GOVERNMENT OF THE PEOPLES' REPUBLIC OF BANGLADESH

Ministry of Communications, Bridges Division

Bangladesh Bridge Authority (BBA)

Pre-Feasibility Study of Dhaka-Ashulia Elevated Expressway (DAEEP) PPP Project

Department of Civil Engineering

BUREAU OF RESEARCH, TESTING AND CONSULTATION (BRTC)

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Executive summary

In order to minimize the traffic congestion in and around Dhaka-Ashulia area as well as to improve road connectivity of the northern part of Dhaka linking important commercial, industrial and business centers of the Dhaka city, Bangladesh Bridge Authority (BBA) has undertaken to construct approximately 34 km (excluding ramps) of Elevated Expressway in northern part of Dhaka City on a Public Private Partnership (PPP) basis. Tentative route alignment of the Dhaka Ashulia Elevated Expressway Project (DAEEP) is Hazrat Shahjalal International Airport Abdullahpur-Ashulia-EPZ-Chandra connecting Savar Martyrs Monument. The DAEEP project would be an extension of ongoing Dhaka Elevated Expressway Project (DEEP).

Alternative Alignments

Tentative route alignment of the Dhaka Ashulia Elevated Expressway Project (DAEEP) is Hazrat Shahjalal International Airport Abdullahpur-Ashulia-EPZ-Chandra connecting Savar Martyrs Monument. This alignment forms a T- shape. An alternative alignment to connect existing DEE with Chandra may be achieved by a linear configuration connecting Abdullahpur-Ashulia-Savar BPATC-Nabinagar-Baipayl-Zirani. Basically, both routes start at the termini of the proposed Dhaka Elevated Expressway (DEE), close to the entrance of Hazrat Shahjalal International Airport (on the opposite of the Airport Road) and follow the same alignment along the railway tract through Uttara Sectors 4, 6 and 8 (to the east of the Airport Road) up to Arichpur Road level crossing. Both routes then turn west toward Abdullahpur intersection, following the same alignment, and then follow the Ashulia Road (up to 4.8 km from the starting point). From this point, the two alternatives follow separate alignments. Alternative 1 follows the Ashulia Road up to Baipayl (about 21 km from the starting point); from Baipayl it stretches up to Chandra to the north and Nabinagar to the south.

On the other hand, Alternative 2 turns south toward Sonargaon Janapath, and then follows the Sonargaon Janapath (running between Sectors 11 and 13 of Uttara). It then goes through Uttara 3rd Phase, crosses the Beri Bandh Road, Turag River-Tongi Khal and meets the Ashulia-Savar Road (about 14 km from the starting point). It then follows the Ashulia-Savar Road and meets Dhaka-Aricha Highway close to Jahangirnagar University and then follows Dhaka-Aricha Highway up to Nabinagar (Savar). From Nabinagar (Savar) to Chandra, Alternative 1 and Alternative 2 follow the same alignment. The total length of alignments along Alternative 1 and Alternative 2 are about 36 km and 42 km, respectively.

Alternative 2 is considered as a potential candidate, since it will connect Savar which a rapidly growing Upazila with huge population, economic activities and most importantly with its enormous economic growth potential. The Upazila is being urbanzied fast owing to expansion of manufacturing and real estate development by commercial, housing companies, development of residential accommodation and promotion retail activities. There are some public sector housings in the planning area that include, Cantonment residential colonies, Radio Colony, Jahangirnagar University Staff Housing, PATC Staff Housing, Agrani Bank Residential Area, etc. However, there are also large numbers of private commercial and cooperative housing estates in the planning area that are yet to be developed.

Traffic Survey

We had to conduct our very own traffic survey in order to verify the authenticity of the collected data and to adjust the past O-D matrices in accordance with the present traffic scenario. As the landuse pattern and traffic usage characteristics of the studied region are very dynamic in nature, a rigorous study of traffic was warranted to get a reliable forecast. Accordingly, a survey program was developed and three different types of surveys were undertaken:

- Road Traffic Counts
  - Manual classified traffic volume count at major sections
  - Video recording to verify and authenticate manual counts
- Journey Time Survey
- Pilot Origin Destination Survey to get potential sources and pools

Traffic Modeling

A four-step transport demand model was developed to forecast the future traffic at different scenarios and to calculate expected revenues. This model inputs are based on available statistics, information from previous traffic studies conducted for other previous projects and several traffic surveys. The main part of the transport modeling is performed using a commercially available professional transport modeling software suite e.g. Cube Voyager.

Traffic Forecasts

Traffic forecast for the model is predicted on daily transactions basis. Results have been provided for both the alignment alternatives. The alignment 1 option has been further explored with variation in at-grade roadway capacity, GDP growth rates and toll amounts.

Travel Time Forecasts

In order to find out the benefit of travel time savings for the DEEAP, travel time forecasts are made. This forecast is made for each of the modeled year, for each of the time slots (peak, off-peak, super-off-peak) and for each of the following scenarios.

- A => No Change Scenario/ Business-As-Usual (Scenario 1)
- B => Expressway in Alternative Alignment- 1 (Scenario 2)
- C => Existing At-Grade Road in Alternative Alignment-1 (Scenario 2)
- D => Existing At-Grade Road with Widening (Scenario 3)
- E => F Expressway in Alternative Alignment- 1+ At-Grade Road Widening (Scenario 4)
- F => Existing At-Grade Road in Alternative Alignment- 1+ At-Grade Road Widening (Scenario 4)
- G => Existing At-Grade Road in Alternative Alignment-2 (Scenario 5)
- H => Expressway in Alternative Alignment- 2 (Scenario 5)

Costs of the Project

Alternative-1

Total capital costs for I-girder system is around Tk. 8,364 crores, whereas for Box-girder system the total capital cost is around Tk. 9,312 crores. Per kilometer costs in million USD are appeared to be 27 and 30 respectively for I and Box-girder. The total project costs which also includes Government equity are estimated at Tk.13,654 crores and Tk. 14,940 crores for I and Box girder. The Public and Private share is found to be 38:62.

Alternative-2

Total capital costs for I-girder system is around Tk. 9073 crores and for Box-girder system the total capital cost is around Tk. 10,125 crores. Per kilometer costs in million USD are appeared to be 27 and 30 respectively for I and Box-girder. The total project costs which also includes Government equity are estimated at Tk.16,250 crores and Tk. 17,675 crores for I and Box girder. The Public and Private share is found to be 43:57. As compared to Alignment-1, public share with Alignment-2 is relatively higher mainly due to land acquisition issues.

Benefit-cost Analysis

Alternative Scenarios

For benefit-cost analysis, in the pre-feasibility stage five possible alternatives are considered. These are:

1. Scenario 1 – No Change
2. Scenario 2 – Alternative 1: elevated expressway along existing route
3. Scenario 3 – Widening of existing route
4. Scenario 4 – Alternative 1 + Widening
5. Scenario 5 – Alternative 2: elevated expressway along existing route via Savar

Toll Strategy

Only Flag fall modified toll strategy was considered, where full toll is applicable for end-end trips and half toll rate for trips from intermediate points. The base toll is increased every year reflecting the increase in GDP, but not directly linked with GDP for sensitivity analysis cases. In addition, the base toll rate has been increased over the years to reflect the growth in GDP, and increased travel time benefits. However, toll growth rate is not directly linked to GDP growth rates or travel time savings. Alternate toll strategy must be explored in detail during the feasibility stage.

Economic Benefits

Economic analysis is made for predicting the economic benefit cost for the four possible scenarios. The economic NPV analysis shows that the elevated expressway along Alignment-2 is the most viable option, although it is difficult for practical reasons (e.g. land acquisition and associated delay, discontent and adverse ecological impact). The Alignment-2 has the potential to attract more freight traffic than that of Alternative Alignment-1 as it would connect Savar. The next best alternative is the elevated expressway for Alignment-1, along the existing Ashulia-Baipayl road. The project offers large economic benefits if procured under the government, resulting from large travel time savings. One *key* concern about the project is the integration with DEE and resulting allowance of freight trucks to travel through the expressway during the day. Since freight travel benefits are the major benefit of the project, if day travel is not allowed or DEE is not connected to Dhaka-Chittagong highway directly, then a large share of the benefits will not be realized. It is anticipated that the DEE alignment may undergo further change and may not connect Dhaka-Chittagong highway directly. In such circumstance, the project will not be viable from a social and economic perspective. It is therefore important that such integration is considered not only for DAEEP but also for DEE. This economic analysis during the pre-feasibility study reveals that the project could be feasible and requires a detailed feasibility study. However, present economic analysis shows that EIRR is appeared to be nearly 10 to 12%.

Financial Viability

Considering the fact that due to suburban nature of the project, most of the expressway users are long hauled and through, which definitely implies that the expressway capacity in terms of transactions is comparatively low particularly as compared to the Dhaka Elevated Expressway Project (DEEP) which covers mostly the urban area with high per km density of entry-exit facilities. Moreover, due to suburban nature of the project it is most likely that during lean period particularly at late night, the freight traffic would not use the facility due to availability of at grade free road. As such, the financial benefits of the project to the concessionaire will most likely be smaller than the wider economic benefits of the project.

Given the fact that the project's net present financial value is negative (without VGF), FIRR is appeared to be only 2 to 3%. This essentially suggests that the DAEEP is not financially feasible on its own, unless it receives support from the government in the form of VGF. In this regard, the Viability Gap Fund (VGP) from the Government, reserved for PPP projects can be useful to the concessionaire for the project to become financially profitable, even while keeping the toll structure affordable to the users. In this regard, in line with Dhaka Elevated Expressway project, it is considered that VGF should not be more that thirty percent (30%) of the estimated project cost. The actual amount will be determined by the investor of the winning bidder. The amount of VGF required varies with various alternate scenarios. However, a significantly higher toll structure than what are tested here can bring down the VGF amount. A more detailed analysis during the feasibility study will be required before a final decision. Beside, investors' financial model needed to be undertaken by them, as cost estimation process for large capital intensive infrastructure projects are complex, as inherently it relies on many assumptions and projections which may differs from those assumed and described herein. Moreover, each bidder has its own strategy and required rate of return and comfort factor for important parameters such as capital cost estimates and the required rate of return.

Considering the fact that concessionaire will return the expressway after operating period, which is shorter than the entire life of the project, there is enough reason to provide capital sharing/VGF financing by the government.

Sensitivity Analysis

Among the various parameters tested, capital cost parameter is found to have a relatively large impact. GDP's impact is not large (unlike economic NPV) because increases in GDP and thus increases in travel saving did not translate into larger toll directly. Alternate toll structures (e.g. larger than GDP toll escalation, toll escalation linked to value of time savings etc.) can have significant impact on the financial analysis and needs to be undertaken during the feasibility stage. The impact of toll structure in noteworthy. An increase in toll improves the financial performance of the project, but worsens the economic performance and net consumer surplus of the project.

Preliminary Environmental Assessment

The proposed project, i.e., construction of Dhaka-Ashulia Elevated Expressway, falls under Red Category of project according the ECA 1995 and ECR 1997. Carrying out Initial Environmental Examination (IEE), followed by Environmental Impact Assessment (EIA) is mandatory for such projects. The preliminary environmental assessment carried out as a part of this pre-feasibility also identified significant environmental issues requiring more detailed investigation. Therefore, IEE of the proposed project would have to be carried out first, followed by detailed EIA to be carried out during the feasibility study and design phase of the project.

Inventories of Utilities

Proposed path for DAEE might hamper the utility service systems during construction phase. Existing electricity lines are provided in a suspended stage, hanging with poles. Similar condition also observed for telephone and internet lines. Moreover, there are also some utility service lines, particularly gas lines spread beneath ground level. Therefore, interruption in such services might become unavoidable.

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INTRODUCTION

1.1 Background

The Honorable Prime Minister in Executive Committee of the National Council (ECNEC) meeting on 24th February 2011 has instructed to take up the construction of Dhaka Ashulia Elevated Expressway public-private partnership (PPP) project and finally approved the summary for the same on 3rd March 2011. The idea of Dhaka Ashulia Elevated Expressway Project (DAEEP) has been initiated through the successful launching of Dhaka Elevated Expressway Project (DEEP). Reasons behind this project is to cater the traffic that would be travelling between Northern and Southern parts of Bangladesh through Dhaka City which has been suffering tremendously from chronic at-grade congestion. Alleviation of this congestion would not only pacify movements within the city but also help boosting up the life line of our economy that is freight movements from industries to ports.

Accordingly with a view to minimize the traffic congestion in and around Dhaka Ashulia area as well as to improve road connectivity of the northern part of Dhaka linking important commercial, industrial and business centers of the Dhaka city, Bangladesh Bridge Authority (BBA) has undertaken the step to construct approximately 34 km (excluding ramps) of Elevated Expressway in northern part of Dhaka City on a Public Private Partnership (PPP) basis. In this regards BBA has requested the Consultants of Department of Civil Engineering, BUET to provide the necessary consulting services for conducting a prefeasibility and environmental screening study of the Dhaka Ashulia Elevated Expressway Project (DAEEP).

1.2 Scope of Services

In order to render the consultancy services, accordingly the following scope of services are set out :

- *Reconnaissance and Alignment Studies*: A reconnaissance survey of the proposed alignment and its nearby area will be carried out to identify the key constraints influencing the alignment, possible alternative routes connecting the proposed end-points, important origin-destinations along the route and potential interchange locations, as well as to qualitatively evaluate the advantages and disadvantages of the candidate alignments for Dhaka Ashulia Elevated Expressway Project.

- *Topographic Survey:* A total-station based digital strip survey will be carried out along the whole corridor to get detailed geometric features of at-grade road as well as road adjacent landuse development condition.

- *Review of Relevant Projects and Integration:* The STP and all relevant projects will be reviewed and their potential impacts on Dhaka Ashulia Elevated Expressway Project (DAEEP) as well as DAEEP's impacts on them will be qualitatively examined. Comments will also be provided on integration of DAEEP with other proposed projects to attain maximum synergy or on alleviation strategy if DAEEP adversely affects other proposed projects.

- *Traffic Studies:* Traffic data will be collected from on-spot surveys at several key locations of the Dhaka Ashulia Elevated Expressway Project catchment area. Existing traffic information collected during the feasibility phase of DEE project by AECOM will be complemented by these new surveys. Special considerations will be given to understand the freight traffic movement along the corridor. At this point of prefeasibility study, no household survey, Origin-Destination survey or willingness to pay surveys will be conducted.

- *Traffic Modeling:* The collected data will be fed into a simplified four-step transport demand model to quantify the potential traffic demand in the proposed expressway. Traffic demand modeling will also help quantify the potential in travel time saving for the users of Dhaka Ashulia Elevated Expressway (DAEEP) as well as the reduction in congestion in the nearby roads due to traffic diversion to DAEEP. Wider network impacts will not be considered during this prefeasibility study.

- *Environmental Screening/Assessment:* An environmental screening exercise will be carried out to understand the potential environmental impacts of the project. The screening will involve listing of potential impacts and the qualitative magnitude of the impacts. The purpose of the screening process is to identify:

  - the project nature to ascertain the level of environmental assessment required at the project feasibility level and also
  - tentatively the impacts (positive or negative) that may need more detailed investigation and mitigation (or enhancement) to be conducted during environmental and social impact assessment (ESIA) during the feasibility and design phase

  Major concerns and issues related to environmental sustainability, if any, will be raised and discussed based on reconnaissance survey and available information.

- *Survey of Utilities:* The current location of various utility networks (electricity, sewer, sewage, etc.) will be identified using field survey as well as through secondary sources such as maps from various utility companies.

- *Assessment of Soil Conditions:* Geotechnical assessment will be carried out to determine the soil profile of the proposed alignment. The assessment will primarily be based on, bore-logs, SPT, CPT data, collected from secondary sources. Primary data may also be produced if necessary.

- *Preliminary Design:* Guided by results of the reconnaissance survey, review of planned projects, traffic study and geotechnical investigation, a suitable preliminary geometric and structural design for the proposed expressway (elevated or at grade or a combination) will be provided.

- *Project Viability and Attractiveness:* - Project viability and attractiveness would be assessed based on :

  Economic Analysis - Potential economic benefits of the project will include travel time savings of DAEEP users, travel time savings of users of other roads (where congestion is reduced because of traffic diversion to DAEEP), possible fuel savings and possible environmental benefits through reduced pollution due to reduced congestion. Potential costs include the road tolls (to users), project construction costs, land acquisition costs and/or resettlement costs (if any). Only a preliminary analysis will be conducted at this stage, i.e. results from preliminary traffic modeling and preliminary designs will be used for economic benefit-cost and IRR (Internal Rate of Return) modeling.

Financial Analysis and Potential for PPP - In order to assess the viability of DAEEP under a public private partnership (PPP), where the private entity will undertake the construction costs, it is important to quantify the potential financial cash flows from the project. The financial analysis will be different from the economic analysis because it would deal from a private entity's perspective instead of the whole economy's perspective. The costs included are generally the preliminary construction costs and costs for operations and maintenance, while the benefits will be the revenues from user fees (tolls) from the users of DAEEP and the viability gap fund (VGF) from the Government, if any. The financial rate of return will be compared against the likely rate of return required by the private sector for toll road projects. This comparison will indicate the attractiveness of the project to the private sector and potential Government involvement to facilitate private sector participation.

As per the above scope of services, the consultants have made the prefeasibility study for the Dhaka Ashulia Elevated Expressway Project (DAEEP). Accordingly, this report has been prepared on behalf of Bangladesh Bridge Authority (BBA) to assist each Consortium in their preparation of bids to build, own and operate the Dhaka Ashulia Elevated Expressway Project (DAEEP). As this study is prefeasibility in nature, detail studies could not be done and several logical assumptions were made in the absence of rigorous field data. Therefore, responsibility on the part of bidders is warranted by consultants to interpret the results of the study and if possible, they are encouraged to conduct their own traffic studies to optimize their tolling strategies and financial feasibility.

Section 2

THE PROJECT AND ITS CONTEXT

2.1 Alternative Alignments

It is proposed that the Dhaka Ashulia Elevated Expressway shall be a four lane carriageway with a design speed of 80 kmph. Tentative route alignment of the Dhaka Ashulia Elevated Expressway Project (DAEEP) is Hazrat Shahjalal International Airport Abdullahpur-Ashulia-EPZ-Chandra connecting Savar Martyrs Monument. The Ashulia Elevated Expressway Project project would be an extension of ongoing Dhaka Elevated Expressway Project (DEEP); which has started from Hazrat Shahjalal International Airport and following the railway alignment it eventually ended at Dhaka-Chittagong highway near Kutubkhali (Shanirakra). The tentative alignment of Ashulia Elevated Expressway Project can be seen from Figure 2.1. This alignment forms a T- shape. An alternative alignment to connect existing DEE with Chandra may be achieved by a linear configuration connecting Abdullahpur-Ashulia-Savar BPATC-Nabinagar-Baipayl-Jirani. This alternative alignment is depicted in Figure 2.2.

Basically, both routes start at the termini of the proposed Dhaka Elevated Expressway (DEE), close to the entrance of Hazrat Shahjalal International Airport (on the opposite of the Airport Road) and follow the same alignment along the railway tract through Uttara Sectors 4, 6 and 8 (to the east of the Airport Road) up to Arichpur Road level crossing. Both routes then turn west toward Abdullahpur intersection, following the same alignment, and then follow the Ashulia Road (up to 4.8 km from the starting point). From this point, the two alternatives follow separate alignments. Alternative 1 follows the Ashulia Road up to Baipayl (about 21 km from the starting point); from Baipayl it stretches up to Chandra to the north and Nabinagar to the south. On the other hand, Alternative 2 turns south toward Sonargaon Janapath, and then follows the Sonargaon Janapath (running between Sectors 11 and 13 of Uttara). It then goes through Uttara

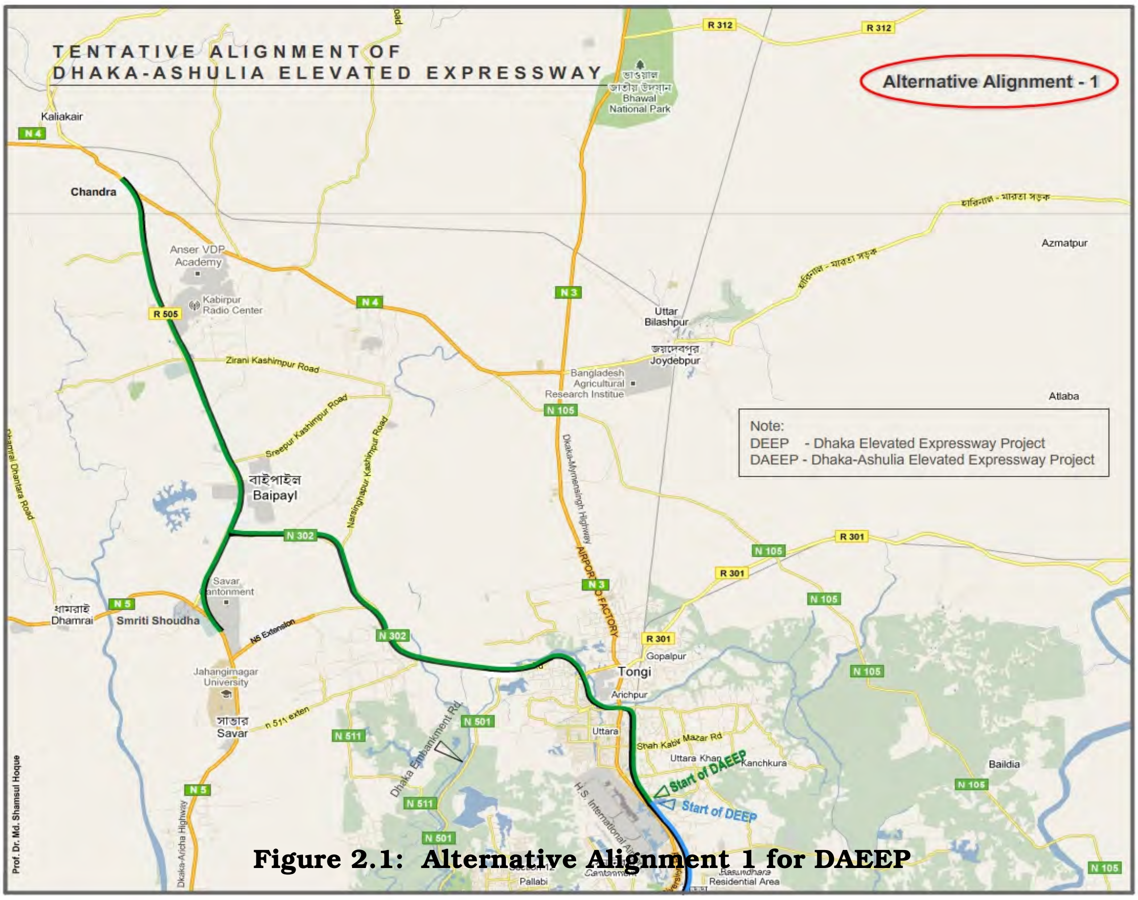


Figure 2.1: Alternative Alignment 1 for DAEEP

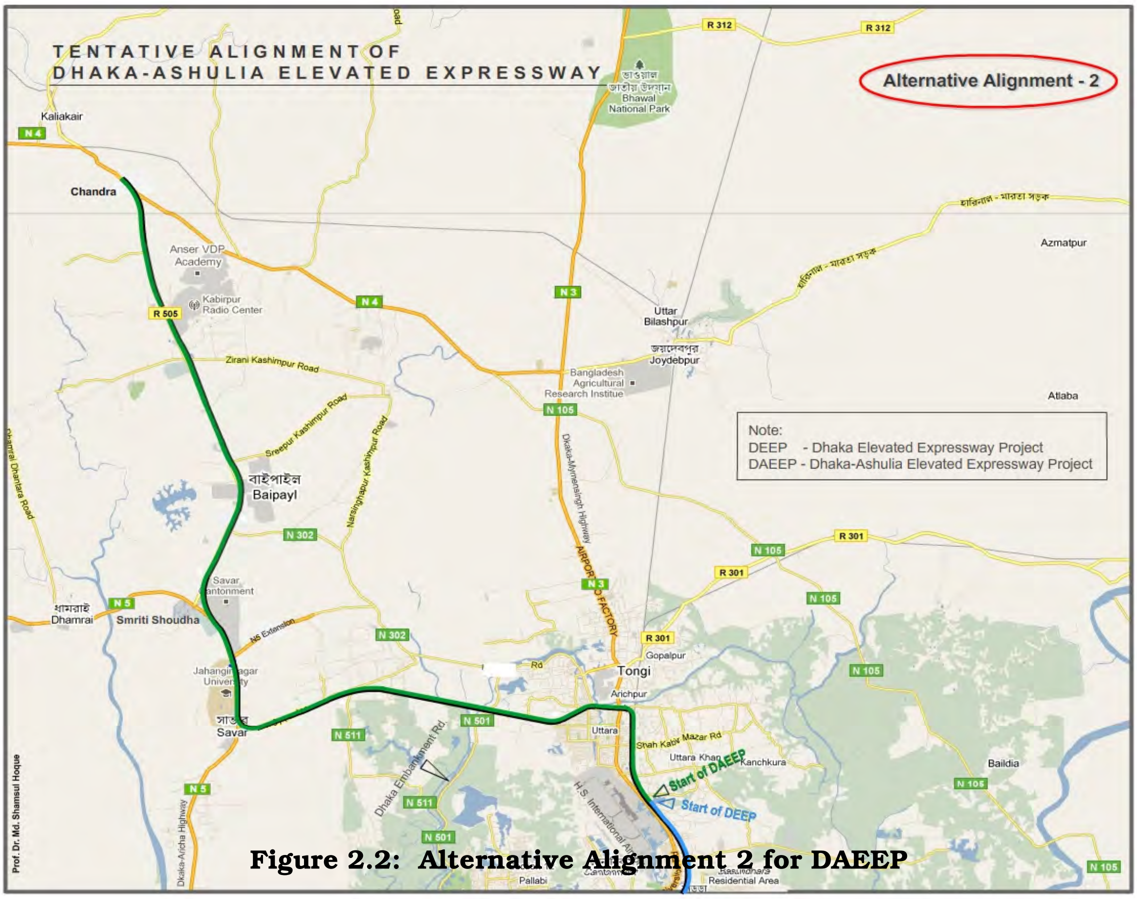


Figure 2.2: Alternative Alignment 2 for DAEEP

3rd Phase, crosses the Beri Bandh Road, Turag River-Tongi Khal and meets the Ashulia-Savar Road (about 14 km from the starting point). It then follows the Ashulia-Savar Road and meets Dhaka-Aricha Highway close to Jahangirnagar University and then follows Dhaka-Aricha Highway up to Nabinagar (Savar). From Nabinagar (Savar) to Chandra, Alternative 1 and Alternative 2 follow the same alignment. The total length of alignments along Alternative 1 and Alternative 2 are about 36 km and 42 km, respectively.

Alternative 2 is considered as a potential candidate, since it will connect Savar which a rapidly growing Upazila with huge population, economic activities and most importantly with its enormous economic growth potential. The Upazila is being urbanzied fast owing to expansion of manufacturing and real estate development by commercial, housing companies, development of residential accommodation and promotion retail activities. As per detailed area plan study undertaken by RAJUK, there has been 56.19% population growth in between 1991 to 2001 in Savar upazila. This has been the result of expansion in manufacturing activities in the area owing to locational advantages and induced by growth of Export Processing Zone in the area. There are some public sector housings in the planning area that include, Cantonment residential colonies, Radio Colony, Jahangirnagar University Staff Housing, PATC Staff Housing, Agrani Bank Residential Area, etc. However, there are also large numbers of private commercial and cooperative housing estates in the planning area that are yet to be developed.

The major problem about commercial development is that they develop haphazardly as chain along road. Without have adequate provision for road width or parking the roads become too congested for smooth movement of vehicular traffic and pedestrians. As a result, capitalizing true potential of the area is being hampering, which warrants improved accessibility for the area to sustain its growth potential. Most importantly, it is expected that the additional connection with the Savar upazila, this alternative Alignment-2 would be able to attracted more users than the Alternative 1.

The actual alignment may be one of the two alignments. This prefeasibility analysis explores five alternative scenarios combining these alternative alignments. The final alignment will depend on how the winning consortium addresses the following factor and how the government decides to plan its improvements:

- Ease of Construction
- Minimized Interruption to Existing Traffic
- Benefits to Bangladeshi people; and
- Financial Feasibility

2.2 Importance of the Corridor

The proposed Dhaka-Ashulia Elevated Expressway Project (DAEEP) alignment follows an existing road link, which forms a part of the most important road link connecting the north-east part of the country to the capital Dhaka and beyond. At present users from around 20 north-western districts use the existing Abdullahpur-Ashulia-Baipayl-Chandra link to enter Dhaka whereas users from a further 5-6 south-western districts use the Abdullahpur-Ashulia-Baipayl-Nabinagar link.

Most of the motorists from the northern districts enter Dhaka using Abdullahpur gateway. Consequently more than 40 million people of 30 districts are connected with the Capital city through this corridor. As such, the proposed infra-structure development project has a significant bearing from both improved connectivity and socio-economic point of view for a large number of people. It is envisaged that if DAEEP is implemented motorist of these regions would be able to enjoy lower transport costs and quicker travel times. Figure 2.3 shows the project influenced areas. From the Figure it can be seen that the Dhaka-Ashulia corridor provides important transport connectivity for the traffic from three national highways namely N2, N3, N4 and N5.

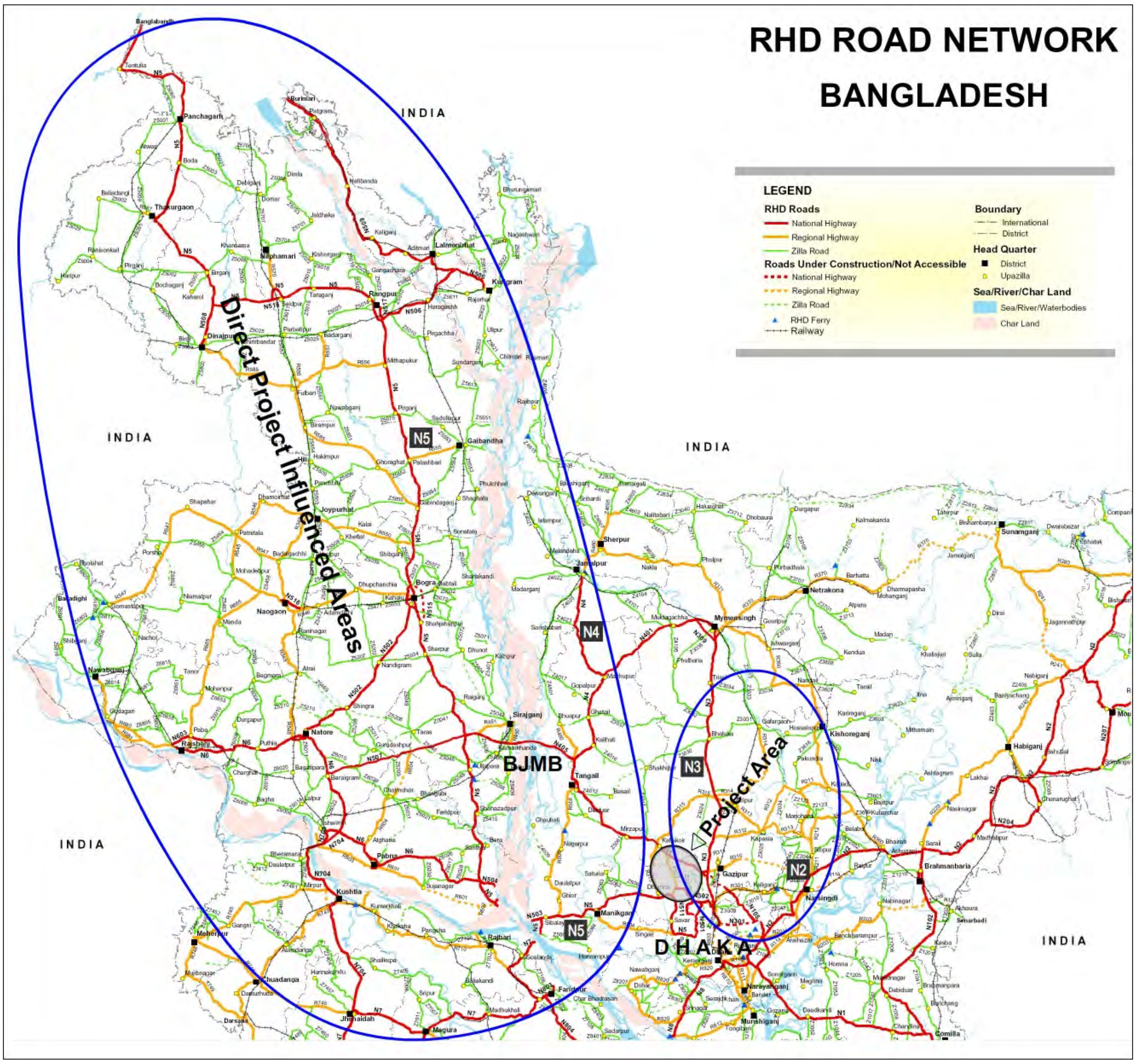


Figure 2.3: DAEEP Project Influenced Areas

The Dhaka Elevated Expressway Project (DAEEP) corridor is also a part of the Asian Highway Routes in Bangladesh, which can be seen from Figure 2.4. As such, the corridor is vital for establishing an improved transport link on the Trans-Asia highway and facilitating movement of trade from Nepal, Bhutan and Northeastern India to and through Bangladesh. Further, Dhaka Elevated Expressway Project (DAEEP) would provide improved access to Bangabandhu Jamuna Multipurpose Bridge (BJMB) (which currently does not have good access from south Tangail) and accelerate the associated economic growth.

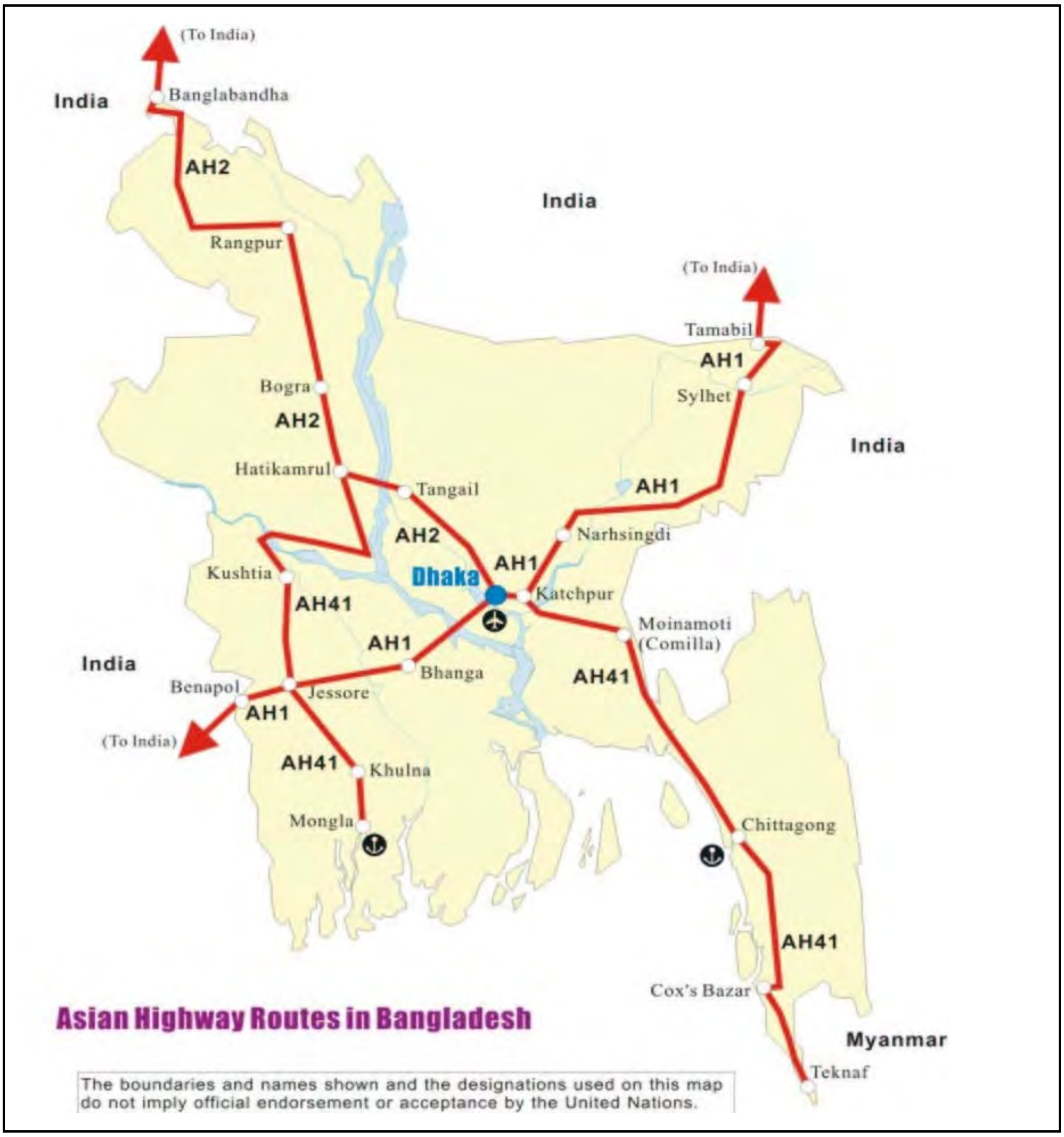


Figure 2.4: Asian Highway Routes in Bangladesh

Along the corridor, the landuse pattern is found to be largely dominated by industrial development including the largest export processing zone (EPZ) of Bangladesh which essentially demands improved transport facilities. Moreover, since the Chittagong port is a major origin or destination of a large share of the freight traffic generated from the Dhaka EPZ and its adjoining areas, the Baipayl-Ashulia-Abdullahpur road is acting as a pseudo economic corridor.

Besides, implementation of DAEEP as well as DEEP would essentially increase the amount of primary road of Dhaka city. Together these two projects will form an arterial free flow corridor which currently Dhaka city is lacking. It is anticipated that at present due to meager amount of road network, construction process of BRT, MRT or other road improvement projects would severely interrupt normal traffic operation and would make the congestion problem unmanageable and chaotic. In this regard DEEP and DAEEP would be a great reliever in proving diversion to the affected motorists and thereby would help in implementing different roadway alignment based important mega projects. If integration can be made properly it will also facilitate in developing the proposed multi-level-multi-modal interchange facilities at Airport Railway station.

Moreover, instead of making the project totally auto and freight biased; encouragement of public transport and high occupancy vehicle use of the Expressway can be made by offering preferential usages rates for such vehicles. Thereby the project would also be important for the public transport mobility along this corridor; particularly for regular inter district bus operations as well as for free flow movements of huge number of long haul buses during festival seasons.

2.3 Roadway Conditions along DAEEP Corridor

The geometric configuration of existing roadway along DAEEP corridor is found to be 2-lane undivided and without any geometric treatment. Observation on right-of-way shows that most of the 34 km corridor has enough space for future expansion provision; except road segment between Zirabo to Baipayl has tight right-of-way (18m-20m). Traffic composition is dominated by heavy vehicles viz. inter-district buses, trucks, covered vans and semi-trailers.

There are major traffic bottlenecks at different points of these road links, especially at Baipayl T-junction and near Abdullahpur T-junction, which delays the vehicular traffic carrying passengers by a significant amount. Other major bottlenecks at various locations on the link further delaying the travel into or out of the capital. During festival season this corridor becomes havoc and causes unbearable 2-5 hr delay and enormous suffering to the home going and Dhaka bound passengers on their return trips. Moreover, accident data reveals that along this corridor Baipayl, Zirani, Nabinagar are very accident prone spots with high accident records.

Observation on geometric and operational conditions shows that the corridor suffers from uncontrolled movements of pedestrians, non-motorized and motorized vehicles. Due to high concentration of labor intensive garment industries, there are huge numbers of pedestrians all along the corridors and surprisingly there is no safe walking and crossing facilities to protect and segregate this most vulnerable and fully exposed road user group. In the absence of these facilities, during field visit it is observed that random pedestrian crossings are rampant and resulting undue conflicts with the vehicular flow. Besides pedestrians, uncontrolled way of plying slow moving non-motorized vehicles along this whole corridor is also interrupting smooth flow of through traffic and inducing high overtaking demand. It is also observed that in the absence of bus lay-by facilities as well as for the lack of enforcement; buses and other motorized and non-motorized para-transits are being stopped at junctions for passenger loading and unloading operation and thereby causing serious bottleneck at the junction points. Moreover, roadside uncontrolled parking activities and development of arcade of shopping complex are also observed along the critical sections of the corridor. Evidently during the field visits chronic congestion situations are observed at all the junction points and busy segments of this corridor.

During field visit it is observed that unplanned and uncontrolled densified landuse activities are going on rampantly in and around the whole corridor and most importantly without internal area-wide functional road network provision, resulting heavy dependence of local traffic on the highway. At present the corridor is used both by local and through traffic without any priority control.

In general, the critical sections of the corridor is operating at very low level of service (LOS D to E) mainly due to lack of access control and also due to presence of excessive side frictions caused by various types of non-motor activities. At present, both functionally and operationally the corridor cannot be considered as a highway. Instead of providing mobility function for the through traffic it is predominantly providing accessibility functions for the local traffic.

Few snap shots that are taken during field visits are presented in Figures 5a-5l to demonstrate the operating conditions of the corridor. The most critical sections of the corridor in terms of recurrent chronic congestion and frequent accident occurrences are schematically depicted in Figure 2.6.

In consideration of above mentioned existing operating conditions of the corridor, there is a strong need for undertaking appropriate traffic management measures. Side by side, as a part of corridor improvement measure, the DAEEP can be implemented with a particular objectives of providing better access facility for the Dhaka EPZ economic zone and better connectivity for the through traffic. Besides, as DAEEP would act as traffic flush-out system it would be an important peak hour traffic supply management tool to relieve excessive traffic demand induced particularly during daily commuting hours and festival seasons or in case of any temporary bottleneck created by worker unrest or road accident along this corridor.

Considering the fact that construction of DAEEP would require at least 3m-4m space from the median of existing 2-lane single carriageway; naturally widening of the corridor would be necessary for successful implementation of the proposed elevated expressway project. Moreover, since along this corridor there is no suitable alternative road for traffic diversion purpose, 4-lane widening project has to be completed well before construction of the DAEEP project. The widening project should be implemented considering necessary right-of-way that would be required for accommodating expressway piers, entry-exit ramps, toll plazas etc. and also for making the at-grade road functional as well as for maintaining traffic flow during construction periods.

As such the already planned 4-laneing project, which is now suspended with an aspersion that it would be redundant if DAEEP is implemented, should be undertaken immediately without any further delay. It is to be noted here that the 4-lane widening is not a redundant project rather it is a vital prerequisite for successful implementation of DAEEP project. It is also envisaged that in order to maximize the benefits of DAEEP, matching road improvement measures should also be undertaken between Chandra more to Tangail and Nabinagar to Manikganj segments.

Figure 2.5a: Consultants in Discussion

Figure 2.5b: Abdullahpur Junction

Figure 2.5c: Ashulia Junction

Figure 2.5d: Tight R.O.W at Zirabo

Figure 2.5e: Congestion at Zirabo

Figure 2.5f: Road side activities at Baipayl

Figure 2.5g: Road side shops at Baipayl

Figure 2.5h: Traffic conflicts at Baipayl

Figure 2.5i: NMV movements at Baipayl

Figure 2.5j: Parking activities at Baipayl

Figure 2.5k: Heavy vehicles at Nabinagar

Figure 2.5l: Traffic movements at Chandra

Figure 2.6: Congestion and Accident Hot-Spots along DAEEP Alignment

2.4 Access and Distribution Facilities of DAEEP

Traffic access and distribution to the Dhaka Ashulia Elevated Expressway is planned to make the facility accessible by the potential users from the desired locations as well as to avoid additional congestion to the existing at-grade road due to convergences of traffic at the ramp areas. Two types of site specific access and distribution facilities are considered for DAEEP these are :

- Entry-exit without turning facility
- Interchange with turning as well as entry-exit facilities

For the proposed route alignment-1 - altogether 4 nos. interchanges and 5 nos. entry-exit facilities and for alignment-2 - 4 nos. interchanges and 4 nos. entry-exit facilities have been identified based on preliminary assessment of the proposed route alignment and traffic distribution patterns within the road network. The exact number and appropriate locations of these access facilities need to be finalized by undertaking a comprehensive O-D and land surveys. The list of tentative interchanges and entry-exit facilities are presented in Table 2.1 and Table 2.2 below and shown in Figure 2.7 and Figure 2.8 along with identified toll plazas.

Table 2.1: Access and Distribution Facilities of Alignment-1

Sl. No.	Interchange Facilities	Sl. No.	Entry-Exit Facilities
1	Turag Interchange	1	Abdullahpur Entry-Exit
2	Ashulia Interchange	2	Zirabo Entry-Exit
3	Baipayl Interchange	3	EPZ Entry-Exit
4	Chandra Interchange	4	Zirani Entry-Exit
		5	Nabinagar Entry-Exit

Table 2.2: Access and Distribution Facilities of Alignment-2

Sl. No.	Interchange Facilities	Sl. No.	Entry-Exit Facilities
1	Ashulia Interchange (Roundabout Type)	1	Abdullahpur Entry-Exit
2	Baipayl Interchange	2	EPZ Entry-Exit
3	Savar Interchange	3	Zirani Entry-Exit
4	Chandra Interchange	4	Nabinagar Entry-Exit

Detailed layout configurations for these proposed interchanges and entry-exit ramps are schematically presented in Appendix-A.

2.4.1 Access Facilities for Alternative Alignment-1

All the interchanges are provided at the at-grade T-intersections of the proposed alignment-1 except at the Nabinagar and Abdullahpur T-intersections. At the Nabinagar junction though interchange is warranted but due to aesthetic as well as security reasons of the national memorial no interchange facility, which usually needed 2nd level ramp construction, is recommended. Instead, normal Entry-Exit ramps are considered for providing accessibility to the expressway. In addition, one U-loop facility is planned at the southern side of Nabinagar junction to accommodate diverted turning traffic that are bound for Aricha corridor. Likewise, at Abdullahpur, though interchange is warranted but due to proximity of Tongi Bridge it could not be accommodated. Alternatively, the required interchange is configured considering both Abdullahpur and Turag (i.e. meeting point of new bypass road passing beside the Estema ground and Ashulia embankment road) intersections. Among the four interchanges, classical Trumpet interchange is found to be feasible only at Baipayl intersection. At other locations, due to site-specific constraints particularly unavailability of required land, hybrid typed interchange is considered.

It is appeared that instead of normal extry-exit facilities, direct ramp connection with the DAEEP would be more beneficial for the EPZ traffic; provided there is enough space inside the EPZ blocks to accommodate the development length of ascending and descending ramps and most importantly EPZ authority agree with the plan. Finalization of this plan needs further studies.

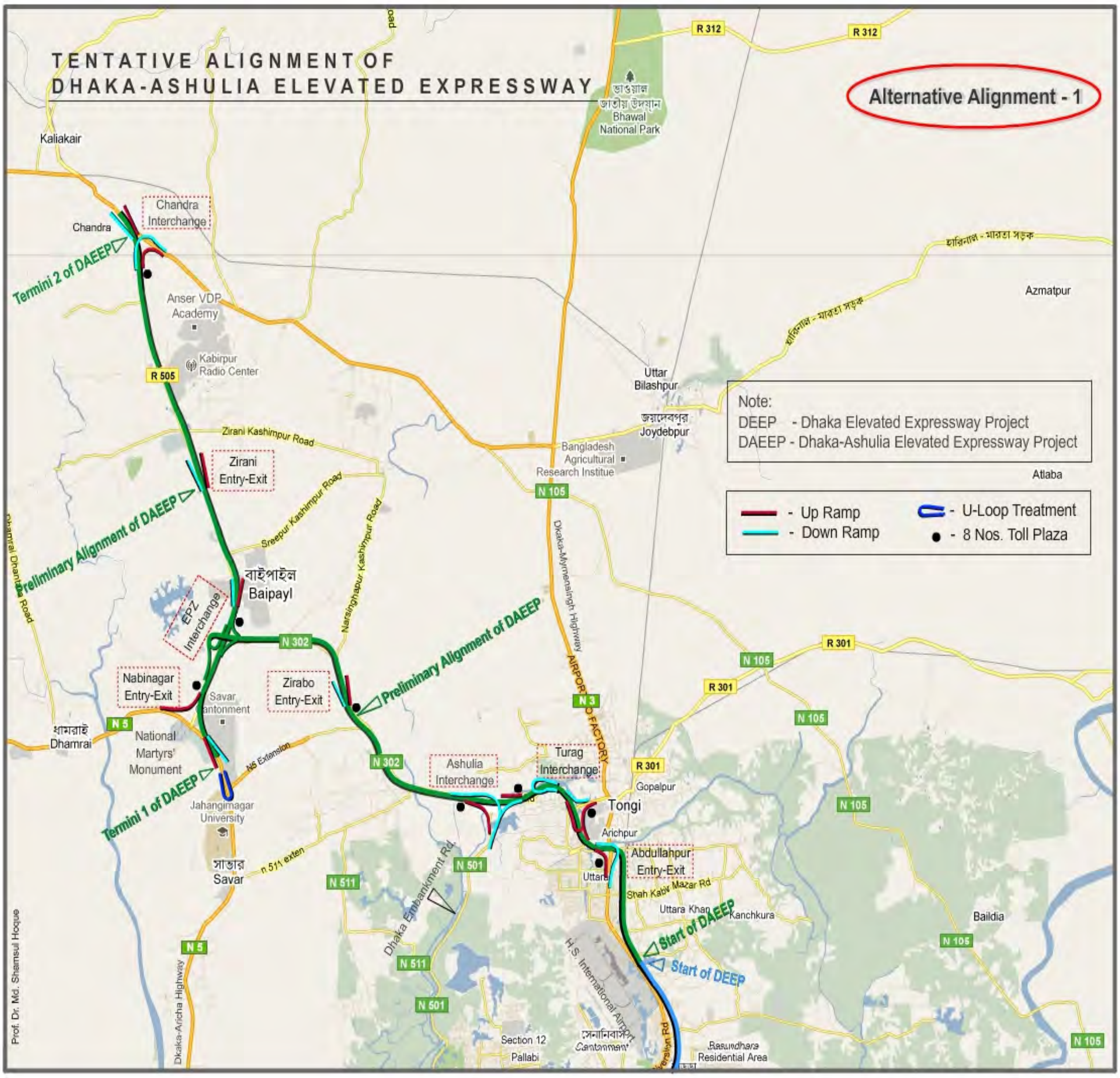


Figure 2.7: Tentative Interchange and Entry-Exit Facilities of Alignmnet-1

2.4.2 Facilities for Alternative Alignment-2

For Alignment-2, in place of Interchanges at Turag and Ashulia - a large roundabout type at-grade interchange facility is provided, taking land between Ashulia canal and embankment or beribandh road, to cater for traffic coming from Turag and Zirabo catchment areas. It is expected that due to availability of better at-grade roadway facilities within this segment (Turag-Zirabo), diverted traffic would not face any difficulties to avail the expressway other than some detouring. Due to its proximity and easy accessibility, it is also expected that this roundabout type interchange would also be beneficial for the users from Uttara residential areas. For the Alignment-2 an interchange facility, comprises of one direct and one semi-direct 2nd level ramps, is also considered to cater for Savar based generated traffic.

Besides access and distribution facilities, open architecture typed suspended termini is considered at the terminal points (viz. Nabinagar and Chandra) of DAEEP to keep the provision for future expansion of the Expressway.

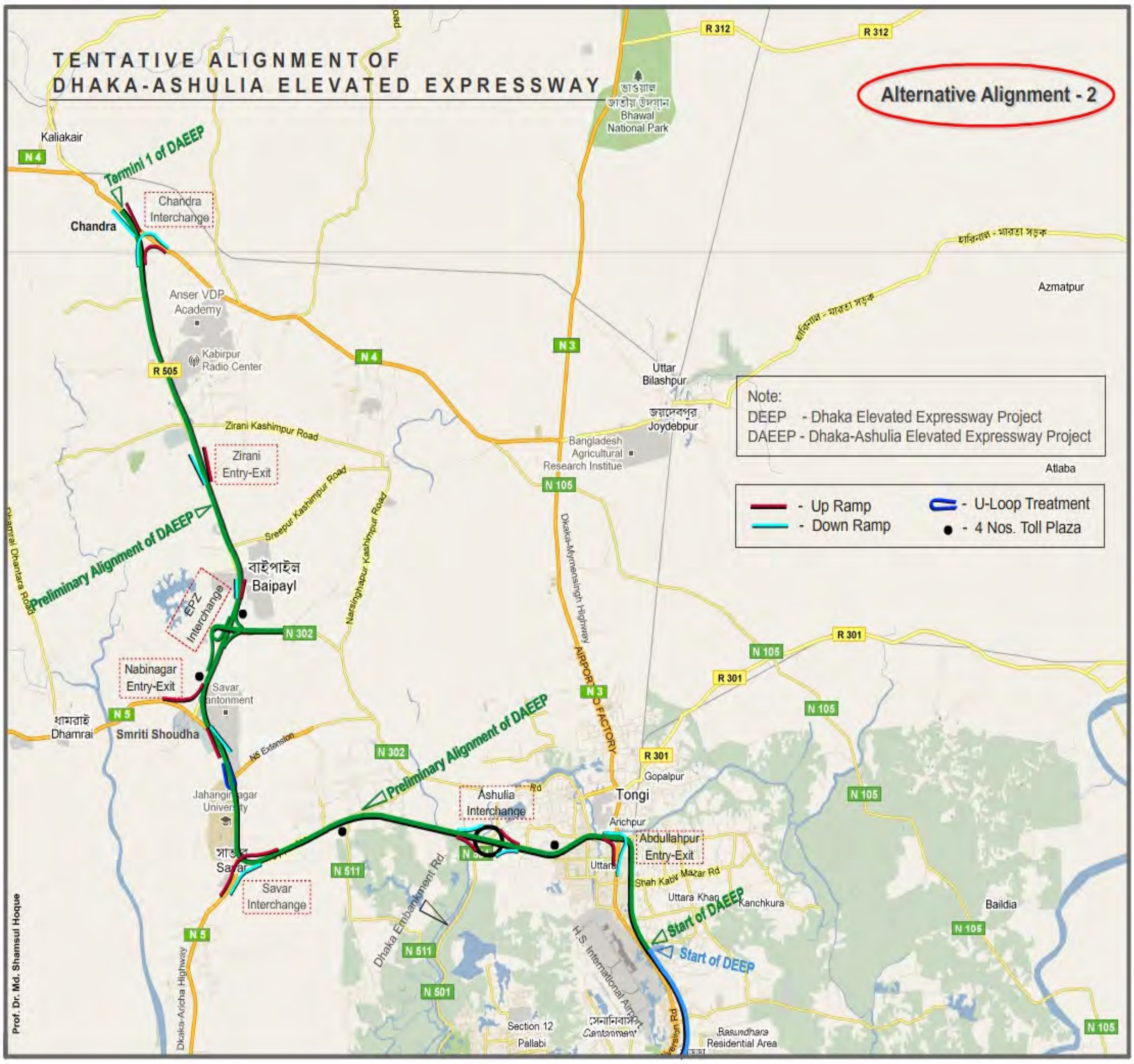


Figure 2.8: Tentative Interchange and Entry-Exit Facilities of Alignmnet-2

Section 3

RECONNAISSANCE AND LAND SURVEY

3.1 Reconnaissance Survey

On 5th May and 11th May, the team of Consultants along with the official from Bangladesh Bridge Authority (BBA) carried out reconnaissance survey of the areas surrounding the proposed Dhaka Ashulia Elevated Expressway (DAEE) Project site and the possible alternative alignments of DAEE were inspected. The specific purposes of those visits were reconnaissance of in-field conditions, inspection of existing transportation facilities including variation in traffic modes, multimodal transfer facilities, and roadside landuse and activity patterns. Movement of freight traffic and traffic generation and destination patterns of heavily built-up industrial regions beside this corridor were examined with special attention. Several key locations are treated with special consideration based on their importance in our national transport and economy.

Initially available Google maps of the area and relevant information were gathered and studied. There after field visits were carried out more objectively at the end of May 2011 for further assessment of the site area and alternative corridors. Based on the reconnaissance survey, field observations as well as analysis of relevant data and maps, two alternative alignments are tentatively proposed for the prefeasibility study with a view to meet the following objectives:

- to fulfill the project objectives
- to have better accessibility for the project area
- to match with existing as well as future road network
- to utilize public land as much as possible and thereby
- to minimize private land acquisition requirement

These potential alternative alignments for the Dhaka Ashulia Elevated Expressway are shown in Figures 2.1 and 2.2 respectively.

3.2 Observations from Field Visits

During reconnaissance survey it was observed that, at present, Chandra is the entry point of all traffic from North-Western part of Bangladesh and Nabinagar is the gateway of Dhaka from the South-Western region. A part of this traffic has destinations within Dhaka city and the remaining part is through traffic passing through Dhaka. Also the surrounding regions of the proposed DAEEP e.g. Zirabo, Zirani, Ashulia, Nabinagar have been facing tremendous growth in urbanization and industrialization in recent years generating and attracting huge amount of traffic. Nabinagar, Abdullahpur-Embankment Road Junctions and Baipayl junction have also been identified as very important points to cater to this traffic.

As observed in the field visit, currently there is significant congestion in several locations e.g. Baipayl-Ashulia Road, EPZ areas, Embankment Road Junction. A significant portion of this is caused due to lack of access control and interaction between local and through traffic. DAEEP can reduce travel time of through traffic by providing an access controlled right-of-way segregated from local traffic and having negligible side friction. It can also help in reduction of local traffic congestion by reducing the proportion of through traffic interfering with the local traffic. DAEEP will provide improved transport facility and direct access to Dhaka-EPZ which has 388 industrial plots in an area of 143.84 hectares (346.51 acres). In particular, the freight traffic transported to and from the EPZ will benefit by DAEEP.

In addition, DAEEP has the potential to be connected with the proposed circular ring road around Dhaka which can significantly contribute to better distribution of traffic originating from or heading to the Eastern/Western fringes. In line with the strategic transport plan (STP) recommended Circular ring road as well as JICA (DHUTS study 2010) proposed outer ring road, the route alignment has been schematically shown in Figure 4.1. Further, DAEEP can provide improved access to Bangabandhu Multipurpose Bridge (which currently does not have good access from south Tangail) and accelerate the associated economic growth.

3.3 Topographic Land Survey

Based on the finding of the reconnaissance survey, subsequent topographic survey was undertaken along both the proposed alternative routes and the survey was carried out by using high precision digital total station (one sec accuracy).

Initially, satellite image was consulted to identify the location of the proposed alternative alignments with respect to the few prominent ground controls. After preliminary identification of the proposed alternative alignments on the superimposed Google map, the detailed topographic survey of the area was conducted during the month of June and July 2011. The strip topographical survey was carried out only along the critical segments of the proposed expressway alignments particularly where land acquisition and demolition would be needed. The width of the strip was chosen to be about 150 m i.e. 75 m on either side of the centre line. The locations of all features including homestead, permanent and semi-permanent structures, existing roadways, electric/utility poles, high ground and low areas were recorded.

3.4 Preparation and use of Drawings

The topographic maps along with the expressway layout plan for both the alternative alignments have been drawn on sixteen sheets prepared with a scale of 1:1000 and are appended in Appendix-B. Physical checks have been carried out in the field to see if all the features have been properly recorded on the maps and necessary corrections were made. As, in the prefeasibility stage the detailed geometric design is not made, only the overall or crest width of the proposed Dhaka Ashulia Elevated Expressway (DAEE) is shown on the AutoCad drawings along with the proposed entry/exit and interchange ramps areas. Eventually, these layout configuration plans of the proposed route alignments of DAEE project would be required to superimpose on the Mouza maps for the preparation of subsequent land acquisition and rehabilitation purposes, which could not be performed due to the lack of detailed information. As such, the prepared AutoCad drawings are used only to determine the amount of land acquisition without any title schedule as well as to assess the need for demolition of structures.

Section 4

ORBITAL / RING ROAD

4.1 Background

Close observation of route alignment of 26 km Dhaka-Elevated-Expressway (DEE) and 34km Dhaka-Ashulia-Elevated-Expressway (DAEE) revealed that these two expressways would provide improved transport facilities mainly for the eastern and northern parts of Dhaka city. Consequently, it is expected that these two elevated expressway projects would improve the traffic flow situation of northern and southern parts of Dhaka city by providing bypass facility for the through traffic and better circulation/mobility O-D pattern for local traffic. It can easily be perceived that the benefits to these two projects would be further enhanced if the 40 km missing elevated link on the western part of Dhaka city can be constructed by connecting with the ongoing DEEP and proposed DAEEP. If it is planned then these three elevated expressway projects would form a quasi orbital or ring road and would make Dhaka city more accessible to the rest of the country. It would similar to the Dhaka Circular Elevated Road project but with extended scope, which the government is currently planning to implement. A conceptual layout configuration of the elevated orbital roadway system is presented in Figure 4.1. From the Figure it can be observed that the proposed ring road would connect all the national highways converging towards Dhaka viz. N1, N2, N3, N4, N5 and N8 and thereby would provide better traffic distribution pattern by integrating these national highways.

4.2 Specific Benefits

The seamless integration among these three elevated expressway projects (i.e. DEEP, DAEEP and missing link) would essential augment traffic volume as well as usage-ability of the orbital road; which would create a win-win situation for both the Government and investors. A few other important perceived benefits of orbital road would be as follows :

- Would help in bypassing through traffic and distributing local traffic; in a way it would act as bypass-cum-distributor road
- Would help traffic from national highways to get several gateways to enter into Dhaka
- Would solve congestion problems arises from confluence of couple of gateways (N1, N2 & N8) at Jatrabari intersection
- Would act as stimulus to development activities in the western fringe and southern part of Dhaka city; where at present development is going on with slow pace due to accessibility problems
- Would reduce the demand for construction of river crossing bridges over Buriganga for western part of Dhaka
- Would help in even expansion of Dhaka city by providing better connectivity to the CBD adjacent western and southern parts of Dhaka city

Taking these above mentioned benefits in cognizance, it is strongly recommended that for the construction of orbital road; provision for required right-of-way, particularly at the western part of Dhaka where right now uncontrolled land use activities are going on very aggressively, should be kept prudently before it becomes too late.

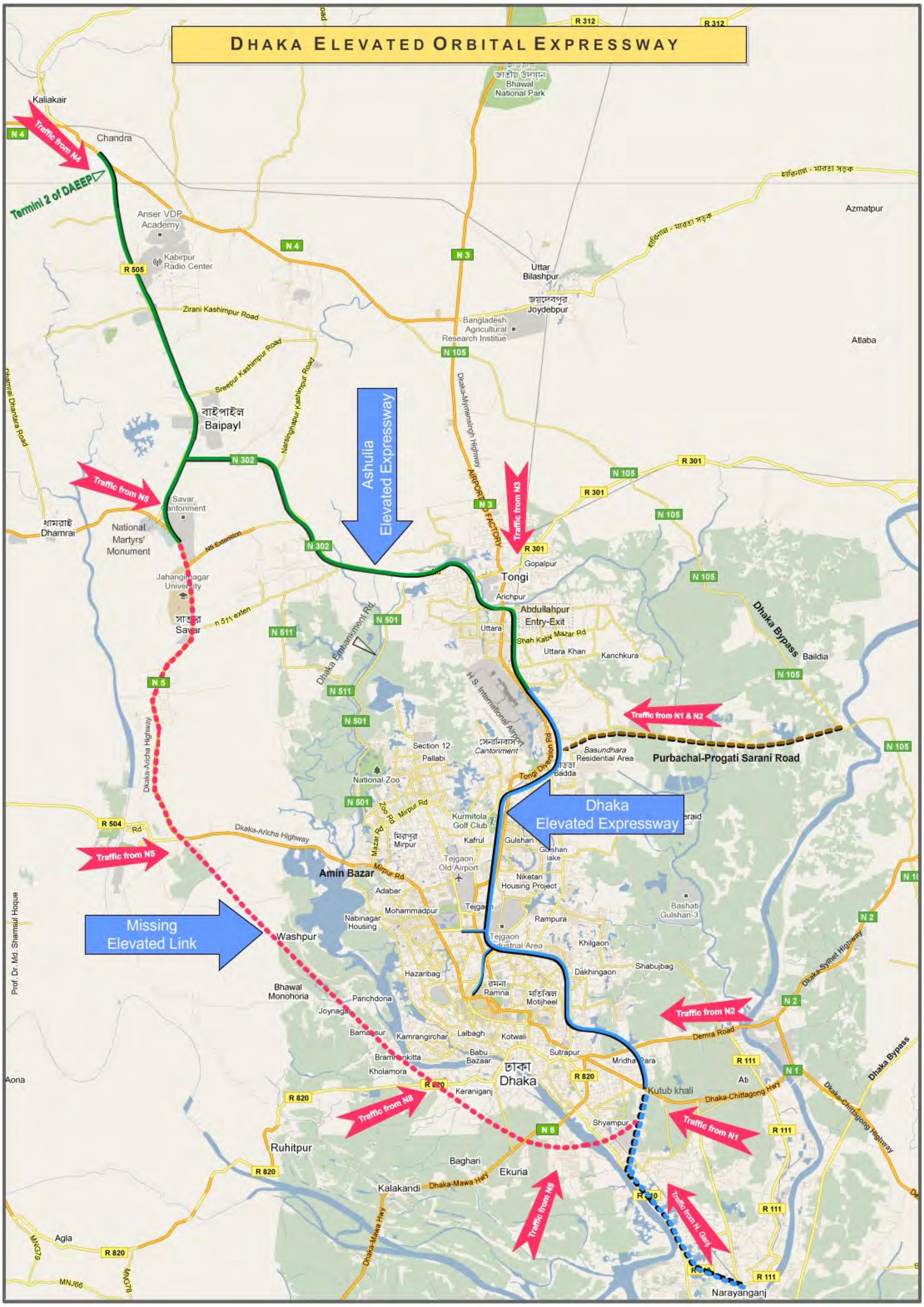


Figure 4.1: The Proposed DAEEP with Dhaka Elevated Orbital Expressway

Section 5
TRAFFIC STUDY

5.1 Introduction

In 2011, Bureau of Research, Testing and Consultancy (BRTC) of Bangladesh University of Engineering and Technology (BUET) was commissioned to assist Bangladesh Bridge Authority (BBA) in the preparation of Pre-feasibility and Environmental Screening Studies of Dhaka Ashulia Elevated Expressway Project (DAEEP). Among many commitments of the study team are traffic studies and traffic modeling services.

The preparation of traffic studies and traffic modeling includes:

- The conduction of traffic counts
- The conduction of journey time surveys
- Development of base year diversion model
- Development of future year demand OD matrices
- Preparation of traffic forecast for four different scenarios and two different alignment options for the expressway

This Section documents the model development and results, and has been prepared on behalf of BBA to assist each Consortium in their preparation of bids to build, own and operate the Dhaka Ashulia Elevated Expressway Project (DAEEP).

5.2 Methodology

The methodology includes the following tasks:

- Establishing the project and its context
- Finding alternative scenarios and alignment
- Review of socio-economic data
- Review of travel patterns
- Traffic data collection
- Modeling traffic
- Analysis of result; and
- Sensitivity analysis

Further details on each of these tasks are provided as follows.

A review of the project area and its context along with possible alternative alignments for the Dhaka Ashulia Elevated Expressway and their connectivity to the existing road network are provided in **Section 2.0.**

The surrounding road network was also reviewed to allow us to form an opinion on the road network conditions for the traffic modeling of each forecast year. Information from various sources, including the Strategic Transport Plan (STP), RAJUK, Dhaka City Corporation (DCC), Dhaka Transport Coordination Board (DTCB), Roads and Highways

Department (RHD) and Bangladesh Bridge Authority (BBA), were collected to provide a calendar of improvements on the surrounding network which may affect the Dhaka Ashulia Elevated Expressway Project (DAEEP).

5.2.1 Socio-Economic Review

A description on socio-economic research and analysis is provided in Section 6.0. Information on population forecast has been collected from the database of Bangladesh Bureau of Statistics (BBS).

5.2.2 Traffic Data Review and Collection

A traffic data review and collection is provided in Section 7.0. Data has been sourced, surveyed and reviewed to help identify traffic patterns on the road network to enable future forecasts to be performed.

The methodology for review was as follows:

- Major areas of catchment for Dhaka Ashulia Elevated Expressway Project (DAEEP) are identified from a pilot survey done in May 2011 and visual survey of land use pattern concentration in these areas.
- From these surveys primary Origin Destination (OD) pairs are established.
- An extensive classified traffic volume study is done on the roads surrounding the project during the period of May 2011 to July 2011.
- The sourced OD matrix is then adjusted according to the base year link volumes.
- Also travel time surveys were undertaken on the proposed alternative routes to determine network travel speeds.

5.2.3 Traffic Modeling

A detail traffic model has been done to capture future year conditions at different scenarios. The description of the modeling process is done in Section 8.0. The traffic modeling was undertaken using transportation planning software, Cube Voyager. This software is an internationally recognized modeling package, similar to the TP+ in the USA, STRADA model in Japan. and TRIPS Modeling Package used in Europe.

Network

- The road network (including distances, speeds, and lane numbers) was sourced from the Strategic Transport Plan (STP) EMME/2 model, and converted to Cube Voyager. This converted file is collected from BBA that was previously done for them by AECOM in the feasibility study of Dhaka Elevated Expressway Project (DEEP).
- The base year (2011) road network was verified from aerial photography sourced from www.maps.google.com as well as site inspections of the key routes. Minor adjustments to capacities, speed, and speed-flow relations were made from the actual network file used in STP.
- Information regarding possible future road networks, including lane expansions, was sourced from RHD, DTCB and BRTC, BUET. Then these likely projects were added to future year networks.

Trip Tables

- From the STP model the base year matrices were obtained.
- Using known link flow volumes in peak period this OD matrix is adjusted and modified to be used in the model.

- Three time periods were chosen to represent the daily traffic profile, peak (6 am – 12 am and 6 pm - 12 pm), off-peak (12 am – 6 pm) and super off peak (12 pm- 6 am). This segmentation represents an average hour during these periods to be modeled. As the proposed DAEEP will be an extension of Dhaka Elevated Expressway, it will act as an elevated bypass for the city. Hence, existing daytime truck- curfew has been lifted up in the model of flyover.
- Calibration is then done by assigning the trip tables to the network and comparing the modeled flows and journey times against observed values. Method of matrix estimation was used to get a better fit between observed and modeled values.
- Future year matrices for 2015, 2020 and 2025 were developed form the base year matrix.

Assignment Model Development

- The "Best Path" method was used in the assignment model to assign trips from the matrices to the road network. This assignment depends on the relative differences in travel times, distances and costs (tolls).
- Parameters of the assignment algorithm, including value of time, were determined from AECOM calculations on Dhaka Elevated Expressway, RHD Values and World Bank Guidelines.
- The traffic forecasts for DAEEP were determined for each of the future years modeled with toll levels kept constant in real terms. Intermediate traffic years between the modeled years were interpolated from the results to provide traffic forecasts for the future years.

5.2.4 Analysis of Results

The forecasts from the traffic study are summarized in Section 9.0. During the model development, assumptions were made in regards to:

- Population Growth
- Driver's willingness to pay
- Short and long term forecasts for GDP, purchase power and CPI
- Road network changes of competing and connecting roads and the impact of these changes on capacity both during and post-construction; and
- Future toll scenarios

5.3 Alternative Scenarios

5.3.1 Scenario 1 – No Change

This is the no change scenario that is evaluated for the future years with no augmentation of capacity in the proposed alignment. But the forecasted change of landuse, population, traffic and other socio economic factors will be the same as that is considered in the other scenarios.

Evaluation of this scenario is important to get the amount of potential benefit that may arise from constructing any facility over this alignment.

5.3.2 Scenario 2 – Alternative 1

The second scenario involves alternative-1 alignment of the proposed expressway as discussed earlier. It will follow the alignment of existing roadway from Abdullahpur to

Chandra and Nabinagar through Baipayl with a bifurcated T-shaped alignment. The connectivity of the expressway from Abdullahpur to the existing Dhaka Elevated Expressway project will be ensured by following the alignment of existing railway corridor.

Potential interchange locations for entry/exit would be :

- Start and end points near the airport, Chandra and Nabinagar;
- Baipayl at the intersection of N302 and R505;
- Ashulia at intersection of N302 and N501;
- Zirani entry and exit ramp in between Chandra and Baipayl ;
- Zirabo entry and exit ramp in between Ashulia interchange and EPZ (Baipayl) interchange;
- Turag entry and exit ramps with U-loop treatment;
- Abdullahpur entry and exit ramps to provide access to Uttara and Tongi region.

There would be five toll plazas at Abdullahpur, Turag, Ashulia, Nabinagar and Baipayl .

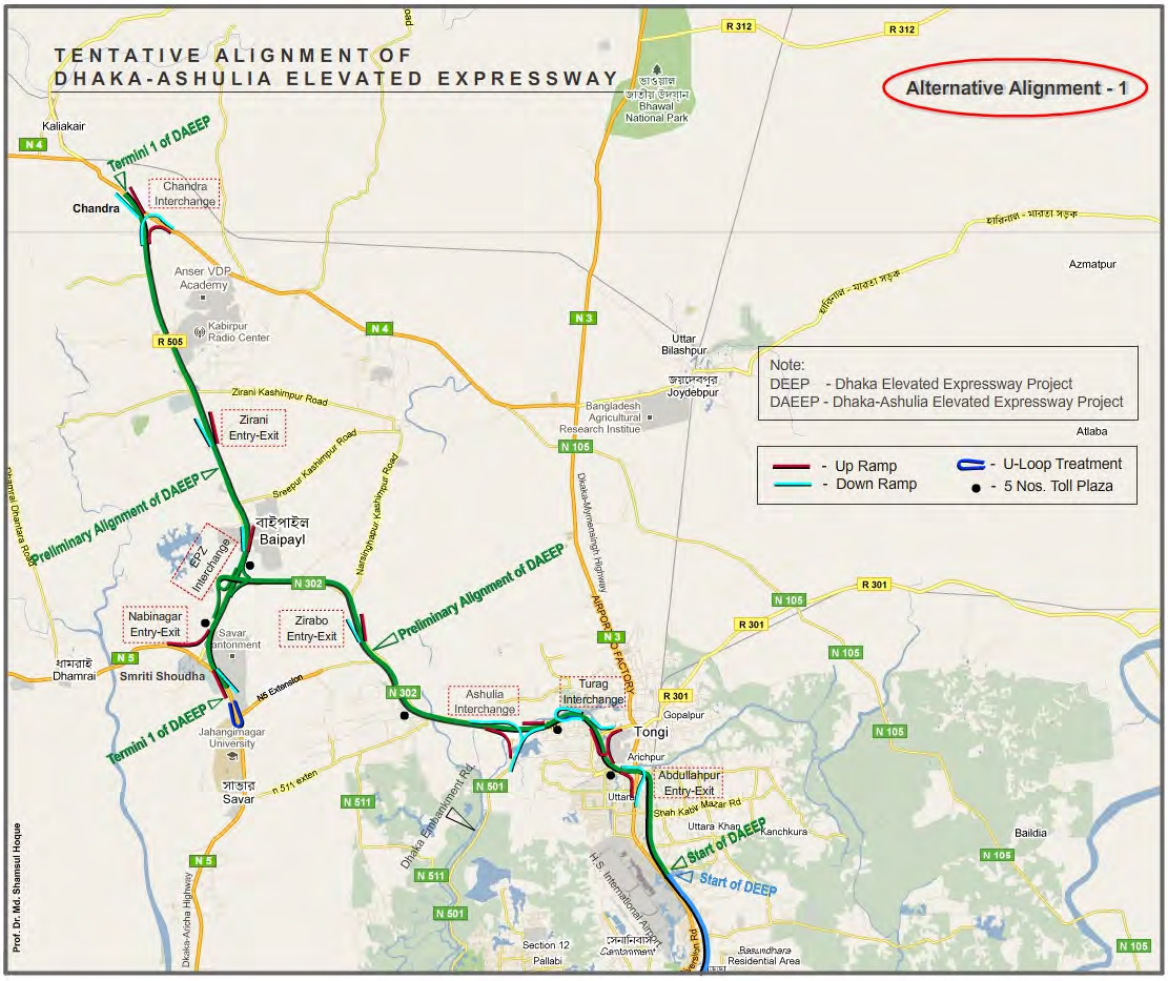


Figure 5.1: Scenario 2 – Alternative Alignment-1

5.3.3 Scenario 3 – Road Widening

This scenario evaluates the proposed road widening of the existing N302 (Abdullahpur – Baipayl) and R505 (Nabinagar – Chandra). Currently both of the roads are undivided two lane two way highways with a little access control from the surrounding region. Sporadic roadside industrial developments at Ashulia, Zirabo and EPZ surrounding regions have also imposed hindrances in smooth flow of traffic though this commercially important corridor. Estimated cost of road widening is presented in Appendix-C.

Scenario 3 will involve widening of the proposed road alignment to four lane divided highway with controlled access from the surrounding facilities. For modeling, this scenario has been evaluated separately considering the growth of other demographic and socio-economic factors as forecasted.

5.3.4 Scenario 4 – Alternative 1 + Widening

Evaluation of this scenario involves improvements proposed in both scenarios 2 and 3. This requires widening of the at-grade roadway and construction of expressway following alternative alignment-1.

5.3.5 Scenario 5 – Alternative 2

Scenario 5 includes a grade separated expressway over alternative alignment 2. This alignment mainly follows the same path from the airport to Abdullahpur as alternative alignment 1. But directly connects Abdullahpur with Ashulia through Uttara 3rd phase project and then goes through Savar BPATC. Ultimately this alignment connects Nabinagar following N5 and reaches to Chandra through Baipayl following the existing alignment of R 505. Accordingly, due to connecting Savar upazila, which is urbanizing and industrializing rapidly, this alternative would serve more catchment areas than alternative 1.

Potential interchange locations for entry/exit would be:

- Start and end points near the existing Dhaka Elevated Expressway and Chandra;
- Ashulia roundabout type interchange over N 511 (Dhaka Embankment Road);
- Baipayl interchange to serve the traffic moving in and out of the EPZ area;
- Nabinagar entry and exit with a U-loop treatment near Savar Smriti Shoudha;
- Abdullahpur entry and exit;
- Zirani entry and exit;
- Savar interchange to serve the traffic generated from this area and to provide better access facility with the EPZ and central part of Dhaka city via Birulia.

With this alternative, altogether there would be four Toll Plazas at Turag (between Abdullahpur and Ashulia segment), Zirabo (between Ashuial and Baipayl), Nabinagar entry and Baipayl.

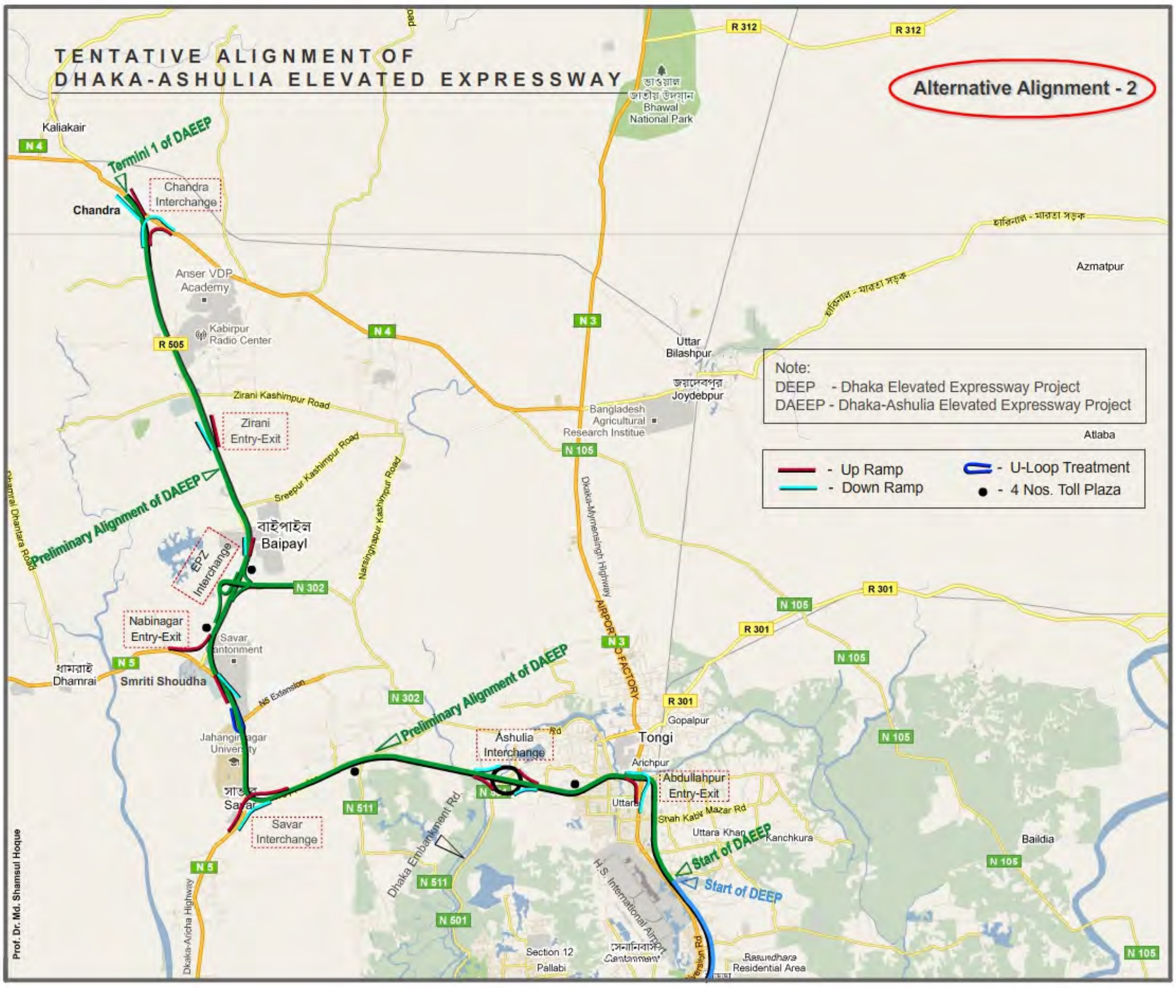


Figure 5.2: Scenario 5- Alternative Alignment-2

5.4 Review of Project Surround Road Network

5.4.1 Road Infrastructure

Geographically, most of the proposed project adjacent area lies above flood level and as a result road is the prime means of movement. Two major highways pass through the project area connecting Dhaka with the northern and north-western districts of the country. These are, Dhaka-Paturia/Aricha Highway (N5) connecting north-western districts; and Dhaka-Mymenshingh Road leading to northern districts (N3). Besides, Dhaka-Ashulia Road links, Dhaka-Tongi Road with Nabinagar-Chandra Road connecting Dhaka-Tangail and Hemayetpur-Singair Road connects Dhaka with Manikgaj through Singair Thana as regional highway.

Within the project area there are regional R-1 and R-2 roads connecting the vast rural areas with the district headquarters through Thana and union headquarters. It has been observed from the physical infrastructure survey conducted by RAJUK in preparation of detailed area plan that the project area served by about 3190 km of road in which 42 km of national highway, 13 km of regional highway and 3135 km of local and other roads. The highest part of the national (7.96 km) highway passes through Pathalia Union followed by Savar Pourashava (7.17 km) and Dhamsona Union (5.36 km). The road network of the project area is shown in Figure 5.3.

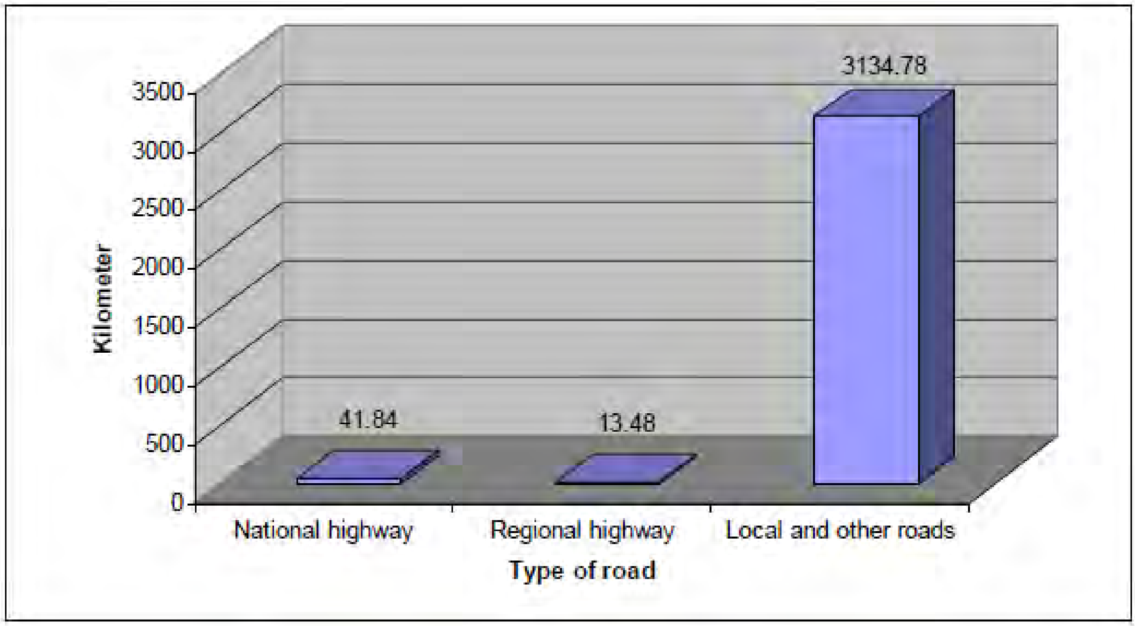


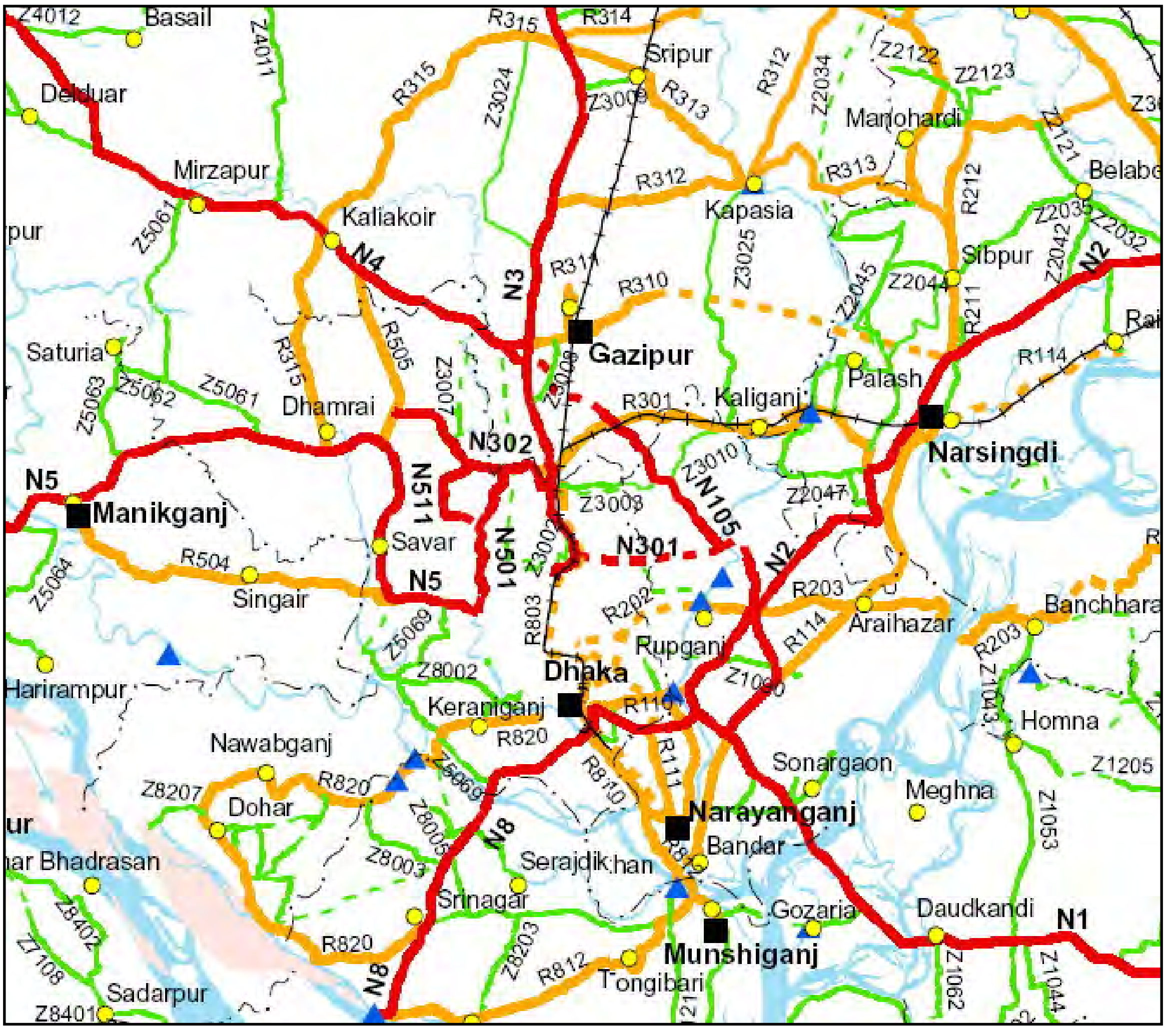
Figure 5.3: Length of road network by hierarchy
(Source: Final Plan Report, Preparation of Detailed Area Plan for Group-E for DMDP, RAJUK)

Parts of three regional highway passes through the project area sharing three unions namely Basan (9.33 km), Pathalia (1.27 km) and Ashulia (2.88 km). These roads are Dhaka bypass, Joydebpur-Kaliakair road, Nabinagar-EPZ road and Ashulia-Tongi road. All roads in the category of Upazila and Union roads are being accounted as local and other roads. It is observed from the physical infrastructure survey that about 3135 km roads of this category are exist in the study area. These includes bituminous, HBB and earthen roads.

The project area accommodates two national highways. One connects Dhaka with south-western region of Bangladesh through Paturia Ferry Ghat and the other highway links the capital city with northern districts through Uttara-Ashulia-Chandra-Tangail-Jamuna Bridge. Nabinagar-Baipail (EPZ) Road links both the highways. The total of bituminous roads in the project area stands at 572.86 km.

5.4.2 Proposed Road Network Improvements

In detailed area plan (DAP) prepared by RAJUK, revealed that a number of primary and collector, tertiary and access roads have been recommended for the project area. Besides, widening of many existing narrow roads has been suggested. The road proposals are based on review of Structure Plan and Strategic Transport Plan (STP) proposals. Some modifications have been suggested for STP proposals, while full support has been extended to the Structure Plan road recommendations.



Source: RHD

Figure 5.4: Project Area Road Network

Following are the different categories of new roads proposed for development in the project area.

a. Primary or Arterial Road Proposals

The purpose of arterial roads is to set up regional links as well as to create bypass facilities to avoid congestion in existing major roads. Instead of connecting the proposed north-south main road with Nabinagar-Chandra Road near EPZ extending from Baliarpur point in the south, as per STP proposal, the road is proposed to be moved further north through Kashimpur and join Joydebpur-Chandra Road (13.22 km). As per Structure Plan there is a proposal of C&B Road upgradation into a main road to establish an alternative east-west link. There is also a proposal of upgradation of Cantonment-Jirabo Road as a Collector Road instead of a main road as proposed by STP. Other main road improvement proposals of STP, like, Hemayetpur-Singair Road and Hemayetpur-Harindhara Road are also proposed.

b. Service Road

In the highways there should be uninterrupted movement of traffic. But local traffic moving in the highways often disrupts free movement of highway traffic. To relieve the main traffic from possible interruption, the Structural Plan suggested service lanes on either side of BKSP-Kashimpur Road, which is a very busy road.

c. Road Overpass at Intersection and Bridge/Culvert

Road overpass has become imperative at some points in the study area. Savar bazaar is the busiest point where there is cross connection between Savar Bazar and Rajashan through Rajashan Road crossing Dhaka-Aricha Highway. The Dhaka–Aricha Highway at Savar bazaar point is often interrupted by traffic moving eastward to Savar Bazar or westward to Rajashan. To keep the highway traffic movement uninterrupted the Structural Plan proposes to develop an overpass the highway on Savar-Rajashan Road. Another overpass is proposed at EPZ point. At this point traffic from south turning to the industrial areas including EPZ in the east and traffic coming from the north turning to the EPZ often create interruption of highway traffic movement.

Beside the above project area specific road improvement and development proposals, Table 5.1 enlists the major improvements from the Strategic Transport Plan (STP) that will be made to the road network in the model between 2005-2009, 2010-2014 and 2015-2019. Additionally, other proposed network improvements not part of the STP are listed in Table 5.2. STP was developed in the year of 2004/05 and many of the proposed improvements in Phase 1 have not occurred even now. So, it may be inferred that the project planned for later periods will also be delayed possibly.

Table 5.1: Summary of Proposed Projects in STP

No	Name/Location	Type of Work	Agency
STP Phase 1 Projects for S.T.P. for Dhaka (2005-2009)			
1.	Zia Colony to Mirpur Road	Road	DCC
2.	Pantha Path to Rampura Highway	Road	
3.	Tejgaon – Airport Tunnel	Tunnel	DCC
4.	Merul Badda to Golokandial Highway Upgrading- this is a link to the Dhaka Bypass	Road	RHD
5.	Tongi to Ghorashal Highway	Road	RHD
6.	Malibagh to Janapath Highway 700 m dual 3 lane highway	Road	RAJUK
7.	Dhaka Elevated Expressway	Road	BBA
8.	Gulistan to Jatrabari Flyover	Flyover	DCC
9.	MoghBazar Mouchak Flyover (possibly DEE phase 1)	Flyover	BBA
10.	BRT Line (1)	BRT	
11.	BRT Line (2)	BRT	
STP Phase 2 Projects for S.T.P. for Dhaka (2010-2014)			
12.	Agargaon Road to Mirpur Section 2	Road	DCC
13.	Bangla College to Kafrul	Road	DCC
14.	Baijoy Sarani – Shaheed Tazuddin Road	Road	RAJUK
15.	Tongi-Ghorashal	Road	RHD
16.	Circular Ring Road	Road	RHD
17.	Jikatala – Hazaribaag	Road	DCC
18.	Mirpur 14 (Sagorika) – New Airport Road Banani	Road	DCC
19.	Gulistan – Jatrabari Flyover	Flyover	DCC
20.	Jatrabari Bridge – Polder Road	Road	RHD
21.	MoghBazar – Mouchak Flyover	Flyover	BBA

22.	Pallabi – Western Embankment	Road	RHD
23.	BRT line (3)	BRT	
STP Phase 3A Projects for S.T.P. for Dhaka (2015-2019)			
24.	Khilkhet- Eastern Bypass	Road	RHD
25.	Eastern Bypass – Dhaka Bypass	Road	RHD
26.	Bashabo Mosque – Balu River	Road	RAJUK
27.	Eastern Bypass	Road	RHD
28.	Moghbazar – Malibagh	Road	RAJUK
29.	Western Bypass	Road	RHD
30.	Jatrabari – Demra Ghat	Road	RHD
31.	Dhaka Link Road	Road	
32.	All MRT lines	MRT	
STP Phase 3B Projects for S.T.P. for Dhaka (2020-2024)			
33.	Pragati Sarani – Balu River	Road	RHD

Table 5.2: Summary of Other Proposed Projects

No	Name/Location	Type of Work	Agency	Present Status
34.	Golap Shah Mazar to Babu Bazar (2nd Buriganga Bridge)	Flyover	BBA	Feasibility Stage
35.	Tejgaon Sat Rasta crossing to Moghbazar crossing upto Ramna P.S.	Flyover	LGED	Contractor Selection Stage
36.	Banani Rail Crossing – Zia Colony - Mirpur	Flyover	ARMY	On Going
37.	Pragati Sarani – Purbachal Road to Airport Road Junction (Kuril Flyover)	Multilayer Flyover	RAJUK	On Going
38.	Jurain Rail Crossing	Flyover	RHD	Opening 2012-13
39.	BRT Line 3 Extension (Gazipur – Airport Road)	BRT	RHD	Design Final Stage
40.	Gabtoli to Azimpur (Bangabandhu Memorial Corridor) Improvement Project	Road	DCC	Completed Feasibility
41.	Gulshan 1 to Gulshan 2 Corridor Improvement Project	Road	RHD	Completed Feasibility
42.	4 U- Loop project between Banani and Kuril Intersection	U-Loop	ARMY	Completed Feasibility

In addition to the above STP recommended road development projects, in Dhaka Urban Transport Network Development Study (DHUTS) conducted by JICA in 2010 - has recommended a few more important city peripheral road development projects particularly the outer ring road and road-grids for the fringe areas, which would provide better connectivity of the project areas viz. Ashulia, Savar, Baipayl and Dhamsona with the central part of Dhaka city. This extended road network development plan that is proposed for RAJUK area in a way for the Greater Dhaka can be seen from the following Figure 5.5.

Figure 5.5: Proposed Road Network in the RAJUK Area
(Source: Dhaka Urban Transport Network Development Study-Phase II Report)

5.5 Review of Public Transport Infrastructure

5.5.1 Bus Rapid Transit (BRT)

Strategic Transport Plan (STP) has suggested constructing three Bus Rapid Transit (BRT) routes within next ten years. Figure 5.6 shows the route alignment of these proposed routes. There has been an extension of BRT Line 3 route (Yellow Line) that extends form Shahjalal International Airport to Gazipur. Construction of this part of the project is already underway.

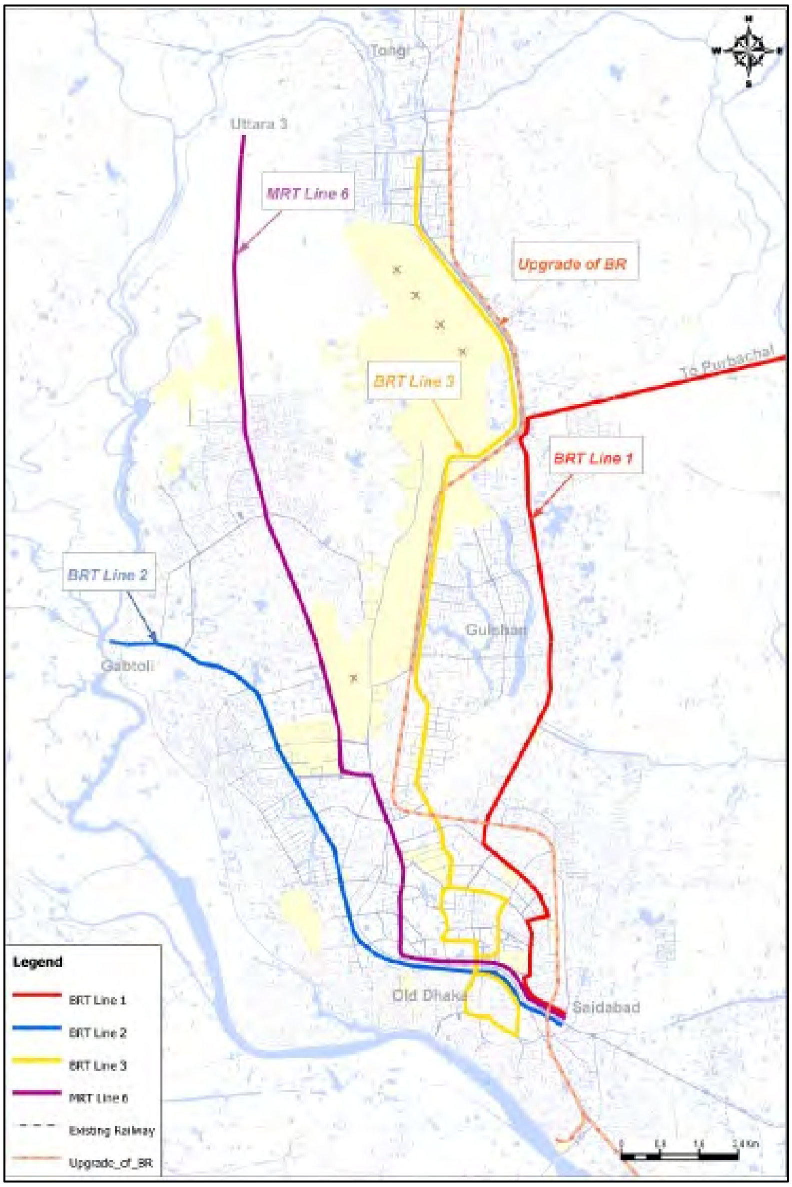


Figure 5.6: Proposed BRT Routes in STP
(Source: Dhaka Urban Transport Network Development Study-Phase II Report)

5.5.2 Mass Rapid Transit (MRT)

Three metro lines were also proposed in the Strategic Transport Plan (STP) report. Figure 5.6 summarizes route delineations of the proposed lines by STP and also shows the extended line proposed by JICA in Dhaka Urban Transport Network Development Study (DHUTS). A feasibility study on MRT Line 6 is already underway. From the close look of the Figure 5.7 it can be seen that mass rapid transit (MRT) master plan that is prepared considering planning horizon upto 2050 is also considered Savar and its adjoin areas.

