

Multi-channel analysis of Surface Wave (MASW) profiling for delineation of sub surface stratigraphy at various locations within and surrounded Kolkata High Court

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Abstract - Hon'ble High Court Building, Kolkata is a heritage structure in India. This Building is situated by the river Ganga. It Was Observed that Building some portion settlement for a long period. Cause of this settlement building have some cracks are developed in some area. It was decided to identify of Sub surface stratigraphy of surrounding Hon'ble High Court Building due to some cracks was developed in Building. A comprehensive Integration of remote sensing, GIS and Multi-channel Analysis of Surface Wave (MASW) method in study of sub surface strata surrounding the Hon'ble High Court Building Kolkata.

Key Words: Multi-channel Analysis of Surface Wave (MASW), Kolkata, Soil Strata, GIS.

1. INTRODUCTION

Application of Remote Sensing, GIS and Geophysical techniques for Identification of Sub Surface Strata using physical properties of Soil. Each Soil and Rock have own physical properties. Identifying this physical property, We categories Sub Surface Strata. Using these both techniques we identify Hon'ble High Court Building within and surrounded area Soil Strata.

2. DESCRIPTION OF THE STUDY AREA

The Study area fall in the city of Kolkata, in the state of west Bengal, India. The geology of the area surrounding the study area is characterized by the alluvial plain of the River Hooghly, which flows nearby.

The Study area is situated in the central part of the city, near the bank of the River Hooghly. The area is mostly flat and low-lying, with the river being the dominant feature of the landscape. The Soil in the area is predominantly clayed and loamy, with occasional sandy patches

In terms of geology, Kolkata is located in the Ganges Delta, which is a vast region of sedimentary deposits formed by the Ganges, Brahmaputra, and Meghna rivers. The soil in this region is predominantly alluvial, consisting of fine-grained sediments like clay, silt, and sand, and is known for its fertility.

The region surrounding Kolkata is part of the Bengal Basin, which is a large sedimentary basin that extends across parts of India, Bangladesh, and Myanmar. The geological history of the area is characterized rivers, which has resulted in the formation of extensive alluvial deposits.

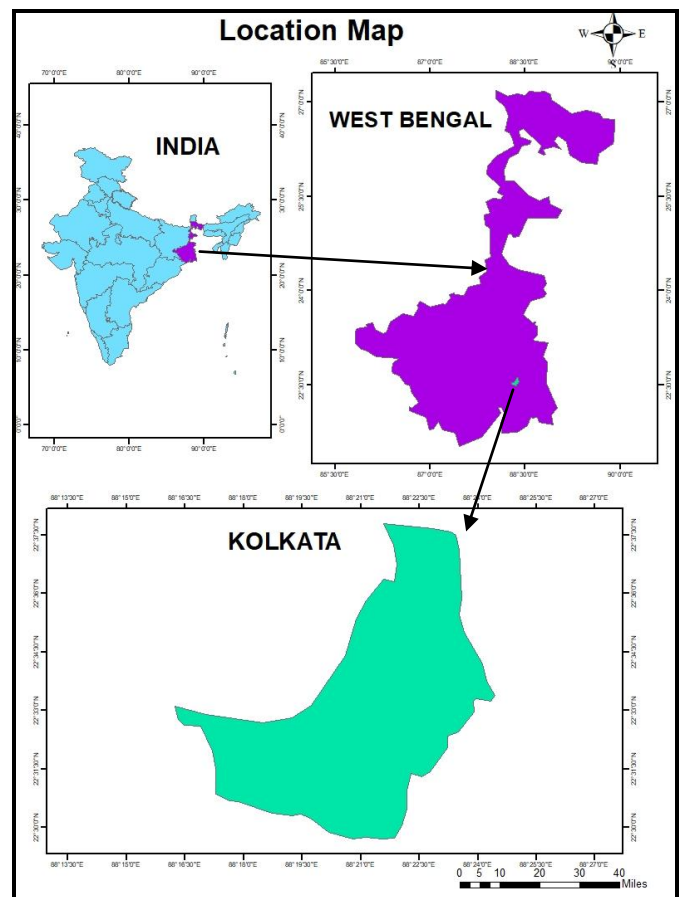
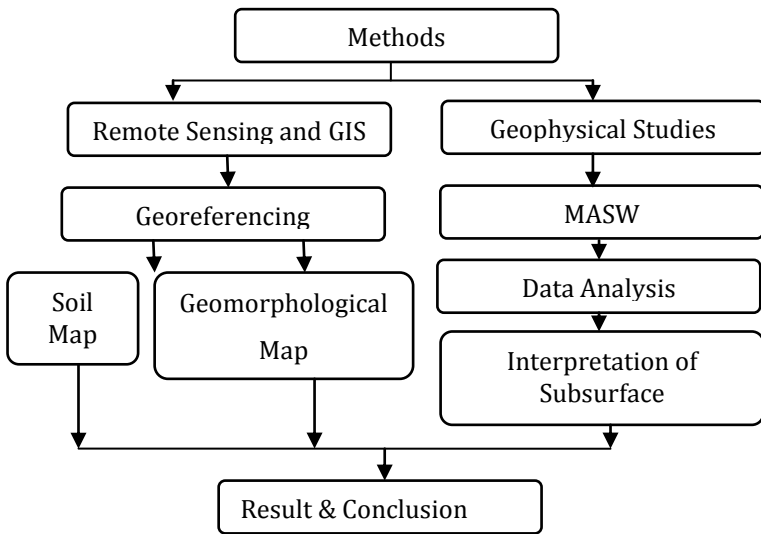


