inner)	m	0.6	0.6
Median Width	m	1.2/1.5*	1.2/1.5*
Minimum Stopping Sight Distance	m	75	55
Minimum Radius	m	120	70
Minimum Curve Length	m	100	80
Minimum Spiral Curve	m	70	50
Minimum Spiral Curve Length	m	50	40
Minimum Radius for without Spiral Curve	m	600	400
Minimum Radius for Normal Cross Slope	m	1500	1000
Maximum Grade	%	5	6
Minimum Length of Vertical Curve	m	50	40
Minimum "K" for Crest		11	8
Minimum "K" for Sag		18	7
Maximum Superelevation	%	8	8
Normal Cross Slope	%	1.5	1.5
Maximum Superelevation Transition	m/m	1/125	1/115
Composite Gradient	%	10.5	11.5
Vertical Clearance	m	5.5 (4.5)	5.5(4.5)

Note: The figure in ( ) shows absolute minimum value to be used only when the condition necessitates.

** Tunnel/Depressed Section*

Table 7.1-2 Geometric Design Standards for an Interchange

Description	Unit	Value					
Design Speed	kph	60		50		40	
Lane Width	m	3.3		3.3		3.3	
Number of Lane	-	2	1	2	1	2	1
Shoulder Width (outer)	m	1.2	2.1	1.2	2.1	1.2	2.1
Shoulder Width (inner)	m	0.6	0.6	0.6	0.6	0.6	0.6
Minimum Stopping Sight Distance	m	75		55		40	
Minimum Radius	m	120		70		40	
Minimum Curve Length	m	100		80		70	
Minimum Spiral Curve	m	70		50		35	
Minimum Spiral Curve Length	m	50		40		35	
Minimum Radius for without Spiral Curve	m	600		400		300	
Minimum Radius for Normal Cross Slope	m	1500		1000		600	
Maximum Grade	%	5		6		7	
Minimum Length of Vertical Curve	m	50		40		35	
Minimum "K" for Crest		11		8		4.5	
Minimum "K" for Sag		18		7		4.5	
Maximum Superelevation	%	8		8		8	
Normal Cross Slope	%	1.5		1.5		1.5	
Maximum Superelevation Transition	m/m	1/125		1/115		1/100	
Composite Gradient	%	10.5		11.5		11.5	
Vertical Clearance	m	5.5(4.5)		5.5(4.5)		5.5(4.5)	

Note: The figure in ( ) shows absolute minimum value to be used only when the condition necessitates

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Table 7.1-3 Standard Acceleration and Deceleration Lengths

Lane	Design Speed	Expressway Design Speed	
		60 kph	50 kph
Acceleration Lane	Single Acceleration Length (m)	120	90
	Double Acceleration Length (m)	180	140
	Taper Length (m)	50	40
Deceleration Lane	Single Deceleration Length (m)	70	50
	Double Deceleration Length (m)	110	80
	Taper Length (m)	50	40

Table 7.1-4 Geometric Design Standards for On/Off Ramp

Description	Unit	Value	
Design Speed	kph	50	40
Lane Width	m	3.3	3.3
Shoulder Width (outer)	m	2.1	2.1
Shoulder Width (inner)	m	0.6	0.6
Minimum Stopping Sight Distance	m	55	40
Minimum Radius	m	70	40
Minimum Curve Length	m	80	70
Minimum Spiral Curve		50	35
Minimum Spiral Curve Length	m	40	35
Minimum Radius without Spiral Curve	m	400	300
Minimum Radius for Normal Cross Slope	m	1000	600
Maximum Grade	%	6	7
Minimum Length of Vertical Curve	m	40	35
Minimum "K" for Crest		8	4.5
Minimum "K" for Sag		7	4.5
Maximum Superelevation	%	8	8
Normal Cross Slope	%	1.5	1.5
Maximum Superelevation Transition	m/m	1/115	1/100
Composite Gradient	%	11.5	11.5
Vertical Clearance	m	5.5(4.5)	5.5(4.5)

Note: The figure in ( ) shows absolute minimum value to be used only when the condition necessitates.