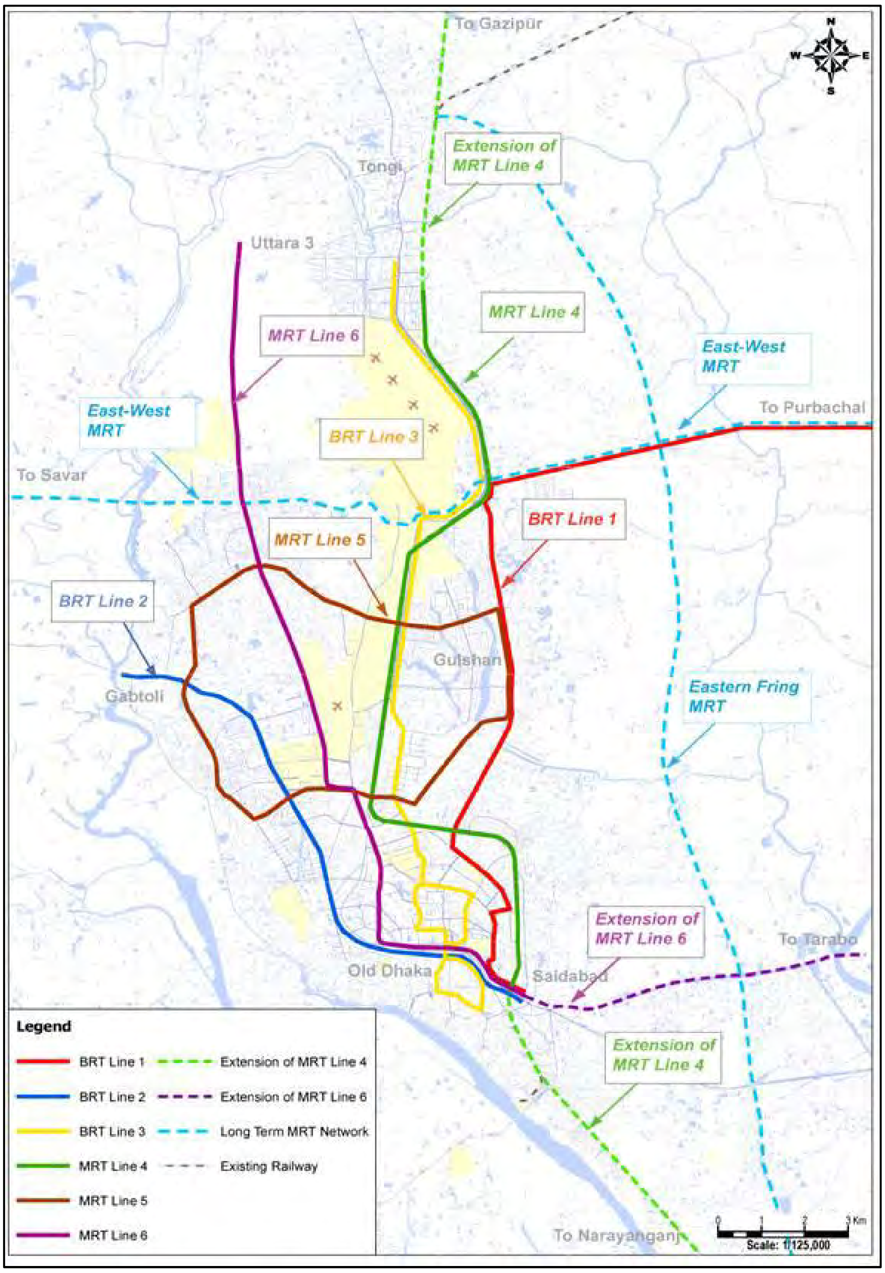


Figure 5.7: Proposed Mass Transit Network towards 2050
(Source: Dhaka Urban Transport Network Development Study-Phase II Report)

Section 6

REVIEW OF SOCIO ECONOMIC DATA

6.1 Introduction

This section reviews the influences likely to impact the traffic demand and growth in the corridor of Dhaka Ashulia Elevated Expressway (DAEEP). The primary influences on the traffic demand include :

- Population
- Vehicle Ownership
- Gross Domestic Product (GDP), GDP by main sector of the economy and GDP per capita (GDPPC)

The historic and forecast trends for these key traffic demand drives have been reviewed to assess the likely impacts on traffic growth in the area and the sensibility of the trip growth within the traffic model. The following figure shows the administrative zoning of Bangladesh. The hierarchy is as Division, District, Thana/Upazilla, Union/Ward, Village/Moholla. Generally Bangladesh Bureau of Statistics (BBS) is the designated authority that collects various important data on socio economic matters. But this data is often aggregated on the national level and level of detail of these data is also very coarse. For this reason, this study has used data from international organizations like World Bank (WB), International Monetary Fund (IMF) etc. as additional data source.

Figure 6.1: Political and Administrative Boundaries in Bangladesh and Locality Plan of Dhaka (Source:

6.2 Population and Households

Bangladesh covers an area of 1,44,000 square kilometers with a total estimated population of approximately 147 million in 2008 and annual growth of 1.7% pa. Dhaka is the capital and largest city. A large portion of the population is located around the two main cities of Dhaka and Chittagong in 2008, the population was distributed as follows:

- Dhaka division has an estimated population of 47 million people;
- Chittagong division – 29 million;
- Rajshahi division – 19 million;
- Rangpur division – 16 million;
- Khulna division – 17 million;
- Barisal division – 9 milion; and
- Sylhet division – 9 million

This country has experienced a very high rate of population growth historically. It had been growing at a rate of 2 % per annum in a period of 1971 to 1990. After 1991 we are still growing at a steady rate of 1.7% per annum. This increment implies that the capacity to accommodate more people has been decreased and we are experiencing better economic conditions in recent years.

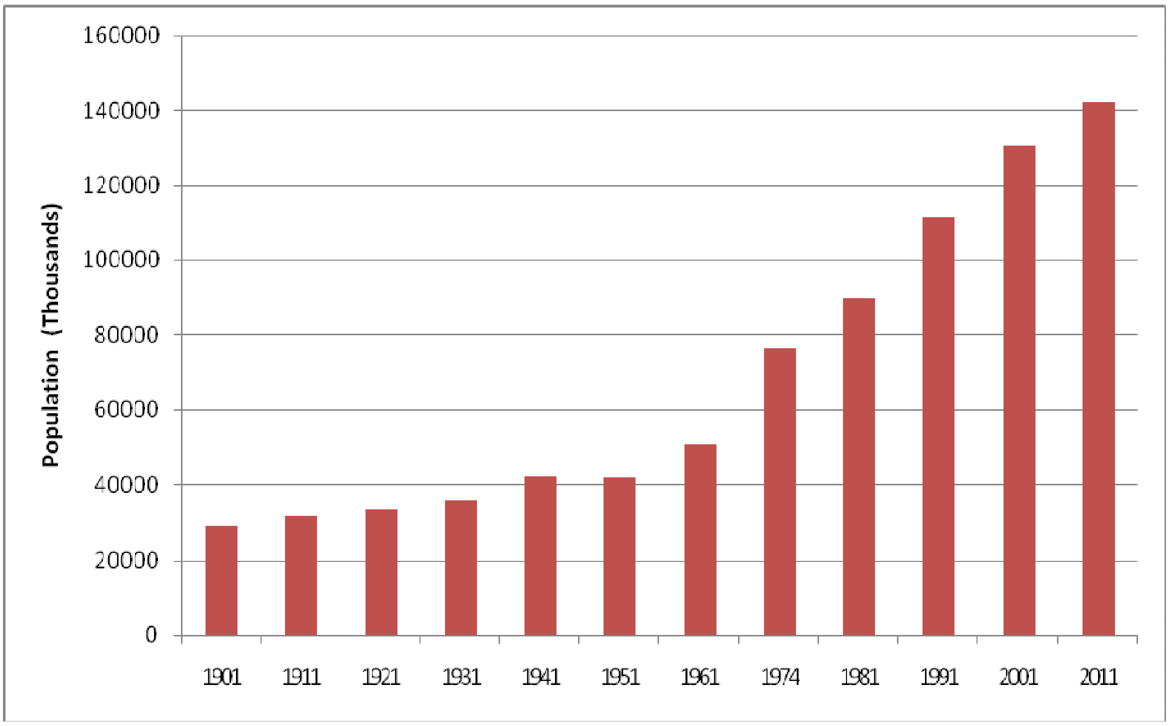


Figure 6.2: Historic Population of Bangladesh
(source: 2011 Population and Housing Census: Preliminary Results)

About thirty percent of our population lives in urban areas, primarily in Dhaka and Chittagong. However, the trend of moving towards an urban setup is more evident recently as the growth of GDP is improving. So, the population forecast model must encompass this consideration to produce a reliable estimate.

The medium variant projection that assumes NRR=1 and life expectancy at birth of 68 years by 2016, shows that Bangladesh's population will increase up to 172.3 million in 2021 and 218.04 million in 2051 which mean addition of 78.0 million more people to the present population in a span of four decades. Population growth rate will be reduced from current level of 1.5 percent to 0.56 percent in 2051. The implications of this projection are that there shall be a considerable shift in the age-structure of population.

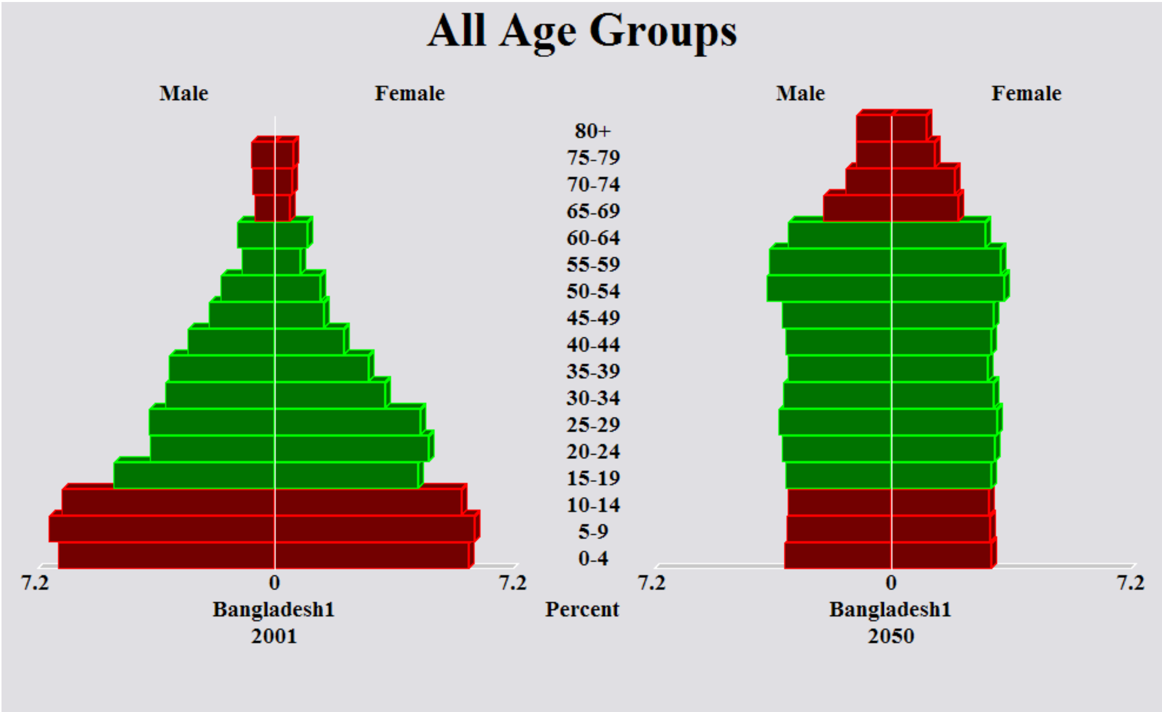


Figure 6.3: Change in Demographics in Forecasted Future
(Source: Bangladesh Population: Prospects and Problems by Dr. Mohammed A. Mabud)

For example, the size of the population below 15 years shall be 49 million in 2051 against 52.4 in 2001. The size of the school age population in absolute number shall decrease to 32.4 million against 34.2 in 2001; while the working age population (15-64) will increase up to 155 million (as against 85 million now); and number of elderly population (i.e. 65 year+) shall be 29.8 million as against 5.8 million. The other obvious implications include: population density of 4157 persons per square mile as against the present density of 2591 persons. The existing man-land ratio of 1:14 decimals shall be reduced to a half.

6.3 Vehicle Ownership

Bangladesh at present has one of the lowest vehicle ownership levels in the world. The following study done by International Monetary Fund (IMF) reveals relationship with vehicle ownership level and per-capita income.

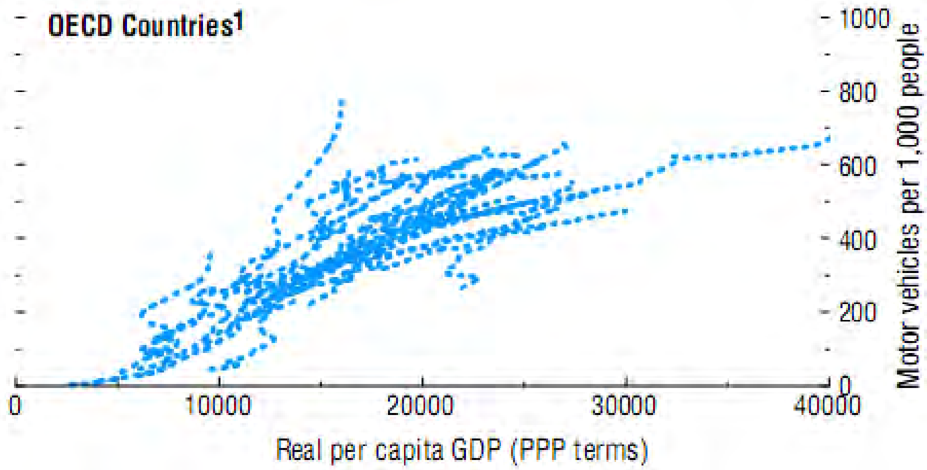


Figure 6.4 (a)

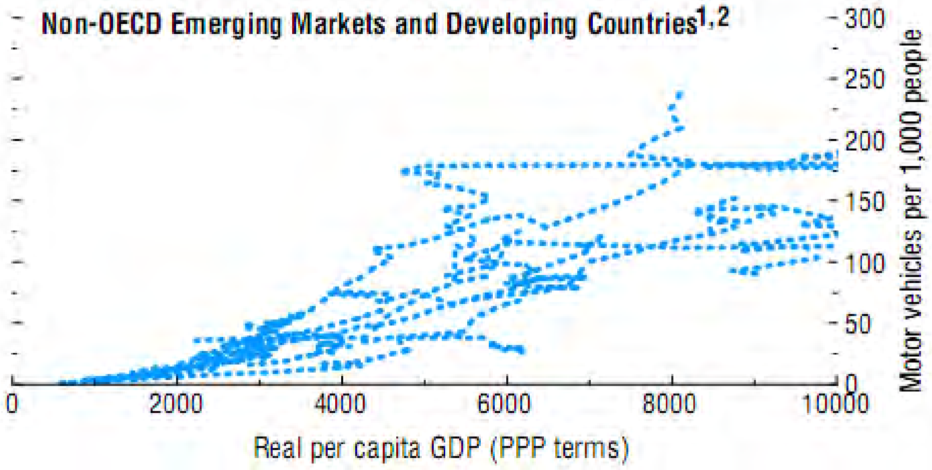


Figure 6.4 (b)

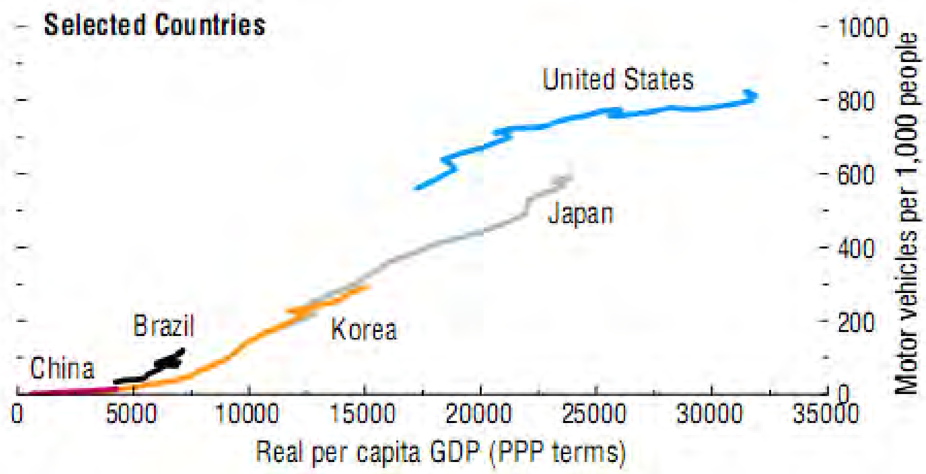


Figure 6.4 (c)

Figure 6.4 (a), (b) and (c) : Vehicle Ownership vs. per Capita Income
(Source: United Nations Statistical Yearbook; OECD analytical database; and IMF staff calculations)

The following table enlists number of registered vehicle in Bangladesh as found from Statistical Yearbook of Bangladesh.

Table 6.1: Registered Vehicle in Bangladesh

Year	Bus	Truck	Jeep (SUV)	Car	Taxi	Auto Rickshaw	Motor-cycle	Others	Total
1985	21000	30900	16800	49350	1545	19800	77000	1854	218249
1986	22050	31830	17640	51820	1590	21780	84700	1910	233320
1987	23150	32780	18520	54480	1640	23958	93170	1910	249608
1988	24250	33800	19650	58000	1850	26460	100750	2000	266760
1989	24600	35200	25505	65000	2500	30200	125000	2500	310505
1990	25655	37312	28008	68380	2650	32616	138750	2750	336121
1991	26449	38448	30133	71373	2671	36796	150171	2817	358858
1992	26946	39307	31600	72719	2690	40114	158588	2830	374794
1993	27469	40373	33477	75243	2780	43863	165360	2860	391425
1994	28463	42337	36332	79411	2787	52851	173167	3328	418676
1995	29484	45805	38513	86375	2804	68039	182035	3372	456427
1996	30428	48734	41321	98854	2863	79293	196012	4059	501564
1997	31398	50016	43080	107208	2877	85839	208092	5577	534087
1998	32281	52749	45253	113084	2980	90242	222617	7253	566459
1999	33027	54767	46476	118070	3196	92382	239128	9541	596587
2000	33768	57492	48295	122157	3776	95517	253742	10571	625318
2001	35580	60067	50760	128744	4547	95914	278151	13071	666834
2002	38634	62444	53798	135501	6780	101393	307198	15702	721450
2003	40649	65239	55602	142546	11800	115249	328294	19916	779295
2004	42128	67822	58116	147956	12340	124223	353235	22187	828007
2005	43272	70613	62079	154387	12855	129100	396461	25592	894359
2006	44533	73678	67619	162834	13130	135998	447567	29164	974523
2007	46283	76199	73269	174775	13145	146528	532698	32630	1.10E+06
2008	47232	78808	79806	191702	13154	165599	626289	36706	1.20E+06
2009	48736	85369	88833	213163	13166	180501	711431	43340	1.40E+06
2010	50280	95425	96873	233853	13166	199519	799930	56671	1.50E+06

From the above table it is evident that number of registered motorcycle in Bangladesh is very high compared to the other modes. Generally, with the increase of wealth of a country, motorcycle ownership is the first to take off. That is also reflected in slightly higher rate (2.58) of motorcycles per 1000 people in Bangladesh. The level of motorcycle ownership is more evenly distributed between Dhaka and the remainder of Bangladesh. As per "Statistical Year Book of Bangladesh, 2007", car ownership per 1000 people is 0.64 cars. Majority of the cars are registered in Dhaka, primarily because it has the largest proportion of high income earners.

Figure 6.5 and Figure 6.6 describe the incremental trend of different vehicles and passenger cars respectively for a time period of 2003 to 2009.

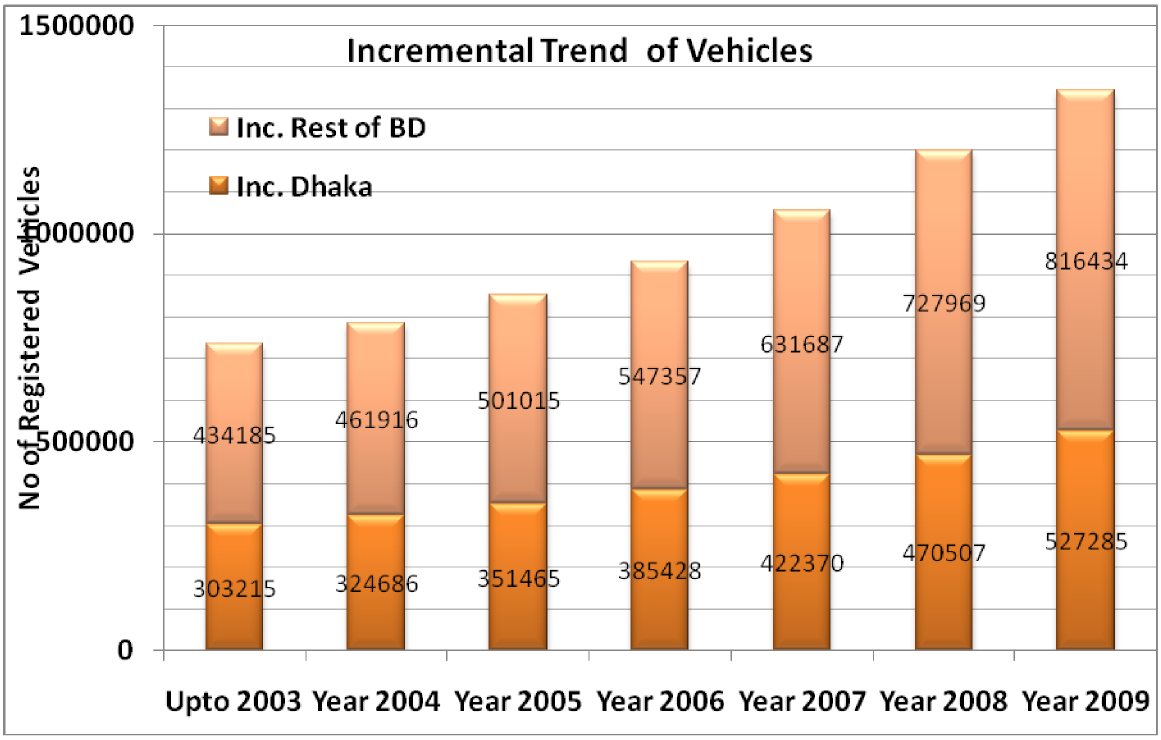


Figure 6.5: Incremental Trend of Traffic for Dhaka and Rest of Bangladesh

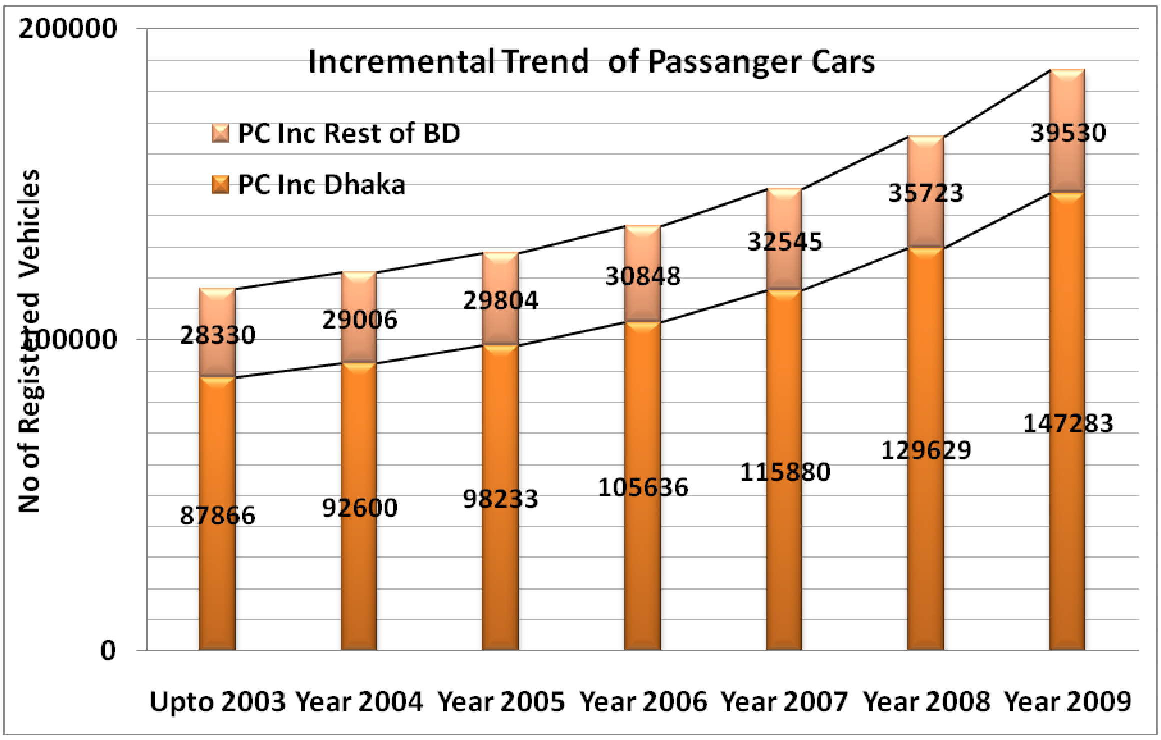


Figure 6.6: Incremental Trend of Passenger Cars for Dhaka & Rest of Bangladesh

The vehicle ownership model is developed using these data and combining them with demographic and economic forecasts. Figure 6.7 describes the forecasted growth rates for the modeled time horizon. Also, variation of rates due to change in GDP growth rates is also reflected into the prediction.

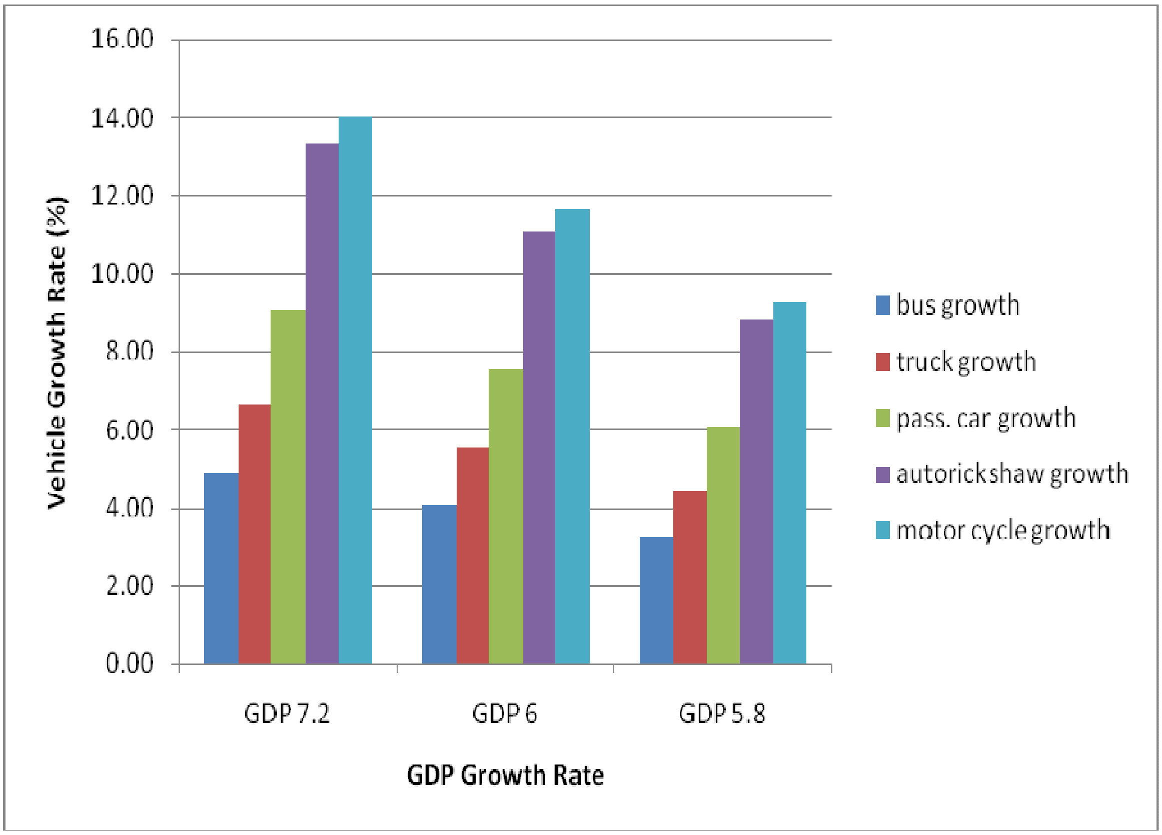


Figure 6.7: Forecasted Vehicle Growth at different Economic Growth Conditions

6.4 Economic Parameters

6.4.1 Gross Domestic Product (GDP)

GDP forecast is adopted from International Monetary Fund (IMF) World Economic Outlook (April 2012). Figure 6.8 shows the line diagrams of the forecast from different aspects.

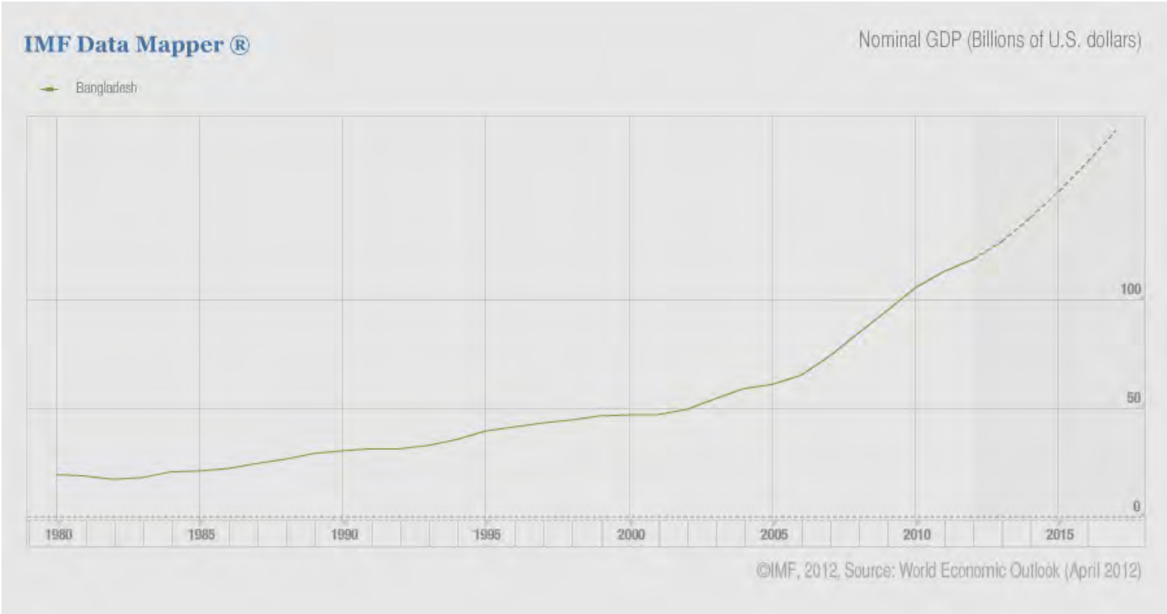


Figure 6.8 (a): Nominal GDP Forecast

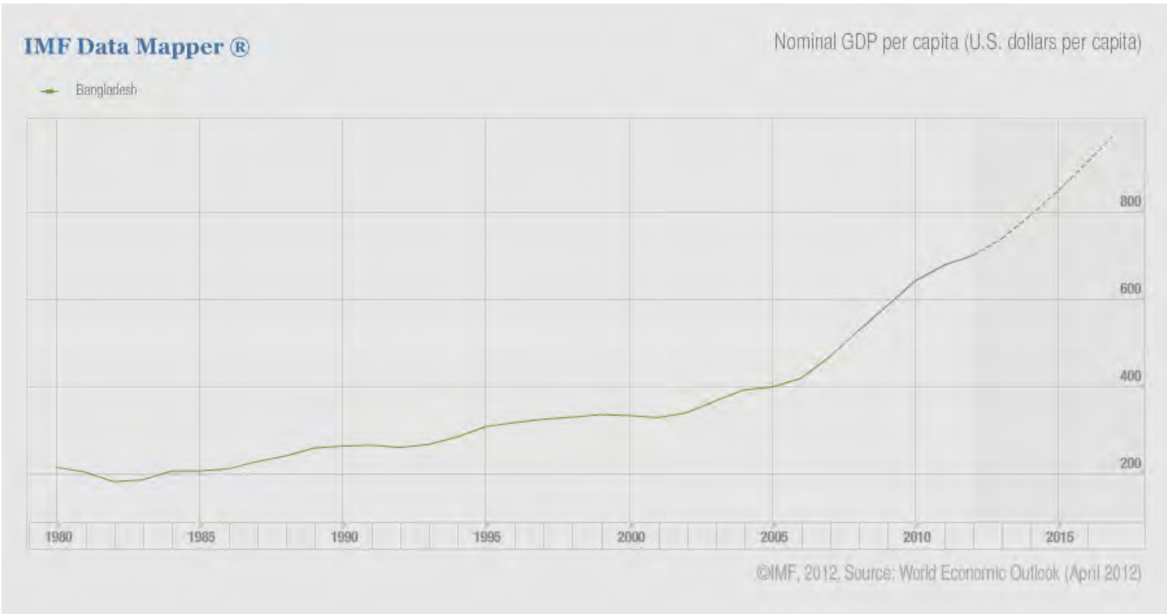


Figure 6.8 (b): Nominal GDP per Capita Forecast

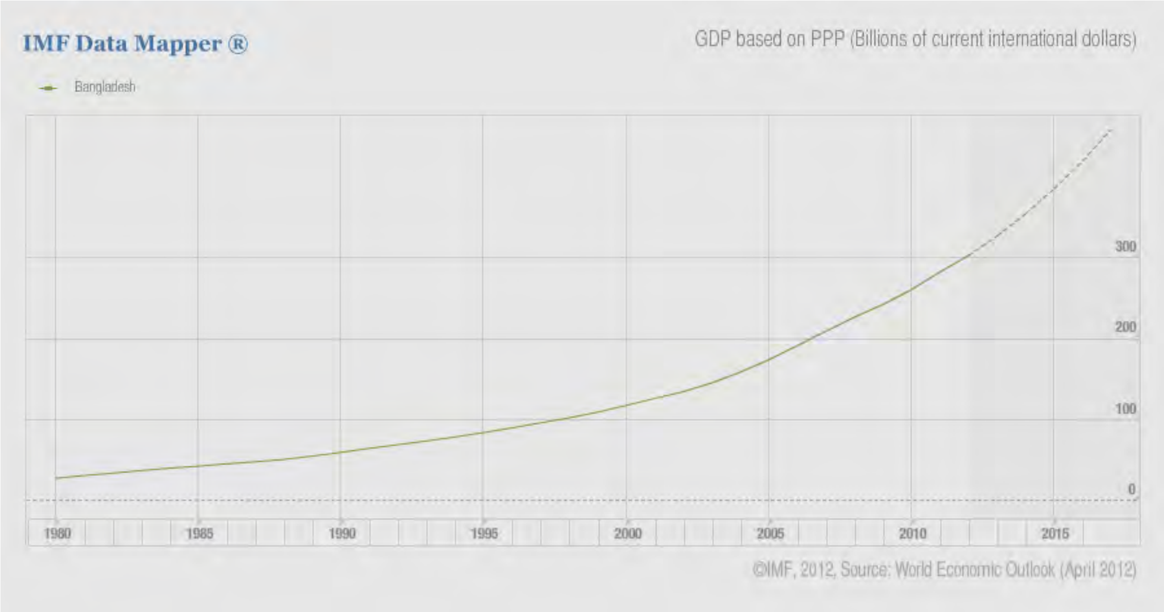


Figure 6.8 (c): GDP based on Purchasing Power Parity (PPP) Forecast

Figure 6.8 (d): GDP based on Purchasing Power Parity (PPP) Per Capita Forecast

IMF had provided this forecast based on regression analysis done on historic database. Major events in the timeline are also included into consideration that may affect the forecasted value. In the broader context of time it becomes increasingly difficult to get a proper prediction of future values. From the analysis it is found that beyond 2012 the nominal GDP will experience a growth rate of about 11 percent and real GDP will experience a growth rate of nearly 7 percent. The adopted growth rate for the main modeling is described in Table 6.2.

Table 6.2: Adopted Forecasts on Real GDP and GDPPC for Modeling

Timeline	Real GDP Growth	Real GDPPC Growth
2011 – 2015	6.4%	4.9%
2015 – 2020	5.5%	4.3%
2020 - 2025	5.3%	4.2%
2025 - 2050	5.2%	4.1%

6.4.2 Consumer Price Index (CPI)

A consumer price index (CPI) measures changes in the price level of consumer goods and services purchased by households. Historically, the inflation rate of Bangladesh is limited within 2 percent to 8 percent per annum. Very recently this indicator has reached double figures and IMF has also forecasted a similar outcome in their World Economic Outlook (April 2012) report. Figure 6.9 shows the CPI getting near 5 in the forecasted future. That implies the long term average of inflation will be around 6% per year (according to IMF prediction).

Figure 6.9: Consumer Price Index (CPI) Forecast

Section 7

TRAFFIC DATA REVIEW AND COLLECTION

7.1 Traffic Survey Conducted in 2011

We had to conduct our very own traffic survey in order to verify the authenticity of the collected data and to adjust the past matrices in accordance with the present traffic scenario. As the landuse pattern and traffic usage characteristics of the studied region are very dynamic in nature, a rigorous study of traffic was warranted to get a reliable forecast. Accordingly, a survey program was developed and three different types of surveys were undertaken:

- Road Traffic Counts
    - Manual classified traffic volume count at major sections
    - Video recording to verify and authenticate manual counts
- Journey Time Survey
- Pilot Origin Destination Survey to get potential sources and pools

The locations of traffic survey are shown in the following Figure 7.1. Summary of results of the surveys are presented in the subsequent sections as follows :

- Traffic Count Data – Section 7.2
- Journey Time Survey – Section 7.3
- Pilot Origin and Destination Survey – Section 7.4
- Characteristics of Traffic at Survey Locations – Section 7.5
- Comparison of Survey Data – Section 7.6

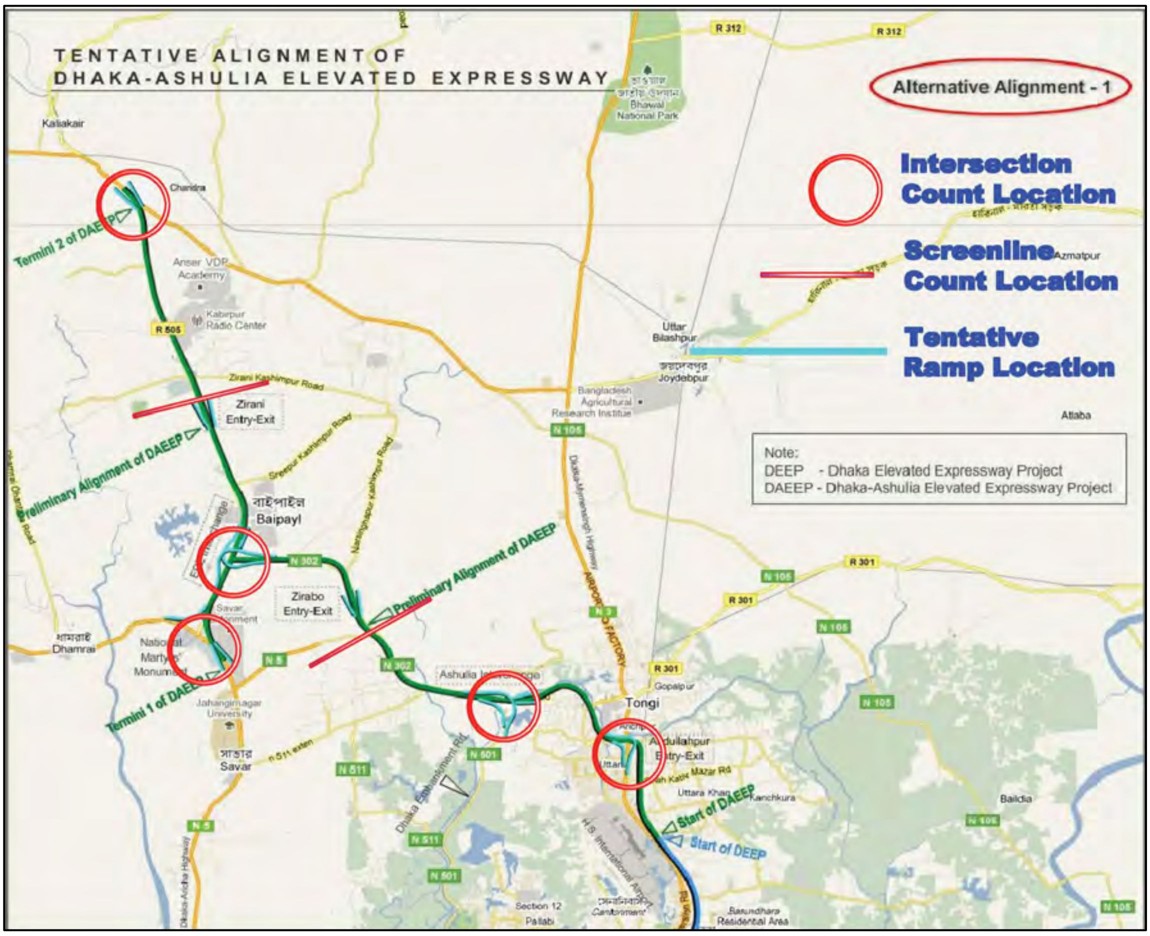


Figure 7.1: Traffic Survey Locations

Adopted value of travel time savings and willingness to pay for the improved facility is discussed in **Section 8.0.**

7.2 Traffic Count Data

The traffic counts were undertaken from May 2011 to July 2011. We have employed both manual counting and video recording to cross check the validity of our collected data. All our surveyors were final year civil engineering students of Bangladesh University of Engineering and Technology and had previous exposure to transportation engineering surveying techniques. This expertise has enabled us a better collection of data as verified in our cross check with video recording.

We had employed different groups of surveyors to our strategically selected traffic count locations at different hours of the day. Moreover, we have conducted a whole day survey on 26th May 2011 to capture the variation of vehicle movement with time of the day over the total network.

7.2.1 Vehicle Classes

Though Roads and Highways Department (RHD) has ten standard motorized vehicle classes, we have employed seven classes of motorized vehicles for suitability to be used in our model. These classes are:

- Heavy Trucks (HT)
- Trucks (T)
- Mini Buses (MB)
- Buses (B)
- Passenger Car (C)
- Motor Cycle (MC)
- Three Wheelers (TW)

Heavy Trucks (HT)
These vehicle classes are basically designated to heavy trucks, container carriers, covered vans and multi axel semi trailers. Basically this class of vehicle is employed to commercially important movements. Movement of this type of vehicle is generated from the nearby industrial developments e.g. EPZ area, Dhaka- Tangail Highway and mostly targeted towards the port at Chittagong and the capital itself.

Trucks (T)
This vehicle class contains the usual trucks that are used for good movements in daily basis. Usually they have shorter trip lengths compared to the heavy trucks and the travel behavior of these vehicles is different compared to the HTs.

Mini Buses (MB)
This vehicle category consists of local passenger buses that are basically employed for commuting services for people living nearby. Trip length is usually shorter than intercity travels. As the location of this proposed project is at the outskirts of the city, most minibus trips generates within the city and ends at different suburban localities and nearby towns.

Buses (B)
These are large buses with greater passenger capacity and usual trip length is higher than MBs. These buses also make less frequent stoppage than MBs. Travel behavior of this vehicle category is entirely different because most of the trip makers are intercity travelers.

Passenger Cars (C)
This class includes all passenger cars, taxi-cabs, micro-buses, Sports Utility Vehicles (SUVs). Trip making characteristics of this class does not conform to any usual pattern. But it is evident that most of the trips of this class generates within the city.

Motor Cycles (MC)
This vehicle is the highest growing vehicle class of this country. Mostly used for commuting purposes of the individuals, this class is the most sensitive group to any tolling strategy. Since they have a major vehicle share with an interesting travel behavior pattern, they should be analyzed with careful examination.

Three Wheelers (TW)
This vehicle class represents the most common para-transit system of Dhaka. It can carry two to three passengers at a time. Its use is more widespread in recent years as they are using a cleaner mode of fuel e.g. Compressed Natural Gas (CNG) that is available at lower price than its alternatives.

All other non motorized vehicles were counted as another different class. As the grade separated infrastructure would not be able to accommodate NMTs, in modeling they were purposefully been eliminated in the elevated portions. NMTs in our region mainly consisted of Rickshaws, Push Carts and Van Carts.


Figure 7.2 (a): Trucks (T)


Figure 7.2 (b): Semitrailer (HT)


Figure 7.2 (c): Minibus (MB)

Figure 7.2 (d): Buses (B)

7.2.2 Traffic Count Sheet

The traffic count sheet was designed as a general one to be used by all the surveyors. Provision of inclusion for traffic counts at strategically selected time packs (usually 5 minutes) was provided. All the surveyors were required to put in their names, date, time, location, position and weather conditions in every sheet. At intersection counts all the surveyors are teamed under a station supervisor who coordinates and synchronizes the process. The prepared traffic count data sheet is shown in Figure 7.3.

Pre Feasibility Study of Dhaka-Ashulia Elevated Expressway Project
Classified Directional Manual Traffic Count Survey Data Sheet

Date:______________ Station Name:____________________ Surveyor Name:______________________
Day: ______________ Station Number:__________________ Surveyor ID:___________________
Count hrs: from__________ Approach Name:__________________ Weather Condition:Sunny / Fair / Cloudy / Rainy
to__________hrs

Time Pack	Time (*Sample 9:00 to 9:05*)	1 Car, Jeep, Taxi, Micro	2 Minibus (Local)	3 Bus (Intercity)	4 NMT	5 ***Freight Vehicle***	6 Other Trucks, Pickups	7 3 Wheelers	8 Motorcycle	9 Others	**Total Traffic/ Time Pack**
1											
2											
3											
4											
5											
6											
7											
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10											
11											
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17											
18											
19											
20											
21											
22											
23											
Total Vehicle/type											

Figure 7.3: The Traffic Count Sheet

7.2.3 Survey Locations

Basically we have used two types of survey locations:

- Intersection count location;
- Screen line count location.

There were five strategically selected intersection count locations and two screen line locations. Studying the basic flow patterns in and out of these locations could provide us with valuable insight of origin destination pattern, speed-flow characteristics and congestion levels of the studied region. The following figures describe different flows that were surveyed distinctly to capture vehicle movement pattern over the network.

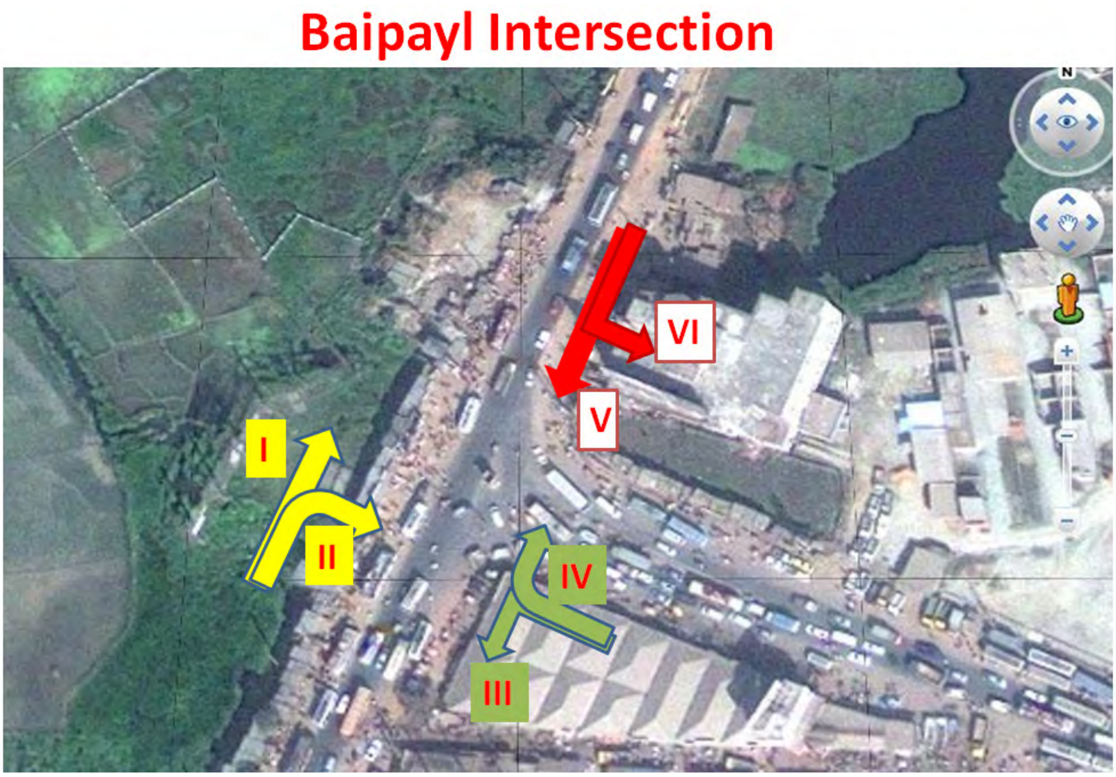


Figure 7.5(a): Location and Flow Distribution in Baipayl Intersection (BP)

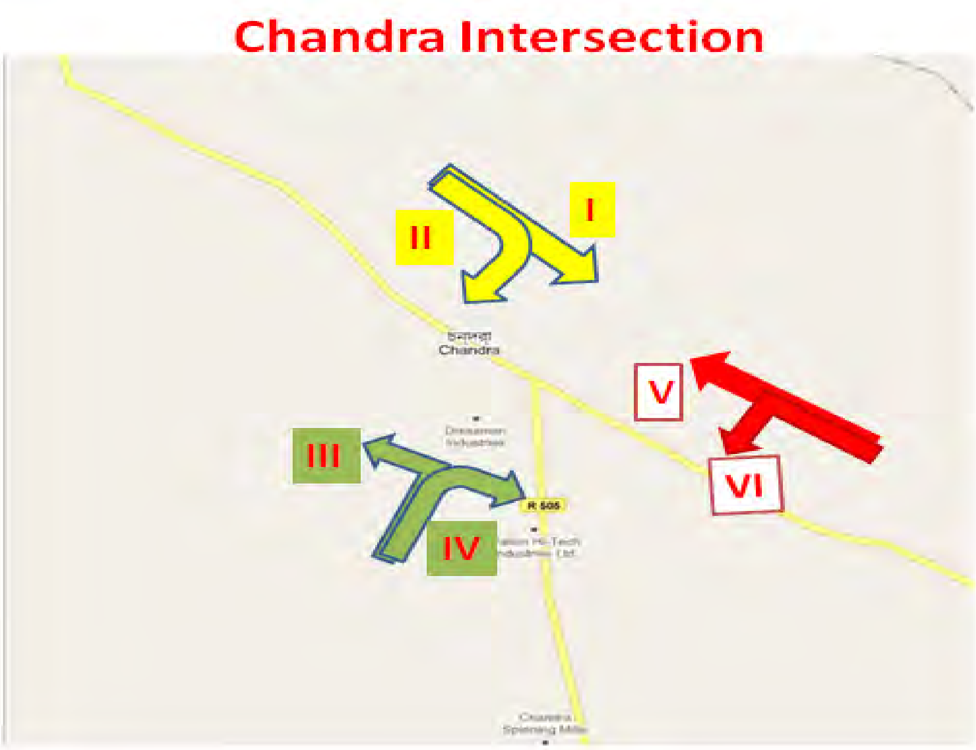


Figure 7.5(b): Location and Flow Distribution in Chandra Intersection (CRA)

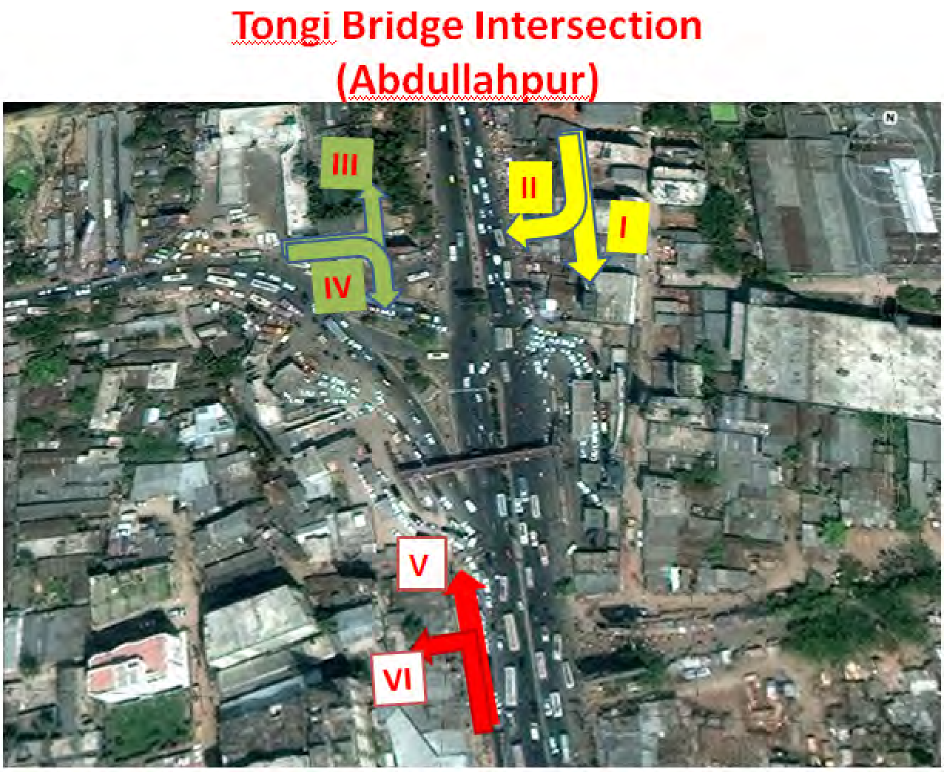


Figure 7.5(c): Location and Flow Distribution in Abdullahpur Intersection (TB)

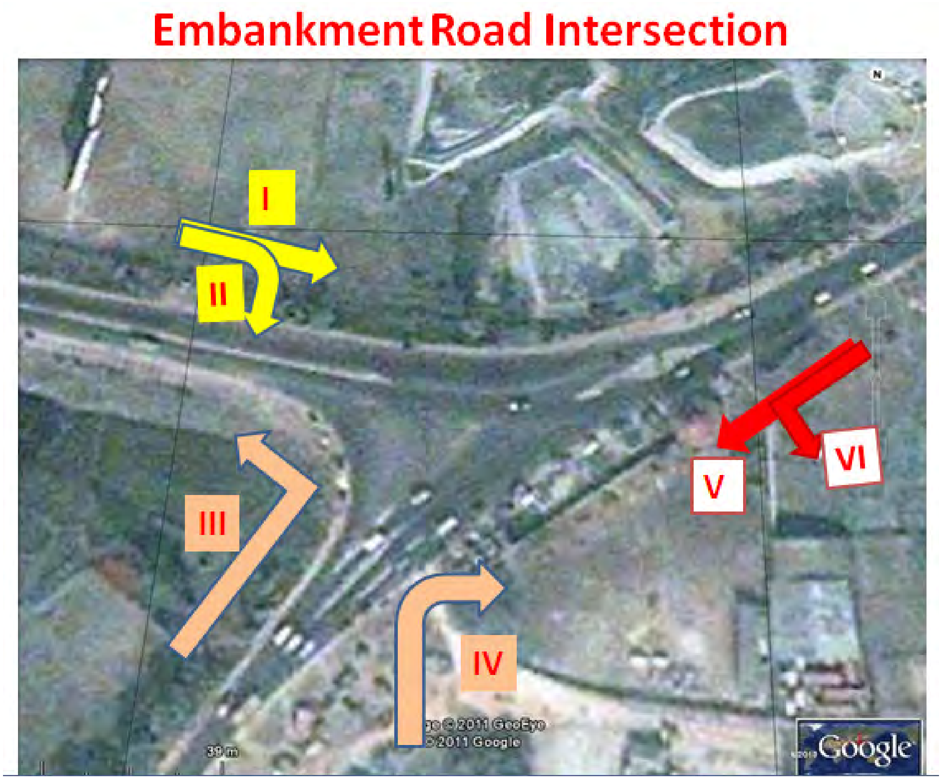


Figure 7.5(d): Location & Flow Distribution in Ashulia Beribandh Intersection (ERI)

Jirabo Point

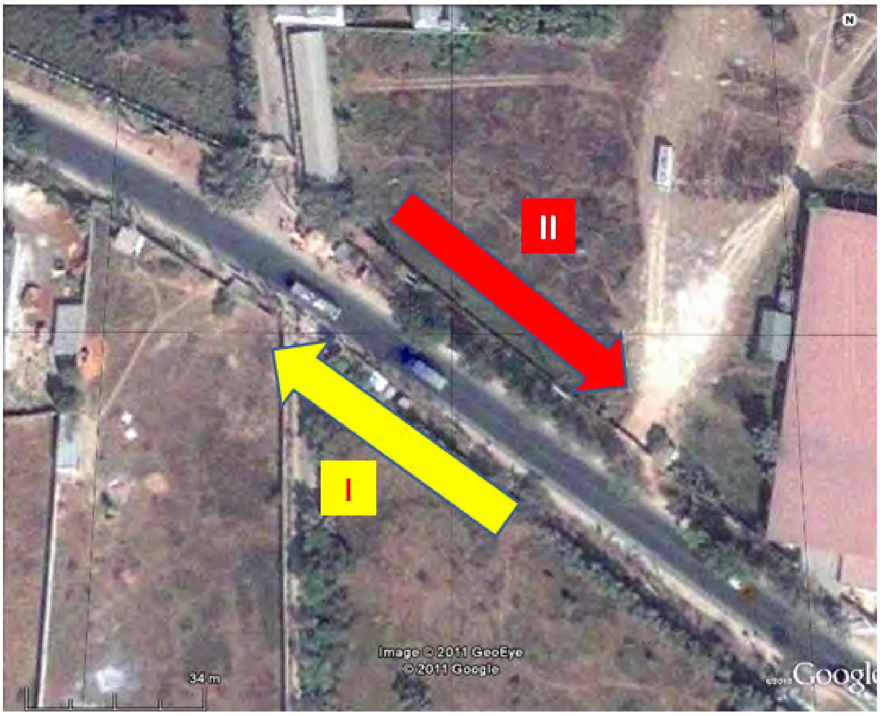


Figure 7.5(e): Location and Flow Distribution at Jirabo (JBO)

Jirani Point

Figure 7.5(f): Location and Flow Distribution at Jirani (JNI)

Nabinagar Intersection

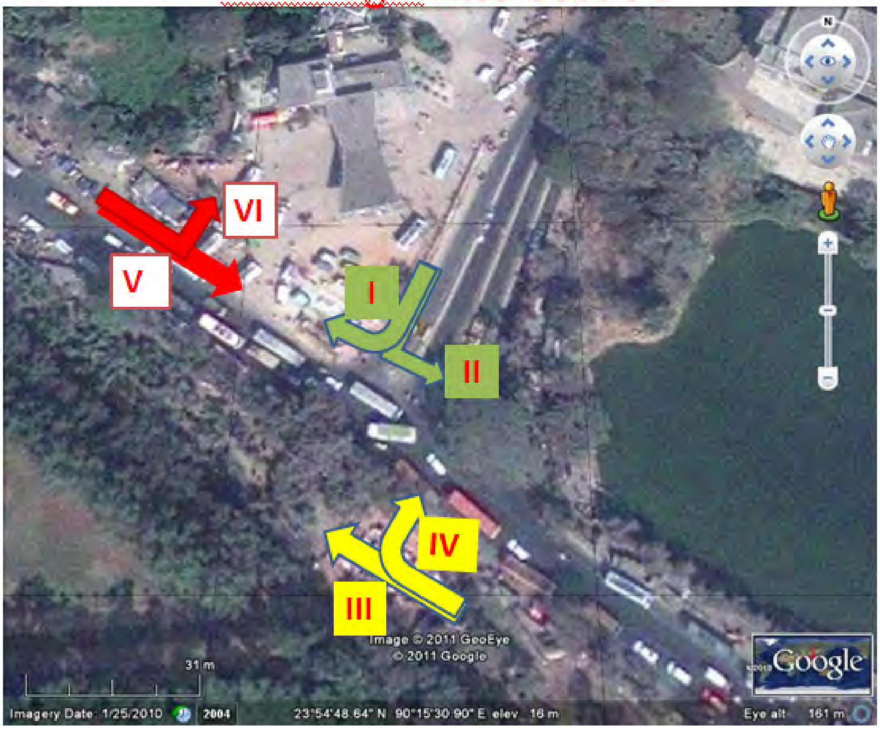


Figure 7.5(g): Location and Flow Distribution in Nabinagar Intersection (NN)

7.2.4 Survey Process

With the participation of over 100 surveyors, the day 26th May, 2011 is marked with great significance in the traffic forecasting of this pre-feasibility study. As that is true about all transportation projects in Bangladesh, we too did face tremendous scarcity of reliable and applicable data to capture the base year network scenario and to adjust other parameters for traffic modeling. But in collaboration with the Transportation Engineering Division, BUET, we could manage the best quality surveyors and lab facilities of the country to overcome this problem. This over the day data collection throughout the whole network has also enabled us to verify other available secondary data sources e.g. RHD, BRTA etc. We could also establish required expansion factors for different periods of the day. In conjugation with the surveyed data within the period of May 2011 to June 2011 collected at other days of the week we have been able to capture for both weekend and weekday traffic.

The surveyors were divided in two groups: Flange Group (Nabinagar, Baipayl, Jirani, Chandra) and Web Group (Abdullahpur, Ashulia and Jirabo). Each group was appointed with one group leader who was in charge of deployment, synchronization and coordination of the group members. Group leaders managed sub-group leaders at each survey location and the sub- group leaders managed the team leaders for the flow count of each individual flows that are marked in the figures of survey locations. All the surveyors are trained in two successive sessions by expert transportation engineering professionals of the consulting team.

During this survey period we have collected data on both day and night traffic for several days to get the proper idea on average traffic volume. But manual traffic counting is error prone and past experience shows us that it tends to underestimate the total counting as it gets increasingly difficult to count all the vehicles in a congested stream. For that reason, this survey also included video recording of the traffic data at different times and at different locations that can complement the manual count data. From our video counting it is found that manual counting of this survey tend to underreport the number by 2 percent to 13 percent in some cases. So, the calculation includes a multiplier of 1.07 to properly reflect the base year traffic count.

Figure 7.6: Training Surveyors on Data Collection

Figure 7.7: Surveyors with the Experts before Starting (26th May, 2011)

Figure 7.8: A Team of Surveyors Collecting Data at Baipayl (Survey Location)

Figure 7.9: Surveyors Collecting Data at Night

7.3 Journey Time Survey

In our survey we have also conducted journey time surveys to get the actual travel time for getting through the study area in base year. Data was collected by Floating car method. Vehicle mounted GPS devices were used for this purpose. These devices can store vehicle position data along with the time stamp during the entire journey in traffic stream. Travel time raw data is presented in Appendix C. Survey results are then used to calibrate our journey time model. Figures 7.10, 7.11, 2.12 and 7.13 describe the results of journey time surveys, show the base year model can predict journey time quite effectively.

Two journey time routes are surveyed over several days and during different time periods. They are Abdullahpur – Baipayl section and Nabinagar – Chandra section. Approximate average speed in both these section remains near 15 km/hr. However, great variation of time is observed for the first route compared to the second one.

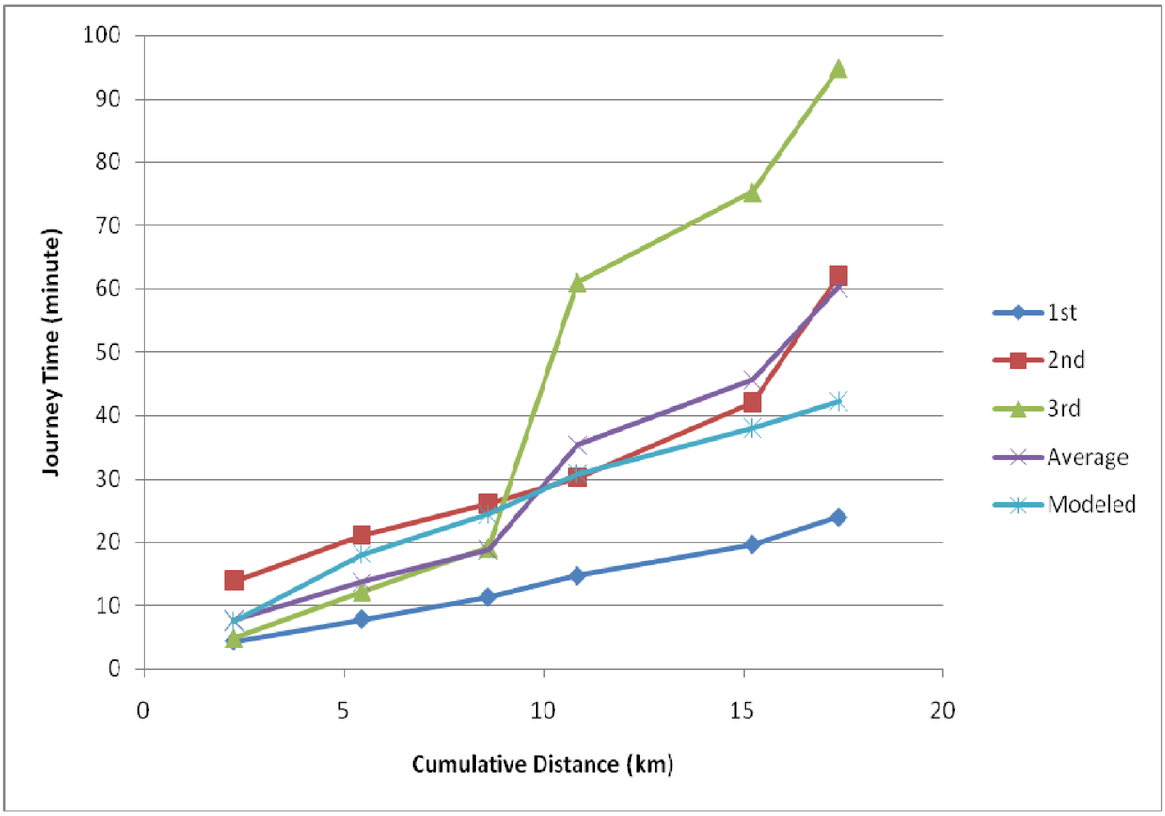


Figure 7.10: Journey Time vs. Distance in Abdullahpur – Baipayl section

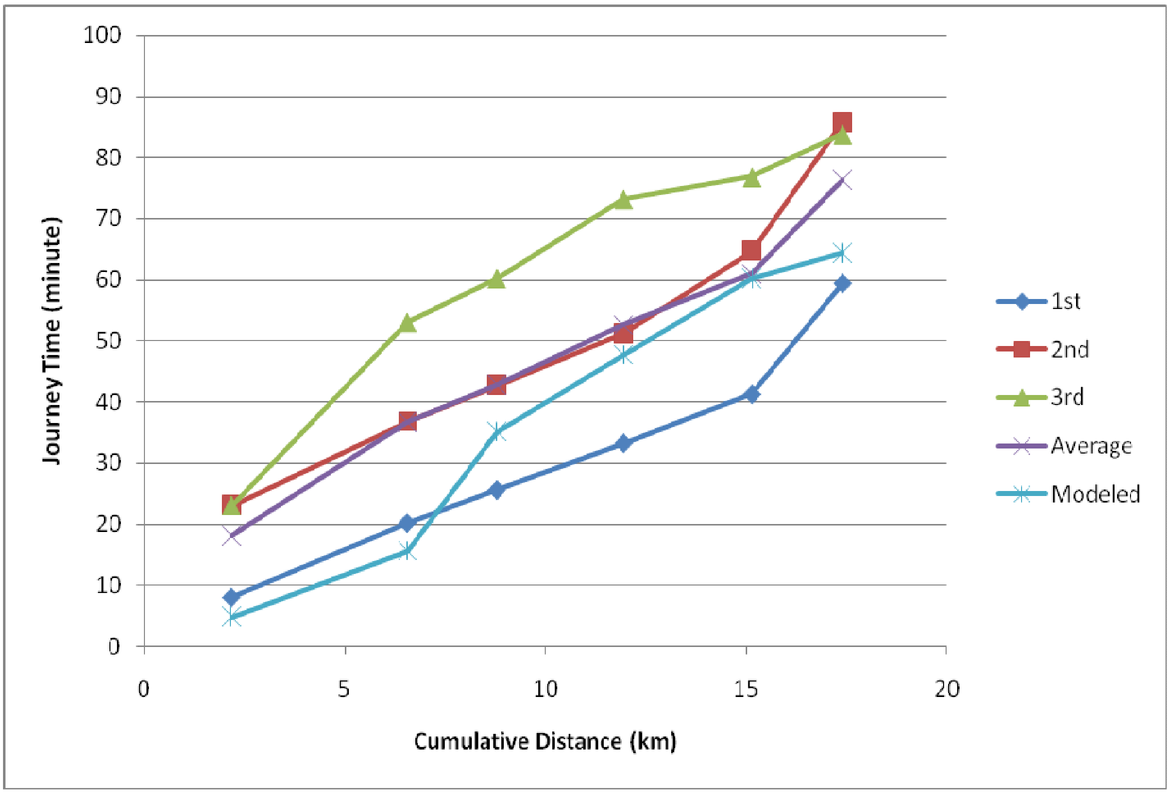


Figure 7.11: Journey Time vs. Distance in Baipayl – Abdullahpur Section

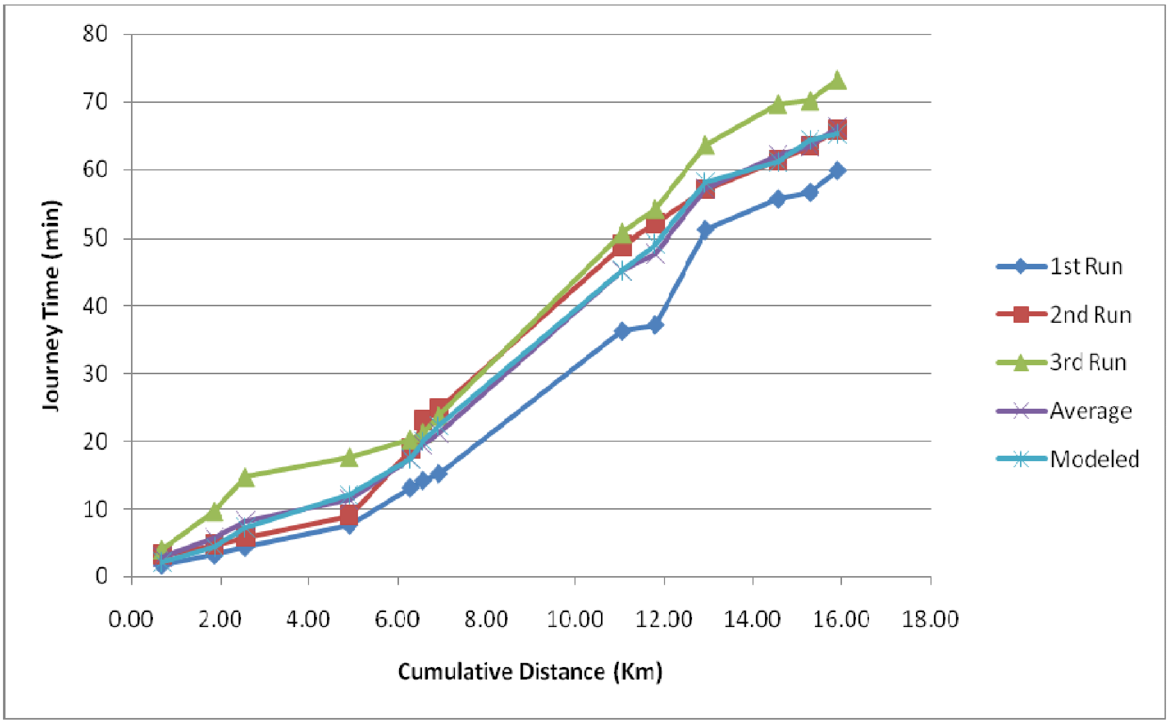


Figure 7.12: Journey Time vs. Distance in Chandra – Nabinagar section

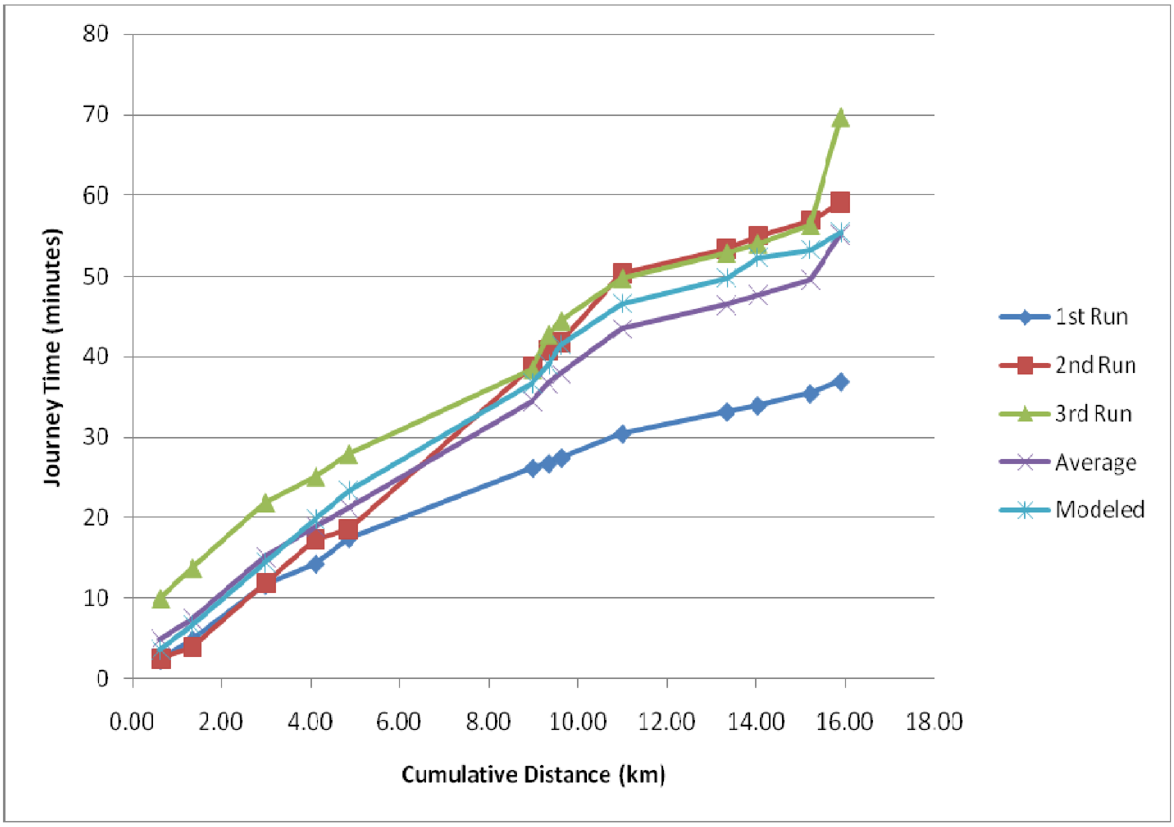


Figure 7.13: Journey Time vs. Distance in Nabinagar - Chandra section

7.4 Pilot Origin Destination Survey

A very small scale origin-destination survey was also conducted during the survey period to compare with the estimated origin destination matrix found from the link count observations. This study comprised interviewing vehicle drivers entering into the study area for their starting point and terminal point of the trip. Identified key generators and attractors for the vehicle traversing the region are:

- Ashulia Export Processing Zones (EPZ)
- Industrial developments near Ashulia, Baipayl and Kaliakoir (Gazipur)
- North-Western Districts of the country
- Central Business District (CBD) region of Dhaka
- The Ports (mainly Chittagong Sea Port)

7.5 Traffic Flow Characteristics

The traffic survey has revealed some salient characteristics of the study area. Figure 7.14, 7.15 and 7.16 depict traffic flow profiles of major points of the area. Figure 7.14 shows traffic flow profile at Chandra intersection. It is one of the terminals of proposed Dhaka Ashulia Elevated Expressway (DAEEP). Here it is seen that traffic flows are maximum at morning peak time, lessens gradually during mid of the day and then again increases at evening.

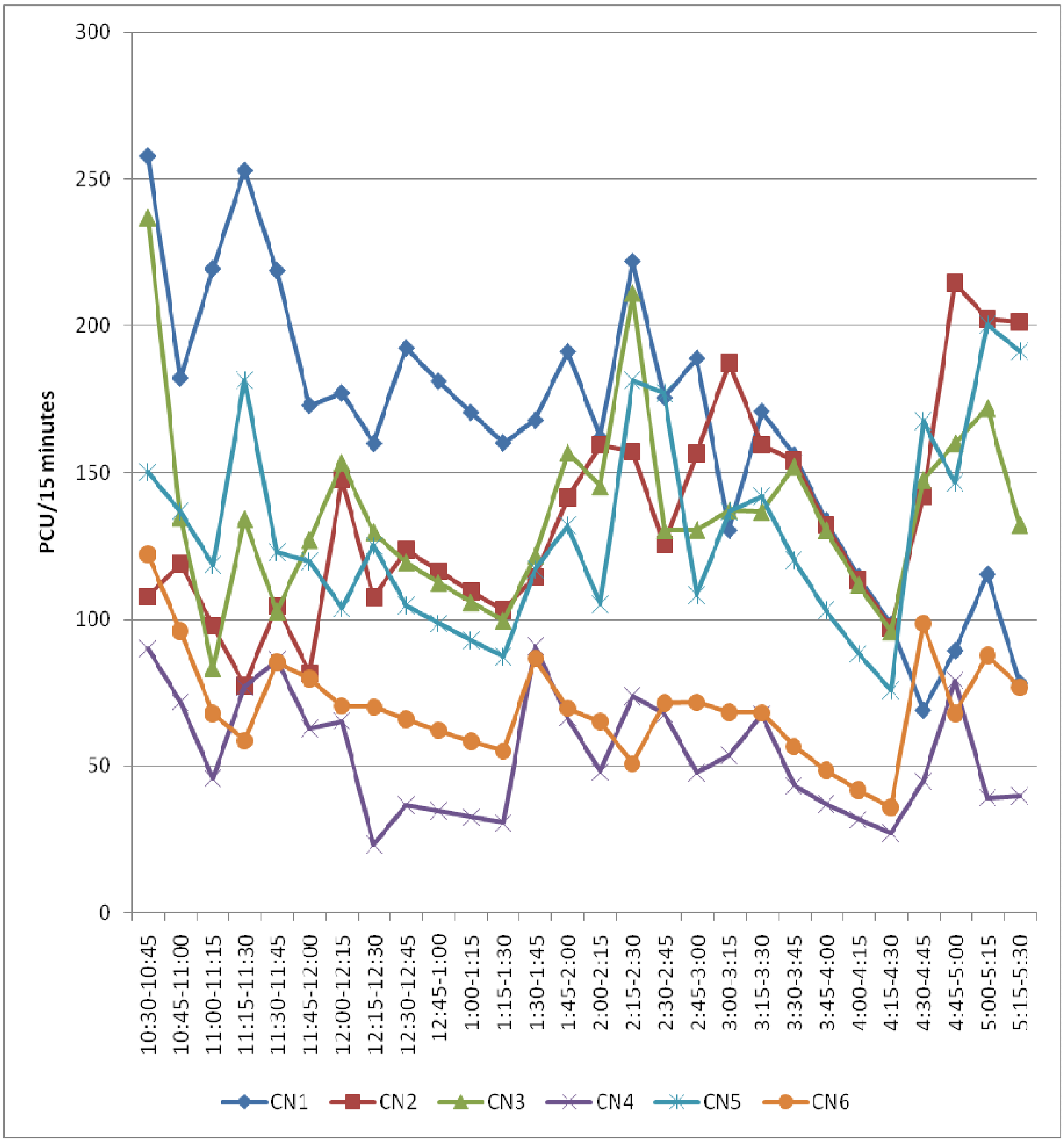


Figure 7.14: Traffic Flow Profile at Chandra

Flow profile at Baipayl intersection is shown in Figure 7.15. It also showed a sustained morning peak, subsequent slight reduction at afternoon, rising in traffic volume in afternoon and again reduction in traffic volume around midnight. The intersection of Baipayl is actually very important for the proposed project as all the major flows that will use this facility pass through this point. This is an important confluence point of the major highways of the project area.

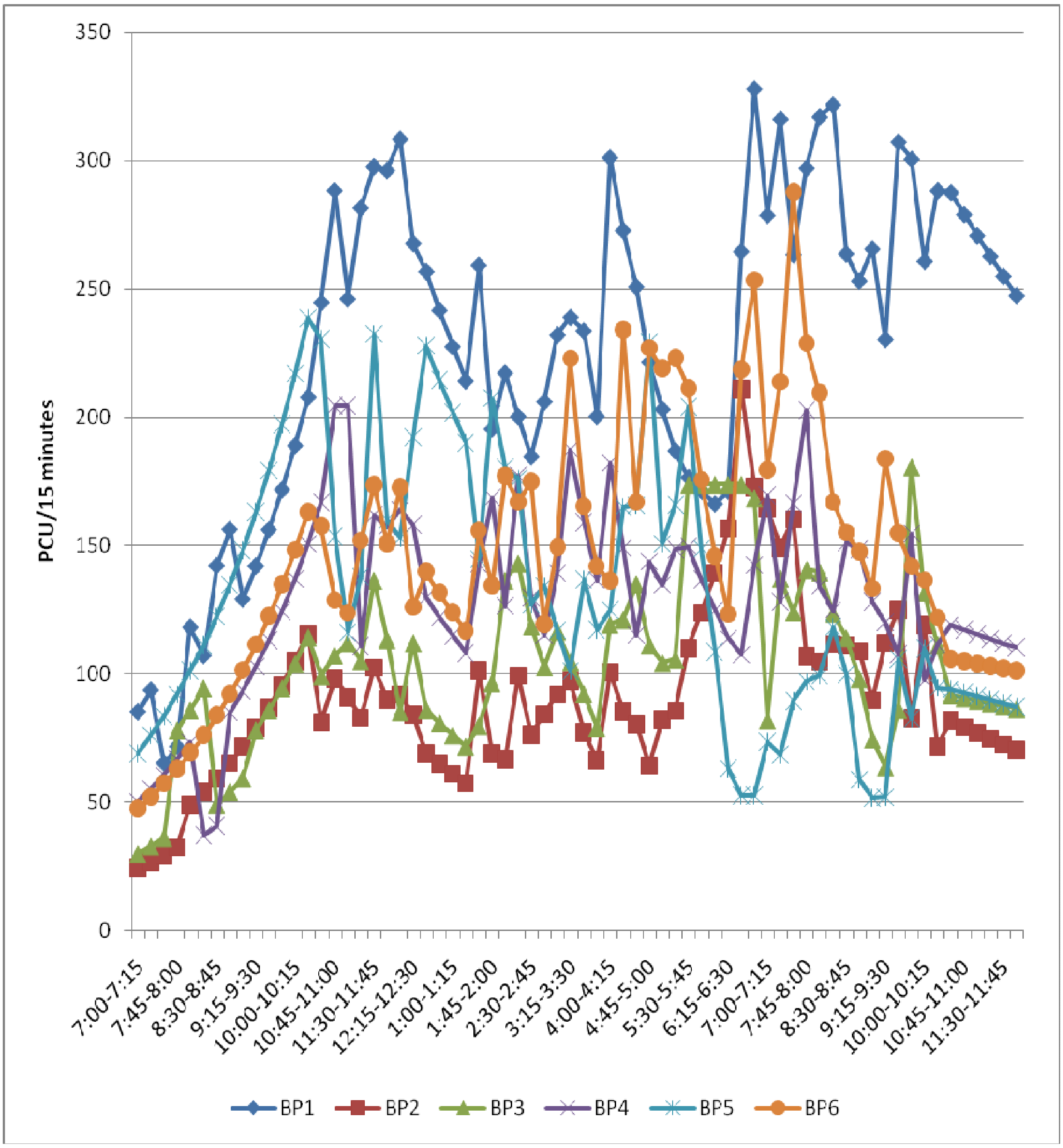


Figure 7.15: Rate of Flow Pattern Observed at Six Flows in Baipayl

Figure 7.16 shows the traffic profile at Embankment Road intersection at Ashulia. It is another important survey location for this proposed infrastructure. Traffic connecting between central regions of Dhaka city and terminal regions pass through this point. Here it can be seen that flows ERI3 and ERI4 (refer to figure 7.5 (d)) are the minimum of the flows. These flows represent traffic stream from the embankment road (beribandh road).

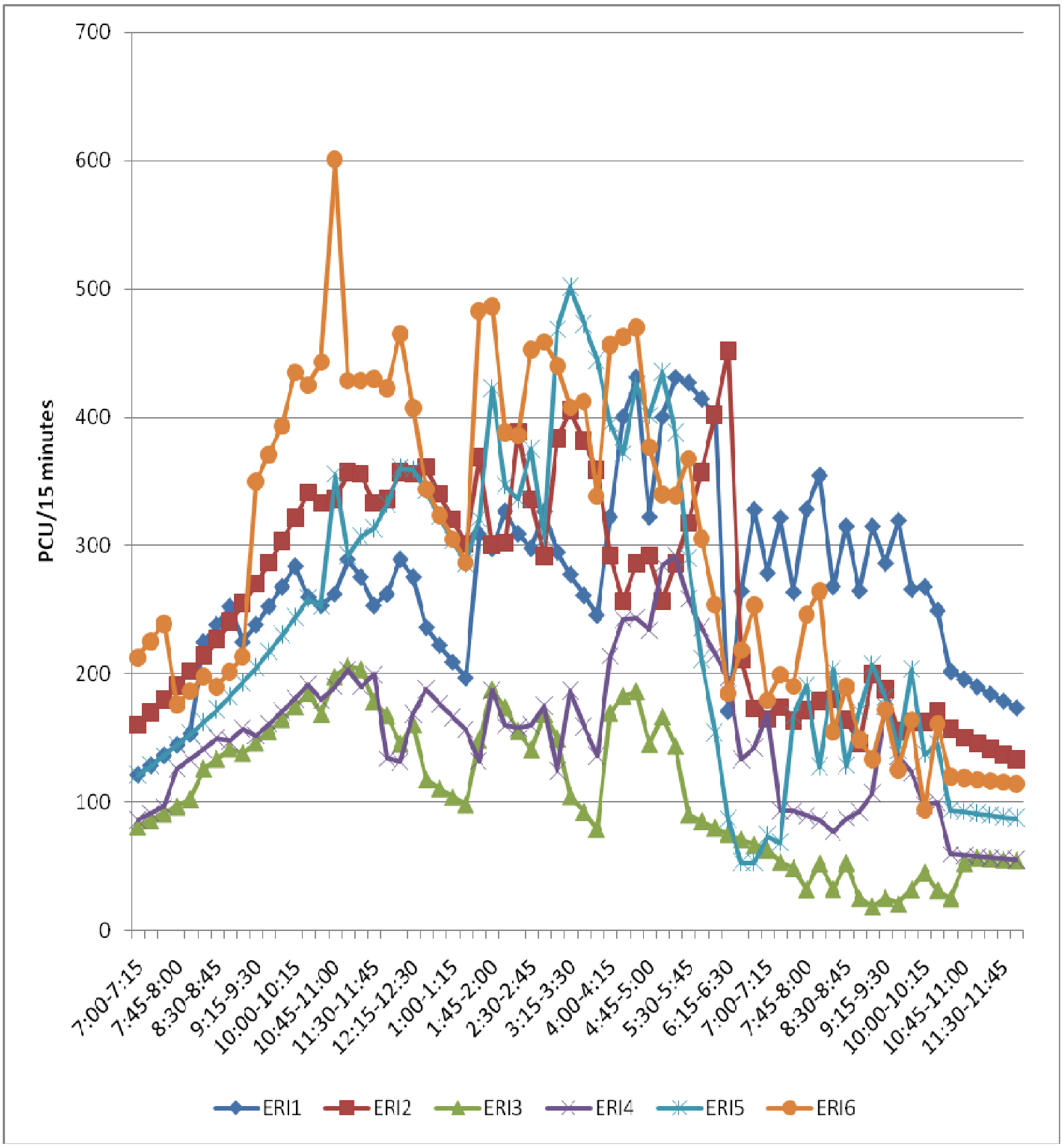


Figure 7.16: Rate of Flow Pattern Observed at Six Flows in Embankment Road Intersection

Modal distribution of the traffic mix is presented in Figure 7.17 to Figure 7.23. These Figures clearly show the dominant users of the study area are the passenger cars (Car, Jeep, Taxi, and Microbus). But the relative proportion of freight trucks, other trucks and pickups are significantly higher as compared to the proportion observed in the main city area. This traffic composition essentially depicts the typical pattern of suburban traffic stream. Expectedly, maximum domination of car proportion (48%) is found at Abdullapur and Ashulia which represents urban traffic stream and gradually reduced to 27% at Baipayl and Nabinagar which typically represents suburban traffic stream and at the farthest junction i.e. at Chandra the proportion of car reduced to 24%.

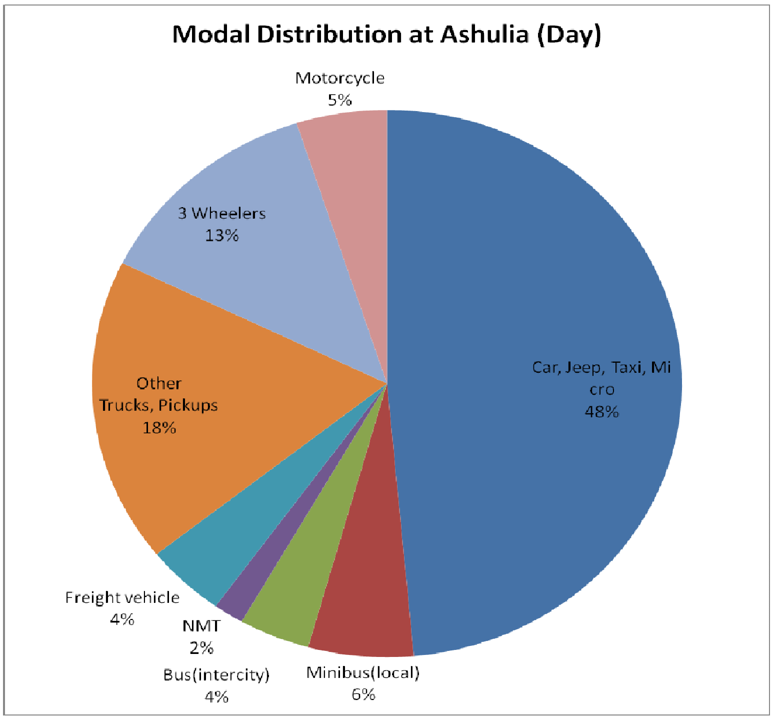


Figure 7.17: Daytime Modal Distribution at Ashulia

At daytime in Ashulia almost 50% of the traffic is passenger cars, whereas 22% are truck traffic and only 10% are mass transit. During night period truck traffic increases nearly two times due to withdrawal of embargo on trucks imposed at daytime. If one considers the space occupancy of this truck traffic, then this proportion will represent the major flow at nighttime.

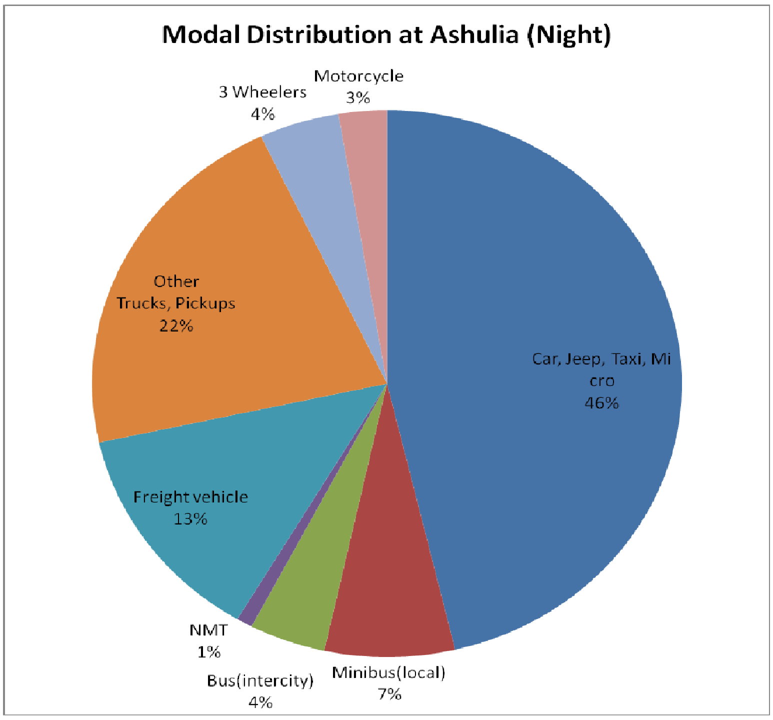


Figure 7.18: Nighttime Modal Distribution at Ashulia

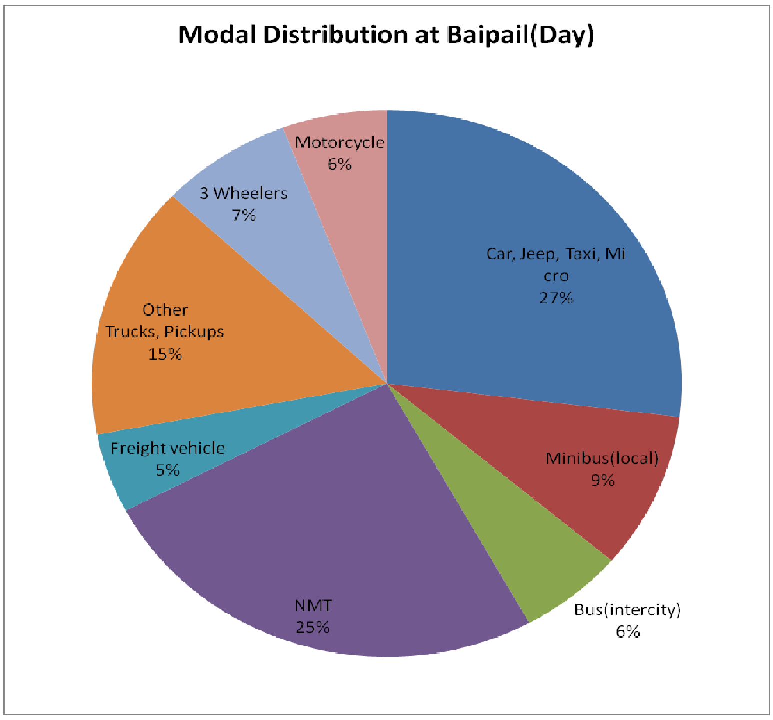


Figure 7.19: Daytime Modal Distribution at Baipayl

At Baipayl passenger cars constitute nearly a quarter of the flow. There is also a significant number of non motorized traffic at this point. 30% of the nighttime flow is public transportation (Bus and Minibus) that is halved at daytime.

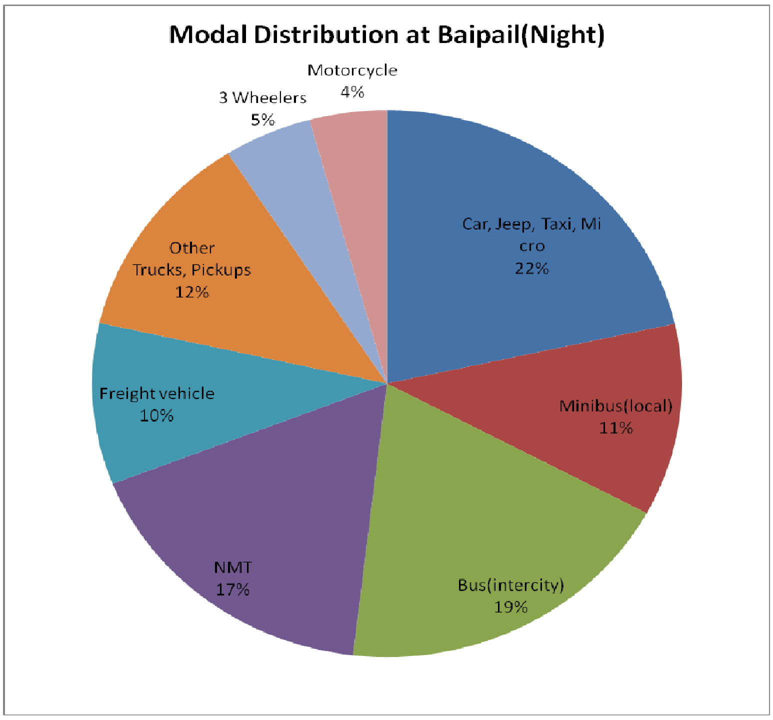


Figure 7.20: Nighttime Modal Distribution at Baipayl

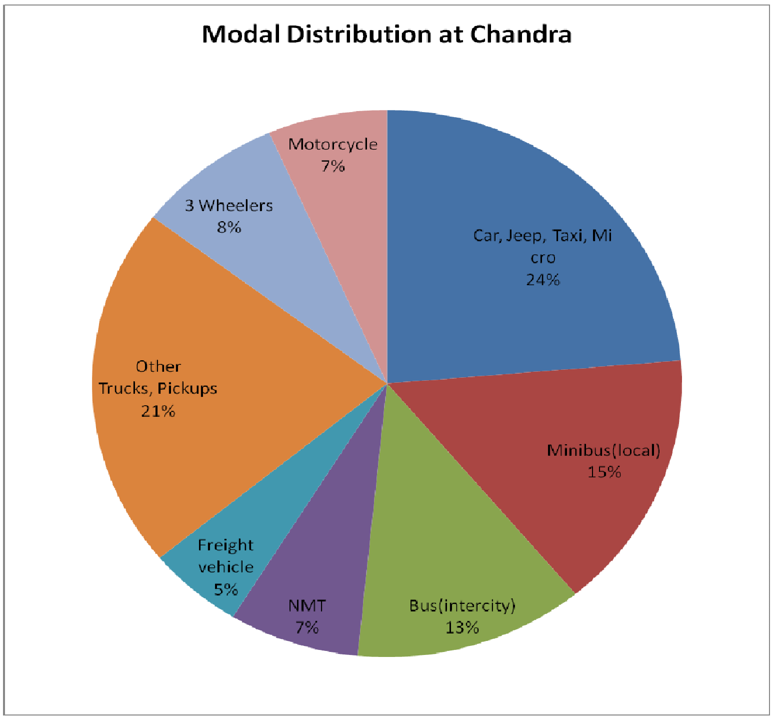


Figure 7.21: Modal Distribution at Chandra

Chandra, one of the terminal points of the proposed expressway, has a significant portion of truck traffic and public transportation compared to other survey points. With around 60% of the traffic being truck traffic and public transits, this location is the connecting point between Dhaka and North-Western part of Bangladesh.