Fig -1: Location Map of Study Area

3. DATA USED AND METHODOLOGY



3.1 GEOREFERENCING

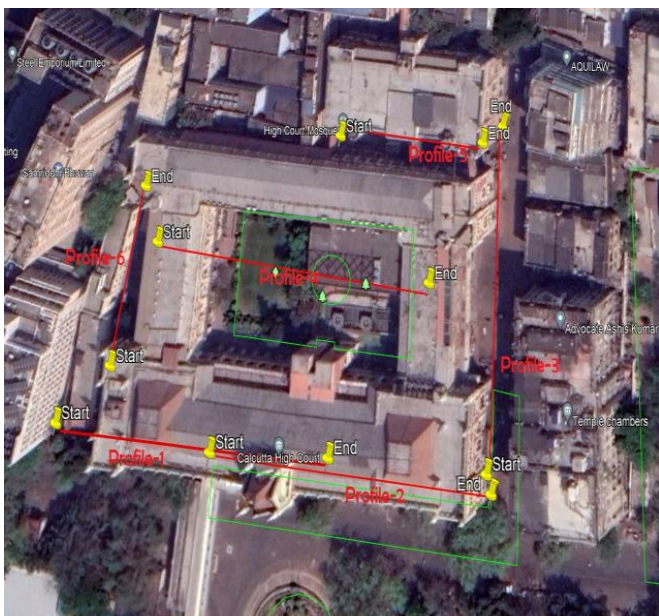


Fig -2: Google image of Study Area Red Mark in profile

Table 1-MASW Profile Coordinate

MASW Profile Coordinate			
Profile	Coordinate		Length(M)
	Start	End	
Profile-1	2496370	2496339	92
	638032	638121	
Profile-2	2496350	2496317	92

	638082	638172	
Profile-3	2496322	2496411	92
	638172	638209	
Profile-4	2496409	2496374	92
	638076	638168	
Profile-5	2496423	2496408	46
	638149	638200	
Profile-6	2496380	2496426	46
	638053	638075	

