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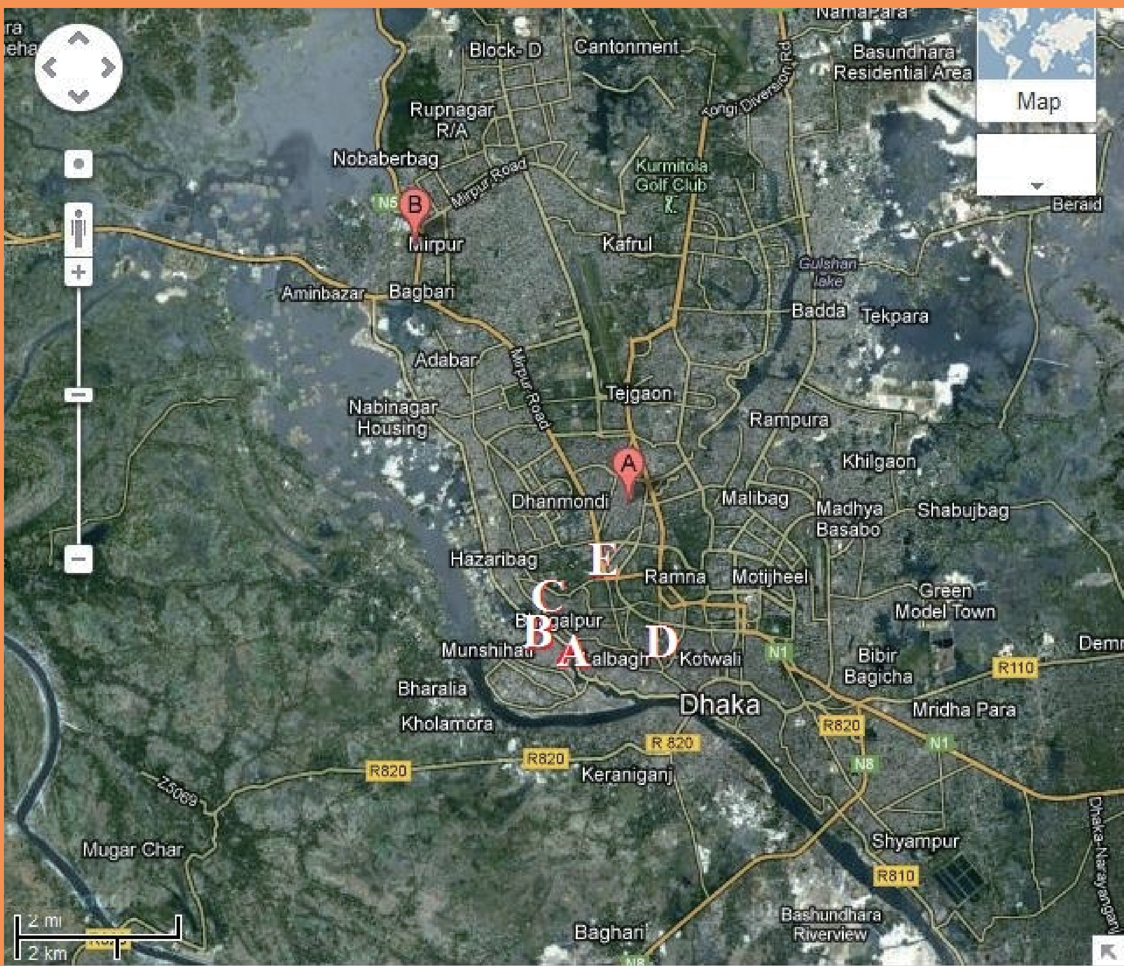

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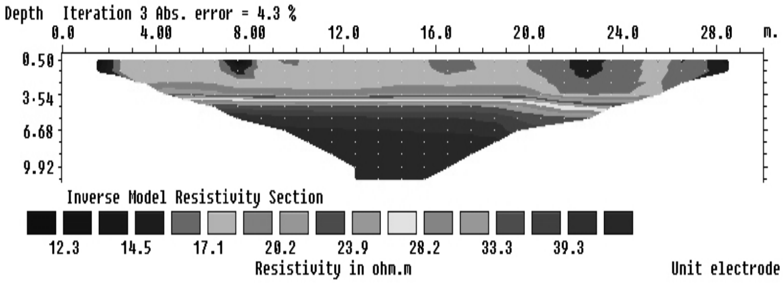

BANGLADESH
NETWORK
OFFICE FOR
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SAFETY

BUET, DHAKA, BANGLADESH

Prepared By:

Mehedi Ahmed Ansary

BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

CONTENTS

PART-I

STRUCTURAL ASSESSMENT REPORT
ON EXISTING BUILDING VULNERABILITY
EVALUATION FOR MLSS QUARTER, BUET

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: **KM Khaleduzzaman**
Ram K. Mazumder
Mehedi Ahmed Ansary

General

The devastating social and economic impacts of recent earthquakes in urban areas have resulted in an increased awareness of the potential seismic hazard and the corresponding vulnerability of the built environment. Greater effort has been given to reasonably estimates, predictions and mitigation of the risks associated with these potential losses.

This report is based on engineering judgment arrived at from the site visit, review of available architectural drawings, and non-destructive test carried out at site. All possible efforts have been made to provide accurate and authoritative seismic vulnerability assessment of the building in the given circumstances of information provided by the client and limited number of field-tests. Therefore, neither BNUS nor any of its employees make any warranty, expressed or implied, nor assumes any responsibility for the accuracy, completeness, or usefulness of the statement made in this report in case the starting information does not stand correct.

Basic Information

Building Name : BUET Staff Quarter Building
Building Type : Masonry
Construction Year :
Building Shape : Rectangular
No. of Storey : 02
Occupancy Type : Residential
Number of Occupants :30-40
Name of Owner : BUET

Building Plan

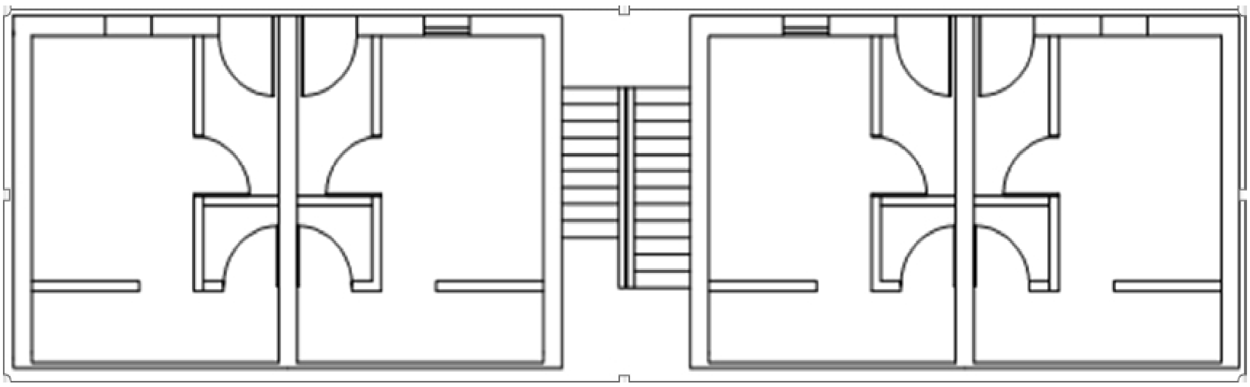

Figure 1: Ground Floor Plan

Load Calculation

Dead Load Calculation

Wall Load Calculation

Load Calculation for Ground Floor						
		Wt.	Height	Area	Area	Weight, w
S.N.	Part	(kN/m^3)	Ht. (m)	mm^2	(m^2)	(kN)
1	Wall	19.0	3.05	26212076	26.2	1519.0
2	Window -Type1	-19.0	1.22	929506	0.9	-21.5
3	Window -Type2	-19.0	1.22	743605	0.7	-17.2
6	Doors -Type1	-19.0	2.38	2230815	2.2	-100.9
						1379.3

Load Calculation for 1st Floor						
		Wt.	Height	Area	Area	Weight, w
S.N.	Part	(kN/m^3)	Ht. (m)	mm^2	(m^2)	(kN)
1	Wall	19.0	3.05	27327483	27.3	1583.6
2	Window -Type1	-19.0	1.22	929506	0.9	-21.5
3	Window -Type2	-19.0	0.76	1208358	1.2	-17.5
6	Doors -Type1	-19.0	2.38	1115408	1.1	-50.4
						1494.2

Slab Load Calculation

Floor Level - 1		Wt.	Thickness	Area	Area	Weight
S.N.	Part	(kN/m3)	t (m)	mm^2	(m^2)	(kN)
1	Slab - S1(1)	25.00	0.42	109588786.0	109.59	1141.53
					109.59	1141.5

Floor Level - 2		Wt.	Thickness	Area	Area	Weight
S.N.	Part	(kN/m3)	t (m)	mm^2	(m2)	(kN)
1	Slab - S2(1)	25.00	0.42	109588786.0	109.59	1141.53
					109.59	1141.5

Summary Dead Load		
Floor	*Height h_i (m)*	Seismic Weight(KN)
1st Floor	6.10	2520.8
2nd Floor	3.05	2713.7

Base Shear Calculation (Ref: BNBC)

No. of Stories =	2	
StoreyHt (Level)	Each Story Ht(m)	Ht. from GL(m)
1	3.05	3.05
2	3.05	6.1

Total StoreyHt (h_n) =	6.1	*m*
C_{t} =	0.049	
T =	0.19	*second*
S (Site Class) =	2.0	*S4*
Response reduction factor,R =	6.0	
C =	2.75	
Seismic Zone =	2	
Z =	0.15	
Importance factor, I =	1	
Seismic Weight,W =	5234.5	*KN*
Base Shear, V =	359.87	*KN*
F_{t} =	0.00	*KN*
V-F_{t} =	359.87	*KN*

Note: 1. V=ZICW/R,
2. $C=1.25S/T^{(2/3)}$,
3. $T=Ct(hn)^{(3/4)}$

4.5 Seismic load distribution (floor wise):

	weight	*Height*			*Storey Shear*	
Seismic load distribution (Floor)	w_i *(KN)*	h_i *(m)*	$W_i h_i$	Q_i	V_i*(KN)*	
2	2713.7	6.100	16553.57	245.74	245.74	@1 Storey Shear
1	2520.8	3.050	7688.44	114.13	359.87	@0 Storey Shear
		Sum=	24242.01	359.87		

Structural Integrity Check

Direct Shear Test of Masonry

Destructive Test has been performed using Hi-Force Hydraulic Jack. Result of this test is given below. Figure 2 shows application of Direct Shear Test.

jack diameter =	35	mm		
Area =	962.5	mm^2		
Brick Size	Length	Width	Height	
	247.65	146.05	69.85	mm
Contact Area	89636.9175	sq. mm		
Dial Gauge Reading	P bar	Force, N		Shear Stress, N/mm^2
	220	**27963**		0.312

Shear strength for the sample, τ	0.311958519	N/mm^2
Nos of brick above testing brick	58	Nos.
height of wall above brick	4.35	m
unit wt of wall	19	KN/m^3
Vertical pre-stress on testing brick, σ	82.65	KN/m^2
$\sigma*\mu$	0.08265	N/mm^2

Shear Stress due to mortar bond only=	$\tau-\sigma*\mu$	
	0.229	N/mm^2

Figure 2: Direct Shear Test of Masonry for BUET Staff Quarter

Seismic load at the height of 1.35 m from the Ground level is **296.26 KN**

Shear Stress in Shear Walls (Ref: IIT KanpurGuideline)

τwall = Vj / Aw
Vj = Storey shear at level j
Aw = Total area of walls in the direction of the loading.

For unreinforced masonry load bearing wall buildings, the average shear stress, τ_{wall}shall be less than 0.11 MPa (0.11 N/mm2)

Direction of earthquake force	Shear force (V_j)	Area of wall (A_w)	Shear stresses (V_{avg})	Remark
	KN	Sq.m	N/mm^2	
Along the Length	345.4	13.29	0.026	Satisfied
Along the width	345.4	12.92	0.027	Satisfied

Height to Thickness Ratio Check (Ref: IIT Kanpur Guideline)

Wall Type	**Zone II (z=0.15)**
Top storey of multi-storey building	14
First storey of multi-storey building	18
All other conditions	16

Actual h/t Ratio Check							
		Floor height, h					
Bl. No.	Floor	ft	in	=height(in), h	thickness(in),t	h/t	Remark
B1	Top Storey	10	0	120	10	12.0	Ok
	First Storey	10	0	120	10	12.0	Ok

Non-Destructive Test

In order to identify the resonance criteria, microtremor test has been performed. One sensor was deployed on free field and other sensor was placed on roof of the building. Figure 3 and Figure 4 represent results of microtremor.

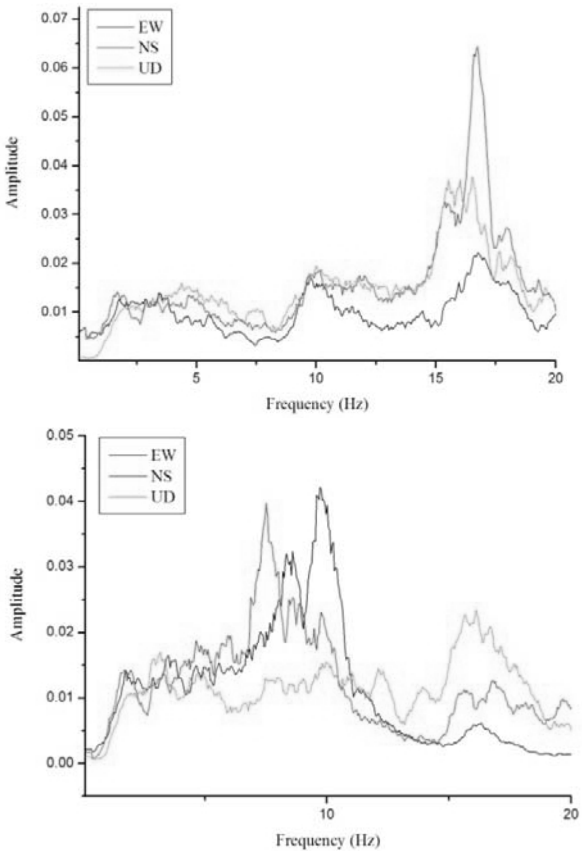

Figure 3: First Fourier Transform (FFT) for Sensor 1 (left) and Sensor 2

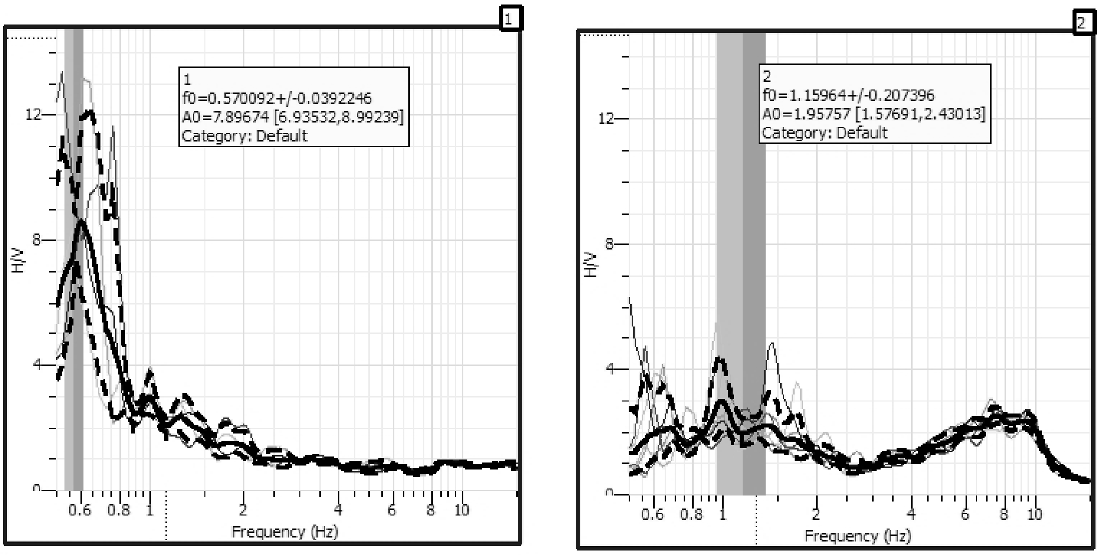

Figure 4: H/V Spectrum for Sensor 1 (Left) and Sensor 2

Laboratory Test

Compressive Strength of Brick: BUET Staff Quarter Building			
Date : 12 December, 2011			
Sample No.:	1		
Special Remark:	Wet Condition and Dark Red, Well Burnt		
Surface Area	Length	117	mm
	Width	108	mm
Crashing Load		150	kN
Crashing Strength		**11.9**	MPa
Sample No.:	2		
Special Remark:	Dry and Light Red		
Surface Area	Length	120	mm
	Width	115	mm
Crashing Load		146	kN
Crashing Strength		**10.6**	MPa

PART-II

FIRE AT NIMTOLI RESIDENTIAL AREA IN OLD DHAKA

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: Naima Rahman

Mehedi Ahmed Ansary

Nimtoli at Old Dhaka often faces fire hazard due to mixed land uses in the residential areas. Recently a devastating fire broke out on 26 March 2012 at a house at Mazed Sardar road of Chankharpool area in Nimtoli. Local people said the fire originated from an electric short circuit at the ground floor of the five-story residential building at around 2:45pm and immediately engulfed the whole floor. The building has polythene factory and paper store at the ground floor. The other floors are used for residential purpose. The fire occurred at polythene factory. On receiving information, four fire-fighting units from headquarters and Palashi fire stations went to the spot and extinguished the fire after more than one and a half hour's efforts at around 5:00 pm. Thus the fire could not be spread at upper level of the house and also the paper store. Though only the factory was affected due to fire but the economic loss was huge. Properties including hardware machineries, plastic materials and several raw materials of the polythene factory worth about Tk. 60 lakh were gutted in the fire. The fire occurred on a national holiday. Workers were absent in the factory. The inhabitants of the buildings were also visited outside. They rushed the spot hearing the incident through cellular phone by a neighbor. That's why no human casualties happened due to fire. Some photographs of the fire affected factory are showed as bellow:

Figure 1: Broken entrance of the factory

Figure 2: Burnt factory

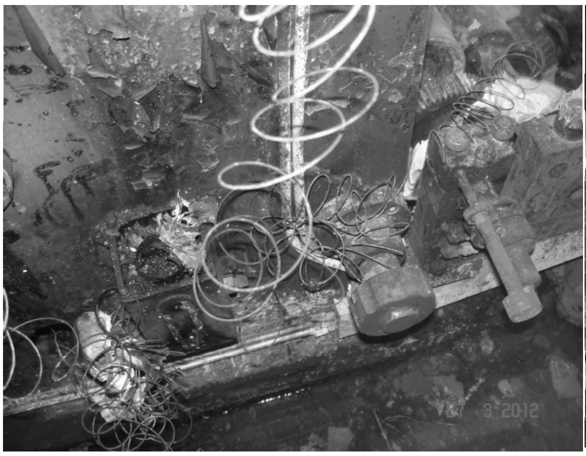

Figure 3: Burnt machine

Figure 4: Burnt machine

Figure 5: Burnt machine

Figure 6: Burnt machine

Figure 7: Burnt wire and electric switch board

Figure 8: Burnt electric switch board

Figure 9: Burnt roof and wall

Figure 10: Burnt factory

Figure 11: Burnt machine and wall

Figure 12: Burnt electric wire

Figure 13: Burnt machine

Figure 14: Burnt materials

Figure 15: Burnt factory

Figure 16: Burnt floor and materials

PART-III

SEISMIC RISK ASSESSMENT OF SOME HISTORICAL MOSQUE OF DHAKA USING NON-DESTRUCTIVE TESTING METHODS

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: KM Khaleduzzaman

Mehedi Ahmed Ansary

1. INTRODUCTION

Ancient masonry structures are particularly vulnerable to dynamic actions, especially seismic actions. South Asian Cities are particularly at risk due to the large number of ancient monuments (temples, mosques, churches etc.) and dwellings. Due to the ageing process and environmental factors, many cultural heritage buildings, as structures planned and constructed in the past, are vulnerable to dynamic loads, which may unpredictably induce a collapse of a portion of the building or drive the whole structure to a rapid failure. However, the high vulnerability of historical masonry buildings to seismic actions is mostly due to insufficient connections between the various building parts.

The Seismic risk assessment of five heritage masonry mosques of Dhaka city using nondestructive testing techniques have been presented in this paper. These mosques are Musa Khan Mosque, Lalbag Fort Mosque, Khan Muhammad Mridha Mosque, Daira Sharif Mosque and Aambur Shah Shahi Mosque. The simplified method of earthquake risk assessment suggested by Lourenco and Oliveira (2004) has been applied and microtremor has been used to determine the predominant period of the buildings.

2. STUDY AREA

The entire assessed mosques have been located in Dhaka city. Among these, Lalbag Fort Mosque and Khan Muhammad Mridha Mosque are located in ward no.61. Daira Sharif Mosque is in ward no. 62, Aambur Shah Shahi Mosque is in 39 and Musa Khan Mosque is located in ward no. 56. The location of the mosques are shown in Figure 1.

Figure 1: Location of the study area (A - LalBag Fort Mosque, B - Khan Muhammad Mridha Mosque, C - Daira Sharif Mosque, D - Musa Khan Mosque, E - Aambur Shah Shahi Mosque)

3. METHODOLOGY

3.1 Simplified methods of analysis

The usage of simplified methods of analysis usually requires that the structure is regular and symmetric, that the floors act as rigid diaphragms, and that the dominant collapse mode is in-plane shear failure of the walls. The following simplified methods of analysis and corresponding indexes are considered.

In-plane indexes:
- Index 1: In-plan area ratio
- Index 2: Area to weight ratio
- Index 3: Base shear ratio

Out-of-plane indexes:
- Index 4: Slenderness ratio of columns
- Index 5: Thickness to height ratio of columns
- Index 6: Thickness to height ratio of perimeter wall

3.1.1 In-Plane Area Ratio

The simplest index to assess the safety of ancient constructions is the ratio between the area of the earthquake resistant walls in each main direction (transversal x and longitudinal y, with respect to the central axis of the mosque) and the total in-plane area of the building. According to Eurocode 8 (CEN-EC8 2003), walls are only considered as earthquake resistant if the thickness is larger than 0.35 m, and the ratio between height and thickness is smaller than nine. The first index, $\gamma_{1,i}$ reads:

$$\gamma_{1,i} = A_{wi} / S$$

Where A_{wi} is the in-plane area of earthquake resistant walls in direction "i" and S is the total in-plane area of the building.

3.1.2 Area to Weight Ratio

This index provides the ratio between the in-plane area of earthquake resistant walls in each main direction and the total weight of the construction, reading

$$\gamma 2,i = A_{wi} / G$$

where A_{wi} is the in-plane area of earthquake resistant walls in direction "i" and G is the quasi-permanent vertical action. This index is associated with the horizontal cross-section of the building, per unit of weight

3.1.3 Base Shear Ratio

The total design base shear in a given direction shall be determined from the following relation (BNBC):

$$V = (ZIC / R) * W$$

Where,
Z = Seismic zone for a building site shall be determined based on the location of the site on the Seismic Zoning Map provided in BNBC (1993)
I = Structure importance coefficient
R = Response modification coefficient for structural systems
W = the total seismic dead load
C = Numerical coefficient given by the relation:

$$C = \frac{1.25S}{T^{2/3}}$$

The value of C need not exceed 2.75
S = Site coefficient for soil characteristics
T = Fundamental period of vibration in seconds, T of the structure is determined from the following methods:

For all buildings the value of T may be approximated by the following formula

$$T = C_t (h_n)^{3/4}$$

Where, C_t= 0.083, for steel moment resisting frames
= 0.073, for reinforced concrete moment resisting frames, and eccentric braced steel frames
= 0.049, for all other structural systems

h_t= Height in meters above the base to level n.

Finally, the base shear ratio provides a safety value with respect to the shear safety of the construction. The total base shear for seismic loading ($V_{Sd, base} = F_E$) can be estimated from an analysis with horizontal static loading equivalent to the seismic action ($F_E = \beta G$), where β is an equivalent seismic static coefficient related to the peak ground acceleration. The shear strength of the structure ($V_{Rd, base} = F_{Rd}$) can be estimated from the contribution of all earthquake resistant walls $F_{Rd,i} = \Sigma A_{wi} f_{vk}$, where, according to Eurocode 6 (CEN-EC6 2003), $f_{vk} = f_{vk0} + 0.4\sigma_d$. Here, f_{vk0} is the cohesion, which can be assumed equal to a low value or zero in the absence of more information, σd is the design value of the normal stress, and 0.4 represents the tangent of a constant friction angle φ, equal to 22º. The index, γ_3, reads:

$$\gamma_{3,i} = F_{Rd,i} / F_E$$

If a zero cohesion is assumed ($f_{vk0} = 0$), $\gamma_{3,i}$ is independent from the building height, reading:

$\gamma_{3,i} = V_{Rd,i} / V_{Sd} = A_{wi} / A_w \times \tan\varphi / \beta$

For a non-zero cohesion, which is most relevant for low height buildings, $\gamma_{3,i}$ reads:

$\gamma_{3,i} = V_{Rd,i}/V_{Sd} = A_{wi}/A_w \times [\tan\varphi + f_{vk0}/(\gamma \times h)]/\beta$

where A_{wi} is the in-plan area of earthquake resistant walls in direction "i," A_w is the total in plan area of earthquake resistant walls, h is the (average) height of the building, γ is the volumetric masonry weight, φ is the friction angle of masonry walls, and β is an equivalent static seismic coefficient. Here, it is assumed that the normal stress in the walls is only due to their self-weight, i.e. $\sigma_d = \gamma \times h$, which is on the safe side and is a very reasonable approximation for historical masonry buildings, usually made of very thick walls.

For indexes 1, 2 and 3 (in-plane indexes), assumed thresholds as functions of PGA/g are shown in Figure 2 (a), 2 (b) and 2 (c) respectively,

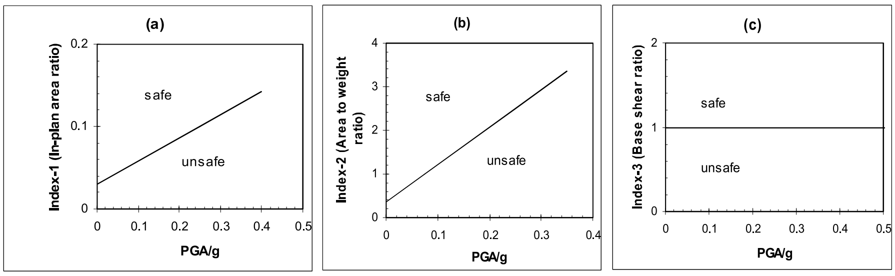

Figure 2: Assumed thresholds as functions of PGA/g: (a) index 1, (b) index 2 and (c) index 3 (after Laurenco and Oliviera, 2004)

3.1.4 Out-of-plane Indexes

Besides the three indexes exposed above, other key indexes related to structural performance were computed for the monuments under analysis. In this study, three geometric ratios concerning the structural out-of-plane behaviour of columns and walls in main space were adopted, when applicable; slenderness ratio ($\gamma 4$), and thickness to height ratio of the columns ($\gamma 5$), as well as thickness to height ratio of the perimeter walls ($\gamma 6$), were analyzed, reading:

$\gamma_4 = h_{col} / (I/A)^{1/2}$

$\gamma 5 = d_{col} / h_{col}$

$\gamma 6 = t_{wall} / h_{wall}$

where h_{col} is the free height of the columns, I and A are the inertia and the cross section area of the columns, respectively, d_{col} is the (equivalent) diameter of the columns, and t_{wall} and h_{wall} are the thickness and the (average) height of the perimeter walls, respectively. All of the out-of-plane indexes are dimensionless and do not consider the local seismicity.. For indexes 4, 5 and 6, Assumed thresholds as functions of PGA/g are shown in Figure 3 (a), 3 (b) and 3 (c) respectively,

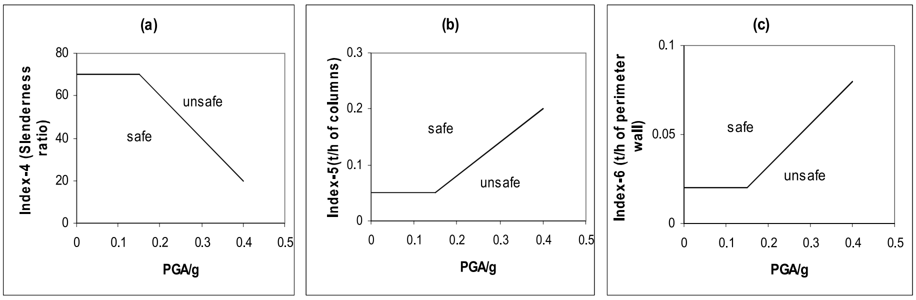

Figure 3: Assumed thresholds as functions of PGA/g: (a) index 4, (b) index 5 and (c) index 6 (after Laurenco and Oliviera, 2004)

3.2 Microtremor observation

Soil characteristics have been assessed by Microtremor measurement. Hard soil gives high frequency and soft soil gives low frequency. A structure may experience a vibration period at which it oscillates in the earthquake vibration motion and will tend to response to that. Natural frequency of structure is obtained based on the spectral ration of horizontal component of the structure to that of ground. Wave propagation mechanism of Microtremor and its relation with ground vibration characteristics were studied from the beginning of Microtremor studies (Aki, 1957; Kanai and Tanaka, 1961).

3.2.1 Data collection and processing

For Microtremor observation at the mosque, initially two sensors are deployed. One sensor is fixed on the roof of the buildings and another one on the free field near the structure. After taking the observation with the help of microtremor, the time domain velocity data is converted to frequency domain data and the natural period of the structures have been estimated.

The computation steps of the spectrum analysis is shown in Figure 4 and described as follows:

- Pre-Processing:

- 3-dimensional input (the accelerometer in northward direction to get North-South, East-West and vertical components)
- Windowing of the signal (in our case only the ambient parts are of interest, observe, in case of transient excitation only the transient parts of the time response are of interest)

- Main Data-Processing:

Hence the three different components of the signal were considered separately. The main data processing is repeated for every input-signal (n-Steps according to the numbers of preliminary separated windows).
- FFT is applied to obtain the several spectral amplitudes of the three components
- Smoothing of the three spectral amplitudes with a bandwidth factor of 10 to 15
- Afterwards the resulting horizontal component and vertical component are plotted to obtain the amplitude in frequency domain.

4 RESULTS AND DISCUSSION

4.1 Findings of simplified methods of analysis

The relationship between the different indexes and PGA/g is shown in Figure 4. The Legends used in the Figure 4 indicates the findings of the corresponding mosque provided at Table 1.

Table 1: Indicated meaning of Legends

Legend	Indicated meaning
▭	Musa Khan Mosque (X-Direction)
○	Khan Muhammad Mridha Mosque (X-Direction)
△	LalBag fort Mosque (X-Direction)
☆	Aambur Shah shahi Mosque (X-Direction)
◇	Daira Sharif Mosque (X-Direction)
■	Musa Khan Mosque (Y-Direction)
●	Khan Muhammad Mridha Mosque (Y-Direction)
▲	LalBag fort Mosque (Y-Direction)
★	Aambur Shah shahi Mosque (Y-Direction)
◆	Daira Sharif Mosque (Y-Direction)

N.B: For index 4 and index 5 the legends indicate the corresponding mosque only, not the direction

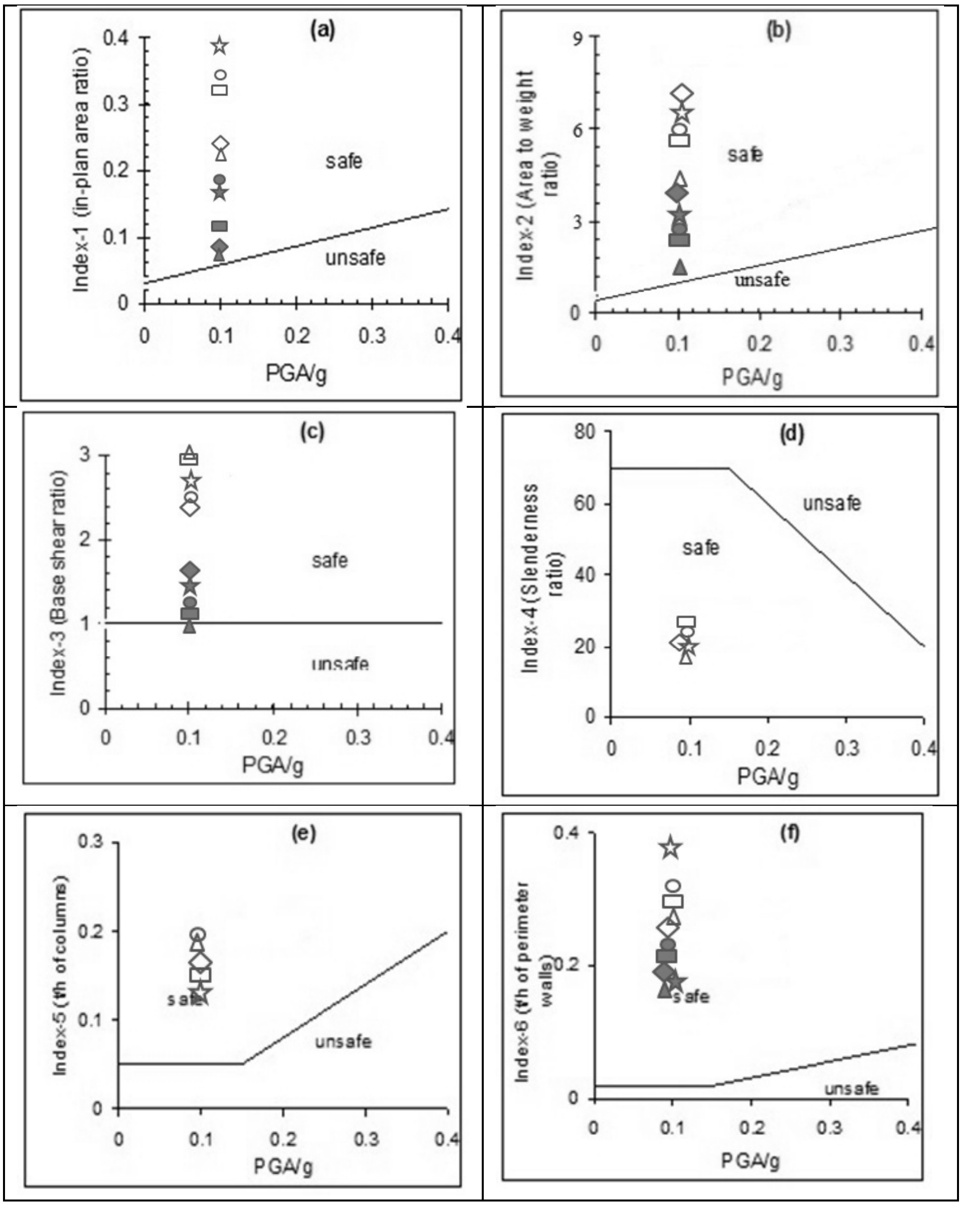

Figure 4: Relationship between Indexes ((a) In-plane area ratio, (b)Area to weight ratio, (c) Base shear ratio, (d) Slenderness ratio, (e) t/h of columns, (f) t/h of perimeter wall) and PGA/g (after Kamruzzaman, 2011)

4.2 Findings of Microtremor Observation

Figure 5 shows individual time histories for X, Y and Z components for Khan Muhammad Mridha Mosque. Figure 6 shows FFT of those time histories. Figure 5 also presents the predominant frequency of the buildings in both directions. Figure 6 shows the H/V ratio of the soil.

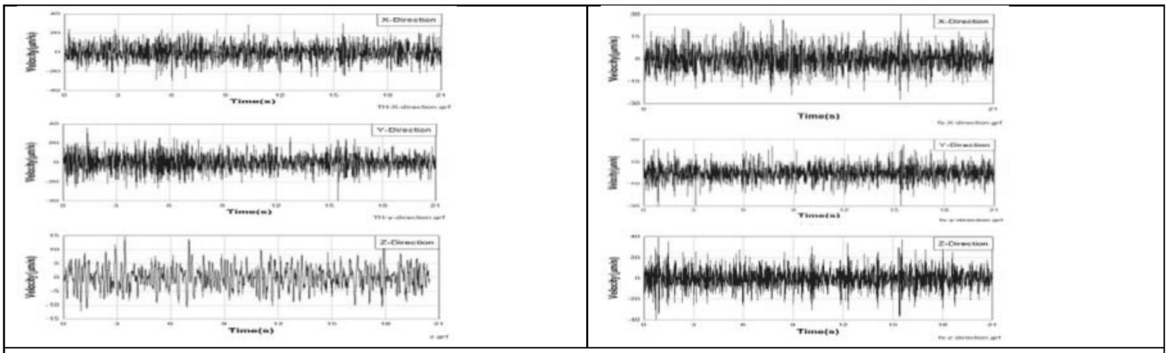

Figure 5 : Time history of soil and building

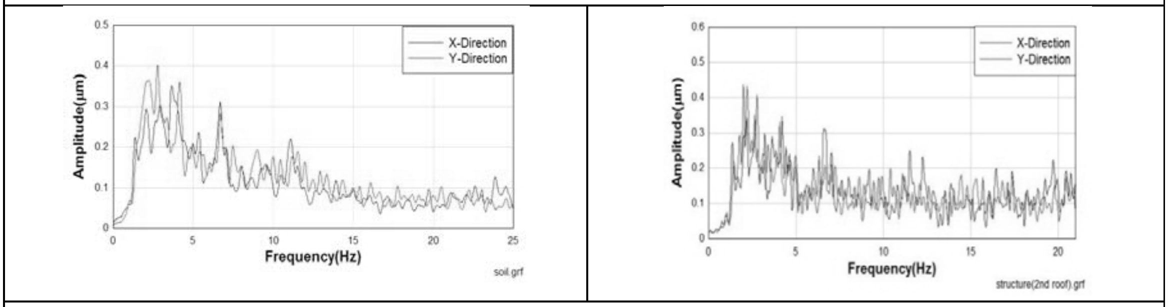

Figure 6 : Fourier Spectrum of soil and building

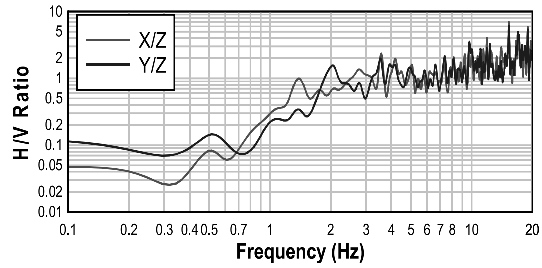

Figure 7 : H/V ratio

The predominant period of mosque buildings and corresponding soil are given in Table 2.

Table 2: Predominant period of mosque buildings and corresponding soil

Name of Mosque	Soil Period (s)	Structural Period (s)
Boro Daira Mosque	No clear peak	0.40
Khan Mohammad Mridha Mosque	No clear peak	0.50
Lalbagh Fort Mosque	0.25	0.20
Aambour Shah Shahi Mosque	0.50	0.33
Kurzon Hall Musa Khan Mosque	No clear peak	0.29

5. CONCLUSIONS

In this study, five historical mosques of Dhaka city have been assessed using analytical techniques and NDT. The analytical techniques have used six indexes, namely In-plane area ratio, Area to weight ratio, Base shear ratio, Slenderness ratio, t/h of columns and t/h of perimeter wall) and PGA/g. From this study, it has been found that all of those five masonry structures are safe against their respective seismic loads. For those five structures, microtremor observations have been carried out at the nearby free-field and on the top of the mosque roofs. The results show that for four structures, no resonance between soil and structure will occur. For Lalbagh Fort Mosque, there is high chance of resonance to occur between soil and structure, and the structure may collapse.

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PART-IV

APPLICATION OF MICROTREMOR ARRAY FOR ESTIMATING SHEAR WAVE VELOCITY IN BANGLADESH

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

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Mehedi Ahmed Ansary

3. INTRODUCTION

Bangladesh is a small country situated at the south of The Himalayas. The Indian tectonic plate and the Asian tectonic plate had a collision in The Himalayan region. Bilham et al. (2001) has shown the high possibility of large earthquake occurrence around the Himalayan region. Sylhet is one of the major cities of Bangladesh. There are several faults near Sylhet with significant past earthquakes. Seismic activity in Sylhet is higher than any other region in Bangladesh. According to Bangladesh National Building Code (BNBC, 1993), Sylhet is situated in the most vulnerable zone. Dhaka is one of those cities which remain in highest relative earthquake disaster risk (Cardona et al, 1999). Both Sylhet and Dhaka city have experienced a lot of historical earthquakes like 1869 Cachar, 1897 Shillong and 1918 Srimangal earthquakes due to their geological location. Recently UNDP, Bangladesh has conducted some studies (CDMP, 2009) to evaluate earthquake risk of Chittagong, Dhaka and Sylhet cities. Several kinds of structural and geotechnical data have been collected for this purpose. For evaluation of site amplification shear wave velocity of soil is the key parameter. Static properties of soil can be determined easily by field tests like SPT, CPT, Vane shear tests etc. but determination of dynamic soil properties is a complex and expensive task. Dynamic properties like shear modulus (G_{max}) and shear wave velocity (V_s) are important parameters for estimating dynamic behavior of soil and for liquefaction susceptibility. Determination of V_s can be done by different methods like seismic downhole method, crosshole method, spectral analysis of surface wave (SASW) etc. In this study, Shear wave velocity of soil has been determined using a geophysical technique named microtremor array method. This method has been developed and used in several projects like Network for Earthquake Engineering Simulation (NEES) funded by National Science Foundation (NSF), USA, and Site Effects Assessment Using Ambient Excitation (SESAME) in Europe. In Bangladesh this is the first time this method has been applied.

