In Joint Venture with

COWI A/S – Denmark

ACE Consultants Ltd. – Bangladesh

Dhaka Road Tunnel Feasibility Study Project

Jahangir Gate of Dhaka Mymensingh Road - Mohakhali Road (East Side) under the Old Tejgaon Airport to Rokeya Sarani at Agargoan (West Side).

FINAL REPORT

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Introduction

The rapid growth of population in Dhaka City has led to a growing demand for transport that the city's infrastructure, services, and management are insufficient to meet and there is little scope to develop any new roads within the limited and congested area. In order to ease the traffic problem and improve the living standards of city dwellers, the Government of Bangladesh (GOB) has committed to:

- Improve transport access and mobility for the residents of the Dhaka City
- Reducing traffic congestion
- Address long term transport planning, coordination and institutional issues

In line with these objectives the GOB has planned to construct a multilane 'Dhaka Road Tunnel Project' (DRTP), 1 km in length starting from Jahangir Gate of Dhaka Mymensingh Road - Mohakhali Road (East Side), crossing under the Old Tejgaon airport, and ending at Rokeya Sarani at Agargoan (West Side). The Bangladesh Bridge Authority (BBA) has commissioned the SMEC–COWI–ACE Joint Venture to carry out a Feasibility Study to determine the economic viability and technical feasibility of constructing this tunnel.

Existing Road Network

The Dhaka City road network is comprised of several main arterial roads and various internal secondary and link roads. These roads primarily connect the Shahjalal International Airport from the northeast and the sub-district of Mirpur from the northwest to the sub-districts of Dhanmondi and Motijheel in the south. The vehicle types in Dhaka are quite varied and range from motorcycles and auto rickshaws to heavy buses and trucks. There is also a significant amount of rickshaw, bicycle, and pedestrian traffic that often freely mixes with motorised traffic, even on major roads. Traffic congestion is prevalent in a number of areas in Dhaka as the transport capacity is insufficient to meet demands.

Dhaka City is generally structured such that a large number of the population is living in the western part of the city with most of the key employment centres situated in the east. This results in the western sub-districts and other concentrated residential areas producing the bulk of traffic during the morning peak as people travel from home to work and school, most often in the eastern and south-eastern parts of the city. In the evening peak period the direction of travel generally reverses as most people are heading home.

Surveys and Investigations

A detailed topographical survey was conducted in the project area comprising surveys of the existing road, runway and land area covering Mohakhali Flyover, Jahangir Gate, New Link Road, and old Tejgaon airport. Total 21 nos. of Bench Marks were established along the proposed alignment at suitable locations for surveying. The topographic survey consisted of the existing land level, the location of all existing physical features, and the utility service facilities, and the survey results are presented in the form of topographic maps detailed in Appendix A. The Geotechnical exploration consisted of field and laboratory programs detailed in Appendix B.

Hydrological Investigations

Dhaka is bounded by rivers and situated at the southern tip of a large relatively upland area in the central part of Bangladesh known as the Madhupur Tract and the City is protected from flooding by a series of embankments around its perimeter. The Dhaka Road Tunnel project area has been classified as being at 'extremely low' to 'low' flooding risk. Any flood water from the project area is drained into two drainage channels: to the south through closed drainage brick/concrete channels and to the north via overland flows. Based on hydrological data analysis it is likely that the flood protection required for

the proposed tunnel is manageable, although the road alignment and ramp periphery may require extra protection to ensure that surface run-off water from the surrounding areas is intercepted. Ultimately further study on the potential impacts of flooding will be required once access to the airport has been established. Full detailed presented in Appendix C.

Environmental Impact Assessment

Baseline conditions were surveyed in the Project Influence Area, the area within a 1 km radius from the center of the development site, to determine its physic-chemical environment, biological environment, and socio-economic environment, and then potential impacts and appropriate mitigation measures were identified. Field data was collected on air quality, noise level, and surface and groundwater quality. Focus group discussions with local people and stakeholder consultations have also been conducted during the Environmental Impact Assessment (EIA) to assist with determining potential impacts and possible mitigation options.

The EIA reveals that there will be both negative (mainly temporary construction related) and positive environmental impacts due to the construction and operation activities of the project. Possible mitigation measures have been recommended to eliminate or reduce the negative impacts and enhance the positive impacts of the project. Implementation of these mitigation measures during pre-construction, construction and operation phases will minimize the negative impacts of the project to acceptable levels.

A full Environmental Management Plan will be prepared after the proposed road tunnel project gets environmental clearance from the Department of Environment and will be necessary to manage off-setting the negative impacts arising from the project and enhancing positive impacts. Designing an appropriate monitoring plan is also essential to safeguard the protection of the environment during pre-construction, construction, and operation. The contract documents will contain a listing of all required monitoring measures and a time frame for the compliance monitoring of these activities. The Project Implementation Unit (PIU) through a Construction Supervision Consultant (CSC) will be responsible to supervise monitoring activities of all contractors procured under the Project. The total cost for implementation of the environmental activities is estimated as USD 178,000 during construction and operation.

Social Study

The broad objective of the social study component is to present a socio-economic profile through analysing data obtained from a household baseline survey, stakeholder consultations, and secondary sources. The aim is to determine whether the proposed road tunnel project is socially feasible; what the potential impacts on people living in the project influencing zone and other tunnel user groups are; and what the views, concerns, and suggestions of these potential user groups and stakeholders are.

Survey data was obtained from a sample of 261 households living in the project influencing zone providing information on demographics, settlement patterns, occupation and income, water and sanitation, and transport expenditure among others. Households were also surveyed for their views on project impact, their opinion on toll collection for cost recovery, and on safety measures during tunnel construction and operation. Focus group discussions with local groups as well as key stakeholder consultations expanded upon the views of surveyed households.

The majority of comments by both surveyed households and consulted stakeholders were on the project's benefits to the city. Potential negative impacts discussed were mostly minor and temporary in nature. Increased traffic congestion during construction period would only be a temporary negative impact. The DWASA sewerage and drainage system as well as the water supply network system could be impacted during the project activities also. Toll collection was a controversial issue because even though transport fares might increase, the use of the tunnel should decrease the route distance and likely travel time so eventual travel cost could be reduced.

From a social perspective the Project is found to be feasible and highly appreciated by all stakeholders and the studied population. The Study also found that the key stakeholders are positive about the Project and are willing to assist and cooperate in the project implementation process as necessary.

Traffic Studies, Surveys, and Modelling

Three types of traffic data were surveyed for three-hour periods in both the AM- and PM-peak periods within the study area for traffic micro-simulation model estimation as part of the Dhaka Road Tunnel Project. These surveys include an Origin-Destination Survey conducted at ten external and eight internal zones, an Intersection Count Survey of full classified turning movement counts for 13 major intersections, and a Travel Time Survey for five routes through the study area.

Traffic micro-simulation estimation, calibration and simulation processes were conducted to evaluate the benefits of a tolled tunnel bypass constructed under Tejgaon Airport. Three scenarios were tested: the existing configuration ('Do Nothing') and two options for the tolled tunnel bypass ('Option 4' and 'Option 5'). The tunnel options were simulated for a selection of toll values (Tk0, Tk50 and Tk100) and bulk performance statistics were extracted. The modelling results indicate that the projected traffic growth results in extreme congestion and that the tunnel will bring a small benefit only if the toll is less than Tk50.

Stakeholder Consultations

The considerable number of external stakeholders involved in this Project include Government agencies, the Military, public bodies, political parties, private concerns, technical institutions, the media and the public at large. Some stakeholders have a direct influence on the scheme and also have a direct involvement and physical interface with the project. In view of the sensitive nature of the project and its impact on Dhaka City and the airfield it is recommended that BBA engage with these 'primary' stakeholders at an early stage in the study. From the Consultant's direct experience with projects including airports and military agencies early stakeholder involvement can offset predetermined ideas and allow for constraints to be agreed upon rather than 'imposed' in an arbitrary manner. Of course all such interaction with stakeholders will need to be approved by BBA.

Land Requirement

The land of the Airport belongs to Government, so land acquisition will not be required for the main component. However, at either end some private lands with structures might be impacted. However, the impacts on privately owned lands are likely to be very small. The Socio-Economic profile informs that some squatters are operating various small businesses but they will not be entitled to any benefit as the government doesn't recognize these sorts of illegal occupations.

For these reasons this Abbreviated Resettlement Policy Frameworks (ARPF) is proposed for the project. Mainly the *Acquisition and Requisition of Immovable Ordinance 1982* and its subsequent amendments have been taken into consideration while preparing this framework. At this stage since the alignment has not been finalized and the land acquisition survey has not been done, the total quantity of land to be acquired from private ownership and resumption of public lands can't be predicted. If land acquisition is at all required this framework will be applied and procedures would be adapted.

Alignment Options Investigation

Seven options were investigated. These were as shown in the table below.

Table: Airport Connection Options

Road Alignment	Description	Capital (BDT) Crore	USD $M	O&M Cost (BDT) crore/y	USD $M/y	EIRR no toll	FIRR Tk50 Toll
Option 1	Do Nothing (Base Case)	0	0	0	0	-	-
Option 2	Surface road connection	123	15.4	2.5	0.31	26.9%	25.9%
Option 3	Cut & Cover underpass of runway	295	36.9	4.1	0.51	12.8%	11.0%
Option 4	Twin Tunnel 900m length steep ramps grades 7%	3156	394.5	15.0	1.88	-0.2%	-0.5%
Option 5	Twin Tunnel 1300m length ramps 4% grades	4011	501.4	16.4	2.05	-0.5%	-0.7%
Option 6	Underpass and Flyover	408	50.9	5.2	0.65	4.7%	7.6%
Option 7	2 Underpasses	304	38.0	5.2	0.65	6.6%	10.3%

* No land acquisition cost is included.

Options 2 and 3 do not meet Bangladesh Air Force requirements that the base not be disturbed, and Option 4 requires a steep ramp grade in order to reach the necessary cover depth within its short length. For these reasons only option 5 was carried forward as it was the only option that did not disturb the Bangladesh Air Force base and also met the design criteria for entry and exit ramps of 4% grade.

Scope of Work for Preferred Option

The Bangladesh Air Force requirements for the proposed project mandate an excavated tunnel with negligible impact on airport operations both during and after construction. It is expected that cut and cover construction will be adopted near the tunnel portals.

The eastern interchange is a partial interchange with the tunnel connecting only to the Mohakali Flyover. At the western there is a full interchange, i.e. all movements are allowed for, with Sayed Manbub Morshed Ave providing the east-west route, and Begum Rockeya Avenue provided a north-south connection. The tunnel alignment runs diagonally under the airport runway to conform to the geometry of the eastern and western approach roads. The existing airport bypass road is relocated to connect to the interchange opposite the westbound exit ramp, allowing its continued use by vehicles prohibited from the tunnel and also for use during tunnel closure.

The tunnels will be two separate structures separated by a 13.0 m median and connected by cross passages. Each tunnel will include two 3.5 m traffic lanes, a 1.0 m median shoulder (providing pedestrian access to cross passages), and a 2.5 m left shoulder for breakdowns. The vertical clearance proposed is 5.7 m. Emergency median crossovers are required outside the tunnel to allow traffic flow in the peak direction should one tunnel be closed. The tunnel and its approaches are unsuitable for providing tolling facilities

using boom gates, therefore if tolling is required it is recommended that free flow electronic tolling be implemented.

Option 6 & 7 were look at as a cheaper more feasible option but still obtaining the benefit of reducing congestion. Option 6 looks at the East interchange. Option 7 addresses the east and west interchange in the most cost effective manner.

Economic and Financial Evaluation

The tunnel is very costly. The amount of traffic that would use the tunnel is nowhere near enough to justify its construction. The economic return on investment is negative. Charging a toll makes it more negative because tolls suppress demand. There is no conceivable combination of cost reduction and benefit enhancement that would make the tunnel worthwhile or economically viable.

Recommendation

To build a project based on the traffic model data to meet the economic criterion of 12%pa the cost must be no more than 295.8 crore BDT ($36.1M USD) with 8.2 crore BDT ($1M USD) operation and maintenance costs per year. These figures assume the connection is free; by charging a toll you suppress demand and thus suppress benefits. As long as work inside the Air Force base is prohibited there is no viable tunnel project that can be undertaken within these funds.

The final recommendation is to undertake a comprehensive, strategic network-wide investigation. This would extend the existing traffic model for the tunnel project and the elevated highway project to include all the current and future works. A series of projects can then be developed and prioritized base on cost effectiveness. This would require interagency cooperation to achieve a successful outcome.

ABBREVIATIONS AND ACRONYMS

Abbreviation / Acronym	Description
AB	Acquiring Body
ADB	Asian Development Bank
AE	Assistant Engineer
BAF	Bangladesh Air Force
BAF	Bangladesh Air Force
BBA	Bangladesh Bridge Authority
BBS	Bangladesh Bureau of Statistics
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BMD	Bangladesh Meteorological Department
BR	Bangladesh Railway
BRB	Bangabandhu Multipurpose Bridge
BRTA	Bangladesh Road Transport Authority
BWDB	Bangladesh Water Development Board
BWDB	Bangladesh Water Development Board
CBD	Central Business District
CLAC	Central Land Allocation Committee
CMP	Construction Management Plan
CSC	Construction Supervision Consultant
CUL	Compensation Under Law
DC	Deputy Commissioner
DCC	Dhaka City Corporation
DESA	Dhaka Electric Supply Authority
DF	Department of Forest
DFPEP	Dhaka Flood Protection Embankment Project
DG	Director General
DMP	Dhaka Metropolitan Police
DOE	Department of Environment
DPHE	Department of Public Health Engineering
DRTP	Dhaka Road Tunnel Project
DTCB	Dhaka Transport Coordination Board
DUTP	Dhaka Urban Transport Project
DWASA	Dhaka Water Supply and Sewerage Authority
EA	Environmental Assessment
EA	Executing Agency
ECA	Environmental Conservation Acts
ECC	Environmental Clearance Certificate
ECR	Environmental Conservation Rules
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EQS	Environmental Quality Survey
EU	Environmental Unit
FGD	Focus Group Discussion
GOB	Government of Bangladesh
GWL	Groundwater Level
ha	Hectare
IEE	Initial Environmental Examination

Abbreviation / Acronym	Description
JICA	Japan International Cooperation Agency
km	Kilometers
LAP	Land Acquisition Plan
LGED	Local Government Engineering Department
LOC	Library of Congress
m	Meters
MOC	Ministry of Communication
MOEF	Ministry of Environment and Forest
NAPA	National Adaptation Programme of Action
NEQS	National Environmental Quality Standards
NCS	National Conservation Strategy
NEMAP	National Environmental Management Action Plan
NWMP	National Water Management Plan
O&M	Operation and Maintenance
OH&SP	Occupational Health and Safety Plan
PAPs	Project-Affected Persons
PD	Project Director
PIA	Project Influence Area
PIU	Project Implementation Unit
PMBP	Padma Multipurpose Bridge Project
PMO	Project Management Office
PPE	Personnel Protective Equipment
PPP	Public Private Partnership
PWD	Public Works Department
RAJUK	Rajdhani Unnayan Kartipakkha
RB	Requiring Body
RHD	Road and Highway Department
RIU	Resettlement Implementation Unit
ROW	Right-of-Way
SAE	Sub-Assistant Engineer
SC	Stakeholder Consultation
SMF	Social Monitoring Framework
SOB	Survey of Bangladesh
STP	Strategic Transport Plan
TBM	Tunnel Boring Machine
TMP	Traffic Management Plan
TOR	Terms of Reference
WMP	Waste Management Plan

1 INTRODUCTION

According to a recent UN data sheet, Dhaka City is currently the 22nd largest urban agglomeration in the world and will by 2015 be the 5th largest with a population of 19.5 million. The rapid growth of population in Dhaka City has led to a growing demand for transport that the city's infrastructure, services, and management are insufficient to meet. The number of vehicles operating within the city has been increasing at an alarming rate, but there is little scope to develop any new roads within the limited and congested area. Public transport conditions continue to deteriorate and traffic jams, long delays and a high incidence of road accidents have become a daily experience for residents across the city.

Considering the seriousness of the situation, concerned authorities like Bangladesh Road Transport Authority (BRTA), Dhaka Metropolitan Police (DMP), Dhaka Transport Coordination Board (DTCB) and Bangladesh Road Transport Corporation (BRTC) have taken several measures for its improvement, but so far efforts have been inadequate. In order to ease the traffic problem and improve the living standards of city dwellers, the Government of Bangladesh (GOB) has committed to:

- Improve transport access and mobility for the residents of the Dhaka City
- Reducing traffic congestion
- Address long term transport planning, coordination and institutional issues

As part of the above mentioned objectives, the GOB has planned to construct a multilane 'Dhaka Road Tunnel Project' (DRTP). The total length of the proposed Dhaka Road Tunnel is 1 km. The Project area lies within the northern part of the City and includes part of the Bangladesh Air Force (BAF) Airport and runway which also serves as the National Parade Square. The proposed tunnel starts from Jahangir Gate at Farmgate-Mohakhali Road (east side) and after crossing under the Old Tejgaon airport it ends at Rokeya Sarani at Agargoan (west side). This should reduce traffic congestion and enhance traffic movement for the entire Dhaka City.

The Dhaka Road Tunnel Project Feasibility Study is part of a Government of Bangladesh initiative to ascertain the economic viability and technical feasibility of constructing this tunnel from Jahangir Gate to Rokeya Sarani. The Bangladesh Bridge Authority (BBA) is the technical as well as administrate arm of the 'Bridges Division' of the Ministry of Communication (MOC), which is responsible for planning, construction and maintenance of regional and national roads, railway and bridge infrastructure in the country. The BBA is representing the Government of Bangladesh as the Executing Agency (EA) of the Multi-Lane Dhaka Road Tunnel Project and as such has commissioned the SMEC–COWI–ACE Joint Venture to carry out the Feasibility Study.

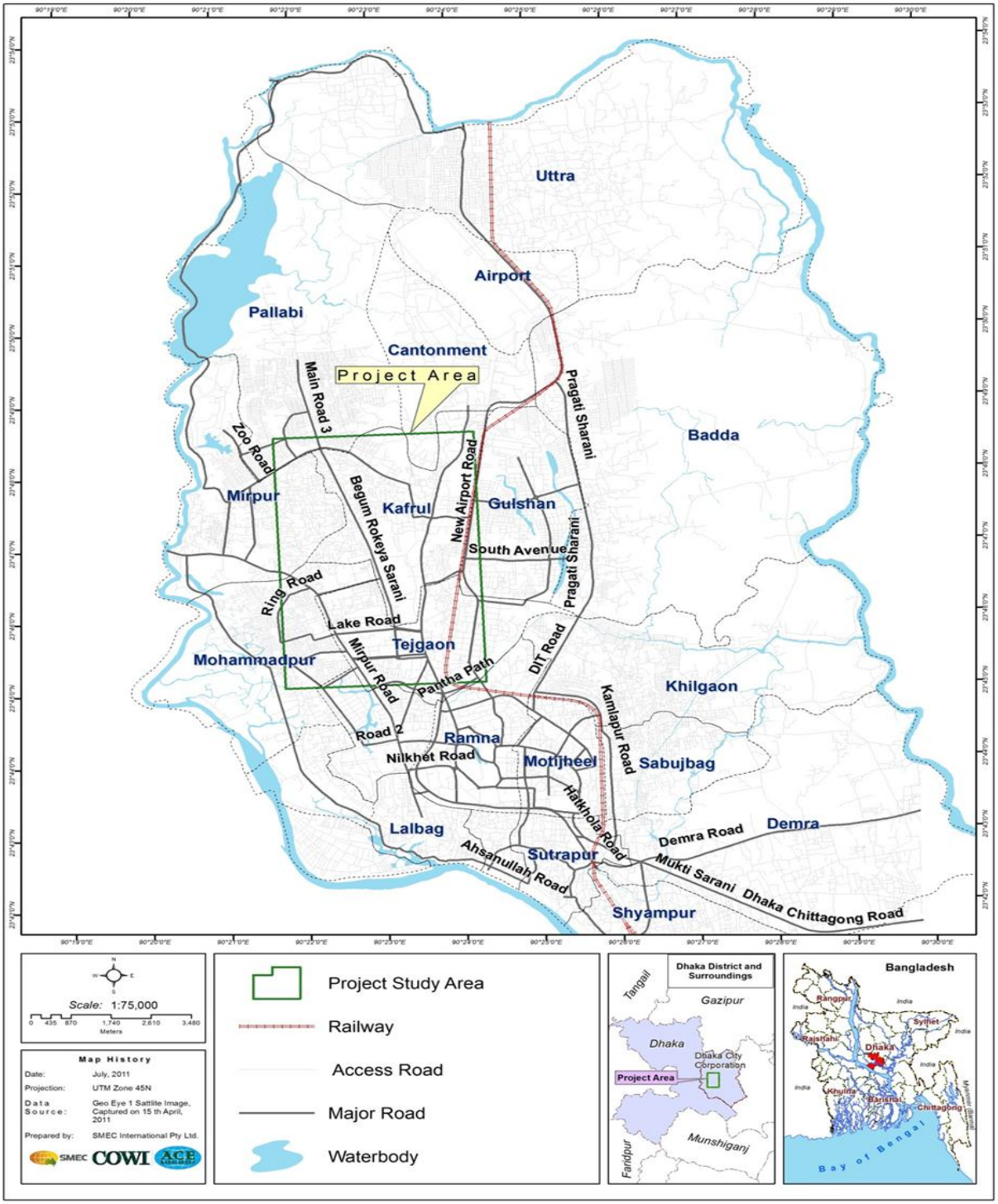


Figure 1.1: Project Site in Relation to Dhaka City

2 OBJECTIVE OF THE STUDY

The broad objective of the study is to present the economic viability and technical feasibility of the Dhaka Road Tunnel Project. This has been completed by way of a thorough investigation of the available data, comprehensive studies of environmental and social impacts, and detailed modeling and evaluation to determine the feasibility of options.

3 SCOPE OF STUDY

The Scope of Work for this feasibility study includes:

- Determination of alignments and Engineering Options
- Route options
- Geotechnical investigations
- Traffic study and forecasting
- Environmental studies
- Environmental Impact Assessment
- Land use study
- Preliminary Design of Preferred Engineering Solution
- Construction Methodology appreciation
- Procurement Models including PPP
- Socio-economic Model
- Financial Model including cost estimates, NPV, FIRR, EIRR and BCR

4 REVIEW OF EXISTING FACILITIES AND SERVICES

4.1 Existing Dhaka Road Network

There are two main types of road in Dhaka City: Primary/Main Roads and Local Roads. The primary roads are the major, arterial roads and the local roads are the internal secondary and link roads.

The major north-south roads of the Dhaka City road network include the following:

- Mirpur Road
- Begum Rokeya Sharani
- New Airport Road / Shaheed Tazuddin Road
- Pragati Sharani / DIT Road

These roads primarily connect the Shahjalal International Airport from the northeast and the sub-district of Mirpur from the northwest to the sub-districts of Dhanmondi and Motijheel in the south. The Mirpur Road passes through the sub-districts of Mohammadpur and Hazaribag on the western side of Dhaka City, while New Airport Road and Pragati Sharani / DIT Road pass through the sub-districts of Gulshan, Badda and Tejgaon on the eastern side.

The major east-west routes in the northern part of Dhaka, which are relatively shorter compared to the north-south ones, include Agargaon Road, Mirpur Link Road (also called New Link Road or Mirpur / Mohammadpur & Gulshan / Banani Link Road), and Manik Mia Avenue in central Dhaka. New Elephant Road / Shahbag Road and Zahir Raihan Sharani provide the major east-west links in the southern part of Dhaka. To the north of the Tejgaon Airport, the main east-west connector is Shaheed Yousuf Road, which links with Kachukhet Road and eventually connects with Mirpur Road.

A location map showing the streets is shown below in Figure 4.1.