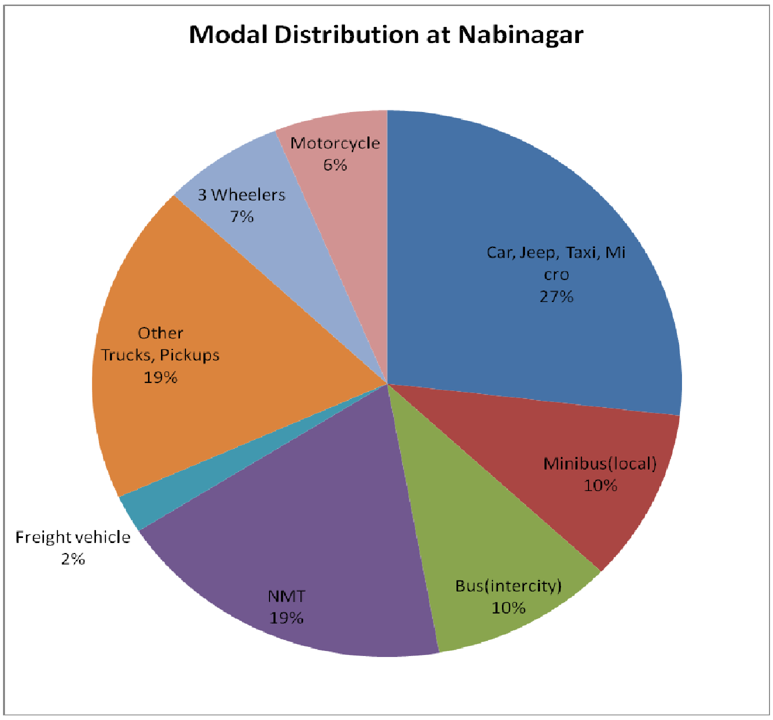


Figure 7.22: Modal Distribution at Nabinagar

Nabinagar is another terminal point of the proposed expressway. It has also similar modal distribution as Chandra. But Abdullahpur at Figure 7.23 has different modal distribution with passenger cars, three wheelers and motorcycles constituting 65% of the total flow. This has mainly happened as this point is located within the city region.

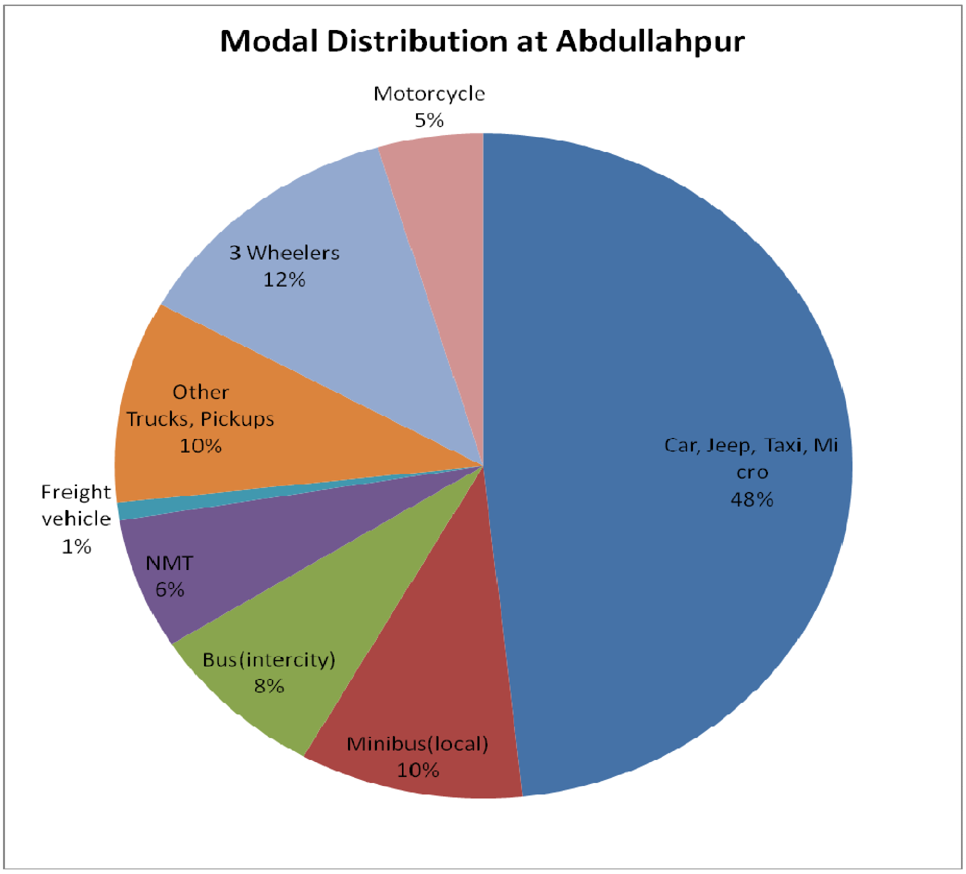


Figure 7.23: Modal Distribution at Abdullahpur

7.6 Comparison of Survey Results

The survey result was compared with other results for authentication. Department of Roads and Highways conducts link count survey at major national and regional highways time to time. For comparison we had the survey data (ADT) of the year 2004. But this survey showed significantly lower level of traffic as compared with our survey in 2011. The rate of traffic increase is much higher than rate of vehicle growth in Bangladesh, even for Dhaka. This variation may occur due to significant landuse changes in the study area e.g. dense industrialization, urban sprawl etc. The comparison is summarized in the Table 7.1. It is also clear from the change in traffic types that number of heavy trucks, medium trucks and three wheelers have increased manifold. It clearly indicates the level of local and regional increase in economic activities.

Table 7.1: Comparison of Traffic Survey

Count Station	Survey Horizon	Passenger Car	Mini Bus	Bus	NMT	Heavy Truck	Medium Truck	Three Wheelers	Motor Cycle
Kamarpara	RHD 2004	4028	1181	1082	506	158	2364	255	244
	Survey 2011	19299	2318	2206	656	5186	9863	4143	1699
Ashulia	RHD 2004	2669	1298	1143	7003	145	2449	768	674
	Survey 2011	18798	2462	2121	553	3113	9346	4272	1839
Jirani (BKSP)	RHD 2004	3162	1744	3081	2046	103	4564	923	498
	Survey 2011	4843	1748	5073	4851	2066	3853	1036	1546

Section 8
TRAFFIC MODELING

8.1 Travel Demand Model

Transport modeling is a tool that planners use to help weigh up some of the factors that might influence the choice of a preferred transport strategy. Predicting the travel requirements of a future generation is a challenging task, particularly at a time when so many influencing factors are undergoing dramatic change (i.e. the rising cost of fuel price, global warming, and rapid state population growth). The manner in which we plan our future transport networks is also changing and a high priority is being placed on sustainable transport solutions that address walking and cycling, public transport, freight, as well as the need for new roads. It's more about achieving a desired future urban environment rather than simply just responding to traffic congestion on the roads.

A transport model tests how well different scenarios might satisfy people's future travel requirements and helps in reaching a decision about which strategy to adopt. Transport models are 'built' on a computer. Some software (often called micro-simulation) is designed to undertake a highly detailed analysis of traffic operations over small areas. Other software is used to model strategic (or more general) transport strategies over much larger areas. A transport network strategy is a package of proposals designed to address future travel demand. It details key future transport network improvement options and why they were selected. For this project the strategy involved prediction of future traffic conditions at different hypothetical scenarios and choosing the best possible alternative from them. To serve our purpose we had to develop a simplified version of the real world connecting activities such as work, residence, commercial, economic, recreational, etc, to show how people travel between these activities. For this reason, the places are segmented into 'zones' (areas of trip origins and trip destinations) and travel paths are defines as 'links' (roads, railways, waterways, airways).

One of the basic assumptions used in transport modeling is that it reproduces current transport conditions and can therefore project future transport conditions. The model is tested to see if it reflects current transport operations (i.e. by using on-site traffic counts). If the model reproduces current conditions, the input data can be changed to reflect future year demographics and transport infrastructure, and thus be used to predict/forecast future year transport operations. The model is particularly useful in comparing alternative future network options to see differences in performance. A travel demand model predicts the number of trips between trip origins and destinations, such as between a place of residence and work. Trips are estimated by time of day for an average weekday, and then are distributed around the geographical area being analyzed (trip distribution), assigned to a travel mode (mode choice), and then to a route taken (trip assignment).

Traditional trip based models constitutes the majority of travel models used for project level decision making and often referred to as a four-step model because its original formulation included four submodels: trip generation, trip distribution, trip mode choice and trip assignment. To ensure consistency between the inputs to any given submodel and the results of submodels down the chain, the model uses "feedback loops" as shown in Figure 7.1. For example, after highway assignment, travel time on every road segment is calculated as a function of the estimated road volume, and then the entire sequence of models is repeated, using the newly estimated travel times. When the travel times between consecutive highway assignments are approximately the same, it is said that the model has achieved "convergence". Convergence is very important when modeling tolling applications, because the effect that charging a toll has on road volumes, and consequently on travel times, is known only after the highway assignment step.

When tolling is a factor of analysis, travel demand models will produce the necessary information regarding the patronage of the toll facility, as well as the impacts of tolling and pricing on corridor and regional travel and for different groups of travelers. How well the model predicts patronage and revenues depends on the structure of the model, how well it is calibrated and validated, and how it is applied to quantify the uncertainty inherent in any forecast of future economic activity:

- A model structure that adequately incorporates all the relevant responses to road pricing is a necessary condition, and in our opinion the most important factor that contributes to the sufficiency of a travel demand model. Three structural characteristics are most important, and are discussed below in detail: representation of relevant travel choice decisions, representation of travel costs, and representation of travelers' willingness to pay.

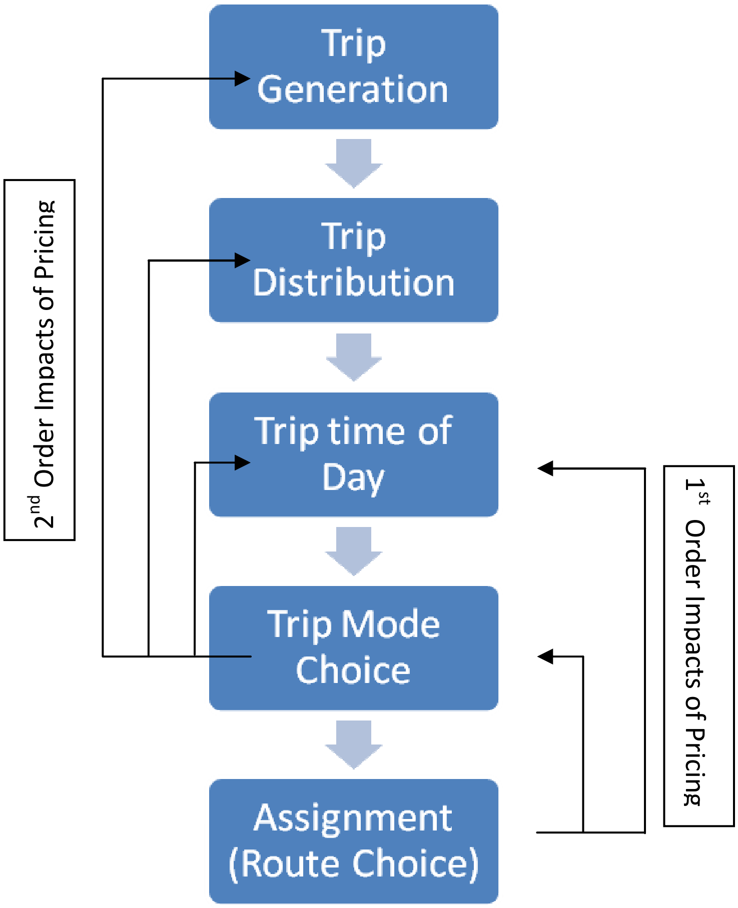


Figure 8.1: Typical trip based demand model structure

- Another important contributing factor to model sufficiency is related to model calibration and validation; that is, how well the model reproduces current travel conditions at a regional, corridor and facility level. Regional travel demand models are evaluated in terms of how closely they reproduce regional travel patterns, such as traffic volumes on major facilities, transit ridership, and origin-destination person movements. However, this level of model validation may be insufficient for the specific facility, corridor, or subarea under study. Therefore a critical step before initiating a road pricing or traffic and revenue study is ensuring that the model is well-validated at a geographic scale commensurate with the scale of the project.

- A traffic forecast is necessarily made under conditions of uncertainty. Therefore the quantification of uncertainty and its impact on toll road traffic and revenue should be an integral part of the forecasting process, and provides important information to investors and decision-makers about the likelihood of achieving the anticipated revenue and other goals related to the realized traffic volume.

How travel demand models estimate tolling effects can be classified into first-order and second-order responses. A first-order response estimates how a traveler would immediately or most directly react to being tolled. This response includes the following travel choices: route choice (whether to use the toll road or an alternative free route), mode choice (for example, if pricing is applied, some users may choose to use a reasonable transit alternative instead of paying the toll), and time-of-day choice (for example, a traveler may choose to travel at a different time of day when tolls may be reduced).

Tolling models incorporate a “feedback loop” in which the results of the initial travel assignments, resultant travel times, and costs are fed back through the model until the input and output travel times and costs do not fluctuates much (called “convergence”).

The second-order responses are the additional pricing impacts that can affect almost any travel choice. For example, as a response to tolling, travelers can change the destination of their trip, decide not to implement the trip and substitute it with some other activity, or link the trip to another tour or outing as a stop on the way to their final destination. These impacts are characterized by little or no immediate change in behavior to pricing, though the accumulated effects over a long time period can still be very significant and even affect the population's residential choices and the region's land use development. They are also more difficult to directly measure and require more extensive feedback iterations to achieve the model’s convergence. Table 8.1 below summarizes the wide range of possible responses to congestion and pricing that can be incorporated into a travel demand model.

8.2 Model Design

A four-step transport demand model was developed to forecast the future traffic at different scenarios and to calculate expected revenues. This model inputs are based on available statistics, information from previous traffic studies conducted for other previous projects and several traffic surveys as stated in Section 8.1. The main part of the transport modeling is performed using a commercially available professional transport modeling software suite e.g. Cube Voyager.

Table 8.1: Possible Responses to Congestion and Pricing

Choice Dimension	Time Scale for Modeling	Expected Impact
First Order Responses		
Route Choice	Short Term Trip Episode	Likelihood of choosing the toll road is expected to vary by type of traveler
Pre Route Choice (Toll vs. Non Toll)	Short Term Trip Episode	Likelihood of choosing the toll road is expected to vary by type of traveler
Car Occupancy	Short-term tour/trip episode	Increased likelihood of forming carpools, or increased likelihood of existing carpools to choose the toll road
Mode choice	Short-term – tour/trip episode	Shift to transit, especially to rail and among low/medium income groups
Time-of-day / schedule choice	Short-term – tour/trip episode	Increased likelihood of traveling during non-peak hours (peak spreading).
Second Order Responses		
Destination / stop location	Short-term – tour/trip episode	Improved accessibility effect combined with negative pricing effect on trip distribution for non-work trips
Joint travel arrangements	Short-term – within day	Planned increased occupancy of vehicle users
Tour frequency, sequence, and formation of trip chains	Short-term – within day	Lower tour frequency and higher chaining propensity
Daily pattern type	Short-term – weekly (day to day)	More compressed workdays and work from home
Usual locations and schedule for non-mandatory activities	Medium-term – 1 month	Compressed / chain patterns; weekly planned shopping in major outlets
Household / person mobility attributes (transponder, transit path, parking arrangements at work)	Medium-term – 1 to 6 months	Higher percentage of transponder users and parking arrangements for high incomes, higher percentage of transitpath holders for low incomes
Household car ownership choice	Long-term – 1 year	Stratified response by income group (higher car ownership for high incomes, lower car ownership for low incomes)
School / university location and schedule	Long-term – 1 to 5 years	Choice by transit accessibility; flexible schedules
Job /usual workplace location and schedule	Long-term – 1 to 5 years	Local jobs for low incomes; compressed / flexible schedules
Residential location	Long-term – 5 yrs +	Income stratification (high income suburbs around toll roads, low income clusters around transit)
Land use development	Long-term – 5 yrs +	Urban sprawl if no transit; otherwise shift to transit

8.3 Road Network

8.3.1 Base Year Network

The base year network was imported from the EMME/2 coded network used for the Strategic Transport Plan (STP) model. This network was recorded by AECOM in Cube Voyager format for the study Dhaka Elevated Expressway. The current study had used the same network, but the link representation of the previous maps have been reviewed and updated to the current situations. The update includes addition of new roads and changed junction types.

Link attributes e.g. capacity, no of lanes, mode restriction, speed-flow relationship etc. for the base year network have also been transferred from the previous studies. But adjustment was made to them as they tend to under estimate the level of congestion on the road network. Consequently, the speed-flow curves are adjusted using the Bureau of Public Roads (BPR) curves from the Highway Capacity Manual (HCM). Figure 42 shows the speed flow curves that are considered for the model.

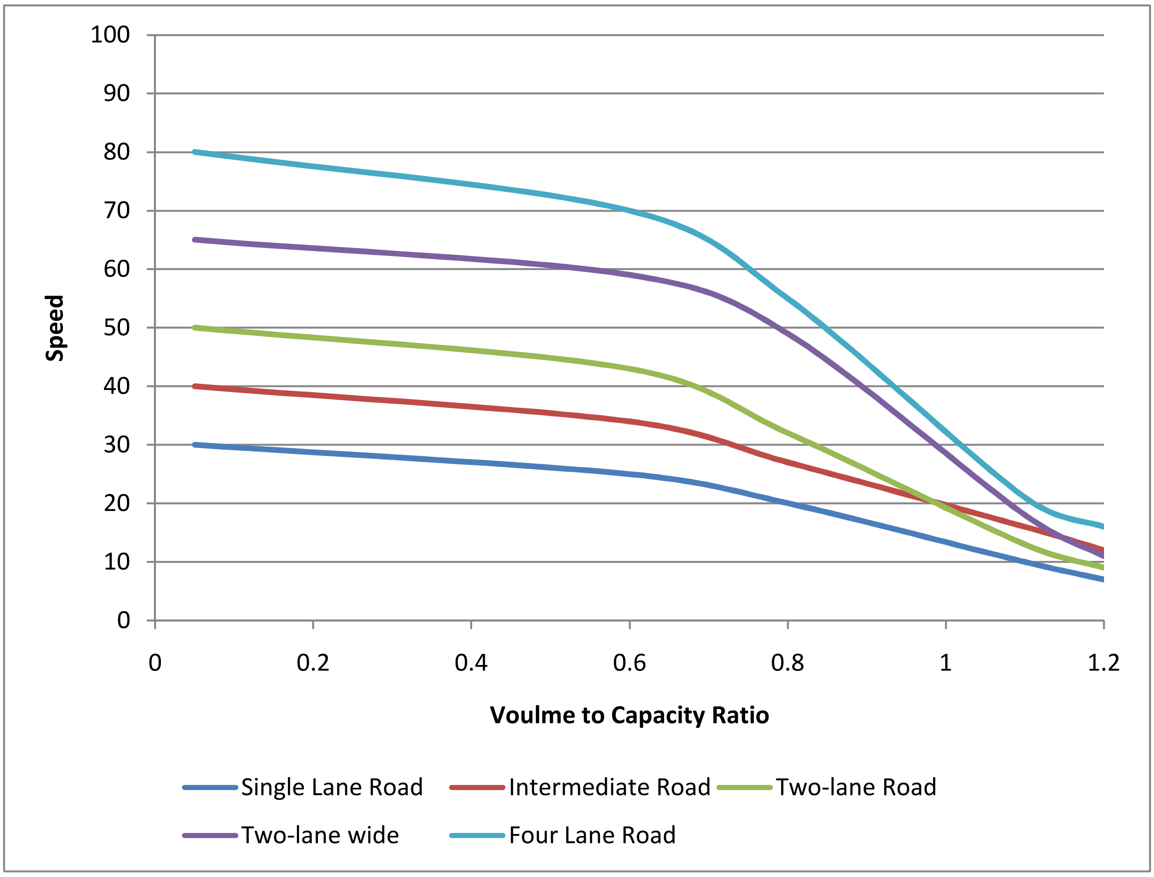


Figure 8.2: Speed Flow Curves used in the model

Some other adjustments were also done to produce a well calibrated model that effectively represents the base year network. A capacity factor of 0.60 was applied for all peaks, off-peak and super-off-peak time slots. Free flow journey time was increased by a factor of 2.0 for peak period, 1.5 for off-peak period and 1.2 for super-off-peak period.

8.3.2 Future Year Network

The future year network consists all the roads, flyovers and junctions that are being improved and constructed and assumed to be opened by 2015, 2020 and 2025 consecutively. Table 8.2 summarizes the changes that are brought into the future year network.

Table 8.2: New links to be opened by 2015

No.	Name/Location	Type of Work	Agency
Under Construction Projects/ Projects Underway			
1.	Banani- Rail Crossing- Zia Colony-Mirpur	Fly Over	ARMY
2.	Jahangir Gate – IDB Building	Tunnel	BBA
3.	Kuril Fly Over	Multilayer Fly Over	RAJUK
4.	Hatirjheel Project	Road	RAJUK/ ARMY
5.	Zia Colony – Mirpur Road	Road	DCC
6.	FDC Rail Crossing to Hatirjheel	Flyover	RAJUK
7.	Dhaka Elevated Expressway	Road	BBA
8.	Gulistan to Jatrabari Flyover	Flyover	DCC
9.	MoghBazar Mouchak Flyover (possibly DEE phase 1)	Flyover	BBA
10.	Cantonment – Mirpur Section-12	Road	ARMY
11.	BRT Line (1)- Red Route	BRT	
12	Jurain Rail Crossing	Flyover	RHD
13	Tejgaon Sat Rasta crossing to Moghbazar crossing upto Ramna P.S.	Flyover	LGED
Projects expected to be opened within period 2015-2020			
13.	Khilkhet – Eastern Bypass	Road	RHD
13.	Eastern Bypass – Dhaka Bypass	Road	RHD
14.	Baijoy Sarani – Shaheed Tazuddin Road	Road	RAJUK
15.	Tongi-Ghorashal	Road	RHD
16.	Circular Ring Road	Road	RHD
17.	Jikatala – Hazaribaag	Road	DCC
18.	Mirpur 14 (Sagorika) – New Airport Road Banani	Road	DCC
19.	Gulistan – Jatrabari Flyover	Flyover	DCC
20.	Jatrabari Bridge – Polder Road	Road	RHD
21.	MoghBazar – Mouchak Flyover	Flyover	BBA
22.	Pallabi – Western Embankment	Road	RHD
23.	BRT line (3)	BRT	
Projects expected to be opened within a period 2020 – 2025			
24.	Khilkhet- Eastern Bypass	Road	RHD
25.	Eastern Bypass – Dhaka Bypass	Road	RHD
26.	Bashabo Mosque – Balu River	Road	RAJUK
27.	Eastern Bypass	Road	RHD
28.	Moghbazar – Malibagh	Road	RAJUK
29.	Western Bypass	Road	RHD
30.	Jatrabari – Demra Ghat	Road	RHD
31.	Dhaka Link Road	Road	
32.	All MRT lines	MRT	

8.4 Traffic Demand

8.4.1 Base Year Demand

A novel matrix estimation technique is employed to calculate the base year demand. This demand is processed for the model as 'Origin- Destination Trip Matrix' for the base year 2011. To develop this matrix we have processed the historic O-D matrix developed for Strategic Transport Plan (STP) of year 2004. Other data sources used to validate the historic matrix of STP were:

1. Survey data collected for the Dhaka Urban Transport Network Development Study (DHUTS) by Dhaka Transport Coordination Board (DTCB) and Japan International Cooperation Agency (JICA)
2. OD survey data for Dhaka Elevated Expressway Project (DEEP) conducted at 2010
3. Pilot OD survey done by our surveyors at May 2011

The OD information for the matrix was expanded to represent three distinct time segments of the day to be modeled (Figure 43):

i. Peak Traffic Conditions (7 am to 1 pm and 4pm to 10 pm)
ii. Off Peak Traffic Condition (1 pm to 4 pm and 10 pm to 1 am)
iii. Super Off Peak Traffic Condition (1 am to 7 am)

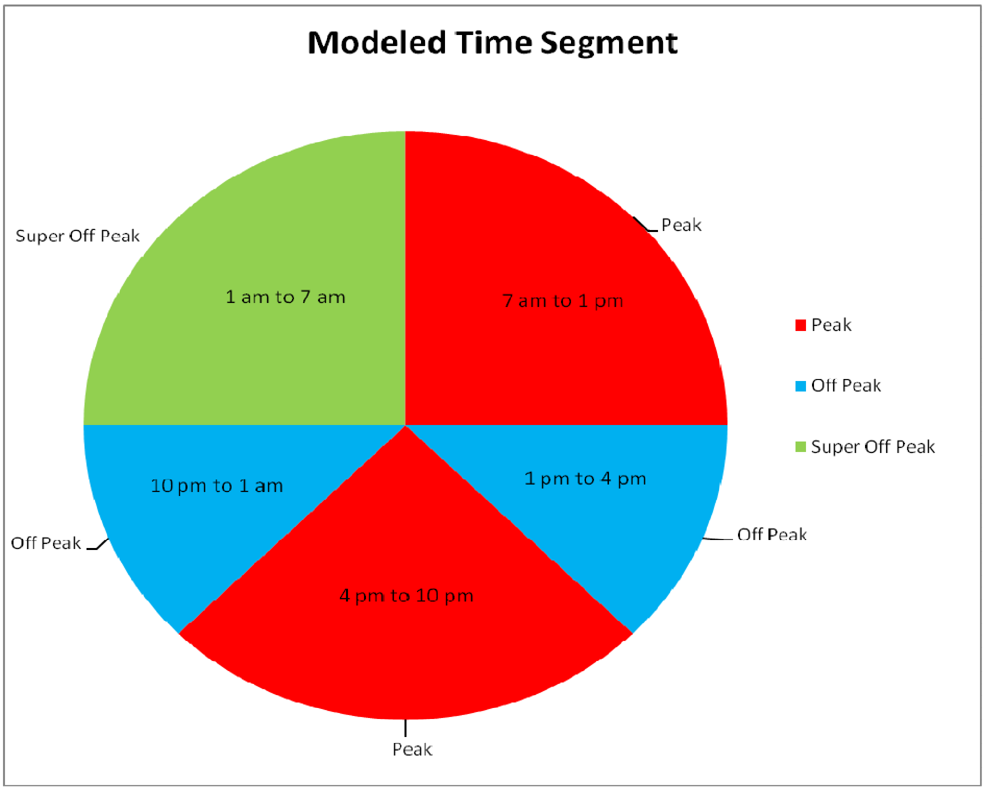


Figure 8.3: Time segmentation followed in model development

The definition of the time segmentation is consistent with the Morning Peak Period (6 hours; from 7 am to 1 pm), Evening Peak Period (6 hours; from 4 pm to 10 pm). Also at present trucks are only permitted to enter into the city area during late off- peak hours (3 hours; 10 pm to 1 am) and super off peak hours (6 hours; from 1 am to 7 am). It is to be noted that a different time segmentation is provided for the super off peak time period that shows a period when the evening commuting vehicles are rarely present. Only nighttime freight service vehicles, long distance inter-city buses are the major vehicles for this time period.

Origin-destination (OD) demand matrices per time slice are very important for many traffic planning, control and management policies. The off-line estimation of the OD demand matrices for freeway networks has been widely addressed by Cascetta et al. (1993), who analyzed several methods for combining traffic counts with historical information. In particular, simultaneous estimation gives in one step the matrices for all the time slices by using traffic counts referring to the whole day, whilst sequential estimation iteratively produces the OD demand matrix for an interval by using traffic counts for the same interval and the previous ones and, possibly, the OD matrices estimated for the previous intervals. A number of models have been developed for estimating an O-D matrix from link traffic counts. Typically, the entropy maximizing, information minimizing and least square estimators have been proposed and applied. These models seek to update or improve an old O-D matrix. But a major problem with these methods is that they do not show us the optimal traffic counting locations. So we have used the theory of Maximum Possible Relative Error (MPRE) to find out the locations of our link traffic counting sites.

Evidently, link traffic counts should contain information as much as possible to increase the certainty or reduce the feasible space of the OD matrices. This is equivalent to selecting traffic counting points so that the resultant MPRE is minimized. From this calculation we have found a minimum of 16 (Sixteen) traffic link count locations and their optimal positioning is ensured in data collection plan described in Section 7.2.

Thus the daily STP all vehicle base year matrix was split into three time segments and seven vehicle classes. To the best knowledge of the consultants, a travel demand model consisting this level of disaggregation has never been attempted for Dhaka. Following are some of the useful references that were used to develop formulations for base year OD matrix from the observed traffic counts and historic (aggregated and static) demand matrix.

- Cascetta, E., D. Inaudi and G. Marquis, 1993, Dynamic estimators of Origin-Destination matrices using traffic counts, Transportation Science, 7a, 363-374.
- H.V. Zuylen and L. Willumsen, 1980, The most likely trip matrix estimated from traffic counts. Transportation Research 14B.
- H. Yang and J. Zhou. Optimal traffic counting locations for origin-destination matrix estimation. Transportation Research Part B, 32B (2):108–126, 1998.
- M. Maher. Inferences on trip matrices from observations on link volumes: a Bayesian statistical approach. Transportation Research PartB, 17B (6):435–447, 1983.

8.4.2 Future Year Demand

Future year demand from STP matrices was compared to the socio–economic drivers described in section 3.0. The average annual growth rate in total motorized trips from 2004 to 2024 was calculated to be 3.1% (As per AECOM, 2010 calculations). This value is significantly lesser than the other factors, such as population growth or economic growth, as shown in Figure 8.4. Vehicle ownership is also significantly higher than the growth in STP trips, with car ownership growing historically by 5% and motorcycle growing by 8%.

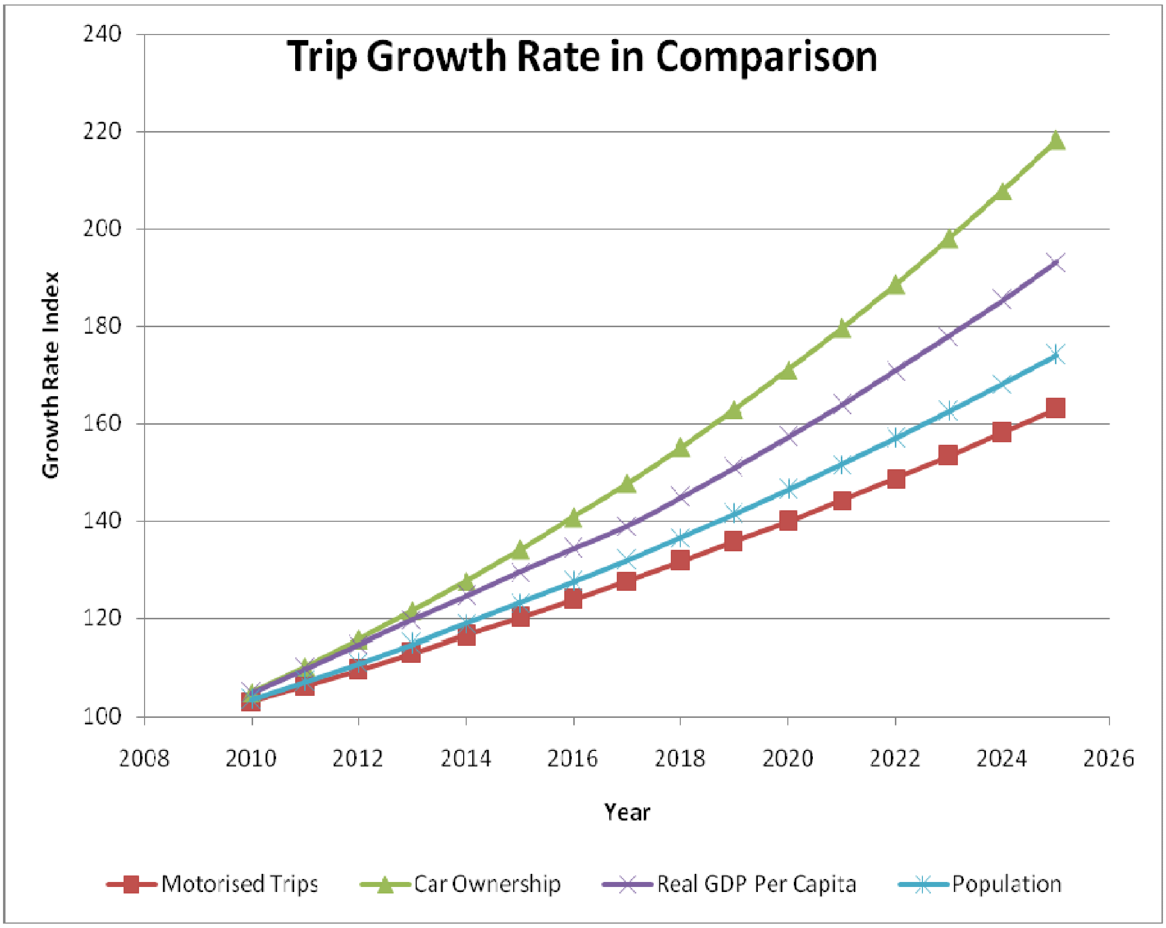


Figure 8.4: Trip Table Growth Rates Compared to Economic Indicators

As the population of the metropolitan region and their economic activity increases, their requirement or demand for trip making will also increase. But the lack of capacity of the existing roadway infrastructure will not allow such growth in trip making. For this reason the trip growth rate estimation has been considered to be relatively low or conservative in STP. Thus we have used STP future year matrices with adjustments made to the base year matrices for calibration purpose.

8.4.3 Vehicle Class Proportions

The future year matrices were divided into different vehicle classes. Vehicle class proportions in future years will be determined their projected growth rate. As Bangladesh is projected to be enjoying a sustained economic growth in the near future, private vehicles e.g. car and motorcycles are going to be increased in a high growth rate. This growth rate is calculated from the past year vehicle growth trends e.g. National level data from Bureau of Statistics (BBS) and data for Dhaka city only from Bangladesh Road Transport Authority (BRTA). Other vehicle proportions are calculated according to total traffic at the forecasted year.

Table 8.3: Future Year Trip Table Class Proportions

Year	Heavy Truck	Medium & Small Truck	Bus	Minibus	Car	Motor Cycle	Three Wheelers
2011	8%	18%	10%	13%	31%	8%	12%
2015	6%	15%	9%	8%	38%	10%	14%
2020	5%	14%	8%	7%	43%	11%	12%
2025	4%	12%	7%	5%	48%	12%	12%

The above proportions show us relative percentage of every traffic mode with respect to total traffic. Here decrease in proportion of any particular traffic mode does not indicate decrease in their numbers. There would still be growth in vehicle numbers but the proportion is getting lowered by greater growth in private vehicle number. After the year 2025 the growth of vehicles will be constrained by the capacity of the roadways. So, after that relative proportion of the vehicle modes will not be a critical factor in making the forecast.

An ideal four step demand model requires survey of households and businesses to understand the origin and destination of the trips in the region. However, such large scale survey administration is out of scope of any pre-feasibility study. There is also a lack of (or, unreliable) data on the growth of vehicle traffic on the proposed route. Instead, traffic growth rate on the existing corridor and proposed DAEEP is assumed to follow the future vehicle ownership growth in future, for which some time series data is available.

8.4.4 Vehicle Growth Model

Future vehicle growth is an important parameter during the feasibility of any transportation project. There are different types models among which simple trend based growth models and S-curve ownership models use aggregate time series data to forecast vehicle growth. Recent trend, however, is to use disaggregate cross-sectional data to understand the vehicle ownership at the household level and then use forecast changes in household characteristics to model vehicle ownership. In the absence of disaggregate information, in this pre-feasibility stage, focus has been on aggregate vehicle ownership/vehicle growth models.

Among the aggregate models, trend models are too simplistic, using time as the only explanatory factor. S-curve models incorporate the fact that growth in vehicle ownership is initially low, which then rises rapidly and then stabilizes at a large ownership level. While this has an intuitive appeal, it has been found that vehicle ownership in Bangladesh is very low and the rapid growth phase is yet to arrive in the next decades. Instead, the vehicle growth model links vehicle numbers to GDP, which allows for a rapid (or slow) growth in future, if GDP grows rapidly (slowly). The dependence on GDP captures the vital link that vehicles ownership indeed depends on income, and thus GDP of a country.

Vehicle registration statistics since 1981 was collected from BBS for different vehicle classifications. Figure 8.5 presents the vehicle registration for different vehicle classes in Bangladesh over the years. Real GDP statistics has also been collected from the World Bank's World Development Indicators Database.

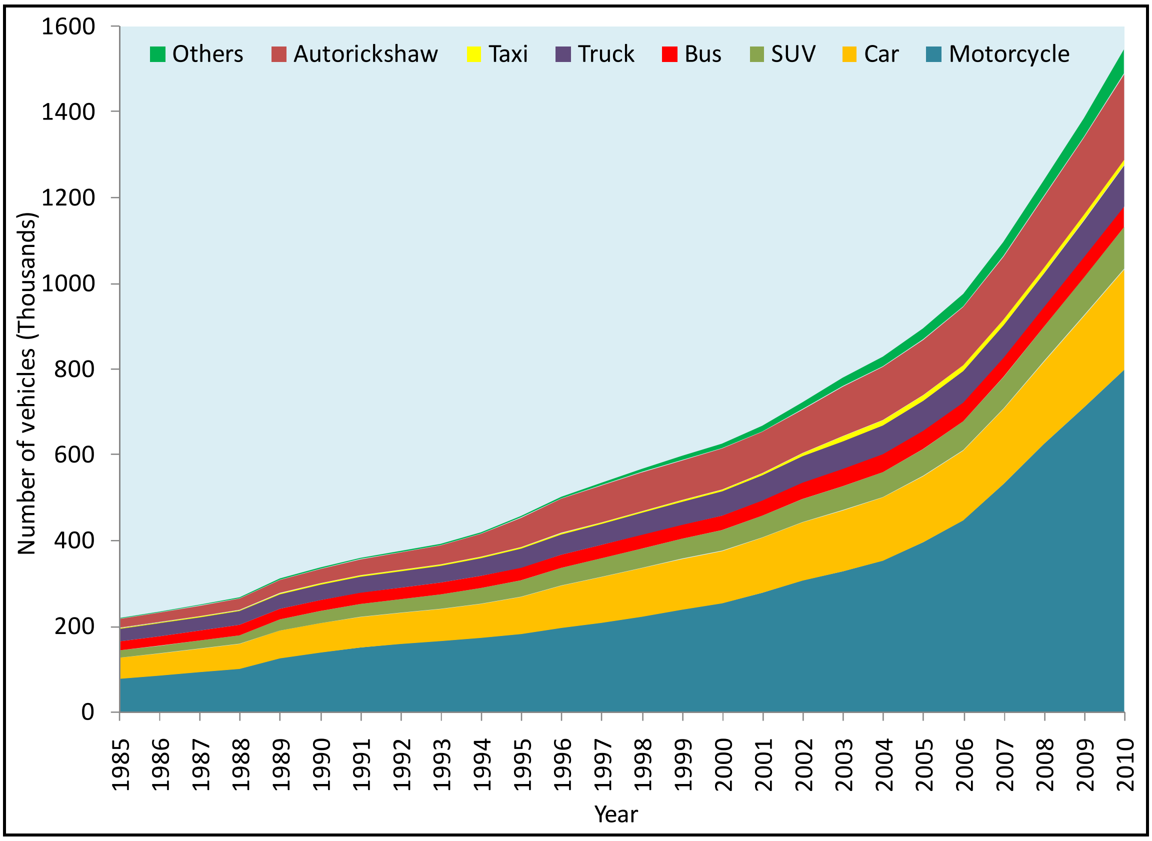


Figure 8.5: Number of Registered Vehicles in Bangladesh

Using the vehicle and GDP data, differenced econometric model has been used to develop vehicle growth for the seven vehicle classes (cars, SUVs, buses, trucks, motor cycles, auto-rickshaws and others). Instead of modeling each vehicle class separately, all the vehicles are modeled at the same time as a system. Seemingly unrelated regression (SUR) models were used in order to allow cross correlation of the error terms, which is quite plausible (e.g. fuel price increases at the same time for all vehicles, and any such changes will generate a cross correlation among errors). The variables are all converted to logarithms so that the parameter estimates are elasticities directly, and any potential heteroskedasticity is minimized. The log variables are all differenced (i.e. changes in vehicle numbers from year to year) to get around the potential correlation and non-stationarity in the time dimension. The final estimated model has the following specification:

$$\Delta \ln VEH_{it} = \Delta \ln GDP_t + \varepsilon_{it}$$

Where, i = vehicles types (car, SUV, truck, bus, autorickshaw, motorcycle, others)
t = time (1981-2008)
ε = errors in observations which are correlated vehicle types

Table 8.4 presents the results of the vehicle growth model. All the parameters for different vehicles classes are statistically significant at 99% confidence level.

Table 8.4: Parameter estimates of the vehicle growth model

Dependent variable	Coefficient of GDP	Standard error	R2
Car	1.250	0.118	0.819
SUV	1.389	0.188	0.685
Truck	0.925	0.076	0.854
Bus	0.682	0.070	0.792
Autorickshaw	1.799	0.237	0.697
Motorcycle	1.886	0.175	0.822
Other	2.896	0.343	0.741

Using this vehicle growth model, and a real GDP growth rate of 6% every year, growth in vehicles in future years are forecast. The forecast growth in vehicle numbers are presented in Figure 8.6. The figure is for 'unconstrained' growth, i.e. if there is no additional roads (such as DAEEP, DEE etc.) the resulting congestion will discourage vehicle buying and the 'constrained' growth will be smaller than the projected scenario. Note that the vehicle projection is done until 2026 only, as the proposed expressways reach capacity by then.

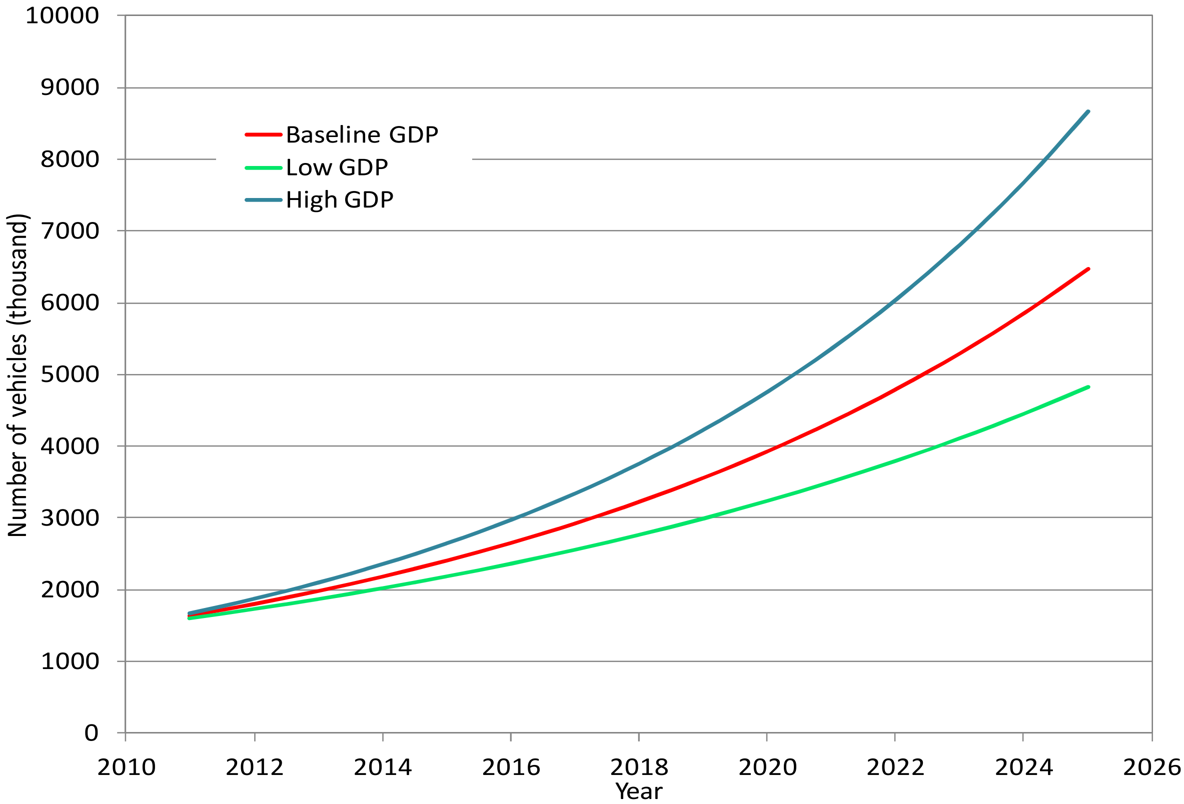


Figure 8.6: Vehicle Projection under different GDP Scenarios

This is converted to per cent growth every year, and applied to the existing traffic on the proposed route. CUBE then returns the diverted traffic on the proposed Dhaka Elevated Expressway (DAEE) and existing at grade road. Detail of the assignment process is described below.

One limitation of this modeling approach is that it ignores the potential for generated traffic due to the new expressway, although a high GDP growth rate (forecast of 6% real GDP growth rate appears on the higher side in the current global recession) for the baseline scenario will compensate for some of this. It is vital during the feasibility stage to develop a proper four-step transport planning model, starting from spatially and temporally differentiated socio-economic information. For the vehicle growth, two alternate GDP rates have been considered to test the sensitivity of the results.

8.4.5 Bus Routes

The bus routes in the study area is not that structured to be included into the model as transit route. Buses using this facility may be divided into two main groups: Large Buses (Intercity) and Minibuses (Intra-city). The intercity buses generally tend to avoid city traffic and the proposed facility will provide them opportunity to bypass. Therefore no post model reduction was applied to this class.

But the mini buses tend to follow the points of local interest and important establishments on the way. That's why they are prone to avoid the elevated expressway due to the need to service local destinations. So, there is a 50% post model reduction to the forecast applied on mini bus traffic.

8.5 Traffic Assignment

8.5.1 Measuring Travel Cost

Before examining the impact of tolling or pricing on travel decisions, it is necessary to model a representation of the total cost of going from one place to another. This includes travel time, distance, tolls, parking, fuel, and vehicle maintenance and depreciation costs, as well as fares and waiting times when transit is used, combined in a *generalized cost function*. When included in the core demand model, the generalized cost function helps to determine the impact of tolls on all choice decisions. The specific nature of the generalized cost function varies with each choice decision.

For route choice, the generalized cost associated with using any given road segment includes the cost of travel time, in addition to the tolls, fuel costs, and other monetary costs. Travel time is expressed as a monetary cost using a concept termed the value of time (VOT); a VOT of BDT 100, for example, means that a traveler would be willing to pay BDT 100 to reduce her travel time by one hour. Generalized costs may vary for different vehicle types, such as private auto, light truck, heavy truck, etc. for the following reasons:

- Different vehicle types and occupancy classes may have very different values of time (VOTs). For example, commercial trucks tend to exhibit higher VOTs than personal vehicles.
- Toll rates might be differentiated by vehicle types and/or occupancy classes, for example, such as when a high occupancy toll (HOT) lane allows three-person carpools to travel for free, allows two-person carpools to pay half of the toll, and single occupant vehicles pay a full toll.
- General prohibitions and eligibility rules can be applied for certain vehicle types on certain facilities (for example, trucks prohibited on expressways or truck-only toll (TOT) lanes) or auto occupancy classes (for example, HOT lanes).

A priced, or tolled, facility may represent a more attractive option because of the enhanced reliability and other considerations that are not directly measured by average time and cost. The approach that has been applied in many models is to estimate an additional bias constant associated with priced facilities. This bias constant can be most effectively incorporated in a model element that is frequently referred to as pre-route choice, commonly placed between mode choice and route choice.

To study traveler responses to pricing, which may include changes in mode, destination, time of day, and/or trip frequency, all of these choice decisions must be sensitive to generalized costs. There are two key steps to accomplish this: first, to include the toll costs along with all other modal attributes in the mode choice submodel; and second to calculate the accessibility from each origin to each possible destination by all available travel modes.

Accessibility is often expressed in minutes, yet besides travel time it also includes toll costs, transit fares and modal preferences for all modes. For example, if a toll is charged to cross a bridge, all destinations beyond the bridge are considered less accessible than before, when one could cross the bridge for free. However, if as a result of the toll, there are no longer delays at the bridge then accessibility will have actually improved for those persons willing to pay the toll. Accessibility is derived from the mode choice submodel because this is where information about all potential travel modes for a given trip resides.

Once these multimodal accessibilities are known, they are used to represent generalized costs in destination, time-of-day, and trip frequency decisions. Another option, frequently used in practice, is to employ the highway generalized cost itself in the destination choice or time-of-day choice. This simplified option, however, is recommended only if transit usage is very low.

8.5.2 Travelers Willingness to Pay

Willingness to pay refers to the tradeoff that travelers make between time and money, and it is a critical factor for tolling applications. For the price of the toll fee, travelers are “buying” travel time savings or travel time reliability, or some other trip-related improvement. The value of time (VOT) can be thought of as the “price” of travel time savings. The value of reliability (VOR) has a similar interpretation, but it measures willingness to pay for increased travel time reliability for a given trip. Travelers exhibit different VOT and VOR, partly as a function of personal and household characteristics (such as income, gender, worker status, etc.), and partly as a function of the context in which a trip is made (trip purpose, time of day, time pressure, outbound versus inbound trip, etc.). A person’s response to a tolling situation will depend to a large extend on his or her VOT, all else being equal. Therefore, a good travel demand model classifies trips and/or travelers into groups of relatively homogeneous VOT or VOR. This is referred to as travel market segmentation.

How to appropriately segment the travel market is a critical modeling issue. The term "aggregation bias" identifies the error that results when travelers with very dissimilar attributes are treated as exhibiting a common "average" attribute value. This error arises from the non-linear nature of travelers' response to road pricing. A typical toll diversion curve, such as that shown in Figure 8.7, has the steepest (most elastic) part in the middle, while the ends are quite flat. This type of curve gives the likelihood of choosing a toll road as a function of the toll, all else (time savings, distance traveled, etc.) held equal.

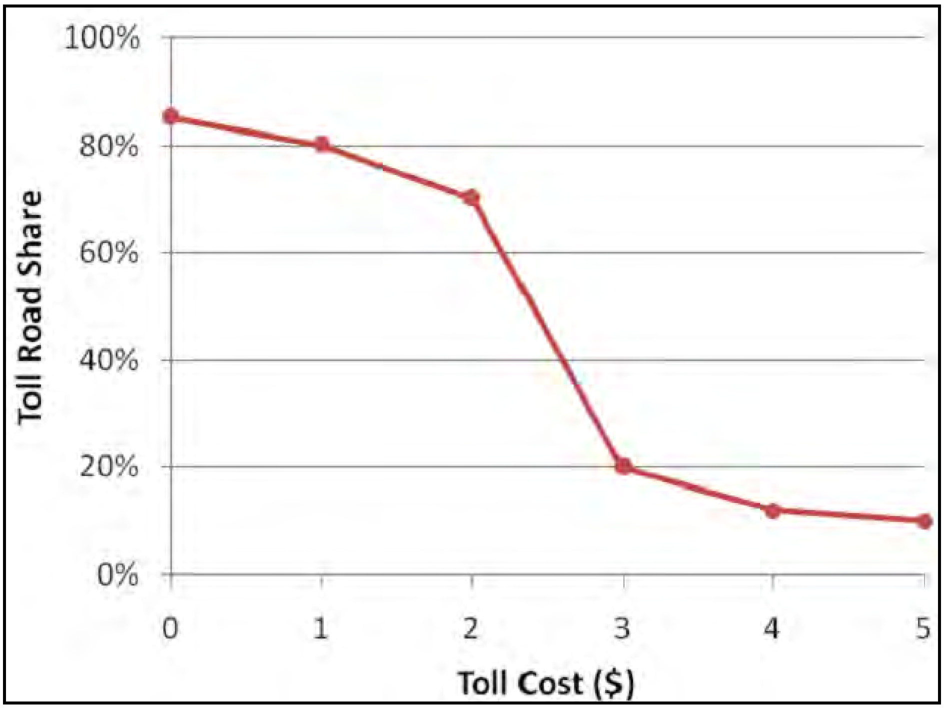


Figure 8.7: Sample Toll Diversion Curve

A variety of traveler and trip type dimensions are understood to be important market differentiators. These dimensions can be grouped into attributes of the traveling population (income, age, etc.), attributes of their activities, and attributes of their trips:

Population attributes: These characteristics are independent of any trip-related decision. Thus, their effect on travel choices is achieved either by partitioning the travel market into subgroups (for example high income vs. low income households), or by using them as explanatory variables in the model. The following are the better understood socioeconomic differentiators:

- Income, age, gender
- Worker status
- Household size, composition and auto-ownership

Activity attributes: These are attributes of the specific activity for which one is traveling, but independent of the trip itself. Activity attributes include the following:

- Travel purpose
- Day of week: weekday vs weekend
- Activity/schedule flexibility

Trip attributes: Given that a travel demand model is a sequence or chain of sub-models, attributes of trips that are modeled in one submodel can be used as segmentation variables further down the model chain. For example, if the time-of-day (TOD) model is placed after mode and occupancy choice, then mode and occupancy can be used to segment the TOD model. If the order of models is reversed (TOD choice before mode and occupancy choice), the segmentation restrictions also need to be reversed. Some important trip attributes include:

- Trip frequency
- Time of day
- Vehicle occupancy and travel party composition
- Trip length/distance
- Toll payment method
- Situational context: time pressure versus flexible time

8.5.3 Toll Diversion Methodology

Toll is visualized as the payment made by a traveler for an improved facility e.g. reduced travel time, greater comfort, higher reliability etc. The travel demand model considers the effect of tolling on the route choice behavior of the traveler. In real life, there is an initial friction to tolls by the users. They must be able to identify the benefits that the improved facility has to offer to them. Therefore the toll model should consider users using different lengths of toll road and alternating between the tolled road and free alternative. The toll model also must evaluate and compare tolled and non-tolled alternatives. It must have the capability to analyze varying road section lengths.

The simplest way to model toll choice is to treat the decision to use the toll road the same as all other decisions on which road to use. The toll road is included as a standard link in the network, and the toll is included as a cost component on that link. This is usually done using a generalized cost route choice model, where paths are built based on minimizing aggregate cost (including value of time and vehicle operating costs as well as tolls). It is also possible to incorporate tolls within a minimum-time path build, by converting the toll into equivalent travel time.

The traffic assignment model will assign traffic to the toll road whenever it is a part of the shortest path for a particular travel segment (trip between an origin and a destination). In the absence of congestion, this would be an all-or-nothing process. This can lead to discontinuities in demand (and elasticities) with varying toll levels. A link that is on the shortest path will be assigned all relevant demand, and this will be unaffected by increasing toll levels until a critical point is reached where the road stops being on the shortest path. At this point all relevant demand will switch to an alternative route. Depending on the characteristics of the travel market for the road this can lead to sudden drops in demand, as a key market segment switches to the next best route.

The inclusion of congestion reduces this somewhat, as an equilibrium process will ensure that traffic will switch to alternative routes as the shortest path route becomes congested. This can reduce discontinuities but is unlikely to eliminate them. This toll modeling approach assumes that when people are choosing their route they make a high-level choice between the best tolled route and the best non-tolled route. This is treated as a binomial logit choice, where the deterministic part is the generalized cost of each route.

The utility function for each alternative route is given by

$$U_k = \beta1 * \text{Toll} + \beta2 * \text{Travel Time} + \beta3 * \text{Delay Time} + \text{Alternative Specific Constant (ASC)}$$

Where Travel Time (t) is the number of minutes spent travelling in (relatively) unconstrained conditions, whereas Delay Time (d) is the number of minutes travelling at speeds less than desired condition. Utility values can be scaled by a constant factor or have a constant factor added to them. But any scaling will also affect the variance of the error term. The scaling is somewhat arbitrary, and sometimes scaling is done to give a specified variance. However it is easier to understand what the parameters mean if the utilities are scaled to understandable units. Thus we have scaled the equation above to give utilities in monetary units by setting the factor on the toll to one. This gives

$$U_k = Toll + \beta2/\ \beta1 * Travel\ Time + \beta3/\ \beta1 * Delay\ Time + ASC/\ \beta1$$

Then a Random Utility Model (RUM) e.g. Logit model is employed within the model to find out the best path in assignment stage. The basic assumptions behind logit model are:

- People make choices by determining the desirability of each alternative (its utility) and choosing the one that is most desirable.
- There is variation in people's assessment of utility, due to both individual variability and modeler ignorance and so utility can be understood as a random variable, with parameters such as variance and mean that show how it is distributed across a population.
- The utility variable is made up of two parts – a deterministic component that is (to some extent) observable, and a random error. That is, for each alternative i, the utility is given by $U_i = V_i + \varepsilon_i$, where U_i and ε_i , are random variables.
- The random error ε is i.i.d. – that is it is independently and identically distributed across all alternatives. This means that if we know exactly how a person feels about one alternative it tells us nothing about how they feel about another alternative (independent). Further, the degree of variation in how people perceive one alternative is the same across all alternatives; no option is more or less random than any other (identically distributed).
- The error term takes a particular random distribution, called the Gumbel or Type I extreme value distribution. It is chosen because it has a similar bell-shaped curve to the normal distribution, but a much simpler probability density function which makes the entire math much easier.

The final mathematical expression is given as:

$$Umax = \sum_{i=1-Zones} c + \left(\sum_{i=1-Zones} t + \epsilon \right) * VOT$$

8.5.4 Model Application

A different best path is created for each zone of the coded network based on randomly distributed value of time. This methodology was first developed by French Transport and Traffic Engineering Laboratory (INRETS). It has been used for many tolled roads around the world. A review of distributed value of time studies was done to determine the most appropriate methodology for estimating key variables. Following are the steps of toll diversion model:

- Paths are built on the network based on a generalized cost of travel times and tolls. Time and costs are both converted to a common value using Value of Time (VOT).
- Road users are then assigned to these network paths using an equilibrium assignment.
- With the help of the speed-flow curve the travel speeds are updated taking the traffic volume as an input.
- The VOT is also updated by randomly choosing another value within the log-normal distribution.

$$Log(VOT) \sim N(\mu, \sigma)$$

Where,
μ = average Value of Time (VOT)
σ = standard deviation for VOT

- In each iteration of the assignment process, each origin zones are assigned a VOT randomly chosen from the log normal distribution. The process uses the following algorithm:

  1. Generating a number X1, between 0 and 1
  2. Determining the inverse normal Y of the random number
  3. Calculating $Log(VOT) = \mu + \sigma * Y$
  4. Taking the exponent gives a randomly generated Value of Time (VOT)

- This procedure is iterated continuously until convergence occurs. This builds paths each time on the loaded network that updates the travel time input into the generalized costs.

8.5.5 Model Parameters

There are two main components of model parameters that are applied in the toll model: Value of Time (VOT) and Alternative Specific Constants (ASC). The value of time (VOT) is the simplified form of value of travel time savings. It is the most critical input to a toll choice model. Numerous methods are available to find out the proper VOT value for different user classes. Two of the most accepted methods are empirical methods based on demographics such as wage rate of the users or indirectly using stated preference (SP) surveys. The second one is generally much easier to obtain a response to a range of circumstances through stated preference surveys. This is because we can ask people about a whole range of different options in a single sitting. It is much more difficult to find and collect data on people's actual behavior across a wide range of options, particularly when some of those options do not exist. There is a growing body of literature on the problems with stated preference surveys, most notably the incidence of hypothetical bias. Even with simple choices, there is evidence that when people are asked what they would hypothetically do, they are often wrong. For simpler product-based choices a range of studies have found that respondents overstate their willingness to pay, often by a large amount. It is not clear how much worse people are when asked to make hypothetical preferences between complex choices, such as is the case in many stated preference surveys for toll road preference.

The scope of this study does not permit any preference surveys. So, for VOT values the model relied on Roads and Highway Department (RHD) Road User Cost Annual Report for 2004-05. In this report, National Average figures for Travel Time Cost (TTC) are published and that is summarized in the following table.

Table 8.5: Travel Time Costs (TTC) per Vehicle (Taka/hr)

Vehicle Class	2004-05	2009-10
Truck	73	107
All Buses	653	960
Micro Bus	199	290
Car/Utility	99	145
Auto-Rickshaw	61	90
Motor Cycle	24	40

Source: RHD Road User Cost Annual Report 04-05 Table 4.7 page 33

Alternative specific constants (ASC) are the next important parameter in the toll model. It mainly accounts for the attractiveness of the facility that ensues from the intangible conditions the toll road offers and cannot be measured by VOT alone. Example of these benefits include: uninterrupted journey condition, reliable journey time, comfort, improved safety and generally more pleasant driving conditions experienced on the road. The ASC therefore reflects the fact that even if travel times might be similar on the toll road compared to the alternative route, a proportion of drivers will opt to use the toll road, despite the tolls, because of these other factors.

Thus travel times and costs are converted into a common unit (takas) using a value of time (VOT) and together with tolls, the model calculates the total generalized cost for each route. The adopted values are shown in the following table.

Table 8.6: Adopted Parameters in Assignment Model (in 2009/10 Taka)

	Heavy Truck	Truck	Bus	Minibus	Passenger Car	Motor Cycle	Three Wheeler
Adopted VOT	107	107	555	555	145	40	40
Adopted ASC (ε)	40	40	40	40	40	40	40

The Alternative Specific Constant is derived from a Stated Preference (SP) survey conducted by AECOM in 2009. The study concluded that irrespective of vehicle class the toll road bonus is a constant value of approximately 40 Taka. Mean VOT is adopted from the RHD report. Growth in Value of Time (VOT) is assumed to be occurring in line with 50% growth in real GDPPC. The forecasted Real Value of Time per vehicle class is summarized in the following table.

Table 8.7: Forecast Future VOT (In 2009/10 taka)

Year	Heavy Truck	Truck	Bus	Minibus	Passenger Car	Motor Cycle	Three Wheeler
2009	107	107	555	555	145	40	40
2015	125	125	648	648	169	46	46
2020	144	144	736	736	192	53	53
2025	163	163	849	849	221	60	60
2030	186	186	964	964	252	69	69
2040	240	240	1241	1241	324	88	88
2050	292	292	1509	1509	394	107	107

8.6 Model Calibration and Validation

8.6.1 Scatter Plot Analysis

Observed and modeled traffic volumes are compared using a scatter plot analysis. Desirable quality to achieve in a scatter plot is:

- Coefficient of Determination (R2) of 0.90 or greater
- The slope of the best fit line through the origin should be in a range of 0.9 and 1.1 to represent a strong correlation.

The scatter plots of the peak, off-peak and super off peak model calibration meet the above criteria and are shown in the following figures.

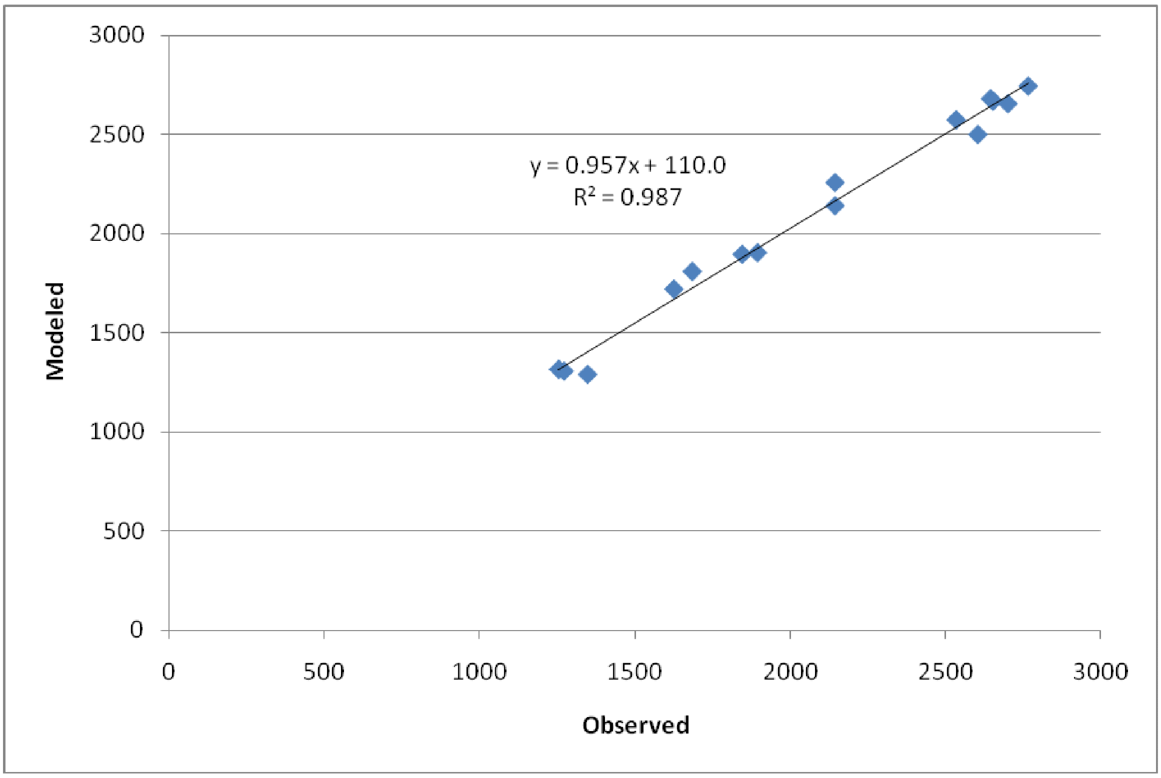


Figure 8.8: Modeled Vs. Observed Traffic Count – Peak Period

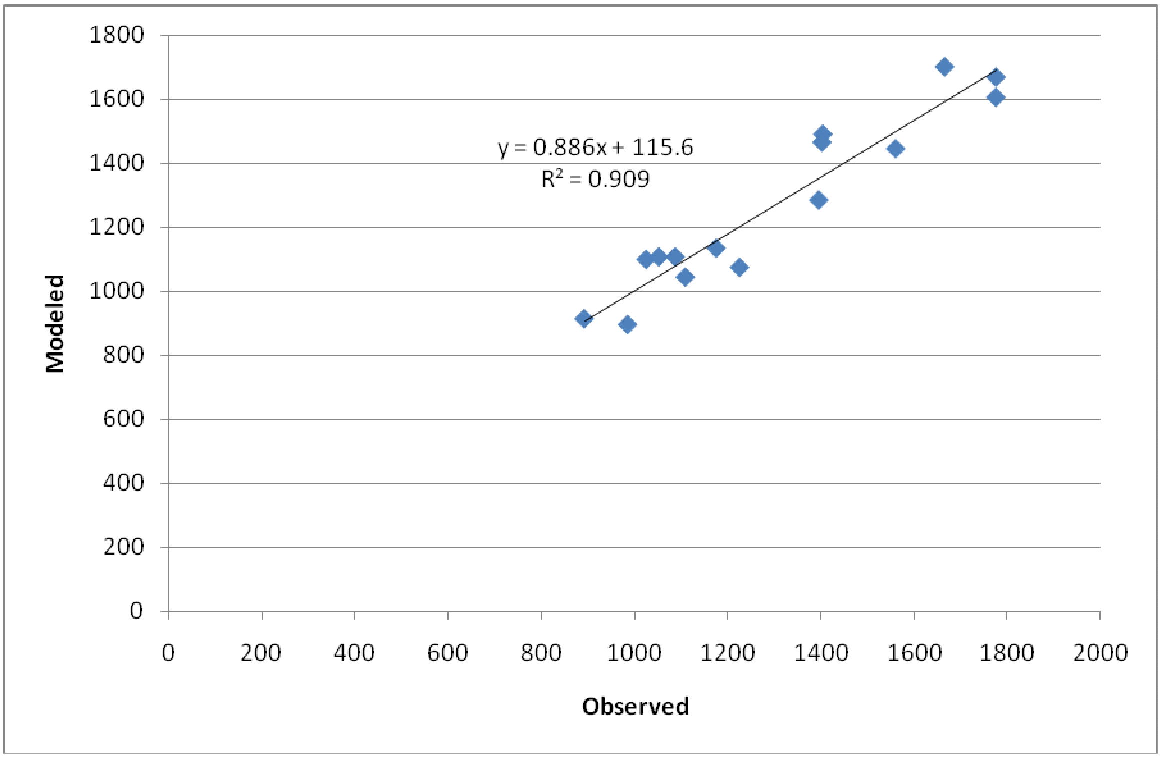


Figure 8.9: Modeled Vs. Observed Traffic Count – Off Peak Period

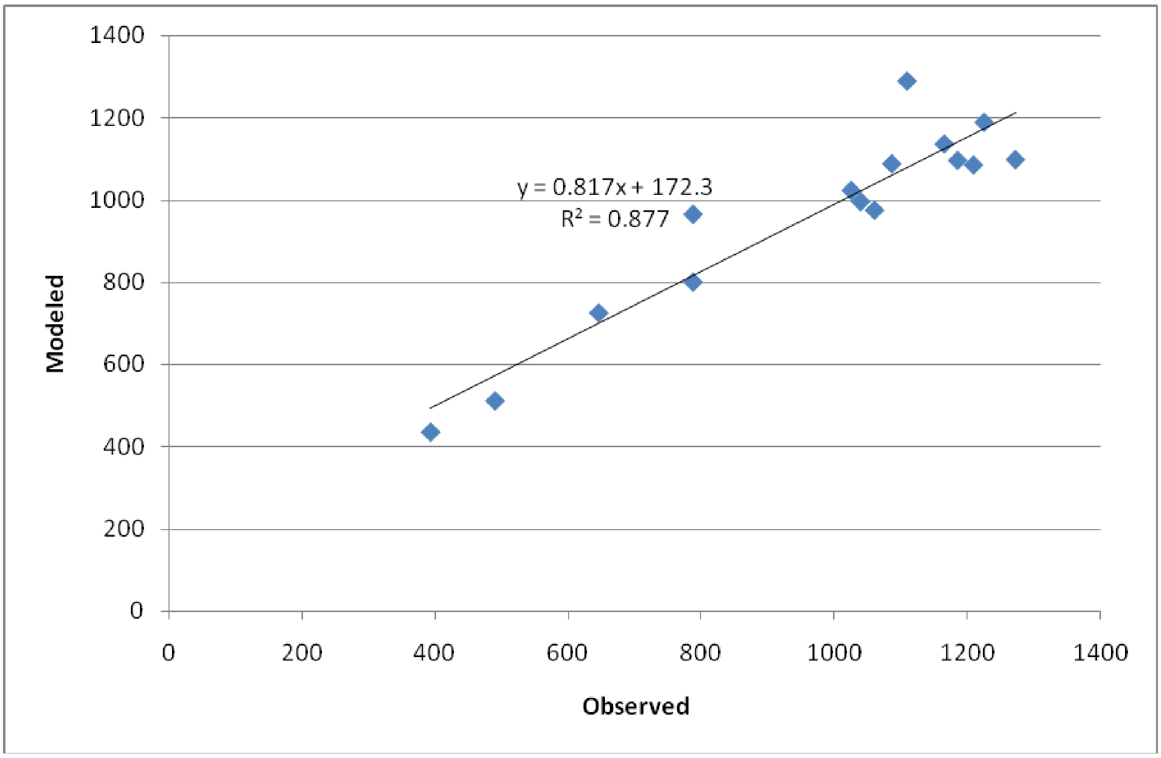


Figure 8.10: Modeled Vs. Observed Traffic Count – Super Off Peak Period

8.6.2 Root Mean Square Error (RMSE)

The Percent Root Mean Square Error (% RMSE) is defined as follows:

$$\%RMSE = 100 * N * \frac{\sqrt{\sum \frac{(M-C)^2}{N-1}}}{\sum C}$$

Where,

N = number of count/modeled link pairs
Σ = summation of count/modeled link pairs from 1 to N
M = modeled one-way link volume (peak period or 24- hr)
C = measured average one-way link volume (peak period or 24- hr)

The %RMSE statistic provides a good indication of the percent difference between measured and modeled parameters. The industry practice for acceptable criterion of the value is 30% that represents single standard deviation from the mean. The RMSE in calibration for peak period is 11%, for off-peak period is 19% and for super-off peak period is 23%. All these values fall within the desired range.

8.6.3 Journey Time Calibration

Modeled journey time is plotted against the mean observed journey times to show the calibration. Figure 49 to Figure 52 show that for all the routes of different directions there is close agreement between the modeled and observed result.

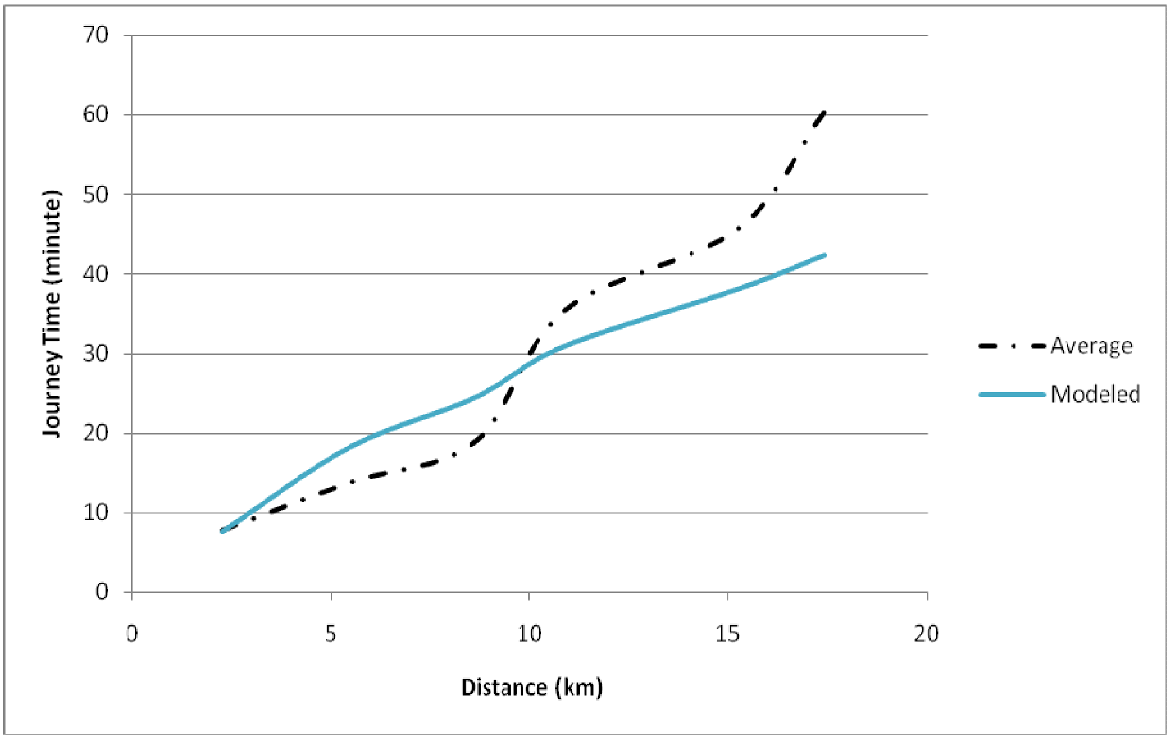


Figure 8.11: Modeled vs. Observed Journey Times (Abdullahpur- Baipayl section)

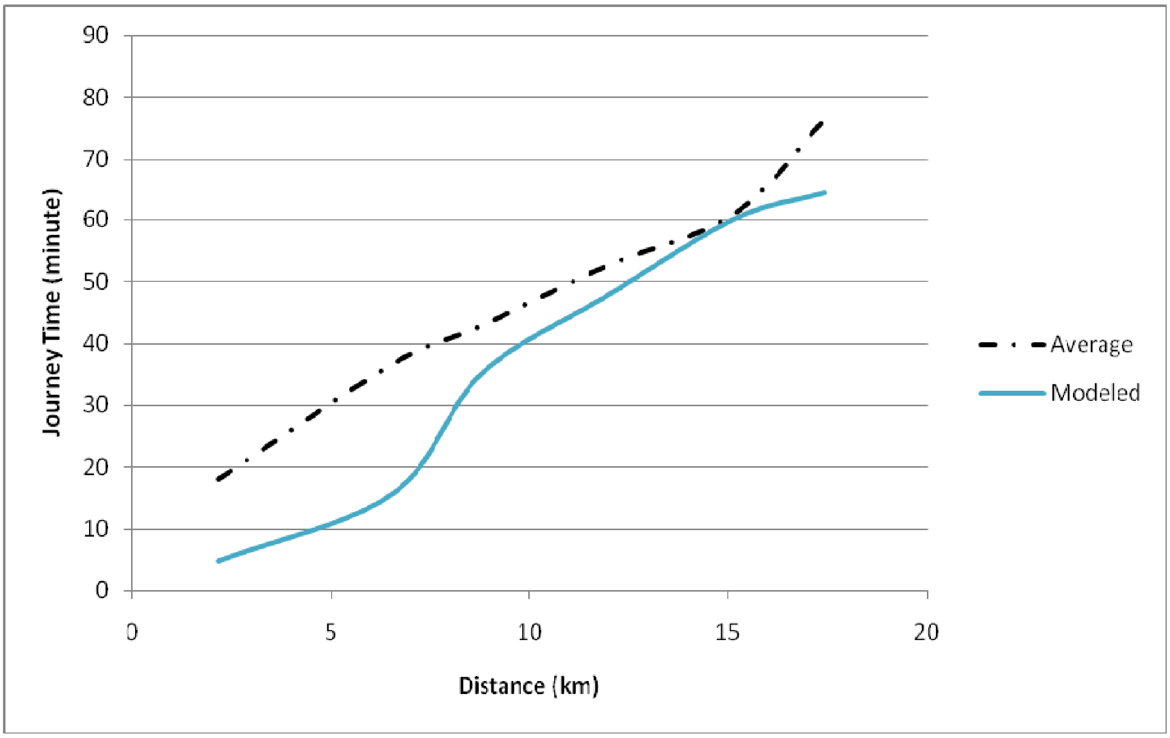


Figure 8.12: Modeled vs. Observed Journey Times (Baipayl- Abdullahpur section)

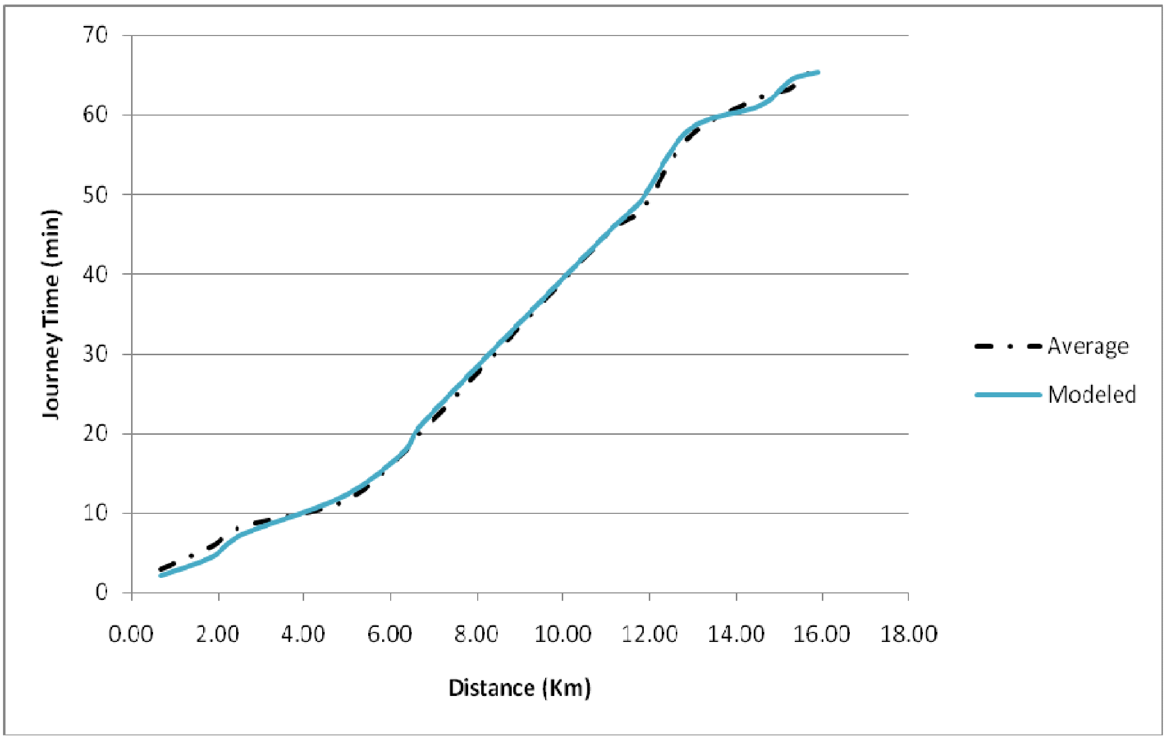


Figure 8.13: Modeled versus Observed Journey Times (Chandra-Nabinagar section)

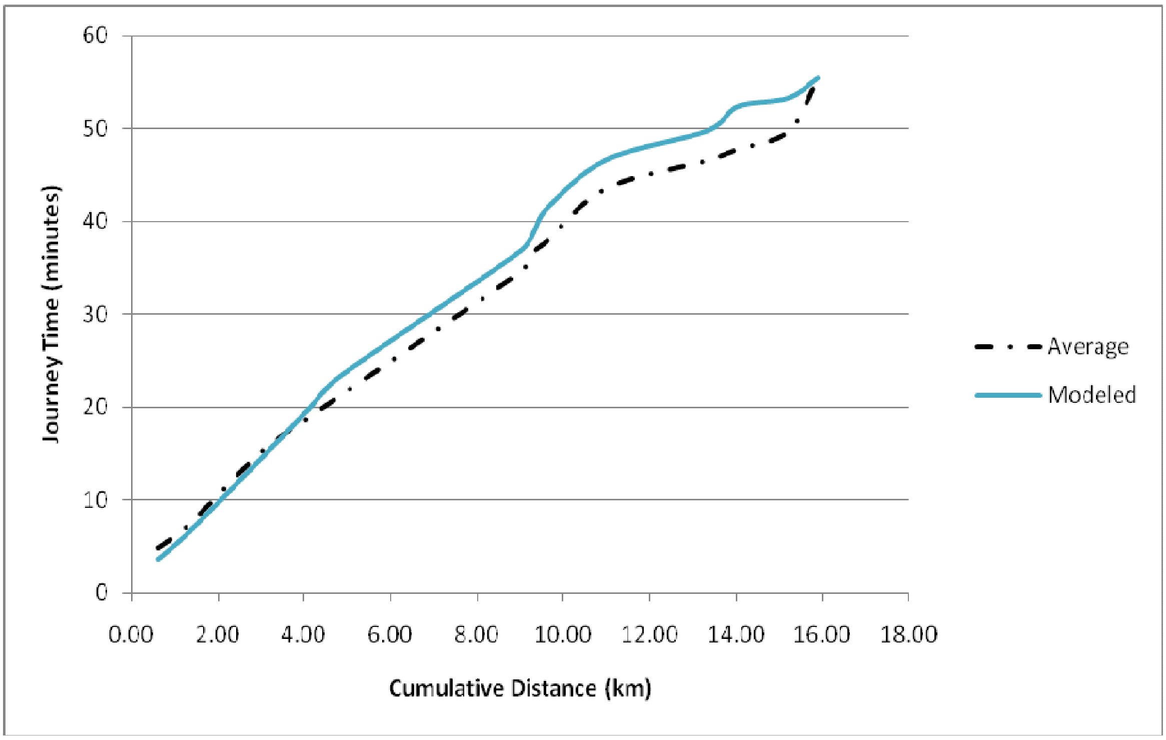


Figure 8.14: Modeled vs. Observed Journey Times (Nabinagar – Chandra section)

In all the cases where there is a discrepancy of 5% or more, the modeled travel time is less than the observed travel time. This indicates the model underestimates the congestion of road network. So, the travel time benefits estimated from the model will be a conservative estimate.

8.7 Spreadsheet Modeling

8.7.1 Expansion and Annualization Factors

Expansion Factors

In this traffic model the daily traffic is represented in three different time slots as discussed in section 6.3.1 namely Peak Traffic Conditions (7 am - 1 pm and 4pm - 10 pm), Off Peak Traffic Condition (1 pm - 4 pm and 10 pm - 1 am) and Super Off Peak Traffic Condition (1 am to 7 am). Separate models for each of these three different time slots were developed. Then a 12 hour expansion for peak hour time period, 6 hour expansion for off-peak time period and 6 hour expansion for super-off-peak time period is employed. These expansion factors were unchanged for the future year models also.

Annualization Factors

Daily traffic profile for weekdays and weekends does not change very much. In fact, the roadways in the study area are very important links that it seems to be unaffected by small weekly and seasonal variation in traffic flows. Therefore, annualization factor used for modeling is 365. So, the daily traffic derived after using expansion factor becomes Average Daily Traffic (ADT)

8.7.2 Ramp Up

The ramp-up period reflects a toll facility's traffic performance during its early years of operation. This period may be characterized by unusually high traffic growth. The end of the ramp-up period is marked by annual growth figures that have (or appear to have) stabilized and that are closer to traffic patterns that have been observed on other, similar facilities. The ramp-up period reflects the users' unfamiliarity with a new highway and its benefits ("information lag"), as well as a community's reluctance to pay tolls (if there is no prior tolling culture) or to pay high tolls (if there is a history). The performance of the facility during ramp-up is particularly important to the financial community because the probability of default is typically at its highest during the early project years. Ramp up has three dimensions:

- Scale of the ramp up (magnitude of the departure from forecast)
- Duration of the ramp-up (from instantaneous to beyond five years)
- Extent of catch-up (having experienced low usage upon opening, to what extent observed traffic volumes catch-up with later year forecasts?)

Ramp up period is made faster when there is a higher level of congestion on the alternative routes. In case of proposed Dhaka Ashulia Elevated Expressway the alternative at-grade road is already highly congested. So, the perceived level of benefit to the users is high enough to influence them in choosing the improved facility within a shorter time frame.

For this model a four year ramp-up period is assumed following the scheme:

1st Year: 40%
2nd Year: 65%
3rd Year: 90%
4th Year: 100%

8.7.3 Non- Modeled Years

The traffic model considers up to year 2025 for the forecast. Beyond this period the projected traffic at the facility will be constrained by the capacity of the roads. So, the model considers years after 2025 based on a long-term growth forecast with capacity constraints applied. The modeled years in this model are 2015, 2020 and 2025. The intermediate years are obtained from these forecasts using interpolation. The capacity constraint applied is 66,000 vehicles for Average Daily Traffic on the mainline per direction. This figure is based on:

- 2200 hourly capacity per lane
- 2 lanes
- 15 hours
- 2200 X 2 X 15 = 66,000 vehicles

Section 9

MODEL RESULTS

9.1 Summary of Assumptions

The summary of assumptions to produce this forecast is summarized in the following table.

Table 9.1: Assumptions Made for Forecasts

Category	Assumption/Source	Reference
Socioeconomic		
Population Growth	BBS, Assumptions	Section 6.2
GDP Growth	IMF forecast, Calculation	Section 6.4.1
CPI Growth	IMF	Section 6.4.2
Modeling		
Value of Time	RHD	Section 8.5.5
Purchase Power	50% growth in Real GDPPC	
Alternative Specific Constant	SP Survey by AECOM (2009)	
Peak Period	7 am - 1 pm and 4pm - 10 pm	Section 8.4.1
Off-Peak Period	1 pm - 4 pm and 10 pm - 1 am	
Super-Off-Peak Period	1 am to 7 am	
Trips		
2011 (base year)	From STP Model, DHUTS, AECOM OD Survey (2009), Pilot OD Survey (2011)	Section 8.4.1
Future Years	2015, 2020, 2025 from STP, Calculations	Section 8.4.2
Vehicle Composition	Base Year- based on Traffic Survey 2011 Future Year- based on growth in private vehicle	Section 8.4.3
Buses	50% post model reduction in number of Mini-Buses	Section 8.4.4
Network		
Base Year (2011)	From STP with adjustments for current roads	Section 8.3.1
Future Year	Adjustments made on the base year network depending on expected changes at that time	Section 8.3.2
Alternative Alignments and Scenarios	Network coded in accordance with the description in section 2.1	Section 2.1 & 5.4.2
Factors		
Annualization Factor	365 (constant for future years)	Section 8.7.1
Ramp Up	1st Year: 40% 2nd Year: 65% 3rd Year: 90% 4th Year: 100%	Section 8.7.2

9.2 Traffic Forecasts

Traffic forecast for the model is presented daily transactions as the following tables. Results have been provided for both the alignment alternatives. The alignment 1 option has been explored with variation in at-grade road capacity, GDP growth rate and toll amounts. Other relevant data are presented in Appendix C.

Table 9.2: Forecasts for Alternative Alignment 1- (Scenario 2) - with 6% GDP growth rate

Year	Daily Transactions							
	HT	T	B	MB	C	MC	TW	Total
2015	722	1691	1022	910	6805	121	271	11543
2016	961	2250	1035	921	7434	183	472	13257
2017	2010	4710	1946	1732	14463	397	1064	26322
2018	2989	7004	2732	2432	20702	602	1637	38099
2019	3745	8775	3302	2940	25335	762	2093	46951
2020	4501	10546	3872	3447	29967	922	2548	55803
2021	5734	13436	4320	3845	36451	1016	2744	67546
2022	6968	16326	4767	4244	42936	1110	2939	79289
2023	8201	19216	5215	4642	49420	1203	3135	91033
2024	9435	22106	5662	5041	55905	1297	3330	102776
2025	10668	24996	6110	5439	62389	1391	3526	114519
2026	11346	26586	6356	5658	65955	1443	3634	120978
2027	11346	26586	6356	5658	65955	1443	3634	120978
2028	11346	26586	6356	5658	65955	1443	3634	120978
2029	11346	26586	6356	5658	65955	1443	3634	120978
2030	11346	26586	6356	5658	65955	1443	3634	120978

Table 9.3: Forecasts for Alternative Alignment 1-(Scenario 2) with 4.8% GDP gr. rate

Year	Daily Transactions							
	HT	T	B	MB	C	MC	TW	Total
2015	692	1622	991	882	6428	111	250	10976
2016	903	2117	992	883	7032	166	415	12509
2017	1879	4402	1855	1652	13689	361	924	24762
2018	2785	6526	2597	2312	19601	545	1416	35781
2019	3483	8161	3132	2788	23991	690	1804	44050
2020	4181	9796	3667	3265	28382	835	2193	52318
2021	5245	12289	4056	3610	33375	888	2317	61779
2022	6309	14782	4444	3956	38367	940	2441	71240
2023	7372	17275	4833	4302	43360	993	2566	80701
2024	8436	19767	5222	4648	48353	1046	2690	90162
2025	9500	22260	5610	4994	53345	1099	2815	99623
2026	10564	24753	5999	5340	58338	1151	2939	109084
2027	11628	27246	6387	5686	63331	1204	3063	118545
2028	11894	27869	6484	5772	64579	1217	3095	120910
2029	11894	27869	6484	5772	64579	1217	3095	120910
2030	11894	27869	6484	5772	64579	1217	3095	120910

Table 9.4: Forecasts for Alternative Alignment 1- (Scenario 2) - with 7.2% GDP growth rate

Year	Daily Transactions							
	HT	T	B	MB	C	MC	TW	Total
2015	753	1763	1054	938	7199	132	294	12133
2016	1021	2392	1079	961	7854	201	537	14045
2017	2149	5036	2040	1816	15271	438	1223	27973
2018	3206	7512	2873	2558	21852	663	1892	40555
2019	4024	9428	3479	3097	26736	841	2424	50029
2020	4841	11344	4086	3637	31621	1018	2957	59503
2021	6053	14183	4507	4012	38063	1105	3101	71024
2022	7265	17022	4928	4387	44505	1193	3244	82544
2023	8476	19861	5349	4762	50947	1280	3388	94064
2024	9688	22700	5770	5137	57390	1368	3532	105585
2025	10900	25539	6191	5511	63832	1455	3676	117105
2026	11263	26391	6318	5624	65765	1481	3719	120561
2027	11263	26391	6318	5624	65765	1481	3719	120561
2028	11263	26391	6318	5624	65765	1481	3719	120561
2029	11263	26391	6318	5624	65765	1481	3719	120561
2030	11263	26391	6318	5624	65765	1481	3719	120561

Table 9.5: Forecasts for Alternative Alignment 1 + At- Grade Road Widening-(Scenario 4)

Year	Daily Transactions							
	HT	T	B	MB	C	MC	TW	Total
2015	650	1527	932	822	6115	109	244	10398
2016	865	2032	943	832	6681	165	424	11941
2017	1809	4251	1774	1565	12997	358	956	23709
2018	2691	6322	2490	2197	18603	542	1471	34315
2019	3371	7921	3010	2655	22766	686	1880	42288
2020	4051	9519	3529	3113	26929	830	2289	50260
2021	4983	11721	3815	3391	31790	895	2414	59008
2022	5915	13923	4101	3668	36650	960	2538	67756
2023	6848	16126	4386	3946	41511	1025	2663	76504
2024	7780	18328	4672	4223	46371	1090	2787	85252
2025	8712	20530	4958	4501	51232	1155	2912	94000
2026	9644	22732	5244	4779	56093	1220	3037	102748
2027	10576	24934	5530	5056	60953	1285	3161	111496
2028	11509	27137	5815	5334	65814	1350	3286	120244
2029	11509	27137	5815	5334	65814	1350	3286	120244
2030	11509	27137	5815	5334	65814	1350	3286	120244

Table 9.6: Forecasts for Alternative Alignment 2 - (Scenario 5)

Year	Daily Transactions							
	HT	T	B	MB	C	MC	TW	Total
2015	550	1649	1092	997	6163	117	255	10822
2016	731	2194	1106	1009	6733	177	444	12393
2017	1530	4592	2079	1898	13098	384	1001	24580
2018	2276	6829	2918	2665	18748	581	1540	35556
2019	2851	8555	3527	3221	22943	736	1969	43801
2020	3426	10282	4136	3777	27138	891	2397	52046
2021	4321	13099	4614	4214	33010	982	2581	62820
2022	5216	15917	5092	4650	38882	1072	2765	73594
2023	6112	18734	5570	5087	44755	1163	2948	84369
2024	7007	21552	6048	5523	50627	1253	3132	95143
2025	7902	24369	6526	5960	56499	1344	3316	105917
2026	8797	27186	7004	6397	62371	1435	3500	116691
2027	9137	28257	7186	6563	64603	1469	3570	120785
2028	9137	28257	7186	6563	64603	1469	3570	120785
2029	9137	28257	7186	6563	64603	1469	3570	120785
2030	9137	28257	7186	6563	64603	1469	3570	120785

Table 9.7: Forecasts for Alternative Alignment 1- (Scenario 2) with 20% Toll Increase-GDP growth 6%

Year	Daily Transactions							
	HT	T	B	MB	C	MC	TW	Total
2015	649	1517	896	798	6546	116	261	10783
2016	874	2044	914	814	7187	175	450	12457
2017	1836	4294	1725	1537	14010	379	1011	24791
2018	2735	6398	2427	2162	20077	573	1554	35927
2019	3431	8025	2937	2617	24588	725	1985	44309
2020	4127	9653	3447	3071	29099	878	2416	52690
2021	5296	12389	3862	3441	35452	969	2608	64019
2022	6466	15126	4278	3811	41806	1061	2800	75348
2023	7636	17862	4693	4181	48160	1153	2992	86677
2024	8806	20599	5108	4551	54514	1245	3184	98006
2025	9976	23335	5523	4921	60867	1337	3376	109335
2026	11146	26072	5938	5291	67221	1428	3568	120664
2027	11146	26072	5938	5291	67221	1428	3568	120664
2028	11146	26072	5938	5291	67221	1428	3568	120664
2029	11146	26072	5938	5291	67221	1428	3568	120664
2030	11146	26072	5938	5291	67221	1428	3568	120664

Table 9.8: Forecasts for Alternative Alignment 1-(Scenario 2) with 20% Toll Decrease-GDP growth 6%

Year	Daily Transactions							
	HT	T	B	MB	C	MC	TW	Total
2015	776	1822	1126	1002	7178	129	289	12323
2016	1040	2440	1146	1019	7863	196	505	14208
2017	2180	5116	2159	1920	15315	426	1139	28255
2018	3245	7616	3035	2700	21936	645	1753	40930
2019	4068	9547	3672	3266	26855	817	2241	50466
2020	4891	11478	4308	3832	31774	989	2729	60002
2021	6152	14439	4740	4216	38140	1078	2910	71675
2022	7414	17399	5171	4600	44506	1167	3090	83348
2023	8675	20360	5603	4984	50872	1256	3270	95021
2024	9937	23320	6034	5369	57238	1345	3451	106694
2025	11198	26281	6466	5753	63604	1434	3631	118367
2026	11387	26725	6531	5810	64559	1447	3658	120118
2027	11387	26725	6531	5810	64559	1447	3658	120118
2028	11387	26725	6531	5810	64559	1447	3658	120118
2029	11387	26725	6531	5810	64559	1447	3658	120118
2030	11387	26725	6531	5810	64559	1447	3658	120118

9.3 Travel Time Forecasts

In order to find out the benefit of travel time savings for the proposed Dhaka Ashulia Elevated Expressway Project travel time forecasts are made. This forecast is made for each of the modeled year, for each of the time slots (peak, off-peak, super-off-peak) and each of the scenarios. The result is summarized in the following tables. In these tables we have listed travel times in six different scenario designations from A to H.

- A => No Change Scenario/ Business-As-Usual (Scenario 1)
- B => Expressway in Alternative Alignment- 1 (Scenario 2)
- C => Existing At-Grade Road in Alternative Alignment-1 (Scenario 2)
- D => Existing At-Grade Road with Widening (Scenario 3)
- E => F Expressway in Alternative Alignment- 1+ At-Grade Road Widening (Scenario 4)
- F => Existing At-Grade Road in Alternative Alignment- 1+ At-Grade Road Widening (Scenario 4)
- G => Existing At-Grade Road in Alternative Alignment-2 (Scenario 5)
- H => Expressway in Alternative Alignment- 2 (Scenario 5)

Other relevant data are presented in Appendix C.

