MNK Publication

International Journal of Latest Research in Science and Technology **ISSN (Online):2278-5299**
Volume 10, Issue 2: Page No.1-18 (2021)
https://www.mnkjournals.com/journal/ijlrst/index.php

INTEGRATED TRANSPORT PLANNING A GAME-CHANGING PHENOMENON IN BUILT ENVIRONMENT: A CASE FROM MEGACITY DHAKA, BANGLADESH

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Received: 7 February, 2021; Accepted :4 March, 2021; Published :18 August, 2021

***Abstract**: Transport is one of the influential components in the built environment that directly and indirectly affects our daily life: economic, education, land use, health and wellbeing, goods and services, job, culture, and social, environmental, and political context. An Integrated Transport Planning aims to achieve a positive outcome for these aspects ensuring sustainable mobility, including public transport, walking, cycling, freight, private vehicles and the street network, especially for community and neighbourhood, government and international agencies' decision-making. This study brought a case example of the 6.3-kilometre long, and 60-feet (18.3m) wide link road between Zia Colony (Opposite to Hotel Radisson, Dhaka) to Mirpur Cantonment constructed under the Special Work Project of Army Engineering Core in Dhaka, Bangladesh. The study detailed the road planning, design, execution and mapping the aerial history, socio-economic, changing footprint in the essence of time, compared to a few megacities. The research has shown that efficient planning, design, and building road network, especially in an urban area can shape the built environment, a more infill compact city, a better neighbourhood. The government had the opportunity to achieve safety and progress towards zero philosophies (net zero-emission, vision zero, zero harm, zero waste) applying context-sensitive policy governance. The study concludes that megacities have experienced a dramatic shift from rural to urban areas, especially in developing countries, such as Bangladesh, where authorities require fast, comprehensive strategic planning and direction. Without it, there will be very little room to rectify the problems with the missing links. The findings will fill literature gaps through a network planning of the infill design or compact city. The closing analysis and discussion will also offer some potential tonics for megacity planning (tailoring consideration between heroic and robotic), where the conventional planning process not always function.*

Keywords- Sustainable Mobility, Integrated Transport Planning, Built Environment, megacity, socio-economic.

INTRODUCTION

In the 21st century, globalisation impacts urbanisation and ecosystems both positively and negatively, where a megacity regions development is affected if any component changes (Tian et al., 2019). It is almost impossible to design and achieve a sustainable transport system in megacity without pollution and environmental impacts. Therefore, action policy and governance play a critical role in the megacity (Mohan and Tiwari, 1999). Moreover, a daily 1700 new population arrives in Dhaka, due to such demand and rapid urban expansion, the megacity facing various crises resulting from natural hazards; flooding, and waterlogging in the inner city each year. This cause filling natural *lakes and canals, losing forests, illegal land grabbing and filling low land in the urban periphery* (The Daily Prothom Alo, 2016). Due to high land values, rapidly growing megacities; buyer, investor and developers desirous of building housing or development in the restricted area; *flood zones, lakes, canals, ditch and drainage channels and many more in* Dhaka city, resulting in environmental damage (Alam, 2018). *The urban population will be more than two-third of the world* by 2025, and the rate of urbanisation will be much higher in developing countries by 2020 (World Bank, 2007). Despite a positive outlook (megacities bring the human society, form better neighbourhoods, shape compact cities), it threats *social and environmental, including living space and quality of life, employment, education, crimes, housing, health and nutrition, environmental degradation, pollution and waste disposal, freshwater, recreational area* and so on (Li, 2003), threatens the future generations (Fred and Markov, 2007). *Without strategic interventions in land-use management and transportation planning, environmental and economic constraints will increasingly affect megacities* (Guest, 1994). Uniting with the above discussion; this study has brought a case; Zia Colony to Mirpur Cantonment road project from megacity Dhaka, where comprehensive integrated transport planning accomplished. The above environmental constraints were eliminated and mitigated.

Dhaka City is expanding randomly in all direction. To the North of Dhaka Cantonment Mirpur Cantonment, a housing estate of the Housing and Settlement Directorate, Manikdi and North-east part of Mirpur are located within the envelope of Dhaka-Mymenshing Road N3 and RHD proposed Pallabi-Dhourh-Kodda Road N3. Some important institutions like Defense Staff College, NDC and MIST, and DOHS are situated within the Mirpur Cantonment. Besides a modern ceramic brick manufacturing industry and handloom industries for making fancy traditional Mirpur Katan shares are located within this road's vicinity. These areas had no direct access to the city's centre or link to the existing road network. Due to lack of proper communication, the people of these areas are deprived of the township facilities. Construction of the proposed East-west connecting road will provide a direct link between the two cantonments and offer transportation facilities for a large population of the adjacent areas of Manikdi and North-eastern part of Mirpur. Besides, the communication system and traffic management in Dhaka City would be greatly improved. Because of this Special Works Organization, Corps of Engineers, Bangladesh Army under the Ministry of LGED and Co-operatives has taken up the proposed scheme of constructing 6.3km road from **New Airport Road to Mirpur Cantonment** to a 4-lane dual carriage-way standard (***Figure-II)***. They engaged Design Vision Ltd. for Topographic Survey and Detailed Design of the road. This report has been prepared covering activities of the Consultants and the procedures and methodologies adopted for surveying and designing this road, pavement, bridges and drainage structures including road appurtenances.

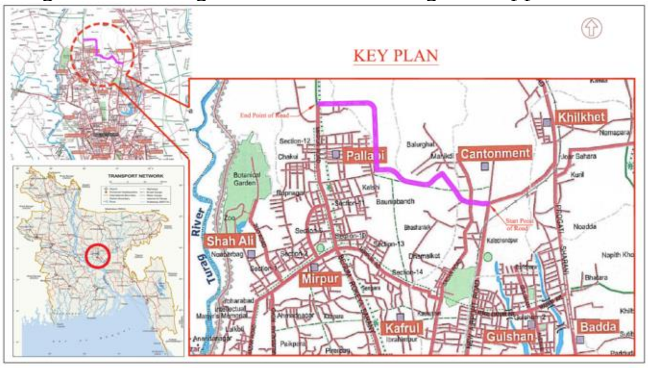


Figure 1: Location Map of Project Road

The study broadly explains the challenges in infrastructure planning, design, and construction from the integrated transport and compact city context—secondly, Dhaka city's urbanisation and socio-economic footprint, and its shift within the last two-decade. Thirdly the study will represent the global megacity footprint and its shift and importance of comprehensively transport planning viewpoints. The closing discussion will provide recommendations on project planning and implementation in the megacity towards a sustainable transport outcome. The study has detailed some scopes of work accomplished with the challenges of infrastructure planning, design and construction towards integrated transport planning and compact city context. The few major tasks executed among the five process groups as part of this unique project were as follows:

Reconnaissance and Inventory of the Proposed Corridor
Traffic Analyses and Relevant Aspect of Achieving Integrated Transport Planning
Conducting Topographical Surveys
Hydraulic and Hydrological Analysis
Geometric Design and Preparation of Alignment Plans, Profile and Cross-sections
Alignment Soil and Sub-soil Investigations
Pavement Design and Preparation of Drawings
Structural Design and Preparation of Drawings and Reinforcing Schedule
Hydrological Analysis for Structural Design and Design Level
Preparation of Cost Estimates

Terminology	
AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway Transport Officials
ADT	Average Daily Traffic
ARI	Average Recurrence Interval
AEP	Annual Exceedance Probability
BH	Bore Hole
BM	Benchmark
BR	Bangladesh Railway
BRRL	Bangladesh Road Research Laboratory
BWDB	Bangladesh Water Development Board
CADD	Computer-Aided Design and Drafting
CUM	Cubic Meter
DTM	Digital Terrain Model
DVL	Design Vision Ltd.
GOB	Government of Bangladesh
HFL	Highest Flood Level
HQ	Headquarter
IP	Intersection Point
JICA	Japan International Cooperation Agency
KPH	Kilometre Per Hour
MDD	Maximum Dry Density
MSL	Mean Sea Level
MV	Motorized Vehicle
N3	National Highway N0. 3
NMV/T	Non-Motorised Vehicle/Traffic
PCU	Passenger Car Unit
PWD	Public Works Department
RCC	Reinforced Cement Concrete
RHD	Roads and Highways Department
RMSS	Road Materials Standard Specification
ROW	Right of Way
SN	Structural Number
TBM	Temporary Benchmark
TRRL	Transport and Road Research Laboratory
UK	United Kingdom
VDF	Vehicle Damage Factor
WPO	Word Processor
ESAL	Equivalent Standard Axle Load
PVD	Prefabricated Vertical Drain

Project Team

The Special Works Organization, Corps of Engineers, Bangladesh Army engaged the consultants (Design Vision Limited, DVL). The Consultants Project Team Comprised of the Following Staff position, where the author worked as Highway Engineer cum CADD Engineer:

The Consultants Project Team:

Director/Advisor
Team Leader
Highway Engineer
Structures Engineer
CADD Engineer
Structures Engineer/CADD Engineer
Pavement Engineer/ Hydrologist
Materials Engineer
Quantity/Cost Engineer
Surveyor/SAE
Surveyor/SAE for LA preparation
CAD Operator (Highways)
CAD Operator (Structures)

METHODOLOGY

This study's methodology includes a literature review, planning and field investigation, design and consultations, aerial history, socio-economic footprint and land information verification. These all described through a project called "Zia Colony to Mirpur Cantonment Road Construction Project" throughout the project life cycle and stages.