3.2 SOIL MAP & GEOMORPHOLOGICAL MAP OF STUDY AREA

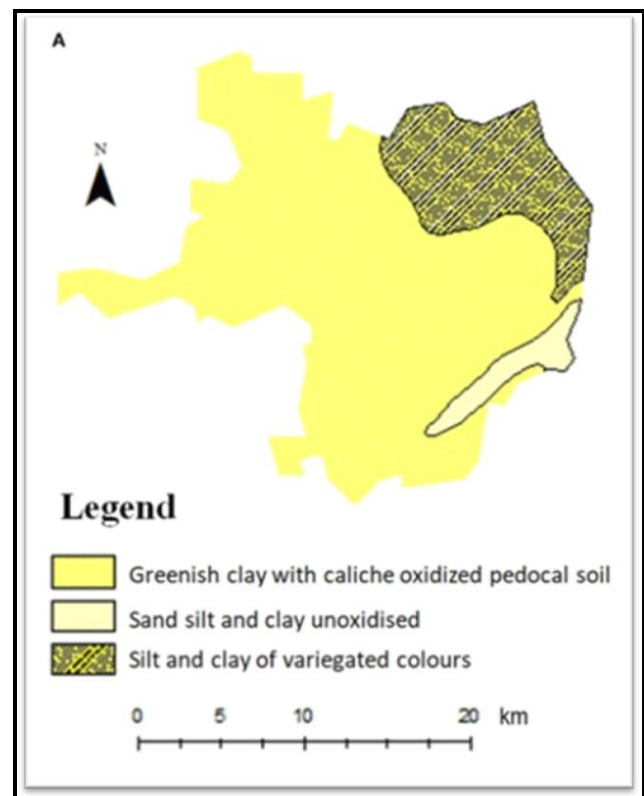


Fig -3: Soil Map of Study Area

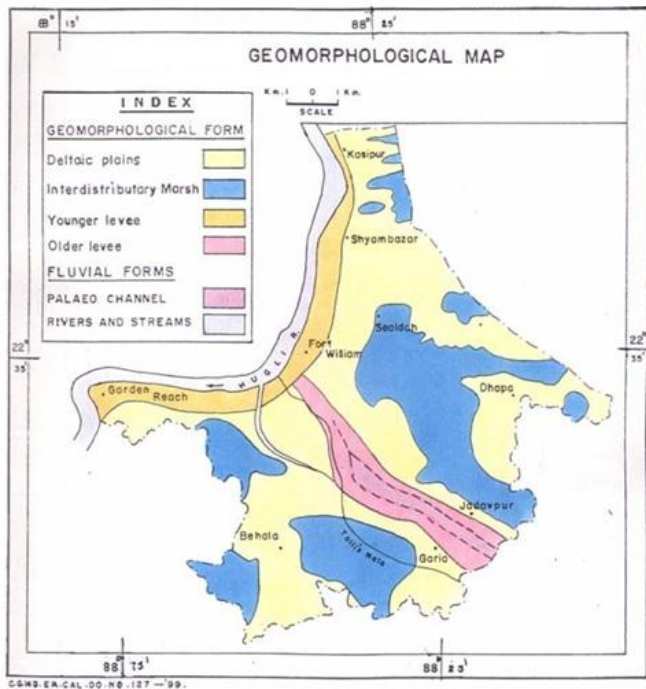


Fig -4: Geomorphological Map of Study Area

3.3 MULTICHANNEL ANALYSIS OF SURFACE WAVES (MASW)

The multichannel analysis of surface wave (MASW) method, a powerful geophysical exploration technique has been used increasingly since 1980 in applications shallower than 30-50 m depth. The MASW method provides the velocity of S-waves in subsurface materials. The S-wave velocity is a good indicator of the shear property of soil or rock for evaluating the elastic condition (stiffness) of the ground for geotechnical engineering purposes.

