

LAYOUT OF TOTAL LAND UNDER POSSESSION OF TNSCB WITH PROPOSED SITE FOR GHTC-INDIA

**TAMIL NADU SLUM CLEARANCE BOARD**  
 PROPOSED PART LAYOUT FOR CONSTRUCTION OF MULTI-STORYED TENEMENTS AT NUKKAMPALAYAM ROAD, PERUMBAKKAM, CHENNAI IN S.NOS.479/2, 482, 483, 484, 485, 508, 509, 510, 511, 516, 517, 518, 523, 524/1, 524/2, 536/1, 537, 538, 539/2, 540/1, 540/2 & 541, PERUMBAKKAM VILLAGE, TAMBARAM TALUK, KANCHIPURAM DISTRICT.

**REFERENCE:**  
 PERUMBAKKAM TYPE DESIGN AS PER TYPE DESIGN - 7/2008 (G+7) PLINTH AREA - 36.22 sq.m  
 192 UNITS/BLOCK  
 (GROUND FLOOR - 4 UNITS/UNIT FOR ELECTRICAL AND OTHER AMENITIES)  
 EZHIL NAGAR TYPE DESIGN AS PER TYPE DESIGN - 9/2008 (G+7) PLINTH AREA - 28.87 sq.m  
 192 UNITS / BLOCK  
 (GROUND FLOOR - 4 UNITS/UNIT FOR ELECTRICAL AND OTHER AMENITIES)  
 PERUMBAKKAM PHASE-II TYPE DESIGN AS PER TYPE DESIGN - 7A/2008 (G+7) PLINTH AREA - 37.18 sq.m  
 96 UNITS / BLOCK  
 (GROUND FLOOR - 2 UNITS/UNIT FOR ELECTRICAL AND OTHER AMENITIES)

NAME OF THE SCHEME	NO. OF FLOORS	NO. OF UNITS	NO. OF UNITS ALLOCATED	BALANCE NO. OF UNITS	NO. OF UNITS ELECTRICITY & OF DWELLING UNITS
PERUMBAKKAM	11	192	212	00	2008
EZHIL NAGAR	11	192	491	126	366
PERUMBAKKAM PHASE II	11	96	1494	145	1349
<b>TOTAL</b>	<b>33</b>	<b>480</b>	<b>2696</b>	<b>171</b>	<b>2074</b>

**AREA STATEMENT**  
 EXTENT (as per document) - 81.20 HECT  
 EXTENT (as per plan) - 81.20 HECT  
 EXTENT (as per site) - 22.0715 HECT  
 DENSITY - 348 / HECT  
 F.S.I - 1.1026  
 PLOT COVERAGE - 13.36%

**FLOOR WISE AREA DETAILS:**

NAME OF THE FLOOR	7/2008 (G)	9/2008 (G)	9/2008 (G)	7/2008 (G)	7A/2008 (G+7)
	FSI	NON FSI	NON FSI	FSI	NON FSI
	AREA (sq.m)	AREA (sq.m)	AREA (sq.m)	AREA (sq.m)	AREA (sq.m)
G. FLOOR	677.46	176.50	542.57	138.41	175.08
1st FLOOR	677.46	176.50	680.98	433.24	433.24
2nd FLOOR	677.46	176.50	680.98	433.24	433.24
3rd FLOOR	677.46	176.50	680.98	433.24	433.24
4th FLOOR	677.46	176.50	680.98	433.24	433.24
5th FLOOR	677.46	176.50	680.98	433.24	433.24
6th FLOOR	677.46	176.50	680.98	433.24	433.24
7th FLOOR	677.46	176.50	680.98	433.24	433.24
<b>TOTAL</b>	<b>11466.0</b>	<b>1146.0</b>	<b>11466.0</b>	<b>1146.0</b>	<b>11466.0</b>

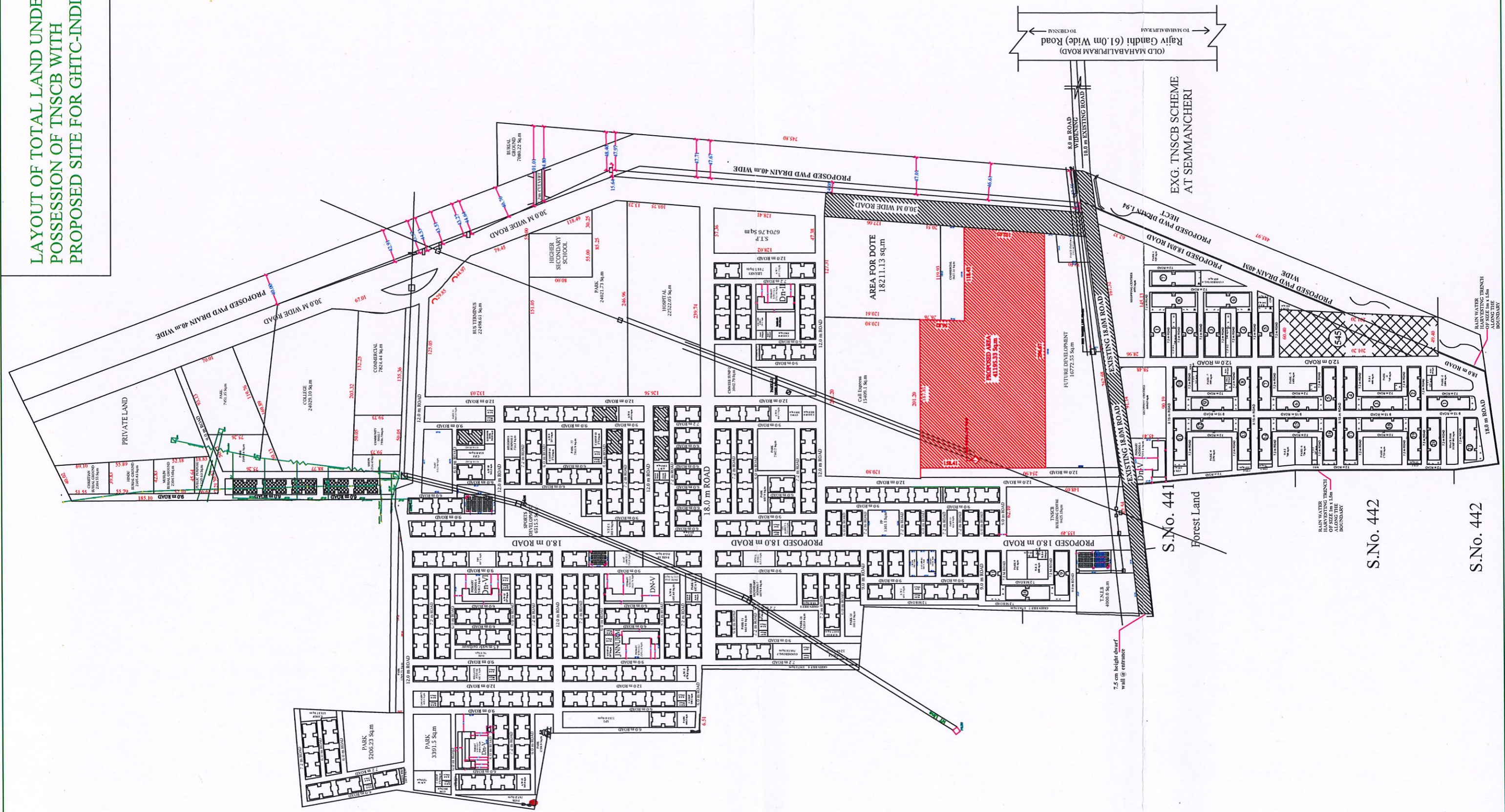
**PARK AREA DETAILS:**  
 EXISTING - 11466.0 sq.m (BELOW PROPOSED 18.0m ROAD-1)  
 PARK - 10 - 972.2 sq.m  
 PARK - 11 - 435.7 sq.m  
 PARK - 12 - 860.2 sq.m  
 PARK - 13 - 607.9 sq.m  
 PARK - 14 - 607.9 sq.m  
 PARK - 15 - 1010.9 sq.m  
 PARK - 16 - 1265.5 sq.m  
 PARK - 17 - 653.9 sq.m  
 PARK - 18 - 2051.9 sq.m  
 PARK - 19 - 2051.9 sq.m  
 PARK - 20 - 845.8 sq.m  
 PARK - 21 - 714.3 sq.m  
 PARK - 22 - 2181.2 sq.m  
 PARK - 23 - 1700.2 sq.m  
 PARK - 24 - 1290.9 sq.m  
 PARK - 25 - 746.3 sq.m  
 PARK - 26 - 3391.5 sq.m  
 PARK - 27 - 1700.2 sq.m  
 PARK - 28 - 782.8 sq.m  
 PARK - 29 - 782.8 sq.m  
 PARK - 30 - 721.1 sq.m  
 PARK - 31 - 658.9 sq.m  
 PARK - 32 - 1078.4 sq.m  
 PARK - 33 - 1078.4 sq.m  
 G.B - 1 - 163.2 sq.m  
 G.B - 2 - 67.1 sq.m  
 G.B - 3 - 67.1 sq.m  
 G.B - 4 - 163.2 sq.m  
 G.B - 5 - 163.2 sq.m  
 G.B - 6 - 98.7 sq.m  
 G.B - 7 - 98.7 sq.m  
 G.B - 8 - 34.6 sq.m  
 G.B - 9 - 111.0 sq.m  
**TOTAL** - 81200.1 sq.m  
**PARK AREA** - 18.6%

**LEGEND:**  
 GHTC (PROPOSED LAND) - (41195.33sq.m)

**NOTE:**  
 - SUMP FOR SULLAGE WATER  
 - SUMP FOR FIRE FIGHTING WATER  
 - SUMP FOR DRINKING WATER  
 - SUMP FOR RAIN WATER COLLECTION

SCALE - 1:1200

PLANNING ASST.	PLANNING ASST.
SENIOR PLANNER	CHIEF ENGINEER



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### 2.5.3 Soil Testing Report

**REPORT ON SOIL INVESTIGATION AND RECOMMENDATION ON FOUNDATION FOR  
THE CONSTRUCTION OF STILT+8 STOREYED HIG FLATS AT ZONE 'H' OF  
PERUMBAKKAM PROJECT**

**Job No: SF/KI-49/ Perumbakkam/Zone 'H'/TNSCB/2013**

**Client: The Executive Engineer,  
ETRP (C-II) Division, TNSCB  
Semmenchery, Chennai-600 119.**

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Project Coordinator  
&  
Professor and Chairman (Civil)

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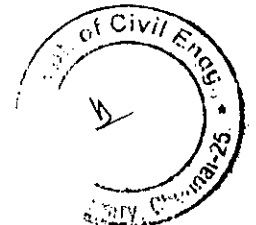
**Client: The Executive Engineer,  
ETRP (C-II) Division, TNSCB  
Semmenchery, Chennai-600 119.**

**1. Introduction**

The Executive Engineer, ETRP (C II) Division of TNSCB has sent a request to conduct soil investigation in their housing project site at Perumbakkam TNSCB scheme area through Lr.No:203/E.C/ETRP CII/2012, dt: 03.01.2013 for the construction of MIG and FIG Flats. The Board proposed to construct residential flats in their housing scheme area as detailed below:

Sl.No	Detail	Number of blocks	Area of each unit (m <sup>2</sup> )	Number of units
1.	MIG Flats (Stilt + 8 Floors)	12 (64 units in block each)	73.9	768
2.	FIG Flats (Stilt + 8 Floors)	4 (64 units in each block)	97.3	256

To construct these residential blocks an area of 7.13 Hectares is allotted covering survey Nos: 539/2, 540/1, 540/2 and part of 537. The area earmarked for the said purpose is shown in key map (Fig.1a) of the TNSCB Perumbakkam scheme. The proposal of the Board comprises of building nine storeyed (Stilt + 8 floors) framed structures. The Perumbakkam village is located at a distance of about a kilometer towards western direction from OMR. A road of 18m wide is connecting this village



with OMR. On the southern side of this road and adjacent to existing TNSCB scheme at Semmencherry, the Executive Engineer (Div VI) of TNSCB executed similar project over an area of 30 Acres covering S.Nos: 542 to 544 during 2009. At this area eight storied framed structures were constructed and they are ready for occupation. These buildings are supported on raft foundation and the depth of foundation of all the buildings is around 4m. The Fig A1 shows the land allotted for the proposed construction including the area where project is completed.

On allocation of land by the Government The Executive Engineer (Div.II), TNSCB took initiative to implement the project and requested the services of Department of Civil Engineering to conduct Soil Investigation for the construction of Block 12 to 18 (S.No: 528) and constructions of Blocks covering area coming under S.Nos:479/2 and 482 to 485. These two locations are marked as Zone 'A' and Zone 'B' in layout plan (Fig A1) and they lie in the south and north west part of the land allotted for the project.

At Zone 'A' investigation was conducted at 5 locations during April 2010. The top layer is expansive clay of 1.5m thick followed by clayey sand of 1m. Weathered rock was met at the depth of 2.75m invariably and fairly good rock was seen at depth around 4m. The water table was met at the depth of 2.5m. Based on the soil condition of the area, it was recommended to adopt raft foundation at the minimum depth of foundation of 3m (RL -1.45m).

At Zone 'B' investigation was carried out during the second week of June 2010 by drilling eight boreholes. The deposit of this area composed of highly plastic clay of 2m to 2.7m thick followed by residual soil (weathered rock reduced to soil) of 1m to 1.5m thick. However the deposit below 4.5m was fractured rock. At this area the water table was at the depth of 3m. The foundation recommended for the eight storeyed structures was raft foundation and minimum depth of foundation was 2.75m (i.e. RL -1.35m) from the lowest ground level. Recommended bearing capacity was 200kN/m<sup>2</sup>. The board commenced the construction work at Zone 'A' and 'B' in the second week of May 2012.



In the remaining part of allotted land of Perumbakkam village, the Executive Engineer, JNNURM Division sent a request through Lt.No:171/JNNURM Dn/A1/2011, dt:28.3.2012 to inspect and conduct subsurface investigation covering survey nos: 509,510,511,516,517,518,536,537 & 538 for the construction of eight storeyed residential block in these location. Accordingly investigation was conducted at 40 locations covering 125 acres of land. Since the area was large, it was divided conveniently in to Zone 'C', Zone 'D', Zone 'E' and Zone 'F' as indicated in Fig A1.

The sub-surface investigation in all these areas was commenced on 25<sup>th</sup> April 2012 and completed on 19<sup>th</sup> May 2012. The report was released for each zone independently. The recommended foundation was raft for the eight storeyed buildings irrespective of the Zones in which buildings are proposed to locate. The recommended depth of foundation at different Zones is as below:

Zone	RL of Foundation (m)	Bearing capacity
C	between - 1.0m and -1.2m	220kN/m <sup>2</sup>
D	between - 1.9m and -2.6m	220kN/m <sup>2</sup>
E	between - 1.1m and -1.6m	220kN/m <sup>2</sup>
F	between - 0.9m and -1.2m	220kN/m <sup>2</sup>

Foundations of buildings were located at depths as recommended without difficulty except one or two blocks. As stated in the first paragraph of the report the board has drawn a proposal to construct MIG and HIG Flats in this area for the public, since the area lies within a distance of 2km from OMR and demand for house is more in this area.

The board has earmarked the area for this proposal, which lies in the south east part of the Perumbakkam scheme, which is about 7.13 Hectares. The project site was inspected along with the Executive Engineer of ETRP Division and other officials on 28.02.2013. Since the project area is large (total extent is 7.13 Hectares) the buildings are nine storeyed framed structure and this area comes under zone III as per IS1893-2002(Part-1), it is decided to investigate over entire area covering all the 16 blocks. At the end of investigation it is proposed to explore at two locations for each MIG block and at three locations for each HIG block. This proposal is been accepted by the Executive Engineer.



Accordingly locations of boreholes for each block were selected and mutually agreed to investigate at 36 locations as detailed below:

Zone	Number of Blocks	Boreholes
M1	M1 to M6	BH1 to BH12
M2	M7 to M12	BH13 to BH24
H	H1 to H4	BH1 to BH12

Since large part of Perumbakkam Housing Project area was covered in earlier investigation and over all soil condition of this area is known to consultant. In this area, the hard stratum with good bearing resistance occurs within a depth of 4.5m; therefore it is felt sufficient to investigate to a depth of 9m. However one or two boreholes were drilled beyond the depth of 9m to know relative degree of weathering of rock deposit and its quality. The soil investigation work in all the three zones is commenced on 04.03.2013 simultaneously and completed on 9.4.2014.

## 2. Details of the project

The project to be executed in this area is construction of multi-storeyed blocks for the middle and high income group people under Rajiv Awas Yojana scheme. In this project the Board is proposed to construct 9 storeyed (Stilt + 8 Floors) framed structure by adopting two different type design; one is for MIG and the other is for HIG. Apart from construction of residential buildings they develop other amenities like club house, Gym, Park etc. However the soil investigation carried out is found mainly for the construction of multi-storeyed buildings. Each block of MIG is designed to accommodate eight families in each floor with plinth area of 73.9m<sup>2</sup>/ family. Similarly the HIG flats are also designed to accommodate eight families in a block with plinth area of 97.3m<sup>2</sup>/unit.

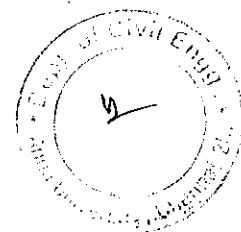
The structure is nine storeyed building and the area of construction is located within 20km distance from Chennai. The Chennai and its neighboring areas is coming under Zone III, hence the structure of this area is to be designed for Zone III conditions. Moreover in the recent past Chennai has experienced mild tremors and the earthquakes



occurred in Sumatra islands and Pondicherry coast also felt in some parts of Chennai. Therefore the board has analyzed the building for the Zone III condition. The minimum and maximum load at the foundation level for the critical load combination was reported as 869kN and 1890kN respectively. Since the soil is in the heterogeneous condition and in hard layer (i.e. weathered rock) clay lumps are seen during investigation, which is not conducive for isolated footing. Therefore the average load at the foundation level for the raft was obtained for the critical combination of load, which is 219kN/m<sup>2</sup>.

### **3. Preliminary Inspection of the project area**

Perumbakkam area has experienced fast development within a period of four years. The land of Perumbakkam area covering survey numbers as per the key plan (Fig. 1a) was occupied by the local people of the area. This entire area was covered with thatched roof houses, semi permanent and permanent buildings. The local town Panchayat laid temporary roads and provided water and power connections to the houses. Certain houses were provided with soak pits and were connected to toilets. These soak pits are 3.5 to 4m deep from the existing ground level. The area identified for the development of project is covered by 18m road on the south, compound wall of Bollini Hill Housing complex on the west, open private land on north and proposed PWD Drain of 40m wide on the east. This area is at a distance of approximately 2km from the OMR. The ground level of this area though it appears uniform, it is slopping from west to north east direction. The construction of multi-storeyed buildings in this project area was commenced during 2010 in Zone A and covered most part of the area part by part. The part of land, on the south east side of the area covering Survey Nos: 537, 539/2, 540/1, 504/2, 541 is vacant and is been identified for the construction of multi-storeyed flats. This area lies within the boundary of 18m wide Semencherry-Perumbakkam road on the south; 30m wide road and PWD drain are on the east, Zone D on north and community facilities of Zone A on the west. The total area is 71330m<sup>2</sup>. The ground level of this area is almost uniform and is also free from shrubs and old structures; hence the site is ready for soil investigation. There is a mountain at a distance of about a kilometer or more on





the western side and the ground is slopping from the foot of the hill towards east. At the proposed construction site the ground level is the lowest while comparing with the ground level of neighboring areas. This area is prone for water logging hence the board is proposed to raise the existing ground level.

As stated in the introduction, the area of Perumbakkam (Zone A to Zone F) was already investigated at different pint of time for the purpose of locating suitable depth for foundation of eight storeyed structures and reported occurrence of hard stratum invariably at the depth below 4.5m and the weathered residual soil at depth of around 2.75m. The weathered residual soil was in hard/dense condition with N values more than 50 blows. However on the east and north east part of the area (Zone D) the deposit over a depth of 3m is soft. Keeping this in mind, it is proposed to investigate up to the depth of occurrence of hard stratum ( $N > 100$ ) at all the 36 boreholes. In a few boreholes rock drilling using single tube core barrel with diamond cutter is also recommended in order to confirm the presence of true hard stratum to a reasonable depth. The officials of TNSCB have agreed for this suggestion and proceeded accordingly.

Since the soil condition at major part of Perumbakkam project area is known from the earlier subsurface investigation carried out for the blocks at Zone 'A' to zone 'F' it is agreed mutually by the consultant and the officials of TNSCB to restrict the number of investigation points as minimum as possible. Since buildings are located as clusters accommodating other amenities for each cluster, it is decided to group at each cluster as individual zone. Thus there are three zones (M1,M2&H) and is mutually agreed to investigate at 12 points in each zone by distributing minimum of two exploratory points for each block. The subsurface investigation at the proposed construction area was commenced during the fourth week of February 2013. At all the borehole locations, the borehole was advanced using rotary drilling technique and standard penetration tests were conducted in each borehole at spacing of 0.75m using standard split spoon without liner as per IS2731-1972. The subsurface investigation work in this area was executed by M/s. Geotechnical solutions, Chennai under my (Prof.K.Ilamparuthi, Professor and Chairman,



Faculty of Civil Engineering) supervision. This report presents salient details of investigation and soil type encountered along with recommendation on foundation for the construction of HIG flats at Zone H.

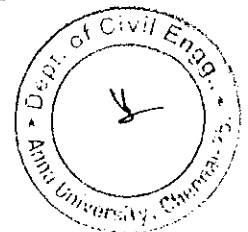
#### 4. Site condition

The topography of Zone 'H' is almost uniform and if at all any difference in the levels within the area of investigation, which may not be more than 0.4m. The deposit on the surface exhibited honey comb pattern tension cracks, which confirm that the top soil is dominantly clay with shrink and swelling quality. Further there is a mountain at a distance about a kilometer or more from the western boundary of proposed construction area. It provides the clue that the rocky stratum will be at a shallow depth in the construction area and the soil cover that lies above is certainly residual deposit. However there is a chance for transported soil deposit on the surface since the ground is slopping from mountain on the west to canal on the east and the ground level is lower in this zone.

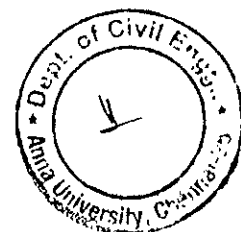
#### 5. Details of soil investigation

At Zone 'H' it was proposed to construct four blocks. Soil investigation was carried out at three locations in each block and in total investigation was conducted at 12 locations as shown in Fig.1b. It can also be seen that the locations of various blocks in the figure. The details of borehole locations and the ground level at each location are presented below:

Bore hole No	Identification	Location	Ground level (RL)	Water Table (RL)
1	BH1	Block H1	+1.582m	+0.282m
2	BH2	Block H1	+1.312m	+0.112m
3	BH3	Block H1	+1.550m	+0.250m
4	BH4	Block H2	+1.280m	+0.180m
5	BH5	Block H2	+1.535m	+0.135m
6	BH6	Block H2	+1.592m	+0.192m
7	BH7	Block H3	+1.456m	+0.206m
8	BH8	Block H3	+1.376m	+0.176m
9	BH9	Block H3	+1.335m	+0.085m
10	BH10	Block H4	+1.210m	+0.210m
11	BH11	Block H4	+1.480m	+0.180m
12	BH12	Block H4	+1.500m	+0.300m



The boreholes were made to collect information on nature of overburden and depth of occurrence of hard stratum. They were drilled using rotary method with bentonite mud circulation. This method is normally adopted to advance the boreholes both in residual and sedimentary deposit. The circulation of drilling fluid was employed through drill rods and letting out through the jets provided in the cutting tool. The jetting action with pressure flow brings the cut material to the surface through the annular space between the sides of boreholes and drill rod. Boreholes of diameter 150mm were drilled by adopting this method. During drilling it was ensured that the borehole was kept full with drilling fluid to avoid disturbance to the sides as well as bottom heave. In the boreholes, standard penetration tests were conducted at required depth or wherever there was a change in the soil layer. This test was conducted using standard dimension split spoon without liner as per the procedure given in IS 2731-1972 using donut type hammer dropped mechanically (2 turns of rope in the cathead arrangement). The energy of impact was around 70%. Thus the field value was  $N_{70}$ . However the filed N values were corrected for the installation procedure and the value was very close to  $N_{60}$ . Therefore recorded values were taken as  $N_{60}$ . The values thus recorded were not corrected for overburden since the top soil to the depth of 2.5m was having fines more than 50%. Further the correction for saturation was also not applied for the resistance values recorded below water table since the deposit was not fine sand. Further the overburden correction factor is greater than unity for the N values recorded at shallow depths; hence the said conditions will certainly result in conservative resistance of deposit. The soil samples obtained from the split spoon were visually identified and tested in the laboratory for assessing index properties. Soil samples collected in split spoon samplers are subjected to test for index properties. The boring and sampling operations were continued at each location until refusal N value (rebound) was recorded or two consecutive N values were greater than 50 blows and the third N value was more than 100 blows. However at locations wherever rock was encountered, exploration was continued using single tube core barrel with diamond cutter. In the rock stratum drilling was done to a depth not less than 1m and obtained core samples. Attempt was also made to record water table in each borehole, after a time



lapse of 24 hours from the time of termination of investigation at each borehole location. The depth of ground water table recorded at various locations is included in the table presented in this section.

## 6. Soil profile of the proposed site

The investigation at this area was commenced after marking borehole locations and their reduced levels. The reduced levels of borehole locations are almost uniform at most of the locations except at BH6 and BH10. The difference in level is 0.4m between BH6 and BH10 and the RL at BH6 is +1.592m whereas at BH10 RL is +1.210m. However within a block the variation in ground level is marginal and not exceeding 0.3m. As stated in the previous section, the soil profile is logged at each location based on soil samples obtained using split spoon sampler. The profiles thus logged at 12 locations are presented in Figs 2 to 13 along with N values recorded. The field N values recorded are taken as  $(N_1)_{60}$  (i.e. design N values) for the reasons already stated irrespective of the depth and nature of deposit of this area.

The disturbed samples of each borehole are tested for index properties inclusive of swell quality. The index properties such as Gradation, Atterberg limits, and Free Swell Index are presented in Table 1 to 12 for the boreholes BH1 to BH12. The gradation curves are presented in Annexure G. The undisturbed samples obtained from the clay layers are tested for strength. The strength is determined by conducting unconsolidated undrained test at their natural moisture contents on undisturbed samples of three boreholes and the respective stress-strain responses are present in Annexure-U along with Mohr-Coulomb envelope. The strength and secant modulus are also presented. The compressibility properties of clay deposits are also determined from the tests on UDS samples of BH1 and BH2 and presented in Annexure-C. The results include pre-consolidation pressure ( $P_c$ ), Compression Ratio (CR) and Recompression Ratio (RR). The compressibility parameter,  $m_v$  is determined from index properties using established empirical relations between N and  $I_p$ . The  $m_v$  values thus obtained are presented in Table 13. The soil deposits logged at each block are presented and discussed below.



## Block H1

The block H1 is located on the northwest corner of the Zone H. At the block H1 three exploratory boreholes (BH1, BH2 & BH3) were made by locating two boreholes (BH1 & BH3) directly opposite to each other in the northeast and southeast corners of the block and the other on the middle of west side. At these three boreholes (BH1 to BH3) exploration was done to a depth of 9.3m, 8.5m and 8.0m respectively and the boreholes were terminated in severely jointed gneiss rock.

The difference in ground level at both the borehole locations is about 0.1m, which shows that the terrain is almost uniform at Block H1. The soil profile logged at BH1, BH2 and BH3 is presented in Fig 2, 3 and 4 respectively along with N values recorded.

At BH1 (Fig.2) the top layer to a depth of 2.4m is silty clay. This layer recorded a minimum N value of 2 blows at the depth of 0.75m and a maximum value of 14 blows at the depth of 1.8m. The top 1.4m clay layer is in soft consistency. Its stiffness is increased with depth and is in stiff condition between the depth 1.4m and 2.4m. Results of Atterberg limit tests show that this layer is high plastic clay (CH) and it possess volume change quality. Its liquid limit and plasticity index (Table 1) are more than 67% and 46% respectively. The strength and compressibility results of UDS of depth 1.5m show that  $C_u=29\text{kN/m}^2$  and pre-consolidation pressure of  $255\text{kN/m}^2$  with over-consolidation ratio of 10. The over-consolidation ratio of 10 is attributed to desiccation. Despite over-consolidation the CR value is high, which is because of high moisture content in the sample. The deposit between the depth of 2.4m and 5.3m is a residual deposit. In this residual deposit, clay content is about 33% and is classified as SC. This intermediate layer is in dense condition and becomes very dense layer by recording N value  $> 100$  blows. The rock is encountered at the depth of 5.3m, which is highly weathered and further exploration to depth of 9.3m confirms that the rock deposit is becoming strong. However the deposit at the depth of termination is severely jointed with core recovery ratio of 21%, which can be seen from the plate 1 wherein core samples obtained between the depth 7.3m and 9.3m are shown. Thus the deposit at BH1 within the depth of investigation of 9.3m is three layer system comprises of top layer of

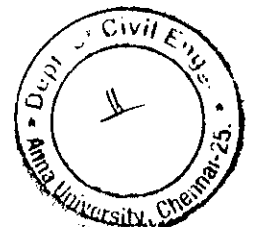


high plastic clay (CH), intermediate residual deposit of clayey sand (SC) followed by weathered rock. The weathered rock between the depth of 5.3m and 8.3m is calcareous sandstone and the rock is gneiss at the depth below 8.3m, which belongs to granitic family.

The BH2 which is been made at the middle of western side of block H1 has also recorded identical soil condition (three layer system) as that of BH1 within the depth of investigation of 8.5m. The soil profile logged is presented in Fig.3 along with resistance recorded. The top soil to a depth of 2.2m is silty clay. This layer is in soft condition at the depth of 0.75m and is becoming medium stiff at depth 1.5m. This layer contains plastic clay which is known from the plastic index values of the clay ( $I_p > 48\%$ ). Its free swell index values are also more than 60% (Table 2). Thus the soil is clay of high plastic (CH) and is susceptible for volume change. The layer that follows the clay is clayey sand/silty sand with fines in the range of 22% to 25%. The N values recorded in this layer are more than 70 blows, indicating that the layer is very dense condition. The deposit that lies below the depth of 4.8m is weathered rock; its degree of weathering appears to decrease, which is known from the recovery ratio of core samples. The recovery ratio of rock core between the depth of 5.5m and 6.5m is zero and between 6.5m and 8.5m is between 20% and 25% with nil RQD.

The test results of top layer (clay) and intermediate silty sand/clayey sand layer are represented in Table 2. From the test results it can be seen that the clay layer is highly plastic and susceptible for volume change due to seasonal moisture variation. The strength and compressibility test results of undisturbed sample also confirm that the clay deposit is soft and compressible than the clay at BH1.

The soil profile logged and test results on soil samples of BH3 are presented in Fig 4 and Table 3 respectively. At this location investigation was conducted up to the depth of 8.0m and the deposits were top layer of silty clay, intermediate layer of silty/clayey sand followed by weathered rock. The deposits encountered at this location are almost identical to that of other two locations of Block H1. The difference is only in their thickness. Top layer is clay of high plastic of 1.6m thick with  $I_p > 49\%$ . The layer that



follows the clay is residual deposit of silty sand/clayey sand of 2.5m thick. It contains fines less than 15% and classified as SC/SW. The rock deposit between 6m and 8m is highly weathered gneiss with RQD of rock core 10%. Its unconfined compression strength is  $7,000\text{kN/m}^2$  (Annexure CS1)

## **Block H2**

The Block H2 is located on the southern side of Block H1. In the location of Block H2 three boreholes (BH4&BH6) were made as shown in Fig.1b. BH4 was made on the southwest corner of the block. At BH4 exploration was terminated at the depth of 8.1m from the existing ground level. The ground levels at BH4 is +1.28m respectively. The soil profile logged and N values recorded at these two borehole locations are presented in Fig 5.

At this borehole location top soil to a depth of 2.2m is silty clay with zero resistance. Its index test results are presented in Table 3. It has high liquid limit (between 67% and 85%) and plasticity index values between 45% and 62%, which indicates that the fines of this layer is plastic and the soil is classified as clay of high plastic (CH). The layer that lies below the silty clay layer is clayey sand/silty sand with fines less than 22%. Thickness of this layer is about 1.5m and is in dense ( $N > 41$ ) to very dense condition ( $N > 100$ ). There is a transition layer between top clay and residual silty sand, which is SC/CI. The weathered rock that lies below residual sand layer is highly weathered and fractured. However the presence of strong layer is confirmed by drilling to a depth of 8.1m at BH4, at which depth the deposit is severely jointed fractured rock, belongs to granitic gneiss. The core sample obtained from gneiss between the depth of 7.1m and 8.1m recorded RQD of 32%. Thus the rock mass is strong even though possessing vertical joints.

The soil profile logged at BH5 is presented in Fig 6. The test results conducted on samples of split spoon are presented in Table 5. Top layer is silty clay and its thickness is approximately 1.8m. In this clay layer liquid limit value is more than 65% and FSI



values are also more than 45%. These values confirm that the clay layer is active and is susceptible for volume change due to seasonal moisture variation. The N values recorded show that the clay layer is in very soft condition ( $N=0$ ).

The deposit between the depth 1.8m and 4.5m is residual clayey sand layer with fines between 20% and 27%. This layer is in dense ( $N=42$ ) to very dense condition. The maximum N value recorded in this layer is 150 blows (extrapolated value) at 3.75m, which indicates that the stratum is becoming strong. At the borehole location weathered rock layer is met at depth approximately 4.5m and presence of rock deposit is confirmed by drilling to an additional depth of 3.5m. The borehole was terminated at the depth of 8.0m, at which the rock is granitic gneiss, which is jointed. The recovery ratio of core sample obtained between the depth of 7m and 8m is 48%. The RQD of sample is also 48%. Plate 1 presents the core samples of BH5. The core sample is tested for strength under unconfined condition. Its stress-strain response is presented in Annexure CS2. The peak strength of rock is  $43,800\text{kN/m}^2$ .

The borehole 6 (BH6) is drilled at the northeast part of the block. The soil profile logged at this location is presented in Fig 7 along with N values recorded. At BH6 the top soil to a depth of 1.4m is silty clay, which is in soft condition ( $N \leq 3$ ). The deposit that follows the clay is silty sand of 3.4m thick. This sand deposit is in dense condition with N values greater than 45 blows. The deposit that follows silty/clayey sand layer is weathered rock which is highly weathered with RQD of zero. This weathered rock changes to strong (hard) rock at the depth of 7.2m and the core sample obtained between the depth of 7.2m and 8.2m recorded the recovery ratio of 32% and RQD of 20%. These values confirm that the rock occurring at depth below 7m is hard and is classified as gneiss. The strength of core sample is  $10,400\text{kN/m}^2$ , which is far less than the core sample of BH5.

The laboratory test results of samples of clay layer and silty sand layer are presented in Table 6. The liquid and plastic limits of clay are in the range between 64% and 77% and 19% and 24% respectively. The samples also recorded FSI values more than 42%. Thus clay fines are active and plastic and the soil is classified as clay of high



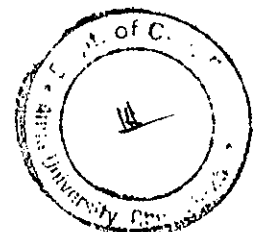


and intermediate plastic (CH). In the silty sand fines are in the range of 7% to 24% and sand fractions are more than 75% in deposit below the depth of 3m. Thus classified as clayey sand / silty sand (SC/SM).

### **Block H3**

The block H3 is located on the eastern side of block H2 and the investigation was conducted at three locations by disposing the boreholes in triangular pattern as in Fig 1b. Two boreholes are in the northwest (BH7) and north east (BH9) corners and the third borehole is made at the centre of south side of the block. At BH7 exploration was made to a depth of 8.1m and was terminated in grayish jointed hard rock (gneiss). The deposit at this borehole location comprises of soft clay layer of 1.9m thick followed by stiff clayey sand layer of 0.6m thick. The N value recorded in the clay layer is between 2 and 4 blows. In the sand layer the resistance is high ( $N > 38$ ) and recorded refusal condition at the depth of 5.1m. The rock that follows the clayey sand is highly weathered and fractured wherein recovery ratio is nil between the depth of 5.1m and 6.1m. However the degree of weathering is reduced with depth, which is confirmed from the recovery ratio and RQD values. The RQD of core sample is 23% (Plate 1) for the deposit between the depth of 7.1m and 8.1m.

The soil profile logged at BH8 (Fig.9) is almost identical to that of BH7. Top layer is soft clay of 1.8m thick with N value 3. This layer is underlain by stiff clay of 1.1m thick with N value of 12 blows. The deposit that follows the stiff silty clay is residual clayey sand layer, which is hard to very dense condition. Thickness of this layer is 2.1m and its fine fraction is less than 15%. It is becoming very strong by recording N value  $> 100$  at depth below 3.75m. The refusal condition is encountered at 5.0m depth where the deposit is highly weathered rock. This layer continues up to 8m at which depth the borehole was terminated. The core samples extracted at various depths of this borehole recorded minimum core recovery of zero and maximum core recovery of 58%. The rock available between the depth 5.0m and 7.0m is weak whereas at depth between 7m and 8m is strong with RQD of 58%. However the deposit below the depth of 5.0m

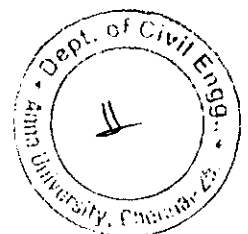


can be considered as strong bearing layer. The laboratory test results of top clay layer are presented in Table 9. The liquid and plasticity index values are high and its plasticity indices are between 41% and 47%. Free swell index of the clay is between 66% and 100%. Thus the clay layer of BH8 is high plastic clay with swelling clay minerals. It is classified as clay of high plastic (CH). The rock sample is also tested for strength and its stress-strain response is presented in Annexure CS4. The peak strength of rock under unconfined condition is 26,300kN/m<sup>2</sup>.

The deposits encountered at BH9 are logged and presented in Fig.10 along with N values recorded. The deposits of this borehole location are almost identical that of BH7 except marginal variation in thickness. The top layer is clay of high plastic (Table 9) as seen at BH7, but its thickness is 2.1m. However the clay layer has almost identical character as that seen in the clay of BH7. The second layer is clayey sand/silty sand, its thickness is about 2.4m and is in hard condition and becomes very dense ( $N > 100$ ) at the depth of 3m. The deposit that follows the sand layer is weathered fractured rock and recorded refusal N value at the depth of 4.5m. This stratum continues up to 7.8m, at which depth, the borehole was terminated. The rock deposit available at depth between 5.8m and 6.8m is moderately strong but weathered since recovery ratio and RQD values are 26% and zero respectively.

#### **Block H4**

At Block H4, exploration was done at three locations as shown in Fig.1b. Borehole 10 (BH10) and borehole 12 (BH12) are located directly opposite to each other and borehole 11 (BH11) is drilled at the middle of western face of the block. At BH10 the deposits are soft silty clay followed by silty clayey sand up to 3.6m from the existing ground level followed by weathered rock up to 5.3m, at which depth; the borehole was terminated (Fig 11). The clay layer is in soft condition with N value of 2 blows. This layer is classified as clay of high plastic (CH) since liquid and plasticity index values are more than 56% and 38% respectively. The sand layer that follows the clay is classified as clayey sand in which fines are about 30% and sand fractions are more than 60% (Table

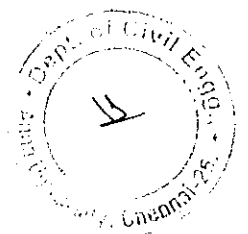


10). It is in very dense condition with N value much higher than 100 blows at depth below 3m. The rock layer that lies below the clayey sand is highly weathered till the depth of 5.3m. However the degree of weathering in rock layer is reduced with depth and core recovery of 14% is obtained in the rock between the depth of 4.3m and 5.3m. The occurrence of hard stratum at this borehole is at shallow depth from the ground level (RL +1.210m) when compared to other locations of the Zone H.

The deposit encountered at BH11 and BH12 are presented in Figs 12 and 13. At both the locations the top layer is soft clay with negligible strength ( $N=0$ ) and its thickness is approximately 2.6m. The thickness of residual soil is about 1m only at these boreholes and weathered rock occurs at depth of 3.5m, which occurs almost at uniform level in the area of block H4. The borehole 11 was terminated at the depth of 6.4m, where the deposit was jointed gneiss rock. The recovery ratios of core samples obtained in this deposit was 26% and RQD=14%. At BH12 exploration was terminated at 7.5m at which depth the deposit was severely jointed weathered rock. The recovery ratio of core samples in 15% and 18% for the deposit between 5.5m and 7.5m. The clay layer possesses characteristics as that of clay of intermediate to high plastic (Table 11). The rock layer that lies below the sand is highly weathered but strong bearing layer. The degree of weathering is reduced with depth and the strength of rock between the depth of 5.4m and 6.4m at BH11 is  $31,700\text{kN/m}^2$ .

The overall variation of deposits at locations of each block are combined and presented in Fig 13 to 16 for blocks H1 to H4 respectively. From the figures presented and properties given in tables it is clear that the deposit of the area within the depth of investigation comprises of three layer system. The top layer is clay of high plastic (CH) with liquid limit higher than 60% in general. The swelling quality of the clay is critical to high and is confirmed through the free swell index values more than 60% in most of the samples. Its thickness is found to vary between 1.9m and 2.7m and is in soft condition at most of the locations. The soil of this layer is not even suitable for filling work.

The deposit that lies below the clay layer (CH layer) is clayey sand/silty sand. Its maximum thickness is about 3m. This layer is in dense condition with recorded N values



are close to 50 blows or more except at the transition zone between clay and sand layers. The limitation in this layer is presence of clay lumps and, clay patches at certain locations. These lumps are part of highly weathered soil derived from the parent material rock. As long as clayey sand layer is intact there may not be change in their property but due to release in pressure and direct contact with water it will become soft. Thus the condition is not favorable for isolated footing. Moreover excavation of this layer in presence of water or below the water table will create a problem to locate the foundation in this layer provided the water table is reduced well below so that the soil is not losing its strength and provides good environment for construction.

The third layer is weathered rock. In this deposit degree of weathering is decreasing with depth and the thickness of strongly weathered portion is around one meter. The recovery ratio of rock generally less than 10% in weathered layer of the rock and in most of the locations the RQD is nil. The rock stratum at depth below 6.0m is strong deposit however it is, fractured and severely jointed. This rock mass recorded maximum recovery ratio of 58% at BH8 and the RQD is 56%. The rock cores obtained from the boreholes are shown in Plate 1. Rock samples of certain boreholes are tested for strength under unconfined condition and test results are presented in Annexure CS1 to CS5. The unconfined strength of samples is presented below along with secant modulus of samples. The strength of rock found to vary widely, the minimum and maximum strength values are 7000kN/m<sup>2</sup> and 43,800kN/m<sup>2</sup> respectively. The high value is in granitic rock of BH5 at the depth between 7.0 and 8.0m. The RQD of sample tested for strength is 48%. The strength of rock of Zone H is higher than the strength of rock deposit of Zone M2.

S.NO:	Identification	Depth, (m)	Unconfined Strength, (kN/m <sup>2</sup> )	Secant Modulus (kN/m <sup>2</sup> )
1.	BH3	7.0-8.0	7000	169200
2.	BH5	7.0-8.0	43800	413200
3.	BH6	7.2-8.2	10400	336400
4.	BH8	7.0-8.0	26300	359500
5.	BH11	5.4-6.4	31700	353000



The properties of various soil layers both strength and compressibility are obtained from the  $N$  values using existing correlations and presented in Table 13. In case of clay Terzaghi's relation is used for obtaining undrained cohesion ( $C_u$ ) values. The values thus obtained are found to vary between  $10\text{kN/m}^2$  and  $20\text{kN/m}^2$  in soft clay and the values are in the range between  $30\text{kN/m}^2$  and  $70\text{kN/m}^2$  in medium stiff to stiff clay. The strength obtained from UCC test on undisturbed samples is  $9\text{kN/m}^2$  and  $17\text{kN/m}^2$ , which are in comparison with the values <sup>obtained</sup> by empirical correlation. In silty sand/clayey sand angle of shearing resistance ( $\phi$ ) is obtained using Meyerhof recommendations. However the modification suggested by Housh for the percentage fines present in the deposit is applied. The  $\phi$  values obtained are varying between  $32^\circ$  and  $42^\circ$ .

In sand compressibility parameter is obtained by the relation  $C=1.9 q_c/\sigma'_0$ , where  $q_c$ —cone resistance and  $\sigma'_0$ —effective overburden pressure. This procedure was developed by DeBeer and Martens (1957) and later on modified by Meyerhof to determine the elastic settlement in non plastic cohesionless deposit. IS 8009 (Part I), is also recommends this method to obtain immediate settlement. In the absence of cone resistance ( $q_c$ ), it is considered equal to  $240N$  to  $300N$  ( $\text{kN/m}^2$ ) since the deposit is SC/SM type. The strength and compressibility parameters thus obtained are summarized in Table 13.

In the absence of consolidation test results on samples of certain boreholes, the compressibility parameter,  $m_v$  ( $=1/E$ ) of clay deposit of Zone H is obtained from the chart of Stroud (1975) which accounts for the plasticity of clay fines and the value is based on  $N_{60}$  value and is equal to  $1/F N_{60}$  ( $\text{m}^2/\text{kN}$ ). The "F" is varying between 420 and 480 in medium to stiff clays. However the compression test results on UDS of certain boreholes confirm that the clay deposit is preconsolidated, and overconsolidation ratio of tested samples are between 3 and 10. The shear strength of rock is obtained from the UCC tests conducted on core samples and the values are in the range between  $7,000\text{kN/m}^2$  and  $43,800\text{kN/m}^2$  respectively. The  $C_u$  values are also obtained for highly weathered rock based on Cole and Stroud (1977) chart and the values thus obtained are presented in Table 13.



## 7. Ground water quality

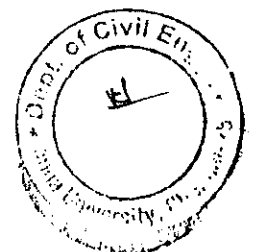
The ground water table at all the boreholes is monitored and the levels are reported in section 5. Water samples are collected and tested for pH, sulphates and chlorides. Since the water is brackish, it is also decided to test the soil for above properties. The chemical test results are presented Table 14:

In water samples tested, pH is in the range between 7.35 and 8.25 and can be said that water is neither acidic nor alkaline. The chlorides and sulphates are very high and the amount of chlorides present in ground water indicates that the ground water of this area is just like sea water.

In soil, the contents of sulphates and chlorides are more in clay layer within the depth of 1.5m. The soil is alkaline at BH12 and rest of the tested locations it is close to neutral condition. It also contains both sulphates and chlorides and they are more than 300ppm and 2100ppm respectively except in soil depth of 1.5m in borehole H1. The results of tests on soil and water are to be reconfirmed. Sulphates and chlorides both in soil and water are more than the permissible limits as per IS 456 (Refer Table 4). Since ground water is very poor in quality suitable measure is to be taken to protect concrete and rebars from sulphate attack and corrosion of reinforcement. The clayey soil is not only plastic but also contains chlorides and sulphates in high quantity, hence not suitable for filling.