Project Life Cycle and Project Phase

The basic framework was considered for managing this project during the project life cycle, and project activities were completed and delivered through the standard project phases. The following figure has detailed the one or multiple activities that were performed from initiating to the closing of this project;

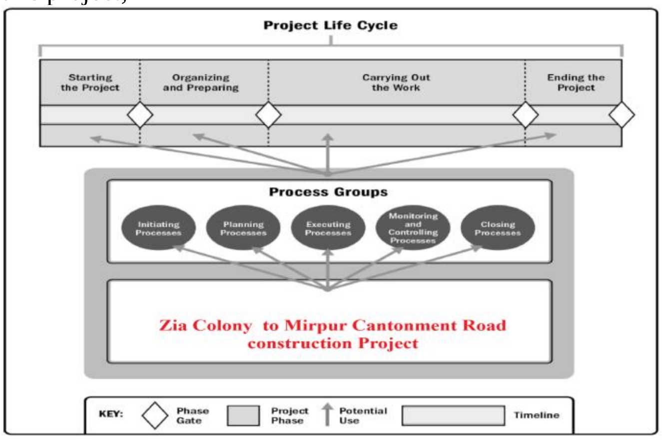


Figure 2: Project Road phases

RECONNAISSANCE OF THE PROPOSED ROAD CORRIDOR

The road starts from the new airport road near Zia Colony and follows a narrow road for about 1.5 km. The section from km 1.5 to km2.7 follows a water body and that from km 2.7 to km 4.3 raised land with the slum. The section between km 4.3 and km 6.3 travels through low land, ditches, fishpond, the developed area of DOHS, etc., and meets the RHD proposed Pallabi-Dhour-Kodda Road.

The client had dictated the road corridor following which the alignment had to be designed. The survey data showed that the proposed corridor d not generally pose any difficulties or obstruction except requirements for minor modifications in the horizontal curves to follow good urban traffic standards and avoid additional land acquisition. The description of the surveyed alignment is given below:

From km 0+000 to km 1+512 was paved with of 5.5 m carriage-way and the surrounding lands were raised and allocated for this road corridor. This section of the road required widening to make the road width to designed standard and could be done with carted earth without any difficulties. There were two sharp turnings almost 90 degrees, which would require improvement by straightening the vehicular traffic's smooth movement. While doing so, some temporary infrastructures and one single-story residential building of cantonment authority were affected.

From km 1+512 to km 2+750, the proposed alignment travelled through a water body, a canal and low lands. A 40 m RC bridge and few Box culverts and Pipe Culverts required in this area. Sub-soil investigations undertaken in this area determine the soil's bearing capacity and form the basis of both embankment and structure's foundation design.

From km 2+750 to km 3+300 the proposed road would follow the flood protection embankment partly and raised land belonging to Housing and Settlement Directorate. The area encroached with temporary structures. Geometric formation of the flood protection embankment was poor and had curves of short radii. The Embankment width also narrow and variable. Cross drainage and traffic sign provided along with the developed/markets areas.

From km 3+300 to km 4+700 the alignment follows a proposed road of Housing and Settlement Directorate's housing state.

From km 4+300 to km 4+700, some fish ponds and the area between km 4+700 and km 5+600 were low and remained submerged during monsoon. The sub-soil investigation required to check the soil and soil strata' bearing capacity for designing road embankment and drainage structures.

The section from km 5+600 to km 6+200 passes through the area developed for DOHS. The site had been developed by sand filling, and the road required no embankment filling.

Almost three-quarter of the total length of 6.3 km of road was part of new construction and reconstruction. The following figure detailed in the line diagram.

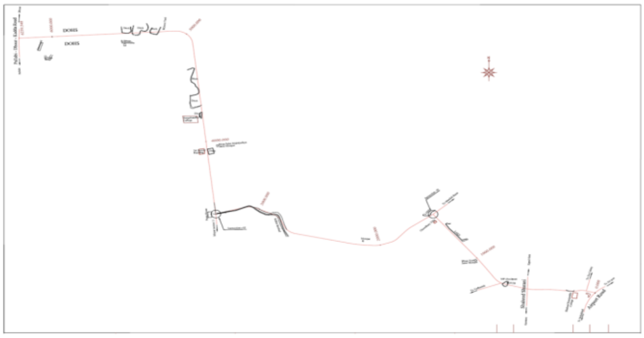


Figure 3: Route Alignment with significant location detail from Airport Road to Mirpur Cantonment Road.

TOPOGRAPHICAL SURVEY

A topographical survey is the most important element of highway design. The modern survey is done using a total station in which ground surface points are recorded by storing x and y coordinates and reduced levels (height). These points then build up a surface model, which is a basis for highway design. In the beginning, benchmark pillars were located to use them as survey reference points for elevation. The survey was carried out using assumed coordinates and the magnetic north as north reference. Next, a close traverse was run for the contract to establish traverse stations. A total station was used to determine coordinates, and a level machine was used to determine the levels for these traverse stations. A detailed survey was carried out through the use of these traverse stations. Also, auxiliary benchmark pillars were constructed along the road corridor at easily identifiable permanent locations. These pillars, for use in the implementation phase, had coordinate and level information. For detailed design, the existing road and features were carefully surveyed. The points surveyed on the road are centreline, the edge of the pavement, edge of shoulder and toe at 25 m intervals. The width of the cross-section on each side of the centreline was at least 50 m or more. Furthermore, wider strips were surveyed in areas with curves and new alignment. Several types of roadside features were surveyed during the detailed design phase. Specifically, markets along the road, homestead (hut, tin shed, buildings etc), graveyards, mosques and other places of worship, offices, factories, borrow pits, ditches, ponds, canals, sluice gates were surveyed. Also surveyed were pylon towers, utility poles, telephone poles, tube wells, kilometre posts etc.

Benchmarks

The prevailing benchmark pillars in the survey area are SOB BM (1994). The benchmarks were correlated to make the survey analyses consistent for the contract. Flood levels *collected from the Bangladesh Water Development Board (BWDB)* were concerning the SOB BM (1990). Therefore, the reduced levels of those BMs were converted to SOB (1994) equivalent, that was compared to the highest flood level (HFL).

Project Photos

During reconnaissance, initiating, planning, design, executing, monitoring and controlling and closing; several photos were captured and recorded in the project folder. A few pictures are shown below as part of project detail to compact the description regarding detail socio-economic footprint and development in the essence of time;

Figure 4: Sagufta Housing embankment preparation at Ch 4+150 in 2006, it was raised appx. 2.5 m from this surface to maintain 100 yrs ARI (1% AEP) during road embankment construction

Figure 5: Photo was taken during road embankment preparation at Ch 4+050

Figure 6: Photo was taken during road embankment preparation at Ch 4+050

Figure 6: Photo was taken during road reconnaissance and field survey preparation, the Chowdhury Villa at Ch 1+550

Figure 7: Photo was taken during road embankment at Kalshi Beribad at Ch 2+950

Figure 8: The endpoint of road, South-eastern corner, Source; project folder, the photo was taken during reconnaissance in 2006.

Figure 9: During Road construction, roadside billboard erected by developers. Source: Google sample photo

Figure 10: A Google street view photo from Bridge at Ch 2+360. The neighbourhood was not built or representing low profile living in Urban Areas (Capital of Dhaka), the road bridge construction completed in 2009.