Evaluation of Average S-Velocity (V_s^{30}) (for Top 30 m)

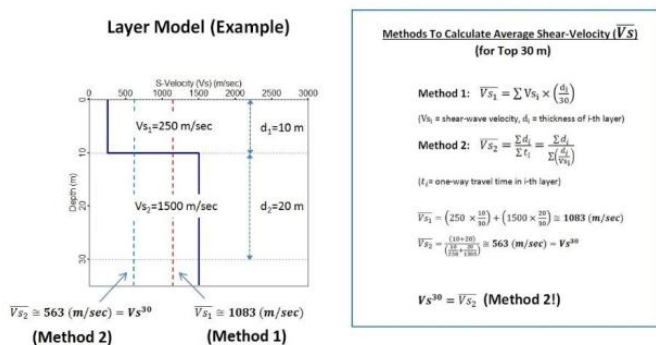


Fig -5: Evaluation of Average S-Velocity

3.3.1 EQUIPMENT DEPLOYED

3.3.1.1 SEISMIC SOURCE

Seismic Source means generate a wave in surface. Lot of source available according to our need like sledgehammers, impact plates, Vibratory. Using this source, we create a S-waves for measurements.

3.3.1.2 GEOPHONES

Geophones is performing a receiver work for MASE Survey. That collect a s-wave arrival timing from source. Geophones convert the ground vibration into electrical signal. These electrical signals is recorded and process in Seismography. In this survey we used PASI 24 Geophone Seismography. Mostly MASW survey use a 24 or 48 Geophones used.

Geophone arrange Vertically in equally space this 4.5 frequency geophone. Geophones detect the ground motion caused by the seismic waves.

3.3.1.3 RECORDING UNIT

Recording unit is the central component for MASW Survey. All Signal received from the geophones and convert analog to digital converts and data storage the recording unit also called Seismograph.

3.3.1.4 TRIGGER DEVICE

In Multichannel Analysis Surface Waves (MASW), a trigger device is used to initiate the seismic wave Source. The purpose of the trigger device to generate a controlled and synchronized seismic waves that propagates through the ground and is detected by the geophones for subsequently analysis. The Trigger device used in in MASW can vary depending upon the seismic source.

3.3.2 SURVEY GEOMETRY

A typical MASE Survey is carried out using receiver spread of 24 or 48 Geophones 1 meter to 10-meter interval making a spread length 20 to 470 meter. We can also make this spread length according to our need in field.

This spread length depends upon our need and field condition which type of survey field and what's our purpose and need in Survey. We also take five shot point along the spread length, this short point position are following

Table 2-Shot Point

Shot Point	24 Geophones Receiver	48 Geophones Receiver
First	Offset double distance between two geophones	Offset double distance between two geophones
Second	Between 6-7 Geophones	Between 12-13 Geophones
Third	Between 12-13 Geophones	Between 24-25 Geophones
Fourth	Between 18-19 Geophones	Between 36-37 Geophones
Fifth	Offset double distance between two geophones	Offset double distance between two geophones

3.3.3 APPLICABLE STANDARDS

The following standards and guidelines were applied in equipment, field procedures, and interpretation methods for the assessment of subsurface conditions while conducting the MASW Survey:

1. ASTM Standard Designation D5777-00: Standard Guide for Using the MASW Method for Subsurface Investigation
2. IS 15681: 2006 – Geological Exploration by Geophysical Method (MASW) – Code of Practice

3.4 DATA ANALYSIS

Field Data in Seg Format after process all five shot. Create a dispersion curve refers to a plot that show relationship between the s- wave velocity and frequency waves propagation through the surface. It provides valuable information about share wave velocity profile of the soil or rock layers.

The 1D dispersion curve is obtained by assuming a horizontally layered subsurface model, where the shear wave velocity is assumed to vary only with depth. It represents the relationship between the phase velocity of the surface waves and the corresponding frequency. The 1D dispersion curve provides a simplified representation of the subsurface, assuming a uniform shear wave velocity profile within each layer. It is commonly used for preliminary site investigations or when a relatively simple subsurface structure is anticipated.