2. METHODOLOGY

There are several methods of determining shear wave velocity from surface wave. Spectral-Analysis-of-Surface-Waves (SASW) have been proposed by Nazarian and Stokoe (1984). Later a more easy and convenient method, Multi Channel Spectral Analysis (MCSA) has been developed and proposed by Tokimatsu (1995) and later by Zywicki (1999). All these methods have one common disadvantage. An energy source is required to create vibration for SASW and MCSA. That energy source usually makes too much noise and vibration. In urban area those methods are not suitable. To recover from those problems, Louie (2001) proposed Refraction Microtremor (ReMi) method. Ambient vibration is used in this method to get deep profile of shear wave velocity of soil.

The steps to get shear wave velocity starts with data acquisition. Different array types have been proposed by different researchers. An irregular array of microtremor has been used in this research after Wathelet (2005). Five numbers of sensors are used in each site except Zindabazar High School in Sylhet. Here due to space limitations, three sensors have been used for data collection. To reduce the effect of noise and to detect low frequency vibration a one hour reading has been taken in 100 data per second sampling rate. Using those data, at first Spectral Auto Correlation (SPAC) has been used to determine the correlation between waves detected from different location at the same time. According to Aki (1957) spectral auto correlation function between two sensors is defined by the following equation.

$$\emptyset(\xi) = \frac{1}{T}\int_0^T v_o(t)v_\xi(t)dt \qquad (1)$$

Here, ξ is the distance between two sensors, T is the data acquisition time, v_o and v_ξ are the signals recorded at the sensors of 0 and ξ distance respectively. If a narrow frequency band filter is used of frequency ω_0 the auto correlation ratios are calculated for all pairs of receivers by the following equation.

$$\rho(\xi, \omega) = \frac{\emptyset(\xi, \omega)}{\emptyset(0, \omega)} \qquad (2)$$

Aki (1957) has shown that, for a given inter sensor distance ξ, the azimuthal average of $\rho(\xi, \omega)$ has the shape of Bessel function. That can be shown as,

$$\overline{\rho(\xi, \omega)} = J_0\left(\frac{\omega_0 \xi}{c(\omega_0)}\right) \qquad (3)$$

Here, J_0 is the Bessel function of the first order and c (ω_0) is the dispersion curve. Than using those correlation dispersion curve has been developed. There is a possibility of obtaining different dispersion curves, so a theoretical dispersion curve has been used to find the dispersion curve for the site. Theoretical dispersion curve developed for Sylhet has been obtained from soil data collected by Comprehensive Disaster Management Program (CDMP, 2009). In the computation of theoretical dispersion curve, a program based on Eigenvalue problem by Thomson (1950) and Haskell (1953) named GPDC has been used. For the computation, the assumptions are the soil layers are perfectly horizontal and isotropic (see Figure 1), they are extended up to infinite horizontal distance. The soil parameters for developing the theoretical dispersion curves for Dhaka and Sylhet have been presented in Tables 1 and 2.

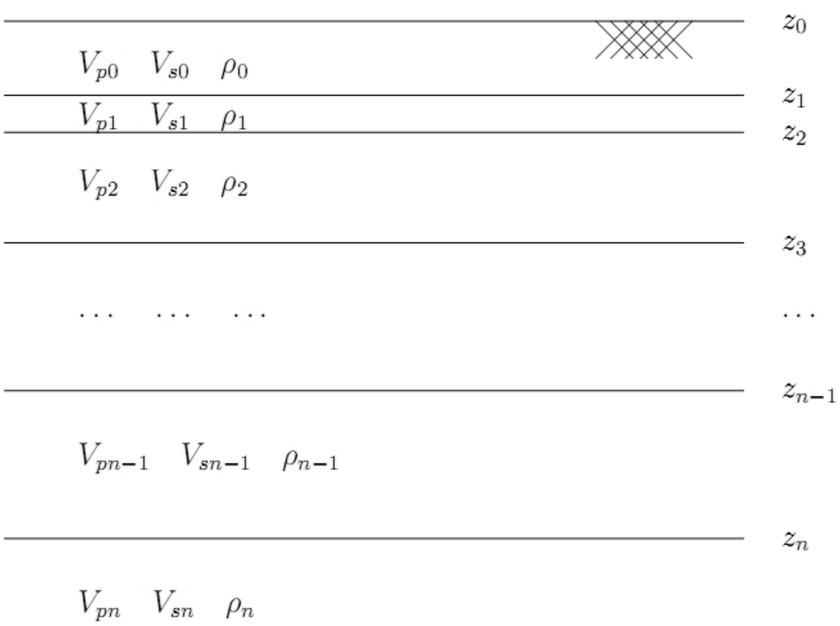


Figure 1: Schematic one dimensional soil model (Wathelet, 2005)

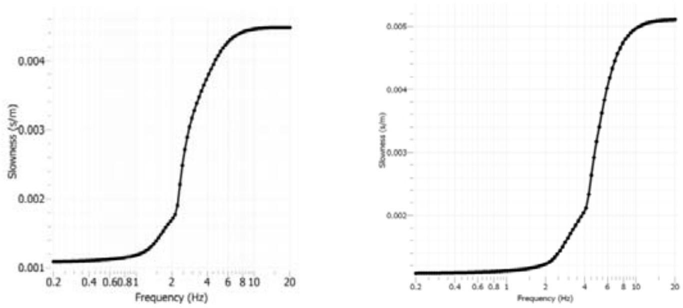
Table 1: Soil parameters for development of theoretical dispersion curve for Dhaka

Thickness(m)	V_p (m/s)	V_s (m/s)	Density (kg/m^3)
25	525	238	1600
42	700	339	1800
0	2000	1000	2200

Table 2: Soil parameters for development of theoretical dispersion curve for Sylhet

Thickness(m)	V_p (m/s)	V_s (m/s)	Density (kg/m^3)
16	420	210	1600
24	800	400	1800
0	2000	1000	2200

The bottom most layer of thickness 0 m is actually the elastic half space. Here 0 m thickness is given just because GPDC program considers the half space by reading 0 values in thickness. The obtained dispersion curves are presented in Figure 2.



(a) (b)

Figure 2: Theoretical dispersion curves for (a) Dhaka and (b) Sylhet.

The inversion of those dispersion curves have been done by using Neighbourhood Algorithm Program Dinver. In the inversion process the assumptions are, shear wave velocity increases with depth of the layer and poison ratio is same for soil from any depth. Less attention is given to the poison's ratio of soil layers because the poison ratio does not have a significant role in forward computation of dispersion curve from soil layer (Wathelet, 2005). It is also necessary to relate shear wave velocity with p-wave velocity.

3. COLLECTION AND ANALYSIS OF DATA

Mictrotremor data have been collected from several locations of Dhaka (two sites) and Sylhet (five sites) as shown in Figure 3. Two kinds of array have been used for data collection as mentioned earlier. In each array five microtremor sensors have been used. Distances between sensors have been varied according to the available space. Figure 4 presents a typical layout of sensors in two arrays. Typical time histories and spectral auto-correlations of collected data are shown in Figure 5.

(a)
(b)

Figure 3: Location of data collection at (a) Dhaka and (b) Sylhet.

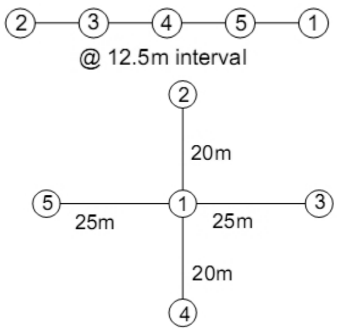
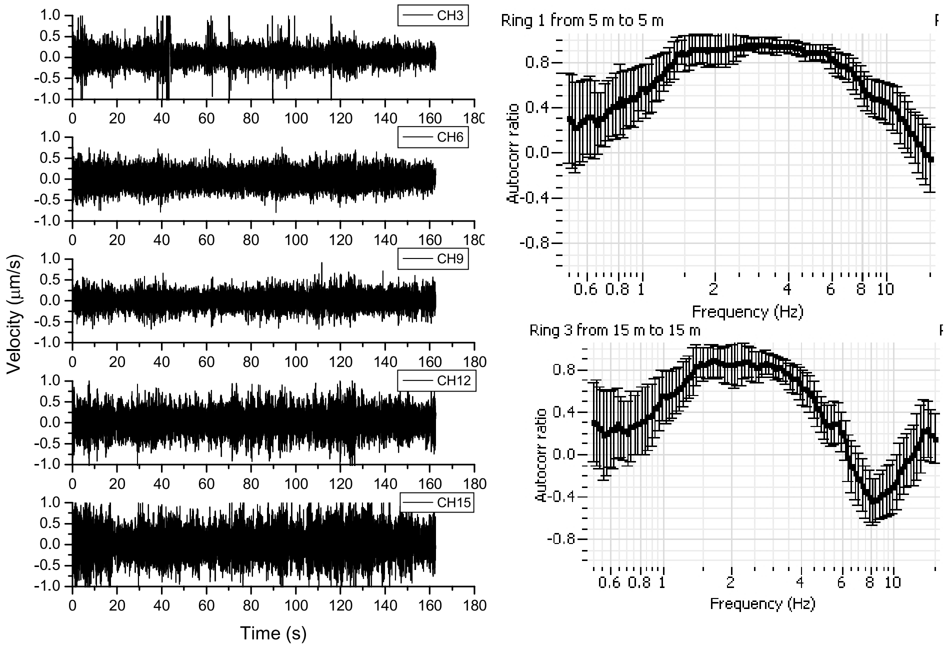


Figure 4: Typical array formations.



(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)

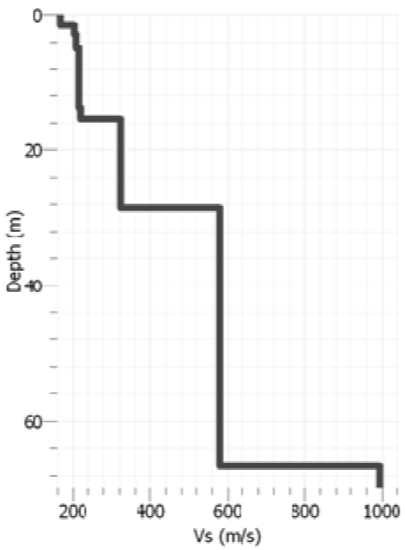
(i) (b)

Figure 5: Time histories (vertical component) and auto-correlations of array data

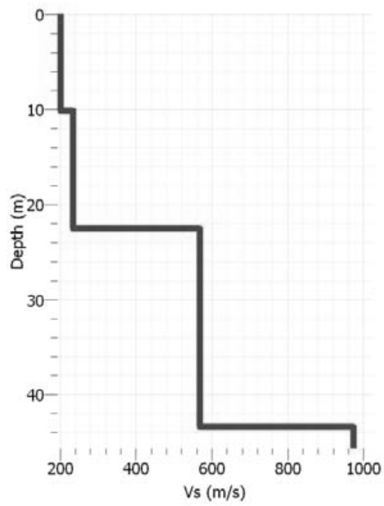
4. RESULTS

Microtremor array method is an approximate method which is highly susceptible to some factors like array formation, noise in collected data, the theoretical dispersion curve and the parameterization. The noise is very high in most of the cases. Generally long time reading is collected to reduce the effect of noise. The shear wave velocity profiles found are average soil profile of all the soil profiles below each sensor. Positions of the sensors provide close but different soil profile in the same field. The theoretical dispersion curve has been estimated based on previous soil profiles. In the parameterization phase, the poison ratio and density of the soil strata are kept same for all the depth. It will not lead to a profile much different from real case.

In this study shear-wave velocity at seven locations (two at Dhaka and five at Sylhet) has been estimated. For Aided School (Sylhet), up to a depth of 16m Vs is 200 m/s, below there up to a depth of 28 m Vs is 320 m/s, up to 68m Vs is 560 m/s and below 68m Vs is around 1000 m/s. From the geology of Sylhet it is found that the deep stratum of sylhet has been formed at tertiary age during the formation of the Himalayans. But top soil of Sylhet is formed by sedimentation of the small channels which carry loose sandy soil from upstream. The soil profile supports the geological information. At Aftab Nagar (Dhaka) at top 4m Vs is less than 200 m/s, than from 4 to 27 m Vs is around 240 m/s, than from 27 to 60 m average Vs is around 320 m/s, from 60 to 76 m average Vs is around 470 m/s and below 76 m Vs is around 950 m/s. From the soil exploration in Aftabnagar, it is found that top layer of soil is reclaimed, below that stiff clay has been obtained, below 20m dense sand is present. The shear wave velocity profile supports the soil profile obtained through subsoil exploration.



(a)



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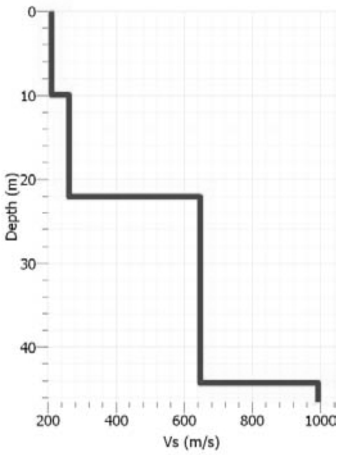

0
10
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40
Depth (m)
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400
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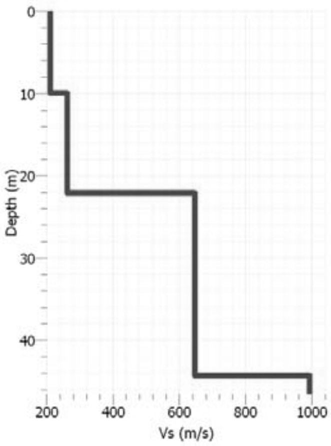
800
1000
Vs (m/s)

(c)



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Depth (m)
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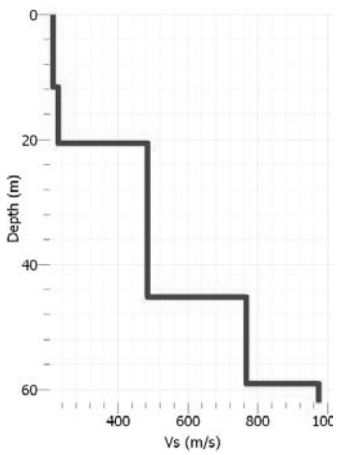
Vs (m/s)

(d)



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40
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Depth (m)
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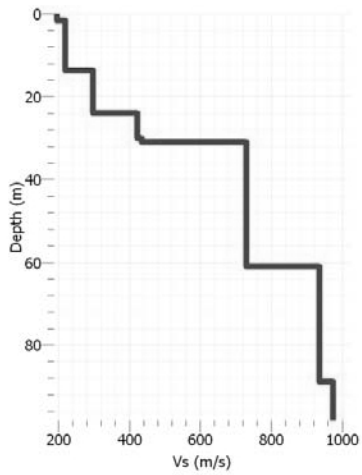
Vs (m/s)

(e)



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Depth (m)
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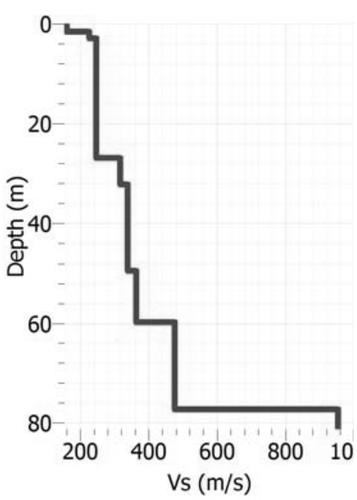
1000
Vs (m/s)

(f)



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Depth (m)
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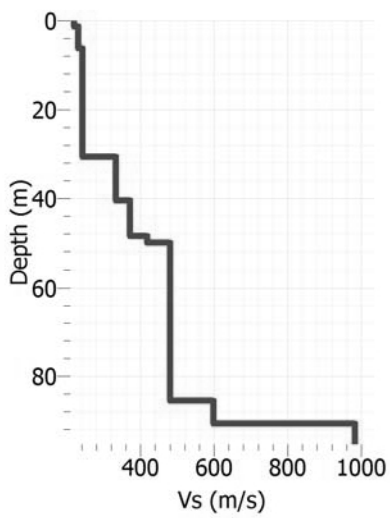
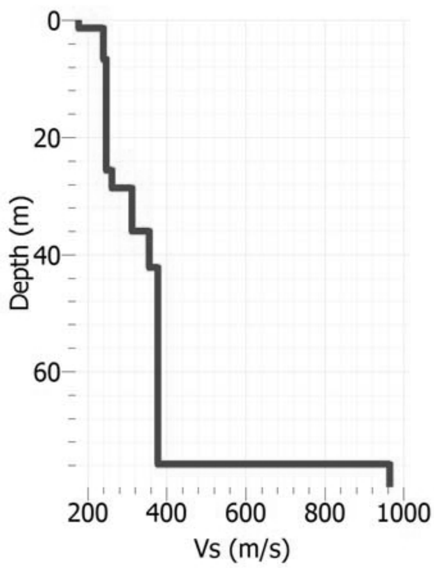
600
800
Vs (m/s)

(g)

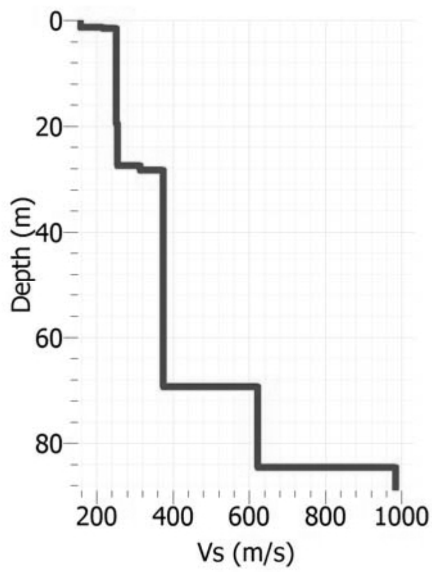


0
20
40
60
80
Depth (m)
400
600
800
1000
Vs (m/s)

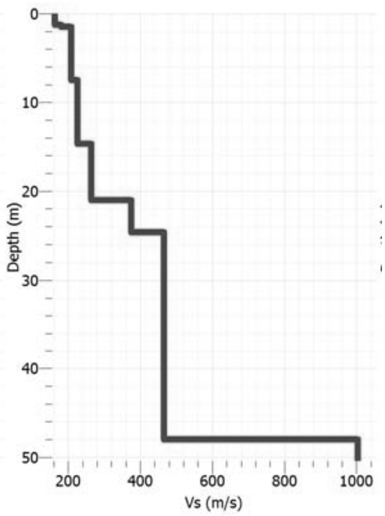
(h)



(i)



(j)



(k)

figure 6: Shear-wave velocity profile at (a) Aided School cross array, (b) Aided School long array, (c) Upashahar long Array, (d) Upashahar cross array, (e) Raza G C School, (f) Zindabazaar High School, (g) Aftab Nagar I cross array, (h) Aftab Nagar I long array, (i) Aftab Nagar II cross array, (j) Aftab Nagar II long array and (k) Abdul Gafur High School

5. CONCLUSIONS

In this study, Microtremor array method has been used to obtain shear-wave velocity profile at seven locations of Sylhet and Dhaka city. Shear-wave velocity profile at Aided School, Upashahar, Raza GC School, Zindabazaar High School and Abdul Gafur High School at Sylhet and two locations of Aftab Nagar Land Fill Project at Dhaka have been obtained. This non-destructive method has been also validated by subsoil exploration up to a depth of 30 m.

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PART-V

COMMUNITY UNDER FIRE THREAT: AN ASSESSMENT OF FIRE HAZARD VULNERABILITY OF WARD 65 IN DHAKA CITY

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Prepared By: Naima Rahman

Mehedi Ahmed Ansary

1. INTRODUCTION

Dhaka City has been experiencing many fire accidents at present and in most cases lack of proper precautionary measures along with the institutional inefficiency, insufficient equipment support and lack of public awareness. In this study, a traditional community of ward 65 of Dhaka has been selected for vulnerability assessment. Community Vulnerability Assessment Tool (CVAT) (Lisa et al, 2002) method has been applied to assess community's fire hazard vulnerability. At first, a hazard map showing the different risk zones of fire has been developed by land use in the study area. Then four vulnerability analyses have been conducted namely social vulnerability, critical facilities vulnerability, economic vulnerability and structural vulnerability. Different field surveys have been conducted for getting complete scenario of the community. By using some parameters and attributes, community vulnerability has been evaluated with respect to fire hazard. Finally some recommendations have been provided to improve the present condition of the community.

2. BACKGROUND

Fires hazards occur frequently in Bangladesh especially in urban areas. Table 1 describes number of fire accidents originated by various causes in the last three years in Bangladesh. Electric fault, kitchen fire, cigarette, naked fire, burning ash, fireworks, friction of machine, sabotage, mob, unknown and misc (engine misfire, spontaneous ignition, and chemical reaction) are different causes of fire. Among these most of the fire occur due to electric fault and kitchen fire.

Table 1: Causes of Fire in Bangladesh

SL	Cause of Fire	Number of Fire Incident					
		2009		2010		2011	
1	Electric Fault	3754	43.27%	3188	39.44%	3760	43.86%
2	Kitchen Fire	2254	25.98%	2166	25.67%	2137	24.89%
3	Cigarette	865	9.97%	789	9.75%	828	9.64%
4	Naked fire	542	6.24%	528	6.52%	450	5.24%
5	Burning Ash	229	3.41%	267	3.16%	358	4.17%
6	Fire Works	162	2.41%	204	2.41%	161	1.87%
7	Friction of Machine	134	1.99%	170	2.01%	244	2.84%
8	Sabotage	85	1.26%	149	1.76%	104	1.21%

9	Mob	113	1.68 %	241	2.85 %	78	0.90 %
10	Unknown	868	-	1105	-	726	-
11	Misc (Engine misfire, spontaneous ignition, Chemical reaction)	536	6.17 %	389	4.61 %	464	5.40 %
	Total	**12182**		**14682**		**13041**	

Source: Bangladesh Fire Service and Civil Defense, 2012

Residential fire events are increasing in every year tremendously and it causes loss of property and injures many people badly. Industrial fire is also in increasing trend. (Bangladesh Fire Service and Civil Defense, 2011) Economic loss due to fire incidents is high. Figure 2 describes amount of loss due to residential fire in Taka crore from 2002 to 2010. Among these years the highest amount of loss (Tk. 272.64 crores) is seen in 2005. In most of the years the loss amount is above Tk. 100 crores. As Bangladesh is a developing country it cannot afford the huge amount of loss due to fire accidents every year.

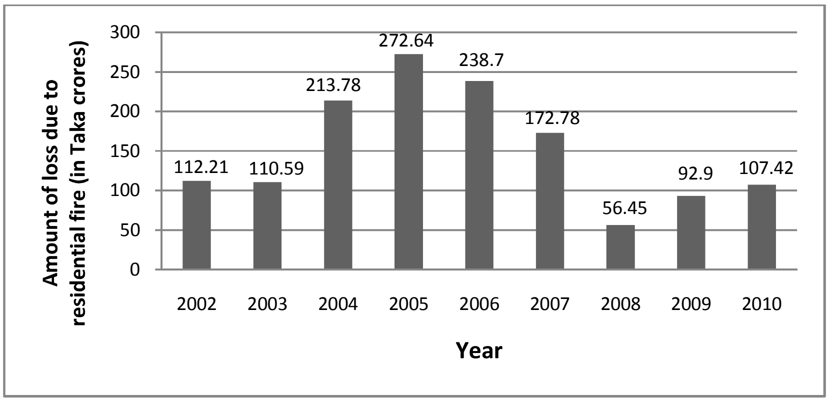


Figure 2: Extent of losses due to fire hazards in recent years
(1 Million USD = Taka 8.6 crore)
(Source: Bangladesh Fire Service and Civil Defense)

Dhaka the capital of Bangladesh often faces fire hazards due to its dense building concentrations, narrow roads, flammable building materials, aging water supply and electrical wire, chemical factory in residential areas as well as the lack of preparedness and response skills among local people and the fire authority. Figure 3 shows the trend of fire in Dhaka City in the last six years. Most of the fire events occurred in 2010 than the other statistical year.

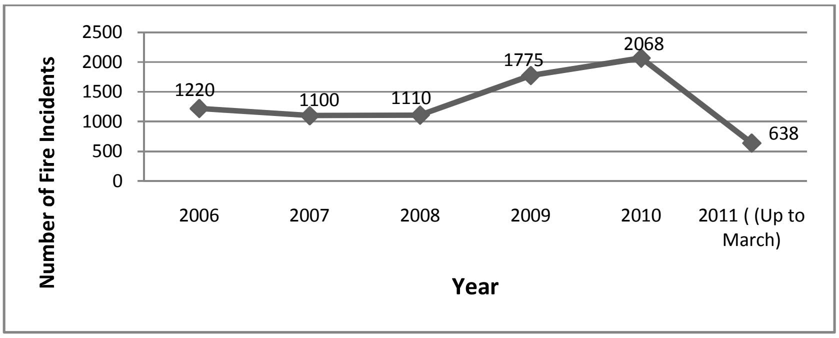
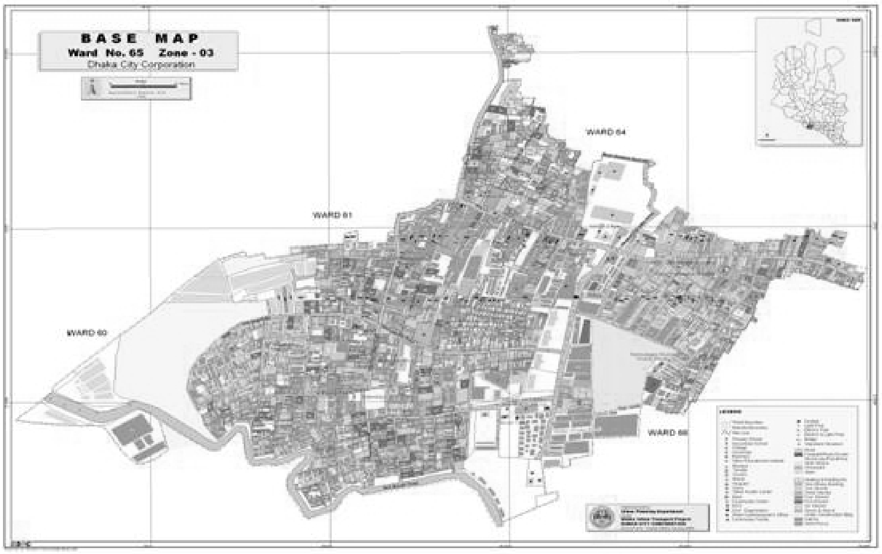


Figure 3: Number of fire event in Dhaka city
(Source: Bangladesh Fire Service and Civil Defense, June 2011)

In 3rd June 2010, a devastating fire broke out in the densely-populated part of Old Dhaka called Nimtoli. Fire killed at least 117 people and caused injury to a hundred people. Most of the affected peoples were women and children. Initially it was thought that explosion of two transformers at Nimtoli started the fire but later it has been known the fire originated from an oil stove and spread to the chemical warehouses nearby and resulted high casualties and damages.

Old Dhaka comprises of mixed land use of buildings where most of the buildings have small factories like chemical, plastic, rubber etc., and Warehouse and food shops up to second floor of the residential building. In Old Dhaka no house is equipped with fire fighting equipments like extinguisher, hose pipe etc. They don't have sufficient width of staircase let alone the emergency exit. In this respect, assessment of fire hazard vulnerability in Dhaka City especially in the old part is very important. The old part 'Puran Dhaka' is the most vulnerable area in Dhaka City. In this study Ward 65 (Map 1) of Old Dhaka is selected for the vulnerability assessment. This ward is one of most vulnerable to fire hazard than other because of its traditional land use and population density. Fire incidents are very common phenomenon in this area. It is also one of the oldest areas of Dhaka City. This ward is mainly used as manufacturing industrial area. Besides several land uses like Warehouse, commercial use, chemical shop, clamber storage and processing shops are also prominent. Land use of this area makes it more unique than the other area of Dhaka City. In this study, assessment of fire hazard vulnerability of the community has been conducted to examine the existing risk of fire in the area and prepare the residents to face this sort of disaster.



Map 1: Study Area (ward 65 of Dhaka city)
Source: Dhaka City Corporation

3. METHODOLOGY

3.1 Study Design and Sampling

For achieving the objectives, depending on the literature review a checklist for the study has been designed which has been modified on the basis of findings from pilot survey. The total number of buildings of Ward 65 is 3210. For this sample size, total 1078 buildings survey has been conducted keeping the confidence level at 95% and confidence interval is 2.5. (http://www.surveysystem.com/sscalc.htm, accessed on 25th March, 2011).

3.2 Data Collection

A base map of the study area was collected from Dhaka City Corporation (DCC) office to become familiar with the environment of the study area. Field survey of the buildings was conducted on the basis of the DCC base map. A checklist survey was conducted in the study area to find out the existing socio-economic condition of the residents.

3.3 Fire Hazard Vulnerability Analysis

To assess the community vulnerability of Ward 65 in Old Dhaka, Community Vulnerability Assessment Tool (CVAT) is used to find out the existing scenario of the area. This tool has 7 steps including:

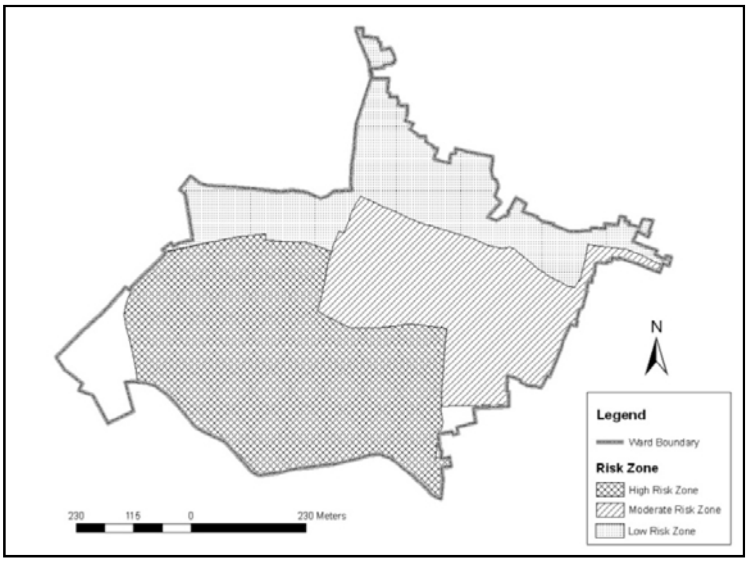
- Hazard identification
- Hazard analysis
- Critical facilities analysis
- Social analysis
- Economic analysis
- Environmental analysis

- Mitigation opportunities analysis

In this study only critical facilities analysis, social vulnerability analysis, economic vulnerability analysis and in addition structural vulnerability analysis has been done to assess the vulnerability of the community.

4. FIRE HAZARD VULNERABILITY ANALYSIS

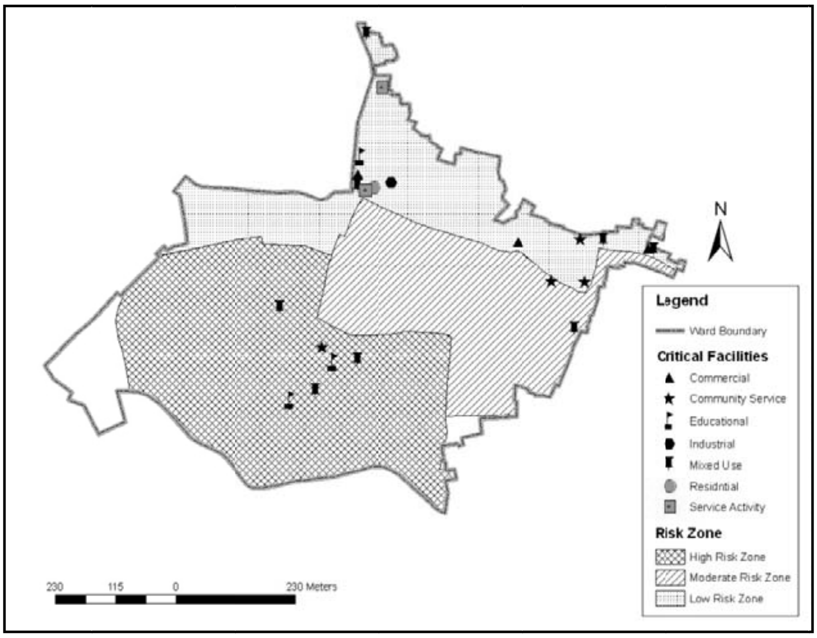
The study area is divided into three risk zones including high risk zone, moderate risk zone and low risk zone according to their land use. The total area of Ward 65 is 118.1668 acres among which high risk zone is 52.84 acres (44.72%), moderate risk zone is 30.89 acres (26.14%) and low risk zone is 27.95 acres (23.65%). (From GIS Map) The livelihoods of the inhabitants of Islambag are primarily based on plastic processing industries like plastic manufacturing, recycling and processing factories. This zone is considered as high risk area. In the moderate risk area processing factory and different Warehouse (plastic Warehouse, cattle food storage) are dominant. Residential use with commercial (retail shop, office, bank and storage) use is considered as the low risk area.



Map 3: Fire risk zone in Ward 65

4.1 Critical Facilities Analysis

There are total 22 numbers of critical facilities including educational institution and religious center in the study area. Critical facilities that are in and within close proximity to high risk areas were identified by overlying the critical facilities location over the map of fire vulnerable areas. Map 4 shows critical facilities map in Ward 65.



Map 4: Critical facilities Map in Ward 65

Figure 4 shows that 27.27% critical facilities are located at the high risk zone i.e. Islambag, 9.09% are located at moderate risk area and 63.64% are located at low risk zone i.e. Lalbag. In Islambag, plastic industries are located to very close proximity to critical facilities. Critical facilities of the study area are not vulnerable to fire. Besides these are located mainly adjacent to wider roads. In case of any fire, these can be used as shelter for the inhabitants.

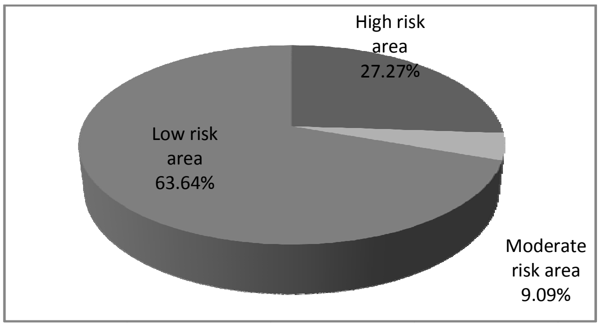


Figure 4: Percentage of critical facilities in different risk zones

4.2 Social Vulnerability Analysis

Number of population in any building of the study area varies from 0 to 400. Most of the buildings (28.53%) have 11 to 20 people. 22.03% have 21 to 30 persons and 18.93% have 6 to 10 persons. Building having population more than 100 is very low (1.6%). But most of the densely populated buildings are situated in the high risk zone (Map 5) which mainly consists of plastic recycling and processing factories. In these factories generally woman and child laborers work. With respect to these conditions of the area it can be said that the area is vulnerable to fire hazard.

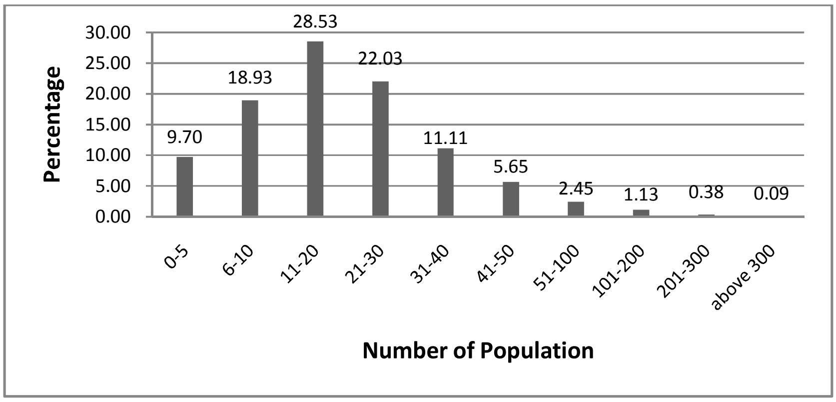
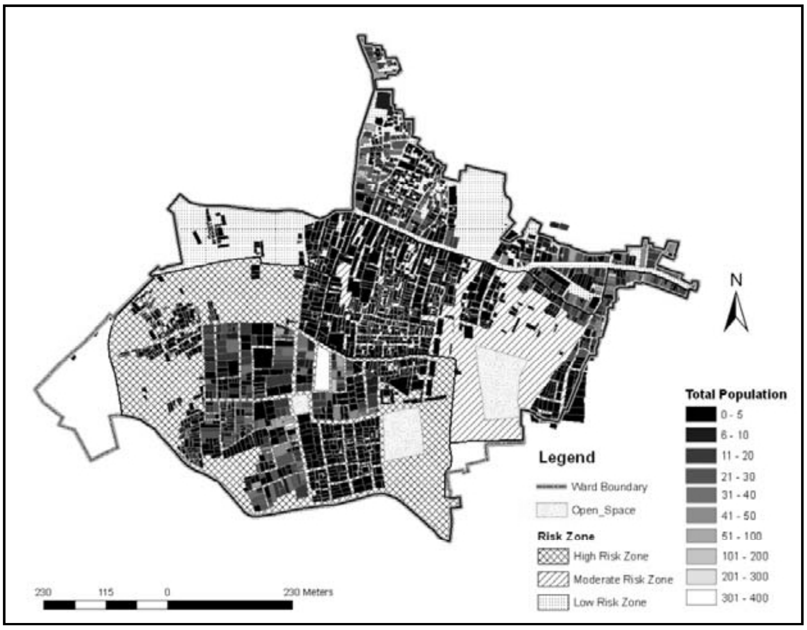


Figure 5: Population distribution in Ward 65.



Map 5: Population Map of Ward 65

4.3 Economic Vulnerability Analysis

Among the surveyed households, 57.22% have different types of economic activities. Plastic manufacturing and processing industry is dominating (20.22%); others are different type of factory (15.19%), warehouse (8.95%), iron/metal shop/factory (2.8%), gold and silver shop (1.49%), electric goods shop (1.3%), chemical shop/factory (1.21%) and other (6.06%) etc. Grocery shop, grocery shop and bank, medicine shop, tailoring shop/laundry, clamber storage, paper shop, bank/services, cloth store, hotel, market and phone shop are in other category. Figure 6 shows different types of economic activities of the study area. Some economic activities make the study area vulnerable to fire hazard. Among them plastic manufacturing industry is totally based on chemicals which promote fire to spread within few seconds to the locality.

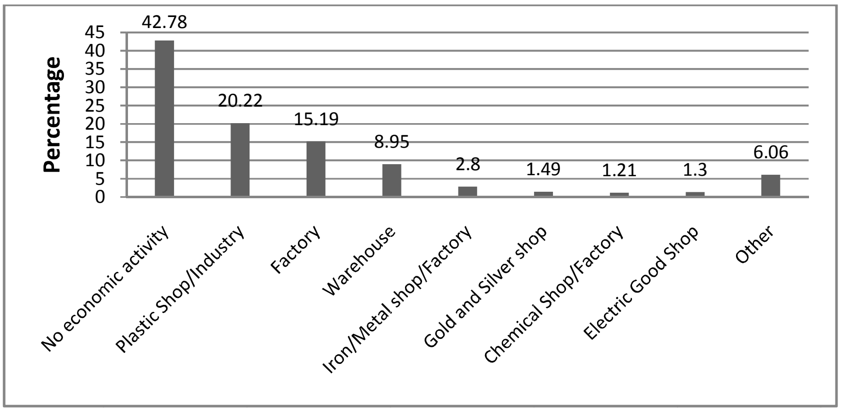


Figure 6: Economic Activities of the Study Area

4.4 Structural Vulnerability Analysis

There are other factors in the area which makes it vulnerable to fire hazard. These factors are width of staircase, road width of the area and accessibility to the building, position of transformer and electricity pole etc. If the roads are not accessible to fire service vehicle to extinguish the fire it may cause a loss to the community. For the emergency evacuation process staircase width is a vital issue to the resident of a building. That's why these factors get importance to the vulnerability assessment. The area consists of total 3210 structures. Among these, 55.66% of the structures are situated in high risk zone; 24.45% structures are situated in moderate risk zone and 19.89% structures are situated in low risk zone.

4.4.1 Age of Structure

From the field survey, 2011, it is found that Ward 65 is composed of both old and newly developed buildings. 23.3% of surveyed buildings have been constructed 0-10 years ago. These are the newest structures of the area. Most of the buildings have been constructed around 11-20 years ago (25.7%). 23.2% and 11.6 % structures have been built 21-30 years and 31-50 years before respectively. 15.9% building are 51-100 years old and 0.4% buildings are more than 100 years old.