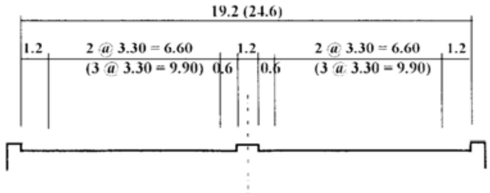
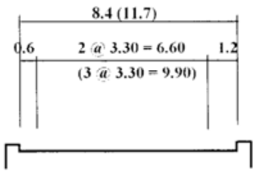
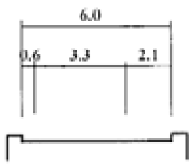
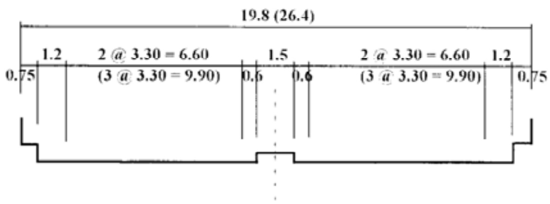
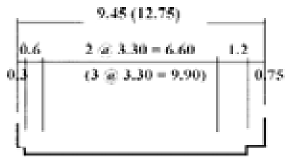
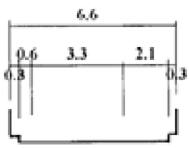
STRUCTURE TYPE	CROSS SECTION
ELEVATED	TWO -WAY : 4 -LANE (6 -LANE) EXPRESSWAY 
	ONE -WAY : 2 -LANE (3 - LANE) EXPRESSWAY / INTERCHANGE RAMP 
	ONE - WAY : 1 - LANE ON/OFF RAMP 
DEPRESSED TUNNEL	TWO -WAY : 4 -LANE (6 -LANE) EXPRESSWAY 
	ONE -WAY : 2 -LANE (3 - LANE) EXPRESSWAY / INTERCHANGE RAMP 
	ONE - WAY : 1 - LANE ON/OFF RAMP 

Figure 7.1-1 Standard Cross Sections

7.2 DESIGN POLICY

The implemented design policy is based on concept that an expressway user will be expected high level of services corresponding to the road charge one has to pay.

Therefore, to achieve the expressway user's satisfaction, all expressway components such as emergency parking bay, lighting, communication, toll booth, etc., and all supplemental facilities are designed based on the level of international standard principally AASHTO, Japanese Standards and also take into consideration Egyptian Design Standards.

7.3 ALTERNATIVES AND COMPARATIVE ANALYSIS

The previous findings of Master Plan and PPP Study are well investigated. Several field surveys are undertaken. The result of topographical surveys, road inventories and geotechnical investigations are assessed. The updated area photo maps are utilized to prepare several alternative plans for the main expressway structure, ramps and interchanges. The established alternative plans are assessed and examined not only by the Study Team members but also together with Egyptian government officials as well as stakeholders.

Assessment to select optimum alternative is carried out in terms of socio-environmental impacts (air pollution, noise, vibration, land acquisition, privacy, sunlight right, historical building / monument, landscape, etc.) as well as other economic aspects such as construction cost, operation, maintenance and management, etc.

The lengths of the selected feasibility and pre-feasibility expressway alignments under this Study are presented in Table 7.3-1.

Table 7.3-1 Lengths of Expressways under Study

Expressway	Length (km)	Starting Station	Ending Station
E 1-2	5.56	0 + 000.000	5 + 560.000
E 2-2	1.88	0 + 000.000	1 + 880.000
E 3-1	6.52	0 + 000.000	6 + 520.000
E 3-2	6.88	6 + 520.000	13 + 400.000
E 3-3	5.50	13 + 400.000	18 + 900.000

Source: JICA Study Team

7.4 INTERCHANGES AND RAMPS

7.4.1 Location of Interchanges

The findings of CREATS MP Study and PPP Study both undertaken before by JICA support are assessed. Interchange locations are investigated based on the selected alternative expressway alignments. Figure 7.4-1 shows the locations of selected interchanges that should be constructed to granite the smooth and uninterrupted traffic circulation of the new expressway network.

7.4.2 Alternative Scheme of Interchanges

The basic schemes of interchange types are shown in Figure 7.4-2 and briefly described as follows:

- T- and Y- Interchanges

  A trumpet interchange is suitable for orthogonal or skewed junctions. Trumpet type favors the left turn on the expressway with the provision of a semi-direct connecting ramp. T-type interchange has advantages that all turning movement is facilitated similar to trumpet type.

- Diamond Interchange

  A diamond interchange is fitting to urban area because of small right-of-way acquisition required. The major flow is grade separated, but minor flow directions have intersections at-grade. One disadvantage of the diamond interchange is the possibility of wrong-way turns which can cause accidents.