## 8. Summary

1. The top soil is highly plastic clay at all the borehole locations. Its thickness is found to vary between 1.9m and 2.7 m. It is susceptible for volume change due to seasonal variation in the moisture content. Free swell index value is as high as 100% at a few locations indicating clay is active. It is in medium stiff to stiff condition at certain depth and at most of the locations the clay is in soft state. Native clay soil is not at all suitable for any construction work including back fill of basement and foundations.



2. The deposit below the depth of 2.7m from the existing ground level is residual deposit (highly weathered rock), which is a strong layer. The minimum N value recorded in this layer is 27 blows, which indicates that the deposit is in medium dense state. Further fines are less than 25% in sand at most of the location except at the transition zone between clay and sand and the balance content is dominantly sand and gravel fractions. This layer is strong enough to support any shallow foundation. However presence of clay lumps and clay patches need to be considered while deciding the foundation type.
3. The deposit below 5.5m is highly fractured rock which has recorded refusal N value. The recovery ratio of rock samples found to vary between 0 and 20% at most of the depths of rock deposit, which indicates that the rock is jointed and fractured. However a value of 58% is also recorded at certain depth of rock deposit. RQD is generally zero and more than 20% is recorded in rock samples obtained at depth below 7m at five boreholes located in Blocks H2 and H4. The maximum RQD is 56%, which is recorded in BH8 at the depth between 7.0m and 8.0m.
4. The water table level is at shallow depth (1m to 1.4m) from the existing ground level. The lowest level of ground water table is +0.085m (RL) at the time of investigation (March 2013). The sulphates and chlorides are present in both soil and water samples.

From the summary presented it is evident that the deposit of area is suitable for providing foundation at shallow depth. However the top soil to a depth of 3.0m is not good particularly in the southwest region of Zone H; hence foundation cannot be located within the depth of 3m. Therefore it is felt essential to locate the foundation at a minimum depth of 3.2 from the existing ground level. The depth suitable to locate the foundation is 3.2m or below from the existing ground level. The maximum variation in the reduced level of borehole locations is about 0.4m (maximum + 1.592m and minimum +1.210m); hence minimum level of foundation shall be -2.0m



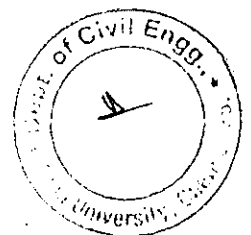
(RL). However depth of foundation for each block of Zone H area is given in the Section 10.

### 9. Selection of foundation

The subsurface condition of deposit of area is very much suitable for shallow foundation except that the foundation needs to be taken below the top clay layer. In this case it is suggested to locate the foundation at a minimum depth of 3.2m from the existing ground level. In order to decide the depth of foundation of the blocks, N value more than 50 blows and location of water table are compared as below:

Borehole No:	Block No:	RL of stratum at N>50, (m)	RL of min.Depth of foundation, (m)	WT RL, (m)	Remarks
BH1	H1	-2.068	-1.920	+0.282m	Water table is above the foundation level
BH2	H1	-1.388	-1.490	+0.112m	Water table is above the foundation level
BH3	H1	-1.05	-1.250	+0.250m	Water table is above the foundation level
BH4	H2	-1.870	-1.720	+0.180m	Water table is above the foundation level
BH5	H2	-1.615	-1.215	+0.135m	Water table is above the foundation level
BH6	H2	-1.558	-1.608	+0.192m	Water table is above the foundation level
BH7	H3	-1.694	-1.744	+0.206m	Water table is above the foundation level
BH8	H3	-1.774	-1.824	+0.176m	Water table is above the foundation level
BH9	H3	-1.665	-1.865	+0.085m	Water table is above the foundation level
BH10	H4	-1.790	-1.990	+0.210m	Water table is above the foundation level
BH11	H4	-1.920	-1.920	+0.180m	Water table is above the foundation level
BH12	H4	-1.400	-1.400	+0.300m	Water table is above the foundation level

From the comparison made it is clear that foundations are to be located below the water table. The water table level reported is obtained from the borehole during





investigation; there is a possibility for variation in the water table level. Therefore it is suggested to ascertain the water table level at each block at least at two corners before proceeding with the work of foundation. Normally the actual water level may be higher than that recorded in the boreholes. It is suggested to locate the foundation a few centimeters above the water level in order to avoid excavation below the water table otherwise excavation below water table makes the soil to lose its strength. However at Zone H area the foundations are to be located below the water table, hence dewatering is essential.

The bearing capacity and settlement of foundation for the minimum depth of foundation given in the table are determined. The bearing capacity is determined for the raft foundation of size 23mx46m (approximate) using Teng (1961) equation and bearing capacity equation given in IS6403. The allowable bearing pressure is obtained for 25mm settlement using Teng equation and it varies between 306kN/m<sup>2</sup> and 368kN/m<sup>2</sup> for the N values of 35 and 42 respectively. The net safe bearing capacity value obtained from IS6403 for  $\phi=36^\circ$  is 1300kN/m<sup>2</sup> for FS=3. The soil at the foundation level of certain boreholes is stiff sandy clay with fines around 25%. Though thickness of sandy clay layer is less the bearing capacity value is determined by considering the lowest N value of 35 is 306kN/m<sup>2</sup> for a settlement of 25mm. Thus it is sure that the soils at the foundation levels are having good bearing strength and more over raft foundation of large size will provide higher bearing resistance and the settlement is real concern. The recommended bearing capacity is 250kN/m<sup>2</sup>. The bearing capacity is reduced from the minimum value of 306kN/m<sup>2</sup> obtained, in order to account for the undesirable condition like presence of clay pockets. The average load intensity expected at the foundation level for the combination of load may not exceed 220kN/m<sup>2</sup>, which is close to the bearing capacity recommended. The shallow foundation like isolated footing is not considered because of heterogeneous nature of soil (weak zones like clay patches and clay lumps). However as an academic exercise the capacity was worked for the isolated footing of 2.5mx2.5m for the  $\phi=36^\circ$ . The net safe bearing capacity obtained is 190kN/m<sup>2</sup>, which is less than the expected average pressure of 220kN/m<sup>2</sup> of raft foundation. However the



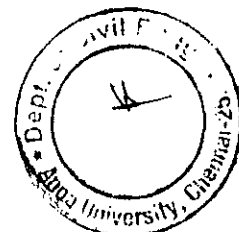
contact pressure expected will be more than  $190\text{kN/m}^2$  if isolated footing is proposed to adopt for each column. If the bearing capacity is limited to  $190\text{kN/m}^2$  then foundations of columns are to be combined. Thus only option to support stilt+eight storeyed buildings in the Zone 'H' of Perumbakkam project is raft foundation

The settlement of raft foundation is also worked out for the soil conditions of individual borehole for the net pressure of  $250\text{kN/m}^2$ . The foundation is supported in silty sand / clayey sand layer which is non-plastic with coarse fractions around 70% followed by weathered/fractured rock. Therefore elastic settlement of foundation is obtained using DeBeer and Martens (1957) equation. The elastic settlement obtained at various locations is less than 25mm for the contact pressure of  $250\text{kN/m}^2$ . Thus the raft foundation is the ideal choice for supporting the foundations of proposed stilt + eight storeyed blocks H1 to H4 at Zone 'H'.

The one more issue is depth of foundation of each block can be different because of variation in depth of occurrence of bearing stratum within the Zone H. The occurrence of bearing stratum within a block itself is varying, therefore among the minimum level of foundation referred in the above table for a given block, the lowest level is considered as a suitable foundation level. The minimum depth of foundation (RL) required at various blocks is varying between -1.8m and -2.0m. In this area the water table level at boreholes is found to vary between +0.28m and +0.085m, and is above the recommended level of foundation, hence interference of water table cannot be avoided while executing the earthwork excavation to reach proposed level of foundation. The foundation excavation in presence of water is to be avoided. Adopt suitable dewatering method to lower the level of water table at least to a level of 0.5m below the foundation level.

## 10. Recommendations

The subsurface exploration conducted confirms presence of good bearing stratum at a depth of 3.2m at most of the area of Zone H. Thus occurrence of good bearing stratum is at shallow depth and it occurs more or less at uniform depth. Further the deposit at the depth below 5.5m over the entire area of Zone H is certainly weathered rock. The top



layer is soft at most of the locations and at locations wherever clay is medium stiff to stiff possesses volume change characteristics. This layer will exhibit high swelling (DFS>100%). Thus it is recommended to locate the foundation at a minimum depth of 3.2m from the lowest ground level, thus foundation level is varying between -1.9m and -2.0m (RL). However it is proposed to adopt uniform foundation level of -2.0m for all the four blocks, since the difference in level is marginal. For the structure of stilt + 8 storeyed building it is recommended to support the structure on a raft foundation. The recommended bearing capacity of soil for the raft foundation of 23m x 46m (approximate size) is 250kN/m<sup>2</sup>. Though the soil below the depth of foundation possesses higher bearing strength, it is advised not to exceed the value of 250kN/m<sup>2</sup> because of non-homogenous nature of the deposit. Recommended level of foundation for the blocks H1 to H4 is as below:

Sl.No:	Block	Reduced level of Foundation,(m)
1	H1	-2.0
2	H2	-2.0
3	H3	-2.0
4	H4	-2.0

The level of foundation refers to base of a raft and the raft shall be laid on leveling course followed by sand cushion of adequate thickness each as per the practice in the board.

### 11. Precautions

1. The top soil to the depth of 2.0m is poor and highly swelling (expansive) hence does not suitable for any construction or filling work.
2. The maximum depth of occurrence of water table in zone H is +0.30m (RL) and the soil at this depth is clayey at most of the location hence excavation under this condition without dewatering will lead to collapse of cut and also reduction in strength of soil because of seepage through the bearing stratum.



3. Earth work excavation particularly below the water table to be allowed unless the water level is lowered to minimum depth of 0.5m from the recommended level of foundation. Adopt suitable scientific method for dewatering.
4. The depth of foundation recommended for each block is minimum depth of foundation. There may be chances for variation in foundation depth because of uncertainty in the characteristics of highly weathered residual deposit in the Zone H area. Improper dewatering and submergence of weathered soil may lead to significant reduction in strength, which may demand foundation at deeper depth than recommended to realize bearing capacity of  $250\text{kN/m}^2$ . Do not reduce the foundation depth without obtaining proper approval from the consultant in case of good bearing stratum is met at higher level than the recommended level of foundation.
5. The water table in this area is at shallow depth. The seepage of water at the interface of weathered rock and soil cover will be critical hence conduct a pilot study to determine seepage parameters of deposits and to design suitable dewatering system. Technical support required for designing the dewatering system will be provided if required by the client. No case seepage is permitted directly through the foundation soil i.e. seepage of water shall be away from the excavation area (i.e. foundation area) and not towards the excavation area.
6. The quality of ground water is not suitable for any construction work especially for foundation construction. Since the environment of both ground water and soil is aggressive, this will lead to sulphate attack on concrete and corrosion of reinforcement. The concrete and steel need to be protected from the aggressive action. Thus provide minimum cover of 75mm in addition to any other protective measures considered suitable. Obtain opinion from structural consultant for protecting foundation elements and part of columns and beams buried below the ground. Further the cement quality and the content shall satisfy the requirement of Table 4 of IS 456-2000.
7. Since the ground water is not satisfying the requirement, use good water for all concrete related work. Minimum grade of concrete recommended for the foundation



work is M25. Follow the conditions relevant to quality of water for concrete work as per IS 456-2000 including minimum cover thickness.

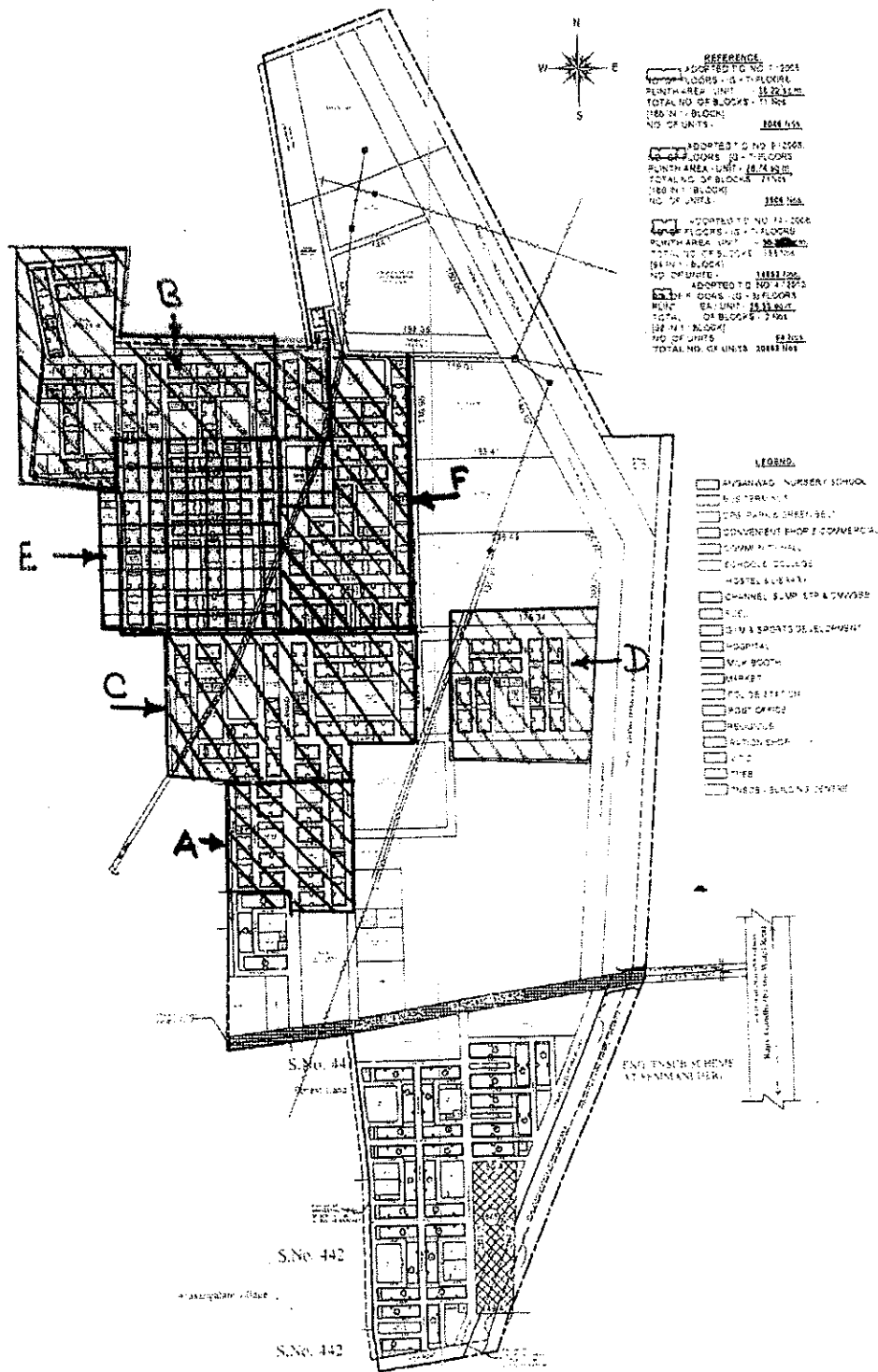
8. For filling works both inside the basement and outside around the building use good earth. The native soil particularly the high plastic clay is not at all suitable for any construction work including basement filling.
9. The basement filling will be more than 3.0m hence conventional flooring for the ground storey may lead to settlement problem on later days. It is suggested to provide RCC floor for ground floor base slab.
10. In case of any variation observed from the soil profile reported while execution of foundation work, bring it to the notice of consultant immediately for suitable advice. Do not change the recommended level of foundation without the knowledge of foundation consultant.

*h.g.* *bwi*  
*30/7/2014*

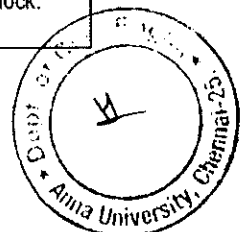
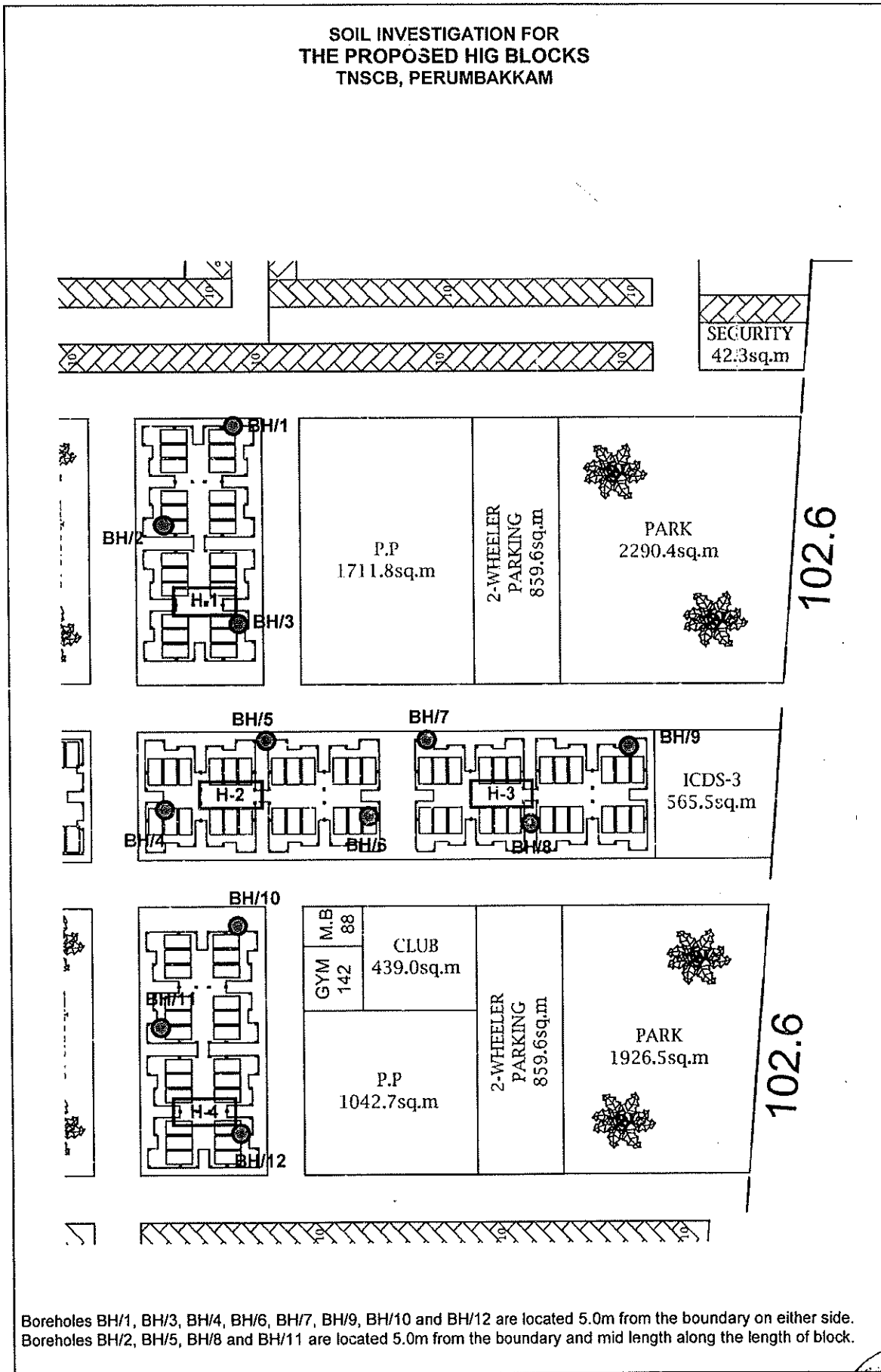
**Dr. K. ILAMPARUTHI**  
Project Co-Coordinator &  
Professor and Chairman  
Department of Civil Engineering  
Anna University  
Chennai - 600 025.

**Dr. K. ILAMPARUTHI, M.E., Ph.D.,**  
Professor & Chairman  
Faculty of Civil Engineering  
Anna University, Chennai-600 025.

**Figure A1 Perumbakkam Project – Zones of Investigation**



**FIGURE 1b LOCATION OF BORE HOLES**



**FIGURE 2 SOIL PROFILE AND SPT N VALUES AT BH 1 - H**

PROJECT NO:	SF/KI-49/PMPKM/Zone H
BORE HOLE NO:	BH1

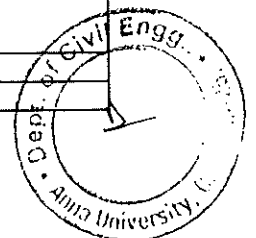
Project : **HIG Tenements, TNSCB, Perumbakkam**  
 Site : **Perumbakkam**  
 Co-ordinates : **Block H-1**  
 Diameter and type of boring : **150mm Rotary boring with drilling mud circulation**

Date of start : **25-Mar-2013**  
 Date of finish : **25-Mar-2013**  
 GWL from GL : **1.30m**  
 Ground level RL : **+1.582m**

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		Test depth m	SPT / VST					RD / Consistency	
			UDS	DS		SPT blow counts						
					15	30	45	60	N**			
1.0		Yellowish grey soft to medium stiff silty clay		0.50							Soft	
1.4				0.75	0.75	2	1	1	1	2		Stiff
1.8		Gr grey med stiff to stiff silty clay with red patches	1.50									Stiff
2.0		Lt brownish grey sandy silty clay with few stones		1.80	1.80	4	7	7	10	14		Stiff
2.4		Yellowish grey sandy silty clay with few stones and white patches		2.55	2.55	10	14	25		39		Hard
3.0		Yell grey & gr grey clayey silty fine to coarse sand with weathered stones		3.50	3.50	25	32	41		73		Very dense
3.3				4.50	4.50	50/15cm			>100			
4.0		Yellowish grey clayey silty fine to coarse sand with weathered stones		5.30	Rebound				RB			
5.3			5.30-6.30	TC core drilling							Very weak	
6.0		Yellowish grey and white highly weathered fractured calcareous sandstone		6.30	Rebound				RB			
7.0			6.30-7.30	Diamond core drilling NX size, recovery nil							Very weak to weak	
7.4		Yellowish white highly weathered calcareous sandstone		7.30-8.30	Diamond core drilling NX size, recovery 15%, RQD nil						Moderate to weak	
8.0				8.30-9.30	Diamond core drilling NX size, recovery 21%, RQD nil						Moderate to weak	
8.3		Light brownish grey highly weathered severely jointed rock (gneiss)										
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0		Note: Ground level RL is with respect to the site reference datum										
19.0												
20.0		TC core drilling from 5.30m to 6.30m DC core drilling from 6.30m to 9.30m										

Borehole terminated at 9.30m

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>65</sub>





**FIGURE 3 SOIL PROFILE AND SPT N VALUES AT BH 2 - H**

<b>PROJECT NO:</b>	<b>SF/KI-49/PMPKM/Zone H</b>
<b>BORE HOLE NO:</b>	<b>BH2</b>

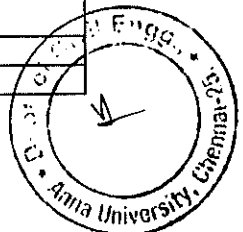
Project **HIG Tenements, TNSCB, Perumbakkam**  
 Site **Perumbakkam**  
 Co-ordinates : **Block H-1**  
 Diameter and type of boring : **150mm Rotary boring with drilling mud circulation**

Date of start : **23-Mar-2013**  
 Date of finish : **23-Mar-2013**  
 GWL from GL : **1.20m**  
 Ground level RL : **+1.312m**

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.6		Brownish and yellowish grey silty clay with roots		0.50								
1.0		Yellowish grey soft silty clay with roots		0.75	0.75	1	1	1	1	2		Soft
1.4		Light brownish grey soft silty clay with reddish brown and yellow patches	1.50	1.80	1.80	1	2	5	5	7		Med stiff
2.0												
2.2		Yell grey sandy silty clay with weathered stones	2.55	2.55	2.55	15	35	40		75		
2.7												
3.0		Yellowish grey dirty fine to coarse sand with weathered stones	3.50	3.50	3.50	20	32	39		71		Very dense
4.0												
4.6												
5.0		Yellowish grey highly weathered fractured rock	4.80-5.50	4.80	4.80	TC core drilling	5.50	Rebound		RB		Very weak
5.5												
6.0		Brownish grey and highly weathered severely jointed rock (gneiss)	5.50-6.50	6.50-7.50	6.50-7.50	Diamond core drilling NX size, recovery 20%, RQD nil						Very weak to weak
7.0												
8.0												
8.1		Light grey brown and weathered jointed rock	7.50-8.50	7.50-8.50	7.50-8.50	Diamond core drilling NX size, recovery 25%, RQD nil						Moderate
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0		Note: Ground level RL is with respect to the site reference datum										
19.0												
20.0		TC core drilling from 4.80m to 5.50m DC core drilling from 5.50m to 8.50m										

**Borehole terminated at 8.50m**

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>65</sub>



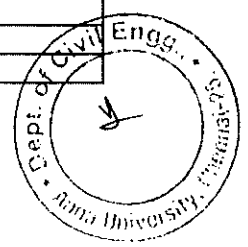
**FIGURE 4 SOIL PROFILE AND SPT N VALUES AT BH 3 - H**

PROJECT NO:	SF/KI-49/PMPKM/Zone H
BORE HOLE NO:	BH3

Project HIG Tenements, TNSCB, Perumbakkam  
 Site Perumbakkam  
 Co-ordinates : Block H-1  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 6-Mar-2013  
 Date of finish : 6-Mar-2013  
 GWL from GL : 1.30m  
 Ground level RL : +1.550m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST					RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts					
						15	30	45	60		N**
0.6		Yellowish grey silty clay		0.50							Soft
1.0		Light brownish grey silty clay		0.75	0.75	1	1	2	2	3	
1.6		Greenish grey and yellowish grey sandy silty clay with weathered stones		1.80	1.80	5	6	13	15	19	Stiff
2.0				2.55	2.55	50/10cm				>100	
2.5		Dark yellowish grey dirty fine to coarse sand with weathered stones		3.50	3.50	50/6cm				>100	Very dense
3.0				4.50	4.50	50/10cm				>100	
3.5				5.00	5.00	Rebound				RB	
4.0		Yellowish and brownish dirty fine to coarse sand with weathered stones (weathered disintegrated rock)		6.00	6.00	Rebound				RB	Very weak
4.5				5.00-6.00	5.00-6.00	TC core drilling					
5.0		Brownish grey highly weathered fractured rock		6.00-7.00	6.00-7.00	Diamond core drilling NX size, recovery 13%, RQD nil					Weak
5.5				7.00-8.00	7.00-8.00	Diamond core drilling NX size, recovery 25%, RQD 10%					
6.0		Brownish and grey highly weathered severely jointed rock (gneiss)									Moderate
6.5											
7.0		Light brownish grey highly weathered jointed rock (gneiss)									Moderate
7.5											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0											
		Note: Ground level RL is with respect to the site reference datum  TC core drilling from 5.00m to 6.00m DC core drilling from 6.00m to 8.00m									
		Borehole terminated at 8.00m									
		**Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>65</sub>									



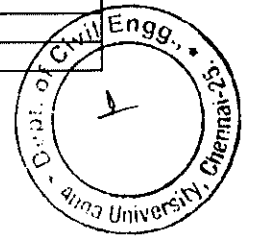
**FIGURE 5 SOIL PROFILE AND SPT N VALUES AT BH 4 - H**

PROJECT NO:	SF/KI-49/PMPKM/Zone H
BORE HOLE NO:	BH4

Project : HIG Tenements, TNSCB, Perumbakkam  
 Site : Perumbakkam  
 Co-ordinates : Block H-2  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 2-Apr-2013  
 Date of finish : 2-Apr-2013  
 GWL from GL : 1.10m  
 Ground level RL : +1.280m

Depth from GL (m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST					RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts					
						15	30	45	60		N**
0.6		Yellowish grey silty clay		0.50							Soft
1.0		Light brownish grey soft silty clay with few stones and reddish brown patches		0.75	0.75		1			0	Very soft
2.0				1.50	1.50	Sunk @ SPT wt				0	
2.2		Dark grey soft silty clay with fine sand		2.25	2.25	Sunk @ SPT wt				0	
2.9				3.00	3.00	15	23	32		55	
3.0		Dark greenish grey dirty fine to coarse sand		3.00	3.00	15	23	32		55	Dense to very dense
3.7		Yell grey dirty fine to coarse sand with stones		3.75	3.75	50/8cm			>100		
4.0				4.40	4.40	Rebound			RB		
4.4		Yellowish grey highly weathered fractured rock	4.40-6.10	TC core drilling					RB		
5.0				6.10 Rebound							
6.0		Light greyish brown highly weathered severely jointed rock (gneiss)	6.10-7.10	Diamond core drilling NX size, recovery 10%, RQD nil					Weak		
6.1											
7.0		Greyish weathered severely jointed rock (vertically jointed rock) (gneiss)	7.10-8.10	Diamond core drilling NX size, recovery 32%, RQD 32%					Moderate to strong		
7.2											
8.0		Note: Ground level RL is with respect to the site reference datum  TC core drilling from 4.40m to 6.10m DC core drilling from 6.10m to 8.10m									
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0		Borehole terminated at 8.10m									
19.0		**Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>65</sub>									



**FIGURE 6 SOIL PROFILE AND SPT N VALUES AT BH 5 - H**

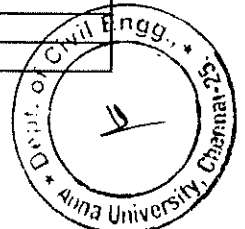
Project **HIG Tenements, TNSCB, Perumbakkam**  
 Site **Perumbakkam**  
 Co-ordinates : **Block H-2**  
 Diameter and type of boring : **150mm Rotary boring with drilling mud circulation**

<b>PROJECT NO:</b>	<b>SF/KI-49/PMPKM/Zone H</b>
<b>BORE HOLE NO:</b>	<b>BH5</b>
Date of start	: 3-Apr-2013
Date of finish	: 3-Apr-2013
GWL from GL	: 1.40m
Ground level RL	: +1.535m

Depth from GL(m)	Soil Profile	Field Descriptor	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.8	[Pattern]	Yellowish grey silty clay with roots		0.50								Soft
1.0				0.75	0.75		1			0		Very soft
1.8	[Pattern]	Light brownish grey silty clay with red patches										
2.0				1.50	1.50	1	1	6	7	7		Stiff
2.4	[Pattern]	Light yellowish brown and grey sandy silty clay										
3.0				2.25	2.25	12	22	20	25	42		Dense
3.7	[Pattern]	Yell brown clayey silty fine to coarse sand with sandy silty clay patches										
4.0				3.00	3.00	23	25	30		55		Dense
4.5	[Pattern]	Dark yellowish grey dirty fine to coarse sand with weathered stones										
5.0				3.75	3.75	27	50/10cm			>100		Very dense
6.0	[Pattern]	Dark yellowish grey highly weathered fractured rock	4.50-6.00									
6.6					6.00	Rebound				RB		Very weak
7.0	[Pattern]	Greyish & brown partly weathered jointed rock	6.00-7.00									Weak
8.0	[Pattern]	Greyish granitic hard rock with joints (gneiss)	7.00-8.00									Moderate to strong
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0		Note: Ground level RL is with respect to the site reference datum										
19.0												
20.0		TC core drilling from 4.50m to 6.00m DC core drilling from 6.00m to 8.00m										

**Borehole terminated at 8.00m**

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>65</sub>

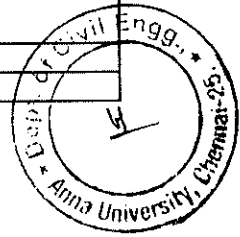


**FIGURE 7 SOIL PROFILE AND SPT N VALUES AT BH 6 - H**

<b>PROJECT NO:</b>	<b>SF/KI-49/PMPKM/Zone H</b>
<b>BORE HOLE NO:</b>	<b>BH6</b>
Date of start	: 4-Apr-2013
Date of finish	: 5-Apr-2013
GWL from GL	: 1.40m
Ground level RL	: +1.592m

Project HIG Tenements, TNSCB, Perumbakkam  
 Site Perumbakkam  
 Co-ordinates : Block H-2  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency		
			UDS	DS	Test depth m	SPT blow counts							
						15	30	45	60	N**			
1.0	[Soil Profile Diagram]	Yellowish grey silty clay		0.50								Soft	
1.4			0.75	0.75	1	1	2	2	3				
2.0	[Soil Profile Diagram]	Yellowish grey silty clay with gravel and sand		1.50	1.50	7	16	20	25	36		Very stiff	
2.4			2.25	2.25	6	20	25		45				
3.0	[Soil Profile Diagram]	Yellowish brown dirty fine to coarse sand with sandy clay lumps		3.00	3.00	21	37	42		79		Dense	
3.2			3.75	3.75	50/11cm				>100				
4.0	[Soil Profile Diagram]	Yellowish brown dirty fine to coarse sand with weathered stones		4.50	4.50	50/9cm				>100		Very dense	
4.8			5.10	5.10	Rebound				RB				
5.0	[Soil Profile Diagram]	Yellowish brown highly weathered fractured rock		5.10-6.20	TC core drilling						Very weak		
6.0			6.20	6.20	Rebound				RB				
6.2	[Soil Profile Diagram]	Dark grey and brown highly weathered severely jointed rock (gneiss)		6.20-7.20	Diamond core drilling NX size, recovery 15%, RQD nil						Weak		
7.0			7.20-8.20	Diamond core drilling NX size, recovery 32%, RQD 20%									
7.8	[Soil Profile Diagram]	Greyish hard rock (gneiss)		7.20-8.20							Strong		
8.0													
9.0	[Soil Profile Diagram]												
10.0													
11.0													
12.0													
13.0													
14.0													
15.0													
16.0													
17.0													
18.0													
19.0													
20.0													
		Note: Ground level RL is with respect to the site reference datum  TC core drilling from 5.10m to 6.20m DC core drilling from 6.20m to 8.20m											
		Borehole terminated at 8.20m **Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>65</sub>											



**FIGURE 8 SOIL PROFILE AND SPT N VALUES AT BH 7 - H**

PROJECT NO:	SF/KI-49/PMPKM/Zone H
BORE HOLE NO:	BH7

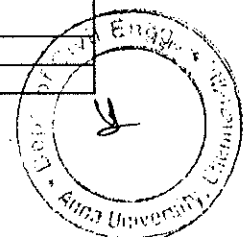
Project: HIG Tenements, TNSCB, Perumbakkam  
 Site: Perumbakkam  
 Co-ordinates: Block H-3  
 Diameter and type of boring: 150mm Rotary boring with drilling mud circulation

Date of start: 9-Apr-2013  
 Date of finish: 9-Apr-2013  
 GWL from GL: 1.25m  
 Ground level RL: +1.456m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		Test depth m	SPT / VST					RD / Consistency
			UDS	DS		SPT blow counts					
					15	30	45	60	N**		
1.0	Yellowish grey silty clay with brown patches			0.50							Soft
1.9				0.75	0.75	1	1	1	1	2	
2.0				1.50	1.50	0	1	3	13	4	
2.5	Greyish and brownish silty clay with stones			2.25	2.25	13	20	18	21	38	Stiff
3.0	Greyish brown clayey silty fine to coarse sand			3.00	3.00	15	31	36		67	Dense
3.5	Greyish brown dirty fine to coarse sand			3.75	3.75	35	50/6cm			>100	Very dense
4.0				4.50	4.50	50/5cm			>100		
4.5				5.10	5.10	Rebound			RB		
5.0	Dark yellowish grey highly weathered fractured rock			5.10-6.10	TC core drilling					Very weak	
6.0				6.10	Rebound						RB
6.1				6.10-7.10	Diamond core drilling NX size, recovery 15%, RQD nil						Weak
7.0	Brownish and yellowish grey highly weathered severely jointed rock (gneiss)		7.10-8.10	Diamond core drilling NX size, recovery 37%, RQD 23%					Strong		
7.6	Greyish jointed hard rock (gneiss)										
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0		Note: Ground level RL is with respect to the site reference datum									
19.0											
20.0		TC core drilling from 5.10m to 6.10m DC core drilling from 6.10m to 8.10m									

Borehole terminated at 8.10m

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>65</sub>

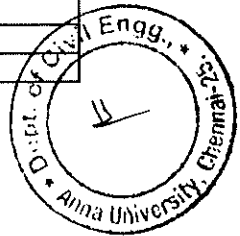


**FIGURE 9 SOIL PROFILE AND SPT N VALUES AT BH 8 - H**

Project HIG Tenements, TNSCB, Perumbakkam  
 Site Perumbakkam  
 Co-ordinates : Block H-3  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

PROJECT NO:	SF/KI-49/PMPKM/Zone H
BORE HOLE NO:	BH8
Date of start	: 5-Apr-2013
Date of finish	: 6-Apr-2013
GWL from GL	: 1.20m
Ground level RL	: +1.376m

Depth from GL (m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency
			UDS	DS	Test depth m	SPT blow counts					
						15	30	45	60	N**	
1.0	Yellowish grey silty clay with roots at surface		0.50								Soft
1.8			0.75	0.75	1	1	2	2	3		
2.0			1.50	1.50	3	4	8	10	12		
2.9	Light yellowish grey silty clay with few stones		2.25	2.25	4	6	7	10	13	Stiff	
3.0			3.00	3.00	17	28	32		60		
3.6	Yellowish brown and grey sandy silty clay with weathered stones		3.75	3.75	50/10cm					>100	Hard
4.0			4.50	4.50	50/6cm					>100	
5.0	Brownish dirty fine to coarse sand with weathered stones		5.00	Rebound					RB	Very dense	
6.0			5.00-6.00	TC core drilling					RB		
6.6	Brownish and yellowish grey highly weathered severely jointed rock		6.00-7.00	Diamond core drilling NX size, recovery nil					RB	Weak	
7.0			6.00-7.00	Diamond core drilling NX size, recovery nil					RB		
7.4	Lt brown & lt grey highly weath jointed rock		7.00-8.00	Diamond core drilling NX size, recovery 58%, RQD 56%					RB	Moderate	
8.0			7.00-8.00	Diamond core drilling NX size, recovery 58%, RQD 56%					RB		
9.0	Greyish hard rock (gneiss)									Strong	
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0											
		Note: Ground level RL is with respect to the site reference datum									
		TC core drilling from 5.00m to 6.00m DC core drilling from 6.00m to 8.00m									
Borehole terminated at 8.00m											
**Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>65</sub>											



**FIGURE 10 SOIL PROFILE AND SPT N VALUES AT BH 9 - H**

<b>PROJECT NO:</b>	<b>SF/KI-49/PMPKM/Zone H</b>
<b>BORE HOLE NO:</b>	<b>BH9</b>

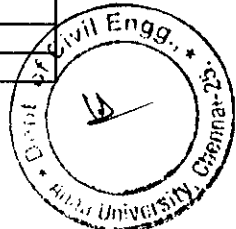
Project    HIG Tenements, TNSCB, Perumbakkam  
 Site       Perumbakkam  
 Co-ordinates    : Block H-3  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start        : 6-Apr-2013  
 Date of finish      : 8-Apr-2013  
 GWL from GL       : 1.25m  
 Ground level RL    : +1.335m

Depth from GL (m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST					RD / Consistency		
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60		N**	
1.0	[Soil Profile Pattern]	Yellowish grey silty clay with roots		0.50							Soft to medium	
1.4		0.75	0.75	2	2	2	2	4				
2.0	[Soil Profile Pattern]	Yellowish grey silty clay with light grey patches		1.50	1.50	3	4	7	9	11	Stiff	
2.1		2.25	2.25	11	20	25	20	45				
2.9	[Soil Profile Pattern]	Greyish brown / yellowish grey sandy silty clay with stones		2.25	2.25	11	20	25	20	45	Stiff	
3.0		3.00	3.00	45	50/5cm			>100				
3.7	[Soil Profile Pattern]	Dark yellowish grey clayey silty sand with weathered stones		3.00	3.00	45	50/5cm			>100	Very dense	
4.0		3.75	3.75	50/10cm			>100					
4.5	[Soil Profile Pattern]	Dark yell grey dirty fine to coarse sand (comp weathered disintegrated rock)		4.50	4.50	Rebound				RB	Very dense	
5.0		4.50-5.80	TC core drilling								Very weak	
5.8	[Soil Profile Pattern]	Dark yellowish grey highly weathered fractured rock		5.80	5.80	Rebound				RB	Very weak	
6.0		5.80-6.80	Diamond core drilling NX size, recovery 17%, RQD								Weak to moderate	
7.0	[Soil Profile Pattern]	Light yellowish grey and brown highly weathered severely jointed rock		6.80-7.80	6.80-7.80	Diamond core drilling NX size, recovery 26%, RQD nil					Moderate	
8.0		6.80-7.80	Diamond core drilling NX size, recovery 26%, RQD nil									
9.0	[Soil Profile Pattern]											
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0			Note: Ground level RL is with respect to the site reference datum									
19.0												
20.0			TC core drilling from 4.50m to 6.80m DC core drilling from 6.80m to 7.80m									

**Borehole terminated at 7.80m**

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>65</sub>



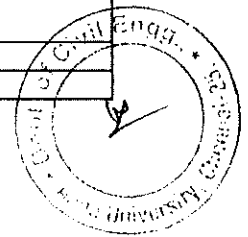


**FIGURE 11 SOIL PROFILE AND SPT N VALUES AT BH 10 - H**

Project **HIG Tenements, TNSCB, Perumbakkam**  
 Site **Perumbakkam**  
 Co-ordinates : **Block H-4**  
 Diameter and type of boring : **150mm Rotary boring with drilling mud circulation**

<b>PROJECT NO:</b>	<b>SF/KI-49/PMPKM/Zone H</b>
<b>BORE HOLE NO:</b>	<b>BH10</b>
Date of start	: 14-Mar-2013
Date of finish	: 14-Mar-2013
GWL from GL	: 1.00m
Ground level RL	: +1.210m

Depth from GL (m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST					RD / Consistency		
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60		N**	
0.5		Yellowish grey silty clay with coarse particles		0.50								
1.0		Light brownish silty clay		0.75	0.75	0	1	1	1	2		Soft
1.8				1.50	1.50	0	2	12	14	14		Stiff
2.0		Greyish sandy silty clay with yellowish brown patches and gravel		2.25	2.25	7	9	18	29	27		
2.8				3.00	3.00	50/15cm Rebound				>100 RB		Very dense
3.0		Brownish grey clayey silty sand with weathered stones & sand clay lumps		3.60	3.60	Rebound				RB		Very weak
3.6				4.30	4.30	Rebound				RB		
4.0		Brownish highly weathered fractured rock	3.60-4.30		TC core drilling							Weak to moderate
4.3				4.30	4.30	Rebound				RB		
5.0		Lt yel grey & brown highly weathered severely weathered jointed rock (gneiss)	4.30-5.30		Diamond core drilling NX size, recovery 14%, RQD nil							
6.0												
7.0												
8.0												
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0		Note: Ground level RL is with respect to the site reference datum										
19.0												
20.0		TC core drilling from 3.60m to 4.30m DC core drilling from 4.30m to 5.30m										
Borehole terminated at 5.30m												
**Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>65</sub>												



**FIGURE 12 SOIL PROFILE AND SPT N VALUES AT BH 11 - H**

Project **HIG Tenements, TNSCB, Perumbakkam**  
 Site **Perumbakkam**  
 Co-ordinates : **Block H-4**  
 Diameter and type of boring : **150mm Rotary boring with drilling mud circulation**

<b>PROJECT NO:</b>	<b>SF/KI-49/PM<sup>PKM</sup>/Zone H</b>
<b>BORE HOLE NO:</b>	<b>BH11</b>
Date of start	: 28-Mar-2013
Date of finish	: 28-Mar-2013
GWL from GL	: 1.30m
Ground level RL	: +1.480m

Depth from GL (m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
1.0	[Hatched pattern]	Yellowish grey silty clay with roots and reddish brown patches		0.50								Very soft
1.4			0.75	0.75		1		1	0			
2.0	[Hatched pattern]	Dark grey very soft silty clay with fine sand		1.50	1.50	Sunk @ SPT wt					0	Very soft
2.7			2.25	2.25	0	1	6	15	7			
3.0	[Hatched pattern]	Yellowish grey dirty fine to medium sand		3.00	3.00	7	9	34		43	Dense	
3.4			3.8	3.8	3.75	29/4cm & Rebound					RB	Very dense
4.0	[Hatched pattern]	Yell grey clayey silty sand with weathered stones		3.75-4.40	TC core drilling						Very weak	
4.5			5.0	4.40-5.40	Diamond core drilling NX size, recovery 13%, RQD nil							Moderate
5.8	[Hatched pattern]	Yellowish grey and grey highly weathered closely jointed rock		5.40-6.40	Diamond core drilling NX size, recovery 26%, RQD 14%						Strong	
6.0			7.0									
7.0		Greyish jointed hard rock (gneiss)										
8.0												
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0		Note: Ground level RL is with respect to the site reference datum										
19.0												
20.0		TC core drilling from 3.75m to 4.40m DC core drilling from 4.40m to 6.40m										

**Borehole terminated at 6.40m**

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to  $N_{65}$



**FIGURE 13 SOIL PROFILE AND SPT N VALUES AT BH 12 - H**

**PROJECT NO:** SF/KI-49/PMPKM/Zone H  
**BORE HOLE NO:** BH12

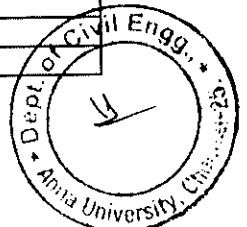
**Project** HIG Tenements, TNSCB, Perumbakkam  
**Site** Perumbakkam  
**Co-ordinates** : Block H-4  
**Diameter and type of boring** : 150mm Rotary boring with drilling mud circulation

**Date of start** : 1-Apr-2013  
**Date of finish** : 1-Apr-2013  
**GWL from GL** : 1.20m  
**Ground level RL** : +1.500m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.7		Yellowish grey silty clay		0.50								
1.0		Brownish grey silty clay with coarse particles		0.75	0.75	1		1			1	Soft to very soft
1.4		Greyish very soft silty clay	1.50	2.00	2.00	Sunk @ SPT wt			0			
1.9		Greyish very soft silty clay with very fine sand		2.75	2.75	35	50/10cm			>100		
2.0		Yellowish grey completely weathered disintegrated rock		2.75	2.75	35	50/10cm			>100	RB	Very dense
2.6		Yellowish grey completely weathered disintegrated rock		2.75	2.75	35	50/10cm			>100	RB	
3.0		Yellowish grey completely weathered disintegrated rock		2.75	2.75	35	50/10cm			>100	RB	Very weak
3.5		Yellowish grey completely weathered disintegrated rock		2.75	2.75	35	50/10cm			>100	RB	
4.0		Yellowish grey highly weathered fractured rock	3.50-4.50			TC core drilling						Very weak
4.5		Yellowish grey highly weathered fractured rock	3.50-4.50			4.50	Rebound				RB	
5.0		Light brownish and grey highly weathered severely jointed rock	4.50-5.50			Diamond core drilling NX size, recovery nil						Weak
6.0			5.50-6.50			Diamond core drilling NX size, recovery 15%, RQD nil						
7.0			6.50-7.50			Diamond core drilling NX size, recovery 18%, RQD nil						
8.0												
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0												