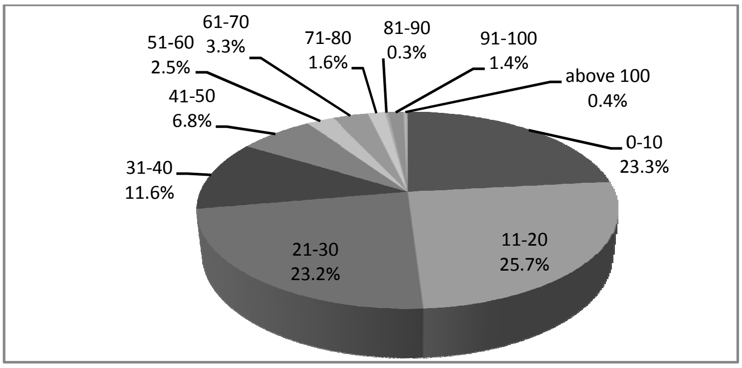


Figure 8: Age of building in the study area

4.4.2 Number of Floor

From field survey it has observed that in the study area most of the buildings (29.64% of surveyed buildings) are one storied. 22.27% buildings are two storied and mainly used as residential and plastic processing activity. 3 storied are 14.35%, 4 storied are 13.05%, 5 storied are 12.3% and 6 to 14 storied are 7.36%. 1.03% buildings are under construction.

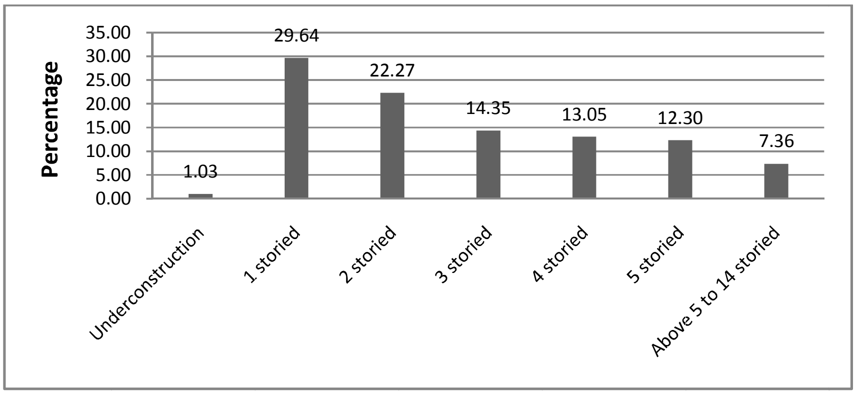


Figure 9: Number of floor of the building in the study area

4.4.3 Staircase Width

In the older portion of Dhaka city it is a tradition that the width of staircase is smaller than the new part of Dhaka. From the field survey it has been observed that staircase width of buildings varies from 1-5 feet. Most of the buildings (41.82%) have 3 feet wide staircase. 4 feet wide staircases are seen in 28.09% buildings. In case of some newly constructed buildings the width is 5 feet (11.73%). Wider staircase is essential for any building during the evacuation process for any disaster. In this respect the study area is vulnerable to fire hazard.

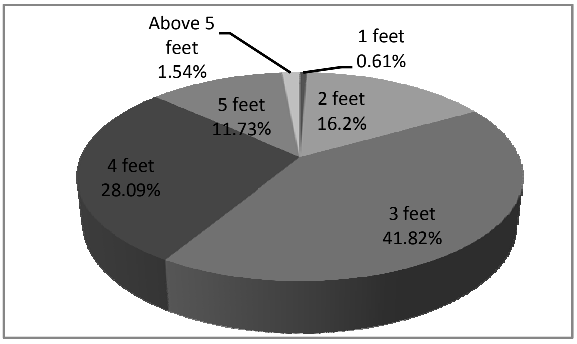


Figure 10: Staircase width (feet) of building in the study area

4.4.4 Road Width/ Accessibility to Building

Road width varies from 1 foot to 33 feet in the study area. Most of the residents have 6-10 feet roads in front of their houses (44.73%). 16.31% have 11-15 feet roads and 20.42% have above 15 feet roads. 18.55% households have only 0-5 feet roads which is inaccessible for fire truck. These narrow roads are totally impossible for evacuation and recue process. In this respect this community is also vulnerable to fire hazard. People of the study area are not aware about widening the road.

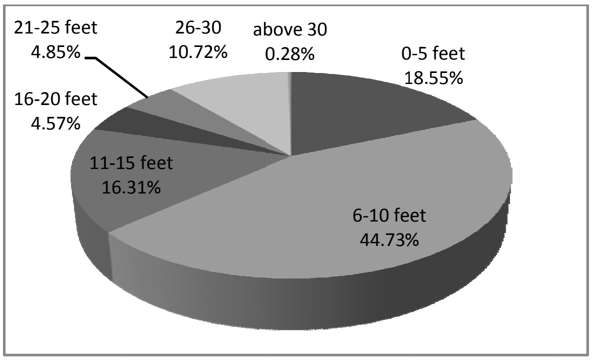


Figure 11: Road width (feet) / accessibility to building in the study area

4.4.5 Transformer and Electricity Pole

Position of transformer and electricity pole to a building is also assessed in this study because these may cause serious fire hazard to the locality. Among the surveyed buildings electric pole is located in front of 13.51% buildings and transformer is located in front of 11.37 % building.

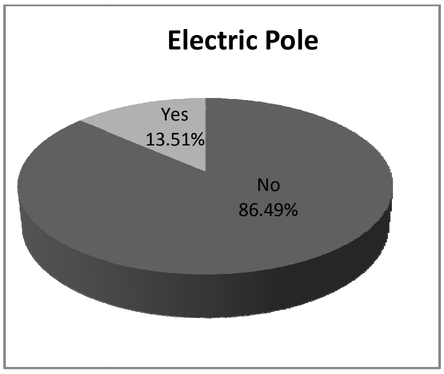


Figure 12: Electric pole in the study area

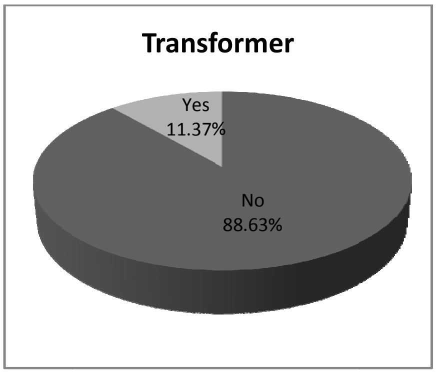


Figure 13: Transformer in the study area

4.4.6 Existence of Fire Source

Most of the buildings of the study area have different type of fire sources. Gas stove, electric wire, chemical factory and plastic factory are the main sources of fire. Besides, there are also some ornament factories, metal factories, recycled plastic shop, printing press and wholesale paper market in the area all of which can be source of great fire hazard. Residential houses are vulnerable due to gas stove (38.4%) and electric wire (15.84%). Households with mixed use are mainly vulnerable due to plastic factory (17.8%), chemical shop (16.59%), metal factory (2.8%) and gold ornament factory (1.5%). 3.26% buildings have no fire source. In this respect this community is vulnerable to fire hazard.

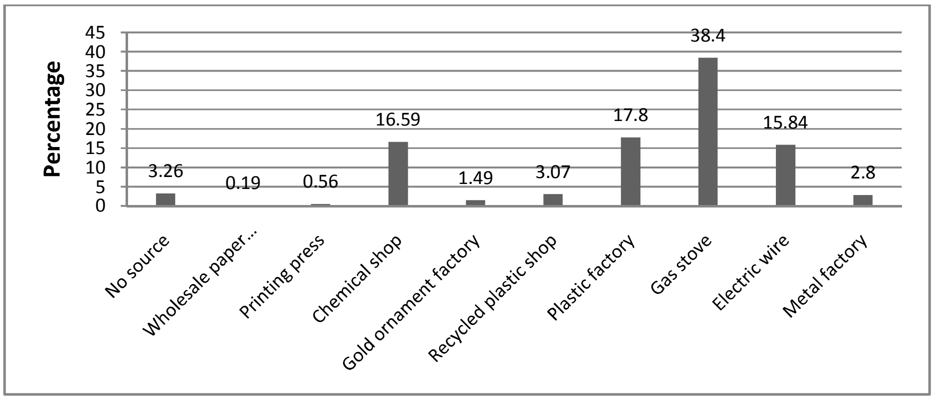


Figure 14: Existence of fire sources in the study area

5. CONCLUSIONS

Urban fire incidents have been determined to have a high likelihood of occurrence in our country. In this study after conducting vulnerability assessment using Community Vulnerability Assessment Tool (CVAT), it is found that ward 65 is vulnerable to fire hazard. The land use pattern of ward 65 indicates the possibility of this kind of hazard. The area comprises of residential use as well as commercial and industrial uses like plastic manufacturing and processing factory and chemical factory which may induce massive fire. As being a mixed use residential area, the loss due to fire may be catastrophic. To minimize the social and economic loss, Mitigation Planning is required. A change in present land use pattern is required. Chemical factory and plastic factory should be relocated. Road network as well as staircase of building should be wider to evacuate the community people. Community awareness should be raised. Although CVAT has been applied in this small area of Dhaka city, it can be applied to any type of hazard in any location of the country both at micro and macro levels.

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PART-VI

GEOPHYSICAL INVESTIGATION AT PROPOSED GANGES BARRAGE SITE IN PANGSHA RAJBARI AND AT BANGORA GAS PLANT SITE IN BRAHMANBARIA

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A. SHALLOW SEISMIC SURVEY

Dispersion, or change in phase velocity with frequency, is the fundamental property utilized in surface wave methods. Shear wave velocity can be derived by inverting the dispersive phase velocity of surface waves. Surface wave dispersion can be significant in the presence of velocity layering, which is common in the near-surface environment (upper 100 meters). There are other types of surface waves (waves that propagate along the earth's surface), but for this application we are concerned with the Rayleigh wave, also known as "ground roll". Although there are other wave types, the term "surface wave" when used in the SASW (Spectral Analysis or Surface Waves), MASW (Multi-channel Analysis of Surface Waves), or MAM (Micro-tremor Array Measurement) context has come to mean the Raleigh wave.

There are two ways surface waves are generated. "Active source" means that seismic energy is intentionally generated at a specific location and recording begins when the source energy is imparted into the ground. This is in contrast to "passive source" or "micro-tremor" surveying where there is no time break and motion from passive, ambient energy generated by cultural noise, traffic, factories, wind, wave motion, etc. is recorded.

Surface wave energy decays exponentially with depth beneath the surface. The energy or amplitude of any particular frequency is dependent on the ratio of depth to wavelength. Thus, for each frequency, the amplitude decreases by the same factor when the depth increases by a wavelength. This means that the longer wavelength (longer-period, lower-frequency) surface waves travel deeper and they contain more information about deeper velocity structure and shorter wavelength (shorter-period, higher-frequency) surface waves travel shallower and thus contain more information about shallower velocity structure.

In this context, by their nature and proximity to the geophone spread, it can be said that active source surface waves resolve the shallower velocity structure and passive source surface waves sample the deeper velocity structure. Since the shallower section can have a relatively large impact on the average shear-wave velocity profile, it is important to sufficiently sample the shallower depths. In SeisImager/SW the results from active and passive source surveys can be combined to maximize the depth of investigation and yield a composite high-resolution result over all depths (to the maximum depth of penetration).

i) Active Source Data Acquisition

Seismic energy for active source surface wave surveys can be created various ways, but we recommend using a sledgehammer to impact a striker plate on the ground since it is a low-cost, readily available item. To signal to the seismograph when the energy has been generated, a trigger switch is used as the interface between the hammer and the seismograph. When the sledgehammer hits the ground, a signal is sent to the seismograph to tell it to start recording.

Table 1 summarizes the parameters used for active source MASW surveys. Most parameters are self-evident, but one setting to consider further is the geophone interval and resultant spread length.

There is a general rule of thumb that surface waves sample to an approximate depth of their wavelength divided by two. In surface wave surveying it is assumed that the longest wavelength that can be sampled is as long as the spread length. When combining active and passive results, because the passive source survey will be used to sample the greater depths, the active source survey spread length need not be two times the depth of interest.

To determine the spread length, we suggest that you consider the maximum distance that source energy propagates and the shallowest depth of interest.

For an active source survey with a 10 to 20-pound sledgehammer, a geophone interval of 5 to 10 feet is suggested. Using a 24-channel seismograph, this would give a spread length of 115 feet using the 5-foot geophone interval. Applying the one-half-wavelength rule of thumb, the depth of penetration would be about 58 feet. Depending on the site materials and conditions, source energy may not strongly propagate to an offset of 115 feet, and stacking may be needed and/or the geophone interval may need to be reduced.

Note that the spread length has more importance on data resolution than geophone interval. You need to find the balance between signal propagation and maximizing the spread length. Site-specific testing and judgment should always be applied to confirm that the suggested recording parameters are appropriate.

If you were only doing active source survey and would not have passive data to resolve greater depths, it is recommended that the spread length equal about two times depth of interest. Additionally, the active source testing can include two (or more) spreads, one with a shorter and lighter weight hammer and one with a longer spread length and heavier weight hammer, to sufficiently sample a range of depths.

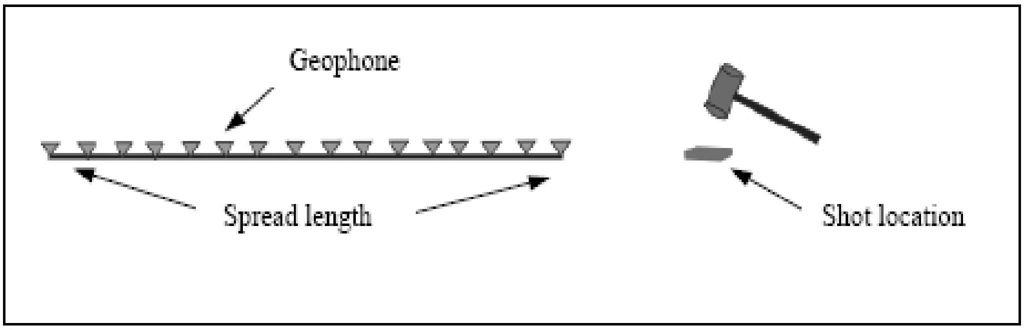


Figure 1: Schematic linear active source spread configuration.

Table 1. Active Source Acquisition Parameters

Parameter	Setting
Spread configuration	Linear
Spread length	About equal to depth of interest when supplementing with passive source data; about equal to two times depth of interest if no passive data available*
Geophone interval	2 to 3 m or 5 to 10 ft*
Total number of geophones	16 or more
Geophone type	4.5 Hz vertical geophones, with base plates for surveys on paved ground
Shot location	Minimum of one shot, located in-line and off-end (either end) of spread by about 10 to 20% of spread length; an additional shot located at about 40% of spread length and reverse shots also recommended
Source equipment	Sledgehammer, 8 lbs (3.6 kgs), 16 lbs (7.2 kg), 20 lbs (9 kg), scale hammer weight up with increase in spread length*, and striker plate
Trigger	Hammer switch taped to sledgehammer handle and connected to seismograph trigger port
Sample interval	0.5 or 1 milliseconds (ms)
Record length	1 to 2 seconds (s)
Stacking	As needed to improve data quality

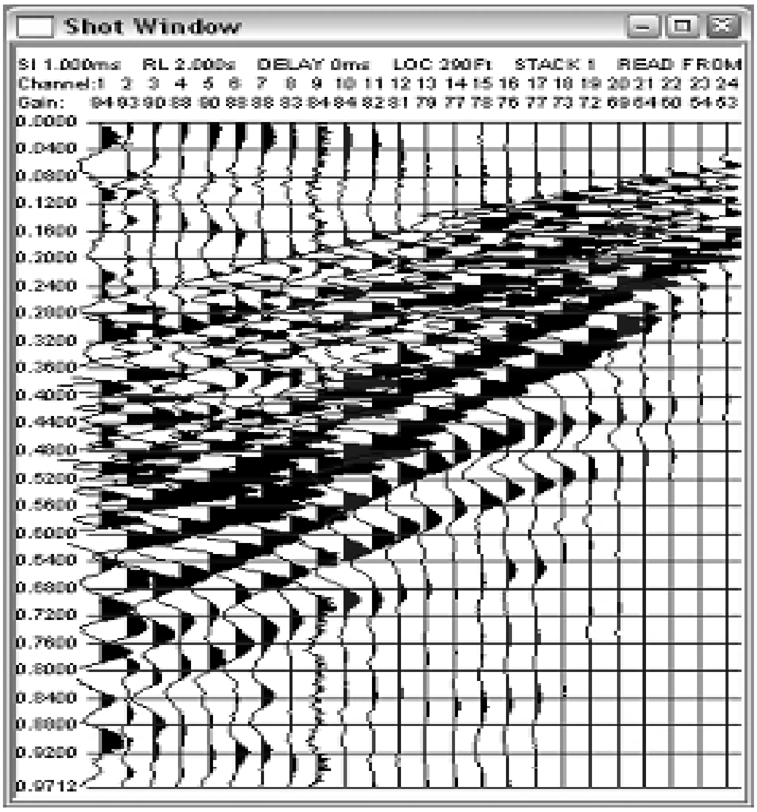


Figure 2: A 24 channel active source data

ii) Passive Source (Micro-tremor) Wave Method

The Earth's surface is always vibrating weakly. This vibration is known as micro-tremors.The micro-tremors are generated by the various sources, such as winds, ocean waves at ther sea shore, traffic noises, heavy machinery factories and household appliances. Micro-tremors are generated on the ground surface and are mainly consist of surface waves. The vertical component of the micro-tremors can be considered as Rayleigh waves. The dispersion curve of the vertical component of the micro-tremors is the dispersion curve of Rayleigh waves. Micro-tremors of surface waves consist of a wide range of frequency from the period of 0.1 second to 10 seconds. Wide range of frequency allows obtain S wave velocity model down to several kilometers using passive surface waves.
Okada (2003) has developed a large scale passive surface wave method, so called micro-tremors array measurements, using long period micro-tremors. The penetration depth of the method is from 100m to several kilometers. By selecting high frequencies depth can be restricted to few 10s of meters and can be applied it to solve shallower problems like geo-technical, environmental and earthquake engineering. Unlike the active source surface wave methods, the passive method does not need any sources and needs two dimensional arrays, such as triangles, circles or crosses. The sources of micro-tremors are distributed randomly in space, the micro-tremors do not have any specific propagation direction and need to have two directional arrays for calculating the phase velocity of micro-tremors.

Passive Source (Micro-tremor) Data Acquisition

During a passive source survey the system will "listen" and record the energy generated by cultural noise, traffic, factories, wind, wave motion, etc. There is no timing device to trigger the seismograph.
The preferred noise sources are steady, at a constant level. The fundamental assumption of micro-tremor array measurements (MAM) analyzed using the spatial autocorrelation method of SeisImager/SW is that the signal wavefront is planar, stable, and isotropic (coming from all directions). A high level of intermittent noise (like passing cars) is tolerable if the sources are relatively distant (greater than one array length). Even if the intermittent noise sources are near, this will usually be countered by recording long records (a minimum of 10 minutes total recommended). Such a body of data will provide a statistically steady representation of noise.

Table 2 summarizes the recommended passive source acquisition parameters.

Table 2. Passive Source Acquisition Parameters

Parameter	Setting
Spread/array configuration	L-shape, Triangle, Circle, Linear, or custom
Array size	Minimum of 1 times depth of interest
Geophone interval	Up to 10 m or 30 ft, adjust to suit spread configuration
Total number of geophones	Various based on spread configuration
Geophone type	4.5 Hz vertical geophones, with base plates for surveys on paved ground; alternatively, if available, 1 or 2 Hz seismometers can be used, especially if depth of interest is greater than 30 m
Trigger	Manual keyboard or automatic software trigger
Sample interval	2 milliseconds (ms)
Record length	30 seconds (s) each record, total of at least 20 records

Passive Source Survey Spread Configurations

Four types of passive source spread or array configurations as noted in Table 2. Figure 4 illustrates the L shape configuration. In Figure 4, the black line represents the spread cable and the green inverted triangles represent the geophones.

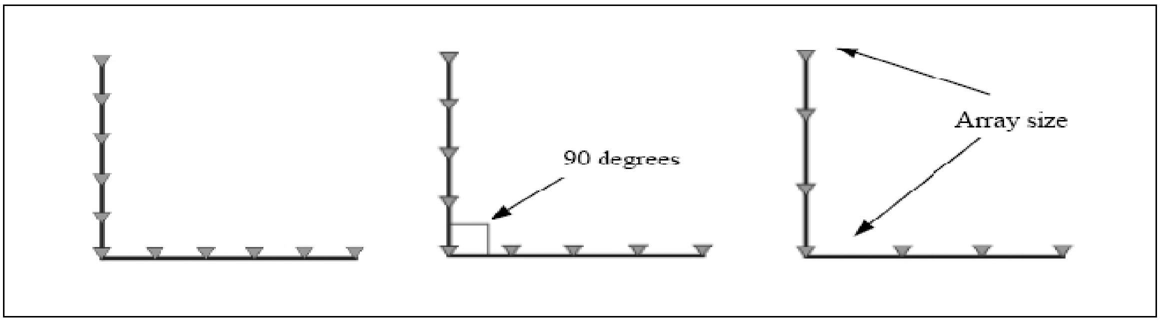


Figure 4: Schematic of passive source L-shape spread configurations with 11 (*L11*), 9 (*L9*), and 7 (*L7*) geophones. The *Angle* between the branches of the L is typically 60 to 90 degrees, buttechnically can be as small as 0 degrees, which is a linear array. Both branches are the same length;*Array size* equals the length of the branches.

For a L-shape array, the velocity curve is representative of a point between the two branches of the L, close to the origin. The L-shape array is the two-dimensional array that is easiest to construct in the field. The L-shaped array can easily be constructed after an active source survey by turning one-half of the spread 90 degrees. A typical passive source record is shown below.

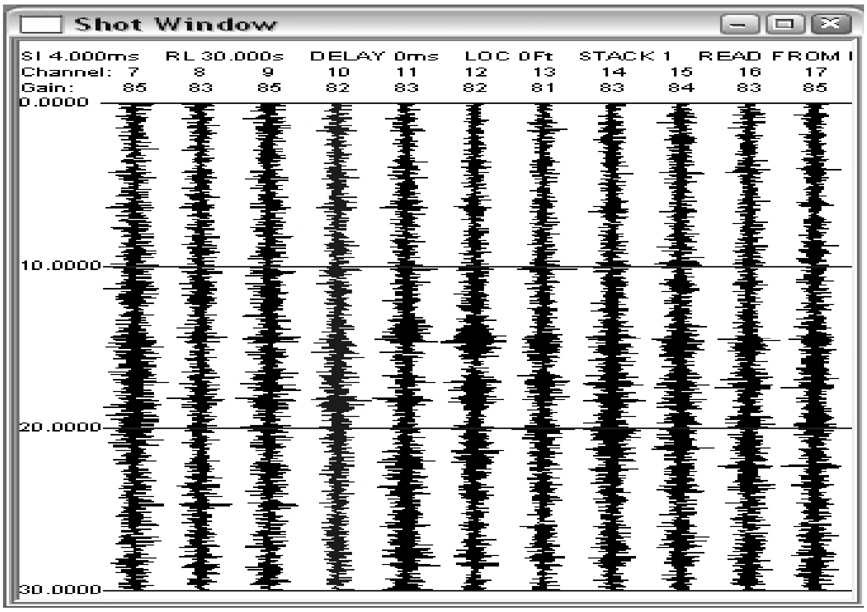


Figure 5: A typical passive source record

B. ELECTRICAL RESISTIVITY SURVEY

Introduction

The electrical properties of the subsurface vary with the ground material, the presence and saturation level of fluids, and the presence of buried objects. Electrical techniques seek to describe the distribution of these properties as a function of depth and horizontal distance. The most commonly used electrical technique is Electrical Resistivity Imaging (or Electrical Resistivity Tomography, ERT). Measurements of ground resistance are made by introducing an electric current into the subsurface via two metal stakes (current electrodes) planted into the ground. The current passing through the ground sets up a distribution of electrical potential in the subsurface. The difference in electrical potential between two additional electrodes (potential electrodes) is measured as a voltage. Using Ohm's law, this voltage can be converted into a resistance reading for the ground between the two potential electrodes. Main types of procedure related to the resistivity survey are: Vertical electrical sounding (VES), Constant separation traversing (CST), and 2D resistivity imaging.

2D Resistivity Imaging:

To build a cross-sectional image of ground resistance, a string of connected electrodes are deployed along a straight line with an inter-electrode spacing of a. Once a measurement of ground resistance has been determined for one set of four electrodes, the next set of four electrodes is automatically selected and a second measurement of resistance is made. This process is repeated until the end of the line is reached. The line is then re-surveyed with an inter-electrode spacing of 2a, 3a, 4a, etc. Each increase in inter-electrode spacing increases the effective depth of the survey. The measured resistance values are converted to value of apparent resistivity, r (in ohm-meters) which can then be a used to model the true subsurface resistivity distribution.

Electrical resistivity imaging can be used for Mapping buried dykes and other ore bodies, Locating fissures, faults and mineshafts, Landslide assessments, Buried foundation mapping, Time-lapse infiltration studies, Cross-borehole tomography, Assessment of aquifer heterogeneity, Soil corrosivity assessment, Landfill Investigation, Mapping and monitoring leachate plumes, Mapping and monitoring of groundwater pollution, Determination of depth to bedrock, Locating sinkholes / cave systems, Stratigraphic mapping, Locating buried channels, etc..

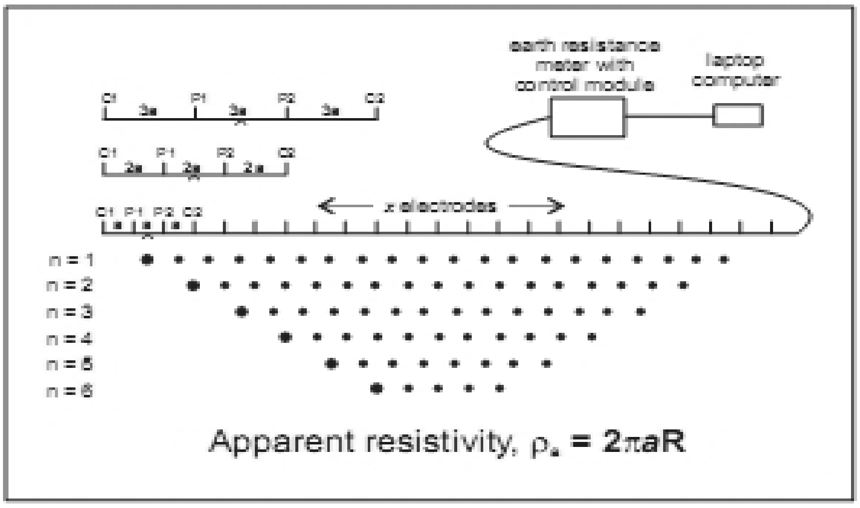


Figure 6: 2D imaging Wenner configuration showing the Subsurface imaging points

Figure 7: A typical resistivity imaging survey, above comprises an array of ground electrodes connected to a resistivity meter. The length of line determines the depth penetration and resolution of the data.

RESULTS OF GEOPHYSICAL INVESTIGATION AT GANGES BARRAGE SITE

In the study area 3 shallow seismic with source (profile) and without source (L pattern) and 3 2D imaging following Wenner configuration were carried out to delineate the subsurface geology and to calculate the shear wave velocity to a depth of 30m (average Vs 30 m). The study area is a plain agricultural land on the river bank and is mostly covered by silty/sandy clay soil. The 2D resistivity imaging and the shallow seismic (SS) locations are shown in figure 8.

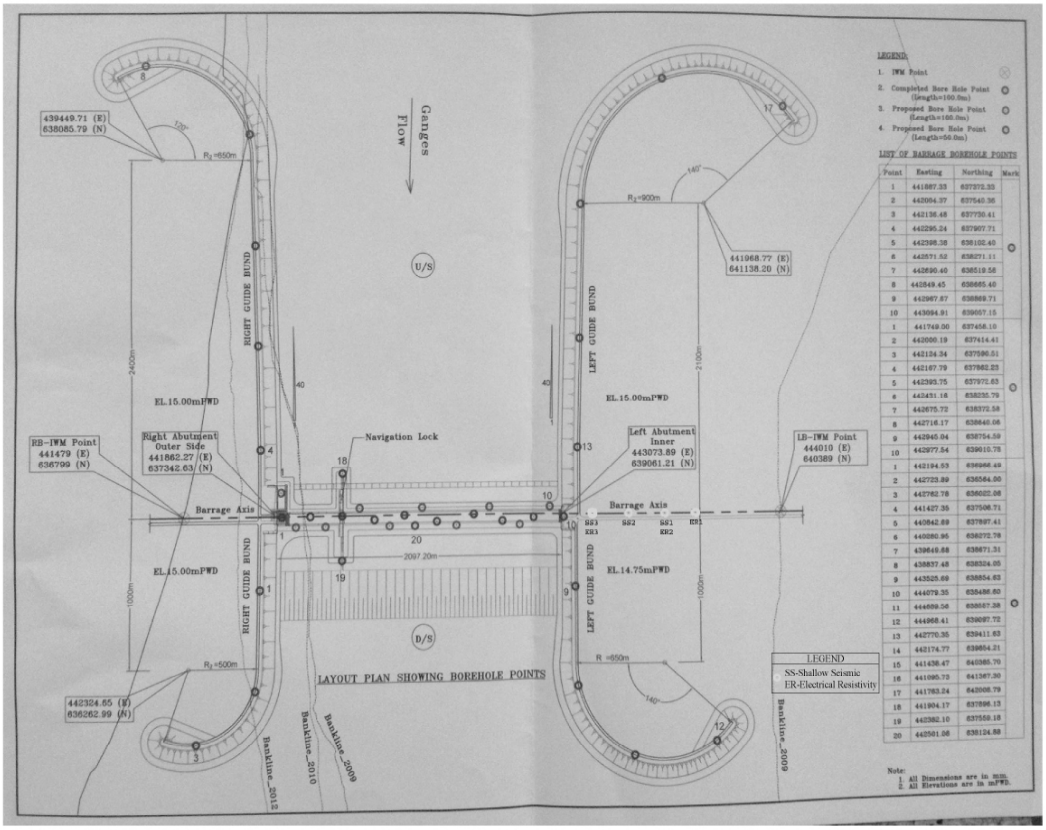


Figure 8: Location Map showing the 2D Electrical Resistivity imaging (ER) and the Shallow Seismic (SS) Survey Points

Shallow Seismic Survey Results:

Shallow seismic survey was carried out at three SS 1, SS 2 and SS 3 locations (Fig. 8) to decipher the shear wave velocity Vs average 30m. The spread without active source was L pattern and consists of 11 geophones (5 geophones on each side) with 3m spacing between geophones. The active source spread was 30m along a line with 11 geophones. In each station both ambient and artificial fields are recorded. The record length and the sampling interval were selected 500ms and 2ms respectively. The software used for collecting and processing the data is Pickwin. The active source data provided shear wave velocity with reliability to depth of around 5 to 10m. Shear wave velocity for the deeper part of the section is achieved through the interpretation of the passive source data.

Shallow Seismic Profile 1 (SS1)

The final velocity model (Fig. 9) obtained through combining active and passive sources data processing shows that shear wave velocity (Vs) average 30m for SS 1 is 256 m/s. The distribution of the points on velocity-density curve shows the reliability of the data.

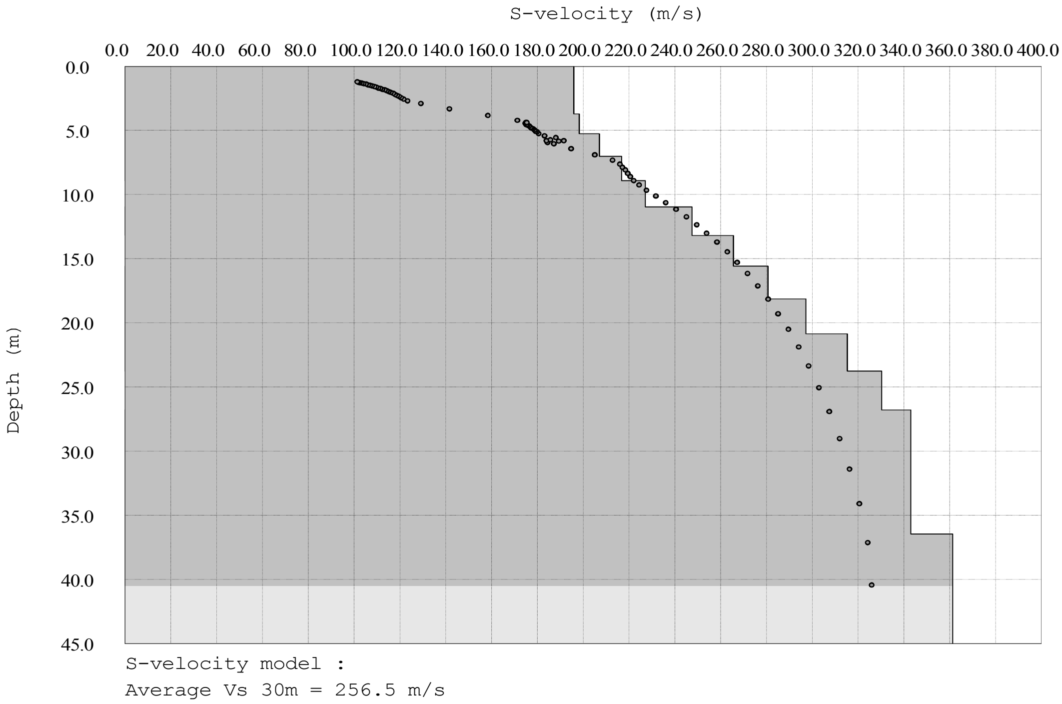


Figure 9: Shear wave velocity (Vs) average 30m model obtained combining active and passive source data for SS 1

Shallow Seismic Profile 2 (SS2)

Shear wave velocity model for shallow seismic at location SS 2 (Fig. 10) shows that the shear wave velocity (Vs) for SS 2 is 280m/s. Passive source data is reliable to depth of 48m and the shear wave velocity can be calculated to a depth of 48m.

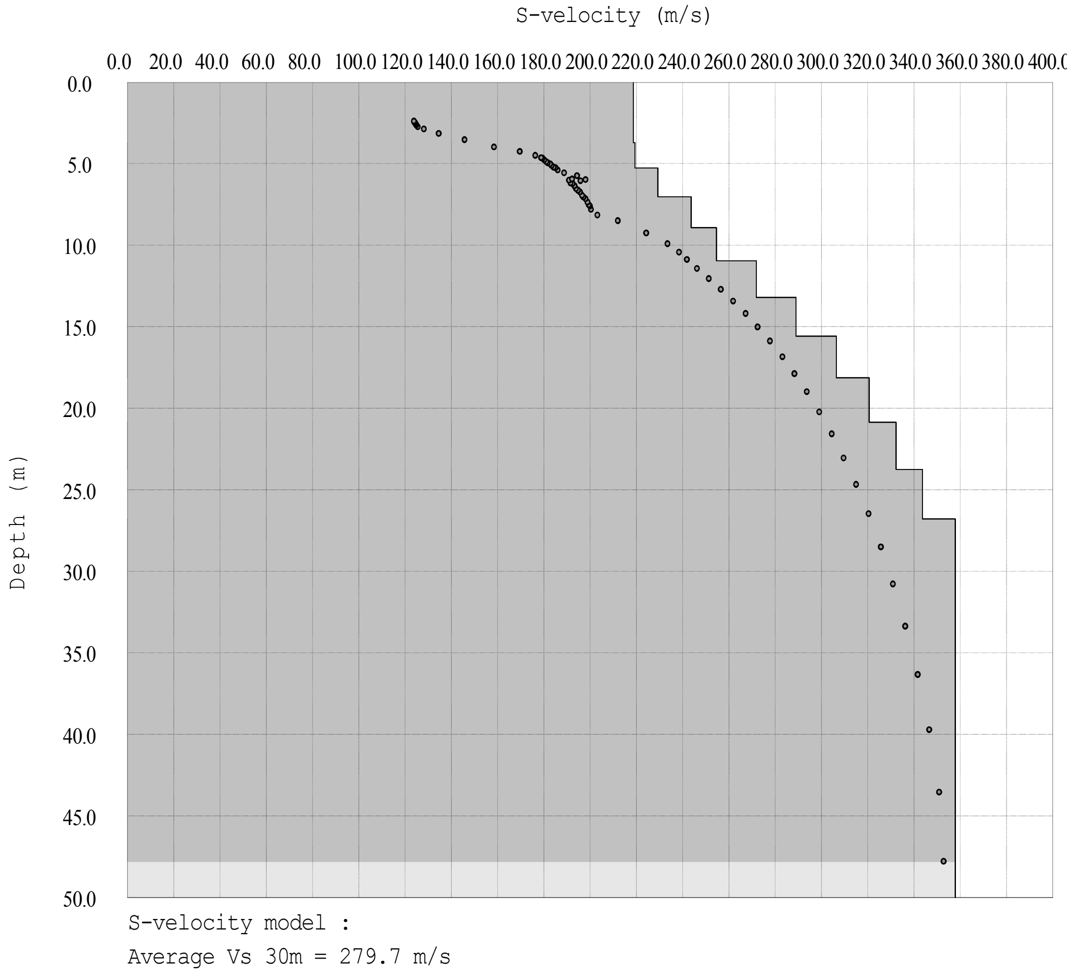


Figure 10: Shear wave velocity (Vs) model obtained combining active and passive source data for SS 2

Shallow Seismic Profile 3 (SS3)

Shear wave velocity model for shallow seismic at location SS 3 with source (Fig. 11) shows that the first layer with thickness of 5m has the velocity of 130m/s. The second layer continuing to depth of 15m has the velocity of 230m/s and the third layer has the velocity of 340m/s. The second layer showing the velocity of 230m/s may act as the supporting layer. Shear wave velocity models for recordings with source and without source show almost identical models indicating that shear wave velocity model is independent on the type of recording whether it is with or without source.

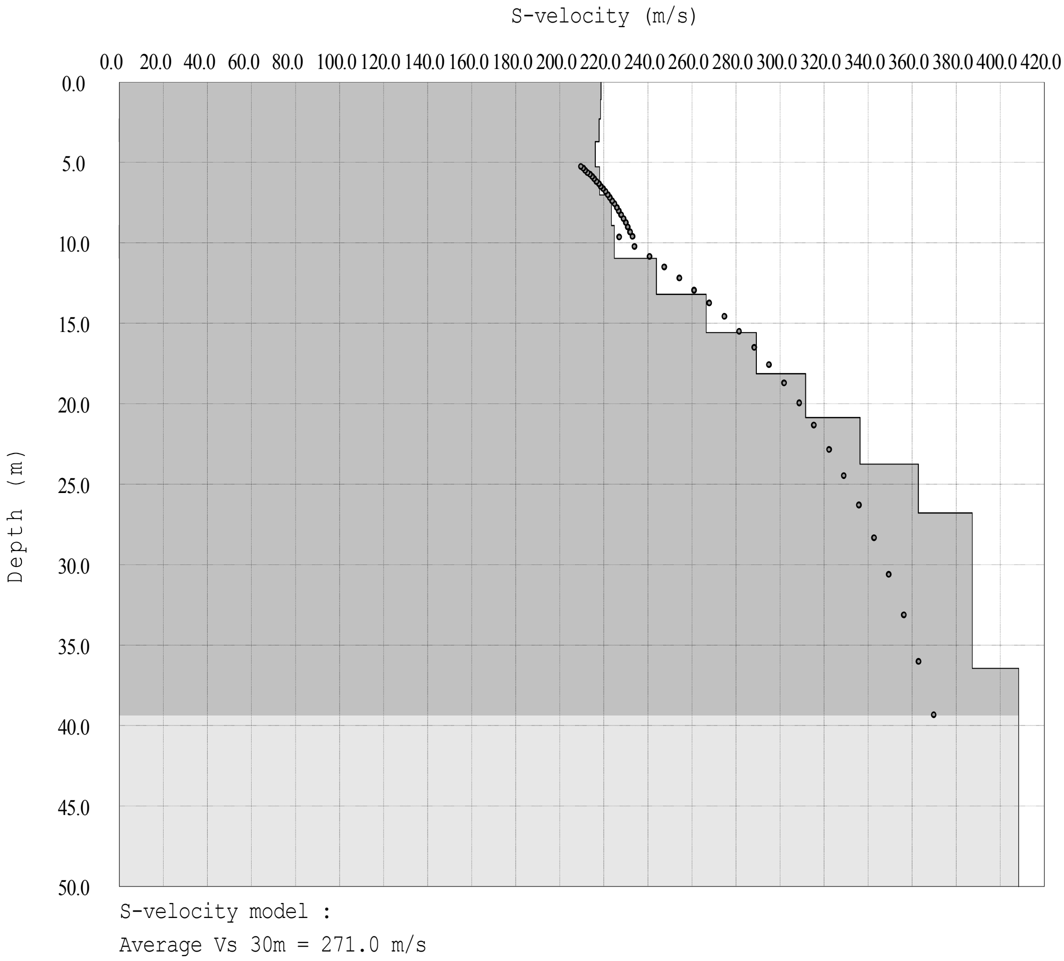


Figure 11: Shear wave velocity (Vs) model obtained combining active and passive source data for SS 3 (with source)

2D Resistivity Imaging Results:

2D Imaging Profile 1 (ER 1)

Profile 1(ER 1) is located about 5m west of the bench mark (fig. 8). The length of the profile is 30m and the selected electrode spacings are 1, 3, 5, 7 and 10m. The direction of the profile is N-S parallel to the flood protection road. 2D resistivity pseudo section (Fig. 12) prepared based on the profiling data shows that the surface layer (top soil) resistivity ranges from 15 to 22 Ωm. The resistivity of the top soil at the centre of the profile is maximum reaching about 22 Ωm. Top soil is composed of silty sand and the variation in the resistivity of the top soil is related to the variation in the moisture content of the soil. Resistivity then reduces to 12 to 15 Ωm at the middle depth of the section reflecting the water saturated zone. At the deeper part of the section resistivity again increases indicating the presence of more compacted sandy soil.