- Partial and Full Cloverleaf

  In place of diamond interchange, the partial cloverleaf is sometimes adapted. Traffic can leave the major flow either before or after the grade separation structure, depending on the quadrant layout.

  The more conventional arrangement of the full cloverleaf eliminates at-grade crossings of all traffic streams for both major and minor roads. Although all crossing movements are eliminated, the cloverleaf design has the following disadvantages:

- A layout requires large land areas

- Decelerating traffic wishing to leave the through lanes must weave into accelerating traffic entering the through lanes. However, using collector-distributor roads can be utilized to overcome this disadvantage.

- Directional Interchange

Generally, the directional interchanges are used whenever one freeway joints or intersects another expressway. The outstanding design characteristics of this type of interchange are the use of a high design speed throughout, with curved ramps and roadways with large radius.

Figure 7.4-1 Location of Interchanges

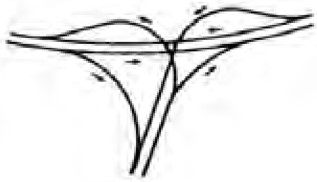
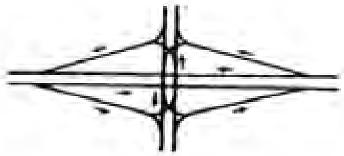
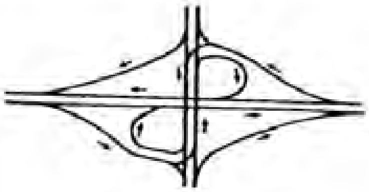
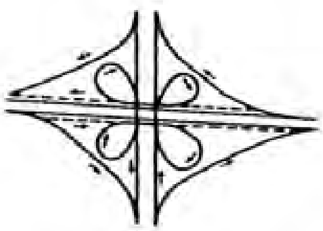
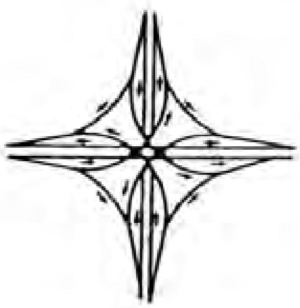
INTERCHANGE TYPE	TYPICAL DIAGRAMMATICAL PLAN	VARIATION TYPE
T and Y Interchanges		• Y–Type (3–Leg Directional) • T–Type (3–Leg Directional) • Trumpet Type
Diamond Interchange		• Conventional Diamond Type • Compressed Diamond Type • Split–Diamond Type
Partial and Full Cloverleaf	 	• Full Cloverleaf • Full Cloverleaf with Collector–Distributor Roads • Partial Cloverleaf (2–Loops) • Partial Cloverleaf (3–Loops)
Directional		• Four–Level Full Directional • Three–Level Full Directional • Semi–Directional • Rotary Type

Figure 7.4-2 Interchange Types

7.4.3 Recommended Types of Interchanges

The factors considered in selecting the most appropriate types of interchanges included:

- Design speed of expressway connecting
- Functionality according to traffic volume and highway capacity
- Construction cost
- Difficulty in R.O.W. acquisition
- Topographical feature
- Environmental/aesthetic consideration

Table 7.4-1 summarizes the type of interchanges that can be adopted for the design based on the natural feature, traffic movements and volumes.

Table 7.4-1 Location of Interchanges and Recommended Interchange Types

Expressway	Name of Interchange	Number of Legs	Recommended Interchange Type
E3-1	E3-1/E4&E6	3-Leg Directional	Single Trumpet (Future Implementation
	E3-1/E1	Partial 3-Leg Directional	T-Type
E1-2	E1-2/E1-1	-	-
	E1-2/E11	Partial 3-Leg Directional	Y-Type
E2-2	E2-2/E2-1	-	-
	E2-2/E1	Partial 3-Leg Directional	Y-Type
E3-3	E3-3/E8	3-Leg Directional	T-Type (Future Implementation)

7.4.4 Location of On/Off Ramps

There is always demand to provide many access ramps to expressway. While this meets the desires of local traffic in general, it carries many incidental dangers. Ramps closely spaced create congested weaving area and interference. Therefore, adequate spaces between on/off ramps have been provided to avoid that ramps may closely intervene streets.

Land use underneath a viaduct is considered and ramp placement has been carefully planed since ramps usually interfere with land use under viaduct.