Figure 11: A Google street view photo from Zia Colony at Ch 0+200, where system interchange was constructed due to current expansion of traffic volume, compact development both side of this road as part of the decongestion process.

Figure 12: Mirpur DOHS Entrance, Source: From Wikimedia Commons photos, Dhaka, Bangladesh

Horizontal/Vertical Control Points

The topographical survey team has collected Benchmark (BM) information from the Survey of Bangladesh and used as the survey reference points for elevation. The benchmarks used for the survey are shown in ***Table1***;

Table 1: Summary of Reference Pillars established in Topographic Survey (Feature survey)

Ref. BM No.	Description	Elevation (m)	Datum
SOB BM NO.6194	BM Pillar No. 6194 which was situated in the compound of T.B. Clinic at Shamuli, Dhaka.	7.561	PWD
TBM 8	Marked on the plinth, South East corner of M.P. check post near 20m Bangladesh Military Museum at Mirpur 12.	12.298	PWD
TBM-1	Marked on the plinth, East side of Osmani Hall as shown in the map.	10.979	PWD
Pillar-1	RCC pillar has been embedded on the compound of Osmani Hall as shown in the map.	10.980	PWD
Pillar-2	RCC pillar has been embedded on the compound of Osmani Hall as shown in the map.	10.507	PWD
Pillar-3	RCC pillar has been embedded on the proposed road near M.E. camp as shown in the map.	5.500	PWD
Pillar-4	RCC pillar has been embedded in front of Pump station at Bounia.	7.418	PWD
Pillar-5	RCC pillar has been embedded on the Bounia Embankment near Pump station at Bounia.	7.534	PWD
Pillar-6	RCC pillar has been embedded on the Zia colony road near the internal railway crossing.	7.812	PWD
Pillar-7	RCC pillar has been embedded on the Zia colony road near an island about 30m North from M.P check post.	7.144	PWD
TBM-2	Marked on the top of RCC pillar near Military Engineers camp as shown in the map.	4.351	PWD
TBM-3	Marked on the plinth, N/E corner of Kalshi Bazar Gama Mosque.	9.338	PWD

Note i) Assumed coordinates were used with the magnetic north line for establishing horizontal control. During topographical surveys, intermittent TBM and horizontal control points were kept at suitable locations on RCC pillars. The field survey was delivered to the design office as soon as the survey for each road segment was completed. The survey was delivered in total station memory cards for survey processing, terrain modelling and detail design. Also, provided was level books and survey field books.

GEOMETRIC DESIGN

Highway design begins with survey processing. The processed survey was then used to create a surface model known as the Digital Terrain Model (DTM).

Survey Data Processing

Field Survey data, stored in memory cards of a total station, were downloaded in computers and translated so that Highway Engineering software MOSS can produce a map of the survey. Initially, these downloaded files were checked for survey accuracy and codes. Survey codes were used to capture different field features in different layers in the computer model. These corrected files were then used to produce a survey map in MOSS. The survey maps were then further edited to prepare DTM. Moreover, the survey maps were checked against known reference points to check for accuracy.

Digital Terrain Model

Digital terrain model (DTM) is a computer model that uses total station recorded coordinates and reduced levels for points to create a ground surface. The surface is created by the method of triangulation. Connecting three adjacent contour points of survey forms triangles, each of these triangles represents a small surface area of the ground surface. The combination of these triangles makes up the ground surface. Certain lines in the DTM are declared "break line" to preserve shapes of objects.

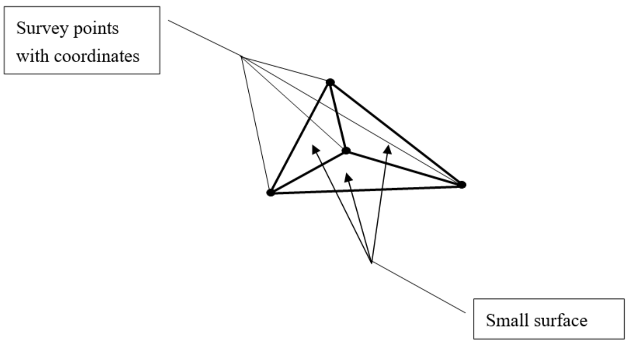


Figure 13: Illustration of triangulation

The DTM provides a lot of flexibility for design. It serves as a basis for horizontal /vertical alignment design, cross-section design and volume calculation. DTM allows the designer to consider several alignment options using the database of the design surface. DTM makes design modifications easy to perform and greatly reduces the time for quality drawing production. Volume calculations were generated instantaneously and accurately using the DTM database.

Design Standards, Criteria, and Parameters

There is no prevailing design standard in the country. In its absence, several standards were studied to incorporate appropriate features from different standards befitting the project's need. The consultants chose a design criterion fulfilling the requirements of the client. The following design standards were adopted:

Overseas Road Note 6 (ORN 6), Transport Research Laboratory (TRL)

A Policy on Geometrical Design of Roads, American Association of State Highway and Transport Official (AASHTO)

Departmental Standards, Department of Transport, UK

TRL Recommendations for safety

Roads and Highway Department (RHD) Standard (RMSS)

Generally, the Geometric Design Standards of AASHTO *"A policy on Geometric Design of Highway and Streets"* had been adopted as design parameters. *The Overseas Road Note 6* "A Guide to Geometric Design" published by *the Transport Research Laboratory (Overseas Unit), 1988* was also consulted, which gives guidance on geometric design standards for single carriage-way rural (inter-urban) roads in developing countries.

Road Hierarchy

The RHD road network was divided into three functional classes: National, Regional and Feeder Type-A as defined in the 1980s. RHD's National and Regional roads fall under the category of "Arterial" and the Feeder roads, which are currently designated as District road under "Collector". However, during the last two decades of road condition changes, the establishment of new road links and construction of new (additional) bridges had changed many roads' function. Accordingly, RHD had prepared design standard (2005) recommending 6 types of cross-sections depending on traffic volume without changing functional classification, which was reproduced, is detailed in *Table-2*. Considering the overall national and regional road network and the forecasted design traffic upgrading of the Feeder roads to Regional roads had been suggested following these standards.

Table-2: RHD Road Cross-Section Standards

Design Type	Design Year PCU/peak hour (Typical MV AADT)	Cross sections width in meters			Indicative Road Classification
		Crest width	Carriage-way & no. of lanes	Paved shoulders	
1	4500-8500 (19000-36000)	36.2	2*11 (6)	1.8m	
2	2100-4500 (7000-19000)	21.6	2*7.3 (4)	1.8m	NH
3	1600-2100 (5000-7000)	16.3	7.3 (2)	1.5	RH
4	800-1600 (1000-50000)	12.1	6.2 (2)	1.5	UZR/ZR
5	400-800 (500-1000)	9.8	5.5 (2)	1.2	
6	<400 (<500)	9.8	3.7 (1)	1.2	

The proposed road was classified as an Urban Road of Residential Collector Street category considering the location and function. Accordingly, the road had been designed with facilities required for an urban road like footpath for pedestrians, street lighting, traffic signs and signals.

Design Speed

The road travels through plain terrain, and urban/suburban areas and the design speed of 65 km/h had been selected as recommended for Residential Collector Street in AASHTO. The 85th percentile value of speed had been used, as the basis of design, considering 10% of the vehicles assumed to exceed the design speed. A 65km/h design speed ensured maximum utilisation of the existing acquired road corridor. Lower speeds had been used with speed restriction signs at the places of constraints.

Horizontal Alignment

This road connects important places, industrial areas, housing areas under development, and there was a potentiality for generated traffic. There was no trafficable road and even any through earth road to communicate the people in this area with the capital or nearest towns/markets. The project road construction improved communication in the area and also accelerated the urbanisation. This road was linked with other roads; therefore, the urban road network was improved. The rapid expansion of urbanisation development and construction activities had enormous volume in the area and traffic pattern ultimately of mix-modal with many non-motorises traffic. Hence to accommodate a large number of local and through traffic, this road alignment had been designed utmost care for optimum utilisation of the proposed corridor and traffic safety. The alignment had been designed as new for the full length except for the beginning section through the Dhaka Cantonment area. Usually, 250 m radii curves were considered as a desirable minimum for designing horizontal alignment of this road, but curves of radii 120 and 65 m had also been provided in cases of constraints and in the intersections. Traffic safety issue had been addressed by providing transitions, speed limit signs, speed reduces signs, and other warning and regulatory signs as appropriate. Two priority intersections had been provided at the junctions with N3 and Z5003. Therefore, this project also included some standard intersections as part of this project road design to improve the overall network and provide links to other roads.