Table 9.9: Travel Time (minutes) for Year 2015 - Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	18.46	5.65	13.71	9.75	5.39	8.36	16.03	DEE - Abdullahpur	5.84
Abdullahpur - Ashulia	12.69	3.88	9.43	6.70	3.71	5.75	11.02	Abdullahpur - Ashulia	5.04
Ashulia - Jirabo	22.57	6.90	16.77	11.91	6.59	10.22	19.59	Ashulia- BPATC	8.91
Jirabo - Baipail	5.08	1.55	3.77	2.68	1.48	2.30	4.41	BPATC - Nabinagar	4.54
Baipail - Jirani	13.85	4.24	10.29	7.31	4.04	6.27	12.02	Nabinagar - Baipail	2.81
Jirani - Chandra	18.46	5.65	13.71	9.75	5.39	8.36	16.03	Baipail- Jirani	5.05
Chandra-Jirani	18.46	5.65	13.71	9.75	5.39	8.36	16.03	Jirani-Chandra	5.95
Jirani - Baipail	13.85	4.24	10.29	7.31	4.04	6.27	12.02	Chandra - Jirani	5.95
Baipail - Nabinagar	6.92	2.12	5.14	3.65	2.02	3.14	6.01	Jirani - Baipail	5.05
Nabinagar - Baipail	6.92	2.12	5.14	3.65	2.02	3.14	6.01	Baipail - Nabinagar	2.81
Baipail - Jirabo	5.08	1.55	3.77	2.68	1.48	2.30	4.41	Nabinagar - BPATC	4.54
Jirabo - Ashulia	22.57	6.90	16.77	11.91	6.59	10.22	19.59	BPATC - Ashulia	8.91
Ashulia - Abdullahpur	12.69	3.88	9.43	6.70	3.71	5.75	11.02	Ashulia - Abdullahpur	5.04
Abdullahpur - DEE	18.46	5.65	13.71	9.75	5.39	8.36	16.03	Abdullahpur - DEE	5.84

Table 9.10: Travel Time (minutes) for Year 2015 - Off-Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	10.67	5.33	10.67	8.14	5.11	7.82	11.18	DEE - Abdullahpur	5.62
Abdullahpur - Ashulia	7.33	3.67	7.33	5.59	3.51	5.37	7.68	Abdullahpur - Ashulia	4.84
Ashulia - Jirabo	13.04	6.52	13.04	9.95	6.24	9.56	13.66	Ashulia- BPATC	8.57
Jirabo - Baipail	2.93	1.47	2.93	2.24	1.40	2.15	3.07	BPATC - Nabinagar	4.36
Baipail - Jirani	8.00	4.00	8.00	6.10	3.83	5.86	8.38	Nabinagar - Baipail	2.70
Jirani - Chandra	10.67	5.33	10.67	8.14	5.11	7.82	11.18	Baipail- Jirani	4.85
Chandra-Jirani	10.67	5.33	10.67	8.14	5.11	7.82	11.18	Jirani-Chandra	5.72
Jirani - Baipail	8.00	4.00	8.00	6.10	3.83	5.86	8.38	Chandra - Jirani	5.72
Baipail - Nabinagar	4.00	2.00	4.00	3.05	1.91	2.93	4.19	Jirani - Baipail	4.85
Nabinagar - Baipail	4.00	2.00	4.00	3.05	1.91	2.93	4.19	Baipail - Nabinagar	2.70
Baipail - Jirabo	2.93	1.47	2.93	2.24	1.40	2.15	3.07	Nabinagar - BPATC	4.36
Jirabo - Ashulia	13.04	6.52	13.04	9.95	6.24	9.56	13.66	BPATC - Ashulia	8.57
Ashulia - Abdullahpur	7.33	3.67	7.33	5.59	3.51	5.37	7.68	Ashulia - Abdullahpur	4.84
Abdullahpur - DEE	10.67	5.33	10.67	8.14	5.11	7.82	11.18	Abdullahpur - DEE	5.62

Table 9.11: Travel Time (minutes) for Year 2015 – Super-Off-Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	8.14	5.05	7.38	7.27	5.03	7.02	9.81	DEE - Abdullahpur	5.25
Abdullahpur - Ashulia	5.59	3.47	5.08	5.00	3.46	4.82	6.74	Abdullahpur - Ashulia	4.53
Ashulia - Jirabo	9.95	6.18	9.03	8.89	6.14	8.58	11.99	Ashulia- BPATC	8.00
Jirabo - Baipail	2.24	1.39	2.03	2.00	1.38	1.93	2.70	BPATC - Nabinagar	4.07
Baipail - Jirani	6.10	3.79	5.54	5.45	3.77	5.26	7.35	Nabinagar - Baipail	2.53
Jirani - Chandra	8.14	5.05	7.38	7.27	5.03	7.02	9.81	Baipail- Jirani	4.53
Chandra-Jirani	8.14	5.05	7.38	7.27	5.03	7.02	9.81	Jirani-Chandra	5.35
Jirani - Baipail	6.10	3.79	5.54	5.45	3.77	5.26	7.35	Chandra - Jirani	5.35
Baipail - Nabinagar	3.05	1.89	2.77	2.73	1.88	2.63	3.68	Jirani - Baipail	4.53
Nabinagar - Baipail	3.05	1.89	2.77	2.73	1.88	2.63	3.68	Baipail - Nabinagar	2.53
Baipail - Jirabo	2.24	1.39	2.03	2.00	1.38	1.93	2.70	Nabinagar - BPATC	4.07
Jirabo - Ashulia	9.95	6.18	9.03	8.89	6.14	8.58	11.99	BPATC - Ashulia	8.00
Ashulia - Abdullahpur	5.59	3.47	5.08	5.00	3.46	4.82	6.74	Ashulia - Abdullahpur	4.53
Abdullahpur - DEE	8.14	5.05	7.38	7.27	5.03	7.02	9.81	Abdullahpur - DEE	5.25

Table 9.12: Travel Time (minutes) for Year 2020 – Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	23.70	6.08	19.52	15.00	5.91	14.40	22.61	DEE - Abdullahpur	5.84
Abdullahpur - Ashulia	16.30	4.18	13.42	10.31	4.06	9.90	15.54	Abdullahpur - Ashulia	5.04
Ashulia - Jirabo	28.98	7.43	23.86	18.34	7.23	17.60	27.64	Ashulia- BPATC	8.91
Jirabo - Baipail	6.52	1.67	5.37	4.13	1.63	3.96	6.22	BPATC - Nabinagar	4.54
Baipail - Jirani	17.78	4.56	14.64	11.25	4.43	10.80	16.96	Nabinagar - Baipail	2.81
Jirani - Chandra	23.70	6.08	19.52	15.00	5.91	14.40	22.61	Baipail- Jirani	5.05
Chandra-Jirani	23.70	6.08	19.52	15.00	5.91	14.40	22.61	Jirani-Chandra	5.95
Jirani - Baipail	17.78	4.56	14.64	11.25	4.43	10.80	16.96	Chandra - Jirani	5.95
Baipail - Nabinagar	8.89	2.28	7.32	5.63	2.22	5.40	8.48	Jirani - Baipail	5.05
Nabinagar - Baipail	8.89	2.28	7.32	5.63	2.22	5.40	8.48	Baipail - Nabinagar	2.81
Baipail - Jirabo	6.52	1.67	5.37	4.13	1.63	3.96	6.22	Nabinagar - BPATC	4.54
Jirabo - Ashulia	28.98	7.43	23.86	18.34	7.23	17.60	27.64	BPATC - Ashulia	8.91
Ashulia - Abdullahpur	16.30	4.18	13.42	10.31	4.06	9.90	15.54	Ashulia - Abdullahpur	5.04
Abdullahpur - DEE	23.70	6.08	19.52	15.00	5.91	14.40	22.61	Abdullahpur - DEE	5.84

Table 9.13: Travel Time (minutes) for Year 2020 – Off-Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	12.15	5.39	11.09	10.28	5.49	9.73	12.24	DEE - Abdullahpur	5.62
Abdullahpur - Ashulia	8.35	3.71	7.62	7.07	4.73	6.69	8.41	Abdullahpur - Ashulia	4.84
Ashulia - Jirabo	14.86	6.59	13.55	12.57	8.37	11.89	14.96	Ashulia- BPATC	8.57
Jirabo - Baipail	3.34	1.48	3.05	2.83	4.26	2.68	3.36	BPATC - Nabinagar	4.36
Baipail - Jirani	9.11	4.04	8.31	7.71	2.64	7.30	9.18	Nabinagar - Baipail	2.70
Jirani - Chandra	12.15	5.39	11.09	10.28	4.74	9.73	12.24	Baipail- Jirani	4.85
Chandra-Jirani	12.15	5.39	11.09	10.28	5.59	9.73	12.24	Jirani-Chandra	5.72
Jirani - Baipail	9.11	4.04	8.31	7.71	5.59	7.30	9.18	Chandra - Jirani	5.72
Baipail - Nabinagar	4.56	2.02	4.16	3.85	4.74	3.65	4.59	Jirani - Baipail	4.85
Nabinagar - Baipail	4.56	2.02	4.16	3.85	2.64	3.65	4.59	Baipail - Nabinagar	2.70
Baipail - Jirabo	3.34	1.48	3.05	2.83	4.26	2.68	3.36	Nabinagar - BPATC	4.36
Jirabo - Ashulia	14.86	6.59	13.55	12.57	8.37	11.89	14.96	BPATC - Ashulia	8.57
Ashulia - Abdullahpur	8.35	3.71	7.62	7.07	4.73	6.69	8.41	Ashulia - Abdullahpur	4.84
Abdullahpur - DEE	12.15	5.39	11.09	10.28	5.49	9.73	12.24	Abdullahpur - DEE	5.62

Table 9.14: Travel Time (min.) for Yr 2020 Super-Off-Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	9.56	5.22	9.06	8.19	5.17	7.83	9.95	DEE - Abdullahpur	5.36
Abdullahpur - Ashulia	6.57	3.59	6.23	5.63	3.56	5.38	6.84	Abdullahpur - Ashulia	4.63
Ashulia - Jirabo	11.69	6.38	11.07	10.01	6.32	9.57	12.17	Ashulia- BPATC	8.18
Jirabo - Baipail	2.63	1.43	2.49	2.25	1.42	2.15	2.74	BPATC - Nabinagar	4.16
Baipail - Jirani	7.17	3.91	6.79	6.14	3.88	5.87	7.46	Nabinagar - Baipail	2.58
Jirani - Chandra	9.56	5.22	9.06	8.19	5.17	7.83	9.95	Baipail- Jirani	4.63
Chandra-Jirani	9.56	5.22	9.06	8.19	5.17	7.83	9.95	Jirani-Chandra	5.46
Jirani - Baipail	7.17	3.91	6.79	6.14	3.88	5.87	7.46	Chandra - Jirani	5.46
Baipail - Nabinagar	3.59	1.96	3.40	3.07	1.94	2.93	3.73	Jirani - Baipail	4.63
Nabinagar - Baipail	3.59	1.96	3.40	3.07	1.94	2.93	3.73	Baipail - Nabinagar	2.58
Baipail - Jirabo	2.63	1.43	2.49	2.25	1.42	2.15	2.74	Nabinagar - BPATC	4.16
Jirabo - Ashulia	11.69	6.38	11.07	10.01	6.32	9.57	12.17	BPATC - Ashulia	8.18
Ashulia - Abdullahpur	6.57	3.59	6.23	5.63	3.56	5.38	6.84	Ashulia - Abdullahpur	4.63
Abdullahpur - DEE	9.56	5.22	9.06	8.19	5.17	7.83	9.95	Abdullahpur - DEE	5.36

Table 9.15: Travel Time (minutes) for Year 2025 – Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	26.37	8.42	23.70	20.56	7.08	19.24	24.62	DEE - Abdullahpur	8.69
Abdullahpur - Ashulia	18.13	5.79	16.30	14.13	4.87	13.23	16.92	Abdullahpur - Ashulia	7.49
Ashulia - Jirabo	32.24	10.29	28.98	25.13	8.65	23.52	30.09	Ashulia- BPATC	13.25
Jirabo - Baipail	7.25	2.32	6.52	5.65	1.95	5.29	6.77	BPATC - Nabinagar	6.74
Baipail - Jirani	19.78	6.32	17.78	15.42	5.31	14.43	18.46	Nabinagar - Baipail	4.18
Jirani - Chandra	26.37	8.42	23.70	20.56	7.08	19.24	24.62	Baipail- Jirani	7.50
Chandra-Jirani	26.37	8.42	23.70	20.56	7.08	19.24	24.62	Jirani-Chandra	8.85
Jirani - Baipail	19.78	6.32	17.78	15.42	5.31	14.43	18.46	Chandra - Jirani	8.85
Baipail - Nabinagar	9.89	3.16	8.89	7.71	2.65	7.21	9.23	Jirani - Baipail	7.50
Nabinagar - Baipail	9.89	3.16	8.89	7.71	2.65	7.21	9.23	Baipail - Nabinagar	4.18
Baipail - Jirabo	7.25	2.32	6.52	5.65	1.95	5.29	6.77	Nabinagar - BPATC	6.74
Jirabo - Ashulia	32.24	10.29	28.98	25.13	8.65	23.52	30.09	BPATC - Ashulia	13.25
Ashulia - Abdullahpur	18.13	5.79	16.30	14.13	4.87	13.23	16.92	Ashulia - Abdullahpur	7.49
Abdullahpur - DEE	26.37	8.42	23.70	20.56	7.08	19.24	24.62	Abdullahpur - DEE	8.69

Table 9.16: Travel Time (minutes) for Year 2025 – Off- Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	14.33	6.23	12.39	11.76	6.17	10.68	13.25	DEE - Abdullahpur	7.25
Abdullahpur - Ashulia	9.85	4.29	8.52	8.09	4.24	7.34	9.11	Abdullahpur - Ashulia	6.25
Ashulia - Jirabo	17.52	7.62	15.14	14.38	7.54	13.05	16.20	Ashulia- BPATC	11.05
Jirabo - Baipail	3.94	1.71	3.41	3.24	1.70	2.94	3.64	BPATC - Nabinagar	5.62
Baipail - Jirani	10.75	4.68	9.29	8.82	4.63	8.01	9.94	Nabinagar - Baipail	3.49
Jirani - Chandra	14.33	6.23	12.39	11.76	6.17	10.68	13.25	Baipail- Jirani	6.26
Chandra-Jirani	14.33	6.23	12.39	11.76	6.17	10.68	13.25	Jirani-Chandra	7.38
Jirani - Baipail	10.75	4.68	9.29	8.82	4.63	8.01	9.94	Chandra - Jirani	7.38
Baipail - Nabinagar	5.37	2.34	4.65	4.41	2.31	4.00	4.97	Jirani - Baipail	6.26
Nabinagar - Baipail	5.37	2.34	4.65	4.41	2.31	4.00	4.97	Baipail - Nabinagar	3.49
Baipail - Jirabo	3.94	1.71	3.41	3.24	1.70	2.94	3.64	Nabinagar - BPATC	5.62
Jirabo - Ashulia	17.52	7.62	15.14	14.38	7.54	13.05	16.20	BPATC - Ashulia	11.05
Ashulia - Abdullahpur	9.85	4.29	8.52	8.09	4.24	7.34	9.11	Ashulia - Abdullahpur	6.25
Abdullahpur - DEE	14.33	6.23	12.39	11.76	6.17	10.68	13.25	Abdullahpur - DEE	7.25

Table 9.17: Travel Time (minutes) for Year 2025 –Super-Off- Peak Period at different Scenarios

Travel Time (minutes)									
Links (A-F)	A	B	C	D	E	F	G	Links (H)	H
DEE - Abdullahpur	10.17	5.78	9.94	8.12	5.47	8.01	10.16	DEE - Abdullahpur	6.06
Abdullahpur - Ashulia	6.99	3.98	6.83	5.58	3.76	5.50	6.99	Abdullahpur - Ashulia	5.22
Ashulia - Jirabo	12.43	7.07	12.15	9.93	6.68	9.79	12.42	Ashulia- BPATC	9.24
Jirabo - Baipail	2.80	1.59	2.73	2.23	1.50	2.20	2.79	BPATC - Nabinagar	4.70
Baipail - Jirani	7.63	4.34	7.45	6.09	4.10	6.01	7.62	Nabinagar - Baipail	2.91
Jirani - Chandra	10.17	5.78	9.94	8.12	5.47	8.01	10.16	Baipail- Jirani	5.23
Chandra-Jirani	10.17	5.78	9.94	8.12	5.47	8.01	10.16	Jirani-Chandra	6.17
Jirani - Baipail	7.63	4.34	7.45	6.09	4.10	6.01	7.62	Chandra - Jirani	6.17
Baipail - Nabinagar	3.81	2.17	3.73	3.05	2.05	3.00	3.81	Jirani - Baipail	5.23
Nabinagar - Baipail	3.81	2.17	3.73	3.05	2.05	3.00	3.81	Baipail - Nabinagar	2.91
Baipail - Jirabo	2.80	1.59	2.73	2.23	1.50	2.20	2.79	Nabinagar - BPATC	4.70
Jirabo - Ashulia	12.43	7.07	12.15	9.93	6.68	9.79	12.42	BPATC - Ashulia	9.24
Ashulia - Abdullahpur	6.99	3.98	6.83	5.58	3.76	5.50	6.99	Ashulia - Abdullahpur	5.22
Abdullahpur - DEE	10.17	5.78	9.94	8.12	5.47	8.01	10.16	Abdullahpur - DEE	6.06

These forecasted traffic flow and travel time data are used in economic analysis of the Dhaka Elevated Expressway Project (DAEEP), which is presented in Section 16.

Section 10

PRELIMINARY ENVIRONMENTAL ASSESSMENT

10.1 Objectives

The main objectives of the environmental assessment study of the proposed Dhaka Ashulia Elevated Expressway (DAEE) project are:

- to identify the project nature to ascertain the level of environmental assessment required at the project feasibility level, and
- to make a preliminary assessment of possible impacts (positive or negative) that may require more detailed investigation during environmental and social impact assessment (ESIA) of the project.

As described earlier, two alternative routes have been considered for the DAEE, identified as Alternative 1 and Alternative 2; Figure 10.1 shows the two routes on a Google image. Both routes start at the termini of the proposed Dhaka Elevated Expressway (DEE), close to the entrance of Hazrat Shahjalal International Airport (on the opposite of the Airport Road). Both routes follow the same alignment along the railway tract through Uttara Sectors 4, 6 and 8 (to the east of the Airport Road) up to Arichpur Road level crossing. Both routes then turn west toward Abdullahpur intersection, following the same alignment, and then follow the Ashulia Road (up to 4.8 km from the starting point).

From this point, the two alternatives follow separate alignments. Alternative 1 follows the Ashulia Road up to Baipayl (about 21 km from the starting point); from Baipayl it stretches up to Chandra to the north and Nabinagar to the south. On the other hand, Alternative 2 turns south toward Sonargaon Janapath, and then follows the Sonargaon Janapath (running between Sectors 11 and 13 of Uttara). It then goes through Uttara 3rd Phase, crosses the Beri Bandh Road, Turag River-Tongi Khal and meets the Ashulia-Savar Road (about 14 km from the starting point). It then follows the Ashulia-Savar Road and meets Dhaka-Aricha Highway close to Jahangirnagar University and then follows Dhaka-Aricha Highway up to Nabinagar (Savar). From Nabinagar (Savar) to Chandra, Alternative 1 and Alternative 2 follow the same alignment. The total length of alignments along Alternative 1 and Alternative 2 are about 36 km and 42 km, respectively.

For the purpose of preliminary environmental assessment, field reconnaissance survey was carried out along the proposed routes (Alternative 1 and Alternative 2) of the DAEE. Based on the information gathered from the survey, secondary information and a preliminary assessment of project related activities, a preliminary assessment of environmental impacts of the proposed project has also been carried out. The following Sections describe the existing environment along the proposed routes of the DAEE and potential significant impacts of the proposed project.

10.2 Existing Environmental Setting along the Proposed Routes of the DAEE

10.2.1 Alternative 1 Alignment

Alternative 1 alignment of the proposed Dhaka-Ashulia Elevated Expressway (DAEE) starts at the termini of the Dhaka Elevated Expressway (DEE) close to the Haji camp (see Fig. D1 in Appendix D). It follows the alignment of the rail track and crosses the level crossing on the road (about 0.24 km from the starting point) leading to Haji camp. The DAEE alignment then follows the railway track bifurcating the Airport Rail Station located within half a kilometer from the starting point.

The DAEE alignment then follows the railway track through built up areas – leaving Uttara Sectors 4, 6 and 8 on the west and Azampur, Dewanpara and Goaltek on the east. At a distance of about three and a half kilometers from the starting point, the railway track crosses the level crossing on Arichpur Road [Teromukh-Rayedia (Mothbari)-Ulukhola Road] (see Fig. D2). Roads and Highways Department is currently carrying out expansion of the one-lane road. The Arichpur area is very densely populated with markets, residential buildings and slums on either side of the road. It should be noted that the railway track bifurcates just before the Arichpur Road crossing and then crosses the Turag river/Tongi khal along two railway bridges.

The DAEE alignment turns west just before the Arichpur Road level crossing, and then follows the Arichpur Road toward the Abdullahpur intersection. Abdullahpur is a very busy intersection with roads going toward Ashulia (to the west) and Joydevpur (to the north). There is a foot over-bridge at this intersection and commercial and residential establishments on all sides.

From Abdullahpur, the Alternative 1 alignment of the DAEE follows the Ashulia Road up to Baipayl (about 21 km from the starting point). Along the two-lane Ashulia road starting at Abdullahpur, there are built up areas on the west and flood plains of Turag river-Tongi khal system on the east. At many places along the Ashulia road, land filling of the river floodplain could be seen; at many locations structures have been built on filled floodplain land (see Fig. D3). Some industries could be seen on the eastern side of the Turag River-Tongi khal. At a distance of about 6.26 km from the starting point, the DAEE alignment crosses the Kamarpara intersection, where a bridge has been constructed over the Turag river-Tongi khal (Fig. D3). The area is heavily built around the intersection. Another bridge has been constructed over the River at a distance of about 7.59 km, connecting the Ashulia Road with a housing project (Fig. D4).

The DAEE alignment reaches the Dhour intersection, about 9.5 km from the starting point, where the Beri Bandh Road from Mirpur connects with Ashulia Road (Fig. D5). The DAEE alignment then crosses the Turag River-Tongi Khal along Ashulia bridge and follows the Ashulia Road, with low lands on either side. It then crosses the Turag River along the bridge at Chak Basaid (at about 12.4 km from starting point) and continues along the Ashulia road. This is a built up area with dense human settlements on the west and brick kilns on the east (Fig. D6); there is a road connecting this area with Savar (Ashulia-Savar Road).

Scattered human settlements (primarily on the western side) and brick kilns (on the eastern side) were identified along Ashulia Road up to Zirabo (Fig. D7, about 14.4 km from the starting point of DAEE). Along the Ashulia road, from Zirabo up to the intersection of Narsingdi-Kashimpur Road (Fig. D8), concentration of industries and residences on both sides of the road (and also DAEE alignment) increases. From

Narsingdi-Kashimpur Road intersection up to Baipayl (i.e., from about 17 km to about 21 km from the starting point), the area is heavily built-up with very high concentrations of industries, commercial facilities and residences on either side of the Ashulia road (Fig. D9).

From Baipayl, the DAEE alignment stretches up to Chandra in the north (about 12.4 km) and Nabinagar in the south (about 3 km) along the Nabinagar-Chandra road. Within about 1 km along Baipayl-Chandra road from the Baipayl intersection, the Dhaka EPZs are located on either side of the Road (Fig. D10). Beyond the Dhaka EPZ area, industrial clusters could be seen on either side of the road. There are also lowlands and agricultural lands on either side of the road.

The BKSP is located about 5.7 km from Baipayl along the Baipayl-Chandra road (Fig. D11). From BKSP/Mazar road area up to Zirani (Fig. D12), there are significant concentrations of industries on either side of the road. From Zirani to Chandra, there are scattered industries, residential areas, agricultural lands and low lands on either side of the road. From Baipayl to Nabinagar (about 3 km), the DAEE alignment follows the Nabinager-Baipayl road. The Nabinagar intersection is about 10m from the boundary wall of the Martyr's Monument.

On the eastern side of this intersection there is a water body and Savar Shena Auditorium. There is also a CNG station right at the intersection (Fig. D13). As one moves toward Baipayl, there are establishments of Savar Cantonment (mainly on the eastern side of the road), residential areas and lowland (close to Baipayl intersection on the western side of the road) on either side of the road.

10.2.2 Alternative 2 Alignment

As noted earlier, from the starting point (near Hazrat Shahjalal International Airport) of DAEE up to about 4.8 km (about 1 km from Abdullahpur intersection on Ashulia Road), both alternatives follow the same alignment. At this point, Alternative 2 turn south toward the Sonargaon Janapath in Uttara. From Ashulia Road to Sonargaon Janapath (4.8 km to 5.5 km), the proposed alignment passes over the middle of a Lake running in between Sector 9 and Sector 11 of Uttara (Fig. D14). The alignment then follows the Sonargaon Janapath (5.5 to about 7 km), a relatively wide road that runs between planned residential areas of Uttara Sector 11 and Sector 13, with concrete structures lining along both sides of the road (Fig. D15). Besides, there are a number of schools, colleges and other educational institutes on both sides of the road. There is also a kitchen market by the side of the road. At many locations, the sides of the Sonargaon Janapath are being used as truck stands and for storing construction materials. A number of slums were also located in the area.

At the end of Sonargaon Janapath, the alignment continues westward along the under-construction road that leads to Uttara 3rd Phase. There are human settlements (villages), low-lands and agricultural lands on either side of this under-construction road (Fig. D16). The alignment then goes through Uttara 3rd Phase and crosses the Beri Bandh Road about 9.5 km from the starting point (Fig. D17). It then crosses the Turag River-Tongi Khal at two locations (just upstream of the point where the two branches of the rivers meet (Fig. D18). Along the floodplains of the rivers, the alignment passes over large numbers of brick fields, especially on the southern bank of the Turag River (Fig. D18). The DAEE alignment then continues westward, eventually meeting the Ashulia-Savar Road at about 14 km from the starting point. It should be noted that along this DAEE alignment from the Beri Bandh Road up to the Ashulia-Savar Road, there is no existing road, and the alignment passes mainly over brick fields, agricultural lands and villages (Fig. D18).

The DAEE alignment then follows the Ashulia-Savar Road (also known as Anwar Jong Road) and meets the Dhaka-Aricha Highway near Jahangirnagar University (at about 18.35 km from the starting point). The Ashulia-Savar Road is a narrow single-lane road with residential, industrial and commercial settlements, as well as agricultural lands on both sides of the road (Figs. D19, D20). A number of Government institutes (e.g., Goat Development Farm, Nutrition Institute, Officer Training Institute) were also identified on the both sides of this road. Major industrial/commercial establishments along Ashulia-Saver Road include Radiant Fashion, Metro Dyeing Mill, Joya Textile, Mozart Knit Limited, Xin-Bangla Fabrics, Dipon Gas Co. Ltd., Garden Fresh Industry, Hitech Industries Limited, and industrial units of Mona Group, Summit Group, and Dynasty Group. Besides there are a number of schools, madrasas, medical clinics, and mosques located by the side or close to the road.

The DAEE alignment then turns north and follows the Dhaka-Aricha Highway (from 18.35 to 23.35 km) up to Nabinagar intersection, a couple of hundred meters ahead of the National Martyrs Memorial (Fig. D21). Along the Dhaka-Aricha Highway, the alignment passes by the Jahangirnagar University and different establishments of the Savar Cantonment. Alignment 1 and Alignment 2 follow the same route from Nabinagar to Baipayl and from Baipayl to Chandra (discussed in the previous Section).

10.3 Potential Significant Impacts

For the purpose of preliminary environmental assessment, the project related impacts have been categorized as follows:

- Impacts during pre-construction phase,
- Impacts during construction phase, and
- Impacts during operational phase

10.3.1 Pre-construction Impacts

The major pre-construction activities include finalization of DAEE alignment and acquisition of necessary land for construction of the expressway and associated facilities including the ramps. Expressway alignment has significant impact on the requirement of private land acquisition, and on ongoing/planned projects.

Significant land acquisition will be required mainly for the expansion of either the two-lane Ashulia road (in case of **Alignment 1**) or the single-lane Ashulia-Savar Road (in case of **Alignment 2**), on which the proposed DAEE would be constructed. Additional land acquisition could be required along the other roads (e.g., Dhaka-Aricha Highway, Nabinagar-Baipyle and Baipyle-Chandra roads). As described earlier, along many stretches of both the proposed DAEE alignments, significant numbers of industries, commercial and residential settlements, offices/ institutes are located at close proximity of the alignments. Land acquisition for the proposed DAEE is therefore likely to adversely affect these establishments (e.g., in the form of loss of land/ property/ income; possible dislocation/ displacement).

In case of **Alignment 2**, land acquisition will also be required for the portion of the alignment where there is no existing road (that is from the Beri Bandh Road up to the intersection point with Ashulia-Savar Road, from 9.5 to 14 km). Land acquisition along this stretch would mainly affect a significant number brick fields, human settlements and agricultural lands.

Socio-economic impacts related to land acquisition for the proposed DAEE are likely to be significant for both Alignments. The impacts could be categorized as: (i) loss of land and property; (ii) permanent dislocation/ displacement; (iii) loss of income/ livelihood.

Since significant stretches along **Alternative 2** (i.e., from Beri Bandh Road up to Dhaka-Aricha Highway) either do not have an existing road or have a narrow (single-lane) road (i.e., Ashulia-Savar Road), land acquisition is likely to be significantly higher for Alternative 2 route. On the other hand, areas on both sides of **Alignment 1** have dense concentrations of permanent structures, and therefore are more susceptible to greater loss (resulting from possible land acquisition). However, quantitative comparison of impacts (mentioned above) between the two proposed Alignments (Alternative 1 and Alternative 2) can be made only after detailed survey and assessment of actual land requirements for each Alternative.

Apart from land acquisition and related impacts, there are a couple of environmental and social issues concerning the **Alignment 2** that need special attention. Firstly, as noted in the previous Section, from Ashulia Road to Sonargaon Janapath (4.8 km to 5.5 km), the proposed **Alignment 2** passes over the middle of a Lake running in between Sector 9 and Sector 11 of Uttara (Fig. D14). If piers of the Expressway are constructed over this Lake, the Lake will be severely affected. This is likely to generate significant public opposition, especially from people living in Uttara Sectors 9 and 11.

Secondly, along Sonargaon Janapath (from 5.5 to 7.1 km), the proposed **Alignment 2** passes through a planned residential area (Uttara Sectors 11 and 13). Construction of the Expressway through the Janapath would invite heavy industrial and passenger traffic through this residential area, significantly interfering with the residential nature of the area. This is also likely to face significant public opposition from people living in the area.

The proposed alignments of the DAEE appear to have some conflicts with proposed and ongoing projects. For example, the proposed alignments (both Alternatives) would interfere with the operation and expansion of the Airport Rail station; these would also conflict with proposed BRT project near the Airport. The proposed alignments (both Alternatives) follow the Teromukh-Rayedia (Mothbari)-Ulukhola Road in Arichpur area, which is currently being expanded by the RHD. These and other apparent conflicts need to be resolved during finalization of alignment of the proposed DAEE.

10.3.2 Construction related Impacts

The proposed project would involve major construction works, and therefore is likely to have impacts on certain ecological, physic-chemical and socio-economic parameters. Considering the nature of the project area and the nature of project works, adverse ecological impacts are likely to be significant for any of the two Alternatives. However, since some portions of the **Alternative 2** passes through floodplains (i.e., southern bank of Turag River), low-lying areas, agricultural lands and villages, adverse ecological impact are likely to be more significant for **Alternative 2** than **Alternative 1**. Both Alternative routes cross river at two locations. However, Alternative 1 crosses river at locations where bridges have already been constructed and river training works implemented; on the other hand, river crossings along Alternative 2 would require river training, possibly generating some adverse ecological impacts and also involving additional costs.

Major physico-chemical parameters to be considered for assessment of environmental impacts include noise pollution, air pollution, possible drainage congestion, and generation and disposal of wastes. The major parameters to be considered for assessment of socio-economic impacts of project activities include loss of income during construction period, temporary dislocation / displacement, traffic congestion, safety, and employment. Other than employment generation, most of these impacts are adverse (though short-term) in nature.

Since significant portions of **Alignment 1** passes through major roads and highways (Ashulia Raod and Nabinagar-Baipayl-Chandra Road) through busy industrial/ commercial areas, construction related adverse impacts, e.g., public exposure to air and noise pollution, traffic congestion and safety, temporary dislocation/ loss of income (e.g., for road side vendors) are likely to be more significant for **Alternative 1**.

10.3.3 Impacts during Operation Phase

The proposed DAEE project would have significant positive impacts during operational phase, especially on traffic congestion and travel time. If Alignment 2 is chosen, industrial establishment located on both sides of Ashulia Road (mainly from Zirabo to Baipyle) and in DEPZ and Zirani areas (along Baipyle-Chandra Road) would have to travel longer to reach Dhaka through DAEE and vice versa. The same is also true for passenger traffic generating from these areas. However, Alignment 2 would be more beneficial to the industrial and passenger traffic in the Saver area.

The DAEE (irrespective of the Alignment chosen), along with DEE, would provide an excellent road network for transportation of industrial raw materials/ finished products to and from the numerous industrial establishments along its alignment, and thereby would contribute significantly in the national economy.

10.4 Observations

The proposed project, i.e., construction of Dhaka-Ashulia Elevated Expressway, falls under Red Category of project according the ECA 1995 and ECR 1997. Carrying out Initial Environmental Examination (IEE), followed by Environmental Impact Assessment (EIA) is mandatory for such projects. The preliminary environmental assessment carried out as a part of this pre-feasibility also identified significant environmental issues requiring more detailed investigation. Therefore, IEE of the proposed project would have to be carried out first, followed by detailed EIA to be carried out during the feasibility study and design phase of the project.

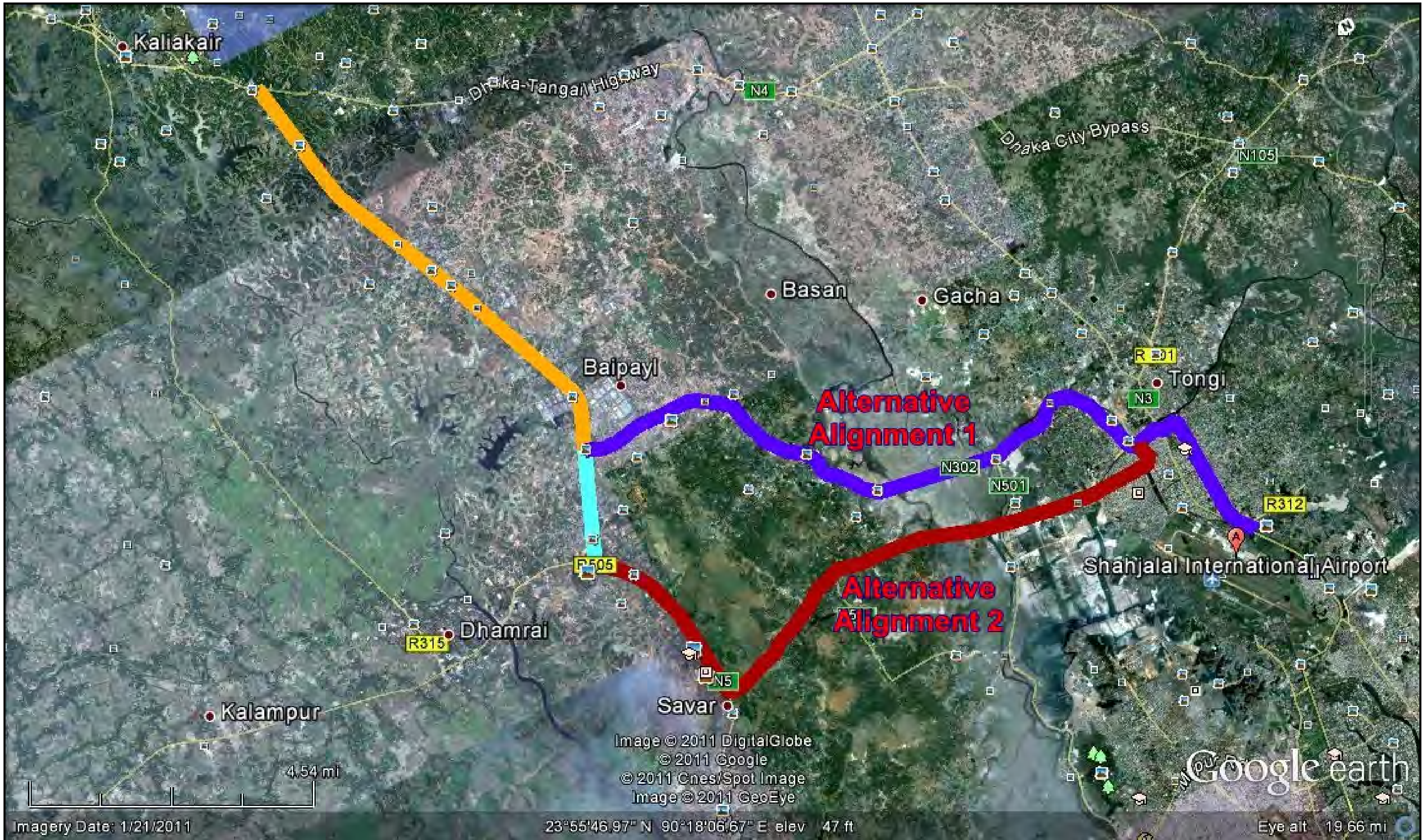


Figure 10.1: Two proposed alternative routes (Alternative 1 and Alternative 2) of DAEE

Section 11

PRELIMINARY UTILITIES INVENTORY SURVEY

11.1 Available Information

The following organizations/agencies were contacted to provide information regarding the location of utilities:

- Titas Gas Transmission and Distribution Company Limited
- Dhaka Electric Supply Company Limited and Dhaka Power Distribution Company Limited
- Dhaka Water Supply & Sewerage Authority
- Bangladesh Telecommunications Company Limited
- Bangladesh Telecommunication Regulatory Commission (BTRC)

However, only limited information without any maps and drawings were obtained from these organizations. Finding no other low cost alternative, a visual inspection of the utilities was carried out for each route alignment option. Information is also gathered from the road adjacent shopkeepers, residents, EPZ officials, local municipalities etc. As a result, the methodology relies heavily upon the data provided by others and therefore it is difficult to guarantee the accuracy or completeness of these data sources. It is also understood that even if authentic data could have been collected from the relevant organizations, these would not have excluded the need for undertaking utility inventory and detection survey by using GPR tracing device in order to get accurate 3D positions of all the utilities. Which is very important for finalizing detailed planning and design of elevated structures.

11.2 Route Alignment Options

The Alternative 1, which is shown in green in Figure 11.1, runs from Shahjalal International Airport alongside New Airport Road. Here, the route would follow the rail alignment with portal frame offset from the railway. At a distance of about three and a half kilometers from the starting point, the railway track crosses the level crossing on Arichpur Road. The alignment turns west just before the Arichpur Road level crossing, and then follows the Arichpur Road toward the Abdullahpur intersection. From Abdullahpur, the Alternative 1 alignment of the DAEE follows the Ashulia Road up to Baipayl (about 21 km from the starting point); from Baipayl it stretches up to Chandra to the north and Nabinagar to the south. On the other hand, Alternative 2, which is shown in blue in Figure 11.1, follows the same alignment starting from Airport upto about 4.8 km (about 1 km from Abdullahpur intersection on Ashulia Road) then it turns south toward Sonargaon Janapath in Uttara, and then follows the Sonargaon Janapath. It then goes through Uttara 3rd Phase, crosses the Beri Bandh Road, Turag River-Tongi Khal and meets the Ashulia-Savar Road (about 14 km from the starting point). It then follows the Ashulia-Savar Road and meets Dhaka-Aricha Highway close to Jahangirnagar University and then follows Dhaka-Aricha Highway up to Nabinagar (Savar). From Nabinagar (Savar) to Chandra, Alternative 1 and Alternative 2 follow the same alignment.

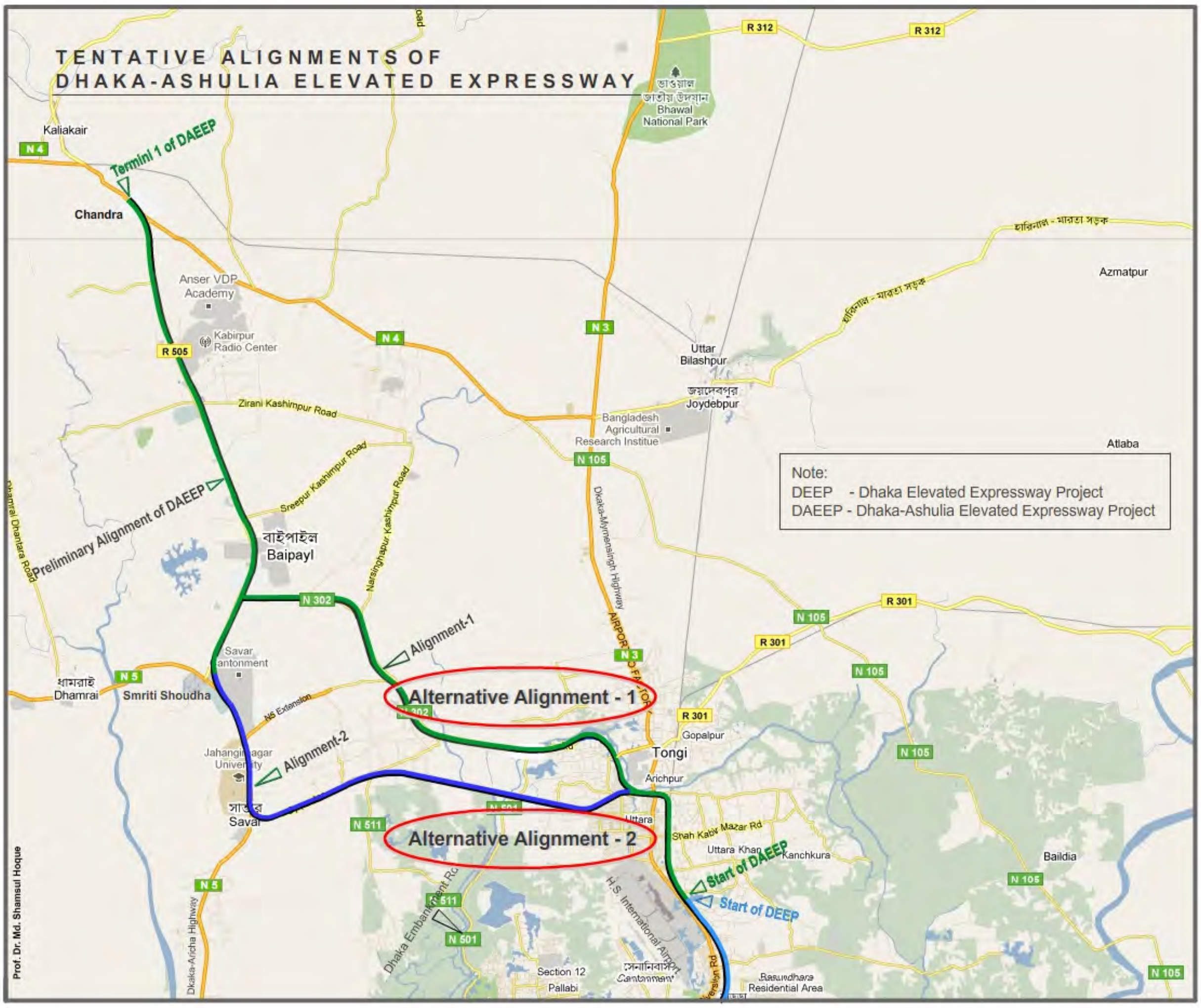


Figure 11.1: Alternative Alignments of Dhaka Elevated Expressway

11.3 Inventories of Utilities

Visual observations as well as available secondary information revealed that along both the alignment corridors, no access manholes were found on the road surface, which essentially suggests that there is no underneath planned sewerage line. It is also informally confirmed by the concerned officials of DWASA. Similar condition also observed with roadway following subsurface telephone, internet lines and electric cables. However, visual observation revealed that there are some aboveground suspended utility lines viz. telephone, cable lines and electric and their posts, travelling following sideways and parallel to road alignment as well as along transverse direction. At few locations, particularly at the junctions, these suspended utility lines criss-crossed haphazardly as can be seen from the following snapshots (Figure 11.2). Some electrical posts and traffic signals are interfering unexpectedly along the roads which can create problems in the implementation phase of the proposed Dhaka Ashulia Elevated Expressway (DAEE). Preliminary estimates shown that DESA will have to relocate about 150 of their poles of the overhead 11KV/0.4 KV lines.

Figure 11.2: Criss-crossed Overhead Electric Lines

Available information also exposed that between Zirabo-Baipayl and Nabinagar-Baipayl segments water lines spread beneath ground level particularly which transversely crosses the road between the adjacent developments. Therefore, interruption in such services might become unavoidable.

An analysis of the site and the preliminary configuration of the expressway, it is found that the underground cables, if any, would be more affected by the side ramps rather than by the piers of the main viaduct. Moreover, experience of the Gulistan-Jatrabari flyover shows that if it is not be possible to shift the utilities due to physical space constraint in the road or any other reason, then slight adjustment of the location of the discrete piers could be a better solution without shifting of the utilities, as the alignment of flyover/ expressway and all the utility lines may not be at the same alignment and position. Moreover utilities are usually at about 1.5m depth from road top. The piers of flyover/ expressway are supported on 1.5m/1.2m dia. piles with pile cap. In general the pile caps may be cast with its top at 1.2m to 2.5m depth from the road surface, thereby the utilities will rest on top of pile cap, and then the shifting of the utilities may not be necessary at all. Every then, adequate provisional sum is proposed liberally for utility relocation purposes so that required money does not fall short during execution of the work.

Similarly, WASA and T&T lines which are usually laid mostly below the ground may need not to be shifted as per adjusted design concept. However T&T service connection/distribution poles of 4 to 5 m height may need to be relocated. Informal information suggests that Titas has 16 inch 140 psig and 8 inch 50 psig gas pipes in the area. Preliminary analysis shows that, these pipe lines in some places would come near to the pier which needs to be by-passed as per the Titas gas safety regulation requirement, where it is required that the gas lines need to be at least 2m away from any civil structure. Segment wise inventory of different utility lines are documented in the following Tables 11.1 and Table 11.2.

11.4 Summary

Proposed path for DAEE might hamper the utility service systems during construction phase. Existing electricity lines, as shown in the inventory Tables, are provided in a suspended stage, hanging with poles. Similar condition also observed for telephone and internet lines. Moreover, there are also some utility service lines, particularly gas lines spread beneath ground level. Therefore, interruption in such services might become unavoidable.

Table 11.1: Inventory of Utility Lines along Alignment - 1

From	To	Chainage (km)	Utility Type	Overhead/ underground	Description	Remarks
Hazarat Shahjalal Airport	Arichpur Level x-ing	0.00 - 3.55	Electric line	Nil		There is no street light as well as main supply line along this segment of the alignment.
			Telephone line	Nil		No overhead/underground line
			Gas line	Underground	Local distribution line for individual holdings	Possibly no relocation is required
			Water supply line	Underground	Local distribution line for individual holdings	Possibly no relocation is required
			Sewerage line	Nil		No formal line
			Optical fiber line	Underground	Railway optic fiber runs parallel to the railway track	Possibly relocation required
Arichpur Road Level Crossing	Abdullahpur intersection	3.55 - 4.01	Electric line	Overhead		There are both street light as well as main supply line along this segment of the alignment and they would need relocation.

			Telephone line	Overhead	Local distribution line for individual holdings	Relocation required
			Gas line	Nil		No formal line
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
Abdullahpur intersection	Dhour intersection	4.01 - 9.51	Electric line	Overhead		There is both local distribution as well as main supply line along this segment of the alignment and they might need relocation.
			Telephone line	Overhead	Local distribution line for individual holdings	Relocation required
			Gas line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
Dhour intersection	Zirabo intersection	9.51 - 14.40	Electric line	Nil		There is no local distribution as well as main supply line along this segment of the alignment.

			Telephone line	Nil		No formal line
			Gas line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
Zirabo intersection	Baipayl intersection	14.40 - 21.00	Electric line	Overhead		There is both local distribution as well as main supply line along this segment of the alignment and possible shifting would be unavoidable.
			Telephone line	Overhead	Few local distribution lines for individual holdings	May need relocation
			Gas line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
Baipayl intersection	Dhaka EPZs	21.00 – 22.14	Electric line	Overhead		There is both local distribution as well as main supply line along this segment of the alignment and possible shifting would be unavoidable.

			Telephone line	Overhead	Local distribution lines for individual holdings	May need relocation
			Gas line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
Dhaka EPZs	Chandra via Zirani	22.14 - 33.40	Electric line	Overhead		There is both local distribution as well as main supply line along this segment of the alignment and possible shifting would be unavoidable.
			Telephone line	Nil		No formal line
			Gas line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
Nabinagar intersection	Baipayl intersection	0.00 - 3.00	Electric line	Overhead		There is both local distribution as well as main supply line along this segment of the alignment and possible shifting would be unavoidable.

			Telephone line	Overhead		May need relocation
			Gas line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Water supply line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Sewerage line	Nil		No formal line

Table 11.2: Inventory of Utility Lines along Alignment - 2

From	To	Chainage (km)	Utility Type	Overhead/ underground	Description	Remarks
Starts at 4.8 km from the starting point on Ashulia Road	Sonargaon Janapath of Uttara	04.8 - 5.5	Electric line	Nil		No formal line
			Telephone line	Nil		No formal line
			Gas line	Nil		No formal line
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
			Optical fiber line	Nil		No formal line

Sonargaon Janapath	Beri Bandh via Uttara 3rd Phase	5.5 - 9.5	Electric line	Overhead		There is both local distribution as well as main supply line along this segment of the alignment and possible shifting would be unavoidable.
			Telephone line	Overhead	Main line & Local distribution line for individual holdings	May need relocation
			Gas line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Water supply line	Underground	Main line & Local distribution line for individual holdings	May need relocation
			Sewerage line	Nil		No formal line
Beri Band	Ashulia-Savar Road	9.5 - 14.4	Electric line	Nil		No formal line
			Telephone line	Nil		No formal line
			Gas line	Nil		No formal line
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line

Ashulia-Savar Road	Dhaka-Aricha Highwa	14.4 - 18.35	Electric line	Overhead		Local street light need relocation
			Telephone line	Overhead	Few lines for individual holdings	Need relocation
			Gas line	Underground	Branch line &local distribution lines for individual holdings	Need relocation
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
Dhaka-Aricha Highway	Nabinagar intersection	18.35 - 23.35	Electric line	Overhead		Need relocation
			Telephone line	Nil		No formal line
			Gas line	Underground	Main line	May need relocation
			Water supply line	Nil		No formal line
			Sewerage line	Nil		No formal line
Alignment 1 and Alignment 2 follow the same route from Nabinagar to Baipayl and from Baipayl to Chandra						

Section 12
SUB-SOIL CONDITIONS

12.1 Introduction

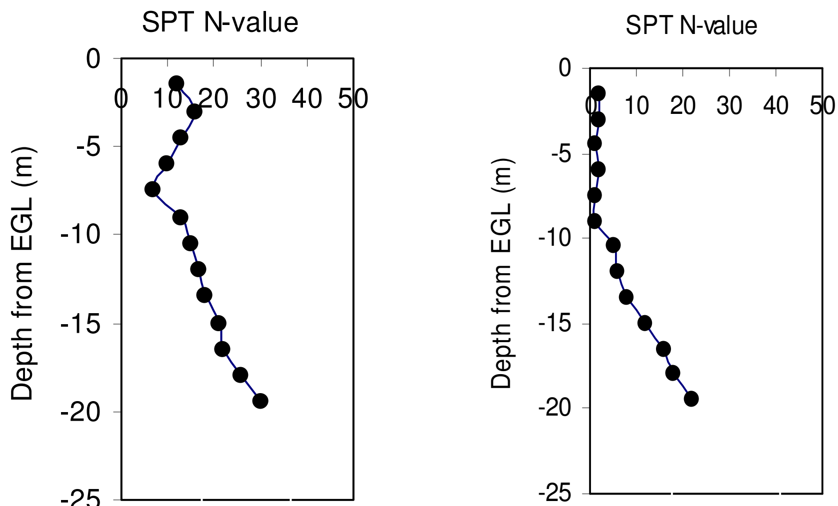
An adequate geotechnical investigation is an essential phase for the execution of a civil engineering project. It provides information to make the structure safe and durable as well as to make it economically viable. The results of a detailed geotechnical investigation should provide adequate information for the selection of the most suitable type of foundation for the proposed structure and to indicate if special problems are likely to be encountered during excavation and filling. Information on the type of sub-soil stratification, geotechnical parameters and its behaviour is obtained from comprehensive soil investigation programme which incorporates drilling of boreholes, collection of undisturbed and disturbed soil samples, performance of specific in situ tests and laboratory testing of soil samples. The results of laboratory tests and in situ tests need to be carefully integrated in soil investigation. An engineering geological study of the project area is also an essential element of soil investigation to establish the physiographic setting and stratigraphic sequences of soil strata of the area.

Sub-soil condition along the proposed expressway has been evaluated by visual inspection during reconnaissance survey. Due to time limitation, sub-soil investigation was not conducted for the pre-feasibility study. However, numerous technical reports and technical publications summarize the sub-soil characteristics of the area through which the expressway will be constructed. Therefore, data has been gathered from secondary sources (i.e., published technical papers and technical reports). To verify the gathered data seven borings were drilled along the proposed expressway.

The major geomorphic units of Dhaka are: 1) the highlands or Dhaka terrace and 2) the low lands or flood plain, depression and abandoned channel, low-lying swamps and marshes located in and around the city. Over the past 40 years, Dhaka city has experienced a rapid growth of urban population. Hence, most of the areas of the city having competent sub-soil for building/infrastructure construction have already been occupied. As a result, different new areas are being reclaimed filling low lands. It has been found that the proposed route mainly passes through the areas having competent sub-soil condition (original ground). In some locations, the proposed expressway has to be founded on/through filling land (reclaimed area) or in ditches, low-lands, marshy land etc. The sub-soil condition has been divided into two main categories-1) original ground (not reclaimed) and 2) reclaimed land.

12.2 Sub-soil Condition of the Original Ground

In general, the sub-soil of the original ground has good bearing capacity. The typical soil profile consists of a red clay layer at the top and a brown fine sand layer below the red clay layer. A typical sub-soil profile is presented in the Fig. 12.1(a). The variation of field SPT N-value with the depth is presented in Fig. 12.2(a) (BRTC No. 003993/09-10/CE dt. 03/11/2009). This red clay is an over consolidated clay. Natural moisture content of the red clay varies in the range between 20 and 25%. Liquid limit (LL) and plastic limit (PL) vary between 40-50 and 18-22, respectively. According to USCS classification the soil is generally classified as CL which is inorganic silty clay of low to medium compressibility. The clay contains very high silt content (0.002 to 0.06 mm) in the range between 40 and 60%. Clay content (<0.002 mm) of the clay varies between 15 and 25%. The consistency of the clay is medium stiff to very stiff. Field SPT N-value varies in the range from 5 to 25 (medium stiff to very stiff). The values of compression index (C_c) vary from 0.10 to 0.15. The swelling index (C_s) of the clay ranges between 0.02 and 0.04. The coefficient of consolidation (c_v) varies in the range between 7-16 m²/year. The depth of the clay layer increases from the southern part of the Dhaka city (from the bank of the Buriganga river) to the northern part. The depth of the red clay varies between 5 to 25 m from the existing ground level (EGL). Below the clay layer, a medium-dense to dense fine sand layer exists. The field SPT N-value of the layer varies from 10 to 50. The value of effective angle of internal friction (ϕ') of the fine sand layer varies between 32 to 36 degree (dry density= 15-17 kN/m^3).

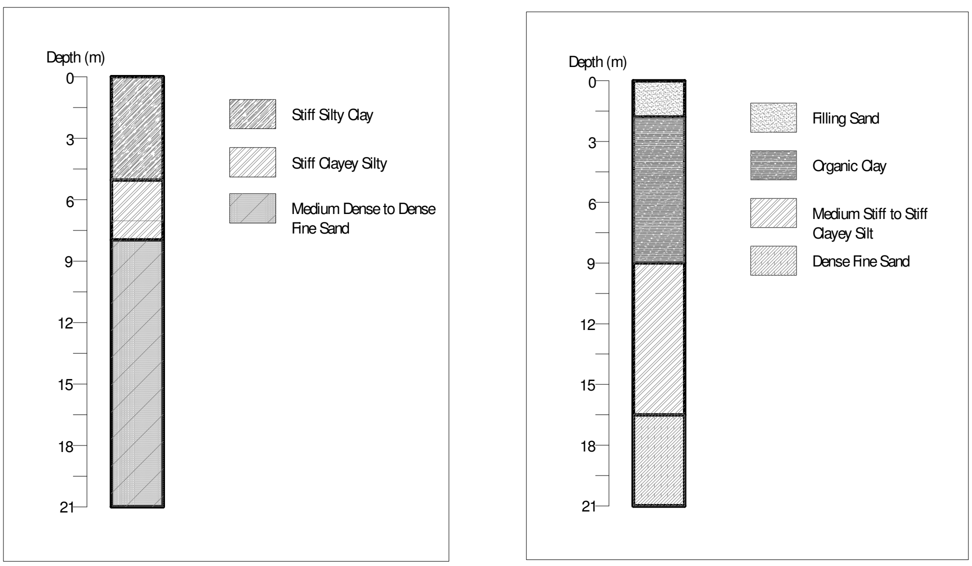


(a) (b)

Figure 12.1: Variation of SPT N-value with depth from the existing ground level for: (a) Original land and (b) Reclaimed land.

12.3 Sub-soil Condition of the Reclaimed Land

Lands are reclaimed in and around the Dhaka city filling low lands (3-12 m) using dredge fill materials. The dredged material is mostly silty sand. The field SPT N-value of the filling layer varies between 2 to 12. A typical bore-log of the reclaimed area has been presented in Fig. 12.2(b). A very soft organic layer (field SPT N-value= 1 to 2) exists below the top of the filling layer. Beneath this soft organic layer, a medium stiff to stiff clay layer exists followed by a medium dense to dense fine sand layer. A typical SPT N-value versus depth curve for a reclaimed area is presented in Fig. 12.1(b).



(a) (b)

Figure 12.2: Typical bore-logs: (a) Original land and (b) Reclaimed land.

Detail sub-soil characteristics of such soil is available in the 'Report on Development Proposal for Uttara Residential Model Town (3rd Phase) Project'. Islam and Hossain (2010) showed that the top filling layer is susceptible to earthquake induced liquefiable in some locations. Besides, Islam *et al.* (2011) showed that the soft organic layer will undergo large settlement due to the weight of the filling layer alone. This soft organic layer may produce negative skin friction to the deep foundation through it.

A total of seven boreholes of 18.0 to 24.0 m depth from EGL were drilled along the two alternative alignments of the proposed expressway during 7-8 October 2011. Dhaka Soil, House No. 18 (1st floor), Road No. 24, Gulshan, Dhaka, was employed for drilling the boreholes at the proposed expressway, including collection of disturbed and undisturbed tube samples and performance of Standard Penetration Test (SPT). The approximate position of the boreholes are presented in Appendix-E. The bore logs are also presented in the Appendix-E. Among these seven boreholes, one was conducted at the middle of the Ashulia Jheel (BH-01). It is found that the top layer at this location is very soft to medium stiff clay up to 13.5 m depth from the EGL. Below this layer medium dense to dense fine sand layer exists up to the boring depth. Other than this the soil profile typically consists of a red clay layer at the top and a brown fine sand layer below the red clay layer. This sub-soil investigation confirms the soil profile that has been presented in the above sections based on the data gathered from the secondary sources.

However, extensive geotechnical investigations will be necessary for the detail design of the foundations in the next steps of the project. Sub-soil investigations should include both field investigations (such as SPT, CPT) and laboratory investigations (index properties, grain size, strength and deformation characteristics). Liquefaction potential and dynamic properties of the sub-soil should also be determined for the proper foundation design since the route of the proposed expressway is in earthquake vulnerable zone. It falls in the seismic Zone-2 (a_{max}= 0.15 g) in the seismicity map of Bangladesh (BNBC, 1993). For the dynamic analyses of the foundation, the dynamic properties (such as shear modulus, G, damping ratio, h and liquefaction resistance) should be determine from field tests (such as seismic down-hole test) and laboratory tests (such as cyclic triaxial test).

References:

1. Final Report on Development Proposal for Uttara Residential Model Town (3rd Phase) Project, Department of Civil Engineering, BRTC, BUET, Dhaka, 2008.
2. Report on Geotechnical Investigations on Sub-soil for Construction of 12-Storied Residential Building for Senior Teachers and Officers of Dhaka University at Fuller Road, Dhaka. BRTC No. 003993/09-10/CE dt. 03/11/2009., Department of Civil Engineering, BRTC, BUET, Dhaka, 2010.
3. Islam, M. S., Nasrin, M. and Khan, A. J. (2011). "Foundation problems in dredge fill soils overlying soft organic layer," Proceedings of the14th Asian Regional Conference on Soil mechanics and Geotechnical Engineering, Hong Kong, Paper No. 5.
4. Islam, M. S. and Hossain, M. T. (2010). "Earthquake induced liquefaction potential of reclaimed areas," ASCE, Geotechnical Special Publication, GSP, No. 201. Paper No. 472, pp. 326-331.

Section 13

GEOMETRIC DESIGN CONSIDERATIONS

13.1 General

The geometric design considerations to be adopted for the Dhaka Ashulia Elevated Expressway are summarized in the following Sections.

13.2 Design Standards

The alignment geometric designs conform to the followings standard: AASHTO: A Policy on Geometric Design of Highways and Streets, (5th Edition, 2004) and Geometric Design Standards – Roads and Highways Department (RHD), People's Republic of Bangladesh (April, 2005). The junction designs conform to the followings standards: TD 22/06 Layout of Grade Separated Junctions - Design Manual for Roads and Bridges, UK and TD 42/95 Geometric Design of Major/Minor Priority Junctions - Design Manual for Roads and Bridges, UK.

13.3 Design of Expressway Alignment

The horizontal and vertical layouts of the expressway make up the alignment. The design of alignment depends primarily on the design speed selected for the roadway and topography. Alignment should be consistent and uniform to reduce problems related to driver expectancy with sudden change in alignment (especially width and curvature) and it should be with a good balance between grade and curvature as well as with a nice blend of straight and flat curvature segments, which has the potential to keep the driver alert and also to reduce headlight glaring problems.

13.4 Design Approach

It is likely that in a number of instances, the horizontal alignment of the elevated section of the Dhaka Ashulia Elevated Expressway will be closely tied to that of the existing main roads or railway that it is following. In order to minimize land acquisition requirement in and around Dhaka city, the centre of the Expressway will be aligned with the median of existing roads, with piers located in the central medians or alongside the road or rail. In narrow sections where central medians are not available or the road boundary cannot accommodate the full expressway width, the elevated structure may be required to bifurcate into separate carriageways. The superstructure structural form must be capable of this in these areas.

Moreover, as the proposed Dhaka Ashulia Elevated Expressway (DAEE) would be the extension of ongoing Dhaka Ashulia Elevated Expressway (DEE) and will make a seamlessly continuous 56km expressway, naturally its geometric standards and requirements would be similar to that of DEE, unless segmental traffic demand dictates otherwise. Accordingly, keeping similarity - the geometric configuration of main viaduct of the DAEE is considered to be 2-lane dual carriageway. The geometric configuration for the whole DAEE corridor would be finalized based on the forecasted traffic demand.

13.5 Horizontal Alignment

The horizontal alignment consists of straight sections of the expressway, known as tangents, connected by horizontal curves. Curves are provided to ensure smooth flow of traffic while changing the direction of travel. The design of the horizontal alignment, therefore, involves the selection of suitable radius for the curved sections. The design speed of the roadway has a significant impact on the design of horizontal alignment. Considering the design standards of Dhaka Elevated Expressway, it is proposed that design speed of Dhaka Ashulia Expressway would also be 80 kmph.

13.5.1 Carriageway

To achieve the nominated design speed of 80kmph on the main viaduct, the minimum horizontal radius is set at 250m. At this radius, there are no major limitations on the structural forms for the superstructure. If straight beam and slab solutions are adopted, it may be necessary to reduce the span lengths through these tighter curves.

It is proposed that the typical cross-section of the main viaduct would follow the Geometric Configuration of the Dhaka Elevated Expressway and as such it would comprised of two dual lanes of 7.3m each, inner and outer shoulders of 0.3m and 1.8 m width respectively and a central median barrier of 0.76m wide giving an internal width of 19.56m between outer barriers with an expected overall width of 20.56m with 0.5m outer or edge barriers. Based on preliminary design configuration, the typical main viaduct section is illustrated in Figure 13.1.

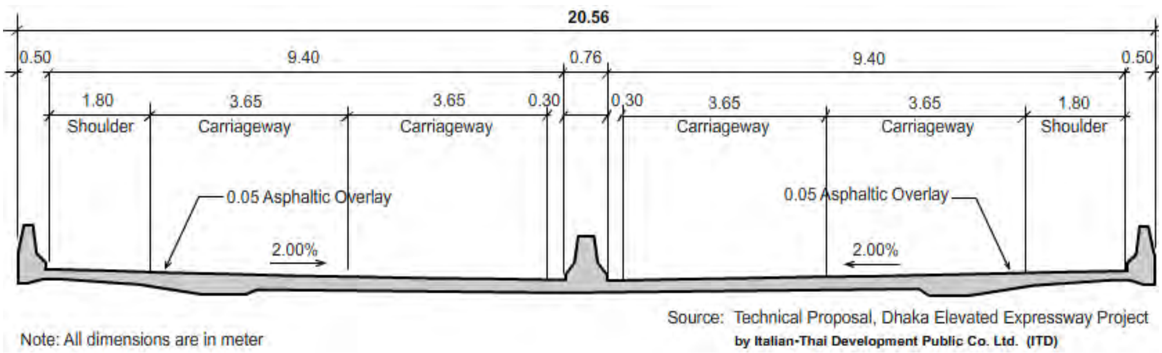


Figure 13.1: Typical Main Viaduct Section

Along some part of alignment the typical roadway section cannot be applied. In these areas, a reduced typical section will be utilized, which reduces the width of outer shoulder to 0.3 m. This non-typical roadway section with overall width of 17.56m will only be applied for part of very restricted areas. The non-typical main viaduct section is shown in Figure 13.3.

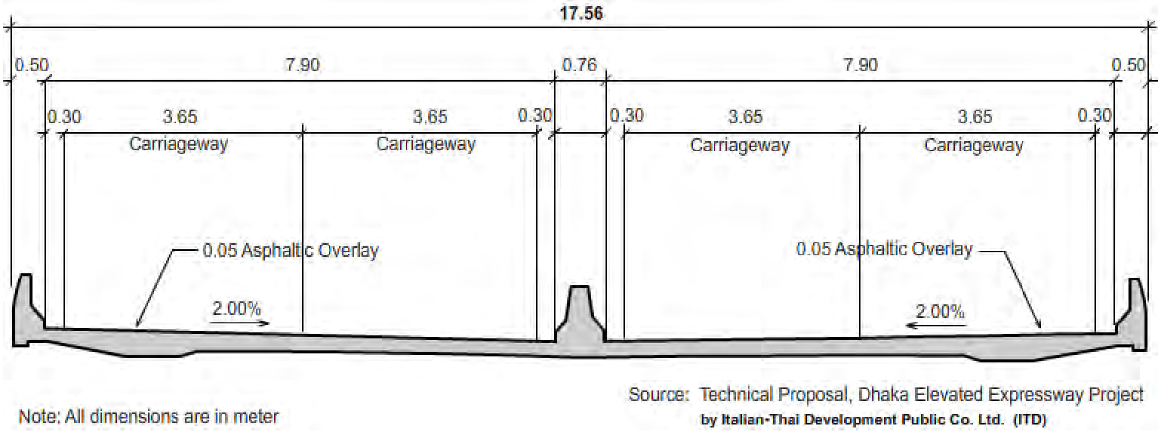


Figure 13.2: Non-typical Main Viaduct Section

The cross-section of expressway entry-exit oneway ramps shall comprise a 5.5m carriageway with a 0.3m wide inner and outer shoulder. The overall width of the ramps would be 7.1m. The typical main oneway ramp section is illustrated in Figure 13.3.

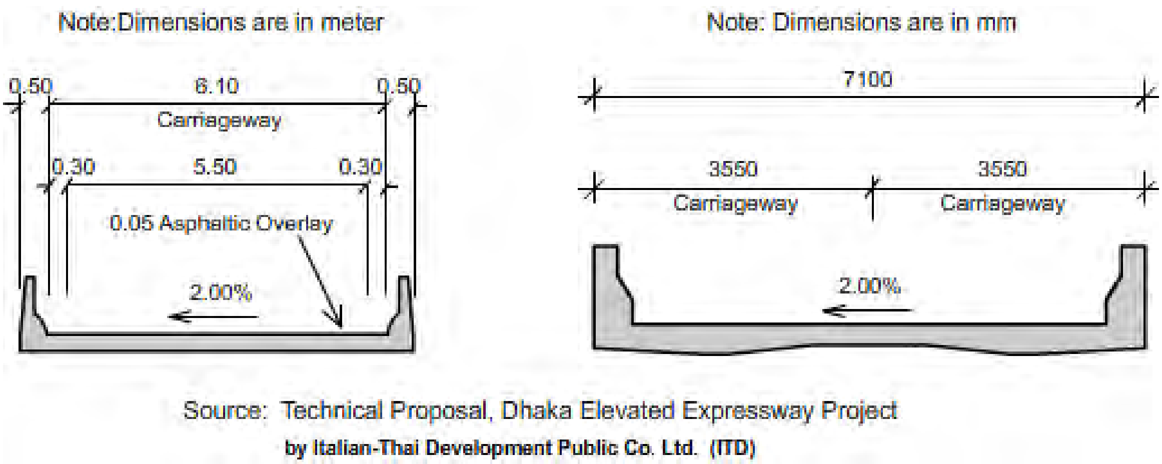


Figure 13.3: Typical Ramp Section

13.5.2 Cross Slope

Normally, cross slope or camber is provided for x-drainage purposes and to quickly remove the water from a traffic lane and thereby to prevent vehicle from hydroplaning. The typical cross slope rate used for this project is 2% as recommended by AASHTO. Because of the main viaduct is dual lane 2 ways, the reverse cross slope will be applied. For the oneway ramps, cross slope will be towards outer direction.

13.5.3 Traffic Barrier

Traffic barriers are required to prevent vehicles that leave the traveled way from hitting an object that has greater crash severity potential than the barrier itself. The New Jersey Type will be applied for this project. There are two types of barriers: a median type and side barrier type. The width is 0.76m and 0.50m for median and side barrier, respectively. The median barrier would be used for only main viaduct to prevent motorists going to wrong side. For oneway entry-exit ramps no median barrier would be required. Geometric configuration and detail dimensions of these traffic barriers are adopted from the technical proposal of Dhaka Elevated Expressway Project (DEEP) submitted by Italian-Thai Development Public Company Limited (ITD). The typical main viaduct section and traffic barriers are illustrated in Figure 13.4.

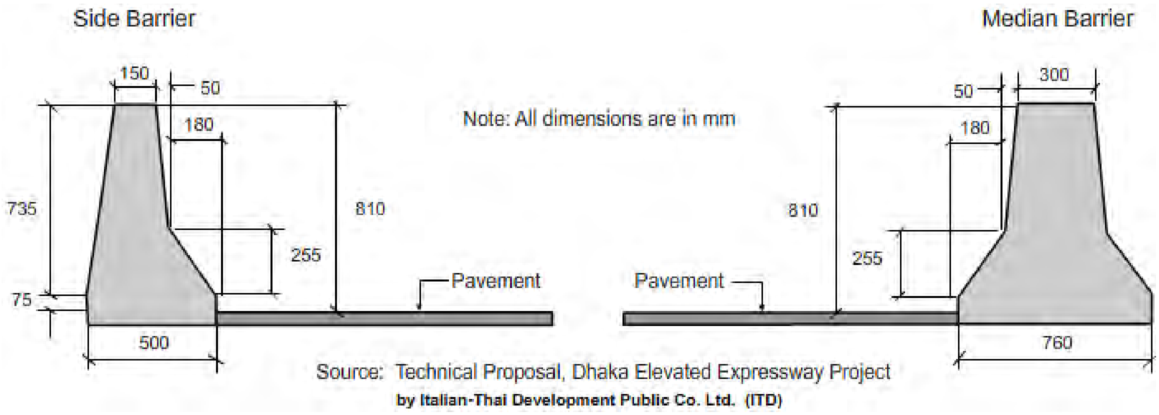


Figure 13.4: Median and Side Barrier

13.5.4 Emergency Breakdown Space

In consistent with the Dhaka Elevated Expressway, the Dhaka Ashulia Expressway is also provided with Emergency Lay-bys at an interval of 2.5 Km in each direction along the mainline expressway. A typical detail of the Emergency Breakdown Lay-by is shown in Figure 13.5 below. Besides, the expressway has emergency breakdown space in the form of wide outer shoulder of 1.8m width for accommodating breakdown vehicles at any location during travelling. It is expected that when it would be needed to provide extra capacity particularly at peak hours this breakdown strip would act as an additional service lane.

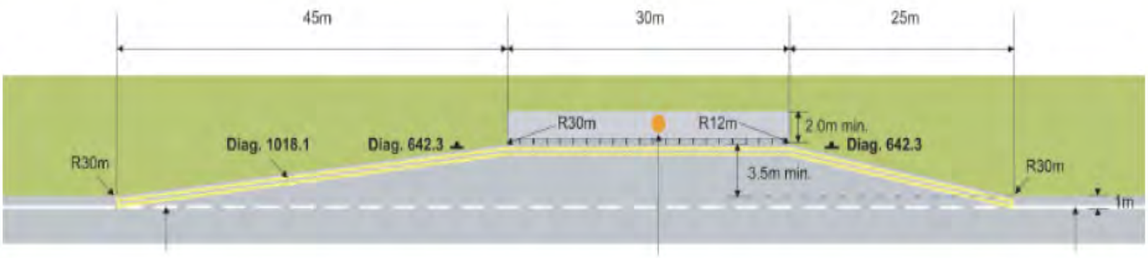


Figure 13.5: A typical detail of the Emergency Breakdown Lay-by

13.5.5 Horizontal Clearance

Horizontal clearances from the edge of the pier columns to existing traffic lanes and from the outer edges of the elevated viaduct to existing buildings shall apply. From the edge of the pier columns, the required minimum lateral clearance is 1000mm which can be narrowed to 600mm in extreme circumstances. As per railway safety guidelines, alongside the rail corridor - the minimum lateral clearance shall be 3,050mm from the track centre to nearest edge of structure.

In line with the Dhaka Elevated Expressway, the following standards to be adopted for the design of the horizontal alignment of the expressway:

Table 13.1: Summary of Geometric Design Considerations for Horizontal Alignment

- For Main Viaduct
    - Design Standard - Urban Expressway
    - Design Speed - 80 kmph
    - Radius of Curvature - 250 m (min.)
    - No. of Lanes - 4 lanes divided carriageway
    - Lane Width - 3.65 m per lane
    - Carriageway width - 7.30 m
    - Inner Shoulder width - 0.30 m (min.)
    - Outer Shoulder width - 0.30 m (min.)
    - Service road width - 1.80 m (in consistent with DEE)
    - Side Safety barrier width - 0.50 m
    - Median barrier - 0.76 m
    - Overall Width - 20.56 m for Non-Critical Section
      - 17.56 m for Critical Section
- For Entry-Exit and Interchange Ramps
    - Design Speed - 50 kmph
    - Radius of Curvature - 90 m (min.)
    - No. of Lanes - 1.5 lanes oneway carriageway
    - Lane Width - 3.65 m per lane
    - Carriageway width - 5.50 m
    - Inner Shoulder width - 0.30 m (min.)
    - Outer Shoulder width - 0.30 m (min.)
    - Side Safety barrier width - 0.50 m
    - Median barrier - 0.76 m
    - Overall Width - 7.1 m

- Merging / Diverging Lane
    - Length of entry/exit taper- 75 m
    - Nose ratio - 1:12
    - Nose length - 40 m
    - Auxiliary lane length - 100 m (min.)
    - Auxiliary lane taper - 40 m (min.)

- Horizontal Clearance
  - Between pier and
    - Roadway lane - 600 - 1000 mm
    - Adjacent structures - 600 - 1000 mm
  - Between railway track centre and
    - Pier of portal frame - 3050 m (min.)
    - Nearest structure - 3050 m (min.)

- Other Features
  - Stopping Sight Distance - 130 m (min. for main viaduct)
    - 65 m (min. for ramps)
  - Cross slope/Camber - 2.00 %
  - Super elevation, e - 6.00 % (max.)
  - Side friction, f - 0.15

13.6 Vertical Alignment

The vertical alignment of a highway consists of straight tangent sections known as grades connected by vertical parabolic curves. The design of the vertical alignment, therefore, involves the selection of suitable grades for the tangent sections and the design of the vertical curved. The topography or special requirement of the at-grade area over which the elevated expressway traverses has a significant impact on the design of vertical alignment.

13.6.1 Grade

Grade has a greater impact on trucks than on passenger cars; truck speed may increase up to 5% on downgrades and decrease by 7% on upgrades, depending on the percent and length of the grade. In consideration of the fact that the Dhaka Ashulia Elevated Expressway would be used by a large number of heavy vehicles including semi-trailer type articulated trucks as well as our vehicular maintenance practice is very poor, it is essentially warranted the use of mild vertical grade particularly in the ascending ramp.

However, the field condition reveals that there are limited scope of accommodating the development length of ascending and descending ramps with mild grade as well as long speed-adjustment diverging and merging lanes due to the presence of many side roads and various permanent unavoidable obstructions along a considerable portion of the corridor. As such, making a trade off with the ground constraints, 3.5 - 4.5% grades are proposed for the ascending ramps and 4.5 - 5.0% grades for the descending ramps. In addition, as per AASHTO, for the design of vertical alignment of expressway main viaduct, K-values may be considered as: 32-49 and 25-32 for crest curve and sag curve respectively and for entry-exit and interchanges ramps, the minimum K-values may be considered as:13 and 7 for crest curve and sag curve respectively.

13.6.2 Vertical Clearance

The Roads and Highways Department's Geometric Design Standard nominates a minimum vertical clearance to existing roads of 5.7m. This value shall apply to clearances to the elevated roadway permanent works superstructure soffit and for the soffit of overhanging pier headstocks, if applicable. Where the elevated expressway is located over a rail corridor, as per railway safety requirements the minimum vertical clearance from top of rail to structure shall be 7.4m.

Consideration may need to be given to raise the vertical alignment of the elevated roadway to allow suitable vertical clearance to major temporary works, such as false work and erection trusses which may allow shorter construction time and/or cheaper structural forms.

The above mentioned geometric design considerations for vertical alignment of the expressway are summarized below:

Table 13.2: Summary of Geometric Design Considerations for Vertical Alignment

- Vertical Clearance
  - Road-Road : 5.7 m
  - Road-Rail : 7.4 m
- Vertical Grade
  - Ascending : 3.5 - 4.0%
  - Descending : 4.5 - 5.0%
- K-Value for main viaduct
  - Crest curve : 26 (min.)
  - Sag curve : 30 (min.)
- K-Value for entry-exit and interchanges ramps
  - Crest curve : 13 (min.)
  - Sag curve : 7 (min.)

13.6.3 Ramp Lengths

The lengths of straight ramps at different entry-exits and curved ramps (direct, semi-direct and indirect) at interchanges are depends on ramp type, rate of grade and vertical height. It is assumed that combined depth of girder and deck slab would be 2.9 to 3.4m based on the girder type and length of its span. With the above nominated average ascending and descending grades and an expected road surface of approximately 7.6m above an existing road or potentially 10.8m above an existing rail line, the approximate required average ramp lengths would be as follows:

Entry-Exits over Road

Headroom Clearance =	5.7 m
Depth of Girder =	2.9 m
Up-ramp average grade =	3.75 %
Straight	229 m
Direct	275 m
Semi-direct	298 m
Indirect	459 m
Down-ramp average grade =	4.75 %
Straight	181 m
Direct	217 m
Semi-direct	235 m
Indirect	362 m

Entry-Exits over Rail

Headroom Clearance =	7.4 m
Depth of Girder =	3.4 m
Up-ramp average grade =	3.75 %
Straight	288 m
Direct	346 m
Semi-direct	374 m
Indirect	576 m
Down-ramp average grade =	4.75 %
Straight	227 m
Direct	273 m
Semi-direct	296 m
Indirect	455 m

13.7 Toll Plazas – Location, Arrangement and Size

Considerable investigation is required to decide between tolling configurations and to determine the optimal tolling locations. This is likely to be a critical issue for the Expressway in order to achieve minimal disruption to traffic. It is proposed that no Toll Plazas would be placed on the at-grade road; where sufficient land is available only ramp toll plazas can be placed at at-garde level; but main expressway toll plaza will be placed at above ground.

Toll plazas along the route shall either be placed at entry points onto the Expressway, at exit points off the Expressway and/or at selected locations along the Expressway route. The location of the toll plazas will be dependent on the results of the detailed traffic surveys and O-D movement matrixes, but will need to be located such that the traffic flow on the expressway itself is not significantly affected by the placement of the plazas. A point of entry toll on the ramps would cause the least amount of interruption to mainline expressway traffic. Both open and closed systems would not be suitable for Dhaka Ashulia Elevated Expressway due to close spacing of interchanges, many entry and exit ramps and also high investment cost of putting main line toll plaza on elevated toll road in between interchanges. Hence, like Dhaka Elevated Expressway point of entry or Flag fall toll system is proposed for project road, where vehicles are charged with flat toll at entry ramps.

If manual tolling is implemented, then the toll plazas will probably need to be located at entry points and possibly one or two intermediate locations along the route. Manual toll plazas require an increased area for implementation as it is necessary to include at least four tolling booths for a two lane carriageway. Thereby, the carriageway at the tolling booth would need to widen to at least 18.6m (2 x 7.3m for four lanes plus ~lm for each tolling both), this combined with the opposing flow of traffic would require an internal width of at least 27.5m, if the toll plaza accommodated tolling of traffic from both directions then the minimum internal width would be approximately 38.2m.

To accommodate a toll plaza along the route would require a widened Expressway at the toll plaza location and therefore the support structure would require widening below, in conjunction with this widened substructure, access from ground to the toll plaza is also required such that toll plaza personnel are able to access the tolling booths, this further increases the required room at the toll plaza. If toll plazas are located on the ramps, then placement would also need to consider appropriate storage capacity and acceleration lengths (of at least 150m).

A toll canopy covering all services lanes shall be provided. Each toll plaza complex including its canopy shall have a clear height no less than 5.7 m in the central portion covering 4 lanes. Toll gates shall be provided with check barriers which can be electrically operated from the toll booths. High mast lighting shall be provided. Power supply shall be from the public power supply system and standby diesel generating sets of adequate capacity shall be provided. An office building with public telephone facility shall be provided at each toll plaza.

Following photographs are presented to demonstrate the example of a typical manual and electronic toll plazas.

Example of Manual Toll-plaza

Example of Electronic Toll-plaza

Section 14
STRUCTURAL SYSTEM

14.1 General

The present section of the report gives a brief outline of probable structural system (substructure and superstructure) and its components for the proposed Dhaka Ashulia Elevated Expressway. Appropriate structural forms are primarily based on geometric constraints and experience from previous and ongoing similar urban viaducts like, Gulistan-Jatrabari Flyover, Banani Flyover, Kuril Interchange and most importantly the Dhaka Elevated Expressway.

14.2 At-Grade Section

Where appropriate, the elevated expressway may be constructed on embankment, with full access control, rather than on structure, which might lead to lower construction cost. However, the conditions necessary for this would include:

- Availability of wide or expandable at-grade road with the provision of
  - Full access controlled median based mobility strip
  - Service road on both sides of at-grade road with proper merging-diverging and grade separated interchange facilities at junctions
  - Grade separated pedestrian crossing facilities
- Availability of exclusive land
- Embankment height above flood level
- Inclusion of shorter bridges sufficient for cross waterway traffic movements

However, these pre-requisites, for having the Dhaka Ashulia Expressway at at-grade level, are not available for a suitable and feasible segment of length along both the proposed alternative alignment corridors.

14.3 Elevated Sections

14.3.1 Typical Structural Forms

Two structural forms may be considered for the preliminary feasibility study viz. precast I-girder system and segmental Box-girder system. The general features of I-Girder are summarized as follows:

Girder: Typical span of girder is 30.00 m. Number of girder is, typically, ten(10) girder for each span with girder spacing of 1.90 m.
Bearing: The elastomeric bearing with capacity of 85 Ton is considered.
Pier: Two types of pier are to be considered as typical type.
- Single Column Pier
- Portal Frame Pier

Typical examples are shown below.

I-Girder Type Expressway with Single Pier

I-Girder Type Expressway with Portal Frame

Alternative type of structure is precast segmental Box-girder type. This type of structure has some advantages compare to the I-girder type. The advantages are as follows:

- Better in aesthetic point of view
- Less interrupting to existing traffic

Nevertheless, this type has higher construction cost and require higher in construction technology. The alternative box-girder structure type has the following characteristics:

Girder: Can be single or dual cell single Box girder. Typical span of girder is 40.00 m. Method of construction is precast segmental Box girder with dry joint. Method of erection is span-by-span method.

Bearing: The pot bearing is considered.

Pier: Two types of pier are to be considered as typical type.

- Single Column Pier
- Portal Frame Pier

Typical examples are shown below.

Box-Girder Type Expressway with Single Pier

Box-Girder Type Expressway with Portal Frame

Though the final selection of preferred options for the main viaduct and interchange ramp structural forms will be subject to input from the end contractor, input on traffic flow data and geometric design considerations, in line with the structural forms of the connecting Dhaka Elevated Expressway, among the available super-structural systems - I-Girder system and Box Girder system are considered for the proposed Dhaka Ashulia Elevated Expressway project. Both I-Girder and Box Girder systems should satisfy the minimum width of the connecting Dhaka Elevated Expressway. For each system, costs of two types of sections will be estimated - one with a width of 20.56m & 17.56m for the main viaduct and another with a width of 7.1m for oneway ramps. Altogether 26 Box Girder sections are assumed following guidelines of AASHTO (2007) and CALTRANS (1992). A two-cell section is assumed for the main viaduct and a single-cell section for the ramps, based on the width of the sections (Figures 13.1, 13.2 and 13.3). Following the AASHTO (2007) and PCI (2003) specifications, probable I-Girder and Box-Girder sections are shown in Figures 14.1 to 14.5.

During the final feasibility study, these superstructure sections for both I and box-girder structural systems would be rationalized based on AASHTO and PCI specifications and guidelines. Generally, pre-stressed concrete structure is applied for reducing structural size which will also reduce disruption to existing traffic. The aesthetic issue needs to be considered during the development of the structural shape.

14.3.2 Proposed Structural Forms

The structural system is considered here on the basis of the two alternate alignments as discussed in Section 2. According to the proposed Alternative-1 alignment (Fig. 2.1), initially the expressway follows the existing rail track starting near the Dhaka Airport Railway Station up to the Turag River. The portal frame pier is typically used where the area beneath the Expressway is restricted by existing facilities such as railway tracks, roadways, etc. Here, two column piers or portal frame is considered to maintain the adequate column free right-of-way for the future multipurpose use of the rail corridor by the Bangladesh Railway.

In this stretch, structural system with 7.4m headroom clearance can be considered for the expressway in order to accommodate provisions for future at-grade electric train and subsurface MRT construction along the same corridor. As per railway safety guidelines there should be at least 19.82m r.o.w to accommodate 3rd and 4th railway tracks between Kamalapur and Tongi segment of railway corridor. Between two center lines of railway track there should be at least 3.57m gap and 3.05m clear safety distance from the track centerline to the nearest track adjacent building structure or pier of portal frame structure. This type of structure composes of pre-stressed concrete cross beam, two column, footings and piles. The pile size and capacity are also the same as for single column pier. Two alternative structural sections (I and Box-girder) using portal frame pier are shown in Figure 14.1 and 14.2.

After the railway corridor, the expressway will run along the existing roadway up to the end of the alignment and a single-column type structural system with 5.7m headroom clearance can be considered for this stretch. The single column pier is typically used where the center area beneath the expressway has no constraints. The ramps and interchanges can also be single-column structural systems with varying pier heights. The structure composes of pre-stressed concrete cross beam, column, footing and piles. Figures 14.3 and 14.4 show overall two alternative structural sections (I and Box-girder) using single column pier. Figure 14.5 shows the single pier based structural form for interchange and entry-exit ramps.

The alignment of Alternative-2 (Fig. 2.2), starts in the same way as in Alternative-1 from Dhaka Airport Railway Station to Abduallahpur. Then from the confluence point of Ashulia road and New Esthema road, the alignment goes through Uttara Third phase east ward and reaches Savar Intersection to the south of Savar Cantonment. Then it bends northward towards Nabinagar. Finally the expressway reaches Chandra through Baipayl. Beyond the rail track, all along the alignment the vertical clearance of the expressway will be 5.7m and structural system will be Single-Column type.

At the starting end the expressway will be connected with the Dhaka Elevated Expressway in a seamless fashion and at other ends i.e. at Nabinagar and Chandra, open architecture termini is adopted and thereby the main-viaduct will be left open at these ends for future extension. Termination will be achieved through ramps.

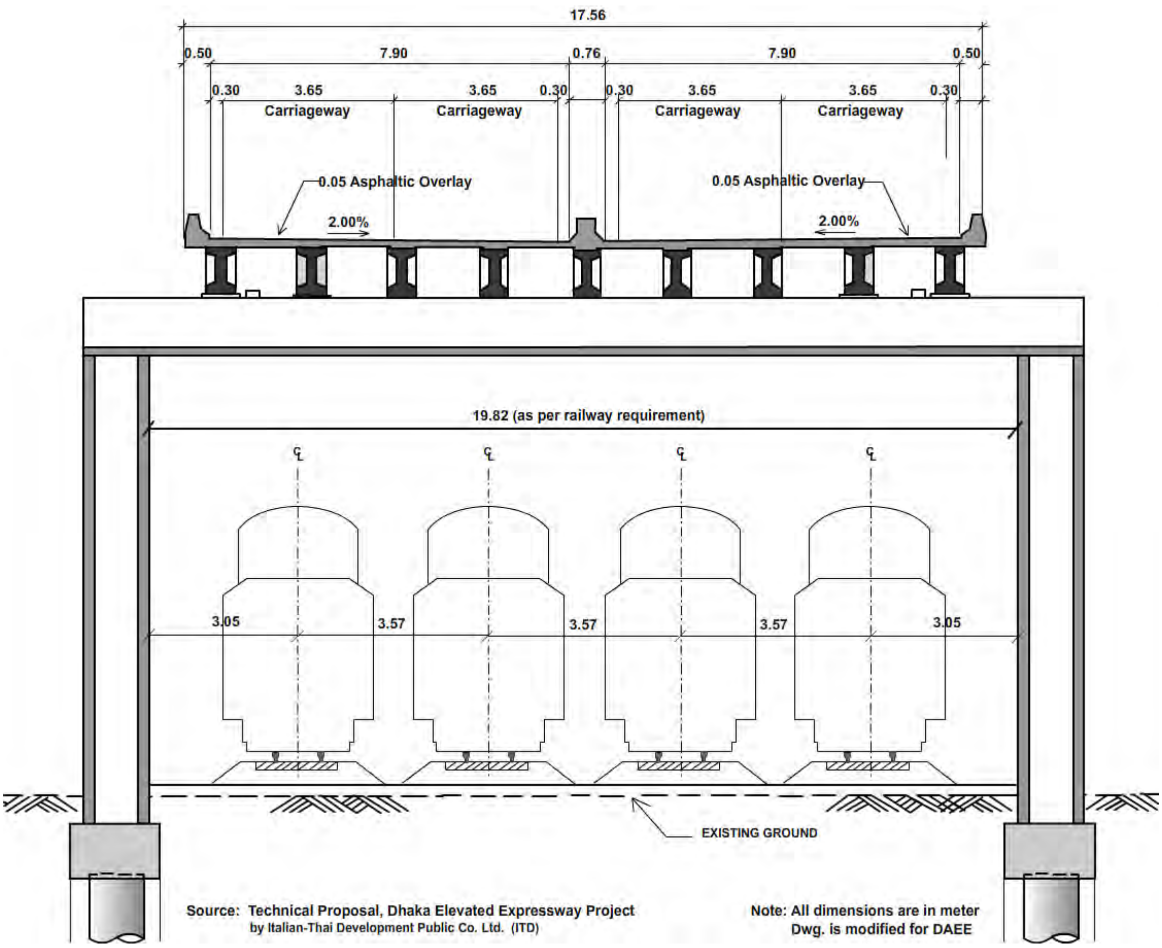


Figure 14.1: Main Viaduct – I-girder System along Railway Corridor

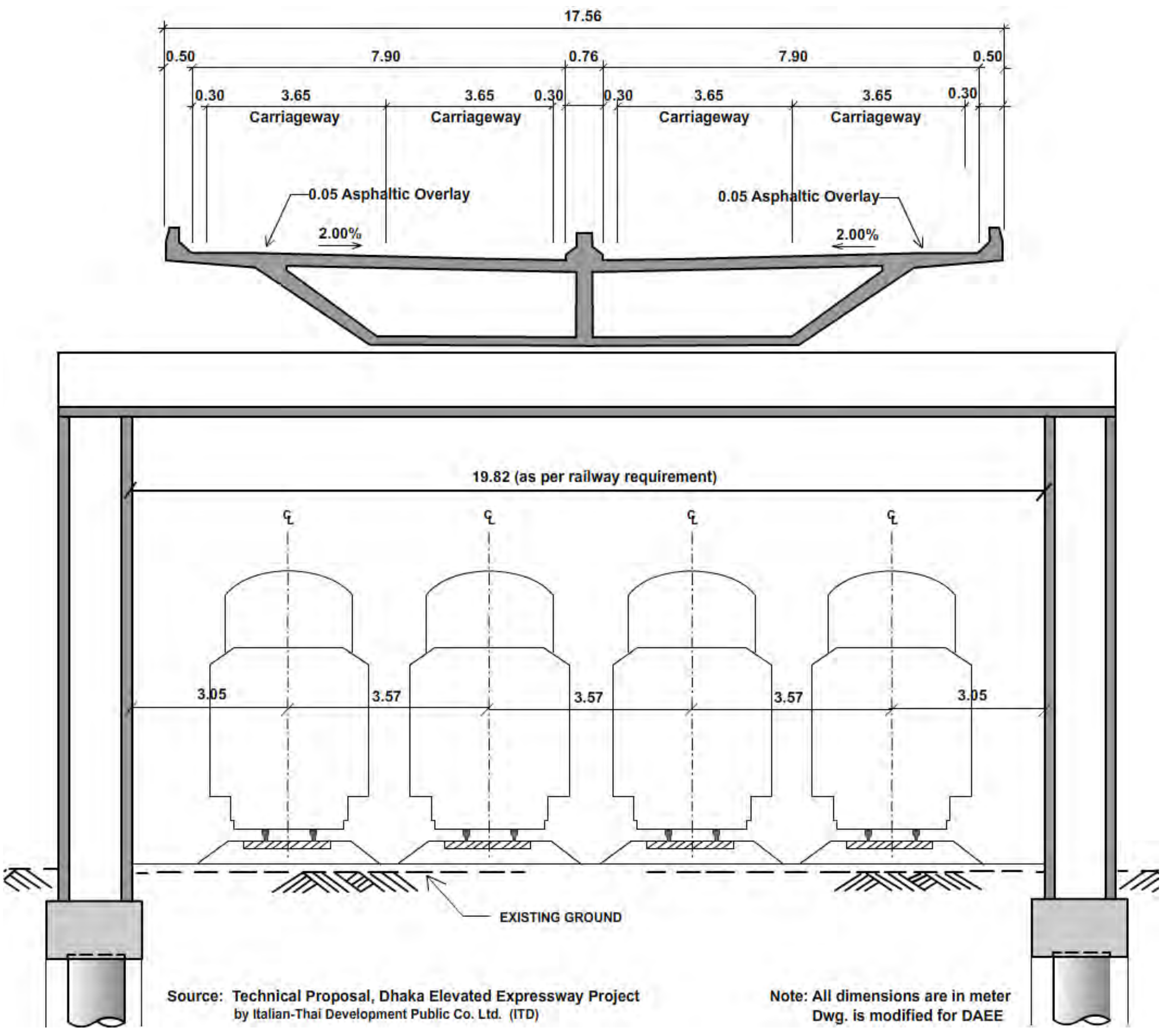
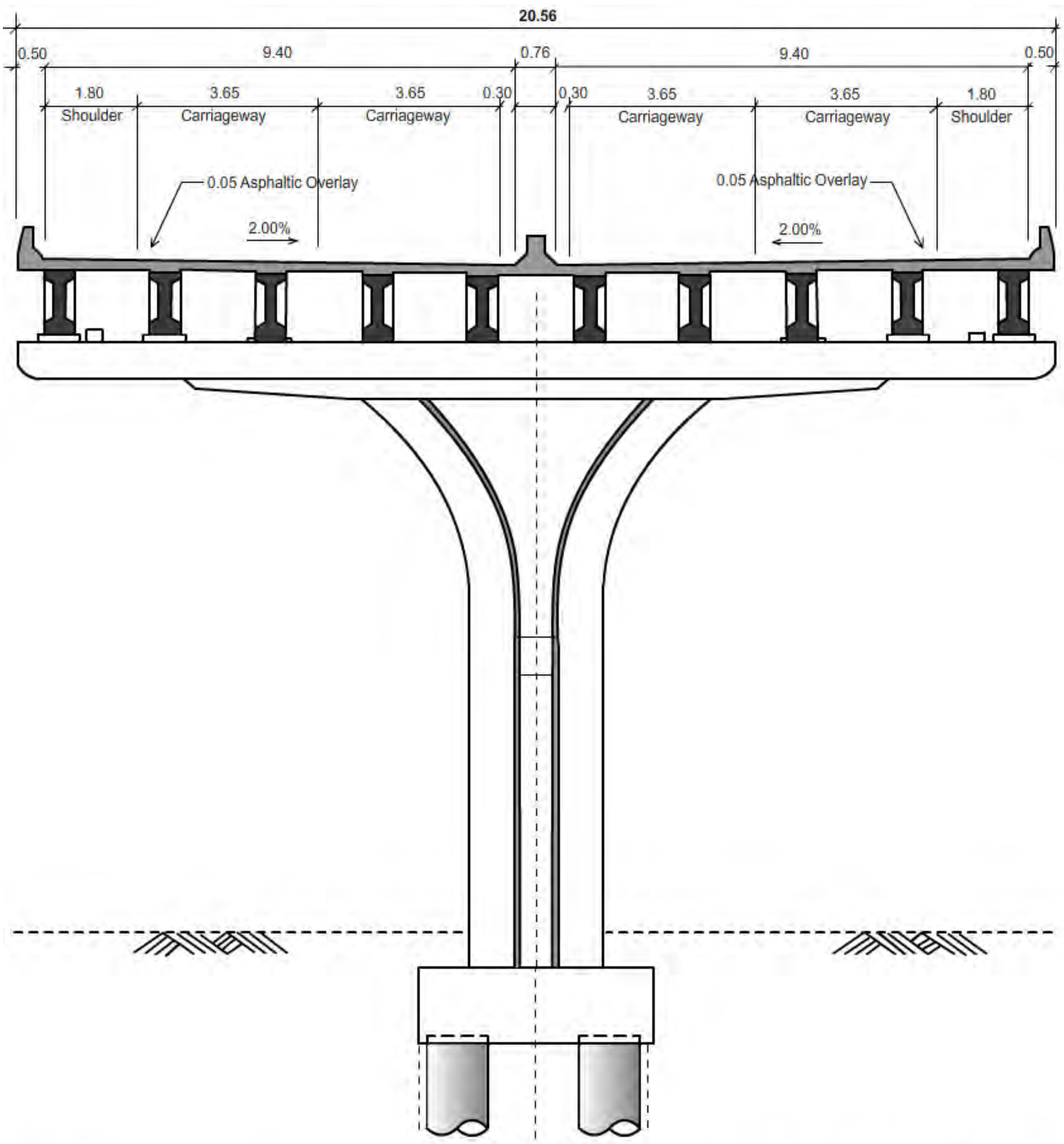


Figure 14.2: Main Viaduct – Box Girder System along Railway Corridor



Note: All dimensions are in meter

Source: Technical Proposal, Dhaka Elevated Expressway Project
by Italian-Thai Development Public Co. Ltd. (ITD)

Figure 14.3: Main Viaduct – I-girder System

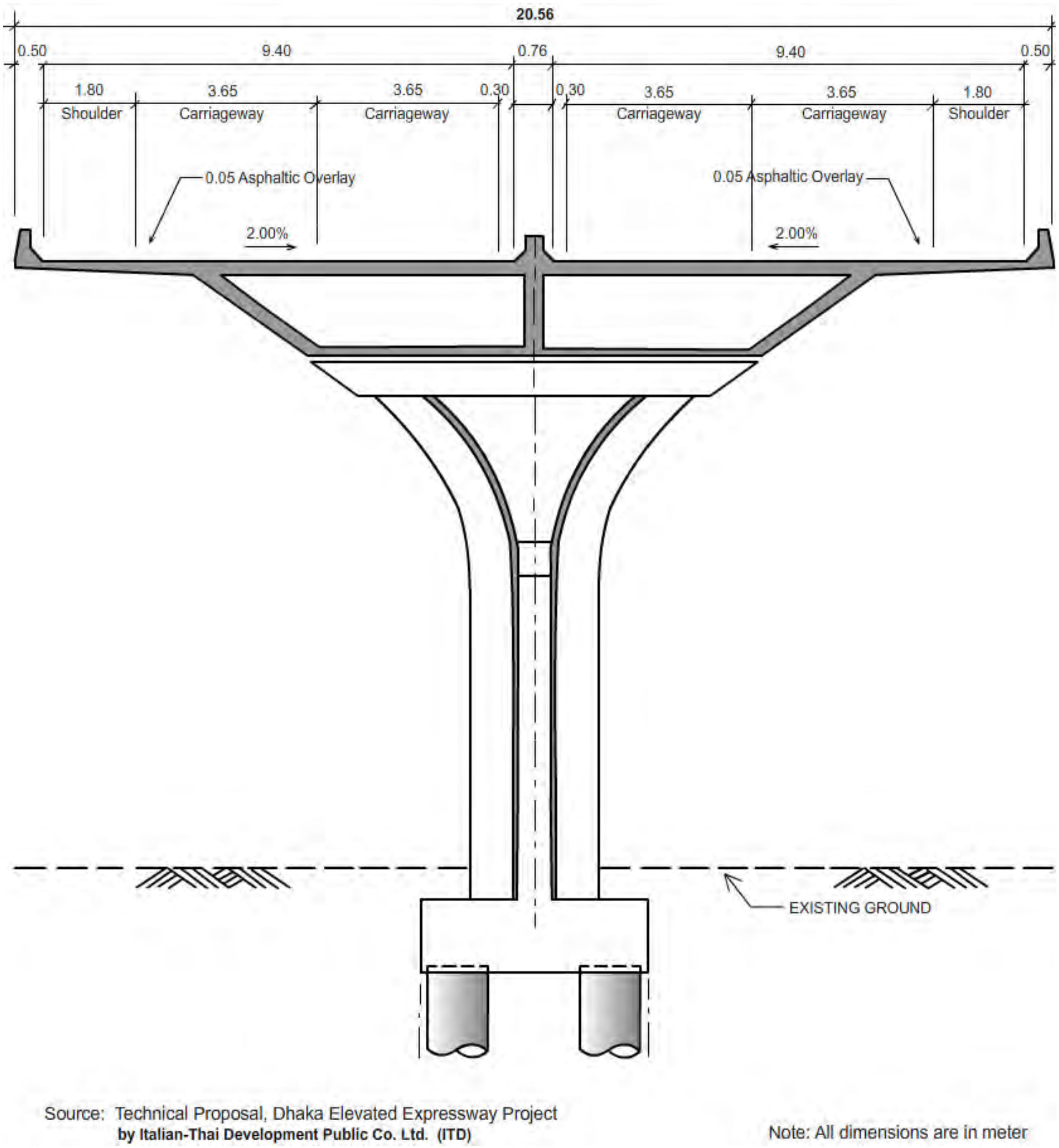
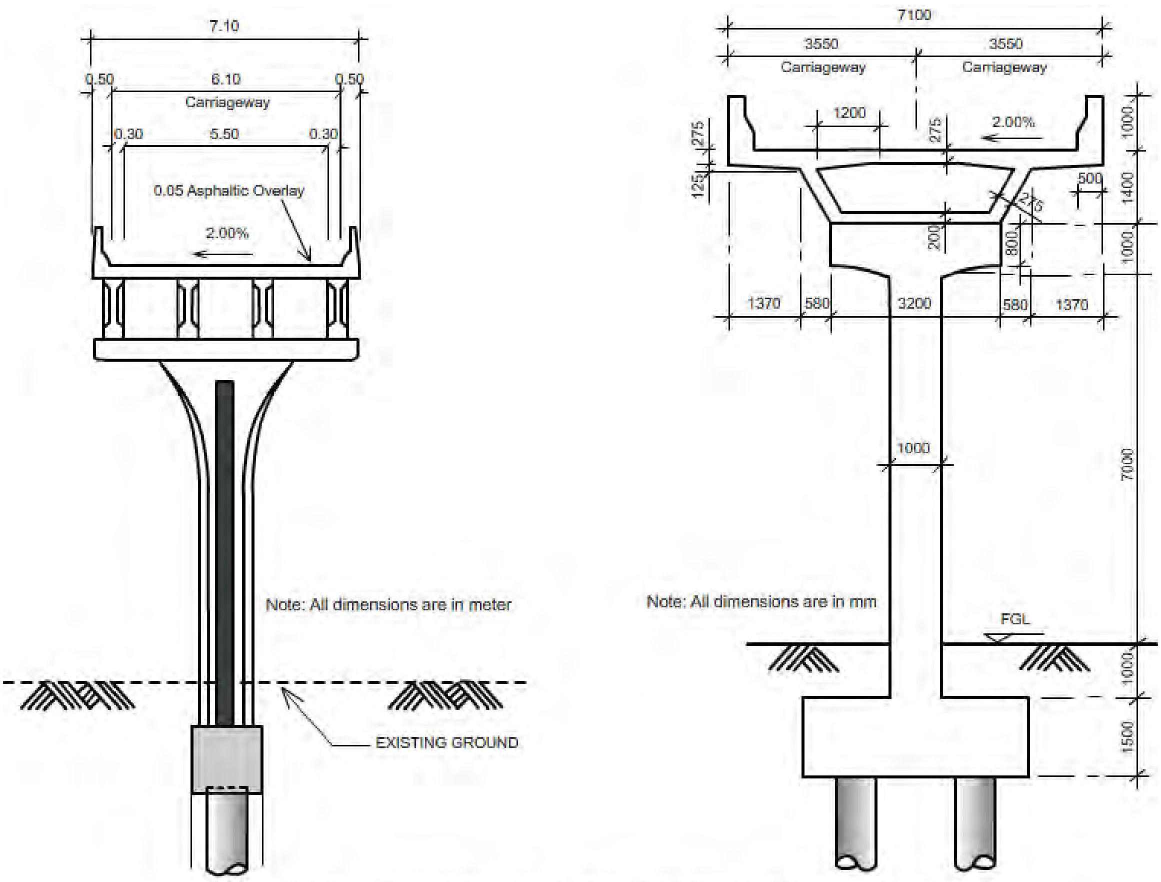


Figure 14.4: Main Viaduct – Box Girder System



Source: Technical Proposal, Dhaka Elevated Expressway Project
by Italian-Thai Development Public Co. Ltd. (ITD)

Figure 14.5: Ramps – I-Girder and Box-Girder Systems

14.4 Structural Components

Basic structural forms of the main viaduct and interchange ramps have three distinct parts – superstructure, pier and foundation. Design of these structural components depends on the span of the structure and the final selection of preferred options for the main viaduct and interchange ramp structural forms, eventually which will be subject to the Client/ Investors' preference for constructability, geometric design considerations, cost effectiveness and input on traffic flow data.