To maximize the functionality of expressway, locations of on/off ramps have been identified at the best location taking into account the following factors:

- Available R.O.W. width for provision of the ramps
- Condition of connection roads
- Traffic condition and road capacity
- Topographical condition
- Distance from adjacent ramp
- Constructability
- Cost
- Impact to the vicinity

Table 7.4-2 summarizes the selected location of ramps and presented the recommended number of lanes and booths for each on/off ramp.

There are six on/off ramps along E3-1, two on/off ramps along E1-2, four on/off ramps along E3-2 and two on/off ramps along E3-3. Total number of fourteen (14) on/off ramps is proposed and placed at the most effective locations for accommodating traffic demands.

Table 7.4-2 List of On and Off Ramps

Route	Station	Provided Ramp	No. of Lanes	No. of Booths	Connecting Road	Remarks	Drawing No.
E1-2	3+400	ON	1	2	Sudan St.	Inner Bound	E1-2/A-01
	3+600	OFF	1	-	Canal St.	Outer Bound	E1-2/A-01
E3-1	0+950	OFF	1	-	Autostrad	East Bound	E3-1/A-01
	1+520	ON	1	2	Autostrad	West Bound	E3-1/A-01
	2+620	OFF	1	-	Autostrad	West Bound	E3-1/A-01
	3+100	ON	1	2	Autostrad	West Bound	E3-1/A-01
	4+600	ON	1	2	Autostrad	East Bound	E3-1/A-01
	5+010	OFF	1	-	Autostrad	East Bound	E3-1/A-01
E3-2	8+500	OFF	1	-	Autostrad	Ease Bound	E3-2/A-01
	9+500	ON	1	2	Autostrad	East Bound	E3-2/A-01
	13+400	OFF	1	-	Autostrad	West Bound	E3-2/A-01
	13+400	ON	1	2	Autostrad	West Bound	E3-2/A-01
E3-3	14+000	ON	1	2	Autostrad	East Bound	E3-3/A-01
	14+000	OFF	1	-	Autostrad	East Bound	E3-3/A-01

7.4.5 Recommended Types of On/Off Ramps

The types and configuration of each on/off ramp were studied applying the design speed and minimum radius as shown in Table 7.1-4. The main finding of this analysis is shown in Table

7.4-3. In the analysis the following design criteria are considered:

- Different Design Speeds on Interchange

  Different design speeds are applied at different expressways. The design speed for ramp is controlled by the expressway design speed. On the other hand, in case that the ramp will be close to lower speed at grade road, it is designed, at-grade road lower speed taken into consideration.

- At-grade Terminals

  Where a ramp joins at-grade road, an intersection is created and a stop sign or traffic signal control is employed. This terminal design is depended on turning requirement conditions at intersection.

- Curvature

  The geometric requirement of curvature for ramps is predicated based on the design speed same as main expressway. Spiral transitions are desirable to fit the desired shape of ramps, to meet site conditions and to fit natural vehicle movement.

- Grade and Profile

  Ramp gradients are directly related to design speed. However, design speed is a general indication of the standards being used, and a gradient for a ramp with a high design speed should be flatter than for one with a low design speed.

- Center Ramps

  Generally, center ramps are contrary to driver's expectancy when they are installed within short distance after and/or before side ramps. In such case, special attention should be given to draw driver's attention. Traffic sign to alert driver that an unusual situation exist should be allocated at location that gives sufficient time and distance for driver's decision making. However, the center on/off ramps have great advantages for viaduct and depressed expressways because required ROW will be minimum.

  In this project, extreme care has been exercised to adapt center ramps in the design of interchange and in providing sufficient safety measures for drivers. Center ramps are also considered satisfactory for collector-distributor roads.

- Distance Between Successive Ramps

Frequently there would be a need for two or more ramp terminals in close succession along the through lanes on urban expressway. In such case, a reasonable distance has been given to provide sufficient maneuvering length and adequate space for signing.

Spacing between successive outer ramp terminals is dependent on the classification of the interchanges, the function of the ramp combination (entrance or exit) and weaving potential.

The following distance requirements between adjacent noses are adopted in the Study. Figure 7.4-3 shows the distance requirements for the above purpose.

- Ramp Terminals

Various type of ramp terminal shall be applied at on/off ramps with at-grade roads, and interchanges or junctions of expressways, where ramp traffic merges with or diverges from through traffic at flat angles. Ramp terminals are further classified according to the number of lanes of the ramp at terminal point, either single or multi-lane, and according to the configuration of the speed-change lane, such as taper type or parallel type.