**Borehole terminated at 7.50m**

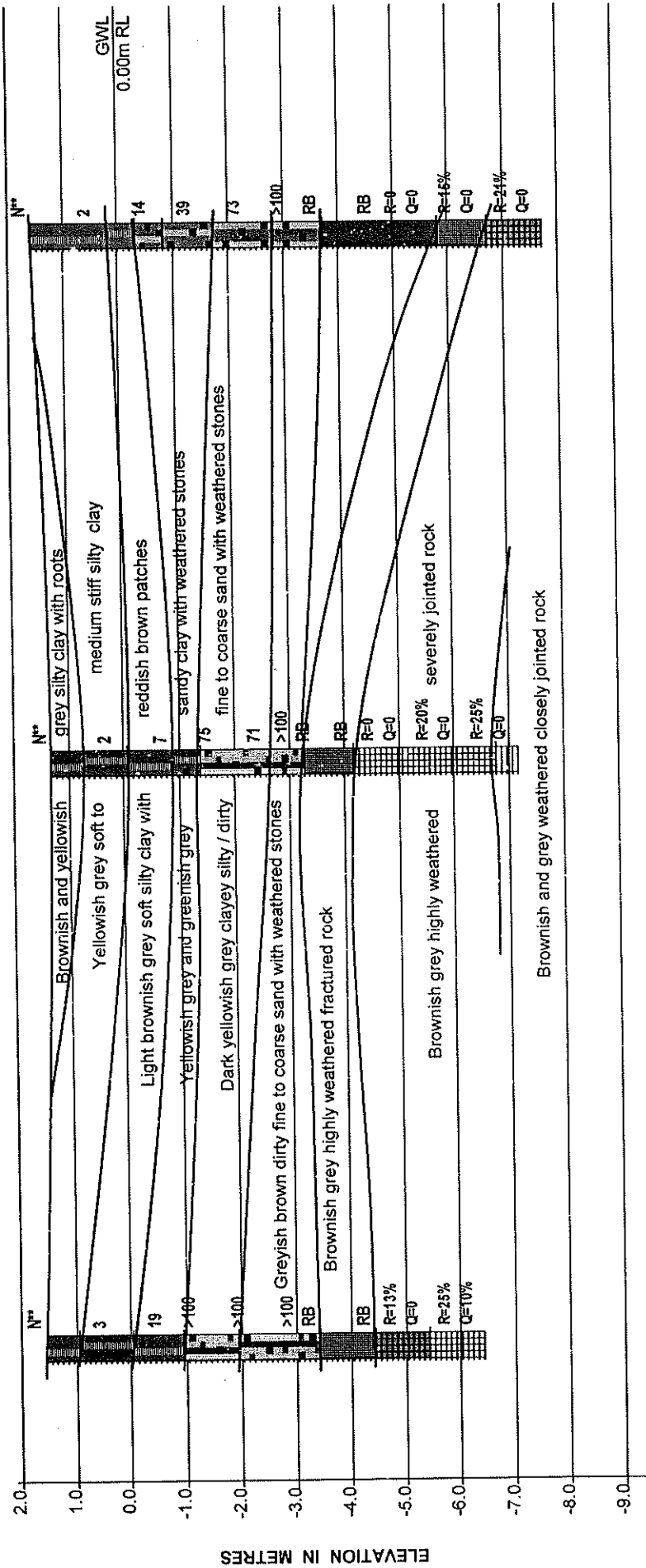
\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>65</sub>



BH1

BH2

BH3

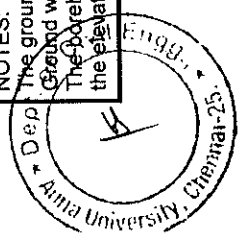


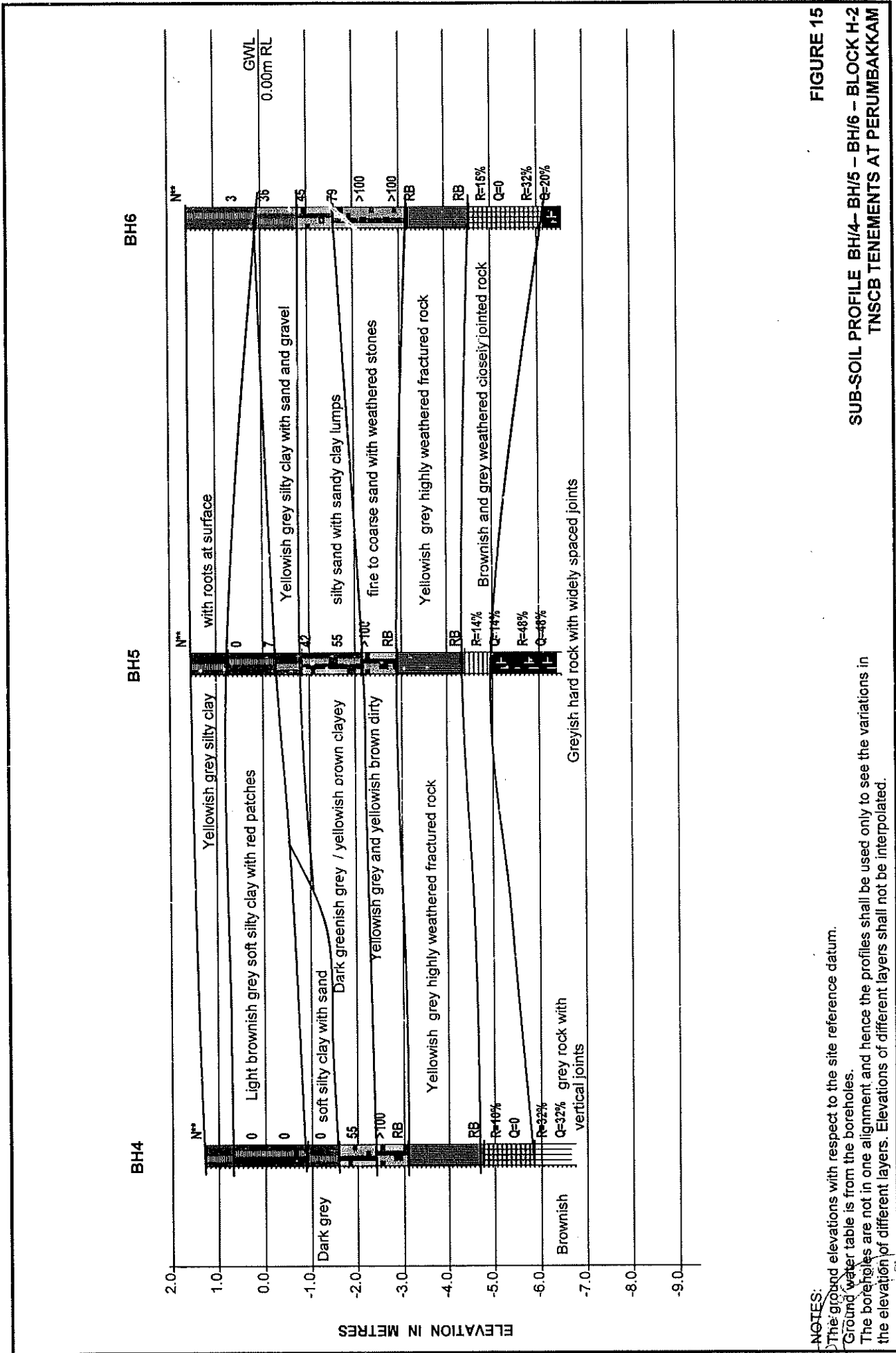
ELEVATION IN METRES

FIGURE 14

SUB-SOIL PROFILE BH/3- BH/2 - BH/1 - BLOCK H-1  
TNSCB TENEMENTS AT PERUMBAKKAM

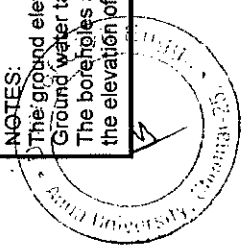
NOTES:  
 1. The ground elevations with respect to the site reference datum.  
 2. Ground water table is from the boreholes.  
 3. The boreholes are not in one alignment and hence the profiles shall be used only to see the variations in the elevation of different layers. Elevations of different layers shall not be interpolated.





**FIGURE 15**  
**SUB-SOIL PROFILE BH/4- BH/5 - BH/6 - BLOCK H-2**  
**TNSCB TENEMENTS AT PERUMBAKKAM**

**NOTES:**  
 1) The ground elevations with respect to the site reference datum.  
 2) Ground water table is from the boreholes.  
 3) The boreholes are not in one alignment and hence the profiles shall be used only to see the variations in the elevation of different layers. Elevations of different layers shall not be interpolated.



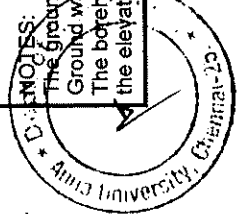
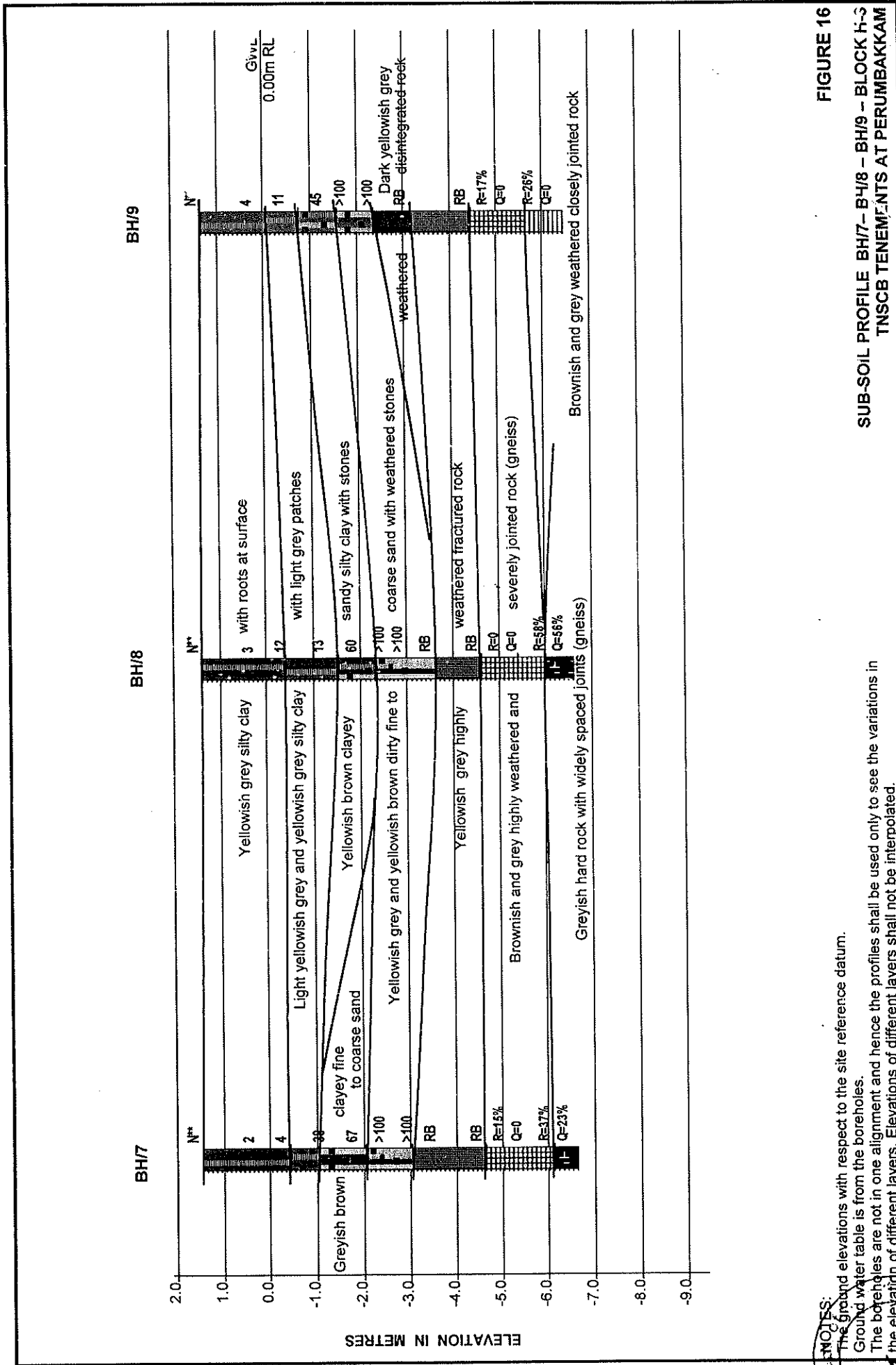


FIGURE 16

SUB-SOIL PROFILE BH/7 - BH/8 - BH/9 - BLOCK H-3 TNSCB TENEMENTS AT PERUMBAKKAM

NOTES:  
 The ground elevations with respect to the site reference datum.  
 The ground water table is from the boreholes.  
 The boreholes are not in one alignment and hence the profiles shall be used only to see the variations in the elevation of different layers. Elevations of different layers shall not be interpolated.

BH10

BH11

BH12

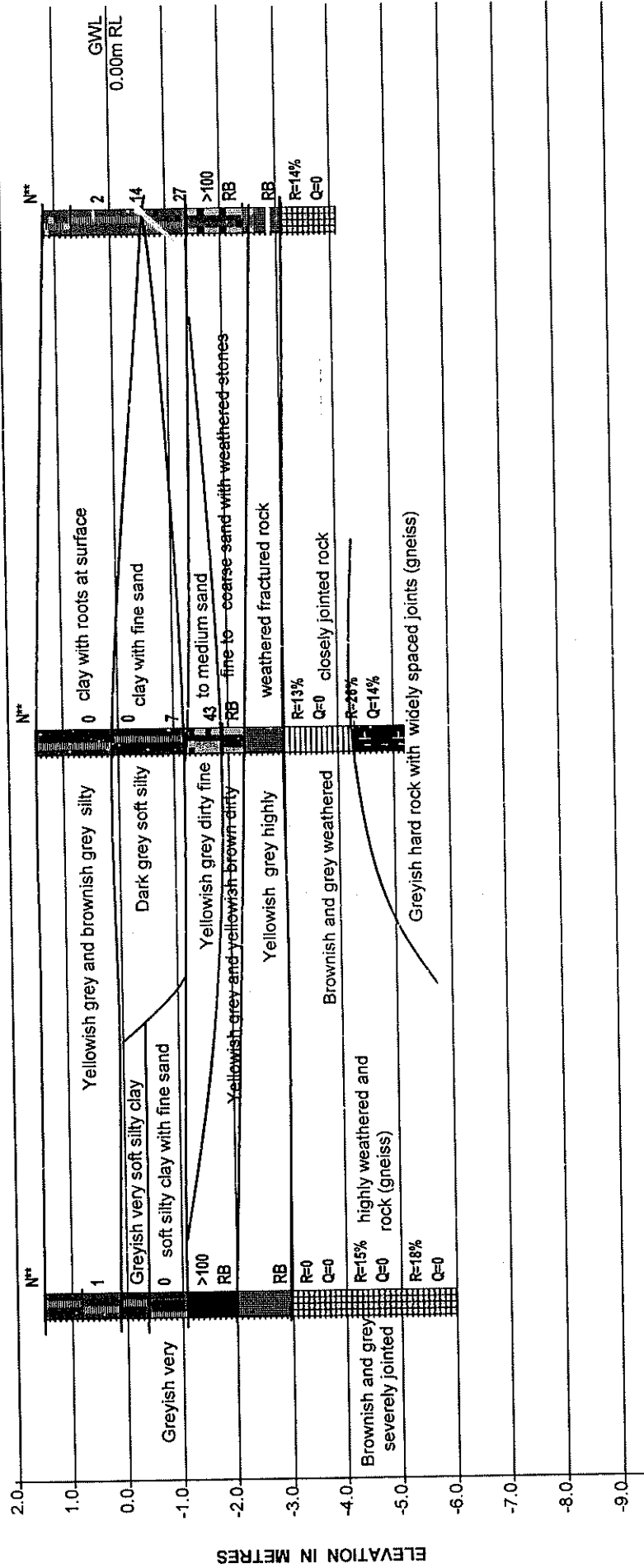
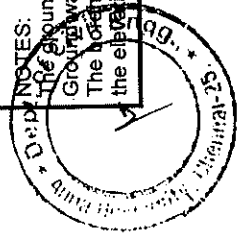


FIGURE 17

SUB-SOIL PROFILE BH/12- BH/11 - BH/10 - BLOCK H-4  
TNSCB TENEMENTS AT PERUMBAKKAM

NOTE: The ground elevations with respect to the site reference datum.  
 Ground water table is from the boreholes.  
 The boreholes are not in one alignment and hence the profiles shall be used only to see the variations in the elevation of different layers. Elevations of different layers shall not be interpolated.



**TABLE 1 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 1 - H**

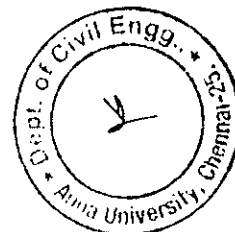
Project: **HIG Tenements, Perumabkkam, TNSCB**

Borehole Nos: **BH1**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Sample Depth m	Sample Type	Visual Identification of Soil	SPT "N"	Classification	Natural Moisture content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Free Swell Index %	Specific Gravity	Gravel %	Coarse Sand %	Medium Sand %	Fine Sand %	Silt %	Clay %
(1)	(2)	Description (3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
		<b>BOREHOLE BH1</b>															
GL-0.5	DS	Yellowish grey soft to medium stiff silty clay		CH	26.7	67.6	21.0	46.6	0.122								
0.75	SPT	Yellowish grey soft silty clay with few stones	2	CH	33.9	78.5	22.1	56.4	0.209								
1.50	UDS	Greenish grey medium stiff to stiff silty clay with reddish brown patches		CH	44.7	92.0	25.2	66.8	0.290								
1.80	SPT	Light brownish grey sandy silty clay with few stones	14		20.7												
2.55	SPT	Yellowish grey sandy silty clay with few stones and white patches	39		23.2												
3.50	SPT	Yell grey & gr grey clayey silty fine to coarse sand with weathered stones	73	SC	14.2							11.2	10.1	20.7	25.5		32.5
4.50	SPT	Yellowish grey clayey silty fine to coarse sand with weathered stones	>100		21.2												
7.30-8.30		Yellowish white highly weathered calcareous sandstone															
8.30-9.30		Light brownish grey highly weathered severely jointed rock															





**TABLE 2 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 2 - H**

Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH2**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Sample Depth m	Sample Type	Visual Identification of Soil		SPT "N"	Classification	Natural Moisture content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Free Swell Index %	Specific Gravity	Gravel %	Coarse Sand %	Medium Sand %	Fine Sand %	Silt %	Clay %
(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
		<b>BOREHOLE BH2</b>																
0.75	SPT	Yellowish grey soft silty clay with roots		2	CH	35.9	70.0	21.7	48.3	0.294	143.4							
1.50	UDS	TOP: Light brownish grey soft silty clay with reddish brown patches BOT: Light brownish grey soft silty with yellow patches		7	CH	56.0	86.1	22.2	63.9	0.529	60.0							
1.80	SPT	TOP: Light brownish grey soft silty clay with yellow patches and gravel BOT: Yellowish grey sandy silty clay with weathered stones		75	SC/CI	21.3	39.4	16.1	23.3	0.223	33.3		3.4	10.4	28.8	32.2	25.2	
2.55	SPT	Yellowish grey dirty fine to coarse sand with weathered stones		71	SC/SM	17.1							1.9	10.0	31.4	34.0	22.7	
3.50	SPT	Yellowish grey dirty fine to coarse sand with weathered stones		>100	SC/SM	13.9												
4.50	SPT	Yellowish grey dirty fine to coarse sand with weathered stones (wdr)				9.8												
6.50-7.50		Brownish grey and highly weathered severely jointed rock																
7.50-8.50		Light grey and brown weathered jointed rock																



**TABLE 3 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 3 - H**

Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH3**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation** Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH3</b>															
GL-0.50	DS	Yellowish grey silty clay		CH	22.5	70.9	21.4	49.5	0.022	70.0							
0.75	SPT	Light brownish grey silty clay	3	CH	41.4	73.0	21.5	51.5	0.386	69.2							
1.80	SPT	Greenish grey and yellowish grey sandy silty clay with weathered stones	19	SC/SM	19.6					40.0							
2.55	SPT	Dark yellowish grey dirty fine to coarse sand with weathered stones	>100		9.0							12.8	20.0	29.6	23.4		14.2
3.50	SPT	Greyish highly weathered fractured rock	>100		7.1												
4.50	SPT	Yellowish and brownish dirty fine to coarse sand with weathered stones	>100	SW	5.0							22.5	31.5	30.4	13.1		2.5
6.00-7.00		Brownish grey highly weathered severely jointed rock															
7.00-8.00		Light brownish grey highly weathered jointed rock															



**TABLE 4 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 4 - H**

Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH4**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH4</b>															
GL-0.50	DS	Yellowish grey silty clay		CH	28.0	67.1	21.9	45.2	0.135	75.0							
0.75	SPT	Light brownish grey soft silty clay with few stones	0	CH	58.0	84.4	24.5	59.9	0.559	63.0							
1.50	SPT	Light brownish grey very soft silty clay with reddish brown patches	0	CH	60.0	84.6	22.2	62.4	0.606	83.3							
2.25	SPT	Dark grey soft silty clay with fine sand	0	SC/CI	38.6	48.3	15.7	32.6	0.702	20.0							
3.00	SPT	Dark greenish grey dirty fine to coarse sand	55	SC/SM	17.5							2.9	13.8	30.3	31.1		21.9
3.75	SPT	Yellowish grey dirty fine to coarse sand with weathered stones	>100	SC/SM	9.7							13.8	21.5	27.2	22.9		14.6
6.10-7.10		Light greyish brown highly weathered severely jointed rock															
7.10-8.10		Greyish weathered severely jointed rock (vertically jointed rock)															



**TABLE 5 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 5 - H**

Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH5**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH5</b>															
GL-0.50	DS	Yellowish grey silty clay with roots		CH	31.7	65.1	20.8	44.3	0.246	45.5							
0.75	SPT	TOP: Yellowish grey silty clay with roots BOT: Light brownish grey silty clay with red patches	0	CH	54.2	77.9	23.3	54.6	0.566	69.2							
1.50	SPT	TOP: Light brownish grey silty clay with red patches BOT: Light yellowish brown and grey sandy silty clay	7	CH	44.8	73.8	22.3	51.5	0.437	71.4							
2.25	SPT	Yell brown clayey silty fine to coarse sand with sandy silty clay patches	42	SC/SM	22.3							8.9	14.7	23.8	29.5	23.1	
3.00	SPT	Yell brown & yell grey clayey silty sand with sandy clay lumps & stones	55	SC	17.3							11.8	11.5	18.9	30.5	27.3	
3.75	SPT	Dark yellowish grey dirty fine to coarse sand with weathered stones	>100	SC/SM	10.4							3.3	9.4	32.8	34.9	19.6	
6.00-7.00		Greyish granitic hard rock with joints															
7.00-8.00		Greyish granitic hard rock with joints															



**TABLE 6 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 6 - H**

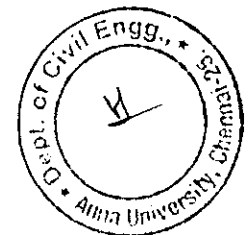
Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH6**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH6</b>															
GL-0.50	DS	Yellowish grey silty clay			27.6					80.0							
0.75	SPT	Yellowish grey silty clay	3	CH	42.6	77.2	24.2	53.0	0.347	91.6							
1.50	SPT	Yellowish grey silty clay with gravel and sand	36	CH	17.4	64.2	18.6	45.6	<0.00	41.6							
2.25	SPT	TOP: Yellowish brown and light grey silty clay with sand and gravel BOT: Yellowish brown dirty fine to coarse sand with sandy clay lumps	45	SC/SM	18.2							4.3	13.0	28.5	30.2	24.0	
3.00	SPT	Yellowish brown dirty fine to coarse sand with few weathered stones	79	SC/SM	15.0							2.9	11.9	31.0	30.9	23.3	
3.75	SPT	Yellowish brown dirty fine to coarse sand with weathered stones	>100	SW/SM	8.7							9.4	26.2	32.8	23.8	7.8	
4.50	SPT	Yellowish brown dirty fine to coarse sand with weathered stones	>100		11.0												
6.20-7.20		Dark grey and brown highly weathered severely jointed rock															
7.20-8.20		TOP: Light grey and brown highly weathered severely jointed rock															
7.20-8.20		BOT: Greyish hard rock															



**TABLE 7 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 7 - H**

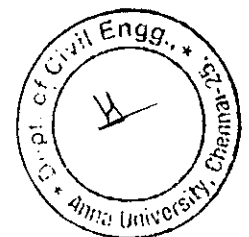
Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH7**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH7</b>															
GL-0.50	DS	Yellowish grey silty clay		CH	21.1	63.5	19.4	44.1	0.039	55.0							
0.75	SPT	Yellowish grey and brown silty clay	2	CH	44.1	71.8	20.9	50.9	0.456	81.8							
1.50	SPT	TOP: yellowish grey silty clay with brown patches BOT: Greyish and brownish silty clay with stones	4	CH	42.5	75.1	24.4	50.7	0.357	100.0							
2.25	SPT	TOP: Light yellowish brown silty clay with sandy clay patches BOT: Greyish brown clayey silty sand / sandy silty clay	38	SC	16.4	27.2						2.9	11.7	27.6	28.0	29.8	
3.00	SPT	Greyish brown clayey silty fine to coarse sand	67	SC-SM	14.9							6.0	26.2	34.3	17.8	15.7	
3.75	SPT	Greyish brown dirty fine to coarse sand	>100		12.3												
4.50	SPT	Dark yellowish grey highly weathered fractured rock	>100		14.0												
6.10-7.10		Brownish and yellowish grey highly weathered severely jointed rock															
7.10-8.10		TOP: Brownish and yellowish grey highly weathered severely jointed rock BOT: Greyish jointed hard rock															



**TABLE 8 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 8 - H**

Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH8**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH8</b>															
GL-0.50	DS	Yellowish grey silty clay with roots		CH	27.9	67.5	21.5	46.0	0.139	70.0							
0.75	SPT	Yellowish grey soft silty clay	3	CH	40.2	67.1	22.3	44.8	0.400	69.5							
1.50	SPT	TOP: Yellowish grey silty clay BOT: Light yellowish grey silty clay with few stones	12	CH	36.1	71.3	23.9	47.4	0.257	100.0							
2.25	SPT	Yellowish brown silty clay with gravel and stones	13	CH	28.1	60.8	20.0	40.8	0.199	63.6							
3.00	SPT	Yellowish brown and grey sandy silty clay with weathered stones	60		14.8												
3.75	SPT	Brownish dirty fine to coarse sand with weathered stones	>100	SC/SM	11.8							10.4	19.6	30.5	24.2	15.3	
4.50	SPT	Yellowish brown dirty fine to coarse sand with weathered stones	>100		9.0												
7.00-8.00		TOP: Light brownish and light grey highly weathered jointed rock and dark grey spots															
7.00-8.00		BOT: Greyish hard rock															



**TABLE 9 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 9 - H**

Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH9**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MC (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH9</b>															
GL-0.50	DS	Yellowish grey silty clay with roots		CH	25.8	70.0	21.9	48.1	0.081	70.0							
0.75	SPT	Yellowish grey silty clay with roots	4	CH	42.3	74.0	24.0	50.0	0.366	58.8							
1.50	SPT	TOP: Yellowish grey silty clay with light grey patches BOT: Yellowish grey silty clay with gravel	11	CH	36.2	73.9	23.8	50.1	0.248	100.0							
2.25	SPT	Greyish brown sandy silty clay with stones	45	SC	16.1							1.0	0.2	13.9	59.8		25.1
3.00	SPT	Dark yellowish grey clayey silty sand with weathered stones	>100	SC/SM	11.4							17.7	15.3	25.8	23.3		17.9
3.75	SPT	Dark yell grey dirty fine to coarse sand (comp weathered disintegrated rock)	>100	SP	8.2							2.2	18.9	48.6	25.7		4.6
5.80-6.80		Light yellowish grey and brown highly weathered severely jointed rock															
6.80-7.80		Light yellowish grey and brown highly weathered closely jointed rock															





**TABLE 10 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 10 - H**

Project: **HIG Tenements, Perumbakkam, TNSCB**  
 Borehole Nos: **BH10**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH10</b>															
GL-0.50	DS	Yellowish grey silty clay with coarse particles		CH	28.1	55.7	17.8	37.9	0.272	70.0							
0.75	SPT	Light brownish silty clay	2	CH	47.5	82.3	23.2	59.1	0.411	75.0							
1.50	SPT	TOP: Brownish grey soft silty clay with stones and yellow patches BOT: Greyish sandy silty clay with yellowish brown patches and gravel	14		41.2												
2.25	SPT	Brownish grey clayey silty sand with weathered stones & sand clay lumps	27		43.0							6.9	13.1	20.3	29.3		30.4
3.00	SPT	Dark brownish grey clayey silty fine to coarse sand with weathered stones		SC	19.8												
4.30-5.30		Lt yel grey & brown highly weathered severely weathered jointed rock	>100														



**TABLE 11 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 11 - H**

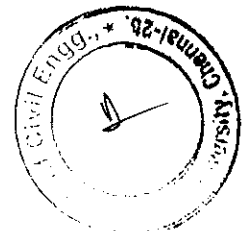
Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH11**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH11</b>															
GL-0.50	DS	Yellowish grey silty clay with roots			25.6					63.0							
0.75	SPT	Light brownish grey silty clay with reddish brown patches	0	CH	39.8	66.2	18.2	48.0	0.450	68.8							
1.50	SPT	Dark grey very soft silty clay with fine sand	0	CI	35.1	40.8	12.8	29.0	0.796	40.0							
2.25	SPT	TOP: Dark grey soft sandy clay with decayed wood BOT: Yellowish grey dirty fine to medium sand	7	CI	41.3	46.4	15.7	30.7	0.834	40.0							
3.00	SPT	Greyish brown clayey silty sand with sandy clay lumps	43	SC/SM	17.0							2.7	6.6	24.3	41.3	25.1	
3.75	SPT	Yellowish grey clayey silty sand with weathered stones	>100	SC/SM	17.7							6.1	8.5	24.5	38.5	22.4	
4.40-5.40		Yellowish grey and grey highly weathered closely jointed rock															
5.40-6.40		Greyish jointed hard rock															



**TABLE 12 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 12 - H**

Project: **HIG Tenements, Perumbakkam, TNSCB**

Borehole Nos: **BH12**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.20m to 1.50m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH12</b>															
GL-0.50	DS	Yellowish grey silty clay			11.3					60.0							
0.75	SPT	Brownish grey silty clay with coarse particles	1	CH	50.7	71.7	21.0	50.7	0.586	90.0							
1.50	UDS	TOP: Greyish very soft silty clay BOT: Greyish very soft silty clay with very fine sand		CH	44.8	55.1	16.7	38.4	0.732	50.0							
2.00	SPT	Greyish very soft silty clay with very fine sand	0	CH	40.2	46.7	15.8	30.9	0.790								
2.75	SPT	Yellowish grey completely weathered disintegrated rock	>100	SC/SM	37.2	51.2	21.0	30.2	0.536	50.0		21.2	13.6	18.8	29.6		16.8
5.50-6.50		Light brownish and grey highly weathered severely jointed rock			11.7												
6.50-7.50		Light brownish and grey highly weathered severely jointed rock															



**TABLE 13 SHEAR STRENGTH PARAMETERS FOR DIFFERENT LAYERS**  
**TNSCB, HIG, PERUMBAKKAM, Ground water table = 1.00m to 1.20m (March-April 2013)**  
**Borehole BH/1 (GL = 1.582m RL)**

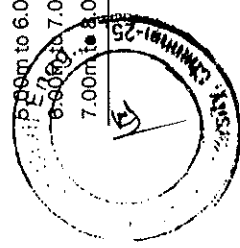
Depth Below GL	Soil	N	Design N*	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.40m	Yellowish grey soft to medium stiff silty clay, LI=0.12 to 0.21	2	4		$c_u = 2.5 \text{ t/m}^2$	46-56%	$P_c=24 \text{ t/m}^2$ , CR=0.258, RR=0.0187
1.40m to 1.90m	Gr grey med stiff to stiff silty clay with red patches, LI=0.29, Lab $c_u=2.9 \text{ t/m}^2$		6		$c_u = 3.0 \text{ t/m}^2$	66.8%	$m_v= 1/(48N) \text{ m}^2/\text{t}$
1.90m to 2.40m	Lt brownish grey sandy silty clay with few stones	14	14		$c_u = 7.0 \text{ t/m}^2$		$m_v= 1/(48N) \text{ m}^2/\text{t}$
2.40m to 3.30m	Yellowish grey sandy silty clay with few stones and white patches	39	40		$c_u = 20 \text{ t/m}^2$		C using $q_c= 28 \text{ N t/m}^2$
3.30m to 4.40m	Yell grey & gr clayey silty fine to coarse sand with weathered stones	73	50	$\phi = 40^\circ$			C using $q_c= 28 \text{ N t/m}^2$
4.40m to 5.30m	Yellowish grey clayey silty fine to coarse sand with weathered stones	100	100	$\phi = 42^\circ$			C using $q_c= 28 \text{ N t/m}^2$
5.30m to 7.40m	Yellowish grey and white highly weathered fractured calcareous sandstone	RB	>200		$c_u = 100 \text{ t/m}^2$		C using $q_c= 35 \text{ N t/m}^2$
7.40m to 8.30m	Yellowish white highly weathered calcareous sandstone						
8.30m to 9.30m	Light brownish grey highly weathered severely jointed rock (gneiss)						

**Borehole BH/2 (GL = 1.312m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.60m	Brownish and yellowish grey silty clay with roots	2	2		$c_u = 1.25 \text{ t/m}^2$	48%	$P_c=8.5 \text{ t/m}^2$ , CR=0.2805, RR=0.0414
0.60m to 1.40m	Yellowish grey soft silty clay with roots, LI=0.294		3		$c_u = 1.5 \text{ t/m}^2$	64%	$m_v= 1/(48N) \text{ m}^2/\text{t}$
1.40m to 2.20m	Light brownish grey soft silty clay with reddish brown and yellow patches, LI=0.53-0.60, Lab $c_u=0.92 \text{ t/m}^2$	2,4			$c_u = 5.0 \text{ t/m}^2$	35%	C using $q_c= 28 \text{ N t/m}^2$
2.20m to 2.70m	Yell grey sandy silty clay with weathered stones, LI=0.223	7,10	8		$c_u = 100 \text{ t/m}^2$		C using $q_c= 35 \text{ N t/m}^2$
2.70m to 4.60m	Yellowish grey dirty fine to coarse sand with weathered stones	75,71,>100	50	$\phi = 40^\circ$			
4.60m to 5.50m	Yellowish grey highly weathered fractured rock	RB	200				
5.50m to 8.10m	Brownish grey and highly weathered severely jointed rock (gneiss)						
8.10m to 8.50m	Light grey brown and weathered jointed rock						

**Borehole BH/3 (GL = 1.550m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.60m	Yellowish grey silty clay					49%	
0.60m to 1.60m	Light brownish grey silty clay, LI=0.386	3	3		$c_u = 2.0 \text{ t/m}^2$	51.5%	$m_v= 1/(48N) \text{ m}^2/\text{t}$
1.60m to 2.50m	Greenish grey and yellowish grey sandy silty clay with weathered stones	19	18		$c_u = 9.0 \text{ t/m}^2$		C using $q_c= 28 \text{ N t/m}^2$
2.50m to 3.50m	Dark yellowish grey dirty fine to coarse sand with weathered stones	>100	50	$\phi = 40^\circ$			C using $q_c= 30 \text{ N t/m}^2$
3.50m to 5.00m	Yellowish and brownish dirty fine to coarse sand with weathered stones (weathered disintegrated rock)	>100	100	$\phi = 42^\circ$			C using $q_c= 35 \text{ N t/m}^2$
5.00m to 6.00m	Brownish grey highly weathered fractured rock	RB	200		$c_u = 100 \text{ t/m}^2$		
6.00m to 7.00m	Brownish and grey highly weathered severely jointed rock (gneiss)						
7.00m to 8.00m	Light brownish grey highly weathered jointed rock (gneiss)						



**Borehole BH/4 (GL = 1.280m RL)**

Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.60m	Yellowish grey silty clay, LI=0.135					45%	
0.60m to 2.20m	Light brownish grey soft silty clay with few stones and reddish brown patches, LI=0.60	0	2		$c_u = 1.0 \text{ t/m}^2$	60%	
2.20m to 2.90m	Dark grey soft silty clay with fine sand, LI=0.702	0	2		$c_u = 1.0 \text{ t/m}^2$	32.5%	
2.90m to 3.70m	Dark greenish grey dirty fine to coarse sand	55	50	$\phi = 38^\circ$			C using $q_c = 26 \text{ N t/m}^2$
3.70m to 4.40m	Yell grey dirty fine to coarse sand with stones	>100	100	$\phi = 40^\circ$			C using $q_c = 30 \text{ N t/m}^2$
4.40m to 6.10m	Yellowish grey highly weathered fractured rock	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 40 \text{ N t/m}^2$
6.10m to 7.20m	Light greyish brown highly weathered severely jointed rock (gneiss)						
7.20m to 8.10m	Greyish weathered severely jointed rock (vertically jointed rock) (gneiss)						

**Borehole BH/5 (GL = 1.535m RL)**

Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.80m	Yellowish grey silty clay with roots, LI=0.246					44%	
0.80m to 1.80m	Light brownish grey silty clay with red patches, LI=0.437 - 0.563	0,2	2		$c_u = 1.0 \text{ t/m}^2$	52-55%	
1.80m to 2.40m	Light yellowish brown and grey sandy silty clay	6	6		$c_u = 3.0 \text{ t/m}^2$		
2.40m to 3.70m	Yell brown clayey silty fine to coarse sand with sandy silty clay patches	42,55	45	$\phi = 37^\circ$			C using $q_c = 26 \text{ N t/m}^2$
3.70m to 4.50m	Dark yellowish grey dirty fine to coarse sand with weathered stones	>100	70	$\phi = 42^\circ$			C using $q_c = 28 \text{ N t/m}^2$
4.50m to 6.00m	Dark yellowish grey highly weathered fractured rock	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 40 \text{ N t/m}^2$
6.00m to 6.60m	Greyish & brown partly weathered jointed rock						
6.60m to 8.00m	Greyish granitic hard rock with joints (gneiss)						

**Borehole BH/6 (GL = 1.592m RL)**

Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.40m	Yellowish grey silty clay, LI=0.347	3	3		$c_u = 2.0 \text{ t/m}^2$	53%	
1.40m to 2.40m	Yellowish grey silty clay with gravel and sand, LI=0	36	36		$c_u = 18 \text{ t/m}^2$	45.6%	$m_v = 1/(42 \text{ N}) \text{ m}^2/\text{t}$
2.40m to 3.20m	Yellowish brown dirty fine to coarse sand with sandy clay lumps	45	45	$\phi = 37^\circ$			C using $q_c = 26 \text{ N t/m}^2$
3.20m to 4.80m	Yellowish brown dirty fine to coarse sand with weathered stones	79, >100	70	$\phi = 42^\circ$			C using $q_c = 28 \text{ N t/m}^2$
4.80m to 6.20m	Yellowish brown highly weathered fractured rock	RB	>200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 40 \text{ N t/m}^2$
6.20m to 7.80m	Dark grey and brown highly weathered severely jointed rock (gneiss)						
7.80m to 8.20m	Greyish hard rock (gneiss)						



**Borehole BH/7 (GL = 1.456m RL)**

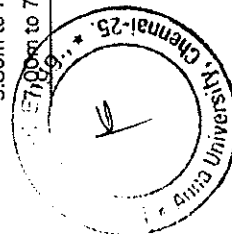
Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.90m	Yellowish grey silty clay with brown patches, LI=0.357-0.456	2.4	4		$c_u = 2.0 \text{ t/m}^2$	44-51%	$m_v = 1/(42N) \text{ m}^2/\text{t}$
1.90m to 2.50m	Greyish and brownish silty clay with stones	13	12		$c_u = 6.0 \text{ t/m}^2$	41%	C using $q_c = 24 \text{ N t/m}^2$
2.50m to 3.50m	Greyish brown clayey silty fine to coarse sand	38	38	$\phi = 36^\circ$			C using $q_c = 28 \text{ N t/m}^2$
3.50m to 4.50m	Greyish brown dirty fine to coarse sand	>100	70	$\phi = 42^\circ$			C using $q_c = 40 \text{ N t/m}^2$
4.50m to 6.10m	Dark yellowish grey highly weathered fractured rock	RB	>200		$c_u = 100 \text{ t/m}^2$		
6.10m to 7.60m	Brownish and yellowish grey highly weathered severely jointed rock (gneiss)						
7.60m to 8.10m	Greyish jointed hard rock (gneiss)						

**Borehole BH/8 (GL = 1.376m RL)**

Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.80m	Yellowish grey silty clay with roots at surface, 0.257-0.400	3.7	4		$c_u = 2.5 \text{ t/m}^2$	45-47.5%	$m_v = 1/(42N) \text{ m}^2/\text{t}$
1.80m to 2.90m	Light yellowish grey silty clay with few stones, LI=0.199	12,13	12		$c_u = 6.0 \text{ t/m}^2$	41%	$m_v = 1/(48N) \text{ m}^2/\text{t}$
2.90m to 3.60m	Yellowish brown and grey sandy silty clay with weathered stones	60	50		$c_u = 25 \text{ t/m}^2$		C using $q_c = 30 \text{ N t/m}^2$
3.60m to 5.00m	Brownish dirty fine to coarse sand with weathered stones	>100	100	$\phi = 42^\circ$			C using $q_c = 40 \text{ N t/m}^2$
5.00m to 6.00m	Brownish and grey highly weathered fractured rock	RB	>200		$c_u = 100 \text{ t/m}^2$		
6.00m to 6.80m	Brownish and yellowish grey highly weathered severely jointed rock						
6.80m to 7.40m	Lt brown & lt grey highly weathered jointed rock						
7.40m to 8.00m	Greyish hard rock (gneiss)						

**Borehole BH/9 (GL = 1.335m RL)**

Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.40m	Yellowish grey silty clay with roots, LI=0.366	4	4		$c_u = 2.5 \text{ t/m}^2$	48-50%	$m_v = 1/(42N) \text{ m}^2/\text{t}$
1.40m to 2.10m	Yellowish grey silty clay with light grey patches, LI=0.248	11	10		$c_u = 5.0 \text{ t/m}^2$	50%	C using $q_c = 24 \text{ N t/m}^2$
2.10m to 2.90m	Greyish brown / yellowish grey sandy silty clay with stones	45	40	$\phi = 36^\circ$			C using $q_c = 26 \text{ N t/m}^2$
2.90m to 3.70m	Dark yellowish grey clayey silty sand with weathered stones	>100	70	$\phi = 42^\circ$			C using $q_c = 30 \text{ N t/m}^2$
3.70m to 4.50m	Dark yell grey dirty fine to coarse sand (comp weathered disintegrated rock)	>100	70	$\phi = 42^\circ$			C using $q_c = 40 \text{ N t/m}^2$
4.50m to 5.80m	Dark yellowish grey highly weathered fractured rock	RB	>200		$c_u = 100 \text{ t/m}^2$		
5.80m to 7.00m	Light yellowish grey and brown highly weathered severely jointed rock						
7.00m to 7.80m	Light yellowish grey and brown highly weathered closely jointed rock						



**Borehole BH/10 (GL = 1.210m RL)**

Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.50m	Yellowish grey silty clay with coarse particles, LI=0.272	2	2		$c_u = 1.2 \text{ t/m}^2$	38%	
0.50m to 1.80m	Light brownish silty clay, LI=0.411	14	14		$c_u = 7.0 \text{ t/m}^2$	59%	$m_v = 1/(42N) \text{ m}^2/\text{t}$
1.80m to 2.60m	Greyish sandy silty clay with yellowish brown patches and gravel	40, >100	45	$\phi = 37^\circ$			C using $q_c = 26 \text{ N t/m}^2$
2.60m to 3.60m	Brownish grey clayey silty sand with weathered stones & sand clay lumps	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 40 \text{ N t/m}^2$
3.60m to 4.30m	Brownish highly weathered fractured rock						
4.30m to 5.30m	Lt. yellow & brown highly weathered severely weathered jointed rock (gneiss)						

**Borehole BH/11 (GL = 1.480m RL)**

Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.40m	Yellowish grey silty clay with roots and reddish brown patches, LI=0.45	0	2		$c_u = 1.2 \text{ t/m}^2$	48%	
1.40m to 2.70m	Dark grey very soft silty clay with fine sand, LI=0.796-0.834	0.1	2		$c_u = 1.2 \text{ t/m}^2$	30%	
2.70m to 3.40m	Yellowish grey dirty fine to medium sand	15	18	$\phi = 32^\circ$			C using $q_c = 26 \text{ N t/m}^2$
3.40m to 3.80m	Yellowish grey clayey silty sand with weathered stones	>50	50	$\phi = 40^\circ$			C using $q_c = 26 \text{ N t/m}^2$
3.80m to 4.50m	Br and grey highly weathered fractured rock	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 40 \text{ N t/m}^2$
4.50m to 5.80m	Yellowish grey and grey highly weathered closely jointed rock						
5.80m to 6.40m	Greyish jointed hard rock (gneiss)						

**Borehole BH/12 (GL = 1.500m RL)**

Depth Below GL	Soil	N	Design N"	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.70m	Yellowish grey silty clay	1	2		$c_u = 1.2 \text{ t/m}^2$	50.7%	
0.70m to 1.40m	Brownish grey silty clay with coarse particles, LI=0.586	0	2		$c_u = 1.2 \text{ t/m}^2$	38.5%	
1.40m to 1.90m	Greyish very soft silty clay, LI=0.732	0	2		$c_u = 1.2 \text{ t/m}^2$	30-31%	
1.90m to 2.60m	Greyish very soft silty clay with very fine sand, LI=0.536-0.790	>100	70	$\phi = 42^\circ$			C using $q_c = 28 \text{ N t/m}^2$
2.60m to 3.50m	Yellowish grey completely weathered disintegrated rock	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 40 \text{ N t/m}^2$
3.50m to 4.50m	Yellowish grey highly weathered fractured rock						
4.50m to 7.50m	Light brownish and grey highly weathered severely jointed rock						

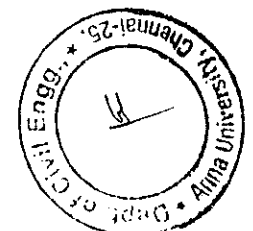


**TABLE 14 CHEMICAL ANALYSIS ON GROUND WATER SAMPLES  
(COLLECTED FROM BOREHOLES)**

Sample No:	Block	Location	Depth	pH	Sulphate (as SO <sub>4</sub> ) ppm	Chloride Cl ppm	Remarks
1	H1	BH/1	1.30m	7.35	1065	17730	
2	H2	BH/5	1.40m	7.65	785	13350	
3	H3	BH/8	1.20m	8.20	750	12650	
4	H4	BH/12	1.20m	8.25	890	14100	

**CHEMICAL ANALYSIS ON SOIL SAMPLES**

Sample No:	Block	Location	Depth	pH	Sulphate (as SO <sub>4</sub> )%	Chloride Cl%	Remarks
1	H1	BH/1	1.50m	8.10	0.020	0.060	
2	H2	BH/6	0.75m	8.15	0.040	0.230	
3	H3	BH/8	0.75m	8.07	0.030	0.210	
4	H4	BH/12	0.75m	6.50	0.050	0.340	