Vertical Alignment

The vertical alignment had been designed following the terrain and to match the levels of the National Highway connected on both ends and other roads and features. The area was situated in the flood-free zone and was protected by flood protection embankments. Hence the finished gradient was designed following the area's topography and existing other roads, Housing and Settlement and DOHS areas. Parameters used for Detailed Design of Alignment of the Project Road had been presented in ***Table-3***;

Table 3: Horizontal and Vertical Curves and Related Parameters

Geometric element	Design Type Urban Road

Horizontal Geometry	
Desirable Parameters	
Design Speed	65 km/h
Radius, R Super-elevation, SE Stopping Sight Distance, SSD	500 m, 3% 120 m
Desirable minimum parameters	
Speed, km/hour	65
Radius, R	250 m
Super-elevation, SE	4%
Stopping Sight Distance, SSD	90 m
Absolute minimum parameters	
Speed, km/hour	40
Radius, R	65 m
Super-elevation, SE	4%
Stopping Sight Distance, SSD	60m
Minimum crest K value	35 m
Minimum length of Vertical curve	50 m
Side friction factor	0.18
Longitudinal friction factor	0.4

Note: i) In recognition of safety considerations, the superelevation had been limited to 4%.

Gradients

The project road was located on plain terrain with an upward gradient from southeast to northwest. The road assumed to be used by multi-modal traffic including slow-moving non-motorised vehicle and pedestrians. To ensure that the road would provide a good level of service, traffic safety, and efficient longitudinal drainage mild and rolling gradient had been designed even at bridge approaches.

Road Cross Section

The cross-section for the project road has been designed to be adequate for accommodating the forecasted traffic of both vehicular and non-motorised for 10 years design life. Wider paved shoulder/footpath had been designed to cater to a large number of NMT and pedestrian.

Design Life

Design life had been considered for ten as the design forecast traffic was an assumed one. The generation and growth were uncertain due to no detail traffic modelling or district traffic study provided by the client. The design year had been considered 2018 with the roads' opening for traffic in the year 2008.

Traffic

The primary objectives of the traffic study were: (a) to forecast the traffic movement of the road network when the Port Access Road would be completed; (b) to recommend an appropriate road network plan among alternative plans based on the forecasted traffic movement, and (c) to recommend appropriate intersection types of the Port Access Road based on the forecasted traffic movement. In order to accomplish the objectives of the study, the traffic study comprises: (a) traffic surveys being carried out, (b) traffic demand forecasts based on the traffic survey made, (c) traffic movement analysis made based on the forecasted traffic demand, and (d) conclusions and recommendation made based on traffic movement analysis. The works' scope did not speculate traffic survey, as the road had to be designed following a proposed new corridor. Design Traffic for the road has estimated based on forecast generated and diverted traffic. It had been assumed that a large number of light vehicle and the non-motorised vehicle supposed to be generated after the development of the housing area and the DOHS and use this road. Besides the proposed housing area of Housing and Settlement Directorate and on-going DOHS, there was a wide scope of the rapid urbanisation of the road vicinity. A high volume of construction activities assumed to continue in the area, resulting in large truck traffic numbers. Other commercial vehicles carrying passengers and materials assumed to be diverted from other national and city streets and use this road. Accordingly, the design traffic was estimated as below:

Design life- 15 years,
Design PCU/Hour-2000,
Design AADT- 5000 to 7000 of MV, and
Design ESAL would be about 20 to 25 million.

Road Cross Sections

Considering mixed modal traffic and the presence of many NMT and pedestrians cross-section widths for the whole section of the road has been selected to be 18.3 m. Two different cross-sections had been designed with footpath and without footpath respectively for the section passing through the immediate urban area and the section passing through low lying open area. A 1.0 m wide kerbed median has been provided for the full length of the road. There would be two lanes in each carriage-way of 3.65 and 3.0 m width respectively. The cross-section through the urban area considered 2*1.70 m footpath-cum-drain, and that through open low-lying area considered 2*1.9 m soft verges instead. Typical cross-sections of the road had been presented in ***Figure 14***. Lane width and other parameters had been selected as per standard but with appropriate modification. To promote road safety, wider and raised footpath with drain was provided for the pedestrians, and reduced design speed adopted where considered appropriate.

Cross fall of Road Cross Section

Considering the heavy rainfall and absence of appropriate maintenance of pavement in Bangladesh, a cross fall of 2.5% had been applied through the code recommends 2.0% for the urban street. A 5% cross fall had been provided for the soft shoulder/verge as the code recommends a cross fall 2% steeper than that of carriage-way. These had been detailed in ***Figure 14***.

Side slope of Road Cross Section

Considering the soil characteristics of the existing embankment, which was likely to be used to construct the earth embankments, the side slope ratio of 2.0 (horizontal) to 1.0 (vertical) had been applied. A typical section has been presented in ***Figure 14***.

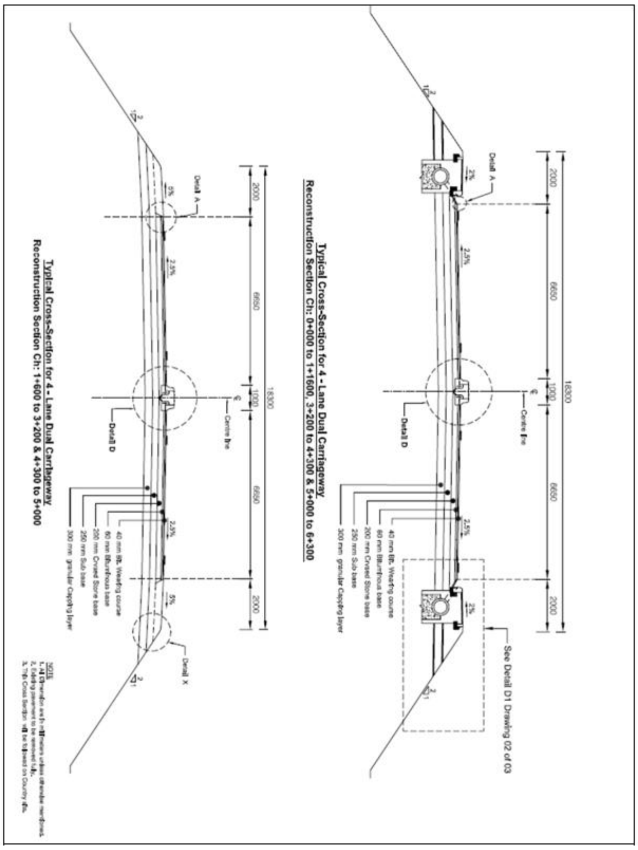


Figure-14: Typical Cross-Section, Source: Project document; the detail design of Road Template.

Preparation of Detailed Engineering Drawings

Detailed Engineering Drawings consisted of general drawings; alignment plan, profile and cross-section had been prepared on A3 size papers in the scales appropriate to each. Drawings had been prepared in MXroad and then transmitted to AutoCAD for labelling, text editing and printing. A set of detail design drawings had been presented as part of deliverables. The drawings were prepared for the project roads based on a detailed topographic survey: plan, profile and cross-section drawings. These drawings had been prepared on A3 size papers and the scales used are: Plan and profile-H1:1500, V1:500, and Cross-section- H1:400, V1:200.

Preparation of Horizontal Alignment Plans

The alignment plan and profile drawings of all roads had been prepared on A3 size papers in 1:1000 scale. All roadside features and the natural topography, details of the existing road, and the design road features with curve details had been shown on the plan drawings.

Preparation of Longitudinal Sections

The embankments' design heights had been fixed concerning the recently developed and adjacent sections of N3, flood protection embankment level and natural terrain of the area with adequate freeboard on top of HFL where available. Generally, the gradient of HFL was used as the road gradient except for the bridge approaches where vertical curves were inserted using proper K values both for crest and sag. The soft topographical survey data downloaded from the total station and digital terrain models were made for the surveyed areas. The horizontal alignment and vertical alignment for the roads were designed. The natural surface and finish grade lines with vertical curve details and the drainage structures had been shown in the profile. The reduce levels along the centreline of both natural and design surfaces had been shown generally at 20 m intervals but levels at change points and at IPs and TPs also shown. The longitudinal profile for the surveyed roads was plotted on A3 size papers in 1:1500 scale and presented in the detail design drawings.

