Paper No. 2-5, Session No. 2. T18. Generating Sustainable Urban System: A Convergence of Geology and Society, Sunday, 4 November

GSA 2018
4-7 November
Indianapolis, Indiana, USA

THE CHALLENGES OF GEOTECHNICAL EXPLORATION IN BANGLADESH FOR SUSTAINABLE URBAN DEVELOPMENT AND RISK REDUCTIONS IN ENGINEERING GEOLOGY

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GSA Annual Meeting in Indianapolis, Indiana, USA - 2018
Paper No. 2-5 Presentation Time: 9:15 AM

THE CHALLENGES OF GEOTECHNICAL EXPLORATION IN BANGLADESH FOR SUSTAINABLE URBAN DEVELOPMENT AND RISK REDUCTIONS IN ENGINEERING GEOLOGY

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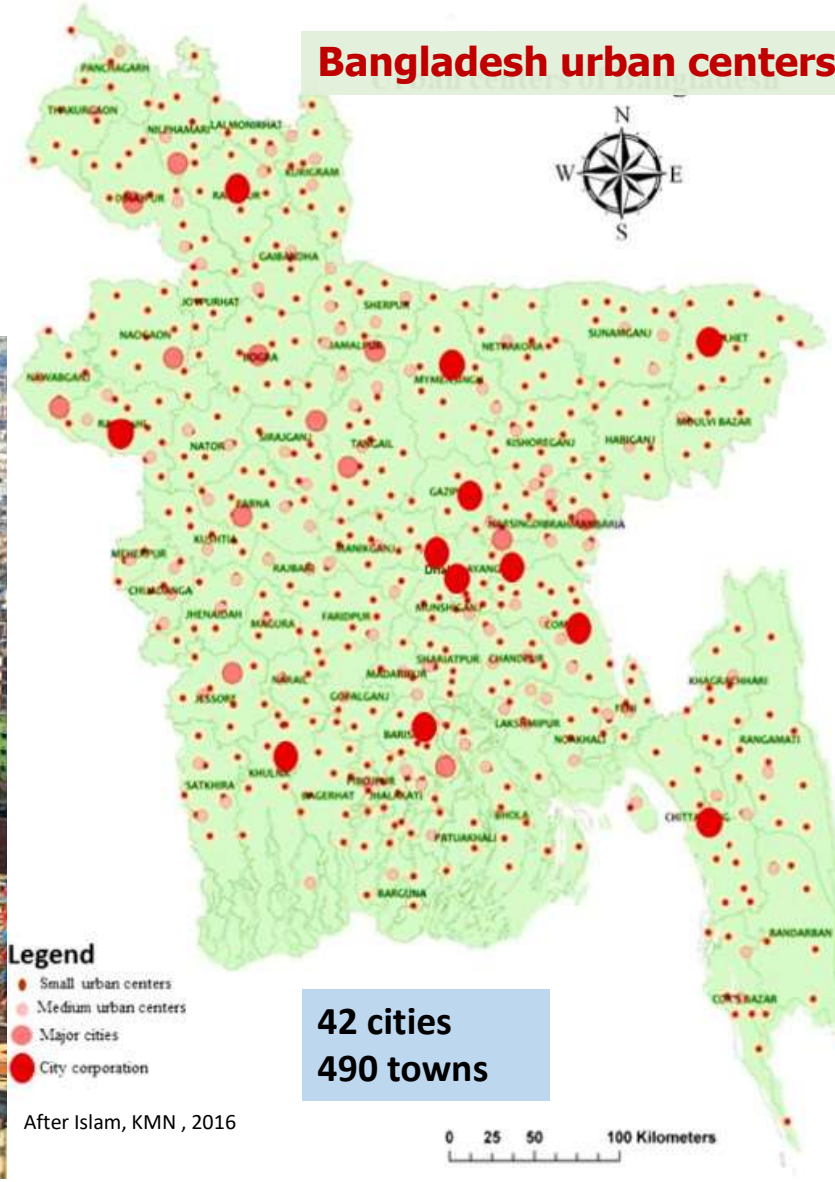
ABSTRACT

Bangladesh is a unique example of rapid urbanization where the urban population increased from 5 to 58 million in last four decades. Due to complex geology and active tectonic setting, the urban ground is impacted by fluvio-deltaic processes and regional seismicity. The densely populated cities of the country are facing risks from many natural hazards like floods, tidal surge, riverbank and coastal erosion, scour, landslides, soil collapse and foundation failures. Geologists anticipate severe seismic threats from yet-undefined tectonic structures and seek to determine their consequential geo-structural responses and conformance to the national building code. With rapid growth, demands on infrastructure have driven the need for better understanding of geotechnical exploration and geologic factors that will contribute to a more manageable, livable, resilient and sustainable infrastructure. The relationship of geo-hazards, geotechnical exploration methods and engineering geologic practices are discussed here. The study indicates that geotechnical exploration method, reporting and laboratory testing practices in current use have yet to adopt standard and quality control techniques. Engineering geology is concerned with subsurface construction, operation and maintenance for safe and sustainable structures. Modified large-scale (1:5000) engineering geologic maps are prepared for selected parts of Dhaka to evaluate and integrate the geologic hazards and engineering geologic risk. Because of unplanned urban expansion, many cities of Bangladesh will require intense modification to the exiting infrastructures including effective utilization of underground space and construction of multilevel transportation system. Risk is always present in any alteration of geologic environment during and after construction. Although the underlying thick hard clay and very dense sand in Dhaka provide advantageous ground condition comparing to other cities of the world, the country is confronting difficult geo-engineering challenges for sustainable development and needs to have standardized geotechnical exploration methods, updated geologic maps and improved laboratory testing system to accurately characterize geologic materials for modeling to meet challenges of sustainable development and risk reduction.

Session No. 2 T18. Generating Sustainable Urban Systems: A Convergence of Geology and Society Sunday, 4 November 2018: 8:00 AM-12:00 PM
Room 135 (Indiana Convention Center). Geological Society of America Abstracts with Programs. Vol. 50, No. 6 doi: 10.1130/abs/2018AM-321408

Bangladesh is a unique example of rapid urbanization where the urban population increased from 5 to 58 million in last four decades.



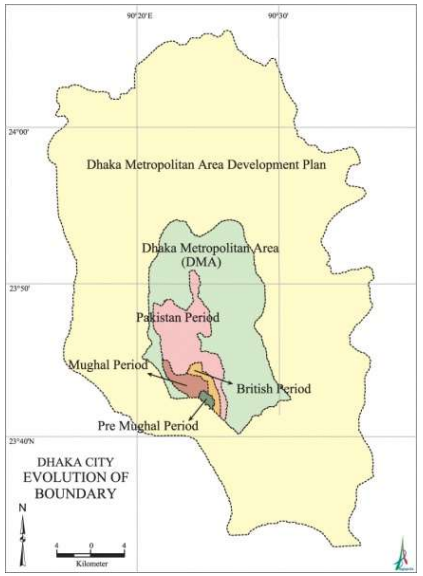
After Islam, KMN , 2016

Rapid chronological expansion of urban area: Case Dhaka Megacity

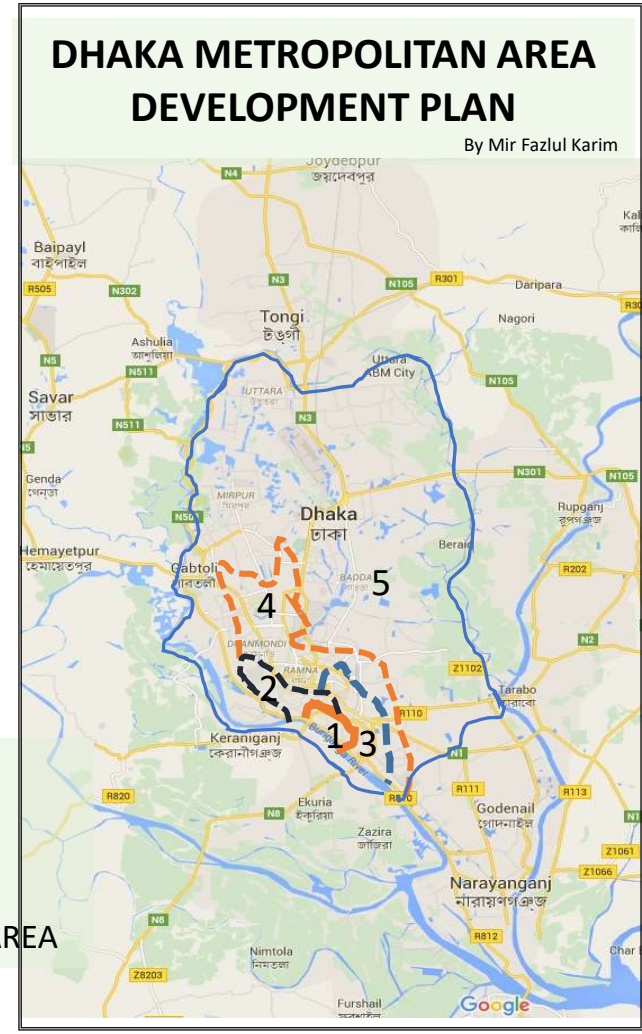
Today Dhaka is one of the 20 Mega cities of the world having population of 19,580,000, ranking 10th in the world.