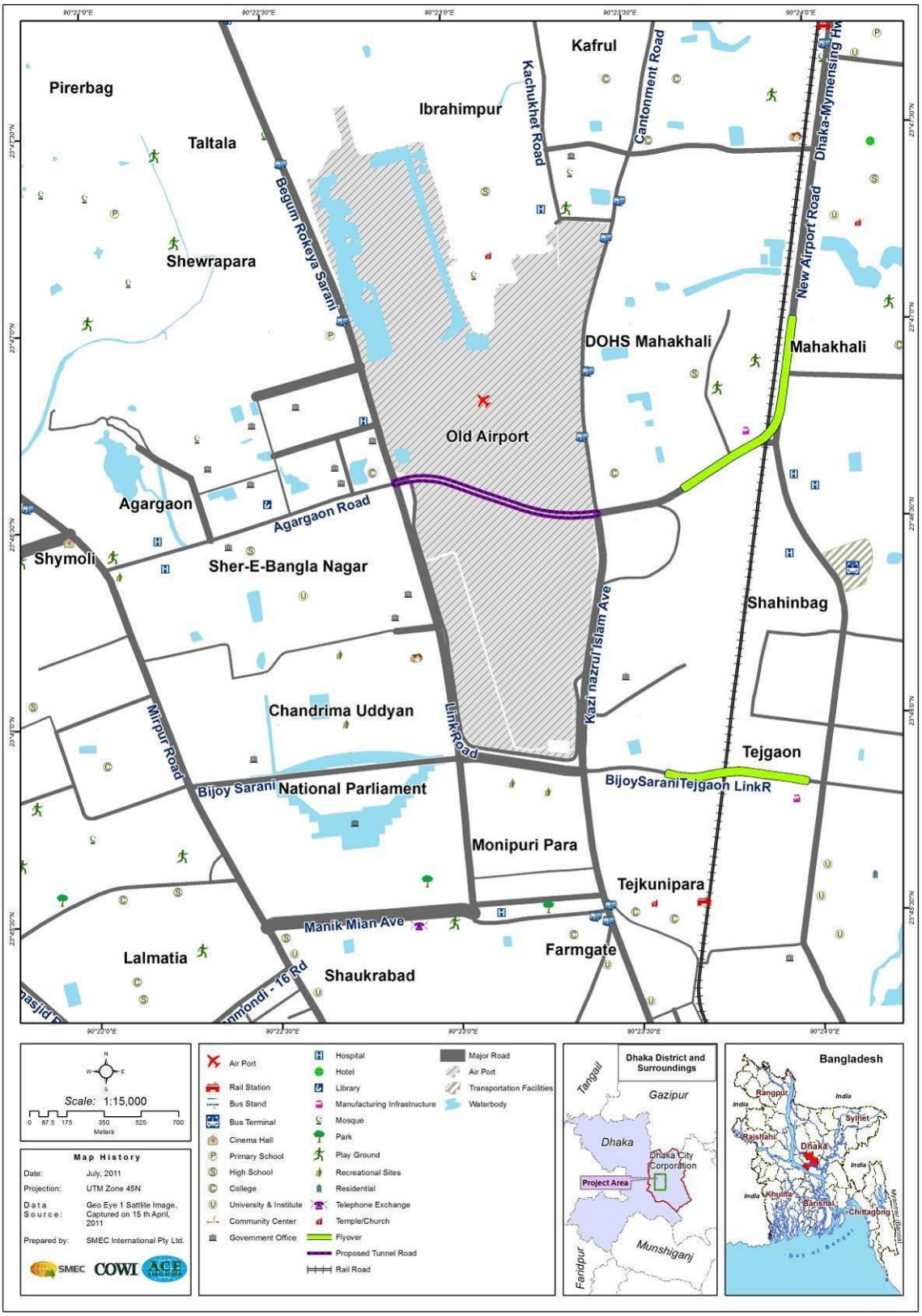


Figure 4.1: Existing Network (Major Road Names)

4.2 Current Traffic Mix

The vehicle types in Dhaka are quite varied and can be classified according to the standard Roads and Highways Department (RHD) motorised vehicle classes, which are as follows:

- Heavy Truck
- Medium Truck
- Light Truck
- Large Bus
- Mini Bus
- Micro Bus
- Utility (Jeep/Pick-up)
- Car/Taxi-cab
- Auto Rickshaw and Tempo
- Motorcycle

There is also a significant amount of non-motorised transport, particularly rickshaws and pedestrians. Although rickshaws mostly operate on the minor roads, a significant number of pedestrians can be seen almost anywhere in the network. Walking is a very common transport mode in Dhaka and this further adds to the network congestion as in some areas, pedestrians freely mix with motorised traffic, even on major roads. The latter is probably a consequence of having approximately 40% of the existing footpaths being occupied illegally.[1]

Bicycles, another form of non-motorised transport, are also being used by some people in Dhaka but not as extensively as walking and rickshaws. The last survey conducted as part of the development of the Strategic Transport Plan (STP) for Dhaka completed in 2005 found that bicycles comprise only 2% of the total vehicles counted.

The major roads are still predominantly used by passenger cars, although a considerable proportion of traffic demand consists of buses and auto-rickshaws (also called 'baby taxi' or 'CNG' by locals). Minor roads are typically used heavily by non-motorised transport (rickshaws), which makes driving through these roads quite challenging.

4.3 Main Traffic Generators

Dhaka City's land use is generally structured such that a large number of the population is living in the western part of the city with most of the key employment centres situated in the east. Commercial areas are mainly located in the Gulshan, Ramna and Motijheel sub-districts, and educational institutions which also generate significant traffic demand are located at different areas of the city, but primarily at Dhanmondi, Mohammadpur, Mirpur, and Gulshan.

Trip generators can be classified as either 'producers' or 'attractors.' Producers generate outgoing trips while attractors generate incoming trips. In the morning peak period when workers and students make their journey to their respective workplaces and schools the main trip producers are the residential zones. The main trip attractors include employment centres (e.g. offices, factories, etc.), educational institutions, and also some shopping centres that open during the morning peak. In the afternoon/evening peak period, the direction of travel generally reverses with most people heading home.

In Dhaka, the main trip producers in the morning peak are the western sub-districts of Pallabbi, Mirpur, Mohammadpur and Dhanmondi, where most of the residential areas are concentrated. Other residential areas with relatively lower densities and mostly located in the eastern part of the city include Banani, Gulshan, Khilgaon, Ramna and Motijheel. The relatively new residential area in the north of Dhaka, Uttarra, is already generating a

[1] The Strategic Transport Plan (STP) for Dhaka, Final Report, December 2005

considerable amount trips during the peak periods and is expected to generate more once fully developed.

The morning peak attractors in Dhaka are mostly situated in the eastern and south-eastern parts of the city. Gulshan, being one of the major commercial areas of Dhaka and a major employment hub, generates significant journey-to-work trips. Similarly, Tejgaon also generates significant demand in the morning peak period as this is the largest industrial area in the city.

Old Dhaka, located in the sub-districts of Ramna and Motijheel and Gulistan is widely regarded as the city's central business district (CBD). It is therefore considered a major trip attractor, being a commercial area and a destination for employees and shoppers alike during the morning peak.

The major trip producers and attractors are shown in Figure 4.2 below.

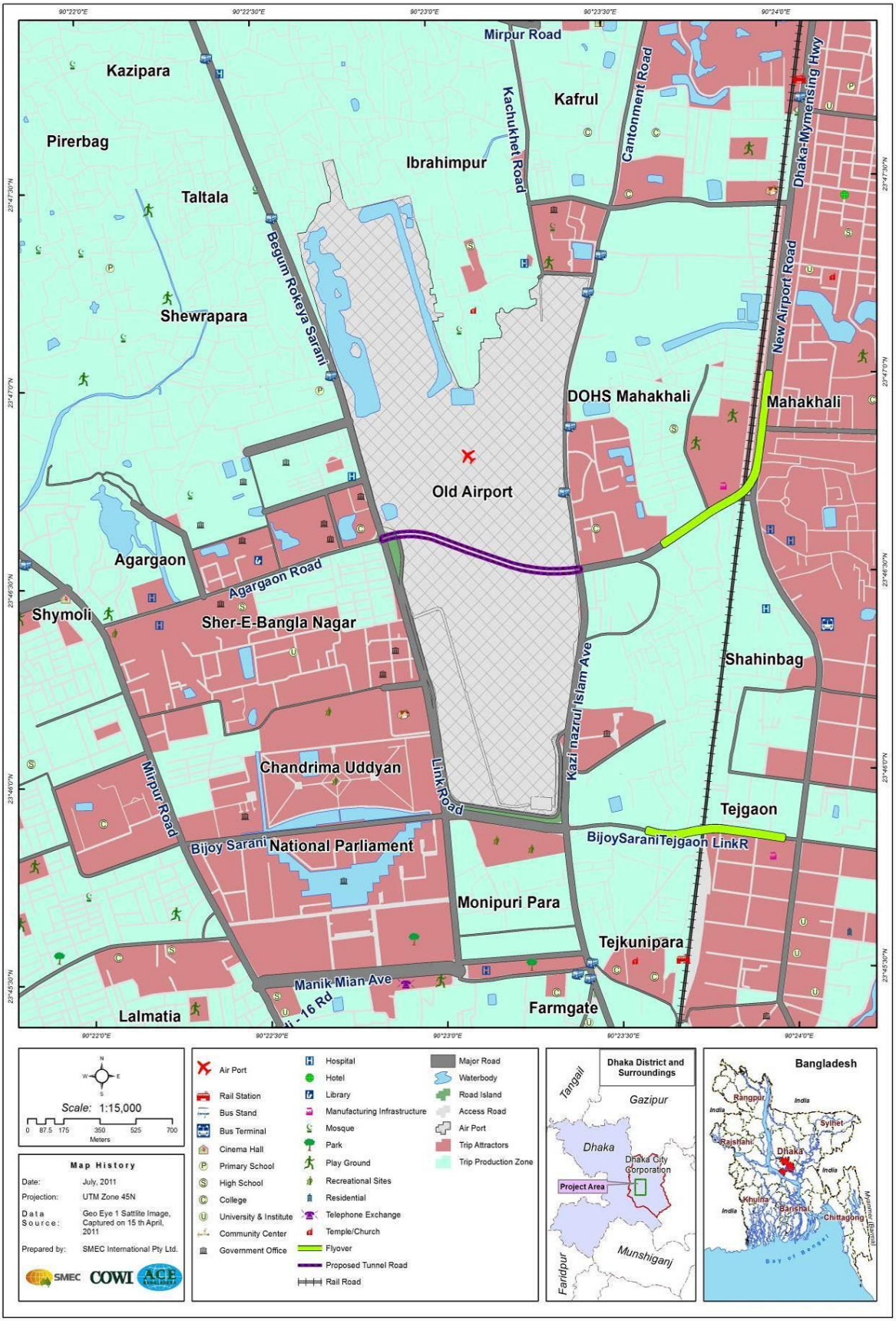


Figure 4.2: Major Trip Producers and Attractors Highlighted

4.4 Qualitative Assessment of Traffic Congestion and Major Problems

Traffic congestion is prevalent in a number of areas in Dhaka. Although the main cause is insufficient capacity to meet demand another significant factor is poor driver behaviour. In addition the large number of auto-rickshaws and private vehicles compete for road space with public vehicles.

Intersections are especially problematic for several reasons. Although major intersections are generally in accordance with good geometric design and mostly manned by the police, intersection performance is not optimal as the flow of traffic is dependent on the judgment of the police officers in charge. Often the police controlling the traffic 'over-rule' the traffic signals which can compound congestion away from the main junctions. Some intersections do not have an optimal geometric layout and also suffer from a shortfall in control strategy.

5 SURVEYS AND INVESTIGATIONS

5.1 Topographical Survey

A detailed topographical survey was conducted in the project area. All the requirements of topographical survey works were completed with proper accuracy. The detailed survey was carried out using high precision instruments e.g. Total Station (TOP CON -105), Level Instrument (WILD-N3) and GPS, etc. The data from the topographical survey was put (E,N,Z), N- Northing, E – Easting & Z- Leveling / Elevation format so that it could be used to establish a sophisticated digital ground model (DGM). For conducting the topographical survey the control points i.e. Bench Marks (BM) were established. The FBM & TBM (Fundamental bench mark & Temporary bench mark) were carried from the SOB (Survey of Bangladesh) bench mark i,e. almost 5km away from the project site and located at Main BM, B O M Engraved on cemented base, South-West Corner of Sluice Gate at Dhaka - Tongi Rail line. The Sluice Gate is situated west side of Mr. Jalal's house, Vill: Kuratoli, P.S. Cantonment, Dist: Dhaka. Which E=23-49'-12", N=90-25'-30", Z=7.132m (SOB).

In connection with this work, the detailed survey conducted comprises topographic survey of the existing road, runway and land area covering Mohakhali Flyover, Jahangir Gate, New Link Road, and runway of old Tejgaon airport. A further detail of the survey area is shown in the enclosed map.

Total 21 nos. of Bench Marks were established along the proposed alignment at suitable locations shown in the alignment plan drawing and valued as listed below (Table 5.1).

Table 5.1: List of Control Points (Bench Marks)

Sl. No.	FBM & TBM	Northing	Easting	Elevation	Locality
1	FBM	783851.760m	398617.219m	7.524m	
2	FBM	783684.875m	398607.252m	7.062m	
3	FBM	783851.760m	398617.219m	7.524m	
4	FBM	783955.105m	398142.217m	8.288m	
5	FBM	783770.104m	398011.961m	8.315m	
6	TBM	785196.903 m	399611.068 m	7.004m	
7	TBM	784835.485m	399657.856m	7.259m	
8	TBM	784501.583m	399584.379m	7.863m	
9	TBM	784403.956m	399398.982m	7.280m	
10	TBM	784229.309 m	399213.324m	6.921m	
11	TBM	784243.916m	399188.025m	7.239m	
12	TBM	784230.903m	399199.098m	7.250m	
13	TBM	784144.479	399103.334m	9.344m	

14	TBM	784082.029 m	398759.819m	7.948m	
15	TBM	783742.043	398430.968m	8.156m	
16	TBM	783742.043	398430.968m	8.156m	
17	TBM	783778.562m	398376.952m	8.120m	
18	TBM	783880.108m	398409.969m	8.714m	
19	TBM	783897.702m	3398276.084m	8.223m	
20	TBM	784023.441m	398282.195m	8.254m	
21	TBM	783985.697m	398211.981m	8.226m	
22	TBM	783967.539m	397589.340m	7.150m	

Note: These Sl. Nos. are clearly marked on the Alignment Drawing.

Features for major and minor structures were detailed within the limits of the survey area and included the following:

- Confirmation of existing BM networks, and some BM fixed with fencing
- Topographic Survey consisting of:
  - Surveying the existing land level
  - Location of all existing physical features comprising the:
    - Buildings
    - Roads
    - Flyover
    - Runway
    - Link Road
    - Other Structures
  - Utility service facilities comprising:
    - Electric and telephone lines
    - Gas pipe lines
    - Drainage and sewerage connections etc.

The survey results are shown in the form of topographic maps.

- 3-D points taken in a series of linear string; maximum 15 m apart throughout the entire survey area.
- All topographical features e.g. change in grade, berms, cuttings, ditches, Major trees, depressions, etc. and other natural elements.
- All existing buildings and structures, fence and barriers, derelicts, partially demolished or otherwise.

5.1.1 Visual Observations

Conditions:

- Whole of the project area was found to be nearly flat.
- No major differences in levels found.
- No major ditches, depressions or heaps are observed.
- Significant physical features are observed.

Features:

- Different kinds of trees are present in the project area.
- Many objects & other topographical elements are located at different locations.

5.2 Geotechnical Investigation

The Geotechnical exploration consisted of field and laboratory programs. The scope of the investigation work was indicated in the Map, locations, depths, etc. The field and laboratory testing shall be performed in conformance with applicable ASTM/AASHTO/BS or other international codes as indicated in BNBC / PWD Standards.

All drilling and sampling equipment was in good working condition. All equipment/instruments were calibrated at the start of work to reflect factual values. All the laboratory equipment was checked regularly to verify that they meet the required tolerances, as established by the AASHTO/ASTM test procedures. The Geotechnical Investigations report is enclosed in Appendix H.

6 HYDROLOGICAL INVESTIGATIONS

6.1 Location and Topography

Dhaka is situated between latitudes 23°42' and 23°54'N and longitudes 90°20' and 90°28'E. The city is bounded by the rivers Buriganga to the south, Turag to the west, Balu to the east and Tongi Khal to the north. Dhaka is situated at the southern tip of a large relatively upland area in the central part of Bangladesh known as the Madhupur Tract. The total extent of this Tract is 4,244 sq km and Dhaka occupies its southern part. Geologically the Tract is a terrace which rises up to ten metres above the adjacent floodplains. It is an ancient geomorphological that has been uplifted several times during its history which has resulted in numerous longitudinal faults. This is considered to have resulted in a horst (fault bounded) feature as shown in **Error! Reference source not ound.**.

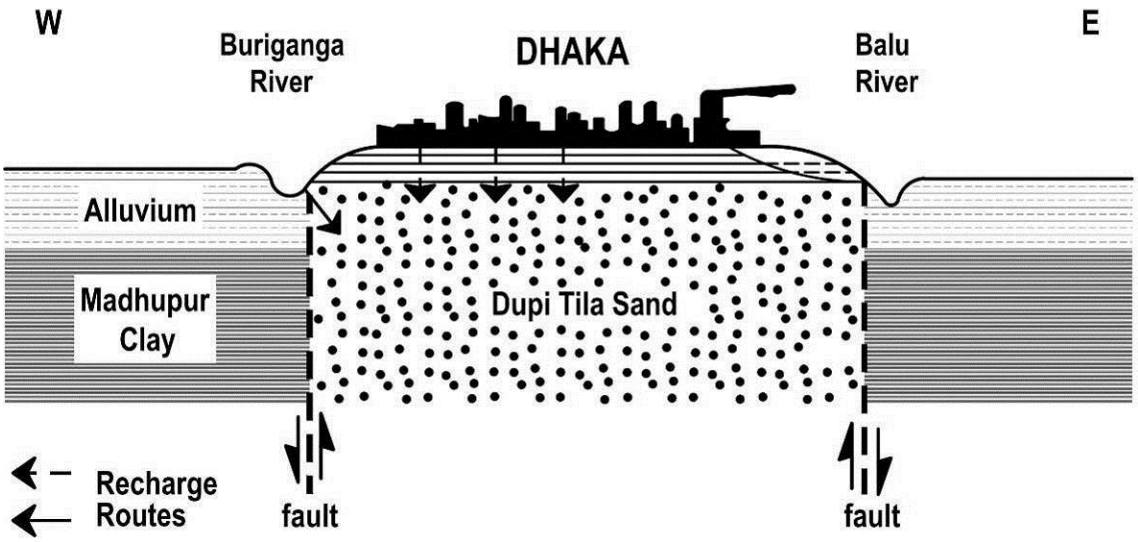


Figure 7.2: Dhaka Located on a 'Horst' Structure (Morris et al., 2003)

6.2 Climate

The City has three distinct seasons:

Season	Months	Rainfall (mm)	Temperature
Winter	November to February	Dry / Showers	10°C to 20°C
Pre-Monsoon / Summer	March-May	Average 400	36°C to 40°C
Monsoon	June-October	Average 1600	28°C to 32°C

In order to define the climatic condition of the project area, temperature, Rainfall, humidity and wind speed data recorded during the years 2005 to 2008 by Bangladesh Meteorological Department have been considered. The average maximum and minimum temperatures in the project area were 38.5°C and 9.6°C respectively. The annual rainfall in Dhaka ranged from 1,991 to 2,885 mm and the maximum daily rainfall recorded was 190 mm in September 2008. June to October is the monsoon season with July being the wettest month with a monthly rainfall of between 331 to 753 mm. December is the driest

period with almost no rainfall. The annual average relative humidity in Dhaka was 73%. Generally, all months have days where the humidity reaches above 94%. The lowest daily humidity recorded in Dhaka was 6%. The wind direction in Dhaka station is generally towards south-east direction. The maximum wind speed recorded in Dhaka between 2005 and 2008 was 22 knots in the eastern direction (October 2007).

6.3 Hydrology

Dhaka City is bounded by several major drainage features: the Tongi Khal to the north, the Turag River to the west, and the Buriganga River on the south. The City is protected from flooding by a series of embankments erected around its perimeter following severe flooding in 1988. Following floods in 1998 the project area was classified on a qualitative basis for flooding risk as being from 'extremely low' to 'low.' Any flood water from the Dhaka Road Tunnel Project area is drained into two drainage channels: the Kallyanpur Khal to the south through closed drainage brick/ concrete channels and the Ibrahimpur Khal to the north via overland flows.

Hydrological data has been collected from the Bangladesh Water Development Board (BWDB) and climatic data were collected from other sources.

6.4 Hydrological Data Analysis

Frequency analyses have been carried out based on yearly maximum one day rainfall and water levels, and hourly rainfall. The General Extreme Value Distribution by L-Moment Method has been used for determining return periods.

Table 7.1: Water Level and Rainfall of Different Return Periods

T (year)	1.5	2	5	10	20	25	50	100	200
WL at Tongi Khal (m PWD)	5.57	5.83	6.48	6.90	7.31	7.44	7.84	8.24	8.63
WL at Mirpur Khal (m PWD)	5.66	5.93	6.64	7.14	7.64	7.81	8.33	8.88	9.45
1-day (max,) Rainfall in mm	106	121	150	163	173	175	183	187	191
2-day (max,) Rainfall in mm	142	161	205	235	263	272	299	327	354
Hourly Rainfall (mm)	47	53	66	72	76	77	80	82	84

The Rational formula for discharge computation is as follows:

Q = CIA/360

Where,

- Q - Discharge in m^3/sec
- C - Co-efficient of run-off
- A - Area in ha
- I - Rainfall Intensity in mm/hour

The rainfall intensity for a 20 year return period is 76 mm/hour and that of a 50 year return period is 80mm/hour. The following flows in the channels have been ascertained for a return period of 50 years:

Table 7.2: Discharge Computations

Channel	C	A (ha)	I (mm/hour)	Q (m3/sec)
Northern	0.8	178	80	15.46
Southern	0.8	87	80	31.64

Based on the above it is likely that the flood protection required for the proposed tunnel is manageable. However the road alignment and the periphery of the ramps may require some form of bund protection to ensure that surface run-off water from the surrounding areas is intercepted. In addition the tunnel drainage system may be designed to deal with heavy rainfall falling directly onto the ramp areas and water from emergency situations (e.g. fire). Ultimately further study on the potential impacts of flooding will be required once access into the airport has been established.

7 ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Introduction

Environmental Impact Assessment (EIA) is an important part of the Feasibility Study and also a legal obligation (outlined in *ECA, 1995* and *ECR 1997*) to the DoE, Bangladesh since the proposed DRTP is considered a 'Red Category' project. All the possible negative and positive impacts of the proposed DRTP have been assessed during the environmental study.

7.2 Environmental Regulations and Requirements

Natural resources conservation and environmental protection are now championed across the world. The GoB has formulated its own various environmental regulations in the form of Acts, Rules and Policies. These regulations are being adhered to in the preparation of the EIA report for the proposed Dhaka Road Tunnel Project. As per ECR 1997, as the proposed DRTP has the length of about 1.0 km it falls under the Red Category and hence, necessitates a full-scale EIA. Some of the environmental regulations are outlined as follows.

Environment Conservation Act (1995) includes environmental guidelines to control and mitigate environmental pollution, conservation and improvement of environment and provisions for obtaining an Environmental Clearance Certificate (ECC) for development projects.

Environment Conservation Rules (1997) provides a first set of rules under the Environment Conservation Act giving categories of development projects and requirements for Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA), and preparation of Environmental Management Plan (EMP), as well as the procedure for obtaining an ECC. Also quality standards for air, surface water, groundwater, drinking water, industrial effluents, emissions, noise and vehicular exhausts are given.

Environment Conservation Act (Amendment 2000) focuses on ascertaining responsibility for compensation in cases of damage to ecosystems, increasing provision for punitive measures of both fines and imprisonment, and the authority to take cognizance of offences.

Environmental Conservation Act (Amendment 2002) includes restrictions on polluting automobiles, restrictions on the sale and production of environmentally harmful items like polythene bags, and guidelines for law enforcement agencies and punitive measures.

National Environmental Quality Standards (NEQS) for ambient air, various types of water, industrial effluent, emission, noise, vehicular exhaust etc. are being further revised in ECR 1997 amendments 2005. Some other relevant regulations are Environmental Policy (1992), Environmental Action Plan (1992), National Environmental Management Plan (NEMAP, 1995) etc.

7.3 Environmental Baseline Determinations

Baseline environment refers to the existing physico-chemical, biological and social condition in and surrounding the project area. The Project Influential Area (PIA) is confined to within a radius of 1 km from the center of the development site since the nature of the project is such that most of the potential impacts are likely to occur within this area. The PIA comprises Shahinbag RA under Tejgoan Thana at east side and Taltola Colony under Kafrul Thana at west side. The project influence area is a fully urban and populated area.

7.3.1 Physico-Chemical Environment

In line with the physico-chemical environment, topography, geology, climatic components, flooding, seismicity, water quality, air quality, noise level, soil quality etc. have been taken into consideration. The topography of the DRTP can be illustrated as flat elevation with paved and grass covered land. The ground elevation of the project site is about 25m (PWD). The land in the project area has been formed in the Pleistocene period and the soil is alluvium in nature with reddish brown colored. According to FAO-UNDP (1988) soil classification, the soil type of the project area is defined under Non-calcareous Dark Grey Floodplain soil.

The climatic condition of the project area has already been described in Section 7 and is given in further detail in Appendices C and D.

The project area in the City of Dhaka where it is located is prone to flooding due to the surrounding Turag and Buriganga Rivers. As per the opinion of the local people, the area was flooded in 1954, 1988 and 1998. It can be noted that the entire Dhaka City has been protected against flood by the project, taken by Bangladesh Water Development Board (BWDB) named as 'Dhaka Flood Protection Embankment Project (DFPEP). According to BNBC (1993) seismic zoning map, the project area falls under Zone –II (Z= 0.15) that denotes moderate seismic risk.

An environmental Quality Survey was conducted to examine the baseline air, noise, and surface and groundwater quality. Samples were collected in two locations in the project area and tested by the Department of Environment (DoE), except for the Manganese (Mn) and Arsenic (As) tests of groundwater which were done in the BUET Laboratory. Air quality and noise levels were examined and monitored at Airport Road near SPKF building (Jahangir Gate) and Rokeya Sarani, East Side of Sayed Mahbub Murshed Road. The ambient air quality in the City of Dhaka has been influenced mainly by the emission from the road transports. The increased number of motorized road transports, old engine driven vehicles, and inconsistent traffic jams on the city's roads are causing deterioration of the ambient air quality. In order to assess the current status of the ambient air quality, tests were performed in two locations of the project area by the DoE. The test report of ambient air satisfied the mixed area standard guided in the ECR 1997. The roads in the project area remain noisy both at day and night as per the noise level monitoring data where noise level exceeds the mixed area standard in the ECR 1997.

To assess the water quality in the project area, surface water was collected from the only pond in the project area and groundwater was collected from the deep well of the Provost & Security Unit, BAF and BAF BASE BASHAR Central Mosque in the east for analysis in the laboratory. The tested parameters of both the surface water and groundwater satisfied the DoE drinking water quality standards with the exception of BOD_5 in the pond water which is above the DoE acceptable range.