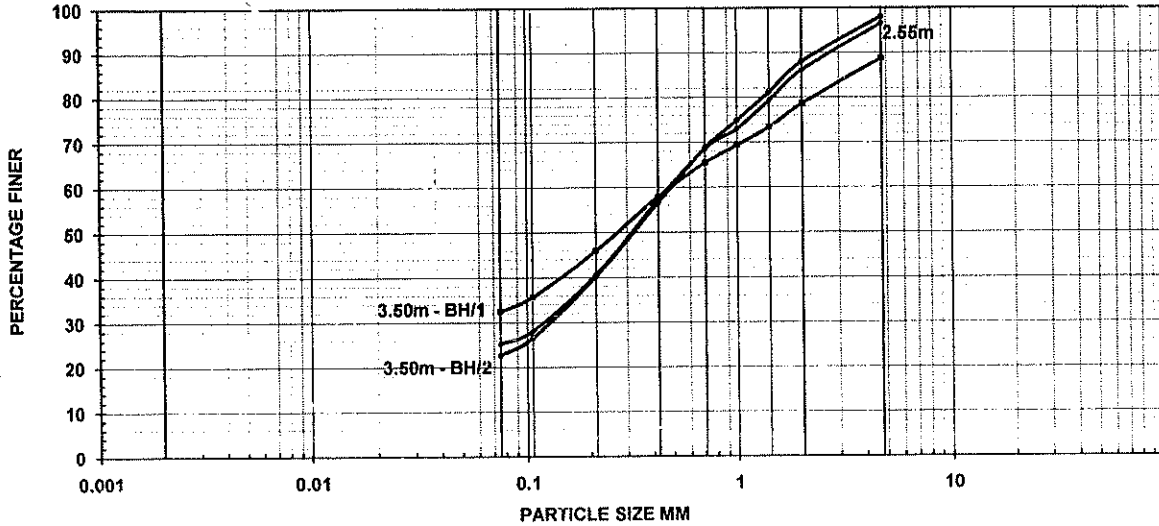




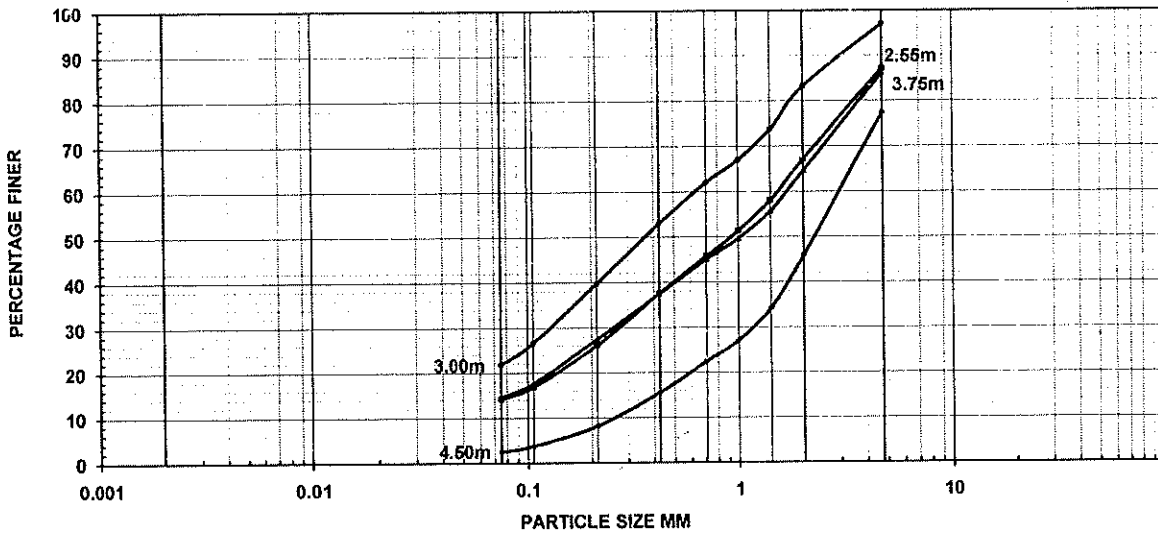
# ANNEXURE G-1

## GRAIN SIZE DISTRIBUTION CURVES

PROJECT: HIG Tenements, TNSCB, Perumbakkam

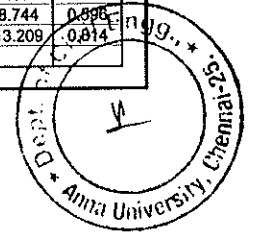


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/1	3.50m	100.0	88.8	78.7	58.0	32.5			11.2	10.1	20.7	25.5		32.5	GC-SP	0.267	10.057	0.539
BH/2	2.55m	100.0	96.6	86.2	57.4	25.2			3.4	10.4	28.8	32.2		25.2	SC-SP	0.312	5.795	0.743
BH/2	3.50m	100.0	98.1	88.1	56.7	22.7			1.9	10.0	31.4	34.0		22.7	SC-SP	0.320	5.605	0.778



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/3	2.55m	100.0	87.2	67.2	37.6	14.2			12.8	20.0	29.6	23.4		14.2	GC-SP	0.918	11.413	0.778
BH/3	4.50m	100.0	77.5	46.0	15.6	2.5			22.5	31.5	30.4	13.1		2.5	GSW	2.232	8.199	1.951
BH/4	3.00m	100.0	97.1	83.3	53.0	21.9			2.9	13.8	30.3	31.1		21.9	SC-SP	0.363	8.744	0.986
BH/4	3.75m	100.0	88.2	64.7	37.5	14.6			13.8	21.5	27.2	22.9		14.6	GC-SP	1.017	13.209	0.814

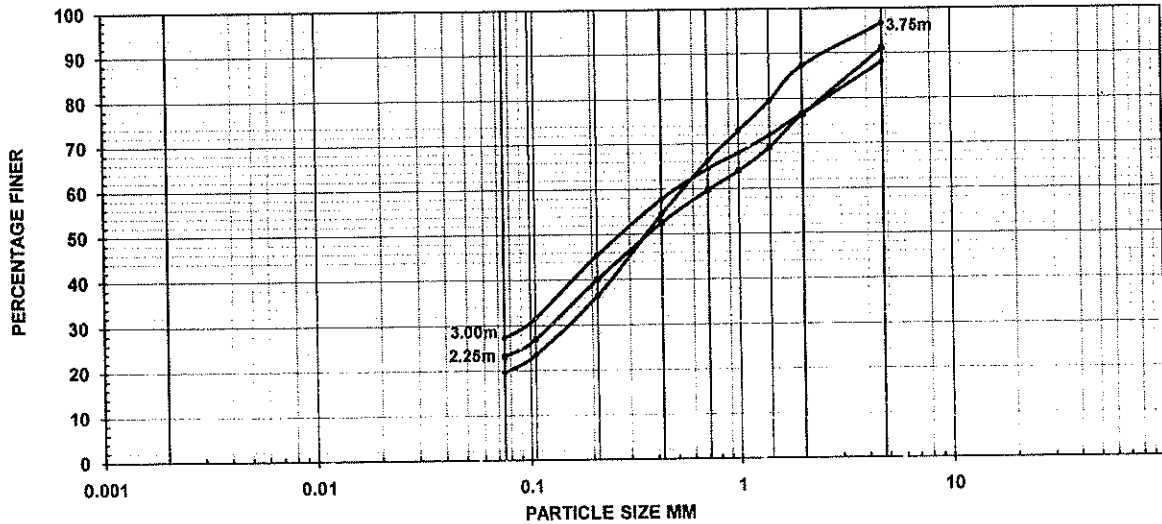
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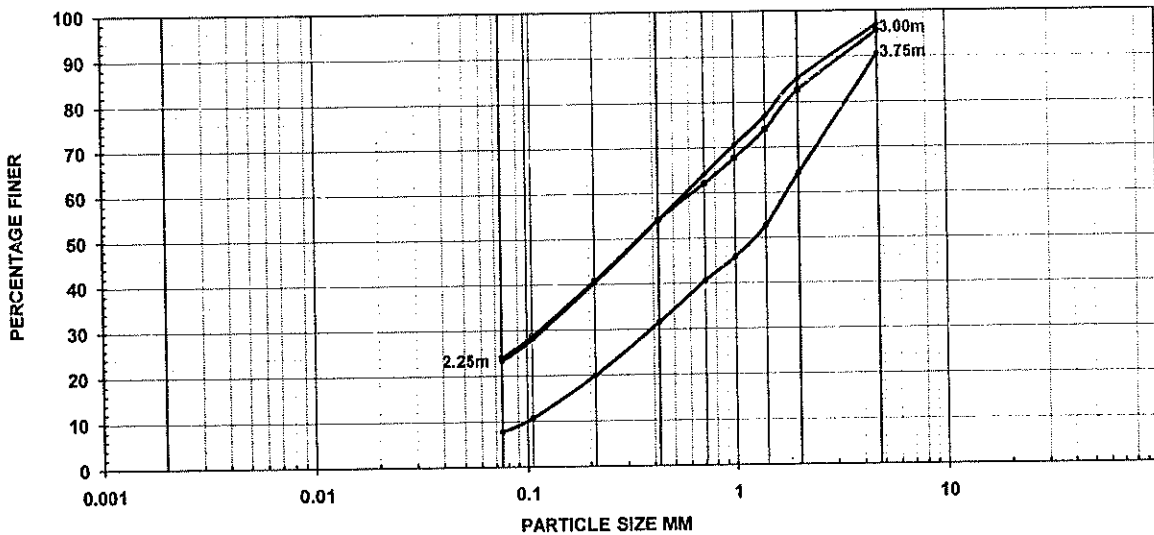
# ANNEXURE G-2

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: HIG Tenements, TNSCB, Perumbakkam

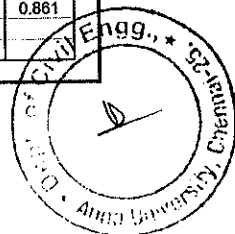


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classifi cation CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/5	2.25m	100.0	91.1	76.4	52.6	23.1		8.9	14.7	23.8	29.5		23.1	SC-SP	0.368	10.791	0.484	
BH/5	3.00m	100.0	88.2	76.7	57.8	27.3		11.8	11.5	18.9	30.5		27.3	GC-SP	0.273	10.468	0.428	
BH/5	3.75m	100.0	96.7	87.3	64.5	19.6		3.3	9.4	32.8	34.9		19.6	SC-SP	0.357	6.794	0.775	



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classifi cation CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/8	2.25m	100.0	95.7	82.7	54.2	24.0		4.3	13.0	28.5	30.2		24.0	SC-SP	0.342	8.786	0.611	
BH/8	3.00m	100.0	97.1	85.2	54.2	23.3		2.9	11.9	31.0	30.9		23.3	SC-SP	0.344	7.421	0.704	
BH/8	3.75m	100.0	90.6	64.4	31.6	7.8		9.4	28.2	32.8	23.8		7.8	GSP	1.218	11.347	0.861	

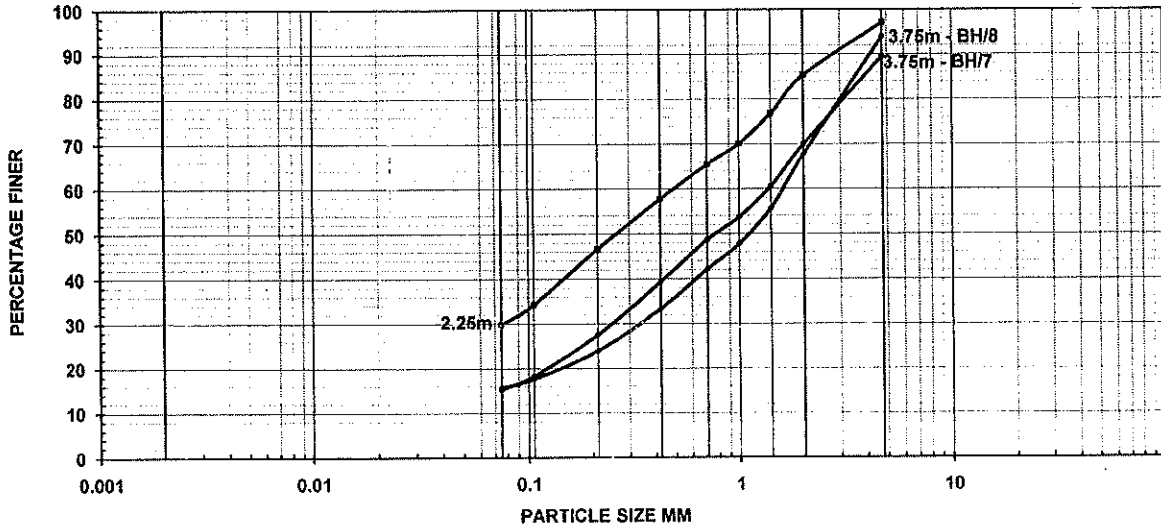
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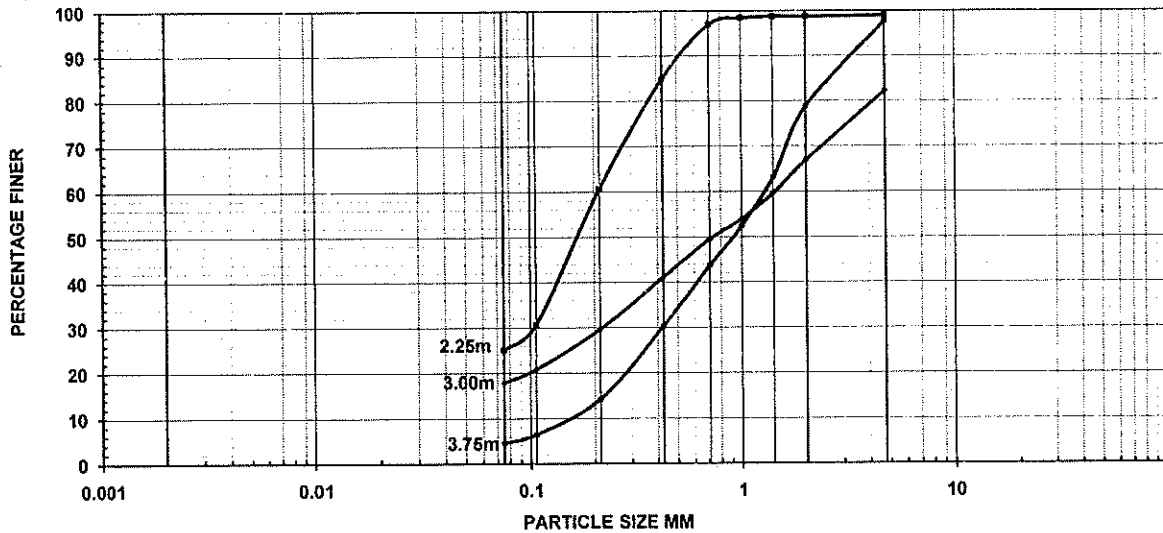
# ANNEXURE G-3

**GRAIN SIZE DISTRIBUTION CURVES**

**PROJECT: HIG Tenements, TNSCB, Perumbakkam**

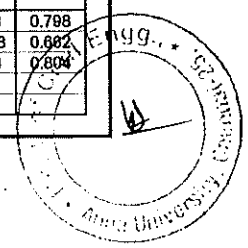


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/7	2.25m	100.0	97.1	85.4	57.8	29.8		2.9	11.7	27.6	28.0		29.8	SC-SP	0.261	8.981	0.566	
BH/7	3.75m	100.0	94.0	67.8	33.5	15.7		6.0	26.2	34.3	17.8		15.7	SC-SW	1.095	8.936	1.057	
BH/8	3.75m	100.0	89.6	70.0	39.5	15.3		10.4	19.6	30.5	24.2		15.3	GC-SP	0.771	10.829	0.750	



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/9	2.25m	100.0	99.0	98.8	84.9	25.1		1.0	0.2	13.9	59.8		25.1		0.166	2.498	0.798	
BH/9	3.00m	100.0	82.3	67.0	41.2	17.9		17.7	15.3	25.8	23.3		17.9		0.733	12.588	0.662	
BH/9	3.75m	100.0	97.8	78.9	30.3	4.6		2.2	18.9	48.6	25.7		4.6		0.906	6.418	0.604	

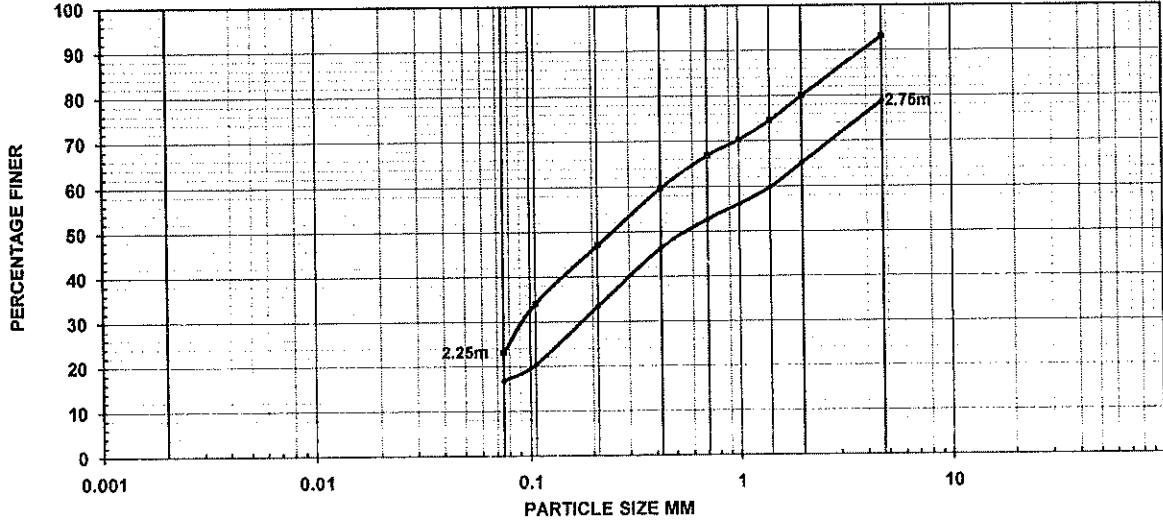
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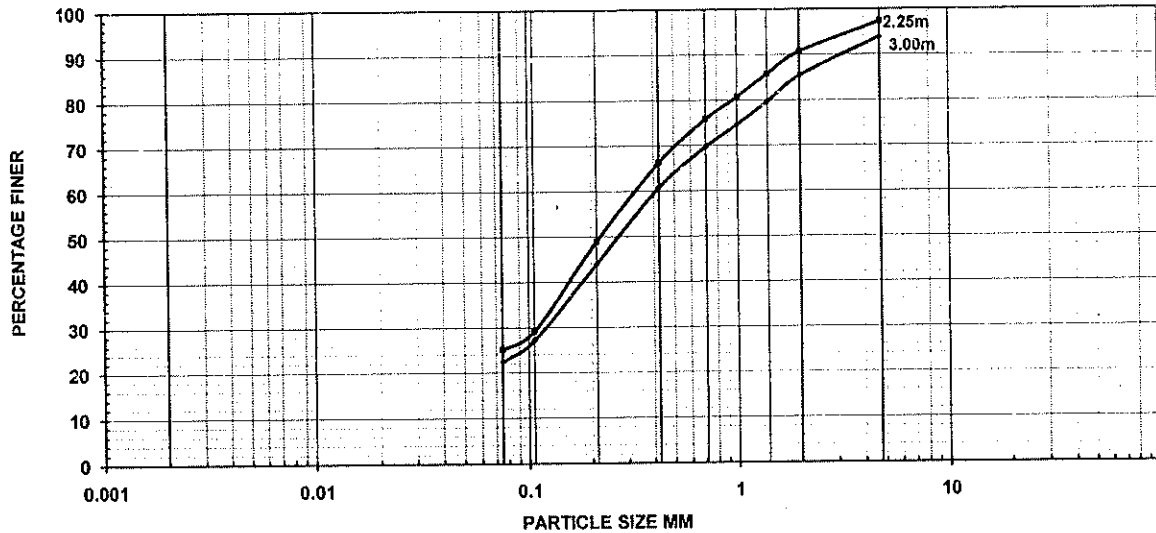
# ANNEXURE G-4

## GRAIN SIZE DISTRIBUTION CURVES

PROJECT: **HIG Tenements, TNSCB, Perumbakkam**

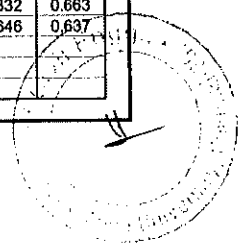


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)								Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		M	80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C	CLASS			
BH/10	2.25m			100.0	93.1	80.0	59.7	23.1		6.9	13.1	20.3	36.6		23.1	SC-SP	0.249	9.391	0.473
BH/12	2.75m			100.0	78.8	65.2	46.4	16.8		21.2	13.6	18.8	29.6		16.8	GC-SP	0.567	15.261	0.387



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)								Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		M	80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C	CLASS			
BH/11	2.25m			100.0	97.3	90.7	88.4	25.1		2.7	6.6	24.3	41.3		25.1	SC-SP	0.222	4.332	0.663
BH/11	3.00m			100.0	93.9	85.4	60.9	22.4		6.1	6.5	24.5	38.5		22.4	SC-SP	0.271	5.646	0.637

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# ANNEXURE U-1

## Unconfined Compression Strength Test UCC on soil sample

**Project:**

TNSCB, Perambakkam, H Block

Date of Test **26-Mar-13**

Borehole **BH/1**

Depth **1.50m**

**Soil**

**Greenish grey silty clay with reddish brown patches**

Insitu bulk density **1.757 gm/cc**

Insitu Dry Density **1.214 gm/cc**

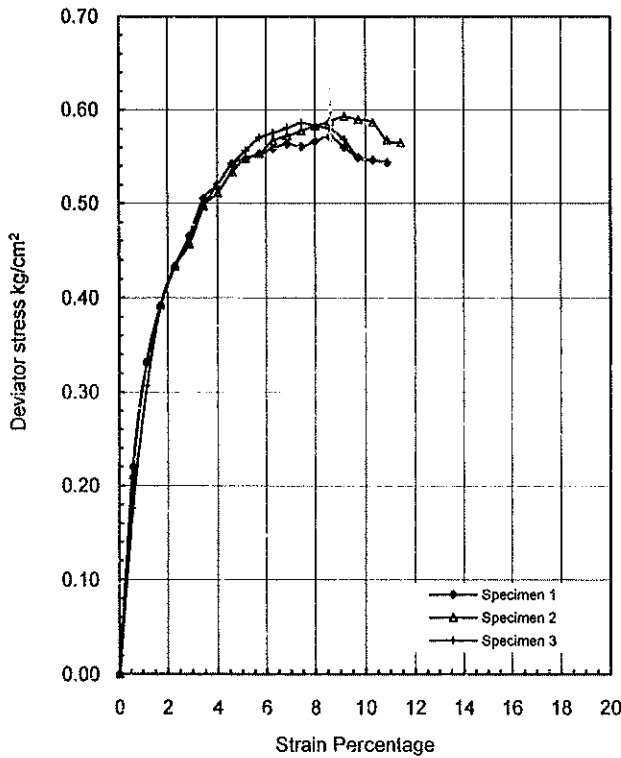
Water Content **44.73 %**

Liquid Limit % **92.00**

Plastic Limit % **25.20**

Plasticity Index % **66.80**

Liquidity Index **0.29**



**Maximum Shear Stress**

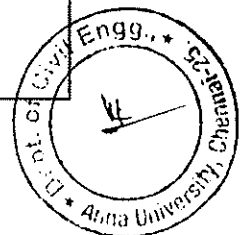
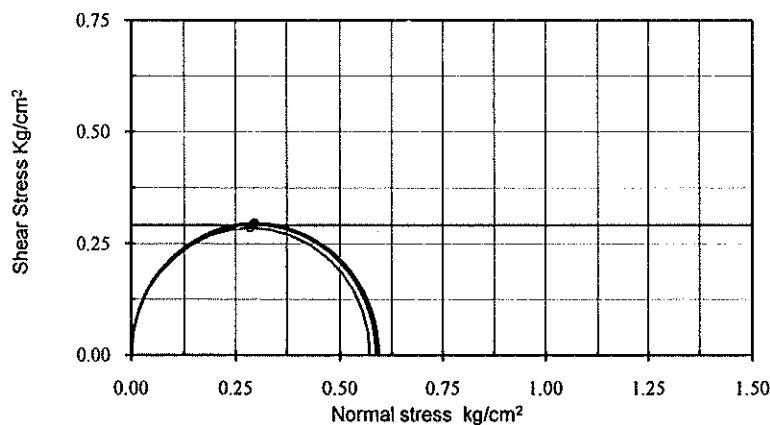
Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.571	0.286
Specimen 2	0.593	0.296
Specimen 3	0.586	0.293

**Results**

Unconfined compression strength  $q_u$  **0.583 kg/cm<sup>2</sup>**

Undrained Cohesion  $c_u$  **0.292 kg/cm<sup>2</sup>**

Secant Modulus (undrained) **35.48 kg/cm<sup>2</sup>**



# ANNEXURE U-2

## Unconfined Compression Strength Test UCC on soil sample

**Project:**

TNSCB, Perambakkam, H Block

Date of Test 26-Mar-13

Borehole BH/2

Depth 1.50m

**Soil**

Light brownish grey soft silty clay with reddish brown patches

In situ bulk density 1.636 gm/cc

In situ Dry Density 1.020 gm/cc

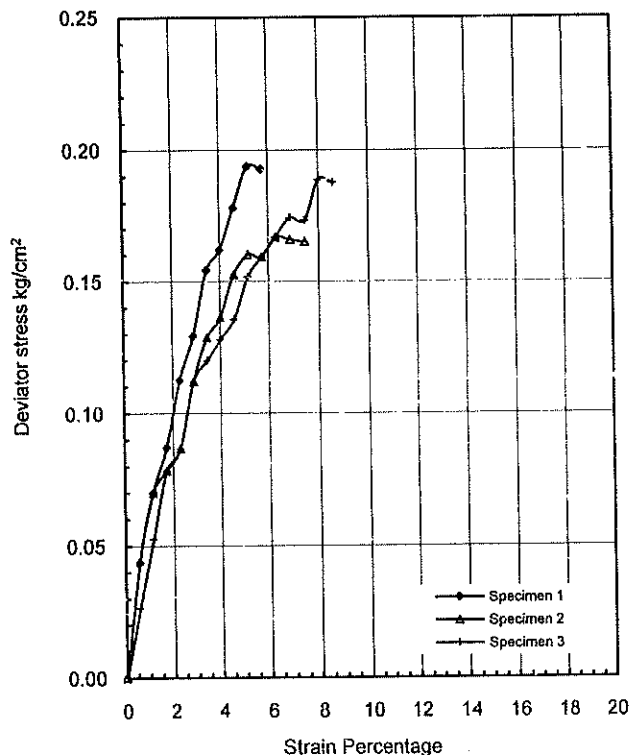
Water Content 60.34 %

Liquid Limit % 86.10

Plastic Limit % 22.40

Plasticity Index % 63.70

Liquidity Index 0.60



**Maximum Shear Stress**

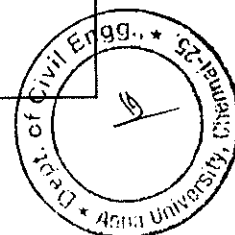
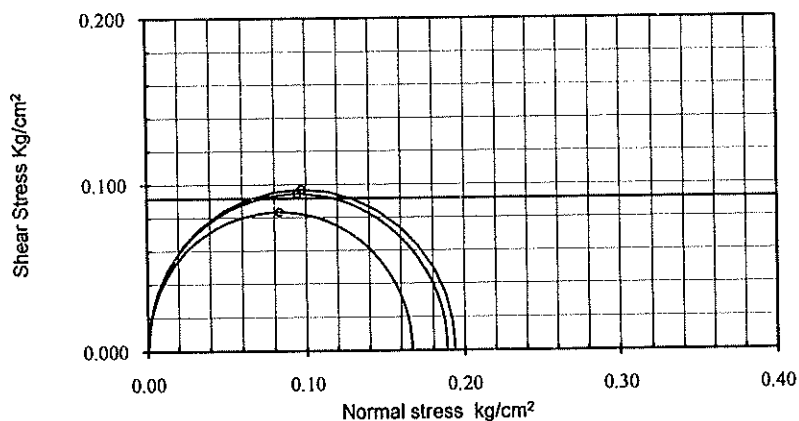
Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.194	0.097
Specimen 2	0.167	0.083
Specimen 3	0.189	0.094

**Results**

Unconfined compression strength  $q_u$  0.183 kg/cm<sup>2</sup>

Undrained Cohesion  $c_u$  0.092 kg/cm<sup>2</sup>

Secant Modulus (undrained) 4.41 kg/cm<sup>2</sup>



# ANNEXURE U-3

## Unconfined Compression Strength Test UCC on soil sample

**Project:**

TNSCB, Perambakkam, H Block

Date of Test **3-Apr-13**

Borehole **BH/12**

Depth **1.50m**

Soil

**Greyish soft silty clay**

In situ bulk density 1.652 gm/cc

In situ Dry Density 1.086 gm/cc

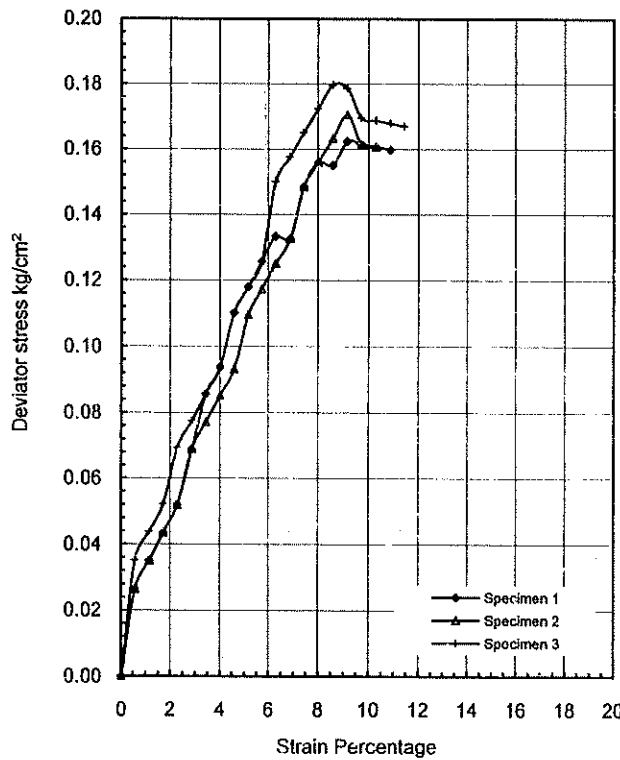
Water Content 52.12 %

Liquid Limit % 46.70

Plastic Limit % 15.80

Plasticity Index % 30.90

Liquidity Index 1.18



**Maximum Shear Stress**

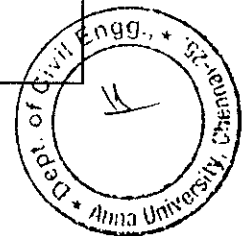
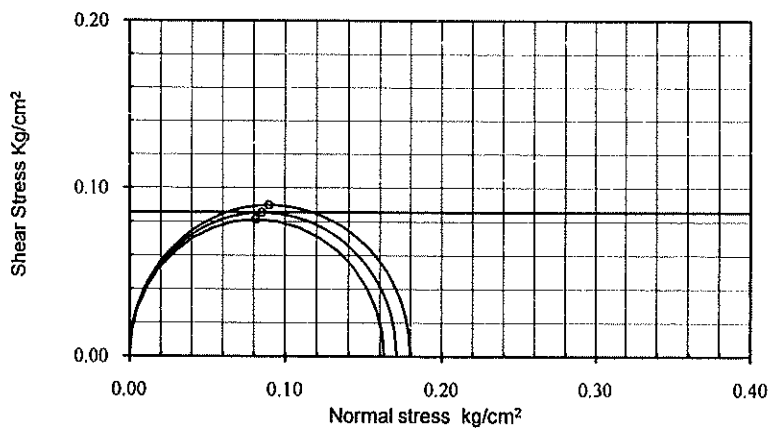
Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.162	0.081
Specimen 2	0.171	0.085
Specimen 3	0.180	0.090

**Results**

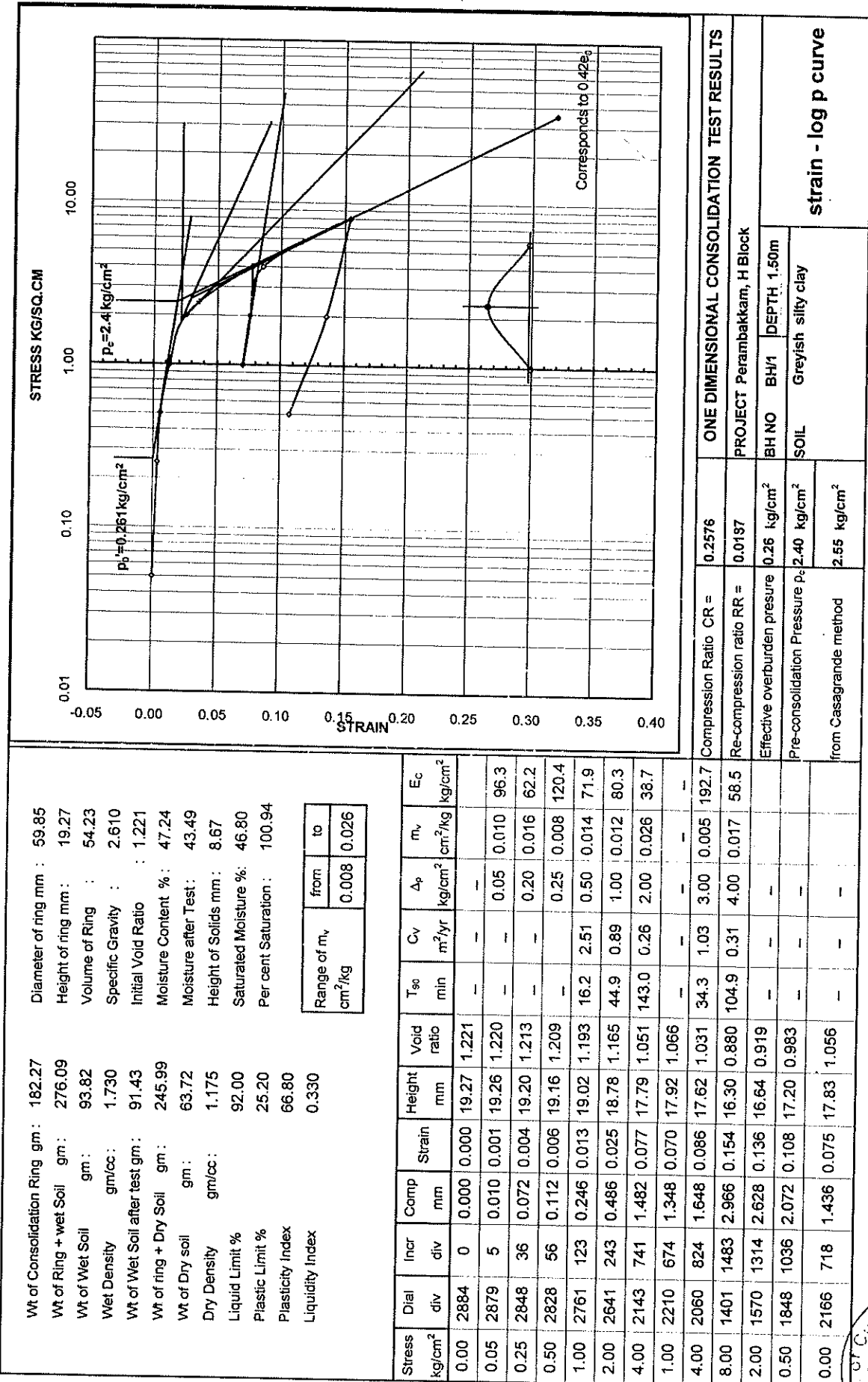
Unconfined compression strength  $q_u$  0.171 kg/cm<sup>2</sup>

Undrained Cohesion  $c_u$  0.085 kg/cm<sup>2</sup>

Secant Modulus (undrained) 2.33 kg/cm<sup>2</sup>



# ANNEXURE C-1



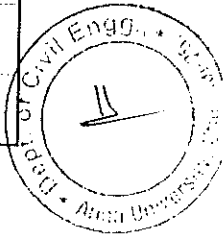
Diameter of ring mm : 59.85  
 Height of ring mm : 19.27  
 Volume of Ring : 54.23  
 Specific Gravity : 2.610  
 Initial Void Ratio : 1.221  
 Moisture Content % : 47.24  
 Moisture after Test : 43.49  
 Height of Solids mm : 8.67  
 Saturated Moisture % : 46.80  
 Per cent Saturation : 100.94

Range of $m_v$ cm <sup>2</sup> /kg		from	to
		0.008	0.026

Wt of Consolidation Ring gm : 182.27  
 Wt of Ring + wet Soil gm : 276.09  
 Wt of Wet Soil gm : 93.82  
 Wet Density gm/cc : 1.730  
 Wt of Wet Soil after test gm : 91.43  
 Wt of ring + Dry Soil gm : 245.99  
 Wt of Dry soil gm : 63.72  
 Dry Density gm/cc : 1.175  
 Liquid Limit % : 92.00  
 Plastic Limit % : 25.20  
 Plasticity Index : 66.80  
 Liquidity Index : 0.330

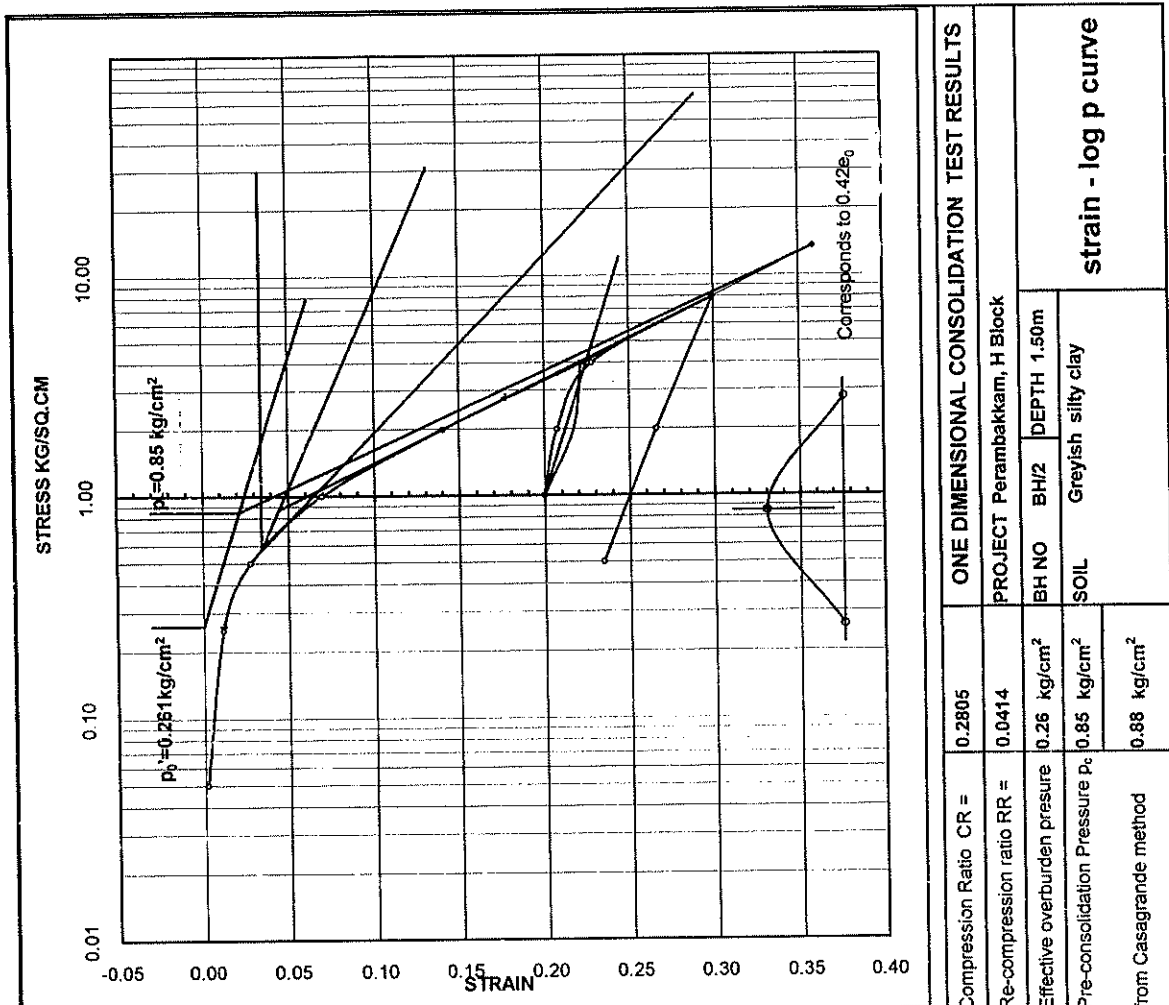
Stress kg/cm <sup>2</sup>	Dial div	Incr div	Comp mm	Strain	Height mm	Void ratio	$T_{90}$ min	$C_v$ m <sup>2</sup> /yr	$\Delta p$ kg/cm <sup>2</sup>	$m_v$ cm <sup>2</sup> /kg	$E_c$ kg/cm <sup>2</sup>
0.00	2884	0	0.000	0.000	19.27	1.221	-	-	-	-	-
0.05	2879	5	0.010	0.001	19.26	1.220	-	-	0.05	0.010	96.3
0.25	2848	36	0.072	0.004	19.20	1.213	-	-	0.20	0.016	62.2
0.50	2828	56	0.112	0.006	19.16	1.209	-	-	0.25	0.008	120.4
1.00	2761	123	0.246	0.013	19.02	1.193	16.2	2.51	0.50	0.014	71.9
2.00	2641	243	0.486	0.025	18.78	1.165	44.9	0.89	1.00	0.012	80.3
4.00	2143	741	1.482	0.077	17.79	1.051	143.0	0.26	2.00	0.026	36.7
1.00	2210	674	1.348	0.070	17.92	1.066	-	-	-	-	-
4.00	2060	824	1.648	0.086	17.62	1.031	34.3	1.03	3.00	0.005	192.7
8.00	1401	1483	2.966	0.154	16.30	0.880	104.9	0.31	4.00	0.017	58.5
2.00	1570	1314	2.628	0.136	16.64	0.919	-	-	-	-	-
0.50	1848	1036	2.072	0.108	17.20	0.983	-	-	-	-	-
0.00	2166	718	1.436	0.075	17.83	1.056	-	-	-	-	-

ONE DIMENSIONAL CONSOLIDATION TEST RESULTS			
Compression Ratio CR =	0.2576	PROJECT	Perambakkam, H Block
Re-compression ratio RR =	0.0197	BH NO	BH/1
Effective overburden pressure	0.26 kg/cm <sup>2</sup>	DEPTH	1.50m
Pre-consolidation Pressure $p_c$	2.40 kg/cm <sup>2</sup>	SOIL	Greyish silty clay
from Casagrande method	2.55 kg/cm <sup>2</sup>	strain - log p curve	





# ANNEXURE C-2

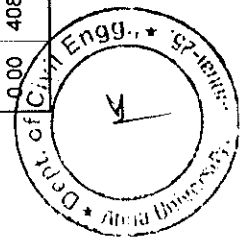


Diameter of ring mm : 59.85 Height of ring mm : 19.33 Volume of Ring : 54.39 Specific Gravity : 2.620 Initial Void Ratio : 1.619 Moisture Content % : 62.11 Moisture after Test : 44.10 Height of Solids mm : 7.38 Saturated Moisture % : 61.81 Per cent Saturation : 100.49	Diameter of ring mm : 185.19 Height of ring mm : 273.38 Volume of Ring : 88.19 Specific Gravity : 1.621 Initial Void Ratio : 78.39 Moisture Content % : 239.59 Moisture after Test : 54.40 Height of Solids mm : 1.000 Saturated Moisture % : 86.10 Per cent Saturation : 22.20 Plasticity Index : 63.90 Liquidity Index : 0.625
---	---

Range of $m_v$ cm <sup>2</sup> /kg	from 0.018	to 0.083
---------------------------------------	---------------	-------------

Stress kg/cm <sup>2</sup>	Dial div	Incr div	Comp mm	Strain	Height mm	Void ratio	$T_{50}$ min	$C_v$ m <sup>2</sup> /yr	$\Delta_p$ kg/cm <sup>2</sup>	$m_v$ cm <sup>2</sup> /kg	$E_c$ kg/cm <sup>2</sup>
0.00	5432	0	0.000	0.000	19.33	1.619	-	-	-	-	-
0.05	5418	14	0.028	0.001	19.30	1.616	-	-	0.05	0.029	34.5
0.25	5320	112	0.224	0.012	19.10	1.589	-	-	0.20	0.051	19.7
0.50	5162	270	0.540	0.028	18.79	1.546	-	-	0.25	0.065	15.3
1.00	4763	669	1.338	0.069	17.99	1.438	44.9	0.84	0.50	0.083	12.1
2.00	4077	1365	2.710	0.140	16.62	1.252	83.5	0.40	1.00	0.071	14.1
4.00	3291	2141	4.282	0.222	15.04	1.039	107.3	0.26	2.00	0.041	24.6
1.00	3502	1930	3.860	0.200	15.47	1.096	-	-	-	-	-
4.00	3231	2201	4.402	0.228	14.92	1.023	36.5	0.70	3.00	0.009	107.0
8.00	2539	2893	5.786	0.299	13.54	0.835	122.5	0.18	4.00	0.018	55.9
2.00	2863	2569	5.138	0.266	14.19	0.923	-	-	-	-	-
0.50	3168	2264	4.528	0.234	14.80	1.006	-	-	-	-	-
0.00	4084	1348	2.696	0.140	16.63	1.254	-	-	-	-	-

ONE DIMENSIONAL CONSOLIDATION TEST RESULTS			
Compression Ratio CR =	0.2805	PROJECT	Perambakkam, H Block
Re-compression ratio RR =	0.0414	BH NO	BH/2
Effective overburden pressure	0.26 kg/cm <sup>2</sup>	DEPTH	1.50m
Pre-consolidation Pressure $p_0$	0.85 kg/cm <sup>2</sup>	SOIL	Greyish silty clay
from Casagrande method	0.88 kg/cm <sup>2</sup>	<b>strain - log p curve</b>	