Preparation of Cross Sections designed

As mentioned above, after making the digital terrain model, horizontal and vertical alignment, the existing and design levels, were plotted at regular intervals in the Cross-sections as per ***Figure 14*** templates. The design cross-sections with 30-50 m offset each side of the centreline, showing every 20 m intervals had been presented. Earthwork volume had been computed using the software with regard to the existing surface and design surface and was presented to calculate the quantities for BoQ.

Road Appurtenance and Road safety measures

The presence of non-motorised vehicles, a large number of accesses and roadside activities, etc. would frequently impact traffic safety and restrain the achievable design speed. To address these potential road safety aspects and for safe traffic management, the following measures had been provided:

- traffic signs and road markings, which are speed limit signs, speed reduction signs, and other warning and regulatory signs as appropriate,
- central median, cross drains, road kerbs,
- transitions and flatter gradients had been provided,
- critical issues of traffic safety at the crossings had been addressed by providing priority intersections with islands as appropriate depending on the traffic pattern,
- standard side road intersections,
- footpaths had been designed to cater to local traffic and safe traffic management,
- proper surface drains and rolling gradient for longitudinal drainage,
- edge kerb and slope drains, and
- street lighting along the central median with Y-shape light post, etc.

All these were designed as appropriate and following International Standards, presented in the Civil drawings.

PAVEMENT DESIGN AND EMBANKMENT CONSTRUCTION

Embankment construction for the full length of the road had proposed in 3 segments, which were:

i) widening and raising of the existing embankment,

ii) the new embankment on soft soil, and

iii)nominal filling and raising through developed land for housing.

The Sections (i) and (iii)

Embankment construction in these sections would be of normal earth fill with carted earth in compacted layers of 200-300 mm at 93% compaction of modified MDD. For widening necessary benching had to make for bonding between the old and new fills.

Section (ii)

After detailed soil investigations on the road section, the thickness of the organic soil/soft clay varies along the entire length. Depending upon the soil condition, the total road work was divided into three categories:

Category A; Normal Road work (length = 3500 m)

Category B; Soil Improvement with preloading (length= 2500 m)

Category C; Soil improvement with preloading using Prefabricated Vertical Drain, PVD, commonly known as wick drain (length = 300 m)

It can be seen in the drawings that a geotextile layer was placed on the existing ground surface, and a 1.5 m thick drainage layer was placed above the geotextile. The geotextile is geo-fabric by nature and acts as a separator between the drainage and existing underground soil. Additionally, the geotextile layer also acts as a reinforcement for the soil against sliding.

Prefabricated Vertical Drain (PVD) commonly known as wick drain can be installed on the ground up to the depth of 8.5 m to 13.0 m depending upon the soil condition. The vertical drain placed the distance of 1.0 m c/c in both directions. Wick drain is geosynthetic consisting of very small pores on its surface to stop the surrounding soil from penetrating inside easily except water. The wick drain function was to collect water from the surrounding and forward it to the upper drainage layer. From the literature review, two research articles were found on alternative cost-effective PVD (Islam and Khan, 2009) and soft soil compaction (Rahman et al., 2011) for this specific project construction challenges.

A three-stage embankment fills and a total of 14 months (4+4+6) surcharge period for consolidation settlement had been proposed above the drainage layer. A geogrid layer was placed above the 3 m from the existing ground surface. The geogrid would act as reinforcement to the soil and work against the possibility of the embankment's slope stability failure.

Settlement plates had been installed on the bottom of the drainage layer at some regular intervals to measure the settlement of the soil. Some displacement pegs had been installed outside the embankment to measure the soil's horizontal movement inside the embankment. The expected settlement would be in the range of 1 to 3 m under an average of 6 m high embankments.

The area remains submerged throughout the year, and the soil in the area was highly compressible. From a shallow boring to a depth of 9.0 m, the underlying soil was very loose silty clay and organic soil. The soil's compressibility had been worked out through settlement analysis based on soil data obtained from boring and the settlement had been estimated to be in the range of moderate to high (maximum 0.45 m for 8.0 m high embankment). There are various methods of embankment construction over soft soil. The best one was the hydraulic fill by dredged sand fill. However, it depends on the constructability and local technology and equipment availability. The recommended construction method was:

Step 1 - The soil improvement works to be carried out in a multi-stage (6 steps) construction. The objective of installing the vertical drain was to speed up the rate of consolidation of the soft peat and clay soils. Before installing the vertical drain, a 1.0 m or 1.5 m thick sand blanket to be placed on geotextile mats spread on the ground surface to assist the dissipation of excess pore water pressure in the soft clay layer.

Wick drains (a spacing of 1.0 m in a square pattern) can be used for vertical drains as had already been used at the crossing point. Embankments to be constructed in two-stage fills. Geogrid mats to be placed above 3.0 m from the ground surface to prevent slope failure from occurring during the construction of the embankment. In addition, counter berms required at both sides of the embankment during the critical construction period. An additional geotextile layer can be provided above 3.0 m from the sand mat if the embankment height exceeds 10.0 m.

The proposed sequence of the multi-stage construction illustrated in civil drawings and the key details of the stage's construction are summarised in ***Table 4***. The geotechnical instrument should also be installed in the embankment to monitor the embankment's stability consolidation settlement during the construction period.

Divide the area into several segments, dewater each segment area and remove the top 0.6m soft soil/mud having excessive organic soil. Place the spoil parallel to the road centreline but outside toe lines to form dikes. Make trenches in between dike and toe line and allow water to accumulate and pump out by submersible pumps and keep the bed dry.

Step 2 - Fill the voids created thereof with local sand of FM 0.8 to 1.0. This sand layer acts as a platform to further support the filling and movement of the equipment and horizontal drainage layer.

Step 3 - Place settlement plates and construct embankment in layers with compaction as specified. Fill embankment up to 3 m height in 4-5 months and stop further filling for the next six months (one rainy season). Monitor the settlement as described. After six months fill the remaining height as per design level.

Step 4 - once the maximum settlement (more than 70% of the total estimated) was achieved, place geogrid and fill the remaining part of the embankment as per design level and grade. Details of the recommended embankment construction procedure presented schematically *in **civil construction drawings***.

Monitoring Settlements

In the section where the ground was soft, and the watertable was high, all settlement and movement of filling and surrounding soils must be closely monitored, as unexpected occurrences may necessitate additional investigations and alternative construction methods. Therefore, the Contractor would be required to set up and maintain the following system:

Supply and install steel settlement plates complete with measuring rods as shown on cross-sections (one section per 100 m)

At the same sections, supply and install stakes for measurement spaced 5 m apart, and 5 to 20 m distances from embankment toes.

Monitor settlement plates and stakes regularly and record all settlement and movements measured (*SPECIAL ATTENTION MUST BE PAID TO MONITORING THE BEHAVIOUR OF THE EMBANKMENT AND SURROUNDING AREA*). Should abnormal settlement or movement occur, the Engineer would immediately suspend filling operations to investigate possible alternatives (such as fill removal, counter width fill, sheet piling, etc.).

Table –4: Embankment Construction Over Soft Ground

Stage	Period Description	Frequency of Measurement
Initial / Critical Stage	First 4 weeks of filling	Once a day
Stabilized Stage	4 weeks to 5 months	Twice a week
Filling Stoppage Stage	After 5 months	Once a week

Steady filling operations shall continue up to max. 3 m in height (First Stage), then filling must be suspended for a minimum of 6 months (one rainy season) to obtain 70% of the expected settlement. During filling operations, special attention to be paid to monitoring the behaviour of embankment and the surrounding area.

When the height of embankment approaches the critical 3 m height (First Stage), monitoring should be increased to twice a day for a two weeks period.

The second stage of filling (after 6 months suspension) would only proceed with the Engineer's instruction which would be dependent on greater than 70% expected settlement having been obtained. If the Engineer was dissatisfied with the stability of embankment filling at this time, he/she might order the suspension period to be increased, or alternatives adopted.