Analysis of soil in the project area is important for the safe disposal of cuttings from the starting and ending points of the tunnel and for proper use as filling/construction material. In order to determine the soil quality in the proposed project area, three points (BH_3 close to the starting point of the tunnel at Jahangir Gate, BH_2 close to the middle point and BH_1 close to ending point at Rakeya Sharoni) have been sampled and tested by the Department of Soil, Water & Environment, University of Dhaka. The test results showed no significant level of heavy metals in the soil sample from the project site except the concentration of copper which is quite high compared with the other parameters.

7.3.2 Biological Environment

A part of the project area is covered by low growing grasses and a few varieties of trees that provide a habitat for birds and other species. Among the tree species, a few timber trees such as Debdaru, Kathbadam, Mehogoni, Shilkoroi and a few fruit trees like Mango, Banana, and Blackberry are found there. A good number of bird species like *Corvus*

Splendens (Patikak) and *Passer Donesticus* (Choroi) can be found in the project area. Mongoose and several snake species are common types of wild animals found in the project area. There are no rare or endangered species in the project area and PIA according to the IUCN red data Book.

7.3.3 Socio-Economic Environment

The total area of land in the study area is about 128 ha as mentioned in the Social Study Interim Report, 2011. The majority of the land, about 63% is occupied by houses and buildings, about 8% are paved feeder roads within the settlements and about 16% of land is health, social and religious infrastructure. The orchards (5%) are mainly within the courtyards of different houses and buildings. Some squatters in slums were evident on the fallow public land (8%) but are not officially recognized. Social Study Report, 2011 shows that the household size per household is 5.5 in the project area. As per the social survey 58% households are 1st and 2nd class government employees, 30% are 3rd and 4th class government employees. Accordingly, 88% households are government employee and living in the government quarters and rented houses. Small businessmen (6%) are living in the rented houses and 3% rickshaw pullers and 3% hawkers belonged to the slums/squatters.

Water supply pipelines and sewerage lines which run under the road sides may be affected due to project activities at the starting point and ending points of the DRTP. All households, offices, and others in these areas have hygienic latrines. Almost all houses, offices etc. have access to electricity and piped gas connection in the project area. There are no places of archaeological, historical and cultural resources/sites, situated within or nearby the project area or PIA (<500 m).

7.3.4 Potential Impacts and Mitigation Measures

The DRTP has some potential negative and positive impacts which will arise at the preconstruction, construction and operation periods. For the best outcome of project development, these impacts need to be carefully identified and mitigated timely. Identification of potential impacts has been done utilizing a checklist and categorizing each impact as none, insignificant, moderate or significant along the three project stages.

a) Pre-Construction Stage

During the pre-construction stage of the project, vegetation/trees and utility connections (water, gas, telephone, and electricity) will be negatively affected. Hence measures must be taken so that project activities do not hamper the living of the local residents due to the unplanned disruption of utility connections.

b) Construction Stage

At the construction period of the project, air, noise, and surface and groundwater will be affected due to earth excavation, pile driving, rock crushing, electricity generation and transportation. To predict the future noise level after opening the tunnel, an existing noise profile must be prepared during detail design stage. Vehicles transporting construction materials must be covered and water must be sprayed on the road regularly to prevent dust creation. Wastes from the construction and labour camp need to be properly managed.

Temporary drainage congestion will occur due to earth excavation of the proposed tunnel, especially during monsoon season. In addition, drainage congestion will also occur in places such as the construction yard, labour camp, etc. While performing excavation of the tunnel, the starting and ending points must be covered to prevent rain water penetration of the tunnel and pumping facilities must be kept ready in case of any

emergency. Vegetation and other faunal species will be disturbed and measures must be ensured to minimize the impact on the biological environment.

Due to the construction activities, movement of transports on the existing roads will be significantly hampered and may cause serious traffic congestion and even road accidents. To avoid such unwanted situations, a proper Traffic Management Plan (TMP) should be prepared during the detailed design stage and acted on accordingly during the construction stage of the project. Moreover, occupational health and safety measures must be provided for the construction workers. In order to ensure uninterrupted construction work, an emergency management plan must be prepared in case of any sudden environmental risks like flooding or a seismic event. The project will likely provide employment for nearly 200 personnel in various positions related to the construction work of the project.

c) Operation Stage

At the operation stage of the project, there are chances of drainage congestion, road accidents, or groundwater level changes. Noise and air pollution will be created in and surrounding the project area due to the movement of vehicles along the tunnel. Proper measures for avoiding drainage congestion and a proper computerized traffic signal system must be available to prevent any unwanted road accidents. Aesthetic beauty plays an important role in improving the working environment of an area, so the construction of the proposed tunnel can improve the aesthetic view of the Dhaka City.

7.4 Environmental Management Plan

The Environmental Management Plan is necessary on the grounds that it will off-set the negative impacts through mitigation measures and enhance the positive impacts within the allocated funds for the project. Environmental Monitoring is a very important tool to safeguard the protection of the environment. In accordance with the EMP, an Environmental Monitoring Plan (MP) has been developed and presented in the EIA report. The contract documents will contain a listing of all required monitoring measures and a time frame for the compliance monitoring of these activities. The monitoring will be composed of surveillance by responsible agencies to determine whether the contractor is meeting the provisions of the contract during construction and operation of the Project.

The Project Implementation Unit (PIU) through a Construction Supervision Consultant (CSC) will be responsible to supervise monitoring activities of all contractors procured under the Project. A table with details of the environmental monitoring program for different environmental issues centred the Dhaka Road Tunnel Project, monitoring parameters, frequency of monitoring, location where to be monitored and responsible agency for implementation & supervision has been given in the EMP section of Appendix D.

Institutional arrangement and capacity development are the most important parts for the project development. The BBA is the technical as well as administrate arm of the ‘Bridges Division’ of the Ministry of Communication (MOC), which is responsible for planning, construction and maintenance of regional and national roads, railway and bridge infrastructure in the country. Presently, the BBA has no permanent Environmental Unit (EU) within it. Generally, short term EU’s are established within the project implementation units created for projects undertaken by the BBA. The staffs are deputed from other departments. After completion of these projects, the staffs of the temporary EU return to their parent department. A Project Implementation Unit (PIU) for the DRTP has been established as an ad hoc office to manage the preparation (and subsequently implementation) of the proposed DRTP. The PIU will hire a CSC for supervision of the implementation of civil works, including supervision and implementation of the EMP. The CSC will consist of an Environmental Unit with national environmental specialists. The

total cost for implementation of the environmental activities is estimated as USD 178,000 during construction and Operation.

7.5 Public Consultations

In order to ensure community involvement for the development of DRTP, public consultations such as Focus Group Discussions (FGDs), Individual Interviews and Stakeholder Consultations (SCs) have been conducted continuously during the EIA study in conformity with the DoE. FGDs were held with the following group of people:

- Government Employees, Department of Military Lands & Cantonments
- Government Employees, Dhaka Transport Co-Ordination Board (DTCB)
- Business Community, BAFWA Shopping Complex
- School Teachers', Sher-e- Bangla Nagar Govt. Boys' High School, Dhaka

Stakeholder consultations were held with the personnel of the following departments/organizations:

- Dhaka City Corporation (DCC)
- Department of Environment (DoE)
- Managing Director (CC) & Chief Engineer Dhaka Water Supply & Sewerage Authority (DWASA)
- Chairman, Bangladesh Road Transport Authority (BRTA)
- Additional Chief Engineer, Local Government Engineering Department (LGED)
- Principal & Acting Principal, BAF Shaheen School and College, Dhaka

7.6 Conclusions and Recommendations

The EIA reveals that there will be both negative (mainly temporary construction related) and positive environmental impacts due to the construction and operation activities of the project on the physical, biological and social components of the environment. Possible appropriate mitigation measures have been recommended to eliminate or reduce the above mentioned negative impacts and enhance the positive impacts of the project. Implementation of these mitigation measures during pre-construction, construction and operation phases will minimize the negative impacts of the project to acceptable levels.

Based on the findings of this study, the following items are recommended:

- With incorporation of the updated baseline data, the EIA report needs to be updated
- Based on the preliminary EMP, the detailed EMP should be prepared
- To ensure that the proposed mitigation measures as mentioned in Appendix D will be included in the contract document of the project for implementation.

8 SOCIAL STUDY REPORT

8.1 Objectives and Methodology

As a part of the 'Feasibility Study' a Social Study has been carried out in order to find:

a) whether the proposed project is socially feasible
b) the potential impacts of the Project on the people living in its social influencing zone and among the tunnel user groups
c) the views, concerns and suggestions of the potential user groups and stakeholders regarding the project.

The broad objective of the Study is to present a socio-economic profile of the population living in the project influencing zone.

To achieve these objectives the methods of the study included:

a) A baseline household survey in order to provide a socio-economic profile of the population living in the project influencing zone. The studied population included 1166 from 261 sampled households.
b) Focus group discussions and meetings with small groups of different stakeholders who could be potentially impacted by the project
c) Individual consultations with key stakeholders who could air their views, concerns and benefits of the project, and who could effectively participate and cooperate in the project implementation process.

8.2 Household Baseline Survey

Data collected from households living close to the Project sites finds the average household size to be 4.45, higher than the 2001 census. Typical of urban areas nuclear families the most common household, about 90 percent, joint families were about 8 percent and extended families were about 2 percent only. The household survey found that the male to female ratio of the sample population was 110:100. Nearly 97% of the surveyed population is Muslim and the rest are Hindus. Ethnically all those sampled in the study area are Bangladeshi and linguistically Bangla speaking.

Settlements within the Study Area are mostly government staff quarters, some rented households and some squatters on the government fallow lands. Apart from housing there are evident commercial settlements close to the Jahangir Gate and at the starting point of the M Morshed Sarani starting from Rokeya Sarani (Close to the approach of the Tunnel). Field findings showed that the majority of the households, 42 percent, live in multi-story buildings, 22 percent live in single story buildings, and 16 percent in the semi-pucca houses, which were mainly the government quarters and rented houses. The remaining households were squatters.

Houses and buildings occupy about 63 percent of lands, 8 percent are paved feeder roads within the settlements and 16 percent of lands are used for health, social, educational and religious infrastructures. The orchards (5 percent) were mainly within the courtyards of different houses and buildings. Some slums (8 percent) were evident on the fallow government land. None of the surveyed households (261) own any land within the Study Area but many own some type of land at their home villages which gives them some economic return from land resources.

Using the extended definition, employment rates of the surveyed 861 population within the 15-65 year age bracket is 97.3 percent**.** If the usual definition is used then unemployment rates of the surveyed population would be far higher as housework/ housewife constitutes a significant proportion, 36 percent, of occupations within the area. If retired and disabled are not treated as an economically active population there is no unemployment within the surveyed population using the extended definition.

From the 261 households surveyed, it was revealed that only 1.2 percent of households earn income within the lower bracket (Poverty Group) of 1,000-5,000 per month. The marginal poor group belonging to the income bracket 5,001- 10,000 were about 18.8 percent of households. Nearly half of households, 43.7 percent, earn between 10,001-40,000 taka per month. The majority of households, about 48.7 percent spend 10,000-20,000 taka per month. The survey findings show that livestock rearing is significantly low in the urban areas; 87 percent of households do not rear any livestock. The surveyed households in the study area do own different types of trees at their residence and at their home villages, although 51.7 percent of households do not own any trees at all.

Within the Study Area nearly 90 percent of surveyed households now use electricity, most commonly for lighting houses, whereas the remaining 10 percent have no electricity and alternatively use gas, kerosene and other energy sources. The majority of households also rely on piped gas supply (around 80 percent) whereas 18 percent use firewood and 2 percent use electricity for cooking. It is assumed that most of the illegal squatters have no electricity or piped gas connections.

Findings from the Study Area show that 96 percent of households have piped water supply connections and the rest have tube wells with hand pumps. Piped water is supplied to 86 percent of households by DWASA and other water sources are owned by the community. It is likely that another 10 percent of households receive piped water from DWASA distributed through the community. The tube wells used by 4 percent of households were likely provided by DCC. Within the Study Area 90 percent of surveyed households had access to sanitary latrines and the other 10 percent using non-sanitary latrines were found in the slums.

Among the surveyed population in the Study Area the literacy rate is higher than the population census in 2001, at about 91 percent now. Analyzing education levels by gender among the surveyed population finds that females have higher rates of illiteracy than males, and males continue to be more likely to complete higher levels of education, Secondary School Certificate (SSC) and above. Within 41 percent of the surveyed households, the primary decision maker in the family decision making process was the head of the household alone, whereas 58 percent of households regularly take decisions jointly with other family members, particularly with their spouse.

Almost all surveyed households use and are mostly dependent on road transports for their mobility in Dhaka city. The lowest transport related average monthly expenditure was below 500 taka, reported by 12 percent of the surveyed households. The most common expenditure is within the Tk. 1001-2000 expenditure bracket, for 29 percent of households, 13 percent of households spend within Tk. 2001-3000 and 19 percent spent above Tk. 3000.

Electronic media, multi-channeled television in particular, is the dominant form of information dissemination and recreation in the Study area. Of surveyed households 89 percent watch multi-channelled television while only 43 percent of households read daily newspapers. Typically nobody listened to radio. The mobile phone network is the predominant means of connecting people socially. Of surveyed households in the study area, 94 percent use mobile phones for social communication, 5 percent use land phones and 8 percent use e-mail. No household was found without any means of social communication.

Both public and private health facilities and services are quite available nearby the study area, including modern and high quality health services. Additionally public health services were comparatively low cost, subsidized by the Government, and found available in the project influencing zone. About 57 percent of surveyed households report they have easy access to public health services. About 28 percent receive private health services. No studied households visit or consult traditional health service providers, even the homoeopathic doctor.

8.3 Stakeholder Consultations

Surveyed households as well as consulted stakeholders expressed their views and perceptions regarding different Project related issues that could potentially impact the stakeholders. The majority of comments, about 74 percent, were on the project's benefits and positive impact and about 23 percent of comments were about the negative impacts which were mostly minor and temporary in nature. Other significant comments were on the economic benefit to the people and the nation, improved communication system and decreased traffic congestion, and decreased travel time. Increased traffic congestion during construction period would only be a temporary impact. Toll collection was a controversial issue because even though transport fares might increase, the use of the tunnel should decrease the route distance and likely travel time so eventual travel cost could be reduced.

In general, stakeholders believe the mobility of the residents of Dhaka city will be increased and their standard of living will be improved due to the project. The Project Influencing Zone is an important area connected with the National Parliament, The Office of the Prime Minister of the Government of Bangladesh, Dhaka Cantonment, different government offices, international donor agencies, and UN offices at the starting and ending point of the Tunnel. Apart from that there are five educational institutions and various businesses and commercial settlements that are likely to get benefit of the project. The DWASA sewerage and drainage system as well as the water supply network system could be impacted by the project activities. No private land is required to be acquired for the Project implementation. It should be noted that these potential impacts were assessed on the basis of the anticipated 'Cut & Cover' tunnel construction method.

8.4 Conclusions

From a social perspective the Study found that the Project is feasible and most stakeholders expect that the Government aims to improve transport access and mobility for residents of Dhaka city, reduce traffic congestion, and address long term transport planning and traffic management, will be achieved by the Project.

The study has achieved its set objectives and produced the expected document output. The study findings showed that the proposed project is socially feasible and highly appreciated by all stakeholders and the studied population. The Study also found that the key stakeholders, particularly DCC, DWASA, BRTA and DTCB, were quite cooperative with the Study and positive about the Project as well, stating that they would assist and cooperate in the project implementation process.

9 TRAFFIC STUDIES AND SURVEY

This report details the traffic survey data that was collected for traffic micro-simulation model estimation as part of the Dhaka Road Tunnel Project and can be found in Appendix F. Back ground details can be found in the Interim Report attached as Appendix H.

Three data types were surveyed for three-hour periods in both the AM- and PM-peak periods within the study area:

1) Origin-Destination Survey – used to determine the travel patterns of different vehicle types in the study area network; conducted at ten external and eight internal zones.
2) Intersection Count Survey – full turning movement counts classified by vehicle for 13 major intersections.
3) Travel Time Survey – floating vehicle survey indicating average travel time and speed conducted for the five major alternative routes through the study area.

10 TRAFFIC MODELLING

This report contains details of the traffic micro-simulation estimation, calibration and simulation processes that were conducted for the Dhaka Road Tunnel Project to evaluate the benefits of a tolled tunnel bypass constructed under Tejgaon Airport as shown below.

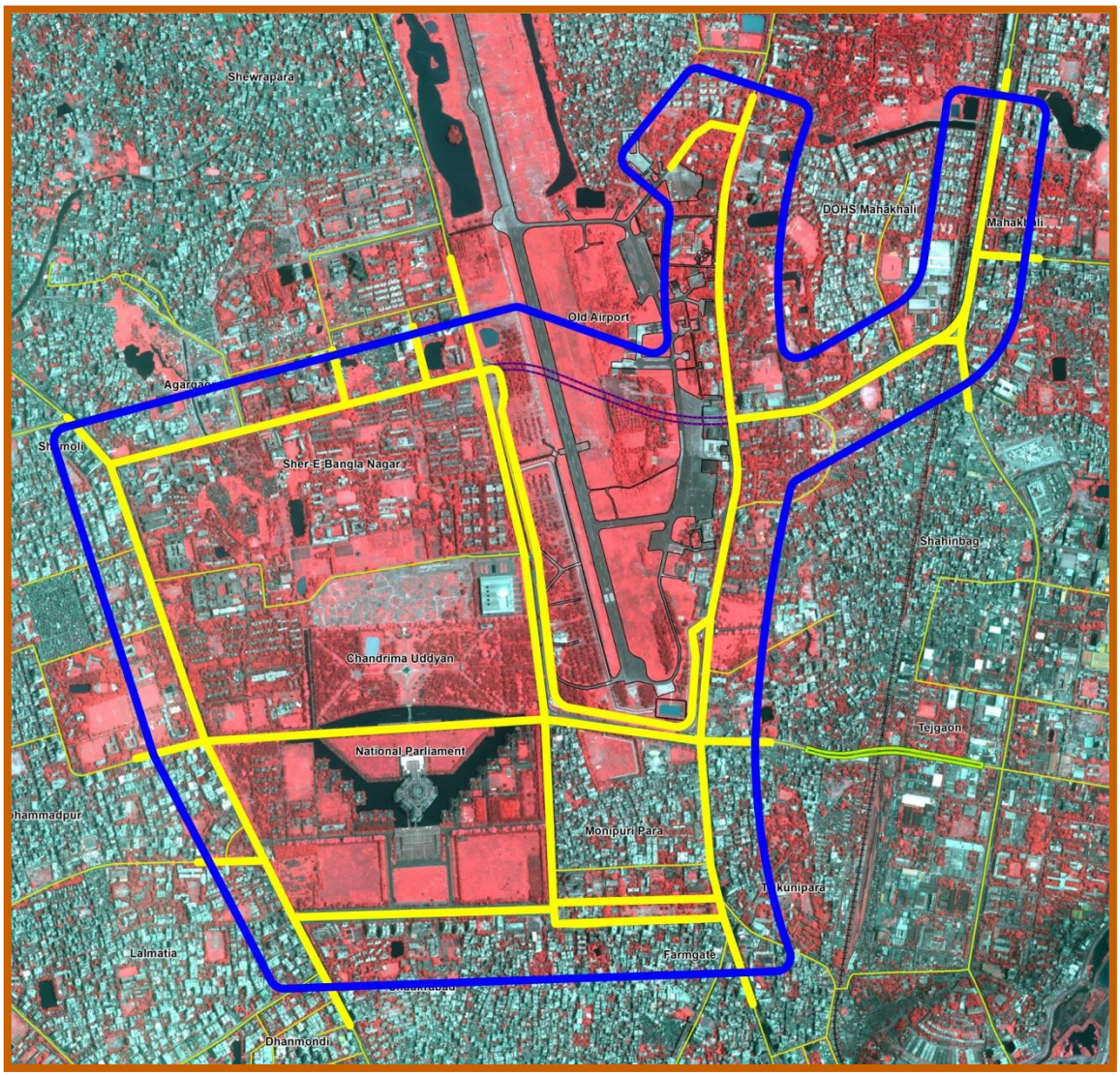


Figure 10.1: Proposed Tunnel

Micro-simulation modelling was performed using Pitney Bowes Paramics 6.1. The available traffic survey data (origin-destination and intersection count surveys) was split into three major vehicle classes (light vehicles, heavy vehicles and three-wheelers) used as input into the estimation process, generating AM- and PM-peak hour micro-simulation models for the existing road configuration in 2011. The estimation output was measured to be a good fit to the observed traffic counts. Growth calculations to model the 2030 AM- and PM-peak periods were performed using an annual growth rate of 3.1% as reported in *Dhaka Elevated Expressway Preliminary Traffic Study Report* (AECOM, SARM and Gide Loyrette Nouel 2010). This annual growth rate gives a total growth from 2011 to 2030 of 78.6%.

Three scenarios were tested; the existing configuration ("Do Nothing"); and two options for the tolled tunnel bypass ("Option 4" and "Option 5"). The tunnel options were simulated for a selection of toll values (Tk0, Tk50 and Tk100) and bulk performance statistics were extracted. The overall performance of each scenario is shown below in Tables 11.1-11.3.

Table 10.1: Overall Average Performance Summary (No Toll)

Statistic	2030 AM			2030 PM		
	Do Nothing	Option 4	Option 5	Do Nothing	Option 4	Option 5
Released Demand	58%	56%	60%	56%	59%	61%
Vehicle Kilometres Travelled	68,815	62,530	69,355	68,476	72,019	73,517
Vehicle Hours Travelled	14,047	14,782	13,566	14,141	13,672	14,006
Average Speed [km/hr]	4.9	4.2	5.1	4.8	5.3	5.2
Average Trip Length [km]	3.1	2.9	3.0	3.2	3.2	3.2

Average Travel Time and Average Trip Length are per vehicle averages for every vehicle using the network.

Table 10.2: Overall Average Performance Summary (Toll = Tk50)

Statistic	2030 AM			2030 PM		
	Do Nothing	Option 4	Option 5	Do Nothing	Option 4	Option 5
Released Demand	58%	52%	56%	56%	57%	58%
Vehicle Kilometres Travelled	68,815	59,165	65,957	68,476	70,099	68,311
Vehicle Hours Travelled	14,047	14,298	13,614	14,141	13,414	13,838
Average Speed [km/hr]	4.9	4.1	4.8	4.8	5.2	4.9
Average Trip Length [km]	3.1	3.0	3.1	3.2	3.2	3.1

Average Travel Time and Average Trip Length are per vehicle averages for every vehicle using the network.

Table 10.3: Overall Average Performance Summary (Toll = Tk100)

Statistic	2030 AM			2030 PM		
	Do Nothing	Option 4	Option 5	Do Nothing	Option 4	Option 5
Released Demand	58%	50%	44%	56%	57%	56%
Vehicle Kilometres Travelled	68,815	55,142	41,563	68,476	69,819	66,973
Vehicle Hours Travelled	14,047	14,813	12,845	14,141	13,742	13,952
Average Speed [km/hr]	4.9	3.7	3.2	4.8	5.1	4.8
Average Trip Length [km]	3.1	2.9	2.5	3.2	3.2	3.1

Average Travel Time and Average Trip Length are per vehicle averages for every vehicle using the network.

The modeling results indicate that the expected growth is unsustainable and that the tunnel will bring a small benefit only if the toll is less than Tk50.

11 STAKEHOLDER CONSULTATIONS

There are a considerable number of stakeholders involved in this Project. Internal stakeholders at this stage of the project are effectively BBA and the Consultant but the external stakeholders include Government agencies, the Military, public bodies, political parties, private concerns, technical institutions, the media and the public at large. Stakeholders may be opposed to, supportive of or neutral in respect of the implementation of the Project.

An initial listing of external stakeholders and a tentative classification in terms of the Consultant's perception of the respective levels of "influence – involvement" with respect to the project is shown below (Table 13.2).

Some of the stakeholders have a direct influence on the scheme and also have a direct involvement and physical interface with the project. In view of the sensitive nature of the project and its impact on Dhaka City and the airfield it is recommended that BBA engage with these 'primary' stakeholders at an early stage in the study.

From the Consultant's direct experience with projects including airports and military agencies early stakeholder involvement can offset predetermined ideas and allow for constraints to be agreed upon rather than 'imposed' in an arbitrary manner. Of course all such interaction with stakeholders will need to be approved by BBA.

In terms of dealing with the various stakeholders a general approach is outline below:

Table 11.1: Stakeholder Involvements

		INVOLVEMENTT	
		LOW	HIGH
INFLUENCE	HIGH	(Keep Satisfied) II	(Key Players) I
	LOW	(Routine Interaction) IV	(Keep Informed) III

Table 11.2: Stakeholder Analysis: Influence Involvement Matrix

		LEVEL OF INVOLVEMENT FOR THIS PROJECT	
		INDIRECT	**DIRECT**
LEVEL OF INFLUENCE FOR THIS PROJECT	**DIRECT**	• Bangladesh Civil Aviation Authority • Department of Environment (DoE) • Ministry of Finance • Ministry of Land (legal aspects of land use/ownership) • Department of Forests	• Bangladesh Air Force (Runway User) • Bangladesh Army (Runway User) • Fire Service and Civil Defence • Capital Development Authority of Bangladesh (Rajdhani Unnayan Kartipakkha – RAJUK) • Local Member of Parliament (MP) • Local Community Leaders • Local Business Community • Dhaka Water and Sewerage Authority (DWASA) • Dhaka City Corporation (DCC)
	INDIRECT	• River Authority • Survey of Bangladesh (Geological) • Power Development Board (PDB) • Bangladesh Water Development Board (BWDB)	• Bangladesh Road Transport Authority (BRTA) • Dhaka Transport Coordination Board (DTCB) • Transport Operators' Association • Bangladesh Investment Climate Fund (BICF) • Public NGOs • Future Contractors International / Local • Local / International consultants • Funding Agencies / Banks • Private Investment Agencies • Institute of Engineers of Bangladesh (IEB) • Local Residents • Road Traffic Users • Public Transport Providers • Flying Club • Media

12 LAND REQUIREMENT

The Dhaka Multi-Lane Road Tunnel Project intends to provide direct connectivity between Jahangir Gate and Rokeya Sarani by crossing under the Tejgaon old Airport which is now being used by the Bangladesh Air Force and Bangladesh Army Aviation Unit.