# ANNEXURE CS-1

## Unconfined Compressive Strength Test on Rock Core Sample

**Project:**  
TNSCB, HIG, Perambakkam

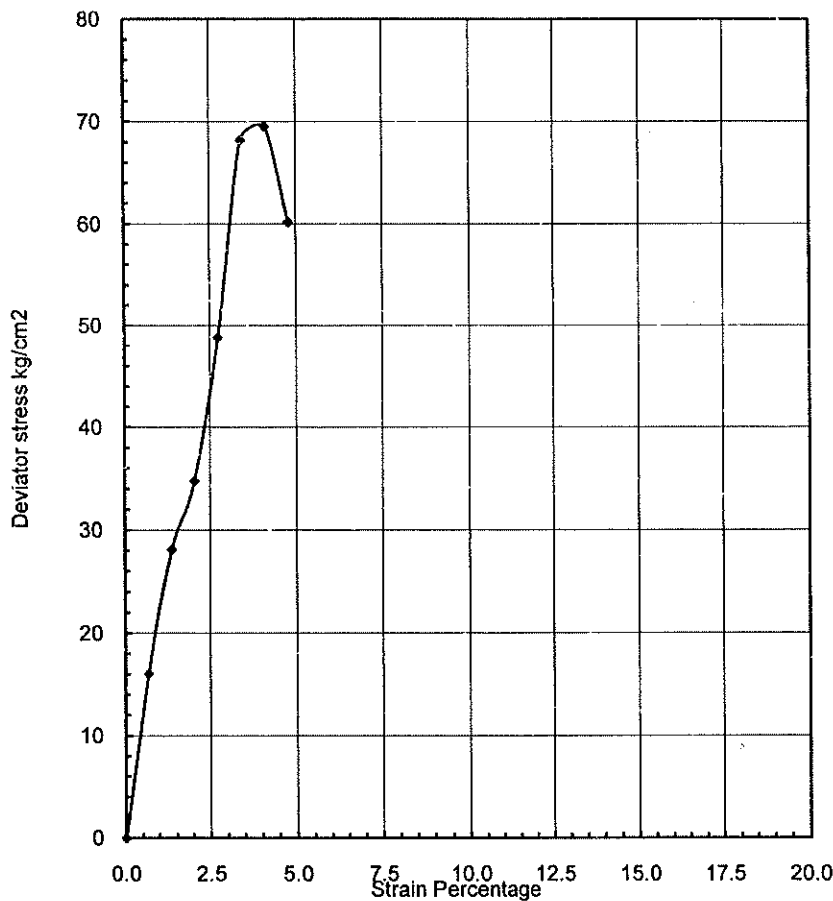
Date of Test           **22-Apr-13**  
Borehole               **BH/3**  
Depth                   **7.00m to 8.00m (S1)**

Description  
**Greyish jointed rock**

Insitu bulk density           **2.807 gm/cc**  
Insitu Dry Density           **2.689 gm/cc**  
Water Content               **4.39 %**

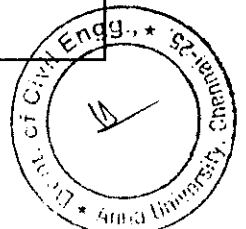
### Maximum Shear Stress

Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>	
Specimen 1	0.0	70.0	Failed at vertical joint



### Results

Unconfined compression strength  $q_u$            **70.0 kg/cm<sup>2</sup>**  
Young's Modulus (secant)                   **1692 kg/cm<sup>2</sup>**



# ANNEXURE CS-2

## Unconfined Compressive Strength Test on Rock Core Sample

**Project:**  
**TNSCB, HIG, Perambakkam**

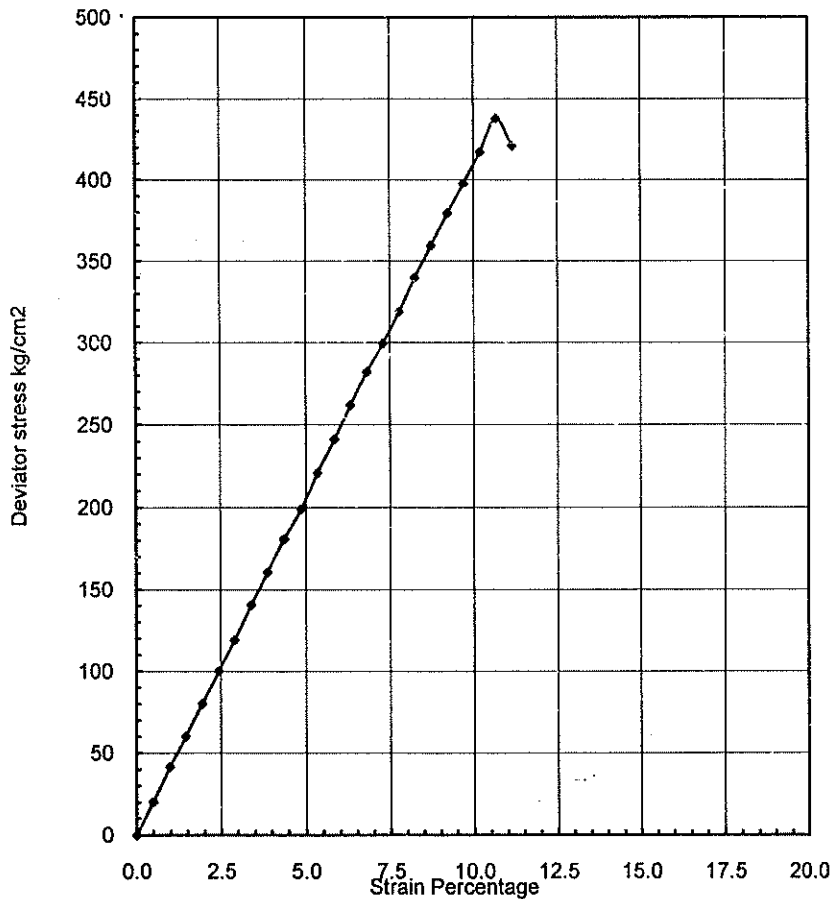
Date of Test           **22-Apr-13**  
 Borehole               **BH/5**  
 Depth                   **7.00m to 8.00m (S2)**

Description  
**Greyish granitic hard rock with joints**

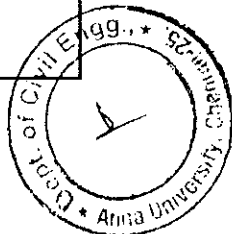
Insitu bulk density           **2.852 gm/cc**  
 Insitu Dry Density           **2.781 gm/cc**  
 Water Content               **2.53 %**

**Maximum Shear Stress**

Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.0	438.0



<b>Results</b>	
Unconfined compression strength $q_u$	438.0 kg/cm <sup>2</sup>
Young's Modulus (secant)	4132 kg/cm <sup>2</sup>



# ANNEXURE CS-3

## Unconfined Compressive Strength Test on Rock Core Sample

**Project:**  
TNSCB, HIG, Perambakkam

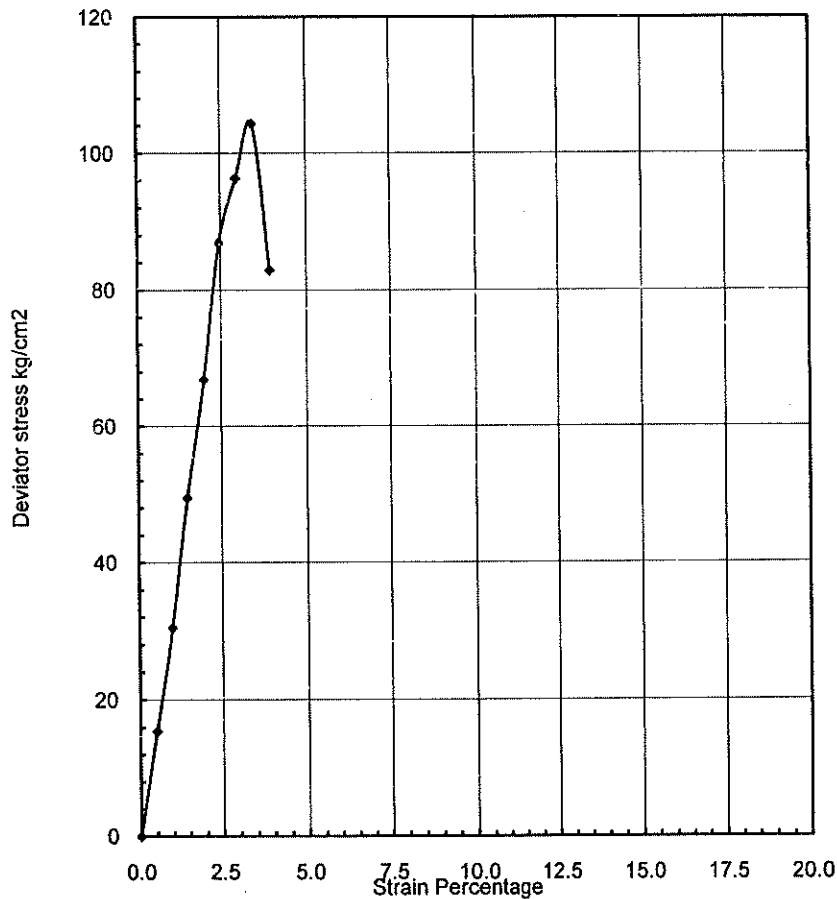
Date of Test            22-Apr-13  
Borehole                BH/6  
Depth                    7.20m to 8.20m (S1)

Description  
Greyish jointed rock

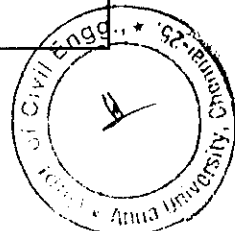
Insitu bulk density            2.840 gm/cc  
Insitu Dry Density            2.764 gm/cc  
Water Content                2.73 %

### Maximum Shear Stress

Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>	
Specimen 1	0.0	104.0	Failed at vertical joint



Results	
Unconfined compression strength $q_u$	104.0 kg/cm <sup>2</sup>
Young's Modulus (secant)	3364 kg/cm <sup>2</sup>



# ANNEXURE CS-4

## Unconfined Compressive Strength Test on Rock Core Sample

**Project:**  
TNSCB, HIG, Perambakkam

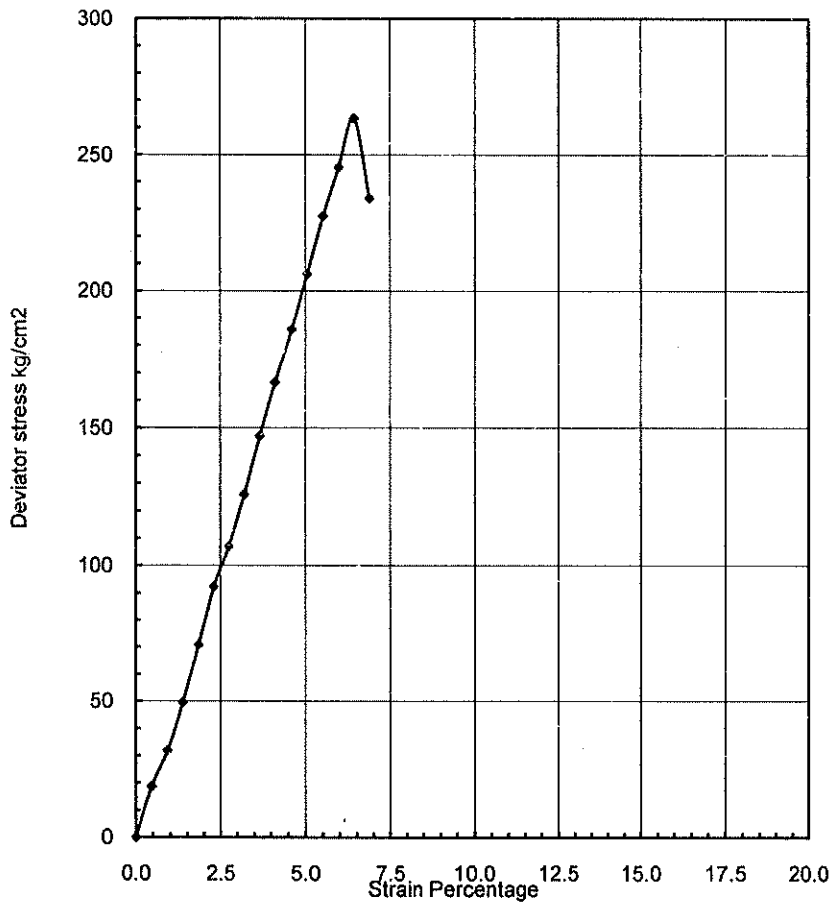
Date of Test            22-Apr-13  
Borehole                BH/8  
Depth                    7.00m to 8.00m (S1)

Description  
Greyish jointed rock

Insitu bulk density            2.932 gm/cc  
Insitu Dry Density            2.844 gm/cc  
Water Content                3.07 %

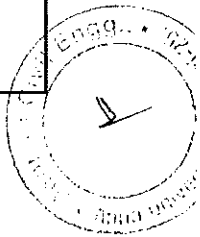
### Maximum Shear Stress

Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.0	263.0



### Results

Unconfined compression strength  $q_u$             263.0 kg/cm<sup>2</sup>  
Young's Modulus (secant)                    3595 kg/cm<sup>2</sup>



# ANNEXURE CS-5

## Unconfined Compressive Strength Test on Rock Core Sample

**Project:**  
TNSCB, MIG, Perambakkam

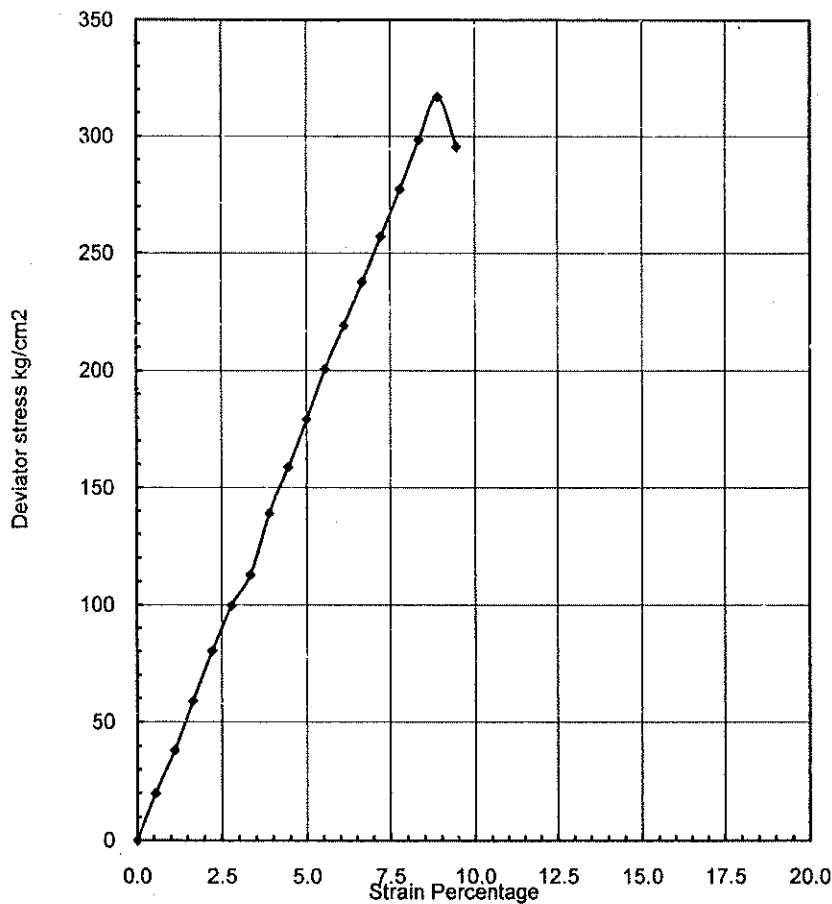
Date of Test           **22-Apr-13**  
Borehole               **BH/11**  
Depth                   **5.40m to 6.40m (S1)**

Description  
**Greyish jointed hard rock**

Insitu bulk density           **2.866 gm/cc**  
Insitu Dry Density           **2.810 gm/cc**  
Water Content               **1.97 %**

### Maximum Shear Stress

Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.0	317.0



### Results

Unconfined compression strength  $q_u$            **317.0 kg/cm<sup>2</sup>**  
Young's Modulus (secant)                   **3530 kg/cm<sup>2</sup>**

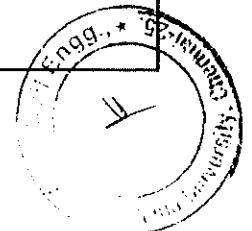
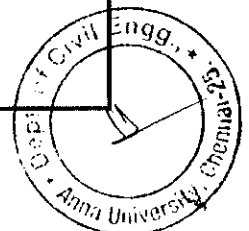
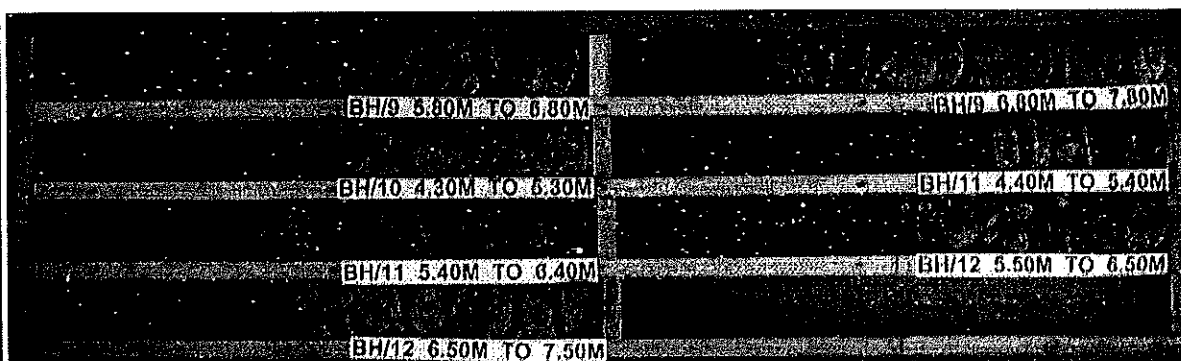
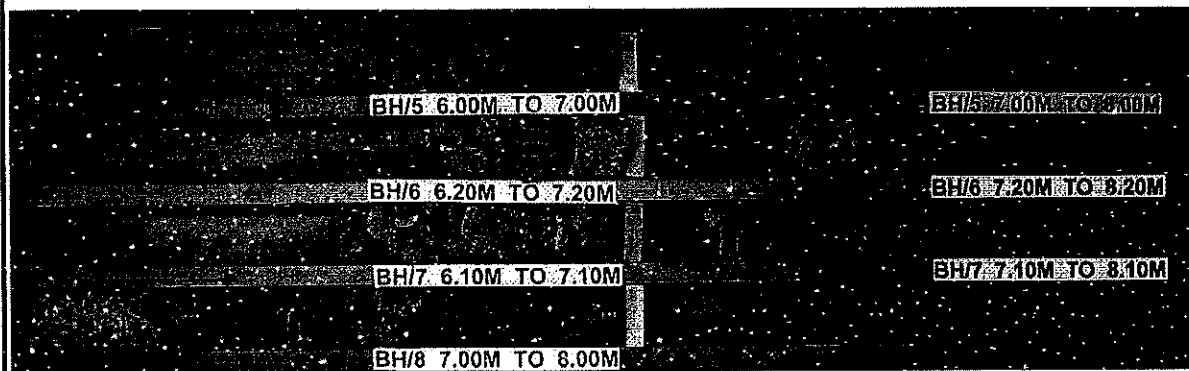
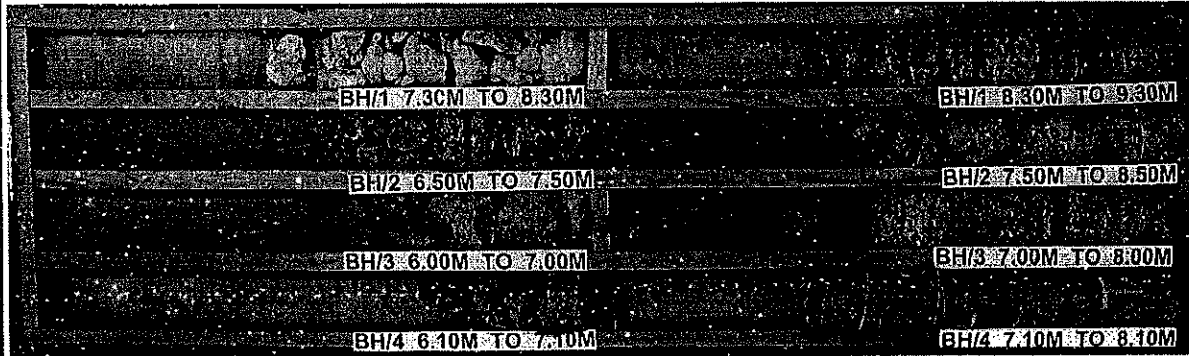


PLATE 1 CORE SAMPLES FROM BH1 to BH12

CORE SAMPLES FROM BH/1 to BH/12  
HIG TENEMENTS, TNSCB, PERAMBAKKAM



**REPORT ON SOIL INVESTIGATION AND RECOMMENDATION ON FOUNDATION FOR  
THE CONSTRUCTION OF STILT+8 STOREYED MIG FLATS AT ZONE 'M2' OF  
PERUMBAKKAM PROJECT**

**Job No: SF/KI-48/ Perumbakkam/Zone 'M2'/TNSCB/2013**

**Client: The Executive Engineer,  
ETRP (C-II) Division, TNSCB  
Semmenchery, Chennai-600 119.**

<b>S.No</b>	<b>Titles</b>	<b>Page.No</b>
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2.	Details of the project	4
3.	Preliminary Inspection of the project area	5
4.	Site condition	7
5.	Details of soil investigation	7
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**Dr. K. ILAMPARUTHI**  
Project Coordinator  
&  
Professor and Chairman (Civil)

**REPORT ON SOIL INVESTIGATION AND RECOMMENDATION ON FOUNDATION FOR  
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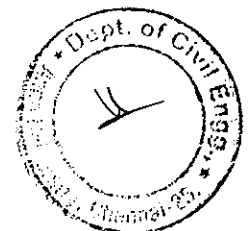
**Client: The Executive Engineer,  
ETRP (C-II) Division, TNSCB  
Semmenchery, Chennai-600 119.**

**1. Introduction**

The Executive Engineer, ETRP (C II) Division of TNSCB has sent a request to conduct soil investigation in their housing project site at Perumbakkam TNSCB scheme area through Lr.No:203/E.C/ETRP CII/2012, dt: 03.01.2013 for the construction of MIG and FIG Flats. The Board proposed to construct residential flats in their housing scheme area as detailed below:

Sl.No	Detail	Number of blocks	Area of each unit (m <sup>2</sup> )	Number of units
1.	MIG Flats (Stilt + 8 Floors)	12 (64 units in block each)	73.9	768
2.	FIG Flats (Stilt + 8 Floors)	4 (64 units in each block)	97.3	256

To construct these residential blocks an area of 7.13 Hectares is allotted covering survey Nos: 539/2, 540/1, 540/2 and part of 537. The area earmarked for the said purpose is shown in key map (Fig.1a) of the TNSCB Perumbakkam scheme. The proposal of the Board comprises of building nine storeyed (Stilt + 8 floors) framed structures. The Perumbakkam village is located at a distance of about a kilometer

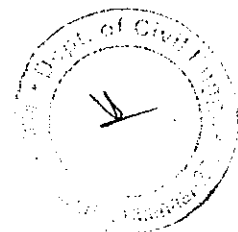


towards western direction from OMR. A road of 18m wide is connecting this village with OMR. On the Southern side of this road and adjacent to existing TNSCB scheme at Semmencherry, the Executive Engineer (Div VI) of TNSCB executed similar project over an area of 30 Acres covering S.Nos: 542 to 544 during 2009. At this area eight storied framed structures were constructed and they are ready for occupation. These buildings are supported on raft foundation and the depth of foundation of all the buildings is around 4m. The Fig A1 shows the land allotted for the proposed construction including the area where project is completed.

On allocation of land by the Government The Executive Engineer (Div.II), TNSCB took initiative to implement the project and requested the services of Department of Civil Engineering to conduct Soil Investigation for the construction of Block 12 to 18 (S.No: 528) and constructions of Blocks covering area coming under S.Nos:479/2 and 482 to 485. These two locations are marked as Zone 'A' and Zone 'B' in layout plan (Fig A1) and they lie in the south and north west part of the land allotted for the project.

At Zone 'A' investigation was conducted at 5 locations during April 2010. The top layer is expansive clay of 1.5m thick followed by clayey sand of 1m. Weathered rock was met at the depth of 2.75m invariably and fairly good rock was seen at depth around 4m. The water table was met at the depth of 2.5m. Based on the soil condition of the area, it was recommended to adopt raft foundation at the minimum depth of foundation of 3m (RL -1.45m).

At Zone 'B' investigation was carried out during the second week of June 2010 by drilling eight boreholes. The deposit of this area composed of highly plastic clay of 2m to 2.7m thick followed by residual soil (weathered rock reduced to soil) of 1m to 1.5m thick. However the deposit below 4.5m was fractured rock. At this area the water table was at the depth of 3m. The foundation recommended for the eight storeyed structures was raft foundation and minimum depth of foundation was 2.75m (i.e. RL -1.35m) from the lowest ground level. Recommended bearing capacity was 200kN/m<sup>2</sup>. The board commenced the construction work at Zone 'A' and 'B' in the second week of May 2012.



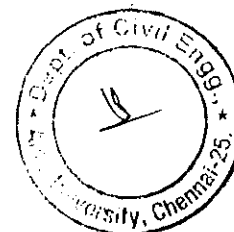
In the remaining part of allotted land of Perumbakkam village, the Executive Engineer, JNNURM Division sent a request through Lr.No:171/JNNURM Dn/A1/2011, dt:28.3.2012 to inspect and conduct subsurface investigation covering survey nos: 509,510,511,516,517,518,536,537 & 538 for the construction of eight storeyed residential block in these location. Accordingly investigation was conducted at 40 locations covering 125 acres of land. Since the area was large, it was divided conveniently in to Zone 'C', Zone 'D', Zone 'E' and Zone 'F' as indicated in Fig A1.

The sub-surface investigation in all these areas was commenced on 25<sup>th</sup> April 2012 and completed on 19<sup>th</sup> May 2012. The report was released for each zone independently. The recommended foundation was raft for the eight storeyed buildings irrespective of the Zones in which buildings are proposed to locate. The recommended depth of foundation at different Zones is as below:

Zone	RL of Foundation (m)	Bearing capacity
C	between - 1.0m and -1.2m	220kN/m <sup>2</sup>
D	between - -1.9m and -2.6m	220kN/m <sup>2</sup>
E	between - -1.1m and -1.6m	220kN/m <sup>2</sup>
F	between - 0.9m and -1.2m	220kN/m <sup>2</sup>

Foundations of buildings were located at depths as recommended without difficulty except one or two blocks. As stated in the first paragraph of the report the board has drawn a proposal to construct MIG and HIG Flats in this area for the public, since the area lies within a distance of 2km from OMR and demand for house is more in this area.

The board has earmarked the area for this proposal, which lies in the south east part of the Perumbakkam scheme, which is about 7.13 Hectares. The project site was inspected along with the Executive Engineer of ETRP Division and other officials on 28.02.2013. Since the project area is large (total extent is 7.13 Hectares) the buildings are nine storeyed framed structure and this area comes under zone III as per IS1893-2002(Part-1), it is decided to investigate over entire area covering all the 16 blocks. At the end of investigation it is proposed to explore at two locations for each MIG block and at three locations for each HIG block. This proposal is been accepted by the Executive Engineer.



Accordingly locations of boreholes for each block were selected and mutually agreed to investigate at 36 locations as detailed below:

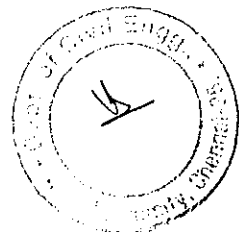
Zone	Number of Blocks	Boreholes
M1	M1 to M6	BH1 to BH12
M2	M7 to M12	BH13 to BH24
H	H1 to H4	BH1 to BH12

Since large part of Perumbakkam Housing Project area was covered in earlier investigation and over all soil condition of this area is known to consultant. In this area, the hard stratum with good bearing resistance occurs within a depth of 4.5m; therefore it is felt sufficient to investigate to a depth of 9m. However one or two boreholes were drilled beyond the depth of 9m to know relative degree of weathering of rock deposit and its quality. The soil investigation work in all the three zones is commenced on 04.03.2013 simultaneously and completed on 9.4.2014.

## 2. Details of the project

The project to be executed in this area is construction of multi-storeyed blocks for the middle and high income group people under Rajiv Awas Yojana scheme. In this project the Board is proposed to construct 9 storeyed (Stilt + 8 Floors) framed structure by adopting two different type design; one is for MIG and the other is for HIG. Apart from construction of residential buildings they develop other amenities like club house, Gym, Park etc. However the soil investigation carried out is found mainly for the construction of multi-storeyed buildings. Each block of MIG is designed to accommodate eight families in each floor with plinth area of 73.9m<sup>2</sup>/ family. Similarly the HIG flats are also designed to accommodate eight families in a block with plinth area of 97.3m<sup>2</sup>/unit.

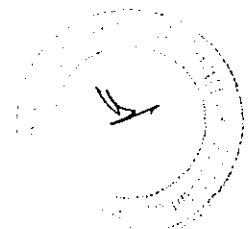
The structure is nine storeyed building and the area of construction is located within 20km distance from Chennai. The Chennai and its neighboring areas is coming under Zone III, hence the structure of this area is to be designed for Zone III conditions. Moreover in the recent past Chennai has experienced mild tremors and the earthquakes occurred in Sumatra islands and Pondicherry coast also felt in some parts of Chennai.



Therefore the board has analyzed the building for the Zone III condition. The minimum and maximum load at the foundation level for the critical load combination was reported as 869kN and 1890kN respectively. Since the soil is in the heterogeneous condition and in hard layer (i.e. weathered rock) clay lumps are seen during investigation, which is not conducive for isolated footing. Therefore the average load at the foundation level for the raft was obtained for the critical combination of load, which is 219kN/m<sup>2</sup>.

### **3. Preliminary Inspection of the project area**

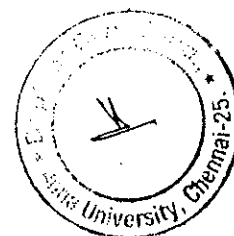
Perumbakkam area has experienced fast development within a period of four years. The land of Perumbakkam area covering survey numbers as per the key plan (Fig. 1a) was occupied by the local people of the area. This entire area was covered with thatched roof houses, semi permanent and permanent buildings. The local town Panchayat laid temporary roads and provided water and power connections to the houses. Certain houses were provided with soak pits and were connected to toilets. These soak pits are 3.5 to 4m deep from the existing ground level. The area identified for the development of project is covered by 18m road on the south, compound wall of Bollini Hill Housing complex on the west, open private land on north and proposed PWD Drain of 40m wide on the east. This area is at a distance of approximately 2km from the OMR. The ground level of this area though it appears uniform, it is slopping from west to north east direction. The construction of multi-storeyed buildings in this project area was commenced during 2010 in Zone A and covered most part of the area part by part. The part of land, on the south east side of the area covering S.Nos: 537, 539/2, 540/1, 504/2, 541 is vacant and is been identified for the construction of multi-storeyed flats. This area lies within the boundary of 18m wide Semencherry-Perumbakkam road on the south; 30m wide road and PWD drain are on the east, Zone D on north and community facilities of Zone A on the west. The total area is 71330m<sup>2</sup>. The ground level of this area is almost uniform and is also free from shrubs and old structures; hence the site is ready for soil investigation. There is a mountain at a distance of about a kilometer or more on the western side and the ground is slopping from the foot of the hill towards east. At the



proposed construction site the ground level is the lowest while comparing with the ground level of neighboring areas. This area is prone for water logging hence the board is proposed to raise the existing ground level.

As stated in the introduction, the area of Perumbakkam (Zone A to Zone F) was already investigated at different pint of time for the purpose of locating suitable depth for foundation of eight storeyed structures and reported occurrence of hard stratum invariably at the depth below 4.5m and the weathered residual soil at depth of around 2.75m. The weathered residual soil was in hard/dense condition with N values more than 50 blows. However on the east and north east part of the area (Zone D) the deposit over a depth of 3m is soft. Keeping this in mind, it is proposed to investigate up to the depth of occurrence of hard stratum ( $N > 100$ ) at all the 36 boreholes. In a few boreholes rock drilling using single tube core barrel with diamond cutter is also recommended in order to confirm the presence of true hard stratum to a reasonable depth. The officials of TNSCB have agreed for this suggestion and proceeded accordingly.

Since the soil condition at major part of Perumbakkam project area is known from the earlier subsurface investigation carried out for the blocks at Zone 'A' to zone 'F' it is agreed mutually by the consultant and the officials of TNSCB to restrict the number of investigation points as minimum as possible. Since buildings are located as clusters accommodating other amenities for each cluster, it is decided to group at each cluster as individual zone. Thus there are three zones (M1,M2&H) and is mutually agreed to investigate at 12 points in each zone by distributing minimum of two exploratory points for each block. The subsurface investigation at the proposed construction area was commenced during the fourth week of February 2013. At all the borehole locations, the borehole was advanced using rotary drilling technique and standard penetration tests were conducted in each borehole at spacing of 0.75m using standard split spoon without liner as per IS2731-1972. The subsurface investigation work in this area was executed by M/s. Geotechnical solutions, Chennai under my (Prof.K.Ilamparuthi, Professor and Chairman, Faculty of Civil Engineering) supervision. This report presents salient details of



investigation and soil type encountered along with recommendation on foundation for the Zone M2.

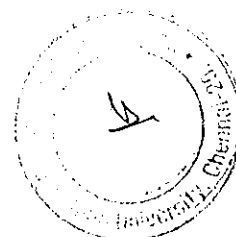
#### 4. Site condition

The topography of Zone 'M2' is almost uniform and if at all any difference in the levels within the area of investigation may not be more than 0.5m. The deposit on the surface exhibited honey comb pattern tension cracks, which confirm that the top soil is dominantly clay with shrink and swelling quality. Further there is a mountain at a distance about a kilometer or more from the western boundary of proposed construction area. It provides the clue that the rocky stratum will be at a shallow depth in the construction area and the soil cover that lies above is certainly residual deposit. However there is a chance for transported soil deposit on the surface since the ground is slopping from mountain on the west to canal on the east and the ground level is lower in this zone.

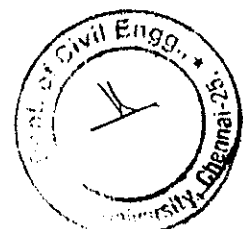
#### 5. Details of soil investigation

At Zone 'M2' soil investigation was carried out at 12 locations as shown in Fig.1b. It can also be seen that the locations of various blocks. The details of borehole locations and the ground level at each location are presented below:

Bore hole No	Identification	Location	Ground level (RL)	Water Table (RL)
1	BH13	Block M7	+1.688m	+0.288m
2	BH14	Block M7	+1.415m	+0.051m
3	BH15	Block M8	+1.339m	+0.039m
4	BH16	Block M8	+1.240m	+0.140m
5	BH17	Block M9	+1.492m	+0.092m
6	BH18	Block M9	+1.409m	+0.009m
7	BH19	Block M10	+1.409m	+0.109m
8	BH20	Block M10	+1.250m	+0.150m
9	BH21	Block M11	+1.354m	+0.154m
10	BH22	Block M11	+1.267m	+0.267m
11	BH23	Block M12	+1.200m	+0.200m
12	BH24	Block M12	+1.295m	+0.295m



The boreholes were made to collect information on nature of overburden and depth of occurrence of hard stratum. They were drilled using rotary method with bentonite mud circulation. This method is normally adopted to advance the boreholes both in residual and sedimentary deposit. The circulation of drilling fluid was employed through drill rods and letting out through the jets provided in the cutting tool. The jetting action with pressure flow brings the cut material to the surface through the annular space between the sides of boreholes and drill rod. Boreholes of diameter 150mm were drilled by adopting this method. During drilling it was ensured that the borehole was kept full with drilling fluid to avoid disturbance to the sides as well as bottom heave. In the boreholes, standard penetration tests were conducted at required depth or wherever there was a change in the soil layer. This test was conducted using standard dimension split spoon without liner as per the procedure given in IS 2731-1972 using donut type hammer dropped mechanically (2 turns of rope in the cathead arrangement). The energy of impact was around 70%. Thus the field value was  $N_{70}$ . However the field N values were corrected for the installation procedure and the value was very close to  $N_{60}$ . Therefore recorded values were taken as  $N_{60}$ . The values thus recorded were not corrected for overburden since the top soil to the depth of 2.5m was having fines more than 50%. Further the correction for saturation was also not applied for the resistance values recorded below water table since the deposit was not fine sand. Further the overburden correction factor is greater than unity for the N values recorded at shallow depths; hence the said conditions will certainly result in conservative resistance of deposit. The soil samples obtained from the split spoon were visually identified and tested in the laboratory for assessing index properties. Soil samples collected in split spoon samplers are subjected to test for index properties. The boring and sampling operations were continued at each location until refusal N value (rebound) was recorded or two consecutive N values were greater than 50 blows and the third N value was more than 100 blows. However at locations wherever rock was encountered, exploration was continued using single tube core barrel with diamond cutter. In the rock stratum drilling was done to a depth not less than 1m and obtained core samples. In all the boreholes level of water table was recorded. The depth of





ground water table recorded at various locations is included in the table presented in this section.

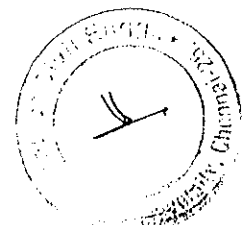
## 6. Soil profile of the proposed site

The investigation at this area was commenced after marking borehole locations and their reduced levels. The reduced levels of borehole locations are almost uniform at most of the locations except at BH13 and BH23. The difference in level is 0.5m between BH13 and BH23 and the RL at BH13 is +1.688m. As stated in the previous section, the soil profile is logged at each location based on soil samples obtained using split spoon sampler. The profiles thus logged at 12 locations are presented in Figs 2 to 13 along with N values recorded. The field N values recorded are taken as  $(N_1)_{60}$  (i.e. design N values) for the reasons already stated irrespective of the depth and nature of deposit of this area.

The disturbed samples of each borehole are tested for index properties inclusive of swell quality. The index properties such as Gradation, Atterberg limits, and Free Swell Index are presented in Table 1 to 12 for the boreholes BH13 to BH24. The gradation curves are presented in Annexure G. The undisturbed samples obtained from the clay layers are tested for strength. The strength is determined from the samples by conducting unconsolidated undrained test at their natural moisture contents and the respective stress-strain responses are present in Annexure-U along with Mohr-Coulomb envelope. The strength and secant modulus are also presented. The compressibility properties of clay deposits are determined from index properties using established empirical equations. The soil deposits logged at each block are presented and discussed below.

### Block M7

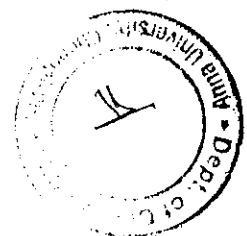
The block M7 is located on the northwest corner of the Zone M2. At the block M7 two exploratory boreholes (BH13&BH14) were made by locating them diagonally opposite to each other in the northwest and southeast corners of the block. At these two boreholes exploration was done to a depth of 8.3m and 8.7m respectively and the borehole were terminated in severely jointed rock.



The difference in ground level at both the borehole locations is about 0.2m, which shows that the terrain is almost uniform at Block M7. The soil profile logged at BH13 and BH14 is presented in Fig 2 and 3 respectively along with N values recorded.

At BH13 the top layer to a depth of 1.9m is silty clay. This layer recorded a minimum N value of 10 blows at the depth of 0.75m and a maximum value of 25 blows at the depth of 1.5m. This clay layer is in medium stiff to stiff condition and its stiffness is increased with depth. Results of Atterberg limit tests and free swell index show that this layer is high plastic clay (CH) and it possess volume change quality. Its liquid limit and plasticity index are more than 67% and 43% respectively. The deposit between the depth of 1.9m and 5.5m is a residual deposit. In this residual deposit, clay content is about 20% and is classified as SC/SM. This intermediate layer is in dense condition and becomes very dense layer by recording N value  $> 100$  blows. The rock is encountered at the depth of 5.5m, which is highly weathered and further exploration to depth of 8.3m confirms that the rock deposit is becoming strong. However the deposit at the depth of termination is severely jointed with core recovery ratio of 13%, which can be seen from the plate 1 wherein core sample obtain between the depth 7.3m and 8.3, is shown. Thus the deposit at BH13 within the depth of investigation of 8.3m is three layer system comprises of top layer of high plastic clay (CH), intermediate residual deposit of clayey sand (SC/SM) followed by weathered rock.

The BH14 which is been made at the southeast corner of block M7 has also recorded identical soil condition (three layer system) as that of BH13. The top soil to a depth of 2.2m is silty clay. This layer is in medium stiff condition at the depth of 0.75m and is becoming stiff at depth 1.5m. This layer contains plastic clay which is known from the plastic index values of the clay ( $I_p > 61\%$ ). Its free swell index values are also more than 67% (Table 2). Thus the soil is clay of high plastic (CH) and is susceptible for volume change. The layer that follows the clay is clayey sand/silty sand with fines in the range of 15% to 30%. The N values recorded in this layer are between 25 and 100 blows, indicating that the layer is dense to vary dense condition. The deposit that lies below the depth of 5.0m is weathered rock; its degree of weathering appears to be the same, which



is known from the recovery ratio of core samples. The recovery ratio of rock core between the depth of 5.0m and 8.7m is between 8% and 15% with nil RQD.

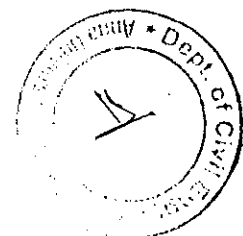
### **Block M8**

The Block M8 is located on the southern side of Block M7. In the location of Block M8 two boreholes (BH15&BH16) were made as shown in Fig.1b. BH15 was made on the northwest corner whereas BH16 was made at the southeast corner of the block. At BH15 exploration was terminated at the depth of 7.6m whereas BH16 was terminated at the depth of 10.2m from the respective ground levels. The ground levels at BH15 and BH16 are +1.339m and +1.24m respectively. The soil profile logged and N values recorded at these two borehole locations are presented in Figs 4&5.

At these two borehole locations top soil to a depth of 2m is silty clay with N values in the range between 8 and 21 blows. The silty clay layer is medium stiff at the depth 0.75m and becomes stiff at 1.5m. Its index test results are presented in Table 3 and 4. It has high liquid limit (between 62% and 88%) and plasticity index values between 43% and 65%, which indicates that the fines of this layer is plastic and the soil is classified as clay of high plastic (CH). The layer that lies below the silty clay layer is clayey sand/silty sand with fines less than 22%. Thickness of this layer is about 1.5m and 2.6m at BH15 and BH16 respectively and is in dense ( $N > 41$ ) to very dense condition ( $N > 100$ ). The weathered rock that lies below residual sand layer is highly weathered and fractured. However the presence of strong layer is confirmed by drilling to a depth of 7.6m at BH15 and 10.2m at BH16. At which depths the deposits are jointed fractured rock. However at BH16 the fractured rock between 8.1m and 9.2m is highly weathered and reduced to fractions of sand and stones. Despite high degree of weathering the deposit is strong ( $N > 100$ ).

### **Block M9**

At Block M9 also exploration was conducted at two locations by locating the boreholes diagonally opposite to each other. The soil profile logged at BH17 and BH18 are presented in Fig 6&7 respectively. The test results conducted on samples of split spoon are presented in Table 5 and 6.

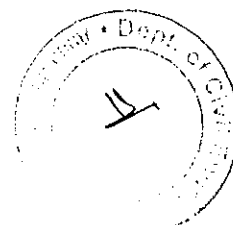


Top layer is silty clay and its thickness is approximately 2.3m at BH17. In this clay layer liquid limit value is more than 58% and FSI values are also more than 55%. These values confirm that the clay layer is active and is susceptible for volume change due to seasonal moisture variation. The N values recorded show that the clay layer is in very soft condition (N= 0). However at BH18 the top clay layer is soft to medium stiff with maximum N value of 8 blows.

The deposit between the depth 2m and 4.5m is residual clayey sand layer with fines between 12% and 25% at BH18. This layer is in medium dense (N=24) to very dense condition. The maximum N value recorded in this layer is 187 blows (extrapolated value) at 3.75m at BH18, which indicates that the stratum is becoming strong. At these two borehole locations weathered rock layer is met at depth approximately 4.5m and presence of rock deposit is confirmed by drilling to an additional depth of 3m. The borehole was terminated at the depth of 9.0m and 8.5m at BH17 and BH18 respectively, at which the rock is silt stone, which is weathered and jointed. The recovery ratio of core samples at the depth of 7.5m is 22%. The RQD of sample is zero. Plate 2 presents the core samples of BH17 and BH18.

### **Block M10**

The Block M10 is located on the south side of Block M9 and at the location of the Block M10 exploration was done by drilling at two points (BH19&BH20) within the area of the block. The borehole 19 (BH19) is drilled at the northeast part of the block whereas borehole 20 (BH20) is drilled at the southwest part. The soil profile logged at both the locations is presented in Figs 8 and 9 along with N values recorded. At BH19 the top soil to a depth of 2.4m is silty clay, which is in soft condition ( $N \leq 2$ ). The deposit that follows the clay is silty sand of 1.6m thick between the depth of 2.4 and 4.0m. This sand deposit is in dense condition with N values greater than 44 blows. Weathered rock changes to strong (hard) rock at the depth of 6.7m and the core sample obtained between the depth of 6.5m and 7.5m recorded the recovery ratio of 31% and RQD of 28%. These values confirm that the rock occurring at depth below 7m is hard and is classified as stilt stone. The core recovered at depth below 6.5m is shown in plate.2.



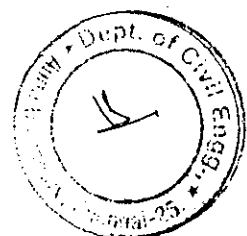
The laboratory test results of samples of clay layer and clayey sand layer are presented in Table 7. The liquid and plastic limits of clay are in the range between 42% and 65% and 13% and 20% respectively. The samples also recorded FSI values more than 70%. Thus clay fines are active and plastic and the soil is classified as clay of high and intermediate plastic (CH and CI). In the silty sand fines are in the range of 14% to 16% and sand fractions are more than 80%. Thus classified as poorly graded sand / silty sand (SP/SM).

The deposits encountered at BH20 are marginally different from BH19, though the overall condition of the deposits is almost identical. The top layer is clay of high plastic (Table 8) as seen at BH19, but its thickness is 2.2m. However the clay layer has almost identical character as that seen in the clay of BH19. The second layer is clayey sand/silty sand, its thickness is about 1.2m and is in medium dense condition at the depth of 2.4m and in dense condition ( $N > 100$ ) at the depth of 3m. The deposit that follows the sand layer is weathered fractured rock and recorded refusal N value at the depth of 3.75m. This stratum continues up to 6.8m, at which depth, the borehole was terminated. The rock deposit available at depth between 3.75m and 6.8m is strong and less weathered since recovery ratio and RQD values are 25% and 25% respectively.

### **Block M11**

Borehole 21 and 22 are made at Block M11 which is located almost at the centre of Zone M2. At BH21 exploration was made to a depth of 8.5m and was terminated in weathered and closely jointed rock. The deposit at this borehole location comprises of soft clay layer of 1.9m thick followed by stiff clayey sand layer of 0.4m thick. The N value recorded in the clay layer is between 2 and 7 blows. In the sand layer the resistance is high ( $N > 44$ ) and recorded refusal condition at the depth of 4.5. The weathered rock that follows the sand is highly weathered and it belongs to silt stone group wherein recovery ratio is between 17% and 19% in the layer between the depth of 5.5m and 8.5m. However the RQD of core samples is zero.