Urbanization in Bengal started during the Kingdom of Kamarupa between 350 and 1140 CE. The city of Dhaka achieved importance during Sultanate Period in 16th Century and became capital of Bengal during Mughal rule, flourished during British East India Company rule (1772—1857) and British Raj (1858—1947).

http://worldpopulationreview.com/world-cities/



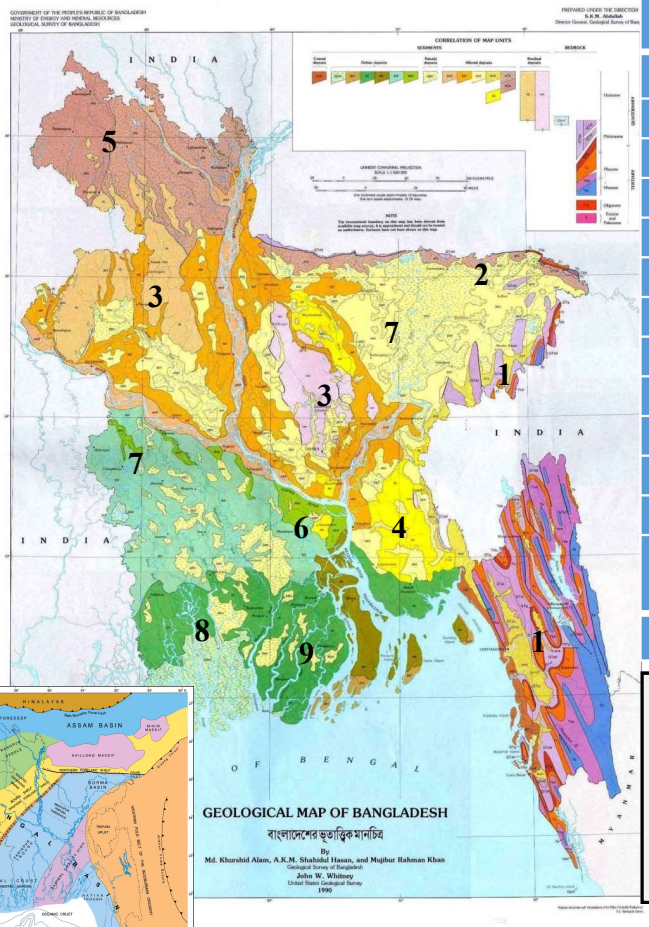
1 - PRE MUGHAL
2 – MUGHAL
3 – BRITISH
4 – PRE BANGLADESH
5 – DHAKA METROPOLITAN AREA



PEOPLE ARE RUSHING TO URBAN ENVIRONMENT

AFFECT OF UNPLANNED URBAN GROWTH

Geology of Bangladesh
and the associated challenging hazards vs geological environment

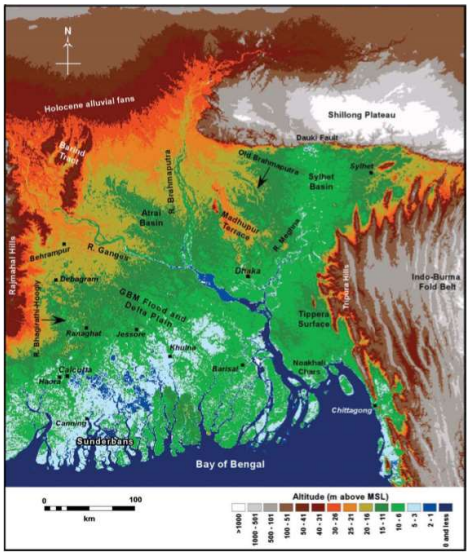


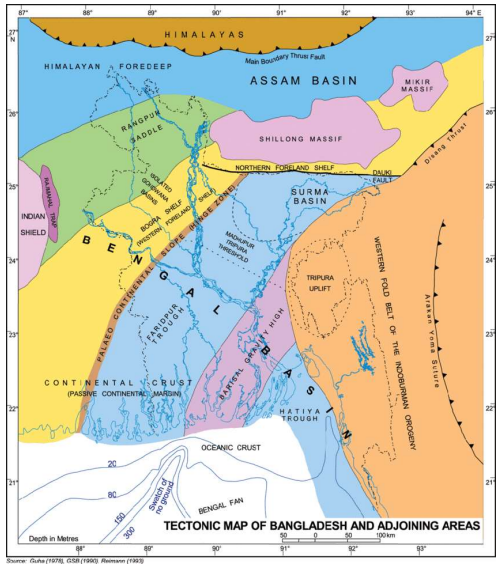
Visible Geological Hazards	Geological Environment					
	Fluvial/ Piedmont plain	Flood plain	Coastal plain	Terrace	Hills	Valleys
River bank erosion	Y	Y	Y	N	N	N
Scour	Y	Y	Y	N	N	Y
Soil erosion	Y	Y	Y	Y	Y	N
Earthquake	Y	Y	Y	Y	Y	Y
Debris flow	N	N	N	Y	Y	Y
Slope failure	N	N	N	Y	Y	Y
Sand flow	Y	Y	N	N	Y	Y
Subsidence	N	Y	Y	N	N	N
Swelling soil	N	N	N	Y	Y	Y
Water logging	N	Y	Y	Y	Y	Y
Flash flood	Y	N	N	Y	Y	Y
Annual flood	N	Y	Y	Y	N	N
Saline water intrusion	N	N	Y	N	N	N
Tidal flood	N	Y	Y	N	N	N

Geological Units : **1 and 2 –** Folded hills of Tertiary sedimentary rock
3 – Pleistocene Terraces Barind and Madhupur, **4 –** Old Alluvial Deposit (Chandina Alluvium),
5 – Alluvial Fan Deposit, **6 –** Paludal Deposit, Marshy clay & peat
7 – Young Alluvial Deposit (Inter-stream deposit), **8 and 9 –** Deltaic and Coastal Deposit. Including Beach, Estuarine and Mangrove swamp deposits.

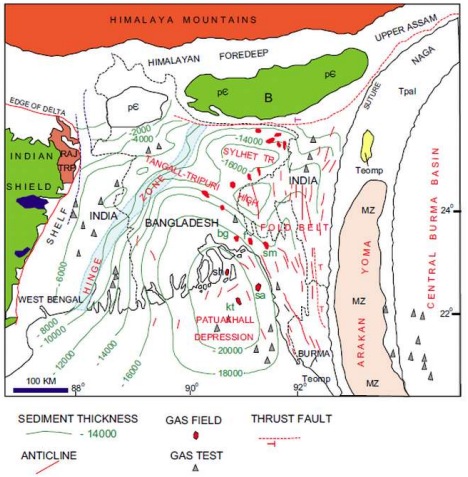
Due to complex geology and active tectonic setting, the urban ground is impacted by fluvio-deltaic processes and regional seismicity.

Geology is the key factor of all natural hazards and risks. Consistent to physical distribution





Geomorphic map of the Bengal basin super imposed on the Shuttle Radar Topography Mission (SRTM) DEM distinguishing different geological features and cities, and consistent to the tectonic map of Bangladesh prepared by Geological Survey of Bangladesh.



Hiller, K. and Elahi, M. (1984) Structural development and hydrocarbon entrapment in the Surma Basin, Bangladesh (northwest Indo-Burman fold belt): Singapore Fifth Offshore Southwest Conference pp.656–663.