- Entrance and Exit Terminals

Since Cairo Urban Toll Expressway is first urban expressway project in Egypt, ramp design and dimensioning become subject of intensive study taking into consideration standards applied in other countries. Unfortunately, higher vehicle speed over design speed has to be considered since usually drivers make maneuvers at high speeds; even enforcement is managed by traffic control. Taking into consideration of accident prone area at entrance and exit ramp terminals and for traffic safety, adequate length of terminals have been planned to apply much longer than the length specified by geometrical design standards.

Terminals are designed either as a taper, blending into the through lane, or as an auxiliary lane parallel to the through lane.

In either case, sufficient lengths have been provided to permit the vehicles to accelerate and merge into or decelerate and diverge from the main traffic flow.

Figure 7.4-3 shows the proposed minimum spacing length between ramps for different alignment conditions.

Table 7.4-3 On/Off Ramp Scheme (1/2)

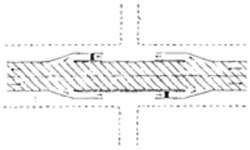
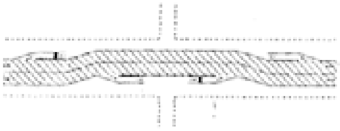
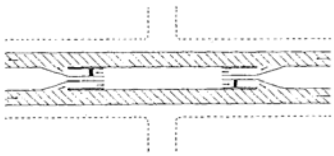
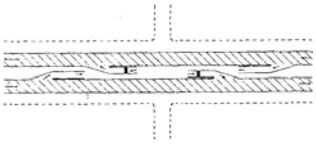
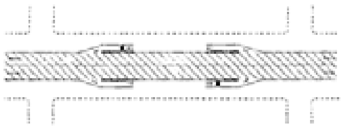
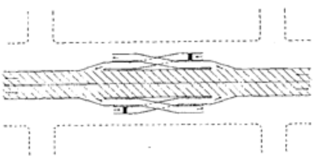
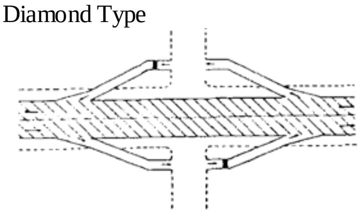
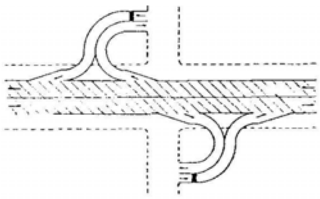
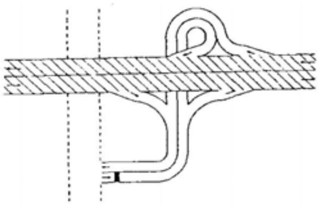
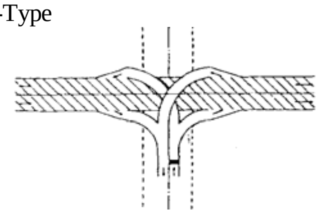
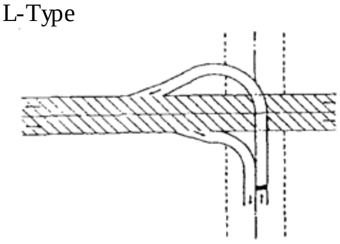
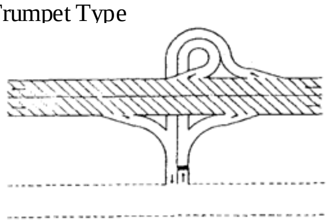
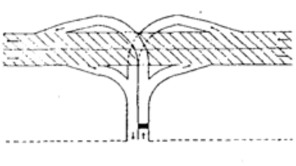
LOCATION OF AT-GRADE STREET	RAMP LAYPUT	FEATURES
AT-GRADE STREET UNDER AN EXPRESSWAY	Parallel Side Ramp : Type A 	On/off-ramps are placed parallel to each other at outer sides of an expressway and are connected with an at-grade street near an intersection 40.2m ROW required without at-grade street Reduces traffic capacity near an intersection
	Staggered Side Ramp 	On/off-ramps are placed staggered to each other at outer sides of an expressway and are connected with an at-grade street near an intersection 33.0m ROW required without at-grade street Lane reduction of an at-grade street is required
	Parallel Center Ramp 	On- and off-ramps are placed parallel to each other at inner sides of an expressway and are connected with an at-grade street near an intersection 40.2m ROW required without at-grade street Left hand entrances and exits to/from an expressway are contrary to the general concept of driver's expectancy
	Staggered Center Ramp 	On/off-ramps are placed staggered to each other and are connected with an at-grade street near an intersection 33.0m ROW required without at-grade street Left hand entrances and exits to/from an expressway are contrary to the general concept of driver's expectancy
	Parallel Side Ramp : Type B 	On/off-ramps are placed parallel to each other at outer sides of an expressway and are connected with an at-grade street in between intersections 40.2m R.O.W. required without at-grade street Exit traffic and entrance traffic from/to an expressway weaves each other. An appropriate weaving section between an exit and entrance will be provided
	Braided Side Ramp 	This type is developed to eliminate problems of above type, i.e. to eliminate weaving section of at-grade street and to shorten distance from an exit/entrance to an intersection 54.6m ROW required without at-grade street Complicated on- and off-ramps required, as they have to cross each