Right of Way (ROW)

The alignment design had been done following the proposed corridor dictated by the client. The proposed ROW was 150 ft (45 m) wide. Two sections pass through the areas belonging to Cantonment and Housing & Settlement Directorate where the ROW had not been specified except the road width of 60 ft (18.3 m) and 75 ft (22.75 m) respectively. These sections were not adequate to accommodate the embankment base width, and further land had to be acquired. It had been gathered from the DTCB and State office people of Bangladesh Army that ROW would not pose any problem for embankment construction in these sections. However, the required ROW along the road had been presented in a **land acquisition plan** for information and knowledge of the DTCB by previous design Consultants. Also, 3 to 5 m additional lands on either side had been included in the ROW as per the recommendation of Road Note of TRRL (Road Note recommends that the right of way should extend to a minimum of 3 m from the toe of road embankment). There was no provision of borrow-pit within the ROW.

Land Acquisition Plan (LAP)

The client had prepared Land Acquisition Plan (LAP), and the land acquisition was still being processed.

Around 412 non-Bangali (Biharis) families were rehabilitated at Pallabi in the city on April 2008 as they lost their dwellings due to *Zia Colony-Mirpur Road's* construction works. *The 6.3-kilometre long and 60-feet (18.3m) wide* road were being constructed under *the Special Work Project of Army Engineering*. The estimated project cost Tk 69.85 Crore for the major road components excluding interchanges. *The road, named after Shaheed Bir Uttam Havilder Shah Alam, connected to Mirpur Cantonment with Airport Road through Zia Colony in Dhaka Cantonment. LGRD and Cooperatives Adviser Anwarul Iqbal handed over the rooms' keys to the affected families at a simple ceremony at Kalapani in Pallabi as part of land acquisition and resettlement*. The rooms were housed in several tin-shed structures with sufficient toilets and water facilities. A mosque had also been built for the residents. Addressing the function, the government had decided to construct the road from its own fund considering its importance—the road construction progress was in advance compare to the construction schedule. Lt Col Abu Sayeed Md Masud, commanding officer of 16 Engineering Construction Battalion, which was implementing the project, Lt Masud highlighted that this was the first time non-Bangalis residing on the government land had been rehabilitated. Lt Masud claimed that *his team had constructed the houses after five months of relentless efforts* (TDS, 2008).

Bill of Quantities

Engineer's Estimate: Engineer's estimate was prepared under this contract during detail design and updated during the project implantation stage. Engineer's estimate was divided into seven-part under the name of Bill, i.e. *General and Site facilities*, *Earthwork*, *Pavement work*, *Foundation work*, *Structures*, *Incidentals* and Daywork. Engineer's estimate was prepared on the basis of quantity estimated from the works specified as per design, drawing and materials specification with unit rate. Tentative quantities for Labour, Materials and Equipment are considered for Day work. 10 % of the total bill amount is considered for Contingencies.

Unit Rate Analysis: Unit rate analysis was conducted based on the principle of RHD's unit rate schedule. Analysis of unit rate was done considering materials cost at possible Source near project location, labour cost at surrounding areas and Plant & Equipment cost. The proportion of construction materials for a specific item was considered on the basis of materials properties, specified gradation and design requirements. An additional cost was added to direct cost (Materials Cost + Labour Cost + Plant & Equipment Cost) for Contractor's profit, Contractor's overhead and Taxes. 10% for Contractor's profit, 5% for Contractor's overhead, 4% for income tax and 4.5% for VAT was imposed over direct cost. Finally, the project was delivered at the cost of TK 69.85 Crore (appx. US 8.5 M) for major road components, excluding interchanges at both ends confirmed by (TDS, 2008).

DISCUSSION

The study detailed the road planning, design, execution and mapped the aerial history, socio-economic changing footprint in the essence of time to compare the project road from 2006 to 2021. The study detailed a few design and constructional activities from five process groups due to limited text for this article. However, the significant tasks had been executed during the project initiation to closing. It revealed that the project started in 2006 and completed in 2011 (the major components of the road), the interchanges were constructed at

Zia colony entrance. From this scenario, this study would like to summary that infrastructure development is a time-consuming matter in megacity achieving various approval from various agencies, including utility relocation and upgrade in conjunction with Environmental impact mitigation and restrictions as well as complex constructional challenges and many more. ***Figure 15*** showed that the project road location was constructed in low land, marshy land with clayed soft soil, where embankment was maximum 11m high from exiting natural surface in the waterbody. ***Figure 16*** showed the current scenario from google earth that the socio-economic footprint has completely changed from its original, where the compact city was formed with a series of tall buildings with the densely populated urban environment that can reflect in ***Figure 18***. The term "megacity" primarily refers to the metropolitan area, with a total population of more than ten million of an urban agglomeration (WEF, 2021). The study brought a comparison of project population in 2018 and 2035. It revealed that Bangladesh's capital, *Dhaka, is predicted to be the fourth biggest city in the world by 2030, with a staggering 28 million inhabitants* as detailed in ***Figure 21*** and ***22***.

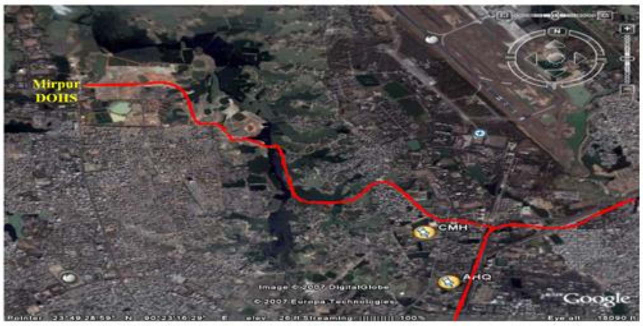


Figure 15: Proposed Road Alignment of Google Earth Image in 2007

Figure 16: Proposed Road Alignment of Google Earth Image in 2021 completely infilled

Figure 17: Zia Colony Entrance Interchange, Source: Syed Abbas timeline photos, Dhaka, Bangladesh

Figure 18: Mirpur DOHS Lake 1 on Project Road, Source: Tripadvisor.com

During the implementation of five process group such as *initiation, planning, execution, monitoring and controlling and closing* the project also considered following essential aspects as part of integrated transport planning aims to achieve a positive outcome ensuring sustainable mobility, including public transport, walking, cycling, private vehicles and the street network, especially for community and neighbourhood.

Physicochemical Impacts

The major physicochemical parameters considered for assessment of environmental impacts of project activities include (i) Noise pollution, (ii) Air pollution, (iii) Vibration, (iv) Possible drainage congestion, and (v) Generation and disposal of wastes. Noise and air pollution and vibration are essential considerations. The design road alignment was proposed to the current and future development from the Dhaka urban transport corridor project findings or the instruction from the Dhaka City Councils (DCC) guidelines. Drainage congestion may result from possible obstruction to drainage water's natural flow during construction activities and future plans. A single-span bridge was constructed in this project.

Socio-economic Impacts

The major parameters considered for assessment of socio-economic impacts of project activities include (i) Loss of income, (ii) Temporary dislocation/ displacement, (iii)

Traffic congestion, (iv) Safety, and (v) Employment. The matter was assessed and noted as per DCC development management plan.

Environmental Impacts and Management Plan

Traffic impacts, vehicular air pollution, noise pollution and vibration, emission from traffic movement are the significant impacts during the construction and operational phase of the proposed route. An Environmental Management Action Plan (EMAP) based on EIA addressing the impacts of controlling and protecting the natural, social environment reducing the adverse effects at an acceptable level according to the DCC guidelines were implemented.

Safety Issues

To address the road safety measures; the road design was carefully reviewed through senior safety experts in regards to speed, sightlines, crashes, future consequences, side roads, signage and line markings, street lightings, road median, barriers and many more as required to ensure the safety as per DCC and road safety requirement during the design stage.

Geology, Soils and Seismicity

Geology and Soil: *Geology of Bangladesh is generally dominated by poorly consolidated sediments deposit over the past 10,000 to 15,000 years (Holocene age). It is mostly characterised by the rapid subsidence and filling of a basin. A huge thickness of deltaic sediments was deposited as a mega-delta out built and progressed towards the south. The delta building is continuing into the present Bay of Bengal, and a broad fluvial front of the Ganges-Brahmaputra-Meghna river system gradually follows it from behind. Figure xx has detailed the formation of soil tracts in Bangladesh*.