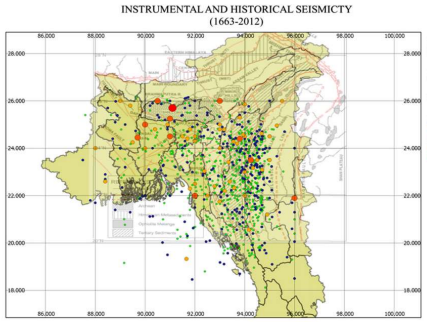
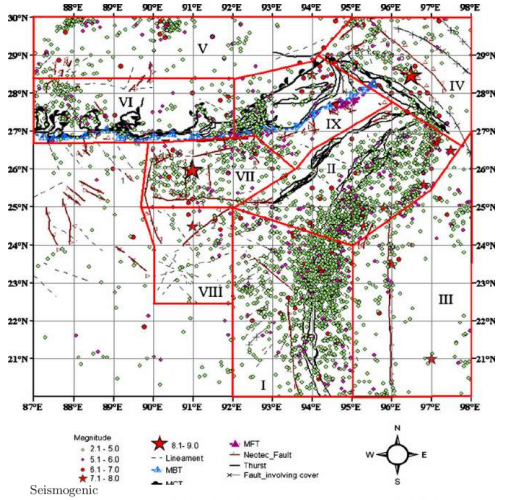


Fig. 4 Composite earthquake catalogue

Probabilistic seismic hazard analysis at a strategic site in the Bay of Bengal, By Sara Cristina Teresa Trianni • Carlo Giovanni Lai • Erio Pasqualini, Springr, 14 June, 2014



Seismogenic

ne	Major division	Subdivision
	Indo Burma Fault Belt	North–south Indo-Burma Fold Belt
	Indo Burma Fault Belt	NE–SW Indo-Burma Fold Belt
I	Plateau region	Sagging Fault region
'	Mishmi Massif	NW–SE trending feature
'	Plateau region	Tibetan Plateau
I	Himalayan Mountain Belt	Eastern MCT
II	Shillong Massif	Shillong Plateau
III	Bengal Basin	Sylhet Fault
:	Himalayan Mountain Belt	NE–SW trending structure

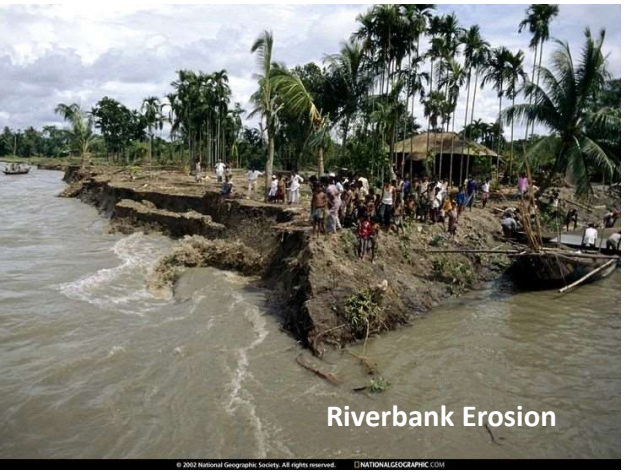
Ranjit Das et al

Temporal and spatial variations in the magnitude of completeness for homogenized moment magnitude catalogue for northeast India, Journal of Earth System Science 121(1):19-28 · September 2011

Dynamic Convergence of Geology and Society

(In fact society is not aware of the geology under their feet. Geologists need to identify and disseminate the real status of engineering geology.)

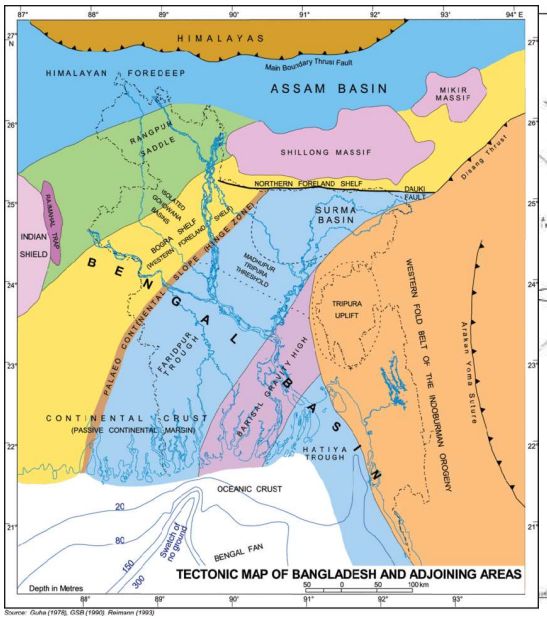
WHY IT IS SO NECESSARY? Let's see next..

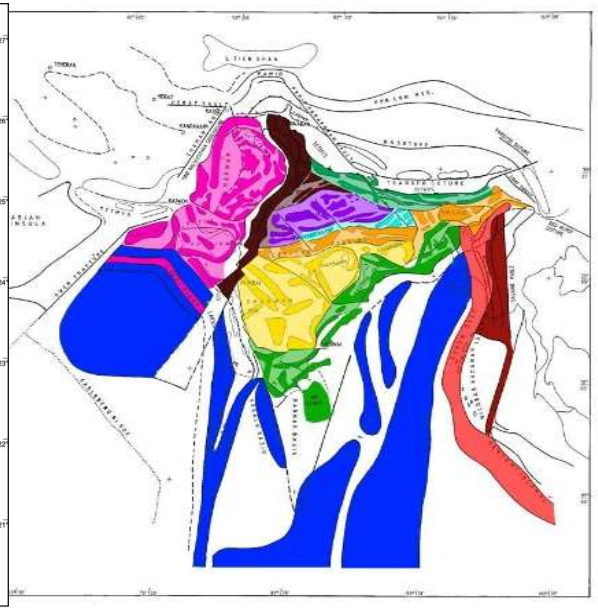


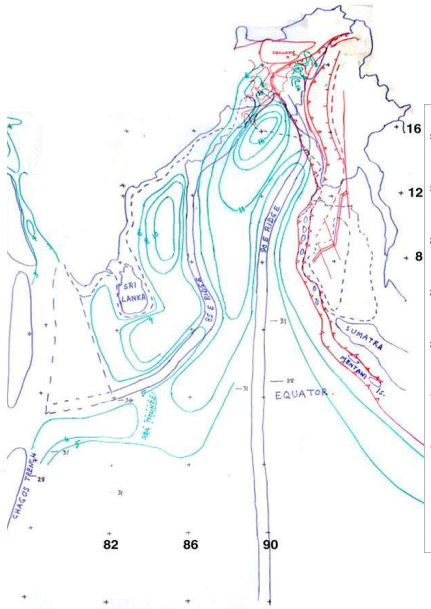
The densely populated cities of the country are facing risks from many natural hazards like floods, tidal surge, riverbank and coastal erosion, scour, landslides, soil collapse and foundation failures.

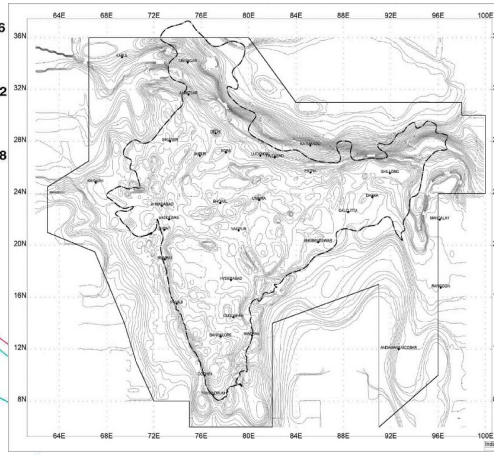
A paradigm shift in tectonic configuration of Bengal Basin

Recently geologists anticipate severe seismic threats from yet-undefined tectonic structures and seek to determine their consequential geo-structural responses and conformance to the national building code.





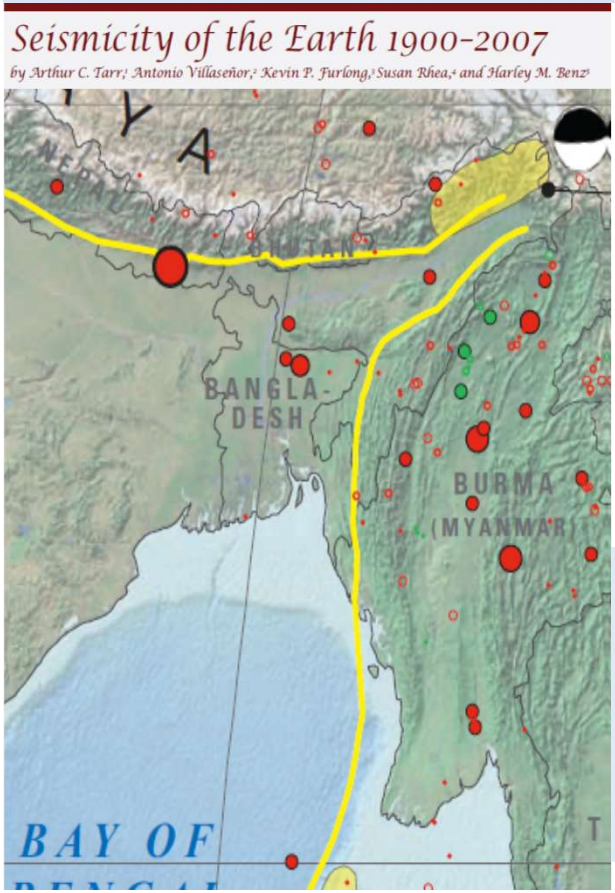


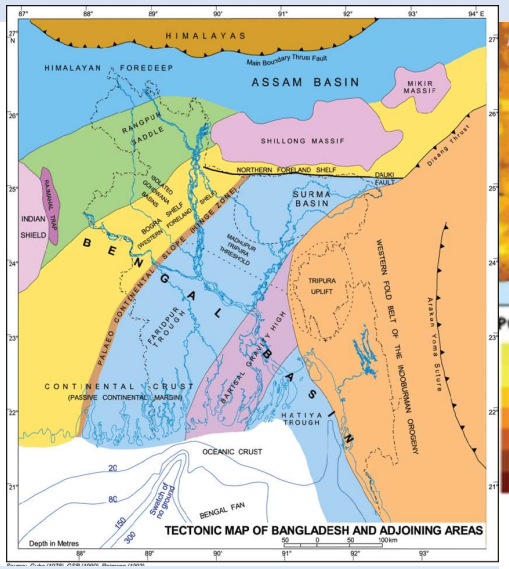


Impact of gravity and other geophysical data on the geology of Indian subcontinent.