The land of the Airport belongs to Government, so land acquisition will not be required for the main component. However, at the east end opposite to Jahangir gate Shahinbagh area, some land with structures belonging private persons might be impacted. Similarly, at the other end at Agargaon-Rokeya Sarani (Mirpur) junction on the southern side some private land with structures may also be impacted. However, the impacts on privately owned lands are likely to be very small. The Socio-Economic profile informs that some squatters are operating various small businesses but they will not be entitled to any benefit as the government doesn't recognize these sorts of illegal occupations.

For these reasons this Abbreviated Resettlement Frameworks Policy (ARFP) is proposed for the project. The primary object of the Land Acquisition Framework is to meet the legal requirements to identify the (i) type and extent of loss of assets likely to be impacted, including land and structures, (ii) principles and legal framework applicable for mitigation of these losses and (iii) the entitlement issues. Mainly the *Acquisition and Requisition of Immovable Ordinance 1982* and its subsequent amendments have been taken into consideration while preparing this report. At this stage the total quantity of land to be acquired from private ownership and resumption of public lands can't be predicted, as the alignment has not been finalized and the land acquisition survey has not been done. If land acquisition is at all required this framework will be applied and procedures would be adapted.

Bangladesh Bridge Authority (BBA) of the Bridge Division, Ministry of Communications (MOC) is representing the Government of Bangladesh as the Executing Agency (EA) of the Multi-Lane Dhaka Road Tunnel Project. A Project Management Office (PMO), headed by a Project Director (PD), has already been set up within BBA for execution of the Project's Feasibility Studies. Since the impact of Land acquisition is very small there might not be any need for a Resettlement Implementation Unit (RIU). The Project Management Unit will be enough to cater to the needs of land acquisition. No resettlement would be required as no 'Donor Agency' is likely to be involved. Everything will be guided according to *Acquisition and Requisition of Immovable Property Ordinance, 1982 (Ordinance II of 82)* as has been mentioned earlier. No NGOs will be required to implement measures in response to the issues of land acquisition.

When the final Engineering Design is prepared the Land Acquisition Survey will be carried out through use of an efficient Survey Form and the relevant Mauza Maps will be collected and converted to Digital Mauza Maps on which the Engineering design will be imposed and thus preparing the land acquisition plans (LAPs). This will indicate the plots of lands characterized by type and use along with quantity of land to be acquired. Thereafter, the LAPs will be submitted to DC for commencing the land acquisition process. BBA will establish a monitoring and evaluation (M&E) system for collecting, collating and analyzing information on Land Acquisition Plan implementation in a systematic manner.

Since the project location is within Dhaka City, the capital of Bangladesh, the decision to acquire the land shall be made by the Central Land Allocation Committee (CLAC), headed by the Honorable Minister for Land, and the process will then continue as outlined in Appendix H. Only the principles of *Acquisition and Requisition of Immovable Property Ordinance, 1982 (Ordinance II of 82)* shall be applied and the mitigation principles laid down therein shall have to be complied with. The total estimated cost of implementation of Land Acquisition will be borne by the Government. The required amount of compensation is to be placed with DC Dhaka for compensation payment and the lands would be handed over to BBA by DC on execution of the appropriate documents for implementation of the project.

The following immediate actions are still required:

a) Finalization of Engineering Drawing

b) Appointment of Surveyors for Land for land Acquisition Survey

c) Preparation of LAP

d) Obtaining of Administrative Approval

e) Submission of LAP to the Deputy Commissioner Dhaka

f) Obtaining Land Acquisition Cost Estimate from the Deputy Commissioner, Dhaka

g) Obtaining Budget to Bear the Land Acquisition Cost

h) Designate someone to look after the Land Acquisition task and processing. If required he may be trained to cope with the tasks.

When the Government decides to implement the project then the Land Acquisition Framework described in the next section will be updated and the impact along with detailed results of consultations will be incorporated.

13 LAND ACQUISITION FRAMEWORKS (ALAPF)

13.1 INTRODUCTION

13.1.1 Background

The Dhaka Multi-Lane Road Tunnel Project intends to provide direct connectivity between the roads and locations mentioned in a table below:

Table 13.1: Names of Roads and Matching Points

Roads to be Connected		Proposed Connectivity
New Airport Road	Rokeya Sarani	
Matching Point (East) Close to Jahangir Gate on the Northern Side and Civil Aviation Authority's staff quarter on the Southern side	Matching Point (West) Close to Government High School Agargaon on the Northern side and the PWD colony on the southern side	Dhaka Road Tunnel Underneath the Tejgaon old Airport

The Tejgaon old Airport is now being used by the Bangladesh Air Force and Bangladesh Army Aviation Unit. This is the feasibility study phase of the project. The implementation phase is contingent upon acceptability of the feasibility study report by the Government. It is expected that the Project will bring direct economic and social benefits not only to the city dwellers but also to a vast majority of population living outside Dhaka City, especially on the western part having easy access and exits from inside Dhaka, the Capital city of Bangladesh through the proposed Tunnel.

Currently the means of communication within Dhaka Metropolitan city are both motorized and non-motorized. Buses and Taxis used by private consumers and the different government agencies and departments including the Law and Order agencies are the dominant motorized transports. The existence of three and two wheelers (CNG, Mishuk Auto and Battery operated Rickshaws and Motorcycle) can't be overlooked. The inter-district buses along with international buses (Calcutta route connection) also operate from Dhaka city. During a fixed period of the night trucks, containers, long vans, and covered vans are also operating from the heart of Dhaka City. Human-driven rickshaws and vans both paddled and pushed are the primary non-motorized transports operating on city roads except for few restrictions. All these vehicles have overwhelmed the inadequate road network system, resulting in the retarding and blocking the transport operation.

The walkways built by the Urban Local Government (Dhaka City Corporation) or RHD or RJUK have become the haven of small traders, vendors, and crowds of interested buyers resulting in the blockage of footpaths or walkways. As a result the regular pedestrians are frustrated and are even put at great risk and subject to frequent accidents. During certain parts of the day the lives of road users are put on hold; the emission of carbon and other fumes from the idling of engines aggravates respiratory problems and threatens health by risks of lung disease.

The Government has therefore decided to take different measures to improve the Dhaka City Transport by construction of several Flyovers and a Metro Railway. Construction of a 1,000 m long Dhaka Multi-Lane Road Tunnel Project is one of the new additions in the location mentioned above in Table 13.1 in order to achieve the following major goals:

- Improve transport access and mobility for residents of the Dhaka Metropolitan Area
- Reduce traffic congestion
- Address long term transport planning, coordination and institutional issues
- Enhance the cost of transportation commodities, etc.

13.1.2 Needs for Land Acquisition

The land of the Airport belongs to Government, so land acquisition will not be required for the main component. However, at the east end opposite to Jahangir gate Shahinbagh area, some land with structures belonging private persons might be impacted. Similarly, at the other end Agargaon-Rokeya Sarani (Mirpur) junction on the southern side some private land with structures also may be impacted. Still the impacts on privately owned lands are likely to be very small. The Socio-Economic profile informs that some squatters are operating various small businesses but they will not be entitled to any benefit as the government doesn't recognize these sorts of illegal occupations.

For these reasons this Abbreviated Resettlement Policy Frameworks (ARPF) is proposed for the project. Mainly the Acquisition and Requisition of Immovable Ordinance 1982 and its subsequent amendments have been taken into consideration while preparing this document. At this stage the total quantity of land to be acquired from private ownership and resumption of public lands can't be predicted, as the alignment has not been finalized and the land acquisition survey has not been done. If land acquisition is at all required this framework will be applied and procedures would be adapted.

13.1.3 Legal Instruments Requirement

This Land Acquisition Policy framework is to be directly guided by the legal instrument of the governing on land acquisition in Bangladesh, namely *Acquisition and Requisition of Immovable Property Ordinance, 1982 (Ordinance II of 82)* with subsequent amendments in 1989, 1993, and 1994. In addition to that the following Legal instruments will be applied indirectly as and when requires:

1. State Acquisition and Tenancy Act
2. Survey Act
3. Law of Inheritance, Muslim, Hindus & others

13.1.4 Components of Dhaka Tunnel Project

- 1000 m Multilane Tunnel
- Interchange on the east end toward Dhaka cantonment and Shahinbagh Section toward PM's office
- Interchange on the west end towards North and South of Rokeya Sarani
- Electrification in the tunnel
- Signaling System
- Safety Arrangements
- Artificial Air Circulation System,
- Provision for Draining Out of Water
- Emergency Bays
- Toll Plaza

- Watch house with Close Circuit TV Camera (CCTV)

13.1.5 Stakeholders Consultation

The Dhaka Road Tunnel Project is not only complex but also a challenging new venture for the Government in the domain of communication systems. Thus, consideration of the Social Safeguard Issues is necessary. Here the Bangladesh Army and Air Force are the Key stakeholders as BAF and Bangladesh Army Aviation are the users of the Air Field. From the Defense Strategic point of view the importance of the location can't be over-emphasized. Certain areas of the old airport are also used as a 'Parade Square' too. Therefore consultations in the form of Focus Group Consultations, Individual Stakeholder Consultations, Consultations with civil society, and Interviews were the main strategies used. The following key national and other organizations were consulted, amongst others:

Bangladesh Air Force, Bangladesh Army, Dhaka Canton Board, Civil Aviation Authority, Dhaka Transport Co-Ordination Board(DTCB), Bangladesh Road transport Authority, Dhaka City Corporation, Dhaka Water Supply & Sewerage Authority (DWASA), Transport Operator's Association, Traders and vendors, Transport users, & Schools & Colleges Authorities, etc. The results of consultations were all recorded in the relevant document.

13.1.6 Objectives of Land Acquisition Framework

The primary objective of this Land Acquisition Framework is to meet the legal requirements to identify the (i) type and extent of loss of assets likely to be impacted, including land and structures, (ii) principles and legal framework applicable for mitigation of these losses and (iii) the entitlement issues.

13.1.7 Institutional Arrangement

Bangladesh Bridge Authority (BBA) of the Bridge Division, Ministry of Communications (MOC) is representing the Government of Bangladesh as the Executing Agency (EA) of the Multi-Lane Dhaka Road Tunnel Project. A Project Management Office (PMO), headed by a Project Director (PD), has already been set up within BBA for execution of the Project's Feasibility Studies. Since the impact of Land acquisition is very small there might not be any need for a Resettlement Implementation Unit (RIU). The Project Management Unit will be enough to cater to the needs of land acquisition. No resettlement would be required as no 'Donor Agency' is likely to be involved. Everything will be guided according to *Acquisition and Requisition of Immovable Property Ordinance, 1982 (Ordinance II of 82)* as has been mentioned earlier. No NGOs will be required to implement measures in response to the issues of land acquisition.

13.1.8 Land Acquisition and Preparation of Budget

When the final Engineering Design is prepared the Land Acquisition Survey will be carried out through use of an efficient Survey Form and the relevant Mauza Maps will be collected and converted to Digital Mauza Maps on which the Engineering design would be imposed and thus the land acquisition plan (LAPs) will be prepared. This will indicate the plots of lands characterized by type and use along with quantity of land to be acquired. Thereafter, the LAPs will be submitted to DC for commencing the land acquisition process.

Since the project location is within Dhaka City, the capital of Bangladesh, the decision to acquire the land shall be made by the Central Land Allocation Committee (CLAC), headed by the Honorable Minister for Land. On receipt of decision from the CLAC, the next processes will be launched by DC through the issuance of notice under section 3 of the Ordinance. On the issuance of notices u/s 6 and 7 of the Ord. the valuation of assets, names and particulars of affected persons will be available or the calculated value will be put in an instrument known as Award Compensation Assessment Roll and the result

would be assimilated to complete the document. As has been mentioned before, the total estimated cost of implementation of Land Acquisition will be borne by the Government. The required amount of compensation is to be placed with DC Dhaka for compensation payment and the lands would be handed over to BBA by DC on execution of the appropriate documents for implementation of the project. Since there is no plan to obtain fund from any Donor agency, the application of Donor's Policy on Involuntary Resettlement shall not be applied. Only the principles of *Acquisition and Requisition of Immovable Property Ordinance, 1982 (Ordinance II of 82)* shall be applied and the mitigation principles laid down therein shall have to be complied with.

13.1.9 Funding for the Project

It is understood that funding will be from the Government of Bangladesh but that a Public Private Partnership (PPP) may be appropriate with the provision of private sector investment recovery and operation and maintenance of the tunnels through income generation from a toll system.

13.2 POLICY FRAMEWORKS

13.2.1 Constitutional Obligation

According to Article 42(2) of the *Constitution of the People's Republic of Bangladesh* no land can be used for any development works without compensation, according to law made for the purpose by the government.

13.2.2 Legislations Governing Land Acquisition in Bangladesh

The principal legal instrument governing land acquisition in Bangladesh is the *Acquisition and Requisition of Immovable Property Ordinance 1982* (Ordinance II with amendments in 1989, 1993, and 1994). The 1982 Ordinance requires that compensation be paid for (i) lands and assets permanently acquired (including houses, trees, and standing crops), and (ii) any other impacts caused by such acquisition. The Ordinance provides certain safeguards for the owners and has provision for payment of 'fair value' for the property acquired. The Deputy Commissioner (DC) of Dhaka district shall have to determine market value of acquired assets on the date of notice of acquisition under section 3 of the Ordinance. In case of land it is the value recorded in the registered deed of similar property bought and/or sold in the area over the preceding 12 months of notice u/s-3 with 50% premium on the assessed value, other than crops due to compulsory acquisition. The DC payment of compensation to project-affected owners is called compensation under law (CUL). The Ordinance does not permit the affected persons to take the salvageable materials for which compensation has been paid by the DC. Places of worship, graveyard and cremation grounds, cemeteries, and places of Historical importance declared by the Government through gazette notification Archeologically and Historically to be preserved are not to be acquired. Under the 1982 Ordinance, the Government is obliged to pay compensation only for the assets acquired of a legal owner and titleholder.

13.2.3 Role of Deputy Commissioners' Office Land Acquisition Branch Dhaka

The Deputy Commissioner, Dhaka as head of the acquiring body (AB) has domain over the land acquisition matter in respect to both government and non-government purpose for land acquisition. He has the legal responsibility of acquiring land and paying compensation directly to the PAPs as per the *Acquisition and Requisition of Immovable*

Property Ordinance, 1982 and subsequent amendments made thereafter. Furthermore DC is the custodian of the records relating to land acquisition and as such has access to official records and the Legal/Administrative authority for title of land and eligibility of PAPs for Compensation under Law (CUL) for land and other assets. The BBA, the Executing Agency (EA), and the implementing agency will work with the representatives of the DC Dhaka during Joint Verification & Investigation of assets and properties both movable and immovable. This will require recording detailed descriptions of the property/assets.

13.2.4 Valuation of Assets

Deputy Commissioner (DC) Dhaka will follow the rules laid down in the 1982 Ordinance and any instructions issued by the government to determine market prices for assets like land, structures and trees/crops, with assistance from other relevant departments such as Public Works Department (PWD) for structures, Forest Department for trees, and Departments of Agricultural Extension and Agriculture Marketing for crops, etc. The cutoff date will be considered the date on which the notice u/s-3 will be issued. Any activity carried out after that date of notice issued under section-3 will be disqualified for consideration of compensation.

13.2.5 The Land Acquisition Task Process

The *Acquisition and Requisition of Immovable Property, Ordinance 1982* (Ordinance II of 1982) is meant to guide the land acquisition process. In absence of clear understanding of the process and certain other related issues the project proponents are to face certain difficulties and the project implementation may suffer dely. Delay in project implementation means price escalation and many other undesirable circumstances. So some important sections of Ordinance II of 1982 and beyond are reflected below in Table 13.2 for ready reference as applicable to this Dhaka Multi-Lane Road Tunnel Project only.

Table 13.2: The Land Acquisition Task Process

Sl.No.	Process	Guiding Section	Time required	Management Plan
1	Preparation of L A Plan	Survey Act	Seven days	Monitoring required
2	Ministry's Approval	Administrative Procedure	Seven days	Co-ordination required
3	Submission LAP to DC	Administrative Procedure	Seven days	Monitoring required
4	Field Verification by DC	Administrative Procedure	Within 21 days	Co-ordination required
5	Submission of LA P to M/O Land for approval of CLAC by DC, Dhaka	Administrative Procedure	90 days (max)	Personal Contact may minimize time
6	In Issue of preliminary notice by DC	U/S-3 of Ordinance/82	Not more than seven days	RB to assist in making & serving the notices
7	Objection submission by interested persons	U/S- 4 of Ordinance/82	Not later than15 days	This schedule is fixed
8	Decision by Divisional Commissioner	U/S-4(3) +5(b of Ordinance/82	15 days but additional 15 days may extended	Personal Contact by may minimize time
9	JIVOA by: RB+AB	Legal Process	Actual time	RB to work with AB

Sl.No.	Process	Guiding Section	Time required	Management Plan
10	Item-wise value of assets determination.	u/s-7+8 of Ord.	No fixed time	RB to work with AB
11	Notice to interested persons	U/S- 6(4)of Ord.82	15 days	RB to work with AB
12	DC Estimate to RB for placement of fund	U/S-7(3) of Ordinance/82	seven days	Project office to assist
13	Proponent to place fund to DC	U/S-7(4) of Ordinance/82	Not later than 60 days	Project office places fund within the stipulated time otherwise all the proceeding shall be nullified
14	Considerations in determining compensation by AB	U/S 8 of Ordinance/82	No time limit	No outside intervention is possible
15	Compensation payment to EPs	U/S 9 of Ordinance/82	60 days	RB to participate actively
15	Arbitration	U/S 28 of Ordinance/82	Within 45 days from the service of award. This doesn't affect the process	Actions, as may require from time to time

13.2.6 Highlights on Some of the Important Sections Ordinance

The task process has been shown above. In addition some of the important sections of the Ordinance-82 (Ord.-ii of 82) are highlighted below for easy understanding and acting upon as and when the occasion arises.

13.2.6.1 Section 4: Objection against Acquisition

(1) Any person interested in any property which has been notified under section 3 as being needed or likely to be needed for this purpose may, within *fifteen days* after the publication of the notice, object to the acquisition of the property.

(2) Every objection under sub-section (1) shall be made to the Deputy Commissioner, Dhaka in writing and the Deputy Commissioner, Dhaka shall give the objector an opportunity of being heard either in person or by an agent and shall, after hearing all such objections and after making any further inquiry as he thinks necessary, prepare a report containing his opinion on the objections.

(3) (a) The Deputy Commissioner, Dhaka shall then submit the record of the proceedings held by him, together with his report, for the decision of the *Divisional Commissioner, Dhaka*. (b) Provided that if no objection is raised within the period specified in sub-section (1), the Deputy Commissioner, Dhaka shall, instead of submitting the records of the proceedings to the Divisional Commissioner, Dhaka make a decision about the acquisition of the property and such a decision of the Deputy Commissioner, Dhaka shall be final.

13.2.6.2 Section 5: Final Decision Regarding Acquisition

(1) The Divisional Commissioner, after considering the report to be submitted by the Deputy Commissioner, Dhaka under section 4 (3), shall make a decision about the acquisition of the property and such decision of the Divisional Commissioner shall be final.

Provided that-

(a) Where the decision is to be made by the Divisional Commissioner, it shall be made within *fifteen days* from the date of submission of the report, or within such further time but not exceeding *one month*, as he may think fit for reasons to be recorded by him in this behalf

(b) When the Divisional Commissioner or the Deputy Commissioner, as the case may be makes a decision for acquisition of the property under sub-section (1) or the provision to section 4 (3) (b) as the case may be, such decision shall be conclusive evidence that the property is needed for a public purpose or in the public interest.

13.2.6.3 Section 6: Notice to Persons Interested

(1) When the Divisional Commissioner or the Deputy Commissioner, as the case may be, has made a decision for acquisition of any property under section 5 or the provision to section 4 (3) (b), as the case may be, the Deputy Commissioner shall cause public notice to be given in the prescribed manner at convenient places on or near such property stating that the Divisional Commissioner or the Deputy Commissioner, as the case may be, has decided to acquire the property and intends to take possession thereof and that claims to compensation for all interests in such property may be made to him.

(2) Such notice shall state: the particulars of the property to be acquired and taken possession of and shall require all persons interested in the property to appear personally or by agent before the Deputy Commissioner at a time not being earlier than *fifteen days* after the date of publication of the notice, and place mentioned therein and to state the nature of their respective interests in the property and the amount and particulars of their claims to compensation for such interests.

(3) The Deputy Commissioner shall also serve notice to the same effect in the prescribed form on the occupier, if any, of such property and on all persons known or believed to be interested therein.

(4) The Deputy Commissioner may also, by notice, require any such person to make or deliver to him at a time, not being earlier than *fifteen days* after the date of service of the notice, and place mentioned therein a statement containing so far as may be practicable, the name of every other person possessing any interest in the property or any part thereof as co-sharer, mortgage or otherwise, and of the nature of such interest and profits, if any, received or receivable on account thereof.

(5) Every person required to make or deliver a statement under this section shall be deemed to be legally bound to do so within the meaning of *section 175 and 176 of the Penal Code (XLV of 1960).*

13.2.6.4 Section 7: Award of Compensation by Deputy Commissioner

(1) On the date so fixed, or on any other date to which the enquiry has been adjourned, the Deputy Commissioner shall proceed to enquire into the statement, if any, which any person has made pursuant to a notice given under section 6 and into the value of the property at the date of the publication of the notice under section 3, and into the respective interests of the persons claiming the compensation and shall make an award:

(a) The compensation which, in his opinion, shall be allowed for the property

(b) The apportionment of the said compensation among all the persons known or believed to be interested in the property, of whom, or of whose claims he has information.

(2) The award made by the Deputy Commissioner shall, except as hereinafter provided, be final.

(3) The Deputy Commissioner shall within seven days from the date of making award of compensation:

(a) Give notice of his award to the person interested

(b) Send the estimate of the award of compensation to the requiring person

(4) The requiring person shall deposit the estimated amounts of the award of compensation with the Deputy Commissioner in the prescribed manner within sixty days from the date of receipt of the estimate

13.2.7 Approving Authority of Land Acquisition Proposal

The quantity of land to be acquired for this project shall not exceed 50 standard bigha and as such the approval of Ministry of Land on that issue would not be required, but for administrative approval the LAPs shall have to be submitted to Ministry of Communication first and then through the DC it will go to M/O Land for CLAC.

Table 13.3: List of Documents to be Submitted with Proposal for CLAC

Sl.No.	Particular of Document
1	Proposal of Bangladesh Bridge Authority (BBA)
2	Administrative Approval from the Ministry of Communication
3	Certificate of minimum requirement of land from BBA
4	Project lay out plan
5	Land acquisition plan (LAP)
6	Schedule of Land
7	Project proforma
8	Detail description of the project

NB: The DC Dhaka will send the record to Ministry of Land for CLAC's consideration

13.3 IDENTIFICATION OF OPERATIONAL RISK FACTORS

BBA will identify the Operational Risk Factors (ORF), external and internal, immediately so that nothing can hinder the progress of land acquisition.

13.4 GENERAL RISK FACTORS IDENTIFICATION

In the process of land acquisition starting from submission of LA plan to DC up to the issue of notice u/s 7 and finally payment of CUL, certain factors may seem risk smooth implementation of the project as a whole. Therefore, if the risk factors can be identified at an early stage then overcoming of the situation becomes easier and smooth. Some risk factors are mentioned below:

Administrative Approval by Sponsoring Agency **–** Any land acquisition proposal requires approval from the administrative ministry. Good coordination may help.

Non-compliance – The time-frame is seldom adhered in completing the land acquisition process. The result is a very long time consumed for such small activities. Monitoring the process may be helpful.

Performance of JIVC – The subordinate staff of Acquiring Body (AB) and Requiring Body (RB) can't conduct the verification properly, so senior officials' intervention is suggested.

Valuation of Structures – Strong persuasion is needed to have the valuation report done by the PWD and the other departments.

13.5 IMMEDIATE ACTIONS REQUIRED/NEEDED

i) Finalization of Engineering Drawing

j) Appointment of Surveyors for Land for land Acquisition Survey

k) Preparation of LAP

l) Obtaining of Administrative Approval

m) Submission of LAP to the Deputy Commissioner Dhaka

n) Obtaining Land Acquisition Cost Estimate from the Deputy Commissioner, Dhaka

o) Obtaining Budget to Bear the Land Acquisition Cost

p) Designate someone to look after the Land Acquisition task and processing. If required he may be trained to cope with the tasks.

13.6 MONITORING OF LAND ACQUISITION ACTIVITIES

BBA will establish a monitoring and evaluation (M&E) system for collecting, collating and analyzing information on Land Acquisition Plan implementation in a systematic manner.

13.7 CONCLUSION

When the Government finally decides to implement the project then this Land Acquisition Framework will be updated and the impact along with detail results of consultation will be incorporated.