Seismicity: *There were areas of high seismic activity, and some of the significant earthquakes originating in these areas have affected the adjacent regions of the country. The whole of Bangladesh is divided into three seismic zones*. The appropriate measures and consideration were made during the Bridge design and other design activities as part of the policy requirement. ***Figure 20*** has detailed the seismic location of Dhaka Metropolitan City in Bangladesh.

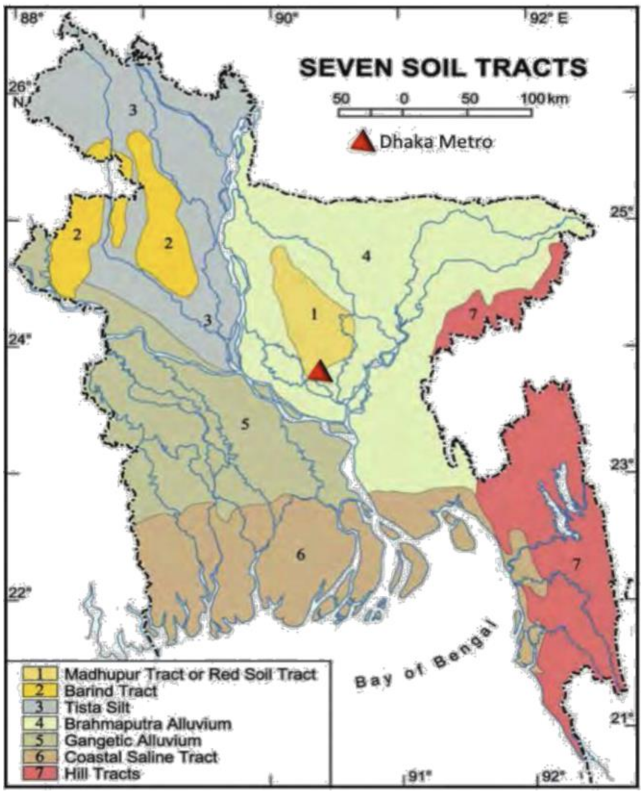


Figure 19: Map showing the Dhaka Metropolitan City area on the seven soil tracts of Bangladesh (map source: www.banglapedia.org)

Threatened Flora and Fauna

Floral and faunal species that exist as the threatened (endangered, critically endangered, etc.) condition were endangered species. There were specific criteria to declare a species as endangered species. A total of 54 freshwater fish and 147 inland wildlife species are endangered species in Bangladesh (IUCN, 2000a; 2000b; 2000c; 2000d; 2002). The study was going through the report where any action required at that time.

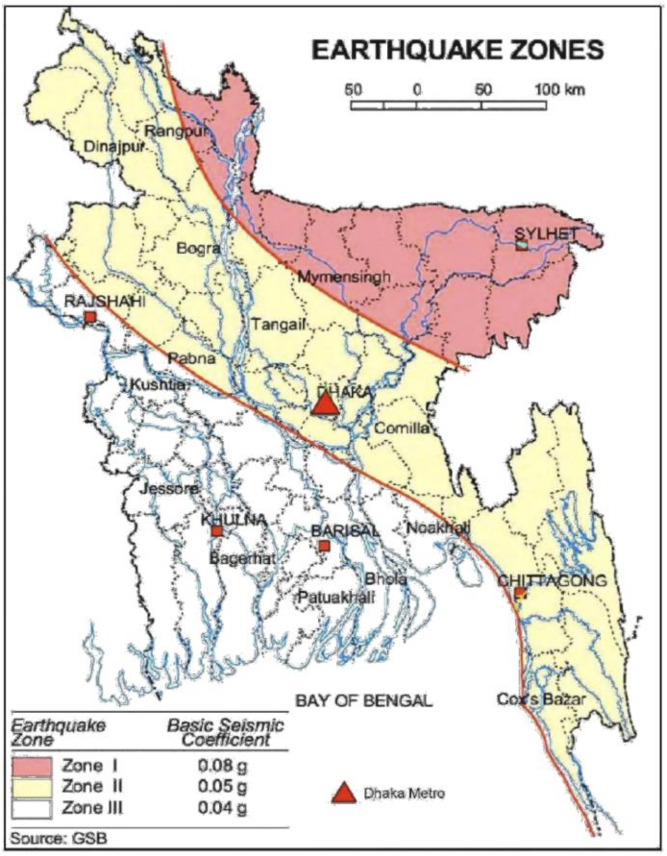


Figure 20: Location of Dhaka Metropolitan City on the seismic map of Bangladesh (map source: www.banglapedia.org)

Socio-economic Impacts

The major parameters for assessment of socio-economic impacts of the project activities include Loss of income; Temporary dislocation/ displacement; Traffic congestion; Safety, and employment. The project assessed the matter during road design and implementation. For instance, *around 412 non-Bangali (Biharis) families were rehabilitated at Pallabi in the city as they lost their dwellings due to Zia Colony-Mirpur Road's construction works*.

Therefore, the megacity required fast and concrete planning and decision making, where there is very little room to change the context overnight. It is impossible to fill the gaps in missing links in most cases. This study also brought some historical scenarios from various parts of the world to see the megacities' outlooks as detailed in figure 23 to 40. It revealed that megacities have a mega plan and compact environment. It can form a concrete jungle unsafe environment with unfitting accessibility and mobility, high living cost, congestion, high operation and maintenance cost without integrated planning. There may be inappropriate to mitigate risks and hazards in the daily life of the respective country's elite society such as fire and emergency, accessibility of emergency or ambulance services, air pollution, water pollution, waste management, emission and many more.