T.S. Balakrishnan, Sneh Sadan, Matunga, Mumbai, India, 2003. Journal of the Virtual Explorer 12, 83-92.

THE CHALLENGE IS TO ASCERTAIN THE RISK LEVEL AND ENGINEERING GEOLOGICAL CHARACTERIZATION FOR SAFE AND SUSTAINABLE DESIGN OF INFRASTRUCTURES





The Geological Survey of Bangladesh prepared tectonic map of Bangladesh in eighties and requires to be updated following new findings and hypotheses for ultimate seismic resilience of urban growth.

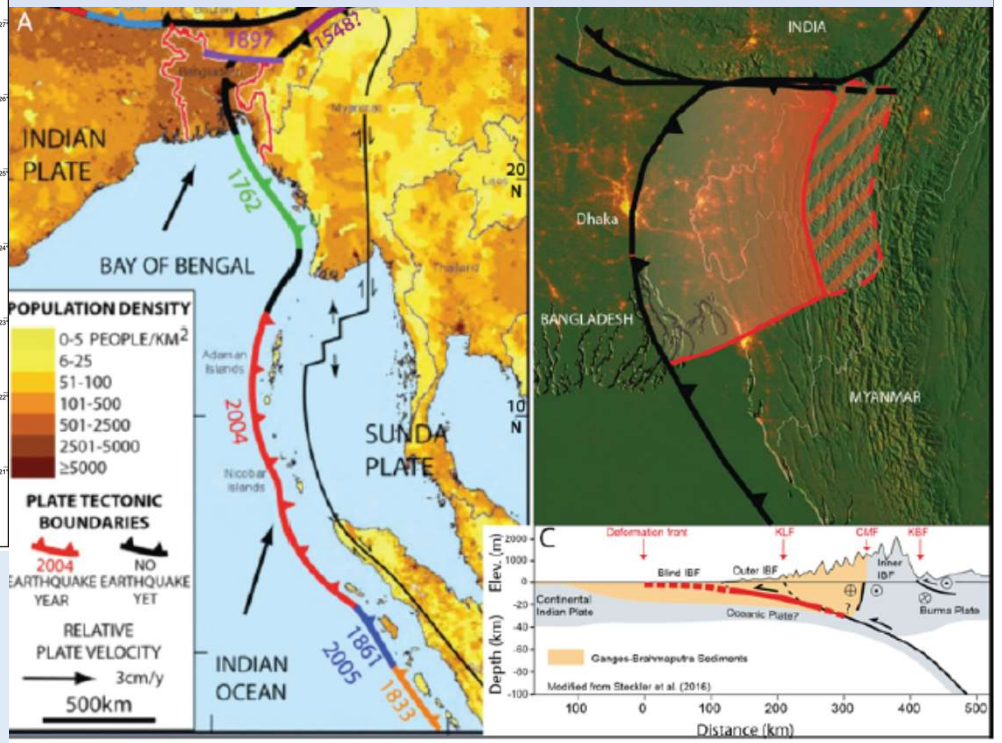


Fig. 1. (a) Major tectonic boundaries of the northeast Indian plate. Numbers represent the years for

Ref : Michael S. Steckler, S. Humayun Akhter, Leonardo Seeber 2016

Real vs the speculated risk.
What the society will judge for a sustainable development from the findings of the geologists?

With rapid growth, demands on infrastructure have driven the need for better understanding of geotechnical exploration and geologic factors that will contribute to a more manageable, livable, resilient and sustainable infrastructure.

IS MEGA CITY A BIG CLUSTER OF MEGA-RISK? !!

Image shows dense urban settlement and geomorphological constraints in lateral expansion of the city. The neighboring unused geomorphic segments can pose various geodynamic hazards. Compliance of building code is necessity for engineering geological risk reduction.

THE MISSING DIALECT
AMONG PRACTICING GEOLOGISTS, ENGINEERS,
POLICY MAKER AND SOCIETY.

Need to articulate or formulate a realist compliance system.

Should introduce acceptable testing and probing system

- **The relationship of geo-hazards, geotechnical exploration methods and engineering geologic practices will be discussed.**
- **The study indicates that geotechnical exploration method, reporting and laboratory testing practices in current use have yet to adopt standard and quality control techniques.**

Geotechnical exploration by percussion drilling, while SPT is done manually and cone penetration testing in a remote part of Bangladesh

Geotechnical exploration by Geoprobe drilling and cone penetration testing in Indiana, US

WHAT STANDARD IS FOLLOWED IN BANGLADESH?
WHO CONTROLS THE QUALITY OF TESTING?

- Practice of geotechnical exploration and testing exists in Bangladesh. The testing organizations owned by private companies, except controlled institutes like BUET and different universities or technical colleges.
- But the testing system is yet to adopt controlled quality, standard, unified and acceptable methods.
- BUET and GSB led to form Bangladesh Society for Geotechnical Engineering in 1993 with an objective to create an standard and reliable practice for testing and exploration in Bangladesh by providing training.

COST OF TESTING IS A BIG FACTOR IN QUALITY CONTROL

- Entering into a new urbanization process, the development projects of the Bangladesh received finance / funding from various sources and were monitored by respective agencies with prescribed methodology for execution and implementation. This dilemma of funding and ownership over the projects put the geotechnical exploration and testing system in challenging state.
- The large engineering projects are either funded by WORLD BANK, ADB, USAID, DID, EU, JICA and NGOs where the consultants are designated from respective agency and multi-standard practice made hindrance in development of national standard method, though there is Bangladesh Standard and Testing Institute (BSTI). BSTI has yet to take strong shape towards controlling are auditing engineering or technical services.

THE WORLD OF STANDARDS

BANGLADESH HAS BSTI – BANGLADESH STANDARD TESTING INSTITUTE BUT DOES NOT INCLUDE OR MENTION CONTROLLED BY STANDARD GEOLOGICAL AND GEOTECHNICAL METHODS

BS

ASTM INTERNATIONAL

British Standard Methods of Test for Soils for Civil Engineering Purposes

ISO **International Organization for Standardization**

Indian Standard.

CODE OF PRACTICE FOR SUBSURFACE *INVESTIGATION*

GERMAN

LANDWIRTSCHAFTLICHE UNTERSUCHUNGS- UND FORSCHUNGSANSTALT SPEYER

The Japanese Geotechnical Society (**JGS Standards**) /(Laboratory Testing Standards for Geomaterials and Geotechnical and Geoenvironmental Investigation Methods)

CNIS China National Institute of Standardization

STANDARD, CONTROLLED AND ACCRIDETED LABORATORY TESTING SYSTEM FOR GEOLOGICAL AND GEOTECHNICAL DATA GENRERATION HAVE BECOME AN ESSENTIAL TASK FOR BANGLADESH

- Engineering geology is concerned with subsurface construction, operation and maintenance for safe and sustainable structures. And need large scale maps.
- Modified large-scale (1:5000) engineering geologic maps are prepared for selected parts of Dhaka to evaluate and integrate the geologic hazards and engineering geologic risk.