The 2D dispersion curve is derived by considering a more realistic and complex subsurface model. It considers lateral variations in the shear wave velocity, allowing for a more accurate representation of the subsurface structure. The 2D dispersion curve represents the relationship between the phase velocity of the surface waves, frequency, and the wave

propagation direction (usually azimuth). It provides a more detailed and spatially varying picture of the subsurface, which is particularly useful when investigating complex geological conditions or near-surface heterogeneities.

Obtaining 1D and 2D dispersion curves in MASW involves similar data acquisition and processing steps. The primary difference lies in the interpretation and inversion methods used to extract the shear wave velocity profile. In the case of 1D dispersion curves, simpler inversion algorithms assuming layered structures are typically employed. For 2D dispersion curves, more sophisticated inversion techniques considering lateral variations in the shear wave velocity are applied.

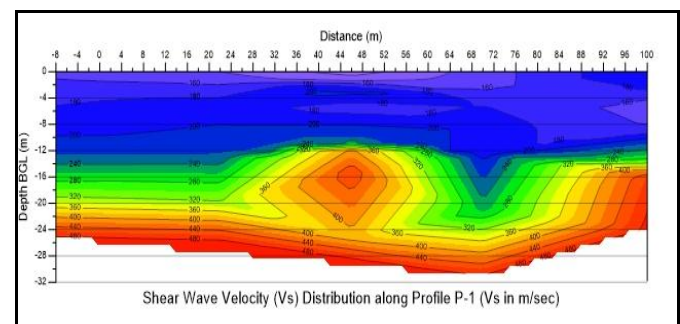
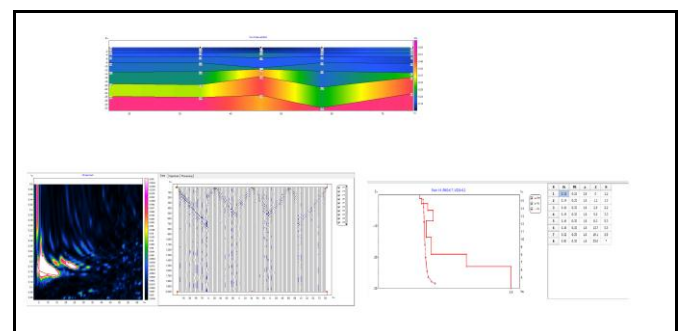
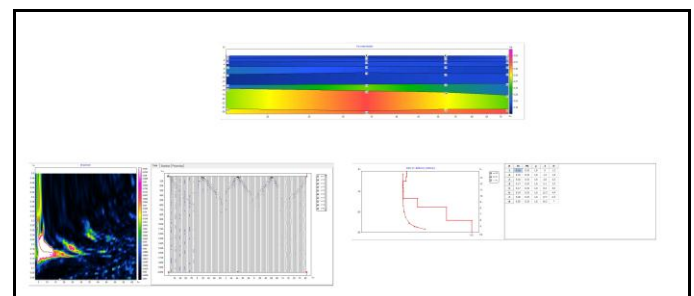


Fig -6: Share Wave Velocity (vs) Distribution along Profile P-1(vs in m/sec)



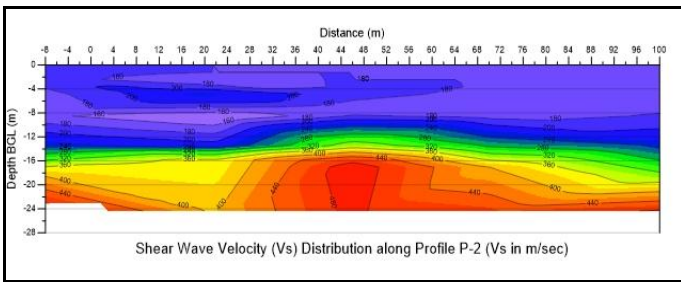


Fig -7: Share Wave Velocity (vs) Distribution along Profile P-2(vs in m/sec)