14 ALIGNMENT OPTIONS INVESTIGATION

14.1 Design Consider

The horizontal and the vertical alignments of the roads will have a significant impact on the design of the tunnel which will need to account for aspects such as stoppage distances, lines of sight in narrow curves, speed limits, number of lanes, gradients, etc. In addition the design must consider all applicable Codes and Standards. In this case the options were based on the design criteria of having four total lanes, two in each direction, at a maximum gradient of 4%. Only after the options had been prepared did the additional requirement of the Air Force that the base not be disturbed and remain operational become official, leaving only one potentially feasible option remaining.

14.1.1 Alignment

A number of horizontal alignments have been considered although their feasibility will be subject to the constraints and restrictions imposed by the airport stakeholders. The vertical alignment will depend on the allowable gradients for traffic given the constraints imposed on any approach structures and will also be limited by the tunnelling method.

As stated above the choice of tunnelling method is a prerequisite to design; each tunnelling methodology has its own advantages and disadvantages which will be discussed in a later section. In broad terms though, cut & cover tunnels and 'jacked box' tunnel methods can provide shallower tunnels with less steep approaches whereas bored or excavated tunnels require more cover which requires steeper approaches. Under all methodology there will be some requirement for sections of cut & cover to accommodate the approach roads.

Five options were looked at.

- Option 1 is the base case – Do nothing. This gives the existing traffic conditions.
- Option 2 is a surface road across the airport (this does not meet Air Force requirements and so is not feasible).
- Option 3 is a short cut and cover tunnel under the runway (this does not meet Air Force requirements and so is not feasible).
- Option 4 is a straight connection between the two sides with a 900m twin tunnel. This meets air Force requirements but because the bored or dug tunnel requires a large cover depth the ramps down into the tunnel are too steep as there is limited length available and so this option is not feasible.
- Option 5 is a 1300m twin tunnel that allows for longer approach ramp lengths to meet the required 4% grade and given the requirements of the Air Force and the limitations of the straight connection this is the only tunnel option potentially feasible.

These options are discussed in more detail in the following below.

14.2 Option 1

Option 1 is the base case – Do nothing. This gives the existing traffic conditions and is used to compare against all other options. The traffic model delay times and costs are based on this option.

14.3 Option 2

Option 2 is a surface road from Jahangir Gate at Farmgate - Mohakhali Road (east side) across the Old Tejgaon airport to Rokeya Sarani at Agargoan (west side). This is the cheapest option although it disturbs the Air Force operations and so does not meet their requirements for the tunnel. This design is used however in other parts of the world as can be seen from the below photographs.

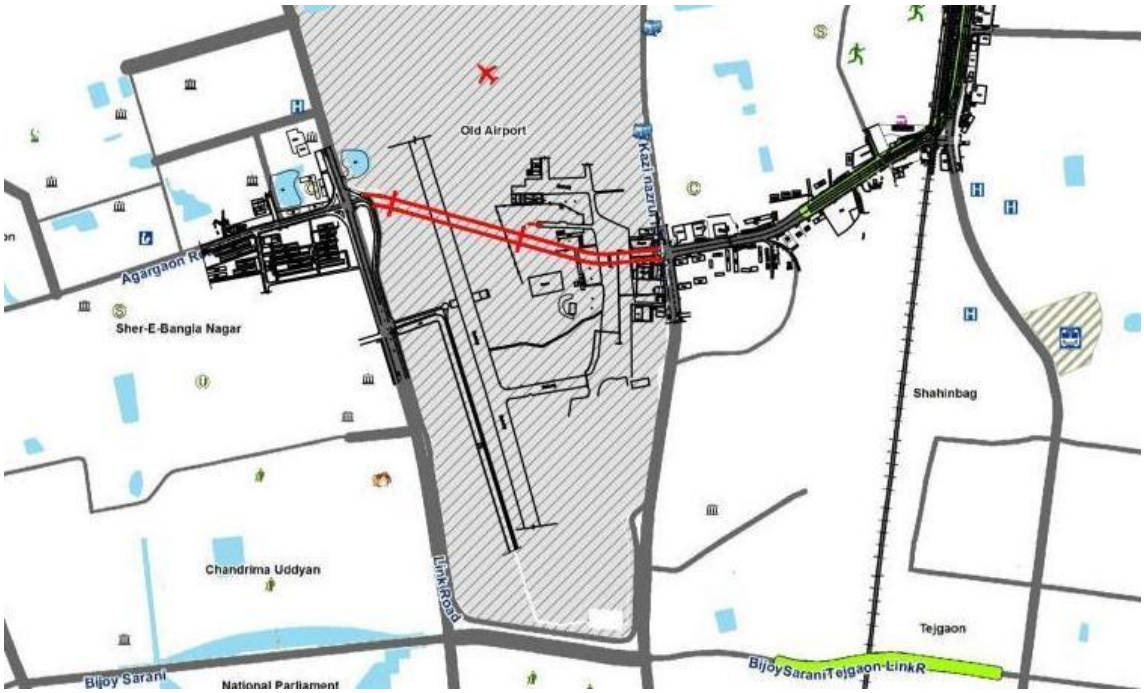


Figure 14.1: Option 2 – Surface road crossing

Figure 14.2 & 14.3: Surface road crossing Gibraltar Airport

Figure 14.2 and 14.3 are photographs depicting the runway at Gibraltar Airport. This runway is traversed by a busy road and as the photographs show, the traffic on the road crossing the runway is controlled by traffic lights and boom gates thereby allowing aircraft

to land unhindered. A surface road option is cheapest because it does not require any tunnelling operations, but the traffic will be disrupted by use of the runway.

14.4 Option 3

Option 3 is to construct separate relatively short tunnels under the runway and taxiway/apron only through an underpass that will require temporary closure of the facility and restrictions on the types of aircraft that can continue to use the airport during the construction period. The depressed roadway through the airport would be uncovered except at the underpass under the runway as shown in Figure 14.5.

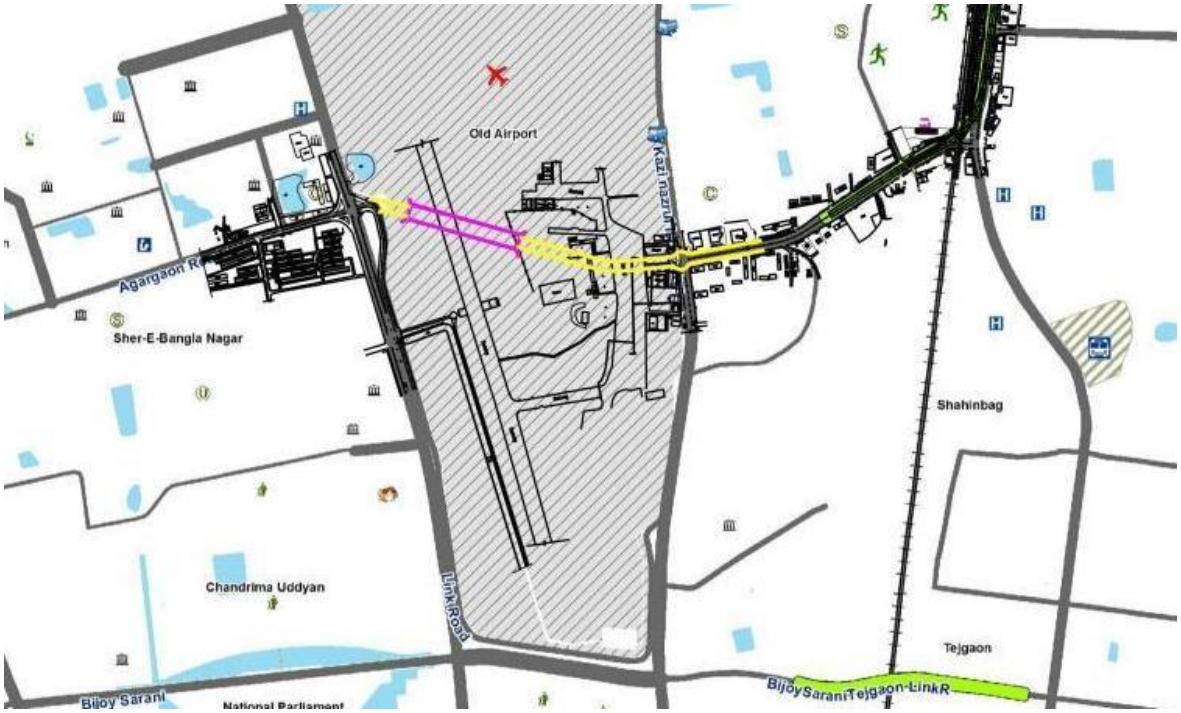


Figure 14.4: Option 3 – Runway Underpass

Figure 14.5: Cut and cover tunnel under runway.

14.5 Option 4

Option 4 is a straight connection between the two sides with a 900m twin tunnel. This meets air Force requirements but because the bored or dug tunnel requires a large cover depth the ramps down into the tunnel are too steep as there is limited length available. The necessary grade of the ramps to reach this depth over the short distance is above the maximum allowed for this project and is not feasible for traffic

Figure 14.6: Option 4 – 900m Tunnel

Figure 14.7: Twin Tunnel

14.6 Option 5

Option 5 is a 1300m twin tunnel that allows for longer approach ramp lengths to reach the necessary tunnel cover depth without exceeding the required 4% grade. This is the only feasible design option given the Air Force requirements that the airport remain operational at all times.

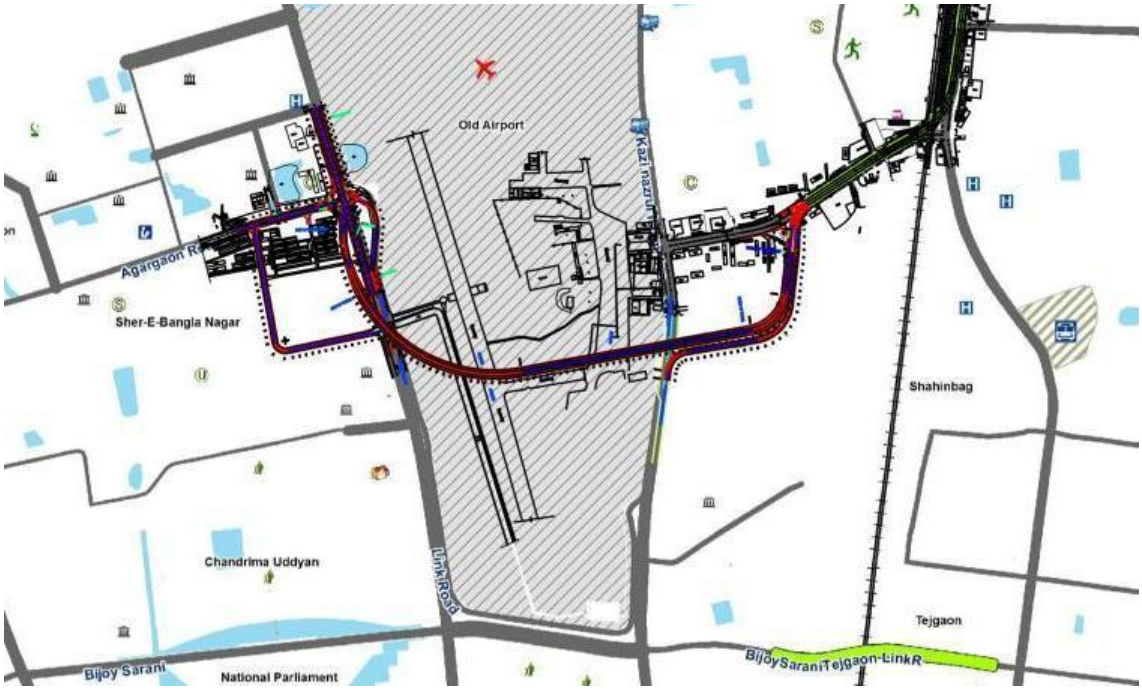


Figure 14.8: Option 5 – 1300m Twin tunnel

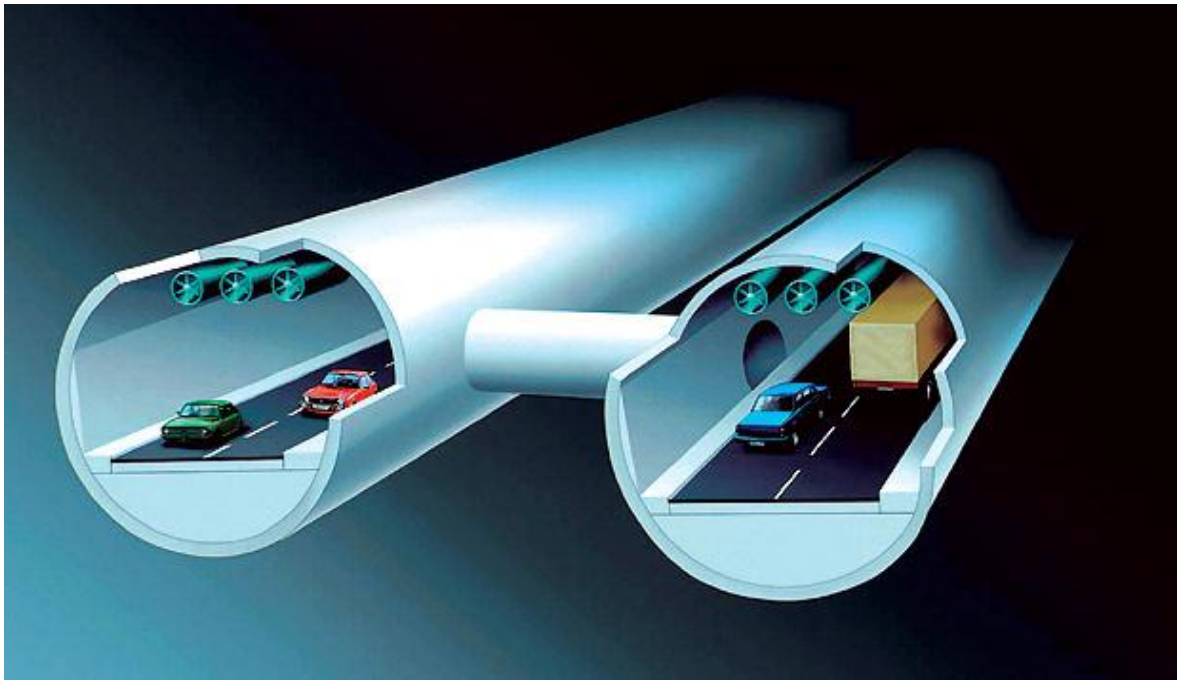


Figure 14.9: Twin tunnel

14.7 Option 6

Option 6 is a flyover joining to M flyover and an underpass under Kazi Narul Islam Ave.

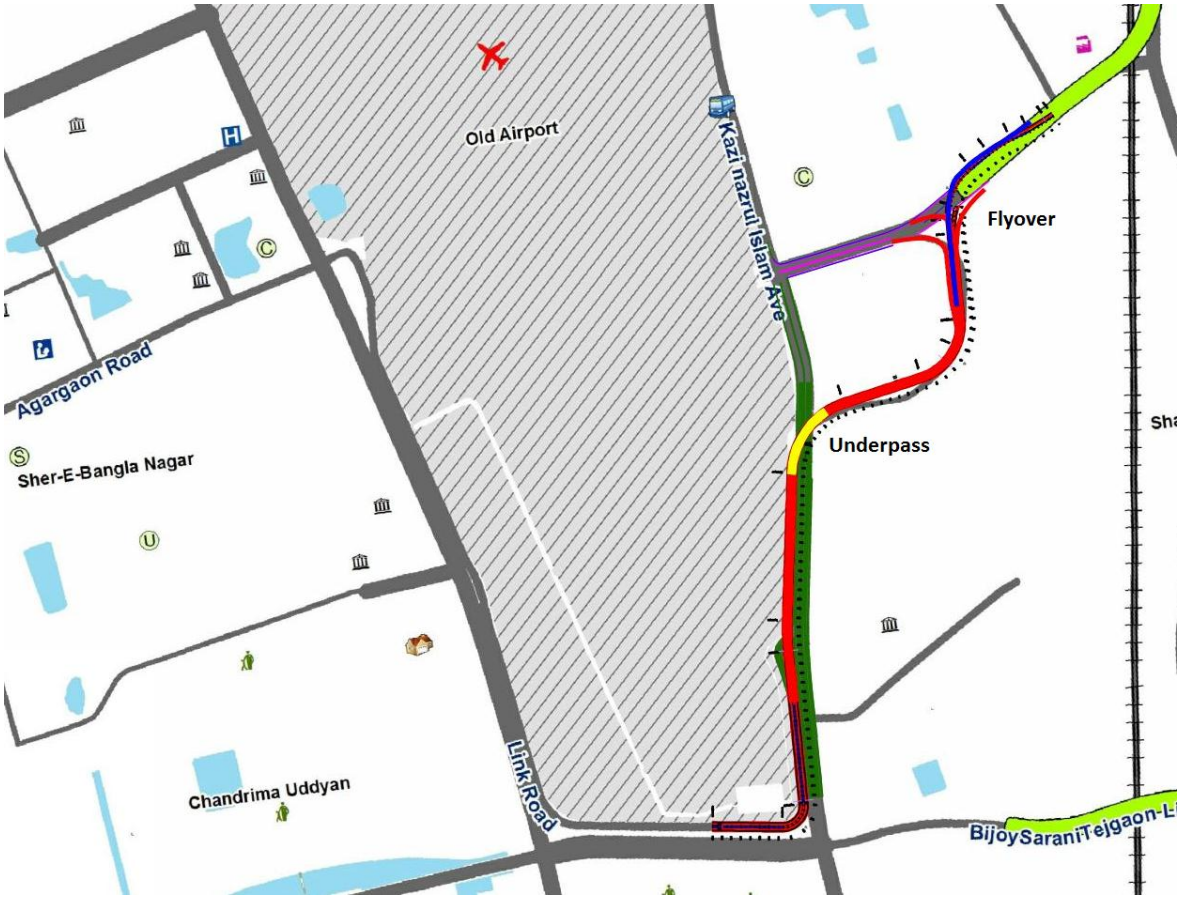


Figure 14.10: Option 6 – Flyover and Underpass

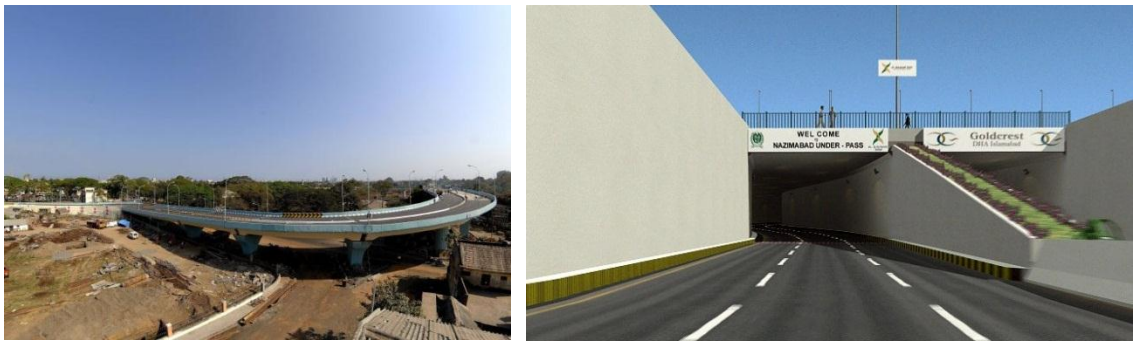


Figure 14.11: Option 6 – Flyover and Underpass

14.8 Option 7

Option 7 is 2 simple underpasses. One at the Prime Minister's office intersection lights on Kazi Narul Islam Ave for south bound right turning traffic. This is called the "BUET Option" as BUET has previously done some preliminary work on this option. The second underpass is on the western side at the link road junction near IDB Bhaban.

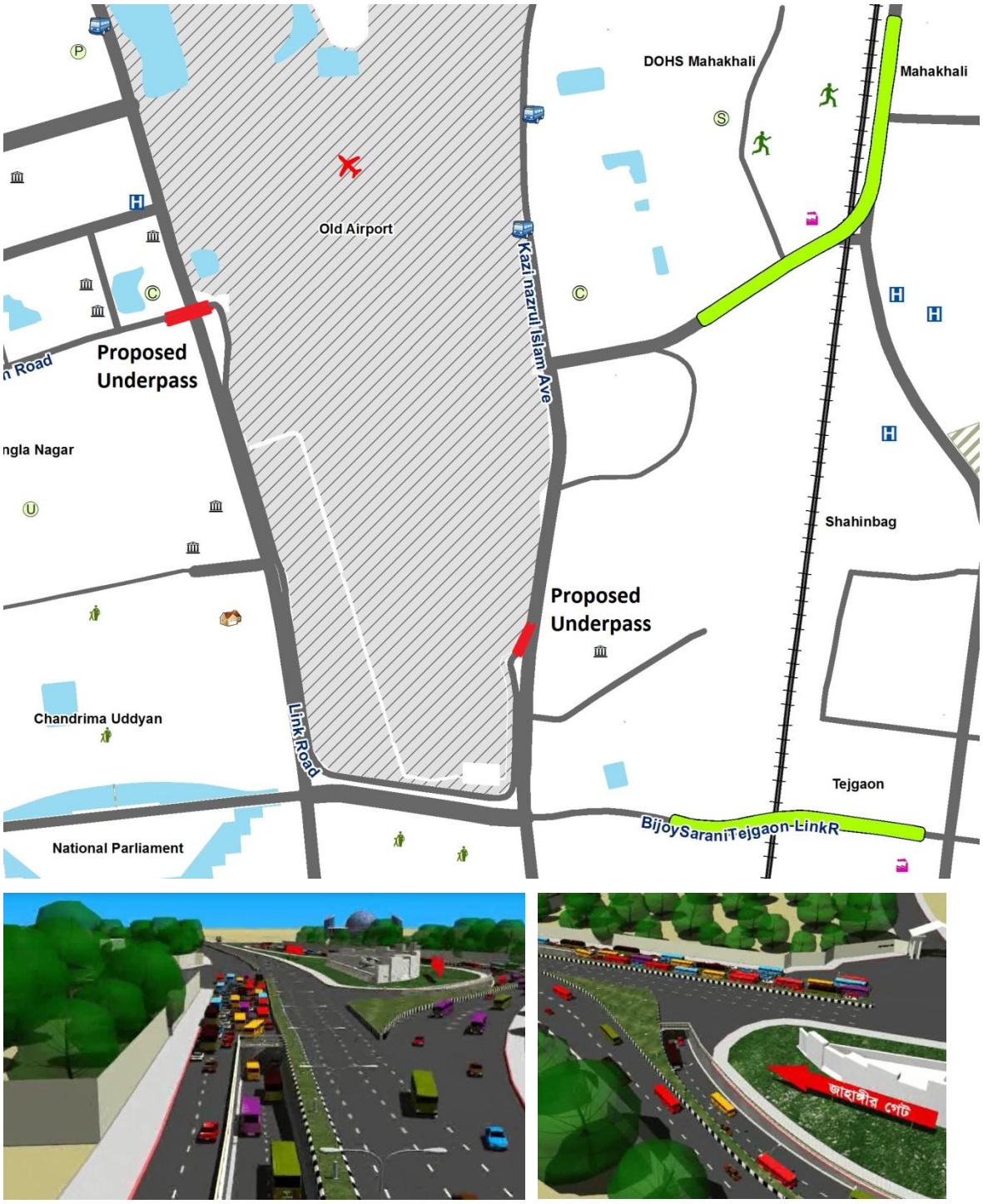


Figure 14.12: Option 7 – Two Underpasses (BUET animation)

15 SCOPE OF WORK FOR PREFERRED OPTION

15.1 Options

The Bangladesh Air Force requirements for the proposed tunnel mandate an excavated tunnel with negligible impact on airport operations both during and after construction. Near the tunnel portals it is expected that cut and cover construction could be adopted, although a canopy tube support could be done if temporary road traffic diversions are to be avoided.

At the eastern end, the existing Mokahali Flyover provides the eastern connection point. At the western end, Sayed Manbub Morshed Ave provides the east-west route, and Begum Rockeya Avenue provides a north-south connection. The tunnel alignment runs diagonally under the airport runway to conform to the geometry of the eastern and western approach roads.

If the tunnel entries are designed below flood level, the tunnel and its equipment must be designed to withstand being submerged, or alternatively, flood gates should be fitted.

The tunnel and its approaches are unsuitable for providing tolling facilities using boom gates. If tolling is required it is recommended that free flow electronic tolling be implemented, with no provision for cash payments. This is normal international practice for new toll ways.

15.2 Tunnel

The tunnel (see Figure 14.8) is to be constructed by excavation under the airport so that the airport remains operational at all times.

The tunnels will be two separate structures separated by 13.0 m median. The median narrows on the horizontal curves to match the existing medians on the approaches. The tunnels will be connected by cross passages with fire rated doors at spacing in accordance with Bangladesh FLS requirements.

The cross section in the tunnel is 2 x 3.5 m traffic lanes, a 1.0 m median shoulder (that provides pedestrian access to cross passages) and a 2.5 m left shoulder for breakdowns. The vertical clearance proposed is 5.7 m.

The median width is intended to provide adequate space for the tunnel structure and the construction process, as well as space for a refuge area in the cross passages which may be desirable in the event of simultaneous incidents in both tunnels, or a delay in stopping traffic in the non-incident tunnel.

Emergency median crossovers are required outside the tunnel to allow traffic flow in the peak direction should one tunnel be closed for repair (e.g. fire damage or damage from over-height vehicle).