STANDARD, CONTROLLED AND ACCRIDETED TESTING SYSTEM WILL GENERATE ACCURATE MAPS AND DOCUMENTS

A GEOMORPHOLOGICAL SHIFT

2001

2015

We have created many environment like Savar Building Failure which was simply an Engineering Geological Failure

Location Dhaka:

23°44'37.16" N

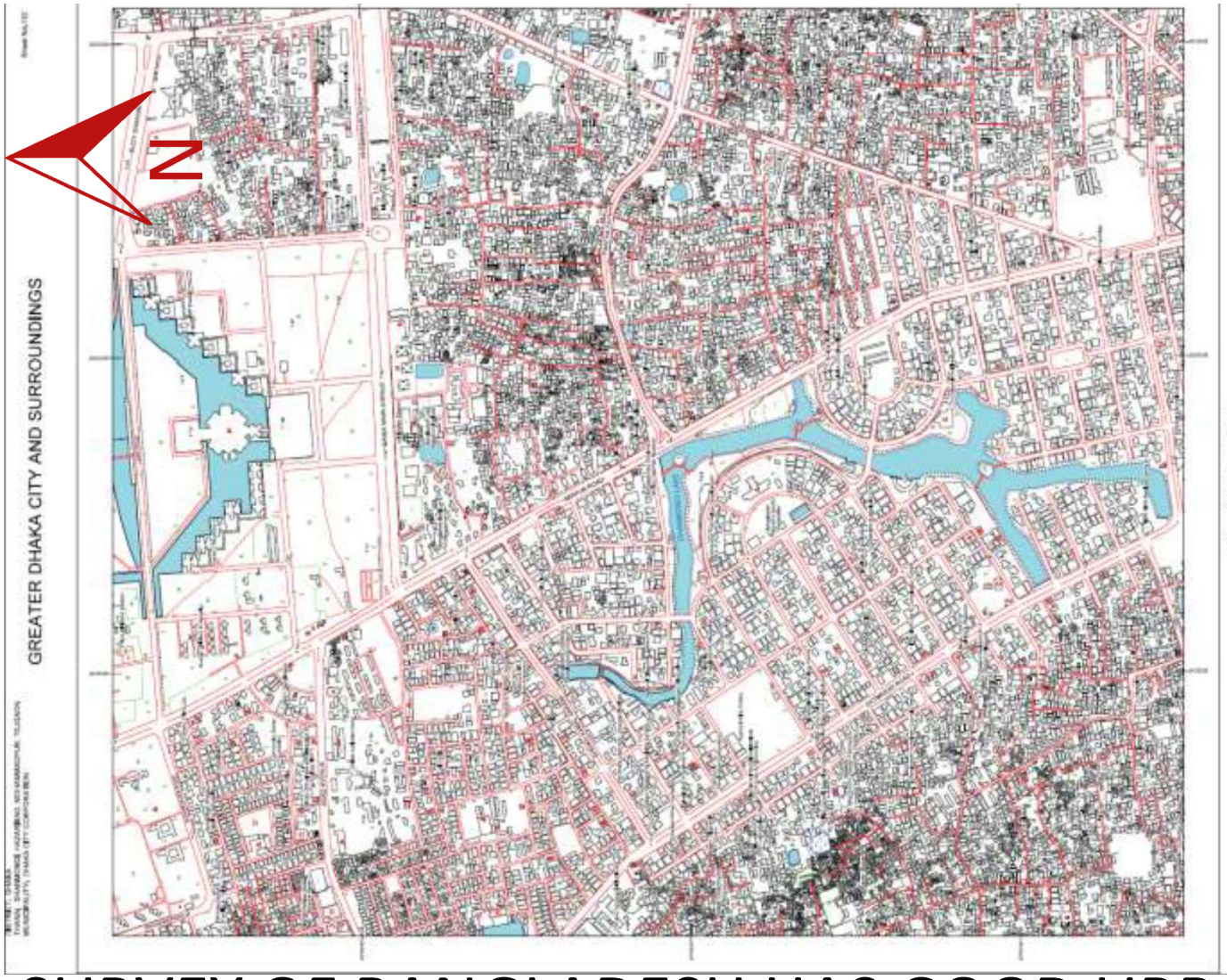
90°21'43.12" E

Geology: Low Floodplain

THE COLLAPSE OF A BUILDING, SAVAR AND AN EXAMPLE OF ENGINEERING GEOLOGICAL FAILURE

Bangladesh Industrial Holocaust, 2013: Could this be avoided?

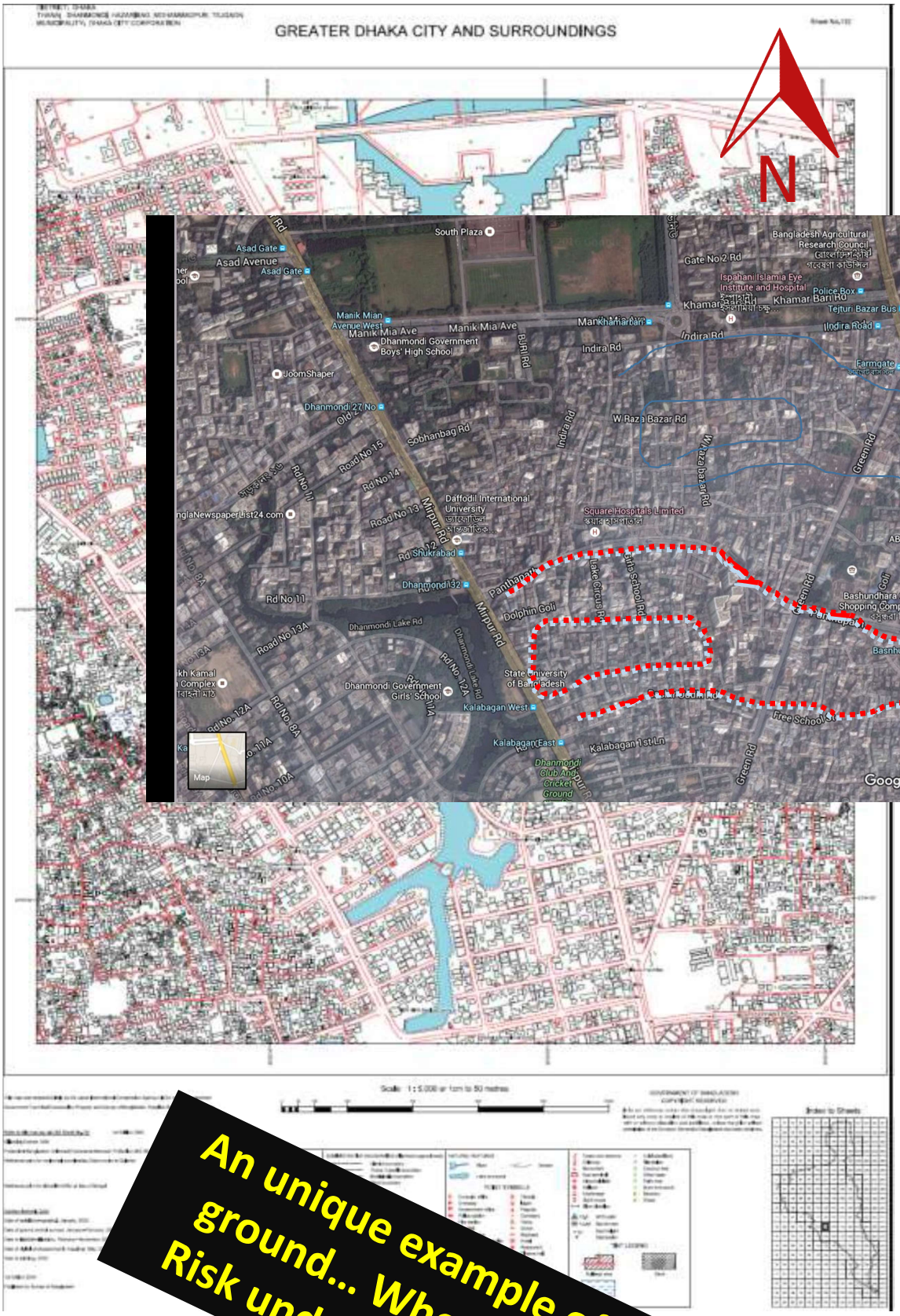
The building occupied a part of a slope of a depression of an abandoned channel, filled up with uncompact soil and municipal waste, raised to the road level from the annual flood level. The building was constructed on 18 inches diameter and 60ft long bored cast in situ RCC piles where the pile-tips were rested on an abandoned channel fill. The conventional and simple soil investigation would not explain the simple geology and solve the elevation puzzle unless materials are geologically judged.