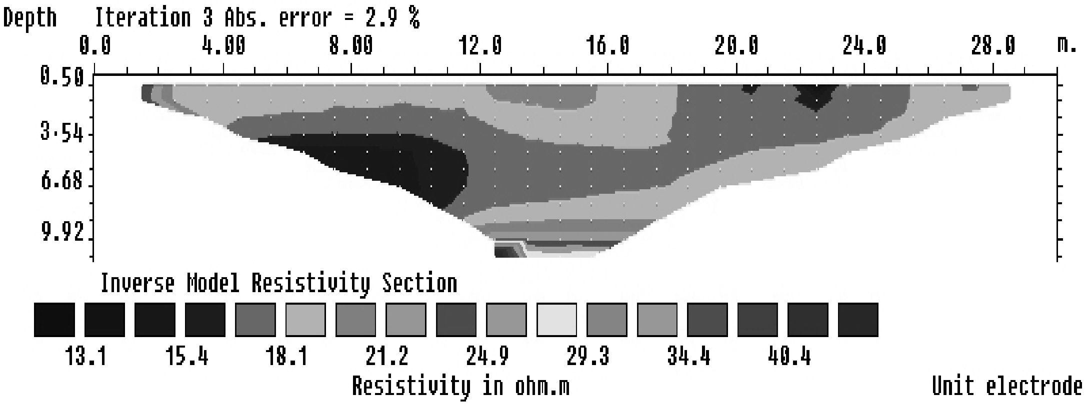


Figure 12: 2D resistivity imaging along profile1 (ER 1)

Imaging Profile 2 (ER 2)

Profile 2 (SSER 2) is located about 100m west of the bench mark (Fig. 8). The length of the profile is 30m and the selected electrode spacings are 1, 3, 5, 7 and 10m. The direction of the profile is E-W parallel to the barrage axis. 2D resistivity pseudo section (Fig. 13) prepared based on the profiling data shows that the surface layer (top soil) resistivity ranges from 18 to 60 Ωm. The resistivity of the top soil increases from east to west with maximum values reaching about 60 Ωm at the west corner. The elevation of the land increases to the west towards the river bank. Top soil is composed of silty sand and the variation in the resistivity of the top soil is related to the variation in the moisture content of the soil. At the deeper part of the section resistivity ranges from 15 to 30 Ωm.

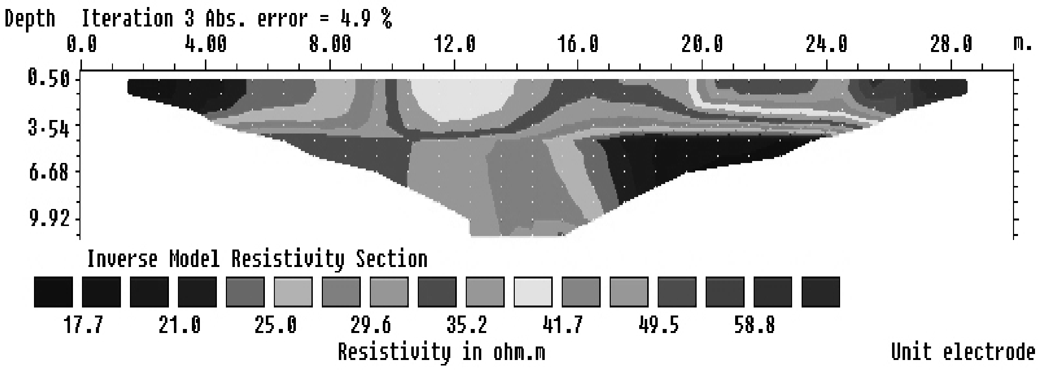


Figure 13: 2D resistivity imaging along profile 2 (ER 2)

Imaging Profile 3 (ER 3)

Profile 3 (SSER 3) is located about 300m west of the bench mark and is about 10m east from the river bank (Fig. 8). The length of the profile is 30m and the selected electrode spacings are 1, 3, 5, 7 and 10m. The direction of the profile is N-S. 2D resistivity pseudo section (Fig. 14) prepared based on the profiling data shows that the surface layer (top soil) resistivity dominantly is around 18 Ωm with some isolated patches showing lower resistivity (about 15 Ωm). Middle part of the section shows resistivity around 25 Ωm while the resistivity of the deeper part of the section is about 45 Ωm.

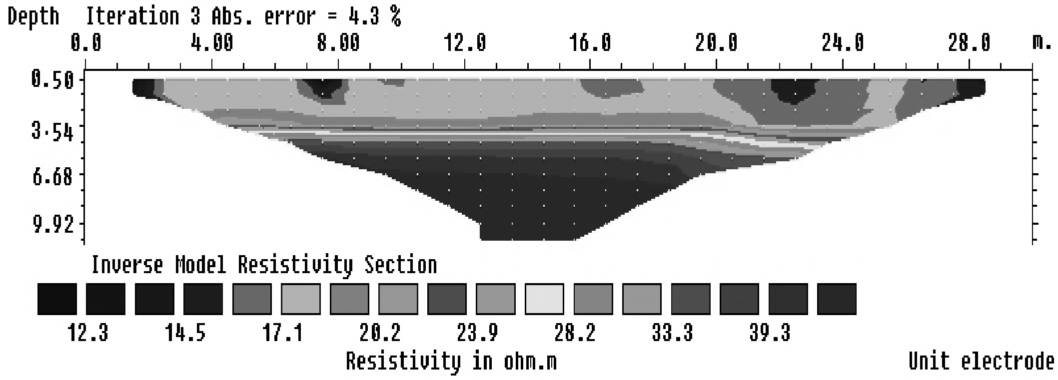


Figure 14: 2D resistivity imaging along profile 3 (ER 3)

RESULTS OF GEOPHYSICAL INVESTIGATION AT BANGORA GAS PLANT SITE

In the study area 2 shallow seismic with source (profile) and without source (L pattern) and 2 2D imaging following Wenner configuration were carried out to calculate the shear wave velocity to a depth of 30m (average Vs 30 m) and to delineate the subsurface geology. The study area is a sand filled land and gas production and supply facilities are installed there. The shallow seismic (SS) and the 2D resistivity imaging (ER) locations are shown in figure 8.

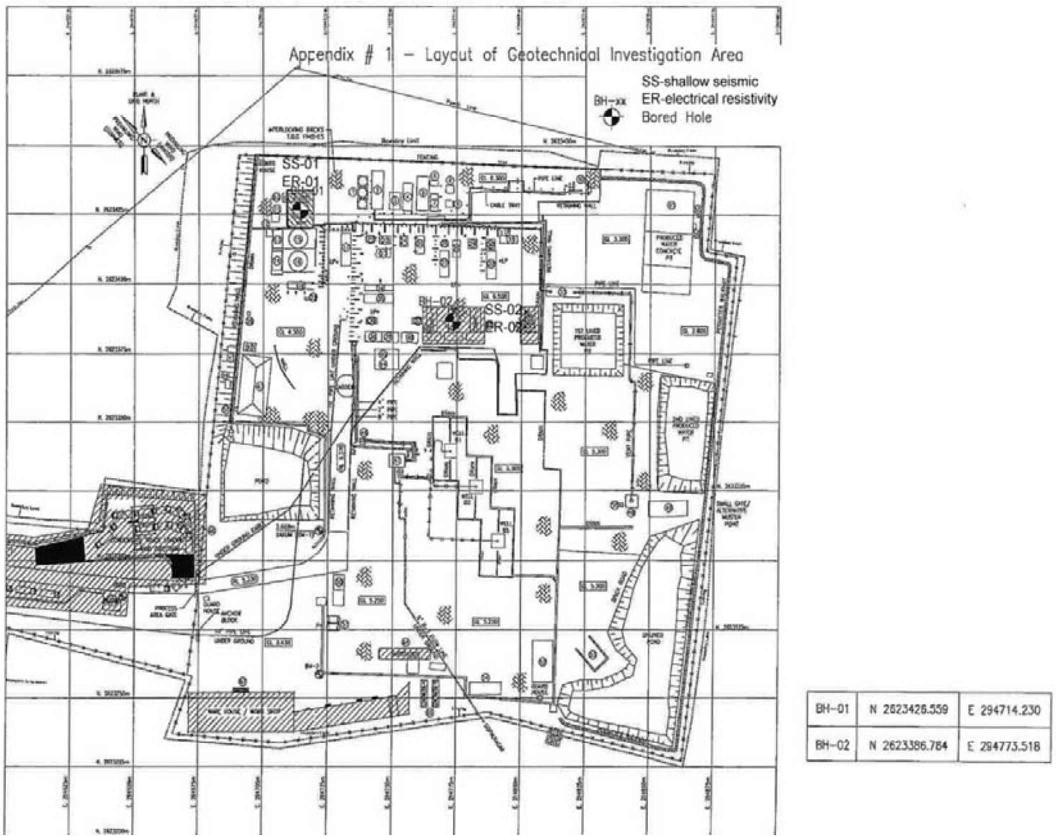


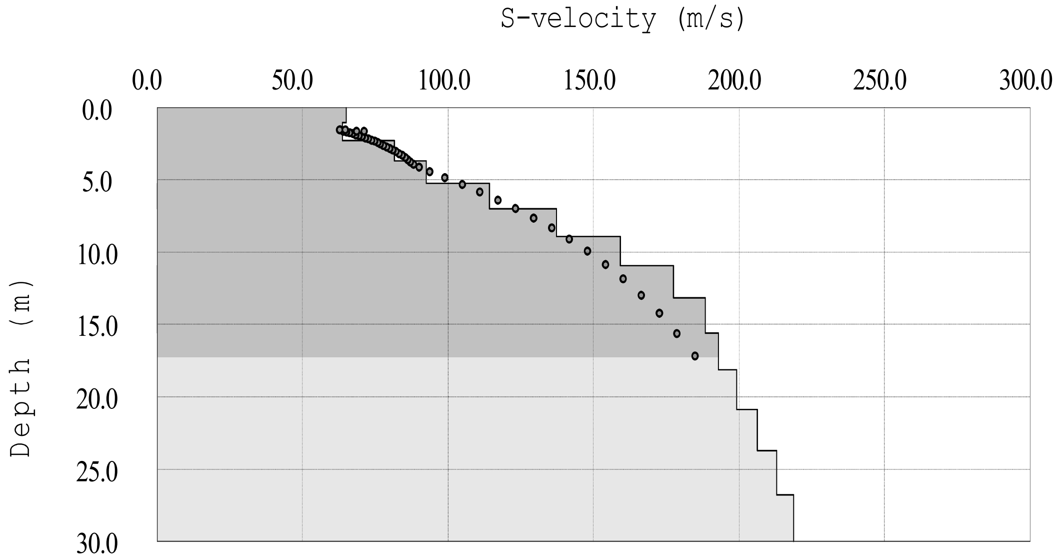
Figure 8: Location Map showing the Shallow Seismic (SS) and the 2D Electrical Resistivity imaging (ER) Survey Points

Shallow Seismic Survey Results:

Shallow seismic survey was carried out at three SS 1 and SS 2 locations (Fig. 8) to decipher the shear wave velocity Vs average 30m. The spread without active source was L pattern and consists of 11 geophones (5 geophones on each side) with 3m spacing between geophones. The active source spread was 30m along a line with 11 geophones. In each station both ambient and artificial fields are recorded. The record length and the sampling interval were selected 500ms and 2ms respectively. The software used for collecting and processing the data is Pickwin. The active source data provided shear wave velocity with reliability to depth of around 5 to 10m. Shear wave velocity for the deeper part of the section is achieved through the interpretation of the passive source data.

Shallow Seismic Profile 1 (SS1)

Profile SS1 is located close to bore hole BH 1 at the north-west corner of the surveyed area (Fig. 8). The final velocity model (Fig. 9) obtained through combining active and passive sources data processing shows that shear wave velocity (Vs) average 30m for SS 1 is 145 m/s. The distribution of the points on velocity-density curve shows the reliability of the data.



S-velocity model : 17.dat-21.dat

Average Vs 30m = 145.0 m/s

Figure 9: Shear wave velocity (Vs) average 30m model obtained combining active and passive source data for SS 1

Shallow Seismic Profile 2 (SS2)

Profile SS2 is located close to bore hole BH 2 at the central-west of the surveyed area (Fig. 8). Shear wave velocity model for shallow seismic at location SS 2 (Fig. 10) shows that the shear wave velocity (Vs) for SS 2 is 207.5m/s.

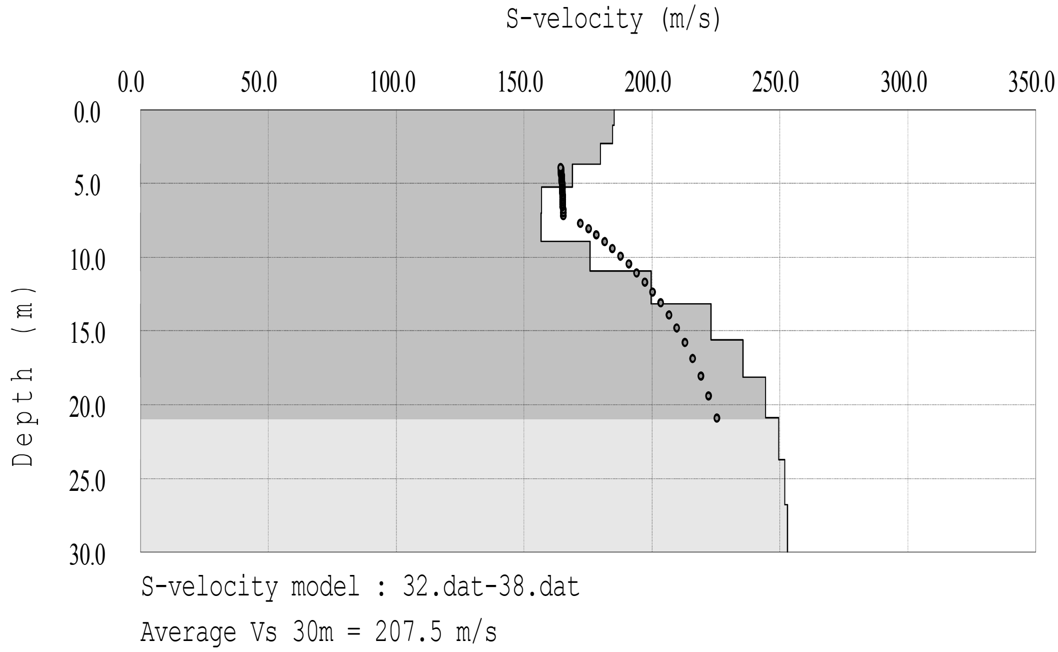


Figure 10: Shear wave velocity (Vs) model obtained combining active and passive source data for SS 2

2D Resistivity Imaging Results:

2D Imaging Profile 1 (ER 1)

Profile 1(ER 1) is located close to borehole BH 1at north-west corner of the investigated area (fig. 8). The length of the profile is 30m and the selected electrode spacings are 1, 3, 6 and 9m. The direction of the profile is E-W parallel to the northern boundary of the Tullow installations. 2D resistivity pseudo section (Fig. 11) prepared based on the profiling data shows that the surface layer (top soil) resistivity ranges around 80Ωm. Top soil is composed of filled dry sand. At the middle depth of the section resistivity in the western part increases to more than 100Ωm. At the deeper part of the section resistivity varies from 12 to 40 Ωm.

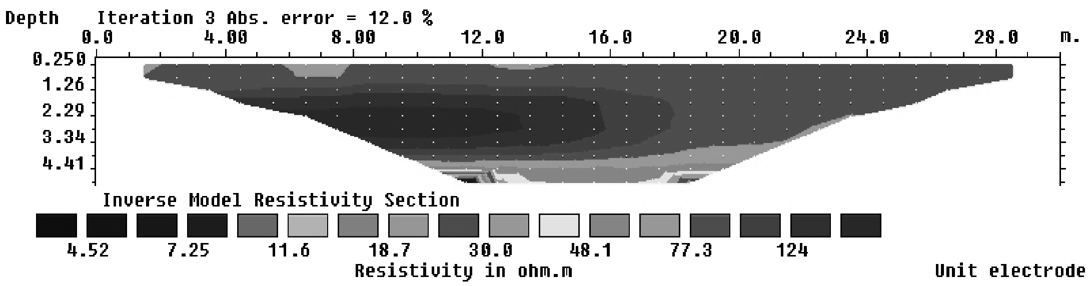


Figure 11: 2D resistivity imaging along profile1 (ER 1)

Imaging Profile 2 (ER 2)

Profile ER 2 is located close to bore hole BH 2 at the central-west of the surveyed area (Fig. 8). The length of the profile is 30m and the selected electrode spacings are 1, 3, 6 and 9m. The direction of the profile is E-W. 2D resistivity pseudo section (Fig. 12) prepared based on the profiling data shows that the surface layer (top soil) resistivity ranges from 85 to more than 100 Ωm. The resistivity of the top soil at the west of the profile is maximum reaching to more than 100Ωm. Top soil is composed of filled dry sand and the variation in the resistivity of the top soil is related to the variation in the moisture content of the soil. Resistivity then reduces to 33 to 64 Ωm at the middle depth of the section. At the deeper part of the section resistivity varies from 12 to 24 Ωm.

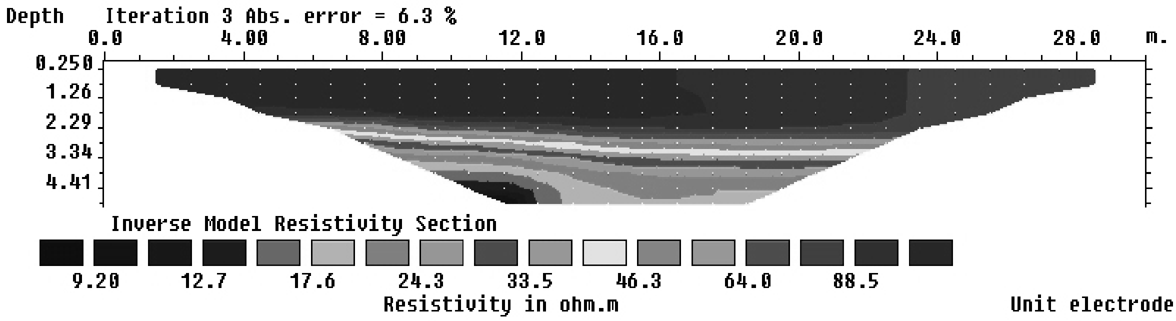


Figure 12: 2D resistivity imaging along profile 2 (ER 2)

BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

PART-VII

FIRE AT HAZARIBAG RESIDENTIAL AREA IN OLD DHAKA

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: Naima Rahman
Mehedi Ahmed Ansary

A devastating fire broke out at around 3:00 am of 18 November 2012 (Sunday) through Hazaribagh's Bou Bazar slum which is situated at the south-west periphery of Dhaka City. The fire caused death of at least 11 people including six women and five children dead and gutted 700 shanties.

From the point of view of local residents the fire originated from a cigarette butts, mosquito coils or kerosene stove in a rickshaw garage right in front of the slum. Just minutes after it broke out, the fire engulfed the nearby houses after coming in contact with some kerosene drums, which had been kept for sale. The fire spread quickly and destroyed 150 rickshaws and six auto-rickshaws in the garage, and some 700 shanties. These shanties were the homes of about 3,000 low-income people who have lost everything in the fire. Besides thirty shops, two bakeries, five rickshaw garages and a mosque were also burned while five adjacent buildings were partly damaged.

All the fatalities occurred in the 'Shamsu Professor's Slum' which is generally a compound; occupies over nearly five-katha land, surrounded by a wall and has a two-storied concrete building with tin-shed roof and temporary shanties on the edge of the Bou Bazaar slum. There is only one entrance of the slum which is a six-feet high and four-feet wide.
The 11 dead were the tenants of the two-story tin-shed house, where 46 families lived. The two-storied concrete building has kitchens, bathrooms and toilets. As the fire began to spread, all the tenants ran for their lives through a common exit. But the 11 victims, being women and children, could not run as fast. So instead of getting out of the house, they took shelter in a bathroom and a kitchen. But soon the blaze, gushing through the exit, engulfed the bathroom and the kitchen and burned them alive. Some people, mostly men and youths, escaped the fire by jumping over the boundary walls. Others cut through their bamboo boundaries and jumped outside. Seventeen fire fighting units from seven stations extinguished the fire after two and a half hours of hectic efforts at around 7am in the morning.

Government has announced to provide aid for the affected families. Families of deceased would receive Tk 20,000 from the local administration and Tk 10,000 from the City authorities. In addition Tk 900,000 will be handed later to rebuild their houses. The prime minister gave 6,000 pieces of blankets, 3,000 pieces of saris, 3,000 pieces of three-pieces, 3,000 pieces of sweaters, 3,000 pieces of shawls and 409 pieces of lungis for the affected people. The relief materials were handed over to the deputy commissioner of Dhaka for distribution among the victims.

Burnt Household Materials

Burnt Rickshaws

Affected Adjacent Buildings

Affected Water Supply

Temporary Shelter

Temporary Shelter

PART-VIII

FIRE AT A READYMADE GARMENT FACTORY AT NISCHINTAPUR IN ASHULIA INDUSTRIAL AREA

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: Naima Rahman

Mehedi Ahmed Ansary

At the night of November 24, 2012 a catastrophic fire attacks a nine-storey garment building named Tazrin Fashion of Tuba Group Ltd. The factory is situated at Nischintapur which is a part of Ashulia industrial belt near Dhaka City.

The fire, started at 7:30 PM at the ground floor of the factory seemed to be caused by an electrical short circuit. The fire spread quickly to other floors because of the large amount of fabrics and yarn which was stored in front of the staircase at the ground floor the factory. Thus the workers at the upper floors were trapped and could not come out of the building using the staircase. The fire burned for more than seventeen hours before firefighters succeeded in extinguishing it. Due to lack of water in surrounding areas, the dousing operation was delayed.

Most of the victims at least 69 bodies were found on the second floor, 21 from the third floor and 10 from the fourth floor. 12 victims died leaping from windows to escape the flames, some of them dying of their injuries after being taken to area hospitals. Other workers who had escaped to the roof of the building were successfully rescued.

Many workers had been unable to escape through the narrow exits. The fire department's operations manager stated that the factory lacked emergency exits that led out of the building. All three staircases of the building led through the ground floor, making them unusable in the fire. Some workers who managed to escape the fire by jumping from windows complained that after hearing the alarm of fire they rushed to the supervisors. But they told them the alarm was not working properly and locked the collapsible gate. Fire Service started rescue operations on the ninth floor in the morning after dousing the blaze. The fire fighters also found the gate locked and they had to cut the padlock to enter at upper floor. Thus the rescue operation was delayed. Army's Ninth Infantry Division, police; RAB and Border Guard Bangladesh members took part in the rescue. Meanwhile, relatives of the trapped workers thronged the factory area and spent a sleepless night there in the hope of getting their loved ones back alive. In the morning, rescuers started retrieving burnt bodies from inside the building and gathering them at the Nischintopur Government Primary School premises.
Prime Minister Sheikh Hasina stated her shock at the death toll, called for thorough search-and-rescue operations and also suspected the incident as sabotage. Home Minister Mohiuddin Khan Alamgir also supported the suspicion, citing a series of recent fires at clothing factories. In one incident, two employees were caught on CCTV attempting to set fire to stockpiled cotton. But some recent enquiries found no involvement of the suspect in this fire accident. The administration, police and Fire Brigade have formed three separate committees to investigate the cause of the devastating fire. Three supervisors from the factory were arrested on 28 November on charges of criminal negligence. Police accused them of padlocking exits and preventing workers from leaving the building.
The Bangladesh Garment Manufacturers and Exporters Association (BGMEA) offered support to the victims' families and announced giving Tk 100,000 each to the families of the deceased. The Ministry of Labour announced giving Tk 10 million for the injured. The district administration announced Tk 20,000 each for the families of the victims as funeral

costs. Hong Kong sourcing giant Li & Fung which has orders placed with Tazreen Fashions offered to give $1,200 to each of the families of those who died in the blaze.

According to the website of Tuba Group it has 13 other garment factories other than Tazreen. Around 1,500 people used to work at Tazreen Fashions. Authorities said there were around 300 employees in the nine-storied factory to ensure fire safety. They comprised fire fighters, rescue workers and primary medics. However, there were no visible efforts on their part to extinguish the fire. Eight fire-extinguishers placed on each floor from the first to the seventh. The equipments were last tested on the fifth of this month and bore the authority's signatures on them. The 'open rings' of two of the fire extinguishers found lying on the second and third floors were intact. There was evidence of using one of the extinguishers on the seventh floor. The thread warehouse on the ground floor was found burned to ashes. Fire brigade officials assumed fire to have originated from there.

Opened in 2009, the Tazreen Fashion factory employed 1,630 workers, who produced T-shirts, polo shirts and jackets. The factory produced clothes for various companies, including Dutch company C&A, American company Walmart and Hong Kong company Li & Fung. The Tuba group is a major exporter of garments from Bangladesh to the U.S., Germany, France, Italy and the Netherlands, whose clients include Wal-Mart, Carrefour and IKEA. According to Tazreen Fashions' web site, the factory was flagged in May 2011 with an orange grade by a Walmart ethical sourcing official for violations and/or conditions which were deemed to be high risk. The notice said that any factory receiving three such assessments in two years would not receive Wal-Mart orders for one year. The orange rating was the first the company had received, and was followed by a yellow medium risk rating the following August, which pertained to the factory where the fire occurred.
On 27 November, Walmart America ended its relationship with Tuba and stated that the Tazreen factory was not authorized to produce merchandise for Wal-Mart. A supplier subcontracted work to this factory without authorization and in direct violation of their policies. The corporation also said that it would be working with suppliers to improve fire safety.

Three trade unions demanded that US retailer Walmart compensate the families of those who were killed or injured in a deadly fire at Tazreen Fashions Ltd in Ashulia on November 24. Apart from compensations, the unions in a letter asked Walmart to bear all expenses of the required treatment of the injured. Leaders of the workers' rights groups requested the world's largest retailer not to stop outsourcing to Bangladeshi factories. Cancellation of orders would only add to the plight of garment workers, leaving many of them jobless. It should be mentioned that Walmart is the largest buyer of Bangladesh's readymade garment products, purchasing items worth over $1billion annually.

Prime Minister Sheikh Hasina handed over Tk 2.58 crore to the families of 43 of the 112 victims on 4 December 2012 at the Prime Minister's Office. Each of the family was given Tk. 6 lakhs. The amount needed for the families of all the 112 dead workers will total Tk 6.72 crore. Of the Tk 6 lakh given to each family, Tk 2 lakh came from the Prime Minister's Relief and Welfare Fund and Tk 1 lakh each from the labour and employment ministry, BGMEA, Bankers Association of Bangladesh and Hong Kong-based readymade garment (RMG) importer Li & Fung.

Tazreen Fashions will get a fire-insurance of Tk 18 crore as a compensation for the devastating blaze killing 112 workers of the RMG industry. The RMG had a one-year fire-insurance with Karnaphuli Insurance Company Limited in 2011. The Tazreen Fashions is going to get the compensation as tenure of the year-long insurance would be effective till December in 2012, just before a month of the completion of the tenure.

Figure 1: Blaze

Figure 2: Fire fighting operation

Figure 3: Burnt machineries

Figure 4: Injured worker

Figure 5: Crowd at outside

Figure 6: Mourning relative

Insurers worried over rising RMG accidents

Insurance companies are concerned over the growing number of accidents in apparel factories as the insurers' compensation for their clients in the garment sector has been on the rise over the years. In a move, the companies have decided to devise new policies to handle the menace, especially the fire accidents that kill people and occur mainly due to poor factory management. “We are the worst sufferers of accidents in factories as we are the leading insurer in the country,” said Nasir A Chowdhury, managing director of Green Delta Insurance Company. Green Delta paid Tk 5.6 crore as compensation for fire accidents in garment factories in 2010. The amount rose to Tk 12.20 crore in 2011. Till September this year, the insurer has paid Tk 4.5 crore as compensation. According to the Clean Clothes Campaign, an alliance of organisations in 15 European countries, more than 500 Bangladeshi workers have died in factory fires since 2006. In February 2006, at least 57 workers were killed and more than 100 seriously injured when fire engulfed KTS, a textile factory in Chittagong. Fire at Spectrum, a garment factory near Dhaka killed 29 people in the same year. The latest fire incident in Tazreen Fashions claimed more than 100 lives. Fire insurance is a must for factories. The companies that are engaged in export-import business have to cover some additional risks. Before issuing insurance coverage, insurers need to inspect the factories to know about their safety measures and compliance. “We think twice before insuring a hazardous factory, such as garments,” said Sabir Ahmed, chief financial officer of Reliance Insurance, one of the top two companies in the country. “We inspect factories on our own,” said Ahmed. “We did not need to pay a big amount of compensation last year.” Chowdhury said they also carry out survey of the factories before issuing any coverage. Insurers usually ignore minor loopholes, he said. “But we find a lot of shortcomings when a factory goes for claims settlement,” he said. “And, we minus the cost for negligence.” The issue has become a worry for the insurers' association as well. “We have convened a special board meeting after the fire accident in Tazreen Fashions. We've formed a committee to devise new policies to handle the growing number of accidents,” said Sheikh Kabir Hossain, president of Bangladesh Insurance Association. Hossain said insurers face problems during claims settlement as the policyholders do not cover all the machinery and risks.“When we carry out survey for claims settlement we find major loopholes,” he said. Hossain, who is also the chairman of Sonar Bangla Insurance, said his company is witnessing a rise in claims for accidents in garment factories. He said factory owners do not insure their workers, their policies only cover the factories. The garment industry having more than 5,000 factories produces clothes for the western countries. Garments account for 80 percent of Bangladesh's exports, with earnings of nearly $19 billion in the last financial year. Nearly 3.5 million people, mostly women, are employed in the industry.

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY

PART-IX

COLLAPSE OF AN UNDER-CONSTRUCTION FLYOVER AT BAHADDARHAT IN CHITTAGONG

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: Naima Rahman

Mehedi Ahmed Ansary

Three concrete girders of an under-construction flyover at Bahaddarhat in Chittagong collapsed on 24 November 2012 evening, burying a makeshift kitchen market and passersby.Each concrete girderwas 42 metre in length and two-and-half metres in height.At least 13 people died and more than 50 were injured when the concrete girders collapsed. Eyewitnesses said at around 8:00pm three concrete girders of the flyover fell on some people, mostly vegetable vendors of the kitchen market. The accident occurred when workers were shifting the girders on the flyover, said Hasanul Islam, a student of the Chittagong University of Engineering and Technology, who observed the whole thing from a close distance. At one stage, he saw one girder which was in the middle go off balance and push the other two to the roadside and adjacent pond.

Communication experts said that there were faults in the construction and safety measures in the project. The construction company did not issue any warning to the public while carrying out the shifting work of the girders And the Chittagong Development Authority (CDA), who is constructing the flyover at a cost of Tk 106 crore, had failed to ensure security at the site and had apparently no supervisory role when the work was going on. They should have ensured enough precautionary measures in the entire project area for the flyover. And the district administration was allowing pedestrians, peddlers and others to move about freely and use the place. Meanwhile, a girder on the pillar numbers 20 and 21 has been found vulnerable by the. People have been advised to remain cautious while travelling through the area,

On June 29, a concrete girder connecting pillars No. 22 and 23 of the same flyover fell on the road below, slightly injuring a rickshaw-puller. Luckily, the accident happened on a Friday during Juma prayer time when the road was almost empty.

The construction work of the four-lane flyover began in December 2010.

The girder which collapsed at 29 June, 2012

The girder which collapsed at 24 November, 2012

PART-X

VIBRATION MEASUREMENT AND NDT AT A CEMENT FACTORY SITE

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: KM Khaleduzzaman

Raquib Ahsan

Mehedi Ahmed Ansary

1.0 Measurement of Vibrations

Figure 1 shows the location map (showing the point of measurement) of the area over which vibration measurements were made. Figure 2 shows the microtremor observation system. The BRTC, BUET team conducted the measurement of vibrations using a 15-channel recorder at five locations of the plant, simultaneously, as shown in Figure 1. Each of the sensors has three components in X, Y and Z directions. For this study, however, only the vertical components (Z-directions) at the selected locations were measured. The following channels were assigned: Ch 3 (for free-field - at the river side), Ch. 6 (for Gear-box foundation), Ch. 9 (for Ball Mill outlet foundation), Ch. 12 (for Ball Mill inlet foundation) and Ch. 15 (for free-field - within the plant). For the initial several minutes, the ball mill was kept shut off and it then was started until the machine ceases to work after two days. Even after the cease of the ball mill readings of vibrations were also taken for another 48 hours continuously.

Ch15

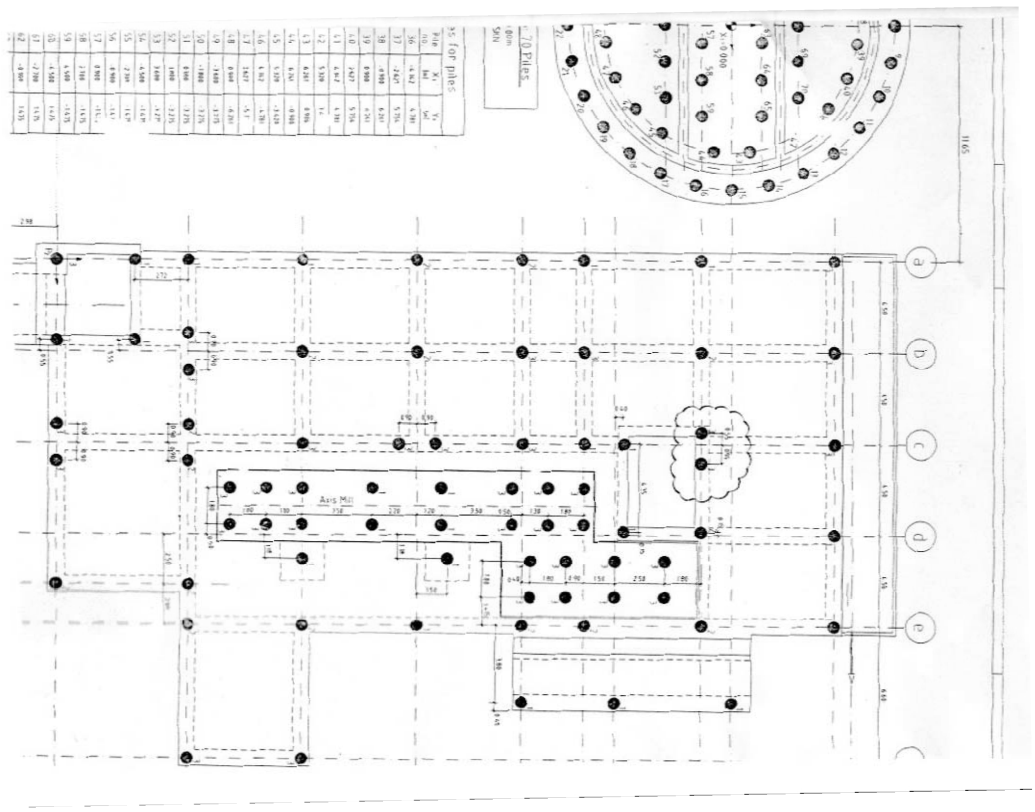


Fig. 1 Locations of Vibration Ch3 River Side Measurement

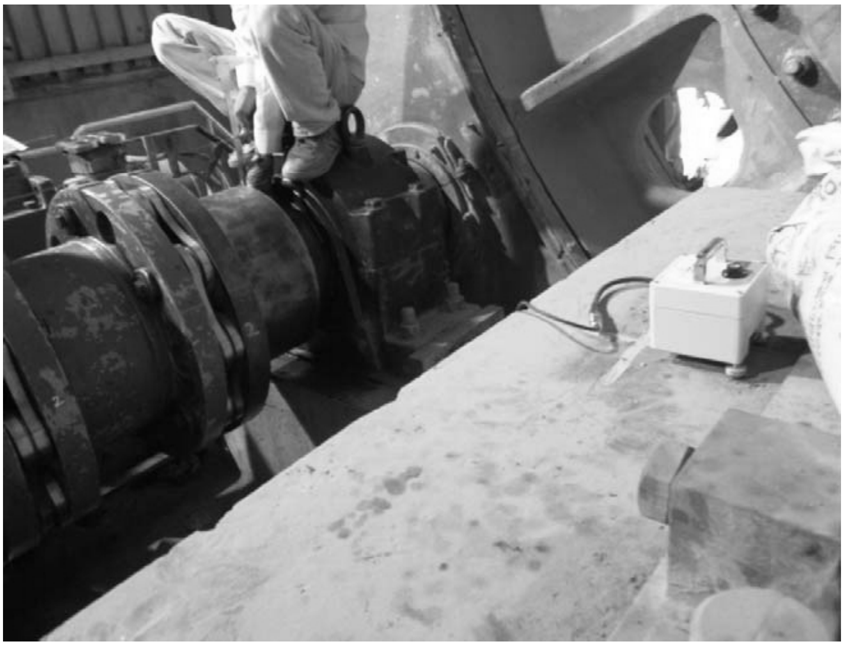
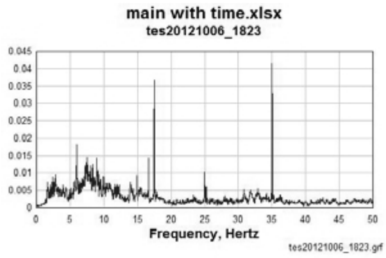


Fig. 2 Measurement of Plant Vibration using Microtremor System

Fig. 2 (Continued) Measurement of Plant Vibration using Microtremor System

2.1 Vibration Plots at Channel 6 (Gear Box Base) for Different Time Segments

In the following figures (Fig. 3), the collected data are presented for several time segments. In the following sections they are described and analysed.



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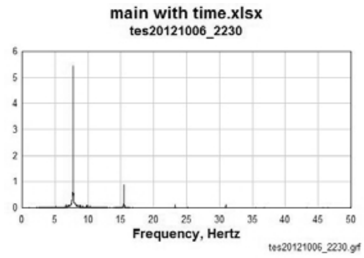

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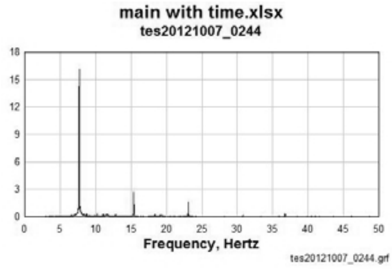

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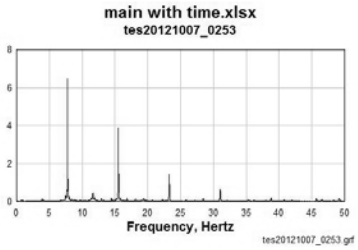

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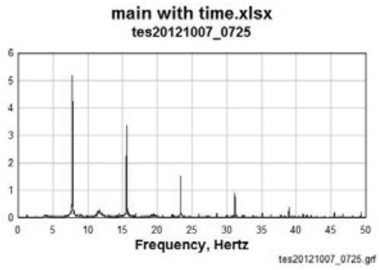

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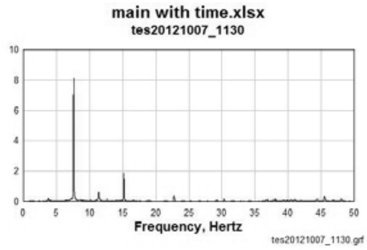

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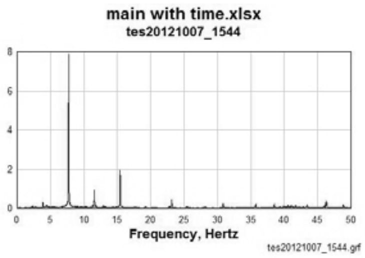

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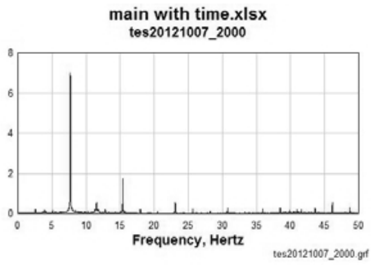

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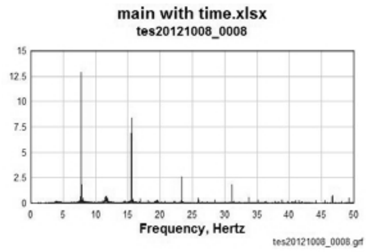

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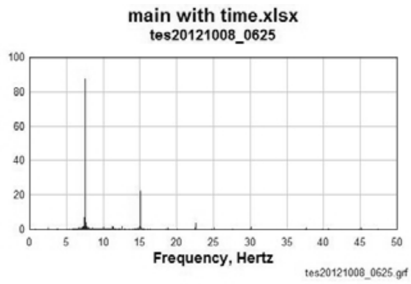

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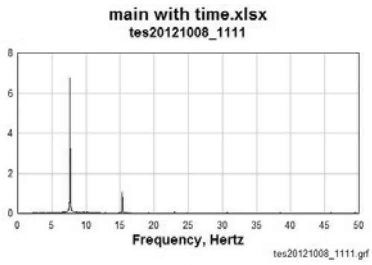

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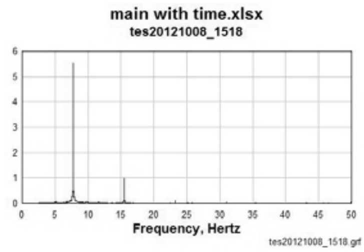

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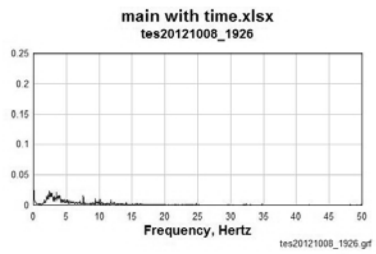

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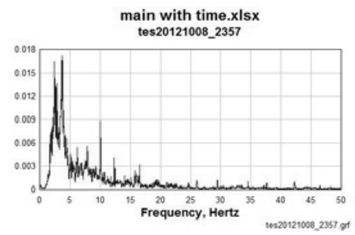

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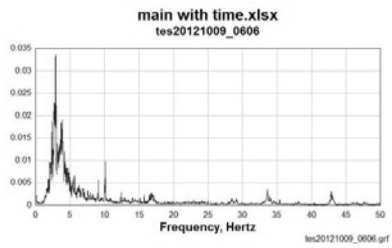

Time: 06:06 on 09/10/2012

Fig. 3 Vibration Plots at Channel 6 (Gear Box Base) for Different Time Segments

2.2 Comparison of Vibrations at Channel 6 (Gear Box Base) for Different Time Segments

Figure 4 shows the Fourier Spectrum of the vibrations at gear box base (Channel 6). The Fourier Spectrum shows the predominant frequency of the Mill to be 7.5 Hz when the mill is running (October 6: 22:30 and October 7: 20:00). The amplitude of the vibration is around 7. The machine did not show any peak while the Mill is at rest (October 6: 18:23 and October 8: 19:26).