14.4.1 Superstructure

a. Span

A number of superstructure options are applicable to the elevated roadway section. The use of steel plate girders is not considered because of the higher maintenance requirements for this material type. The use of cast-in-situ construction using false work supported off the ground is also discarded due to the unacceptable disruption to existing traffic (road and/or rail). Precast and pre-stressed concrete girder based structural form is considered for the proposed expressway project. Based on the previous experience, applicable span lengths would be in the range of 30m to 45m subject to the form of superstructure. In consistent with the Dhaka Elevated Expressway, typical span of 40m may be assumed for the proposed Dhaka Ashulia Elevated Expressway and for cost estimation of the project. Applicable span lengths for interchange ramps are generally shorter than the main viaduct, since ramps are connected to the main viaduct through curvature. The applicable span lengths for interchange ramps should be in the range of 20m to 35m. A typical span of 25m for the ramps can be assumed for the preliminary feasibility study.

Based on preliminary assessment of articulation, superstructure modules are limited to approximately 200m to minimize the size and number of deck expansion joints and allow use of low maintenance laminated elastomeric bearings to support the superstructure. Seismic restraint is provided through reinforced concrete plinths.

b. Traffic Barrier

Traffic barriers are required to prevent vehicles that leave the traveled way from hitting an object that has greater crash severity potential than the barrier itself. In line with Dhaka Elevated Expressway, traffic barriers are proposed as full height New Jersey style reinforced concrete at both the outer edges and as median divider. The width is 0.76m and 0.50m for median and edge barriers, respectively. The typical roadway section and traffic barriers are illustrated in Figure 13.4.

14.4.2 Pier

Single column piers provide the minimum footprint for substructure. It is suitable for tightly constrained sites such as the proposed Dhaka Ashulia Elevated Expressway. Whereas, two column piers or portal frames shall apply only in circumstances where a single column pier cannot be accommodated due to the requirement of column free space underneath the structure. Which is the case particularly along the rail corridor.

Minimum vertical clearance from top of rail to structure shall be 7.4m and in other places the vertical clearance would be 5.7m and hence poured in a single operation would be possible. For beam and slab superstructure options, headstocks are required to support the precast or prefabricated beams. Headstock construction could incorporate the following:

- Cast-in-place using steel forms
- Precast permanent formwork shells
- Fully precast headstocks stressed down to the pier column or using in-situ pockets
- Cast parallel to the alignment and subsequently rotated through ninety degrees and fixed into final position

For Box-girder superstructure options, the pier column would incorporate a flared upper section to accommodate bearings.

14.4.3 Pile Foundation

It is expected that the structural form of the piles would be bored reinforced concrete piles because of the close proximity of many existing structures along both the alternatives. Consideration should be given to the use of driven precast reinforced concrete piles where the effects of ground vibration can be tolerated. Preferably, no more than four bored piles per pier column should be necessary. The size of the piles is dictated by the loading from the superstructure. With the current lack of availability of geotechnical information, a detailed analysis of the pile sizes is not possible but for the sack of cost estimate, the design considerations of Dhaka Elevated Expressway as proposed by Italian-Thai Development Public Co. Ltd. (ITD) are taken into cognizance. Accordingly, reaction at the base of a column of an 7.4m high portal frame for main viaduct under service load is estimated to be 800 tons. Two 1.0m diameter bored piles of around 30m length, each having almost 500 ton capacity, may be provided. The 5.7m) high single column type pier of the main viaduct will be required to withstand 1300 tons service load with additional moment. Four 1.0m diameter bored piles of around 25m length each with an estimated capacity of 400 tons may be provided.

For interchanges and entry-exit ramps an average 9.0m (5.7m -13.4m) high single column pier will be required to sustain 300 tons service load with additional moment. Two 750mm diameter piles of 30m length of capacity 250 tons per pile may be provided. The pile capacities are estimated on the basis of soil investigation of different flyover projects that have been carried out in Dhaka. Weight of I-girder superstructure is slightly less than that of the Box girder system. For a liberal estimate, pile foundations to support the weight of Box-girder system are only considered here.

Section 15

PROJECT COST ESTIMATION

15.1 General

On the basis of the assumed superstructural sections as mentioned above as well as pier and pile configurations, the unit cost per kilometer for the viaduct and ramps can be calculated by using costing details of different ongoing projects which are being implemented by the Government and also on the basis of Public Private Partnership in Dhaka city. Total construction cost may then be estimated for the entire extent of the proposed alignment based on this calculated unit cost. Eventually, the project cost, on the basis of Public Private Partnership (PPP), can be estimated by including physical & price contingencies, taxes and duty, interest during construction period, different PPP soft costs viz. SPV (special purpose vehicle) development cost, fees for engaging independent engineers & financial advisor etc. and land acquisition, rehabilitation and utility shifting cost components.

15.2 Unit Structural Cost Estimation

The per kilometer structural cost of the main viaduct and ramps is estimated based on the preliminary layout considerations of route alignment and the preferred structural forms as described in the previous sections.

Here, estimates of a number of items have been made from the experience of previous projects' construction methods and item-wise costs of different ongoing as well as completed bridge, flyover and expressway projects in Dhaka City (for details pl. see Appendix-F). Besides, in estimating unit structural cost, the Cost Schedule 2011 of Roads and Highways Department (RHD) is also consulted.

Accordingly, the unit cost of Box-girder type main viaduct with single column piers of 5.7m is approximately estimated at Tk. 138 crore per kilometer. Unit cost of Box-girder type with portal frames of 7.4m height is about Tk. 145 crore per kilometer. The estimated cost of the Box-girder type oneway ramps is Tk. 72 crore per kilometer on an average.

Cost figures for I-girder type sections are somewhat less. The unit cost of I-girder type main viaduct having single column piers of 5.7m height is approximately estimated at Tk. 120 crore per kilometer. I-girder type main viaduct supported by portal frames of 7.4m height may cost around Tk. 127 crore per kilometer. For I-girder single lane ramps, the unit cost is about Tk. 65 crore per kilometer.

15.3 Total Direct Cost Estimation

Total basic structural cost for each option and alternative route alignments are estimated by using the above structural unit costs and also knowing the total route and ramp lengths. Detailed estimates of ramp length for both I and Box girder structural forms are provided in Appendix-G. For costing purposes, ramp structure is calculated from the total ramp length by a multiplying factor of 0.76. The total length ramp and ramp structures for both alternative route alignments are summarized in Table 15.1 as follows:

Table 15.1: Summary of Total Length of Ramp and Ramp Structures

Alternative – 1

Total route length = 35 km

Girder Type	Ramps (m)	Structure (m)
I-Girder	8,372	6,363
Box-Girder	8,878	6,747

Alternative – 2

Total route length = 38.5 km

Girder Type	Ramps (m)	Structure (m)
I-Girder	10,370	7,881
Box-Girder	10,973	8,339

The total direct cost estimate also incorporates:

a. the general permanent works components of the project viz. cost for mobilization and site facilities establishment, traffic diversion, noise barriers, street lighting, environmental monitoring and management plan etc.
b. the general Public Private Partnership (PPP) infrastructures viz. toll plazas including booths and canopy, toll collection system, traffic control and surveillance system including weight bridge, central control building etc.

It is to be noted that compared to purely government funded project, development of infrastructure under Public Private Partnership (PPP) frame structure needs additional items particularly toll collection infrastructures and various standard PPP soft items. Which essentially suggests that the construction cost of PPP based infrastructure would be relatively higher than that of the Public funded project. Table 15.2, 15.3, 15.4 and 15.5 provides summary of the total estimated direct costs for two alternative alignments and two structural forms. The tables revealed that :

Alternative-1
Total direct cost for construction of the whole extent of the structure of Dhaka Ashulia Expressway has been grossly estimated at Tk. 5923 crore for I-girder system and Tk. 6631 crore for Box-girder.

Alternative-2
Total direct cost for construction of the whole extent of the structure of Dhaka Ashulia Expressway has been grossly estimated at Tk. 6432 crore for I-girder system and Tk. 7186 crore for Box-girder.

Table 15.2: Total Direct Cost of I-Girder System for Alternative-1

Main Viaduct (km) = 35.00
Ramps Structure (km) = 6.36

Item No.	Item	Quantity	unit	Unit cost (Million Tk.)	Total Cost (Million Tk.)
1	General, Mobilization and Site Facilitiest	-	L.S.	-	4,788.82
2	Traffic Diversion, Temporary Diversion Works/Protection Works:	-	L.S.	-	899.12
3	Main Viaduct				
3a	Single Column 5.7m height & 20.56m width	34.59	km	1200.00	41,508.00
3b	Portal Column 7.4m height & 17.56 m width	0.41	km	1300.00	533.00
4	Single Ramp Structure	6.36	km	650.00	4,135.75
5	Toll Plaza	5	no.	150.00	750.00
6	Central Control Building	1	no.	450.00	450.00
7	Toll Collection System	-	L.S.	-	1,069.10
8	Traffic Surveillance System (including Weighing Stations)	-	L.S.	-	3,749.35
9	Street light	-	L.S.	-	725.51
10	Environmental Monitoring and Management plan	-	L.S.	-	35.79
11	Miscellaneous	-	L.S. 1%	-	586.44
				Total Direct Cost in Million Taka =	**59,230.88**

Tk. 5923 crore for I-girder system

Table 15.3: Total Direct Cost of Box-Girder System for Alternative-1

Main Viaduct (km) = 35.00
Ramps Structure (km) = 6.75

Item	Item	Quantity	unit	Unit cost (Million Tk.)	Total Cost (Million Tk.)
1	General, Mobilization and Site Facilities	-	L.S.	-	4,788.82
2	Traffic Diversion, Temporary Diversion Works/Protection Works:	-	L.S.	-	899.12
3	Main Viaduct				
3a	Single Column 5.7m height & 20.56m width	34.59	km	1380.00	47,734.20
3b	Portal Column 7.4m height & 17.56 m width	0.41	km	1450.00	594.50
4	Single Ramp Structure	6.36	km	720.00	4,581.14
5	Toll Plaza	5	no.	150.00	750.00
6	Central Control Building	1	no.	450.00	450.00
7	Toll Collection System	-	L.S.	-	1,069.10
8	Traffic Surveillance System (including Weighing Stations)	-	L.S.	-	3,749.35
9	Street light	-	L.S.	-	725.51
10	Environmental Monitoring and Management plan	-	L.S.	-	35.79
11	Miscellaneous	-	L.S. 1%	-	653.78
				Total Direct Cost in Million Taka =	**66031.30**

Tk. 6631 crore for Box-girder system

Table 15.4: Total Direct Cost of I-Girder System for Alternative-2

				Main Viaduct (km) =	38.50
				Ramps Structure (km) =	7.88
Item No.	Item	Quantity	unit	Unit cost (Million Tk.)	Total Cost (Million Tk.)
1	General, Mobilization and Site Facilities	-	L.S.	-	4,788.82
2	Traffic Diversion, Temporary Diversion Works/Protection Works:	-	L.S.	-	899.12
3	Main Viaduct				
3a	Single Column 5.7m height & 20.56m width	38.09	km	1200.00	45,708.00
3b	Portal Column 7.4m height & 17.56 m width	0.41	km	1270.00	533.00
4	Single Ramp Structure	7.88	km	650.00	5,122.83
5	Toll Plaza	4	no.	150.00	600.00
6	Central Control Building	1	no.	450.00	450.00
7	Toll Collection System	-	L.S.	-	1,069.10
8	Traffic Surveillance System (including Weighing Stations)	-	L.S.	-	3,749.35
9	Street light	-	L.S.	-	725.51
10	Environmental Monitoring and Management	-	L.S.	-	35.79
11	Miscellaneous	-	L.S. 1%	-	636.82
				Total Direct Cost in Million Taka =	**64,318.32**

Tk. 6432 crore for I-girder system

Table 15.5: Total Direct Cost of Box-Girder System for Alternative-2

				Main Viaduct (km) =	38.50
				Ramps Structure (km) =	7.88
Item No.	Item	Quantity	unit	Unit cost (Million Tk.)	Total Cost (Million Tk.)
1	General, Mobilization and Site Facilities	-	L.S.	-	4,788.82
2	Traffic Diversion, Temporary Diversion Works/Protection Works:	-	L.S.	-	899.12
3	Main Viaduct				
3a	Single Column 5.7m height & 20.56m width	38.09	km	1380.00	52,564.20
3b	Portal Column 7.4m height & 17.56 m width	0.41	km	1450.00	594.50
4	Single Ramp Structure	7.88	km	720.00	5,674.51
5	Toll Plaza	4	no.	150.00	600.00
6	Central Control Building	1	no.	450.00	450.00
7	Toll Collection System	-	L.S.	-	1,069.10
8	Traffic Surveillance System (including Weighing Stations)	-	L.S.	-	3,749.35
9	Street light	-	L.S.	-	725.51
10	Environmental Monitoring and Management	-	L.S.	-	35.79
11	Miscellaneous	-	L.S. 1%	-	711.51
				Total Direct Cost in Million Taka =	**71862.40**

Tk. 7186 crore for Box-girder system

15.4 Total Project Cost Estimation

15.4.1 Key Assumptions in Project Cost Estimates

In estimating total capital costs for each of the route alignment options, the following key assumptions are made based on experiences of going Dhaka Elevated Expressway Project:

- Cost of engaging Independent Engineers 1% of estimated project cost
- Transfer of Technology at 0.1% of estimated project cost
- Physical Contingency has been allowed for at 3% to direct cost
- Price contingency estimated at 6% p.a. of construction cost
- Duties and taxes estimated at 6.5% of foreign items of the construction costs
- Interest during construction estimated at 6% of estimated project cost
- Contractor's head office overhead & profit estimated at 10% of estimated project cost
- SPV set up cost estimated at Tk. 60 million
- Advisory Fees (Financial Soft Cost) estimated at Tk. 800 million
- Supervision and Coordination Charges estimated at Tk. 40 million
- Viability gap funding (VGF) fixed at maximum 30% of estimated project cost; however, this VGF including concession period would be the main bidding parameters – where potential bidders would try to offer these two parameters as much low as possible.

15.4.2 Construction Program

Considering the extent of the proposed expressway and construction of other ongoing flyover projects, it is assumed that the duration of construction would be approximately 4 years and the yearly expenditure profiles would be as follows: 1st Year - 20%; 2nd Year - 30%; 3th Year - 30% and 4th Year - 20%.

15.4.3 Project Cost Estimates

It is to be noted that the total project construction costs are estimated for two alternative alignments and for two super structural forms. These costs includes total direct cost, physical and price contingencies. In order to estimated public private partnership based capital cost, the following additional items are considered – Special Purpose Vehicle (SPV) set up cost, advisory fees, provision of transfer of technology, cost of engaging independent expert, supervision and coordination charges, interests during construction and investor's profit.

The total project cost comprises of bidder's total capital cost and government equities in the form of waving taxes & duties, bearing cost of land acquisition and rehabilitation, utilities relocation and providing necessary viability gap funding to make the project financially feasible.

The costs for land acquisition, compensation and utility relocation are estimated based on presently ongoing 4-Laining Nabinagar-DEPZ-Chandra Road Widening Project and Joydebpur-Mymensingh Road Improvement Project (JMRIP) undertaken by Roads and Highways Department (RHD). The derived costs of these public funded projects are finally refined by considering the experience of Dhaka Elevated Expressway Project. The estimates of land acquisition and relocation are presented in Table 15.6.

Tables 15.7, 15.8, 15.9 and 15.10 provide summary of the total estimated project costs for two structural forms and two alternative route alignments. These tables revealed that:

Alternative-1
Total capital costs for I-girder system is around Tk. 8,364 crores, whereas for Box-girder system the total capital cost is around Tk. 9,312 crores. Per kilometer costs in million USD are appeared to be 27 and 30 respectively for I and Box-girder. The total project costs which also includes Government equity are estimated at Tk.13,654 crores and Tk. 14,940 crores for I and Box girder. The Public and Private share is found to be 38:62.

Alternative-2
Total capital costs for I-girder system is around Tk. 9073 crores and for Box-girder system the total capital cost is around Tk. 10,125 crores. Per kilometer costs in million USD are appeared to be 27 and 30 respectively for I and Box-girder. The total project costs which also includes Government equity are estimated at Tk.16,250 crores and Tk. 17,675 crores for I and Box girder. The Public and Private share is found to be 43:57. As compared to Alignment-1, public share with Alignment-2 is relatively higher mainly due to land acquisition issues.

However, these estimated costs need to be refined further to arrive at the most cost effective solution by knowing forecasted design traffic demand vis-à-vis exact geometric configuration of the structures, by doing detailed structural analysis, investigating several construction options, by knowing the direct purchasing cost of materials, equipment and different services from the local contents and resources. These issues will be addressed in the final feasibility report or will be undertaken by the potential bidders while preparing their estimates for the project cost.

Table 15.6: Estimated Land Acquisition, Rehabilitation & Utility Shifting Cost

Items	Tongi railway-Abdullahpur		Ashulia - Baipayl		Turag – Savar	
Length of Segment	0.41	km	14	km	18.8	km
Existing crest width	8	m	9	m	9	m
Widened Crest width	15	m	15	m	15	m
Embankment Height	3	m	0	m	0	m
Embankment Slope	1:1.5		1:1		1:1	
Base width	24	m	20.56	m (min)	20.56	m (min)
Land to be acquired	**1.63**	**Acres**	**40.30**	**Acres**	**54.12**	**Acres**

Per Ramp Land Required		
Ramp Length (avg)	289	m
Width	7.1	m
Land to be acquired	0.51	Acres

Land required to accommodate Ramps		
Alignment - 1 (35.0 km)		
31 no. ramps	15.82	Acres
Trumpet Interchange	5.00	Acres
Land to be acquired	20.82	Acres
Alignment - 2 (38.5 km)		
33 no. ramps	16.84	Acres
Roundabout Interchange	8.00	Acres
Land to be acquired	24.84	Acres

Total Land to be acquired for Alignment – 1	67.76	Acres
Total Land to be acquired for Alignment – 2	123.27	Acres
Estimated land acquisition cost/acre	10.5	Crores *

Alignment - 1 (35.0 km)		
Total Cost for Land Acquisition (LA)	711	Crores
Total Cost for Resettlement	400	Crores *
Total Cost for utilities shifting	300	Crores *
Grand Total (approx)	**1411**	**Crores**
Alignment - 2 (38.5 km)		
Total Cost for Land Acquisition (LA)	1294	Crores
Total Cost for Resettlement	800	Crores *
Total Cost for utilities shifting	200	Crores *
Grand Total (approx)	**2294**	**Crores**

Note: * Based on ongoing 4 Laining of Nabinagar-DEPZ-Chandra Road and Joydebpur-Mymensingh Road Improvement Project (JMRIP) undertaken by Roads & Highways Department (RHD)

Table 15.7: Total Capital and Project Costs of I-Girder System for Alignment-1

Amount in million Tk

Item	Total Cost	Year 1	Year 2	Year 3	Year 4
Total Direct Cost	**59,231**	**11,846**	**17,769**	**17,769**	**11,846**
Physical Contingency	1,777	355	533	533	355
Price Contingency	9,411	711	2,196	3,394	3,109
Total Estimated Construction Cost	**70,418**	**14,084**	**21,126**	**21,126**	**14,084**
PPP related additional costs					
Development Cost (SPV Set up Cost)	60	12	18	18	12
Advisory Fees (Financial Soft Cost)	800				
Supervision and Coordination Charges	40				
Transfer of Technology	70	14	21	21	14
Independent Expert	714	143	214	214	143
Total PPP based Construction Cost	**72,103**	**14,421**	**21,631**	**21,631**	**14,421**
Interest during construction	4,326				
Contractor's head office overhead & profit	7,210	1,442	2,163	2,163	1,442
Total Bidder's Capital Cost in million Tk.	**83,639**	**14,421**	**21,631**	**21,631**	**14,421**
Total Bidder's Capital Cost in million USD	**1,020**	**176**	**264**	**264**	**176**
Per km Capital cost in million Tk.	**2,191**				
Per km Capital cost in million USD	**27**				
Government's Equity					
Duties and Taxes	4,687	937	1,406	1,406	937
Land acquisition and rehabilitation	20,119	20,119	-	-	-
Utility relocations	3,000	3,000	-	-	-
Viability Gap Funding (VGF) – max. 30%	25,092	-	8,364	8,364	8,364
Total Equity	**52,897**	39	% of Total Project Cost		
Total Estimated Project Cost in million Tk	**136,537**				
Total Estimated Project Cost in million USD	**1,665**				

Note: 1 USD = 82 Tk.
Total Length of 4-lane Equivalent Expressway = 38.18 km

Table 15.8: Total Capital and Project Costs of Box-Girder System for Alignment-1

Amount in million Tk

Item	Total Cost	Year 1	Year 2	Year 3	Year 4
Total Direct Cost	**66,031**	**13,206**	**19,809**	**19,809**	**13,206**
Physical Contingency	1,981	396	594	594	396
Price Contingency	10,491	792	2,448	3,784	3,466
Total Estimated Construction Cost	**78,503**	**15,701**	**23,551**	**23,551**	**15,701**
PPP related additional costs					
Development Cost (SPV Set up Cost)	60	12	18	18	12
Advisory Fees (Financial Soft Cost)	800				
Supervision and Coordination Charges	40				
Transfer of Technology	79	16	24	24	16
Independent Expert	795	159	238	238	159
Total PPP based Construction Cost	**80,277**	**16,055**	**24,083**	**24,083**	**16,055**
Interest during construction	4,817				
Contractor's head office overhead & profit	8,028	1,606	2,408	2,408	1,606
Total Bidder's Capital Cost in million Tk.	**93,121**	**16,055**	**24,083**	**24,083**	**16,055**
Total Bidder's Capital Cost in million USD	**1,136**	**196**	**294**	**294**	**196**
Per km Capital cost in million Tk.	**2,427**				
Per km Capital cost in million USD	**30**				
Government's Equity					
Duties and Taxes	5,218	1,044	1,565	1,565	1,044
Land acquisition and rehabilitation	20,119	20,119	-	-	-
Utility relocations	3,000	3,000	-	-	-
Viability Gap Funding (VGF) – max. 30%	27,936	-	9,312	9,312	9,312
Total Equity	**56,273**	38	% of Total Project Cost		
Total Estimated Project Cost in million Tk	**149,394**				
Total Estimated Project Cost in million USD	**1,822**				

Note: 1 USD = 82 Tk.
Total Length of 4-lane Equivalent Expressway = 38.37 km

Table 15.9: Total Capital and Project Costs of I-Girder System for Alignment-2

Amount in million Tk

Item	Total Cost	Year 1	Year 2	Year 3	Year 4
Total Direct Cost	**64,318**	**12,864**	**19,295**	**19,295**	**12,864**
Physical Contingency	1,930	386	579	579	386
Price Contingency	10,219	772	2,385	3,686	3,376
Total Estimated Construction Cost	**76,467**	**15,293**	**22,940**	**22,940**	**15,293**
PPP related additional costs					
Development Cost (SPV Set up Cost)	60	12	18	18	12
Advisory Fees (Financial Soft Cost)	800				
Supervision and Coordination Charges	40				
Transfer of Technology	76	15	23	23	15
Independent Expert	774	155	232	232	155
Total PPP based Construction Cost	**78,218**	**15,644**	**23,465**	**23,465**	**15,644**
Interest during construction	4,693				
Contractor's head office overhead & profit	7,822	1,564	2,347	2,347	1,564
Total Bidder's Capital Cost in million Tk.	**90,733**	**15,644**	**23,465**	**23,465**	**15,644**
Total Bidder's Capital Cost in million USD	**1,106**	**191**	**286**	**286**	**191**
Per km Capital cost in million Tk.	**2,138**				
Per km Capital cost in million USD	**26**				
Government's Equity					
Duties and Taxes	5,084	1,017	1,525	1,525	1,017
Land acquisition and rehabilitation	37,463	37,463	-	-	-
Utility relocations	2,000	2,000	-	-	-
Viability Gap Funding (VGF) – max. 30%	27,220	-	9,073	9,073	9,073
Total Equity	**71,767**	44	% of Total Project Cost		
Total Estimated Project Cost in million Tk	**162,500**				
Total Estimated Project Cost in million USD	**1,982**				

Note: 1 USD = 82 Tk.
Total Length of 4-lane Equivalent Expressway = 42.44 km

Table 15.10: Total Capital and Project Costs of Box-Girder System for Alignment-2

Amount in million Tk

Item	Total Cost	Year 1	Year 2	Year 3	Year 4
Total Direct Cost	**71,862**	**14,372**	**21,559**	**21,559**	**14,372**
Physical Contingency	2,156	431	647	647	431
Price Contingency	11,418	862	2,665	4,118	3,772
Total Estimated Construction Cost	**85,436**	**17,087**	**25,631**	**25,631**	**17,087**
PPP related additional costs					
Development Cost (SPV Set up Cost)	60	12	18	18	12
Advisory Fees (Financial Soft Cost)	800				
Supervision and Coordination Charges	40				
Transfer of Technology	85	17	26	26	17
Independent Expert	864	173	259	259	173
Total PPP based Construction Cost	**87,285**	**17,457**	**26,186**	**26,186**	**17,457**
Interest during construction	5,237				
Contractor's head office overhead & profit	8,729	1,746	2,619	2,619	1,746
Total Bidder's Capital Cost in million Tk.	**101,251**	**17,457**	**26,186**	**26,186**	**17,457**
Total Bidder's Capital Cost in million USD	**1,235**	**213**	**319**	**319**	**213**
Per km Capital cost in million Tk.	**2,373**				
Per km Capital cost in million USD	**29**				
Government's Equity					
Duties and Taxes	5,674	1,135	1,702	1,702	1,135
Land acquisition and rehabilitation	37,463	37,463	-	-	-
Utility relocations	2,000	2,000	-	-	-
Viability Gap Funding (VGF) – max. 30%	30,375	-	10,125	10,125	10,125
Total Equity	**75,512**	43	% of Total Project Cost		
Total Estimated Project Cost in million Tk	**176,763**				
Total Estimated Project Cost in million USD	**2,156**				

Note: 1 USD = 82 Tk.
Total Length of 4-lane Equivalent Expressway = 42.67 km

Section 16

PROJECT VIABILITY

16.1 Benefits of the Project

The primary benefits of any improvements in an existing transportation system or a new transportation infrastructure is the saving of travel time and associated productivity increases. The proposed DAEEP also has travel time saving at the core of its benefits. The travel time savings would accrue to not only the users of the proposed DAEEP, but also to the users of other nearby roads where congestion would be reduced since some traffic will be diverted to the DAEEP. In addition to the travel time savings and associated productivity benefits, there will also be potential savings in fuel cost and possible environmental benefits through reduced pollution due to reduced congestion. The following sections briefly describe the benefits and beneficiaries.

16.1.1 Passenger Travel Time Benefits

The proposed DAEEP alignment follows an existing road link, which forms a part of the most important road link connecting the north-east part of the country to the capital Dhaka and beyond. At present users from around 18 north-western districts use the existing Abdullahpur-Ashulia-Baipayl-Chandra link to enter Dhaka whereas users from a further 5-6 south-western districts use the Abdullahpur-Ashulia-Baipayl-Nabinagar link. There are major traffic bottlenecks at different points of these road links, especially at Baipayl T junction and near Abdullahpur junction, which delays the vehicular traffic carrying passengers by a significant amount. Other major bottlenecks as identified at various locations on the link (see Figure 2.5), further delaying the travel into or out of the capital.

The proposed DAEEP will significantly improve the traffic flow by separating the through traffic from the local traffic and thus reduce the travel time of the passengers entering and exiting Dhaka to the north-eastern and south-eastern districts. The benefits to these users will be further enhanced because of the connectivity of DAEEP with the ongoing DEEP: especially for users traveling to the south-eastern parts of the country will particularly benefit from the seamless transition between DAEEP to DEEP.

In addition to the travel time benefits to the direct users mentioned above, there will also be potentially large benefits to the users on other nearby roads. The primary beneficiary will be the traffic on the Dhaka-Mymensingh road, which inevitably gets delayed at the Ashulia/Abdullahpur junction at present because of the north-east bound traffic. Since the major through traffic to the north-eastern region now will now be grade-separated on the DAEEP, the traffic on the Dhaka-Mymensingh road will not be interrupted and should enjoy significant travel time savings. Similarly, all the local traffic using the existing link roads and nearby regions should benefit because the through traffic will be using the DAEEP. Note that benefits of the DAEEP in reducing the traffic congestion in major parts of Dhaka city (apart from Uttara region and possibly on Pallabi-Farmgate road) will most likely be negligible. All these travel time savings must be verified using proper traffic network models in the feasibility phase before making a conclusion.

16.1.2 Freight Travel Time Benefits

All the freight traffic from north-eastern and south-eastern parts of the country will enjoy the same travel time benefits as the passenger vehicles. Freight, however, requires special mention in the proposed corridor. The Dhaka Export Processing Zone (DEPZ) is located at the Baipayl junction and is a major cause of the traffic congestion at that junction. In addition, there are a large number of industrial establishments along the existing Ashulia-Baipayl-Chandra link. Freight vehicles are particularly trucks, covered vans and semi-trailers are responsible for congestion in the existing route because of their lower travel speed and lower maneuverability. Since the Chittagong port is a major origin or destination of a large share of the freight traffic, the Baipayl-Ashulia-Abdullahpur road is almost inevitably be used by a large share of the freight vehicles on this route. Another major destination (or origin) of the EPZ freight is the Inland Container Terminal at Kamalapur. The proposed DAEEP will reduce the travel time of all these freight vehicles.

The major benefits to the freight traffic, however, go further. At present, the entrance of freight vehicles in Dhaka city is prohibited during 8:00 am to 8:00 pm in order to reduce congestion within the city. Since the freight vehicles must enter Dhaka city to go to Chittagong (or any south-eastern destination) these vehicles can operate only at night. This adds significant idle time in the supply chain, which reduces the industrial productivity and adds to the economic costs. The proposed DAEEP, in combination with DEEP, will act as a grade-separated bypass to Dhaka city for this large volume of freight vehicles. Since these vehicles will not affect the at-grade traffic in Dhaka city, 'through' freight vehicles should be allowed to travel without the time restrictions through DAEEP-DEEP. This should impart large benefit in business and industrial productivity not only to the EPZ businesses but all other businesses in the north-eastern region that requires the use of Chittagong port. Productivity increases will directly lead to economic benefits to the regions that will be able to capture this benefit. The primary benefit of the proposed DAEEP is expected to be the travel time savings in freight traffic, assuming they are allowed during the day through the seamless integration between DAEEP and DEEP.

Note, however, the benefits of day time travel through Dhaka using the DAEEP and DEEP depend on the existing supply chain management and the traffic conditions at other major highway as well. For example, if there remains major traffic bottlenecks at other locations on the highway, businesses may want to move goods only during the night to avoid those bottlenecks. In such cases, the benefits of the DAEEP and DEEP will be much reduced. Also, DAEEP alone or an incomplete DEEP will not be able to generate these benefits and this will adversely affect the project benefit.

16.1.3 Fuel Impacts

Removal of the bottlenecks for the through traffic and reduction of congestion in nearby local roads will encourage a smoother flow of traffic with less acceleration, deceleration and idle times. This would reduce the consumption of fuel by the vehicles and benefit the vehicle owners of all types using the DAEEP and possibly in nearby roads. Ultimately, benefits of fuel saving also positively affect the foreign currency reserves of the country (although at the aggregate level the benefits may not be that large, but again, a thorough study is required to understand the fuel savings benefits). At the moment there is no speed/consumption profile available for vehicles in Bangladesh, and it is not included in the calculations in this study. One important aspect which is often ignored is the extra fuel consumption due to the induced traffic because of the DAEEP. Once this is included, there may not be net fuel savings at all. It is therefore important to conduct a detailed analysis of fuel savings (or not) during the feasibility stage.

16.1.4 Environmental Impacts

A smoother flow of traffic due to reduced congestion can result in reduced emissions from the vehicles operating on the DAEEP and nearby local roads. Emissions from vehicles have many harmful effects on human health and agricultural productivity, and lower emission will therefore improve the air quality and reduce air quality related health hazards. These health benefits will primarily accrue to the population in the nearby region. However, similar to fuel benefits, the impact of induced traffic should be considered during the feasibility stage.

The impact of the DAEEP on noise reduction is not clear at the moment. There is a possibility of some reduction at the ground level since much of the traffic can be diverted to the DAEEP. However, vehicles on DAEEP will be driving at a higher speed, generating more noise. Qualitatively, it is possible that the noise characteristics will remain unchanged, as the noise of honking of vehicles may govern instead of the noise generated by running vehicles.

16.1.5 Potential Synergy Effects

The area near Baipayl junction already has developed into an unorganized industrial zone supporting a significant number of non-EPZ industries. The productivity benefit that the DAEEP will offer to this region will likely further enhance the concentration of industries in this region and may possibly encourage industrialization up to the High-Tech park in Kaliakoir. Such changes in land use patterns, if implemented in an unplanned manner – as it is now – may have an adverse impact. However, a proper landuse plan in the region accompanying the DAEEP project can have a synergistic effect in spurring further economic growth in the region. The synergies should be quantitatively modeled in the feasibility stage.

16.2 Costs of the project

The major cost elements of the proposed DAEEP are the road tolls, project construction, operations and maintenance costs, land acquisition costs and/or resettlement costs (if any). Under a potential PPP project for DAEEP, the project construction costs will accrue to the project implementation entity. If the same project management practices as DEE are followed, then the land acquisition and resettlement costs will accrue to the Government of Bangladesh. Construction and land acquisition and/or settlement costs are lump-sum in nature.

Road tolls will be paid by the individual users of the DAEEP. The local traffic will not bear any of the costs, although will gain from increased vehicle speed in local roads. Operations and maintenance costs will accrue to the project operators/concessionaire if done on a PPP basis, or to the government if done on government procurement. All of these cost elements are recurring in nature, i.e. they will occur every year.

There is a potential for some environmental costs as well. Ashulia-Baipayl area already has a large industrial concentration which could increase due the improved productivity offered by the DAEEP, and thus increase industrial emissions and affect the local air and water quality and other associated industrial pollution. Unplanned growth in the region may also have other adverse effects resulting in economic costs to the society. In the pre-feasibility only the construction (including contractors profit share, if done on PPP basis) and resettlement costs are considered, but these wider issues should be considered in further detail in the feasibility study.

16.3 Alternative Scenarios

As mentioned earlier in the report (Section 5.3), in the pre-feasibility stage, five possible alternatives are considered. These are:

1. Scenario 1 – No Change
2. Scenario 2 – Alternative 1: elevated expressway along existing route
3. Scenario 3 – Widening of existing route
4. Scenario 4 – Alternative 1 + Widening
5. Scenario 5 – Alternative 2: elevated expressway along existing route via Savar

Brief descriptions of the scenarios are as follows:

Scenario 1 – This is the no change scenario that is evaluated for the future years with no augmentation of capacity in the proposed alignment. But the forecasted change of landuse, population, traffic and other socio economic factors will be the same as that is considered in the other scenarios. Evaluation of this scenario is important to get the amount of potential benefit that may arise from constructing any facility over this alignment.

Scenario 2 – It will follow the alignment of existing roadway from Abdullahpur to Chandra and Nabinagar through Baipayl with a bifurcated T-shaped alignment. The connectivity of the expressway from Abdullahpur to the existing Dhaka Elevated Expressway project will be ensured by four interchanges and five entry-exit facilities.

Scenario 3 – This scenario evaluates the proposed road widening of the existing N302 (Abdullahpur – Baipayl) and R505 (Nabinagar – Chandra). Currently both of the roads are undivided two lane two way highways with a little access control from the surrounding region.

Scenario 3 will involve widening of the proposed road alignment to four lane divided highway with controlled access from the surrounding facilities. For modeling, this scenario has been evaluated separately considering the growth of other demographic and socio-economic factors as forecasted.

Scenario 4 – Evaluation of this scenario involves improvements proposed in both scenarios 2 and 3. This requires widening of the at-grade roadway and construction of expressway following alternative alignment-1.

Scenario 5 – Scenario 5 includes a grade separated expressway over alternative alignment 2. This alignment mainly follows the same path from the airport to Abdullahpur as alternative alignment 1. But directly connects Abdullahpur with Ashulia through Uttara 3rd phase project and then goes through Savar BPATC. Ultimately this alignment connects Nabinagar following N5 and reaches to Chandra through Baipayl following the existing alignment of R 505. Accordingly, due to connecting Savar upazila, which is urbanizing and industrializing rapidly, this alternative would serve more catchment areas than alternative 1.

Section 17

ECONOMIC BENEFITS MODELING

17.1 Benefit Items Considered

For the prefeasibility phase, *only* passenger and freight travel time savings benefits are considered as these are the primary transportation benefits. While fuel saving and environmental benefits can be significant, both depends on extensive speed-fuel consumption or fuel-emissions relationships which is not available for Bangladesh. Also, both of these items may result in costs to the economy, especially if the induced traffic impact is considered. Also potential synergy effects in terms of productivity increase, logistics and supply chain effects have not been considered as well. All of these items should be considered in the detailed feasibility study.

Passenger travel time savings were modeled using CUBE, as described earlier. Freight travel times were calculated in a similar fashion as well. However, the freight travel time saving can be significantly larger than the model predictions, since the model has been calibrated using current conditions, where freight traffic into Dhaka during the day is minimal because of the restrictions on truck entry. As discussed earlier, once DAEEP is complete, there is a potential to lift the ban for through traffic, and this freight traffic will save significantly more time. Based on the feedback from shippers and truckers, we assume an average 180 min travel time saving for freight traffic during peak periods, 90 minutes for off-peak and 0 minutes for super off peak traffic over the model predicted travel time savings to allow for the possibility of day time travel.

17.2 Economic Benefits and Consumer Surplus

During the economic benefits modeling, it is very important to differentiate between diverted and induced traffic. Diverted traffic refers to those vehicles which are diverted from existing roadways to the proposed DAEE. Induced traffic is the additional traffic generated because of the DAEE, which would not otherwise have occurred. Induced traffic can be a very important source in the current case, since the project is expected to spur a growth near Nabinagar and Chandra region which would be quickly connected to the central city through the DAEE.

Note that the diverted traffic reaps the full benefit of travel time savings due to the new project. For the induced traffic, the economic benefit is only half of the total traffic time savings. This can be explained through the traditional definition of consumer surplus in Figure 17.1. AB represents a simple travel (traffic) demand curve, which depicts that traffic increases with reduced travel time (ideally, reduced generalized travel costs). If there were no DAEE, travel demand, or traffic on road, would be OP = FC, representing point C on the demand curve. If travel time is reduced from F to G due to construction of the DAEE, new equilibrium demand is OQ=GE. Of these, OP represents the original or diverted traffic, whereas PQ represents induced traffic. Increase in consumer surplus, which represents the economic benefits of the project, is the trapezoid FCEDGF. Clearly, this area consists of the total travel time savings of the diverted traffic (FCDGF) and half of total travel time savings of induced traffic (CDEHC).

An alternate scenario is also run assuming the same travel time saving for all vehicles without distinguishing between diverted and induced traffic.

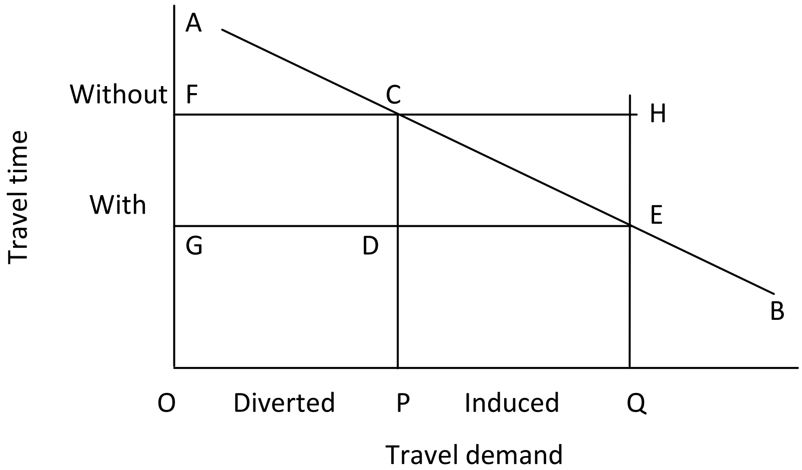


Figure 17.1: Consumer surplus due to transport projects

17.3 Cost-Benefits and Procurement Methods

The net present value (NPV) of a project considers both economic benefits and the economic costs of the project:

NPV = net road user benefits – net resource costs

The economic benefits of the tolled expressways such the GBB2E can vary depending on the project procurement methods. For example, if the project is procured and funded by the government, and the government collects the tolls, toll revenues are simply a transfer payment between the road users and the government (which is the producer here). In such cases, the economic benefits of the project are directly the road user benefits, expressed by the consumer surplus.

NPV = (road user benefits – tolls) + (tolls – construction costs – recurring costs)

The first half is the net consumer surplus, while the second half is the net producer (government's) surplus. Rearranging,

NPV = road user benefits – (construction costs + recurring costs)

The road user benefits are the trapezoidal area FCEDGF in Fig. 17.1 above.

On the other hand if the project is procured by the private sector, which keeps the toll revenue to itself, net present value by,

NPV = (road user benefits – tolls) – (construction costs + recurring costs – tolls) – viability gap fund

Under private procurement, in projects such as these, it is possible that the project may not financially be viable for the private contractor/operator. Therefore the government has to step in by providing additional viability gap funding (VGF) to the operator. Since the VGF aims to offset any negative producer surplus, it is expected that the net of producer surplus and VGF will be zero. This leaves the NPV of the project under private procurement to be

NPV = road user benefits – tolls

This is equal to the trapezoidal area FCEDGF in Figure 17.1 less the total toll revenue.

In this section only the economic benefit-cost under government procurement and net consumer surplus are reported. Results for the private level procurement and the attractiveness of the project for a PPP structure is presented in the next section.

17.4 Benefit-Cost Analysis

17.4.1 Cost Elements and Considerations

Table 17.1 briefly summarizes the benefits and costs used for economic benefit-cost modeling for the proposed Dhaka Elevated Expressway Project (DAEEP).

Table 17.1: Cost Elements for Benefits-costs Analysis

Item	Cost/benefit	Temporal characteristics	Comments
Construction and resettlement	Cost	Lump sum	See Section 15 for detail Varied later for sensitivity
Maintenance	Cost	Annual	1% of construction costs Not varied for sensitivity, possible price escalation not considered
Operations	Cost	Annual	10% of toll revenues Varies with toll revenue directly Not varied for sensitivity, possible price escalation not considered
Toll revenue	No effect for govt. procurement Cost for user benefit/consumer surplus	Annual	From traffic assignment model Varies with toll schedule for sensitivity
Time savings	Benefit	Annual	Varies with respect to toll Varied later for sensitivity

17.4.2 Key Assumptions

- Real discount rate of 10 percent;
- Price year of 2011;
- Operations are assumed to commence in 2015;
- All benefit and cost rates are constant in real terms;
- Project life or concession period 25 years;
- No residual asset values at the end of the concession

For both economic and financial evaluation, the discount plays an important role in determining the net present worth of a project. For economic evaluation, the social discount rate for baseline scenario was 10%. For financial evaluation, cost of capital was assumed 10%, which is derived from DEE value of 10.12%. A sensitivity analysis was also carried out later for both types of evaluation using higher and lower discount rates.

17.4.3 Value of travel time savings

As mentioned above in Figure 17.1, trapezoid FCEDGF represents the economic benefit accruing to the road users (both the users of DAEE and the users of at grade roads, where travel speed will improve). Travel time savings and diverted and induced traffic are determined from travel speed considerations and traffic forecasts in Section 8. The value of travel time (VOT) has been escalated at a rate of 80% of the capita GDP growth over those used in AECOM's Strategic Level Cost-Benefit Report for the DEE, which in turn hinges on Roads and Highways information. VOT for different vehicles are different and are presented in Table 17.2.

Table 17.2: Value of travel time used for different vehicle categories

Year	Heavy truck	Truck	Bus	Minibus	Car	Motor cycle	Baby taxi
2010	80.0	52.0	750.0	400.0	145.0	32.0	91.0
2020	127.9	83.1	1198.6	639.3	231.7	51.1	145.4
2030	204.3	132.8	1915.5	1021.6	370.3	81.7	232.4

Vehicle travel time savings have been modeled using CUBE, as described earlier in traffic modeling section.

17.4.4 Toll structure

Use of a reduced form traffic model means toll structure was difficult to model than the travel time savings. There are various toll strategies possible, as described in Table 17.3.

Table 17.3: Toll Strategies

Strategy	Description	Comments
Full distance	Maximum toll regardless of point of entry, toll collected at entry	Requires toll plaza at each entry point, requires verification of exit
Average distance	Toll based on average distance from entry point, toll collected at entry	Requires toll plaza at each entry point, does not require verification at exit
Flag fall modified	Full toll at end points, half toll rate at intermediate points	Requires toll plaza at entry and exit of end points only. Half toll for those entering and exiting within intermediate points

At this prefeasibility stage only Flag fall modified toll strategy was considered. The base toll for different points within the expressway is presented in Table 17.4. The toll is increased every year reflecting the increase in GDP, but not directly linked with GDP for sensitivity analysis cases. Toll multipliers for other vehicle types are given in Table 17.5. In addition, the base toll rate has been increased over the years to reflect the growth in GDP, and increased travel time benefits. However, toll growth rate is not directly linked to GDP growth rates or travel time savings. Alternate toll strategy must be explored in detail during the feasibility stage. The growth rate in this study is given in Table 17.6. Toll rates are used only for the chosen alternative, and toll revenue for alternate alignments (especially alignment 2) should be conducted during the feasibility phase.

Table 17.4: Toll Structure (in Tk.)

	A	B	C	D	E	F	G	H
A	0	50	50	50	50	50	100	100
B	50	0	50	50	50	50	100	100
C	50	50	0	50	50	50	100	100
D	50	50	50	0	50	50	50	100
E	50	50	50	50	0	50	50	50
F	50	50	50	50	50	0	50	50
G	100	100	100	50	50	50	0	50
H	100	100	100	100	50	50	50	0

Where:

Ramp Location	Alignment 1	Alignment 2
A	Chandra	Chandra
B	Zirani	Zirani
C	Baipail	Baipail
D	Nabinagar	Nabinagar
E	Zirabo	BPATC, Savar
F	Ashulia Beribadh	Ashulia Beribadh
G	Abdullahpur	Abdullahpur
H	from DEE	from DEE

Table 17.5: Toll multiplier used for other vehicle types

Heavy truck	Truck	Bus	Minibus	Car	Motor cycle	Baby taxi
1.5	1.5	3.0	3.0	1.0	0.5	0.5

Table 17.6: Temporal growth rate of base toll rate

Year	Base toll growth rate
2011-2015	6.40%
2015- 2020	5.50%
2020- 2025	5.30%
2025- end	5.20%

17.4.5 Benefit-cost Analysis Results

Table 17.7 presents the economic benefit cost for the four possible scenarios. It can be seen that the net benefits are larger for scenarios 4, Alignment-2. This mainly because of the fact that the alignment has the potential to attract freight traffic of both Savar and EPZ areas. Moreover, traffic forecasted data as presented in Section 9, revealed that commuter traffic of Savar suburban area is also would be diverted to this alignment particularly those who are bound for eastern part of central Dhaka and also for the users of Beri-Bandh or embankment road. There are, however, other non-cost constraints of Alignment-2, such as time required for land acquisition and demolition. Option 4, Alignment-2 has relatively large land acquisition associated, which can have large resistance from the affected people and thus adverse political impact. Moreover, since some portions of the Alternative 2 passes through floodplains (i.e., southern bank of Turag River), low-lying areas, agricultural lands and villages, adverse ecological impact are likely to be more significant for Alternative 2 than Alternative 1. While widening existing road has significant economic benefits, in the long run, it would be difficult to maintain speed on highways in Bangladesh because of side-friction, and thus this option has a significant operational constraint. Option 1, elevated expressway along the current Ashulia-Baipayl road alignment is thus economically beneficial. Note that Option 3, the elevated expressway & widening of existing road returns less net benefits as compared to elevated expressway, which appear counter intuitive. The major reason for this is the smaller number of vehicles on the expressway under this option. For all the options, where relevant, the Box-girder is more expensive than the I-girder option.

Table 17.7: Economic cost benefit analysis for 4-options at the baseline scenario

		Whole project NPV (govt. procurement)		Consumer benefits	
		I-Girder	Box-Girder	Travel time saving	Travel time saving - toll
No.	Project Options	NPV (million BDT)	NPV (million BDT)	NPV (million BDT)	NPV (million BDT)
1	Elevated expressway along existing Ashulia-Baipayl road	21,876	9,451	99,939	63,108
2	Widening of Ashulia Baipayl road	15,589	-	26,746	Not applicable
3	Elevated expressway along existing Ashulia-Baipayl road, and widening of at grade road	16,649	7,981	102,150	Not undertaken
4	Elevated expressway along alignment two	35,327	22,864	122,233	Not undertaken

The cumulative NPV for each year for the four alignment options for I-Girder structure is presented in Figure: 17.2.

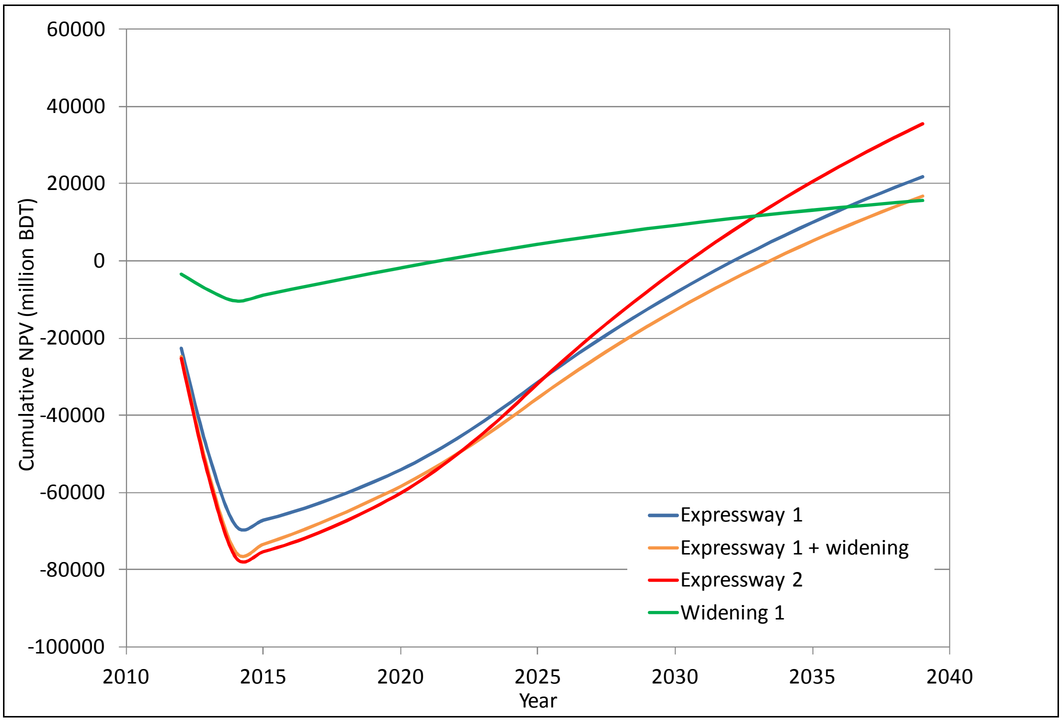


Figure 17.2: Cumulative economic NPV (discounted) for different years for four alternative scenarios

17.5 Sensitivity Analysis

17.5.1 Sensitivity Scenarios

Transportation projects often have large uncertainties associated, since the parameters for the quantitative cost benefit analysis are all based on forecast probabilistic values instead of deterministic values. The uncertainties can arise from any or all of the following sources:

1. Baseline traffic growth in future
2. Future traffic growth with DAEEP
3. Travel speed at grade and on DAEEP
4. Value of travel time (VOT)
5. Vehicle type distribution in the vehicle fleet
6. Toll structure – initial (which can be a decision variable as well)
7. Toll structure - escalation
8. GDP growth in future (which affects both traffic and VOT)
9. Discount rate
10. Project costs
11. Project life
12. Residual value

Instead of running sensitivity analysis for each of these variables for each of the above mentioned alternative road options, benefit-cost analysis were first conducted using the baseline input values for the four alternative options (section 10.5). The best alternative, an elevated expressway along the current Ashulia-Baipayl alignment, is then chosen for further sensitivity analysis to understand the impact of variations in other external factors on project viability.

GDP is the key variable in the sensitivity analysis. GDP has direct impact on vehicle ownership forecasts and thus traffic forecasts in the proposed DAEEP and existing at-grade road. GDP also directly affects the value of travel time, and thus travel times savings due to the proposed project. Sensitivity of the benefit cost results is then carried out for a high and low GDP growth case for the best option found above. It is important to note that as the GDP, value of time and other parameters change, the relative ranking of the feasibility of the options could also change. It is therefore highly recommended that alignment 2 is investigated in depth during the feasibility stage.

In addition to the GDP, the toll rate has also been changed to test the sensitivity of the traffic and resulting economic and financial performance. Toll rate affects the patronage at the elevated expressway by entering the cost function of the users and affects the economic and financial benefits through these fluctuations of patronage. Toll rates also directly affect the financial returns. In addition to the base case toll scenario, two additional rates were considered at 20% higher and 20% lower the baseline rate.

In order to evaluate the uncertainties quantitatively, a sensitivity analysis is run by varying the various parameters above. Table 17.8 presents the parameters related to sensitivity analysis. There are numerous combinations possible if all the input parameters are change simultaneously. Instead, in the scenario analysis, only one input parameter is changed at a time, keeping all other parameters constant at the baseline value. Therefore, joint effect of changing two input parameters at the same time is not modeled in the scenario analysis. The values of the parameters for the sensitivity analysis, and scenario names are presented in the table below. All of these sensitivity analyses are done for both an I-girder and a box-girder type structure.

Table 17.8: Description of scenarios for sensitivity analysis

Sl.	Scenario parameter	Affects	Baseline	Alternate values	Scenario name
1	GDP	Vehicle ownership, traffic patronage, value of time	6% real growth	4.8% growth 7.2% growth	1. GDP low 2. GDP high
2	Toll structure	Traffic patronage, direct financial returns	Car BDT 50	20% smaller tolls 20% larger tolls	3. Toll low 4. Toll high
3	Freight day travel	Travel time for freight	3 hours saving peak, 1.5 hours off peak	switch to day not allowed 5 hour saving peak, 2.5 hour off-peak	5. Day freight no 6. Day freight high
4	Discount rate	Return calculations	10%	8% 12%	7. DR 8 8. DR 12
5	Project costs	Return calculations	Engineering estimates	20% smaller 20% larger	9. Cost low 10. Cost high
6	Residual value	Return calculations	None	20% of initial capital costs	11. Residual yes
7	Travel time saving	Return calculations	Half benefit for induced traffic	Full travel time savings benefit for induced traffic	12. Induced full

17.5.2 Summary Sensitivity Results

Results of the sensitivity of the economic benefit costs analysis are presented in Table 17.9. It can be seen that the social benefits of travel time savings are larger than the project costs as long as the project is procured and funded by the government and tolls are collected by the government, too. Net economic benefit is positive for both I-girder and box girder construction. An I-girder structure costs less and therefore the project return is always better for I-girders than box-girders.

Table 17.9: Economic NPV and consumer benefits of DAEEP under different scenarios, procurement is by the government, or toll is zero

		NPV (million BDT)	NPV (million BDT)	Travel time saving - NPV	Net consumer benefits NPV
No.	Project Scenario	I-Girder	Box-Girder		Travel time saving - toll
	Baseline	21876	9451	99,939	63,108
1	GDP low	1373	(11053)	79,053	46,049
2	GDP high	46701	34276	124,874	86,941
3	Toll low	24951	12526	102,411	71,616
4	Toll high	14782	2357	92,845	51,024
5	Day freight no	(32449)	(44874)	45,614	8,783
6	Day freight high	58093	45667	136,156	99,324
7	DR 8	51896	38823	135,140	85,230
8	DR 12	1566	(10295)	75,333	47,623
9	Cost low	36752	26812	-	-
10	Cost high	7000	(7910)	-	-
11	Residual yes	22,922	10671	-	-
12	Induced full	22,894	10,469	100,957	64,126

The proposed project is sensitive to future GDP growth rates. A low GDP growth rate reduces the net benefits so much that the NPV for Box-girder construction becomes significantly negative, and I-girder just positive. A high toll reduced economic benefits, which is due to the switch of the marginal vehicles to the free at-grade road. As expected, net benefits increase significantly if the construction costs can be kept below the baseline case, but inclusion of residual value at the end of project life, does not increase the benefits significantly. Impact of discount rates are as expected – lower discount rates enhance the projects benefits. Moreover, economic internal rate of return (EIRR) is appeared to be nearly 10 to 12%.

Travel time savings accruing to the freight traffic is a critical parameter in the benefit-cost analysis. If trucks are not allowed on the DAEEP during day time, freight travel time savings will be negligible, and as such the project's economic return will be significantly negative. In fact, this is the only time when the project benefits are negative for an I-girder construction. It is therefore vital for the project to ensure no diurnal restrictions on truck travel on the expressway.

Net benefits of the project will be significantly reduced if it is procured through the private sector and tolls collected by them as is presented in the Net consumer surplus column. Detail benefit/cost flow over the projects 25 year life is presented in charts in the next few subsections.

17.5.3 Impact of GDP on economic NPV (government procurement)

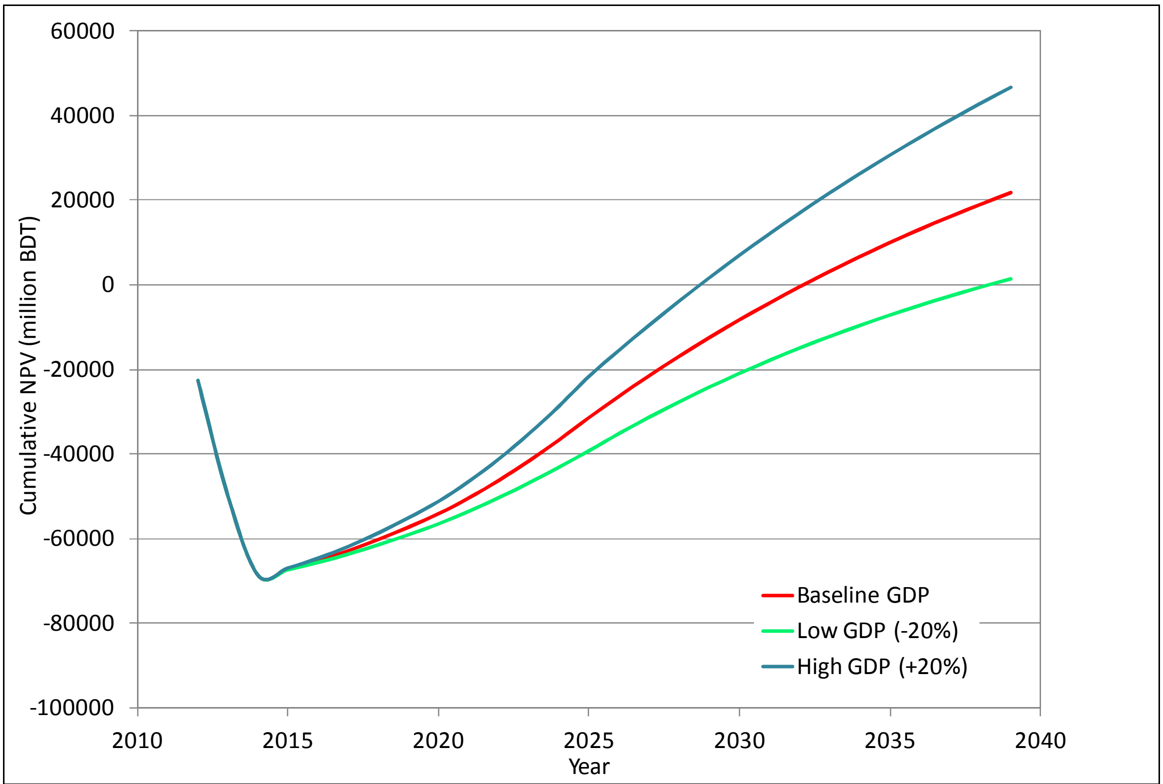


Figure 17.3: Impact of alternative GDP assumptions on cumulative economic NPV (discount) for I-Girder structure for Expressway Alignment 1

17.5.4 Impact of Toll structure on economic NPV (government procurement)

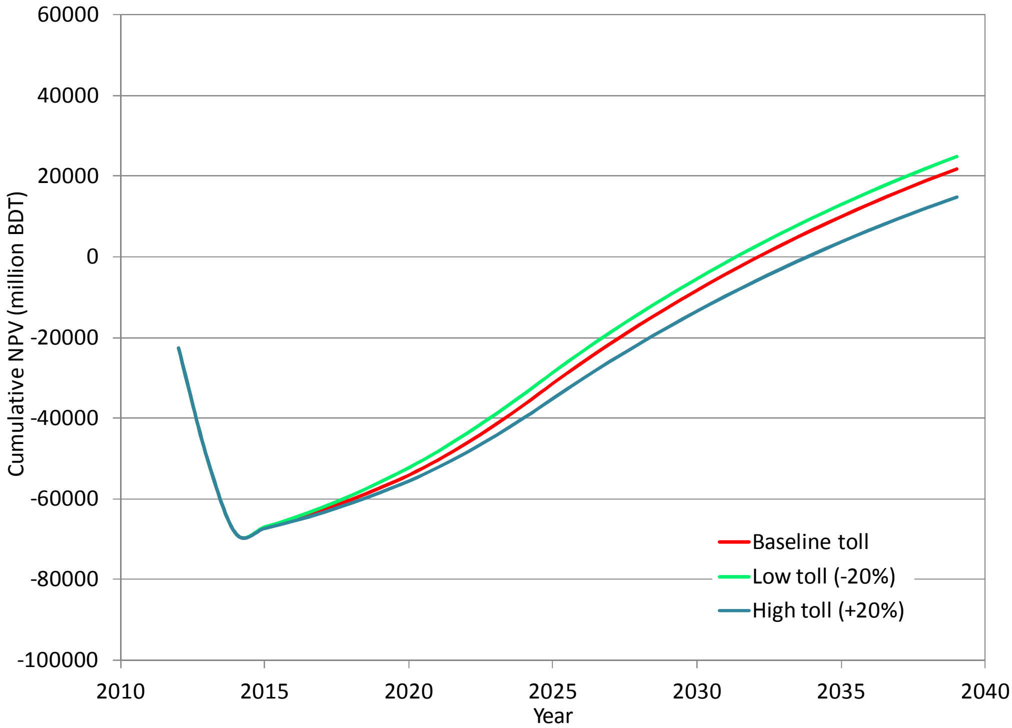


Figure 17.4: Impact of alternative toll assumptions on cumulative economic NPV (discount) for I-Girder structure for Expressway Alignment 1

17.5.5 Impact of freight travel during the day on economic NPV (government procurement)

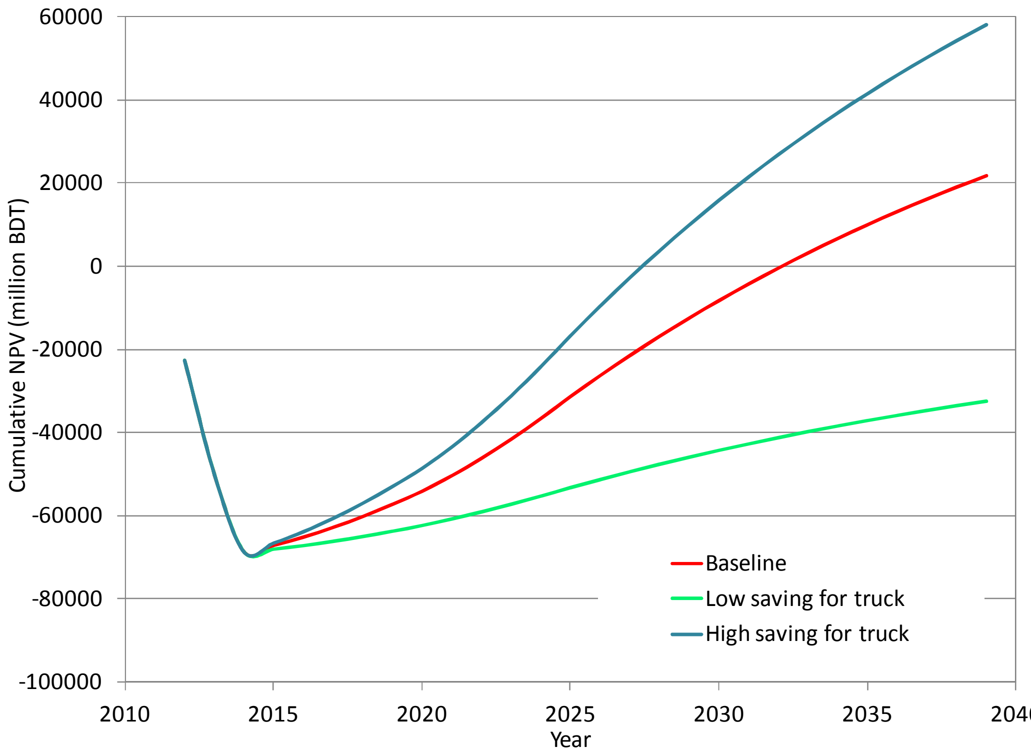


Figure 17.5: Impact of alternative freight travel time saving assumptions on cumulative economic NPV (discount) for I-Girder structure for Expressway Alignment 1

17.5.6 Impact of discount rate on economic NPV (government procurement)

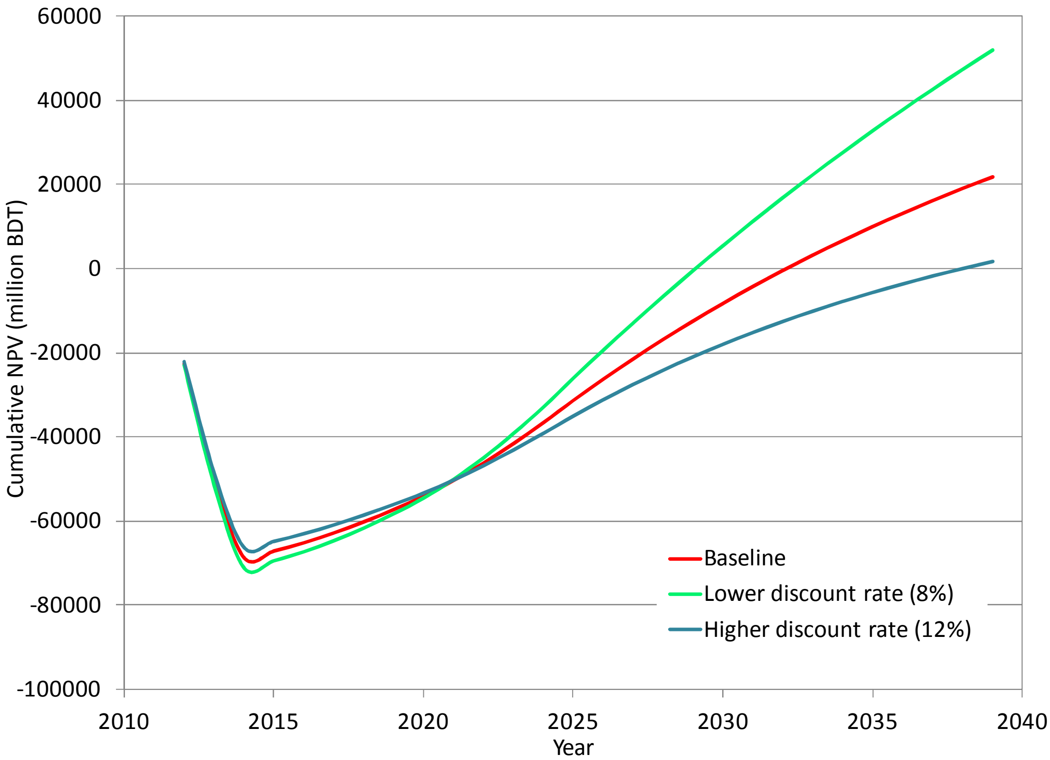


Figure 17.6: Impact of discount rate on cumulative economic NPV (discount) for I-Girder structure for Expressway Alignment 1

17.5.7 Impact of costs on economic NPV (government procurement)

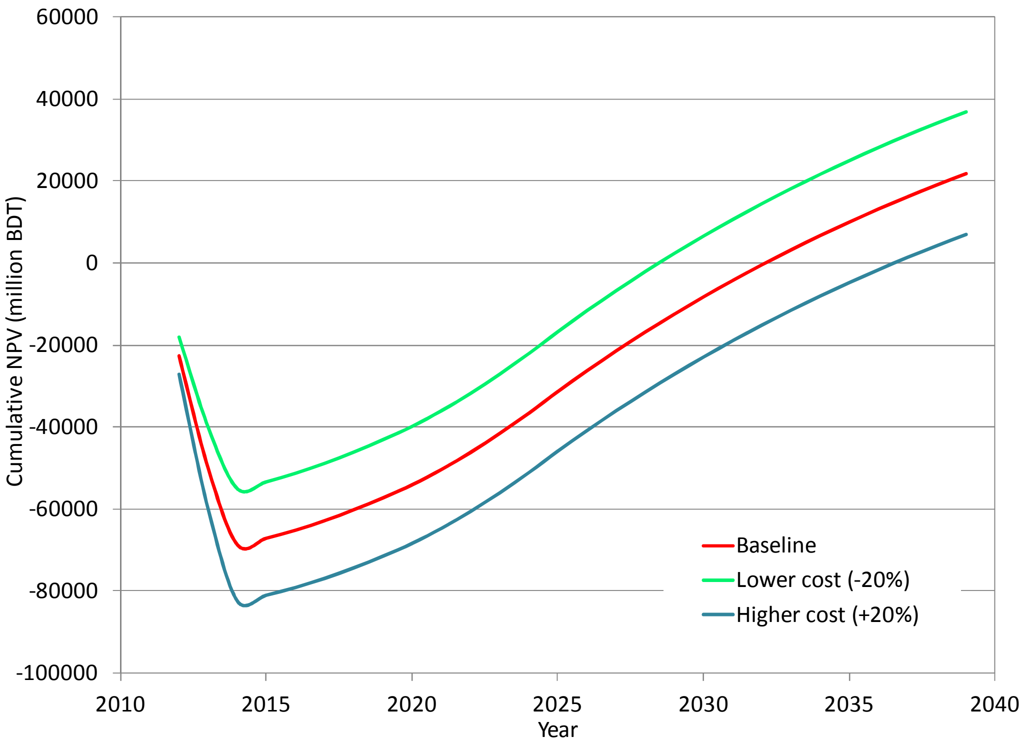


Figure 17.7: Impact of alternative cost assumptions on cumulative economic NPV (discount) for I-Girder structure for Expressway Alignment 1

17.5.8 Impact of different travel time savings due to induced on economic NPV (government procurement)

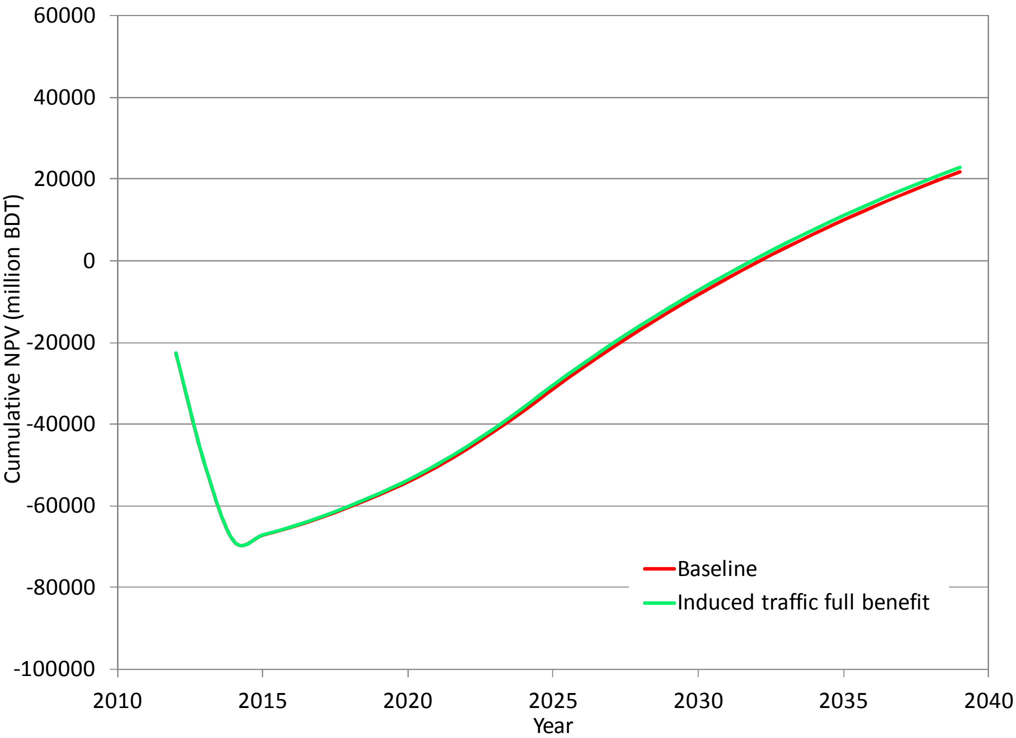


Figure 17.8: Impact of alternative travel time saving assumption for induced traffic on cumulative economic NPV (discount) for I-Girder structure for Expressway Alignment 1

17.5.9 Impact of GDP on net consumer surplus

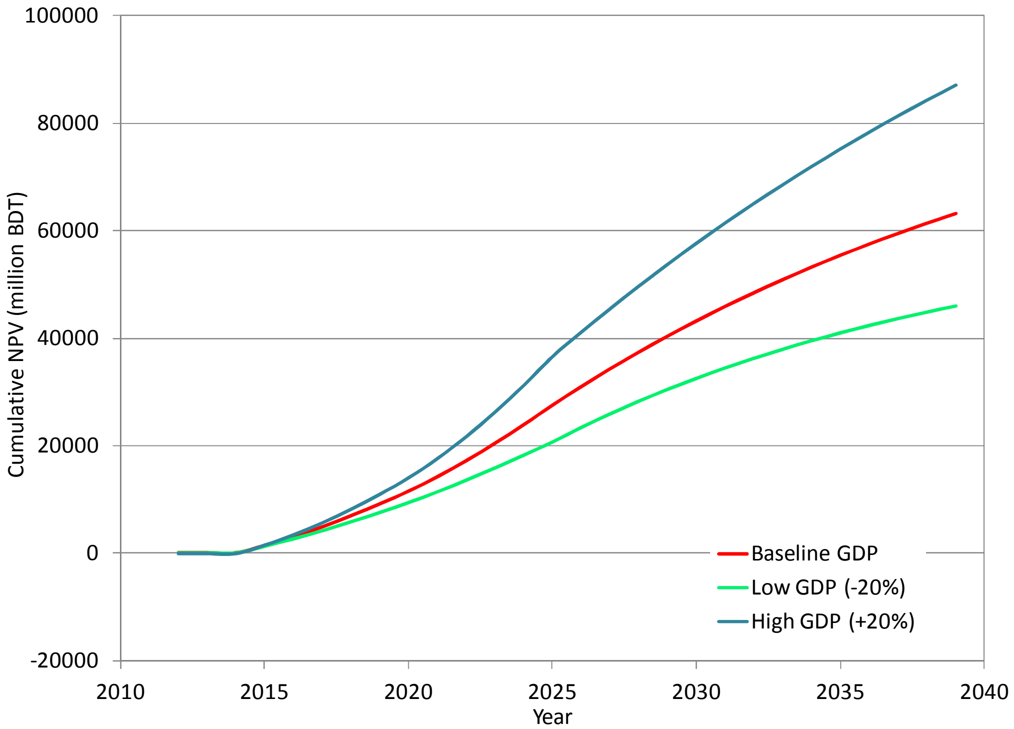


Figure 17.9: Impact of alternative GDP assumptions on cumulative net consumer surplus (discount) for I-Girder structure for Expressway Alignment 1

17.5.10 Impact of Toll structure on net consumer surplus

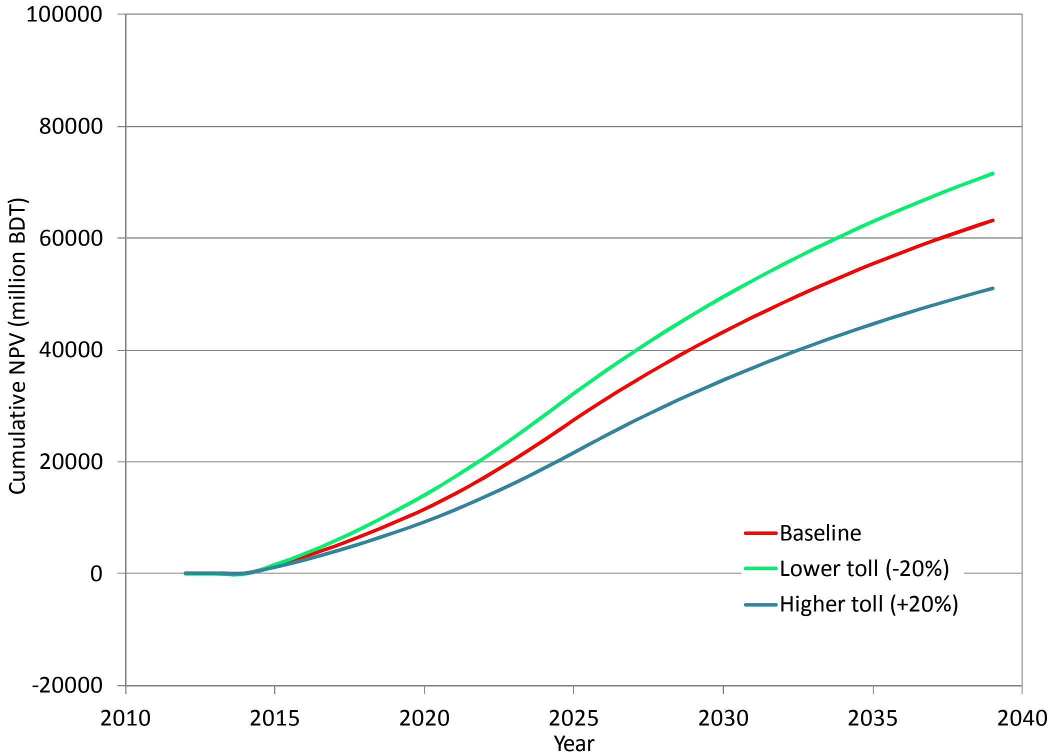


Figure 17.10: Impact of alternative toll assumptions on cumulative net consumer surplus (discount) for I-Girder structure for Expressway Alignment 1

17.5.11 Impact of freight travel during the day on net consumer surplus

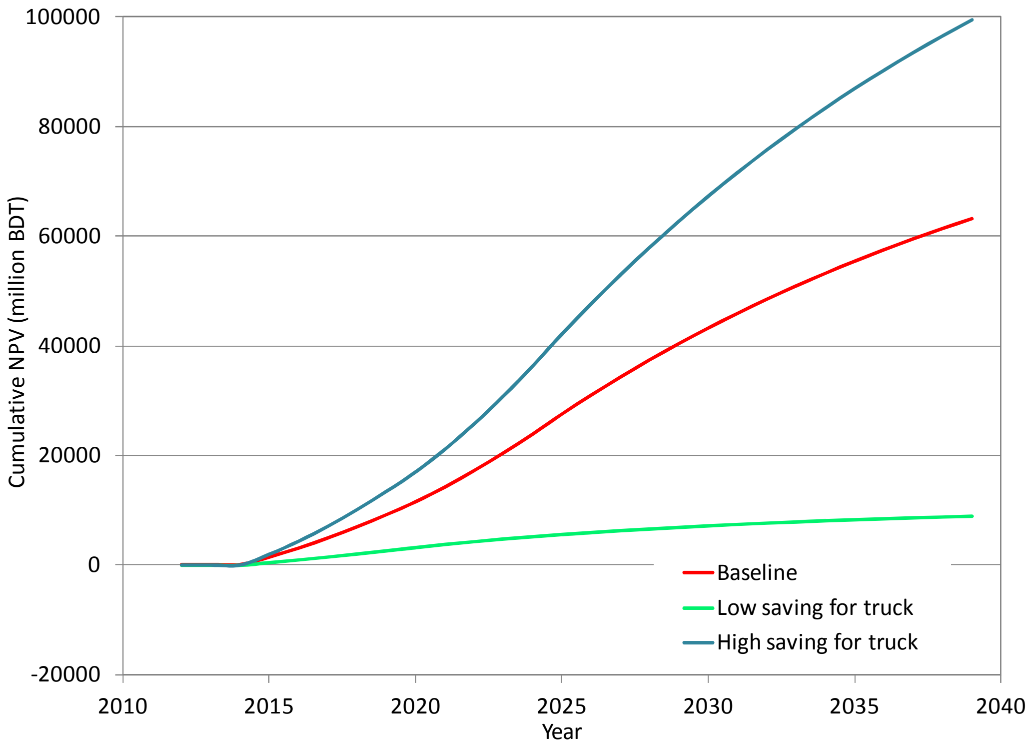


Figure 17.11: Impact of alternative freight travel time saving assumptions on cumulative net consumer surplus (discount) for I-Girder structure for Expressway Alignment 1

17.6 Summary Economic Benefits

The economic NPV analysis shows that the elevated expressway along Alignment-2 is the most viable option, although it is difficult for practical reasons (e.g. land acquisition and associated delay and discontent). The Alignment-2 it has the potential to attract more freight traffic than that of Alternative alignment-1 it would connect Savar area. The next best alternative is the elevated expressway for alignment 1, along the existing Ashulia-Baipayl road. The project offers large economic benefits if procured under the government, resulting from large travel time savings. One *key* concern about the project is the integration with DEE and resulting allowance of freight trucks to travel through the expressway during the day. Since freight travel benefits are the major benefit of the project, if day travel is not allowed or DEE is not connected to Dhaka-Chittagong highway directly, then a large share of the benefits will not be realized. It has been unofficially reported that the DEE alignment may undergo further change and may not connect Dhaka-Chittagong highway directly. In such circumstance, the project will not be viable from a social and economic perspective. It is therefore important that such integration is considered not only for DAEEP but also for DEE. This economic analysis during the pre-feasibility study reveals that the project could be feasible and requires a detailed feasibility study. However, present economic analysis shows that EIRR is appeared to be nearly 10 to 12%.

Section 18

PROJECT ATTRACTIVENESS FOR PPP/FINANCIAL VIABILITY

18.1 Introduction

Under a potential public-private-partnership (PPP) arrangement for the construction and operation of the Dhaka Ashulia Elevated Expressway Project (DAEEP), the primary benefit of the concessionaire will be the tolls from the users of the expressway. Advertisement along the expressway could also be a source of some revenue. As revenue from toll fees is the prime source of income for the concessionaire, it must demonstrate a profit potential in order to attract private investment. Considering the fact that due to suburban nature of the project, most of the expressway users are long hauled and through, which definitely implies that the expressway capacity in terms of transactions is comparatively low particularly as compared to the Dhaka Elevated Expressway Project (DEEP) which covers mostly the urban area with high per km density of entry-exit facilities. Moreover, due to suburban nature of the project it is most likely that during lean period like at late night freight traffic would not use the facility due to availability of at grade free road. As such, the financial benefits of the project to the concessionaire will most likely be smaller than the wider economic benefits mentioned in the earlier section. In this regard, the Viability Gap Fund (VGP) from the Government, reserved for PPP projects can be useful to the concessionaire for the project to become financially profitable, even while keeping the toll structure affordable to the users. Note that the project attractiveness from the private entrepreneur's perspective is represented as the financial NPV, and this is actually the producers surplus as described in Section 17.3. Basically, fore critical elements that determine the financial viability of the project are traffic volume, toll fess, concession period and capital cost. Along the capital cost, the O & M cost comprising routine annual maintenance, periodic maintenance, operational cost (staff, utility bills, insurance etc.) will be borne by the concessionaire during the operation period of the project. The concessionaire has to recover the capital cost and O & M cost from the prime revenue source of toll fees.

The financial viability of the project, and thus its attractiveness significantly depends on the number of users and toll structure during the concession period. There is a delicate balance between toll structure and revenue. If the toll is low, then the number of users will be high, while less vehicles will use the tolled DAEEP if the toll is high. Since vehicle speed on the expressway is a function of volume, the travel time will also change depending on the toll structure. There are two approaches to quantitatively ascertain the effect of tolls on vehicle patronage: the first is to use the elasticity of traffic with respect to generalized travel costs; while the second is to generate willingness to pay estimates directly through stated preference surveys. Unfortunately, estimates for the elasticity of traffic is not available for Bangladesh, or Dhaka, and determining the willingness to pay through stated preference survey is beyond the scope of a pre-feasibility study. The CUBE model used in the earlier analysis of Dhaka Elevated Expressway (DEE) has a built in function to accommodate the elasticity of travel with respect to generalized costs, and that parameter also decides the sensitivity of traffic with respect to the toll structure in this study. The detail toll structure considered in this pre-feasibility stage is described in the previous chapter. The financial analysis is done only for the chosen alternative, Alignment-1, i.e. the elevated expressway along the current Ashulia-Baipayl road.

18.2 Cash flow

During the per-construction and construction period, cash outflow for procurement of material and services will be made through drawdown of fund from both debt and equity. On the other hand, every year during the operation period, a free flow of cash will be generated after deducting from the cash inflows generated, the cash outflows arising from operation and maintenance and debt repayment obligations. For the financial viability of the project, the direct cash flow is more important than monetized benefits, as in economic NPV (where travel time saving was converted to money savings using VOT). The key elements of the financial cost benefit analysis is described in Table 18.1.

Table 18.1: Elements of cost elements for benefits-costs analysis

Item	Cost/benefit	Temporal characteristics	Comments
Construction & resettlement	Cost	Lump sum	See Section 15 for detail Varied later for sensitivity
Maintenance	Cost	Annual	1% of construction costs Not varied for sensitivity, possible price escalation not considered
Operations	Cost	Annual	10% of toll revenues Varies with toll revenue directly Not varied for sensitivity, possible price escalation not considered
Toll revenue	Benefit	Annual	From traffic assignment model varies with toll schedule for sensitivity

18.3 Financial Analysis Results

Figure 18.1 presents the cumulative net present value of the financial analysis. The project has large negative financial return for the private entity in the baseline scenario. This is not unexpected – in most transportation projects, the major economic benefit is travel time savings, which may not always translate into financial benefits. Moreover, given that the project's net present financial value is negative (without VGF), FIRR is appeared to be only 2 to 3%. As such, it can be said that the project is financially weak due to capital intensive nature of project and require government support as Viability Gap Funding (VGF) to make it bankable and profitable to the private sector. At every abscissa year in Figure 18.1, the ordinates represent the amount of VGF from the government to make the project profitable to the private entity if the concession period is for the period represented by the abscissa. Note that the private entity's profit returns are included within the cost estimates already. So, breaking even is a sufficient goal for financial viability. In this regard, in line with Dhaka Elevated Expressway project, it is suggested that VGF should not be more that thirty percent (30%) of the estimated project cost. The actual amount will be determined by the investor of the winning bidder. Moreover, this VGF will be given in taka only during the construction period and is to be used solely for purchase of local goods and services.

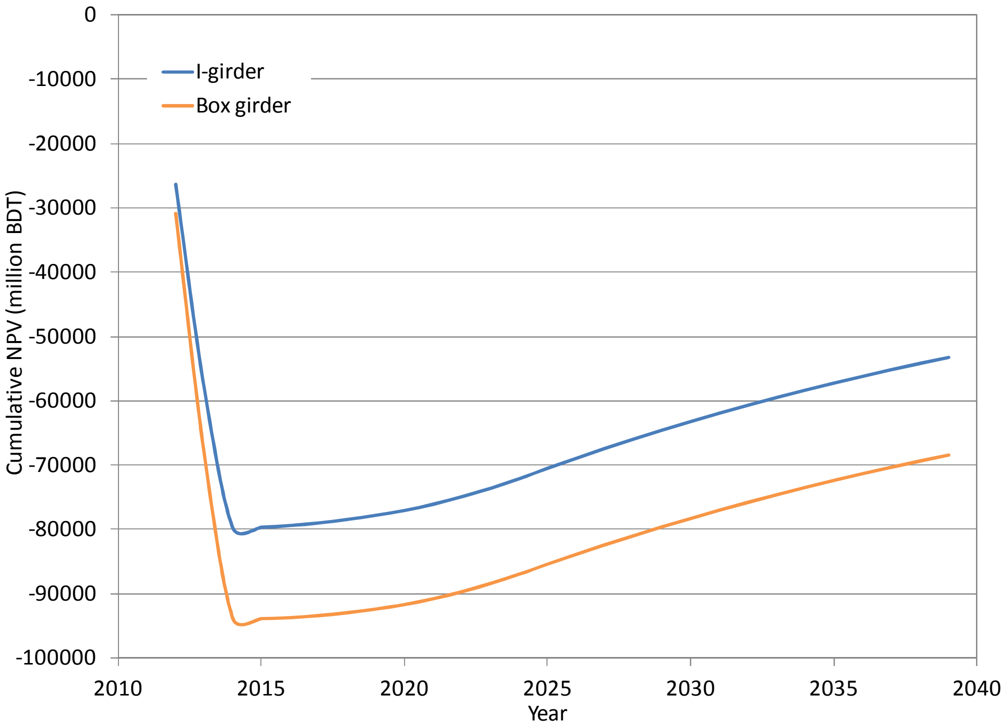


Figure 18.1: Cumulative financial NPV (discounted) for different years for two structure options for Alignment 1

Figure 18.2 presents the discounted cumulative revenue stream arising from the project. It keeps on increasing despite larger discounts at further years, indicating the project will continue to have significant positive revenue benefits beyond 25 years.

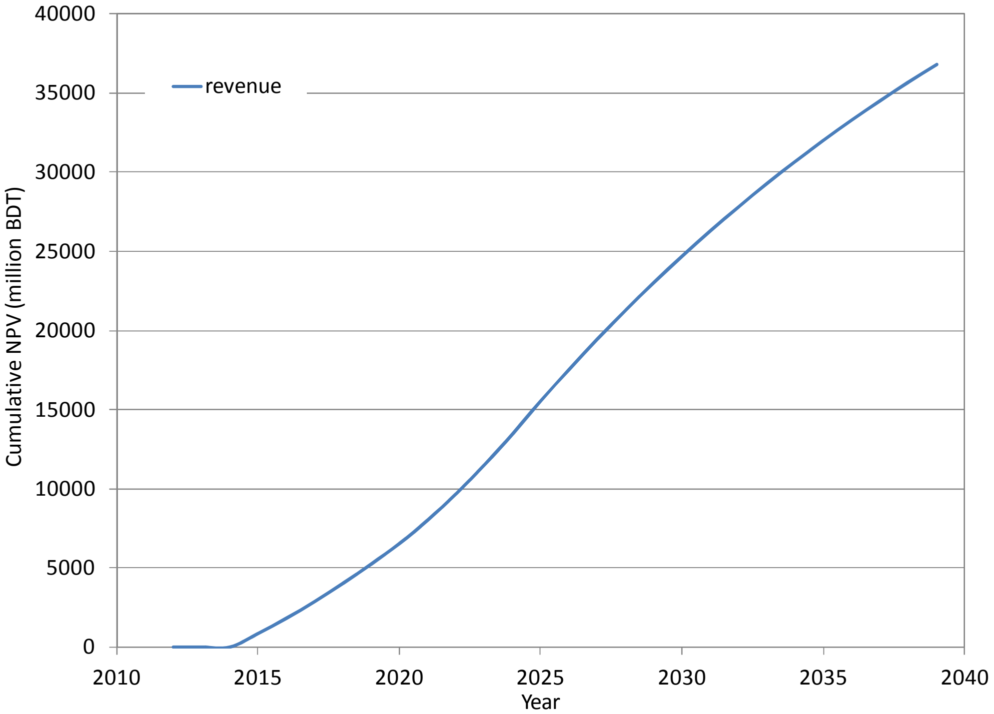


Figure 18.2: Cumulative revenue stream (discounted) for different years for Alignment 1

18.4 Sensitivity Analysis

18.4.1 Sensitivity Scenarios

Following the discussion on Section 17.5.1, Table 18.2 describes the sensitivity scenarios tested for financial analysis of the DAEEP. The sensitivity analysis is carried out to evaluate the impacts on viability and cash flows against expected variations in basic parameters of the project using available information and data. Note that toll structure is an important parameter in determining the financial feasibility of such projects, and there need to be a more detailed analysis of many alternate toll structures in order to get a complete picture of the project. This must be undertaken during the feasibility stage.

Table 18.2: Description of scenarios for sensitivity analysis

Sl.	Scenario parameter	Affects	Baseline	Alternate values	Scenario name
1	GDP	Vehicle ownership, traffic patronage, value of time	6% real growth	4.8% growth 7.2% growth	1. GDP low 2. GDP high
2	Toll structure	Traffic patronage, direct financial returns	Car BDT 50	20% smaller tolls 20% larger tolls	3. Toll low 4. Toll high
3	Discount rate	Return calculations	10%	8% 12%	5. DR 8 6. DR 12
4	Project costs	Return calculations	Engineering estimates	20% smaller 20% larger	7. Cost low 8. Cost high

18.4.2 Sensitivity Results

The financial benefit cost analysis is not as sensitive to the input parameters as the economic benefit cost analysis was. Among the various parameters tested, initial costs have a relatively large impact. GDP's impact is not large (unlike economic NPV) because increases in GDP and thus increases in travel saving did not translate into larger toll directly. Alternate toll structures (e.g. larger than GDP toll escalation, toll escalation linked to value of time savings etc.) can have significant impact on the financial analysis and needs to be undertaken during the feasibility stage. The impact of toll structure in noteworthy. An increase in toll improves the financial performance of the project, but worsens the economic performance and net consumer surplus of the project. I-girder provides a better financial NPV because of its lower initial construction costs.