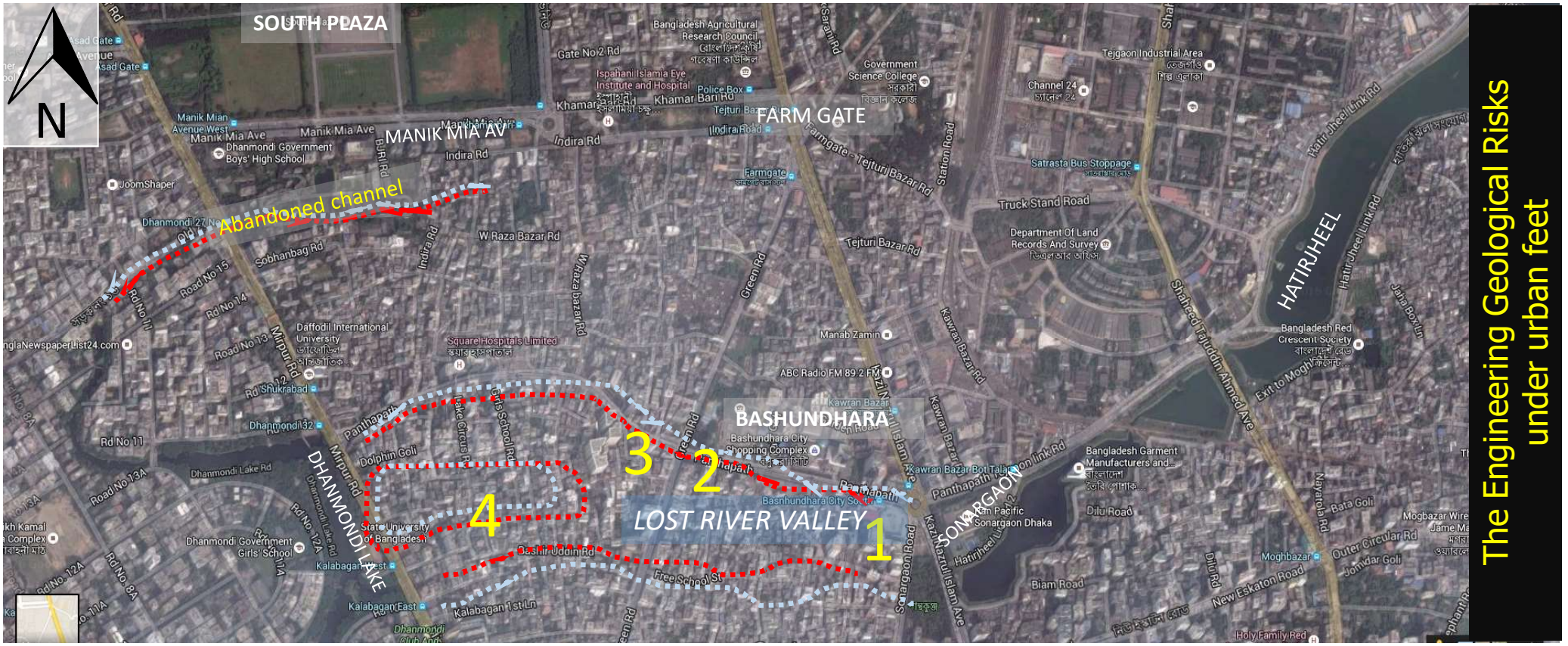
NEED GOOD MAPS - TRANSFER THIS LARGE SCALE MAPS TO DETAILED GEOLOGICAL MAPS WITH ALL POSSIBLE VERTICAL LOGS AND ENGINEERING GEOLOGICAL CHARECTERESTICS FOR SITE SPECIFIC GEOTECHNICAL DATABASE

Analysis and Use of Photogrammetric Methods for Geologic Characterization

SURVEY OF BANGLADESH HAS GOOD URBAN MAPS 1:5,000



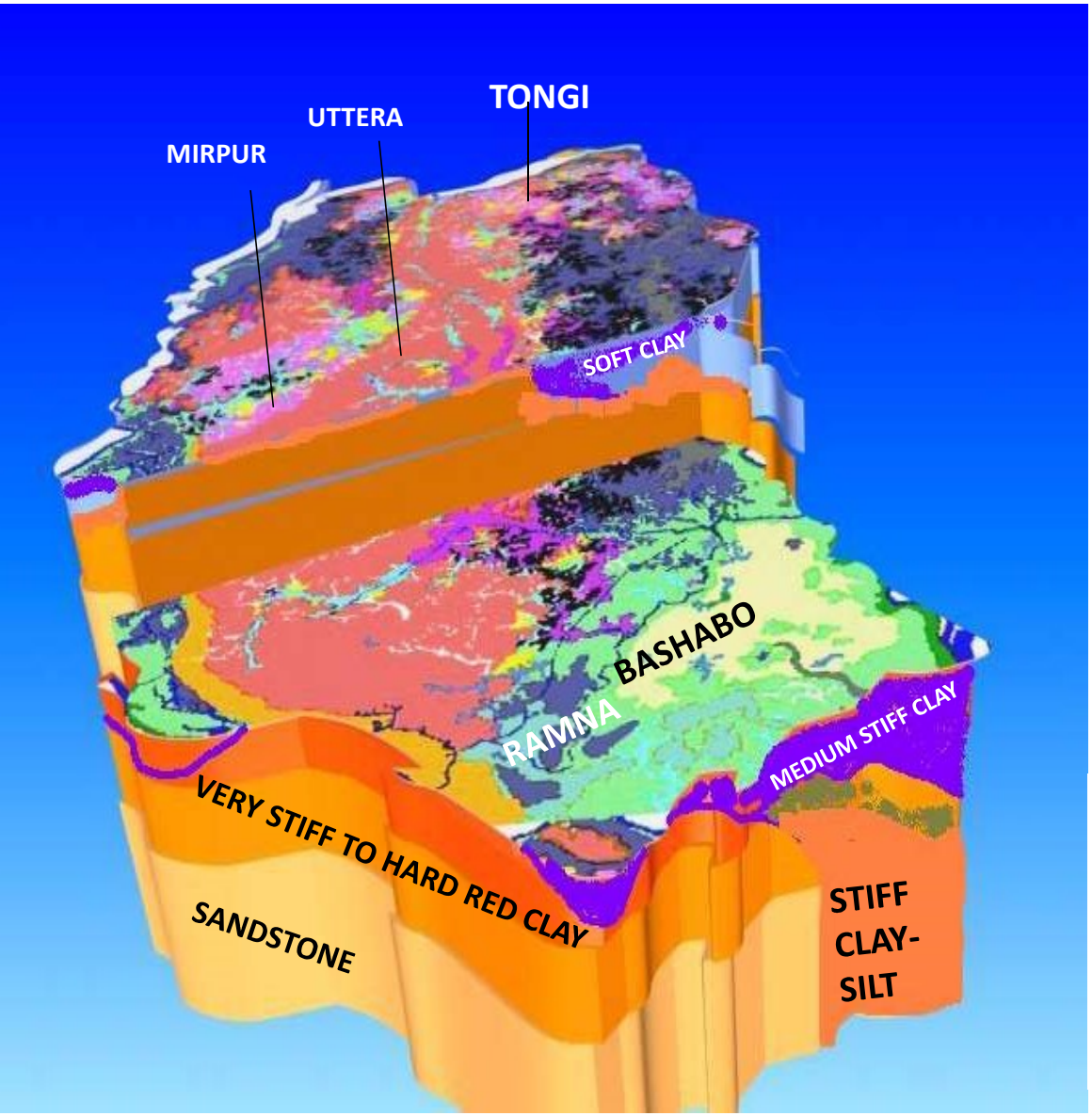
An unique example of altered ground... Where is the risk? Risk under the buildings... !!!



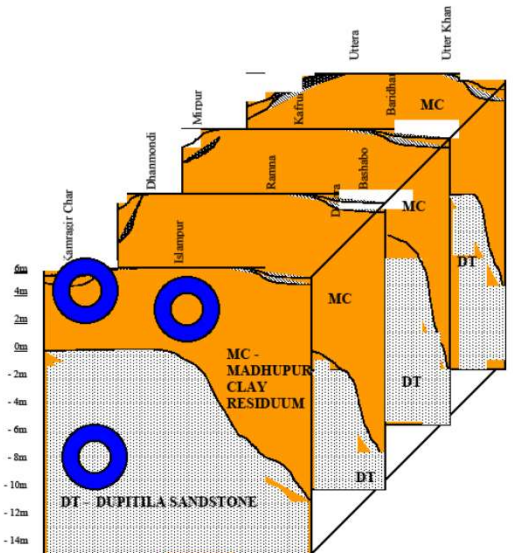
Engineering Geological Risks in the middle of Dhaka City, Bangladesh: The river valleys are lost under the altered ground and urban concrete layers where buildings are collapsed, failed, sinking or living with risks. The locations where recently (1) one under construction high-rise building project failed due to failure of pile construction and site was abandoned, (2) under-construction building failed and one tilted building still being used where the building was tilted during storm sewer drainage construction, (3) the buildings are still sinking and being used (behind Ferdous Tailors) at Green Rd and Panthapoth crossing and (4) building collapsed in Kolabagan by killing several people. (Investigated by – Mir Fazlul Karim).

- Risk is always present in any alteration of geologic environment during and after construction.

- Although the underlying thick hard clay and very dense sand in Dhaka provide advantageous ground condition comparing to other cities of the world, the country is confronting difficult geo-engineering challenges for sustainable development and needs to have standardized geotechnical exploration methods, updated geologic maps and improved laboratory testing system to accurately characterize geologic materials for modeling to meet challenges of sustainable development and risk reduction.



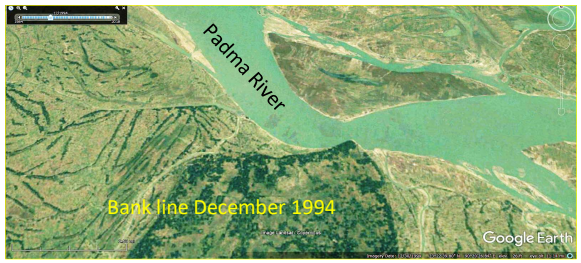
Because of unplanned urban expansion, many cities of Bangladesh will require intense modification to the exiting infrastructures including effective utilization of underground space and construction of multilevel transportation system .