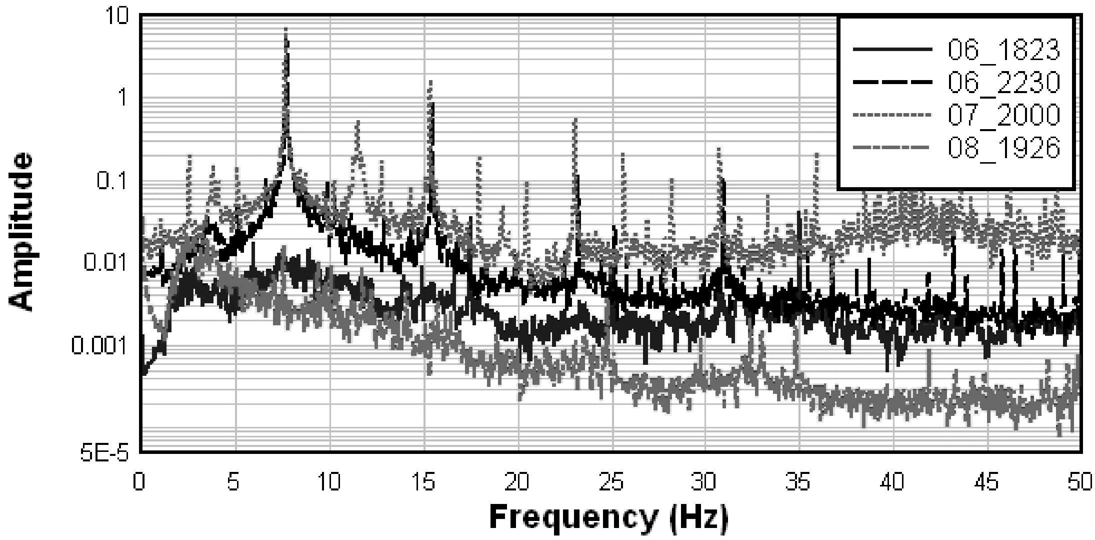

Fig. 4 Fourier Spectrum of the vibrations at Gear Box Base (Channel 6) at Different Time Segements

2.3 Comparison of Vibrations at Channel 6 for Different Time Segments Including the Time when the Mill Ceases

Figure 5 shows the Fourier Spectrum of the vibrations at gear box base (Channel 6) at different time segments including at the time when the mill ceases. The Fourier Spectrum shows the predominant frequency of the Mill to be 7.5 Hz when the mill is running (October 6: 22:30 and October 7: 20:00). The machine did not show any peak while the Mill is at rest (October 6: 18:23). The machine shows a slightly amplified peak just before it ceases (October 8: 00:08). The amplitude of the vibration is around 13.

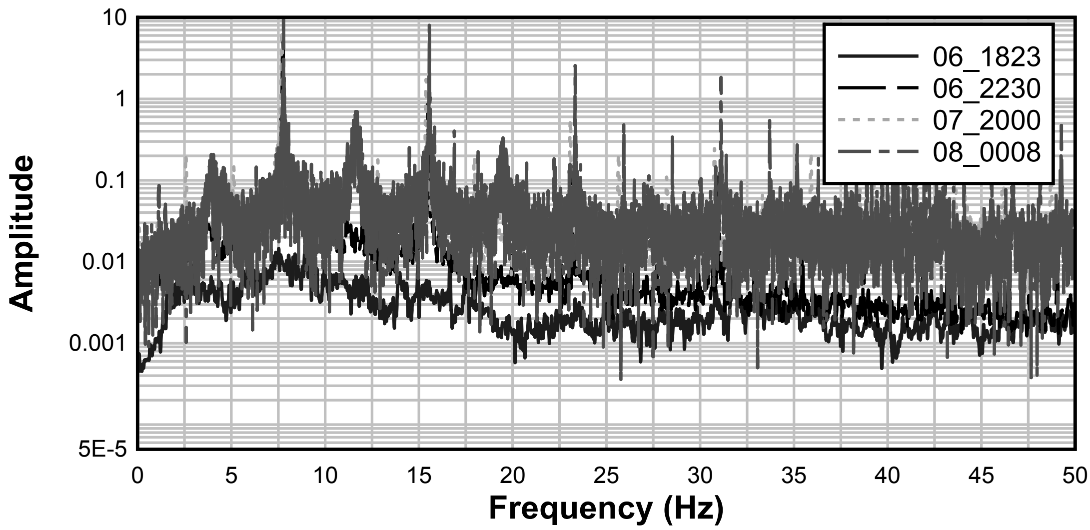

Fig. 5 Fourier Spectrum of the vibrations at Gear Box Base (Channel 6) at Different Time Segments Including the Time Prior to The Mill Ceases

2.4 Comparison of Vibrations at Different Channels for Particular Time Segment

Figure 6 shows the Fourier Spectrum of the vibrations at different channels at a fixed time segment. The predominant frequency, for all the Fourier Spectra, peaks at 7.5 Hz when the mill is running. The amplitude of the vibration is less than 10.

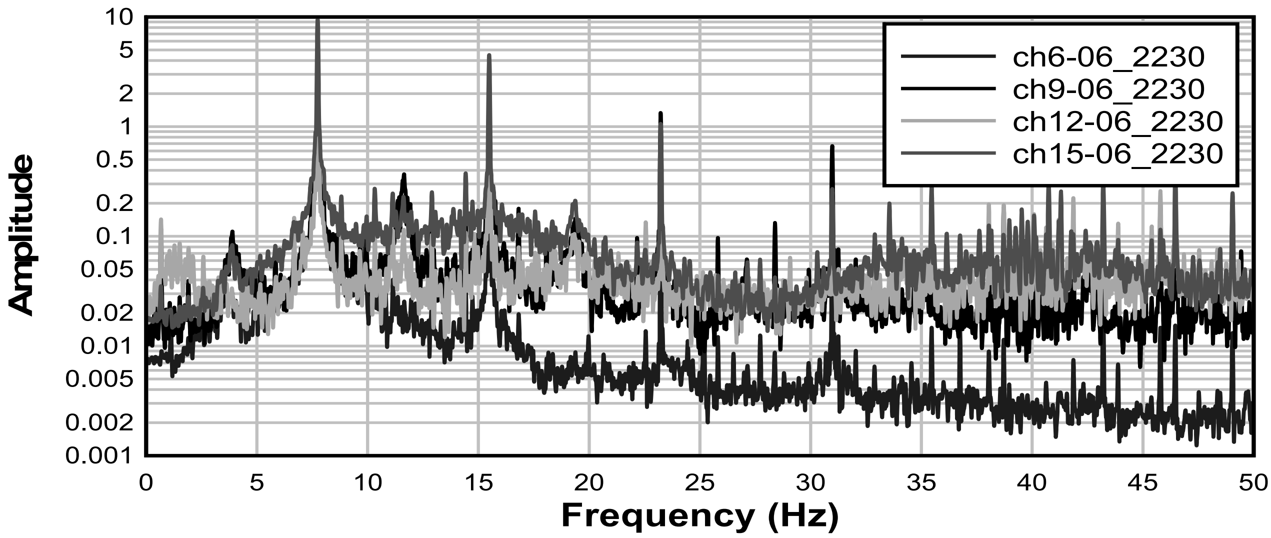

Fig. 6 Fourier Spectrum of the Vibrations at Different Channels

2.5 Comparison of Vibrations at Different Channels for the Time Segment When the Mill Broke Down

Figure 7 shows the Fourier Spectrum of the vibrations at different channels at a fixed time segment prior to the Mill ceases. The predominant frequency, for all the Fourier Spectra, peaks at 7.5 Hz. The amplitude of the vibration is around 13 at all the channels except at channel 9 where the amplitude is around 35.

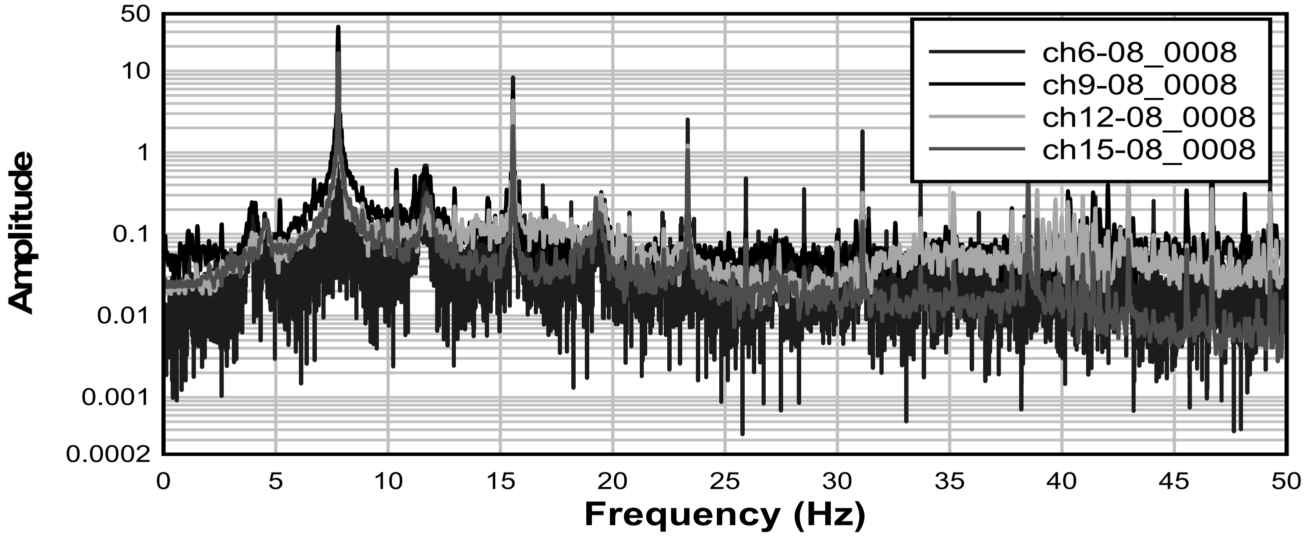

Fig. 7 Fourier Spectrum of the Vibrations at Different Channels at Different Time Segments Including the Time Prior to The Mill Ceases

3.0 Shear –Wave Velocity Estimation through Microtremor Array Observation

Figure 8 shows the estimated value of shear-wave velocity profile for the site. The average shear-wave velocity for a depth of 30 m is 288 m/s. The predominant frequency of the free-field (soil) is 2.4 Hz.

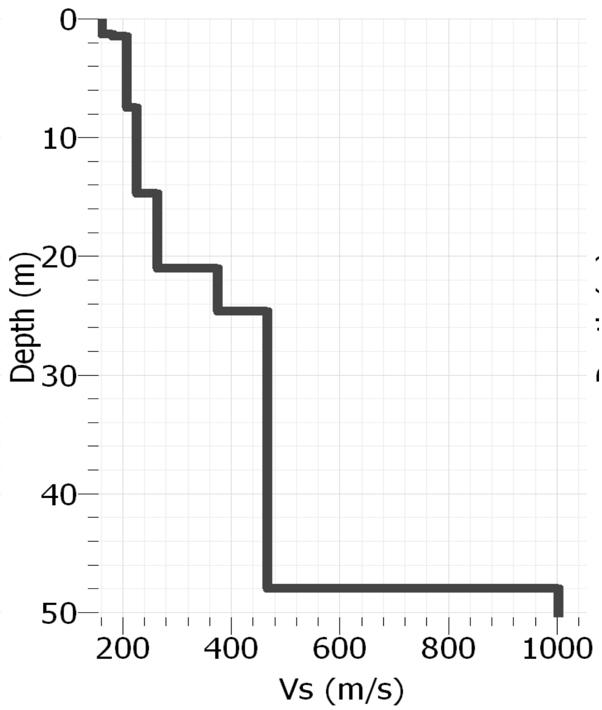

Fig. 8 Estimation of Shear-Wave Velocity at the Plant Site through Microtremor Array

4.0 Remarks on Ball Mill Foundation Vibrations

The predominant frequency of the Mill foundation during operation is 7.5 Hz and for the soil, it is 2.4 Hz. The probability is low for resonance to occur between the Mill foundation and the free field soil.

5.0 Ball Mill Foundation Design

The ball mill foundation consists of P3 type (as designated in design drawings) of bored piles. The salient features of the pile foundation are provided below in Chart 1.

Chart 1: Salient Features of the Pile Foundation of Ball Mill

(i)	Type of foundation	:	Bored cast in situ group pile with continuous pile cap & pedestals at the inlet and outlet of ball mill
(ii)	Total number of piles used in Ball Mill area	:	24 as shown in APPENDIX-B
(iii)	No. of piles in a group in Inlet	:	Six (6)
(iv)	No. of piles in a group in Outlet	:	Six (6)
(v)	No. of piles in a group in gear box & motor base	:	Eight (8)
(vi)	No. of piles in Other areas	:	Four (4) in square
(vii)	Arrangement of piles	:	Rectangular arrangement beneath common pile cap (rectangular irregular shaped)
(viii)	Length of piles	:	20 m
(ix)	Diameter of piles	:	600 m
(x)	Minimum c/c spacing of piles	:	1.8 m
(xi)	Main reinforcement used in pile	:	12-20 mm φ
(xii)	Design strength of pile reinforcement	:	415 Mpa
(xiii)	Design strength of concrete in pile	:	27.5 Mpa
(xiv)	Dimensions of pile cap	:	(3.50 m × 18.6 m) + (3.50 m × 9.9 m)
(xv)	Thickness of pile cap	:	1.5m
(xvi)	Type of pedestals	:	Wall type with rectangular sections

5.1 Subsoil Condition

The subsoil condition of the site was investigated by Development Design Consultants, Dhaka. It is understood from subsoil investigation report that three bore holes (BH. Nos. 15, 16 & 17) were done to a maximum depth of 27 m in the ball mill areas for the purpose designing foundations of the ball mill. Standard Penetration Test (SPT) and other soil parameters were determined. It appears from borehole log and soil report that the soils at all the locations investigated are typical of alluvial sand deposits with a significant depth (approximately 8 meters) of soft soil deposit. The borehole logs are attached as APPENDIX-C.

The soil at the site, in general, consists of four (4) layers of sandy soil deposits. The top layer of 8 m thick is loose fine sand (Av. Field SPT ≈ 2), followed by a thin layer of 3 m of loose to medium dense fine sand (Av. Field SPT ≈ 9) under lain by two thick layer of medium dense to dense fine sand with average field SPTs of 15 and 35 respectively. The water table is approximately at 5.0 m.

5.2 Basic Criteria for Machine Foundation Design

The existing foundations of ball mill can be termed as piled block foundation. According to Srinivasulu & Vaidyanathan (1990), the following criteria should be satisfied from the design point of view for machine foundations.

(a) The machine foundation should be able to carry the superimposed loads without causing shear or crushing failure.
(b) The settlements should be within the permissible limits.
(c) The combined centre of gravity of machine and foundation should as far as possible and be in the same vertical line as the centre of gravity of the base plane.
(d) No resonance should occur, hence, the natural frequency of foundation-soil system should be either too large or too small compared to the operating frequency of the machine. For low-speed machines, the natural frequency should be high, and vice-versa.
(e) The amplitudes under service conditions should be within permissible limits. The permissible limits are generally prescribed by the machine manufacturers.
(f) All rotating and reciprocating parts of a machine should be so well balanced as to minimize the unbalanced forces or moments.
(g) Where possible, the foundation should be planned in such a manner as to permit a subsequent alteration of natural frequency by changing base area or mass of the foundation as may subsequently be found necessary.

From the practical point of view, the following requirements should be fulfilled:

(a) The ground-water table should be as low as possible and ground-water level deeper by at least one-fourth of the width of foundation below the base plane. This limits the vibration propagation, ground-water being a good conductor of vibration waves.
(b) Machine foundations should be separated from adjacent building components by means of expansion joints.
(c) Any steam or hot air pipes, embedded in the foundation must be properly isolated.
(d) The foundation must be protected from machine oil by means of acid resisting coating or suitable chemical treatment.
(e) Machine foundations should be taken to a level lower than the level of the foundations of adjoining buildings.

Keeping the above important points in mind, the foundation design was checked for vertical capacity, settlement and lateral deflection of the pile foundation used. The natural frequency of the piled foundation was also estimated. In the following articles results are reported and discussed.

5.4 Static Analysis of Foundation Capacity and Settlement

The allowable load compressive downward load carrying capacity, vertical settlement and lateral deflection of the pile foundation under inlet and outlet was calculated using the soil parameters as obtained from subsoil investigation report. The results are presented in Chart 3.

Chart 3: Load Carrying Capacity of Pile Groups

Soil Data Taken From	Allowable Compressive Load Capacity with FS =2.5 (kN)	Settlement at Ultimate Compressive Load (mm)	Lateral Deflection at applied Load of 70 kN (mm)
Borehole 15	619	21.8	2.4 - 8.8
Borehole 16	590	22.8	2.4 - 8.8
Borehole 17	624	22.5	2.4 - 8.8

The results indicate that the maximum design capacity of 1034 kN as used in ball mill foundation is an over estimation, while compared to the results using a BNBC recommended factor of safety of 2.5 (Chart 3). However, results appear to be adequate only with a factor of safety of 1.5. The estimated settlement of the foundation is high, thus the expected differential settlement would also be high. It is suggested to carryout a precision topographic survey for the differential settlement at the inlet and outlet pedestals. The lateral deformation is in the range of 2.4mm to 8.8 mm. This should be verified with allowable design deflection.

[

5.5 Dynamic Analysis for Natural Frequency of Piled Foundation

The natural frequency of vertical vibrations (ω_n) of an end bearing pile carrying a load W may be obtained from the relation:

$$\beta \tan \beta = \alpha \qquad (1)$$

Where, α is the ratio of self weight of the pile to the external load carried by it, and

$$\beta = \omega_n H \sqrt{\frac{\gamma}{Eg}} \qquad (2)$$

E and γ are the modulus of elasticity and density of pile material; and H is the height of the pile, g is the acceleration due to gravity. Table 1 shows the values of β for various values of α. For a pile of known characteristics the natural fequency may be obtained using Eq. (2) and Table 1.

Table 1 Coefficients for Natural Frequency of Piles (after Srinivasulu & Vaidyanathan, 1990)

α	0.01	0.10	0.50	0.70	0.90	1.00	1.50	2.00	3.00	4.00	5.00	10.00	20.00	100	∞
β	0.10	0.32	0.65	0.75	0.82	0.86	0.98	1.08	1.20	1.27	1.32	1.42	1.52	1.57	π/2

Now load coming to a pile at the inlet end are basically from mill ball, pile cap and pedestal, and the load can be calculated as 593 kN. The weight of a single pile is 130kN (Chart 2). Therefore,

$$\alpha = \frac{Weight\ of\ pile}{Load\ on\ the\ pile} = \frac{130}{593} = 0.22$$

Corresponding to this value of α, the value of β may a taken as 0.43. Thus the natural frequency may be calculated as:

$$0.43 = \omega_n \times 20\sqrt{\frac{23.5}{24.8 \times 10^6 \times 9.81}} \Rightarrow \omega_n = 69.2$$

The circular natural frequency of the pile is 69.2 rad/sec. This corresponds to a natural frequency of 11 Hz. The predominant frequency of the Mill foundation during operation was measured as 7.5 Hz. The frequency ratio is 0.68 which may result in an amplitude magnification factor of approximately 2.

6.0 Analysis of Vibration Data recorded at Crown Cement Factory

Vibration data has been collected for almost one hour to a nearby Crown Cement Factory. The gearbox in this factory is located axially with the inlet and outlet of the Ball Mill. The BRTC, BUET team conducted the measurement of vibrations using a 15-channel recorder at five locations of the plant, simultaneously. Each of the sensors has three components in X, Y and Z directions. For this study, however, only the vertical components (Z-directions) at the selected locations were measured. The following channels were assigned: Ch 3 (for free-field), Ch. 6 (for Gear-box foundation), Ch. 9 (for Ball Mill outlet foundation), Ch. 15 (for Ball Mill inlet foundation) and Ch. 12 (on the pilecap). Figure 9 shows the Fourier Spectrum of the vibrations at different channels at a fixed time segment. The predominant frequency of the gearbox foundation is 16.5 Hz. The maximum amplitude of the vibration is lower than 1 at all the channels except at channel 6 where the maximum amplitude is around 3.5.

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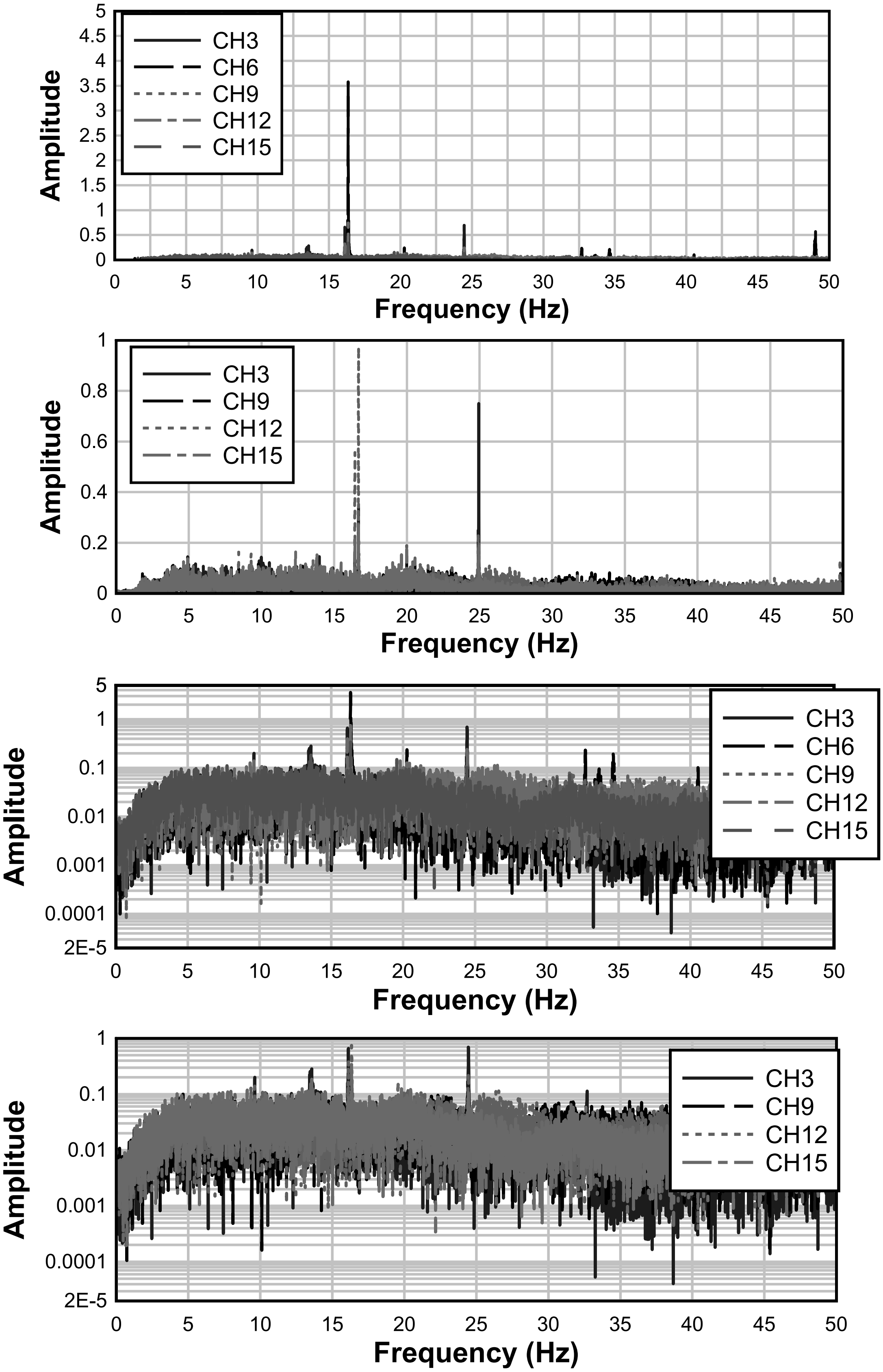

Fig. 9 Vibration analysis at the Crown Cement Factory

7.0 Predominant Frequency of Pile-Foundation System Using Thin Layered Element Method (TLEM)

The dynamic impedance of a groped pile is evaluated by an equivalent single upright beam method, which is first proposed by Konagai *et al* [2000]. A brief description about the equivalent single upright beam analogy is given in this paper. See Ref. [5] for its details. The present single upright beam is a composite of n_p piles and the soil caught among them. Following the assumption of Thin-Layered Element Method ("TLEM"), the soil deposit overlying its rigid bedrock should include a cylindrical hollow of radius R_0. The single upright beam is assumed to be embedded in this hollow. The cross-section πR_0^2 of this hollow is assumed to be identical to the cross-section of the beam A_G enclosed with the broken line circumscribing the outermost piles in the group (Fig. 10). The motion of the hollow is assumed to be compatible with that of the beam. The soil-pile composite together with its exterior soil is divided into n_L horizontal slices as shown in Fig. 10. The following assumptions are adopted to derive the stiffness matrix of the equivalent single beam.

(a) Pile elements within a horizontal soil slice are all deformed at once keeping their intervals constant, and the soil caught among the piles moves with the piles.

(b) Frictional effects due to bending of piles are ignored.

(c) The top ends of piles are fixed to a rigid cap.

(d) All upper or lower ends of the sliced pile elements arranged on the cut-end of a soil slice remain on one plane.

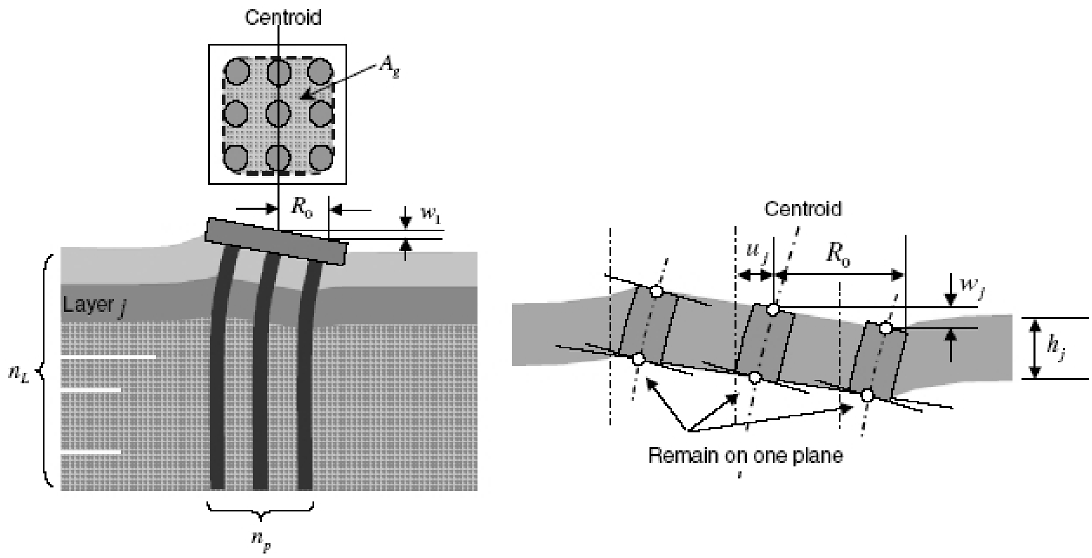

Fig.10 Assumption for evaluation of equivalent single

For the Pile-Soil System in the Emirates Cement Factory:
Predominant frequency for lateral vibration of the whole pile group under an excitation of 7.5Hz has been determined assuming that the superimposed load/mass from the machine and the foundation behaves together as a Single Degree of Freedom (SDOF) system. Total load has been assumed to be 465 ton. Stiffness of the pile group has been determined using Thin Layered Element Method (TLEM) which considers pile-soil-pile interaction of the pile group. To incorporate pile-soil-pile interaction, soil properties were obtained using Microtremor measurements. Soil is assumed to be saturated. Following pile properties have been considered in the present analysis.

Pile length = 20 m
Pile diameter = 600 mm
Number of Piles = 24
Pile locations – as provided in the drawing
Young's modulus of pile = 2.1 E^6 ton/m^2
Unit weight of pile = 2.4 ton/m^3

From the TLEM analysis, it is found that the lateral stiffness of pile group under 7.5 Hz excitation is almost 160,000 ton/m. Thus the predominant frequency of the SDOF system with this stiffness becomes 9.25 Hz.

8.0 Concluding Remarks

The analyses of the data obtained from field observations and scrutiny of the design drawing lead to the following conclusions regarding vibrations and ceasure of ball mill operations of emirates cement factory at East Mukterpur, Munshigonj.

(i) The predominant frequency, for all the Fourier Spectra, peaks at 7.5 Hz when the Ball Mill is running. The amplitude of the vibration is around 10. Just before the Mill ceases, the amplitude of the vibration is around 13 at all the channels except at channel 9 (outlet) where the amplitude is around 35.

(ii) The design static load creates a settlement of approximately 23 mm; this reveals that their might be differential settlement between inlet and outlet of the ball mill. A precision survey should be carried out.

(iii) The circular natural frequency of the pile is 69.2 rad/sec. This corresponds to a natural frequency of 11 Hz. The predominant frequency of the Mill foundation during operation was measured as 7.5 Hz. The frequency ratio is 0.68 which may result in an amplitude magnification factor of approximately 2.

(iv) The fixing arrangement of gear box and motor should be checked against any damage in the arrangements.

(v) At the Crown Cement Factory: The predominant frequency of the gearbox foundation is 16.5 Hz. The maximum amplitude of the vibration is lower than 1 at all the channels except at channel 6 where the maximum amplitude is around 3.5.

(vi) *From the TLEM analysis, it is found that the lateral stiffness of pile group under 7.5 Hz excitation is almost 160,000 ton/m. Thus the predominant frequency of the SDOF system with this stiffness becomes 9.25 Hz. The frequency ratio is 0.81 which may result in an amplitude magnification factor of almost infinity. This high amplification of displacement may be a cause for failure of the gearbox system.*

Bibliography:

Konagai, K., Ahsan, R. and Murayama, D. : "Simple Expression of the Dynamic Stiffness of Grouped Piles in Sway Motion", Journal of Earthquake Engineering 4(3), 2000: 355-376

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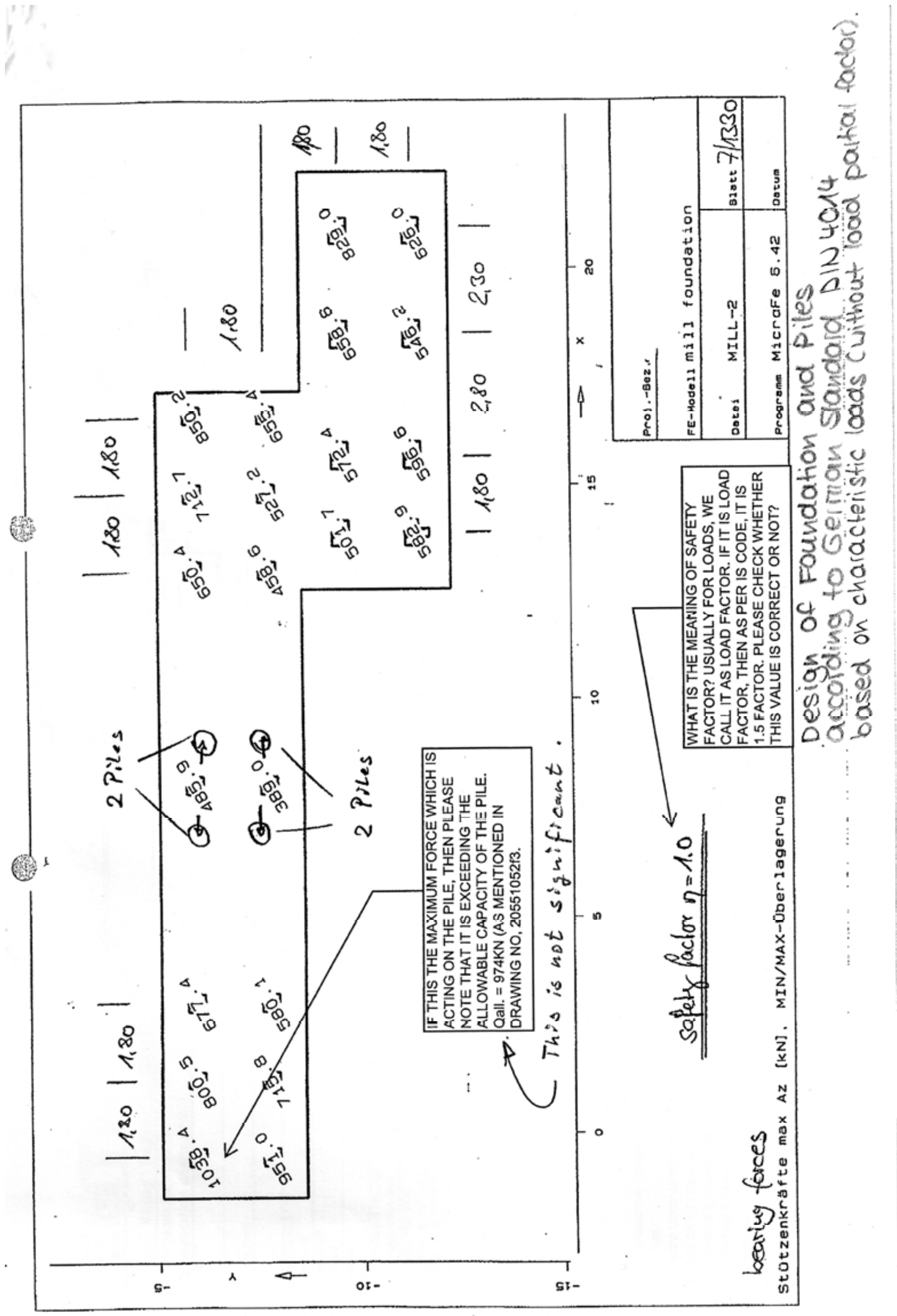
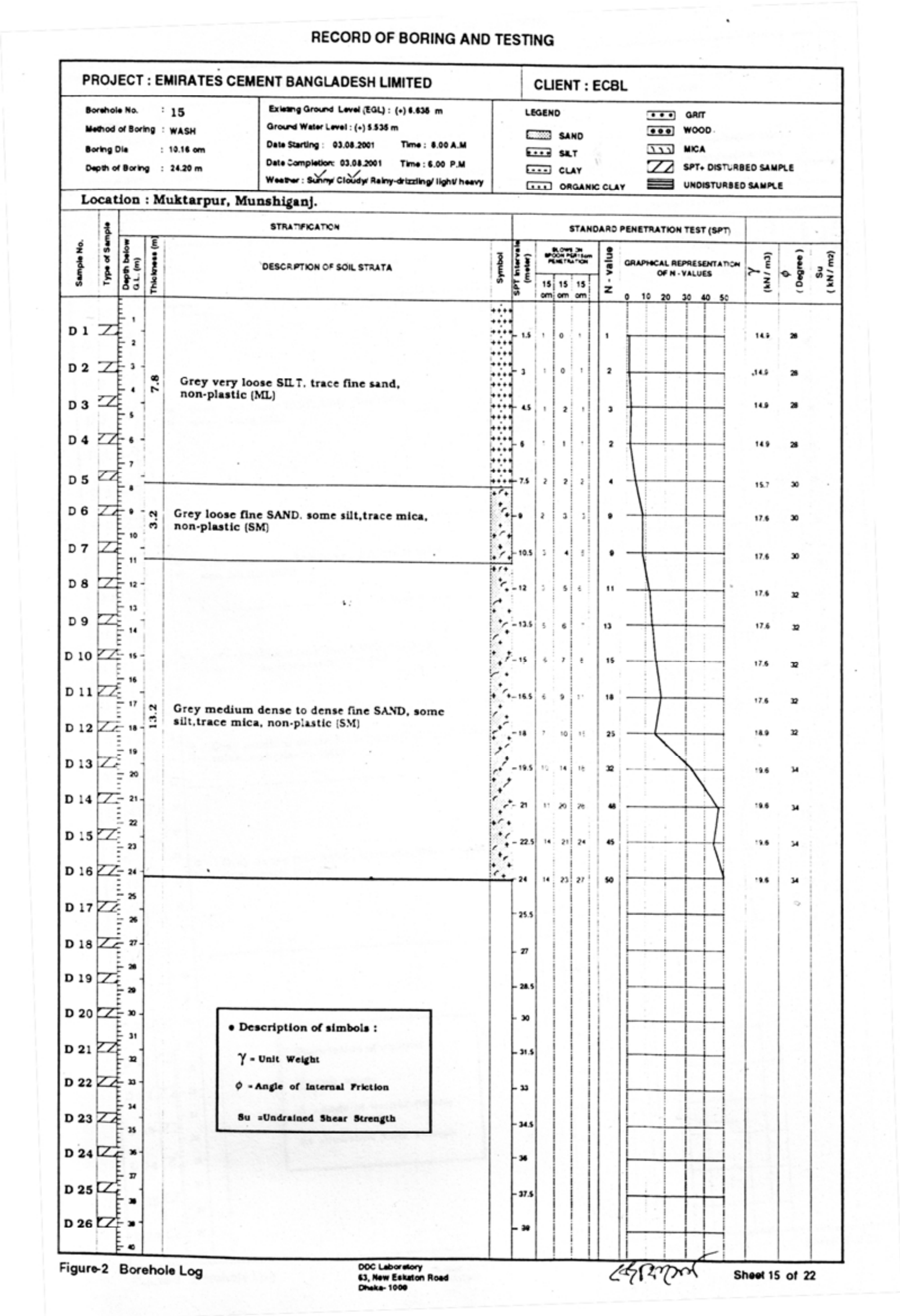
Srinivasulu, P. & Vaidyanathan, C.V. (1990), Handbook of Machine Foundation, Tata McGraw-Hill Publishing Company Ltd., New Delhi.

APPENDIX-B Arrangements of Pile Foundation in Ball Mill



APPENDIX-C Borehole Logs



RECORD OF BORING AND TESTING

PROJECT : EMIRATES CEMENT BANGLADESH LIMITED | CLIENT : ECBL

Borehole No. : 15
Method of Boring : WASH
Boring Dia : 10.16 cm
Depth of Boring : 24.20 m

Existing Ground Level (EGL) : (+) 6.635 m
Ground Water Level : (+) 5.535 m
Date Starting : 03.08.2001 Time : 8.00 A.M
Date Completion: 03.08.2001 Time : 6.00 P.M
Weather : Sunny/ Cloudy/ Rainy-drizzling/ light/ heavy

LEGEND: SAND, SILT, CLAY, ORGANIC CLAY, GRIT, WOOD, MICA, SPT+ DISTURBED SAMPLE, UNDISTURBED SAMPLE

Location : Muktarpur, Munshiganj.