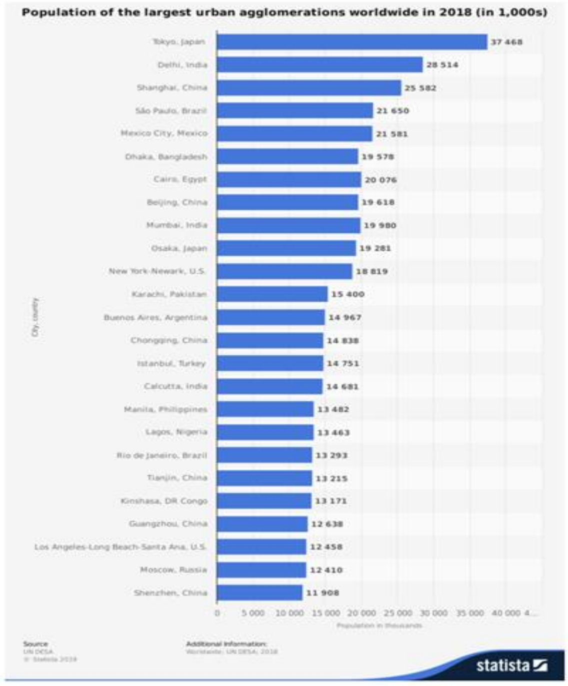


Figure 21: World Largest urban Population in 2018, Source; UN DESA Statista 2019

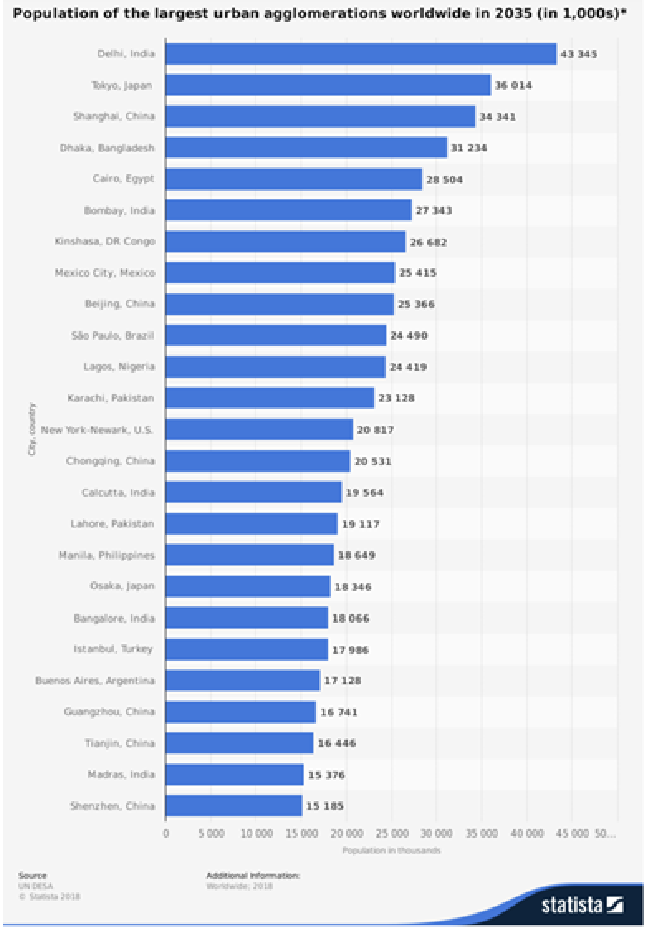


Figure 22: World Largest urban Population in 2035, Source; UN DESA Statista 2018

From current trends, it is tinted that megacity has mega plan. It changes its footprint changing dynamically. The following photos may not be relevant regarding Dhaka city on many occasions regarding per capita income economics, regulation, emission and policy governances, land use planning and many more. However, this study collated this picture from various parts of this world to think that megacity has mega challenges, with better integration in planning and governance, primarily transport planning. It could make it possible to avoid complexity, disaster mitigation, unforeseen future such as pandemic and many more risks for human life and to ease compact city living and healthy environment. *Since millions of people moving into areas that are often struggling to support the populations they already have. Therefore, Housing, pollution, transportation, infrastructure, inequality and social cohesion all require creative solutions.*

Figure 23: Fortaleza, Brazil – 1975 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 24: Fortaleza, Brazil – 1975 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 25: Singapore, Republic of Singapore – 2000 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 26: Singapore, Republic of Singapore – 2000 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 29: Melbourne, Australia – 1920 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 30: Melbourne, Australia – 1920 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 31: Chicago, USA – 1937 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 32: Chicago, USA – 1937 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 33: Shanghai, China – 1987 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

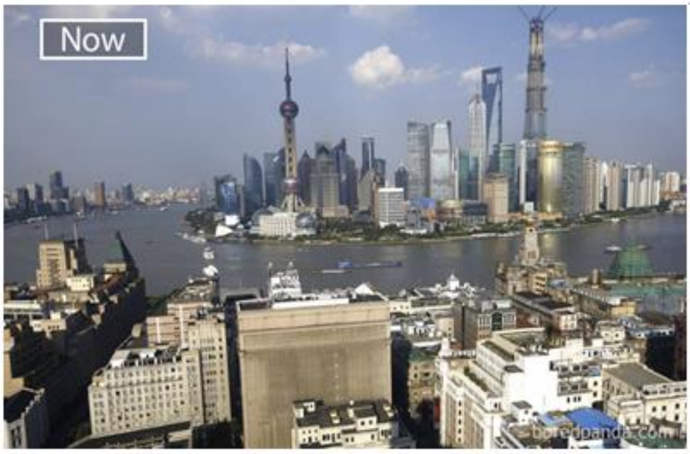


Figure 34: Shanghai, China – 1987 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

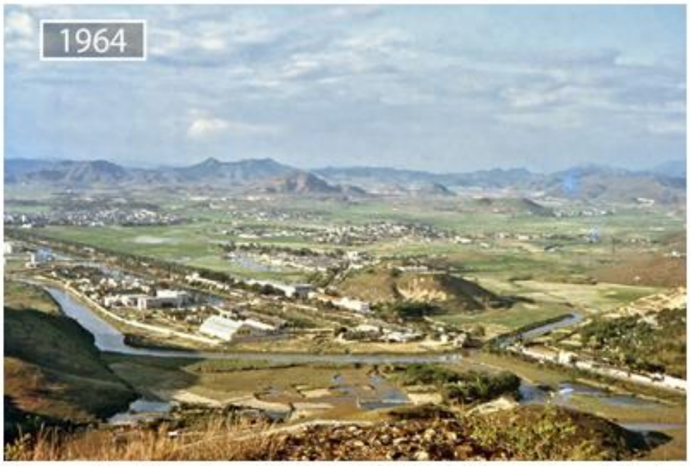


Figure 35: Shenzhen, China– 1964 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 36: Shenzhen, China– 1964 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 37: Dubai, UAE – 2000 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 38: Dubai, UAE – 2000 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 39: Dubai, UAE – 2005 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

Figure 40: Dubai, UAE – 2005 And Now | Bored Panda, Source: how-famous-city-changed-timelapse-evolution-before-after, 2016

CONCLUSION AND RECOMMENDATION

The study acknowledges that many projects are continuously under planning and implementing in the Megacity Dhaka, Bangladesh, by various overarching strategies and policy guidelines from its own and funding agencies. Adopting an integrated transport strategy and acknowledging megacity contends, there is a greater possibility of uptaking such principles across the city, a game-changing spectacle can be achieved. This study aims to reframe how comprehensively transport planning is viewed and managed in the megacity today to be future-oriented. The study recommends some points that could collate during megacity transport planning context:

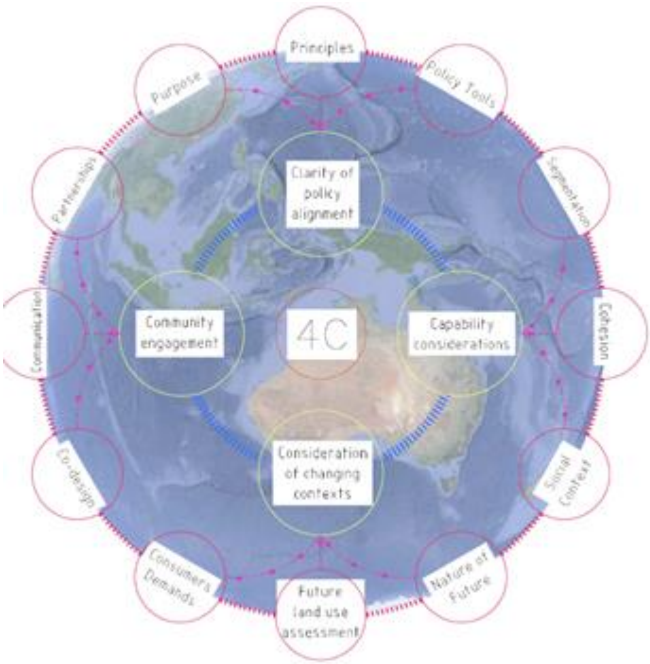
Undertake a transport assessment/transport strategy, traffic study through a four step traffic modelling including Vulnerable Road Users (VRUs) with various primary routes' current and future condition, different networks' build or unbuild condition following a projected direction such as D2035, D2050 so on, employ the appropriate mode for the route or corridor requirements in question, particularly for the critical integration zones that are required to identify in the Megacities Strategic Framework,

Undertake Comprehensive Integrated Transport Planning (CITP) considering each component in turn: Integrated, Intermodal and Interoperable transport to achieve a sustainable outcome, Looking for context-sensitive transport approaches such as TOD (transit-oriented development) or any that could integrate the city's comprehensive land-use model that addresses greenfield, brownfield or infill development,

Undertake more educational programmes through workshops/conferences and round-table discussions to enable local government planners and engineers to better understand broader policy objectives and their implications at the local context, Along with behavioural control measures, road users should be educated to develop mutual respect among users, shared mentality and motivations to contribute to road design,

To reduce greenhouse gas emission; the city should discourage fossil fuels, support solar power, wind power and geothermal power by encouraging the application of renewable and clean energy,

To ensure transport safety in the megacity; the city should adopt a comprehensive safety strategy or philosophy to reduce the fatality. This study highly recommended 4Cs Frameworks that was established in the literature. The following pie diagram has outlined the framework;



Adopt Towards Zero Waste Strategy (TZW) for megacity *to generate less waste and maximise opportunities for material recovery,*

Plan and action comprehensive disaster Management Program (CDMP) to reduce adverse natural and anthropogenic hazards, extreme events,

Plan and action in practice to climate change *to provide more appropriate policy options for energy sectors, transportation, buildings, industry, agriculture, forestry and waste management*,

Adopt technological shift in the economic scale, change direction in strategies and leads *to various social and economic benefits such as employment, better access to health and education services, trade and cultural activities, ITS, automation*, and

Plan and implement a City-wide approach to supporting sustainable development decision-making.

Funding: This research did not receive external funding or any financial support.

Acknowledgments: The author would like to acknowledge ***Design Vision Limited (DVL)*** for inviting as Highway Engineer and engaged for the complex road design and construction project.

Conflicts of Interest: There is no conflict of interest.

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