3D Subsurface geological model of Dhaka city, Bangladesh showing surface morphology and two thick top layers of very stiff to hard clay and moderately lithified sandstone; geologically advantageous strata for construction of underground structures. (CAD by Karim, M. F. 2005)

Furious riverbank erosion, August - September 2018

NOW THE CHALLENGE IS TO DETERMINE
engineering geological characteristics by mapping and geological testing along the areas prone to swinging nature of the river covered ground……..



This year the river Padma was severely furious in her flow and bank erosion and caused severe bank erosion and caused demolishing of hundreds of infrastructures, many villages and number of urban centers like Naria Municipality in Shariatpur. During the last months of September and August., 2018 more than 4,000 families have lost their homes.

- **The mighty river Padma is a complex flow of various pattern, ranging between meandering and swiftly shifting braided at different seasons of the year which is totally dependent on discharge and runoff in the Padma River watershed including human interferences and control along the upstream.**

- **The concerned geological institutes and geotechnical engineering group need to come forward for a detailed geological mapping, scientific investigation and geotechnical analysis of this furious failure. The failure analysis like Naria are not studied or described in American or European text books.**

- **Present authors speculate similar behavior of the river in the coming years due to global climatic shift and intense human interference along the upstream.**

THE CHALLENGES REMAIN FOR BANGLADESH FOR QUALITY and UPDATED LARGE SCALE DIGITAL-INTERACTIVE DERIVATIVE MAPS

YOU ARE INVITED
TO BOOTH 101
TODAY
TO OUR POSTER SESSION

Presentation Time: 9:00 AM-5:30 PM
THE STATUS OF ENGINEERING GEOLOGY: CONSTRAINTS ON INFRASTRUCTURE DEVELOPMENT IN BANGLADESH

Session No. 30--Booth# 101 T71. Recruiting and Retaining K9–16 Students through Field- and Laboratory -Based Geoscience Experiences (Posters) Sunday, 4 November 2018: 9:00 AM-5:30 PM

The Status of Engineering Geology: Constraints on Infrastructure Development in Bangladesh

Mir Fazlul Karim[1], Muhammad Qumrul Hassan[2], Nazrul Islam Khandaker[3], Masud Ahmed[4] and Belal Ahmed Sayeed[5]

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(2) Department of Geology, University of Dhaka, Ramna, Dhaka, 1000, Bangladesh

(3) Geology Discipline, Earth and Physical Sciences, York College Of CUNY, 94-20, Guy R. Brewer Blvd, Jamaica, NY 11451, USA

(4) New York City Department of Environmental Protection, Geotechnical Section, NYCDEP, 59-17, Junction Blvd, Queens, New York, NY 11373, USA

(5) Dewberry Geotechnical Company. 132 W 31st St #301, New York, NY 10001, USA

GSA 2018

4-7 November

Indianapolis, Indiana, USA

ABSTRACT

In recent years, megacity Dhaka is known to have one of the fastest urban population growths in Bangladesh. The population in Dhaka and other megacities has increased from 7 to 50 million during the last four decades. The rapid rate of urban population growth, along with the extreme paucity of real-estate for new infrastructure development upgrading existing facilities, is already exacerbating the situation for the city planners and exerting tremendous pressure to come-up with viable solutions. Although practice of engineering geology, geotechnical exploration, and testing exists in Bangladesh, the system has still yet to adopt controlled quality standards with unified and profession acceptable methods. There is a dire need for accessing shallow borehole data via a central depository system in order to initiate, reassess and provide sound geoengineering recommendations for any contemplated capital construction projects. A well-coordinated system involving city agencies and private sectors can ease the situation for effect communication regarding knowledge-sharing and keeping involved geotechnical personnel informed about already acquired data. Several development projects of the country received finance from various sources and were monitored by various agencies with prescribed methodology for execution and implementation. This diversity of fundi ownership and oversight of the projects has put the geotechnical exploration and testing system into challenging state in Bangladesh. Integration of pertinent geomorphic, regional geology, bedrock, water table and soil data will certainly aid understanding the constraints associated with any subsurface construction. Mega cities such as Dhaka Chittagong will require intense modification in order to accommodate urban facilities, including installation of a multilevel transportation system with underground space utilization. On a positive note, the megacity of Dhaka has suitable natural ground conditions typified by sound geoengineering parameters. Standard geotechnical exploration doup with assessment of geomorphic and geotechnical attributes will augment existing data to characterize geological materials and prepare detailed engineering geotechnical reports to be used for design and capital construction projects. Geotechnical information from the recently completed City Water Tunnel # 3 (New York City) is considered.

History of Engineering Geology in Bangladesh

The history of advancement of engineering geology in Bangladesh dates back to early seventies after the independence of the country. By the virtue of national capacity the Geological Survey of Bangladesh (GSE) led the beginning of professional practice and contribution of engineering geology in Bangladesh. Among the pioneer engineering geologists of this land the most mentionable are Mesbahuddin Ahmed, Anisur Rahman, AKM Shahidul Hasan, Hasan Faruque, Khurshid Alam, Dr Khandokar Musharaff Hossain, Dr. Sajjad Hossain and Mir Fazlul Karim. Though the concept and understanding of engineering geology existed during the early development years (before 1980) of Bangladesh, the quantification of qualitative geological information and data for engineering application was very limited as the practice of civil engineering relied on rule of thumb methods. It is being noted that Mesbahuddin Ahmed was the first engineering geologist of Bangladesh. He coauthored the seismic code for structural design engineering, through a national committee (popularly known as Committee of Experts on Earthquake Hazard Minimization of Geological Survey of Bangladesh), where the structural engineering team was led by renowned civil engineer Dr. Jamilur Reza Choudhury of Bangladesh University of Engineering and Technology (BUET). The first quantitative engineering geological input by a group of young geologists of Dhaka University Geology Department during a 1980 engineering exhibition of Bangladesh Institute of Engineers in Dhaka, sponsored by Md. Nurul Amin, an engineer of Foundation Consultants Ltd. The group was led by Mir Fazlul Karim and other members included Dr. Arif Mohiuddin Sikder and Dr. M. Aziz Hasan. The group made a poster session and participated in the exhibition to demonstrate geological factors responsible for damaging different infrastructures in the cities. The most innovative presentation attempted to convince civil engineers and policy makers that damage to the roads of Dhaka city and surrounding regions were caused by geological factors. The postulated causes were simple and concerned the Madhupur Clay that forms the ground of Dhaka city. The Madhupur Clay is composed of swelling clays and after every rainy season the roads get bumped up with swelling heaves and troughs causing fractures in the asphalt (or tarmacs in the airports) ultimately degrading their physical condition. The engineers from the Roads and Highways adopted a significant change in the design and construction of pavement and sub-base. The underlying red soils are removed and replaced by compacted soil/sand. This practice changed the quality of roads sharply in Dhaka city since early eighties. Afterward many geologists of Bangladesh worked directly or indirectly for the advancement of Engineering Geology in Bangladesh. I would like to mention the names with due respect for their contributions. These include Dr. Badrul Imam in petroleum and mining engineering approaches, Dr. Syed Humayun Akhter in earthquake, structural and tectonics, which provided a direction for hazard assessments, Dr. Hossain Monsur for his great work in understanding of Quaternary geology that is an integral part of engineering geology, Dr. Maksud Kamal and Md. Zillur Rahman for thier great work on Dhaka city and disaster management. Simultaneously, many professional civil engineers continued to support the necessity of geological information in their design and Bangladesh Roads and Highways included the Geological Survey of Bangladesh in their design team during geotechnical investigation and design phase of first Buriganga Bridge.

Geology of Bangladesh

Figure 1: Geological Units

1 and 2 – Folded hills of Tertiary sedimentary rock
3 – Pleistocene Terraces Barind and Madhupur
4 – Old Alluvial Deposit (Chandina Alluvium)
5 – Alluvial Fan Deposit
6 – Pabatal Deposit, Marshy clay & peat
7 – Young Alluvial Deposit (Inter-stream deposit)
8 and 9 – Deltaic and Coastal Deposit. Including Beach, Estuarine and Mangrove swamp deposits.