STRATIFICATION

Depth below G.L. (m)	Thickness (m)	Description of soil strata
0 – 7.8	7.8	Grey very loose SILT, trace fine sand, non-plastic (ML)
7.8 – 11	3.2	Grey loose fine SAND, some silt, trace mica, non-plastic (SM)
11 – 24.2	13.2	Grey medium dense to dense fine SAND, some silt, trace mica, non-plastic (SM)

STANDARD PENETRATION TEST (SPT)

Sample No.	SPT Intervals (meter)	15 cm	15 cm	15 cm	N - value	γ (kN/m3)	ϕ (Degree)	Su (kN/m2)
D 1	1.5	1	0	1	1	14.9	28	
D 2	3	1	0	1	2	14.9	28	
D 3	4.5	1	2	1	3	14.9	28	
D 4	6	1	1	1	2	14.9	28	
D 5	7.5	2	2	2	4	15.7	30	
D 6	9	2	3	3	9	17.6	30	
D 7	10.5	3	4	5	9	17.6	30	
D 8	12	3	5	6	11	17.6	32	
D 9	13.5	5	6	[illegible]	13	17.6	32	
D 10	15	6	7	8	15	17.6	32	
D 11	16.5	6	9	11	18	17.6	32	
D 12	18	7	10	15	25	18.9	32	
D 13	19.5	10	14	18	32	19.6	34	
D 14	21	11	20	28	48	19.6	34	
D 15	22.5	14	21	24	45	19.6	34	
D 16	24	14	23	27	50	19.6	34	
D 17	25.5							
D 18	27							
D 19	28.5							
D 20	30							
D 21	31.5							
D 22	33							
D 23	34.5							
D 24	36							
D 25	37.5							
D 26	39							

GRAPHICAL REPRESENTATION OF N - VALUES (0 10 20 30 40 50)

• Description of simbols :

γ = Unit Weight

ϕ = Angle of Internal Friction

Su = Undrained Shear Strength

Figure-2 Borehole Log

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Sheet 15 of 22

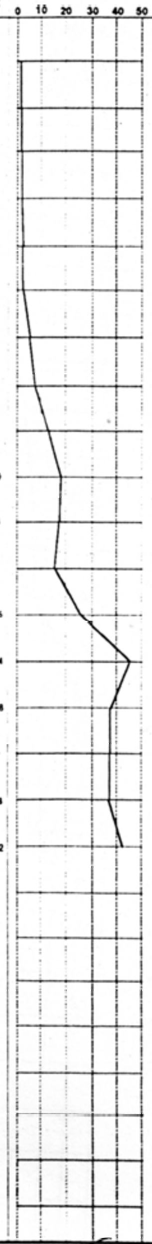
RECORD OF BORING AND TESTING

PROJECT : EMIRATES CEMENT BANGLADESH LIMITED | **CLIENT : ECBL**

Borehole No. : 16	Existing Ground Level (EGL) : (+) 6.600 m	LEGEND	
Method of Boring : WASH	Ground Water Level : (+) 5.500 m	SAND	GRIT
Boring Dia : 10.16 cm	Date Starting : 02.08.2001 Time : 4.00 P.M	SILT	WOOD
Depth of Boring : 27.20 m	Date Completion: 03.08.2001 Time : 1.30 P.M	CLAY	MICA
	Weather : Sunny/ Cloudy/ Rainy-drizzling/ light/ heavy	ORGANIC CLAY	SPT+ DISTURBED SAMPLE
			UNDISTURBED SAMPLE

Location : Muktarpur, Munshiganj.

Sample No.	Type of Sample	Depth below G.L. (m)	Thickness (m)	Description of Soil Strata	SPT Intervals (meter)	Blows 15 cm	Blows 15 cm	Blows 15 cm	N - value	γ (kN/m3)	φ (Degree)	Su (kN/m2)
D 1	SPT	1.5	9.4	Grey very loose SILT, trace fine sand, non-plastic (ML)	1.5	1	0	1	1	14.9	28	
D 2	SPT	3			3	1	0	1	1	14.5	28	
D 3	SPT	4.5			4.5	1	0	1	1	14.5	28	
D 4	SPT	6			6	1	0	1	1	14.5	28	
D 5	SPT	7.5			7.5	1	1	1	2	14.5	28	
D 6	SPT	9			9	1	1	1	2	14.5	28	
D 7	SPT	10.5	3.4	Grey loose fine SAND, and silt, trace mica, non-plastic (SM)	10.5	2	2	3	5	15.3	30	
D 8	SPT	12			12	4	4	4	8	[illegible]	30	
D 9	SPT	13.5	4.4	Grey medium dense fine SAND, trace silt, trace mica, non-plastic (SP- SM)	13.5	4	5	8	13	[illegible]	[illegible]	
D 10	SPT	15			15	5	7	12	19	[illegible]	[illegible]	
D 11	SPT	16.5			16.5	6	8	10	18	[illegible]	[illegible]	
D 12	SPT	18	3.0	Grey medium dense SILT, some fine sand, trace mica, non-plastic (ML)	18	7	[illegible]	8	15	[illegible]	[illegible]	
D 13	SPT	19.5			19.5	8	12	14	26	[illegible]	[illegible]	
D 14	SPT	21	7.0	Grey dense fine SAND, trace silt, trace grit, non-plastic (SP-SM)	21	14	18	26	44	19.6	34	
D 15	SPT	22.5			22.5	11	18	20	38	19.6	34	
D 16	SPT	24			24	10	17	20	37	19.6	34	
D 17	SPT	25.5			25.5	12	19	19	38	19.6	34	
D 18	SPT	27			27	15	20	22	42	19.6	34	
D 19	SPT	28.5			28.5							
D 20	SPT	30			30							
D 21	SPT	31.5			31.5							
D 22	SPT	33			33							
D 23	SPT	34.5			34.5							
D 24	SPT	36			36							
D 25	SPT	37.5			37.5							
D 26	SPT	39			39							



- **Description of simbols :**
  - γ = Unit Weight
  - φ = Angle of Internal Friction
  - Su =Undrained Shear Strength

Figure-2 Borehole Log

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Dhaka- 1000

Sheet 16 of 22

MD. JAGLUL HOSSAIN
Lab. Engr.

RECORD OF BORING AND TESTING

PROJECT : EMIRATES CEMENT BANGLADESH LIMITED | **CLIENT : ECBL**

Borehole No. : 17
Method of Boring : WASH
Boring Dia : 10.16 cm
Depth of Boring : 31.8 m

Existing Ground Level (EGL) : (+) 6.710 m
Ground Water Level : (+) 5.510 m
Date Starting : 01.08.2001 Time : 11.00 A.M
Date Completion: 02.08.2001 Time : 2.30 P.M
Weather : Sunny/ Cloudy/ Rainy-drizzling/ light/ heavy

LEGEND: SAND; SILT; CLAY; ORGANIC CLAY; GRIT; WOOD; MICA; SPT+ DISTURBED SAMPLE; UNDISTURBED SAMPLE

Location : Muktarpur, Munshiganj.

Sample No.	Type of Sample	Thickness (m)	Description of Soil Strata	SPT Intervals (meter)	Blows 15 cm	Blows 15 cm	Blows 15 cm	N - value	γ (kN/m3)	φ (Degree)	Su (kN/m2)
D 1	SPT+Disturbed	3.4	Grey very loose SILT, trace fine sand, trace mica, non-plastic (ML)	1.5	1	0	1	1	14.9	28	
D 2	SPT+Disturbed			3	1	0	1	1	14.9	28	
D 3	SPT+Disturbed	3.2	Grey very loose SILT, and fine sand, trace mica, non-plastic (ML)	4.5	1	0	1	1	14.9	28	
D 4	SPT+Disturbed			6	1	1	1	2	14.9	28	
D 5	SPT+Disturbed	1.4	Grey very loose SILT, some fine sand, trace mica, non-plastic (ML)	7.5	1	1	2	3	14.9	28	
D 6	SPT+Disturbed	4.6	Grey very loose to loose fine SAND, and silt, trace mica, non-plastic (SM)	9	1	2	2	4	15.7	30	
D 7	SPT+Disturbed			10.5	2	2	3	5	15.7	30	
D 8	SPT+Disturbed			12	2	3	7	10	[illegible]	30	
D 9	SPT+Disturbed	6.4	Grey medium dense fine SAND, and silt, trace mica, non-plastic (SM)	13.5	3	5	7	13	[illegible]	32	
D 10	SPT+Disturbed			15	4	8	7	15	[illegible]	32	
D 11	SPT+Disturbed			16.5	5	8	10	18	[illegible]	32	
D 12	SPT+Disturbed			18	4	7	10	17	[illegible]	32	
D 13	SPT+Disturbed	9.0	Grey medium dense dense fine SAND, some silt, trace mica, non-plastic (SM)	19.5	5	10	16	26	18.3	32	
D 14	SPT+Disturbed			21	8	15	22	37	19.5	34	
D 15	SPT+Disturbed			22.5	10	18	20	38	19.5	34	
D 16	SPT+Disturbed			24	10	11	14	25	18.5	32	
D 17	SPT+Disturbed			25.5	7	10	12	22	18.5	32	
D 18	SPT+Disturbed			27	8	14	18	32	19.6	34	
D 19	SPT+Disturbed	3.8	Grey dense fine SAND, little silt, trace mica, non-plastic (SM)	28.5	10	15	20	35	19.6	34	
D 20	SPT+Disturbed			30	10	17	21	38	19.6	34	
D 21	SPT+Disturbed			31.5	12	19	23	42	19.6	34	
D 22	SPT+Disturbed			33							
D 23	SPT+Disturbed			34.5							
D 24	SPT+Disturbed			36							
D 25	SPT+Disturbed			37.5							
D 26	SPT+Disturbed			39							

- **Description of simbols :**

γ = Unit Weight

φ = Angle of Internal Friction

Su = Undrained Shear Strength

Figure-2 Borehole Log

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Dhaka-1000

Sheet 17 of 22

2.0 NDT Using Schmidt Hammer and Ultrasonic Pulse Velocity Meter (UPV)

Figure 1 shows the location map (showing the point of measurement) of the area over which NDTs have been carried out. Figure 2 shows the use of Schmidt Hammer and Ultrasonic Pulse Velocity Meter at the Ball Mill area.

2.1 Crack Detection Using UPV

UPV has been mainly used to detect cracks on the top of the grouted pad on the gearbox foundation. Although some superficial cracks have been observed but their depth of penetration is negligible.

2.2 Concrete Strength Using Schmidt Hammer and UPV

Schmidt Hammer and UPV have been used to estimate concrete strength at the Ball Mill area as shown in Fig. 2. Figure 3 shows the location of the Schmidt Hammer test. Figure 4 shows the conversion curve for Silver Schmidt from rebound number (Q) to concrete strength. The collected rebound number and corresponding concrete strength, and UPV data have been presented in Table 1.

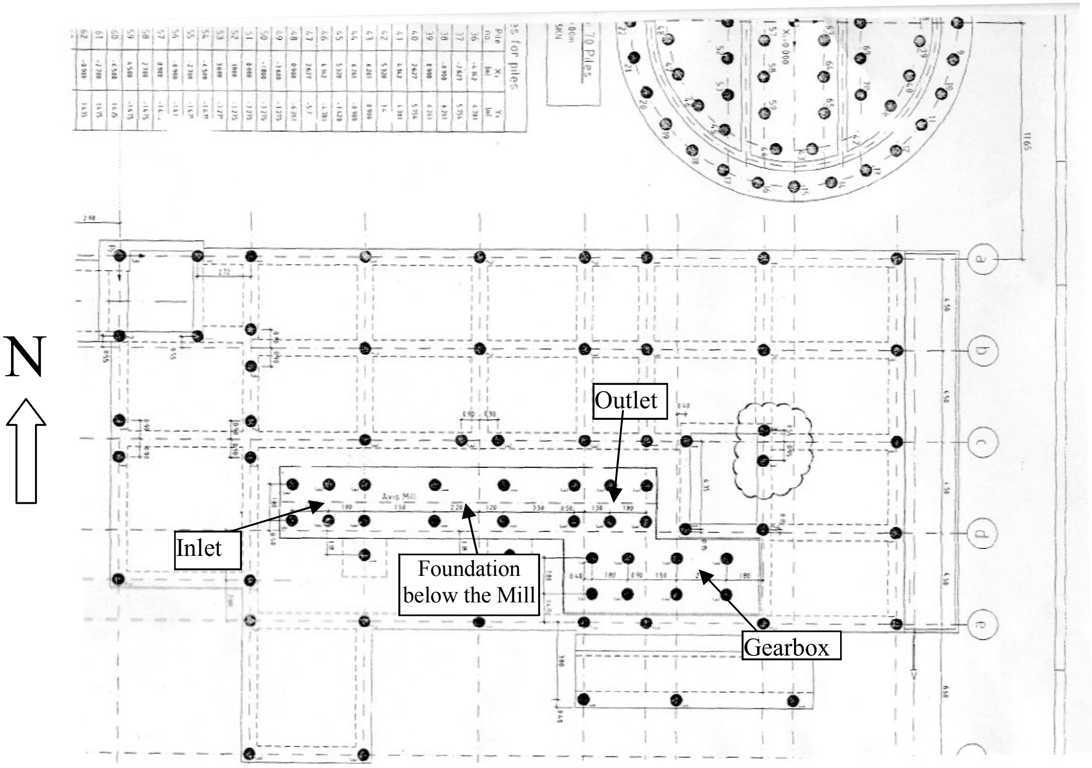

Fig. 1 Locations of NDT Measurement

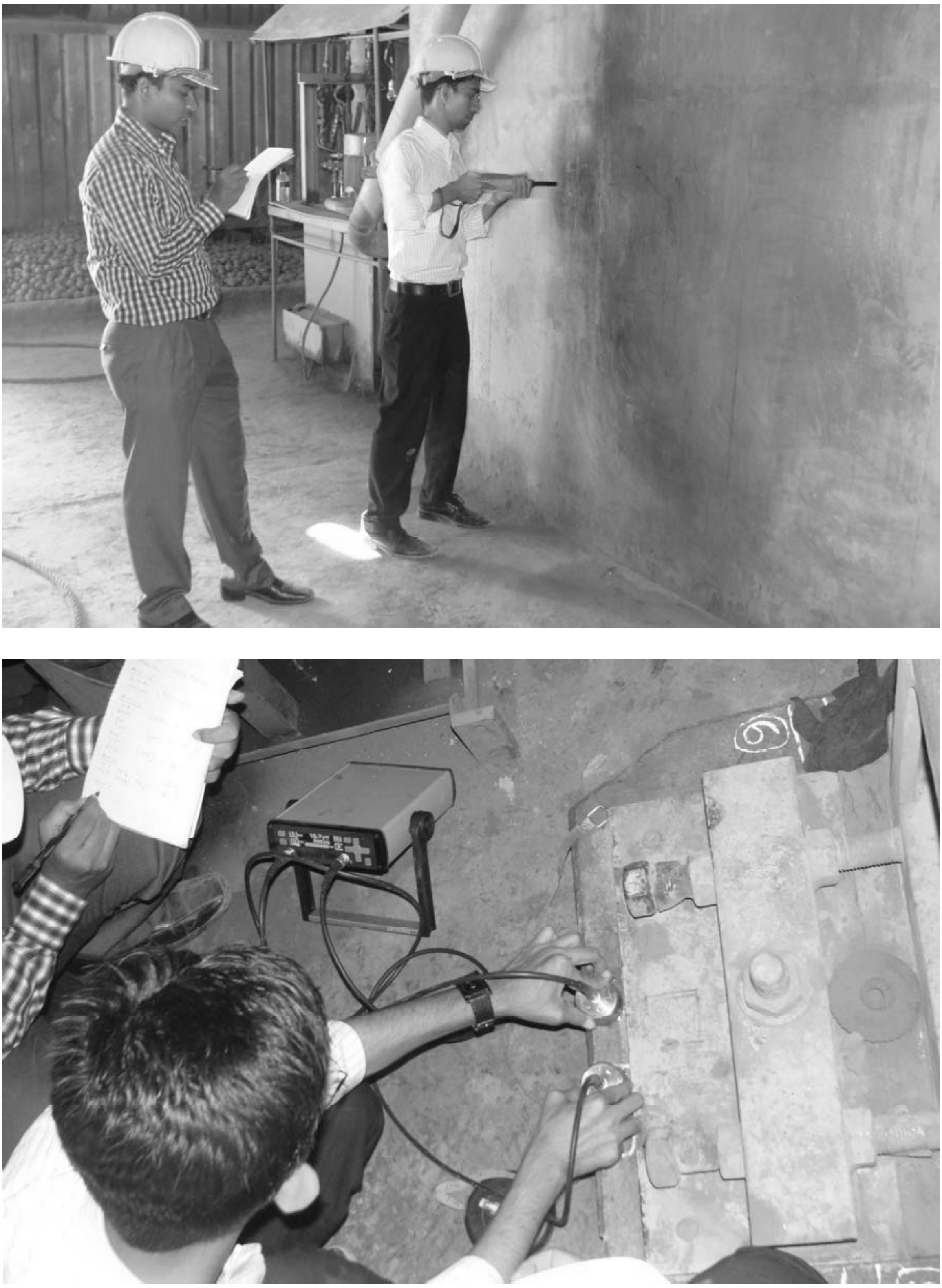

Fig. 2 Use of Schmidt Hammer to estimate concrete strength at the Inlet foundation and use of UPV to detect cracks on the top of gear box

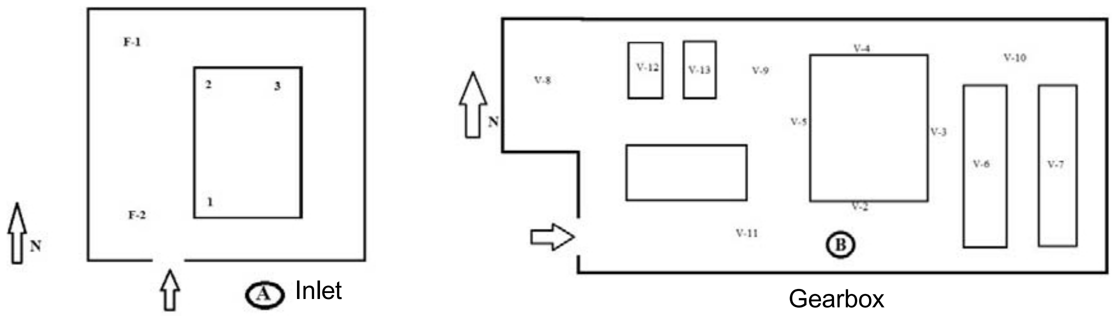

Fig. 3 Location of Schmidt Hammer test

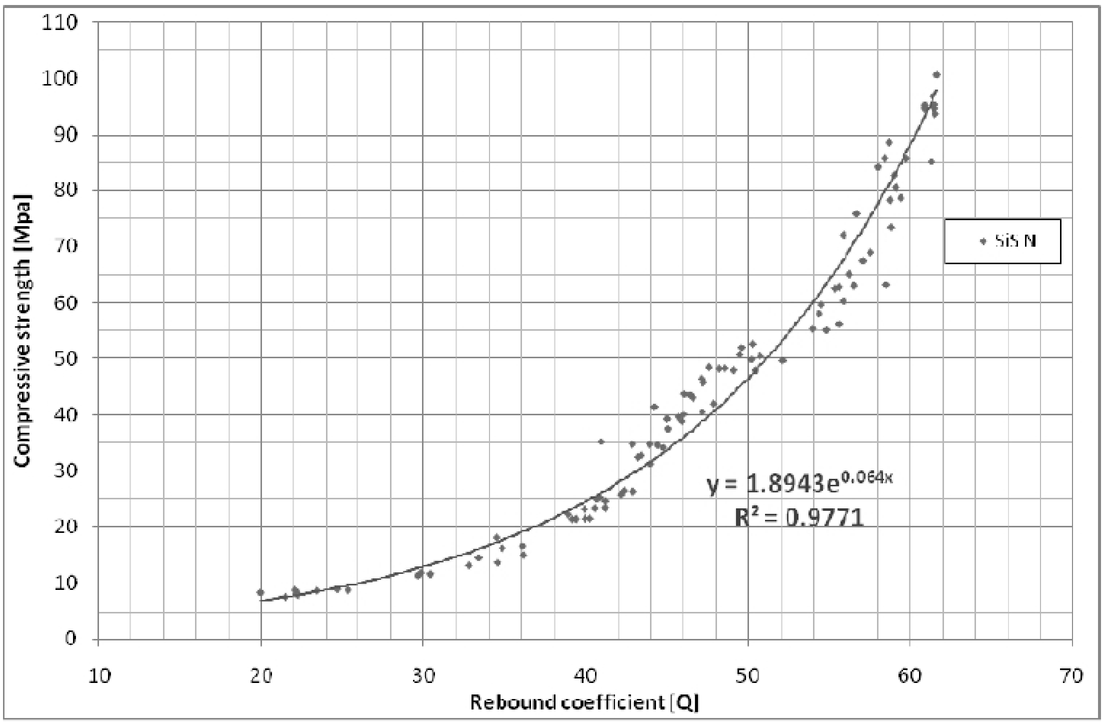

Fig. 4 Conversion curve for Silver Schmidt ST/PC Type N (Valid range 20–62Q, 10-100 MPa)

Table 1 Point location and number, Rebound Coefficient, Compressive Strength and Pulse Velocity

Point location	Point Number	Rebound Coefficient, Q	Compressive Strength, MPa	Average Compressive Strength, MPa	Pulse Velocity (m/sec)
Inlet top grout	1	57	74	71	4115
	2	50	47		3355
	3	61	93		10000
Inlet Foundation	F1	57	74	70	8000
	F2	55	65		4405
Gearbox Foundation	V-1	59	82	76	9900
	V-2	63	109		4201
	V-3	56	66		10000
	V-4	53	57		8264
	V-5	55	64		7352
	V-6	55	64		5988
	V-8	50	47	38	4310
	V-10	49	43		4524
	V-11	47	38		4000
Outlet wall	1	64	113	81	6756
	2	58	76		10000
	3	57	75		10000
	4	54	61		7194
	5	59	80		6329
Inlet wall	1	59	80	70	10000
	2	54	58		10000
	3	55	64		5128
	4	58	77		5154

3.0 NDT Using Ground Penetrating Radar (GPR)

Different frequencies of GPR (1.6 GHz and 400 MHz) have been used to identify the location of reinforcement at different points of the Ball Mill area.

3.1 NDT Using 1.6 GHz GPR

Figure 5 shows an area on the foundation top and a wall to identify the reinforcement locations. Figures 6 to 10 show reinforcement locations on top of the inlet foundation (at a depth of 2 inch) and on wall (at a depth of 1.5 inch), top of the gearbox foundation (at a depth of 1.5 inch) and on wall (at a depth of 1.5 inch), and on the top of the foundation below the Ball Mill (at a depth of 3.5 inch).

3.2 NDT Using 400 MHz GPR

Figure 11 shows an area on the foundation top below the Ball Mill to identify the reinforcement locations. Figure 12 shows reinforcement location on the top of the foundation below the Ball Mill (at a depth of 12 inch).

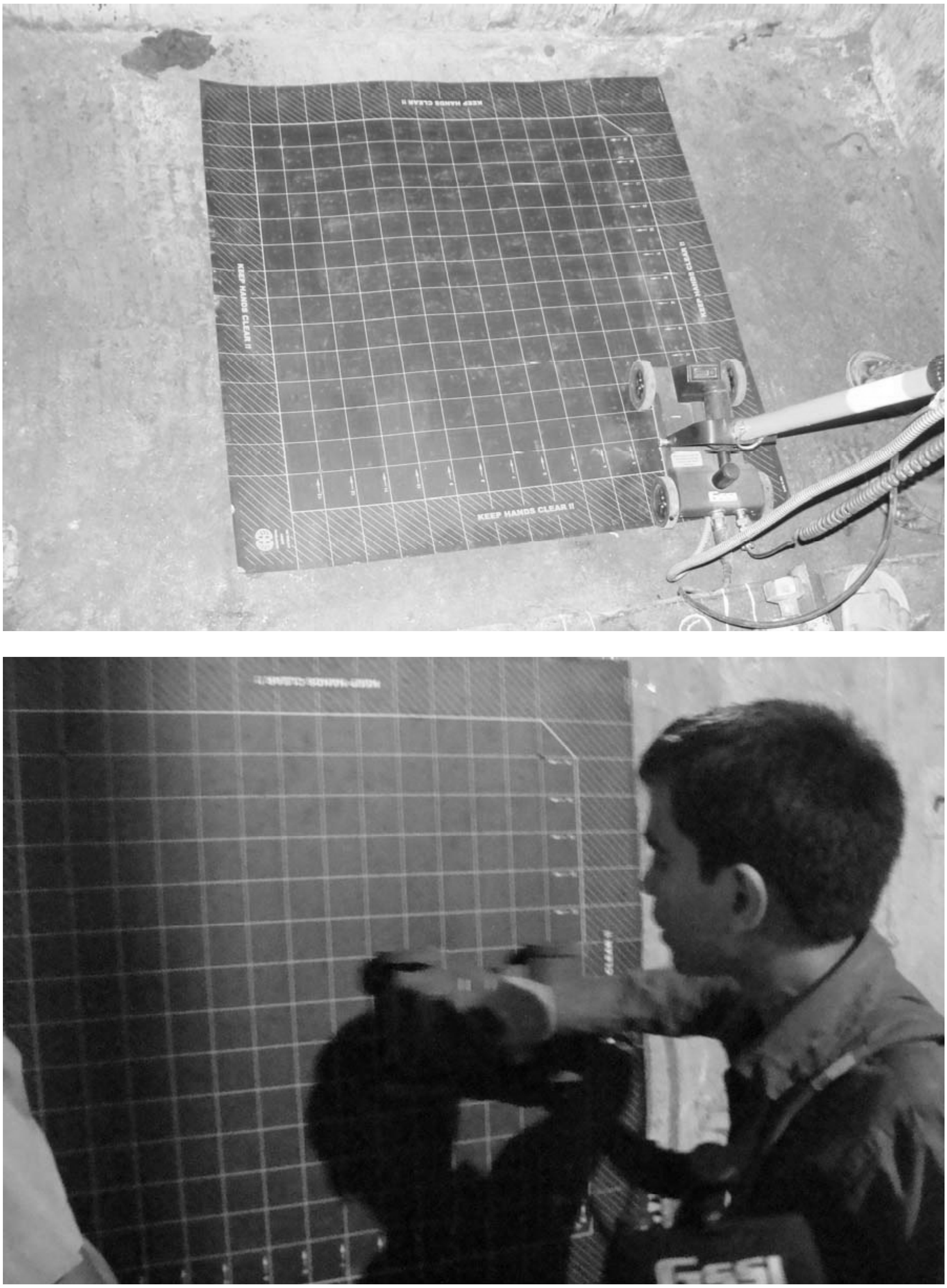

Fig. 5 GPR tests being carried out on the top of the gear box and on the outlet side wall (1.6 GHz)

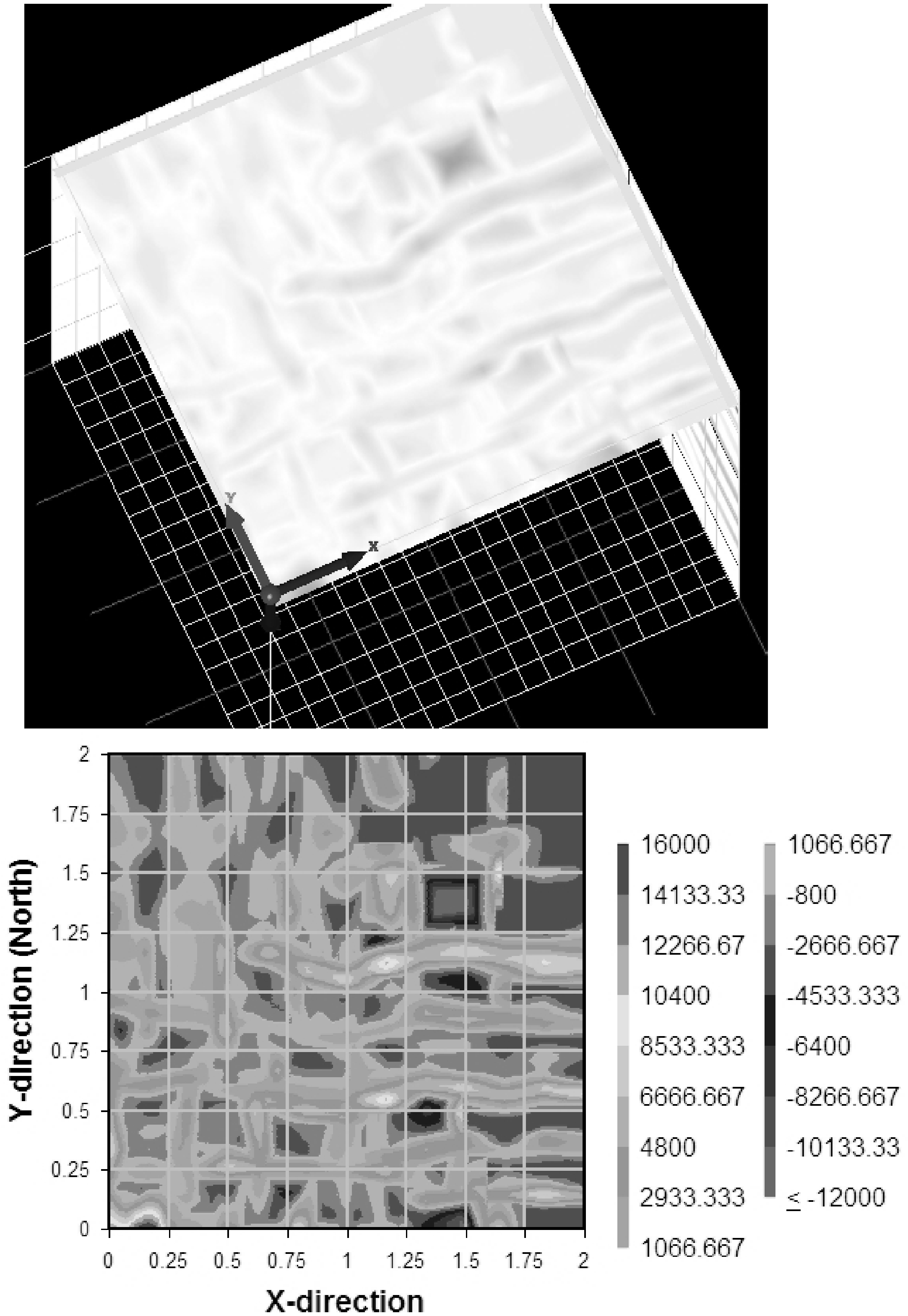

Fig. 6 Analysis of GPR results on the top of the inlet foundation (2

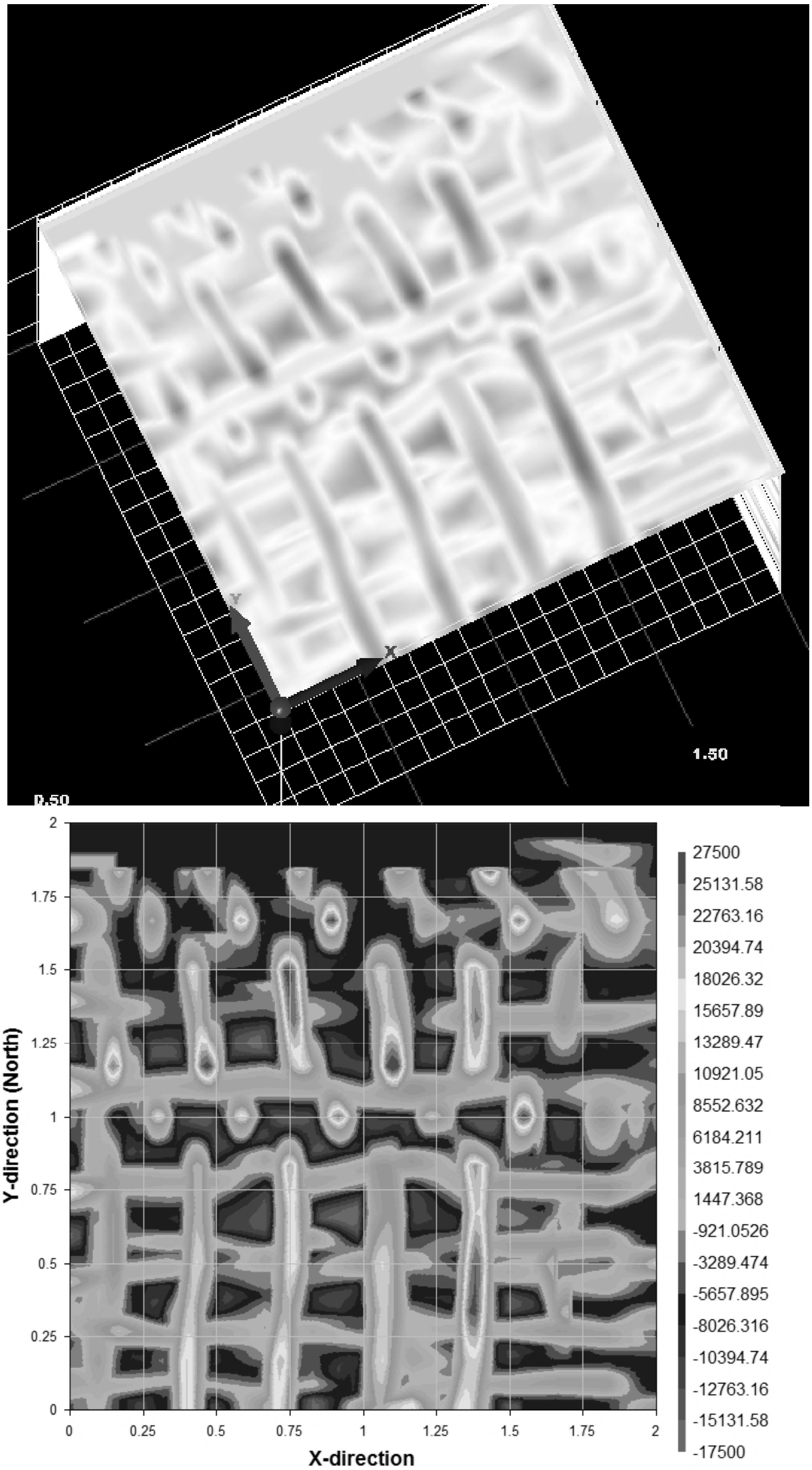

Fig. 7 Analysis of GPR results on the sidewall of the inlet foundation (1.5

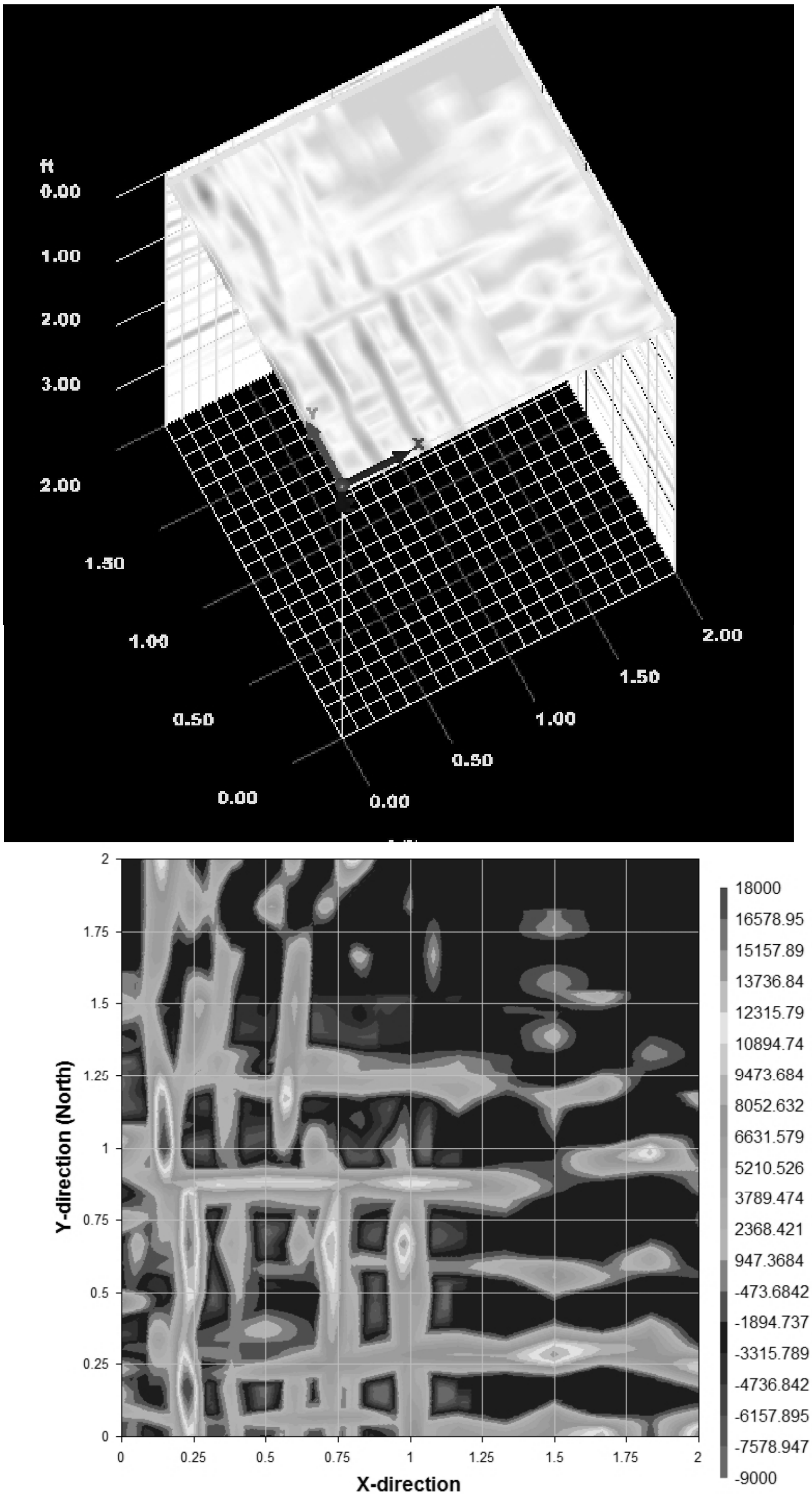

Fig. 8 Analysis of GPR results on top of the gearbox foundation (1.5 inch)

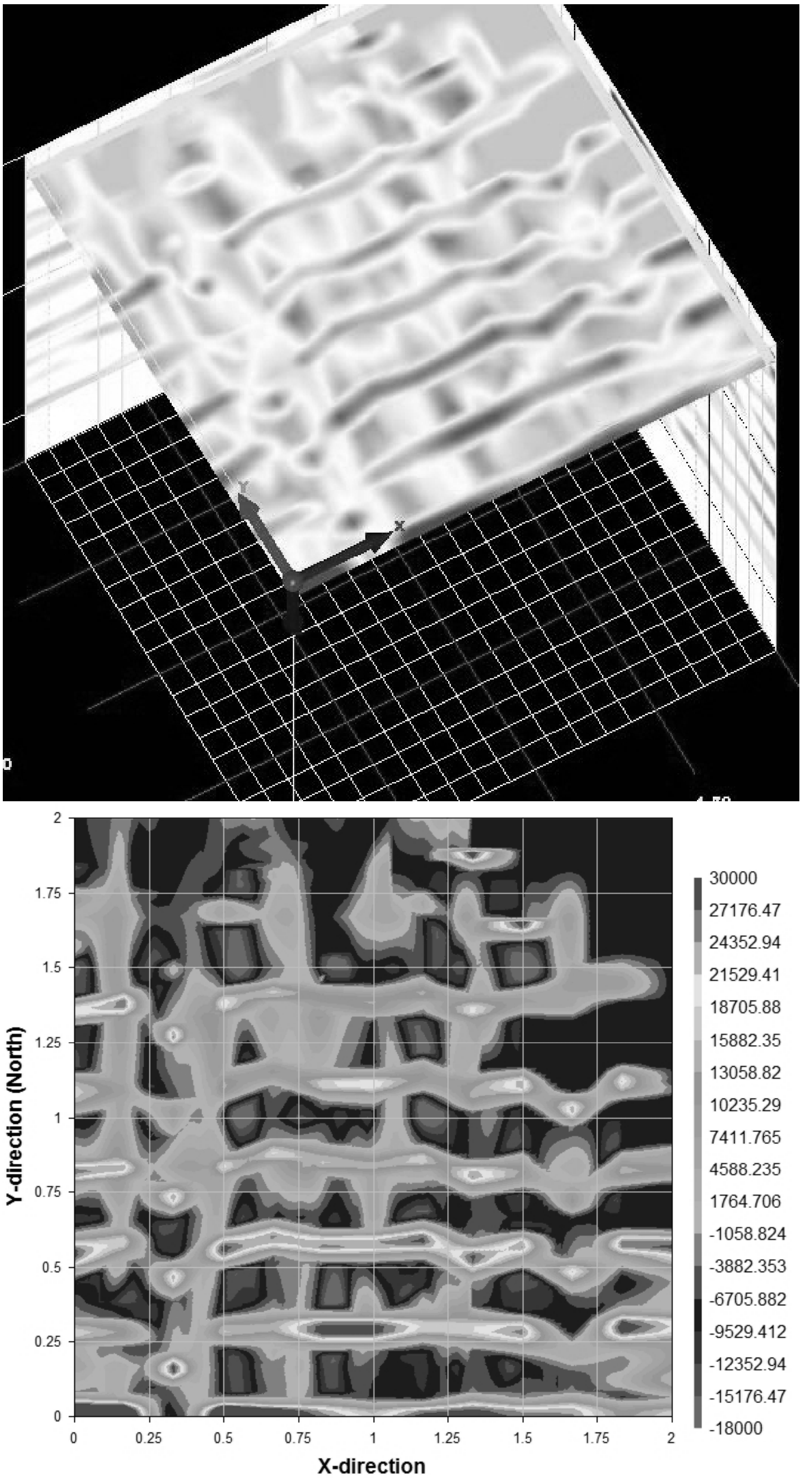

Fig. 9 Analysis of GPR results on the sidewall of gearbox foundation (1.5

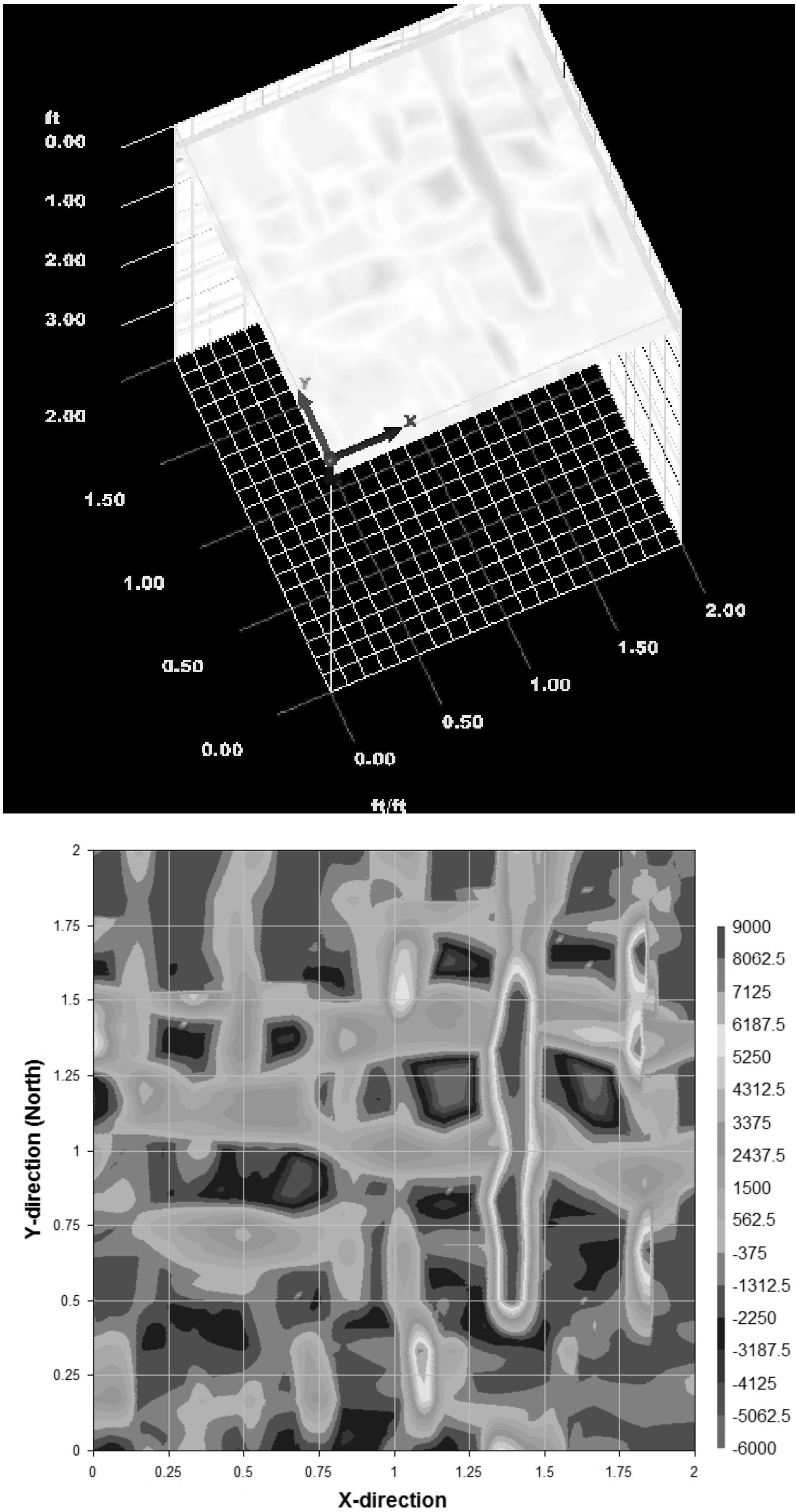

Fig. 10 Analysis of GPR results on the foundation below the Ball Mill (3.5 inch)

4.0 Concluding Remarks

The analyses of the data obtained from field observations and scrutiny of the design drawing lead to the following conclusions regarding Ball Mill foundation area of Emirates Cement factory at East Mukterpur, Munshigonj.