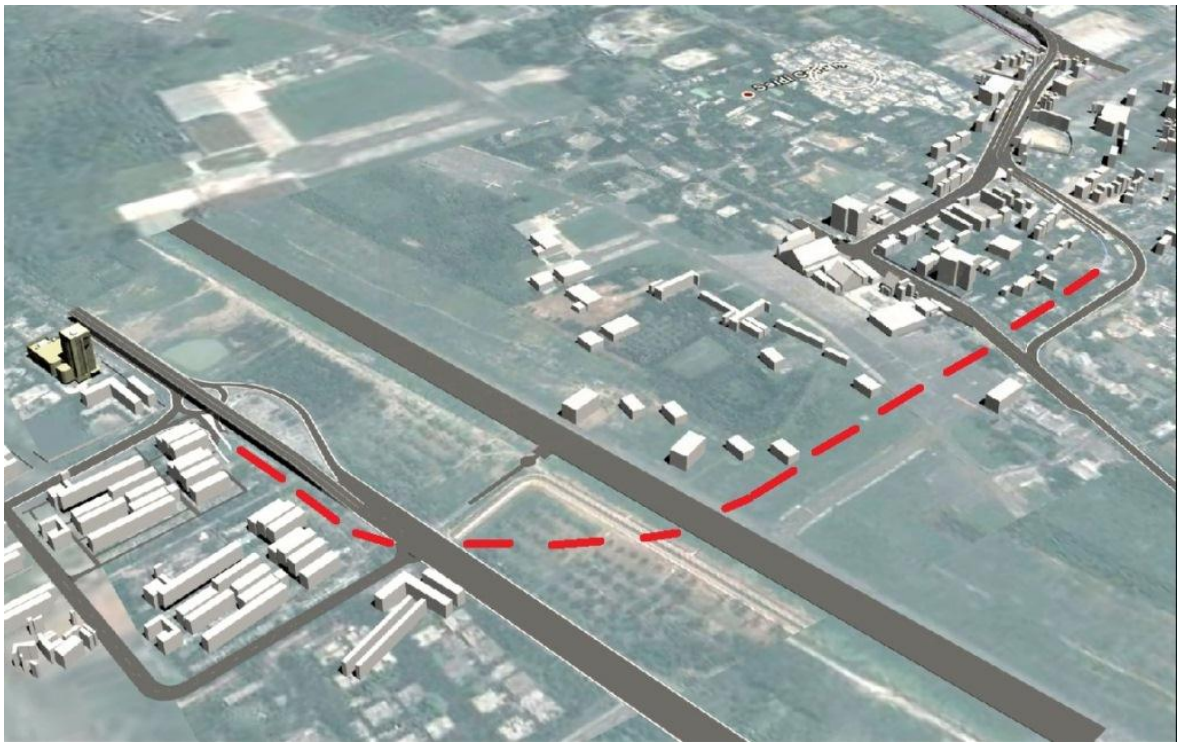


Figure 15.1: Proposed Tunnel and Approaches

15.3 Eastern Interchange

The eastern interchange (see Figure 15.2) is a partial interchange with the tunnel connecting with the Mohakali Flyover only. This is to allow connections from the Mohakali Flyover to New Airport Rd to be provided in addition to the tunnel connections. These connections provide access to important facilities, and traffic analysis indicates that these connections are of greater utility than providing connections from the tunnel to New Airport Rd. There is insufficient distance between the tunnel and the Mohakali Flyover to provide connections to both the Mohakali Flyover and New Airport Rd.

The westbound exit ramp has a weaving section. There is no weaving in the tunnel or the Mohakali Flyover with the recommended ramp layout. Acquisition and demolition of buildings is required.

The maximum grade on the eastbound entry ramps is 7%. The westbound exit maximum gradient is 5%.

Figure 15.3: Eastern Interchange

15.4 Western Interchange

The western interchange (see Figure 15.3) is a full interchange, i.e. all movements are allowed for. The maximum grade on the ramps is 3%, which is also the gradient of the tunnel approaches.

The interchange is a partial cloverleaf type AB. (The A is shorthand for a loop in Advance of the tunnel and the B is shorthand for a loop Beyond the tunnel). This type of interchange is commonly used when two quadrants of the interchange cannot readily accommodate ramps. In this situation, the need to avoid significant impacts on the airport makes this layout appropriate. The minimum loop radius is 60 m.

Local streets adjacent to the interchange will need to be closed as shown on the drawings. Reclamation of ponds will be necessary. Acquisition and demolition of buildings is required. Some buildings (e.g. the school) could remain within the loop ramps with road access from Begum Rockeya Avenue.

Figure 15.4: Western Interchange

15.5 Airport Bypass Road

The existing airport bypass road is relocated to connect to the interchange opposite the westbound exit ramp. This is to allow its continued use by vehicles prohibited from the tunnel (such as non-motorised vehicles and fuel tankers), and also for use during tunnel closure due to potential flooding, incident, or for maintenance.

A sub-option would be to connect the bypass road to the southern side ramps as well as the northern side ramps. This would make the westbound journey on the bypass more direct, but it would require more airport land to allow the development of a satisfactory junction.

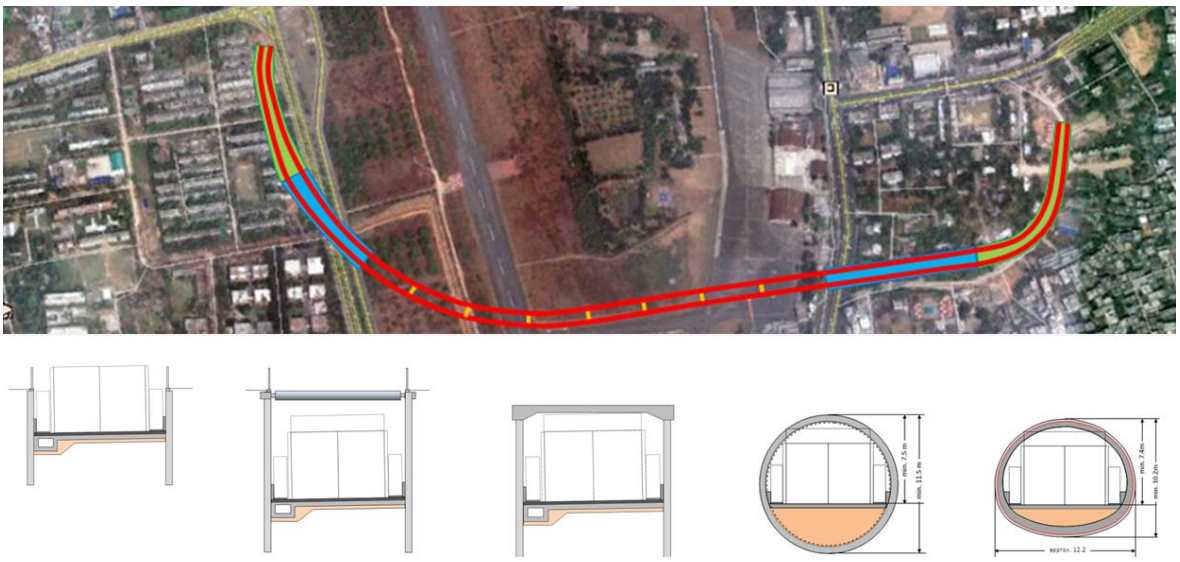
16 TUNNEL CONSTRUCTION

16.1 Construction Options

16.1.1 Introduction

As with any underground scheme there are usually a number of options that may be considered for the methodology for construction. A full discussion on tunnel design and possible construction methodology options is presented in the Interim Report included as Appendix H and the subsequent evaluations identifying the technically viable preferred solution are presented in the 'Viable Tunnel Construction Options' note included as Appendix I.

At this point the requirements of the various airport stakeholders and the restrictions on the use of Tejgaon Airport land imposed on the Project are known; consequently this section limits discussion to the main conclusions related to the technically viable tunnel options compliant with the stakeholder restraints only.



16.1.2 Design Considerations

The design must account for the horizontal and the vertical alignments of the roads and aspects such as stoppage distances, lines of sight in narrow curves, speed limits, number of lanes, gradients, etc. In addition the Codes and Standards that will be used for any design will need to be addressed. Other inputs for tunnel design include tunnel alignment, traffic envelope, tunnel loads, serviceability & ultimate limit state loads, accidental loads, and durability.

A number of horizontal alignments have been considered which are subject to possible constraints and restrictions by the airport stakeholders. The vertical alignment is dependent on the allowable gradients for traffic and the constraints imposed on any approach structures plus the limitations of the particular tunnelling method. In broad terms bored tunnels require more cover which require steeper approaches.

The road design to accommodate the traffic will define the traffic envelope, i.e. the space that is required to contain the requisite number of lanes, shoulders, escape ways, barriers etc. For example if a tunnel contains two lanes of 3.5 m width and an emergency lane of 2.5m width and is to be constructed within a bored tunnel, the internal diameter of the tunnel will have to be around 13.3m. The resulting TBM diameter would be of the order

14.5m. Given the land constraints and acceptable approach gradients for the roads the maximum depth of the tunnel would be about 17.5m below the runway. Hence the cover above a bored tunnel would be only 7.7-7.8m at the deepest point, corresponding to half a tunnel diameter. As the alignment raises to either side of the runway the cover diminishes, so even though a cover of half a diameter is feasible, the bored tunnel would be very short (max. 250-300m), as the length over which a feasible cover is obtainable is short. Such a solution is not considered economically viable. Hence the traffic envelope is a key criterion in deciding the tunnelling technique, length of tunnel and construction cost.

Most loads on tunnels are related to physical properties of soil and water. The principles of applying these loads can be taken from relevant international design codes. The planned site investigations were designed to obtain the parameters necessary for the determination of the loads on the tunnels. Special loads may be needed for planes and heavy vehicles operating in the airport as well as other special cases and this will be a required input from the airport stakeholders. Loads that will need to be considered in the design are outlined in Appendix I.

Durability requirements will need to be established and turned into specific requirements for concrete, steel, etc. taking proper account of such factors as service temperature, typical humidity, and ground/groundwater chemistry (e.g. salinity and arsenic contents). The primary critical processes leading to deterioration of reinforced concrete in tunnels are associated with migration of water through the structure. As the water evaporates at the inner face, any aggressive components of the water build up at the inner face. In the long term the inner face is often more critical than the outer face (even though the outer face is in direct contact with the ground water). Hence the primary factors impacting the reinforced concrete durability are the diffusivity of the concrete, the cover to the reinforcement, and the presence of other membranes preventing or reducing the water migration. The durability should be documented by suitable probabilistic modelling of the main deteriorating mechanisms.

16.1.3 Construction Methodology Options

There are many different types of tunnelling methods but from an appraisal of the ground conditions the construction options considered were: cut & cover, bored tunnel, jacked box, and NATM/SCL, in addition to other soil improvement techniques to assist with ‘primary’ tunnelling method. Each of these construction methods is described in Appendix H and includes a description of the method, advantages offered by the method, disadvantages and hazards associated with the method.

Given the restrictions on airport space and the most feasible alignment option identified the two technically viable solutions for the main tunnel section were examined in more depth in the note attached as Appendix I. The summary table comparing the two closed tunnel construction options are reproduced here:

Geology and hydrogeology	
TBM solution	**SCL solution**
The geology is not particularly difficult for a TBM bored tunnel. Sufficient face pressure shall be maintained, but with the low GWT, there is a limited risk of running sands.	The geological investigations performed are absolute minimum investigations. A comprehensive test programme shall be established with the aim to provide information tailored to the tunnelling methods employed. An American investigation has shown that the amount of claims decreases when the

	level of geotechnical investigations goes up. A level of 1-1½% of the construction costs for pre-investigations was found to be adequate. This percentage may be in the high end for a short tunnel. Another measure mentioned in the investigation is that the total length of geotechnical borings should amount to 60% of the tunnel length. With the changed alignment, the relevant borings from the feasibility study constitute around 20% and include a limited monitoring and test scope.

Construction methodologies

Common

The construction methods both require experienced international contractors employing construction management, designers, key staff and supervision/follow-up by experienced individuals.

Comparing risks between the two methods is difficult. When looking at the severe incidents in soft soil tunnelling projects, the following was found by the research report [The risk to third parties from bored tunnelling in soft ground, Prepared by W S Atkins for the Health and Safety Executive, 2006]

	1970-1979	1980-1989	1990-1999	2000-2005 (part)	Total
NATM	0	9	12	4	25
non-NATM	2	2	9	6	19
Total	2	11	21	10	44

However, as the total number of tunnelling projects in each category is not known and as 'non-NATM' most probably include other construction methods than TBM tunnelling, this can only be used to illustrate that tunnelling is essentially a risk management task.

Nonetheless it is our evaluation that the prevailing geological conditions are significantly more challenging for the SCL method than for the TBM solution.

Temporary and permanent ground support systems

TBM solution For the main part of the tunnel, the TBM solution provides both the temporary and the permanent support system in more or less on go. Risks associated with the TBM are mainly related to the proper operation of the machine. The cross passages requires the same sort of ground support as the SCL method. Risks associated with loosening of the sand is the same, however working in discrete locations and starting from a lined tunnel reduces the risk level.	**SCL solution** The stability of the SCL solution depends on various soil strengthening techniques improving the strength both radially for arching around the tunnel (convergence) and ahead of the tunnel for face stability (pre-convergence). Non-cohesive soils with a relative low stiffness in combination with large spans and rather small covers possess a risk of tunnel collapse.
Ground and groundwater treatment measures	
Common The groundwater table is presently lowered considerably in Dhaka and the relevant soil treatment is not expected to have any impact on the groundwater/drinking water abstraction for any of the two methods	
TBM option The range of chemicals used on TBM's are well proven and considerable focus on environmental impacts, means that relatively environmental friendly products are used today. The problematic parts of the products are often the preservative components, which are often not declared. Muck from TBM's is often used for landscaping and land reclamation.	**SCL option** The superfines cement grouts and silicate grouts are used for soil improvement works generally - and there wide spread use is a result of a continued search for non-toxic soil treatment products. If chemical grouts are needed, a thorough examination of their environmental impact should be carried out.
Ground movements and settlements	
TBM option Ideally a TBM should be able to limit the settlements to near zero. However, based on historical records certain difficult locations bears a risk of higher volume losses and hence settlements. The tunnel contractor is likely to focus on a proper operation of the TBM (plus monitoring) for sufficient settlement control instead of other protection of utility lines.	**SCL option** The SCL method will even with a significant level of mitigation inevitably see settlements. These settlements will follow the entire tunnel. Where the tunnels are shallow, any crossing 'rigid' utility shall be protected while undercut by the SCL works.
Environmental considerations including dust, noise, vibrations, traffic, plant movements (third parties)	
Common Both methods are considered to impose relative low environmental impact to third parties in the form of dust, noise, vibrations etc. Impact on third parties is mainly related to the	

surface work sites and the required transports for the job.

Given the traffic situation in Dhaka it is not expected that the additional traffic will have a measurable impact to third parties

TBM option	**SCL option**
The main concerns related to the bored tunnel are the surface work site and the need for transportation of segments and muck to/from the site. Dust may be a problem for muck transport both above ground and below ground (e.g. on conveyor belts), but technical solutions are well known. The particular risks associated with work underground in a confined space is something that is considered e.g. in the TBM design process.	For SCL works the main environmental impact is also related to traffic and to disposal of excavated material. For the SCL this material include concrete (rebound and temporary side drift walls etc) and excavated glass fibre rods. Due to the more optimal shape, the excavated quantities are lower than for the bored tunnel. None the less the total consumption of concrete for the primary and the secondary lining including rebound is larger for an SCL tunnel than for a bored tunnel.

Health and Safety

Common

Both methods comprise significant health and safety issues. These issues are, however, well known to the international specialist contractors and largely an integrated part of their work and work planning. Irrespectively H&S requirements shall be specified in the tendering stage and Client responsibilities in relation to local law/practice shall be tabled.

Cost and programme

TBM option	**SCL option**
TBM tunnel costs have been entered into the cost estimate in the main report	SCL costs have not been assessed in detail, as they require a more elaborate design of the soil improvement measures. It is roughly estimated that the total cost will be similar to the bored tunnel due to the extensive mitigating works and the associated prolonged construction period.

Appropriate forms of contract

Both construction methods require international experienced contractors and designers. From a tunnelling risk point of view contract forms may be Design & Build, Build only or BOT.

TBM option	**SCL option**
The contractor shall preferably take responsibility for the TBM procurement including the detailed specification	The SCL method may to a larger degree benefit from contract solutions with early contractor involvement in the design, as the final combination of soil strengthening, utility protection, monitoring etc should be based on the contractors preferred methods

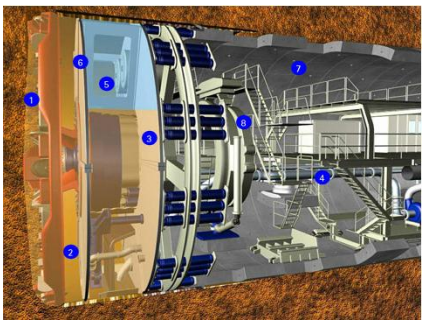
	provided an acceptable risk profile can be obtained.
Other hazards	
Common The geometrical restraints on the alignment means that the largest tunnel, that can be put through at this location is a two lane tunnel possibly with SCL constructed local extensions for diversions or emergency spaces. Hence, there is a risk that the tunnel will not have adequate capacity in the long run. The type of vehicles to be allowed into the tunnel shall be carefully considered. Enforcing lane discipline and avoiding congestion in the tunnel is also a must.	

16.1.3.1 Recommendation for the main tunnel below the airport

Mainly due to the difference in the risk profile it is recommended that a tunnel solution underpassing the entire width of the Tejgaon airport is constructed by use of the bored tunnel method.

It should though be emphasized that additional investigations and a more elaborate development of the SCL solution could potentially be a economically competitive solution. So any further phases of this project should not exclude the SCL solution entirely.

16.1.3.2 The bored tunnel method in brief



A bored tunnel is excavated using a tunnel boring machine (TBM). In the anticipated soil conditions closed shield machines will be used. In this respect either an Earth Pressure Balance (EPB) machine or slurry machine would be appropriate; at this stage of the feasibility study the type of machine, other than it will be a closed TBM, is not important.

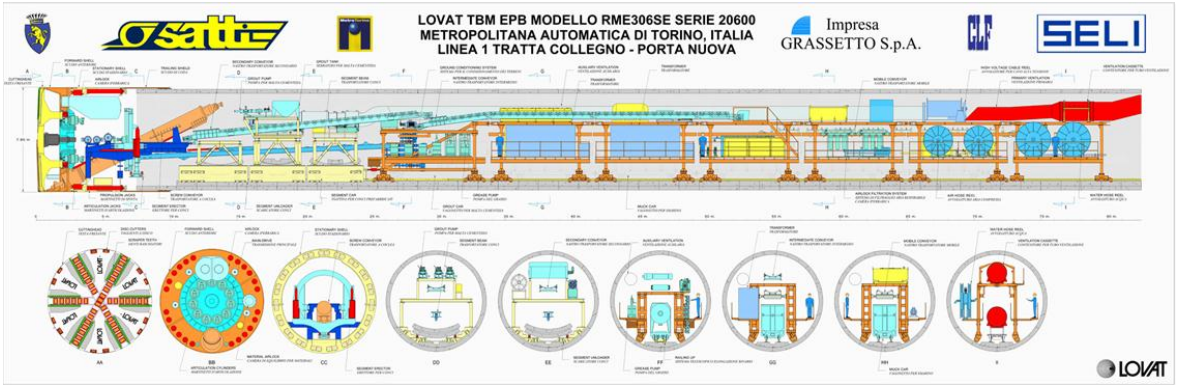


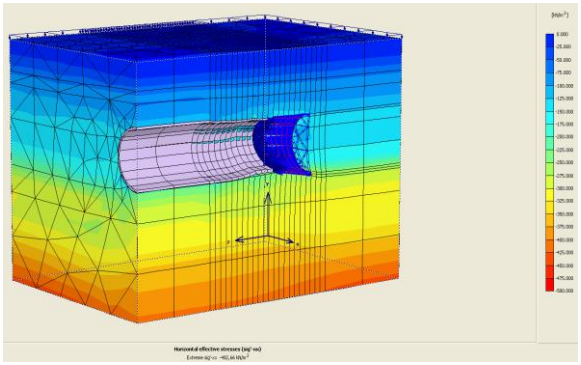
Figure 16.1: Example of TBM (by Lovat/SELI)

The tunnel boring takes place in a sequence, where typically 1.4-1.5m tunnel is excavated by the TBM. Then the TBM is stopped while a concrete ring is erected inside the TBM shield. Once the new concrete ring is established the TBM start boring again pushing off the already constructed concrete lining. As the TBM moves forward previously built rings will one by one leave the TBM shield. As they do this the gap between the outer face of the concrete lining and the soil face excavated by the TBM will be filled with a grout ensuring that the final tunnel is properly embedded in and supporting the surrounding soil.

The vertical soil load acting on the top of the tunnel will make the lining ovalise slightly, thereby mobilising a part passive pressure on the side of the tunnel needed for the overall stability. This means that the ovalising capacity of the lining and the joints between the lining segments is a key issue in the lining design.

16.1.3.3 Lining dimensions

Preliminary calculations have shown that for the Jahangir gate tunnel a lining thickness of 530-550mm, with a minimum contact area between neighbour ring segments of 330mm should be adequate for a minimum cross section without emergency lanes. For a 13.3m ID tunnel a lining thickness of around 600mm would be adequate.



16.1.3.4 Impact on third parties

Settlements above a bored tunnel can in principle be kept to negligible values, but in practice settlements will occur. For the Jahangir gate tunnel the combination of low covers and the presence of non-cohesive soils means that expectable settlements are quite high at certain critical locations. However the finally proposed alignment does not pass below any buildings and where the airport runway is underpassed, the tunnel is so deep that settlements are deemed to be in the acceptable range.

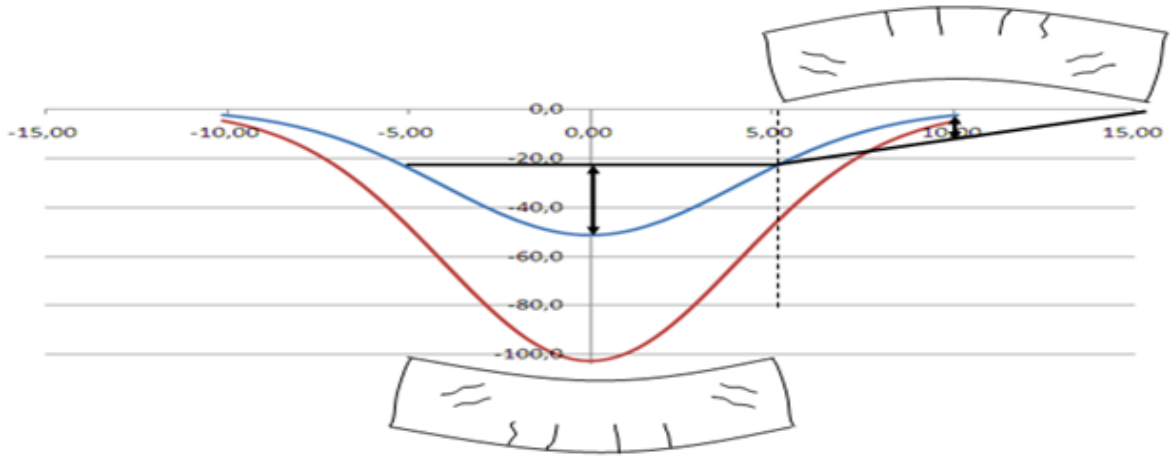


Figure 16.2: Typical bell shaped settlement profile with indication of hogging and sagging induced damages to any above building.

The feasibility investigations have not included an identification of utilities crossing the tunnel. It is however obvious that utilities will need (temporary) relocation, e.g. where the major roads are underpassed by cut & cover tunnels. Also utilities in the airport, especially near the west and east borders, where tunneling is quite shallow are likely to require temporary protection or relocation.

16.1.3.5 The approach structures

For an analysis of the approach structures reference is also made to Appendix I.

Cut and cover solutions are expected to be the most competitive technically viable solution for these structures. The approach structures will typically consist of a ramp taking the roads from the surrounding street level down to a depth, where a closed tunnel can be established. The first part of the closed tunnel will also be constructed by cut & cover methods until the point where the alignment is adequately deep for start of the mechanized TBM tunneling.

As cut and cover methods are carried out from the surface it is obvious that they conflict with the normal urban activities and services in the area. Utility relocations and traffic diversions will normally be required. Even demolition of buildings may be necessitated. Nearby residential and office buildings may experience nuisances in the form of reduced access, noise etc.

In the permanent stage the ramps may constitute barriers for surface movements transverse to the new connection.

These are consequences that are unavoidable, so they should be considered as part of the project planning and mitigation shall be included as appropriate.

16.2 Tunnel Safety

An essential part of the Dhaka Road Tunnel feasibility study is to establish at least the same safety level for future road users in the tunnel as on the open roads outside the tunnel area. As there are no tunnel standards or codes for Bangladesh to follow all tunnel safety issues are related to international standards and recommendations. Basis documents for tunnel planning and design include PIARC (World Road Association)

publications, British Standard (BS 78/99), NFPA 502 (US), AASHTO, and EU Directive 2004/54/EC of 29th April 2004, with due respect to local conditions for Dhaka. It is of utmost importance that all described and recommended design and systems at this stage are tailor-made to suit the conditions in Bangladesh for tunnel planning, design, construction works and later operation and maintenance.