Port City Chittagong

Figure 6: Near Surface Engineering Geological Map of Chittagong City, Bangladesh (Karim, M.F. et al., 1990)

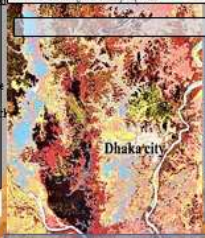
Generalized geology of Chittagong City Chittagong is the largest port city of Bangladesh. The engineering geology of the city is essentially influenced by the flood plain of the Karnaphuli River, the tidal plain along the coast of the Bay of Bengal, and the undulated-to-dissected hills. The hilly area is formed of folded, soft sedimentary rocks of Mio-Pliocene age and it is the southern extension of Sitakunda Anticline. The bedrock formations are moderate to intensely fractured and faulted at a number of places. In the beginning, the city started settling mainly in the higher terrain except for a few patches of port facilities along the river mouth of Karnaphuli. Later, due to rapid increase of the urban population, the city extended into the lower alluvial and coastal plains without considering the geological aspects and constraints of these terrains. The subsurface engineering geologic conditions are strongly suitable for construction of underground tunnels and infrastructures, provided detailed bedrock engineering geology maps are prepared using standard seismic and geotechnical parameters. The city is exposed to landslide and slope instability, excavation of hills and valley fill, flash flood, soft soil, soil collapse, liquefaction, river and coastal erosion, tidal surges and flood. The geological hazards are associated with various geo-dynamic degradational and depositional geomorphological processes in this area.

CONSTRAINTS ON INFRASTRUCTURE DEVELOPMENT IN BANGLADESH

RIVER EROSION AND FLOOD: CASE STUDY OF FURIOUS PADMA RIVER EROSIN IN NARIA URBAN AREA

Figure 7: The mighty river Padma is a complex flow of various pattern, ranging between meandering and swiftly shifting braided at different seasons of the year which is totally dependent on discharge and runoff in the Padma River watershed including human interferences and control along the upstream. This year the river was severely furious in her flow and bank erosion and caused severely furious in her flow and bank erosion and caused demolishing of hundreds of infrastructures, many villages and number of urban centers like Naria Municipality in Shariatpur. During the last months of September and August, 2018 more than 40,000 families have lost their homes. One renowned Bangladeshi geotechnical engineer M Humayun Kabir mentioned that failure due to hydrodynamic action of the Padma river, triggered by geomorphological processes in complex geological environments, including char formation of channel bars (Char) on the offshore of the erosion bank. The phenomena of hydro-soil interaction is further aggravated by the stiffer foundation system of the many infrastructures in urban Naria. The concerned geological institutes and geotechnical engineering group need to come forward for a detailed geological mapping, scientific investigation and geotechnical analysis of this furious failure. The failure analysis like Naria are not studied or described in American or European text books. Present authors speculate similar behavior of this river in the coming years due to global climatic shift and ensuing human interferences along the watercourse.

Dhaka Megacity



The Mega City of Dhaka occupies a unique geological location. The subsurface geology is firm and almost homogeneously consistent. Geologically it is an old terrace raised considerably about 6m above sea level (AMSL). The surrounding floodplains are at about 4m AMSL. The ground is composed of Madhupur Clay. The Clay is Over-consolidated. The shear strength properties are considerably high. The Thickness of Madhupur Clay is about 6 m and it overlies a firm sandstone bed, geologically known as Dupi Tila Formation (Upper Dupi Tila Sandstone). It may be considered as very dense bedrock. The Madhupur Clay and Dupitila Sandstone are very much suitable for construction of underground structure, even for development of underground transportation system for this growing city. The study reveals that the city has been developed on an advantageous geological location consisting of raised Madhupur Clay Formation or older alluvium in respect to the surrounding floodplains of young alluvial deposits.

Figure 2: DEM of Dhaka City and Tongi area. (Ground elevation ranges between 7 and 6m, shaded with dark and light colour while blue shows water or marshy surface. Compare the past drainage map).

Figure 3: 3D Block model of Dhaka city surface geology and top two layers of very stiff to hard clay and moderately lithified sandstone bed showing very dense urban settlement

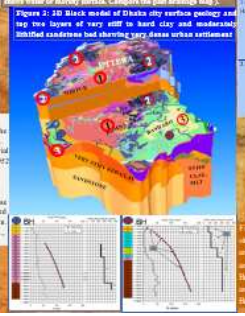


Figure 5: An open cut excavation of Madhupur Clay Residuum consisting of very stiff to hard clay & clay-silt. The average Undrained Shear Strength is >150kPa and Shear Wave Velocity ranges between 0.80 and 1.000 ft/sec. Unit 1 in Figure and Table 1. (Md Fazlul Karim a former Director of Geological Survey of Bangladesh and presently Engineering Geologist at Geocomp Corporation, USA and AKM Khorshed Alam, a former Director General of Geological Survey of Bangladesh working for detailed geological mapping of Dhaka terrace).

LANDSLIDE IN CHITTAGONG

Figure 8: LANDSLIDE IN CHITTAGONG

ADVANCEMENT IN ENGINEERING GEOLOGICAL TESTING

Figure 9: Portion of Manhattan Water Tunnel #3 (New York City) excavated by TBM (prior to 2010). Nazrul Khandaker inspecting samples from the partially weathered zone.

Figure 10: Alamedul Hassan, a civil engineer from Dhaka, visiting a fully Automated Geotechnical Testing Laboratory, consisting of testing facilities for a wide range of rock and soil parameters and properties to accommodate testing facilities for RAJUK (Dhaka City Dev Authority). While Nancy Hubbard demonstrates test with automated Resonant Column and Torsional Shear Test. Mir Fazlul Karim of Geocomp Corporation devoted to transfer the technology to Bangladesh with keen co-operation and support from Qumrul Hassan, Maksud Kamal, Meliah Ansary, Tahmeed Al Hussaini and Md. Zillur Rahman. (Courtesy: Gary Torosian, Geocomp Corporation, Massachusetts, USA).

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Table 1:The distribution of geological hazards in different geological environments of Bangladesh

Geological hazards	Geological Environment					
	Fluvial/ Pleistocene plain	Flood plain	Coastal plain	Terrace	Hills	Valleys
River bank erosion	Y	Y	Y	N	N	N
Scour	Y	Y	Y	N	N	Y
Soil erosion	Y	Y	Y	Y	Y	N
Earthquake	Y	Y	Y	Y	Y	Y
Debris flow	N	N	N	Y	Y	Y
Slope failure	N	N	N	Y	Y	Y
Sand flow	Y	Y	N	N	Y	Y
Subsidence	N	Y	Y	N	N	N
Swelling soil	N	N	N	Y	Y	Y
Water logging	N	Y	Y	Y	Y	Y
Flash flood	Y	N	N	Y	Y	Y
Annual flood	N	Y	Y	Y	N	N
Saline water intrusion	N	N	Y	N	N	N
Tidal flood	N	Y	Y	N	N	N

Note : Y = Consideration of geological hazards is required. N = geological hazard is absented may be ignored. Hydrological hazards such as tidal bores and cyclones are not included in this table

Table 2: Significant geological hazards in major cities of Bangladesh

City	Geological Hazards						
	Water logging	Swelling soils	Subsidence due to soft soils and collapse	Landslide	Seismicity	Tidal flood and saline intrusion
Dhaka	Y	Y	N	Y	N	N
Chittagong	Y	N	N	Y	Y	Y
Khulna	Y	N	Y	Y	N	Y
Rajshahi	Y	Y	N	Y	Y	N

Figure 4: Natural drainage map of the Dhaka-Tongi area. Prepared from aerial photographs of 1972. Arrows show the surface slope and water flow directions. All these streams are clogged due to urbanization. (Karim, M F. et al., 1990)

Table 3: Factors that affect development in Greater Dhaka city.

Rating	Factors	(m/s)	Areas
1. Foundation	a. Liquefaction	3	Floodplain of Buriganga river
	b. Slope failure	2 & 3	Along elevated and depression ridge
	c. Flood	3 & 4	Areas below normal flood level
	d. Waterlogging	1 & 4	Areas where natural drainage is blocked
	e. Subsidence	3	Filled abandoned water-body, ponds and depressions
2. Water	a. Artesian confined and subconfined	3	Low areas with partially saturated sand/silt stratum 1-2 m
	b. Swelling clays	1	Mainly central or high areas
	c. Soft to firm clay, topsoil, soils, and municipal waste	2 & 3	Eastern part of Greater Dhaka city

Summary

Geology played a key role in the construction of the New York City Water Tunnels. Sound geotechnical information not only enabled tunnel to be constructed over th course of allotted time, also prevented New York City agency from encountering an notable geotechnical disaster. Acquisition of proper geological information is extremel vital to any tunnel or capital construction projects in terms of resource utilization, tim and most importantly the welfare of personnel involved in the construction and desig phase. Megacities like Dhaka and other major cities including recent start of tunn construction in Chittagong are now becoming a fertile ground to test out these pivot geoengineering concepts/principles to achieve maximum effectiveness toward accomplishing geoengineering tasks. Knowledge of bedrock and engineering geolog and timely sharing of compiled geotechnical information with engineers, driller management team and adoption of standard geotechnical exploration and testing syste – key to a successful completion of the project and achieve sustainable urba development in Bangladesh.

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