Table 18.3: Financial NPV of DAEEP under different scenarios

No.	Project Scenario	I-Girder NPV (million BDT)	Box-Girder NPV (million BDT)
	Baseline	-53,229	-68,441
1	GDP low	-56,673	-71,885
2	GDP high	-52,238	-67,450
3	Toll low	-58,662	-73,874
4	Toll high	-48,738	-63,950
5	DR 8	-45,957	-61,961
6	DR 12	-57,509	-72,029
7	Cost low	-35,953	-48,123
8	Cost high	-70,504	-88,759

18.5 Further Sensitivity Results

18.5.1 Impact of GDP on financial NPV

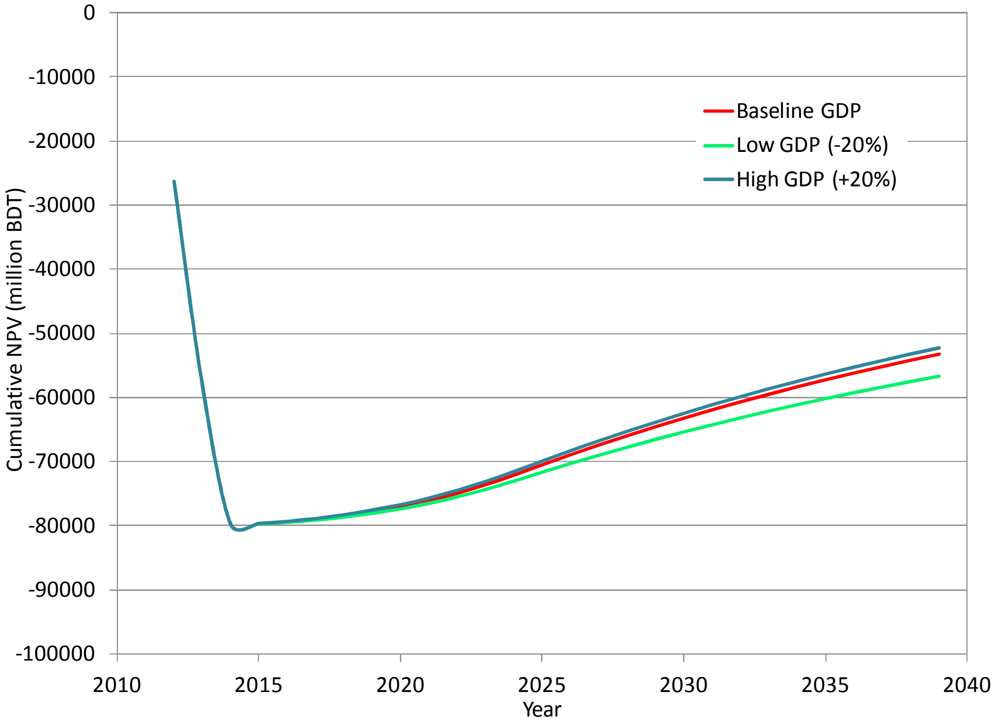


Figure 18.3: Impact of alternative GDP assumptions on cumulative financial NPV (discount) for I-Girder structure for Expressway Alignment-1

18.5.2 Impact of Toll structure on financial NPV

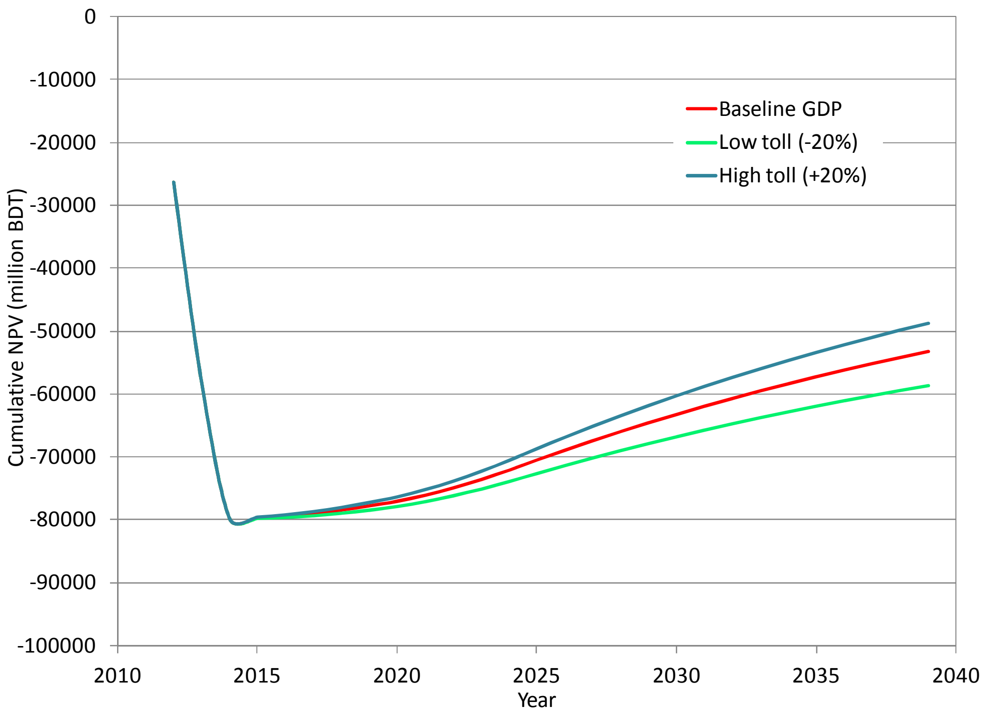


Figure 18.4: Impact of alternative toll assumptions on cumulative financial NPV (discount) for I-Girder structure for Expressway Alignment-1

18.5.3 Impact of discount rate on financial NPV

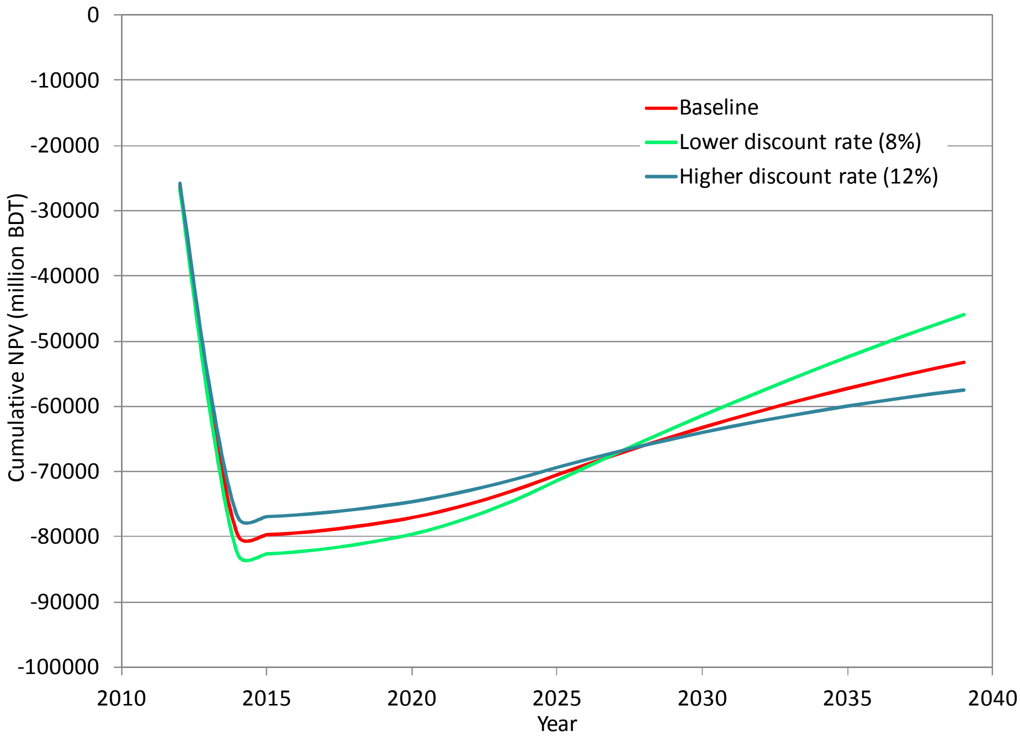


Figure 18.5: Impact of discount rate on cumulative financial NPV (discount) for I-Girder structure for Expressway Alignment-1

18.5.4 Impact of costs on financial NPV

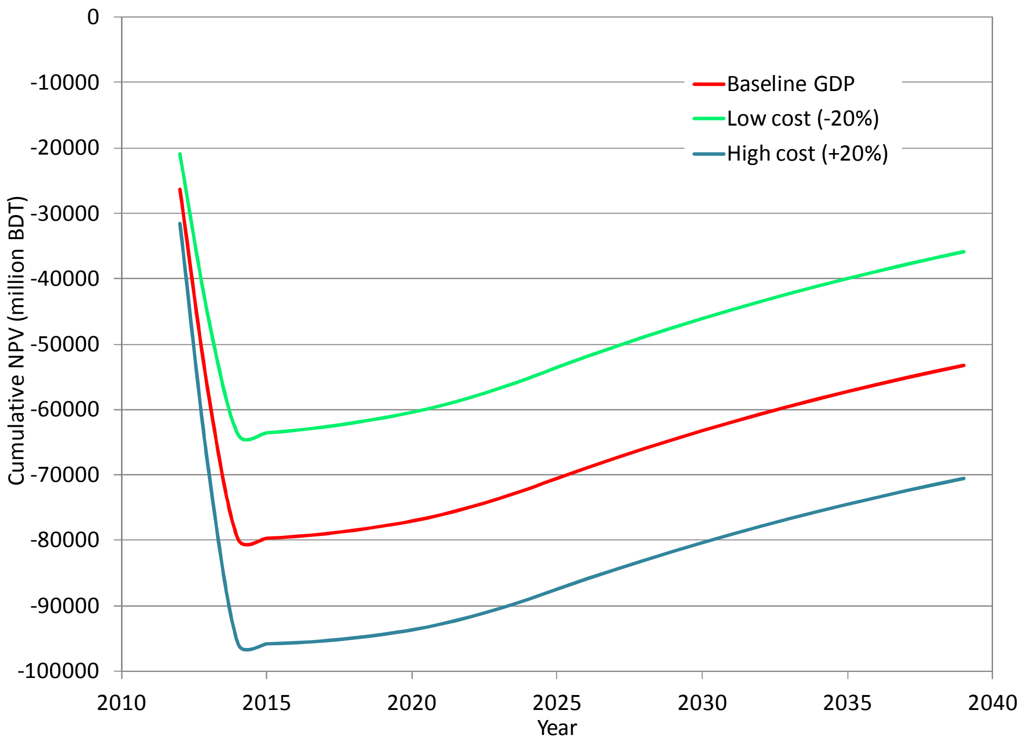


Figure 18.6: Impact of alternative cost assumptions on cumulative financial NPV (discount) for I-Girder structure for Expressway Alignment-1

18.5.5 Impact of Toll structure on revenue

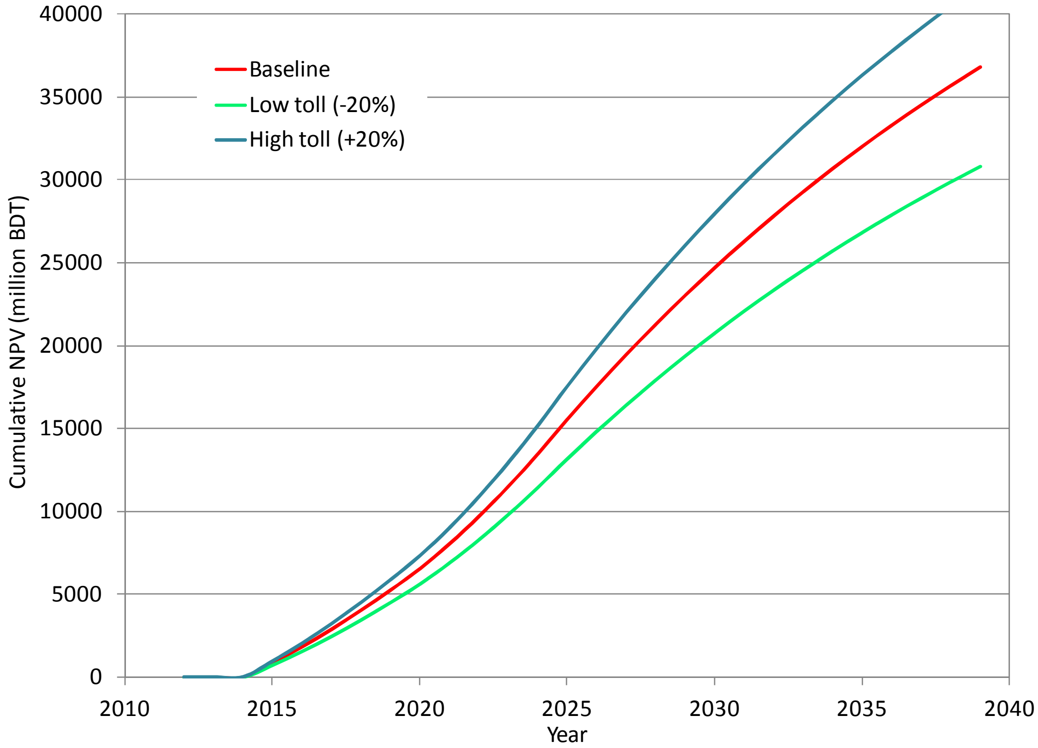


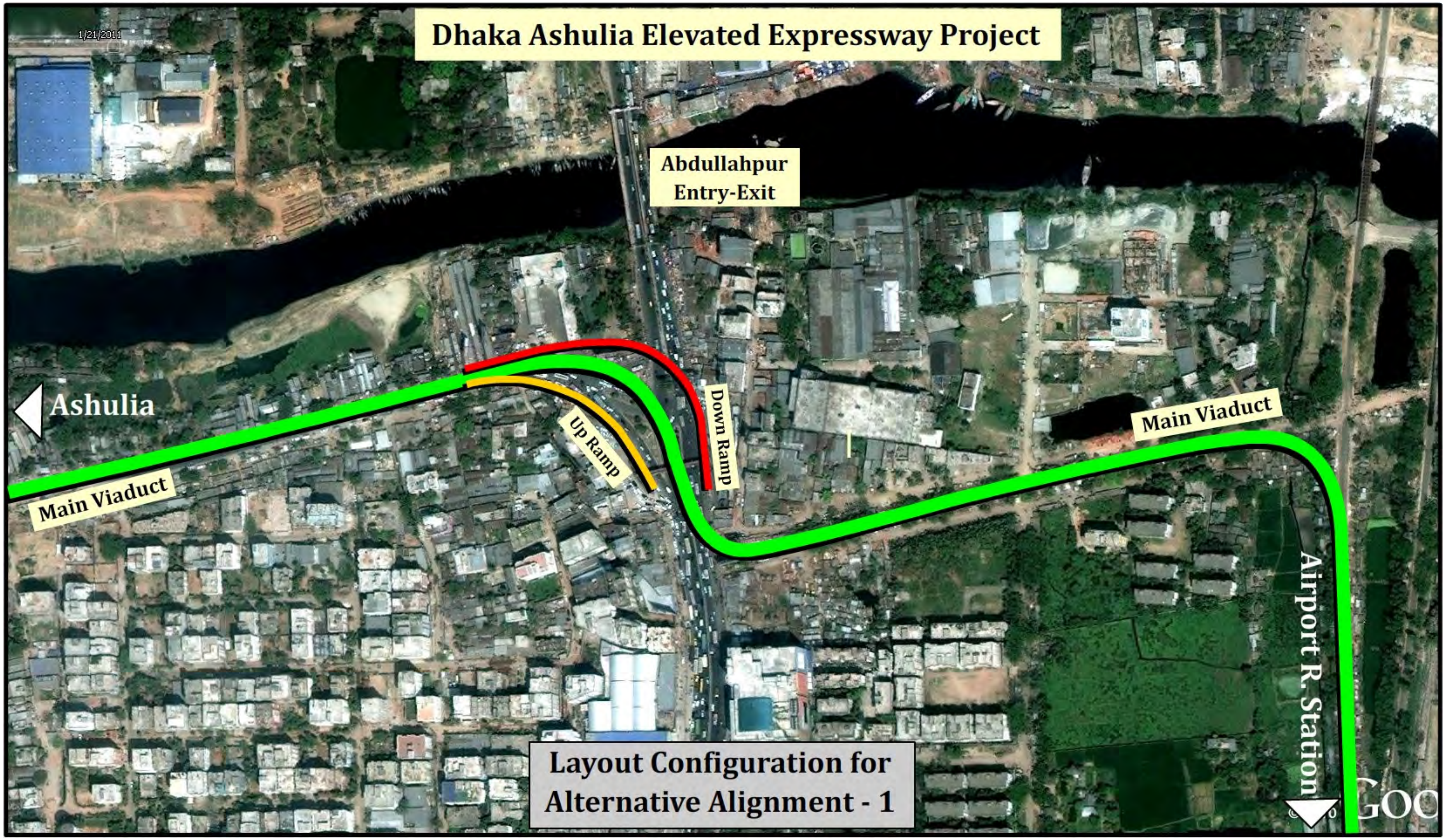
Figure 18.7: Impact of alternative toll assumptions on cumulative revenue NPV (discount) for I-Girder structure for Expressway Alignment-1

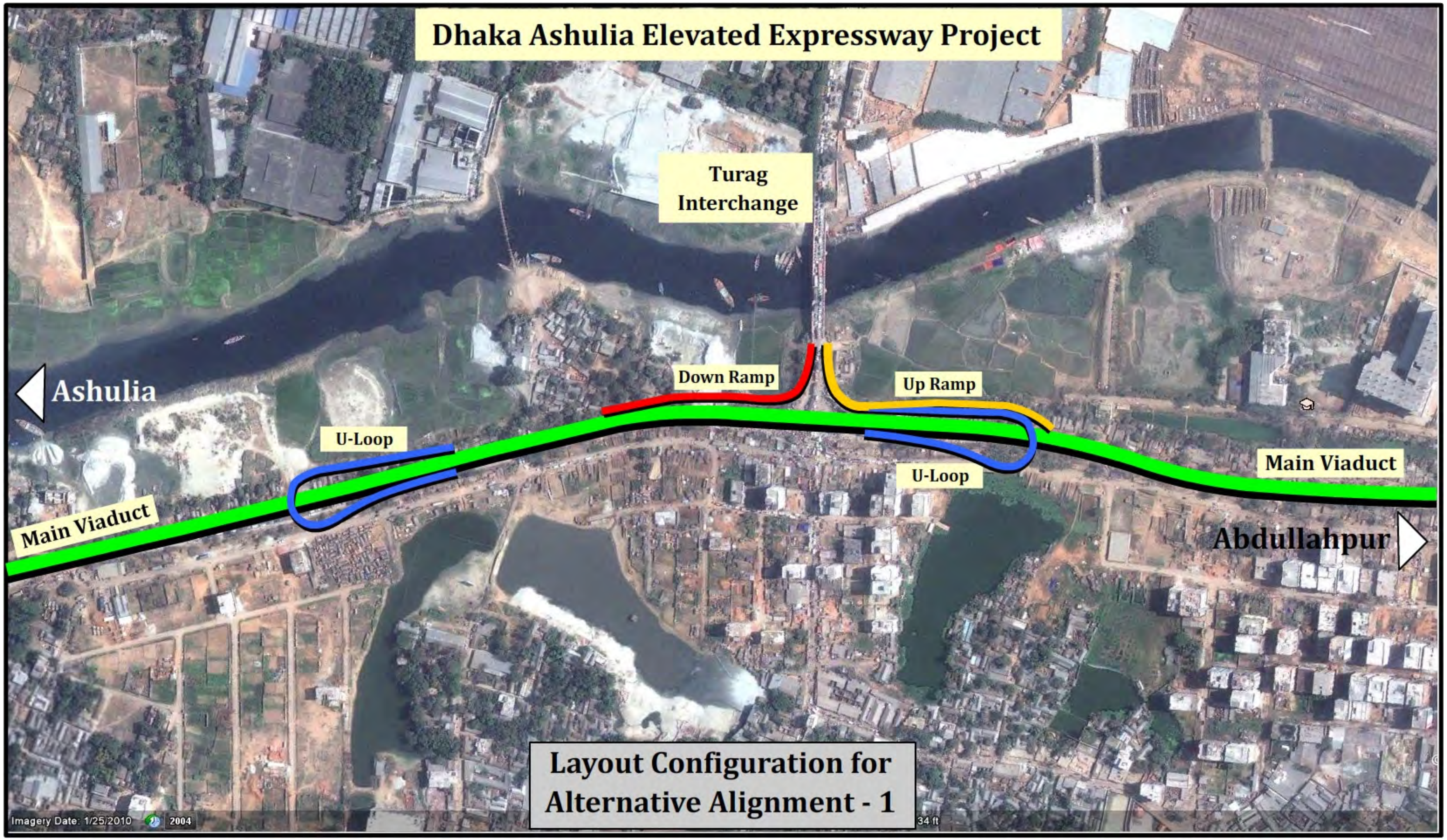
18.6 Summary of Financial Analysis

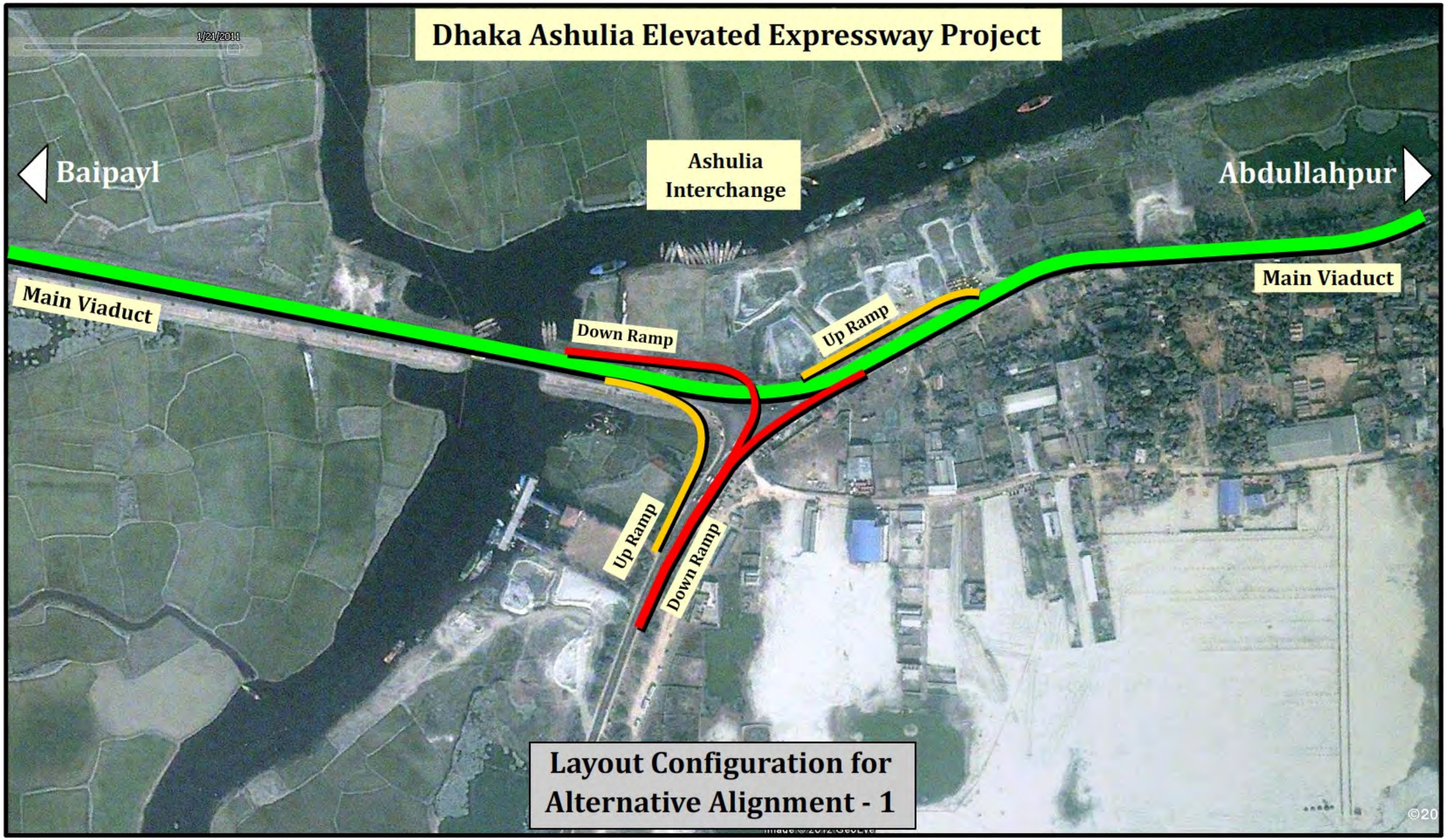
Given the fact that the project's net present financial value is negative (without VGF), FIRR is appeared to be only 2 to 3%. This essentially suggests that the DAEEP is not financially feasible on its own, unless it receives support from the government in the form of VGF. The amount of VGF required varies with various alternate scenarios. However, a significantly higher toll structure than what are tested here can bring down the VGF amount. A more detailed analysis during the feasibility study will be required before a final decision. Moreover, investors' financial model needed to be undertaken by them, as cost estimation process for large infrastructure projects are complex, as inherently it relies on many assumptions and projections which may differs from those assumed and described herein. Moreover, each bidder has its own strategy and required rate of return and comfort factor for important parameters such as capital cost estimates and the required rate of return.

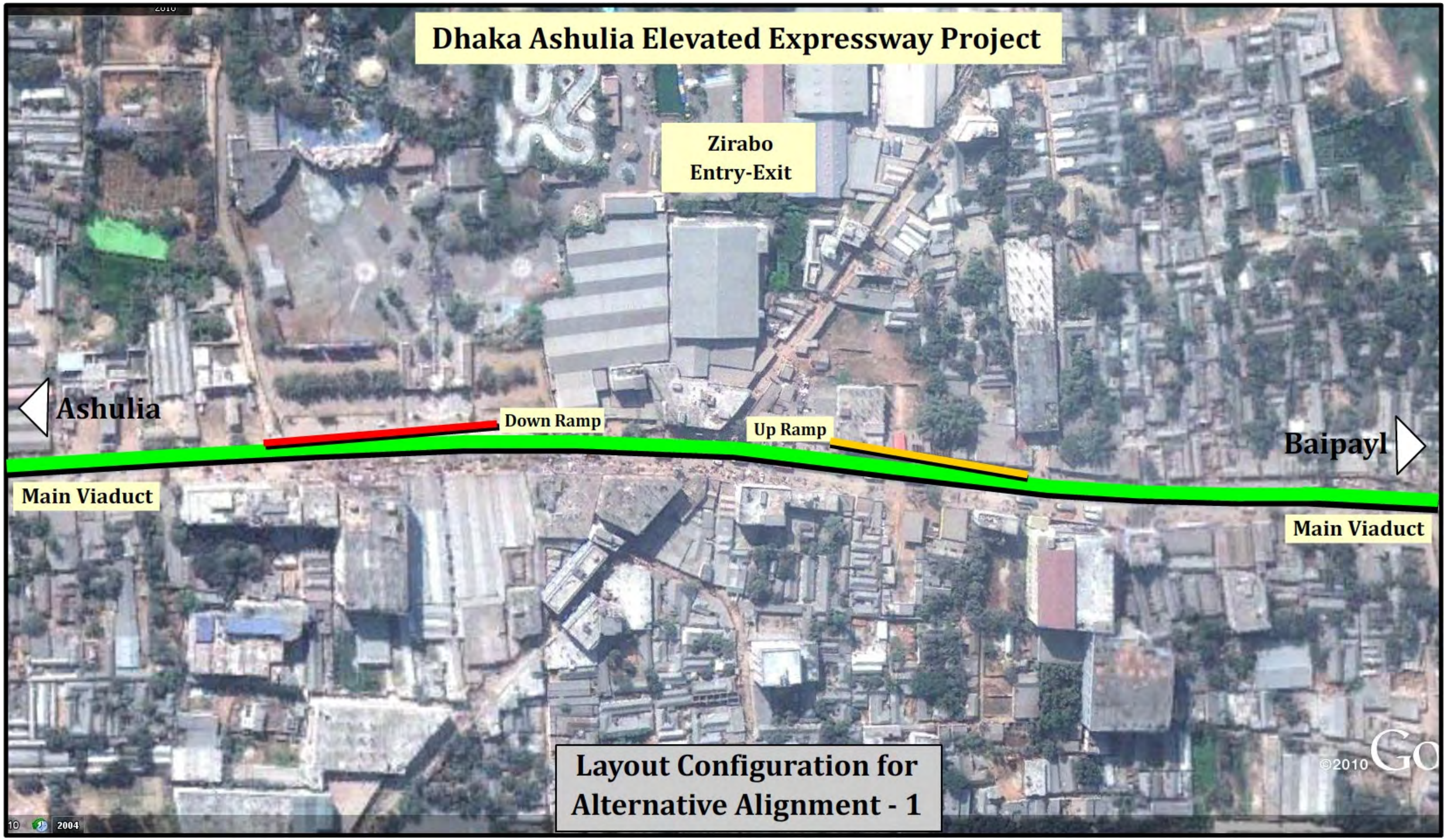
Appendix-A

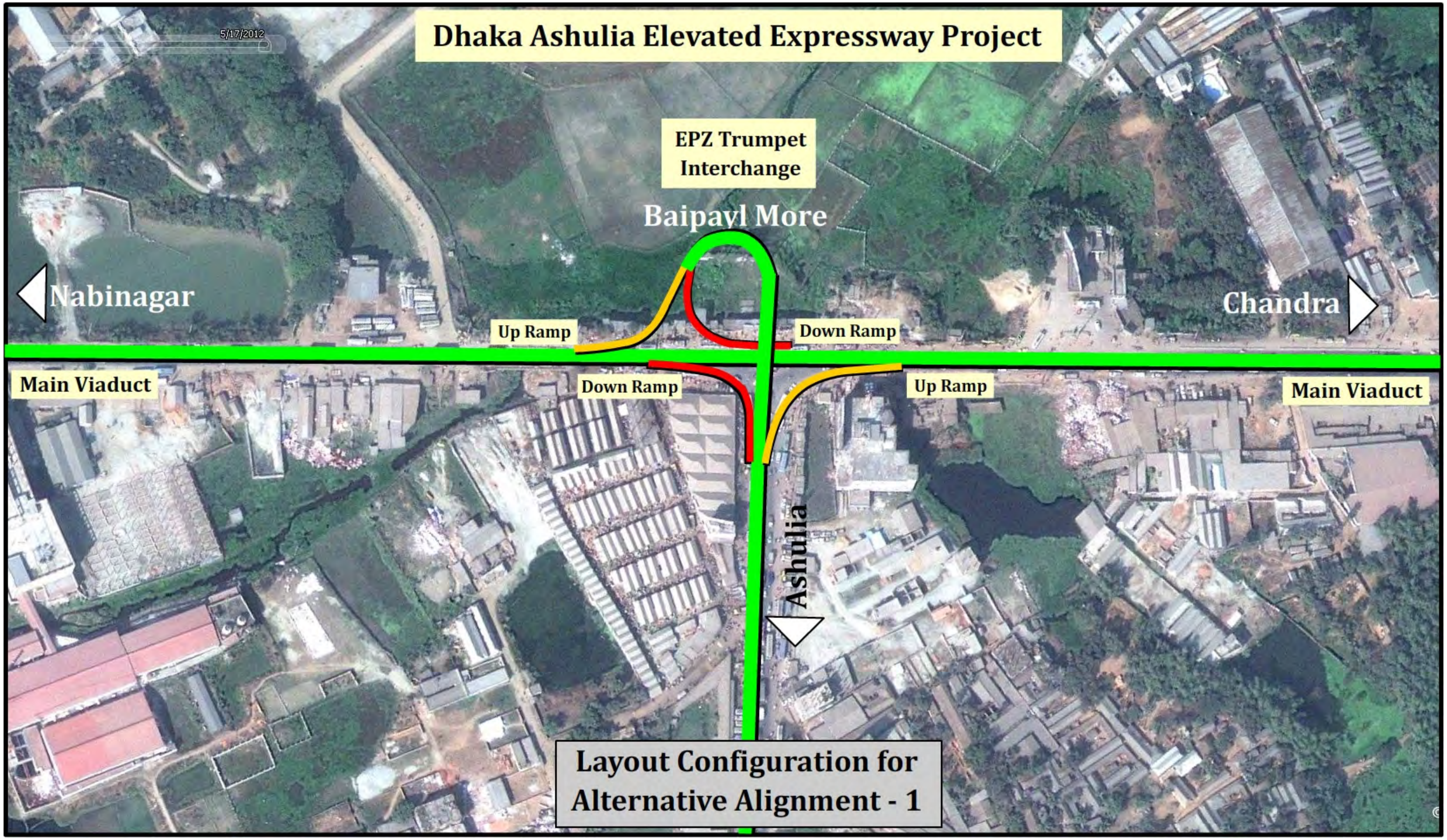
Layout Configurations of Entry-Exits and Interchanges of the Dhaka Ashulia Elevated Expressway (DAEE)

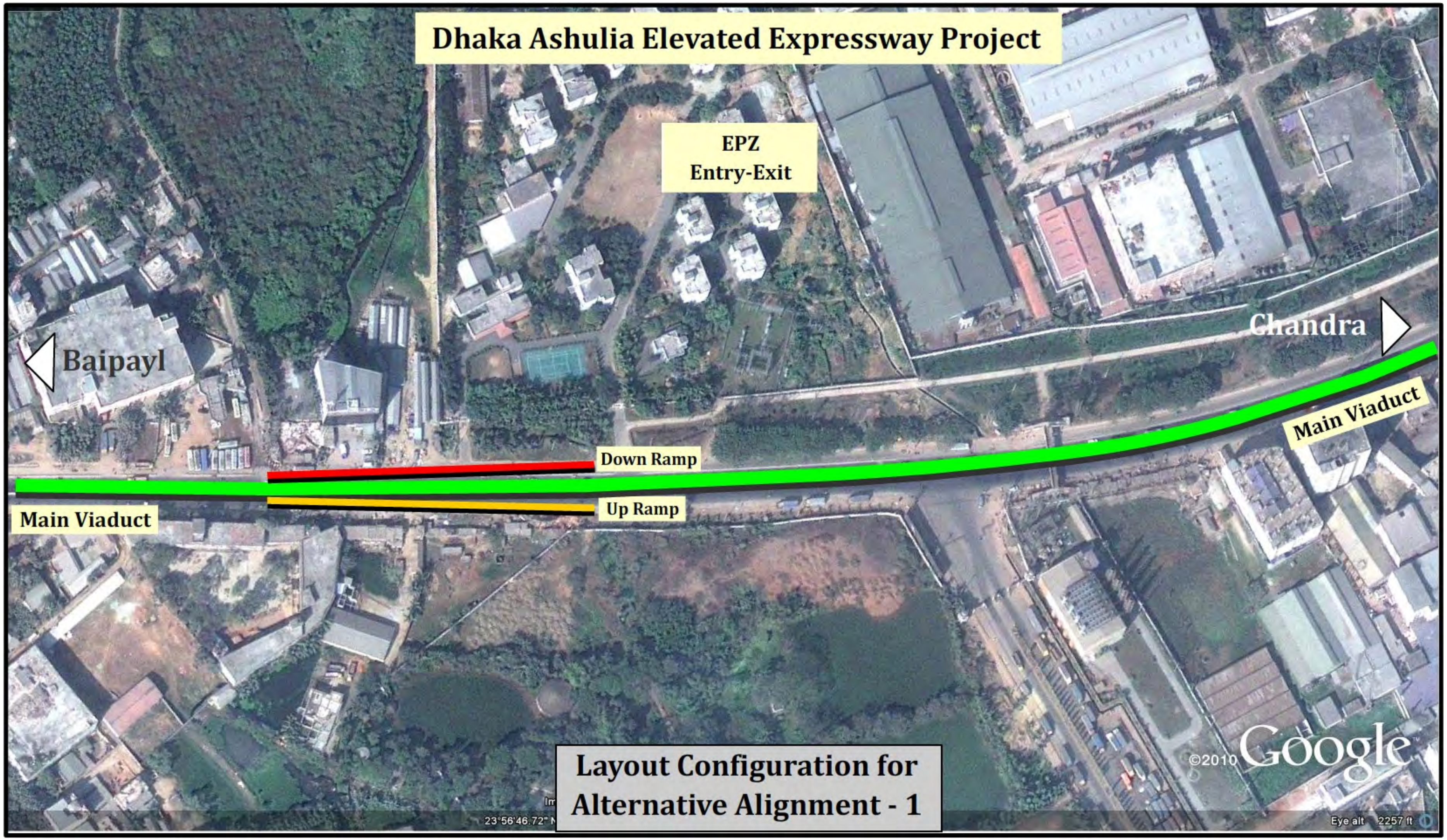

Dhaka Ashulia Elevated Expressway Project
1/21/2011
Abdullahpur
Entry-Exit
Ashulia
Up Ramp
Down Ramp
Main Viaduct
Main Viaduct
Airport R. Station
Layout Configuration for
Alternative Alignment - 1

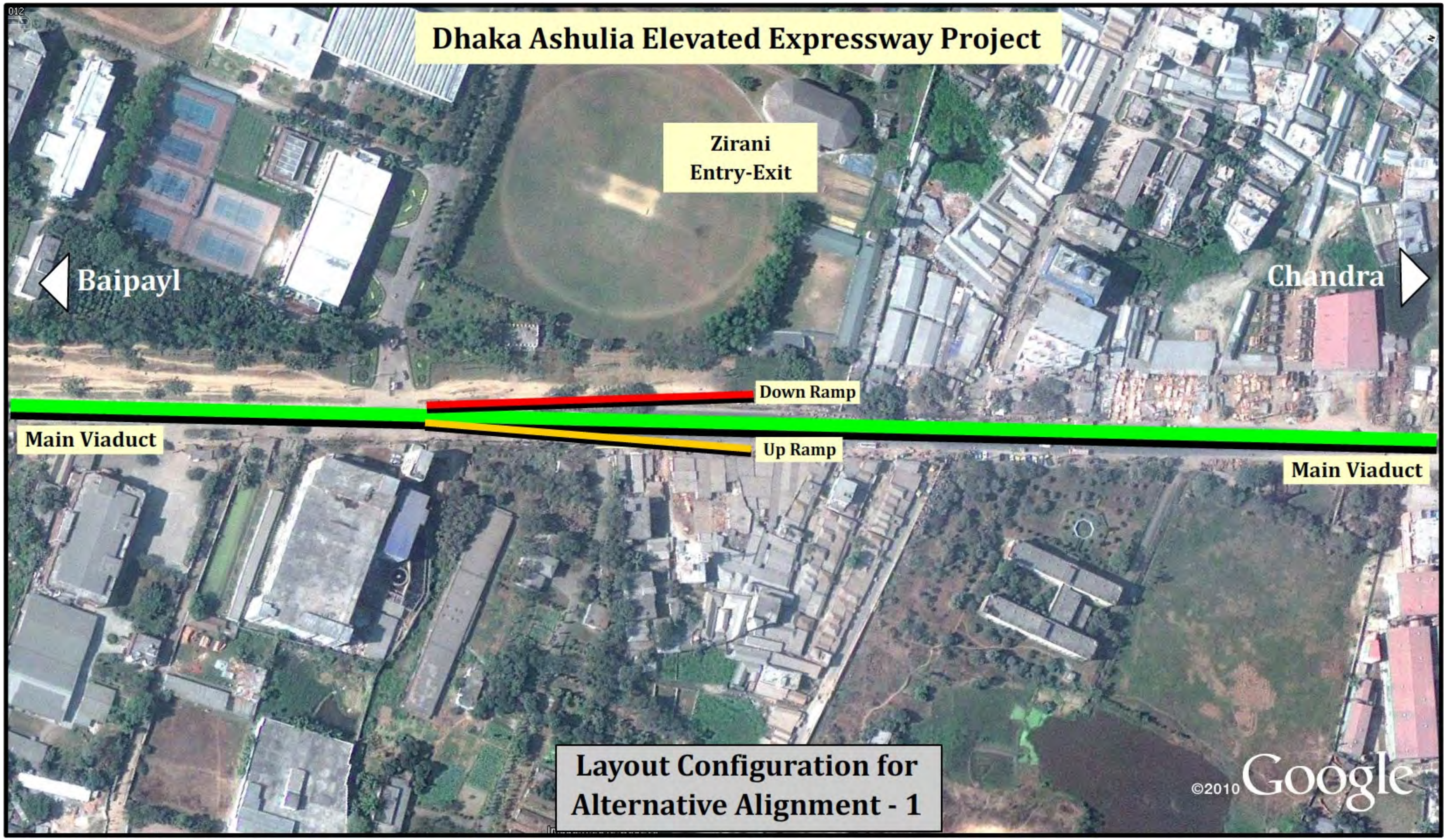

Dhaka Ashulia Elevated Expressway Project
Turag Interchange
Down Ramp
Up Ramp
Ashulia
U-Loop
U-Loop
Main Viaduct
Main Viaduct
Abdullahpur
Layout Configuration for Alternative Alignment - 1
Imagery Date: 1/25/2010
2004

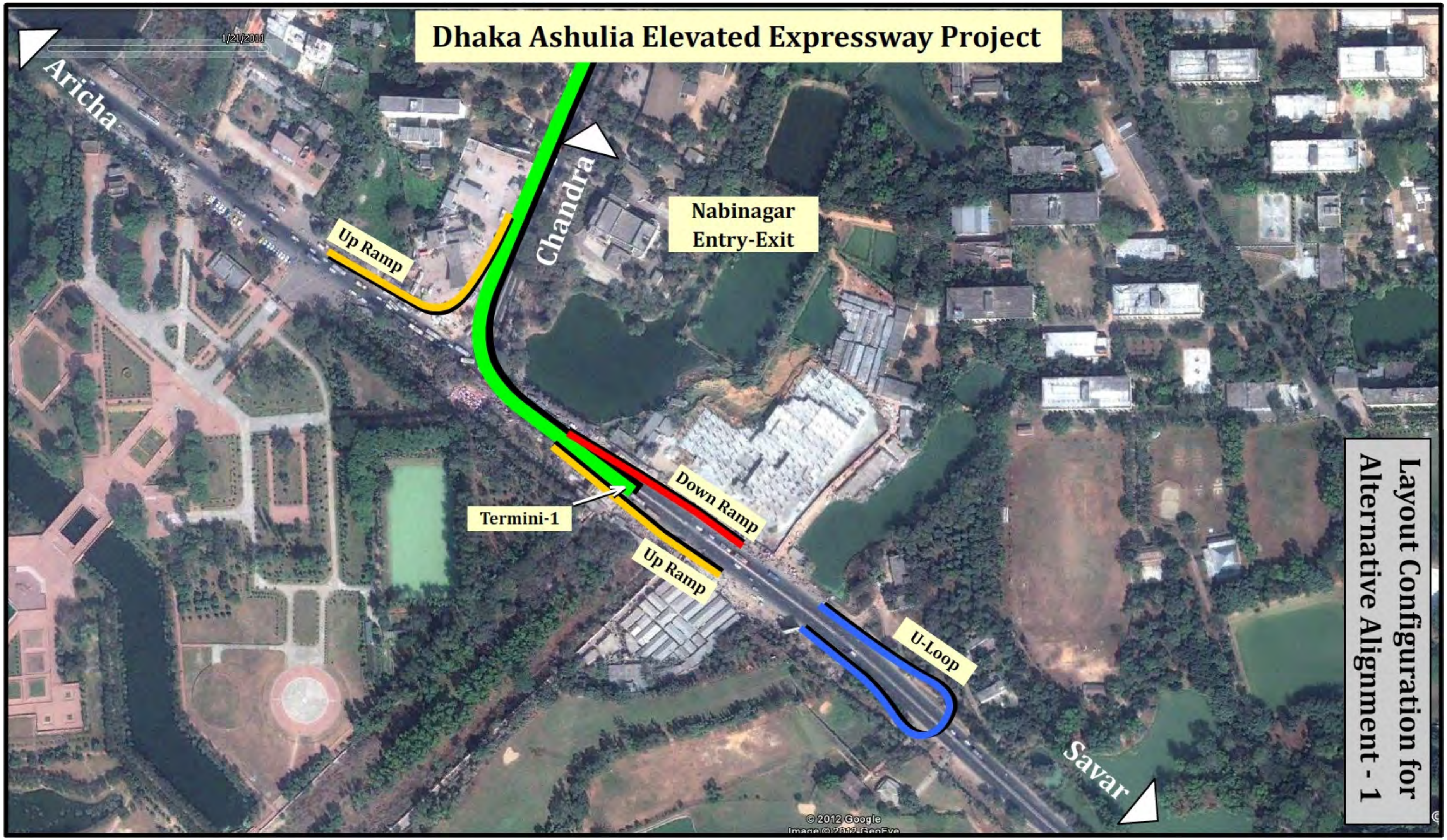

Dhaka Ashulia Elevated Expressway Project
Baipayl
Ashulia Interchange
Abdullahpur
Main Viaduct
Main Viaduct
Down Ramp
Up Ramp
Up Ramp
Down Ramp
Layout Configuration for Alternative Alignment - 1

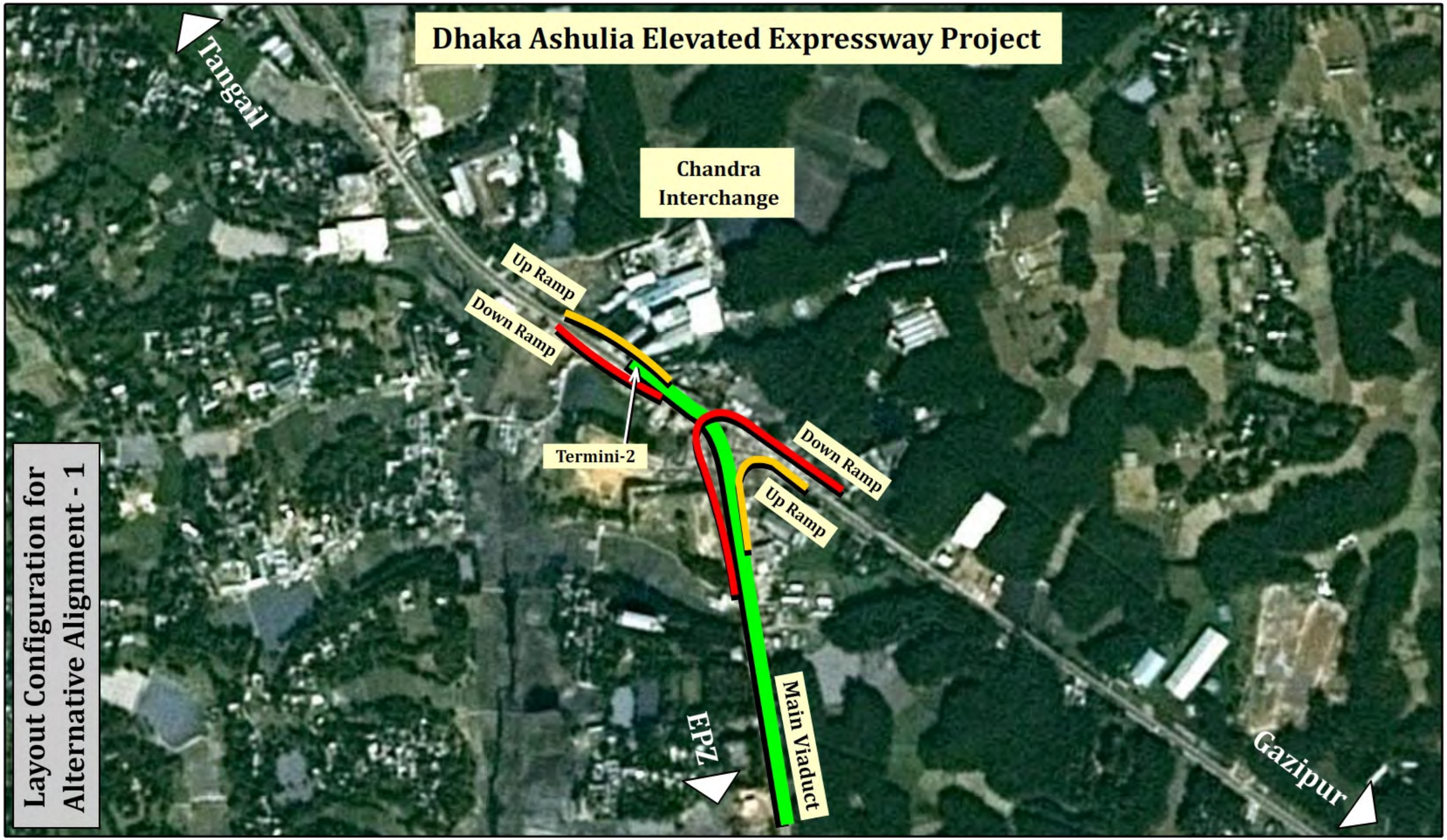

Dhaka Ashulia Elevated Expressway Project
Zirabo
Entry-Exit
Ashulia
Down Ramp
Up Ramp
Baipayl
Main Viaduct
Main Viaduct
©2010
2004
Layout Configuration for
Alternative Alignment - 1

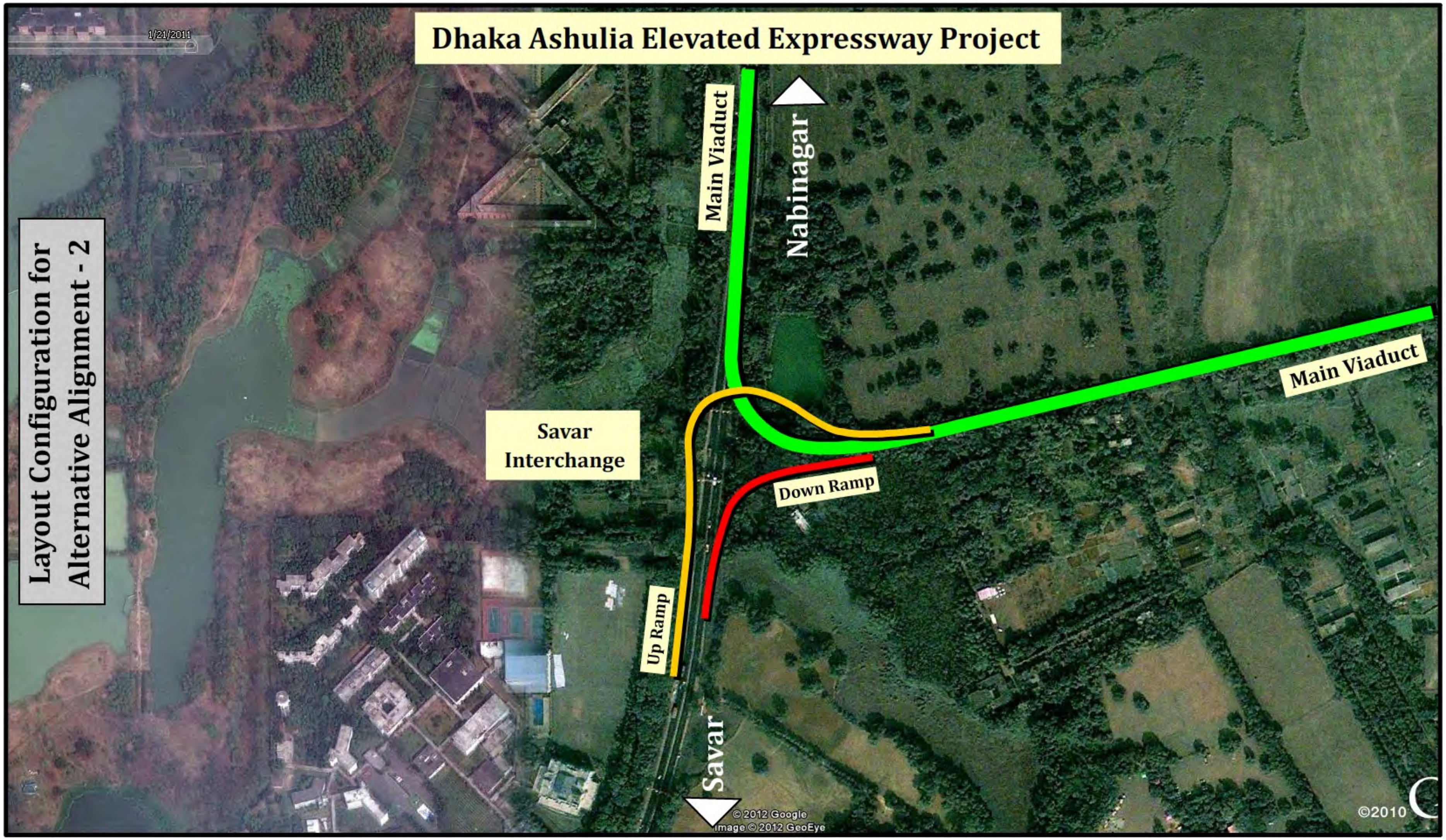

Dhaka Ashulia Elevated Expressway Project
5/17/2012
EPZ Trumpet Interchange
Baipayl More
Nabinagar
Chandra
Up Ramp
Down Ramp
Main Viaduct
Down Ramp
Up Ramp
Main Viaduct
Ashulia
Layout Configuration for Alternative Alignment - 1

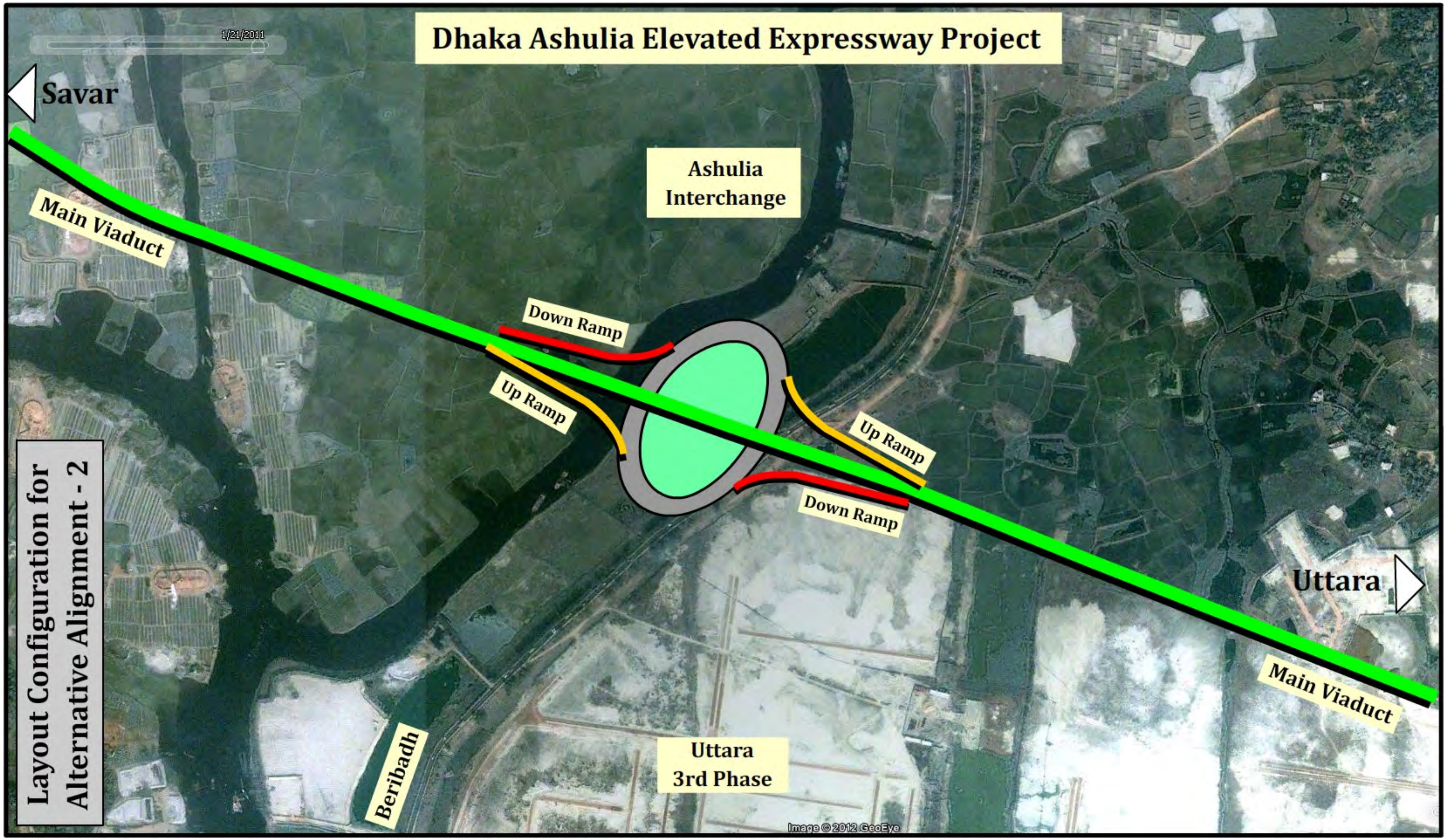

Dhaka Ashulia Elevated Expressway Project
EPZ
Entry-Exit
Baipayl
Chandra
Down Ramp
Up Ramp
Main Viaduct
Main Viaduct
Layout Configuration for
Alternative Alignment - 1
©2010 Google

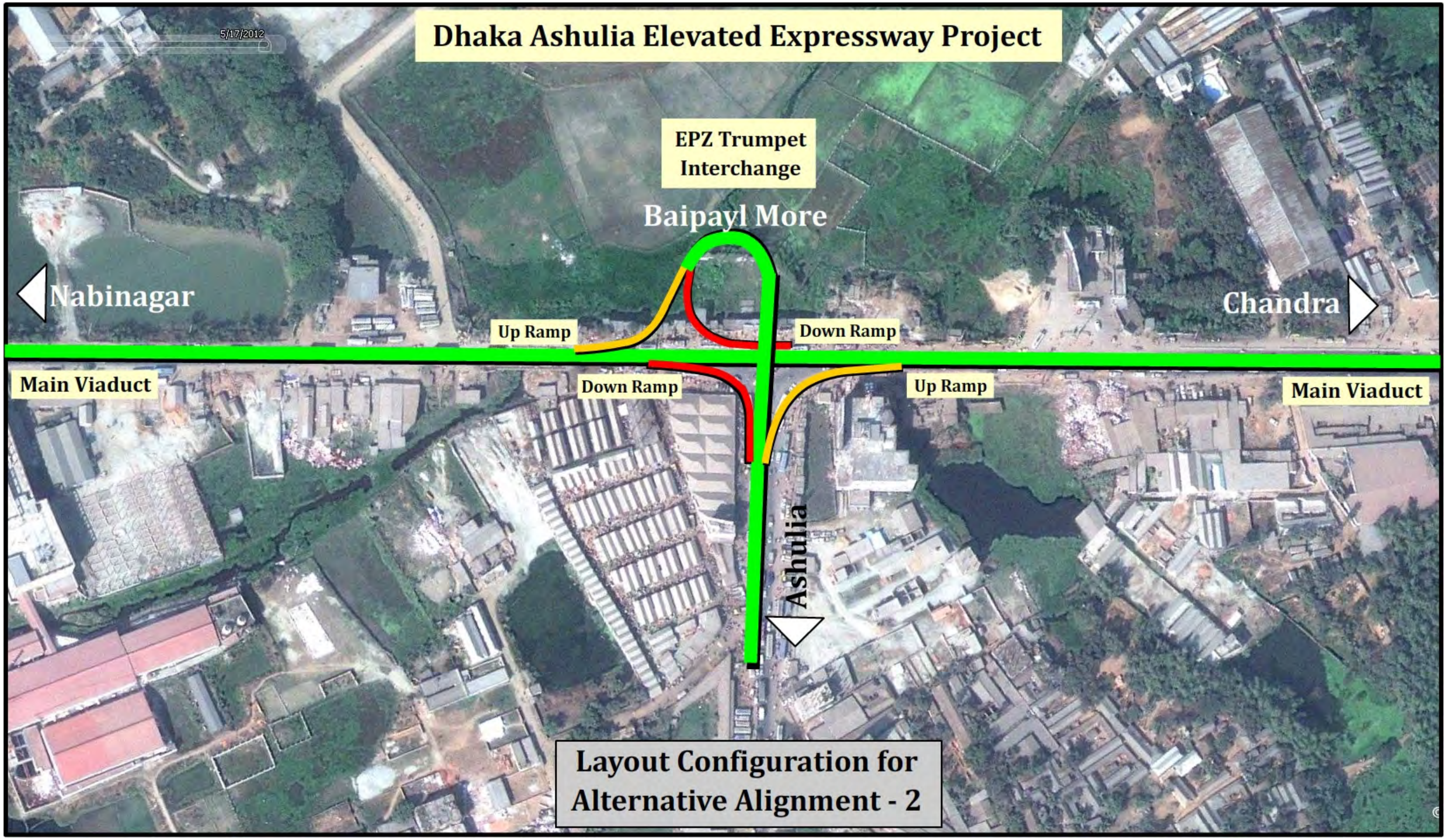

Dhaka Ashulia Elevated Expressway Project
Zirani
Entry-Exit
Baipayl
Chandra
Down Ramp
Main Viaduct
Up Ramp
Main Viaduct
Layout Configuration for
Alternative Alignment - 1
©2010 Google


Dhaka Ashulia Elevated Expressway Project
Aricha
Chandra
Nabinagar
Entry-Exit
Up Ramp
Down Ramp
Termini-1
Up Ramp
U-Loop
Savar
Layout Configuration for
Alternative Alignment - 1
1/21/2011
© 2012 Google


Dhaka Ashulia Elevated Expressway Project
Tangail
Chandra Interchange
Up Ramp
Down Ramp
Termini-2
Down Ramp
Up Ramp
Main Viaduct
EPZ
Gazipur
Layout Configuration for Alternative Alignment - 1

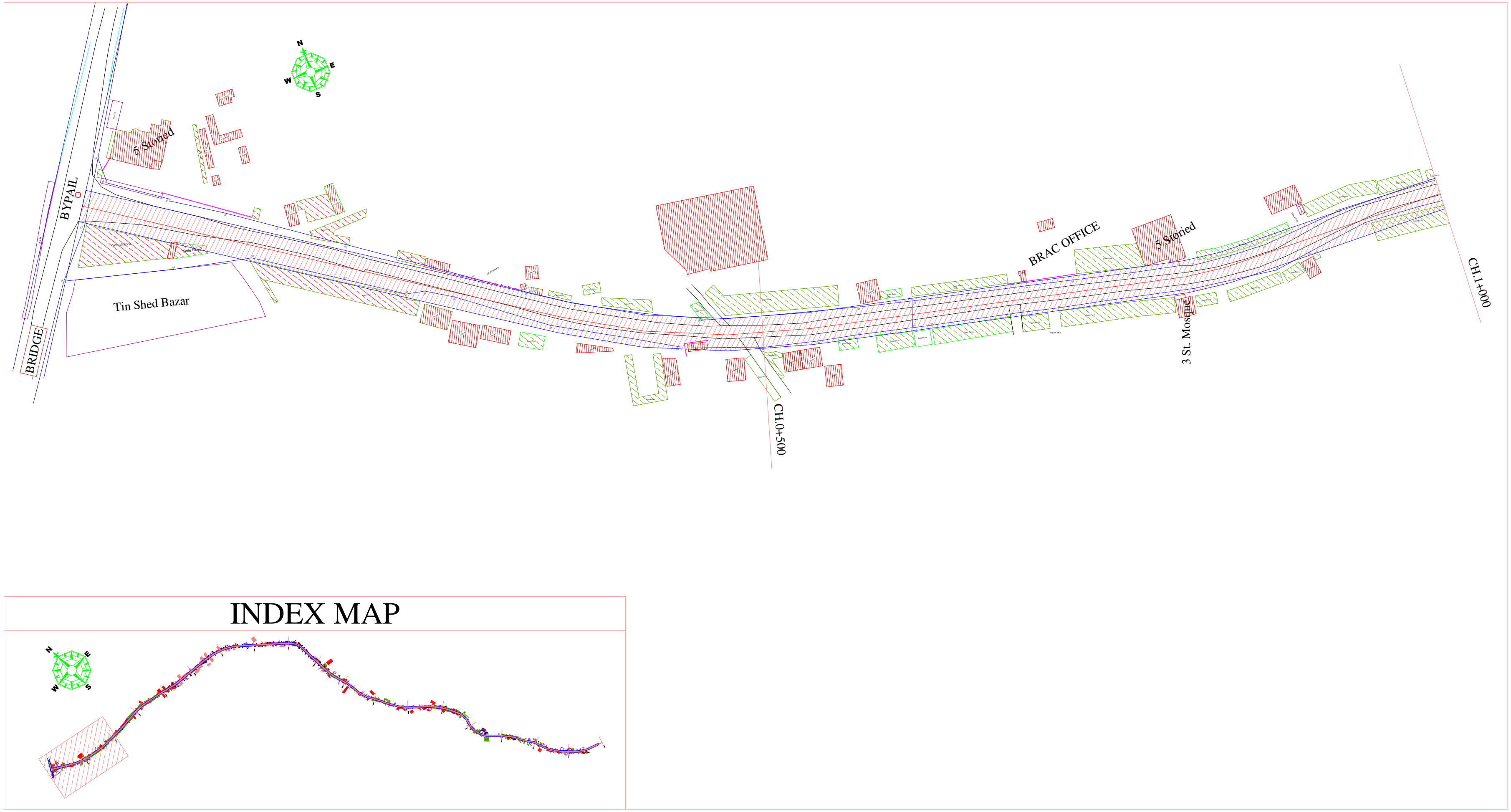

Dhaka Ashulia Elevated Expressway Project
Layout Configuration for Alternative Alignment - 2
Main Viaduct
Nabinagar
Main Viaduct
Savar Interchange
Down Ramp
Up Ramp
Savar
1/21/2011
© 2012 Google
Image © 2012 GeoEye
©2010


Dhaka Ashulia Elevated Expressway Project
Savar
Ashulia Interchange
Main Viaduct
Down Ramp
Up Ramp
Up Ramp
Down Ramp
Uttara
Main Viaduct
Layout Configuration for Alternative Alignment - 2
Beribadh
Uttara 3rd Phase
Image © 2012 GeoEye

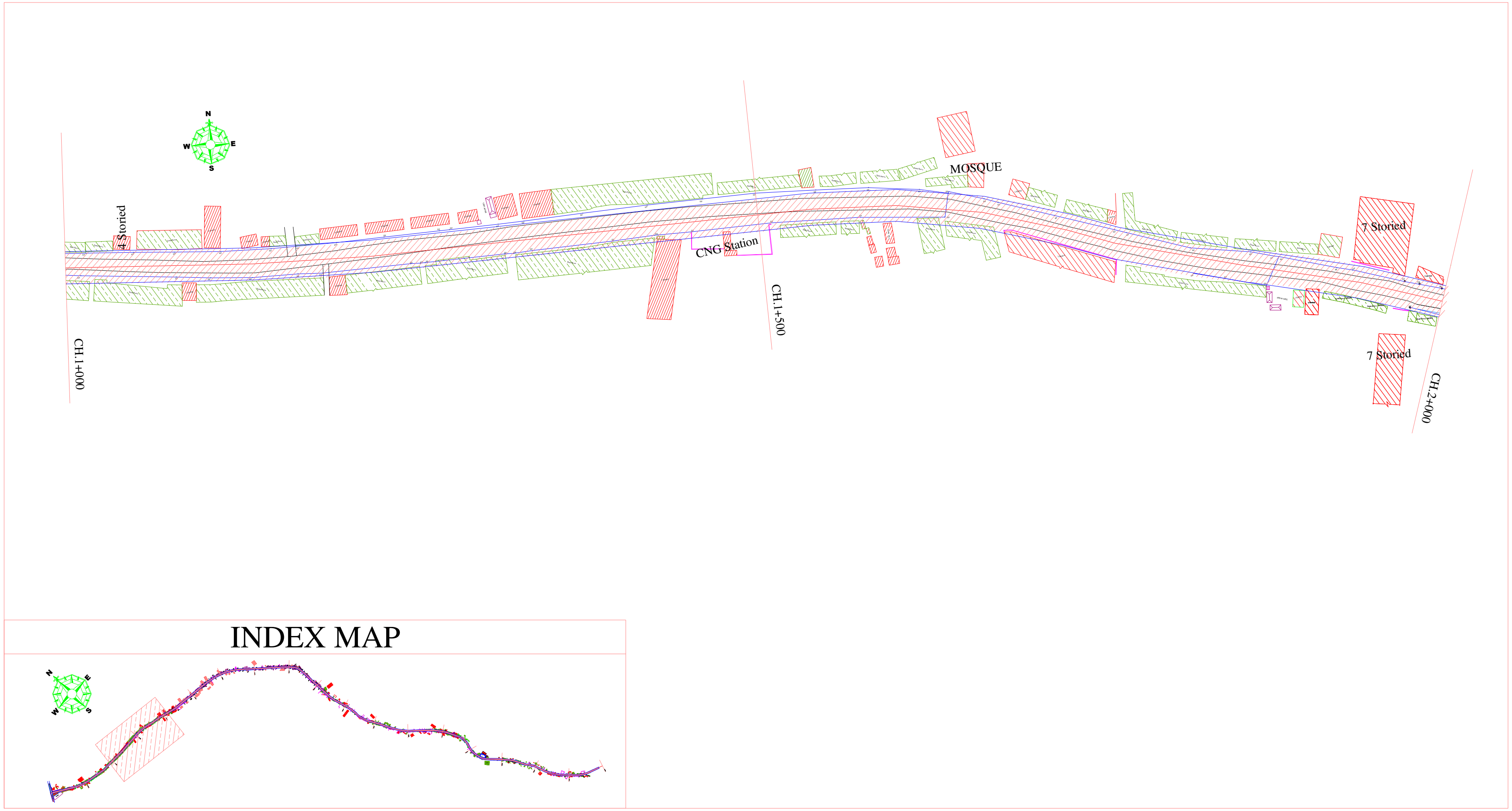

Dhaka Ashulia Elevated Expressway Project
5/17/2012
EPZ Trumpet Interchange
Baipayl More
Nabinagar
Chandra
Up Ramp
Down Ramp
Main Viaduct
Down Ramp
Up Ramp
Main Viaduct
Ashulia
Layout Configuration for Alternative Alignment - 2

Appendix-B

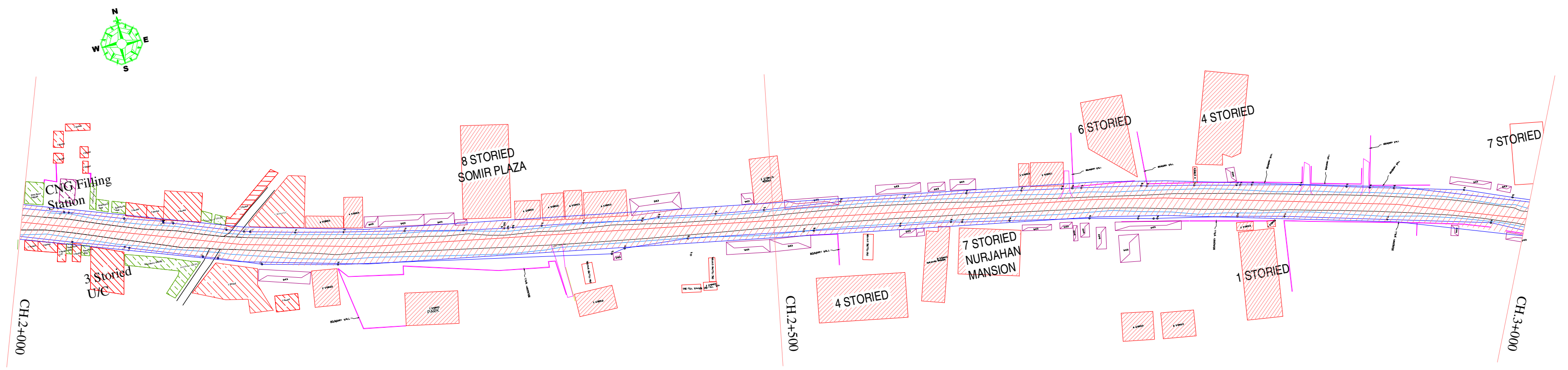
AutoCad Drawing Sheets for the Proposed Routes of the Dhaka Ashulia Elevated Expressway (DAEE)

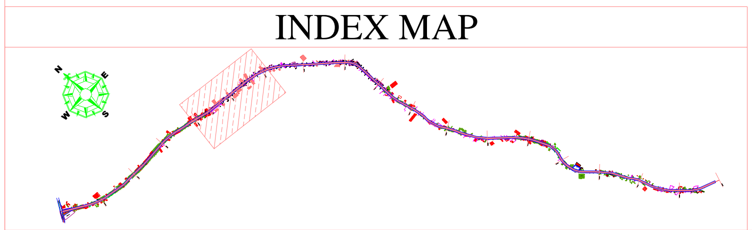


Sheet 1: Topographic Details of Alternative-1 between Ch. 0+000 to 1+000

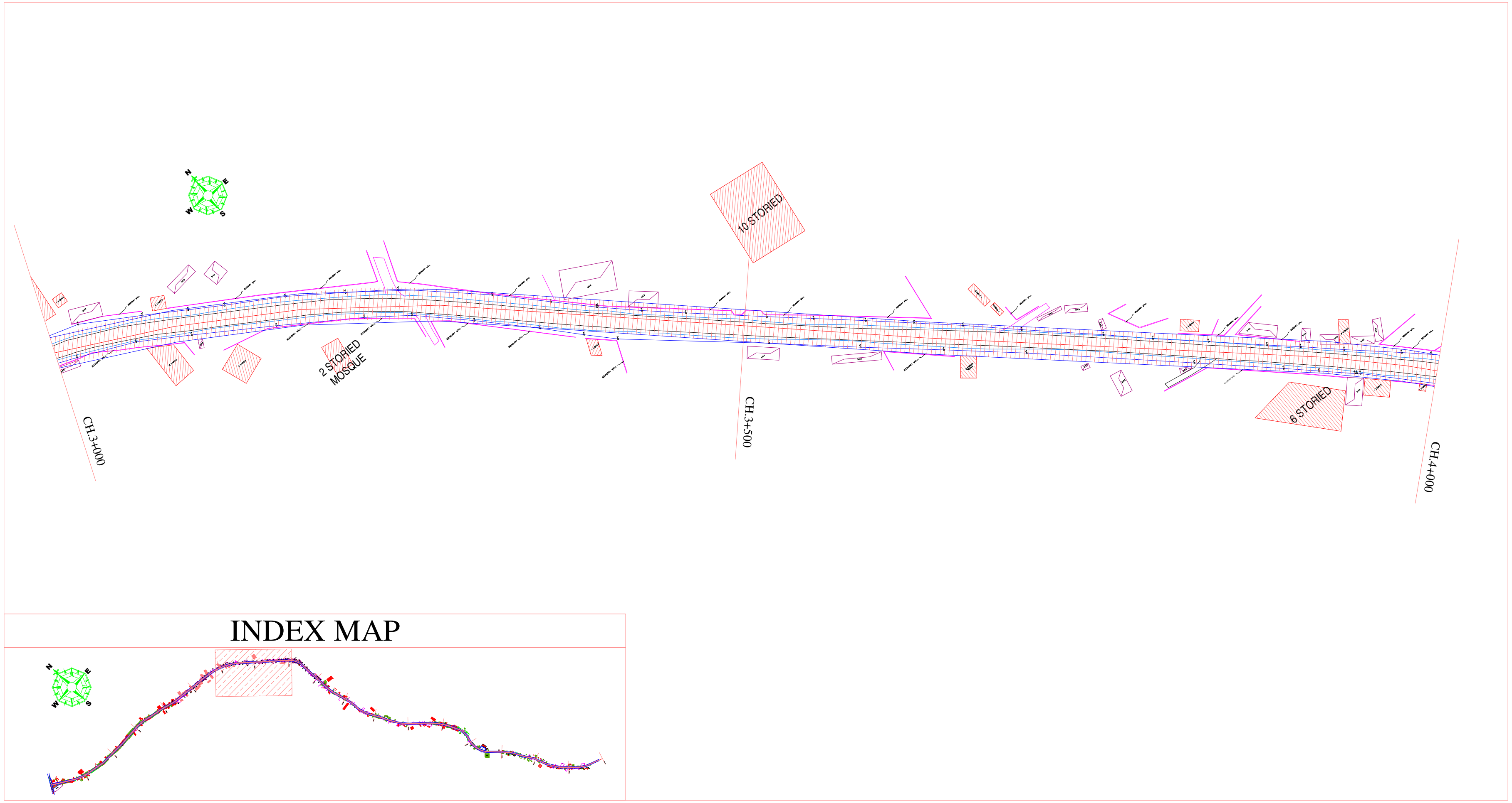


Sheet 2: Topographic Details of Alternative-1 between Ch. 1+000 to 2+000

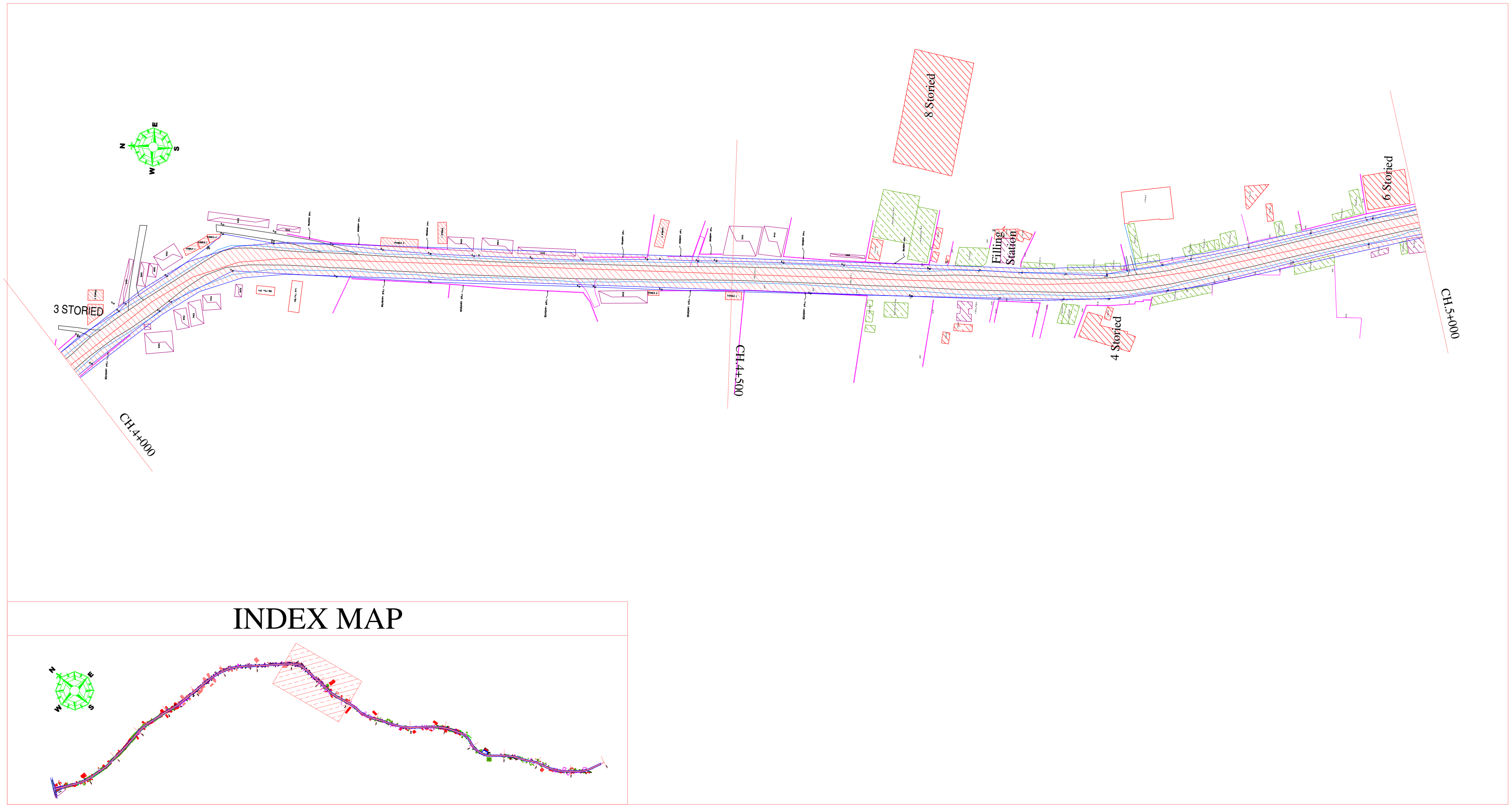




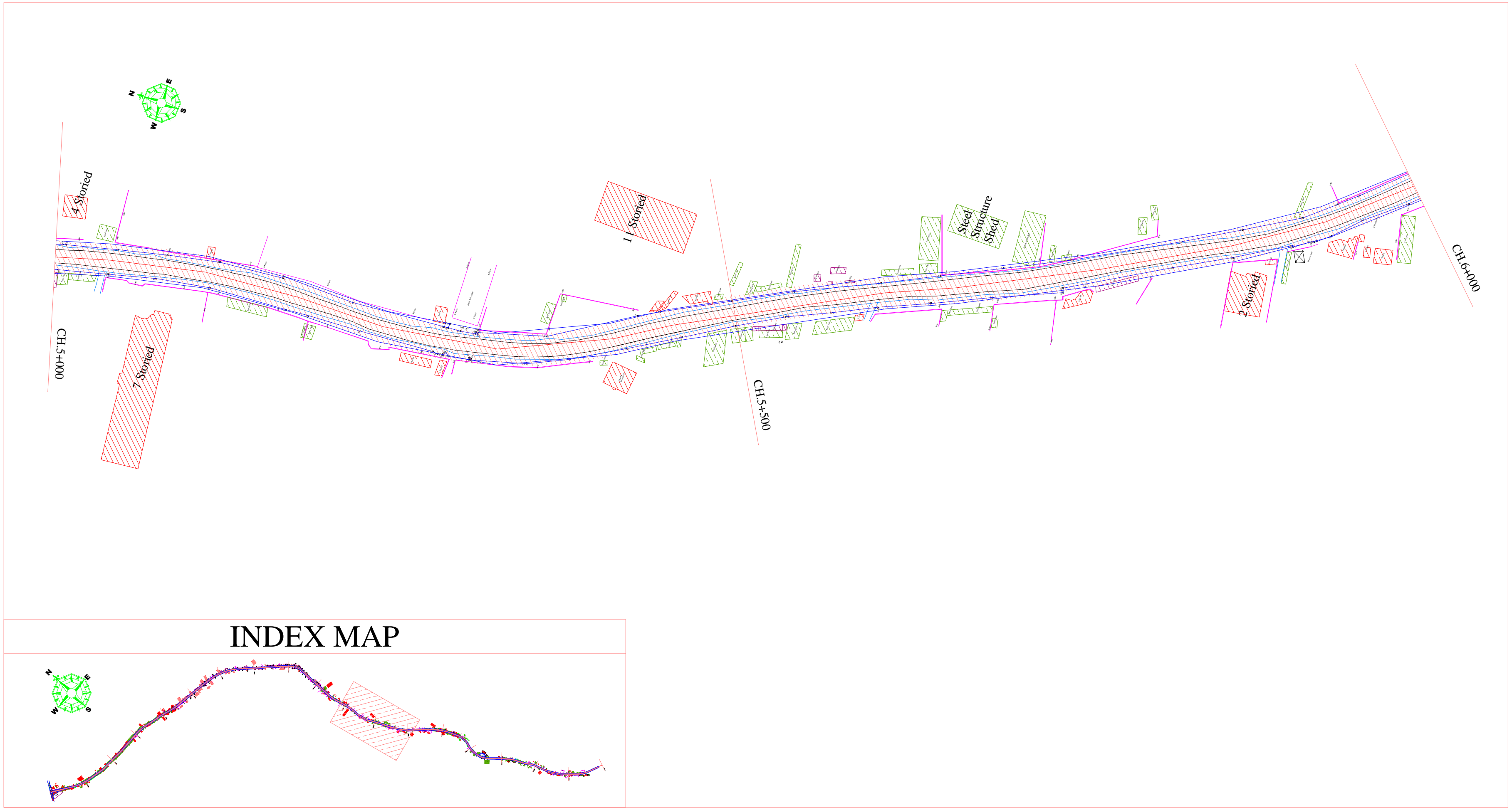
Sheet 3: Topographic Details of Alternative-1 between Ch. 2+000 to 3+000



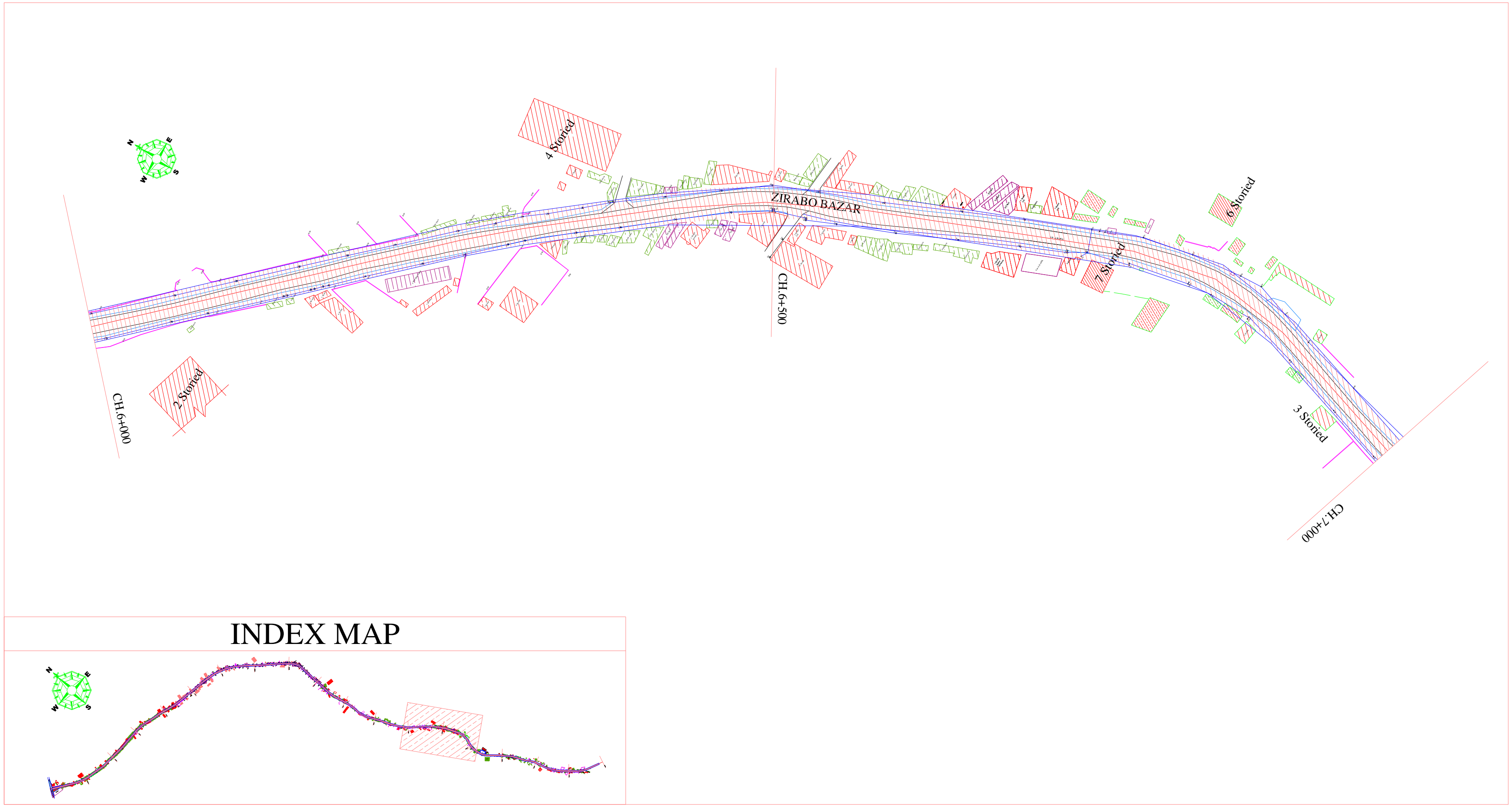
Sheet 4: Topographic Details of Alternative-1 between Ch. 3+000 to 4+000



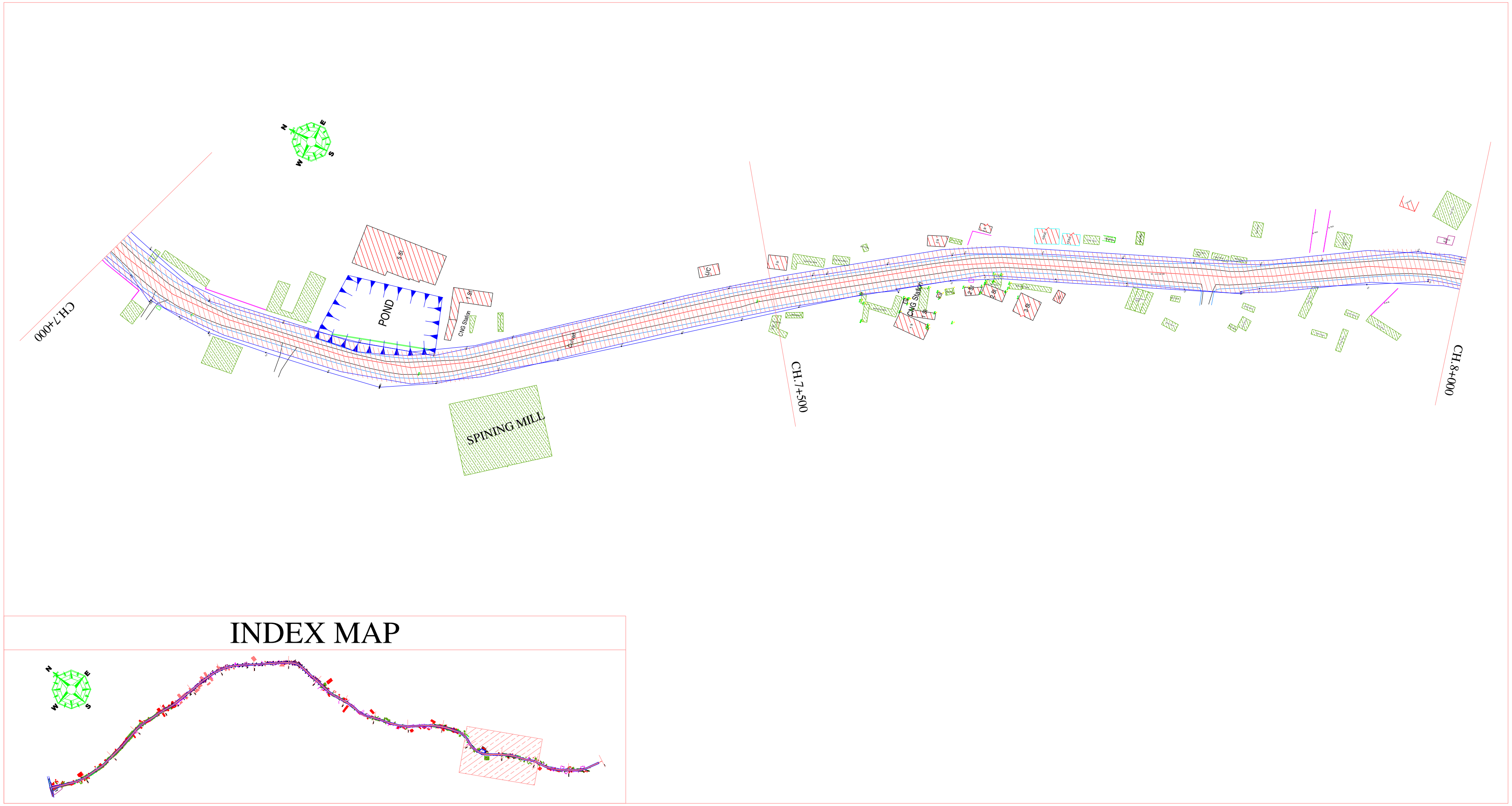
Sheet 5: Topographic Details of Alternative-1 between Ch. 4+000 to 5+000



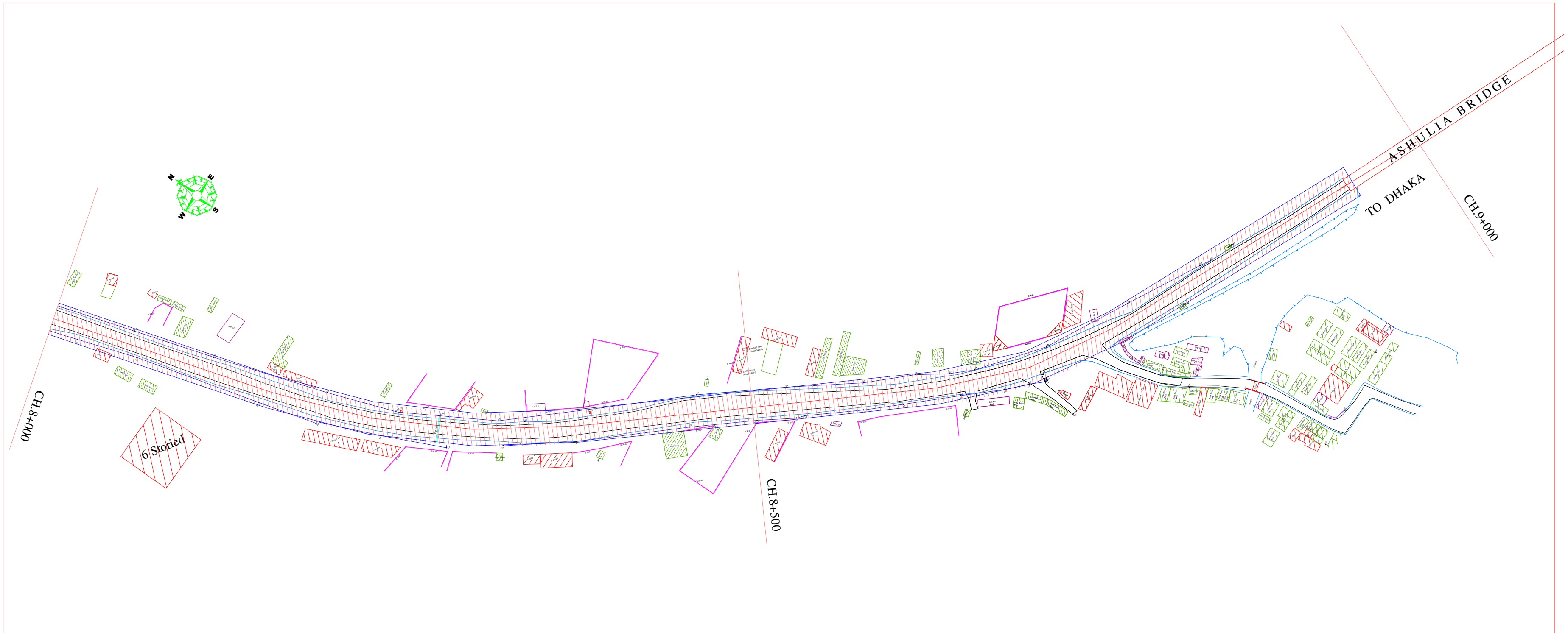
Sheet 6: Topographic Details of Alternative-1 between Ch. 5+000 to 6+000



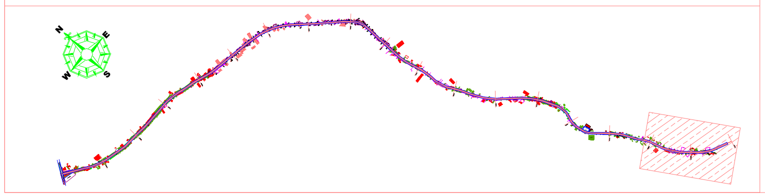
Sheet 7: Topographic Details of Alternative-1 between Ch. 6+000 to 7+000



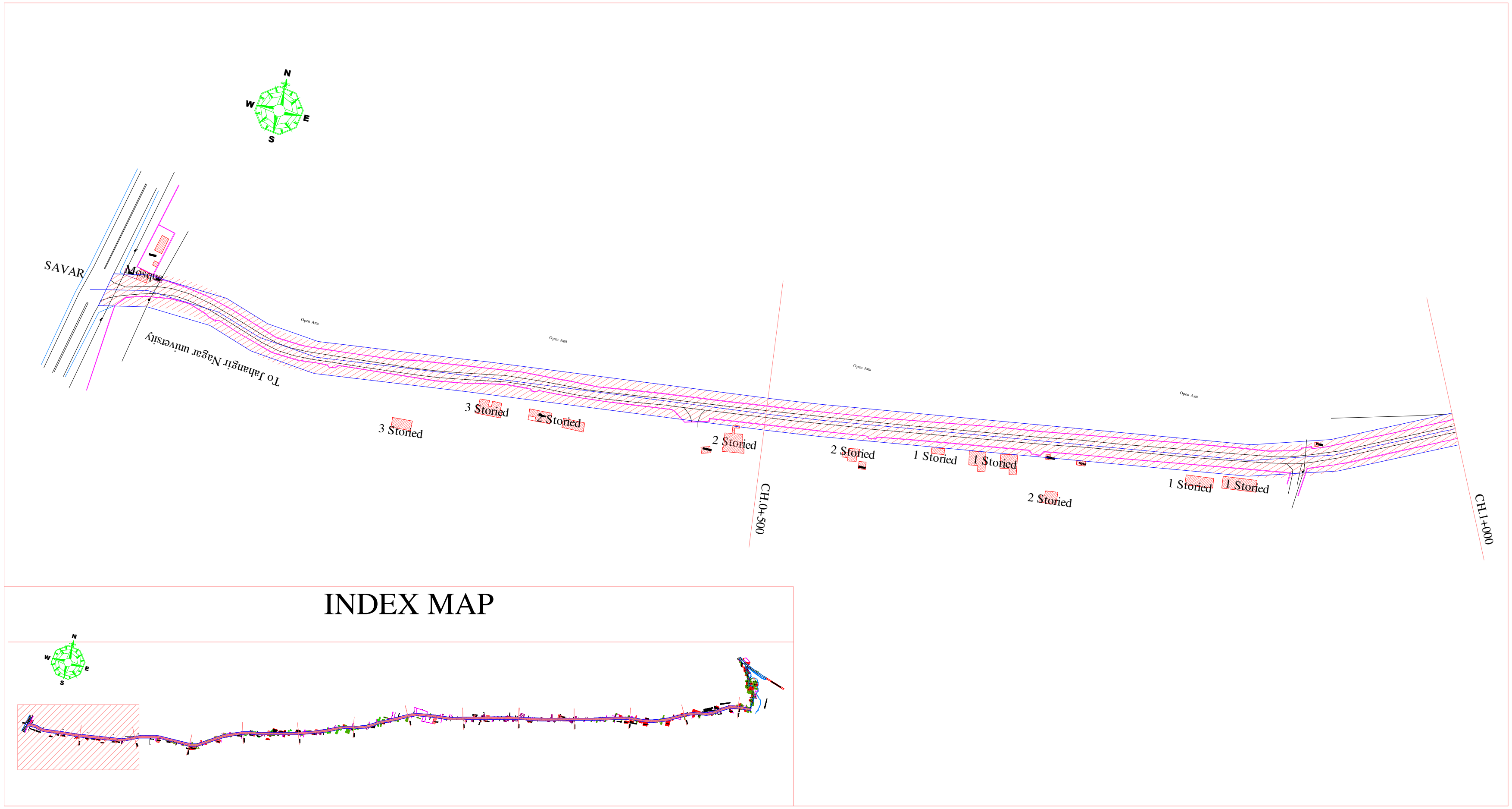
Sheet 8: Topographic Details of Alternative-1 between Ch. 7+000 to 8+000