The general overall safety goals for the Dhaka Road Tunnel are to plan, construct operate and monitor the tunnel to avoid accidents. If an accident, catastrophe or a disaster occurs then the tunnel design and systems must ensure necessary evacuation of people in the tunnel, ensure necessary access for Fire Brigade and rescue teams, limit to a minimum the number of fatalities and injuries, limit to a minimum the damage to structures and installations to maintain the flow of the road traffic as quickly as possible after an accidents, and allow for sectioning of installations and systems so that a major accident has only partial consequences on emergency systems including lighting, emergency telephones, ventilation, power supply, fire fighting, and traffic management.

As part of this Dhaka Road Tunnel feasibility study all safety aspects necessary for any preferred tunnel option will be addressed in line with good international practice; the detailed report is available in Appendix H. Safety is an essential part of any road tunnel and will be a prerequisite for approval of the tunnel concept by relevant authorities.

16.2.1 Tunnel Classification

A preliminary tunnel classification is made on the basis of the future traffic volume and composition and the tunnel length. From an estimate of the likely use of the tunnel and based on the PIARC and British Standard model, BS 78/99 these indicate that the Dhaka Road Tunnel will need to be in the highest safety class. This will need to be incorporated into any subsequent design.

It is considered good practice that modern road tunnels are design as uni-directional with two bores and minimum two lanes in each bore from tunnel safety perspective as well as future operation and maintenance activities. The cross section will be developed based on the assumed traffic volume and traffic composition and the estimated tunnel length. From an estimation of the tunnel length and based on good international practice the Dhaka Road Tunnel is not likely to be less than 2 lanes with a lane width of 3.50 m in each bore plus an escape way/sidewalk of at least 1.00 m in both sides plus crash barrier as type New Jersey (0.40 m).

These are the absolute minimum international requirements and recommendations for a possible cross section design. This solution has no emergency lane, very limited space for escape routes and emergency activities during incidents and accidents. The daily operation and maintenance activities will also very often require one tunnel bore to be closed while executing the work due to limited work space in the tunnel. This work would normally be carried out in either ‘off-peak’ hours or at night during an ‘engineering possession’. The above minimum must also address other issues related to the environment in which the tunnel exists and the traffic situation, and to optimise the tunnel safety for the Dhaka Road Tunnel other features will need to be included and addressed which are listed in Appendix H.

16.2.2 Fire Protection, Safety Monitoring Systems and Equipment

Structures and installations will as a minimum be resistant to a design fire of 100 MW (fire in a heavy lorry). This requires that there must be an adequate ventilation system and the concrete structure must be able to withstand the fire load. The complete modern longitudinal ventilation system will use jet fans with the necessary capacity for smoke extraction in case of fire and fresh air provision during the daily operation situation i.e. congestion in the tunnel. The use of a deluge system will also need to be considered in light of the traffic types and density.

The tunnel structure will need to be protected through the inherent durability and fire resistance of concrete coupled with either sprayed concrete with special mortar (thickness ~ 40 mm) on roof and walls or by special prefabricated panels mounted to the walls. The various installations and equipment in the tunnel will also be resistant to the design fire for at least 2 hours and subsequently protected maintaining necessary functionality to minimize the risk of a disaster or catastrophe during a fire. The installations and equipment will be sectioned through the tunnel to prevent the total immobilisation of the tunnel safety systems due to a severe fire, severe accident involving many cars, or sabotage.

As the Dhaka Road tunnel will be classified within the highest safety category the maximum level of safety equipment and Mechanical & Electrical (M&E) installations is required. Most types of M&E and safety equipment are both standard and mandatory when considering current good industry practice; hence it is normal to include such features in modern road tunnel design. The list of M&E installations the tunnel would need to incorporate is included in Appendix H. The tunnel drainage systems and pump basins will have the necessary capacity to store and discharge water to designated outfalls during the monsoon season, periods of heavy rainfall, and from fire fighting.

In a modern road tunnel there is a requirement for the monitoring, control and management of the daily traffic situation as well as during operation and maintenance activities. By carrying out such surveillance the tunnel management will be able to react promptly during any incident, severe accident or emergency situation that may occur in the tunnel area. The Dhaka Road Tunnel will be provided with modern systems and equipment for the purposes of monitoring the day to day activities and any incidents for accidents that may occur; these are listed in Appendix H along with the supplemental standard ITS systems (Intelligent Transportation Systems) and equipment needed to complete a fully modern Traffic Management System.

The equipment provided for the effective escape and evacuation of the road users to a safe area in case of any emergency in the Dhaka Road Tunnel is listed in Appendix H. The tunnel entrances and exits are also considered to be used as escape routes. The equipment provided for self-rescuing by road users and for fire-fighting by the Fire Brigade In case of fire in the Dhaka Road Tunnel is also listed in Appendix H.

There will be a need for a technical building at each end of the tunnel containing certain equipment and facilities for the operations and maintenance staff. The requirements of this building are listed in Appendix H. A remote office working as a back-up control room will also be required in the case of a major accident or incident involving the main control room. The technical buildings are best integrated with a Control Room for handling SCADA and monitoring the tunnel and traffic condition 24 hours a day. One of the Control Rooms will serve as a back-up room in case of system breakdown, installed with the same SCADA system etc. The technical buildings must be easily accessible from the existing road network.

A technical building for the Dhaka Road Tunnel is estimated to cover approximately 400m^2 in one or two levels. The locations of building and access including the provision of utilities will require inputs from the landowners and airport authorities and such information is required to plan layouts etc.

16.2.3 Operation and Maintenance Aspects

An operation organisation is required in order to ensure effective functioning of the Dhaka Road Tunnel and for the safety of the road users. This organisation could either be one dedicated for the specific tunnel or an existing organisation e.g. the police or a rescue organisation on 24 hours duty (Rapid Response Team).

For the operation organisation it is of utmost importance to define roles and responsibilities for each entity and individual persons involved (who does what, when and

how). For the emergency entities such as Fire Brigade, Police and Rescue Teams it is necessary to have fully comprehensive and pre-prepared emergency plans, procedures and instructions for selected scenarios. Actions are required to be initiated on fire alarms, alarms from drivers, traffic safety alarms and technical alarms. Rapid intervention is required in connection with fire or traffic accidents and for technical malfunctions that affect safety. Therefore, the centre receiving an alarm should be able to call for assistance from rescue services and technicians, who can handle technical malfunctions 24 hours a day. The SCADA system will alert the operator in the control room when an alarm or minor failure occurs. The SCADA system will store alarms and measurements such as temperature, gas concentrations etc. for following use of the O&M personal.

The tunnel will be designed for a 100 year lifetime and 15 - 25 years for mechanical/ electrical equipment. Regular inspection, maintenance and repair should be carried out in order to obtain the required lifetime. Structures are normally checked every 3 - 5 years, whereas technical installations may be checked several times every year. The functioning of many components is monitored automatically and alarms will be given if faults arise. Regular checking and maintenance is typical carried out four times every year as systematic and planned maintenance. It may be necessary to close one lane, one bore or the whole tunnel for some hours or days in order to carry out operation and maintenance activities or for dealing with incidents, accidents or fire. A cross over possibility for the traffic with necessary road barriers and signals will be established on ramps in front of the tunnel as a part of the traffic management system. This will allows bi-directional traffic in one bore while the other bore is closed.

16.2.4 Restrictions on Tunnel Use

Non-motorised vehicles (Pedal rickshaws, bicycles, animal drawn carts) and pedestrians are normally prohibited from using tunnels on major roads. Auto-rickshaws may be able to be accommodated if adequate air quality can be achieved for the occupants, and if gradients are acceptable for their use. (Vehicles with closed cabins can have their windows shut to reduce exposure to fumes, but if the tunnel is relatively short, air quality in the tunnel will be easier to maintain and auto-rickshaws could possibly be allowed).

Driven tunnels would also be severely damaged following large liquid petroleum gas leaks or TNT accidents. The transportation of these materials through tunnels is therefore generally prohibited. Radioactive and toxic materials may also be prohibited. The use of short driven tunnels by dangerous goods vehicles may be acceptable, particularly if the alternate route involves greater risk than the tunnel route. However, the risk of airport closure if a catastrophic fire or explosion were to occur may deter any relaxation of restrictions. There are also a range of products such as margarine, palm oil, tyres, timber, expanded polystyrene, etc. that are not classed as hazardous but can result in powerful fires. These fires must be managed through the coordinated use of deluge or sprinkler systems, smoke extraction system and fire brigade attendance.

Rules for the traffic that may use the tunnel will need to be established as part of any operations strategy for the tunnel.

17 ESTIMATE FOR COST OF PREFERRED OPTION

17.1 Cost Estimation

The estimated cost of preferred option amounts to approximately USD 490 million. This is inclusive of all the capital cost, payment for necessary consulting services, project management expenditure for the Client and contingency, both physical and price. Table 17.1 below illustrates the breakdown of the estimate.

Table 17.1: Engineer's Estimate Summary

BANGLADESH BRIDGE AUTHORITY				
DHAKA ROAD TUNNEL FEASIBILITY STUDY PROJECT				
ENGINEER'S ESTIMATE				
SUMMARY			82	BDT to USD
SL. NO.		**DESCRIPTION**	**ESTIMATED PRICE (BDT)**	**ESTIMATED PRICE (USD)**
1	A	GENERAL REQUIREMENTS	187,500,000	$2,286,585
2	B1	EARTHWORKS (FOR ROAD AND INTERSECTIONS)	84,444,820	$1,029,815
3	B2	PAVEMENT (FOR ROAD AND INTERSECTIONS)	518,733,500	$6,326,018
4	C	MISCELLIONUS WORK (FOR ROAD AND INTERSECTIONS)	170,714,400	$2,081,883
5	D	OVERPASS AT ROKEYA AVE (OVER ROAD AND INTERSECTIONS	303,281,144	$3,698,551
6	E	TUNNEL CIVIL WORK COST	20,642,373,817	$251,736,266
7	F	TUNNEL ELECTRICAL WORK COST	3,538,692,654	$43,154,788
8	G	TUNNEL FIRE FIGHTING & SAFETY WORK COST	2,064,237,382	$25,173,627
9	H	TUNNEL DE-WATERING & SAFETY WORK COST	3,243,801,600	$39,558,556
10	I	TOLL COLLECTION AND BOOTH WITH ELECTRONIC TOLLING SYSTEM, ETC.	76,500,000	$932,927
11	J	ANCILLARY WORKS (RELOCATION OF UTILITY SERVICE)	70,000,000	$853,659
12		**I) SUBTOTAL CONSTRUCTION COSTS**	**30,900,279,317**	**$376,832,675**
13		**II) PHYSICAL CONTINGENCIES 10%of(i)**	3,090,027,932	$37,683,267
14		**III) DESIGN (including topographical and geotechnical survey)**	618,005,586	$7,536,653
15		**IV)CONSTRUCTION SUPERVISION**	1,236,011,173	$15,073,307
16		**V) CLIENT COSTS (administration and supervision)**	618,005,586	$7,536,653
17		**VI) SUBTOTAL = (I) + (II) + (III) + (IV) + (V)**	36,462,329,594	$444,662,556
18		**VII) PRICE CONTINGENCIES 10% on (VI)**	3,646,232,959	$44,466,256
19		**VIII) GRAND TOTAL- (VI) + (VII) =**	**40,108,562,554**	**$489,128,812**
		Price pre meter (1300m)	30,852,740	$376,253

17.2 Analysis

Construction of tunnel using a Tunnel Boring Machine is an expensive treatment already. To add to that, the length of the tunnel had to be increased by nearly 400m to comply with the relevant RHD design standard. In addition, for the tunnel to be effective enough, other infrastructure has also been planned that include overpass, widening of the existing roads etc. This section seeks to analyse these aspects.

Figure 17.1 below illustrates how the different price components of the option stack up against each other. As is evident from the illustration, the cost involvement for construction of the tunnel far outweighs the rest of the components. This is further presented in Figure 17.2 which shows a major 73.7% of the option budget needs to be allocated for the tunnel.

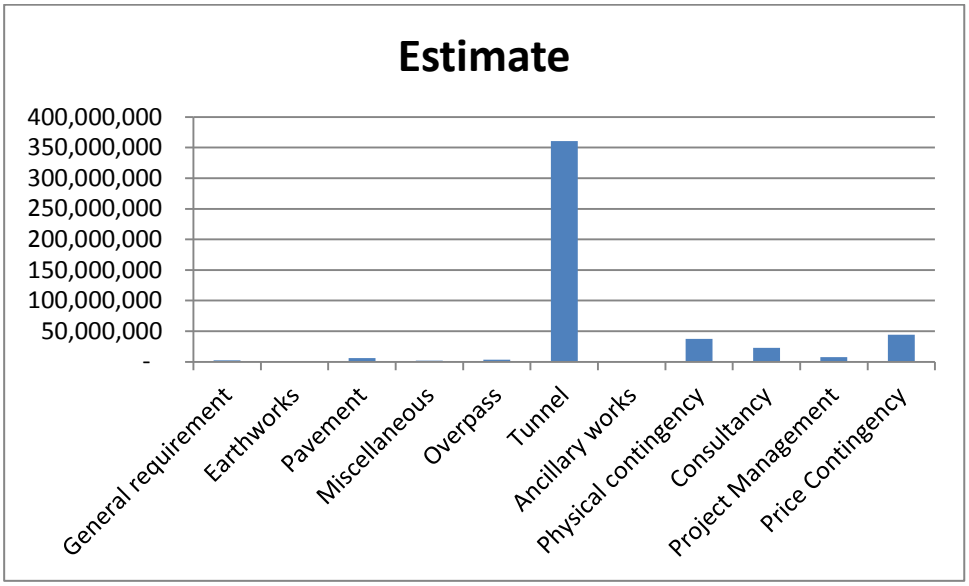


Figure 17.1: Comparison of cost by components (figures are in USD)

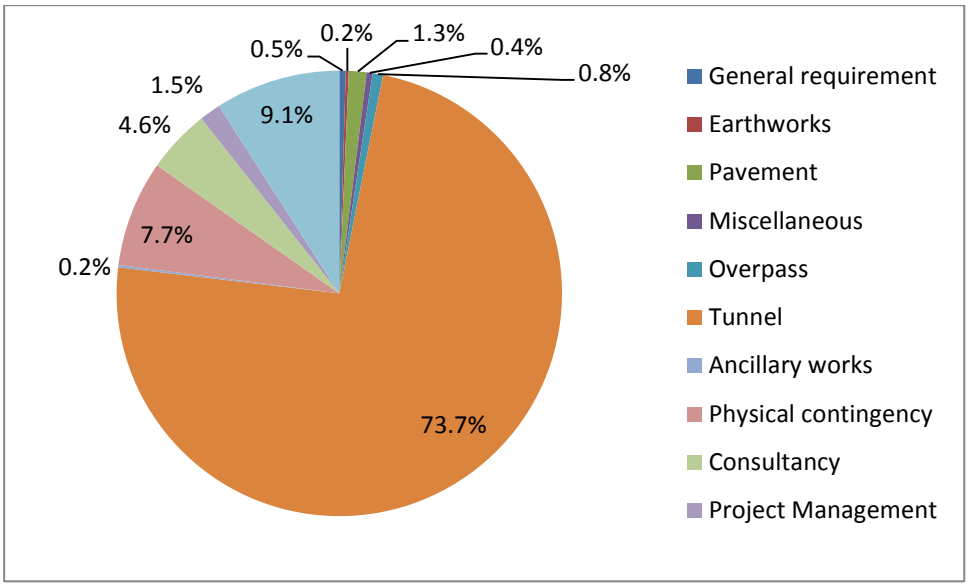


Figure 17.2: Relative share of cost by components

The illustrations above are further analysed in Figure 17.3 and 17.4 below for tunnel vs. rest of the infrastructure in the preferred option. For this purpose the expenses related to project management, consultancy etc. have been distributed between the two components relative to their weight.

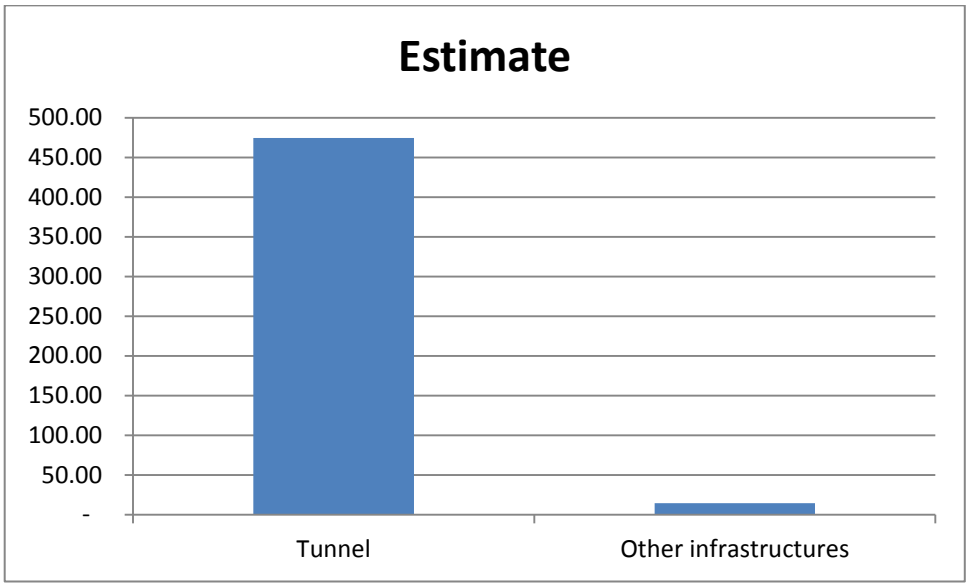


Figure 17.3: Cost comparison for tunnel and other infrastructure (figures in million USD)

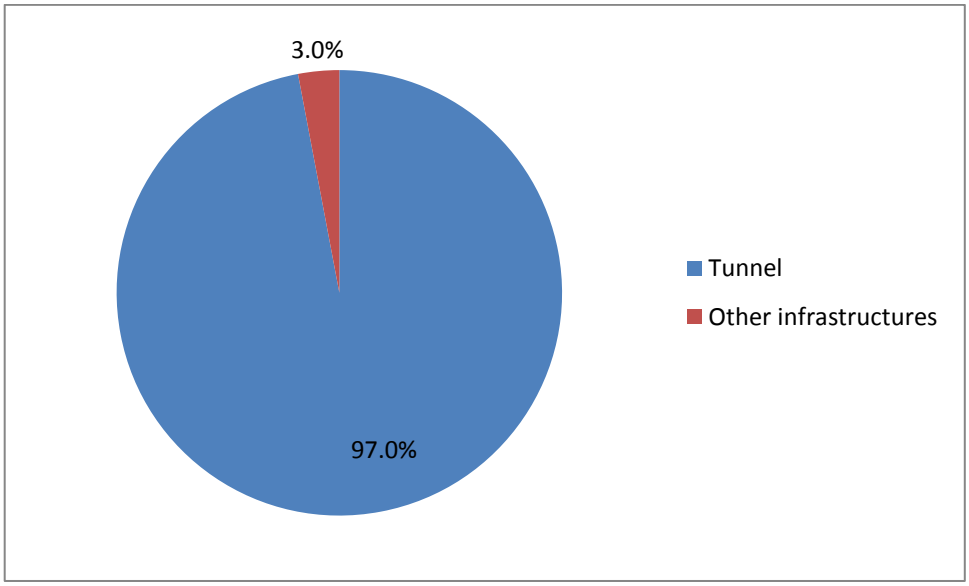


Figure 17.4: Relative share of cost (tunnel and other infrastructure)

As can be seen from the figures above, when costs are attributed between the tunnel and other infrastructures, the tunnel contributes to 97% of the project cost. This also signifies that any cost reduction in tunnel construction will have a significant positive impact on the Project budget as a whole. There is thus an incentive to minimize the cost of this component. The Client should therefore consider other options; including cut and cover method if a meaningful discussion can happen with Bangladesh Air Force (BAF).

Further, the cost of tunnel is analysed in the figures 17.5 and 17.6 below. Within the tunnel system, the cost of civil works constitutes a major share while the remaining components are at similar levels. The civil works component of the tunnel requires a good 250 million dollars which is 70% of the cost of the tunnel.

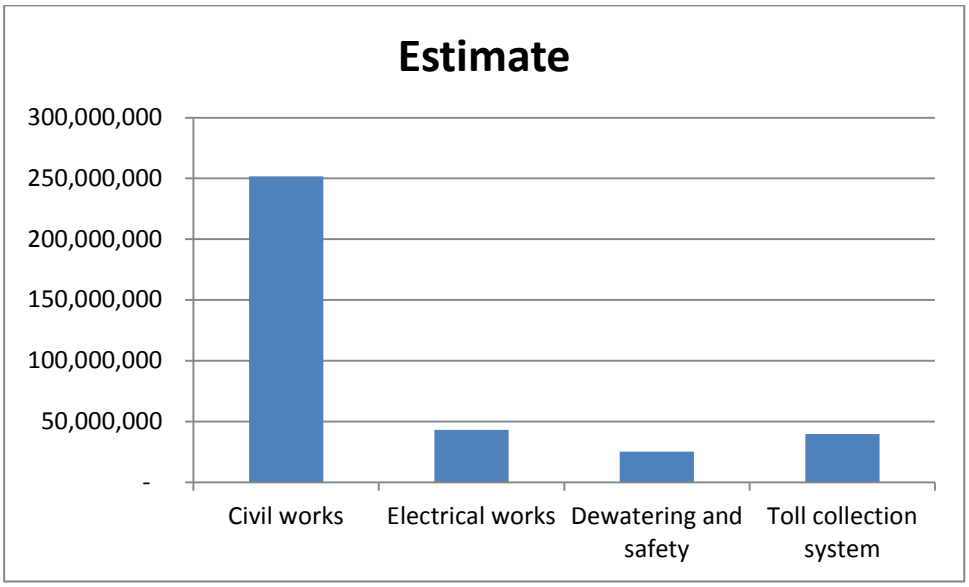


Figure 17.5: Cost comparison for tunnel components (figures in USD)

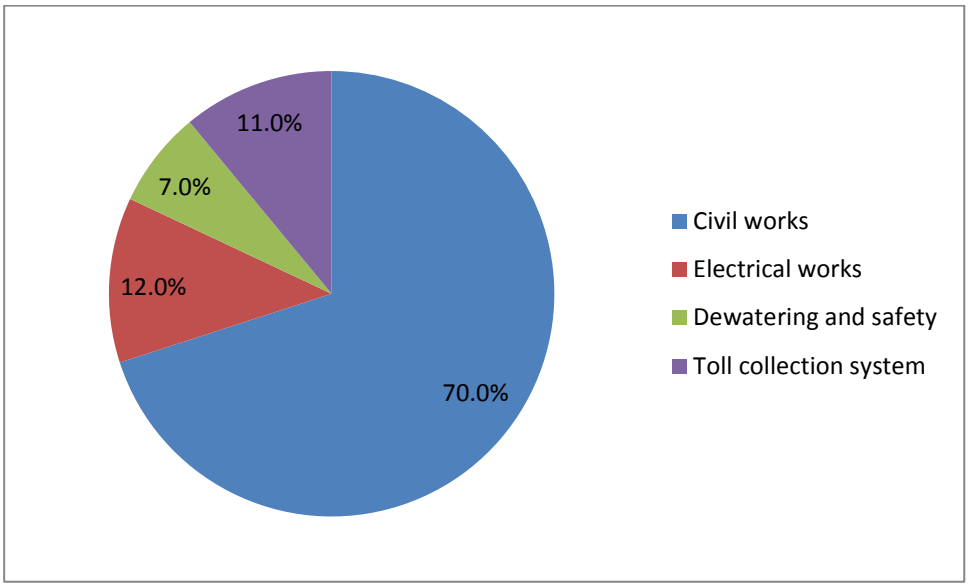


Figure 17.4: Relative share of tunnel components

18 STAGING AND INVESTMENT PROGRAMME

18.1 Staging Program

The preferred option will require a multiyear Construction Program. Remaining phases starting immediately, the Tunnel can commence operation in 2020, i.e. in 7 years. Figure 18.1 below illustrates the staging Program until the operation begins.

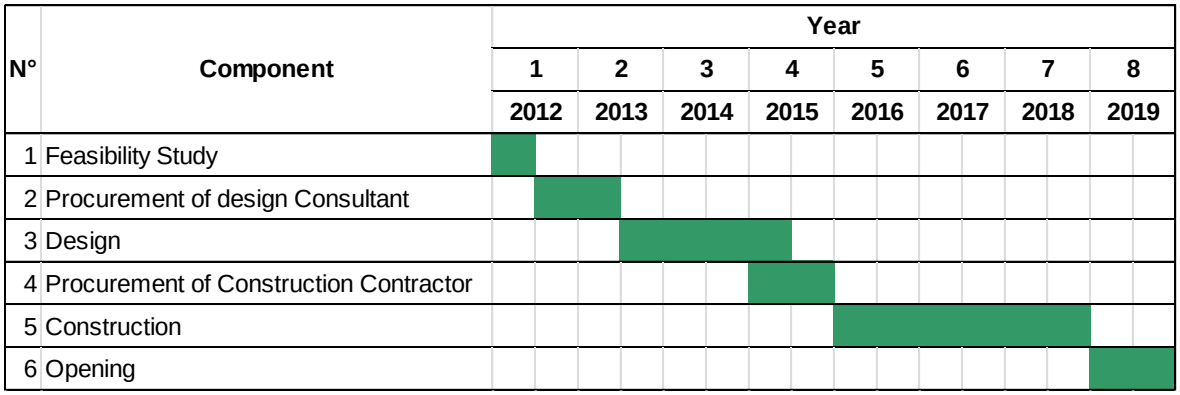


Figure 18.1: Staging Program for preferred option

In order for the program to be efficient, it has been suggested that overlapping of phases be considered. In this particular staging, it is evident that there can be an overlap between design and procurement phases. This will require that procurement phase starts when the design is substantially complete, as opposed to full completion.