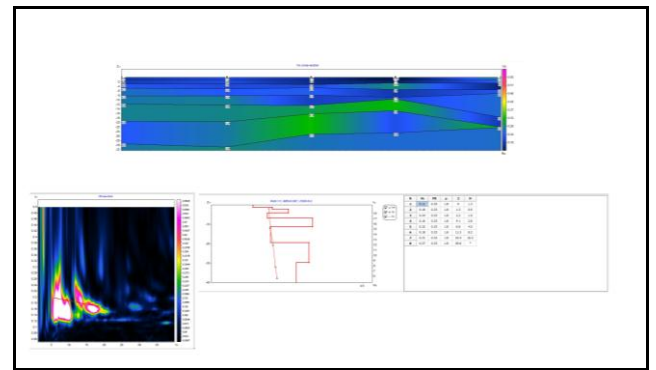


Fig -10: Share Wave Velocity (vs) Distribution along Profile P-5(vs in m/sec)

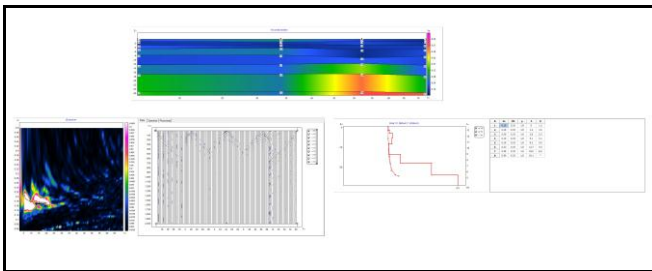


Fig -8: Share Wave Velocity (vs) Distribution along Profile P-3(vs in m/sec)

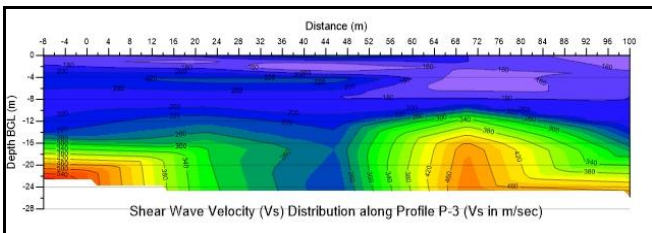


Fig -9: Share Wave Velocity (vs) Distribution along Profile P-4(vs in m/sec)

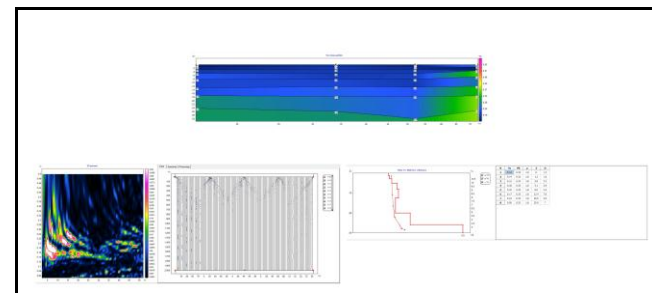
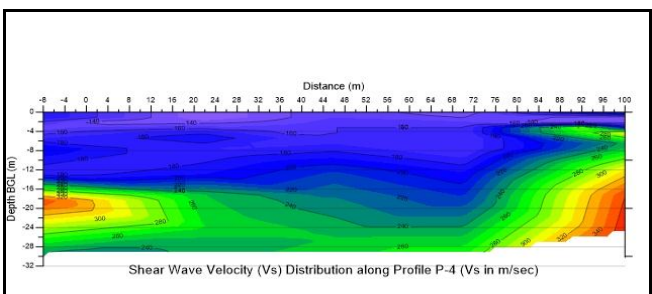


Fig -11: Share Wave Velocity (vs) Distribution along Profile P-6(vs in m/sec)



3.5 SITE CLASSIFICATION

Shear wave velocity (VS) has been an essential parameter for evaluation of dynamic properties of soils. The average shear wave velocity in the top 30 m, based on travel time from surface to a depth of 30 m, is known as VS30. Traditionally, VS30 is determined by seismic measurements in boreholes, using downhole, cross-hole or suspension logging method. However, MASW technique, based on the inversion of surface wave dispersion data, offers advantages of (a) not requiring boreholes and (b) sampling of a larger volume of soil.