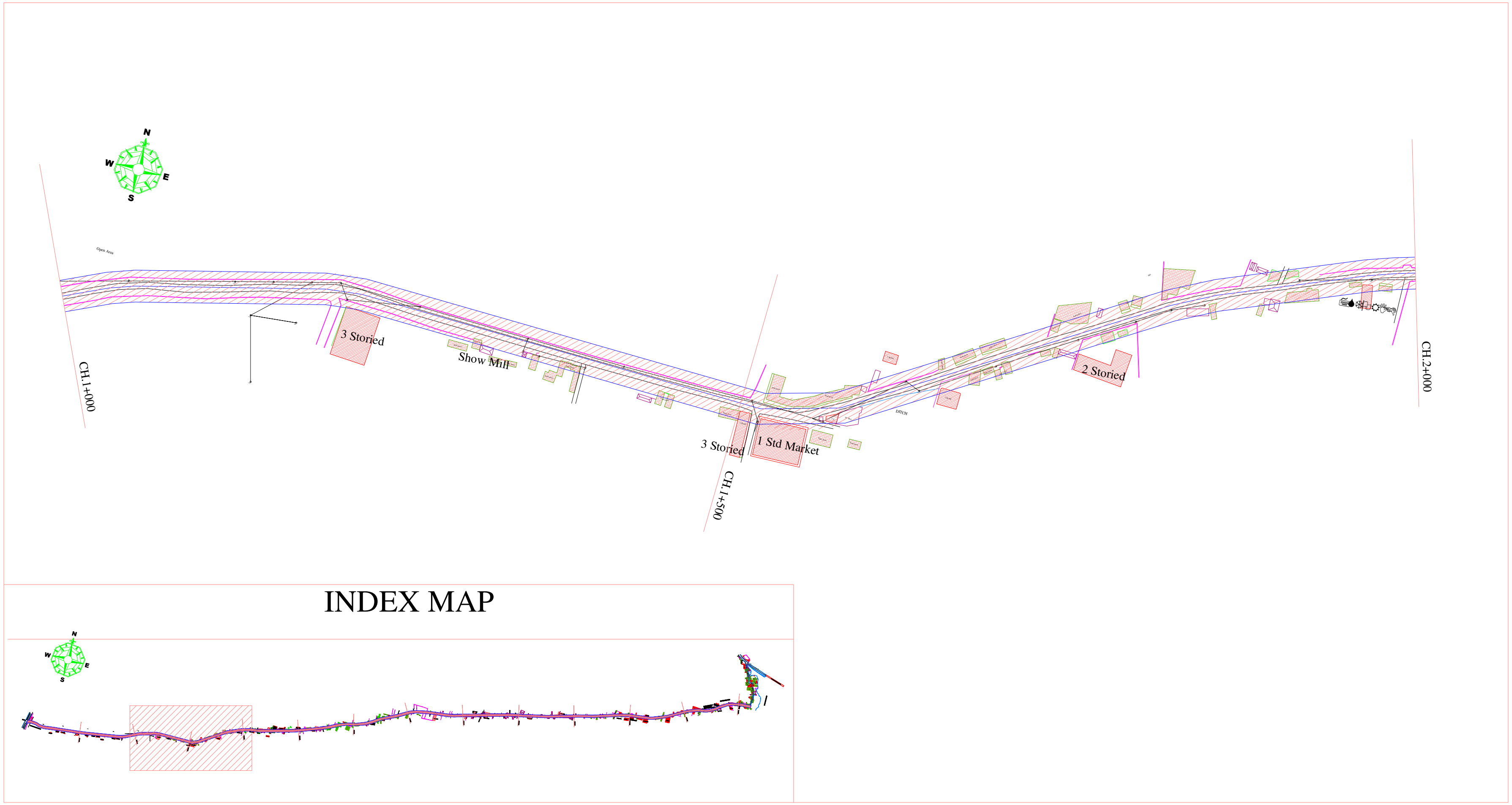
INDEX MAP



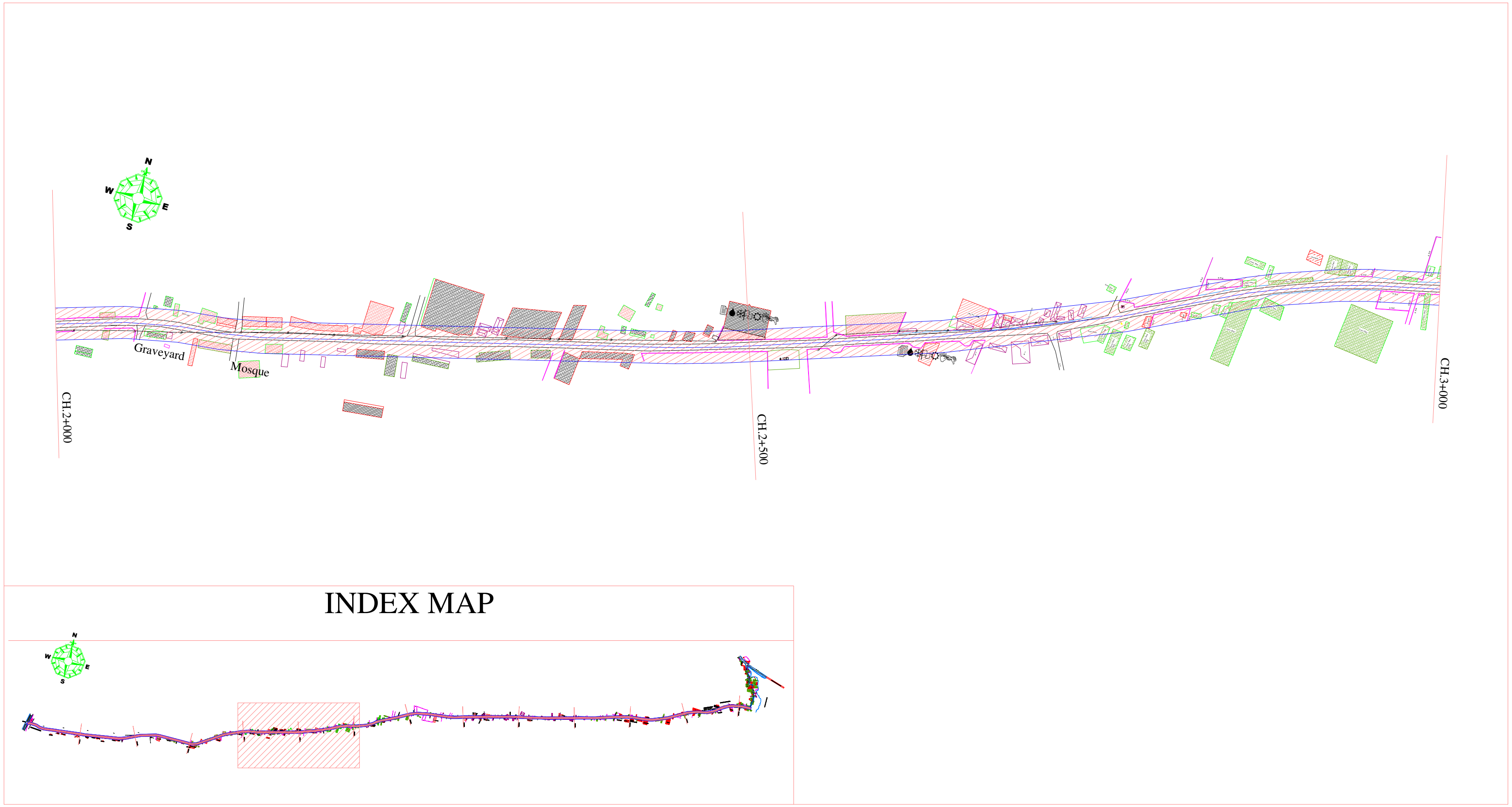
Sheet 9: Topographic Details of Alternative-1 between Ch. 8+000 to 9+000



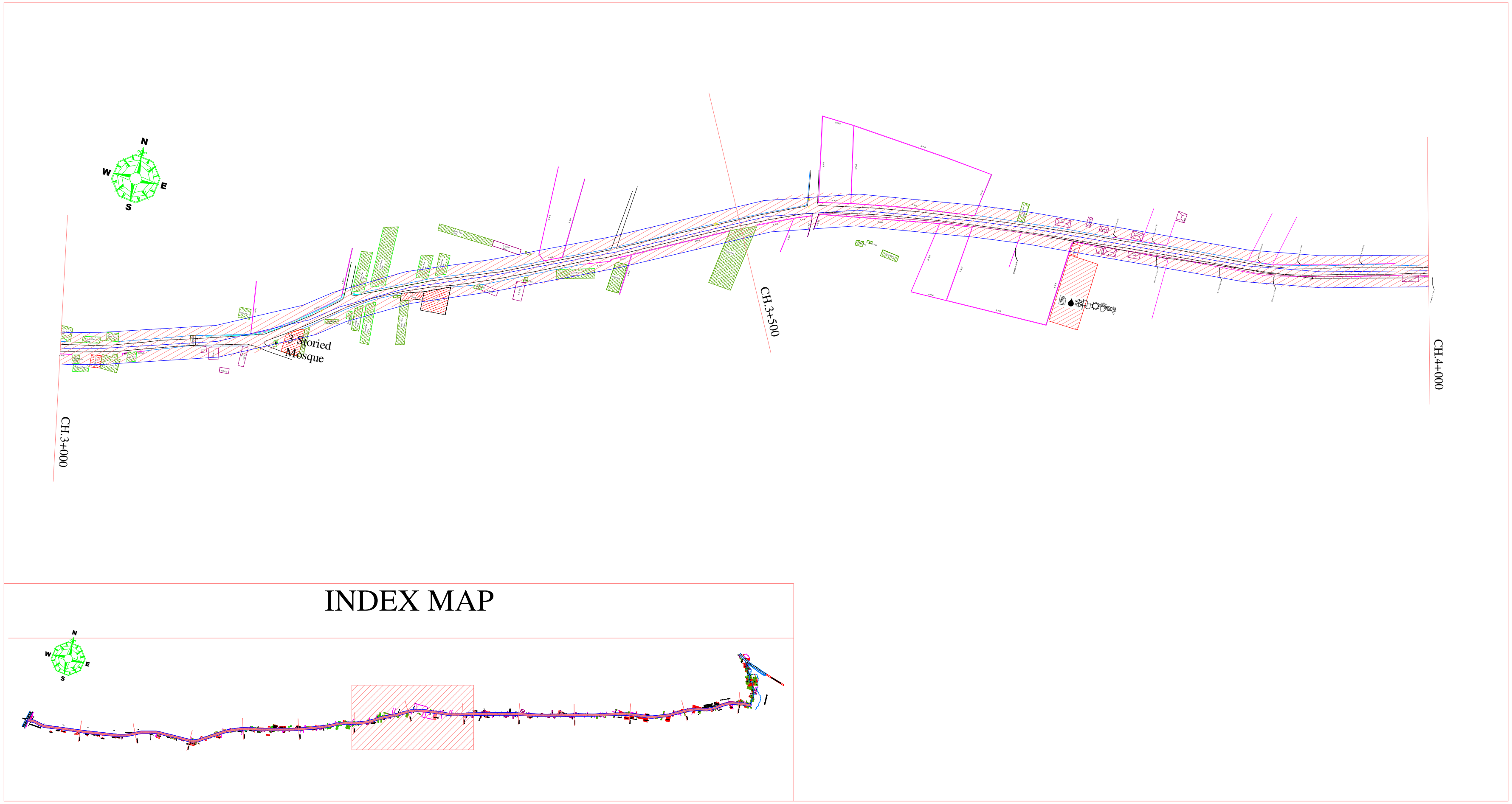
Sheet 10: Topographic Details of Alternative-2 between Ch. 0+000 to 1+000



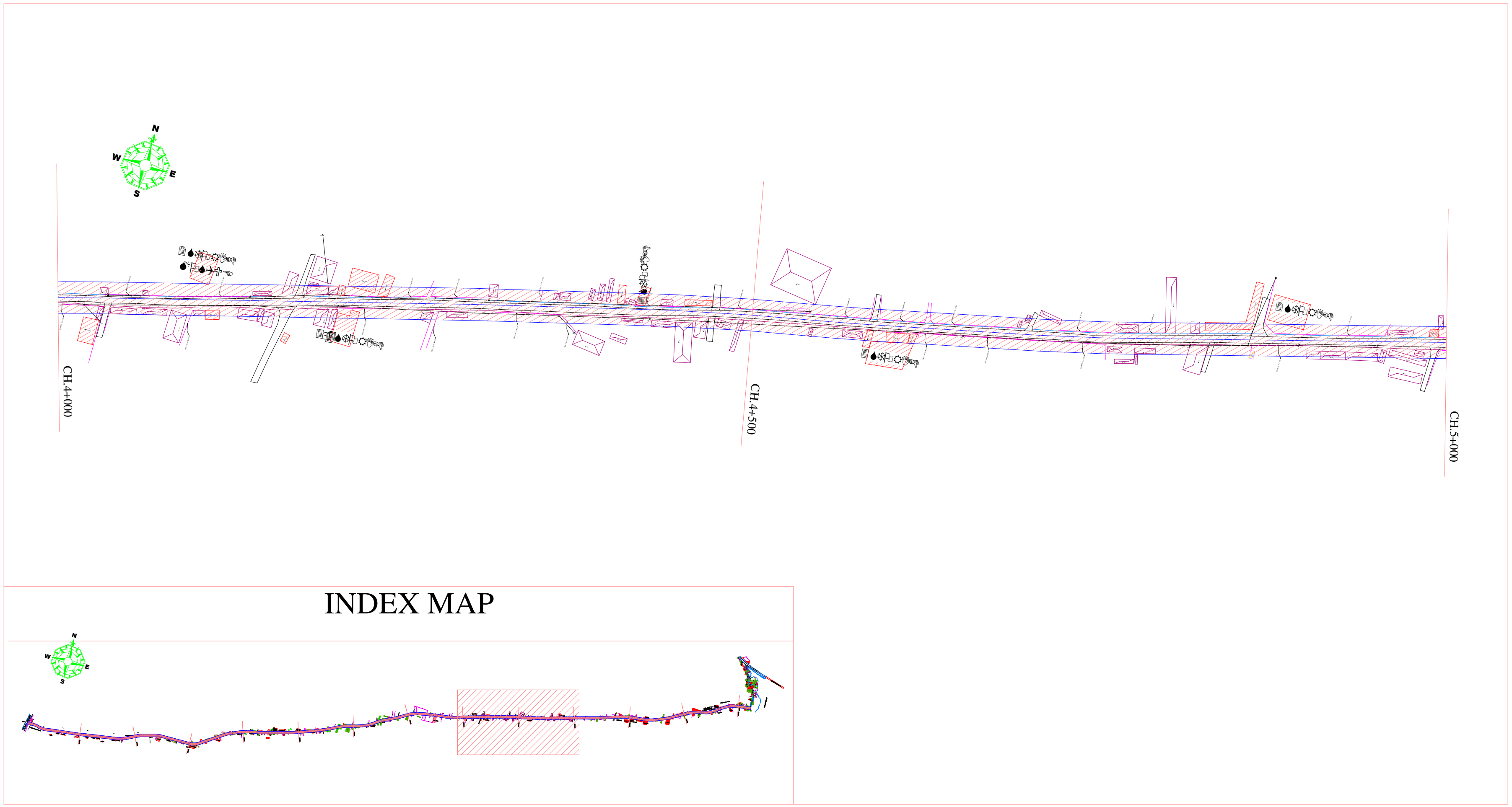
Sheet 11: Topographic Details of Alternative-2 between Ch. 1+000 to 2+000



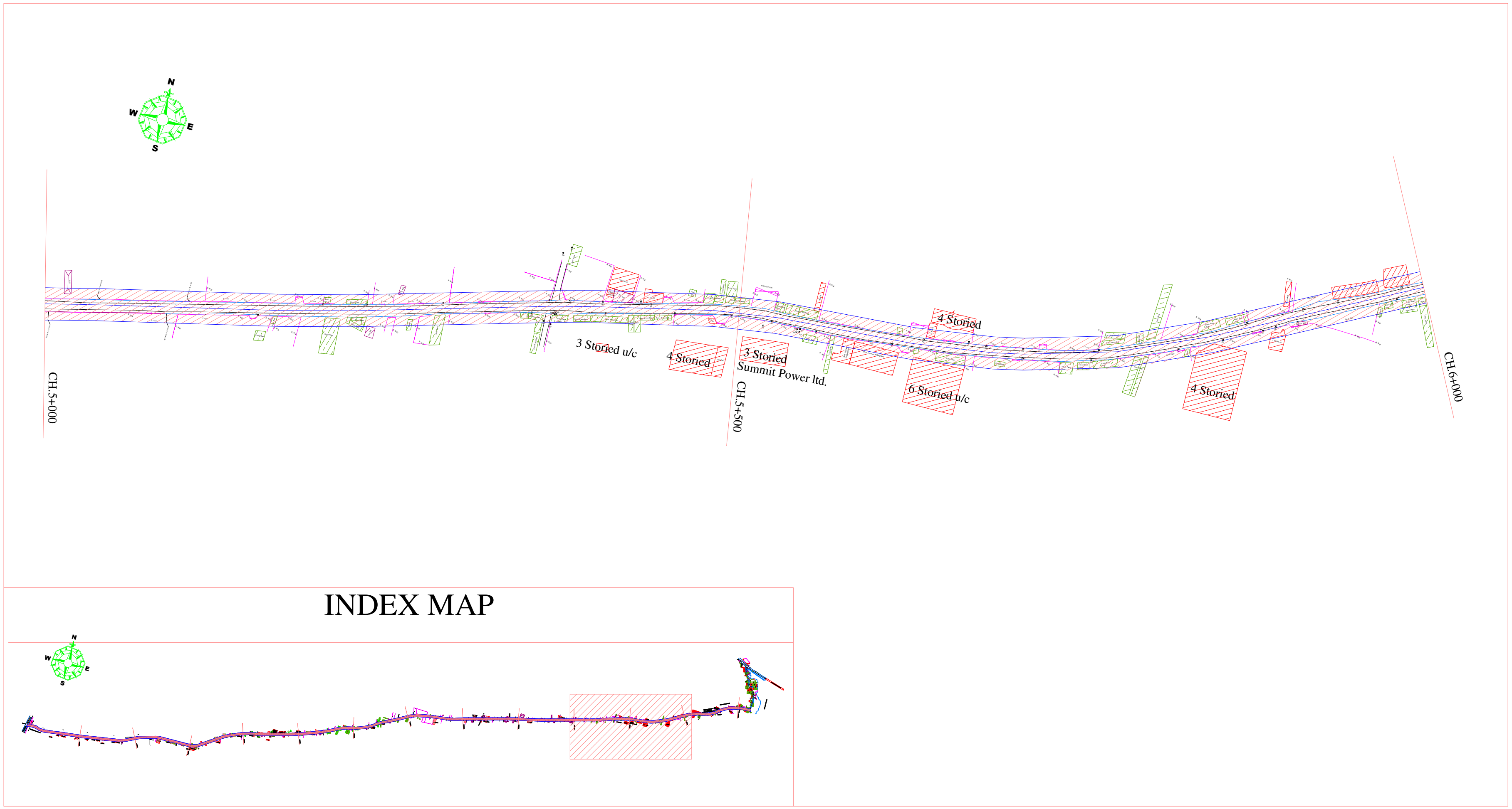
Sheet 12: Topographic Details of Alternative-2 between Ch. 2+000 to 3+000



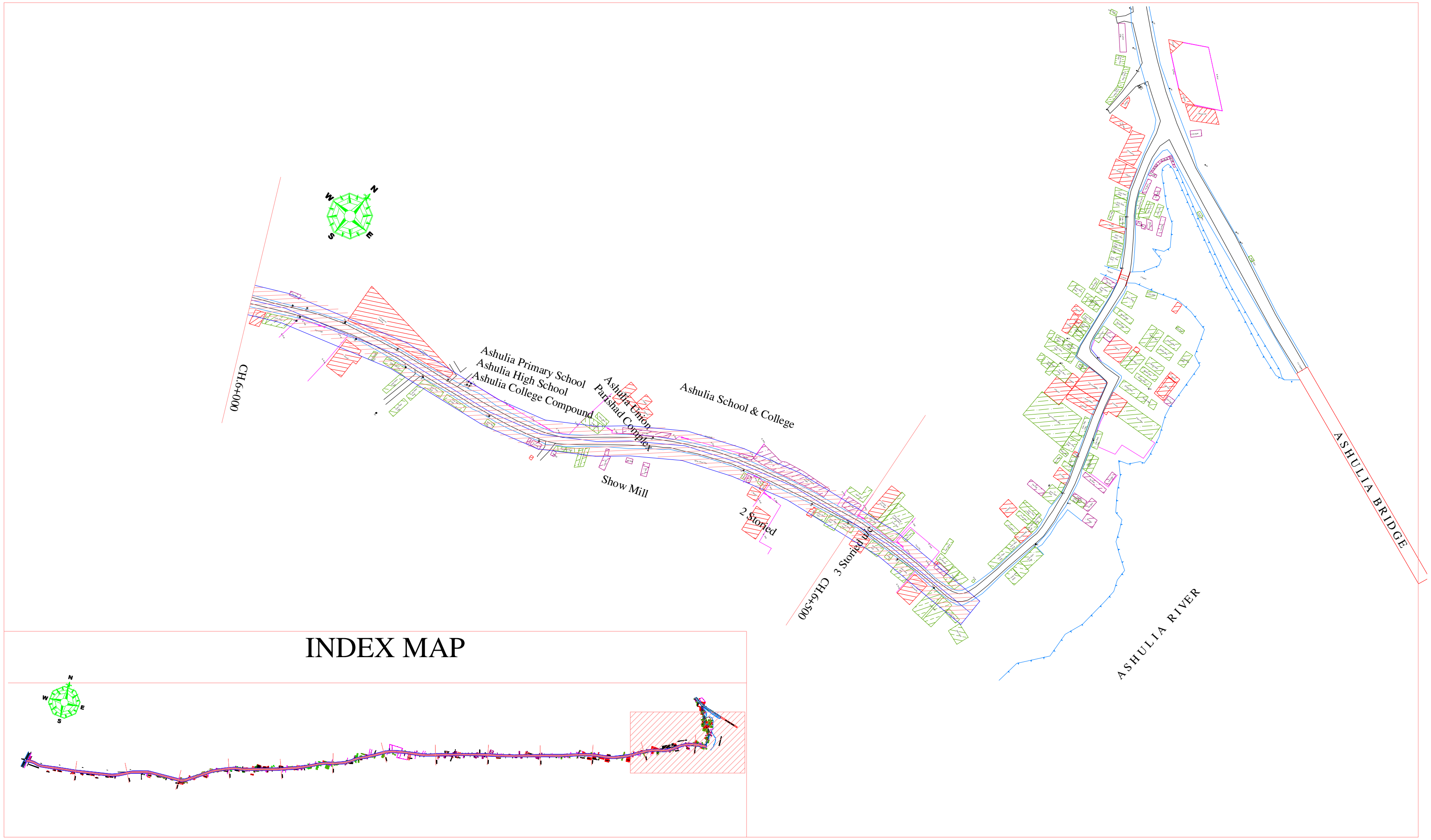
Sheet 13: Topographic Details of Alternative-2 between Ch. 3+000 to 4+000



Sheet 14: Topographic Details of Alternative-2 between Ch. 4+000 to 5+000



Sheet 15: Topographic Details of Alternative-2 between Ch. 5+000 to 6+000



Sheet 16: Topographic Details of Alternative-2 between Ch. 6+000 to 6+500

Appendix-C

C1 - Estimated Per km Cost of Road Widening
C2 - Relevant Traffic Forecasted Data

C1- Estimated Per km Cost of Road Widening (Needed for Scenario Analysis)

A. Joydebpur-Mymensingh Road Improvement/Widening Project (JMRIP) - 87.67 km

Per km cost = 13.4 /= Crore (Excluding bridge)

B. 4-Laining of Nabinagar-DEPZ-Chandra 16 km Road

Per km cost = 56.6 /= Crore (Including couple of bridges)

Considering there is no need to construct any bridge along the proposed widening road segments

Note: These above estimates are based on the previous Rate Schedule of RHD. Current Rate Schedule 2011 is on average 30% higher than the previous Rate Schedule.

Per km cost = 20 /= Crore is proposed for the DAEEP project

C2 - Relevant Traffic Forecasted Data

Forecasted number of vehicles of different categories from entry point to exit point is enlisted in Tablea 1 to 63. Here on and off ramp locations are denoted by alphabets A to H.

Ramp Location	Alignment 1	Alignment 2
A	Chandra	Chandra
B	Jirani	Jirani
C	Baipail	Baipail
D	Nabinagar	Nabinagar
E	Jirabo	BPATC
F	Ashulia Beribadh	Ashulia Beribadh
G	Abdullahpur	Abdullahpur
H	from DEE	from DEE

Table 1: Forecasted transactions at different toll plaza locations for year 2025- Heavy Truck- Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	9	140	37	98	329	259	356
	B	41	0	9	24	31	210	221	260
	C	98	11	0	39	22	72	171	201
	D	178	97	149	0	104	350	460	633
	E	52	9	26	9	0	20	27	88
	F	608	102	311	52	54	0	97	650
	G	278	119	244	162	43	143	0	85
	H	653	327	668	399	164	628	41	0

Table 2: Forecasted transactions at different toll plaza locations for year 2025- Other Truck + Pick Up- Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	9	145	33	118	368	289	375
	B	100	0	24	54	97	605	633	705
	C	379	44	0	138	106	330	776	864
	D	257	146	236	0	192	597	781	1015
	E	457	79	256	72	0	211	276	862
	F	856	148	480	67	98	0	161	1016
	G	1431	638	1374	769	280	870	0	486
	H	991	516	1111	559	317	1125	73	0

Table 3: Forecasted transactions at different toll plaza locations for year 2025- Buses- Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	2	44	12	20	63	33	58
	B	47	0	12	32	27	164	116	174
	C	170	17	0	77	28	85	134	201
	D	366	181	343	0	158	487	429	750
	E	43	7	25	8	0	11	10	42
	F	59	9	34	6	4	0	4	37
	G	230	89	226	154	26	80	0	41
	H	177	80	202	124	33	115	5	0

Table 4: Forecasted transactions at different toll plaza locations for year 2025- Mini Buses- Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	3	54	12	29	84	46	75
	B	51	0	14	30	37	215	156	221
	C	198	25	0	80	41	122	199	281
	D	138	85	145	0	76	225	204	337
	E	91	17	59	16	0	30	27	106
	F	138	26	89	12	12	0	13	102
	G	177	86	196	106	26	76	0	37
	H	179	101	231	112	43	143	7	0

Table 5: Forecasted transactions at different toll plaza locations for year 2025- Passenger Car + Jeep + Taxi - Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	19	305	69	283	881	998	1148
	B	120	0	26	60	123	763	1152	1136
	C	478	51	0	161	140	436	1483	1461
	D	365	192	307	0	286	889	1679	1930
	E	1248	200	642	182	0	605	1142	3151
	F	1900	305	977	138	227	0	541	3021
	G	3107	1281	2740	1549	637	1981	0	1416
	H	3953	1902	4066	2069	1323	4703	444	0

Table 6: Forecasted transactions at different toll plaza locations for year 2025- Motor Cycle- Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	19	4	13	40	27	38
	B	6	0	1	3	5	29	26	31
	C	31	4	0	12	7	23	45	56
	D	20	12	19	0	13	40	44	63
	E	38	7	21	6	0	15	16	56
	F	40	7	22	3	4	0	5	37
	G	57	26	55	32	10	29	0	15
	H	57	31	64	33	16	54	3	0

Table 7: Forecasted transactions at different toll plaza locations for year 2025- Two Wheelers - Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	19	4	17	51	51	65
	B	8	0	2	4	8	48	64	70
	C	41	4	0	14	12	35	105	114
	D	25	13	21	0	19	57	95	120
	E	88	14	46	13	0	40	67	202
	F	74	12	39	5	9	0	17	107
	G	175	72	156	86	35	104	0	72
	H	220	106	229	113	71	244	20	0

Table 8: Forecasted transactions at different toll plaza locations for year 2025- Heavy Truck- Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	9	132	35	90	297	231	326
	B	38	0	8	22	28	186	193	234
	C	88	10	0	34	18	61	143	173
	D	145	79	120	0	81	269	349	493
	E	48	8	24	8	0	18	23	77
	F	475	79	240	40	41	0	71	487
	G	224	96	194	128	33	109	0	66
	H	540	270	546	324	130	491	32	0

Table 9: Forecasted transactions at different toll plaza locations for year 2025- Other Truck + Pick Up- Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	9	139	31	110	337	256	340
	B	93	0	22	50	89	543	550	627
	C	339	40	0	123	93	285	649	739
	D	208	119	192	0	153	466	590	784
	E	419	74	236	66	0	187	237	756
	F	667	117	376	52	75	0	117	757
	G	1138	513	1100	611	219	668	0	370
	H	809	426	913	456	254	887	56	0

Table 10: Forecasted transactions at different toll plaza locations for year 2025- Buses- Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	2	41	11	19	57	30	53
	B	43	0	11	28	24	146	103	155
	C	148	15	0	66	24	72	115	173
	D	287	145	272	0	124	376	330	581
	E	39	6	22	7	0	10	9	37
	F	45	7	26	4	3	0	3	28
	G	182	72	180	120	20	62	0	32
	H	143	66	166	99	26	92	4	0

Table 11: Forecasted transactions at different toll plaza locations for year 2025- Mini Buses- Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	3	51	11	26	76	41	68
	B	46	0	13	27	33	191	137	196
	C	175	22	0	70	36	104	168	239
	D	109	69	117	0	60	173	156	259
	E	82	16	54	14	0	26	23	93
	F	106	20	69	9	9	0	9	76
	G	140	69	157	83	20	58	0	29
	H	145	84	190	90	34	112	5	0

Table 12: Forecasted transactions at different toll plaza locations for year 2025- Passenger Car + Jeep + Taxi - Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	18	290	66	266	816	883	1038
	B	112	0	25	56	113	693	1001	1008
	C	429	46	0	145	125	382	1242	1252
	D	296	157	250	0	229	704	1270	1493
	E	1150	186	594	168	0	544	982	2770
	F	1489	241	769	109	176	0	396	2258
	G	2473	1029	2188	1236	502	1539	0	1075
	H	3222	1565	3326	1692	1067	3743	338	0

Table 13: Forecasted transactions at different toll plaza locations for year 2025- Motor Cycle- Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	18	4	12	36	24	34
	B	5	0	1	3	4	26	22	28
	C	28	3	0	10	6	19	38	47
	D	16	10	15	0	10	31	34	49
	E	34	6	19	6	0	13	14	49
	F	31	6	17	3	3	0	4	28
	G	45	21	44	25	7	22	0	12
	H	47	25	52	27	12	43	2	0

Table 14: Forecasted transactions at different toll plaza locations for year 2025- Two Wheelers - Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	18	4	16	47	45	58
	B	8	0	2	4	7	44	56	61
	C	37	4	0	12	10	31	88	97
	D	20	11	17	0	15	45	72	93
	E	81	13	43	12	0	36	58	177
	F	58	9	30	4	7	0	13	79
	G	139	58	125	69	27	81	0	55
	H	178	87	187	93	58	194	16	0

Table 15: Forecasted transactions at different toll plaza locations for year 2025- Heavy Truck- Alignment 2

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	141	484	85	229	263	202	569
	B	21	0	46	32	86	124	91	214
	C	24	25	0	15	30	145	223	335
	D	5	4	4	0	2	11	12	17
	E	44	17	29	6	0	16	52	67
	F	186	71	183	43	58	0	153	335
	G	213	54	186	52	44	61	0	146
	H	732	187	640	224	91	522	53	0

Table 16: Forecasted transactions at different toll plaza locations for year 2025- Other Truck + Pick Up- Alignment 2

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	241	886	150	401	452	289	805
	B	95	0	252	171	456	643	395	915
	C	78	90	0	56	112	527	673	999
	D	108	93	86	0	47	236	224	311
	E	465	201	369	75	0	189	531	671
	F	299	129	357	81	108	0	233	504
	G	1538	443	1630	442	369	500	0	987
	H	1194	344	1266	429	172	970	83	0

Table 17: Forecasted transactions at different toll plaza locations for year 2025- Buses- Alignment 2

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	227	810	166	264	372	236	638
	B	61	0	73	60	95	168	102	230
	C	48	26	0	19	22	131	167	240
	D	118	48	43	0	17	106	99	134
	E	58	12	21	5	0	10	27	33
	F	31	6	17	5	4	0	10	20
	G	379	51	182	60	30	50	0	96
	H	315	43	152	62	15	105	9	0

Table 18: Forecasted transactions at different toll plaza locations for year 2025- Mini Buses- Alignment 2

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	104	427	73	129	146	80	252
	B	61	0	126	86	152	215	114	298
	C	48	39	0	27	36	171	189	316
	D	132	79	82	0	30	151	123	193
	E	111	34	69	14	0	24	57	82
	F	62	19	57	13	12	0	22	53
	G	237	48	196	53	30	40	0	77
	H	273	55	226	77	20	115	9	0

Table 19: Forecasted transactions at different toll plaza locations for year 2025- Passenger Car + Jeep + Taxi - Alignment 2

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	362	1282	213	782	730	586	1693
	B	110	0	317	210	772	901	694	1672
	C	82	107	0	63	174	676	1086	1674
	D	39	39	34	0	25	105	125	180
	E	1149	562	995	198	0	567	2001	2629
	F	576	282	749	166	304	0	684	1538
	G	2599	847	3002	797	915	1025	0	2643
	H	4208	1372	4861	1612	889	4150	444	0

Table 20: Forecasted transactions at different toll plaza locations for year 2025- Motor Cycle- Alignment 2

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	16	63	11	26	28	17	51
	B	8	0	19	13	31	42	24	61
	C	4	4	0	3	5	24	28	46
	D	12	10	9	0	5	22	20	30
	E	38	15	28	6	0	13	33	46
	F	14	6	16	4	4	0	8	20
	G	61	16	61	17	13	17	0	33
	H	71	18	71	24	9	48	4	0

Table 21: Forecasted transactions at different toll plaza locations for year 2025- Two Wheelers - Alignment 2

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	24	86	14	48	45	34	101
	B	9	0	27	18	60	71	51	126
	C	6	7	0	4	11	42	63	100
	D	6	6	5	0	3	14	16	23
	E	82	39	70	14	0	37	122	166
	F	23	11	30	7	11	0	23	54
	G	151	48	172	45	48	55	0	135
	H	237	75	270	89	45	214	21	0

Table 22: Forecasted transactions at different toll plaza locations for year 2020- Heavy Truck- Alignment 1

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	4	59	16	41	139	109	150
	B	17	0	4	10	13	89	93	110
	C	41	5	0	16	9	30	72	85
	D	75	41	63	0	44	148	194	267
	E	22	4	11	4	0	9	11	37
	F	256	43	131	22	23	0	41	274
	G	117	50	103	68	18	60	0	36
	H	276	138	282	168	69	265	17	0

Table 23: Forecasted transactions at different toll plaza locations for year 2020- Other Truck + Pick Up- Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	4	61	14	50	155	122	158
	B	42	0	10	23	41	255	267	298
	C	160	18	0	58	45	139	327	365
	D	109	62	100	0	81	252	329	428
	E	193	33	108	30	0	89	116	364
	F	361	63	202	28	41	0	68	429
	G	604	269	580	324	118	367	0	205
	H	418	218	469	236	134	475	31	0

Table 24: Forecasted transactions at different toll plaza locations for year 2020- Buses- Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	28	8	13	40	21	37
	B	30	0	7	20	17	104	74	110
	C	107	11	0	48	17	54	85	128
	D	231	114	216	0	100	309	273	477
	E	27	4	16	5	0	7	6	27
	F	37	6	21	4	2	0	3	23
	G	146	57	143	97	17	51	0	26
	H	112	51	128	78	21	73	3	0

Table 25: Forecasted transactions at different toll plaza locations for year 2020- Mini Buses- Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	2	34	7	18	53	29	48
	B	32	0	9	19	23	136	99	140
	C	125	16	0	50	26	77	126	179
	D	87	53	91	0	48	143	130	214
	E	57	11	37	10	0	19	17	68
	F	87	16	56	8	7	0	8	65
	G	113	54	124	67	16	48	0	24
	H	114	64	146	71	27	91	4	0

Table 26: Forecasted transactions at different toll plaza locations for year 2020- Passenger Car + Jeep + Taxi - Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	9	147	33	137	425	477	550
	B	58	0	13	29	59	368	551	545
	C	231	25	0	78	68	211	710	701
	D	176	93	149	0	138	429	803	925
	E	602	97	310	88	0	292	546	1509
	F	916	147	472	67	109	0	258	1445
	G	1493	617	1318	746	306	951	0	675
	H	1898	915	1955	996	635	2256	211	0

Table 27: Forecasted transactions at different toll plaza locations for year 2020- Motor Cycle- Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	12	3	9	26	18	25
	B	4	0	1	2	3	19	17	21
	C	20	2	0	8	5	15	30	37
	D	14	8	12	0	9	26	29	42
	E	25	4	14	4	0	10	11	37
	F	26	5	15	2	3	0	4	25
	G	38	17	36	21	6	19	0	10
	H	38	20	42	22	10	36	2	0

Table 28: Forecasted transactions at different toll plaza locations for year 2020- Two Wheelers - Alignment 1

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	14	3	12	37	37	47
	B	6	0	1	3	6	35	46	50
	C	30	3	0	10	8	25	76	82
	D	18	10	16	0	14	41	69	87
	E	64	10	33	9	0	29	48	146
	F	54	9	28	4	6	0	13	77
	G	127	52	113	62	25	75	0	52
	H	159	77	165	82	52	176	15	0

Table 29: Forecasted transactions at different toll plaza locations for year 2020- Heavy Truck- Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	3	52	14	36	121	95	130
	B	16	0	3	9	12	81	84	98
	C	37	4	0	15	8	27	64	75
	D	70	38	59	0	41	139	180	247
	E	19	3	10	3	0	8	10	33
	F	234	39	120	20	21	0	37	249
	G	108	46	95	63	17	56	0	33
	H	241	121	248	149	61	234	15	0

Table 30: Forecasted transactions at different toll plaza locations for year 2020- Other Truck + Pick Up- Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	3	53	12	44	136	106	137
	B	38	0	9	20	37	231	240	267
	C	142	16	0	52	40	124	292	324
	D	101	57	93	0	76	235	307	397
	E	172	30	96	27	0	80	104	323
	F	329	57	185	26	38	0	62	391
	G	554	247	533	299	109	339	0	188
	H	367	191	412	208	118	419	27	0

Table 31: Forecasted transactions at different toll plaza locations for year 2020- Buses- Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	24	7	11	35	18	32
	B	27	0	7	18	15	94	66	99
	C	96	10	0	44	16	48	76	113
	D	216	106	202	0	93	287	253	442
	E	24	4	14	5	0	6	6	24
	F	34	5	20	3	2	0	2	21
	G	134	52	131	90	15	47	0	24
	H	99	44	113	70	18	64	3	0

Table 32: Forecasted transactions at different toll plaza locations for year 2020- Mini Buses- Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	2	30	6	16	46	25	42
	B	29	0	8	17	21	123	89	126
	C	112	14	0	45	23	69	112	158
	D	81	50	85	0	45	133	121	199
	E	51	10	33	9	0	17	15	60
	F	80	15	51	7	7	0	7	59
	G	103	50	114	62	15	45	0	22
	H	100	56	128	63	24	80	4	0

Table 33: Forecasted transactions at different toll plaza locations for year 2020- Passenger Car + Jeep + Taxi - Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	8	128	29	119	372	415	475
	B	52	0	12	26	54	334	496	487
	C	206	22	0	70	61	189	632	621
	D	164	87	139	0	129	402	746	856
	E	537	86	277	79	0	262	486	1338
	F	837	135	432	61	100	0	236	1313
	G	1370	568	1214	688	282	879	0	616
	H	1664	804	1720	877	559	1993	185	0

Table 34: Forecasted transactions at different toll plaza locations for year 2020- Motor Cycle- Alignment 1 with at grade road widening

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	1	11	3	8	23	15	22
	B	3	0	1	2	3	17	15	19
	C	18	2	0	7	4	13	27	33
	D	13	7	12	0	8	25	27	39
	E	22	4	12	4	0	9	10	33
	F	24	4	14	2	2	0	3	23
	G	35	16	34	20	6	18	0	9
	H	33	18	37	20	9	32	2	0

Table 35: Forecasted transactions at different toll plaza locations for year 2020- Two Wheelers - Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	1	12	3	11	32	32	40
	B	5	0	1	3	5	32	42	45
	C	26	3	0	9	8	23	68	73
	D	17	9	14	0	13	39	64	81
	E	57	9	30	8	0	26	43	129
	F	49	8	26	4	6	0	11	70
	G	116	48	104	57	23	70	0	48
	H	139	67	146	72	45	156	13	0

Table 36: Forecasted transactions at different toll plaza locations for year 2020- Heavy Truck- Alignment 2

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	58	198	34	97	107	88	250
	B	8	0	18	13	36	50	39	93
	C	10	10	0	6	13	58	95	144
	D	1	1	1	0	0	2	2	3
	E	17	7	12	2	0	6	23	29
	F	74	29	75	17	25	0	67	147
	G	83	22	74	20	18	24	0	62
	H	338	89	304	105	45	247	27	0

Table 37: Forecasted transactions at different toll plaza locations for year 2020- Other Truck + Pick Up- Alignment 2

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	102	374	63	169	191	122	340
	B	40	0	106	72	193	271	166	386
	C	33	38	0	24	47	222	284	422
	D	45	39	36	0	20	100	94	131
	E	196	85	156	32	0	80	224	283
	F	126	54	150	34	45	0	98	213
	G	649	187	688	187	156	211	0	417
	H	504	145	534	181	73	409	35	0

Table 38: Forecasted transactions at different toll plaza locations for year 2020- Buses- Alignment 2

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	144	514	105	167	236	150	404
	B	39	0	46	38	60	107	65	146
	C	30	16	0	12	14	83	106	152
	D	75	30	27	0	11	67	63	85
	E	37	7	13	3	0	6	17	21
	F	20	4	11	3	2	0	6	13
	G	240	32	116	38	19	32	0	61
	H	200	27	96	39	9	66	6	0

Table 39: Forecasted transactions at different toll plaza locations for year 2020- Mini Buses- Alignment 2

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	66	271	46	82	92	51	160
	B	39	0	80	54	96	136	72	189
	C	31	25	0	17	23	108	120	200
	D	83	50	52	0	19	95	78	123
	E	70	21	44	9	0	15	36	52
	F	39	12	36	8	7	0	14	33
	G	150	30	124	34	19	25	0	49
	H	173	35	143	49	13	73	5	0

Table 40: Forecasted transactions at different toll plaza locations for year 2020- Passenger Car + Jeep + Taxi - Alignment 2

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	174	616	102	375	351	281	813
	B	53	0	152	101	371	433	333	803
	C	40	52	0	30	84	325	522	804
	D	19	18	16	0	12	50	60	87
	E	552	270	478	95	0	272	961	1263
	F	277	135	360	80	146	0	329	739
	G	1248	407	1442	383	440	493	0	1269
	H	2021	659	2335	774	427	1994	213	0

Table 41: Forecasted transactions at different toll plaza locations for year 2020- Motor Cycle- Alignment 2

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	11	42	7	17	19	11	34
	B	5	0	12	9	20	28	16	40
	C	3	3	0	2	3	16	19	30
	D	8	6	6	0	3	15	13	20
	E	25	10	19	4	0	8	22	30
	F	9	4	11	2	3	0	6	13
	G	41	11	41	11	8	11	0	22
	H	47	12	47	16	6	32	3	0

Table 42: Forecasted transactions at different toll plaza locations for year 2020- Two Wheelers - Alignment 2

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	17	62	10	35	33	24	73
	B	7	0	19	13	43	51	37	91
	C	4	5	0	3	8	31	46	73
	D	4	4	4	0	2	10	11	17
	E	59	28	51	10	0	27	88	120
	F	17	8	21	5	8	0	17	39
	G	109	35	124	33	35	39	0	98
	H	171	54	195	65	33	155	15	0

Table 43: Forecasted transactions at different toll plaza locations for year 2015- Heavy Truck- Alignment 1

	Off Ramp Location								
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	2	24	6	17	55	44	61
	B	7	0	2	4	5	35	37	44
	C	17	2	0	6	4	12	29	34
	D	30	16	25	0	18	59	78	107
	E	9	1	4	1	0	3	4	15
	F	103	17	52	9	9	0	16	110
	G	47	20	41	27	7	24	0	15
	H	111	55	113	67	28	106	7	0

Table 44: Forecasted transactions at different toll plaza locations for year 2015- Other Truck + Pick Up- Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	2	25	6	20	62	49	64
	B	17	0	4	9	16	102	107	120
	C	64	7	0	23	18	56	131	146
	D	44	25	40	0	32	101	132	172
	E	77	13	43	12	0	36	47	146
	F	145	25	81	11	16	0	27	172
	G	242	108	233	130	47	147	0	82
	H	168	87	188	95	53	190	12	0

Table 45: Forecasted transactions at different toll plaza locations for year 2015- Buses- Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	1	18	5	9	26	14	25
	B	19	0	5	13	11	69	49	73
	C	70	7	0	31	12	36	57	86
	D	150	74	139	0	66	204	183	319
	E	18	3	10	3	0	5	4	18
	F	25	4	14	2	2	0	2	16
	G	97	37	94	63	11	34	0	18
	H	74	33	84	51	14	49	2	0

Table 46: Forecasted transactions at different toll plaza locations for year 2015- Mini Buses- Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	1	22	5	12	35	20	32
	B	21	0	6	12	15	89	66	93
	C	81	10	0	32	17	51	85	119
	D	57	34	59	0	32	94	87	143
	E	38	7	24	6	0	12	12	45
	F	57	11	36	5	5	0	5	44
	G	75	36	81	44	11	32	0	16
	H	75	42	95	46	18	61	3	0

Table 47: Forecasted transactions at different toll plaza locations for year 2015- Passenger Car + Jeep + Taxi - Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	5	85	19	78	244	267	311
	B	34	0	7	17	34	212	309	308
	C	134	14	0	45	39	121	398	397
	D	102	54	86	0	79	246	450	523
	E	347	56	179	51	0	167	305	850
	F	526	85	272	39	62	0	144	812
	G	849	352	752	427	173	537	0	376
	H	1078	522	1115	569	359	1274	116	0

Table 48: Forecasted transactions at different toll plaza locations for year 2015- Motor Cycle- Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	0	4	1	3	9	6	8
	B	1	0	0	1	1	6	6	7
	C	7	1	0	3	2	5	10	12
	D	4	3	4	0	3	9	10	14
	E	8	1	5	1	0	3	4	12
	F	9	2	5	1	1	0	1	8
	G	12	6	12	7	2	6	0	3
	H	12	7	14	7	3	12	1	0

Table 49: Forecasted transactions at different toll plaza locations for year 2015- Two Wheelers - Alignment 1

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	0	4	1	3	10	10	12
	B	2	0	0	1	2	9	12	13
	C	8	1	0	3	2	7	20	22
	D	5	3	4	0	4	11	18	23
	E	17	3	9	2	0	8	13	39
	F	14	2	8	1	2	0	3	20
	G	34	14	30	17	7	20	0	14
	H	42	20	44	22	14	47	4	0

Table 50: Forecasted transactions at different toll plaza locations for year 2015- Heavy Truck- Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	1	21	5	14	49	38	52
	B	6	0	1	4	5	32	34	40
	C	15	2	0	6	3	11	26	30
	D	28	15	24	0	16	55	72	99
	E	8	1	4	1	0	3	4	13
	F	94	16	48	8	8	0	15	100
	G	43	19	38	25	7	22	0	13
	H	97	49	99	60	24	94	6	0

Table 51: Forecasted transactions at different toll plaza locations for year 2015- Other Truck + Pick Up- Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	1	21	5	17	54	42	55
	B	15	0	4	8	15	92	96	107
	C	57	7	0	21	16	50	117	130
	D	41	23	37	0	30	94	123	160
	E	69	12	39	11	0	32	42	130
	F	132	23	74	10	15	0	25	157
	G	223	99	214	120	44	135	0	76
	H	148	77	165	83	47	168	11	0

Table 52: Forecasted transactions at different toll plaza locations for year 2015- Buses- Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	1	16	4	7	23	12	21
	B	17	0	4	11	10	62	44	66
	C	62	6	0	28	10	32	51	76
	D	140	69	130	0	62	190	170	296
	E	16	2	9	3	0	4	4	16
	F	22	3	13	2	2	0	2	14
	G	89	34	86	59	10	32	0	16
	H	65	29	74	45	12	43	2	0

Table 53: Forecasted transactions at different toll plaza locations for year 2015- Mini Buses- Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	1	19	4	10	31	17	28
	B	19	0	5	11	14	81	60	84
	C	73	9	0	29	15	45	75	106
	D	53	32	55	0	30	88	81	133
	E	34	6	21	6	0	11	10	40
	F	52	10	33	5	5	0	5	40
	G	68	33	74	41	10	30	0	15
	H	66	37	84	41	16	54	2	0

Table 54: Forecasted transactions at different toll plaza locations for year 2015- Passenger Car + Jeep + Taxi - Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	5	74	17	69	213	232	269
	B	30	0	7	15	31	192	278	276
	C	119	13	0	41	35	109	354	352
	D	95	50	80	0	74	231	418	484
	E	309	50	160	45	0	150	271	754
	F	480	78	249	35	57	0	131	738
	G	779	324	692	393	160	497	0	343
	H	946	459	980	501	316	1125	102	0

Table 55: Forecasted transactions at different toll plaza locations for year 2015- Motor Cycle- Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	0	4	1	2	8	5	7
	B	1	0	0	1	1	6	5	6
	C	6	1	0	2	1	4	9	11
	D	4	2	4	0	3	8	9	13
	E	7	1	4	1	0	3	3	11
	F	8	1	4	1	1	0	1	7
	G	11	5	11	6	2	6	0	3
	H	11	6	12	6	3	10	1	0

Table 56: Forecasted transactions at different toll plaza locations for year 2015- Two Wheelers - Alignment 1 with at grade road widening

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	0	3	1	3	9	8	11
	B	1	0	0	1	1	8	11	12
	C	7	1	0	2	2	6	18	19
	D	5	2	4	0	3	10	17	21
	E	15	2	8	2	0	7	11	34
	F	13	2	7	1	2	0	3	19
	G	31	13	28	15	6	18	0	13
	H	37	18	39	19	12	41	3	0

Table 57: Forecasted transactions at different toll plaza locations for year 2015- Heavy Truck- Alignment 2

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	23	79	14	39	43	35	100
	B	3	0	7	5	15	20	16	37
	C	4	4	0	2	5	23	38	58
	D	0	0	0	0	0	1	1	1
	E	7	3	5	1	0	3	9	12
	F	30	12	30	7	10	0	27	59
	G	33	9	30	8	7	10	0	25
	H	136	36	122	42	18	99	11	0

Table 58: Forecasted transactions at different toll plaza locations for year 2015- Other Truck + Pick Up- Alignment 2

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	41	150	25	68	77	49	136
	B	16	0	43	29	77	109	67	155
	C	13	15	0	9	19	89	114	169
	D	18	16	14	0	8	40	38	53
	E	79	34	63	13	0	32	90	114
	F	51	22	60	14	18	0	39	85
	G	260	75	276	75	62	85	0	167
	H	202	58	214	73	29	164	14	0

Table 59: Forecasted transactions at different toll plaza locations for year 2015- Buses- Alignment 2

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	95	339	69	110	156	99	267
	B	25	0	31	25	40	70	43	96
	C	20	11	0	8	9	55	70	100
	D	49	20	18	0	7	44	42	56
	E	24	5	9	2	0	4	11	14
	F	13	3	7	2	2	0	4	9
	G	158	21	76	25	12	21	0	40
	H	132	18	63	26	6	44	4	0

Table 60: Forecasted transactions at different toll plaza locations for year 2015- Mini Buses- Alignment 2

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	43	179	30	54	61	34	106
	B	25	0	53	36	63	90	48	124
	C	20	16	0	11	15	71	79	132
	D	55	33	34	0	12	63	52	81
	E	46	14	29	6	0	10	24	34
	F	26	8	24	5	5	0	9	22
	G	99	20	82	22	12	17	0	32
	H	114	23	95	32	9	48	4	0

Table 61: Forecasted transactions at different toll plaza locations for year 2015- Passenger Car + Jeep + Taxi - Alignment 2

		Off Ramp Location							
On Ramp Location		A	B	C	D	E	F	G	H
	A	0	99	350	58	213	199	160	462
	B	30	0	86	57	210	246	189	456
	C	22	29	0	17	47	184	296	456
	D	11	11	9	0	7	29	34	49
	E	313	153	271	54	0	155	546	717
	F	157	77	204	45	83	0	187	420
	G	709	231	819	217	250	280	0	721
	H	1148	374	1326	440	242	1132	121	0

Table 62: Forecasted transactions at different toll plaza locations for year 2015- Motor Cycle- Alignment 2

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	4	14	2	6	6	4	11
	B	2	0	4	3	7	9	5	13
	C	1	1	0	1	1	5	6	10
	D	3	2	2	0	1	5	4	7
	E	8	3	6	1	0	3	7	10
	F	3	1	3	1	1	0	2	4
	G	13	3	13	4	3	4	0	7
	H	15	4	15	5	2	10	1	0

Table 63: Forecasted transactions at different toll plaza locations for year 2015- Two Wheelers - Alignment 2

		Off Ramp Location							
		A	B	C	D	E	F	G	H
On Ramp Location	A	0	5	16	3	9	9	7	19
	B	2	0	5	3	12	14	10	24
	C	1	1	0	1	2	8	12	19
	D	1	1	1	0	1	3	3	5
	E	16	8	14	3	0	7	24	32
	F	4	2	6	1	2	0	4	10
	G	29	9	33	9	9	11	0	26
	H	46	14	52	17	9	41	4	0

Appendix 2

Forecasted hourly traffic at different time segments (peak, off-peak, super-off-peak) for different modeled scenarios are summarized in table to table. Hourly traffic estimates are enlisted according to the roadway links and corresponding modeled travel time is also reported in these tables.

Table 1: Hourly Traffic in 2025 – Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	197	321	71	79	1159	43	132	26.37
Abdullahpur - Ashulia	241	673	142	135	1784	75	204	18.13
Ashulia - Jirabo	311	779	150	156	2029	86	223	32.24
Jirabo - Baipail	315	899	159	183	2398	109	276	7.25
Baipail - Jirani	254	787	176	215	1883	103	229	19.78
Jirani - Chandra	282	863	204	250	1989	112	243	26.37
Chandra-Jirani	85	92	23	30	235	24	28	26.37
Jirani - Baipail	145	259	83	107	468	43	57	19.78
Baipail - Nabinagar	190	603	143	178	1392	81	173	9.89
Nabinagar - Baipail	138	225	268	119	362	36	47	9.89
Baipail - Jirabo	226	387	281	181	664	63	83	7.25
Jirabo - Ashulia	240	524	294	211	1069	87	139	32.24
Ashulia - Abdullahpur	232	623	278	223	1413	105	187	18.13
Abdullahpur - DEE	269	823	319	257	1812	124	233	26.37

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	163	266	42	46	1046	15	57	8.42
Abdullahpur - Ashulia	200	557	83	79	1609	25	88	5.79
Ashulia - Jirabo	258	645	88	91	1831	29	96	10.29
Jirabo - Baipail	261	745	93	107	2164	37	119	2.32
Baipail - Jirani	191	596	96	118	1537	32	90	6.32
Jirani - Chandra	214	659	112	138	1633	35	96	8.42
Chandra-Jirani	70	76	13	17	210	8	12	8.42
Jirani - Baipail	119	214	49	62	420	14	25	6.32
Baipail - Nabinagar	157	500	84	104	1256	27	74	3.16
Nabinagar - Baipail	112	183	154	69	320	12	20	3.16

Baipail - Jirabo	185	317	162	105	592	21	36	2.32
Jirabo - Ashulia	197	430	169	122	958	29	60	10.29
Ashulia - Abdullahpur	190	513	161	130	1268	35	80	5.79
Abdullahpur - DEE	220	678	185	150	1629	42	100	8.42

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	110	179	54	60	744	41	108	23.70
Abdullahpur - Ashulia	134	375	109	103	1144	71	167	16.30
Ashulia - Jirabo	174	434	115	119	1301	81	183	28.98
Jirabo - Baipail	175	501	121	140	1538	103	226	6.52
Baipail - Jirani	142	439	134	164	1208	98	188	17.78
Jirani - Chandra	157	481	155	191	1276	106	199	23.70
Chandra-Jirani	47	52	17	23	151	23	23	23.70
Jirani - Baipail	81	145	64	81	300	40	47	17.78
Baipail - Nabinagar	106	336	109	135	893	77	141	8.89
Nabinagar - Baipail	77	125	204	91	232	34	39	8.89
Baipail - Jirabo	126	216	214	138	426	60	68	6.52
Jirabo - Ashulia	134	292	224	161	686	82	114	28.98
Ashulia - Abdullahpur	129	347	212	170	906	99	153	16.30
Abdullahpur - DEE	150	459	243	196	1162	117	191	23.70

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	251	409	85	94	1609	46	139	20.56
Abdullahpur - Ashulia	307	857	170	162	2476	79	215	14.13
Ashulia - Jirabo	397	993	180	187	2817	90	235	25.13
Jirabo - Baipail	401	1146	190	219	3329	115	290	5.65
Baipail - Jirani	324	1004	210	257	2614	109	241	15.42
Jirani - Chandra	359	1100	243	299	2762	118	255	20.56
Chandra-Jirani	107	117	27	35	323	25	29	20.56
Jirani - Baipail	183	329	100	127	647	45	60	15.42
Baipail - Nabinagar	242	769	171	212	1932	85	181	7.71
Nabinagar - Baipail	172	281	314	140	492	38	49	7.71
Baipail - Jirabo	284	488	331	214	911	66	87	5.65

Jirabo - Ashulia	302	662	346	250	1474	91	145	25.13
Ashulia - Abdullahpur	292	789	328	265	1951	110	196	14.13
Abdullahpur - DEE	339	1044	377	305	2506	130	244	20.56

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	131	213	33	37	837	12	45	7.08
Abdullahpur - Ashulia	160	449	67	64	1295	20	71	4.87
Ashulia - Jirabo	206	519	71	73	1470	23	77	8.65
Jirabo - Baipail	210	610	76	88	1773	30	98	1.95
Baipail - Jirani	169	528	82	101	1383	28	80	5.31
Jirani - Chandra	186	578	95	117	1458	30	85	7.08
Chandra-Jirani	63	68	12	15	189	7	11	7.08
Jirani - Baipail	102	177	40	51	355	12	21	5.31
Baipail - Nabinagar	126	403	67	83	1019	22	60	2.65
Nabinagar - Baipail	89	146	123	55	256	10	16	2.65
Baipail - Jirabo	153	259	130	85	489	17	29	1.95
Jirabo - Ashulia	163	359	137	100	815	25	51	8.65
Ashulia - Abdullahpur	159	435	131	108	1096	30	69	4.87
Abdullahpur - DEE	183	569	150	124	1387	35	85	7.08

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	213	347	77	85	1252	47	143	19.24
Abdullahpur - Ashulia	262	739	156	148	1950	82	224	13.23
Ashulia - Jirabo	340	856	165	171	2220	94	245	23.52
Jirabo - Baipail	344	992	174	202	2640	120	305	5.29
Baipail - Jirani	279	870	194	238	2076	114	253	14.43
Jirani - Chandra	310	957	226	278	2197	124	268	19.24
Chandra-Jirani	101	110	27	35	279	29	33	19.24
Jirani - Baipail	169	301	96	123	546	50	67	14.43
Baipail - Nabinagar	208	667	158	196	1535	90	191	7.21
Nabinagar - Baipail	148	243	289	129	390	39	51	7.21
Baipail - Jirabo	254	435	308	202	749	71	94	5.29
Jirabo - Ashulia	270	588	323	235	1207	98	157	23.52

Ashulia - Abdullahpur	261	701	306	250	1595	118	211	13.23
Abdullahpur - DEE	302	923	352	287	2038	139	262	19.24

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	149	242	73	81	953	53	138	24.62
Abdullahpur - Ashulia	183	515	149	141	1483	92	217	16.92
Ashulia - Jirabo	246	609	159	166	1719	107	240	30.09
Jirabo - Baipail	248	702	167	195	2030	136	297	6.77
Baipail - Jirani	199	611	185	227	1589	128	246	18.46
Jirani - Chandra	219	667	212	262	1674	138	259	24.62
Chandra-Jirani	66	72	24	31	199	30	30	24.62
Jirani - Baipail	110	194	85	108	385	52	60	18.46
Baipail - Nabinagar	148	467	150	187	1173	100	185	9.23
Nabinagar - Baipail	103	168	273	122	294	44	49	9.23
Baipail - Jirabo	170	289	286	184	543	76	87	6.77
Jirabo - Ashulia	182	406	301	219	922	109	153	30.09
Ashulia - Abdullahpur	176	483	286	233	1209	131	205	16.92
Abdullahpur - DEE	205	638	329	269	1546	155	254	24.62

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	139	253	40	44	994	14	54	8.69
Abdullahpur - Ashulia	182	588	88	83	1664	26	91	7.49
Ashulia- BPATC	240	684	93	96	1908	30	100	13.25
BPATC - Nabinagar	253	826	102	118	2367	40	130	6.74
Nabinagar - Baipail	256	889	134	163	2336	47	134	4.18
Baipail- Jirani	301	1032	171	210	2555	53	148	7.50
Jirani-Chandra	336	1198	216	269	2820	64	168	8.85
Chandra - Jirani	112	183	154	69	320	12	20	8.85
Jirani - Baipail	132	325	179	119	543	22	38	7.50
Baipail - Nabinagar	112	276	152	101	462	18	32	4.18
Nabinagar - BPATC	111	382	141	110	861	26	58	6.74
BPATC - Ashulia	124	524	151	132	1320	36	88	13.25
Ashulia - Abdullahpur	185	891	204	177	2119	50	132	7.49
Abdullahpur - DEE	230	1035	241	224	2338	57	145	8.69

Table 2: Hourly Traffic in 2025 – Off- Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	127	208	46	51	750	28	85	14.33
Abdullahpur - Ashulia	156	435	92	87	1154	48	132	9.85
Ashulia - Jirabo	202	504	97	101	1313	55	145	17.52
Jirabo - Baipail	204	582	103	119	1552	70	179	3.94
Baipail - Jirani	165	509	114	139	1219	67	148	10.75
Jirani - Chandra	182	559	132	162	1287	72	157	14.33
Chandra-Jirani	55	60	15	19	152	16	18	14.33
Jirani - Baipail	94	168	54	69	303	28	37	10.75
Baipail - Nabinagar	123	390	93	115	900	52	112	5.37
Nabinagar - Baipail	89	146	173	77	234	24	31	5.37
Baipail - Jirabo	146	251	182	117	430	41	54	3.94
Jirabo - Ashulia	155	339	190	136	692	56	90	17.52
Ashulia - Abdullahpur	150	403	180	144	914	68	121	9.85
Abdullahpur - DEE	174	532	207	166	1172	80	151	14.33

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	106	172	27	30	677	9	37	6.23
Abdullahpur - Ashulia	129	361	54	51	1041	16	57	4.29
Ashulia - Jirabo	167	418	57	59	1185	19	62	7.62
Jirabo - Baipail	169	482	60	69	1400	24	77	1.71
Baipail - Jirani	124	386	62	76	995	21	58	4.68
Jirani - Chandra	138	427	73	90	1056	23	62	6.23
Chandra-Jirani	45	49	9	11	136	5	8	6.23
Jirani - Baipail	77	139	32	40	272	9	16	4.68
Baipail - Nabinagar	102	323	54	67	813	18	48	2.34
Nabinagar - Baipail	72	118	100	44	207	8	13	2.34
Baipail - Jirabo	120	205	105	68	383	14	23	1.71
Jirabo - Ashulia	127	278	110	79	620	19	39	7.62
Ashulia - Abdullahpur	123	332	104	84	821	23	52	4.29
Abdullahpur - DEE	143	439	120	97	1054	27	65	6.23

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	71	116	35	39	481	27	70	12.39
Abdullahpur - Ashulia	87	243	70	67	740	46	108	8.52
Ashulia - Jirabo	112	281	74	77	842	52	118	15.14
Jirabo - Baipail	114	324	78	90	995	67	146	3.41
Baipail - Jirani	92	284	87	106	782	63	121	9.29
Jirani - Chandra	102	311	100	123	826	68	128	12.39
Chandra-Jirani	31	33	11	15	97	15	15	12.39
Jirani - Baipail	52	94	41	53	194	26	30	9.29
Baipail - Nabinagar	68	218	71	88	578	50	91	4.65
Nabinagar - Baipail	50	81	132	59	150	22	25	4.65
Baipail - Jirabo	82	140	139	89	276	39	44	3.41
Jirabo - Ashulia	87	189	145	104	444	53	74	15.14
Ashulia - Abdullahpur	84	225	137	110	586	64	99	8.52
Abdullahpur - DEE	97	297	158	127	752	76	123	12.39

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	162	265	55	61	1041	30	90	11.76
Abdullahpur - Ashulia	199	555	110	105	1602	51	139	8.09
Ashulia - Jirabo	257	643	116	121	1823	58	152	14.38
Jirabo - Baipail	260	742	123	142	2154	74	188	3.24
Baipail - Jirani	210	649	136	166	1692	70	156	8.82
Jirani - Chandra	232	712	157	193	1787	76	165	11.76
Chandra-Jirani	69	75	17	23	209	16	19	11.76
Jirani - Baipail	119	213	64	82	419	29	39	8.82
Baipail - Nabinagar	157	497	111	137	1250	55	117	4.41
Nabinagar - Baipail	111	182	203	91	319	24	31	4.41
Baipail - Jirabo	184	316	214	138	590	43	56	3.24
Jirabo - Ashulia	196	428	224	161	954	59	94	14.38
Ashulia - Abdullahpur	189	510	212	171	1263	71	127	8.09
Abdullahpur - DEE	219	675	244	198	1621	84	158	11.76

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	84	138	22	24	541	8	29	6.17
Abdullahpur - Ashulia	104	291	43	41	838	13	46	4.24
Ashulia - Jirabo	134	336	46	47	951	15	50	7.54
Jirabo - Baipail	136	395	49	57	1147	20	63	1.70
Baipail - Jirani	109	342	53	65	895	18	52	4.63
Jirani - Chandra	121	374	62	76	944	20	55	6.17
Chandra-Jirani	41	44	8	10	122	5	7	6.17
Jirani - Baipail	66	115	26	33	229	8	13	4.63
Baipail - Nabinagar	81	261	43	54	660	14	39	2.31
Nabinagar - Baipail	58	95	80	36	166	6	10	2.31
Baipail - Jirabo	99	167	84	55	316	11	19	1.70
Jirabo - Ashulia	106	232	89	65	527	16	33	7.54
Ashulia - Abdullahpur	103	282	85	70	709	19	45	4.24
Abdullahpur - DEE	119	368	97	80	898	23	55	6.17

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	138	224	50	55	810	30	92	10.68
Abdullahpur - Ashulia	170	478	101	96	1262	53	145	7.34
Ashulia - Jirabo	220	554	107	111	1437	61	158	13.05
Jirabo - Baipail	223	642	113	131	1708	78	197	2.94
Baipail - Jirani	180	563	126	154	1343	74	164	8.01
Jirani - Chandra	201	619	146	180	1422	80	174	10.68
Chandra-Jirani	65	71	17	23	181	18	21	10.68
Jirani - Baipail	110	194	62	80	353	32	43	8.01
Baipail - Nabinagar	135	431	103	127	993	58	123	4.00
Nabinagar - Baipail	96	157	187	83	252	25	33	4.00
Baipail - Jirabo	164	281	199	130	485	46	61	2.94
Jirabo - Ashulia	175	381	209	152	781	64	101	13.05
Ashulia - Abdullahpur	169	453	198	162	1032	77	137	7.34
Abdullahpur - DEE	195	597	228	186	1319	90	170	10.68

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	96	157	48	53	617	34	90	13.25
Abdullahpur - Ashulia	119	333	96	91	959	59	140	9.11
Ashulia - Jirabo	159	394	103	108	1112	69	155	16.20
Jirabo - Baipail	160	454	108	126	1313	88	192	3.64
Baipail - Jirani	129	395	119	147	1028	83	159	9.94
Jirani - Chandra	142	431	137	169	1083	89	168	13.25
Chandra-Jirani	43	47	16	20	129	19	19	13.25
Jirani - Baipail	71	125	55	70	249	34	39	9.94
Baipail - Nabinagar	96	302	97	121	759	65	120	4.97
Nabinagar - Baipail	66	109	177	79	190	28	32	4.97
Baipail - Jirabo	110	187	185	119	351	49	56	3.64
Jirabo - Ashulia	118	263	195	142	597	71	99	16.20
Ashulia - Abdullahpur	114	312	185	151	783	85	132	9.11
Abdullahpur - DEE	132	413	213	174	1000	100	164	13.25

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	90	163	26	28	643	9	35	7.25
Abdullahpur - Ashulia	118	380	57	53	1077	17	59	6.25
Ashulia- BPATC	155	443	60	62	1234	20	65	11.05
BPATC - Nabinagar	164	535	66	76	1531	26	84	5.62
Nabinagar - Baipail	166	575	87	105	1511	30	87	3.49
Baipail- Jirani	195	668	111	136	1653	34	95	6.26
Jirani-Chandra	217	775	140	174	1824	42	109	7.38
Chandra - Jirani	72	118	100	44	207	8	13	7.38
Jirani - Baipail	85	210	116	77	352	14	24	6.26
Baipail - Nabinagar	73	179	98	66	299	12	21	3.49
Nabinagar - BPATC	72	247	92	71	557	17	38	5.62
BPATC - Ashulia	80	339	98	86	854	23	57	11.05
Ashulia - Abdullahpur	119	577	132	114	1371	33	86	6.25
Abdullahpur - DEE	149	670	156	145	1513	37	94	7.25

Table 3: Hourly Traffic in 2025 – Super- Off- Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	58	94	21	23	341	13	39	10.17
Abdullahpur - Ashulia	71	198	42	40	525	22	60	6.99
Ashulia - Jirabo	92	229	44	46	597	25	66	12.43
Jirabo - Baipail	93	264	47	54	705	32	81	2.80
Baipail - Jirani	75	232	52	63	554	30	67	7.63
Jirani - Chandra	83	254	60	74	585	33	71	10.17
Chandra-Jirani	25	27	7	9	69	7	8	10.17
Jirani - Baipail	43	76	25	31	138	13	17	7.63
Baipail - Nabinagar	56	177	42	52	409	24	51	3.81
Nabinagar - Baipail	40	66	79	35	106	11	14	3.81
Baipail - Jirabo	66	114	83	53	195	19	25	2.80
Jirabo - Ashulia	71	154	86	62	315	26	41	12.43
Ashulia - Abdullahpur	68	183	82	66	415	31	55	6.99
Abdullahpur - DEE	79	242	94	76	533	36	69	10.17

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	48	78	12	14	308	4	17	5.78
Abdullahpur - Ashulia	59	164	25	23	473	7	26	3.98
Ashulia - Jirabo	76	190	26	27	539	8	28	7.07
Jirabo - Baipail	77	219	27	32	636	11	35	1.59
Baipail - Jirani	56	175	28	35	452	9	26	4.34
Jirani - Chandra	63	194	33	41	480	10	28	5.78
Chandra-Jirani	20	22	4	5	62	2	3	5.78
Jirani - Baipail	35	63	14	18	124	4	7	4.34
Baipail - Nabinagar	46	147	25	31	369	8	22	2.17
Nabinagar - Baipail	33	54	45	20	94	4	6	2.17
Baipail - Jirabo	54	93	48	31	174	6	10	1.59
Jirabo - Ashulia	58	127	50	36	282	9	18	7.07
Ashulia - Abdullahpur	56	151	47	38	373	10	24	3.98
Abdullahpur - DEE	65	200	54	44	479	12	29	5.78

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	32	53	16	18	219	12	32	9.94
Abdullahpur - Ashulia	40	110	32	30	336	21	49	6.83
Ashulia - Jirabo	51	128	34	35	383	24	54	12.15
Jirabo - Baipail	52	147	36	41	452	30	67	2.73
Baipail - Jirani	42	129	39	48	355	29	55	7.45
Jirani - Chandra	46	142	46	56	375	31	58	9.94
Chandra-Jirani	14	15	5	7	44	7	7	9.94
Jirani - Baipail	24	43	19	24	88	12	14	7.45
Baipail - Nabinagar	31	99	32	40	263	23	42	3.73
Nabinagar - Baipail	23	37	60	27	68	10	11	3.73
Baipail - Jirabo	37	64	63	41	125	18	20	2.73
Jirabo - Ashulia	39	86	66	47	202	24	33	12.15
Ashulia - Abdullahpur	38	102	62	50	266	29	45	6.83
Abdullahpur - DEE	44	135	72	58	342	34	56	9.94

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	74	120	25	28	473	13	41	8.12
Abdullahpur - Ashulia	90	252	50	48	728	23	63	5.58
Ashulia - Jirabo	117	292	53	55	828	27	69	9.93
Jirabo - Baipail	118	337	56	64	979	34	85	2.23
Baipail - Jirani	95	295	62	76	769	32	71	6.09
Jirani - Chandra	106	324	72	88	812	35	75	8.12
Chandra-Jirani	31	34	8	10	95	7	8	8.12
Jirani - Baipail	54	97	29	37	190	13	18	6.09
Baipail - Nabinagar	71	226	50	62	568	25	53	3.05
Nabinagar - Baipail	51	83	92	41	145	11	14	3.05
Baipail - Jirabo	84	144	97	63	268	19	26	2.23
Jirabo - Ashulia	89	195	102	73	433	27	43	9.93
Ashulia - Abdullahpur	86	232	97	78	574	32	58	5.58
Abdullahpur - DEE	100	307	111	90	737	38	72	8.12

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	38	63	10	11	246	3	13	5.47
Abdullahpur - Ashulia	47	132	20	19	381	6	21	3.76
Ashulia - Jirabo	61	153	21	22	432	7	23	6.68
Jirabo - Baipail	62	179	22	26	522	9	29	1.50
Baipail - Jirani	50	155	24	30	407	8	24	4.10
Jirani - Chandra	55	170	28	34	429	9	25	5.47
Chandra-Jirani	18	20	3	5	56	2	3	5.47
Jirani - Baipail	30	52	12	15	104	4	6	4.10
Baipail - Nabinagar	37	119	20	24	300	6	18	2.05
Nabinagar - Baipail	26	43	36	16	75	3	5	2.05
Baipail - Jirabo	45	76	38	25	144	5	9	1.50
Jirabo - Ashulia	48	106	40	30	240	7	15	6.68
Ashulia - Abdullahpur	47	128	38	32	322	9	20	3.76
Abdullahpur - DEE	54	167	44	36	408	10	25	5.47

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	63	102	23	25	368	14	42	8.01
Abdullahpur - Ashulia	77	217	46	44	574	24	66	5.50
Ashulia - Jirabo	100	252	49	50	653	28	72	9.79
Jirabo - Baipail	101	292	51	59	777	35	90	2.20
Baipail - Jirani	82	256	57	70	611	34	74	6.01
Jirani - Chandra	91	281	66	82	646	36	79	8.01
Chandra-Jirani	30	32	8	10	82	8	10	8.01
Jirani - Baipail	50	88	28	36	161	15	20	6.01
Baipail - Nabinagar	61	196	47	58	451	26	56	3.00
Nabinagar - Baipail	44	71	85	38	115	12	15	3.00
Baipail - Jirabo	75	128	91	59	220	21	28	2.20
Jirabo - Ashulia	79	173	95	69	355	29	46	9.79
Ashulia - Abdullahpur	77	206	90	73	469	35	62	5.50
Abdullahpur - DEE	89	271	103	85	599	41	77	8.01

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	44	71	22	24	280	15	41	10.2
Abdullahpur - Ashulia	54	152	44	42	436	27	64	7.0
Ashulia - Jirabo	72	179	47	49	506	32	71	12.4
Jirabo - Baipail	73	207	49	57	597	40	87	2.8
Baipail - Jirani	59	180	54	67	467	38	72	7.6
Jirani - Chandra	64	196	62	77	492	41	76	10.2
Chandra-Jirani	19	21	7	9	59	9	9	10.2
Jirani - Baipail	32	57	25	32	113	15	18	7.6
Baipail - Nabinagar	44	137	44	55	345	30	54	3.8
Nabinagar - Baipail	30	49	80	36	86	13	14	3.8
Baipail - Jirabo	50	85	84	54	160	22	26	2.8
Jirabo - Ashulia	54	120	89	65	271	32	45	12.4
Ashulia - Abdullahpur	52	142	84	68	356	39	60	7.0
Abdullahpur - DEE	60	188	97	79	455	46	75	10.2

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	41	74	12	13	292	4	16	6.06
Abdullahpur - Ashulia	53	173	26	24	489	8	27	5.22
Ashulia- BPATC	71	201	27	28	561	9	29	9.24
BPATC - Nabinagar	74	243	30	35	696	12	38	4.70
Nabinagar - Baipail	75	261	39	48	687	14	40	2.91
Baipail- Jirani	89	304	50	62	751	16	43	5.23
Jirani-Chandra	99	352	64	79	829	19	49	6.17
Chandra - Jirani	33	54	45	20	94	4	6	6.17
Jirani - Baipail	39	96	53	35	160	6	11	5.23
Baipail - Nabinagar	33	81	45	30	136	5	9	2.91
Nabinagar - BPATC	33	112	42	32	253	8	17	4.70
BPATC - Ashulia	36	154	44	39	388	11	26	9.24
Ashulia - Abdullahpur	54	262	60	52	623	15	39	5.22
Abdullahpur - DEE	68	304	71	66	688	17	43	6.06

Table 4: Hourly Traffic in 2020 – Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	146	239	57	63	776	41	124	23.70
Abdullahpur - Ashulia	179	500	114	109	1195	70	192	16.30
Ashulia - Jirabo	232	579	121	125	1359	80	210	28.98
Jirabo - Baipail	234	668	127	147	1606	102	260	6.52
Baipail - Jirani	189	585	141	173	1261	97	216	17.78
Jirani - Chandra	209	642	164	201	1332	105	228	23.70
Chandra-Jirani	62	68	18	24	156	22	26	23.70
Jirani - Baipail	107	192	67	85	312	40	54	17.78
Baipail - Nabinagar	141	448	115	143	932	76	162	8.89
Nabinagar - Baipail	100	164	211	94	238	33	44	8.89
Baipail - Jirabo	166	285	222	144	440	59	78	6.52
Jirabo - Ashulia	176	386	233	168	711	81	130	28.98
Ashulia - Abdullahpur	170	460	221	178	942	98	175	16.30
Abdullahpur - DEE	198	609	254	205	1209	116	219	23.70

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	69	112	26	29	502	10	41	6.08
Abdullahpur - Ashulia	84	235	53	50	773	17	64	4.18
Ashulia - Jirabo	109	272	56	58	879	19	70	7.43
Jirabo - Baipail	110	314	59	68	1039	24	86	1.67
Baipail - Jirani	89	275	65	80	816	23	71	4.56
Jirani - Chandra	98	302	76	93	862	25	76	6.08
Chandra-Jirani	29	32	8	11	101	5	9	6.08
Jirani - Baipail	50	90	31	39	202	9	18	4.56
Baipail - Nabinagar	66	211	53	66	603	18	54	2.28
Nabinagar - Baipail	47	77	97	43	154	8	14	2.28
Baipail - Jirabo	78	134	103	66	285	14	26	1.67
Jirabo - Ashulia	83	182	107	77	460	19	43	7.43
Ashulia - Abdullahpur	80	216	102	82	609	23	58	4.18
Abdullahpur - DEE	93	286	117	95	782	28	72	6.08

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	120	195	45	49	557	31	84	19.52
Abdullahpur - Ashulia	147	409	89	85	856	54	130	13.42
Ashulia - Jirabo	197	486	95	100	996	63	144	23.86
Jirabo - Baipail	199	558	100	117	1172	80	178	5.37
Baipail - Jirani	160	486	111	136	918	75	147	14.64
Jirani - Chandra	176	533	128	158	969	81	156	19.52
Chandra-Jirani	61	67	17	22	134	21	21	19.52
Jirani - Baipail	98	168	55	70	246	34	40	14.64
Baipail - Nabinagar	119	372	90	112	678	59	111	7.32
Nabinagar - Baipail	98	161	197	88	204	31	35	7.32
Baipail - Jirabo	157	263	201	126	360	52	60	5.37
Jirabo - Ashulia	166	346	209	145	555	69	95	23.86
Ashulia - Abdullahpur	159	404	197	151	715	81	125	13.42
Abdullahpur - DEE	181	525	223	173	907	95	154	19.52

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	172	280	64	71	966	42	128	15.00
Abdullahpur - Ashulia	211	588	129	122	1487	72	199	10.31
Ashulia - Jirabo	272	681	136	141	1691	83	217	18.34
Jirabo - Baipail	275	786	144	166	1999	106	269	4.13
Baipail - Jirani	222	688	159	195	1570	100	223	11.25
Jirani - Chandra	246	754	184	226	1658	108	236	15.00
Chandra-Jirani	73	80	20	27	194	23	27	15.00
Jirani - Baipail	126	226	75	96	388	41	55	11.25
Baipail - Nabinagar	166	527	130	161	1160	79	168	5.63
Nabinagar - Baipail	118	193	238	106	296	35	45	5.63
Baipail - Jirabo	195	335	250	162	547	61	80	4.13
Jirabo - Ashulia	207	454	262	189	885	84	134	18.34
Ashulia - Abdullahpur	200	541	249	200	1172	101	181	10.31
Abdullahpur - DEE	232	716	286	231	1504	120	226	15.00

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	62	101	24	26	452	9	37	5.91
Abdullahpur - Ashulia	75	209	47	45	689	15	57	4.06
Ashulia - Jirabo	97	242	50	52	785	17	62	7.23
Jirabo - Baipail	99	281	53	61	933	22	77	1.63
Baipail - Jirani	80	246	58	71	732	21	64	4.43
Jirani - Chandra	88	269	67	83	772	22	68	5.91
Chandra-Jirani	29	32	8	11	101	5	9	5.91
Jirani - Baipail	48	83	28	36	189	9	17	4.43
Baipail - Nabinagar	59	188	47	59	540	16	48	2.22
Nabinagar - Baipail	40	66	83	37	131	7	12	2.22
Baipail - Jirabo	70	119	89	58	256	13	23	1.63
Jirabo - Ashulia	75	162	93	68	417	17	39	7.23
Ashulia - Abdullahpur	72	195	89	73	555	21	53	4.06
Abdullahpur - DEE	84	256	102	84	707	25	65	5.91

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	153	250	57	63	712	40	107	14.40
Abdullahpur - Ashulia	184	507	110	105	1069	67	162	9.90
Ashulia - Jirabo	240	591	117	122	1222	77	178	17.60
Jirabo - Baipail	244	693	124	146	1470	100	224	3.96
Baipail - Jirani	197	609	139	172	1156	95	187	10.80
Jirani - Chandra	219	669	162	201	1222	103	198	14.40
Chandra-Jirani	67	73	19	24	147	23	23	14.40
Jirani - Baipail	115	205	68	86	293	40	47	10.80
Baipail - Nabinagar	147	467	114	142	855	75	140	5.40
Nabinagar - Baipail	106	173	212	94	220	33	38	5.40
Baipail - Jirabo	176	302	224	145	410	58	68	3.96
Jirabo - Ashulia	188	416	234	170	676	82	117	17.60
Ashulia - Abdullahpur	182	500	223	182	905	100	159	9.90
Abdullahpur - DEE	210	648	254	208	1137	116	194	14.40

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	144	234	53	59	668	37	101	22.61
Abdullahpur - Ashulia	173	474	103	98	1001	62	152	15.54
Ashulia - Jirabo	228	557	110	115	1153	73	167	27.64
Jirabo - Baipail	230	639	115	134	1351	91	205	6.22
Baipail - Jirani	183	553	126	154	1053	85	168	16.96
Jirani - Chandra	202	604	145	178	1109	92	178	22.61
Chandra-Jirani	64	70	18	23	140	21	22	22.61
Jirani - Baipail	104	181	59	76	263	36	42	16.96
Baipail - Nabinagar	136	422	102	127	776	67	126	8.48
Nabinagar - Baipail	90	148	181	81	187	28	32	8.48
Baipail - Jirabo	155	263	192	125	360	51	60	6.22
Jirabo - Ashulia	166	367	202	149	604	73	104	27.64
Ashulia - Abdullahpur	160	434	192	157	788	87	138	15.54
Abdullahpur - DEE	186	572	221	181	1005	102	171	22.61

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	65	107	25	28	477	9	39	5.84
Abdullahpur - Ashulia	83	248	56	52	799	17	66	5.04
Ashulia- BPATC	107	289	59	61	916	20	72	8.91
BPATC - Nabinagar	113	349	65	75	1137	27	94	4.54
Nabinagar - Baipail	113	375	85	103	1122	31	97	2.81
Baipail- Jirani	132	436	109	133	1227	35	107	5.05
Jirani-Chandra	147	506	137	171	1354	43	121	5.95
Chandra - Jirani	47	77	97	43	154	8	14	5.95
Jirani - Baipail	56	137	113	76	261	14	27	5.05
Baipail - Nabinagar	47	116	96	64	222	12	23	2.81
Nabinagar - BPATC	47	161	90	70	413	17	42	4.54
BPATC - Ashulia	52	221	96	84	634	24	64	8.91
Ashulia - Abdullahpur	78	376	129	112	1018	33	96	5.04
Abdullahpur - DEE	97	437	153	142	1123	38	105	5.84

Table 5: Hourly Traffic in 2020 –Off- Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	95	154	37	41	502	26	80	12.15
Abdullahpur - Ashulia	116	324	74	70	773	45	125	8.35
Ashulia - Jirabo	150	375	78	81	879	52	136	14.86
Jirabo - Baipail	151	433	82	95	1039	66	168	3.34
Baipail - Jirani	122	379	91	112	816	63	140	9.11
Jirani - Chandra	135	415	106	130	862	68	148	12.15
Chandra-Jirani	40	44	12	15	101	14	17	12.15
Jirani - Baipail	69	124	43	55	202	26	35	9.11
Baipail - Nabinagar	91	290	75	92	603	49	105	4.56
Nabinagar - Baipail	65	106	137	61	154	22	28	4.56
Baipail - Jirabo	107	184	144	93	285	38	50	3.34
Jirabo - Ashulia	114	250	150	109	460	52	84	14.86
Ashulia - Abdullahpur	110	298	143	115	609	63	113	8.35
Abdullahpur - DEE	128	394	164	133	782	75	141	12.15

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	45	73	17	19	325	6	27	5.39
Abdullahpur - Ashulia	55	152	34	32	500	11	41	3.71
Ashulia - Jirabo	70	176	36	37	569	12	45	6.59
Jirabo - Baipail	71	203	38	44	673	16	56	1.48
Baipail - Jirani	58	178	42	52	528	15	46	4.04
Jirani - Chandra	64	195	49	60	558	16	49	5.39
Chandra-Jirani	19	21	5	7	65	3	6	5.39
Jirani - Baipail	33	58	20	26	131	6	11	4.04
Baipail - Nabinagar	43	136	34	43	390	12	35	2.02
Nabinagar - Baipail	31	50	63	28	99	5	9	2.02
Baipail - Jirabo	50	87	66	43	184	9	17	1.48
Jirabo - Ashulia	54	117	70	50	298	12	28	6.59
Ashulia - Abdullahpur	52	140	66	53	394	15	37	3.71
Abdullahpur - DEE	60	185	76	61	506	18	47	5.39

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	78	126	29	32	360	20	54	11.09
Abdullahpur - Ashulia	95	265	58	55	554	35	84	7.62
Ashulia - Jirabo	128	314	61	65	644	41	93	13.55
Jirabo - Baipail	129	361	65	76	758	51	115	3.05
Baipail - Jirani	103	315	72	88	594	49	95	8.31
Jirani - Chandra	114	345	83	102	627	52	101	11.09
Chandra-Jirani	40	43	11	14	87	13	13	11.09
Jirani - Baipail	63	109	35	45	159	22	26	8.31
Baipail - Nabinagar	77	241	58	73	439	38	72	4.16
Nabinagar - Baipail	64	104	127	57	132	20	23	4.16
Baipail - Jirabo	102	170	130	82	233	33	39	3.05
Jirabo - Ashulia	107	224	135	94	359	45	62	13.55
Ashulia - Abdullahpur	103	261	128	98	463	52	81	7.62
Abdullahpur - DEE	117	340	144	112	587	61	100	11.09

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	111	181	42	46	625	27	83	10.28
Abdullahpur - Ashulia	136	380	83	79	962	47	129	7.07
Ashulia - Jirabo	176	441	88	91	1094	54	141	12.57
Jirabo - Baipail	178	509	93	107	1293	68	174	2.83
Baipail - Jirani	144	445	103	126	1016	65	144	7.71
Jirani - Chandra	159	488	119	147	1073	70	153	10.28
Chandra-Jirani	47	52	13	17	125	15	17	10.28
Jirani - Baipail	81	146	49	62	251	27	36	7.71
Baipail - Nabinagar	107	341	84	104	751	51	109	3.85
Nabinagar - Baipail	76	125	154	69	191	22	29	3.85
Baipail - Jirabo	126	217	162	105	354	39	52	2.83
Jirabo - Ashulia	134	294	170	122	573	54	87	12.57
Ashulia - Abdullahpur	130	350	161	130	758	66	117	7.07
Abdullahpur - DEE	150	463	185	150	973	77	146	10.28

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	40	65	15	17	293	6	24	5.49
Abdullahpur - Ashulia	49	135	30	29	446	10	37	4.73
Ashulia - Jirabo	63	157	32	33	508	11	40	8.37
Jirabo - Baipail	64	182	34	39	604	14	50	4.26
Baipail - Jirani	52	159	38	46	473	13	41	2.64
Jirani - Chandra	57	174	43	53	499	14	44	4.74
Chandra-Jirani	19	21	5	7	65	3	6	5.59
Jirani - Baipail	31	54	18	23	122	6	11	5.59
Baipail - Nabinagar	38	122	31	38	350	10	31	4.74
Nabinagar - Baipail	26	42	54	24	85	4	8	2.64
Baipail - Jirabo	45	77	57	38	165	8	15	4.26
Jirabo - Ashulia	48	105	60	44	270	11	25	8.37
Ashulia - Abdullahpur	47	126	57	47	359	14	34	4.73
Abdullahpur - DEE	54	166	66	54	458	16	42	5.49

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	99	162	37	41	461	26	69	9.73
Abdullahpur - Ashulia	119	328	71	68	692	43	105	6.69
Ashulia - Jirabo	155	382	76	79	791	50	115	11.89
Jirabo - Baipail	158	449	80	94	951	65	145	2.68
Baipail - Jirani	128	394	90	111	748	62	121	7.30
Jirani - Chandra	142	433	105	130	791	67	128	9.73
Chandra-Jirani	44	48	12	16	95	15	15	9.73
Jirani - Baipail	74	133	44	56	189	26	31	7.30
Baipail - Nabinagar	95	302	74	92	553	48	91	3.65
Nabinagar - Baipail	68	112	137	61	142	21	25	3.65
Baipail - Jirabo	114	196	145	94	265	38	44	2.68
Jirabo - Ashulia	122	269	152	110	438	53	75	11.89
Ashulia - Abdullahpur	118	324	144	118	585	65	103	6.69
Abdullahpur - DEE	136	419	164	134	735	75	126	9.73

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	93	152	35	38	432	24	65	12.24
Abdullahpur - Ashulia	112	307	67	64	648	40	98	8.41
Ashulia - Jirabo	147	361	71	75	746	47	108	14.96
Jirabo - Baipail	149	413	75	87	874	59	133	3.36
Baipail - Jirani	119	358	81	100	681	55	109	9.18
Jirani - Chandra	130	391	94	115	717	60	115	12.24
Chandra-Jirani	41	45	11	15	90	14	14	12.24
Jirani - Baipail	67	117	38	49	170	23	27	9.18
Baipail - Nabinagar	88	273	66	82	502	43	82	4.59
Nabinagar - Baipail	58	95	117	52	121	18	21	4.59
Baipail - Jirabo	101	170	124	81	233	33	39	3.36
Jirabo - Ashulia	108	238	131	96	391	47	67	14.96
Ashulia - Abdullahpur	104	281	124	102	510	56	89	8.41
Abdullahpur - DEE	120	370	143	117	650	66	111	12.24

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	42	69	16	18	309	6	25	5.62
Abdullahpur - Ashulia	53	160	36	34	517	11	43	4.84
Ashulia- BPATC	69	187	38	39	593	13	47	8.57
BPATC - Nabinagar	73	226	42	48	736	17	61	4.36
Nabinagar - Baipail	73	243	55	67	726	20	63	2.70
Baipail- Jirani	86	282	70	86	794	23	69	4.85
Jirani-Chandra	95	327	89	110	876	28	79	5.72
Chandra - Jirani	31	50	63	28	99	5	9	5.72
Jirani - Baipail	36	89	73	49	169	9	18	4.85
Baipail - Nabinagar	31	75	62	42	144	8	15	2.70
Nabinagar - BPATC	30	104	58	45	268	11	27	4.36
BPATC - Ashulia	34	143	62	54	410	16	41	8.57
Ashulia - Abdullahpur	50	243	84	72	659	22	62	4.84
Abdullahpur - DEE	63	283	99	92	727	24	68	5.62

Table 6: Hourly Traffic in 2020 –Super - Off- Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	43	70	17	19	228	12	37	9.56
Abdullahpur - Ashulia	53	147	34	32	351	21	57	6.57
Ashulia - Jirabo	68	170	36	37	400	24	62	11.69
Jirabo - Baipail	69	197	37	43	472	30	77	2.63
Baipail - Jirani	56	172	42	51	371	28	63	7.17
Jirani - Chandra	62	189	48	59	392	31	67	9.56
Chandra-Jirani	18	20	5	7	46	7	8	9.56
Jirani - Baipail	31	56	20	25	92	12	16	7.17
Baipail - Nabinagar	42	132	34	42	274	22	48	3.59
Nabinagar - Baipail	29	48	62	28	70	10	13	3.59
Baipail - Jirabo	49	84	65	42	129	17	23	2.63
Jirabo - Ashulia	52	114	68	49	209	24	38	11.69
Ashulia - Abdullahpur	50	135	65	52	277	29	52	6.57
Abdullahpur - DEE	58	179	75	60	356	34	64	9.56

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	20	33	8	9	148	3	12	5.22
Abdullahpur - Ashulia	25	69	16	15	227	5	19	3.59
Ashulia - Jirabo	32	80	16	17	259	6	20	6.38
Jirabo - Baipail	32	92	17	20	306	7	25	1.43
Baipail - Jirani	26	81	19	23	240	7	21	3.91
Jirani - Chandra	29	89	22	27	254	7	22	5.22
Chandra-Jirani	9	9	2	3	30	2	3	5.22
Jirani - Baipail	15	27	9	12	59	3	5	3.91
Baipail - Nabinagar	20	62	16	19	177	5	16	1.96
Nabinagar - Baipail	14	23	29	13	45	2	4	1.96
Baipail - Jirabo	23	39	30	20	84	4	8	1.43
Jirabo - Ashulia	24	53	32	23	135	6	13	6.38
Ashulia - Abdullahpur	24	64	30	24	179	7	17	3.59
Abdullahpur - DEE	27	84	34	28	230	8	21	5.22

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	35	57	13	15	164	9	25	9.06
Abdullahpur - Ashulia	43	120	26	25	252	16	38	6.23
Ashulia - Jirabo	58	143	28	29	293	19	42	11.07
Jirabo - Baipail	58	164	29	34	345	23	52	2.49
Baipail - Jirani	47	143	33	40	270	22	43	6.79
Jirani - Chandra	52	157	38	46	285	24	46	9.06
Chandra-Jirani	18	20	5	6	39	6	6	9.06
Jirani - Baipail	29	49	16	21	72	10	12	6.79
Baipail - Nabinagar	35	109	26	33	199	17	33	3.40
Nabinagar - Baipail	29	47	58	26	60	9	10	3.40
Baipail - Jirabo	46	77	59	37	106	15	18	2.49
Jirabo - Ashulia	49	102	62	43	163	20	28	11.07
Ashulia - Abdullahpur	47	119	58	45	210	24	37	6.23
Abdullahpur - DEE	53	155	66	51	267	28	45	9.06

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	51	82	19	21	284	12	38	8.19
Abdullahpur - Ashulia	62	173	38	36	437	21	59	5.63
Ashulia - Jirabo	80	200	40	42	497	24	64	10.01
Jirabo - Baipail	81	231	42	49	588	31	79	2.25
Baipail - Jirani	65	202	47	57	462	30	66	6.14
Jirani - Chandra	72	222	54	67	488	32	69	8.19
Chandra-Jirani	22	24	6	8	57	7	8	8.19
Jirani - Baipail	37	66	22	28	114	12	16	6.14
Baipail - Nabinagar	49	155	38	47	341	23	49	3.07
Nabinagar - Baipail	35	57	70	31	87	10	13	3.07
Baipail - Jirabo	57	98	74	48	161	18	24	2.25
Jirabo - Ashulia	61	133	77	56	260	25	40	10.01
Ashulia - Abdullahpur	59	159	73	59	345	30	53	5.63
Abdullahpur - DEE	68	210	84	68	442	35	66	8.19

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	18	30	7	8	133	3	11	5.17
Abdullahpur - Ashulia	22	61	14	13	203	4	17	3.56
Ashulia - Jirabo	29	71	15	15	231	5	18	6.32
Jirabo - Baipail	29	83	15	18	274	6	23	1.42
Baipail - Jirani	23	72	17	21	215	6	19	3.88
Jirani - Chandra	26	79	20	24	227	7	20	5.17
Chandra-Jirani	9	9	2	3	30	2	3	5.17
Jirani - Baipail	14	24	8	11	56	3	5	3.88
Baipail - Nabinagar	17	55	14	17	159	5	14	1.94
Nabinagar - Baipail	12	19	24	11	38	2	4	1.94
Baipail - Jirabo	21	35	26	17	75	4	7	1.42
Jirabo - Ashulia	22	48	27	20	123	5	11	6.32
Ashulia - Abdullahpur	21	57	26	21	163	6	16	3.56
Abdullahpur - DEE	25	75	30	25	208	7	19	5.17

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	45	73	17	19	210	12	32	7.83
Abdullahpur - Ashulia	54	149	32	31	314	20	48	5.38
Ashulia - Jirabo	71	174	34	36	360	23	52	9.57
Jirabo - Baipail	72	204	37	43	432	29	66	2.15
Baipail - Jirani	58	179	41	51	340	28	55	5.87
Jirani - Chandra	64	197	48	59	359	30	58	7.83
Chandra-Jirani	20	22	5	7	43	7	7	7.83
Jirani - Baipail	34	60	20	25	86	12	14	5.87
Baipail - Nabinagar	43	137	34	42	251	22	41	2.93
Nabinagar - Baipail	31	51	62	28	65	10	11	2.93
Baipail - Jirabo	52	89	66	43	121	17	20	2.15
Jirabo - Ashulia	55	122	69	50	199	24	34	9.57
Ashulia - Abdullahpur	54	147	66	54	266	29	47	5.38
Abdullahpur - DEE	62	190	75	61	334	34	57	7.83

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	42	69	16	17	196	11	30	10.0
Abdullahpur - Ashulia	51	139	30	29	294	18	45	6.8
Ashulia - Jirabo	67	164	32	34	339	21	49	12.2
Jirabo - Baipail	68	188	34	39	397	27	60	2.7
Baipail - Jirani	54	163	37	45	310	25	50	7.5
Jirani - Chandra	59	178	43	52	326	27	52	10.0
Chandra-Jirani	19	20	5	7	41	6	6	10.0
Jirani - Baipail	31	53	17	22	77	11	12	7.5
Baipail - Nabinagar	40	124	30	37	228	20	37	3.7
Nabinagar - Baipail	27	43	53	24	55	8	10	3.7
Baipail - Jirabo	46	77	56	37	106	15	18	2.7
Jirabo - Ashulia	49	108	59	44	178	21	31	12.2
Ashulia - Abdullahpur	47	128	56	46	232	26	41	6.8
Abdullahpur - DEE	55	168	65	53	295	30	50	10.0

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	19	31	7	8	140	3	11	5.36
Abdullahpur - Ashulia	24	73	16	15	235	5	19	4.63
Ashulia- BPATC	32	85	17	18	270	6	21	8.18
BPATC - Nabinagar	33	103	19	22	334	8	28	4.16
Nabinagar - Baipail	33	110	25	30	330	9	29	2.58
Baipail- Jirani	39	128	32	39	361	10	31	4.63
Jirani-Chandra	43	149	40	50	398	13	36	5.46
Chandra - Jirani	14	23	29	13	45	2	4	5.46
Jirani - Baipail	16	40	33	22	77	4	8	4.63
Baipail - Nabinagar	14	34	28	19	65	4	7	2.58
Nabinagar - BPATC	14	47	26	21	122	5	12	4.16
BPATC - Ashulia	15	65	28	25	186	7	19	8.18
Ashulia - Abdullahpur	23	111	38	33	299	10	28	4.63
Abdullahpur - DEE	29	128	45	42	330	11	31	5.36

Table 7: Hourly Traffic in 2015 –Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	131	214	53	59	671	40	122	18.46
Abdullahpur - Ashulia	161	449	106	100	1033	68	188	12.69
Ashulia - Jirabo	208	520	112	116	1175	79	206	22.57
Jirabo - Baipail	210	600	118	136	1388	100	254	5.08
Baipail - Jirani	170	525	131	160	1090	95	211	13.85
Jirani - Chandra	188	576	151	186	1152	102	223	18.46
Chandra-Jirani	56	61	17	22	135	22	25	18.46
Jirani - Baipail	96	172	62	79	270	39	52	13.85
Baipail - Nabinagar	127	402	106	132	806	74	159	6.92
Nabinagar - Baipail	90	147	195	87	205	33	43	6.92
Baipail - Jirabo	149	256	205	133	380	57	76	5.08
Jirabo - Ashulia	158	347	215	155	615	79	127	22.57
Ashulia - Abdullahpur	153	413	204	164	814	96	171	12.69
Abdullahpur - DEE	178	546	234	190	1045	113	214	18.46

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	28	45	17	19	285	3	11	5.65
Abdullahpur - Ashulia	34	94	35	33	439	5	17	3.88
Ashulia - Jirabo	44	109	37	38	499	6	19	6.90
Jirabo - Baipail	44	126	39	45	590	8	23	1.55
Baipail - Jirani	36	110	43	53	463	8	19	4.24
Jirani - Chandra	39	121	50	61	489	8	20	5.65
Chandra-Jirani	12	13	6	7	57	2	2	5.65
Jirani - Baipail	20	36	20	26	115	3	5	4.24
Baipail - Nabinagar	27	85	35	44	342	6	14	2.12
Nabinagar - Baipail	19	31	64	29	87	3	4	2.12
Baipail - Jirabo	31	54	68	44	162	5	7	1.55
Jirabo - Ashulia	33	73	71	51	261	6	11	6.90
Ashulia - Abdullahpur	32	87	67	54	346	8	15	3.88
Abdullahpur - DEE	37	115	77	63	444	9	19	5.65

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	116	190	38	42	448	40	122	13.71
Abdullahpur - Ashulia	142	397	76	73	689	68	188	9.43
Ashulia - Jirabo	191	471	82	86	801	80	209	16.77
Jirabo - Baipail	193	542	86	100	943	101	258	3.77
Baipail - Jirani	155	472	95	117	738	95	213	10.29
Jirani - Chandra	171	517	110	136	779	103	226	13.71
Chandra-Jirani	59	65	14	19	108	26	30	13.71
Jirani - Baipail	95	163	47	60	198	43	57	10.29
Baipail - Nabinagar	116	361	77	96	545	75	161	5.14
Nabinagar - Baipail	80	130	141	63	137	32	43	5.14
Baipail - Jirabo	140	235	151	99	268	60	80	3.77
Jirabo - Ashulia	149	324	158	116	442	85	137	16.77
Ashulia - Abdullahpur	143	381	150	123	571	100	180	9.43
Abdullahpur - DEE	165	499	172	141	726	117	223	13.71

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	147	240	59	66	752	45	136	9.75
Abdullahpur - Ashulia	179	498	117	111	1147	76	209	6.70
Ashulia - Jirabo	230	575	124	128	1302	87	228	11.91
Jirabo - Baipail	233	663	130	150	1537	110	282	2.68
Baipail - Jirani	188	580	144	176	1206	105	233	7.31
Jirani - Chandra	208	636	167	205	1273	113	247	9.75
Chandra-Jirani	63	68	19	24	151	24	28	9.75
Jirani - Baipail	107	191	68	87	299	43	58	7.31
Baipail - Nabinagar	140	444	117	145	891	82	176	3.65
Nabinagar - Baipail	101	165	218	97	230	37	48	3.65
Baipail - Jirabo	166	285	229	148	424	64	85	2.68
Jirabo - Ashulia	176	385	240	172	682	88	141	11.91
Ashulia - Abdullahpur	170	457	227	182	900	106	190	6.70
Abdullahpur - DEE	197	604	261	210	1154	125	236	9.75

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	23	38	15	16	242	3	9	5.39
Abdullahpur - Ashulia	29	80	30	28	373	5	14	3.71
Ashulia - Jirabo	38	94	31	33	427	5	16	6.59
Jirabo - Baipail	38	108	33	39	507	7	20	1.48
Baipail - Jirani	31	96	37	46	400	7	16	4.04
Jirani - Chandra	34	105	43	54	423	7	17	5.39
Chandra-Jirani	12	13	6	7	57	2	2	5.39
Jirani - Baipail	19	33	19	24	108	3	4	4.04
Baipail - Nabinagar	23	73	31	38	296	5	12	2.02
Nabinagar - Baipail	16	26	55	24	74	2	3	2.02
Baipail - Jirabo	28	48	59	39	146	4	6	1.48
Jirabo - Ashulia	30	64	61	45	232	6	10	6.59
Ashulia - Abdullahpur	29	76	58	48	305	7	14	3.71
Abdullahpur - DEE	33	100	67	55	389	8	17	5.39

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	141	229	46	51	542	48	147	8.36
Abdullahpur - Ashulia	168	457	88	84	803	79	220	5.75
Ashulia - Jirabo	218	532	93	98	916	91	241	10.22
Jirabo - Baipail	220	616	99	115	1083	116	298	2.30
Baipail - Jirani	178	543	111	136	854	111	248	6.27
Jirani - Chandra	197	597	129	159	903	120	263	8.36
Chandra-Jirani	63	69	15	20	114	28	32	8.36
Jirani - Baipail	105	186	54	69	222	48	65	6.27
Baipail - Nabinagar	133	417	91	113	632	87	187	3.14
Nabinagar - Baipail	95	155	168	75	163	39	51	3.14
Baipail - Jirabo	160	273	178	115	308	69	92	2.30
Jirabo - Ashulia	170	367	186	134	491	95	152	10.22
Ashulia - Abdullahpur	164	435	176	142	645	113	204	5.75
Abdullahpur - DEE	188	566	200	162	816	133	251	8.36

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	140	227	46	51	537	47	146	16.03
Abdullahpur - Ashulia	168	460	89	85	805	79	220	11.02
Ashulia - Jirabo	221	541	94	99	927	92	243	19.59
Jirabo - Baipail	223	620	99	115	1086	116	297	4.41
Baipail - Jirani	178	537	108	132	847	108	244	12.02
Jirani - Chandra	196	586	124	153	892	117	258	16.03
Chandra-Jirani	62	68	15	20	112	27	32	16.03
Jirani - Baipail	101	176	51	65	211	46	61	12.02
Baipail - Nabinagar	132	410	88	109	624	85	183	6.01
Nabinagar - Baipail	88	143	155	69	151	36	47	6.01
Baipail - Jirabo	151	255	165	107	290	65	87	4.41
Jirabo - Ashulia	161	356	173	128	486	93	151	19.59
Ashulia - Abdullahpur	156	422	165	135	634	111	200	11.02
Abdullahpur - DEE	180	555	190	156	808	130	248	16.03

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	26	43	17	18	271	3	10	5.84
Abdullahpur - Ashulia	33	99	37	35	454	6	18	5.04
Ashulia- BPATC	43	116	39	40	520	7	19	8.91
BPATC - Nabinagar	45	140	43	49	645	9	25	4.54
Nabinagar - Baipail	45	150	56	68	637	10	26	2.81
Baipail- Jirani	53	175	72	88	697	12	28	5.05
Jirani-Chandra	59	203	90	113	769	14	32	5.95
Chandra - Jirani	19	31	64	29	87	3	4	5.95
Jirani - Baipail	22	55	75	50	148	5	7	5.05
Baipail - Nabinagar	19	47	63	42	126	4	6	2.81
Nabinagar - BPATC	19	65	59	46	235	6	11	4.54
BPATC - Ashulia	21	89	63	55	360	8	17	8.91
Ashulia - Abdullahpur	31	151	85	74	578	11	25	5.04
Abdullahpur - DEE	39	175	101	93	638	12	28	5.84

Table 8: Hourly Traffic in 2015 –Off- Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	85	139	34	38	434	26	79	10.67
Abdullahpur - Ashulia	104	291	68	65	668	44	122	7.33
Ashulia - Jirabo	134	336	72	75	760	51	133	13.04
Jirabo - Baipail	136	388	76	88	898	65	165	2.93
Baipail - Jirani	110	340	85	103	705	61	137	8.00
Jirani - Chandra	122	373	98	120	745	66	145	10.67
Chandra-Jirani	36	40	11	14	87	14	16	10.67
Jirani - Baipail	62	112	40	51	175	25	34	8.00
Baipail - Nabinagar	82	260	69	85	521	48	103	4.00
Nabinagar - Baipail	58	95	126	56	133	21	28	4.00
Baipail - Jirabo	96	165	133	86	246	37	49	2.93
Jirabo - Ashulia	102	224	139	100	398	51	82	13.04
Ashulia - Abdullahpur	99	267	132	106	527	62	111	7.33
Abdullahpur - DEE	115	354	152	123	676	73	138	10.67

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	18	29	11	13	185	2	7	5.33
Abdullahpur - Ashulia	22	61	23	21	284	4	11	3.67
Ashulia - Jirabo	28	71	24	25	323	4	12	6.52
Jirabo - Baipail	29	82	25	29	382	5	15	1.47
Baipail - Jirani	23	71	28	34	300	5	12	4.00
Jirani - Chandra	26	78	32	40	317	5	13	5.33
Chandra-Jirani	8	8	4	5	37	1	1	5.33
Jirani - Baipail	13	23	13	17	74	2	3	4.00
Baipail - Nabinagar	17	55	23	28	222	4	9	2.00
Nabinagar - Baipail	12	20	42	19	56	2	2	2.00
Baipail - Jirabo	20	35	44	28	105	3	4	1.47
Jirabo - Ashulia	22	47	46	33	169	4	7	6.52
Ashulia - Abdullahpur	21	56	44	35	224	5	10	3.67
Abdullahpur - DEE	24	74	50	40	287	6	12	5.33

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	75	123	25	27	290	26	79	10.67
Abdullahpur - Ashulia	92	257	49	47	446	44	122	7.33
Ashulia - Jirabo	124	305	53	56	518	52	135	13.04
Jirabo - Baipail	125	351	56	65	610	65	167	2.93
Baipail - Jirani	100	306	61	76	478	62	138	8.00
Jirani - Chandra	111	335	71	88	504	67	146	10.67
Chandra-Jirani	38	42	9	12	70	17	20	10.67
Jirani - Baipail	61	106	30	39	128	28	37	8.00
Baipail - Nabinagar	75	234	50	62	353	48	104	4.00
Nabinagar - Baipail	52	84	91	41	89	21	28	4.00
Baipail - Jirabo	90	152	97	64	173	39	52	2.93
Jirabo - Ashulia	96	210	102	75	286	55	89	13.04
Ashulia - Abdullahpur	93	247	97	79	370	65	117	7.33
Abdullahpur - DEE	107	323	111	91	469	76	144	10.67

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	95	155	38	42	486	29	88	8.14
Abdullahpur - Ashulia	116	322	76	72	742	49	135	5.59
Ashulia - Jirabo	149	372	80	83	843	56	148	9.95
Jirabo - Baipail	151	429	84	97	994	71	182	2.24
Baipail - Jirani	122	375	93	114	780	68	151	6.10
Jirani - Chandra	135	411	108	133	824	73	160	8.14
Chandra-Jirani	41	44	12	16	98	16	18	8.14
Jirani - Baipail	69	124	44	56	194	28	38	6.10
Baipail - Nabinagar	91	287	76	94	576	53	114	3.05
Nabinagar - Baipail	65	107	141	63	149	24	31	3.05
Baipail - Jirabo	107	184	148	96	274	41	55	2.24
Jirabo - Ashulia	114	249	155	111	441	57	91	9.95
Ashulia - Abdullahpur	110	296	147	118	582	69	123	5.59
Abdullahpur - DEE	128	391	169	136	747	81	153	8.14

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	15	25	10	11	157	2	6	5.11
Abdullahpur - Ashulia	19	52	19	18	241	3	9	3.51
Ashulia - Jirabo	24	61	20	21	277	3	10	6.24
Jirabo - Baipail	25	70	21	25	328	4	13	1.40
Baipail - Jirani	20	62	24	30	259	4	11	3.83
Jirani - Chandra	22	68	28	35	274	5	11	5.11
Chandra-Jirani	8	8	4	5	37	1	1	5.11
Jirani - Baipail	12	22	12	15	70	2	3	3.83
Baipail - Nabinagar	15	47	20	25	192	3	8	1.91
Nabinagar - Baipail	10	17	35	16	48	1	2	1.91
Baipail - Jirabo	18	31	38	25	94	3	4	1.40
Jirabo - Ashulia	19	42	40	29	150	4	7	6.24
Ashulia - Abdullahpur	19	49	38	31	198	4	9	3.51
Abdullahpur - DEE	21	65	43	35	252	5	11	5.11

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	91	148	30	33	351	31	95	7.82
Abdullahpur - Ashulia	109	296	57	55	519	51	142	5.37
Ashulia - Jirabo	141	344	60	63	593	59	156	9.56
Jirabo - Baipail	142	398	64	74	701	75	193	2.15
Baipail - Jirani	115	352	72	88	552	72	161	5.86
Jirani - Chandra	128	386	83	103	584	78	170	7.82
Chandra-Jirani	41	44	10	13	74	18	21	7.82
Jirani - Baipail	68	121	35	45	143	31	42	5.86
Baipail - Nabinagar	86	270	59	73	409	56	121	2.93
Nabinagar - Baipail	61	100	109	48	105	25	33	2.93
Baipail - Jirabo	104	177	115	75	199	45	60	2.15
Jirabo - Ashulia	110	238	120	87	318	61	99	9.56
Ashulia - Abdullahpur	106	282	114	92	417	73	132	5.37
Abdullahpur - DEE	122	366	130	105	528	86	162	7.82

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	90	147	30	33	348	31	94	11.18
Abdullahpur - Ashulia	109	298	57	55	521	51	142	7.68
Ashulia - Jirabo	143	350	61	64	600	60	157	13.66
Jirabo - Baipail	144	401	64	75	703	75	192	3.07
Baipail - Jirani	115	347	70	86	548	70	158	8.38
Jirani - Chandra	127	379	80	99	577	76	167	11.18
Chandra-Jirani	40	44	10	13	73	18	20	11.18
Jirani - Baipail	65	114	33	42	137	30	40	8.38
Baipail - Nabinagar	86	265	57	70	404	55	119	4.19
Nabinagar - Baipail	57	93	100	45	97	23	30	4.19
Baipail - Jirabo	98	165	107	70	187	42	56	3.07
Jirabo - Ashulia	104	231	112	83	315	60	98	13.66
Ashulia - Abdullahpur	101	273	107	88	410	72	130	7.68
Abdullahpur - DEE	117	359	123	101	523	84	161	11.18

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	17	28	11	12	175	2	7	5.62
Abdullahpur - Ashulia	21	64	24	22	294	4	11	4.84
Ashulia- BPATC	28	75	25	26	337	4	12	8.57
BPATC - Nabinagar	29	90	28	32	418	6	16	4.36
Nabinagar - Baipail	29	97	36	44	412	7	17	2.70
Baipail- Jirani	34	113	46	57	451	7	18	4.85
Jirani-Chandra	38	131	58	73	498	9	21	5.72
Chandra - Jirani	12	20	42	19	56	2	2	5.72
Jirani - Baipail	14	36	48	32	96	3	5	4.85
Baipail - Nabinagar	12	30	41	27	81	3	4	2.70
Nabinagar - BPATC	12	42	38	30	152	4	7	4.36
BPATC - Ashulia	14	57	41	36	233	5	11	8.57
Ashulia - Abdullahpur	20	98	55	48	374	7	16	4.84
Abdullahpur - DEE	25	113	65	60	413	8	18	5.62

Table 9: Hourly Traffic in 2015 –Super-Off- Peak Period

NO CHANGE/ B.A.U.