(vii) No substantial crack has been observed on the grouted area of the foundation top.

(viii) Concrete strength at different locations of the Ball Mill area have been estimated and presented in tabular form using Schmidt Hammer. Additionally pulse velocities of the same locations have been reported.

The obtained concrete strength is quite high (around 70 MPa), then mentioned in the existing design sheet supplied by CEMAG (around 25 MPa).

(ix) GPR has been used to locate the reinforcement at different foundation and wall locations. Reinforcement has been detected at a depth of 1.5 inch from the surface at the top of the outlet and inlet foundations and wall of the outlet and inlet foundations. Reinforcement has been detected at a depth of 3.5 inch and at a depth of 12 inch for the foundation (pile cap) below the Ball Mill area.

The location of reinforcement identified through this study matches with the location of reinforcement shown in the design sheet supplied by CEMAG.

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BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

PART-XI

DEVELOPMENT OF FLOOD MAP OF DHAKA CITY

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: Naima Rahman

Introduction

1.1 Background

Bangladesh is known as the 'land of rivers' and major rivers that flow through Bangladesh are the Ganges, the Brahmaputra and the Meghna with a complex network of 230 rivers including 57 international trans-boundary (cross boundary) rivers. The Ganges (Padma), the Brahmaputra (Jamuna) and the Meghna are the large rivers systems in the world covering a total combined catchment area of about 1.6 million sq km and extending over Bhutan, China, India and Nepal of which only 7% falls in Bangladesh (FFWC, 2001). Topography of the country is mostly flat except some part in the northeast and southeast, which are hilly. The land elevation varies from 3 to 90 m above MSL. More than 50% of the floodplain is within the 5m level above MSL. The very location and the topography make the country vulnerable to floods.

Because of the geographical location Dhaka City is vulnerable to flood more or less. The City is surrounded by Buriganga to the south, Turag to the west, Tongi khal to the north, and Balu to the east. The elevation of Greater Dhaka is 2 to 13 meters above the mean sea level, and most of the urban area located at elevation of 6 to 8 meters above the mean sea level. The land area above 8 meters above mean sea level covers only 20 square kilometers while Dhaka's city area is 360 sq. Kilometers. The land ranging from 6 to 8 meters above mean sea level covers 75 square kilometers, while 170 square kilometers of Greater Dhaka is below 6 meters above mean sea level (JICA 1987). Because of being surrounded by the distributaries of several major rivers, the city has been subjected to periodic flooding since its early days. Major floods in the Greater Dhaka area have been occurred in 1954, 1955, 1970, 1974, 1980, 1987, 1988, and 1998 due to spillover from surrounding rivers. Among these occurrences, the 1988 and 1998 floods were catastrophic. During the 1988 flood about 85 percent of the city was inundated with water depth ranging from 0.3 to over 4.5 meters. About 60 percent of city dwellers were affected by the then 1988 flood. It also disrupted city life, air travel, and communication from the capital city to the outside world. The 1998 flood was most severe in terms of extent and duration. It was estimated that about 56 percent of the city was inundated, including most of the eastern and 23 percent of the western parts of the city.
Because of internal water logging in the city, Dhaka has also experienced flood. It is basically for human activities rapid urbanization of the city. The 1998 flood of Dhaka has been occurred due to internal water logging. During the 1998 flood, excessive rainfall in Dhaka caused short-duration flooding in the areas of Shantinagar, Nayapaltan, Rajarbag, Dhanmodi, Azimpur, and Green Road. Beside this, flood also occurred in 2000, 2004 and 2007 due to water logging. Among these characteristics of flood of 2004 was almost similar to the flood of 1998.
As the City has been facing frequent flooding, it requires vulnerability assessment as the basis of proper planning for Dhaka City. Keeping this in sense the authors tried to indentify the vulnerable area in Dhaka City to flooding. Flood vulnerability refers to the degree of loss of damage due to flood and this damage due to flooding depends of several factors such as

flood depth, duration of the flood, flow velocity, sediment concentration and pollution. The present study only focuses on water depth in preparing the vulnerability map for Dhaka City.

1.2 Objective

The study has been conducted with the following objectives:

- To prepare a flood vulnerability map of Dhaka city.
- To Develop Connectivity Index for Drain

1.3 Scopes

During the last 25 years, so rapid urbanization has taken place in Dhaka City. Substantial increase in built-up areas has taken place due to development of residential and commercial areas mostly through private land developers and real estate business. These activities resulted in substantial increase in impervious area, created obstruction to natural drainage pattern, and reduced detention basins, which in turn lead to shortening of the overflow concentration time and an increase of the peak flow. As a result flood occur frequently causing devastating water logging in the city. It is important to find out the most vulnerable areas of flood and also to realize that very few urban drainage systems. Thus the study focuses to find out the vulnerable areas of flood by preparing vulnerability map of Dhaka City, which will be helpful to take appropriate steps for better management of the problem due to flood.

1.4 Limitations

Some limitations were encountered during the study period to complete research work according to the selected objectives. Very few studies were conducted related to flood and drainage system of Dhaka City. As a result, there was no sufficient literature to enrich the analysis of this study by reviewing their study findings. There was no sufficient secondary data to collect related to past drainage system in terms of width, length, depth, capacity, pick flow rate, drainage coefficient etc. and their layout. Due to the lack of detailed elevation data, sometimes it was very hard to measure the actual depth of flood.

Review

2.1 Flood

A flood is an overflow of an expanse of water that submerges land. The term "flood" is a general or temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters or from the unusual and rapid accumulation or runoff of surface waters from any source.

Flooding and flash flooding are the deadliest of natural disasters. Floodwaters claim thousands of lives every year and render millions homeless. One of the more frightening things about flooding is that it can occur nearly anywhere, at any time. It can result from excess water jams on rivers, even moderate rain, or a single very heavy downpour. (http://www.vigyanprasar.gov.in/comcom/feature64.htm)

2.2 Flood Risk Assessment

The assessment of the flooding risk hazard requires a multidisciplinary approach; coupled with the hydrological/hydraulic modeling, the contribution of geomorphology can play an exhaustive and determining role using the GIS tools (Townsend & Walsh, 1998).

The frequency and importance of floods require further work to reduce flood damages and improve flood monitoring by the agencies in charge of flood protection, such as government agencies, civil protection authorities or municipalities. The analysis and management of floods constitute the first indispensable step towards, and a rational basis for, the development of flood protection. (Craciunescu et al., 2005)

Georgakos et al (1997) undertook an estimation of flash flood potential for large areas in United States of America. A methodology for determining the potential for flash floods in small basins within large geographical area was presented. Geographical Information System (GIS) technology was used to assimilate digital spatial data, remotely sensed data with physically-based hydrological – hydraulic models catchment response.

Okoduwa (1999) applied Geographic Information System (GIS) in the prediction of urban flooding in Benin City. Nigeria. This was achieved by creating a digital database of selected variables such as land use, land cover and soil strength. The software used was Arcview 3.1 and the overlay technique in GIS was used for analysis. In carrying out the overlay operation, the researcher first carried out the land use and the reclassified Digital Elevation Model (DEM). The land use map and the relief map were overlayed using the union function with the geo-processing hazard contained in the Arcview. The union function was used to create new theme by overlaying two polygons of the input theme. That is, the land use them and relief theme, were split at their intersection. The dissolved function contained in the geo-processing wizard was used to enhance the merging of the feature of the two themes which generated a theme called land Relief Map. The land relief map was then overlayed on the soil strength, and high intensity of land use as well as areas with low relief, are areas that are prone to high flooding, while areas with high soils strength, low intensity of land use, as well as with high relief are prone to low flooding. Also areas with medium soil strength, medium intensity of land use as well as areas with medium relief are prone to medium flooding. Having overlayed the land Relief map on the soil strength map, the overlay gave a map (of Benin City), showing areas that are prone to high flooding areas prone to medium flooding, and areas that are prone to low flooding respectively.

A study was carried out to create flood vulnerability map of Munshiganj district using satellite and GIS techniques. Landsat TM data was used to generate a land cover, and JERS-SAR and RADASAT data were combined to map flooded area in a normal flood event. Combining them with population data a population distribution map was produced according to land use types. Subsequently, this outcome was compared with flooded area mapped using satellite data in creating population that is at risk during a normal flood event. Attempt was made to identify shelters in a flood event based on information such as existing schools/hospitals location, topography and accessibility. Prioritization of shelters was carried out based on population at risk during a normal flood event. Finally, a flood mitigation plan for Munshiganj district based on evacuation was proposed considering selected center capacities and the accessibility. (Prathumchai, 2006)

2.3 Floods in Bangladesh

Bangladesh is prone to the natural disaster of flooding due to being situated on the Ganges Delta and the many tributaries flowing into the Bay of Bengal. The coastal flooding twinned with the bursting of Bangladesh's river banks is common and severely affects the landscape and Bangladeshi society. 75% of Bangladesh is less than 10m above sea level and 80% is flood plain, therefore rendering Bangladesh a nation very much at risk of further widespread damage despite its development, especially as its present flood defenses are unsustainable and somewhat amateur. Flooding normally occurs during the monsoon season from June to September during the monsoon. The convectional rainfall of the monsoon is added to by relief rainfall caused by the Himalayas. Melt water from the Himalayas is also a significant input and flood every year.

Each year in Bangladesh about 26,000 km2, (around 18%) of the country is flooded, killing over 5,000 people and destroying 7 million homes. During severe floods the affected area may exceed 75% of the country, as was seen in 1998. This volume is 95% of the total annual inflow. By comparison, only about 187,000 million m3, of stream flow is generated by rainfall inside the country during the same period. The floods have caused devastation in Bangladesh throughout history, especially during the years 1966, 1987, 1998 and 1988. The 2007 South Asian floods also affected a large portion of Bangladesh.

Small scale flooding in Bangladesh is required to sustain the agricultural industry, as sediment deposited by floodwaters fertilizes fields. The water is required to grow rice, so natural flooding replaces the requirement of artificial irrigation, which is time consuming and costly to build. Salt deposited on fields from high rates of evaporation is removed during floods, preventing the land from becoming infertile. The benefits of flooding are clear in El Niño years when the monsoon is interrupted. As El Nino becomes increasingly frequent, and flood events appear to become more extreme, the previously reliable monsoon may be succeeded by years of drought or devastating floods. Also, some 3 thousand people were left homeless or killed. (Wikipedia)

In Bangladesh, the following types of floods are normally encountered.

- **Flash floods** in the eastern and northern rivers are characterized by a sharp rise followed by a relatively rapid recession, often causing high flow velocities that damage crops and property.
- **Local floods** due to high localized rainfall of long duration in the monsoon season often generate water volumes in excess of the local drainage capacity, causing localized floods due to drainage congestion.
- **Monsoon floods** from the major rivers generally rise slowly and the period of rise and fall may extend from 10 to 20 days or more. Spilling through distributaries and over the banks of the major rivers causes the most extensive flood damage, particularly when the three major rivers rise simultaneously.
- **Floods due to storm surges** in the coastal areas of Bangladesh, which are generated by tropical cyclone, cause extensive damage to life and property. These cyclones are predominant during the post-monsoon (October and November) and pre-monsoon (April to June) period. (Wikipedia)

2.4 Floods in Dhaka City

The occurrence of floods in and around Dhaka City can be traced back to as early in 1787-88 when terrible inundation occurred and the streets of Dhaka were submerged to a depth sufficient to admit boats sailing along them. Again in 1833-34, 1870 devastation due to floods were reported (Hunter, 1877). Major floods also occurred in 1954, 1955, 1962 and 1966, which severely affected the city of Dhaka (Rizvi, 1969). Floods that occurred during 1970, 1974, 1987, 1988 and 1998 also affected the city. Among these the floods of 1988 and 1998 were catastrophic. It was estimated that about 77 per cent of city area were submerged to depths ranging between 0.3 to over 4.5 metres and that about 60 per cent of city population were directly affected in the 1988 flood (FAP, 1991). The return period for a 1988 flood was estimated at 70 years but in just 10 years another flood occurred in 1998.

The 1998 flood of Bangladesh was an unprecedented event of its kind in terms of duration, inundation of areas and damages (DMB, 1998). It was estimated that 79 per cent of Dhaka City area were inundated ranging between 0.3 to over 3.0 metres and that about 60 per cent city population were under inundation for about 10 weeks – the longest time in memory. The city experienced colossal loses in housing, infrastructure, industry and commerce sectors. According to DCC estimates, two-thirds of the city roads and 75% of *kutcha* and semi-*pucca* houses were affected in the flood. It was reported that 1000 km of city streets, 400 km of drains, 40 km of foot paths, 400 switch points and 1 lock gate were affected and these were estimated at Taka 4.0 billion or US$ 89 million (DCC, 1998). The total damage in housing sector was estimated at Taka 2310.9 million or US$ 48.2 million (Islam, 1998).

Poor drainage has been identified as the principal cause of flooding in the metropolitan areas of Bangladesh. Flooding in Dhaka City is mainly caused by heavy rainfall, drainage congestion, high surrounding water and overflow of rivers. In whatever way flood occurs, it disrupts city life and inflicts major damages. Local flooding due to poor drainage affects 65 per cent of slums and squatter dwellers and 22 per cent of city dwellers are regularly flooded during minor rainfall (FAP, 1991).

2.5 Mapping Flood of Dhaka City

Dhaka city, the capital of Bangladesh and home for more than 10 million people, has been affected by seasonal flooding almost in every year, however, the situation aggravates depending on rainfall and surrounding river waters. The unplanned growth of the city and filling of water bodies has made the flood situation worse. The catastrophic events of 1988 and 1998 flood affected the whole capital that widely impacted in the financial growth as Dhaka contributes 16.7% to the national development (Dewan *et al.* 2006). Hydro-meteorological assessment of these events revealed that the 1988 flood was severe due to the lack of flood protection in the city together with trans-boundary flow of the major rivers while the 1998 flood was become deluge due to incessant monsoonal downpour along with early peaked of the river water levels (Dewan *et al.* 2003). The 1988 event has done colossal damage to the city compared to the 1988 event. Remote sensing techniques have been used particularly to map the flood concentrating in the capital. The following two case studies show that how the flood maps were developed for Dhaka city for the 1988 and 1998 events. This is to mention that the use of RS techniques in Bangladesh for mapping flood is quite recent. So studies for mapping floods in Dhaka city for the 1988 event is not available widely. Still to provide a basic idea of the process for 1988 event the case study is included. However the case study for the 1998 event is detailed in this paper.

Case Study 1: Mapping Flood of Dhaka City, 1988

Sado et al. (1997) in his research tries to estimate the flood area based on land cover classification. To map the flooded area of 1988 in Dhaka city, two images were considered using MOS 1-, MESSR data. The first image was of October 17, 1988 which was during the flood and the other was of January 27, 1989 which was the dry season. Sun scenes were extracted from the MOS-1, MESSR full scenes of 2400 pixels and 1800 lines with thinning out rate of 1. Geometric correction was performed to avoid distortions. To establish the relationship between the image coordinate system and the geographic coordinate system positions, seven ground control points (GCP) were chosen. The GCPs were selected from the easily identifiable points on the satellite image and topographic map of Dhaka city. The geometric corrections were performed by using Affine transformation. For applying land cover classification, rectangles were cut out from each original image for different classification. Three corner points of the rectangle were selected on the basis of the topographical map. Resampling was performed using nearest neighbor method from the old image. For land cover classification Parallelepiped classification was used. Composite false color image was created from the two satellite images and then was classified by comparing with the Dhaka city land use map. The classification was broadly segmented into two: Water area and Non-water area. The different spectral characteristics of the rivers, lakes and the deposit water helped to establish the relationship. The CCT count for river water was higher than of lake and deposit water as it had more turbidity during flood which influenced the amount of energy back scattered. Extracting the water area from the non-water area finally helped to develop the map of the flood inundated areas which provided an estimating of the total flood area affected in that catastrophic event.

Case Study 2: Mapping Flood of Dhaka City, 1998

Dewan *et al.* (2006) delineated flood hazard areas for the greatest flood of 1998 in the capital. Six RADARSAT SAR images were acquired that covered the whole flood season of 1998 (July – September). SAR data were despeckled using the GMAA-MAP filter with 5X5 window size. Geometric corrections were carried out using a referenced 1999 Landsat TM image of the same area until the root mean square resulted in less than 1 pixel. A second order polynomial fit was applied and the pixel values were resampled to 50m. As the digital format of GIS data was absent for Dhaka city, an elevation map was developed by slicing the DEM into different categories. The land cover map was generated in a GIS platform using IRS-1D Panchromatic data of February 29, 2000. Ground data and topographic maps were assigned to develop the land cover categories from IRS image. A geomorphic map was also developed by using a Landsat TM of 1999. The projection was transformed to BTM for raster based flood hazard assessment. Flood frequency map based on flood duration was developed using the multi-date SAR imagery. The images were classified to water areas and non-water areas based on algorithms. And the six images were combined to 3 images for each month of July, August and September respectively. The images were superimposed to characterize the inundated areas. Four flood frequency categories were obtained showing high, medium, low and non-damaged areas. Multi-temporal SAR images were also used to estimate the flood water depth. A land level map was extracted from the DEM that consisted of four heights of classes and the ground truth data was created and brought to GIS. The signatures were collected to extract training pixels. A minimum distance supervised classification was applied to classify into four depth categories. In order to assess flood hazard for each category of land cover, elevation height and geomorphic category, a weighted score was estimated and hazard map was decided. Drainage network was overlaid on each flood hazard map to depict the river networks. Several flood hazard maps were constructed to attain the best combination. It was found that two maps produced the highest resemblance.

2.6 Theoretical Framework

2.6.1 Concept of Graph Theory

Graph theory deals with abstract configurations consisting of lines and points, and is suitable for representing the topological properties of transport systems such as for roads, water bodies. Important graph theory concepts and their transport equivalents are:

Link: Imaginary straight line that represents a finite length of road, railway, bus route or water body.

Node: Imaginary points where links intersect. Nodes represent road intersections and railway junctions; on public transport networks nodes also indicate the location of stations or bus stops.

At the highest level of abstraction, networks can be represented by a series of vertices (representing nodes on a network) and a set of edges (representing network linkages), together with a relationship of incidence that associates each edge with two vertices. When so defined, the network is a minimal one in terms of its information content- only the presence or absence of connection between nodes. Measures of spatial properties of such a network are structural and deal with the geometrical pattern of the network.

2.6.2 Connectivity

When a network is abstracted as a set of edges (linkages) that are related to a set of vertices (nodes), a fundamental question is the degree to which all pairs of vertices are interconnected. The degree of connection between all vertices is defined as the connectivity of the network. It is the most important structural property of the network.

Two of the most commonly employed graph theoretic measurements of connectivity are the Gamma and Alpha indices.

The Gamma Index

The gamma index is simply the ration of the number of edges in a network to the maximum number possible in that network:

γ = (actual edge) / (maximum edge)

= e/e_{max}

Here, $e_{max} = 3\ (v-2)$

The inclusion of one additional node to a network of more than 2 nodes increases the number of possible linkages by a value of 3. There is no intersection of linkages except a node.

The numerical range for the gamma index is between 0 and 1. For convenience in interpretation, the numerical value may be expressed as a percentage of connectivity.

The Alpha Index

If one linkage is removed, the network is divided into two completely separates parts. On the other hand, if one or more linkages are added to the network, the connectivity is increased beyond the minimal configuration in which only a single and unique path can be identified between all pairs of nodes. Additional linkages in a network create circuitry. A circuit is defined as a finite, closed path in which the initial node of linkage sequence coincides with the terminal node.

In a finite connected network in which the number of linkages is e and the number of nodes is v, the number of linkages is equal to 1 (one) less than the number of nodes i.e. (e= v-1) only when the network is minimally connected. When circuits exist in the network, the number of linkages is greater than (v-1) or (e>v-1). The number of circuit is obtained by subtracting the number of linkages needed for a minimally connected network (v-1) from the actual number of linkages (e). This may be expressed as e- (v-1) or (e-v+1). It is a measure of the number of independent circuits in the network.

The alpha index is the ratio measure of the number of actual circuits to the maximum number of circuits.

α = (actual circuit) / (maximum circuit)

= (e-v+1) / (2v-5)

The range of index is from a value of zero **(0)** for a minimally connected network to a value of one **(1)** for a maximally connected one. For convenience the numerical value may be expressed as a percentage of circuitry in network.

2.6.3 Application of Graph Theory on the Study Area

The study of the researchers is based on connectivity of drain of Dhaka city. In this case the connectivity index has to be identified by using graph theory. This will show the blockages and the missing links of the drains. The indices will give a numerical value of connectivity of drains. With the help of Gamma Index it will reveal the percentage of connectivity of the drains. The Alpha Index will show the degree of connection i.e. whether the drains are minimally connected or maximally connected.

2.7 Operational Definition

Vulnerability: Vulnerability is the weaknesses or gaps in a system that can be exploited by threats. A vulnerability assessment is the process of identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in a system.

Risk: Risk is the potential for loss, damage or destruction of an asset as a result of a threat exploiting vulnerability and the risk assessment is the procedure to predict the probability of loss and damage due to potential hazard.

Hazard: Hazards have the potential to cause disaster. Natural hazards are the forces of nature which have the potential to cause loss of life and damage of properties of human being.

Drainage System: Channels, either constructed or natural, passes through surface or underground or both that are usually used to drain out the flood or rain water.

Khals: Canals passes through Dhaka City that are created naturally and used as drainage channel to drain out the flood as well as rain water of the city to the surrounded outfall rivers. Begunbari khal, Dholai khal, Shegunbagicha khal, Tongi khal etc. are some major khals in Dhaka City.

Mega City: A metropolitan area having population more than 5.0 million is termed as mega city (Population Census, 2001). According to population census 2001, Dhaka is the only mega city of the country.

Retention Area: Natural or man-made depression usually reserved in urban area to retain the flood or rain water.

Water logging: Flooding in built up areas caused by rainfall, where water remains stagnant for long time due to lack of proper drainage system and creates many adverse impact on daily life.

Methodology

Methodology of the study was developed with due consideration to achieve the objective of the study. As such the following methodological procedures were adopted.

3.1 Formulation of Objective

An objective has been formulated to carry out the study.

3.2 Literature Review

A review of relevant literature has been carried out. It included review of international journal, books, thesis, and local newspaper etc specifically addressing flood issues.

3.3 Study Area Selection

Dhaka City has been selected as the study area. There are two main reasons of choosing this city as the study area. The first reason is that it is the capital of Bangladesh and the most important city. The second reason is data availability.

3.4 Data Collection

Shape files of spot height, structures, land uses, drainage and administrative boundary of Dhaka City have been collected from reliable sources. Flood depths of Dhaka City and danger level of surrounding rivers have been collected from literature review.

3.5 Map Preparation using GIS

ArcGIS 9.2 software has been used to prepare flood map. Collected shape files of spot height, structures, land uses, drainage and administrative boundary of Dhaka City have been added in an mxd layer of ArcMap. Land use map, structure use map, drainage map and flood map have been prepared using the following methodology.

3.5.1 Preparation of Flood map

There are two steps of preparing flood map. First a Digital Elevation Model (DEM) has been produced and then the DEM has been reclassified using the following methodology.

3.5.1.1. Preparation of a Digital Elevation Model (DEM)

A Digital Elevation Model (DEM) has been prepared on the basis of spot height of Dhaka City. Spatial resolution of spot is average 10 m. The lowest spot value is 0.11 m and the highest value is 17.62 m. The following process is followed to prepare DEM:

- 3-D Analyst ➔Options➔General➔Working Directory: Working Folder; Analysis Mask: Dhaka; Extent➔Analysis Extent: same as layer Dhaka; Cell Size➔Analysis cell size: As specified bellow; Cell Size➔9.
- 3-D Analyst ➔Interpolate to Raster➔Inverse Distance Weighted➔Input Points: Spot_height; Z value field: RL; Output cell size: 9; Output raster: fix the location & name the file➔Ok.

3.5.1.2 Preparation of a flood map from the DEM

DEM is reclassified into four categories as elevation 0 to 3 m = High Flood Zone, 3 m to5.5 m = Moderate Flood Zone, 5.5 m to7.2 m = Low flood Zone and above7.2 m = No Flood Zone. The reclassified map is the flood map of Dhaka City. The following methodology is the process of preparing flood map using GIS

- 3-D Analyst ➔Reclassify➔Input raster: DEM➔Classify➔Method: Equal Interval; Classes: 4➔Old Value: 0-3, 3-5.5, 5.5-7.2 and 7.2- 17.2; Output raster➔reclassified➔Ok.

3.5.2 Flood vulnerability map

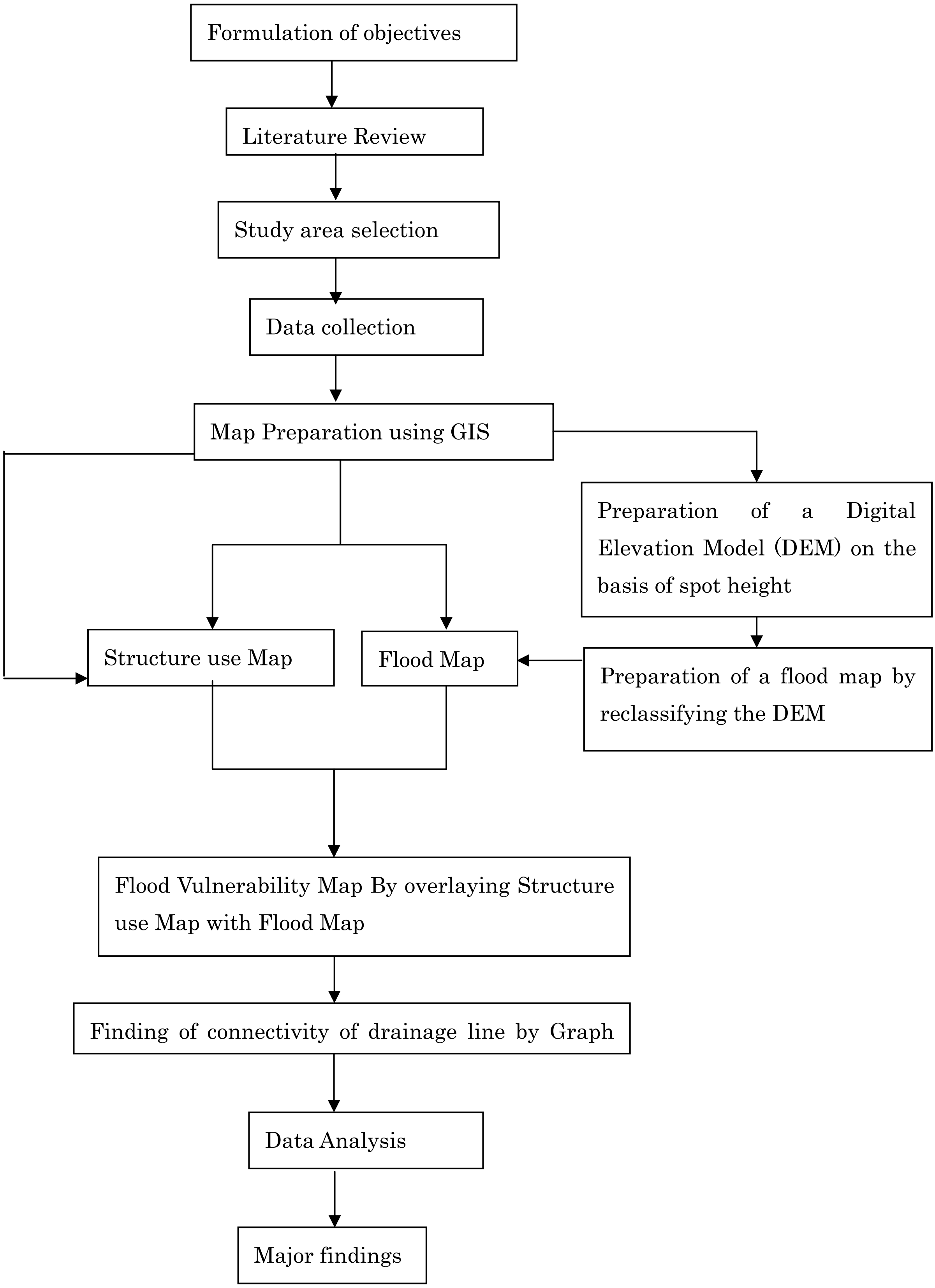
Flood vulnerability map has been generated by overlaying Structure use Map with Flood Map of Dhaka City.

3.6 Calculation of Drainage Connectivity Index

By using graph theory, the connectivity index of Dhaka city drains has been developed and then analyzed by calculating their percentage of connectivity.

3.7 Analysis

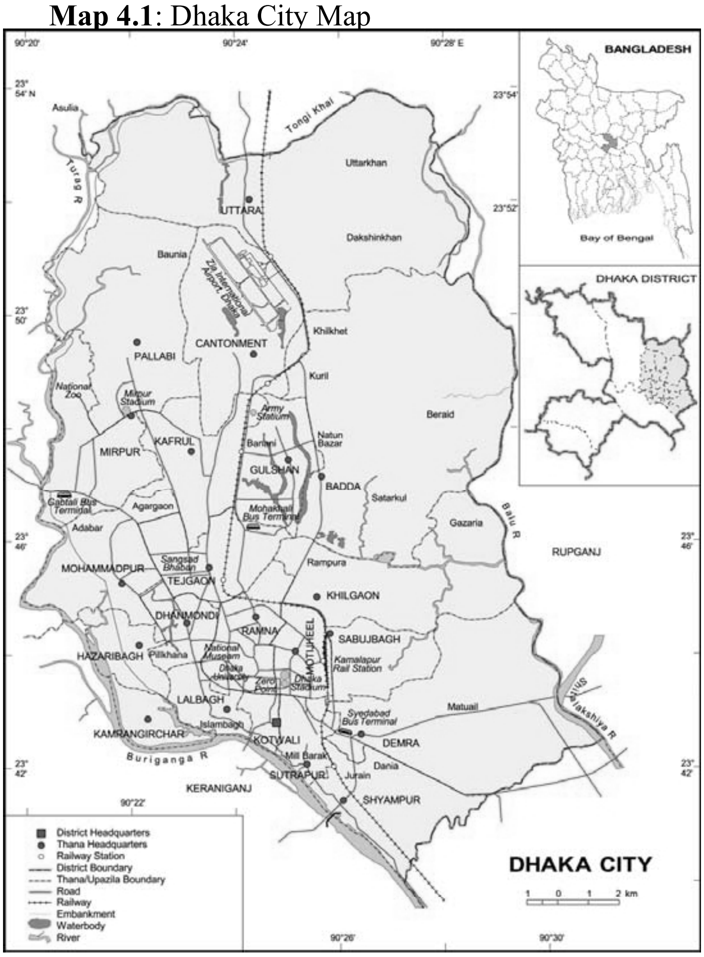
Analysis has been divided into two parts. Firstly, flood affected areas/Wards have been identified. Then the drainage condition of those areas has analyzed by calculating Connectivity Index of drains.


Formulation of objectives
Literature Review
Study area selection
Data collection
Map Preparation using GIS
Preparation of a Digital Elevation Model (DEM) on the basis of spot height
Structure use Map
Flood Map
Preparation of a flood map by reclassifying the DEM
Flood Vulnerability Map By overlaying Structure use Map with Flood Map
Finding of connectivity of drainage line by Graph
Data Analysis
Major findings

Study Area Profile

Dhaka city has two parts. The Greater Dhaka having an area of 258.78 km2 and the DND area having an area of 56.79 km2. The Greater Dhaka includes both flood protected western part (142.75 km2) and unprotected eastern part (116.03 km2). With the rapid urbanization and development of City infrastructure, combined with the reduction of water storage and percolation areas, recent flooding and water logging from local rainfall combined with river spills have reached a dangerous magnitude. Dhaka is located in the central part of Bangladesh. It is almost 200 kilometers from Meghna estuary. The distance hinders any impact of the sea therefore sea water intrusion is not feasible for Dhaka city. The increased amount of the rainfall affects Dhaka is more likely. Because day by day Dhaka is becoming more populated and the excessive population is causing harmful effect to the city sewer system. For this reason even small amount of rainfall is causing water logging and Excessive population is causing all sorts of water related problems.
There are two kinds flood occurs in Dhaka city. Main cause of this flood is water level rising, i.e. river flooding and another is rainfall flooding due to Heavy rainfall & drainage congestion. Based on this two causes of flood this study develop and analysis the reason behind flood vulnerability for Dhaka city.

Map 4.1: Dhaka City Map



Analysis and Findings

5.1 Identification of Flood Affected Areas/Wards

Ground elevation of Dhaka City ranges from 0.16 m to 17.2 m at 10 m spatial resolution. Low lands are found in Ward No. 04, 05, 06, 09, 10, 15, 21, 22, 23, 24, 37, 54 and 55. Large portion of high lands are found in northern part of the city. Most of the wards of the city fall in the category 5.84 m to 9.63 m. Map 5.1 show the Digital Elevation Model (DEM) of Dhaka City.

DEM has been reclassified to prepare Flood Map (Map 5.2) on the basis of the following four categories:

- No Flood Zone: Ground elevation is above 7.2 m
- Low Flood Zone: Ground elevation is from 5.5 m to 7.2 m
- Medium Flood Zone: Ground elevation is from 3 m to 5.5 m
- High Flood Zone: Ground elevation is from 0 m to 3 m

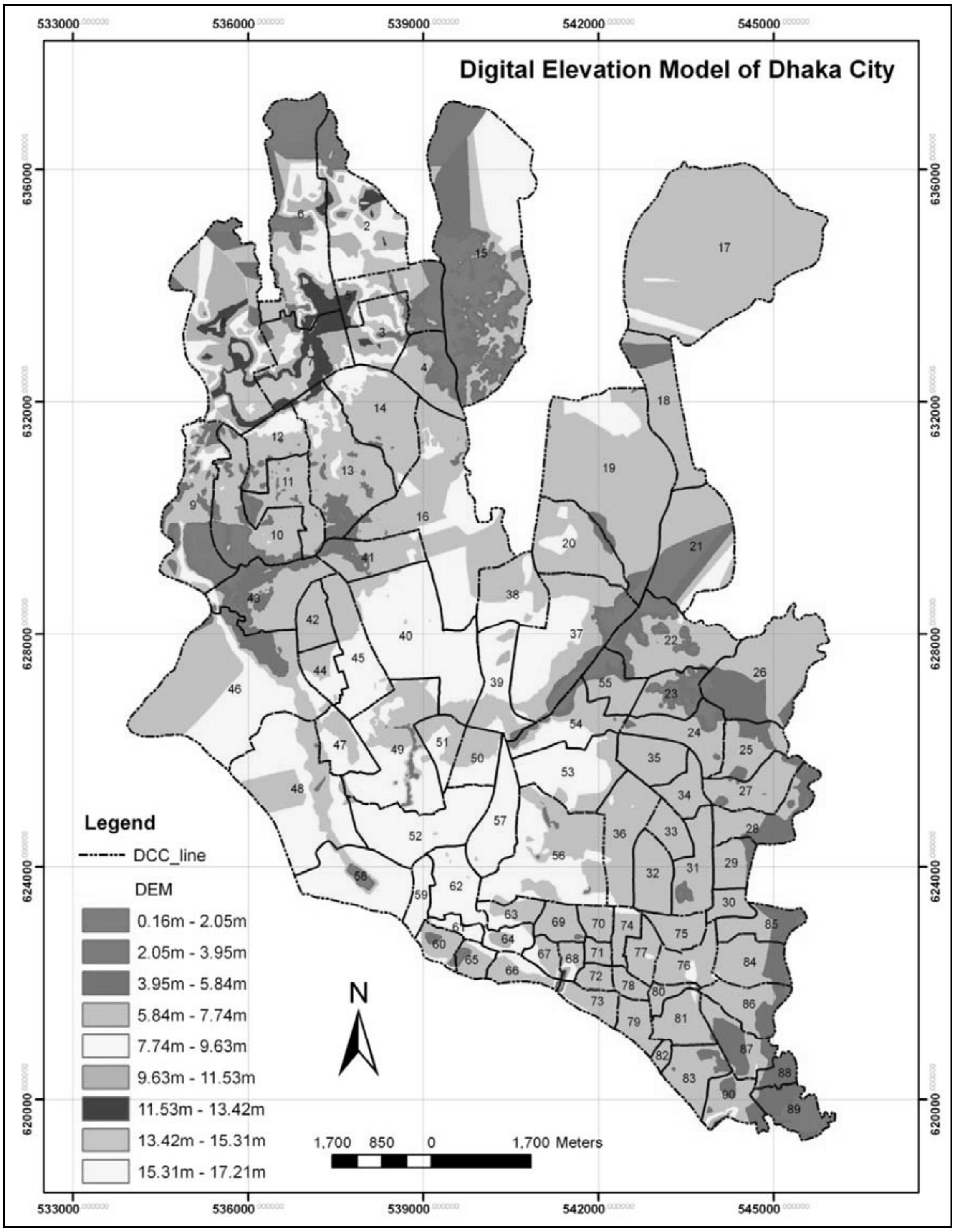
There are 90 wards in Dhaka City. In this study, Dhaka Cantonment and Uttara (Ward No. 01) have been excluded in the map as well as in the analysis due to data unavailability. Rest 89 wards have been categorized according to the flood zone. The following table 4.1 shows the distribution of Wards according to Flood Zone.