Table 7.4-3 On/Off Ramp Scheme (2/2)

LOCATION OF AT-GRADE STREET	RAMP LAYOUT	FEATURES
AT-GRADE STREET CROSSING UNDER AN EXPRESSWAY	Diamond Type 	On/off-ramps are connected at 4 locations with an at-grade street crossing under an expressway Additional two (2) 4-leg intersections are required Type of ramp is simple and ROW acquisition is lesser than other types under this category
	Semi-cloverleaf Type 	On/off-ramps are connected at 2 locations with an at-grade street crossing under an expressway Additional two (2) 3-leg intersections are required As loop ramps are required, wider ROW is needed than the Diamond type
	Trumpet Type 	On/off-ramps are connected at 1 location with an at-grade street crossing under an expressway Additional one (1) 3-leg intersections are required Toll plaza can be integrated at one place Wider ROW and longer ramps are required
	Y-Type 	On/off-ramps are connected at 1 location with only one direction of an at-grade street crossing under an expressway 3-level structures are required Applicable when expressway traffic generating/attracting source is located at only one direction of an at-grade street
	L-Type 	One pair of on- and off ramps is connected with only one direction of an at-grade street crossing under an expressway Applicable when expressway traffic generating/attracting source is located at only one direction of an expressway as well as an at-grade street
AT-GRADE STREET RUNNING PARALLEL TO AN EXPRESSWAY	Trumpet Type 	On/off-ramps are connected with an at-grade street running parallel to an expressway One 3-leg intersection is required Toll plaza can be integrated at one place
	Y-Type 	On/off-ramps are connected with an at-grade street running parallel to an expressway One 3-leg intersection is required Toll plaza can be integrated at one place Though lesser ROW is required than Trumpet Type, construction cost is higher as 3-level structures are required

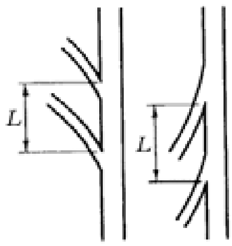
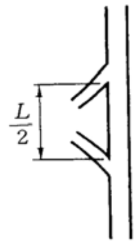
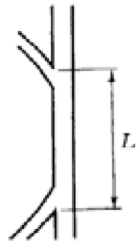
TYPE	EXIT - EXIT ENTRANCE - ENTRANCE	EXIT - ENYRANCE	ENTRANCE - EXIT
Skematic Diagram			
Length of Between Nose	L = 120 m	L/2 = 60 m	L = 120 m

Figure 7.4-3 Distance Requirement for Ramps

7.5 AT-GRADE STREETS

As the proposed alignment for the expressways are located in highly urbanized area, the existing roads were fully utilized to mitigate the adverse social impacts, particularly land acquisitions in case of wide implemented ROW. Supporting elements of superstructure are planned to be constructed in the median of existing at-grade streets. The spacing between supporting elements are planned to avoid traffic interruption at grade level. Standard clearance is also considered to avoid any undesirable control over the large vehicle height using the at grade road network.

Based on the above mentioned concept, number of lanes and lane width at grade level are adjusted to accommodate the existing traffic demand and superstructure supporting elements. The adjustment of these existing roads was carefully examined accounting to the following:

- Traffic congestion on at-grade streets
- Intersection configuration
- Additional spaces for U-turn traffic along the roads
- Maximum utilization of spaces below elevated expressway