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	39	63	16	17	197	12	36	8.1
Abdullahpur - Ashulia	47	132	31	30	304	20	55	5.6
Ashulia - Jirabo	61	153	33	34	346	23	61	9.9
Jirabo - Baipail	62	177	35	40	408	29	75	2.2
Baipail - Jirani	50	155	38	47	321	28	62	6.1
Jirani - Chandra	55	169	44	55	339	30	66	8.1
Chandra-Jirani	16	18	5	6	40	6	7	8.1
Jirani - Baipail	28	51	18	23	79	11	15	6.1
Baipail - Nabinagar	37	118	31	39	237	22	47	3.1
Nabinagar - Baipail	26	43	57	26	60	10	13	3.1
Baipail - Jirabo	44	75	60	39	112	17	22	2.2
Jirabo - Ashulia	47	102	63	46	181	23	37	9.9
Ashulia - Abdullahpur	45	121	60	48	239	28	50	5.6
Abdullahpur - DEE	52	161	69	56	307	33	63	8.1

DAEEP A-1 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	8	13	5	6	84	1	3	5.1
Abdullahpur - Ashulia	10	28	10	10	129	2	5	3.5
Ashulia - Jirabo	13	32	11	11	147	2	5	6.2
Jirabo - Baipail	13	37	11	13	174	2	7	1.4
Baipail - Jirani	10	32	13	16	136	2	6	3.8
Jirani - Chandra	12	36	15	18	144	2	6	5.1
Chandra-Jirani	3	4	2	2	17	1	1	5.1
Jirani - Baipail	6	11	6	8	34	1	1	3.8
Baipail - Nabinagar	8	25	10	13	101	2	4	1.9
Nabinagar - Baipail	6	9	19	8	26	1	1	1.9
Baipail - Jirabo	9	16	20	13	48	1	2	1.4
Jirabo - Ashulia	10	21	21	15	77	2	3	6.2
Ashulia - Abdullahpur	9	26	20	16	102	2	5	3.5
Abdullahpur - DEE	11	34	23	18	131	3	6	5.1

DAEEP A-1 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	34	56	11	12	132	12	36	7.4
Abdullahpur - Ashulia	42	117	22	21	203	20	55	5.1
Ashulia - Jirabo	56	139	24	25	236	23	62	9.0
Jirabo - Baipail	57	159	25	30	277	30	76	2.0
Baipail - Jirani	46	139	28	34	217	28	63	5.5
Jirani - Chandra	50	152	32	40	229	30	66	7.4
Chandra-Jirani	17	19	4	6	32	8	9	7.4
Jirani - Baipail	28	48	14	18	58	13	17	5.5
Baipail - Nabinagar	34	106	23	28	160	22	47	2.8
Nabinagar - Baipail	23	38	41	19	40	10	13	2.8
Baipail - Jirabo	41	69	44	29	79	18	24	2.0
Jirabo - Ashulia	44	95	47	34	130	25	40	9.0
Ashulia - Abdullahpur	42	112	44	36	168	30	53	5.1
Abdullahpur - DEE	49	147	51	41	213	35	66	7.4

ROAD WIDENING

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	43	71	17	19	221	13	40	7.27
Abdullahpur - Ashulia	53	146	34	33	337	22	62	5.00
Ashulia - Jirabo	68	169	36	38	383	26	67	8.89
Jirabo - Baipail	68	195	38	44	452	32	83	2.00
Baipail - Jirani	55	171	42	52	355	31	69	5.45
Jirani - Chandra	61	187	49	60	375	33	73	7.27
Chandra-Jirani	18	20	5	7	44	7	8	7.27
Jirani - Baipail	31	56	20	26	88	13	17	5.45
Baipail - Nabinagar	41	131	35	43	262	24	52	2.73
Nabinagar - Baipail	30	48	64	29	68	11	14	2.73
Baipail - Jirabo	49	84	67	43	125	19	25	2.00
Jirabo - Ashulia	52	113	70	51	200	26	41	8.89
Ashulia - Abdullahpur	50	134	67	54	265	31	56	5.00
Abdullahpur - DEE	58	178	77	62	340	37	69	7.27

DAEEP A-1 + WIDENING (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	7	11	4	5	71	1	3	5.03
Abdullahpur - Ashulia	8	24	9	8	110	1	4	3.46
Ashulia - Jirabo	11	28	9	10	126	2	5	6.14
Jirabo - Baipail	11	32	10	11	149	2	6	1.38
Baipail - Jirani	9	28	11	14	118	2	5	3.77
Jirani - Chandra	10	31	13	16	124	2	5	5.03
Chandra-Jirani	3	4	2	2	17	1	1	5.03
Jirani - Baipail	6	10	5	7	32	1	1	3.77
Baipail - Nabinagar	7	22	9	11	87	2	4	1.88
Nabinagar - Baipail	5	8	16	7	22	1	1	1.88
Baipail - Jirabo	8	14	17	11	43	1	2	1.38
Jirabo - Ashulia	9	19	18	13	68	2	3	6.14
Ashulia - Abdullahpur	8	22	17	14	90	2	4	3.46
Abdullahpur - DEE	10	29	20	16	114	2	5	5.03

DAEEP A-1+ WIDENING (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	41	67	14	15	159	14	43	7.02
Abdullahpur - Ashulia	49	134	26	25	236	23	65	4.82
Ashulia - Jirabo	64	157	27	29	270	27	71	8.58
Jirabo - Baipail	65	181	29	34	319	34	88	1.93
Baipail - Jirani	52	160	33	40	251	33	73	5.26
Jirani - Chandra	58	176	38	47	265	35	77	7.02
Chandra-Jirani	19	20	5	6	34	8	9	7.02
Jirani - Baipail	31	55	16	20	65	14	19	5.26
Baipail - Nabinagar	39	123	27	33	186	26	55	2.63
Nabinagar - Baipail	28	46	49	22	48	11	15	2.63
Baipail - Jirabo	47	80	52	34	91	20	27	1.93
Jirabo - Ashulia	50	108	55	39	144	28	45	8.58
Ashulia - Abdullahpur	48	128	52	42	190	33	60	4.82
Abdullahpur - DEE	55	167	59	48	240	39	74	7.02

DAEEP A-2 (EXISTING)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	41	67	14	15	158	14	43	9.8
Abdullahpur - Ashulia	49	135	26	25	237	23	65	6.7
Ashulia - Jirabo	65	159	28	29	273	27	71	12.0
Jirabo - Baipail	66	182	29	34	320	34	87	2.7
Baipail - Jirani	52	158	32	39	249	32	72	7.4
Jirani - Chandra	58	172	37	45	262	34	76	9.8
Chandra-Jirani	18	20	4	6	33	8	9	9.8
Jirani - Baipail	30	52	15	19	62	13	18	7.4
Baipail - Nabinagar	39	121	26	32	184	25	54	3.7
Nabinagar - Baipail	26	42	46	20	44	11	14	3.7
Baipail - Jirabo	44	75	49	32	85	19	26	2.7
Jirabo - Ashulia	47	105	51	38	143	27	44	12.0
Ashulia - Abdullahpur	46	124	48	40	186	33	59	6.7
Abdullahpur - DEE	53	163	56	46	238	38	73	9.8

DAEEP A-2 (FLYOVER)

Links	HT	T	B	MB	C	MC	TH	T(min)
DEE - Abdullahpur	8	13	5	5	80	1	3	5.25
Abdullahpur - Ashulia	10	29	11	10	133	2	5	4.53
Ashulia- BPATC	13	34	11	12	153	2	6	8.00
BPATC - Nabinagar	13	41	13	15	190	3	7	4.07
Nabinagar - Baipail	13	44	17	20	187	3	8	2.53
Baipail- Jirani	16	51	21	26	205	3	8	4.53
Jirani-Chandra	17	60	27	33	226	4	10	5.35
Chandra - Jirani	6	9	19	8	26	1	1	5.35
Jirani - Baipail	7	16	22	15	44	1	2	4.53
Baipail - Nabinagar	6	14	19	12	37	1	2	2.53
Nabinagar - BPATC	6	19	17	14	69	2	3	4.07
BPATC - Ashulia	6	26	19	16	106	2	5	8.00
Ashulia - Abdullahpur	9	44	25	22	170	3	7	4.53
Abdullahpur - DEE	11	51	30	27	188	4	8	5.25

Appendix-D

Existing Environmental Setting along the Proposed Routes of the Dhaka Ashulia Elevated Expressway (DAEE)

Figure D1: Proposed Alternative 1 alignment of DAEE at the starting point near Airport

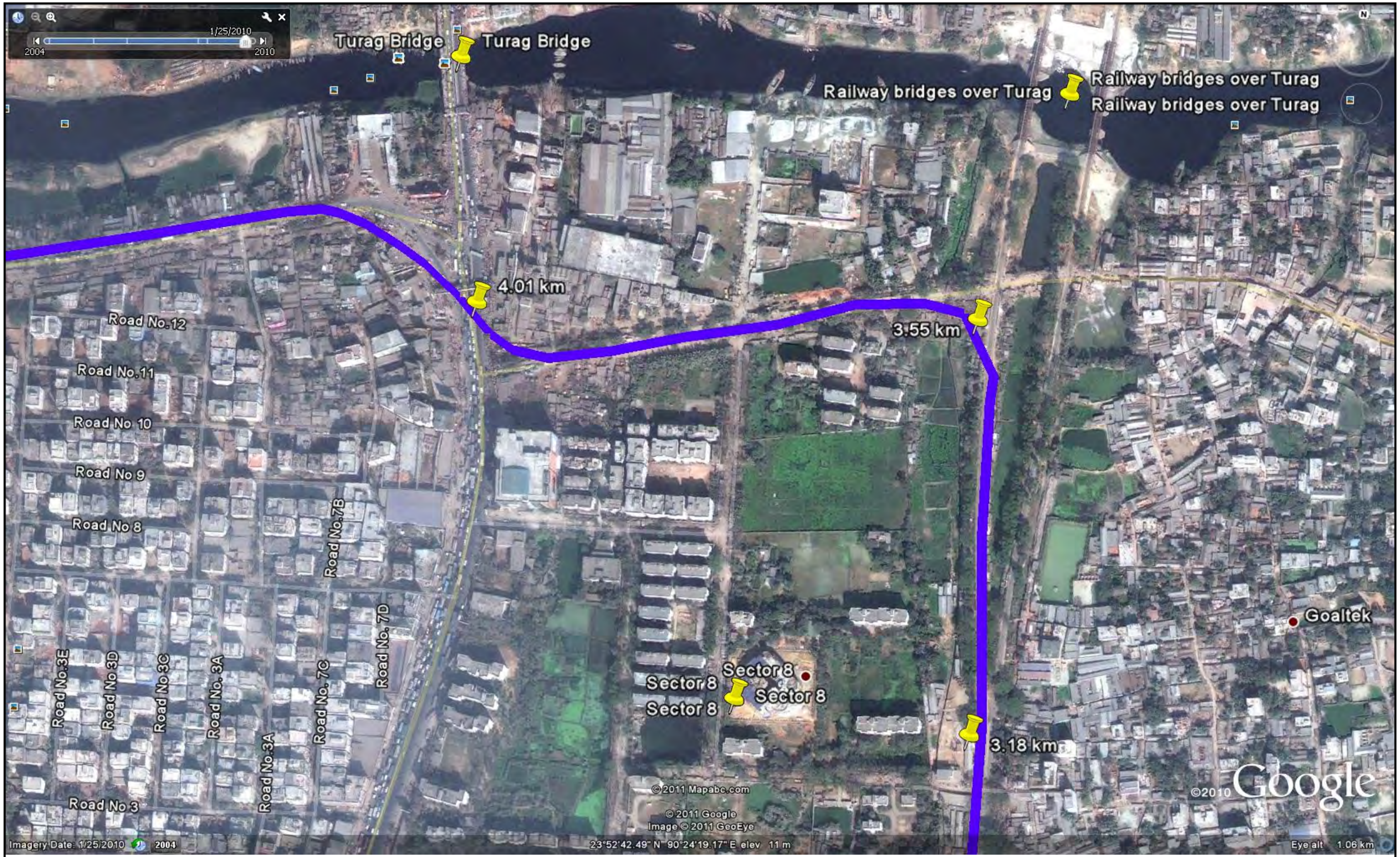


Figure D2: Proposed Alternative 1 alignment of DAEE showing Arichpur area & Abdullahpur Intersection

Figure D3: Kamarpara intersection on Ashulia road where a bridge has been constructed over the Turag river-Tongi khal Intersection

Figure D4: Land filling, apparently unauthorized, on the floodplains of Turga River-Tongi khal

Figure D5: Dhour intersection, about 9.5 km from DAEE starting point, where Beri Bandh Road from Mirpur connects with Ashulia

Figure D6: Chak Basaid (12.4 km from DAEE starting point) showing built up area and brick kilns

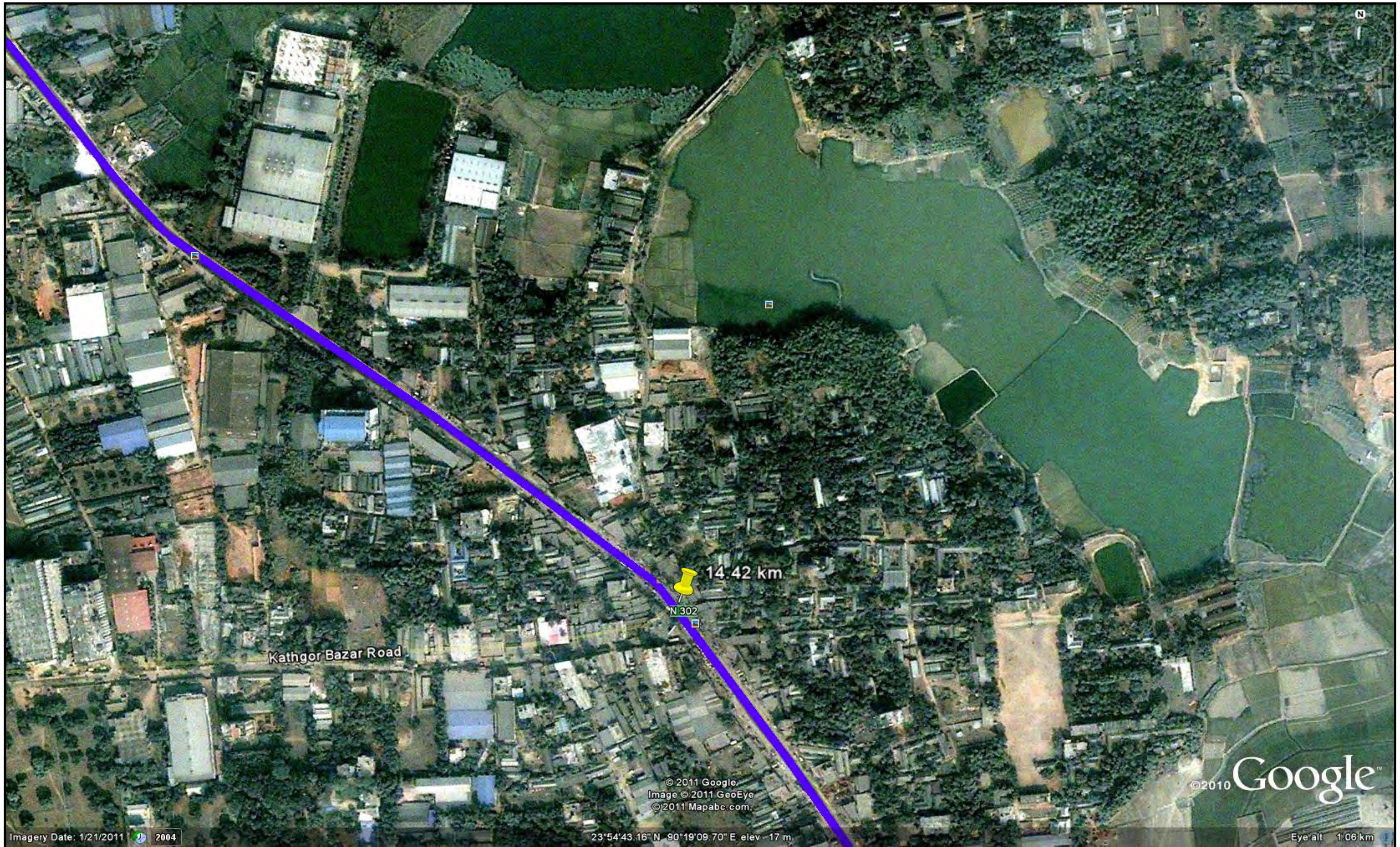


Figure D7: Industrial establishment and human settlements near Zirabo area

Figure D8: Dense industrial settlements along Ashulia road near the intersection with Narsingdi-Kashimpur Road

Figure D9: High concentration of industrial, commercial and residential structures close to Ashulia road near Baipayl

Figure D10: Dhaka EPZ on Baipayl-Chandra Road

Figure D11: BKSP and other built structures along Baipayl-Chandra road

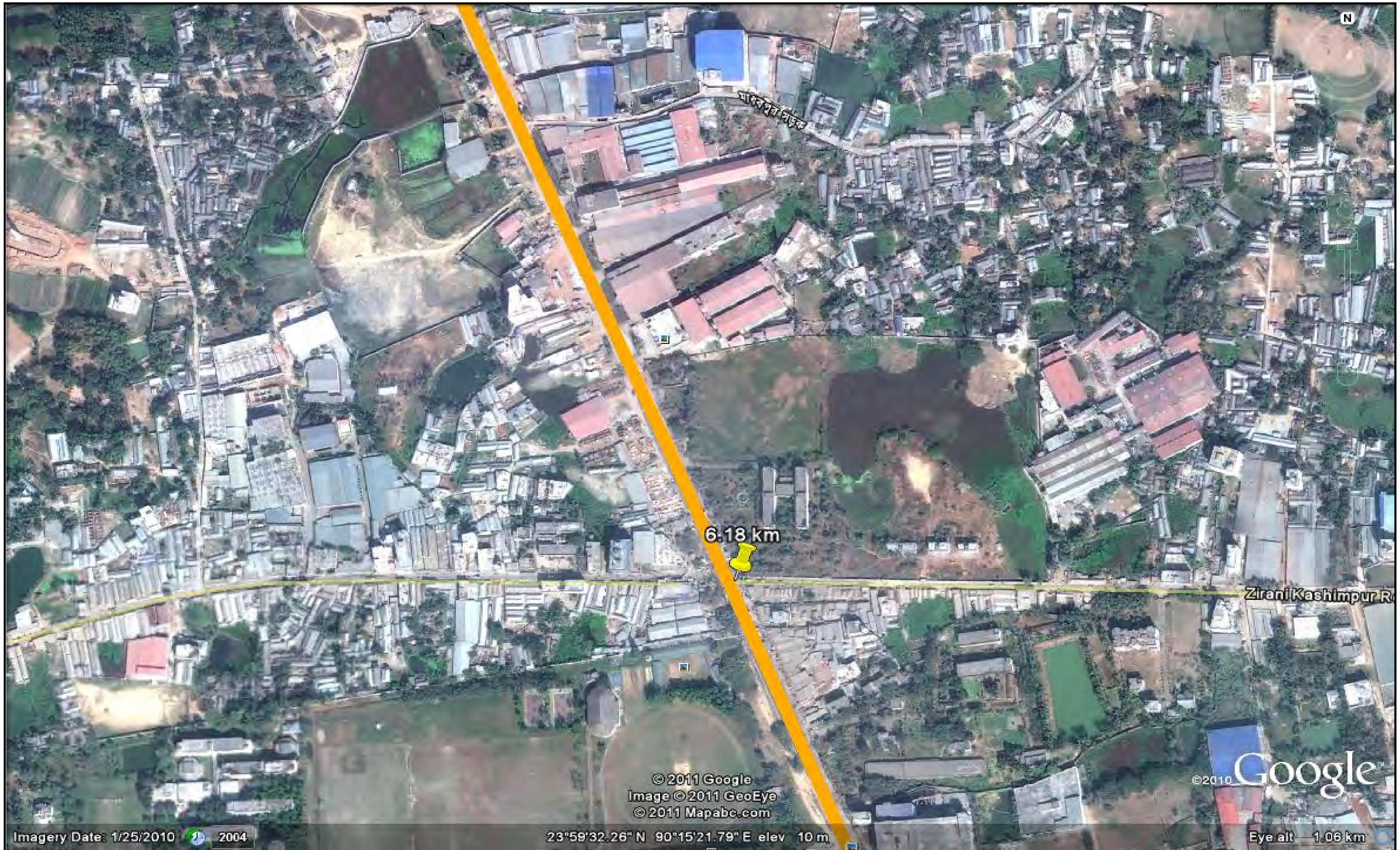


Figure D12: High concentration of built structures including industries in Zirani area

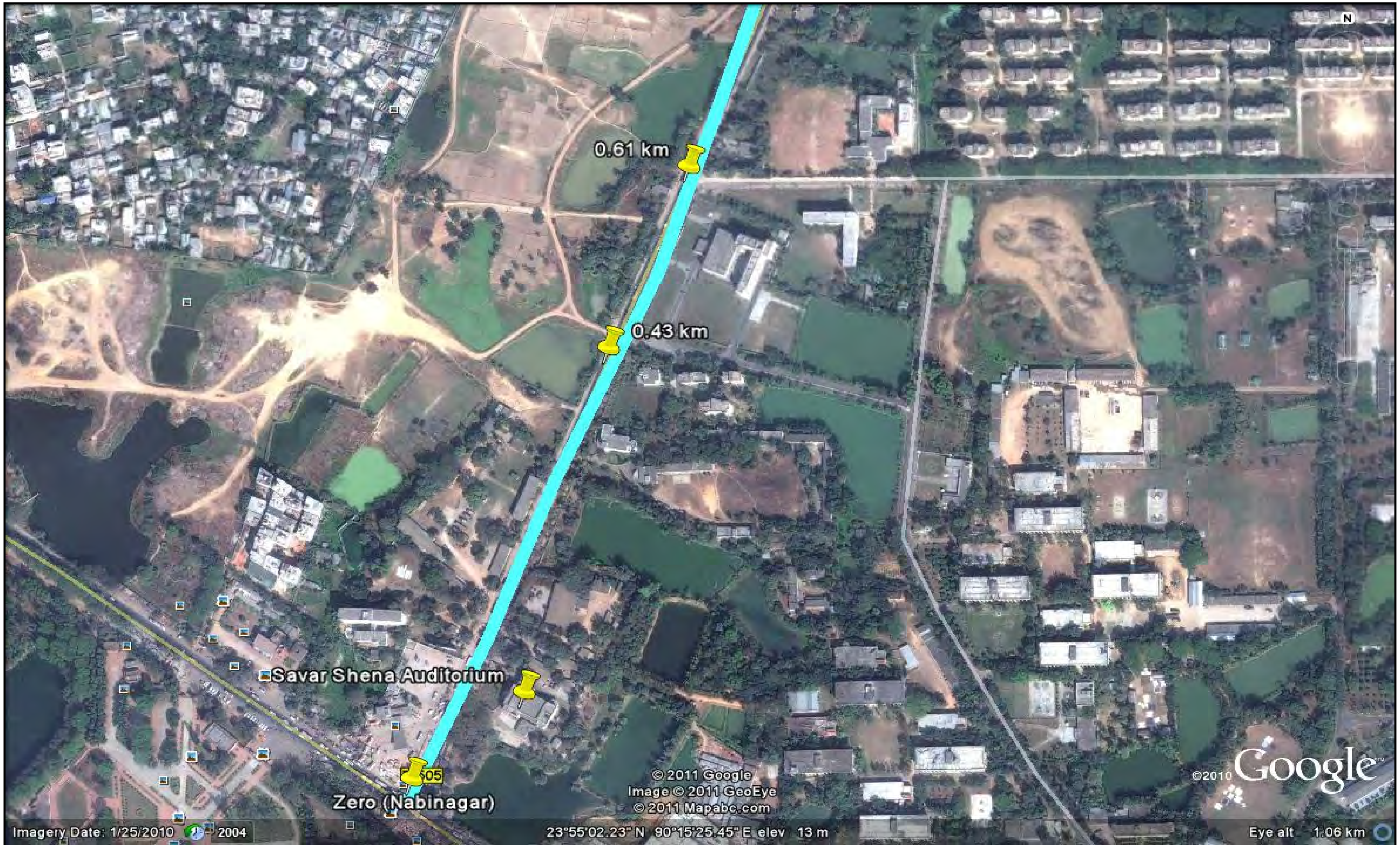


Figure D13: Nabinagar intersection near Savar National Monument

Figure D14: Alternative 2 alignment turning south from Ashulia road to meet Sonargaon Janapath in Uttara

Figure D15: Alternative 2 route running along Sonargaon Janapath, with dense permanent structures on either side

Figure D16: Portion of Alignment 2 between Sonargaon Janapath and Uttara 3rd Phase

Figure D17: Alignment 2 crossing Uttara 3rd Phase

Figure D18: Alignment 2 crossing Beri Bandh Road, Turag River-Tongi Khal (at 2 locations) and running over brick kilns along the southern bank of Turag River

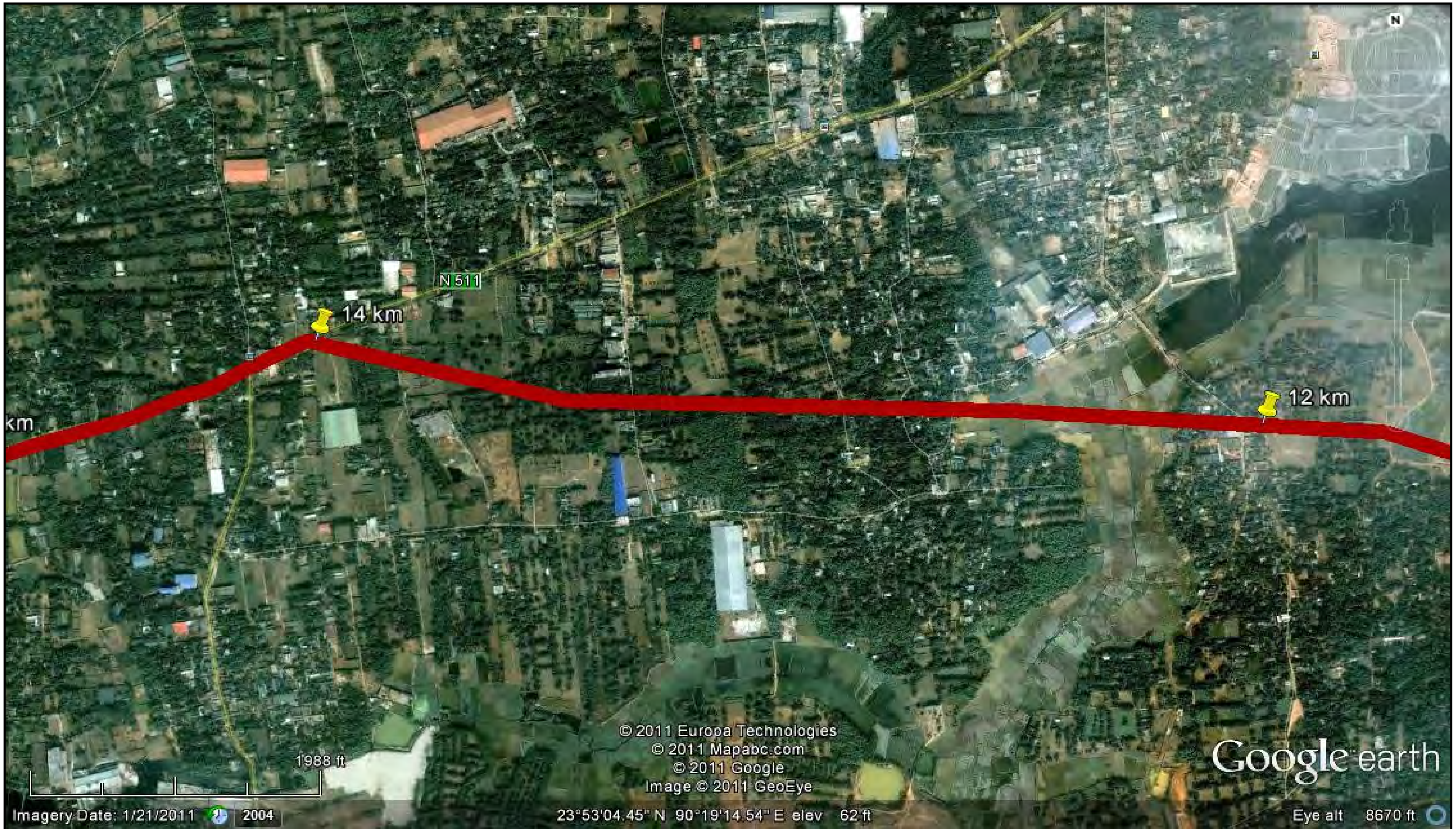


Figure D19: Alignment 2 running through agricultural lands and village areas before meeting the Ashulia-Savar Road (at about 14 km from the starting point)

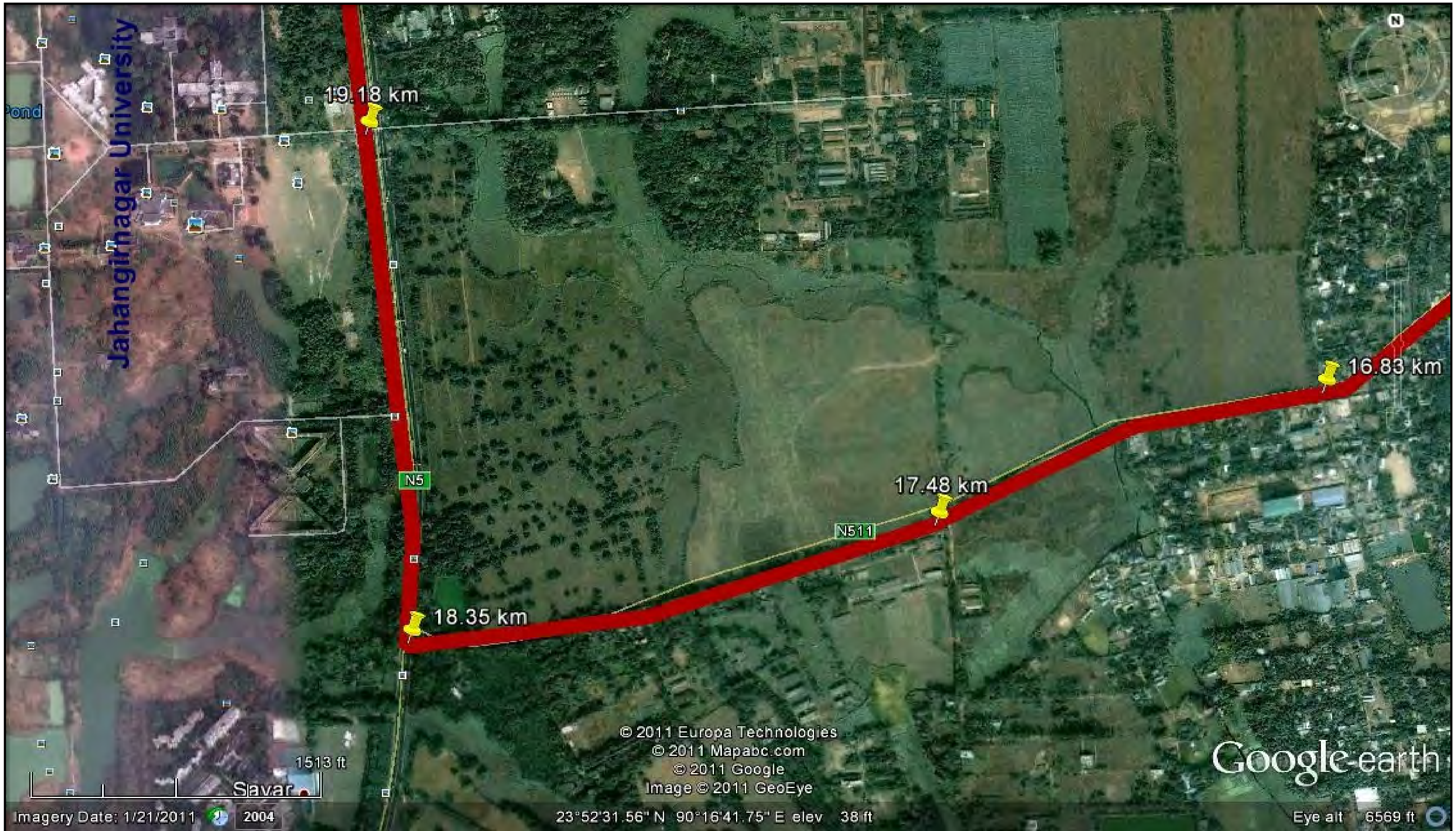
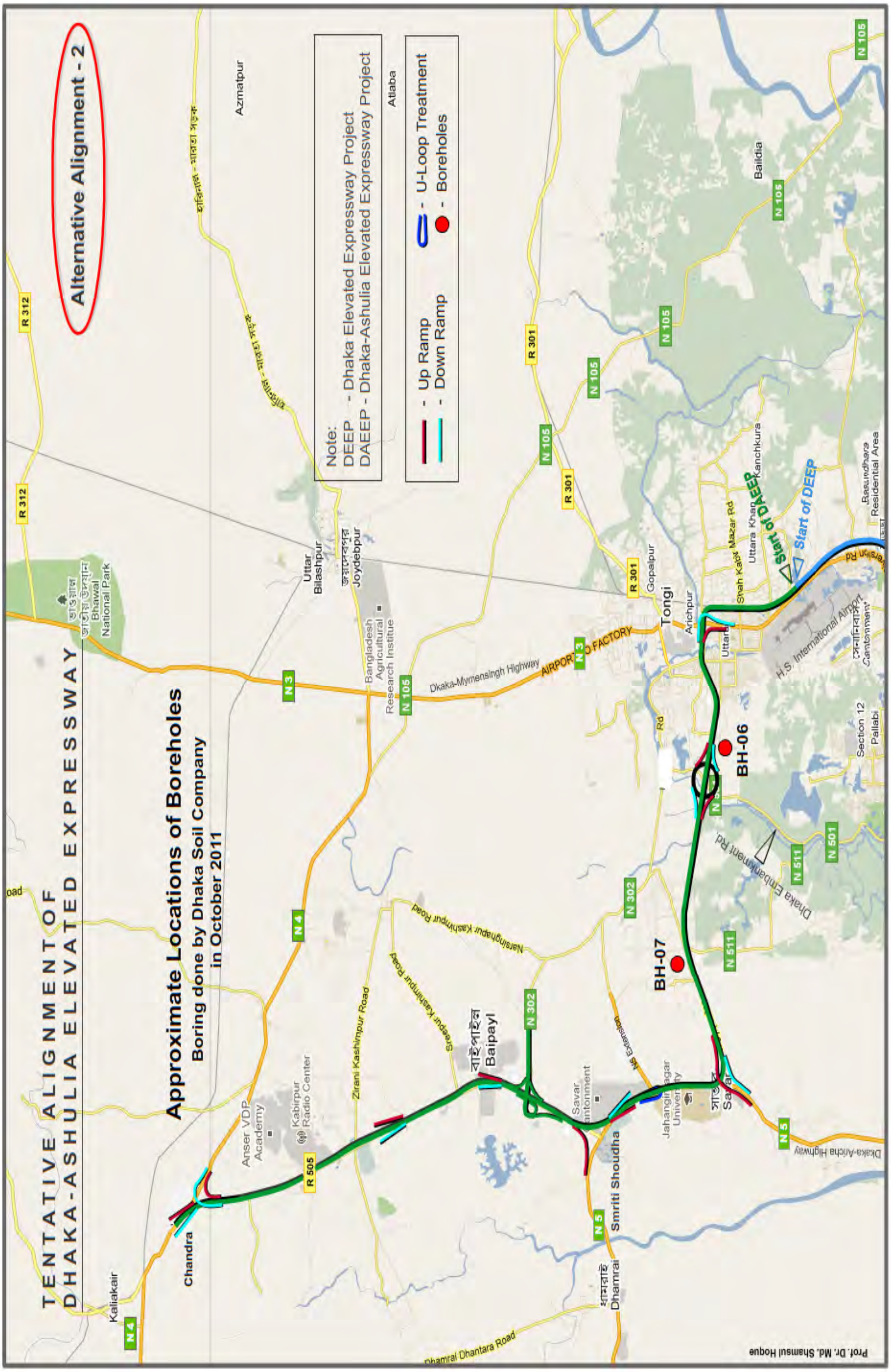


Figure D20: Alignment 2 running along Ashulia-Savar Road meets the Dhaka-Aricha Highway near Jahangirnagar University, then turns north toward Nabinagar intersection

Figure D21: Alignment 2 runs along Dhaka-Aricha Highway up to Nabinagar intersection and then continues along Nabinagar-Baipayl Road

Appendix-E: Position of the Boreholes and Bore Logs


TENTATIVE ALIGNMENT OF
DHAKA-ASHULIA ELEVATED EXPRESSWAY
Alternative Alignment - 1
Approximate Locations of Boreholes
Boring done by Dhaka Soil Company
in October 2011
Note:
DEEP - Dhaka Elevated Expressway Project
DAEEP - Dhaka-Ashulia Elevated Expressway Project
- Up Ramp
- Down Ramp
- U-Loop Treatment
- Boreholes
BH-01
BH-02
BH-03
BH-04
BH-05
Start of DAEEP
Start of DEEP
Tongi
Uttara
Savar
Chandra
Baipayl
Jahangirnagar University
Smriti Shoudha
Dhamrai
Kaliakair
Dhaka-Mymensingh Highway
Dhaka-Aricha Highway
H.S. International Airport
Prof. Dr. Md. Shamsul Hoque


TENTATIVE ALIGNMENT OF
DHAKA-ASHULIA ELEVATED EXPRESSWAY
Alternative Alignment - 2
Approximate Locations of Boreholes
Boring done by Dhaka Soil Company
in October 2011
Note:
DEEP - Dhaka Elevated Expressway Project
DAEEP - Dhaka-Ashulia Elevated Expressway Project
- Up Ramp
- Down Ramp
- U-Loop Treatment
- Boreholes
BH-06
BH-07
Start of DAEEP
Start of DEEP
Tongi
Uttara
Gopalpur
Ashulia
Baipayl
Chandra
Kaliakair
Savar
Smriti Shoudha
Dhamrai
Azmatpur
Bhawal National Park
Bangladesh Agricultural Research Institute
Kabirpur Radio Center
Ansar VDP Academy
H.S. International Airport
Basundhara Residential Area
Dhaka-Mymensingh Highway
Dhaka-Aricha Highway
Dhaka Embankment Rd
Dhamrai Dhantara Road
Zirani Kashimpur Road
Narsinghapur Kashimpur Road
Prof. Dr. Md. Shamsul Hoque

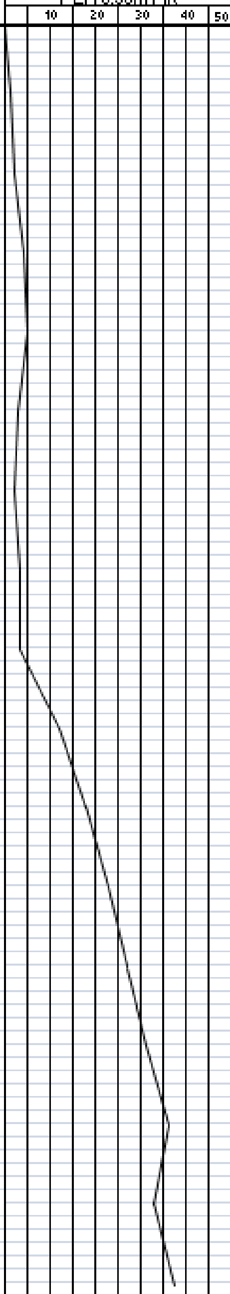
DHAKA SOIL

BORING LOG

PROJECT : DHAKA-ASHULIA ELEVATED EXPRESS WAY PPP PROJECT
LOCATION : MIDDLE PLACE OF ASHULIA JHEEL
BORE HOLE NO. 01

GROUND LEVEL R.L. : - 0.75 m from Road Level
GROUND WATER LEVEL : -3.60 m from EGL
DATE : 08-10-2011 TIME : 09:00 am

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	BLOWS ON SPOON PER 6" 6"	6"	6"	S P T	STANDARD PENETRATION RESISTANCE (S P T) BLOWS PER 0.30m / 1ft	INDEX / REMARKS
07-10-2011	D-1	Disturbed		3.0	Light brown very soft CLAY high plastic.		100 mm (4") φ	1	0	1	1		1.5m
	U-1	Undisturbed											
	D-2	Disturbed	3.0					1	1	1	2		3.0m
	U-2	Undisturbed		3.0	Grey medium stiff CLAY medium plastic.								
	D-3	Disturbed						1	2	2	4		4.5m
	D-4	Disturbed	6.0					1	2	3	5		6.0m
	D-5	Disturbed		6.0	Grey soft CLAY trace fine sand medium plastic.			1	1	2	3		7.5m
	D-6	Disturbed						1	1	1	2		9.0m
	D-7	Disturbed						1	1	2	3		10.5m
	D-8	Disturbed	12.0					1	1	2	3		12.0m
	D-9	Disturbed	13.5	1.5	Light brown stiff CLAY high plastic.			3	5	7	12		13.5m
	D-10	Disturbed		7.5	Light brown to brown medium dense to dense silty FINE SAND trace mica.			5	8	10	18		15.0m
	D-11	Disturbed						6	10	13	23		16.5m
	D-12	Disturbed						6	12	15	27		18.0m
	D-13	Disturbed						8	15	16	31		19.5m
	D-14	Disturbed	21.0					9	17	19	36		21.0m
	D-15	Disturbed		3.0	Brown dense FINE SAND trace mica.			10	15	18	33		22.5m
	D-16	Disturbed	24.0					11	16	21	37		24.0m



Drawn by : Checked by : SHEET 1 OF 7 ATTACHMENT - II

DHAKA SOIL

BORING LOG

PROJECT : DHAKA-ASHULIA ELEVATED EXPRESS WAY PPP PROJECT

LOCATION : RANASA NGV REFUELING CNG STATION, ZIRABO BAZAR, ASHULIA, SAVAR.

GROUND LEVEL R.L. : - 0.25 m from Road Level

GROUND WATER LEVEL : - 0.90 m from EGL

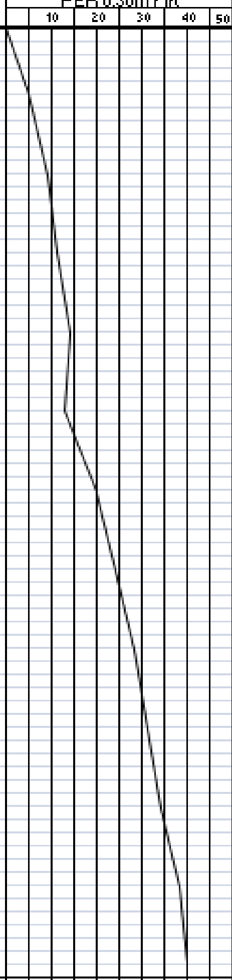
BORE HOLE NO. 02

DATE : 07-10-2011 **TIME :** 09:00 am

INDEX: DISTURBED (hatched); UNDISTURBED (solid)

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	BLOWS ON SPOON PER 6" : 6"	6"	6"	S P T	REMARKS
06-10-2011	D-1	Disturbed		7.5	Reddish brown medium stiff to stiff CLAY high plastic.		100 mm (4") ϕ	2	2	3	5	1.5m
	U-1	Undisturbed										
	D-2	Disturbed						3	4	5	9	3.0m
	U-2	Undisturbed										
	D-3	Disturbed						3	5	6	11	4.5m
	D-4	Disturbed						4	6	8	14	6.0m
	D-5	Disturbed	7.5					3	6	7	13	7.5m
	D-6	Disturbed		10.5	Brown medium dense to dense FINE SAND trace mica.			5	9	11	20	9.0m
	D-7	Disturbed						6	11	13	24	10.5m
	D-8	Disturbed						6	13	15	28	12.0m
	D-9	Disturbed						8	15	16	31	13.5m
	D-10	Disturbed						10	15	19	34	15.0m
	D-11	Disturbed						11	17	21	38	16.5m
	D-12	Disturbed	18.0					11	18	22	40	18.0m

STANDARD PENETRATION RESISTANCE (S P T) — BLOWS PER 0.30m / 1ft



Drawn by : Checked by : SHEET 2 OF 7 ATTACHMENT - II

DHAKA SOIL

BORING LOG

PROJECT : DHAKA-ASHULIA ELEVATED EXPRESS WAY PPP PROJECT

GROUND LEVEL R.L. : - 0.30 m from Road Level

LOCATION : AT THE SIDE ZIRANI POLLI BIDDYUT KENDRA

GROUND WATER LEVEL : - 0.60 m from EGL

BORE HOLE NO. 03

DATE : 07-10-2011 **TIME : 09:00 am**

INDEX: ▨ DISTURBED ■ UNDISTURBED

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	BLOWS ON SPOON PER 6" – 6"	6"	6"	SPT	REMARKS
06-10-2011	D-1	Disturbed		7.5	Light brown stiff CLAY high plastic.		100 mm (4") φ	2	4	6	10	1.5m
	U-1	Undisturbed										
	D-2	Disturbed						3	6	8	14	3.0m
	U-2	Undisturbed										
	D-3	Disturbed						4	7	9	16	4.5m
	D-4	Disturbed						3	6	7	13	6.0m
	D-5	Disturbed	7.5					3	6	8	14	7.5m
	D-6	Disturbed	9.0	1.5	Light brown stiff SILT trace fine sand			2	5	6	11	9.0m
	D-7	Disturbed		4.5	Brown medium dense to dense silty FINE SAND trace mica.			6	9	12	21	10.5m
	D-8	Disturbed						8	12	14	26	12.0m
	D-9	Disturbed	13.5					8	14	17	31	13.5m
	D-10	Disturbed		4.5	Brown dense FINE SAND trace mica.			9	15	18	33	15.0m
	D-11	Disturbed						10	17	20	37	16.5m
	D-12	Disturbed	18.0					11	18	23	41	18.0m

STANDARD PENETRATION RESISTANCE (S P T) BLOWS PER 0.30m / 1ft: 10, 20, 30, 40, 50

Drawn by : Checked by : SHEET 3 OF 7 ATTACHMENT - II

DHAKA SOIL

BORING LOG

PROJECT : DHAKA-ASHULIA ELEVATED EXPRESS WAY PPP PROJECT

GROUND LEVEL R.L. : - 0.25 m from Road Level

LOCATION : AT THE SIDE OF CHANDUA WALTON FACTORY

GROUND WATER LEVEL : - 2.50 m from EGL

BORE HOLE NO. 04

DATE : 07-10-2011 **TIME :** 09:00 am

Index: Disturbed (hatched); Undisturbed (solid)

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	Blows on spoon per 6": 6"	6"	6"	SPT (Blows per 0.30m / 1ft)	REMARKS
06-10-2011	D-1	Disturbed		7.5	Brown to light brown medium stiff CLAY high plastic.		100 mm (4") ϕ	1	2	2	4	1.5m
	U-1	Undisturbed										
	D-2	Disturbed						1	2	3	5	3.0m
	U-2	Undisturbed										
	D-3	Disturbed						1	2	3	5	4.5m
	D-4	Disturbed						2	3	4	7	6.0m
	D-5	Disturbed	7.5					2	3	5	8	7.5m
	D-6	Disturbed		3.0	Light grey SILT trace fine sand			1	2	2	4	9.0m
	D-7	Disturbed	10.5					1	2	2	4	10.5m
	D-8	Disturbed		7.5	Brown medium dense to dense FINE SAND trace mica.			5	8	12	20	12.0m
	D-9	Disturbed						6	10	14	24	13.5m
	D-10	Disturbed						6	12	15	27	15.0m
	D-11	Disturbed						7	13	17	30	16.5m
	D-12	Disturbed	18.0					8	15	19	34	18.0m

Drawn by : Checked by : SHEET 4 OF 7 ATTACHMENT - II

DHAKA SOIL

BORING LOG

PROJECT : DHAKA-ASHULIA ELEVATED EXPRESS WAY PPP PROJECT

LOCATION : AT THE SIDE OF BAIPAYL SEND DOCK SWEATER FACTORY.

GROUND LEVEL R.L. : - 0.90 m from Road Level

GROUND WATER LEVEL : - 2.65 m from EGL

BORE HOLE NO. 05

DATE : 07-10-2011 **TIME :** 09:00 am

INDEX: DISTURBED (hatched); UNDISTURBED (solid)

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	BLOWS ON SPOON PER 6" 6"	6"	6"	SPT	STANDARD PENETRATION RESISTANCE (S P T) BLOWS PER 0.30m / 1ft (10 20 30 40 50)	REMARKS
06-10-2011	D-1	Disturbed		3.0	Light brown soft to very soft CLAY high plastic.		100 mm (4") ϕ	1	1	2	3		1.5m
	U-1	Undisturbed											
	D-2	Disturbed	3.0					1	0	1	1		3.0m
	U-2	Undisturbed		3.0	Brown stiff CLAY high plastic.								
	D-3	Disturbed						3	4	6	10		4.5m
	D-4	Disturbed	6.0					2	4	4	8		6.0m
	D-5	Disturbed		3.0	Brown loose to medium dense silty FINE SAND trace mica.			2	4	4	8		7.5m
	D-6	Disturbed	9.0					4	6	9	15		9.0m
	D-7	Disturbed		9.0	Brown medium dense to dense FINE SAND trace mica.			5	7	10	17		10.5m
	D-8	Disturbed						6	9	11	20		12.0m
	D-9	Disturbed						7	11	15	26		13.5m
	D-10	Disturbed						7	13	15	28		15.0m
	D-11	Disturbed						8	14	18	32		16.5m
	D-12	Disturbed	18.0					9	16	20	36		18.0m

Drawn by : Checked by : SHEET 5 OF 7 ATTACHMENT - II

DHAKA SOIL

BORING LOG

PROJECT : DHAKA-ASHULIA ELEVATED EXPRESS WAY PPP PROJECT

GROUND LEVEL R.L. : - 1.80 m from Road Level

LOCATION : CHARABAG, ASHULIA,

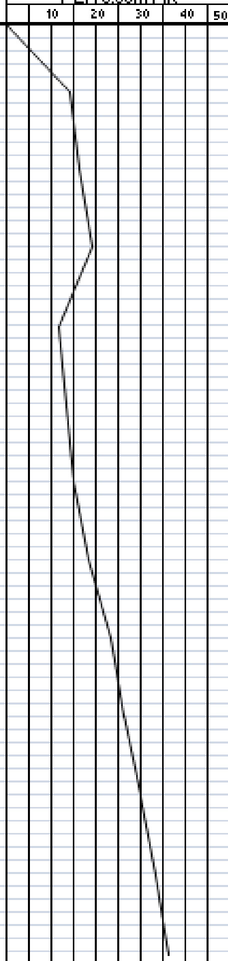
GROUND WATER LEVEL : - 3.30 m from EGL

BORE HOLE NO. 06

DATE : 08-10-2011 **TIME :** 09:00 am

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	BLOWS ON SPOON PER 6" 6"	6"	6"	S P T	INDEX / REMARKS
07-10-2011	D-1	Disturbed		7.5	Reddish brown stiff to very stiff CLAY high plastic.		100 mm (4") ϕ	4	6	8	14	1.5m
	U-1	Undisturbed										
	D-2	Disturbed						4	8	8	16	3.0m
	U-2	Undisturbed										
	D-3	Disturbed						4	9	10	19	4.5m
	D-4	Disturbed						3	5	7	12	6.0m
	D-5	Disturbed	7.5					3	5	8	13	7.5m
	D-6	Disturbed		10.5	Brown medium dense to dense FINE SAND trace mica.			4	6	9	15	9.0m
	D-7	Disturbed						5	8	10	18	10.5m
	D-8	Disturbed						6	10	13	23	12.0m
	D-9	Disturbed						6	12	14	26	13.5m
	D-10	Disturbed						8	13	17	30	15.0m
	D-11	Disturbed						9	15	18	33	16.5m
	D-12	Disturbed	18.0					10	17	19	36	18.0m

STANDARD PENETRATION RESISTANCE (S P T) BLOWS PER 0.30m / 1ft



INDEX: DISTURBED / UNDISTURBED

Drawn by : Checked by : SHEET 6 OF 7 ATTACHMENT - II

DHAKA SOIL

BORING LOG

PROJECT : DHAKA-ASHULIA ELEVATED EXPRESS WAY PPP PROJECT

GROUND LEVEL R.L. : - 0.0 m from Road Level

LOCATION : 1 NO. KOLMA BAZAR, SAVAR.

GROUND WATER LEVEL : - 1.80 m from EGL

BORE HOLE NO. 07

DATE : 08-10-2011 **TIME :** 09:00 am

Index: ▨ DISTURBED, ■ UNDISTURBED

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	BLOWS ON SPOON PER 6" — 6"	6"	6"	SPT	REMARKS
07-10-2011	D-1	Disturbed		4.5	Light brown soft CLAY high plastic.		100 mm (4") ϕ	1	1	1	2	1.5m
	U-1	Undisturbed										
	D-2	Disturbed						1	1	2	3	3.0m
	U-2	Undisturbed										
	D-3	Disturbed	4.5					1	2	2	4	4.5m
	D-4	Disturbed		4.5	Light brown soft SILT trace fine sand.			1	1	2	3	6.0m
	D-5	Disturbed						1	1	1	2	7.5m
	D-6	Disturbed	9.0					1	1	2	3	9.0m
	D-7	Disturbed		4.5	Brown medium dense silty FINE SAND trace mica.			4	6	9	15	10.5m
	D-8	Disturbed						4	7	9	16	12.0m
	D-9	Disturbed	13.5					5	9	11	20	13.5m
	D-10	Disturbed		4.5	Brown medium dense to dense FINE SAND trace mica.			7	11	15	26	15.0m
	D-11	Disturbed						8	13	15	28	16.5m
	D-12	Disturbed	18.0					9	15	18	33	18.0m

STANDARD PENETRATION RESISTANCE (S P T) BLOWS PER 0.30m / 1ft: 10 20 30 40 50

Drawn by : Checked by : SHEET 7 OF 7 ATTACHMENT - II

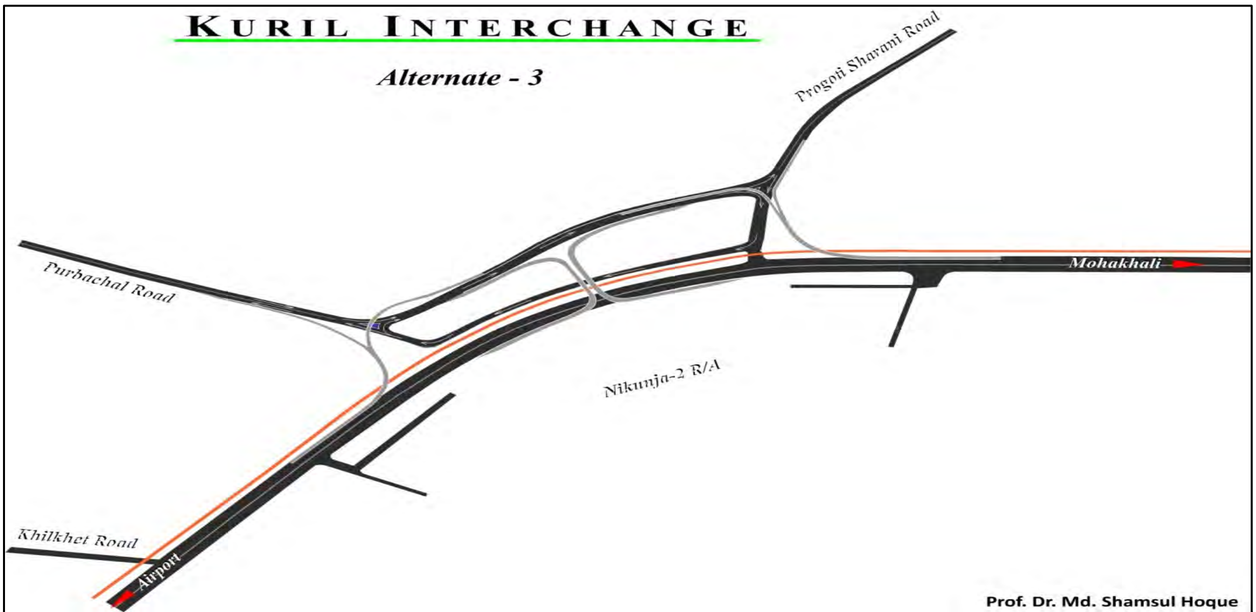
Appendix-F

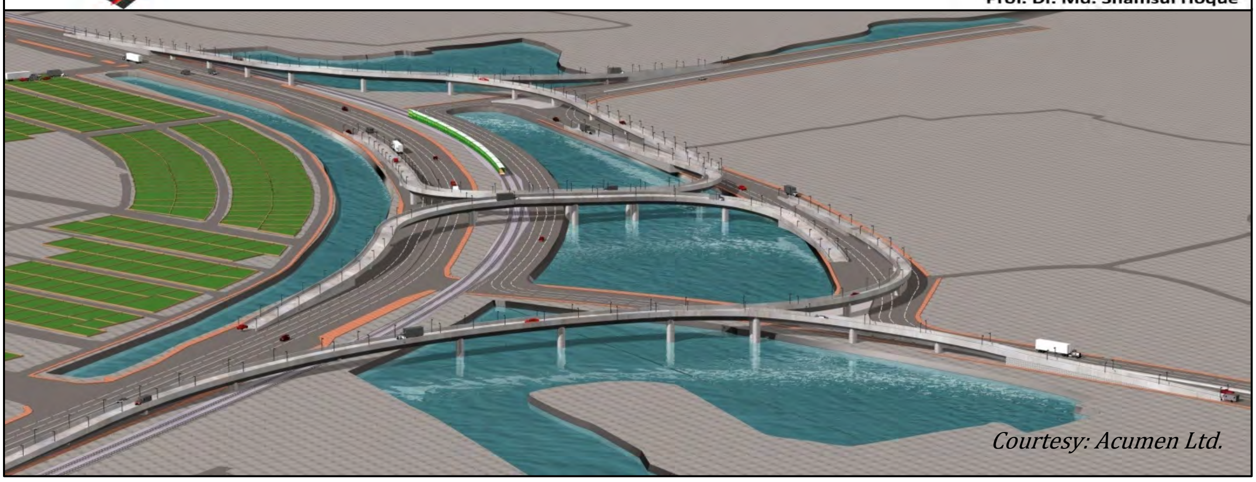
Cost Review of a Few
F1 - Ongoing Flyover and Expressway Projects
F2 - Proposed Flyover Projects
F3 - Completed Flyover Projects

F1 - Cost Review of Ongoing Projects

I. Kuril Multidirectional Flyover

Executing Agency	:	RAJUK
Mode of Construction	:	GoB Financed
Contractor	:	Project Builders Ld. and Major Bridge Engineering Corporation (China)
Total length	:	3.1 km of 2-lane flyover (including 1.5 lane ramp)
Structural Form	:	Box-Girder with single pier
Overall width	:	7.1 m
Vertical clearance	:	7.2 m
Ramps over railway track		
	:	2 nos. 2-lane oneway U-loop ramps
	:	2 nos. 2-lane oneway splitted Y-ramps
Equivalent length	:	1.86 km of 4-lane flyover
Total Project Cost	:	Tk. 307 crore
Construction Cost	:	Tk. 212 crore
Per km Cost	**:**	**Tk. 68 crore of 2-lane flyover**
	:	**Tk. 114 crore of Equivalent 4-lane flyover**





II. Zia Colony Multidirectional Flyover and Banani Overpass

Executing Agency	:	Roads & Highways Department (RHD)
Mode of Construction	:	GoB Financed
Contractor	:	M/s Mir Akhter Ltd.
Flyover Main Viaduct	:	4-lane divided
Total length	:	1.795 km of 4-lane flyover (incl. 1.5 lane 0.375 KM ramp)
Structural Form	:	Combination of Box and I-Girder (mostly) with single pier
Overall width (avg.)	:	15.52 m
Vertical clearance	:	5.50 m
Ramps on roadway		
	:	2 nos. 1.5-lane oneway direct ramps (width 6.7m)
	:	2 nos. 2-lane oneway semi-direct/indirect ramps(avg. 7.8m)
Equivalent length	:	1.645 km of 4-lane flyover
Construction Cost	:	Tk. 167.58 crore
Per km Cost	**:**	**Tk. 98 crore of Equivalent 4-lane flyover**

Zia Colony Multidirectional Flyover or Trumpet Interchange

III. Banani Overpass on Railway Level Crossing

Executing Agency	:	Roads & Highways Department (RHD)
Mode of Construction	:	GoB Financed
Contractor	:	M/s Abdul Monem Ltd.

Flyover Main Viaduct

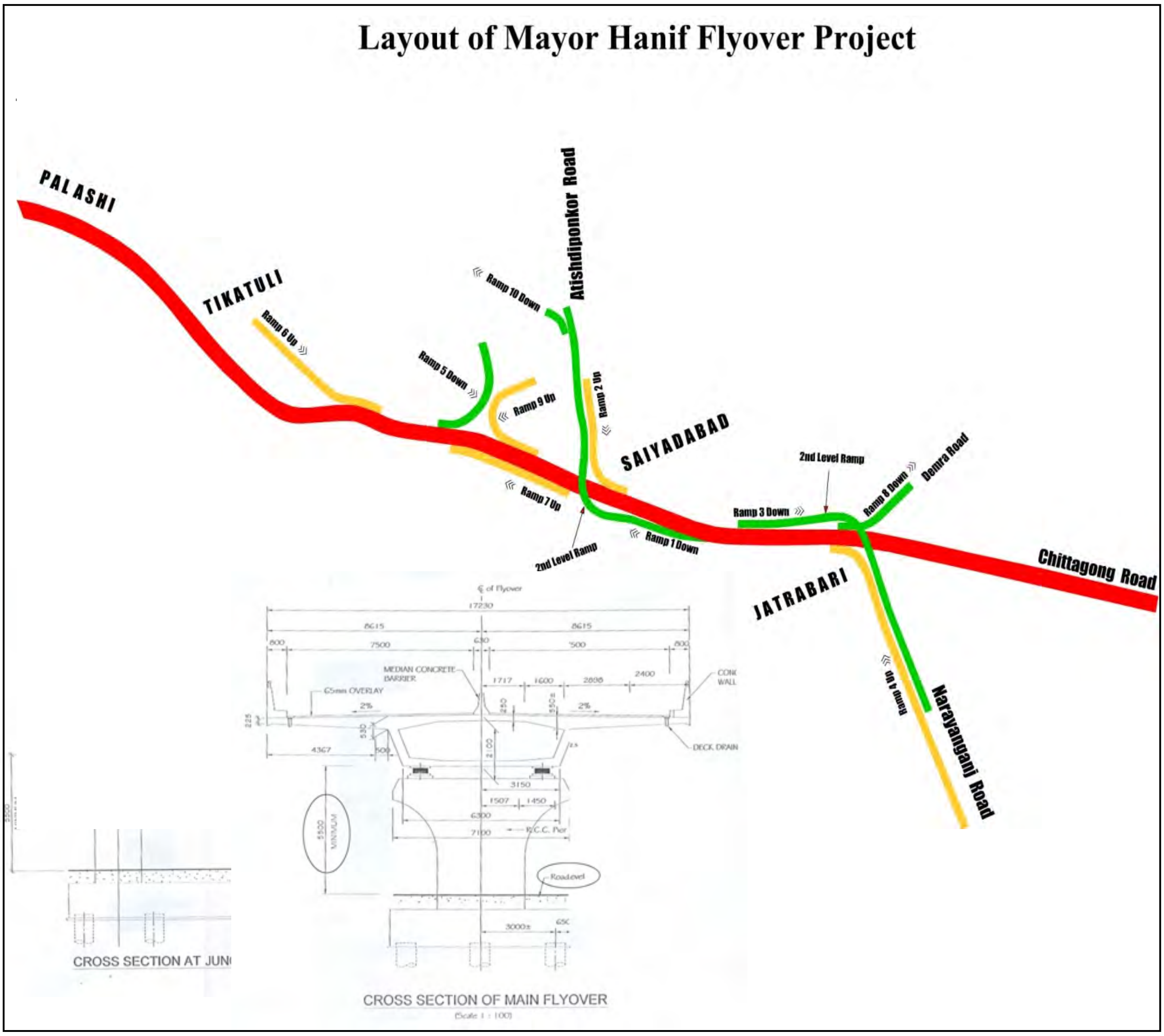
Overpass Class	:	6-lane divided road overpass
Total length	:	0.804 km
Structural Form	:	I-Girder with portal frame
Overall width	:	22.52 m
Vertical clearance	:	7.2 m
Equivalent length	:	1.045 km of 4-lane flyover
Construction Cost	:	Tk. 103.98 crore
Per km Cost	**:**	**Tk. 130 crore of 6-lane flyover**
	:	**Tk. 99 crore of Equivalent 4-lane flyover**

Link Bridge	**:**	**0.560 km**
Overall width	:	6.7 m oneway 1.5 lane ramp
Equivalent length	:	1.86 km of 4-lane flyover
Construction Cost	:	Tk. 30.4 crore
Per km Cost	**:**	**Tk. 54 crore of 1.5-lane flyover**
	:	**Tk. 98 crore of Equivalent 4-lane flyover**

Banani Road Overpass

IV. Mayor Hanif or Jatrabari-Gulistan Flyover

Executing Agency	:	Dhaka City Corporation (DCC)
Mode of Construction	:	Public-Private-Partnership (PPP)
Concessionaire	:	Belhasa - Accom JV
Flyover Main Viaduct	:	4 lane divided
Overall width	:	17.23 m
Structural Form	:	Box-Girder with single pier
Vertical clearance	:	5.5 m to 7.2 m
Total length	:	5.5 km of 4-lane flyover
	:	4.5 km of 1.5 lane ramp
Ramps on roadway	:	8 nos. 1.5-lane oneway direct ramps
	:	2 nos. 1.5-lane oneway Semi direct ramps at 2nd level
Equivalent length	:	8.9 km of 4-lane flyover
Total Project Cost	:	Tk. 2053 crore
Per km Cost	**:**	**Tk. 230 crore or USD 28 million**



V. Dhaka Elevated Expressway (DEE)

Executing Agency : Bangladesh Bridge Authority (BBA)
Mode of Construction : Public-Private-Partnership (PPP)
Concessionaire : Ital-Thai Development Public Company Limited

Salient Features

• **Length:**		
Main Route	:	21 km
2-Elevated Links	:	5 km
Interchanges / Ramps	:	16 km
Total	:	**42 km**
• **Width:**		
Main Route		
a) For single column pier	:	20.56 m
b) For portal frame	:	17.56 m
2-Elevated Links	:	15.96 m
Interchanges / Ramps	:	7.10 m
• **Number of span:**		
Main Route	:	495 nos
2-Elevated Links & Interchanges / Ramps	:	1055 nos
• **Span Length:**		
Main Route	:	40 m
2-Elevated Links & Interchanges / Ramps	:	20 m
• **Girder Type**		
Main Route	:	Precast Segmental Box Girder
2-Elevated Links & Interchanges / Ramps	:	Precast I-Girder
• **Foundation Type**	:	Bored Pile Foundation
• **Pile Diameter**		
Main Route	:	1.20 m
2-Elevated Links & Interchanges / Ramps	:	0.80 m
• **Design speed**	:	**80 kmph**
• **Design Life**	:	**100 Years**
• **Toll Fee for Car**		
End to end	:	Tk. 125
Any intermediate point	:	Tk. 100
* Toll fee for Bus will be 2 times, for Truck up to 6 wheels will be 4 times and for Truck greater than 6 wheels will be 5 times of Car.		
• **Guaranteed Traffic**	:	13,500 vehicles per day
• **Traffic Transaction Ceiling**	:	80,000 vehicles per day
• **Revenue Sharing**	:	25%-GoB, 75%-Concessionaire ceiling, For exceeding traffic transaction
• **Construction Period**	:	**42 month**
• **Concession period**	:	**25 years (Including Construction Period)**
• **Project Cost**	:	**Tk. 8,703** Crore
• **Concession Fee (Royalty)**	:	**Tk.** 272.5 Crore
• **Viability Gap Financing (VGF) by GOB**	:	**Tk. 2349.81 Crore**
• **Technology Transfer & Capacity Building**	:	
a) Technology Transfer	:	1% of the Estimated Project Cost. A full fledged Institute of Civil Engineering and Management (ICEM) would be established.
b) Local Content	:	50% of the Estimated Project Cost shall be earmarked for goods, works and services through established Bangladeshi Firms/contractors or suppliers.

DEE Alignment by Ital-Thai, 2011

Dhaka Elevated Expressway PPP Project
Estimated Project Cost (I-Girder Type)

Sl .NO. Particulars	Total Amount (TK)	Total Amount ($)
1. Preliminaries and General Requirements		
Mobilization, site establishment & other running cost	6,168,369,443	88,119,563
Survey, detailed design and construction drawings	740,771,190	10,582,446
Independent Engineer (See detail in item 12.4)	-	
Other general requirements	1,368,778,378	19,553,977
2. Traffic Diversion, Temporary Diversion Works/Protection Works		
Traffic Management/Diversion during Construction	1,784,701,718	25,495,739
Temporary Diversions	505,515,287	7,221,647
Others	41,093,084	587,044
3. Main Carriageways		
Clearing and Site Possession	623,218,237	8,903,118
Substructures (including Piles and Footings)	7,740,736,548	110,581,951
Superstructures (inc. Pier & Cross Meads, Girders & Deck Slab)	21,559,447,220	307,992,103
Other Incidentals	838,611,284	11,980,161
4. Interchanges and Approach Ramps		
At-Grade Works	1,761,532,511	25,164,750
Structural works	16,118,055,256	230,257,932
Others	-	
5. Toll Plazas, Toll Booths and Canopies	1,616,815,597	23,097,366
6. Central Control Building		
Central Control Building, Police Station and Emergency Buildings	578,880,414	8,269,720
Emergency Generators	Included	
7. Toll Collection System	1,848,032,027	26,400,458
8. Traffic Surveillance System (including Weighing Stations)	3,240,548,304	46,293,547
9. Street Lighting System	522,549,273	7,464,990
10. Environmental Monitoring and Management plan	30,929,953	441,856
11. Others (Bidders id specify)	-	
Total Cost of Construction	**67,088,585,724**	**958,408,367**
Capital Costs escalation, if any	-	
12. Other Soft Costs		
12.1 Development Cost (SPV Set up Cost)	59,196,654	845,666
12.2 Advisory Fees (Financial Soft Cost)	801,573,526	11,451,050
12.3 Transfer of Technology (1% of Estimated Direct Cost)	418,713,281	5,981,618
12.4 Independent Engineer	335,442,929	4,792,042
12.5 Supervision and Coordination Charges	-	
12.6 Other(Bidder to specify)	-	
13. Duties and Taxes	2,492,875,075	35,612,501
14. Interest During Construction	6,466,842,150	92,383,459
Total Estimated Project Cost (of the Bidder)	**77,663,229,339**	**1,109,474,705**
Total Estimated Project Cost (of the Bidder) (In cases of Duties and Taxes are waived)	**75,170,354,264**	**1,073,862,204**

Dhaka Elevated Expressway PPP Project
Estimated Project Cost (Box-Girder Type)

Sl .NO. Particulars	Total Amount (TK)	Total Amount ($)
1. Preliminaries and General Requirements		
Mobilization, site establishment & other running cost	6,493,020,465	92,757,435
Survey, detailed design and construction drawings	1,037,079,666	14,815,424
Independent Engineer (See detail in item 12.4)	-	
Other general requirements	1,440,819,345	20,583,134
2. Traffic Diversion, Temporary Diversion Works/Protection Works		
Traffic Management/Diversion during Construction	1,784,701,718	25,495,739
Temporary Diversions	631,066,488	9,015,236
Others	41,599,394	594,277
3. Main Carriageways		
Clearing and Site Possession	623,218,237	8,903,118
Substructures (including Piles and Footings)	8,038,843,526	114,840,622
Superstructures (inc. Pier & Cross Meads, Girders & Deck Slab)	27,981,951,464	399,742,164
Other Incidentals	875,199,874	12,502,855
4. Interchanges and Approach Ramps		
At-Grade Works	1,761,532,511	25,164,750
Structural works	16,118,055,256	230,257,932
Others	-	
5. Toll Plazas, Toll Booths and Canopies	1,616,815,597	23,097,366
6. Central Control Building		
Central Control Building, Police Station and Emergency Buildings	578,880,414	8,269,720
Emergency Generators	Included	
7. Toll Collection System	1,848,032,027	26,400,458
8. Traffic Surveillance System (including Weighing Stations)	3,240,548,304	46,293,547
9. Street Lighting System	552,549,273	7,893,561
10. Environmental Monitoring and Management plan	30,929,953	441,856
11. Others (Bidders id specify)	-	
Total Cost of Construction	**74,694,843,512**	**1,067,069,193**
Capital Costs escalation, if any	-	
12. Other Soft Costs		
12.1 Development Cost (SPV Set up Cost)	65,881,683	941,167
12.2 Advisory Fees (Financial Soft Cost)	892,049,553	12,743,565
12.3 Transfer of Technology (1% of Estimated Direct Cost)	465,998,221	6,657,117
12.4 Independent Engineer	373,324,218	5,333,203
12.5 Supervision and Coordination Charges	-	
12.6 Other(Bidder to specify)	-	
13. Duties and Taxes	3,371,840,581	48,169,151
14. Interest During Construction	7,197,137,217	102,816,246
Total Estimated Project Cost (of the Bidder)	**87,061,074,985**	**1,243,729,643**
Total Estimated Project Cost (of the Bidder) (In cases of Duties and Taxes are waived)	**83,689,234,404**	**1,195,560,491**

Unit Cost Analysis of Dhaka Elevated Expressway

I-Girder Type

Estimation fo Unit Cost (PPP basis)		
Equivalent Length of Main Viaduct incl. 2-links (4-lane two-way)	20.55	km
Total Length of Ramps (2-Lane one-way)	23.58	km
Total Equivalent (4-lane) Length of Ramp Structure	8.96	km
Total Equivalent Length of Expressway (4-Lane)	29.51	km
Average Per km Construction or Direct Cost of Main Viaduct	150	Tk. crore
Average Per km Construction or Direct Cost of Oneway Ramps	76	Tk. crore
Average Per km Construction or Direct Cost of Expressway (for GoB funding)	227	Tk. crore
Average Per km Capital Cost of Expressway (of the Bidder)	**255**	**Tk. crore**
Average Per km Capital Cost of Expressway (of the Bidder)	**31.1**	**$ million**

Box-Girder Type

Estimation fo Unit Cost (PPP basis)		
Equivalent Length of Main Viaduct incl. 2-links (4-lane two-way)	20.55	km
Total Length of Ramps (2-Lane one-way)	23.58	km
Total Equivalent (4-lane) Length of Ramp Structure	8.96	km
Total Equivalent Length of Expressway (4-Lane)	29.51	km
Average Per km Construction or Direct Cost of Main Viaduct	183	Tk. crore
Average Per km Construction or Direct Cost of Oneway Ramps	76	Tk. crore
Average Per km Construction or Direct Cost of Expressway (for GoB funding)	253	Tk. crore
Average Per km Capital Cost of Expressway (of the Bidder)	**284**	**Tk. crore**
Average Per km Capital Cost of Expressway (of the Bidder)	**34.6**	**$ million**

Observation:

Unit costs are found to be relatively high due to

- Higher average vertical clearance of 7.4m (80% length is on the railway corridor)
- Very high average height i.e. about 18m; which is needed to overpass a total of three existing flyovers and ongoing three flyovers along the alignment
- Wide carriageway of 20.56m width which is nearly 6-lane expressway
- Cost of extra temporary works that are needed during the construction to keep railway traffic operation normal and uninterrupted

The associated cost of land acquisition, rehabilitation and utility relocation are also found to be very high due to construction at built-up urban context with many multi-storied buildings demolition.

F2 - Cost Review of Proposed Projects

I. Moghbazar-Mouchak Flyover (Approved)

Executing Agency : Local Government Engineering Department (LGED)

Functional Class	=	4-lane divided urban elevated road
Flyover Structure Length		
Moghbazar Flyover	=	1,805 m - 4 Lane
Mouchak Flyover (Level-1)	=	3,157 m - 4 Lane
Mouchak Flyover (Level-2)	=	430 m - 2 Lane
Combined Flyover	=	1,858 m - 4 Lane
Total Flyover Length	=	7,250 m
Ramp Length		
No. of Ramps	=	15 Nos.
Total Ramp Length	=	1,000 m
Total (Flyover + Ramp) Length	=	8,250 m
Total Equivalent Length	=	7,535 m of 4-lane
Total Estimated Project Cost	=	772 crore
Total Cost Construction	=	701 crore
Unit cost	**=**	**93 crore of Equivalent 4-lane flyover**

Layout Configuration of Moghbazar-Mouchak Flyover

II. 2 nos. U-Loops at Rampura TV Station (Approved)

Executing Agency	:	RAJUK
Mode of Construction	:	GoB Financed
Functional Class	:	2-lane oneway road overpass
U-Loop	:	2 nos. back to back paired
Total length	:	0.91 km
Structural Form	:	Combination of Box and I-Girder with single column
Overall width	:	9.3 m
Vertical clearance	:	5.5 m
Equivalent length	:	0.546 km of 4-lane flyover
Construction Cost	:	Tk. 56 crore
Per km Cost	**:**	**Tk. 61.5 crore of 2-lane flyover**
	:	**Tk. 102.5 crore of Equivalent 4-lane flyover**

III. 4 nos. U-Loops along Airport corridor (Proposed)

Executing Agency	:	Local Government Engineering Department (LGED)
Mode of Construction	:	GoB Financed
Functional Class	:	2-lane oneway road overpass
U-Loop	:	4 nos. back to back paired
Total length	:	2.217 km
Structural Form	:	Combination of Box and I-Girder with single column
Overall width	:	7.9 m
Vertical clearance	:	5.5 m
Equivalent length	:	1.33 km of 4-lane flyover
Total Project Cost	:	Tk. 169.16 crore
Construction Cost	:	Tk. 140.53 crore
Per km Cost	**:**	**Tk. 64 crore of 2-lane flyover**
	:	**Tk. 105 crore of Equivalent 4-lane flyover**

F3 - Cost Review of Completed Projects

I. Khilgaon Flyover (Completed in March 2007)

Executing Agency	:	Local Government Engineering Department (LGED)
Mode of Construction	:	GoB Financed
Flyover Main Viaduct	:	4-lane divided
Total length	:	1.605 km of 4-lane flyover (including 2 lane U-loop)
Structural Form	:	I-Girder with single pier
Overall width	:	15.92 m
Vertical clearance	:	6.90 m
Ramps	:	1 no. 2-lane U-Loop
Equivalent length	:	1.425 km of 4-lane flyover
Total Project Cost	:	Tk. 76 crore
Per km Cost	**:**	**Tk. 55 crore of Equivalent 4-lane flyover**

Khilgaon Flyover

II. Mohakhali Flyover (Completed in November 2004)

Executing Agency	:	Roads & Highways Department (RHD)
Mode of Construction	:	GoB Financed
Flyover	:	4-lane divided overpass
Total length	:	0.970 km
Structural Form	:	Box -Girder with single pier
Overall width	:	16.12 m
Vertical clearance	:	7.2 m
Total Project Cost	:	Tk. 113 crore
Total Construction Cost	:	Tk. 97 crore
Per km Cost	**:**	**Tk. 100 crore**
	:	**USD 19 million (reported)**

Mohakhali Flyover

Appendix-G

Estimated Ramp Lengths and Ramp Structures Of Dhaka Ashulia Elevated Expressway (DAEE)

Alignment - 1 (35.0 km)

Structural Form: **Prestressed I-Girder**
Assuming, total depth of pier head, girder & deck slab = 2.9 m

Access Facilities	Ramp Type	Ramp Configuration	Directional factor	No. of Ramp	Level	Headroom (m)	Avg. Grade (%)	Length (m)
Abdullahpur Entry-Exit	Up-ramp	Direct-Curved	1.2	1	1	5.7	3.75	275
	Down-ramp	Semi-direct	1.3	1	2	13.4	4.75	471
Turag Interchange	Up-ramp (Splited)	Semi-direct	1.3	1	2	13.4	3.75	596
	Up-ramp (Splited)	Direct-Curved	1.2	1	1	5.7	4.75	217
	Down-ramp	Direct-Curved	1.2	1	1	5.7	4.75	217
	U-loop	Indirect	2.0	1	1	5.7	4.75	362
Ashulia Interchange	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Up-ramp	Direct-Curved	1.2	1	1	5.7	3.75	275
	Down-ramp (Splited)	Semi-direct	1.3	1	2	13.4	3.75	596
	Down-ramp (Splited)	Direct-Curved	1.2	1	1	5.7	4.75	217
Zirabo Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
Baipayl Trumpet Interchange	Level left turn-ramp	Direct-Curved	1.2	1	1	0.0	3.75	93
	Up-ramp	Semi-direct (mild)	1.8	1	1	5.7	3.75	401
	Down-ramp	Indirect	2.0	1	1	5.7	4.75	362
	Level left turn-ramp	Direct-Curved	1.2	1	1	0.0	4.75	73
EPZ Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
Zirani Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
Chandra Interchange	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	550
	Down-ramp	Semi-direct	1.3	2	1	5.7	4.75	471
Nabinagar Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	550
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
	U-loop	Indirect	2.0	1	1	5.7	4.75	362
Note: Assuming ramp structure is on avg. 0.76 of ramp length.			**Total Ramp =**	**31**				**8372**
			Tot. Structure =					**6363**

Alignment - 1 (35.0 km)

Structural Form: **Prestressed Box-Girder**
Assuming, total depth of pier head, girder & deck slab = 3.4 m

Access Facilities	Ramp Type	Ramp Configuration	Directional factor	No. of Ramp	Level	Headroom (m)	Avg. Grade (%)	Length (m)
Abdullahpur Entry-Exit	Up-ramp	Direct-Curved	1.2	1	1	5.7	3.75	291
	Down-ramp	Semi-direct	1.3	1	2	14.8	4.75	498
Turag Interchange	Up-ramp (Splited)	Semi-direct	1.3	1	2	14.8	3.75	631
	Up-ramp (Splited)	Direct-Curved	1.2	1	1	5.7	4.75	230
	Down-ramp	Direct-Curved	1.2	1	1	5.7	4.75	230
	U-loop	Indirect	2.0	1	1	5.7	4.75	383
Ashulia Interchange	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Up-ramp	Direct-Curved	1.2	1	1	5.7	3.75	291
	Down-ramp (Splited)	Semi-direct	1.3	1	2	14.8	3.75	631
	Down-ramp (Splited)	Direct-Curved	1.2	1	1	5.7	4.75	230
Zirabo Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
Baipayl Trumpet Interchange	Level left turn-ramp	Direct-Curved	1.2	1	1	0.0	3.75	109
	Up-ramp	Semi-direct (mild)	1.8	1	1	5.7	3.75	425
	Down-ramp	Indirect	2.0	1	1	5.7	4.75	383
	Level left turn-ramp	Direct-Curved	1.2	1	1	0.0	4.75	86
EPZ Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
Zirani Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
Chandra Interchange	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	582
	Down-ramp	Semi-direct	1.3	2	1	5.7	4.75	498
Nabinagar Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	582
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
	U-loop	Indirect	2.0	1	1	5.7	4.75	383
Note: Assuming ramp structure is on avg. 0.76 of ramp length.			**Total Ramp =**	**31**				**8878**
			Tot. Structure =					**6747**

Alignment - 2 (36.5 km)

Structural Form: **Prestressed I-Girder**
Assuming, total depth of pier head, girder & deck slab = 2.9 m

Access Facilities	Ramp Type	Ramp Configuration	Directional factor	No. of Ramp	Level	Headroom (m)	Avg. Grade (%)	Length (m)
Abdullahpur Entry-Exit	Up-ramp	Direct-Curved	1.2	1	1	5.7	3.75	275
	Down-ramp	Semi-direct	1.3	1	2	14.3	4.75	471
Turag Interchange	Up-ramp (Splited)	Semi-direct	1.3	1	2	14.3	3.75	596
	Up-ramp (Splited)	Direct-Curved	1.2	1	1	5.7	4.75	217
	Down-ramp	Direct-Curved	1.2	1	1	5.7	4.75	217
	U-loop	Indirect	2.0	1	1	5.7	4.75	362
Ashulia Roundabout Interchange	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	550
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	550
	Roundabout (2-ULoop)	Indirect	2.0	2	1	5.7	3.75	917
Savar Interchange	Up-ramp	Semi-direct (mild)	1.8	1	2	5.7	3.75	401
	Down-ramp	Direct-Curved	1.2	1	1	5.7	4.75	217
Nabinagar Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	550
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
	U-loop	Indirect	2.0	1	1	5.7	4.75	362
Baipayl Trumpet Interchange	Up-ramp	Direct-Curved	1.2	1	1	5.7	3.75	275
	Up-ramp	Semi-direct (mild)	1.8	1	2	14.3	3.75	803
	Down-ramp	Indirect	2.0	1	2	14.3	4.75	724
	Down-ramp	Direct-Curved	1.2	1	1	5.7	4.75	217
EPZ Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
Zirani Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
Chandra Interchange	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	229
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	181
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	550
	Down-ramp	Semi-direct	1.3	2	1	5.7	4.75	471
Note: Assuming ramp structure is on avg. 0.76 of ramp length.			**Total Ramp =**	**33**				**10370**
			Tot. Structure =					**7881**

Alignment - 2 (36.5 km)

Structural Form: **Prestressed Box-Girder**
Assuming, total depth of pier head, girder & deck slab = 3.4 m

Access Facilities	Ramp Type	Ramp Configuration	Directional factor	No. of Ramp	Level	Headroom (m)	Avg. Grade (%)	Length (m)
Abdullahpur Entry-Exit	Up-ramp	Direct-Curved	1.2	1	1	5.7	3.75	291
	Down-ramp	Semi-direct	1.3	1	2	14.8	4.75	498
Turag Interchange	Up-ramp (Splited)	Semi-direct	1.3	1	2	14.8	3.75	631
	Up-ramp (Splited)	Direct-Curved	1.2	1	1	5.7	4.75	230
	Down-ramp	Direct-Curved	1.2	1	1	5.7	4.75	230
	U-loop	Indirect	2.0	1	1	5.7	4.75	383
Ashulia Roundabout Interchange	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	582
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	582
	Roundabout (2-ULoop)	Indirect	2.0	2	1	5.7	3.75	971
Savar Interchange	Up-ramp	Semi-direct (mild)	1.8	1	2	5.7	3.75	425
	Down-ramp	Direct-Curved	1.2	1	1	5.7	4.75	230
Nabinagar Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	582
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
	U-loop	Indirect	2.0	1	1	5.7	4.75	383
Baipayl Trumpet Interchange	Up-ramp	Direct-Curved	1.2	1	1	5.7	3.75	291
	Up-ramp	Semi-direct (mild)	1.8	1	2	14.8	3.75	849
	Down-ramp	Indirect	2.0	1	2	14.8	4.75	766
	Down-ramp	Direct-Curved	1.2	1	1	5.7	4.75	230
EPZ Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
Zirani Entry-Exit	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
Chandra Interchange	Up-ramp	Direct-Straight	1.0	1	1	5.7	3.75	243
	Down-ramp	Direct-Straight	1.0	1	1	5.7	4.75	192
	Up-ramp	Direct-Curved	1.2	2	1	5.7	3.75	582
	Down-ramp	Semi-direct	1.3	2	1	5.7	4.75	498
Note: Assuming ramp structure is on avg. 0.76 of ramp length.			**Total Ramp =**		**33**			**10973**
			Tot. Structure =					**8339**