Table 5.1: Distribution of Wards according to Flood Zone

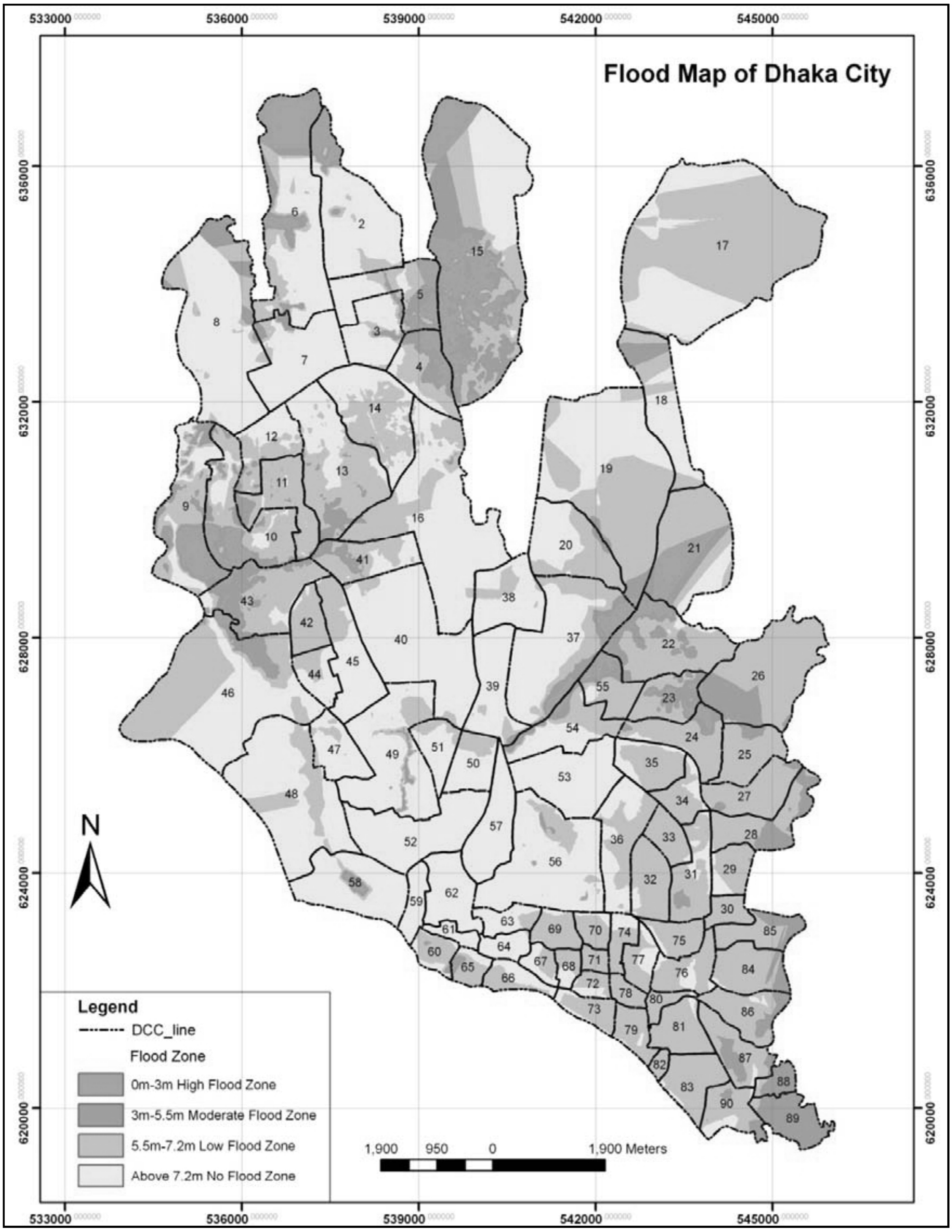
Flood Zone	**Ward Coverage**	**Total Number of Wards**	**Total Area (acres)**	**Percentage**
No Flood Zone	3, 7, 8, 38, 39, 40, 45, 47, 52, 53, 56, 57, 59, 58, 59, 61, 62, 63, 64	19	14074.06	45.59
Low Flood Zone	11, 12, 13, 14, 16, 17, 18, 19, 20, 25, 27, 29, 30, 31, 32, 33, 34, 35, 36, 41, 42, 44, 46, 48, 49, 50, 51, 54, 60, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 86, 87, 90	52	12516.7	40.55
Medium Flood Zone	23, 26, 28, 43, 85, 88, 89	7	2816.35	9.12
High Flood Zone	2, 4, 5, 6, 9,10, 15, 21, 22, 24, 37, 55	12	1461.4	4.73
Total		**89**	**30868.51**	**100**

Structure Map has been overlaid on Flood map to produce Flood Vulnerability Map (Map5.3).

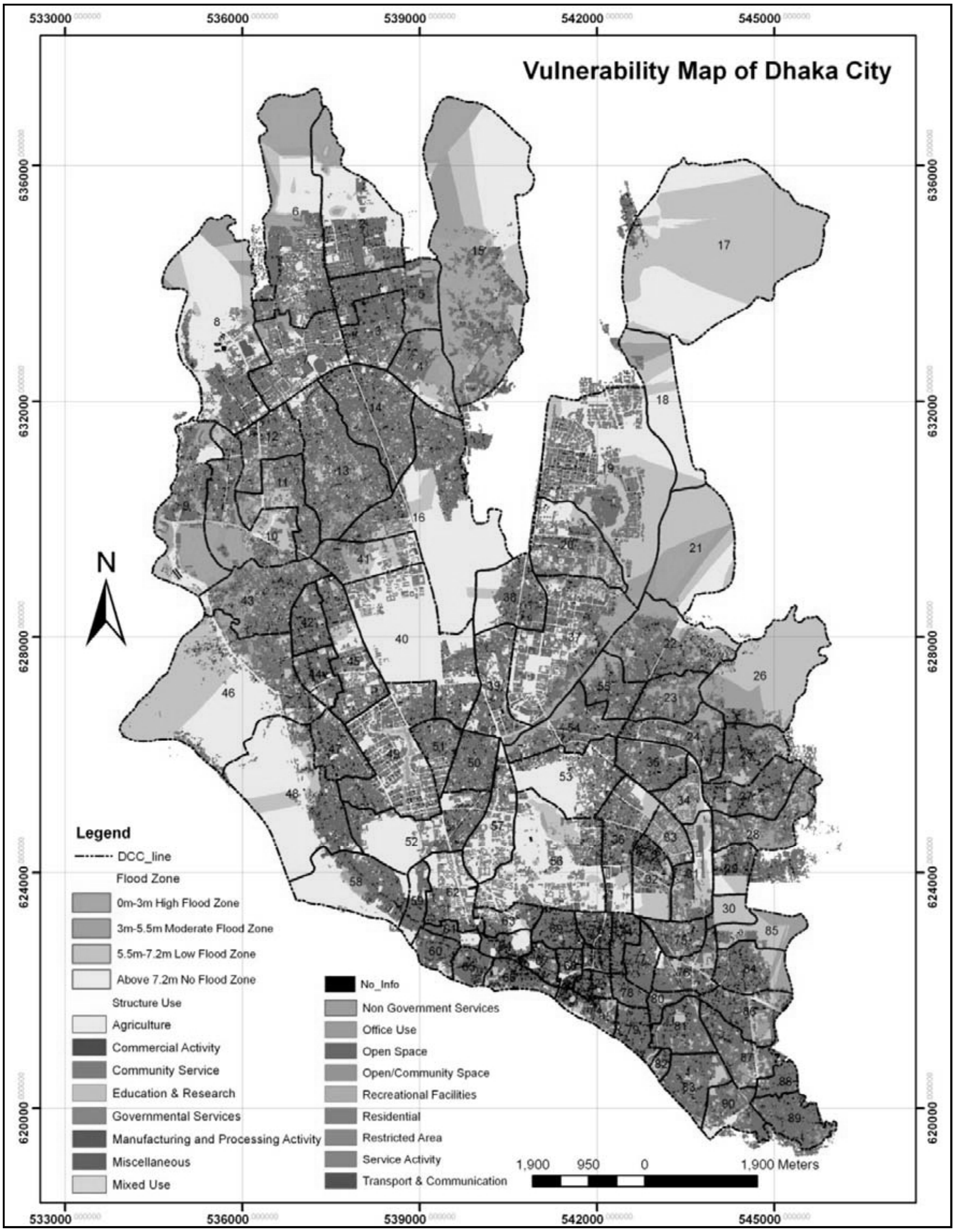
Map 5.1: Digital Elevation Model of Dhaka City



Map 5.2: Flood Map of Dhaka City



Map 5.3: Flood Vulnerability Map of Dhaka City



5.2 Vulnerability Analysis of Structures of Flood Affected Areas/Wards

Analysis of No Flood Zone: No flood zone consists of 19 wards covering almost 14074.06 acres areas (45.59%) of Dhaka City. Most of these wards are situated in the northern parts and the centre of the city. Total 103754 numbers of structures are situated in this zone. Most of them are residential (78.23%), pucca (46%) and one storied (62.9%). This zone contains the most developed areas in Dhaka City. Table 5.2 and figure 5.1 shows the structure use and the structure type of No Flood Zone.

Table 5.2 Structure use of No Flood Zone

Structure Use	**Frequency**	**Percentage**
Agriculture	64	0.06
Commercial Activity	6527	6.29
Community Service	811	0.78
Education & Research	1411	1.36
Governmental Services	415	0.40
Manufacturing and Processing Activity	1730	1.67
Miscellaneous	29	0.03
Mixed Use	8181	7.88
No Information	499	0.48
Non Government Services	18	0.02
Office Use	119	0.11
Open Space	23	0.02
Open/Community Space	36	0.03
Recreational Facilities	12	0.01
Residential	81163	78.23
Restricted Area	45	0.04
Service Activity	2478	2.39
Transport & Communication	193	0.19
Total	**103754**	**100**

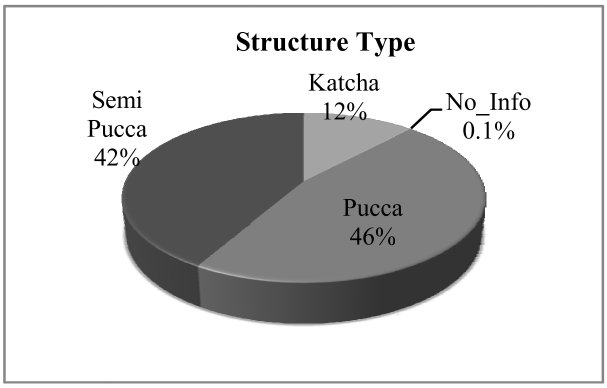


Figure 5.1: Type of Structure of No Flood Zone

Analysis of Low Flood Zone: Low flood zone consists of 52 wards covering almost 12516.7 acres areas (40.55%) of Dhaka City. Most of these wards are situated in the whole southeast parts, some portion of west parts and northern parts of the city. Total 149066 numbers of structures are situated in this zone. Most of them are residential (81.13%), semipucca (40.36%) and one storied (67.4%). Table 5.3 and figure 5.2 shows the structure use and the structure type of Low Flood Zone.

Table 5.3 Structure use of Low Flood Zone

Structure Use	Frequency	Percentage
Agriculture	30	0.02
Commercial Activity	8528	5.72
Community Service	909	0.61
Education & Research	1143	0.77
Governmental Services	191	0.13
Manufacturing and Processing Activity	1749	1.17
Miscellaneous	47	0.03
Mixed Use	11815	7.93
No Info	782	0.52
Non Government Services	15	0.01
Office Use	43	0.03
Open Space	21	0.01
Open/Community Space	14	0.01
Recreational Facilities	19	0.01
Residential	120935	81.13
Restricted Area	43	0.03
Service Activity	2451	1.64
Transport & Communication	331	0.22
Total	**149066**	**100**

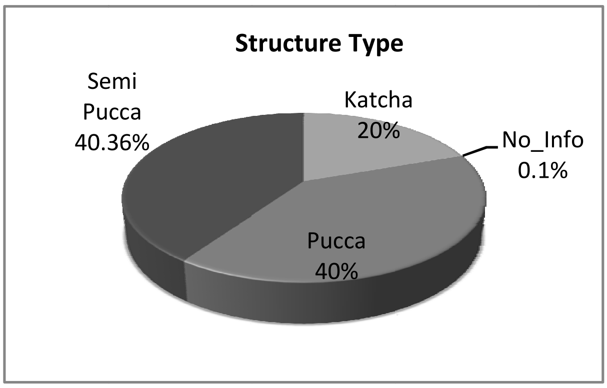


Figure 5.2: Type of Structure of Low Flood Zone

Analysis of Medium Flood Zone: Medium flood zone consists of 7 wards covering almost 2816.35 acres areas (9.12%) of Dhaka City. Most of these wards are situated in the fringe areas of the city. Total 28968 numbers of structures are situated in this zone. Most of them are residential (90.23%), semipucca (43%) and one storied (84.5%). Mainly slum areas are built up in this zone. Table 5.4 and figure 5.3 shows the structure use and the structure type of Medium Flood Zone.

Table 5.4 Structure use of Medium Flood Zone

Structure Use	**Frequency**	**Percentage**
Agriculture	5	0.02
Commercial Activity	886	3.06
Community Service	124	0.43
Education & Research	129	0.45
Governmental Services	14	0.05
Manufacturing and Processing Activity	219	0.76
Miscellaneous	31	0.11
Mixed Use	996	3.44
No Information	121	0.42
Office Use	4	0.01
Open/Community Space	10	0.03
Residential	26138	90.23
Restricted Area	3	0.01
Service Activity	216	0.75
Transport & Communication	72	0.25
Total	**28968**	**100**

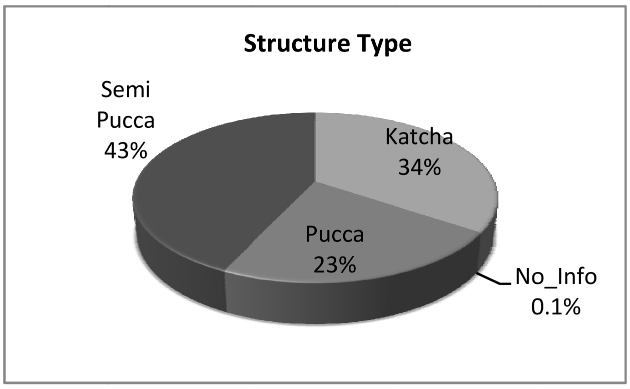


Figure 5.3: Type of Structure of Medium Flood Zone

Analysis of High Flood Zone: High flood zone consists of 12 wards covering almost 1461.4 acres areas (4.73%) of Dhaka City. Most of these wards are situated in the fringe areas of the city. Total 1858 numbers of structures are situated in this zone. Most of them are residential

(94.3%), katcha (60%) and one storied (92.4%). Mainly slum areas are built up in this zone. Table 5.5 and figure 5.4 shows the structure use and the structure type of High Flood Zone.

Table 5.5 Structure use of High Flood Zone

Structure Use	Frequency	Percentage
Agriculture	2	0.1
Commercial Activity	16	0.9
Community Service	6	0.3
Education & Research	10	0.5
Manufacturing and Processing Activity	3	0.2
Mixed Use	28	1.5
No Information	5	0.3
Residential	1752	94.3
Service Activity	35	1.9
Transport & Communication	1	0.1
Total	**1858**	**100**

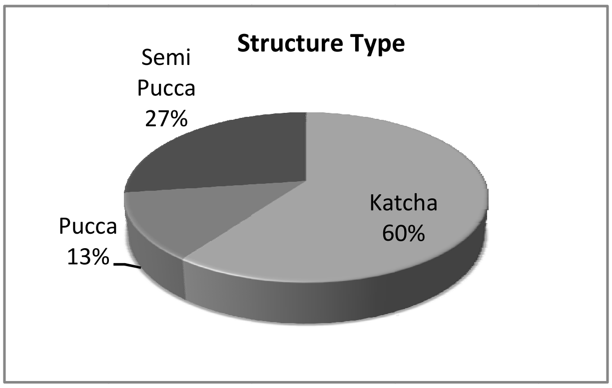


Figure 5.4: Type of Structure of High Flood Zone

5.3 Connectivity Index Development for Drain

This chapter briefly described the connectivity index development for drain in Dhaka city by applying graph theory. On the basis of degree of network completeness by connectivity indices namely α (alpha) and γ (gamma) indices that apply the Graph theory to measure the network system of drain. Where, the network of drains can be represented by a series of vertices (representing nodes on a network) and a set of edges (representing network linkages), together with a relationship of incidence that associates each edge with two vertices. The degree of connection between all vertices is defined as the connectivity of the network.

The drains of Dhaka city should carried water towards the surrounding rivers. So it is necessary to find out the degree of connectivity of drains with rivers (Map 5.4). It will give the result whether the drains carry water to the rivers or not and also show their circulation. For this reason, α (alpha) and γ (gamma) indices developed to know about the connectivity of drain in Dhaka city. Drainage map has been overlaid on Flood map (Map 5.4).

5.3.1 Connectivity index calculation for Ward 23 drain in Dhaka city

All types of flood zone are presented in Ward 23 (Map 5.5).So, the calculation of α (alpha) and a γ (gamma) index for ward no.23 is given below:

Table 5.6: Connectivity Index Calculation

Flood Zone	**Number of Nodes, v**	**Number of Links, e**	**Gamma Index, ɣ**	**Alpha Index, α**
Medium Flood Zone	8	5	**0.28**	**-2/11 = -0.18**
Low Flood Zone	58	51	**0.3**	**-4/151 = -0.27**

*e_{max}= 3(v-2)

5.3.2 Analysis of γ (gamma) index for Ward 23

For medium flood zone the connectivity index of drains is 0.28 and 0.30 for low flood zone. It means that the drains connected 28% and 30% connected for moderate flood zone and low flood zone. Both of the indexes are near to 0 i.e. the drains are minimally connected in ward no. 23.

5.3.3 Analysis of α (alpha) index for Ward 23

Alpha index shows whether the drains create circuit with rivers or not for free flow of water. The range of the index is from a value of 0 for a minimally connected network to a value of 1 for a maximally connected one. Where, actual circuit shows the number of existing circuits of drains with rivers and maximum circuit shows the number of maximum possible circulation.

From Table 5.6 it has been shown that, for medium flood zone and low flood zone drains created no circuit. In ward no. 23 the value of existing circuit is negative but there will remain maximum possible circuits of 11 and 151.

5.3.4 Drainage Condition in Flood Prone Areas

Connectivity index are developed for all wards in Dhaka city (Appendix I). Based on this percentage the drainage condition is analyzed.

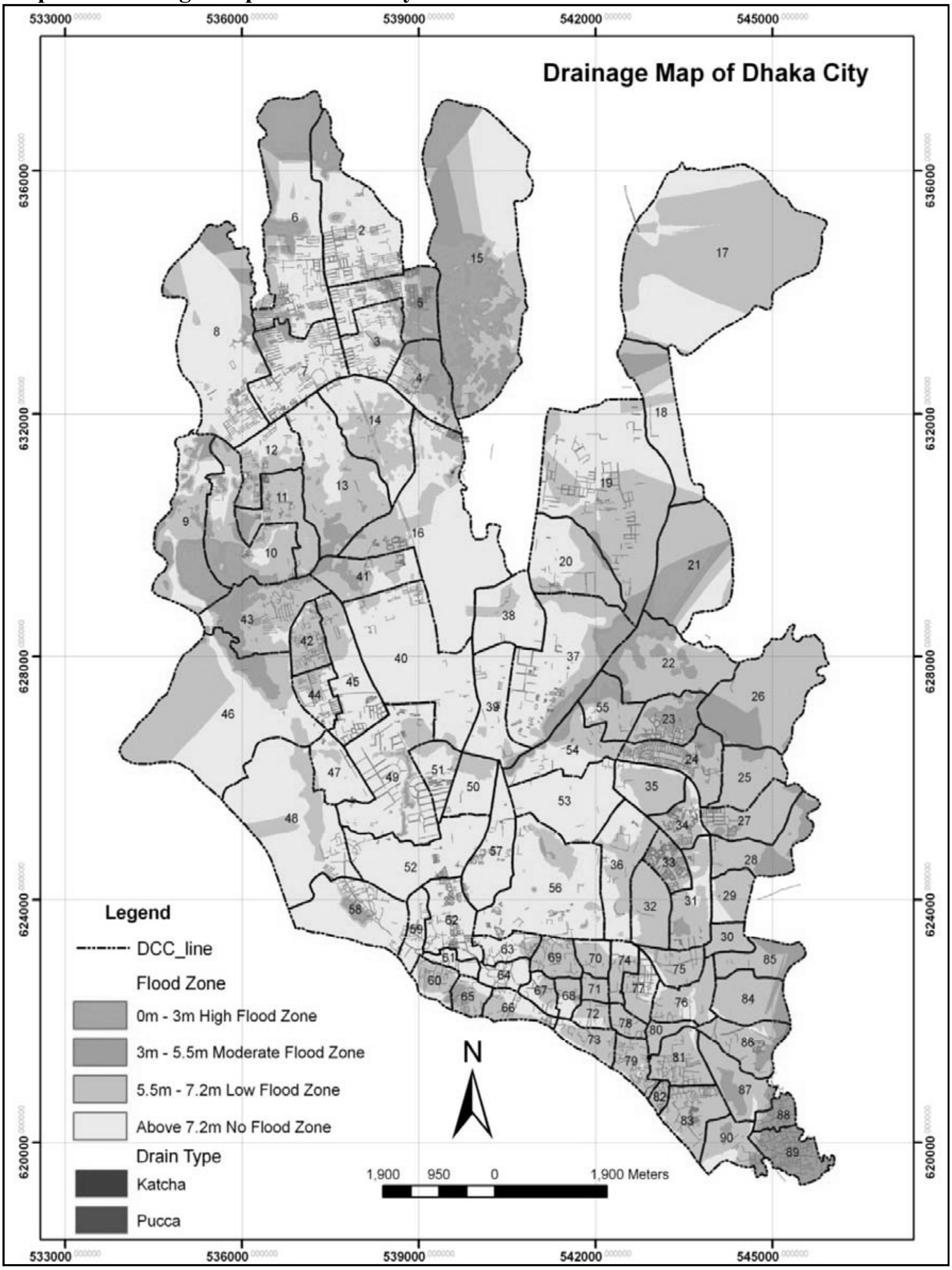
Analysis of No Flood Zone: The connectivity index for no flood zone is (38-40) %**.** It means that in no flood zone area the drainage condition is good. The area does not face water logging problem and flood in Dhaka city does not hampered there life style and their infrastructure.

Analysis of Low Flood Zone: The drainage connectivity percentage for low flood zone is (30-32) %.It means that the flow of water is moderately good. Drains of this area passed water slowly and the area faces less water logging problem.

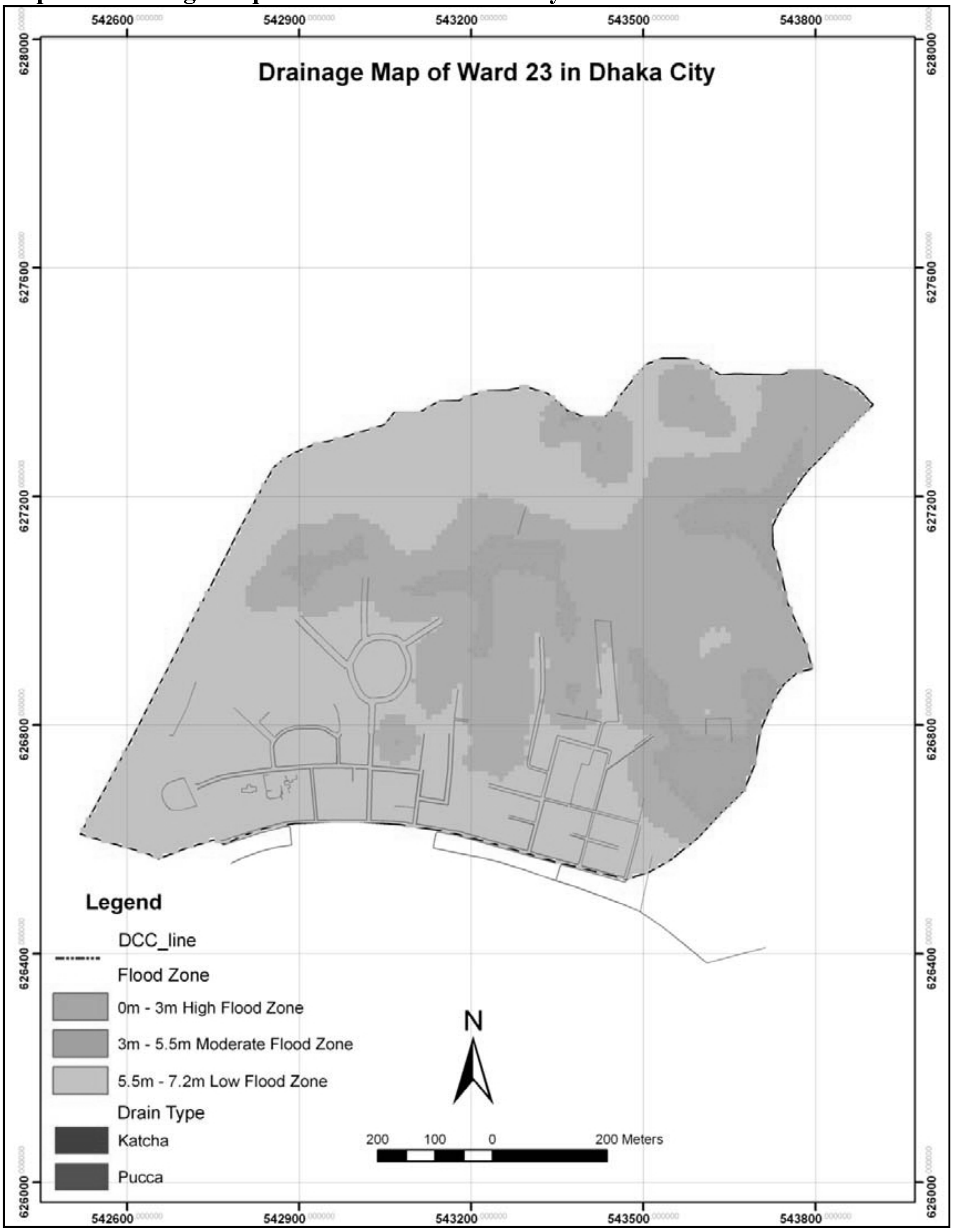
Analysis of Medium Flood Zone: The area of this zone is flood vulnerable because their connectivity percentage is (25-28) %.

Analysis of High Flood Zone: From ***map*** 5.4 it has been shown that, no drains are present in high flood zone area. So, the area faces the problem of water logging and flood in Dhaka city.

Map 5.4: Drainage Map of Dhaka City



Map 5.5: Drainage Map of Ward 23 in Dhaka City



Conclusion

Flood vulnerability assessment for the historical flood event of 1998 in Dhaka City of Bangladesh was examined using GIS in this study. The study established a simple and cost effective way to use geographical information system for creating flood vulnerability maps from the available dataset. Although it was very time consuming to derive the GIS database because of the size of the study area, GIS was invaluable in reducing the complexity associated with vulnerability assessment.

The vulnerability maps showed that a major portion of Dhaka were within low to very high flood zone, especially fringe areas. It is projected that these areas will be fully urbanized by the year 2015, therefore higher priorities must be paid for the development of apposite flood countermeasures for areas having higher vulnerability potential. Based on this above analysis researchers proposed some recommendations which is given below:

- ❖ Existing natural channels should be kept for flood flow.
- ❖ Structures must be flood-proofed.
- ❖ Require preservation of natural drainage systems, existing floodplains.
- ❖ In order to ameliorate flood induced damage, the developed flood vulnerability map would be invaluable.
- ❖ This type of study will provide information about flood protection measure such as construction and development of infrastructure and preparedness of aid and relief operation for high vulnerable areas for future flood event.

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BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

PART-XII

TRAINING COURSES, SEMINARS AND WORKSHOPS

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared By: Mehedi Ahmed Ansary

A three days training program titled "urban community volunteer training program" was held on 23rd -25th November, 2012 at IEB seminar room, IEB, Ramna, Dhaka.The training program was jointly organized by the Occupational Safety Board of Bangladesh (OSBB) and Institute of Engineers (IEB) with the Fire Service and Civil Defense Directorate. Total fourteen classes where conducted by the trainers of The Fire Service and Civil Defense Training Institute, Mirpur during these three days. There were seven theoretical classes and the other seven were practical classes. The classes were on different issues regarding basic concepts of fire hazard, firefighting system, use of firefighting equipment, basic earthquake hazard, earthquake management, basic rescue and evacuation operation system of earthquake and fire accident , first aid, community level collapse structure, search and rescue(CLCSSR) operation etc. 45 participants took part in the training program from different professional group.A research engineer (K.M.Khaleduzzaman) of BNUS participated in the training program. Engr. Kabir Ahmed Vuiya,Vice president of IEB, MostafizurRahman,Chairman of OSBB, A.B.M. NurulHoque, Principal of Fire Service and Civil Defense Training Institute, were present at the closing ceremony and distributed the completion certificate among the participants.

Interviews on Disaster Information Dissemination

BNUS and ICUS jointly conducted a number of interviews with some officials of different organizations of Bangladesh from 9th December 2012 to 12th December 2012. They covered four organizations including Department of Disaster Management (DDM), Bangladesh Red Crescent Society, Institute of Water Modeling (IWM), Center for Environmental and Geographic Information Services (CEGIS) and Asian Disaster Preparedness Center (ADPC) to know how the information of a certain hazard is disseminated from concerning authorities to the local people.

Figure 1: Interview at DDM

Figure 2: Interview at DDM

DDM is concerned with dissemination of information about any hazard. Three important personnels of DDM including the Director General **Mr. Abdul Wazed,** Assistant Director **Mr. Pobil Ghosh** and GIS Specialist **Mr. Nitai Chanda Dash** were interviewed. After getting the information of hazard from Bangladesh Meteorological Department (BMD), DDM spreads the news to **230** stakeholders. These **230** stakeholders are different government organizations, NGOs, multinational companies and private firms etc. Then these stakeholders take necessary steps to disseminate the information about hazard.

Bangladesh Red Crescent Society is one of the stakeholders of DDM. Deputy Secretary General of Bangladesh Red Crescent Society **Mr. K. Jakaria Khaled** was interviewed to know how Cyclone Prepared Program (CPP) responses in case of any cyclone. The CPP plays an important role in the dissemination of cyclone warning, evacuation, rescue, first aid and emergency relief work including mobilization of people toward cyclone shelters through its volunteers in the coastal districts. Currently, CPP has 203 paid employees, 49215 volunteers including 32810 male and 16405 female and 3281 Units covering 321 Unions, 37 Upazilas, 7 Zones and 13 District. Due to global warming, CPP has increased its preparedness and awareness building functions for the community people living in the coastal area of Bangladesh. CPP command area is expanded in more 5 Upazilas of Khulna, Bagerhat and Satkhira districts with the financial help of Comprehensive Disaster Management Program (CDMP) Phase I. CPP is a mechanism which relies on technical skills and volunteers commitment for ensuring that all potential victims of an approaching cyclone are given sufficient warning to 11 million coastal people so as to enable them to move to safe-sit. The system starts with the collection of meteorological data from the Bangladesh Meteorological Department (BMD), which issues bulletins including the designated warning signals of an approaching cyclone. The bulletins are transmitted to the 6 zonal offices and the 30 upazila level offices (sub-district) over HF radio. The upazila offices in turn, pass it to unions and lower level through VHF radios. The union team leaders then conduct the unit team leaders immediately. The unit team leaders with his volunteers spread out in the villages and disseminate cyclone warning signals almost door to door using megaphones, hand sirens and public address system.

Figure 3: Interview with Bangladesh Red Crescent Society

Figure 4: Interview with Bangladesh Red Crescent Society

Institute of Water Modeling (IWM) involves providing flood related information to DDM. Director of Flood Management Division **Mr. Sardar M Shah-Newaz** was the key person of the interview.

Figure 5: Interview at IWM

Figure 6: Interview at CEGIS

Center for Environmental and Geographic Information Services (CEGIS) also involves about river related data. Deputy Executive Director (Development) **Dr. Maminul Haque Sarker,** GIS Specialist **M. Habibur Rahman and** R&D and Training Division Specialist **Syed Ahsanul Haque were the key persons of the interview. CEGIS is currently operating 17 gauges in various flood plains of Jamuna and Dhaleswari Rivers in Bangladesh to monitor water level. This information is disseminated to various organizations including Union Disaster management Committee** (UDMC)**. The UDMC is the lowest tire of National Disaster Management Committee. It comprises of 10 members including 1 chairman and 9 members (3 female) from 9 different Wards. They are the secondary stakeholders where the farmers and local people of the Union are the primary stakeholders of this information system. As most of the villagers are illiterate so a bulletin board is kept in each Union showing the rise and fall of water level by + (plus) sign and – (minus) sign respectively. Other organizations are provided information by fax and short message service (SMS). Banglalink, one of the biggest private telecom companies, helps to distribute SMS without cost in every monsoon.**

Asian Disaster Preparedness Center (ADPC) is currently running some projects involving dissemination of information about landslide at hill tracks areas in Bangladesh. Office in Charge of Bangladesh office of ADPC **Mr. Md. Anisur Rahman**, GIS Technical Specialist **Mr. Dr. Renato Forte** and Senior GIS Coordinator **Mr. Muhammad Murad Billah** were interviewed.

Figure 7: Interview at ADPC

Figure 8: Interview at ADPC

BNUS and ICUS also conducted a field trip to a small village of 3000 people named Boro Boinna on 10 December 2012. The village is situated at Daulatpur Upazila of Manikganj District and only 1.5 km away from the mighty River Jamuna. So flood is a common phenomenon of the village. The village is the study area of a project conducted by CEGIS. The project is a flood early warning system that basically forecasts the possible change of water level of nearby river for the next 48 hours. This information is disseminated to some key persons of the village through short message service (SMS) to their cell phones. After getting information they spread it to the local people by raising flag at the main bazaar. 1 flag indicates 6 inches increase of water level at the river. The project was started on the month of December 2003 and ended on December 2008. The project was a great success and the people still have been benefitted of the outcome of the project.

Figure 9: Interview with the villagers

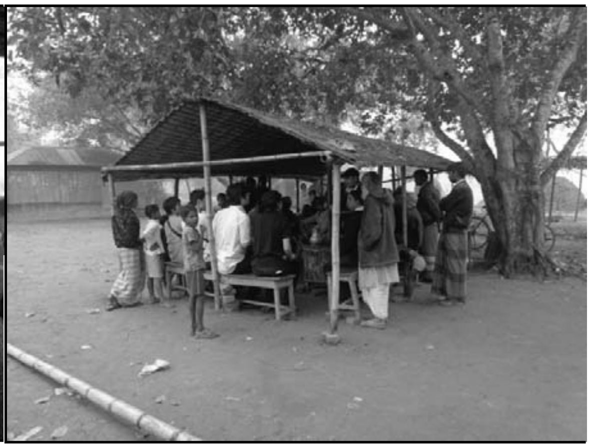


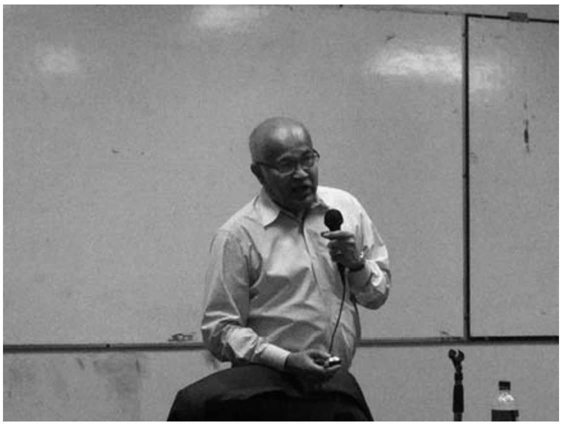
Figure 10: Interview with the villagers

Figure 11: 2 Flag indicates 12 inches rise of water level.

Figure 12: Community Office of Climate Change Adaptation Project

Seminar on Current Trends in Earthquake Resistant Design of Structures

Dr. S. K. Ghosh, President, S. K. Ghosh Associates Inc., USA and an internationally reputed earthquake engineer made a presentation on Current Trends in Earthquake Resistant Design of Structures on 09/02/2013 (Saturday) at 4:30 PM at Environmental Seminar room, Civil building, BUET. This presentation discusses the significant changes that have taken place in recent times in the way seismic design is done in accordance with U.S. codes and standards. Some of the most important changes are: (1) two, rather than one, ground motion parameters are used in seismic design – a short-period and a long-period parameter; (2) the parameters are spectral quantities (specifically, spectral accelerations), rather than peak ground acceleration, as in the past; (3) site soil characteristics play a more important role in seismic design than ever before; (4) seismic design criteria are determined not on the basis of seismic zones, which do not exist any longer, but on the basis of seismic design categories, which are functions of: seismic hazard at the site, occupancy of the structure, and the characteristics of soils at the site. An idea of U.S. codes and standards will be given in the beginning. Risk-targeted and maximum-direction ground motion, introduced in very recent times, will also be briefly discussed.A question and answer session will be an important part of the presentation. **Forty** participants took part in this seminar from different professional group.



Dr. Ghosh delivering the lecture

Dr. Ghosh with Head of Civil Engg.

Participants at the lecture

GLOBAL EARTHQUAKE MODEL (GEM)
SOUTH ASIAN EXPERT MEETING AND GEM TECHNICAL TRAINING
Kathmandu, Nepal: 1-3 March 2013

A One day expert meeting and two days technical training on Global Earthquake model (GEM), jointly organized by National Society for Earthquake Technology (NSET)–Nepal and Global Earthquake Model (GEM) Foundation and supported by USAID, was hold in Dhulikhel Lodge Resort, Nepal in 1-3 March 2013.A number of earthquake experts and young professionals from India, Bangladesh, Pakistan, Nepal, Bhutan and Maldives took part in it.   Mr. Khishore Thapa, Secretary of the Ministry of Urban Development (MUD), Nepal was the chief guest in the opening ceremony.

Fig: Delegation leaders from different countries on the dais and Group Photo session of the participants

The expert meeting involved participatory sessions geared firstly towards introducing GEM's tools, methods, metrics and secondary to have a detailed round –table discussion related to technological and methodological needs within the South Asia Region pertaining to the assessment of socio-economic vulnerability and resilience, to identify relevant contextual factors and variables for measurement, to prioritize the ranking of certain factors and variables.

Fig: Group discussion at expert meeting

Fig: Prof. Ansary presenting the summary of the findings

The GEM Technical Training (GEMTRAIN) was held in 2nd and 3rd March, 2013. There were 3 sessions at the first day that covered the Probabilistic Seismic Hazard Analysis Method, demonstration and exercise using the open Quake-Engine and using tools for PHSA input Model. The second day covered the using method of GEM science tools for seismic risk assessment, an introduction to risk features of Open Quake Engine, Scenario risk and scenario damage distribution calculations and plotting output maps. The training sessions were conducted by officials of GEM foundation.

Fig: GEM Technical Training (GEMTRAIN)

There was a field trip titled "Earthquake walk" and observation of a retrofitted school building named tri-Padma Vidyasgram Higher secondary School in Lalitpur, Nepal. Ms. VidyaPanday, principal of that school welcomed the participants at her school.

Fig: Observing the retrofitted school building and evacuation plan

Then the Earthquake walk was done from PatalDarbar Square to Dau-Baha with a view to feel the earthquake risk of Kathmandu Valley through guided walk along the streets in a core urban area by observing existing and continued build up seismic vulnerabilities and learns about the existing capacities and resources in Kathmandu Valley communities. The walk was expected to assist the need and possibilities of reducing earthquake risk in KathmanduValley.

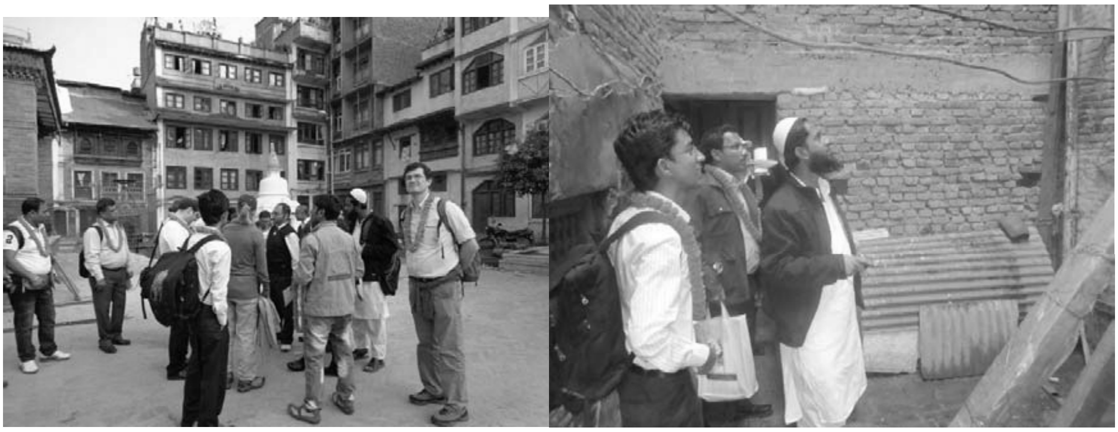


Fig: Observation of some existing buildings of Kathmandu Valley.

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