Vs30 is used in the NEHRP Provisions (BSSC, 1994) and 1997 Uniform Building Code (UBC) to classify sites for engineering design with the expectation that sites in the same class will respond similarly to a given earthquake. The 2000 International Building Code (IBC) permits a similar approach for site classification for the upper 100 ft of soil. The surveyed site is interpreted in this report in accordance with the above Vs based NEHRP site classification

Table 3- NEHRP seismic site classification-based share-wave velocity(vs)ranges

Site Class	S-Velocity (Vs) (ft/sec)	S-Velocity (Vs) (m/sec)
A (Hard Rock)	> 5,000	> 1500
B (Rock)	2,500 – 5000	760 – 1500
C (Very Dense Soil and Soft Rock)	1,200 – 2,500	360 – 760
D (Stiff Soil)	600 – 1,200	180 – 360
E (Soft Clay Soil)	< 600	< 180
F (Soils requiring additional response)	< 600, and meeting some additional conditions.	< 180, and meeting some additional conditions.

3.6 SOIL LIQUEFACTION SUSCEPTIBILITY

Soil liquefaction susceptibility refers to the potential of a soil deposit to undergo liquefaction when subjected to cyclic loading, typically induced by seismic events. Liquefaction occurs when saturated or partially saturated soils lose their shear strength and stiffness due to the buildup of excess pore water pressure, resulting in a loss of bearing capacity and potential ground failure

Standard Penetration Test (SPT), Cone Penetration Test (CPT), Share Wave Velocity Measurement, Laboratory Testing, Empirical Correlations, Liquefaction Hazard Analysis is method for Soil Liquefaction Susceptibility.

3.6 DISCUSSION OF RESULTS

Table 4-Six Profile of MASW Result

Profile No	Result	Classification
P-1	Vs Value (140-190) m/sec in Depth Ground Level to 10 m	Site Class F
	Vs Value (190-390) m/sec in 10m to 30m	Site Class E
P-2	Vs Value (180-170) m/sec in Depth Ground Level to 8.5 m	Site Class F
	Vs Value (240-500) m/sec in 8.5m to 25m	Site Class E
P-3	Vs Value (180-230) m/sec in Depth Ground Level to 14 m	Site Class F
	Vs Value (230-500) m/sec in 14m to 25m	Site Class E
P-4	Vs Value (140-170) m/sec in Depth Ground Level to 13 m	Site Class F
	Vs Value (240-500) m/sec in 13m to 25m	Site Class E
P-5	Vs Value (110-180) m/sec in Depth Ground Level to 12 m	Site Class F
	Vs Value (180-270) m/sec in 13m to 18m	Site Class E
P-6	Vs Value (140-210) m/sec in Depth Ground Level to 5 m	Site Class F
	Vs Value (290-340) m/sec in 5m to 18m	Site Class E

3.7 CONCLUSION

After getting MASW result Hon'ble High Court Building, Kolkata Area Ground level to mostly 15m depth their S-Velocity is very low <200. So, then we can say that is one of problem of settlement of Building.

ACKNOWLEDGEMENT

Thanks for Dr S.N. Shukla Managing Director of Gaveshana Geosciences Private Limited New Delhi. who provide me valuable suggestion and chance to performing a Field Work and Data Interpretation work of Kolkata Site.

Thanks for Valuable Suggestion Dr. Shashank Tripathi and Anil Kumar Chaurasiya, Project Scientist Remote Sensing Application Centers, Lucknow, India

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