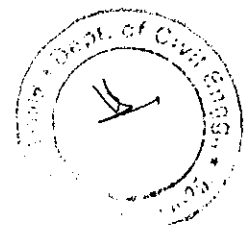
The soil profile logged at BH22 (Fig.11) is almost identical to that of BH21. Top layer is soft clay of 2.6m thick with N value less than 3. This layer is underlain by



organic sandy clay of 0.8m thick with N value zero. However deposit is becoming strong from the depth of 3.4m which is a fine to medium sand. Thickness of this layer is 2.2m and its coarse fraction increases with depth and also becoming very strong by recording N value >100. It is certainly a residual deposit containing weathered stone pieces. The refusal condition is encountered at 5.5m depth where the deposit is highly weathered rock. This layer continues up to 9.7m at which depth the borehole was terminated. The core samples extracted at various depths of this borehole recorded minimum core recovery of zero and maximum core recovery of 19%. The rock available between the depth 6.7m and 8.7m is weak whereas at depth between 8.7m and 9.7m is moderately strong. However the deposit below the depth of 5.5m can be considered as strong bearing layer. The laboratory test results of top clay layer of BH21 and BH22 are presented in Table 9 and 10 respectively. The liquid and plasticity index values are high and its plasticity indices are between 46% and 74%. Free swell index of the clay is between 66% and 175%. Thus the clay layer of BH21 and BH22 is high plastic clay with swelling clay minerals. It is classified as clay of high plastic (CH).

### **Block M12**

At Block M12, exploration was done at two locations as shown in Fig.1b. Borehole 23 (BH23) and borehole 24(BH24) are located diagonally opposite to each other. At BH23 the deposits are soft silty clay followed by silty clayey sand up to 5.5m from the existing ground level followed by weathered rock up to 8.3m, at which depth; the borehole was terminated (Fig 12). The clay layer is in soft condition with minimum and maximum N values of 0 and 3 blows. This layer is classified as clay of high plastic (CH) since liquid and plasticity index values are more than 50% and 43% respectively. The sand layer that follows the clay is classified as clayey sand in which fines are about 22% and sand fractions are more than 60% (Table 11). It is in very dense condition with N value much higher than 100 blows. However there is a decayed wood seam between the depth of 3.15m and 3.45m. Similar organic sandy clay layer is seen at BH22 at depth between 2.6m and 3.4m. The reason for such deposit at these two boreholes is not known, however this formation is problematic deposit and foundation needs to be located below

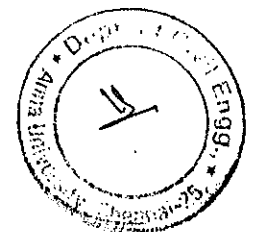


this deposit. The rock layer that lies below the sand is highly weathered till the depth of 6.3m. However the degree of weathering in rock layer is reduced with depth and core recovery of 8% to 12% is obtained in the rock between the depth of 6.3m and 8.3m.

The deposit encountered at BH24 up to the depth of 2.4m is soft clay as recorded at BH23. But the thickness of residual soil is about 0.4m only in this borehole and weathered rock occurs at depth of 2.75m, which is the highest level of occurrence of rock stratum among the twelve boreholes. The borehole 24 was terminated at the depth of 5.3m, where the deposit was severely jointed rock. The recovery ratios of core samples obtained in this deposit were between 19% and 24%. The clay layer possess same characteristics as that at the clay at BH23 (Table 11) and is classified as CH type clay. The rock layer that lies below the sand is highly weathered till the depth of 6.3m. However the degree of weathering is reduced with depth and core recovery of 19% to 24% is obtained in the rock between the depth of 3.3m and 5.3m.

The overall variation of deposits at locations of each block are combined and presented in Fig 14 to 19 for blocks M7 to M12 respectively. From the figures presented and properties given in tables it is clear that the deposit of the area within the depth of investigation comprises of three layer system. The top layer is clay of high plastic (CH) with liquid limit higher than 60% in general. The swelling quality of the clay is critical to high and is confirmed through the free swell index values more than 60% in most of the samples. Its thickness is found to vary between 1.9m and 2.8m and is in soft condition at most of the locations. The soil of this layer is not even suitable for filling work.

The deposit lies below the clay layer (CH layer) is clayey sand/silty sand. Its thickness is about 3m in general. This layer is in dense condition with recorded N values are close to 50 blows or more except at the transition zone between clay and sand layers. The limitation in this layer is presence of clay lumps, clay patches and organic deposits at certain locations (BH22 & BH23). These lumps are part of highly weathered soil derived from the parent material rock. But the reason for organic deposit is not known. As long as clayey sand layer is intact there may not be change in their property but due to release in pressure and direct contact with water it will become soft. Thus the condition is not

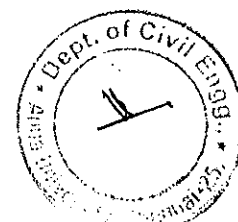


favorable for isolated footing. Moreover excavation of this layer in presence of water or below the water table will create a problem to locate the foundation in this layer provided the water table is reduced well below so that the soil is not losing its strength and provides good environment for construction. Irrespective of type of foundation, the foundation is to be located below the organic deposit.

The third layer is weathered rock. In this deposit degree of weathering is decreasing with depth and the thickness of strongly weathered portion is around one meter. However the rock stratum at depth below 5.5m is strong deposit however it is, fractured and severely jointed. This rock mass recorded maximum recovery ratio of 31% at BH19 and the RQD is 28%. In general recovery ratio of rock deposit is in the range of 4% to 19% and in most of the locations the RQD is nil. The rock cores obtained from the boreholes are shown in Plate 1 and Plate 2. Rock samples of certain boreholes are tested for strength under unconfined condition and test results are presented in Annexure CS1 & CS2. The unconfined strength of samples is presented below along with secant modulus of samples. The strength of rock of Zone M2 is less than the strength of rock deposit of Zone M1.

S.NO:	Identification	Depth, (m)	Unconfined Strength, (kN/m <sup>2</sup> )	Secant Modulus (kN/m <sup>2</sup> )
1	BH19	6.5-7.5	7000	314500
2	BH20	5.8-6.8	16400	324200

The properties of various soil layers both strength and compressibility are obtained from the N values using existing correlations and presented in Table 13. In case of clay Terzaghis' relation is used for obtaining undrained cohesion ( $C_u$ ) values. The values thus obtained are found to vary between 7.5kN/m<sup>2</sup> and 15kN/m<sup>2</sup> in soft clay and the values are in the range between 35kN/m<sup>2</sup> and 75kN/m<sup>2</sup> in medium stiff to stiff clay. The strength obtained from UCC test on UDS of BH24 (Annexure U1) is 6.4kN/m<sup>2</sup>, which is in comparison with the value of 7.5kN/m<sup>2</sup> obtained by empirical correlation. In silty sand/clayey sand angle of shearing resistance ( $\phi$ ) is obtained using Meyerhof recommendations. However the modification suggested by Housh for the percentage





finer present in the deposit is applied. The  $\phi$  values obtained are varying between 32° and 42°.

In sand compressibility parameter is obtained by the relation  $C=1.9 q_c/\sigma'_0$ , where  $q_c$ —cone resistance and  $\sigma'_0$ —effective overburden pressure. This procedure was developed by DeBeer and Martens (1957) and later on modified by Meyerhof to determine the elastic settlement in non plastic cohesionless deposit. IS 8009 (Part I), is also recommends this method to obtain immediate settlement. In the absence of cone resistance ( $q_c$ ), it is considered equal to 220N to 300N ( $kN/m^2$ ) since the deposit is SP/SM type. The strength and compressibility parameters thus obtained are summarized in Table 13.

In the absence of consolidation test results, the compressibility parameter,  $m_v$  ( $=1/E$ ) of clay deposit of Zone M2 is obtained from the chart of Stroud (1975) which accounts for the plasticity of clay fines and the value is based on  $N_{60}$  value and is equal to  $1/F N_{60}$  ( $m^2/kN$ ). The “F” is varying between 420 and 480 in medium to stiff clays. The shear strength of rock is obtained from the UCC test conducted on core samples of BH19 and BH20 and the values are  $7000kN/m^2$  and  $16400kN/m^2$  respectively. The  $C_u$  values are also obtained for highly weathered rock based on Cole and Stroud (1977) chart and the values thus obtained are presented in Table 13.

## 7. Ground water quality

The ground water table at all the boreholes is monitored and the levels are reported in section 5. Water samples are collected and tested for pH, sulphates and chlorides. Since the water is brackish, it is also decided to test the soil for above properties. The chemical test results are presented below:

### Chemical test results of water and soil samples

Location	Sample	Depth m	pH	Sulphate (SO <sub>4</sub> ) ppm	Chloride ppm	Remarks
Block M7	water	1.5 (BH13)	7.65	745	15575	Sulphates and chlorides are very high
Block M9		1.5 (BH18)	8.1	875	13450	
Block M7	soil	1.5(BH14)	8.1	350	750	Sulphates and chlorides are high



In water samples tested, pH is close to neutral, but chlorides and sulphates are very high and the amount of chlorides present in ground water indicates that the ground water of this area is just like sea water.

In soil, the contents of sulphates and chlorides are more in top clay layer. The results of tests on soil and water are to be reconfirmed. Sulphates and chlorides both in soil and water are more than the permissible limits as per IS 456 (Refer Table 4). Since ground water is very poor in quality suitable measure is to be taken to protect concrete and rebars from sulphate attack and corrosion of reinforcement. The clayey soil is not only plastic but also contains chlorides and sulphates in high quantity, hence not suitable for filling.

## 8. Summary

1. The top soil is highly plastic clay at all the borehole locations. Its thickness is found to vary between 1.9m and 2.8 m. It is susceptible for volume change due to seasonal variation in the moisture content. Free swell index value is as high as 100% at a few locations indicating clay is active. It is in medium stiff to stiff condition at Block M7 and M8 and rest of the locations the clay is in soft state. Native clay soil is not at all suitable for any construction work including back fill of basement and foundations.
2. The deposit below the depth of 2.5m from the existing ground level is residual deposit (highly weathered rock), which is a strong layer. The minimum N value recorded in this layer is 24 blows, which indicates that the deposit is in medium dense state. Further fines are less than 25% in sand at most of the location except at the transition zone between clay and sand and the balance content is dominantly sand and gravel fractions. This layer is strong enough to support any shallow foundation. However presence of clay lumps and clay patches need to be considered while deciding the foundation type. However at two locations sand is



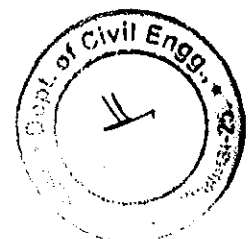
mixed with organic soil, but this layer is at shallow depth; hence foundation can be located below this layer.

3. The deposit below 5m is highly fractured rock which has recorded refusal N. value. The recovery ratio of rock samples found to vary between 0 and 19% at most of the depths of rock deposit, which indicates that the rock is jointed and fractured. However a value of 31% is also recorded at certain depth of rock deposit. RQD is generally zero and more than 25% is recorded in rock samples obtained at depth below 6m at two boreholes located on the south western side of Zone M2. The maximum RQD is 28%, which is recorded in BH19 at the depth between 6.5m and 7.5m.
4. The water table level is at shallow depth (1m to 1.4m) from the existing ground level. The lowest level of ground water table at M2 area is +0.009m (RL) during the time of investigation (March 2013). The sulphates and chlorides are present in both soil and water samples.

From the summary presented it is evident that the deposit of area is suitable for providing foundation at shallow depth. However the top soil to a depth of 2.5 to 3.0m is poor, hence foundation cannot be located in this layer. Therefore it is felt essential to locate the foundation at a minimum depth of 3.2 from the existing ground level. The depth suitable to locate the foundation is 3.2m or below from the existing ground level. The maximum variation in the reduced level of borehole locations is 0.5m (maximum + 1.688m and minimum +1.200m); hence minimum level of foundation shall be -2.0m (RL). However depth of foundation for each block of Zone M2 area is given in the Section 10.

## 9. Selection of foundation

The subsurface condition of deposit of area is very much suitable for shallow foundation except that the foundation needs to be taken below the top clay layer. In this case it is suggested to locate the foundation at a minimum depth of 3.2m from the



existing ground level. In order to decide the depth of foundation of the blocks, N value more than 50 blows and location of water table are compared as below:

Borehole No:	Block No:	RL of stratum at N>50, (m)	RL of min.Depth of foundation, (m)	WT RL, (m)	Remarks
BH13	M7	-1.462	-1.512	+0.288m	Water table is above the foundation level
BH14	M7	-1.735	-1.785	+0.015m	Water table is above the foundation level
BH15	M8	-1.061	-1.061	+0.039m	Water table is above the foundation level
BH16	M8	-1.910	-1.910	+0.140m	Water table is above the foundation level
BH17	M9	-1.658	-1.658	+0.092m	Water table is above the foundation level
BH18	M9	-1.741	-1.741	+0.009m	Water table is above the foundation level
BH19	M10	-2.491	-1.891	+0.109m	Water table is above the foundation level
BH20	M10	-1.900	-1.900	+0.150m	Water table is above the foundation level
B21	M11	-2.396	-1.946	+0.154m	Water table is above the foundation level
BH22	M11	-3.233	-2.733	+0.267m	Water table is above the foundation level
BH23	M12	-2.550	-2.550	+0.200m	Water table is above the foundation level
BH24	M12	-1.505	-1.505	+0.295m	Water table is above the foundation level

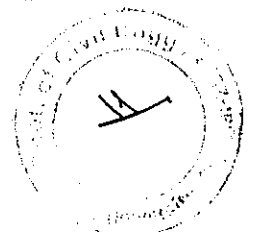
From the comparison made it is clear that foundations are to be located below the water table. The water table level reported is obtained from the borehole during investigation; there is a possibility for variation in the water table level. Therefore it is suggested to ascertain the water table level at each block at least at two corners before proceeding with the work of foundation. Normally the actual water level may be higher than recorded in the boreholes. It is suggested to locate the foundation a few centimeters above the water level in order to avoid excavation below the water table otherwise excavation below water table makes the soil to lose its strength. However at Zone M2



area the foundations are to be located below the water table, hence dewatering is essential.

The bearing capacity and settlement of foundation for the minimum depth of foundation given in the table are determined. The bearing capacity is determined for the raft foundation of size 23mx46m (approximate) using Teng (1961) equation and bearing capacity equation given in IS6403. The allowable bearing pressure is obtained for 25mm settlement using Teng equation and it varies between 358kN/m<sup>2</sup> and 403kN/m<sup>2</sup> for the N values between 41 and 46 respectively. The net safe bearing capacity value obtained from IS6403 for  $\phi=36^\circ$  is 1300kN/m<sup>2</sup> for FS=3. The soil at the foundation level of certain boreholes is stiff sandy clay with fines around 25%. Though thickness of sandy clay layer is less the bearing capacity value is determined by considering the lowest N value of 41 is 358kN/m<sup>2</sup> for a settlement of 25mm. Thus it is sure that the soils at the foundation levels are having good bearing strength and more over raft foundation of large size will provide higher bearing resistance and the settlement is real concern. The recommended bearing capacity is 250kN/m<sup>2</sup>. The bearing capacity is reduced from the minimum value of 358kN/m<sup>2</sup> obtained, in order to account for the undesirable condition like presence of clay pockets. The average load intensity expected at the foundation level for the combination of load may not exceed 220kN/m<sup>2</sup>, which is close to the bearing capacity recommended. The shallow foundation like isolated footing is not considered because of heterogeneous nature of soil (weak zones like clay patches and clay lumps). However as an academic exercise the capacity was worked for the isolated footing of 2.5mx2.5m for the  $\phi'=36^\circ$ . The net safe bearing capacity obtained is 190kN/m<sup>2</sup>, which is less than the expected average pressure of 220kN/m<sup>2</sup> of raft foundation. However the contact pressure expected will be more than 190kN/m<sup>2</sup> if isolated footing is proposed to adopt for each column. If the bearing capacity is limited to 190kN/m<sup>2</sup> then foundations of columns are to be combined. Thus only option to support the buildings of stilt+eight storeyed buildings in the Zone 'M2' of Perumbakkam project is raft foundation.

The settlement of raft foundation is also worked out for the soil conditions of individual borehole for the net pressure of 250kN/m<sup>2</sup>. The foundation is supported in



silty sand / clayey sand layer which is non-plastic with coarse fractions around 70% followed by weathered/fractured rock. Therefore elastic settlement of foundation is obtained using DeBeer and Martens (1957) equation. The elastic settlement obtained at various locations is less than 25mm for the contact pressure of 250kN/m<sup>2</sup>. Thus the raft foundation is the ideal choice for supporting the foundations of proposed stilt + eight storeyed blocks M7 to M12 at Zone 'M2'.

The one more issue is depth of foundation of each block can be different because of variation in depth of occurrence of bearing stratum within the Zone M2. Further providing uniform depth of foundation for all the six blocks (M7 to M12) will lead to more excavation at locations of certain blocks. The minimum depth of foundation (RL) at various blocks is varying between -1.75m and -2.75m. In this area the water table level at boreholes is found to vary between +0.51m and +0.009m, and is above the recommended level of foundation, hence interference of water table cannot be avoided while executing the earthwork excavation to reach proposed level of foundation. The foundation excavation in presence of water is to be avoided. Adopt suitable dewatering method to lower the level of water table at least to a level of 0.5m below the foundation level.

## 10. Recommendations

The subsurface exploration conducted at Zone 'M2' confirms presence of good bearing stratum at a depth of 3.2m at Block M7 and at a depth of 4m at block M11. Thus occurrence of good bearing stratum is at shallow depth on the western side of Zone M2 and slopping towards east direction. However the deposit at the depth below 5.5m is certainly weathered rock over entire area of Zone M2. The top layer is soft at most of the locations and at locations wherever clay is medium stiff to stiff possesses volume change characteristics. This layer will exhibit high swelling (DFS>100%). Thus it is recommended to locate the foundation at a minimum depth of 3.2m from the lowest ground level. For the structure of stilt + 8 storeyed building it is recommended to support the structure on a raft foundation. The recommended bearing capacity of soil for the raft foundation of 23m x 46m (approximate size) is 250kN/m<sup>2</sup>. Though the soil below the



depth of foundation possesses higher bearing strength, it is advised not to exceed the value of  $250\text{kN/m}^2$  because of non-homogenous nature of the deposit. Recommended level of foundation for the blocks M7 to M12 is as below:

Sl.No:	Block	Reduced level of Foundation,(m)
1	M7	-2.0
2	M8	-2.0
3	M9	-2.0
4	M10	-2.0
5	M11	-2.75
6	M12	-2.6

The level of foundation refers to base of a raft and the raft shall be laid on leveling course followed by sand cushion of adequate thickness each as per the practice in the board.

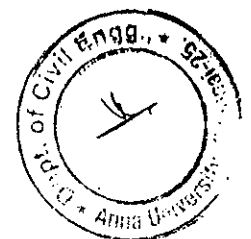
### 11. Precautions

1. The top soil to the depth of 3.0m is poor and highly swelling (expansive) hence does not suitable for any construction or filling work.
2. The maximum depth of occurrence of water table in zone M2 is  $+0.009\text{m}$  (RL) and the soil at this depth is clayey at most of the location hence excavation under this condition without dewatering will lead to collapse of cut and also reduction in strength of soil because of seepage through the bearing stratum.
3. Earth work excavation particularly below the water table to be allowed unless the water level is lowered to minimum depth of 0.5m from the recommended level of foundation. Adopt suitable scientific method for dewatering.
4. The depth of foundation recommended for each block is minimum depth of foundation. There may be chances for variation in foundation depth because of uncertainty in the characteristics of highly weathered residual deposit in the Zone M2 area. Improper dewatering and submergence of weathered soil may lead to significant reduction in strength, which may demand foundation at deeper depth than recommended to realize bearing capacity of  $250\text{kN/m}^2$ . Do not reduce the foundation



depth without obtaining proper approval from the consultant in case of good bearing stratum is met at higher level than the recommended level of foundation.

5. The water table in this area is at shallow depth. The seepage of water at the interface of weathered rock and soil cover will be critical hence conduct a pilot study to determine seepage parameters of deposits and to design suitable dewatering system. Technical support required for designing the dewatering system will be provided if required by the client. No case seepage is permitted directly through the foundation soil i.e. seepage of water shall be away from the excavation area (i.e. foundation area) and not towards the excavation area.
6. The quality of ground water is not suitable for any construction work especially for foundation construction. Since the environment of both ground water and soil is aggressive, this will lead to sulphate attack on concrete and corrosion of reinforcement. The concrete and steel need to be protected from the aggressive action. Thus provide minimum cover of 75mm in addition to any other protective measures considered suitable. Obtain opinion from structural engineer for protecting foundation elements and part of columns and beams buried below the ground. Further the cement quality and the content shall satisfy the requirement of Table 4 of IS 456-2000.
7. Since the ground water is not satisfying the requirement, use good water for all concrete related work. Minimum grade of concrete recommended for the foundation work is M25. Follow the conditions relevant to quality of water for concrete work as per IS 456-2000 including minimum cover thickness.
8. For filling works both inside the basement and outside around the building use good earth. The native soil particularly the high plastic clay is not at all suitable for any construction work including basement filling.
9. The basement filling will be more than 3.0m hence conventional flooring for the ground storey may lead to settlement problem on later days. It is suggested to provide RCC floor for ground floor base slab.





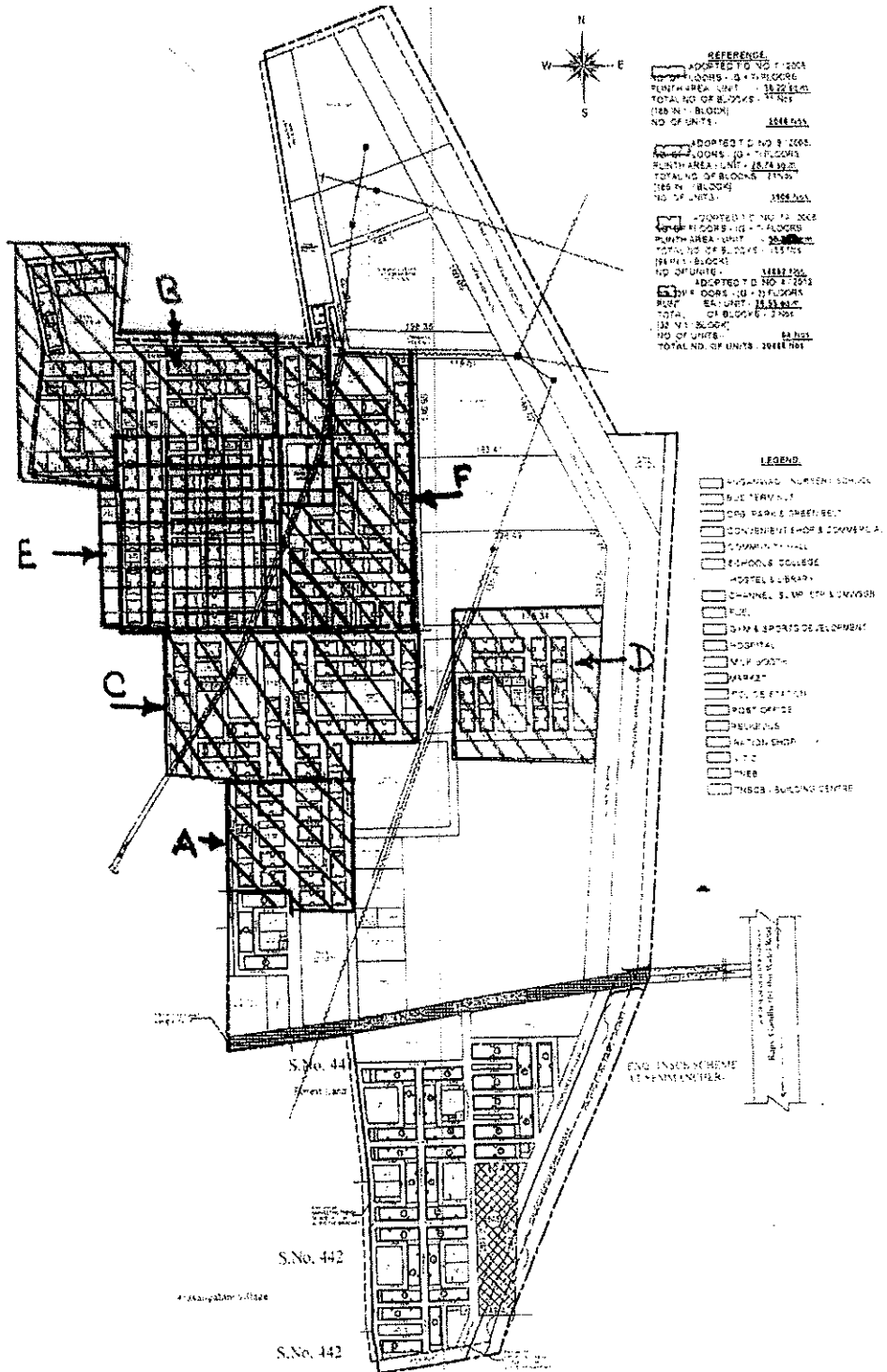
10. In case of any variation observed from the soil profile reported while execution of foundation work, bring it to the notice of consultant immediately for suitable advice. Do not change the recommended level of foundation without the knowledge of foundation consultant.

*K. I.* — *25/7/2014*

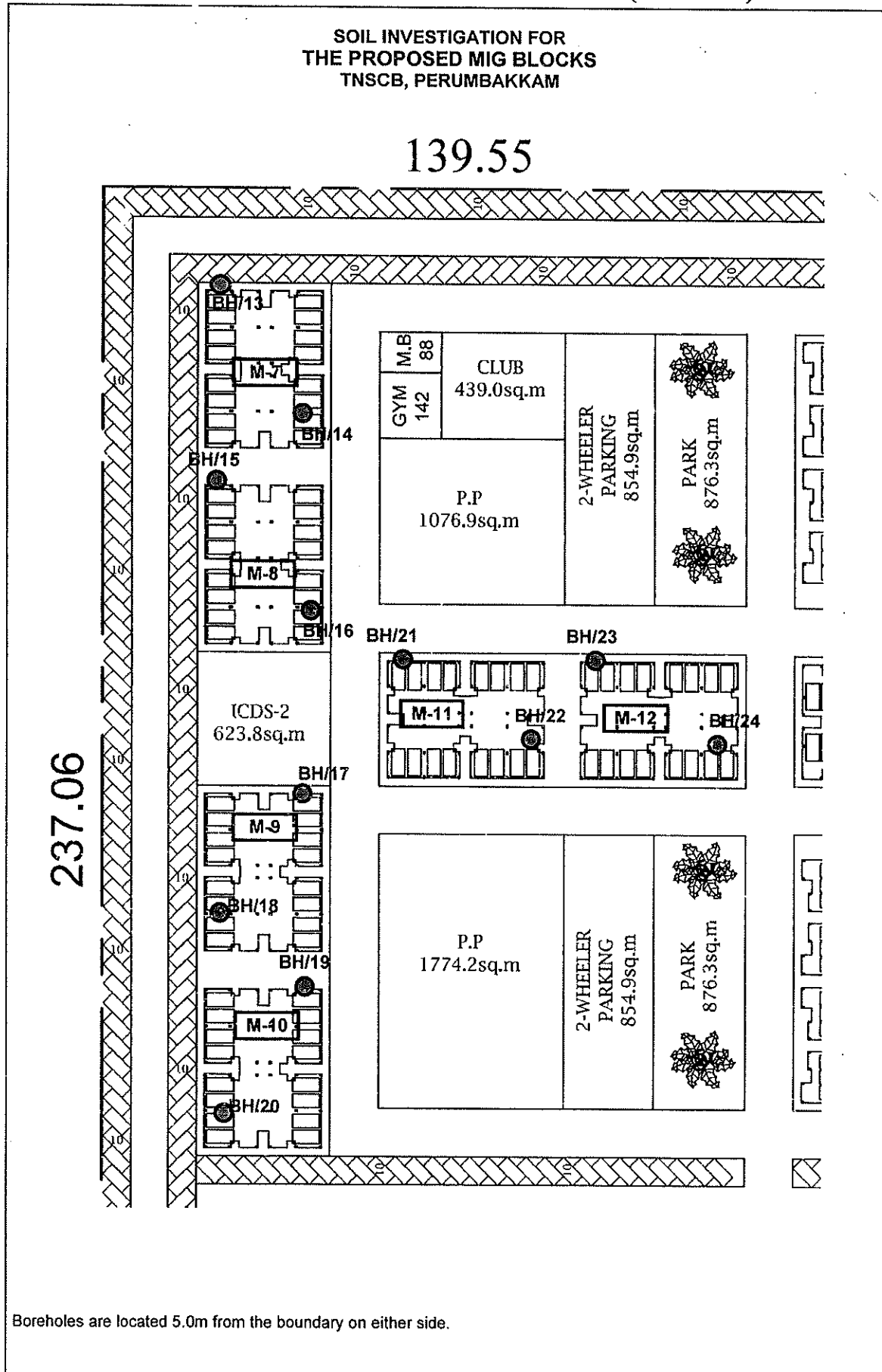
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Project Co-Coordinator &  
Professor and Chairman  
Department of Civil Engineering  
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**Dr. K. ILAMPARUTHI, M.E., Ph.D.,**  
Professor & Chairman  
Faculty of Civil Engineering  
Anna University, Chennai-600 025.

**Figure A1 Perumbakkam Project – Zones of Investigation**



**FIGURE 1B LOCATION OF BORE HOLES (ZONE M2)**



Boreholes are located 5.0m from the boundary on either side.

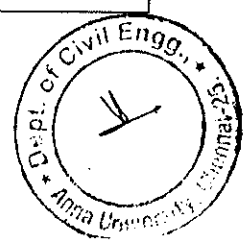


FIGURE 2 SOIL PROFILE AND SPT N VALUES AT BH 13 - M2

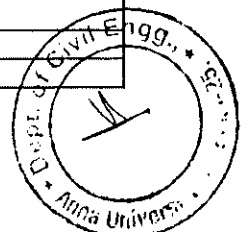
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M7  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/13
Date of start	: 10-Mar-2013
Date of finish	: 11-Mar-2013
GWL from GL	: 1.40m
Ground level RL	: 1.688m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST					RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts					
						15	30	45	60		N**
1.0	[Soil Profile Pattern]	Yellowish grey silty clay with few stones		0.50							Medium stiff
1.3				0.75	0.75	2	4	6	11	10	
1.9	[Soil Profile Pattern]	Greyish brown sandy silty clay with stones		1.50	1.50	5	8	17	23	25	Stiff
2.0											
3.0	[Soil Profile Pattern]	Greyish brown clayey silty fine to coarse sand with sandy clay lumps		2.25	2.25	10	15	32		47	Dense
3.2					3.00	3.00	38	50/8cm		>100	
4.0	[Soil Profile Pattern]	Greyish brown dirty fine to coarse sand with weathered stones (weathered disintegrated rock)		3.75	3.75	50/8cm				>100	Very dense
5.0				4.50	4.50	30/4cm				>100	
5.5				5.50	Rebound						
6.0	[Soil Profile Pattern]	Yellowish grey highly weathered fractured rock	5.50-6.30		TC core drilling						Very weak
6.3					6.30	Rebound				RB	
7.0	[Soil Profile Pattern]	Brownish grey highly / completely weathered severely jointed rock	6.30-7.30		Diamond core drilling NX size, recovery nil						Weak
8.0			7.30-8.30		Diamond core drilling NX size, recovery 13%, RQD nil						
9.0	[Soil Profile Pattern]	Br grey highly weathered severely jointed rock									Weak
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0		TC core drilling from 5.50m to 6.30m DC core drilling from 6.30m to 8.30m									

Borehole terminated at 8.30m

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>70</sub>

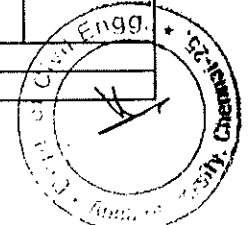


**FIGURE 3 SOIL PROFILE AND SPT N VALUES AT BH 14 - M2**

Project : MIG Tenements, TNSCB, Chennai  
 Site : Perumbakkam, M2 Zone  
 Co-ordinates : Block M7  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/14
Date of start :	12-Mar-2013
Date of finish :	13-Mar-2013
GWL from GL :	1.40m
Ground level RL :	1.451m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
1.0	[Soil Profile]	Yellowish grey silty clay with roots in the top 0.40m		0.50								Medium stiff
1.4			0.75	0.75	2	2	3	4	5			
2.0	[Soil Profile]	Yellowish grey silty clay with white stones and gravel		1.50	1.50	4	7	10	13	17		Stiff
2.2												
3.0	[Soil Profile]	Greyish brown clayey silty sand with sandy clay lumps & weathered stones		2.25	2.25	8	12	13	16	25		Medium dense
3.0												
4.0	[Soil Profile]	Greyish brown dirty fine to coarse sand with weathered stones		3.00	3.00	21	32	50		82		Very dense
4.0												
5.0	[Soil Profile]	Brownish grey dirty fine to coarse sand with weathered stones		3.75	3.75	32	50/12cm			>100		Very dense
5.0												
5.7	[Soil Profile]	Greyish brown highly weathered fractured rock	5.00-5.70		TC core drilling						Very weak	
6.0				5.70	Rebound							
7.0	[Soil Profile]	Greyish brown highly weathered severely jointed rock	5.70-6.70		Diamond core drilling NX size, recovery 15% RQD nil						Weak	
8.0			6.70-7.70		Diamond core drilling NX size, recovery 8%, RQD nil							
8.2			7.70-8.70		Diamond core drilling NX size, recovery 14%, RQD nil							
9.0	[Soil Profile]	Brownish grey highly weathered closely jointed rock (Granitic gneiss)									Moderate	
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0												
Borehole terminated at 8.70m												
**Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>70</sub>												

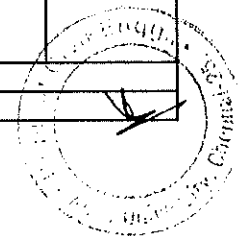


**FIGURE 4 SOIL PROFILE AND SPT N VALUES AT BH 15 - M2**

Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M8  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/15
Date of start	: 13-Mar-2013
Date of finish	: 14-Mar-2013
GWL from GL	: 1.30m
Ground level RL	: 1.339m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST					RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts					
						15	30	45	60		N**
0.5		Brownish grey silty clay with roots		0.50							Medium stiff
1.0		Yellowish grey silty clay		0.75	0.75	2	3	5	7	8	Medium stiff
1.7		Greyish brown clayey silty sand with weathered stones		1.50	1.50	6	9	12	17	21	Med dense
2.0				2.25	2.25	16	34	50		84	Very dense
2.3		Yellowish grey dirty fine to coarse sand with sandy clay lumps		3.00	3.00	30/10cm			>100	RB	
3.0		Brownish grey highly weathered fractured rock	3.00-3.60m		3.60	Rebound					Weak
3.2			3.60-4.60		Diamond core drilling NX size, recovery nil						
4.0			4.60-5.60		Diamond core drilling NX size, recovery nil						
5.0		Brownish grey completely weathered severely jointed rock	5.60-6.60		Diamond core drilling NX size, recovery 4%					Weak	
5.6			6.60-7.60		Diamond core drilling NX size, recovery 13%, RQD nil						
6.0		Greyish partly weathered jointed rock (granitic gneiss)								Moderate	
6.8											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0		TC core drilling from 3.00m to 3.60m DC core drilling from 3.60m to 7.60m									
Borehole terminated at 7.60m											
**Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>70</sub>											

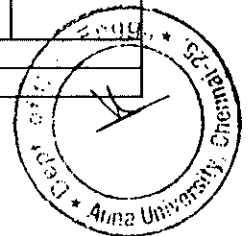


**FIGURE 5 SOIL PROFILE AND SPT N VALUES AT BH 16 - M2**

Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M8  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/16
Date of start	: 14-Mar-2013
Date of finish	: 15-Mar-2013
GWL from GL	: 1.10m
Ground level RL	: 1.240m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.5		Yellowish grey silty clay (dry)		0.50								
1.0		Yellowish grey and brown silty clay with few stones		0.75	0.75	2	4	6	7	10	Medium stiff to stiff	
2.0				1.50	1.50	7	9	10	14	19		
2.1		Yellowish grey clayey silty sand with sandy clay lumps		2.25	2.25	10	14	27	32	41	Dense	
3.0				3.00	3.00	28	32	50		82		
3.8		Brownish grey dirty fine to medium sand with sandy clay lumps		3.75	3.75	50/13cm				>100	Very dense	
4.0				4.50	4.50	Rebound				RB		
4.7		Greyish dirty fine to coarse sand with weathered stones (wdr)									Very dense	
5.0												
5.8		Brownish grey highly weathered fractured rock	4.50-5.80		TC core drilling						Very weak	
6.0						5.80	Rebound					RB
7.0		Yellowish grey highly / completely weathered calcareous sandstone	5.80-6.80		Diamond core drilling NX size, recovery 10%, RQD nil						Weak	
8.0			6.80-7.80		Diamond core drilling NX size, recovery 13%, RQD nil							
8.1			7.80-8.30		DC Core drilling							
8.30		Brownish grey dirty fine to coarse sand with weathered stones		8.30	8.30	50/13cm				>100	Very dense	
9.0				8.30-9.20		TC core drilling						
9.2		Greyish partly weathered and severely jointed rock	9.20-10.20		Diamond core drilling NX size, recovery 16%, RQD nil						Weak	
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0												
			Borehole terminated at 10.20m									
			**Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>70</sub>									



**FIGURE 6 SOIL PROFILE AND SPT N VALUES AT BH 17 - M2**

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/17

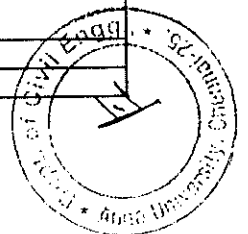
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M9  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 16-Mar-2013  
 Date of finish : 17-Mar-2013  
 GWL from GL : 1.40m  
 Ground level RL : 1.492m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.5		Brownish grey silty clay with sand		0.50								Medium stiff
1.0		Brownish grey soft silty clay		0.75	0.75		1				0	Very soft
1.4		Dark grey soft silty clay with gravel and organic material		1.50	1.50	Sunk @ SPT wt					0	Very soft
2.0				2.25	2.25	7	15	23	29	38		Dense
2.3		Greyish clayey silty fine to coarse sand with weathered stones		3.00	3.00	9	17	24	33	41		Very dense
3.0				3.75	3.75	50/09cm					>100	
3.2		Brownish grey clayey silty fine to coarse sand with weathered stones		4.00	Rebound					RB		
4.0				4.2								
4.2		Dark greenish grey completely weathered fractured rock	4.00-5.00	TC core drilling					RB	Very weak		
5.0				5.00 Rebound								
5.0		Dark greenish grey completely weathered fractured rock	5.00-6.00	TC core drilling					RB			
6.0				6.00 Rebound								
6.0		Yellowish grey highly weathered severely jointed rock	6.00-7.00	Diamond core drilling NX size recovery nil						Weak		
7.0		Brownish and light yellowish fully weathered severely jointed rock	7.00-8.00	Diamond core drilling NX size recovery 9%, RQD nil						Weak		
8.0		Yellowish grey and grey highly weathered severely jointed rock	8.00-9.00	Diamond core drilling NX size recovery 16%, RQD nil						Weak to moderate		
8.3												
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0		TC core drilling from 4.00m to 6.00m DC core drilling from 6.00m to 9.00m										

Borehole terminated at 9.00m

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>70</sub>





**FIGURE 7 SOIL PROFILE AND SPT N VALUES AT BH 18 - M2**

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/18

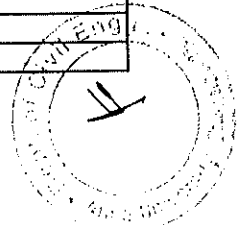
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block MS  
 Diameter and type of boring : 50mm Rotary boring with drilling mud circulation

Date of start : 18-Mar-2013  
 Date of finish : 19-Mar-2013  
 GWL from GL : 1.40m  
 Ground level RL : 1.409m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency		
			UDS	DS	Test depth m	SPT blow counts							
						15	30	45	60	N**			
0.5		Yellowish grey silty clay with black patches		0.50								Medium stiff	
1.0		Brownish grey silty clay with reddish brown patches		0.75	0.75	1	1	1	2	2		Soft	
1.4		Yellowish grey and brownish silty clay		1.50	1.50	2	3	5	11	8		Medium stiff	
2.0		Brownish clayey silty fine to medium sand / sandy silty clay		2.25	2.25	6	10	14	18	24		Med dense	
2.9		Greyish brown dirty fine to coarse sand with weathered stones		3.00	3.00	22	31	43		74		Very dense	
3.0		Yell grey clayey silty fine to coarse sand with weathered stones (wdr)		3.75	3.75	36	50/8cm			>100		Very dense	
4.0				4.50	4.50	Rebound					RB		
4.5		Yellowish grey highly / completely weathered fractured rock	4.50-5.50		TC core drilling								Very weak
5.0				5.50	5.50	Rebound					RB		
5.5		Greyish brown & grey completely weathered severely jointed rock	5.50-6.50		Diamond core drilling NX size recovery 6%								Weak
6.0		Brownish and grey highly weathered severely jointed rock	6.50-7.50		Diamond core drilling NX size recovery 15%, RQD nil								Weak
6.5			7.50-8.50		Diamond core drilling NX size recovery 22%, RQD nil								
7.0													
8.0													
9.0													
10.0													
11.0													
12.0													
13.0													
14.0													
15.0													
16.0													
17.0													
18.0													
19.0													
20.0		TC core drilling from 4.50m to 5.50m DC core drilling from 5.50m to 8.50m											

Borehole terminated at 8.50m

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>70</sub>



**FIGURE 8 SOIL PROFILE AND SPT N VALUES AT BH 19 - M2**

<b>PROJECT NO:</b>	<b>SF/KI-48/Zone M2/PMPKM</b>
<b>BORE HOLE NO:</b>	<b>BH/19</b>

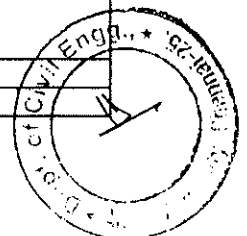
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M10  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 19-Mar-2013  
 Date of finish : 20-Mar-2013  
 GWL from GL : 1.30m  
 Ground level RL : 1.409m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.6		Br grey silty clay with brown & black patches		0.50								Medium stiff
1.0		Yellowish grey soft silty clay with reddish brown patches		0.75	0.75	0	1	1	1	2		Soft
1.4		Grayish soft silty clay with reddish brown patches		1.50	1.50	@SPT wt			1	0		Very soft
2.0				2.25	2.25	2	12	19	27	31		Dense
2.4		Brownish grey dirty fine to coarse sand weathered stones		3.00	3.00	16	20	24	31	44		Dense
3.0				3.75	3.75	16	50			>100		
4.0		Brownish grey completely weathered / highly weathered fractured rock		4.50	Rebound					RB		Very weak
5.0			4.50-5.50	TC core drilling								
5.5				5.50	Rebound					RB		
6.0		Brownish highly weathered severely jointed rock (siltstone)		5.50-6.50	Diamond core drilling NX size, recovery 19%, RQD nil						Weak	
6.7		Light brownish and light grey widely jointed hard rock (siltstone)		6.50-7.50	Diamond core drilling NX size, recovery 31%, RQD 28%						Strong	
7.0												
8.0												
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0		TC core drilling from 4.50m to 5.50m DC core drilling from 5.50m to 7.50m										

Borehole terminated at 7.50m

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>70</sub>



**FIGURE 9 SC IL PROFILE AND SPT N VALUES AT BH 20 - M2**

<b>PROJECT NO:</b>	<b>SF/KI-48/Zone M2/PMPKM</b>
<b>BORE HOLE NO:</b>	<b>BH/20</b>

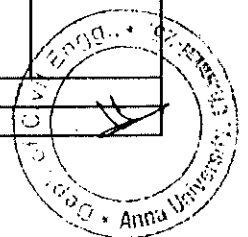
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M10  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 20-Mar-2013  
 Date of finish : 21-Mar-2013  
 GWL from GL : 1.10m  
 Ground level RL : 1.250m

Depth from GL (m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.6		Yellowish grey silty clay		0.50								Soft
1.0		Light grey very soft silty clay with reddish brown patches		0.75	0.75	Sunk @ SPT wt					0	Very soft
1.4												
2.0		Brownish grey silty clay with gravel and sand		1.50	1.50	3	4	6	8	10		Medium stiff
2.6												
3.0		Yellowish grey clayey silty fine to coarse sand with weathered stones		2.25	2.25	7	9	15	18	24		Very dense
3.4												
4.0		Yellowish grey completely / highly weathered fractured rock		3.75	3.00	29	50/14cm			>100	RB	Very weak
4.8			3.75-4.80		TC core drilling							
5.0					4.80	Rebound					RB	
6.0		Light brownish grey weathered closely jointed rock	4.80-5.80		Diamond core drilling NX size, recovery 12%, RQD nil							Weak to moderate
6.2												
7.0		Light brown and grey widely jointed hard rock (siltstone)	5.80-6.80		Diamond core drilling NX size, recovery 25%, RQD 25%							Hard
8.0												
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0		TC core drilling from 3.75m to 4.80m DC core drilling from 4.80m to 6.80m										

**Borehole terminated at 6.80m**

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>70</sub>



**FIGURE 10 SOIL PROFILE AND SPT N VALUES AT BH 21 - M2**

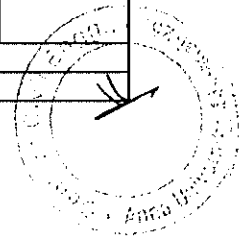
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M11  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/21
Date of start	: 22-Mar-2013
Date of finish	: 23-Mar-2013
GWL from GL	: 1.20m
Ground level RL	: 1.354m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.6		Yellowish grey medium stiff silty clay		0.50								Medium
1.0		Yellowish grey soft silty clay with yellow patches		0.75	0.75	1	1	1	2	2		Soft
1.4		Yellowish grey soft silty clay with yellow patches		0.75	0.75	1	1	1	2	2		Soft
1.9		Lt grey soft silty clay with reddish brown patches		1.50	1.50	1	3	4	10	7		Soft
2.0		Lt grey soft silty clay with reddish brown patches		1.50	1.50	1	3	4	10	7		Soft
2.3		Yell brown and grey sandy silty clay with gravel		2.25	2.25	14	20	24	30	44		Medium stiff
3.0		Yell grey clayey silty sand with sandy clay lumps and weathered stones		2.25	2.25	14	20	24	30	44		Dense
3.0		Yell grey clayey silty sand with sandy clay lumps and weathered stones		3.00	3.00	15	18	31		49		Dense
4.0		Yellowish grey dirty fine to coarse sand		3.75	3.75	23	50/12cm			>100		Very dense
4.5		Yellowish grey dirty fine to coarse sand		4.50	4.50	Rebound				RB		Very dense
5.0		Yellowish grey highly weathered fractured rock	4.50-5.50		TC core drilling							Very weak
5.5		Yellowish grey highly weathered fractured rock	4.50-5.50		5.50	Rebound				RB		Very weak
6.0		Greyish weathered severely jointed rock	5.50-6.50		Diamond core drilling NX size, recovery 17%, RQD nil						Weak	
7.0	6.50-7.50			Diamond core drilling NX size, recovery 19%, RQD nil								
8.0	7.50-8.50			Diamond core drilling NX size, recovery 18%, RQD nil								
8.1		Brownish & grey weathered closely jointed rock										Moderate
9.0		TC core drilling from 4.50m to 5.50m DC core drilling from 5.50m to 8.50m										
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0												

Borehole terminated at 8.50m

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>70</sub>



**FIGURE 11 SOIL PROFILE AND SPT N VALUES AT BH 22 - M2**

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/22

Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M11  
 Diameter and type of boring : 150. mm Rotary boring with drilling mud circulation