It is to be noted that the design activities in this option will take substantially more time than many other Projects for this will be a complex job altogether. Not only will there be several interconnected yet independent components to design for the tunnel, each of the components will also require that the design takes full consideration of all the aspects of the complicated task.

18.2 Investment Program

The estimate for the preferred option, as identified in the preceding chapter will span over different phases. Table 18.1 below illustrates the investment required by phases of the option.

Table 18.1: Investment required by phases

Sl.No.	Phase	Year	Investment (BDT)	Investment (equivalent USD)
1	Feasibility study	Y1		
2	Procurement of Designer	Y1-Y2	40,108,563	$489,129
3	Design year 1	Y2-Y3	601,628,438	$7,336,932
4	Design year 2	Y3-Y4	401,085,626	$489,1288
5	Procurement of Constructor	Y4	80,217,125	$978,258
6	Construction year 1	Y5	10,829,311,890	$132,064,779

Sl.No.	Phase	Year	Investment (BDT)	Investment (equivalent USD)
7	Construction year 2	Y6	16,043,425,022	$195,651,525
8	Construction year 3	Y7	12,032,568,766	$146,738,643
9	Opening	Y8	80,217,125	$978,258
10	O&M year 1	Y9	-	-
11	O&M subsequent years	Y10 onwards	164,000,000/year	$2,000,000/year

18.3 Investment Curve

This section presents the investment program in an S-curve. In order to identify the investment curve, an order of moving average has been applied to cater the uncertainties and unforseen events that the Project may encounter. Figure 18.2 illustrates the curve.

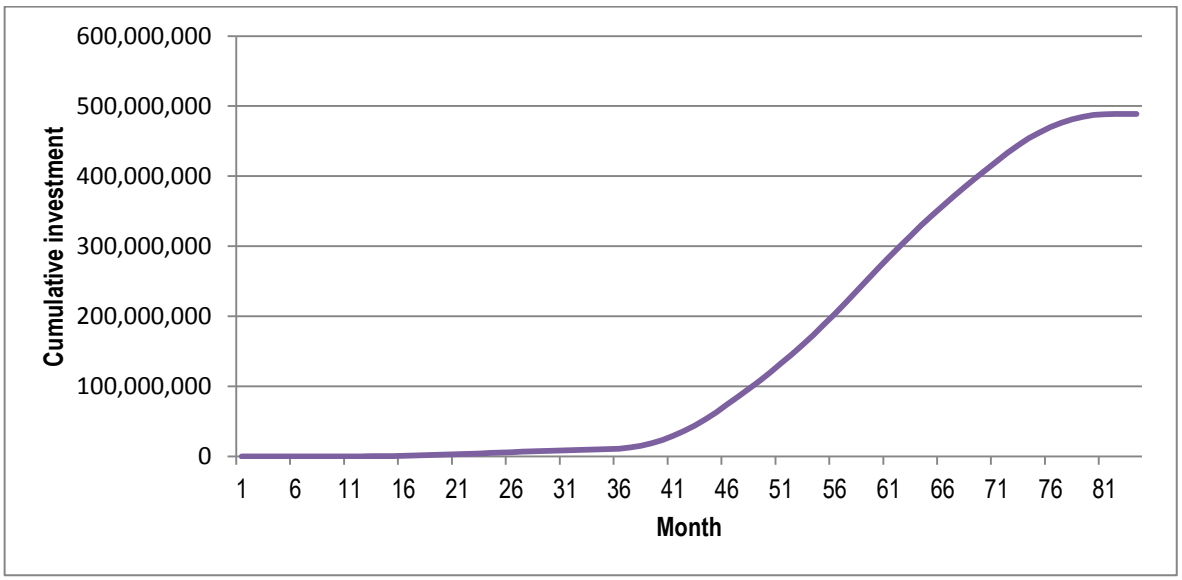


Figure 18.2: Staging Program for preferred option

It is to be noted that the curve is very steep between month 41 and 76 which is when the construction will take place. This underscores that the capital cost required in this project far outweighs the other phases.

19 ECONOMIC AND FINANCIAL EVALUATION

19.1 Introduction

Traffic travelling between the eastern and western sides of the airport will benefit from the tunnel. Other traffic will also benefit because tunnel users will no longer add to the congestion on other roads.

The tunnel's effect on travel patterns was assessed using a transport planning model of the road network near the airport. The model calibrated well, closely replicating the observed 2011 traffic pattern. Inserting the tunnel into the modelled network therefore gave a reliable guide to the effect of the tunnel on traffic patterns in 2011.

Since it is proposed to charge tolls, they are included in the model. Toll *collection* consumes resources and is therefore an economic cost. The tolls themselves are not an economic cost since they merely transfer money from one pocket (the road user's) to another pocket (the tunnel operator's). Nevertheless, tolls diminish economic benefits by suppressing use of the tunnel.

When 2030 traffic demand was modelled, extreme congestion on roads leading to the tunnel restricted tunnel use. This is because the modelled network does not cover the entire city and therefore does not include network improvements such as the elevated expressway. For this reason it was decided to base this analysis on savings in 2011 and escalate them to future years by the expected traffic growth rate.

19.2 Forecast Traffic

The transport planning model generates vehicle-kilometres of travel (VKT) and vehicle-hours of travel (VHT) for the morning and evening peak hours. Comparing the with- and without-tunnel cases, the changes in VKT and VHT measure the time and distance savings by vehicles using the tunnel plus the time savings to other traffic due to a slight reduction in congestion on existing roads. The following table shows the results.

Table 19.1: Network vehicle-kilometres and vehicle-hours, with- and without-tunnel, 2011

	AM Peak Hour				PM Peak Hour			
	Light Vehicle		Heavy Vehicle		Light Vehicle		Heavy Vehicle	
	VKT	VHT	VKT	VHT	VKT	VHT	VKT	VHT
No tunnel	37856	1220	12336	413	37785	1146	13075	409
Tunnel- no toll	37445	1137	12095	374	37043	1095	12791	396
Tunnel- Tk10 toll	37566	1225	12105	404	37582	1113	12912	395

Source: The Consultant's traffic model.

The base rate Taka 10 toll is paid by light vehicles. Buses pay double and trucks pay four-times the base rate. The numbers of vehicles using the tunnel in the peak hours are as follows.

Table 19.2: Numbers of vehicles using the tunnel if it existed in 2011

	AM Peak Hour				PM Peak Hour			
	Light Vehicle		Heavy Vehicle		Light Vehicle		Heavy Vehicle	
	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
Tunnel- no toll	623	270	86	35	420	362	92	67
Tunnel- Tk10 toll	546	119	86	23	219	166	59	52

Source: The Consultant's traffic model.

Revenue is Tk8110/hour (AM and PM average) or US$105 at Tk77 per US$ (Dec 2011).

Dhaka traffic volumes by hour of day are shown below. Daily revenue is taken to be 16-fold average peak hour revenue on the reasoning that about 14 hours are at peak traffic levels and 10 hours are at 20% of peak levels. Accordingly, a Tk10 base rate for tolls the annual revenue would be US$615,000 in 2011.

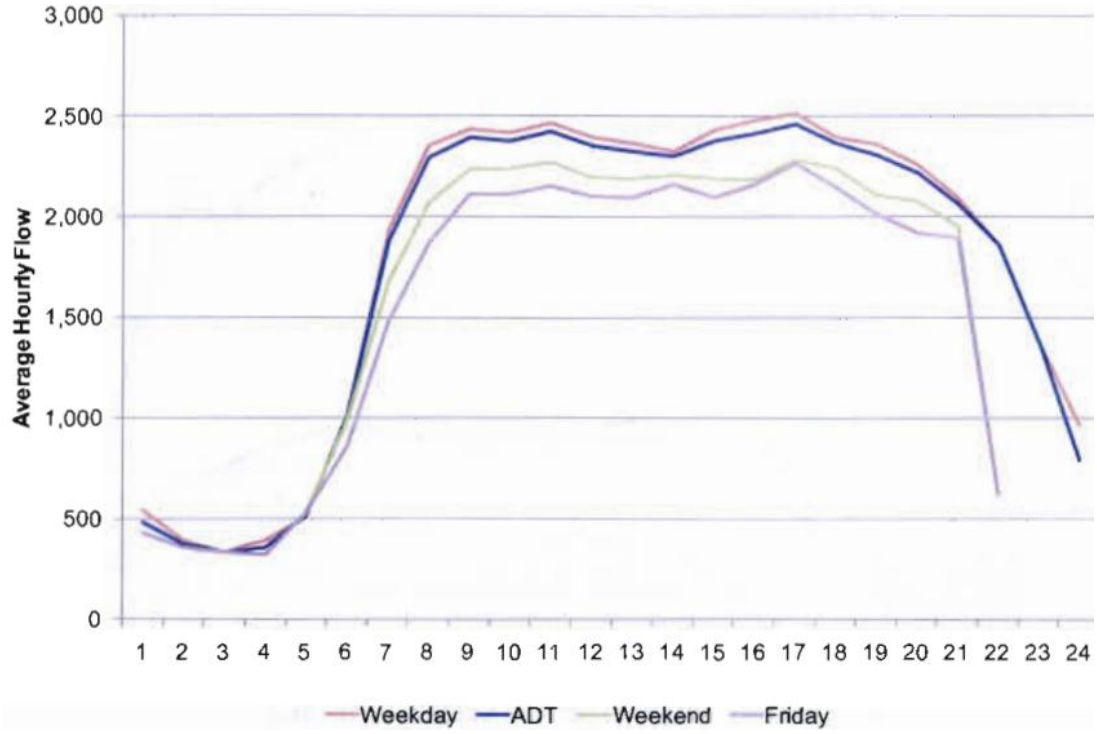


Figure 19.1: Profile of traffic flow by hour of day

Source: Dhaka Elevated Expressway: Preliminary Traffic Report, AECOM, 8 August 2010

19.3 Vehicle Operating Costs and Value of Time

Cost measurement depends on whose viewpoint is adopted. From the viewpoint of a person buying a vehicle, its cost is its price tag in the showroom. From the nation's point of view, the cost is the CIF cost of landing the vehicle in Bangladesh.[2] The difference

[2] Strictly, the distribution cost within the country should be added as well.

between the CIF and retail prices is due to taxes. These taxes are 'transfers' which merely redistribute money within Bangladesh and do not represent consumption of resources.

Thus the retail price of the car is its 'financial cost'. The 'economic cost' is found by subtracting taxes from the retail price as those taxes are merely transferred to the government.

Table 19.3 presents the components of vehicle operating costs (VOCs) in financial and economic terms. They are used to calculate VOCs in terms of Taka per vehicle-kilometre. Calculation of VOCs was achieved using a spreadsheet version of the vehicle operating cost module embedded in HDM-4 (which is a computer model used to optimise road maintenance expenditure).

The starting point for Table 19.3 was a recent report entitled Road User Cost Study for LGED Roads, August 2009. To update the input values needed to generate VOCs, two one-day surveys of bus and truck operators were undertaken in Dhaka. Also, information was collected from PetroBangla to derive the economic price of fuel.

Table 19.3: Components of Vehicle Operating Costs in 2011 values

		Truck- articulated		Truck- medium		Truck- small		Bus- heavy		Minibus		Car		Motorcycle	
		Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic
Purchase cost	Tk 000	4980	3704	2,914	2,167	1,983	1,462	5,768	4,897	3,007	2,158	2,846	1,819	100	90
Cost of new tyre	Tk	26232	17398	26,232	17,398	8,541	7,091	17,890	15,342	7,797	6,911	4,131	3,433	533	480
Maintenance labour cost	Tk/h	100	100	75	75	75	75	75	75	75	75	75	75	50	50
Annual overhead cost	Tk 000	272	150	272	150	126	81	587	382	221	190	165	116	22	20
Crew Wages	Tk/h	130	130	100	100	80	80	130	130	110	110	40	40	20	20
Fuel cost- diesel*	Tk/litre	56	62	56	62	56	62	56	62	56	62	56	62	56	62
Fuel cost- petrol*	Tk/litre	86	62	86	62	86	62	86	62	86	62	86	62	86	62
Fuel cost- CNG**															
Lubricant cost*	Tk/litre	437	393	437	393	437	393	437	393	437	393	437	393	437	393
Annual km	km	150000		72630		66600		116820		60030		45000		13000	
Annual hours	h	3750		2790		3240		3105		2754		2565		1490	
Average service life	Years	11.0		11.0		8.0		12.0		12.0		11.0		8.0	
Manufacturer's GVW	kg	40500		14094		4680		11250		8100				0	
Tare weight	kg	1200		3614		2475		3731		2970				86	
Axles	#	5		2		2		2		2				2	
Length	mm	22000		6273		5423		9005		5373				1710	
Width	mm	2191		2191		1692		2187		1943				671	
Height	mm	3263		3263		1998		1796		1710				918	

Source: Adapted by the Consultants from Road User Cost Study for LGED Roads, Final Report, GTZ, GITEC Consult GMBH, August 2009.

VOCs (in $/km) were calculated from the costs in the above table by using VOC model in HDM-4. The results are shown in the next table. The value for heavy vehicles is a weighted average of 70% buses and 30% trucks.

Table 19.4: Values operating costs per vehicle-kilometre, 2011

	Taka/km	US$/km
Light vehicle	25.6	0.333
Bus	22.5	0.292
Truck	27.8	0.361
Heavy vehicle	24.1	0.313

Source: Calculated from Table using the HDM4 VOC model

Time values used in the transport planning model were drawn from Dhaka Elevated Expressway: Preliminary Traffic Report, AECOM, 8 August 2010 and updated to December 2012. The results are shown in Table 19.5. As above, the value for heavy vehicles is a weighted average of 70% buses and 30% trucks.

Table 19.5: Values travel time per vehicle-hour, 2011

	Taka/h	US$/h
Light vehicle	174	2.26
Bus	666	8.65
Truck	128	1.67
Heavy vehicle	505	6.55

Source: Based on Dhaka Elevated Expressway: Preliminary Traffic Report, AECOM, 8 August 2010

19.4 Economic Evaluation

Economic VOCs were derived from financial costs by removing taxes and subsidies. Since this is too large a task to apply to all goods and services individually, the economic cost is calculated by reducing the financial cost (ie, the cost in the market place) by 10% to allow for taxes. In technical terms, the financial cost is multiplied by the standard conversion factor (SCF) which in this case is 0.9. The SCF is applied to project capital cost and cost of operations and maintenance (O&M).

The capital cost is estimated to be US$489.1 million. An allowance of US$2 million is made for annual O&M. This covers tunnel maintenance, including pavement maintenance, ventilation, tunnel surveillance, and electronic toll collection and follow up for vehicles that do not pay. These figures are multiplied by the SCF of 0.9. The residual value of the investment in year 20 is taken to be three-quarters of the initial cost. This is high, but is considered to be realistic given the tunnel's expected long life.

The unit costs ($/km and $/h) are applied to the savings in vehicle-kilometres and vehicle-hours derived from Table 19.1 for the cases 'no toll' and 'Tk10 toll'. The results are presented in Table 19.6 and Table 19.7.

The project is not economically viable. The usual criterion rate is 12%pa the economic internal rate of return (EIRR). The EIRR is negative: -0.5%pa if there is no toll and -1.2%pa if there is a base rate toll of Tk10 for light vehicles (and Tk20 for buses and Tk40 for trucks). The results are worse when a toll is charged because tolls suppress traffic demand for the tunnel and hence reduce the benefits derived from the tunnel.

Table 19.6: Economic evaluation: no toll

US$ million 2011

Year	Capital cost	O&M cost	Road user benefits	Net benefit
0	-440.2			-440.2
1		-1.8	4.1	2.3
2		-1.8	4.2	2.4
3		-1.8	4.3	2.5
4		-1.8	4.4	2.6
5		-1.8	4.6	2.8
6		-1.8	4.7	2.9
7		-1.8	4.9	3.1
8		-1.8	5.0	3.2
9		-1.8	5.2	3.4
10		-1.8	5.3	3.5
11		-1.8	5.5	3.7
12		-1.8	5.7	3.9
13		-1.8	5.8	4.0
14		-1.8	6.0	4.2
15		-1.8	6.2	4.4
16		-1.8	6.4	4.6
17		-1.8	6.6	4.8
18		-1.8	6.8	5.0
19		-1.8	7.0	5.2
20	330.1	-1.8	7.2	335.6
			NPV @ 12%pa $M	-382.5
			EIRR, %pa	-0.5%

Table 19.7: Economic evaluation: Tk10 base toll

US$ million 2011

Year	Capital cost	O&M cost	Road user benefits	Net revenue
0	-440.2			-440.2
1		-1.8	1.9	0.1
2		-1.8	1.9	0.1
3		-1.8	2.0	0.2
4		-1.8	2.0	0.2
5		-1.8	2.1	0.3
6		-1.8	2.2	0.4
7		-1.8	2.2	0.4
8		-1.8	2.3	0.5
9		-1.8	2.4	0.6
10		-1.8	2.4	0.6
11		-1.8	2.5	0.7
12		-1.8	2.6	0.8
13		-1.8	2.7	0.9
14		-1.8	2.8	1.0
15		-1.8	2.8	1.0
16		-1.8	2.9	1.1
17		-1.8	3.0	1.2
18		-1.8	3.1	1.3
19		-1.8	3.2	1.4
20	330.1	-1.8	3.3	331.7
			NPV @ 12%pa $M	-402.5
			EIRR, %pa	-1.2%

The following graph shows the capital cost that would be needed to achieve a given EIRR. In the 'no toll' case, to reach a zero return would require the cost to be $300 million, not $489 million.

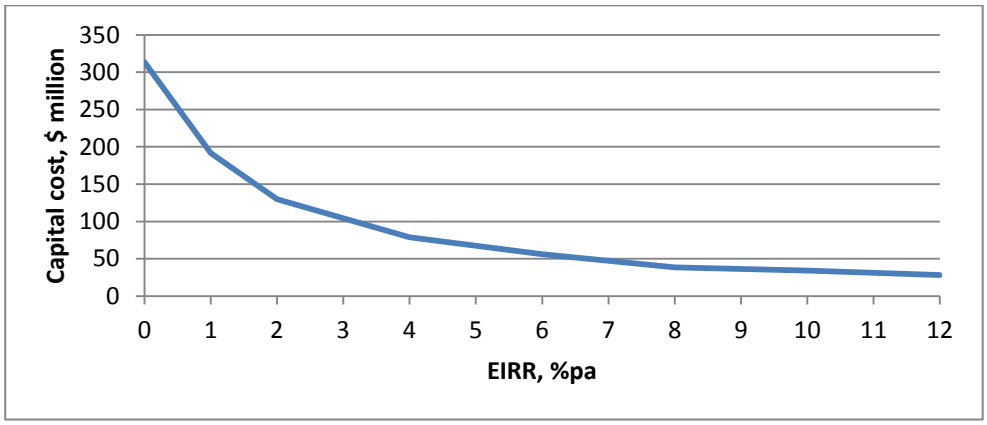


Figure 19.2: Relationship between capital cost and EIRR

Doubling benefits raises the EIRR to 0.9%pa. Multiplying by 10, the EIRR reaches 10%pa.

19.5 Financial Analysis

The financial analysis follows the same process as the economic analysis but uses financial costs rather than economic costs. The benefits are the toll revenues. For there to be any financial analysis there must be revenue. So the toll cannot be zero.

For a base rate toll of Tk10 the financial internal rate of return (FIRR) is negative, *viz*. -0.7%pa.

Table 19.8: Financial analysis: Tk10 base toll

US$ million 2011

Year	Capital cost	O&M cost	Toll revenues	Net benefit
0	-489.1			-489.1
1		2.0	0.7	2.7
2		2.0	0.7	2.7
3		2.0	0.8	2.8
4		2.0	0.8	2.8
5		2.0	0.8	2.8
6		2.0	0.8	2.8
7		2.0	0.9	2.9
8		2.0	0.9	2.9
9		2.0	0.9	2.9
10		2.0	0.9	2.9
11		2.0	1.0	3.0
12		2.0	1.0	3.0
13		2.0	1.0	3.0
14		2.0	1.1	3.1
15		2.0	1.1	3.1
16		2.0	1.1	3.1
17		2.0	1.2	3.2
18		2.0	1.2	3.2
19		2.0	1.2	3.2
20	366.8	2.0	1.3	370.1
			NPV @ 12%pa $M	-429.6

FIRR, %pa	-0.7%

If the base rate toll is Tk50 the FIRR remains negative, at -0.3%pa.

19.6 Conclusion

The tunnel is very costly. The amount of traffic that would use the tunnel is nowhere near enough to justify its construction. The economic return on investment is negative. Charging a toll makes it more negative because tolls suppress demand. There is no conceivable combination of cost reduction and benefit enhancement that would make the tunnel worthwhile.

The conclusion is that construction of the 'link road' around the end of the airport was the correct project. If further congestion relief is needed, a flyover from the eastern side of Airport Road to the link road might show positive benefits. Even if it does, it is unlikely to be the *best* option. The best option seems to be localised widening of Airport Road at its junction with the link road so that separate lanes can be provided for traffic turning right, from Airport Road to the link road.

20 FINAL RECOMMENDATIONS

To build a project based on the traffic model data to meet the economic criterion of 12%pa the cost must be no more than 295.8 crore BDT ($36.1M USD) with 8.2 crore BDT ($1M USD) operation and maintenance costs per year. These figures assume the connection is free; by charging a toll you suppress demand and thus suppress benefits. As long as work inside the Air Force base is prohibited there is no viable tunnel project that can be undertaken within these funds. As can be seen from the table below Option 2 & 3 are viable excluding land cost.

Table 20.1: Airport Connection Options

Road Alignment	Description	Capital (BDT) Crore	USD $M	O&M Cost (BDT) crore/y	USD $M/y	EIRR no toll	FIRR Tk50 Toll
Option 1	Do Nothing (Base Case)	0	0	0	0	-	-
Option 2	Surface road connection	123	15.4	2.5	0.31	26.9%	25.9%
Option 3	Cut & Cover underpass of runway	295	36.9	4.1	0.51	12.8%	11.0%
Option 4	Twin Tunnel 900m length steep ramps grades 7%	3156	394.5	15.0	1.88	-0.2%	-0.5%
Option 5	Twin Tunnel 1300m length ramps 4% grades	4011	501.4	16.4	2.05	-0.5%	-0.7%
Option 6	Underpass and Flyover	408	50.9	5.2	0.65	4.7%	7.6%
Option 7	2 Underpasses	304	38.0	5.2	0.65	6.6%	10.3%

* No land acquisition cost is included.

The Air Force base is very valuable land; selling it would finance developing a new air base outside of the city or relinquishing the land to the Government would allow development of a brand new world-class city centre, a sparkling new financial centre with wide boulevards and nice buildings and parks. While the base remains a restricted area there is no feasible tunnel that could ease the growing traffic congestion of the city.

Two alternate projects were looked at based on the traffic model data. This was to see if there was a more cost effective solution to the traffic congestion other than the airport link. These projects were:

1) Connection between Mohakhali Flyover and the link road (south of the airport): This serves a similar functionality as the proposed tunnel under the runway although this one is less direct and still utilises the link road. This would have to be grade separated at the intersections with New Airport Road and Kazi Narul Islam so it would still be relatively expensive (although not as expensive as the tunnel). It would alleviate congestion at the intersection between Kazi Narul Islam Avenue and New Airport Road because traffic going to/coming from the link road would be diverted to the proposed connection, but only this congestion point would be bypassed and it is doubtful that is enough to make it economically feasible. This could be investigated further in a future project.

2) Grade separation at the Kazi Narul Islam Avenue – Bijoy Sarani intersection: The AM peak model shows heavy congestion in the north-south direction and a flyover would help alleviate congestion at THIS intersection. However, there are also congested intersections north and south of this junction that would considerably reduce the benefits of the grade separation. In the PM peak model, congestion at this intersection is happening on all approaches – i.e. including the east-west direction. Similar to the comment on the AM peak, the proximity of other congested intersections could potentially undermine the benefits derived from the junction upgrade.

From the AM and PM peak models (and also from filed observations), the following intersections (which are mostly the major intersections in the study area) appear to be performing the worst:

- The junction below Mohakhali Flyover
- Kazi Narul Islam Avenue – New Airport Road Intersection
- Kazi Narul Islam Avenue – Bijoy Sarani Intersection
- Begum Rokeya Avenue – Bijoy Sarani Intersection
- Begum Rokeya Avenue – Manik Mian Avenue Intersection (Roundabout)
- Mirpur Road – Lake Road Intersection
- Mirpur Road – Manik Mian Avenue

It is really difficult to suggest 'low cost improvements' given that the problems are network-wide. As per the comment above, any improvement/upgrade done at any given problem point in the network may solve or reduce the problems at that point, but the problem would simply be transferred somewhere else. There should be a more comprehensive, strategic network-wide approach to finding solutions to the congestion problem in Dhaka. Suggestions of improvements at specific intersections or congestion points can be made, but the impacts on other parts of the network need to be considered, otherwise it would simply be a 'Band-Aid approach' and will probably not be helpful in the long run to address the systemic problems. A comprehensive investigation should not only focus on how to increase network capacity (likely not low-cost) but also how to manage traffic demand through other measures, such as providing better public transport, implementing travel demand management measures, etc.

The final recommendation of this report is to undertake such a comprehensive, strategic network-wide investigation. This would extend the existing traffic model for the tunnel project and the elevated highway project to include all the current and future works. A series of projects can then be developed and prioritized based on cost effectiveness. This would require interagency cooperation to achieve a successful outcome.