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

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

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.

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, Springer, 14 June, 2014

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..

Riverbank Erosion

Landslide

Soil Collapse

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.

Urban Flood

Foundation Failure

Tidal surge and coastal erosion

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 and 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

International Organization for
Standardization

British Standard Methods of Test for Soils for Civil Engineering Purposes

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 GENRRERATION 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
CHARACTERISTICS 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... !!!

The Engineering Geological Risks
under urban feet

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

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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, 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 professional 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 geoenvironmental recommendations for any contemplated capital construction projects. A well-coordinated system involving city agencies and private sectors can ease the situation for effective 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 funding 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 geoenvironmental parameters. Standard geotechnical exploration coupled 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 (GSB) 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 Khandoker Musharraf 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 contributed 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. Anisur Rahman Sikder and Dr. M. Anisur Rahman. 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 Inam 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. Maksood Kamal and Md. Zillur Rahman for their 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 Pungro Bridge.

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

Geological hazard	Barisal	Chittagong	Dhaka	Khulna	Comilla	Tangail	Barisal	Barisal
Water logging	Y	Y	Y	Y	Y	Y	Y	Y
Soil erosion	Y	Y	Y	Y	Y	Y	Y	Y
Subsidence	Y	Y	Y	Y	Y	Y	Y	Y
Slip/landslide	Y	Y	Y	Y	Y	Y	Y	Y
Water logging	Y	Y	Y	Y	Y	Y	Y	Y
Subsidence	Y	Y	Y	Y	Y	Y	Y	Y
Water logging	Y	Y	Y	Y	Y	Y	Y	Y
Subsidence	Y	Y	Y	Y	Y	Y	Y	Y
Water logging	Y	Y	Y	Y	Y	Y	Y	Y
Subsidence	Y	Y	Y	Y	Y	Y	Y	Y
Water logging	Y	Y	Y	Y	Y	Y	Y	Y
Subsidence	Y	Y	Y	Y	Y	Y	Y	Y

Table 2: Significant geological hazards in major cities of Bangladesh

City	Water logging	Soil erosion	Subsidence	Slip/landslide	Water logging	Subsidence	Slip/landslide
Dhaka	Y	Y	Y	Y	Y	Y	Y
Chittagong	Y	Y	Y	Y	Y	Y	Y
Khulna	Y	Y	Y	Y	Y	Y	Y
Comilla	Y	Y	Y	Y	Y	Y	Y
Tangail	Y	Y	Y	Y	Y	Y	Y
Barisal	Y	Y	Y	Y	Y	Y	Y

Geology of Bangladesh

Figure 1: Geological map of Bangladesh

Port City Chittagong

Figure 6: Near Surface Engineering Geological Map of Chittagong City, Bangladesh (Karim, M.F. et al., 2008)

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 undulating-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 terraces 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 terraces. The subsurface engineering geologic conditions are strongly suitable for construction of underground tunnels and infrastructure, 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, flood flood, soil sink, and collapse, liquefaction, river cut, coastal erosion, tidal surge and flood. The geological hazards are associated with various geo-dynamic, tectonological and depositional geoenvironmental degradation in this area.

CONSTRANTS ON INFRASTRUCTURE DEVELOPMENT IN BANGLADESH

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

Figure 7: The mighty river Padma is a complex flow of various pattern, taking various meandering and swiftly shifting braided in different seasons of the year which is mostly dependent on discharge and rainfall in the Padma River watershed including human interference and control along the upstream. This year the river was severely furious in the flow and bank erosion and caused severely damage in the flow and bank erosion and caused devastating of thousands of infrastructure, many village and number of urban houses in the Naria Municipality in Shariatpur. During the last months of September and August, 2013 more than 4000 families have lost their houses. One thousand Bangladesh geotechnical engineer, M. Shafiqul Kabir mentioned that failure due to hydrodynamic action of the Padma river, triggered by geomorphological processes is complex geological environmental, including the formation of channel bank (cut) on the left bank of the erosion bank. The phenomena of hydrodynamic interaction is further aggravated by the other foundation systems of the many infrastructure in urban areas. The conceptual geological situation and geotechnical engineering group need to come forward for a detailed geological mapping, scientific investigation and geotechnical analysis of this failure failure. The failure analysis like Naria are not studied or described in American or European text books. Present authors speculate that failure of the river in this coming years due to global climate shift and the erosion of the river bank.

LANDSLIDE IN CHITTAGONG

Figure 8: Landslide in Chittagong, Bangladesh

ADVANCEMENT IN ENGINEERING GEOLOGICAL TESTING

Figure 10: Alomdar 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 RAAIL, Dhaka City Corporation, and other urban infrastructure projects. The laboratory is equipped with state-of-the-art testing equipment and facilities for a wide range of rock and soil parameters and properties to accommodate testing facilities for RAAIL, Dhaka City Corporation, and other urban infrastructure projects. The laboratory is equipped with state-of-the-art testing equipment and facilities for a wide range of rock and soil parameters and properties to accommodate testing facilities for RAAIL, Dhaka City Corporation, and other urban infrastructure projects.

Figure 9: Aerial view of Port City Chittagong showing geological features and infrastructure.

Figure 10: Aerial view of Port City Chittagong showing geological features and infrastructure.

Figure 11: Aerial view of Port City Chittagong showing geological features and infrastructure.

Figure 12: Aerial view of Port City Chittagong showing geological features and infrastructure.

Figure 13: Aerial view of Port City Chittagong showing geological features and infrastructure.

Figure 14: Aerial view of Port City Chittagong showing geological features and infrastructure.

Figure 15: Aerial view of Port City Chittagong showing geological features and infrastructure.

Figure 16: Aerial view of Port City Chittagong showing geological features and infrastructure.

Figure 17: Aerial view of Port City Chittagong showing geological features and infrastructure.

THANK YOU
FOR
YOUR KIND PATIENCE