Date of start : 23-Mar-2013  
 Date of finish : 23-Mar-2013  
 GWL from GL : 1.00m  
 Ground level RL : 1.267m

Depth from GL (m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
1.0		Yellowish grey silty clay		0.50								Soft to medium stiff
1.3				0.75	0.75	1	1	2	2	3		
2.0		Dark grey soft clay with reddish brown patches		1.50	1.50	Sunk @ SPT wt					0	Very soft
2.6				2.75	2.75	@SPT wt					1	Very soft
3.0		Black organic sandy clay		3.50	3.50	3	8	9	23	17		Loose
3.4		Dark greenish grey dirty fine to medium sand		4.50	4.50	35	50/8cm				>100	Very dense
4.0		Dark brownish grey dirty fine to coarse sand with weathered stones		5.50	5.50	Rebound					RB	Very dense
4.8		Brownish grey dirty fine to coarse sand with weathered stones		5.50-6.70	TC core drilling							Very weak
5.0		Brownish grey highly weathered fractured rock		6.70	Rebound						RB	
5.6				6.70-7.70	Diamond core drilling NX size, recovery nil							Weak
6.0		Brownish and grey highly weathered severely jointed rock		7.70-8.70	Diamond core drilling NX size, recovery 10%, RQD nil							
6.7				8.70-9.70	Diamond core drilling NX size, recovery 19%, RQD nil							
7.0		Br and grey weathered closely jointed rock										Moderate
8.0												
9.0												
9.1												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0												
		TC core drilling from 5.50m to 6.70m DC core drilling from 6.70m to 9.70m										
Borehole terminated at 9.70m												
**Note: SPT Conducted using winch cat-head device, N values reported are close to N <sub>70</sub>												

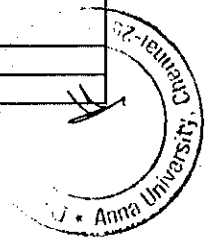


FIGURE 12 SOIL PROFILE AND SPT N VALUES AT BH 23 - M2

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/23

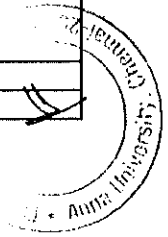
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M12  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 25-Mar-2013  
 Date of finish : 25-Mar-2013  
 GWL from GL : 1.00m  
 Ground level RL : 1.200m

Depth from GL (m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency		
			UDS	DS	Test depth m	SPT blow counts							
						15	30	45	60	N**			
0.6		Yellowish grey silty clay		0.50								Medium stiff	
1.0		Light brownish grey soft silty clay with yellow patches		0.75	0.75	@SPT wt	1	0				Very soft	
2.0				1.50	1.50	Sunk @ SPT wt		0					
2.2		Dark grey very soft silty clay with medium sand patches and decayed wood		2.25	2.25	Sunk @ SPT wt		0				Very soft	
3.0				3.00	3.00	0	1	2	25	3			
3.5		Dark yellowish grey dirty fine to coarse sand weathered stones		3.75	3.75	50/15cm					>100	Very dense	
4.0				4.50	4.50	30/6cm					>100		
4.6		Dark yellowish grey completely weathered fractured rock		5.50	5.50	Rebound						RB	Very weak
5.0				6.00	6.00	TC core drilling						RB	
5.5		Yellowish grey highly weathered fractured rock	5.50-6.30										Very weak
6.0				6.30	6.30	Rebound							
6.3		Brownish and grey weathered severely jointed rock	6.30-7.30			Diamond core drilling NX size, recovery 8%, RQD nil					Weak		
7.0				7.30-8.30			Diamond core drilling NX size, recovery 12%, RQD nil						
8.0		TC core drilling from 5.50m to 6.30m DC core drilling from 6.30m to 8.30m											
9.0													
10.0													
11.0													
12.0													
13.0													
14.0													
15.0													
16.0													
17.0													
18.0													
19.0													
20.0													

Borehole terminated at 8.30m

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>70</sub>



**FIGURE 13 SOIL PROFILE AND SPT N VALUES AT BH 24 - M2**

PROJECT NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/24

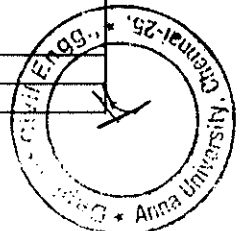
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M12  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 26-Mar-2013  
 Date of finish : 27-Mar-2013  
 GWL from GL : 1.00m  
 Ground level RL : 1.295m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	SPT blow counts						
						15	30	45	60	N**		
0.5		Yellowish grey silty clay		0.50								Soft
1.0		Light brownish grey soft silty clay with few stones		0.75	0.75	Sunk @ SPT wt					0	Very soft
1.8												
2.0		Light grey soft silty clay		2.00	2.00	@SPTwt	20	33			20	Very soft
2.4												
2.8		Yell grey dirty fine to coarse sand with w. stones		2.75	2.75	40/4cm					>100	Very dense
3.0												
3.4		Yellowish grey highly weathered fractured rock	2.75-3.30		3.30	Rebound					RB	Very weak
4.0		Light grey and light brown weathered severely jointed rock	3.30-4.30		Diamond core drilling NX size, recovery 19%, RQD nil						Weak	
5.0			4.30-5.30		Diamond core drilling NX size, recovery 24%, RQD nil							
6.0												
7.0												
8.0												
9.0												
10.0												
11.0												
12.0												
13.0												
14.0												
15.0												
16.0												
17.0												
18.0												
19.0												
20.0		TC core drilling from 5.00m to 6.30m DC core drilling from 6.30m to 8.30m										

Borehole terminated at

\*\*Note: SPT Conducted using winch cat-head device, N values reported are close to N<sub>70</sub>



BH/14

BH/13

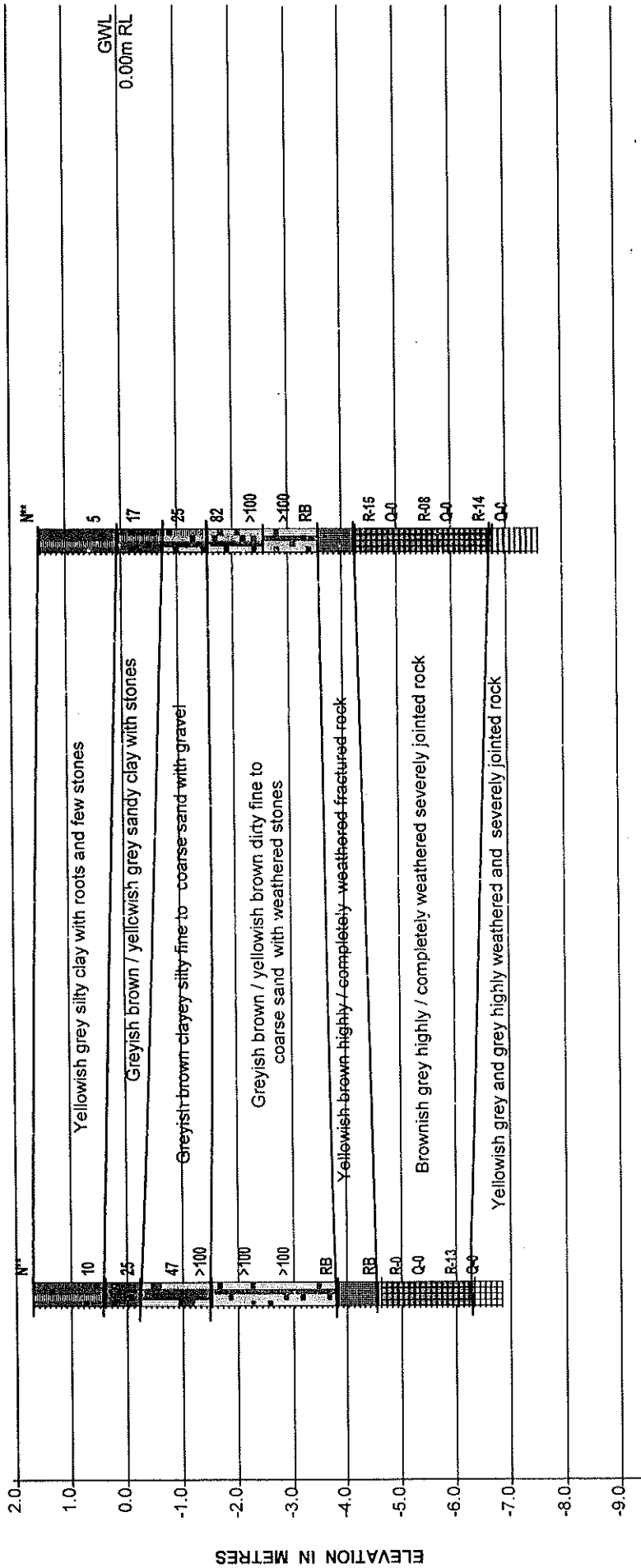
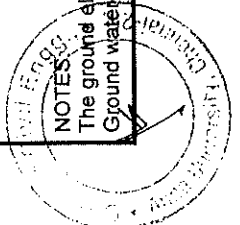


FIGURE 14

SUB-SOIL PROFILE BH/13 – BH/14 – BLOCK M-7  
TNSCB TENEMENTS AT PERUMBAKKAM

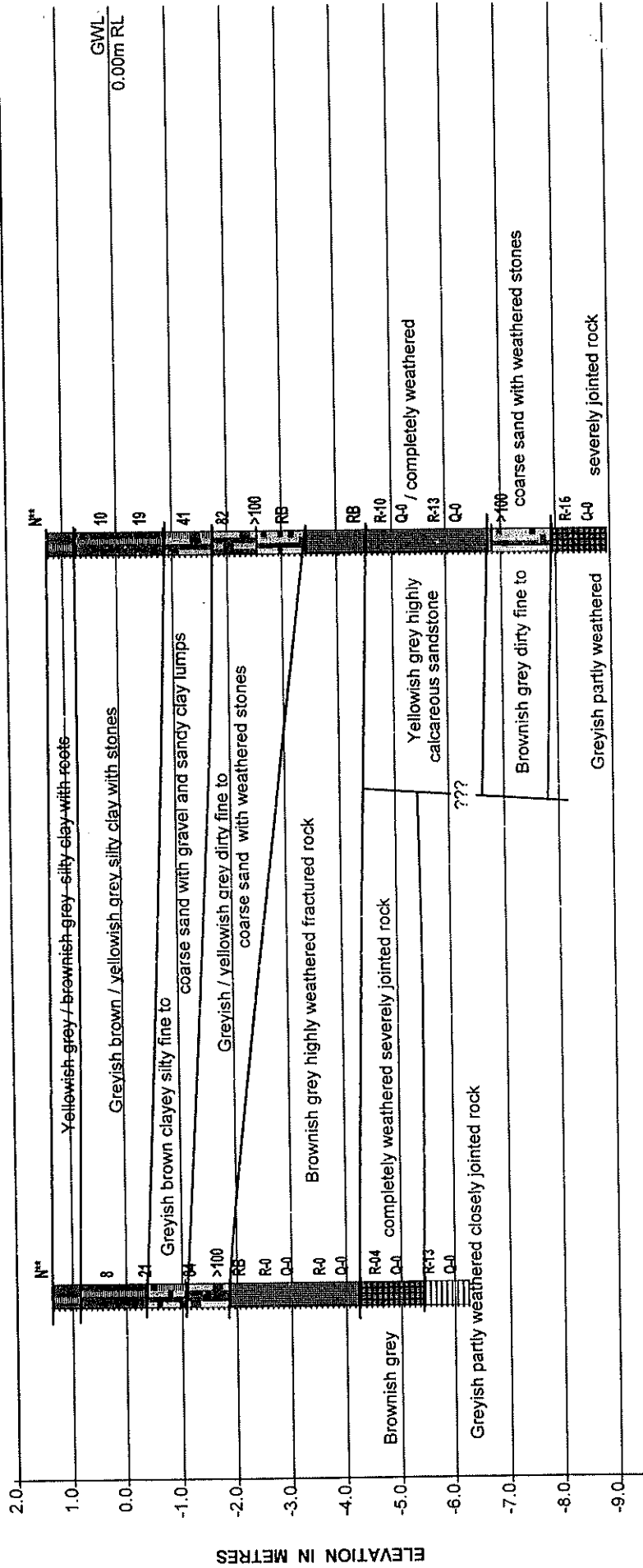
NOTES:  
The ground elevations with respect to the site reference datum.  
Ground water table is from the boreholes





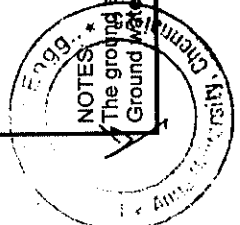
BH/16

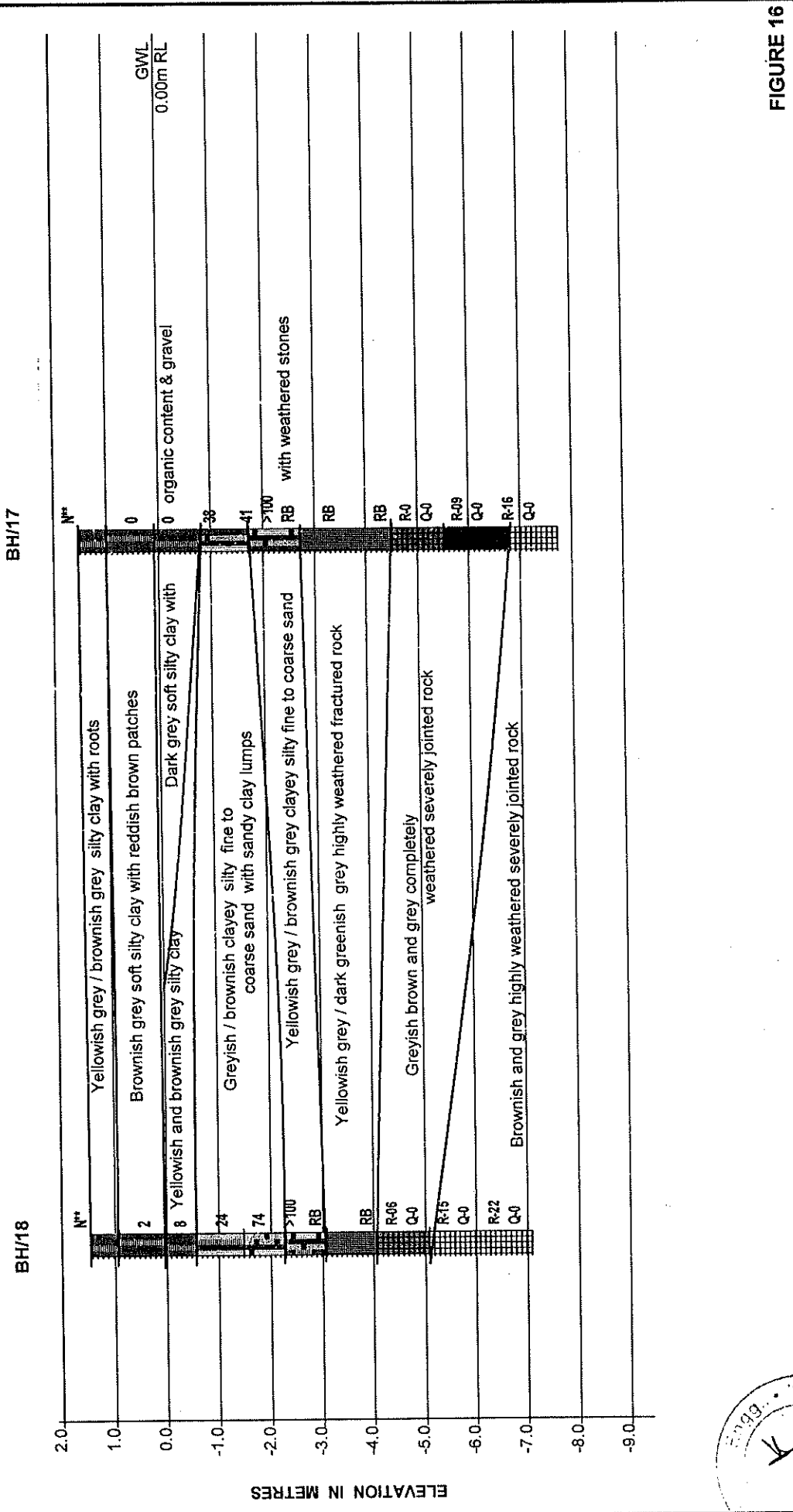
BH/15



**FIGURE 15**  
**SUB-SOIL PROFILE BH/15 - BH/16 - BLOCK M-8**  
**TNSCB TENEMENTS AT PERUMBAKKAM**

**NOTES:**  
 \* The ground elevations with respect to the site reference datum.  
 Ground water table is from the boreholes





NOTES:  
 The ground elevations with respect to the site reference datum.  
 Ground water table is from the boreholes

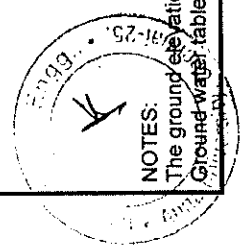
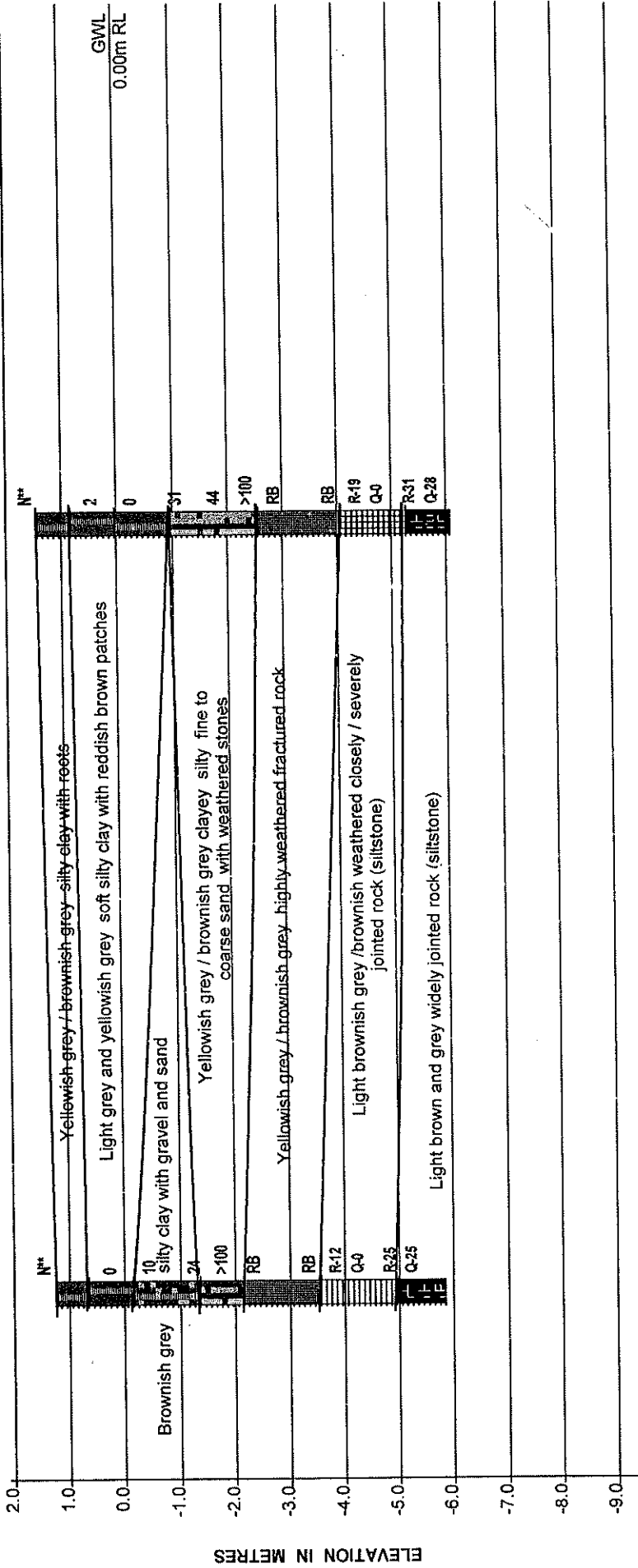


FIGURE 16  
 SUB-SOIL PROFILE BH/18 – BH/17 – BLOCK M-9  
 TNSCB TENEMENTS AT PERUMBAKKAM

BH/19

BH/20



ELEVATION IN METRES

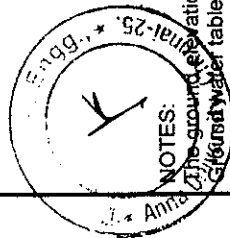
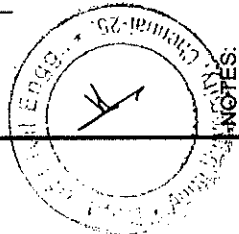
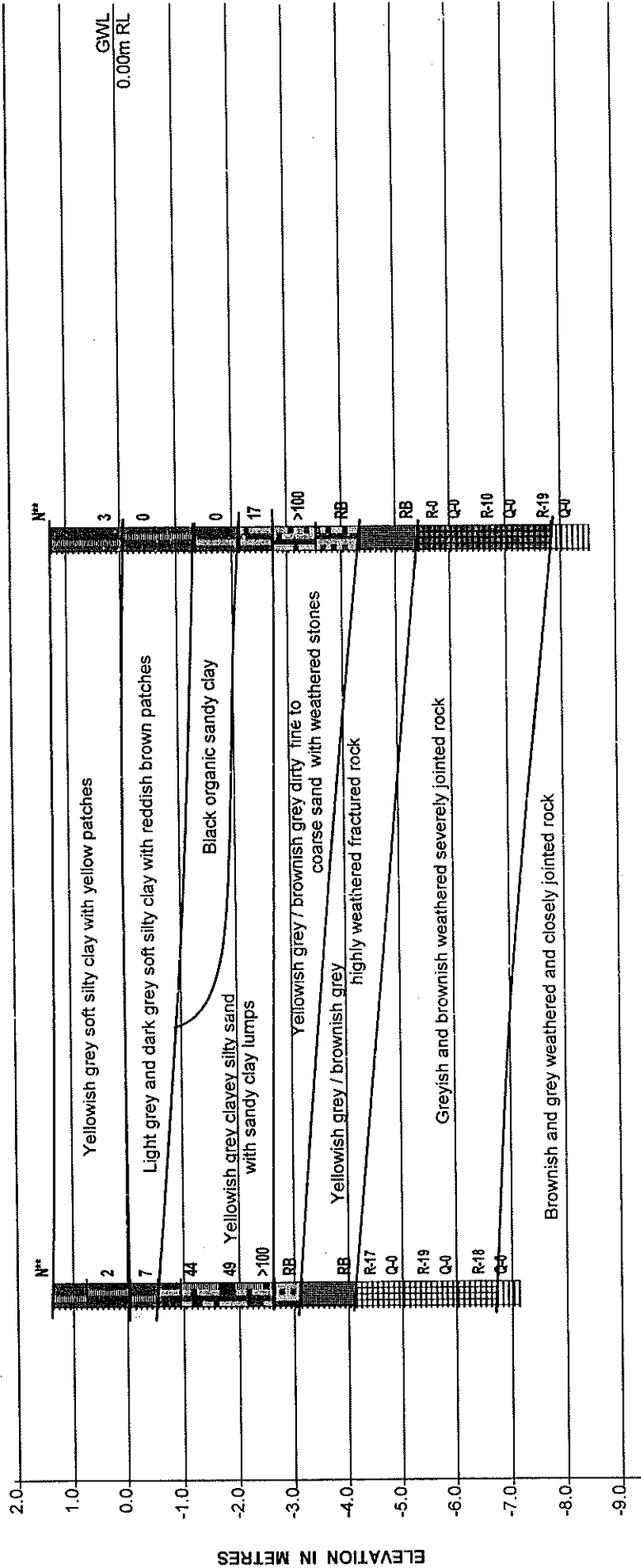


FIGURE 17

SUB-SOIL PROFILE BH/20 - BH/19 - BLOCK M-10  
TNSCB TENEMENTS AT PERUMBAKKAM

BH/22

BH/21



NOTES:  
 The ground elevations with respect to the site reference datum.  
 Ground water table is from the boreholes

FIGURE 18  
 SUB-SOIL PROFILE BH/21 – BH/22 – BLOCK M-11  
 TNSCB TENEMENTS AT PERUMBAKKAM

BH/24

BH/23

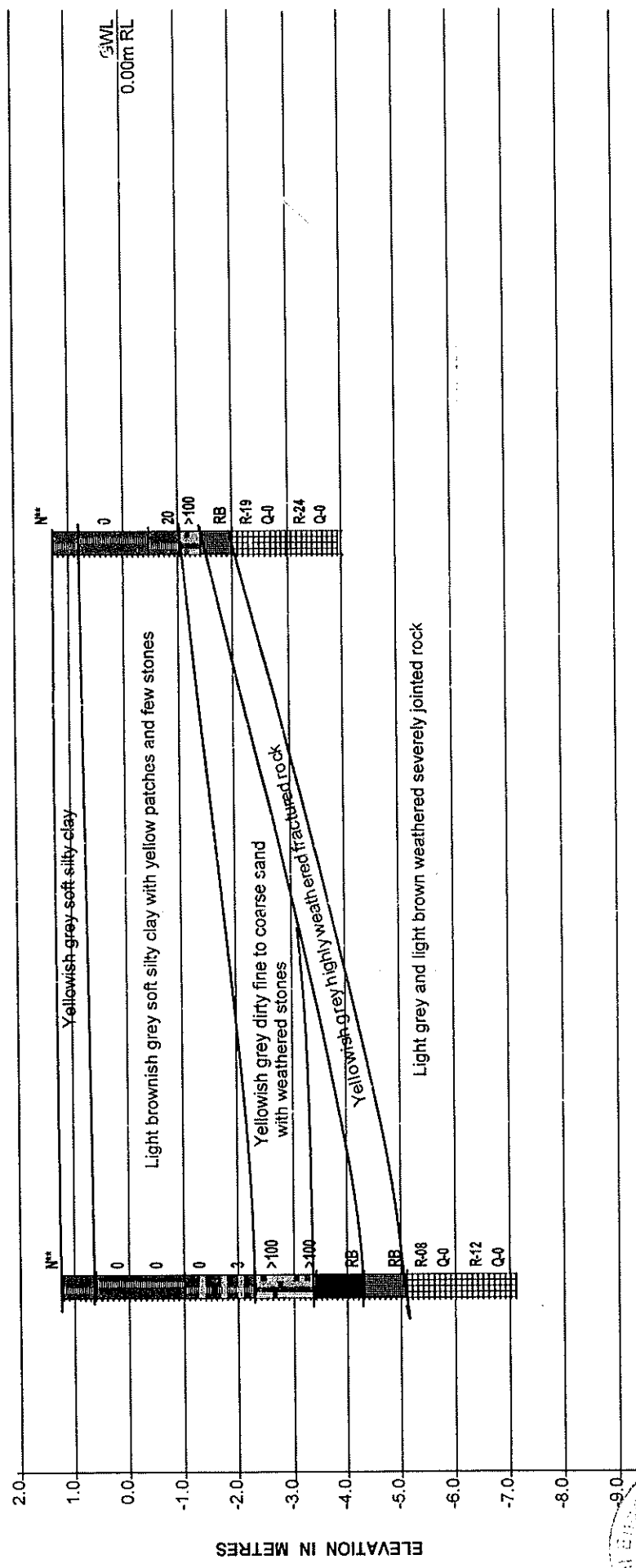
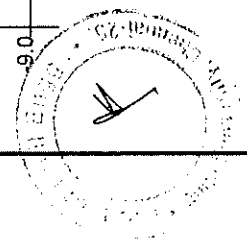


FIGURE 19

SUB-SOIL PROFILE BH/23 - BH/24 - BLOCK M-12  
TNSCB TENEMENTS AT PERUMBAKKAM

NOTES:  
The ground elevations with respect to the site reference datum.  
Ground water table is from the boreholes



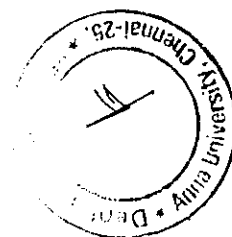
**TABLE 1 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 13 - M2**

Project: **MIG Tenements, TNSCB Perumbakkam**  
 Borehole Nos: **BH13**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.00m to 1.40m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH13</b>															
GL-0.50	DS	Yellowish grey silty clay with few stones			22.1					45.4							
0.75	SPT	Yellowish grey silty clay with gravel and stones	10	CH	33.9	83.3	24.3	59.0	0.163	81.8							
1.50	SPT	TOP: greyish brown sandy silty clay with stones BOT: Greyish brown clayey silty sand with coarse particles	25	SC/CI	23.8	65.6	22.6	43.0	0.028	100.0							
2.25	SPT	Greyish brown clayey silty fine to coarse sand with sandy clay lumps	47	SC/SM	19.1							2.7	15.1	36.3	26.9	19.0	
3.00	SPT	Greyish brown dirty fine to coarse sand with weathered stones	>100	SC/SM	23.9							2.0	16.6	36.3	24.7	20.4	
3.75	SPT	Greyish brown dirty fine to coarse sand	>100		17.1												
4.50	SPT	Greyish brown dirty fine to coarse sand with weathered stones (wdr)	>100		15.4												
7.30-8.30		Brownish grey highly weathered severely jointed rock															



**TABLE 2 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 14 - M2**

Project: **MIG Tenements, TNSCB Perumbakkam**

Borehole Nos: **BH14**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.00m to 1.40m, March- April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH14</b>															
GL-0.50	DS	Yellowish grey silty clay with roots		CH	29.4	82.8	21.5	61.3	0.129	191.6							
0.75	SPT	Yellowish grey silty clay	5	CH	32.9	85.3	24.3	61.0	0.141	66.6							
1.50	SPT	Yellowish grey silty clay with white stones and gravel	17	CH	35.7	85.3	24.4	60.9	0.186	141.6							
2.25	SPT	Greyish brown clayey silty sand with sandy clay lumps & weathered stones	25	SC/SM	20.3							2.0	9.5	26.7	31.6	30.2	
3.00	SPT	Greyish brown dirty fine to coarse sand with weathered stones	82		13.6												
3.75	SPT	Greyish brown dirty fine to coarse sand with weathered stones	>100	SM	16.4							9.5	17.0	33.0	24.7	15.8	
4.50	SPT	Brownish grey dirty fine to coarse sand with weathered stones	>100		14.9												
5.70-6.70		Greyish brown highly weathered severely jointed rock															
6.70-7.70		Greyish brown highly weathered severely jointed rock															
7.70-8.70		Brownish grey highly weathered closely jointed rock (Granitic gneiss)															



**TABLE 3 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 15 - M2**

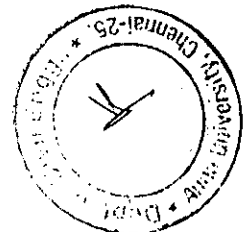
Project: MIG Tenements, TNSCB Perumbakkam

Borehole Nos: BH15

Type of Boring and dia of bore hole: 150mm diameter rotary boring with mud circulation

Ground Water Table: 1.00m to 1.40m, March- April 2013

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH15</b>															
GL-050	DS	Brownish grey silty clay with roots		CH	22.3	62.1	19.6	42.5	0.064	65.2							
0.75	SPT	Yellowish grey silty clay	8	CH	30.4	87.7	24.8	62.9	0.089	73.9							
1.50	SPT	TOP: Yellowish grey silty clay BOT: Greyish brown clayey silty sand with weathered stones	21	CH	28.1	76.4	22.8	53.6	0.099	86.9							
2.25	SPT	Yellowish grey dirty fine to coarse sand with sandy clay lumps	84	SC/SM	16.1							2.4	11.8	44.0	26.3	15.5	
3.00	SPT	Greyish brown dirty fine to coarse sand with weathered stones	>100	SM	14.7							23.4	21.6	26.1	15.9	13.0	
5.60-6.60		Brownish grey completely weathered severely jointed rock															
6.60-7.60		Greyish partly weathered jointed rock (granitic gneiss)															





**TABLE 4 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 16 - M2**

Project: **MIG Tenements, TNSCB Perumbakkam**

Borehole Nos: **BH16**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.00m to 1.40m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH16</b>															
GL-0.50	DS	Yellowish grey silty clay (dry)			15.0												
0.75	SPT	Yellowish grey silty clay with brown patches	10	CH	30.6	84.2	21.5	62.7	0.145	86.9							
1.50	SPT	Yellowish grey and brown silty clay with few stones	19	CH	33.9	88.1	23.9	64.2	0.156	138.4							
2.25	SPT	Yellowish grey clayey silty sand with sandy clay lumps	41	SC/SM	19.8								3.9	44.4	29.2		22.5
3.00	SPT	Brownish grey dirty fine to medium sand with sandy clay lumps	82		12.4												
3.75	SPT	Greyish dirty fine to coarse sand with weathered stones (wdr)	>100	SW/SP	11.3							1.5	21.6	50.5	18.1		8.3
5.80-6.80		Yellowish grey highly / completely weathered calcareous sandstone															
6.80-7.80		Brownish grey completely weathered granitic gneiss / sandstone															
8.30	SPT	Brownish grey dirty fine to coarse sand with weathered stones															
9.20-10.20		Greyish partly weathered and severely jointed rock															



**TABLE 5 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 17 - M2**

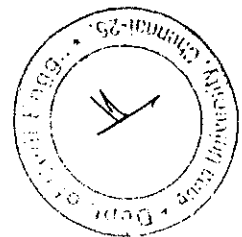
Project: **MIG Tenements, TNSCB Perumbakkam**

Borehole Nos: **BH17**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.00m to 1.40m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH17</b>															
GL-05	DS	Brownish grey silty clay with sand		SC-CH	17.5	58.4	19.5	38.9	<0.00	70.0							
0.75	SPT	Brownish grey soft silty clay	0	CH	70.0	95.6	26.8	68.8	0.628	83.0							
1.50	SPT	Dark grey soft silty clay with gravel and organic material	0	CH	54.8	77.3	25.8	51.5	0.563	55.0							
2.25	SPT	Greyish clayey silty fine to coarse sand with weathered stones	38	SC/SM	16.0							1.6	15.8	29.2	27.7		25.7
3.00	SPT	Brownish grey clayey silty fine to coarse sand with weathered stones	41	SC/SM	15.8							5.1	19.1	29.8	24.6		21.4
3.75	SPT	Brownish grey clayey silty fine to coarse sand	>100		18.5												
7.0-8.0		Brownish and light yellowish fully weathered severely jointed rock															
8.0-9.0		Yellowish grey and grey highly weathered severely jointed rock															



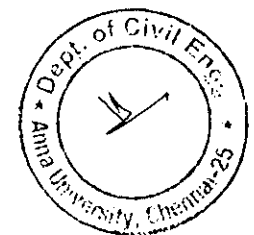
**TABLE 6 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 18 - M2**

Project: MIG Tenements, TNSCB Perumbakkam  
 Borehole Nos: BH18

Type of Boring and dia of bore hole: 150mm diameter rotary boring with mud circulation

Ground Water Table: 1.00m to 1.40m, March-April 2013

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH18</b>															
GL-0.50	DS	Yellowish grey silty clay with black patches		CH	19.9	57.4	17.5	39.9	0.060	60.0							
0.75	SPT	Brownish grey silty clay with reddish brown patches	2	CH	38.1	74.1	21.6	52.5	0.314	108.0							
1.50	SPT	TOP: Yellowish grey and brownish silty clay BOT: Brownish clayey silty fine to medium sand	8	CH	29.5	71.3	21.4	49.9	0.162	54.5							
2.25	SPT	Brownish clayey silty fine to medium sand / sandy silty clay	24	SC	18.9							1.8	6.1	22.3	36.5		33.3
3.00	SPT	Greyish brown dirty fine to coarse sand with weathered stones	74	SM	13.7							9.7	17.5	31.2	27.1		14.5
3.75	SPT	Yell grey clayey silty fine to coarse sand with weathered stones (wofr)	>100	SP/SM	13.7							28.7	24.6	21.0	13.1		12.6
5.50-6.50		Greyish brown & grey completely weathered severely jointed rock															
6.50-7.50		Brownish and grey highly weathered severely jointed rock															
7.50-8.50		Brownish and grey highly weathered severely jointed rock															



**TABLE 7 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 19 - M2**

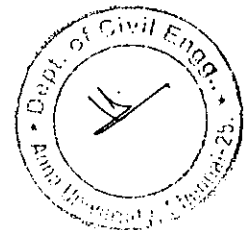
Project: MIG Tenements, TNSCB Perumbakkam

Borehole Nos: BH19

Type of Boring and dia of bore hole: 150mm diameter rotary boring with mud circulation

Ground Water Table: 1.00m to 1.40m, March-April 2013

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH19</b>															
GL-0.50	DS	Brownish grey silty clay with brown and black patches		CH	29.7	65.4	19.9	45.5	0.215	70.0							
0.75	SPT	Yellowish grey soft silty clay with reddish brown patches	2	CH	37.1	61.7	17.0	44.7	0.450	115.0							
1.50	SPT	Greyish soft silty clay with reddish brown patches	0	CI	34.8	41.5	13.4	28.1	0.762	23.8							
2.25	SPT	TOP: Greyish sandy clay with gravel / clayey sand with gravel BOT: Brownish grey dirty fine to coarse sand	31	SP/SM	19.0							7.3	22.2	37.4	19.1		14.0
3.00	SPT	Brownish grey dirty fine to coarse sand weathered stones	44	SP/SM	15.6												
3.75	SPT	Brownish grey dirty fine to coarse sand with weathered stones			16.7												
5.50-6.50		Brownish highly weathered severely jointed rock (siltstone)	>100	SP/SM	13.9							7.9	23.8	35.4	17.2		15.7
6.50-7.50		Light brownish and light grey widely jointed hard rock (siltstone)															



**TABLE 8 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 20 - M2**

Project: **MIG Tenements, TNSCB Perumbakkam**

Borehole Nos: **BH20**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.00m to 1.40m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH20</b>															
GL-0.50	DS	Yellowish grey silty clay		CH	28.9	61.1	18.2	42.9	0.249	70.0							
0.75	SPT	Light grey very soft silty clay with reddish brown patches	0	CH	38.5	65.8	17.8	48.0	0.431	27.0							
1.50	SPT	Brownish grey silty clay with gravel and sand	10	CH	30.4	71.8	22.8	49.0	0.155	180.0							
2.25	SPT	Yell grey clayey silty fine to med sand with stones & sandy clay lumps	24	SC-SM	15.5							5.5	7.7	25.3	36.8	24.7	
3.00	SPT	Yellowish grey clayey silty fine to coarse sand with weathered stones		SC/SM	12.7							17.7	16.6	26.6	22.1	17.0	
4.80-5.80		Light brownish grey weathered closely jointed rock															
5.80-6.80		Light brown and grey widely jointed hard rock (siltstone)															



**TABLE 9 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 21 - M2**

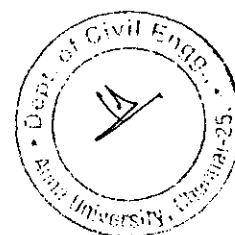
Project: **MIG Tenements, TNSCB Perumbakkam**

Borehole Nos: **BH21**

Type of Boring and dia of bore hole: **150mm diameter rotary boring with mud circulation**

Ground Water Table: **1.00m to 1.40m, March-April 2013**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH21</b>															
GL-0.50	DS	Yellowish grey medium stiff silty clay		CH	22.2	64.4	18.4	46.0	0.083	80.0							
0.75	SPT	Yellowish grey soft silty clay with yellow patches	2	CH	38.2	78.0	21.2	56.8	0.299	175.0							
1.50	SPT	TOP: Light grey soft silty clay with reddish brown patches BOT: Yellowish brown and grey sandy silty clay with gravel	7	SC/CI	60.6	47.6	16.4	31.2	0.099	68.4							
2.25	SPT	Yell grey clayey silty sand with sandy clay lumps and weathered stones	44	SC/SM	12.1							14.2	20.9	25.4	20.1	19.4	
3.00	SPT	Yell grey clayey silty sand with sandy clay lumps and weathered stones	49	SC/SM	15.5							14.5	21.2	22.7	18.4	23.2	
3.75	SPT	Yellowish grey clayey silty sand with weathered stones	>100		11.3												
5.50-6.50		Greyish weathered severely jointed rock															
6.50-7.50		Greyish weathered severely jointed rock															
7.50-8.50		Brownish and grey weathered closely jointed rock															



**TABLE 10 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 22 - M2**

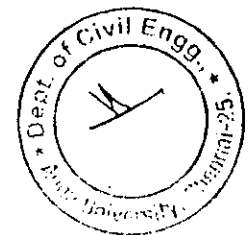
Project: MIG Tenements, TNSCB Perumbakkam

Borehole Nos: BH22

Type of Boring and dia of bore hole: 150mm diameter rotary boring with mud circulation

Ground Water Table: 1.00m to 1.40m, March-April 2013

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH22</b>															
0.50	DS	Yellowish grey silty clay		CH	20.4	66.8	20.8	46.0	<0.00	80.0							
0.75	SPT	Yellowish grey silty clay	3	CH	34.2	75.3	21.2	54.1	0.240	90.0							
1.50	SPT	Dark grey soft clay with reddish brown patches	0	CH	68.5	104.7	30.9	73.8	0.509	66.6							
2.75	SPT	Black organic sandy clay	0		42.6												
3.50	SPT	Dark greenish grey dirty fine to medium sand	17	SC/SM	17.8							3.9	13.8	38.4	23.8	20.1	
4.50	SPT	Dark brownish grey dirty fine to coarse sand with weathered stones	>100	SW/SP	14.6							21.2	25.5	32.2	11.6	9.5	
7.70-8.70		Brownish and grey highly weathered severely jointed rock															
8.70-9.70		Brownish and grey weathered closely jointed rock															

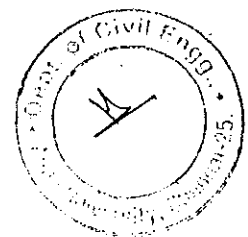


**TABLE 11 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 23 - M2**

Project: **MIG Tenements, TNSCB Perumbakkam**

Borehole Nos: **BH23**

Type of Boring and dia of bore hole: 150mm diameter rotary boring with mud circulation		Ground Water Table: 1.00m to 1.40m, March-April 2013															
Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH23</b>															
GL-0.50	DS	Yellowish grey silty clay		CH	26.7	64.2	20.8	43.4	0.136	90.0							
0.75	SPT	Light brownish grey soft silty clay with yellow patches	0	CH	54.6	93.2	24.9	68.3	0.435	53.8							
1.50	SPT	Light brownish grey very soft clay with yellow patches	0	CH	94.0	100.6	26.8	73.8	0.911								
2.25	SPT	Dark grey very soft silty clay with medium sand patches	0	CH	55.1	58.9	15.7	43.2	0.912	70.0							
3.00	SPT	TOP: Dark grey sandy clay with coarse particles MID: Decayed wood BOT: Dark greenish grey dirty fine to coarse sand weathered stones	3	SC	24.0							9.6	13.2	29.6	25.1		22.5
3.75	SPT	Dark yellowish grey dirty fine to coarse sand weathered stones	>100	SM	12.3							10.6	15.5	27.1	30.1		16.7
4.50	SPT	Dark yellowish grey dirty fine to coarse sand weathered stones	>100	SM/SP	11.7							13.5	15.3	29.9	27.4		13.9
6.30-7.30		Dark yellowish grey dirty fine to medium sand with weathered stones			13.4												
7.30-8.30		Brownish and grey weathered severely jointed rock Brownish and grey weathered severely jointed rock															



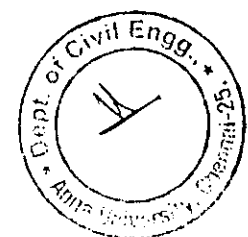


**TABLE 12 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 24 - M2**

Project: **MIG Tenements, TNSCB Perumbakkam**

Borehole Nos: **BH24**

Type of Boring and dia of bore hole: 150mm diameter rotary boring with mud circulation		Ground Water Table: 1.00m to 1.40m, March-April 2013															
Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LJ (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		<b>BOREHOLE BH24</b>															
GL-0.50	DS	Yellowish grey silty clay		CH	22.3	66.3	20.2	46.1	0.046	100.0							
0.75	SPT	Light brownish grey soft silty clay with few stones	0	CH	62.9	93.2	26.8	66.4	0.544	46.0							
1.50	UDS	TOP: Light brownish grey soft silty clay with few stones BOT: Light grey soft silty clay		CH	55.6	83.3	23.2	60.1	1.070	70.0							
2.00	SPT	TOP: Greyish soft silty clay BOT: Yellowish grey dirty fine to coarse sand with weathered stones	20	SC/SM	90.6							3.0	12.7	26.2	36.2		21.9
2.75	SPT	Yellowish grey highly weathered fractured rock	>100		16.6												
3.30-4.30		Light grey and light brown weathered severely jointed rock															
4.30-5.30		Light grey and light brown weathered severely jointed rock															



**TABLE 13 SHEAR STRENGTH PARAMETERS FOR DIFFERENT LAYERS – M2**  
 TNSCB, MIG, PERUMBAKKAM, Ground water table = 1.00m to 1.40m (March-April 2013)

**Borehole BH13 (GL = 1.688m RL)**

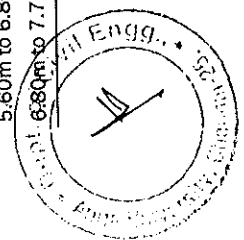
Depth Below GL	Soil	N	Design N'	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.30m	Yellowish grey silty clay with few stones, LI = 0.163	10	10		$c_u = 5.0 \text{ t/m}^2$	59	$m_v = 1/(42N)/\text{m}^2/\text{t}$
1.30m to 1.90m	Greyish brown sandy silty clay with stones, LI = 0.025	25	25		$c_u = 12 \text{ t/m}^2$	43	$m_v = 1/(44N)/\text{m}^2/\text{t}$
1.90m to 3.20m	Greyish brown clayey silty fine to coarse sand with sandy clay lumps	47	45	$\phi = 37^\circ$			C using $q_c = 26 \text{ N t/m}^2$
3.20m to 5.50m	Greyish brown dirty fine to coarse sand with weathered stones (weathered disintegrated rock)	>100	100	$\phi = 42^\circ$			C using $q_c = 30 \text{ N t/m}^2$
5.50m to 6.30m	Yellowish grey highly weathered fractured rock	RE	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
6.30m to 8.00m	Brownish grey highly / completely weathered severely jointed rock						
8.00m to 8.50m	Br grey highly weathered severely jointed rock						

**Borehole BH14 (GL = 1.451m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.40m	Yellowish grey silty clay with roots in the top 0.40m, LI = 0.129 to 0.141	5	5		$c_u = 3.0 \text{ t/m}^2$	61.3	$m_v = 1/(42N)/\text{m}^2/\text{t}$
1.40m to 2.20m	Yellowish grey silty clay with white stones and gravel, LI = 0.186	17	15		$c_u = 7.5 \text{ t/m}^2$	60.9	$m_v = 1/(42N)/\text{m}^2/\text{t}$
2.20m to 3.00m	Greyish brown clayey silty sand with sandy clay lumps & weathered stones	25	25	$\phi = 32^\circ$			C using $q_c = 22 \text{ N t/m}^2$
3.00m to 4.00m	Greyish brown dirty fine to coarse sand with weathered stones	82	70	$\phi = 40^\circ$			C using $q_c = 24 \text{ N t/m}^2$
4.00m to 5.00m	Brownish grey dirty fine to coarse sand with weathered stones	>100	100	$\phi = 42^\circ$			C using $q_c = 26 \text{ N t/m}^2$
5.00m to 5.70m	Greyish brown highly weathered fractured rock	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
5.70m to 8.20m	Greyish brown highly weathered severely jointed rock						
8.20m to 9.00m	Brownish grey highly weathered closely jointed rock (Granitic gneiss)						

**Borehole BH15 (GL = 1.339m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.50m	Brownish grey silty clay with roots	8	8		$c_u = 5.0 \text{ t/m}^2$	63.0	$m_v = 1/(42N)/\text{m}^2/\text{t}$
0.50m to 1.70m	Yellowish grey silty clay, LI=0.145 to 0.156	21	20	$\phi = 32.0^\circ$			C using $q_c = 24 \text{ N t/m}^2$
1.70m to 2.30m	Greyish brown clayey silty sand with weathered stones	84 to >100	80	$\phi = 41^\circ$			C using $q_c = 26 \text{ N t/m}^2$
2.30m to 3.20m	Yellowish grey dirty fine to coarse sand with sandy clay lumps	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
3.20m to 5.60m	Brownish grey highly weathered fractured rock						
5.60m to 6.80m	Brownish grey completely weathered severely jointed rock						
6.80m to 7.70m	Greyish party weathered jointed rock (granitic gneiss)						



**Borehole BH16 (GL = 1.240m RL)**

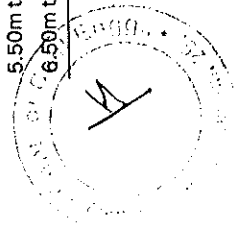
Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $C_u$	PI %	Compressibility
0.00m to 0.50m	Yellowish grey silty clay (dry)	10,19	12		$C_u = 6.0 \text{ t/m}^2$	63.0	$m_v = 1/(42N)/m^2/t$
0.50m to 2.10m	Yellowish grey and brown silty clay with few stones, LI = 0.145 to 0.156	41	40	$\phi = 37^\circ$			C using $q_c = 24 \text{ N t/m}^2$
2.10m to 3.00m	Yellowish grey clayey silty sand with sandy clay lumps	82	80	$\phi = 40^\circ$			C using $q_c = 26 \text{ N t/m}^2$
3.00m to 3.80m	Brownish grey dirty fine to medium sand with sandy clay lumps	>100	100	$\phi = 42^\circ$			C using $q_c = 30 \text{ N t/m}^2$
3.80m to 4.70m	Greyish dirty fine to coarse sand with weathered stones (wdr)	RB	200		$C_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
4.70m to 5.80m	Brownish grey highly weathered fractured rock						
5.80m to 8.10m	Yellowish grey highly / completely weathered calcareous sandstone						
8.10m to 9.20m	Brownish grey dirty fine to coarse sand with weathered stones						
9.20m to 10.20m	Greyish partly weathered and severely jointed rock						

**Borehole BH17 (GL = 1.492m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $C_u$	PI %	Compressibility
0.00m to 0.50m	Brownish grey silty clay with sand	0	1		$C_u = 0.75 \text{ t/m}^2$	68.8	
0.50m to 1.40m	Brownish grey soft silty clay, LI = 0.528	0	1		$C_u = 0.75 \text{ t/m}^2$	51.5	
1.40m to 2.30m	Dark grey soft silty clay with gravel and organic material, LI = 0.563	38	36	$\phi = 35^\circ$			C using $q_c = 24 \text{ N t/m}^2$
2.30m to 3.20m	Greyish clayey silty fine to coarse sand with weathered stones	41, >100	50	$\phi = 38^\circ$			C using $q_c = 24 \text{ N t/m}^2$
3.20m to 4.20m	Brownish grey clayey silty fine to coarse sand with weathered stones	RB	200		$C_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
4.20m to 6.00m	Dark greenish grey completely weathered fractured rock						
6.00m to 7.00m	Yellowish grey highly weathered severely jointed rock						

**Borehole BH18 (GL = 1.409m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $C_u$	PI %	Compressibility
0.00m to 0.50m	Yellowish grey silty clay with black patches	2	3		$C_u = 1.5 \text{ t/m}^2$	52.5	$m_v = 1/(42N)/m^2/t$
0.50m to 1.40m	Brownish grey silty clay with reddish brown patches, LI = 0.314	8	8		$C_u = 4.0 \text{ t/m}^2$	50.0	C using $q_c = 22 \text{ N t/m}^2$
1.40m to 2.00m	Yellowish grey and brownish silty clay, LI = 0.162	24	24	$\phi = 32^\circ$			C using $q_c = 26 \text{ N t/m}^2$
2.00m to 2.90m	Brownish clayey silty fine to medium sand / sandy silty clay	74	70	$\phi = 40^\circ$			C using $q_c = 26 \text{ N t/m}^2$
2.90m to 3.70m	Greyish brown dirty fine to coarse sand with weathered stones	>100	100	$\phi = 42^\circ$			C using $q_c = 26 \text{ N t/m}^2$
3.70m to 4.50m	Yell grey clayey silty fine to coarse sand with weathered stones (wdr)	RB	200		$C_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
4.50m to 5.50m	Yellowish grey highly / completely weathered fractured rock						
5.50m to 6.50m	Greyish brown & grey completely weathered severely jointed rock						
6.50m to 8.50m	Brownish and grey highly weathered severely jointed rock						



**Borehole BH19 (GL = 1.409m RL)**

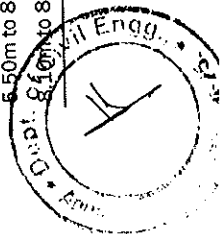
Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.60m	Br grey silty clay with brown & black patches, LI = 0.215	2	2		$c_u = 1.0 \text{ t/m}^2$	45.5	
0.60m to 1.40m	Yellowish grey soft silty clay with reddish brown patches, LI = 0.45	0	1		$c_u = 0.75 \text{ t/m}^2$	44.7	
1.40m to 2.40m	Greyish soft silty clay with reddish brown patches, LI = 0.762	31, 44	32	$\phi = 34^\circ$		28.1	C using $q_c = 24 \text{ N t/m}^2$
2.40m to 4.00m	Brownish grey dirty fine to coarse sand weathered stones	>100	100	$\phi = 42^\circ$			C using $q_c = 28 \text{ N t/m}^2$
4.00m to 5.50m	Brownish grey completely weathered / highly weathered fractured rock	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
5.50m to 6.70m	Brownish highly weathered severely jointed rock (siltstone)						
6.70m to 7.50m	Light brownish and light grey widely jointed hard rock (siltstone)						

**Borehole BH20 (GL = 1.250m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.60m	Yellowish grey silty clay, LI = 0.249	0	1		$c_u = 0.75 \text{ t/m}^2$	42.9	
0.60m to 1.40m	Light grey very soft silty clay with reddish brown patches, LI = 0.431	10	10		$c_u = 5.0 \text{ t/m}^2$	48.0	$m_v = 1/(42 \text{ N}) \text{ m}^2/\text{t}$
1.40m to 2.60m	Brownish grey silty clay with gravel and sand, LI = 0.155	>50	60	$\phi = 38^\circ$		49.0	C using $q_c = 26 \text{ N t/m}^2$
2.60m to 3.40m	Yellowish grey clayey silty fine to coarse sand with weathered stones	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
3.40m to 4.80m	Yellowish grey completely / highly weathered fractured rock						
4.80m to 6.20m	Light brownish grey weathered closely jointed rock						
6.20m to 7.10m	Light brown and grey widely jointed hard rock (siltstone)						

**Borehole BH21 (GL = 1.354m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.60m	Yellowish grey medium stiff silty clay, LI = 0.083	2	2		$c_u = 1.5 \text{ t/m}^2$	46	
0.60m to 1.40m	Yellowish grey soft silty clay with yellow patches, LI = 0.299	7	7		$c_u = 3.5 \text{ t/m}^2$	56.8	
1.40m to 1.90m	Lt grey soft silty clay with reddish brown patches		12		$c_u = 6.0 \text{ t/m}^2$	31.2	$m_v = 1/(48 \text{ N}) \text{ m}^2/\text{t}$
1.90m to 2.30m	Yell brown and grey sandy silty clay with gravel, LI = 0.099	44, 49	45	$\phi = 37^\circ$			C using $q_c = 24 \text{ N t/m}^2$
2.30m to 4.00m	Yell grey clayey silty sand with sandy clay lumps and weathered stones	>100	100	$\phi = 42^\circ$			C using $q_c = 28 \text{ N t/m}^2$
4.00m to 4.50m	Yellowish grey dirty fine to coarse sand	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
4.50m to 5.50m	Yellowish grey highly weathered fractured rock						
5.50m to 8.10m	Greyish weathered severely jointed rock						
8.10m to 8.50m	Brownish & grey weathered closely jointed rock						



**Borehole BH22 (GL = 1.267m RL)**

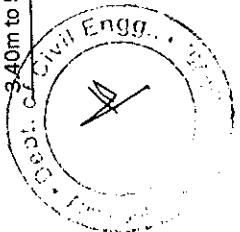
Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.30m	Yellowish grey silty clay, LI = 0.24	3	3		$c_u = 1.5 \text{ t/m}^2$	54.1	
1.30m to 2.60m	Dark grey soft clay with reddish brown patches, LI = 0.509	0	1		$c_u = 0.75 \text{ t/m}^2$	73.8	
2.60m to 3.40m	Black organic sandy clay	0	1		$c_u = 0.75 \text{ t/m}^2$		
3.40m to 4.00m	Dark greenish grey dirty fine to medium sand	17	18	$\phi = 32^\circ$			C using $q_c = 22 \text{ N t/m}^2$
4.00m to 4.80m	Dark brownish grey dirty fine to coarse sand with weathered stones	>50	60	$\phi = 38^\circ$			C using $q_c = 28 \text{ N t/m}^2$
4.80m to 5.60m	Brownish grey dirty fine to coarse sand with weathered stones	>100	100	$\phi = 42^\circ$			C using $q_c = 30 \text{ N t/m}^2$
5.60m to 6.70m	Brownish grey highly weathered fractured rock	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
6.70m to 9.10m	Brownish and grey highly weathered severely jointed rock						
9.10m to 9.70m	Br and grey weathered closely jointed rock						

**Borehole BH23 (GL = 1.200m RL)**

Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.60m	Yellowish grey silty clay, LI=0.136	0	1		$c_u = 0.75 \text{ t/m}^2$	43.4	
0.60m to 2.20m	Light brownish grey soft silty clay with yellow patches, LI = 0.435 to 0.911	0, 3	2		$c_u = 1.0 \text{ t/m}^2$	68-74	
2.20m to 3.50m	Dark grey very soft silty clay with medium sand patches and decayed wood	100	75	$\phi = 40^\circ$		43.2	C using $q_c = 28 \text{ N t/m}^2$
3.50m to 4.60m	Dark yellowish grey dirty fine to coarse sand weathered stones	>100, RB	150		$c_u = 75 \text{ t/m}^2$		C using $q_c = 30 \text{ N t/m}^2$
4.60m to 5.50m	Dark yellowish grey completely weathered fractured rock	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
5.50m to 6.30m	Yellowish grey highly weathered fractured rock						
6.30m to 8.30m	Brownish and grey weathered severely jointed rock						

**Borehole BH24 (GL = 1.295m RL)**

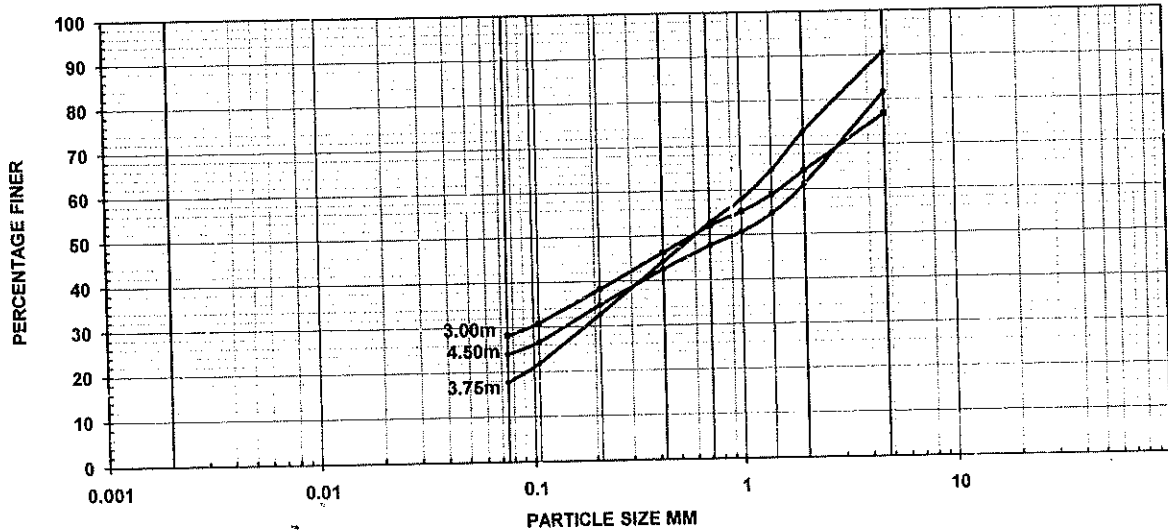
Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.50m	Yellowish grey silty clay, LI = 0.046	0	1		$c_u = 0.75 \text{ t/m}^2$	46.1	
0.50m to 1.80m	Light brownish grey soft silty clay with few stones, LI = 0.544	0	1		$c_u = 0.50 \text{ t/m}^2$	66.4	
1.80m to 2.40m	Light grey soft silty clay, LI = 1.07	>50	60	$\phi = 38^\circ$		60.1	C using $q_c = 26 \text{ N t/m}^2$
2.40m to 2.80m	Yell grey dirty fine to coarse sand with w. stones	RB	200		$c_u = 100 \text{ t/m}^2$		C using $q_c = 35 \text{ N t/m}^2$
2.80m to 3.40m	Yellowish grey highly weathered fractured rock						
3.40m to 5.40m	Light grey and light brown weathered severely jointed rock						



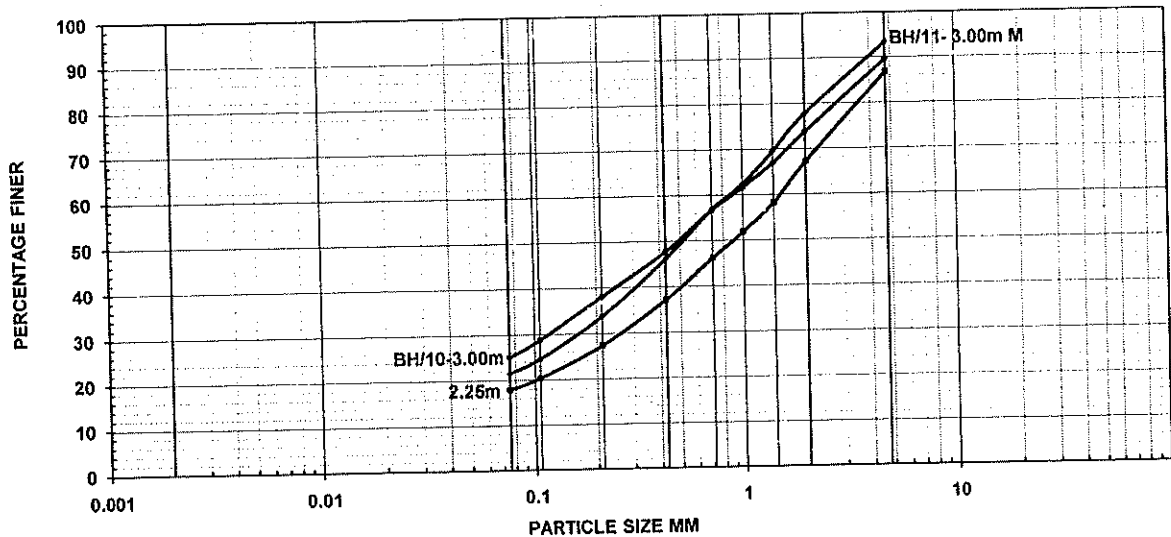
# ANNEXURE G1

## GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Residential Building, Mogapair

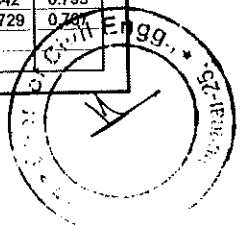


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/9	3.00m	100.0	78.9	64.3	46.3	28.2			23.1	12.6	18.0	18.1	29.2		GCS	0.528	14.684	0.860
BH/9	3.75m	100.0	90.8	73.1	44.3	17.7			9.2	17.7	28.8	26.6	17.7		GC-SP	0.597	11.381	0.670
BH/9	4.50m	100.0	81.8	61.3	42.6	24.0			18.2	20.5	18.7	18.6	24.0		GC-SW	0.921	14.936	1.086



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/10	2.25m	100.0	86.9	67.2	37.2	17.9			13.1	19.7	30.0	19.3	17.9		GC-SP	0.892	10.701	0.890
BH/10	3.00m	100.0	93.5	77.8	48.1	21.5			6.5	15.7	31.7	24.6	21.5		SC-SP	0.512	8.842	0.795
BH/11	3.00m	100.0	89.7	73.8	47.7	25.0			10.3	15.9	28.1	22.7	25.0		GCS	0.485	11.729	0.787

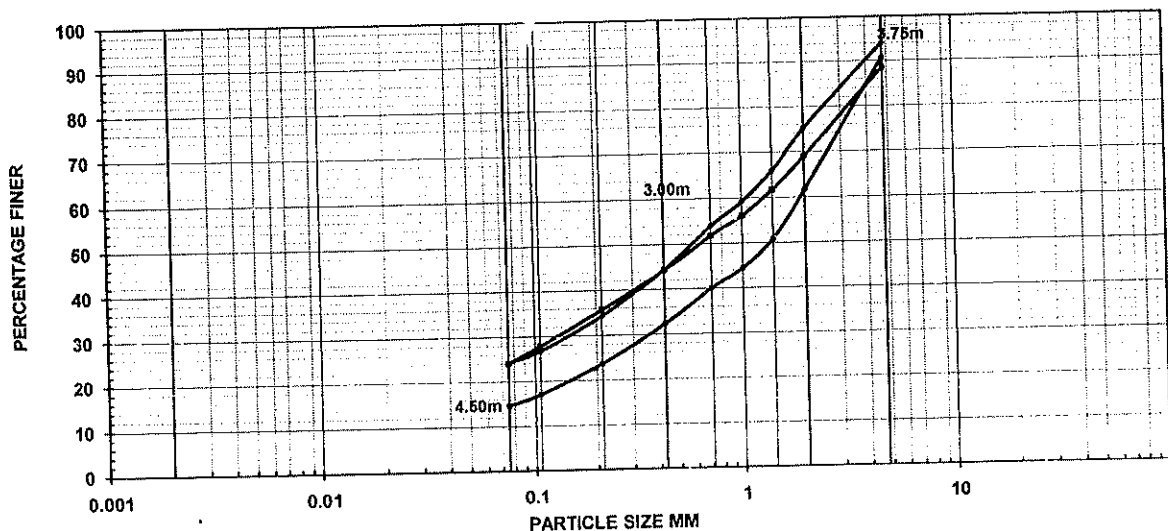
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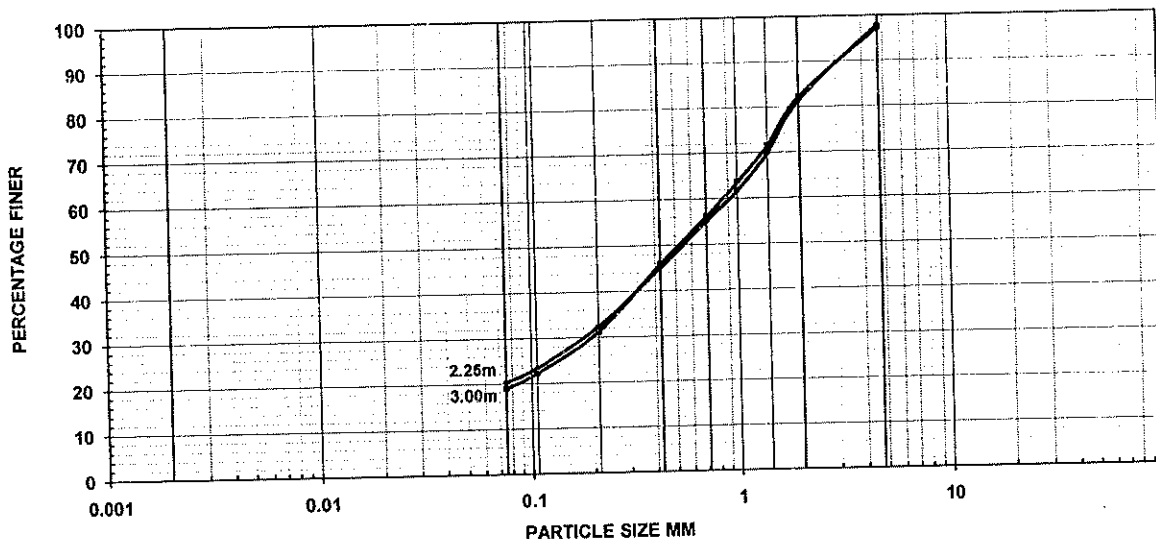
# ANNEXURE G2

## GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Residential Building, Mogapair

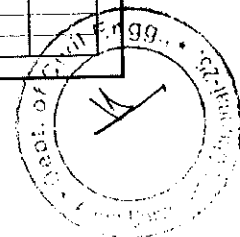


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/12	3.00m	100.0	88.5	69.0	44.3	24.0		11.5	19.5	24.7	20.3		24.0	GCS	0.528	13.751	0.845	
BH/12	3.75m	100.0	94.0	75.2	44.4	24.2		6.0	18.8	30.8	20.2		24.2	SC-SP	0.575	9.605	0.871	
BH/12	4.50m	100.0	90.7	61.7	32.4	14.6		9.3	29.0	29.3	17.8		14.6	GC-SW	1.335	10.975	1.169	



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/13	2.25m	100.0	97.3	82.2	45.9	19.0		2.7	15.1	36.3	26.9		19.0	SC-SP	0.521	7.669	0.770	
BH/13	3.00m	100.0	98.0	81.4	45.1	20.4		2.0	16.6	36.3	24.7		20.4	SC-SP	0.545	8.359	0.819	

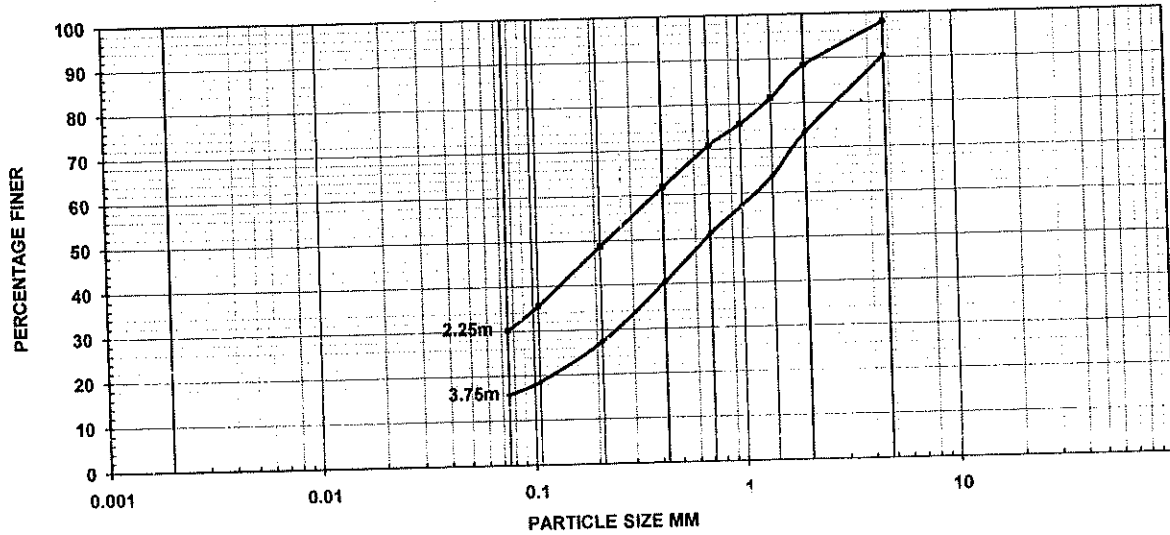
GEOTECHNICAL Solutions, Chennai



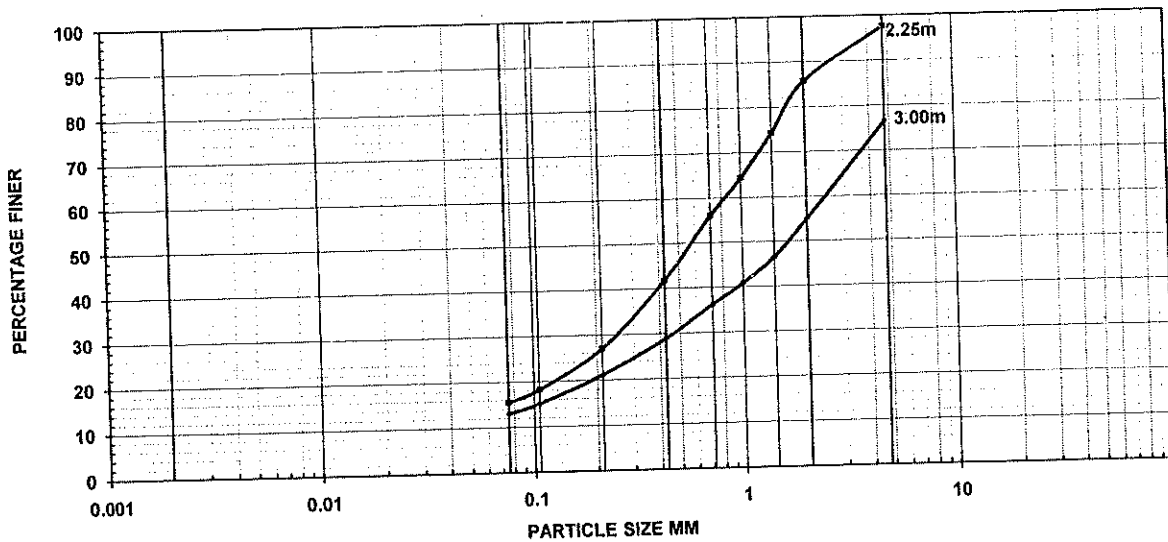
# ANNEXURE G3

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: MIG, Perambakkam

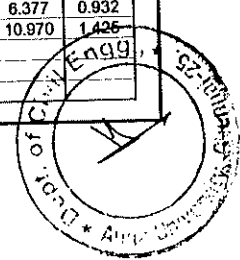


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C	CLASS			
BH/14	2.25m	100.0	98.0	88.5	61.8	30.2		2.0	9.5	26.7	31.6		30.2	SC-SP	0.226	6.717	0.648	
BH/14	3.75m	100.0	90.5	73.5	40.5	15.8		9.5	17.0	33.0	24.7		15.8	GC-SP	0.670	9.308	0.752	



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C	CLASS			
BH/15	2.25m	100.0	97.6	85.8	41.8	15.5		2.4	11.8	44.0	26.3		15.5	SC-SP	0.572	6.377	0.932	
BH/15	3.00m	100.0	76.6	55.0	28.9	13.0		23.4	21.6	28.1	15.9		13.0	GC-SW	1.617	10.970	1.426	

GEOTECHNICAL Solutions, Chennai

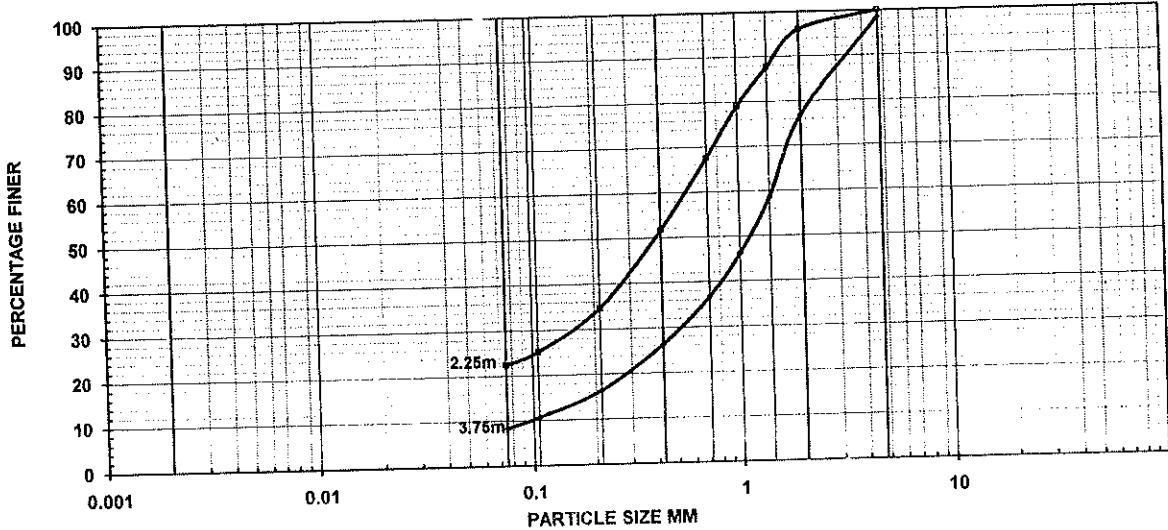




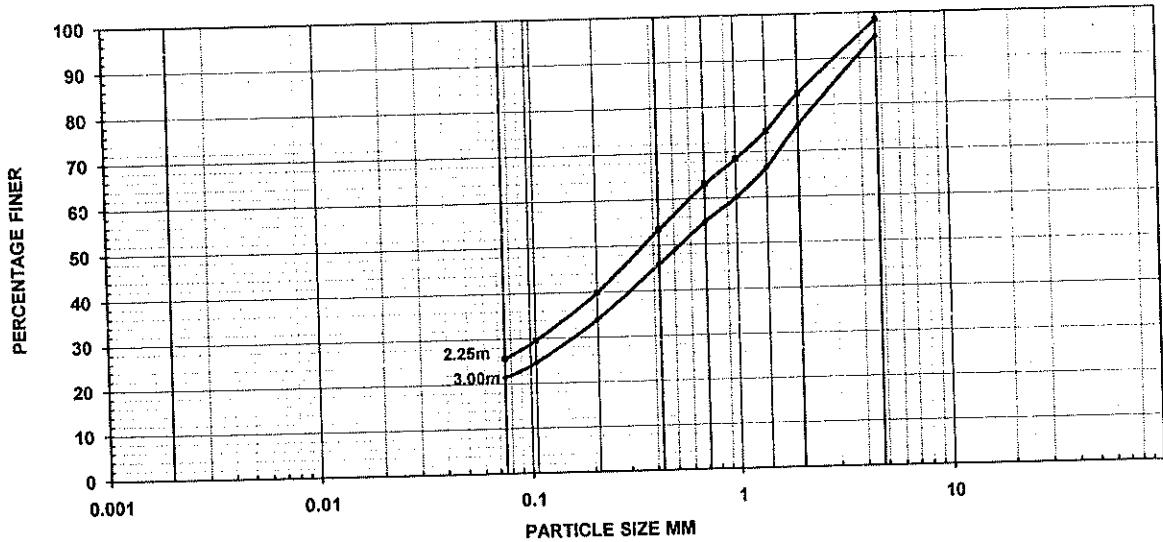
# ANNEXURE G4

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: MIG, Perambakkam

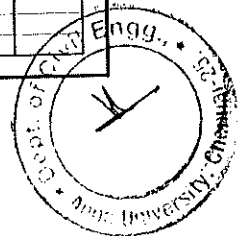


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel G	Coarse Sand CS	Medium Sand MS	Fine Sand FS	Silt Si	Clay C	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0										
BH/16	2.25m	100.0	100.0	96.1	51.7	22.5			3.9	44.4	29.2		22.5	SC-SP	0.397	4.813	0.978	
BH/16	3.75m	100.0	98.5	76.9	26.4	8.3		1.5	21.6	50.5	18.1	8.3	SW	1.107	6.720	1.316		



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel G	Coarse Sand CS	Medium Sand MS	Fine Sand FS	Silt Si	Clay C	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0										
BH/17	2.25m	100.0	98.4	82.6	53.4	25.7		1.6	15.8	29.2	27.7		25.7	SC-SP	0.357	8.152	0.696	
BH/17	3.00m	100.0	94.9	75.8	46.0	21.4		5.1	19.1	29.8	24.6	21.4	SC-CP	0.533	10.144	0.714		

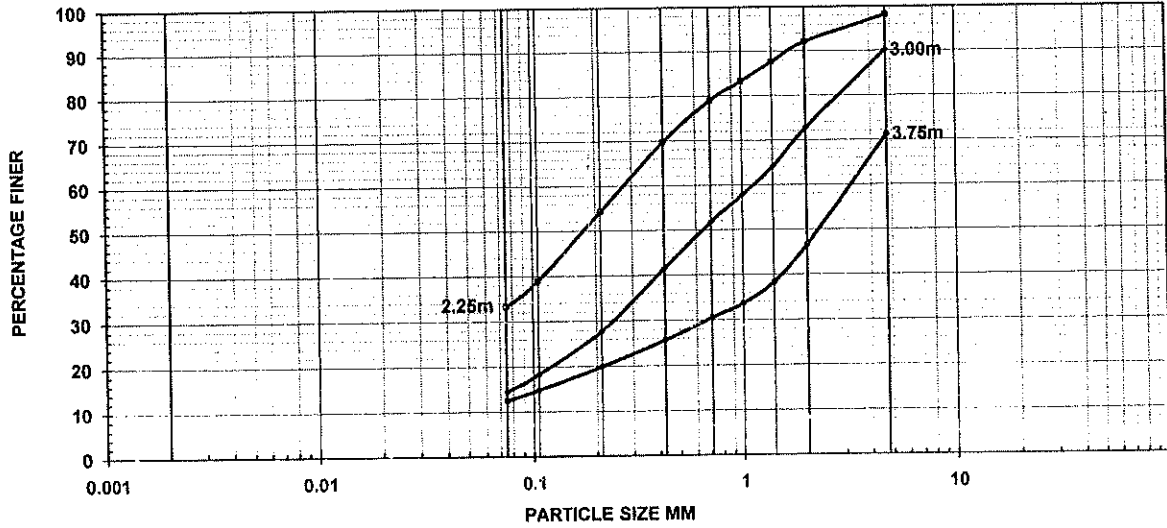
GEOTECHNICAL Solutions, Chennai



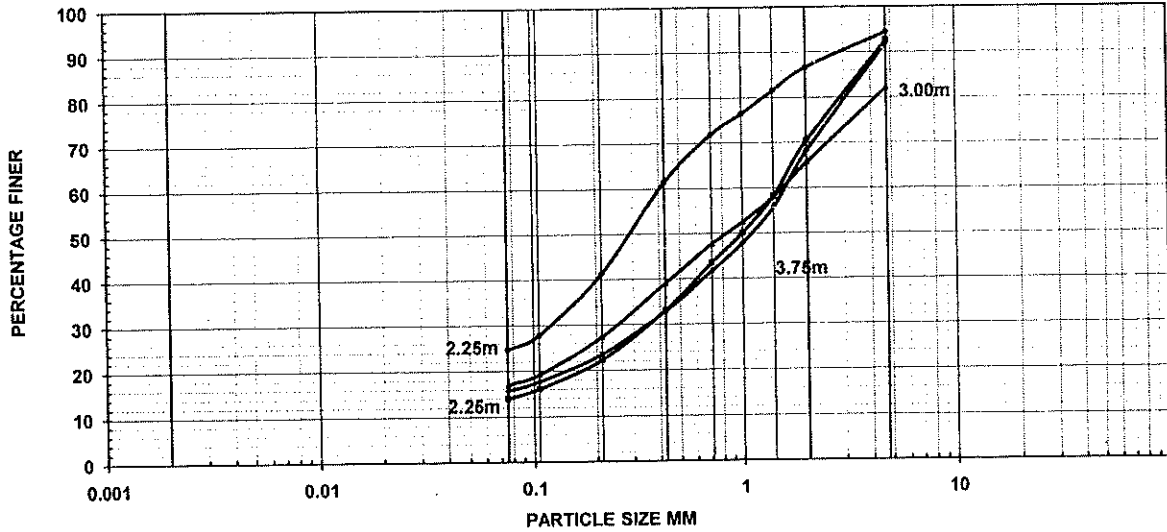
# ANNEXURE G5

## GRAIN SIZE DISTRIBUTION CURVES

PROJECT: MIG, Perambakkam

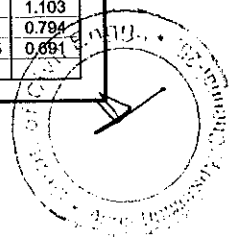


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)								Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C	CLASS				
BH/18	2.25m	100.0	98.2	92.1	69.8	33.3			1.8	6.1	22.3	38.5		33.3		SC-SP	0.175	4.668	0.717
BH/18	3.00m	100.0	90.3	72.8	41.6	14.5			9.7	17.5	31.2	27.1		14.5		GC-SP	0.646	10.048	0.696
BH/18	3.75m	100.0	71.3	46.7	25.7	12.6			28.7	24.6	21.0	13.1		12.6		GS-SW	2.246	10.706	3.046



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)								Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C	CLASS				
BH/19	2.25m	100.0	92.7	70.6	33.1	14.0			7.3	22.2	37.4	19.1		14.0		SC-SW	0.995	8.088	0.934
BH/19	3.75m	100.0	92.1	68.3	32.9	15.7			7.9	23.8	35.4	17.2		15.7		SC-SW	1.092	8.554	1.103
BH/20	2.25m	100.0	94.5	86.8	61.5	24.7			5.5	7.7	25.3	36.8		24.7		SC-SP	0.286	4.828	0.794
BH/20	3.00m	100.0	82.3	65.7	39.1	17.0			17.7	16.6	26.6	22.1		17.0		GC-SP	0.837	11.585	0.691

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# ANNEXURE U1

## Unconfined Compression Strength Test UCC on soil sample

**Project:**

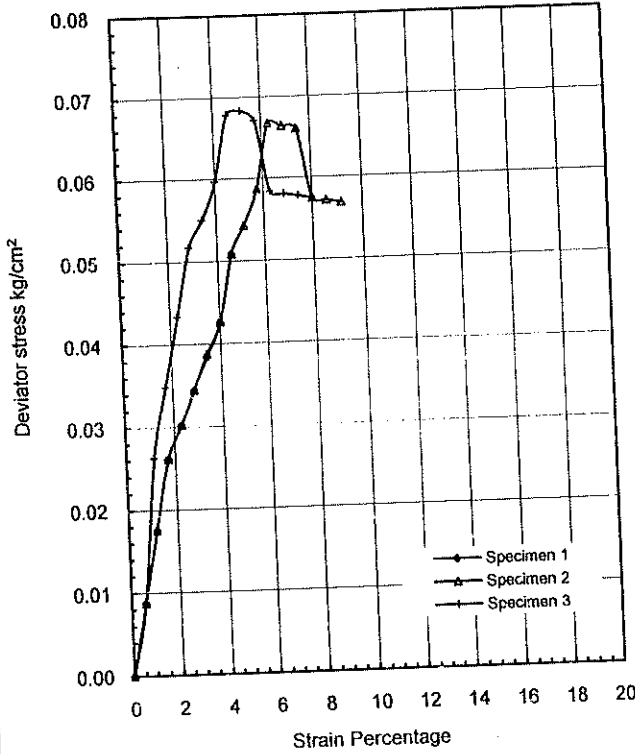
**MIG Perambakkam, M Block**

Date of Test **27-Mar-13**  
 Borehole **BH/24**  
 Depth **1.50m**

**Soil**

**Light yellowish grey silty clay with brown patches**

In situ bulk density **1.460 gm/cc**  
 In situ Dry Density **0.786 gm/cc**  
 Water Content **85.69 %**  
 Liquid Limit % **83.30**  
 Plastic Limit % **23.20**  
 Plasticity Index % **60.10**  
 Liquidity Index **1.04**

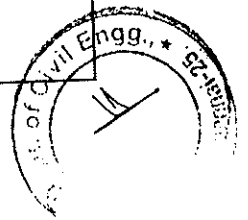
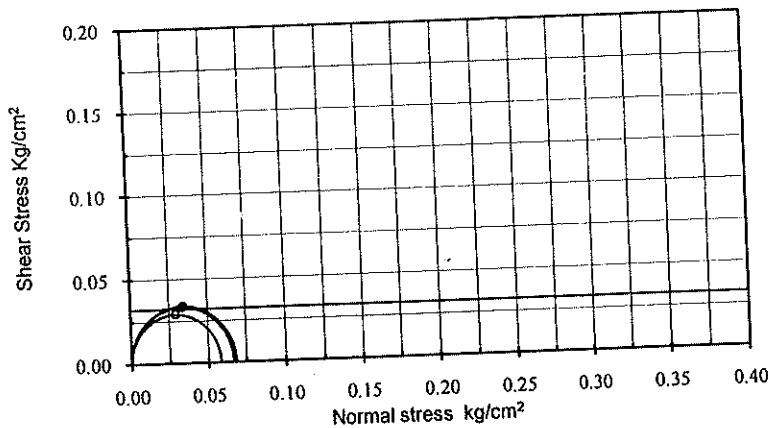


**Maximum Shear Stress**

Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.058	0.029
Specimen 2	0.067	0.033
Specimen 3	0.068	0.034

**Results**

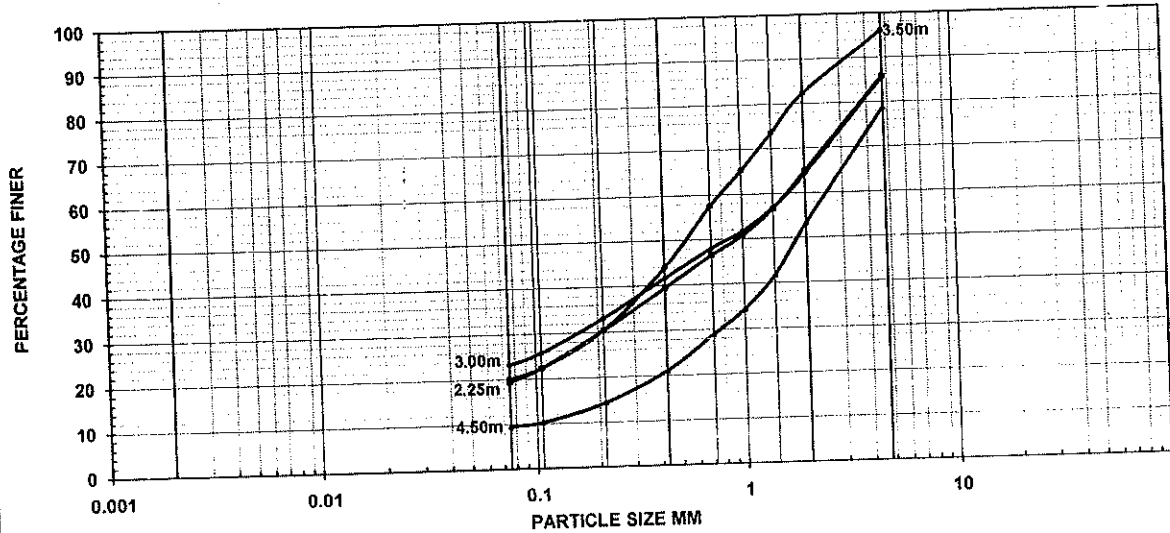
Unconfined compression strength  $q_u$  **0.064 kg/cm<sup>2</sup>**  
 Undrained Cohesion  $c_u$  **0.032 kg/cm<sup>2</sup>**  
 Secant Modulus (undrained) **1.61 kg/cm<sup>2</sup>**



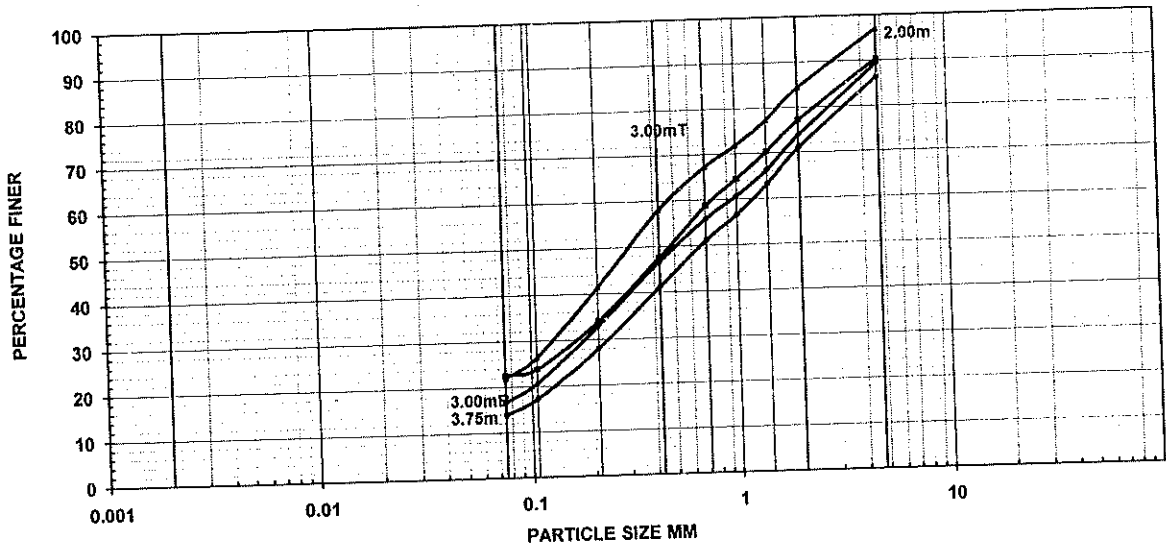
# ANNEXURE G6

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: MIG, Perambakkam



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)								Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		M	80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/21	2.25m		100.0	85.0	64.9	39.5	19.4		14.2	20.9	25.4	20.1		19.4	GCS	0.938	13.022	0.929	
BH/21	3.00m		100.0	85.5	64.3	41.6	23.2		14.5	21.2	22.7	18.4		23.2	GCS	0.854	13.104	0.978	
BH/22	3.50m		100.0	96.1	82.3	43.9	20.1		3.9	13.8	38.4	23.8		20.1	SC-SP	0.535	6.431	0.940	
BH/22	4.50m		100.0	78.8	53.3	21.1	9.5		21.2	25.5	32.2	11.6		9.5	GSW	1.807	7.420	1.547	



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)								Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		M	80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/23	3.00mT		100.0	90.4	77.2	47.6	22.5		9.6	13.2	29.6	25.1		22.5	SC	0.474	7.887	0.704	
BH/23	3.00mB		100.0	89.4	73.9	46.8	16.7		10.6	15.5	27.1	30.1		16.7	GC-SP	0.509	10.486	0.582	
BH/23	3.75m		100.0	86.5	71.2	41.3	13.9		13.5	15.3	29.9	27.4		13.9	GC-SP	0.667	10.502	0.665	
BH/24	2.00m		100.0	97.0	84.3	58.1	21.9		3.0	12.7	26.2	36.2		21.9	SC-SP	0.303	6.383	0.835	

GEOTECHNICAL Solutions, Chennai

# ANNEXURE CS1

## Unconfined Compressive Strength Test on Rock Core Sample

Project:  
TNSCB, MIG, Perambakkam

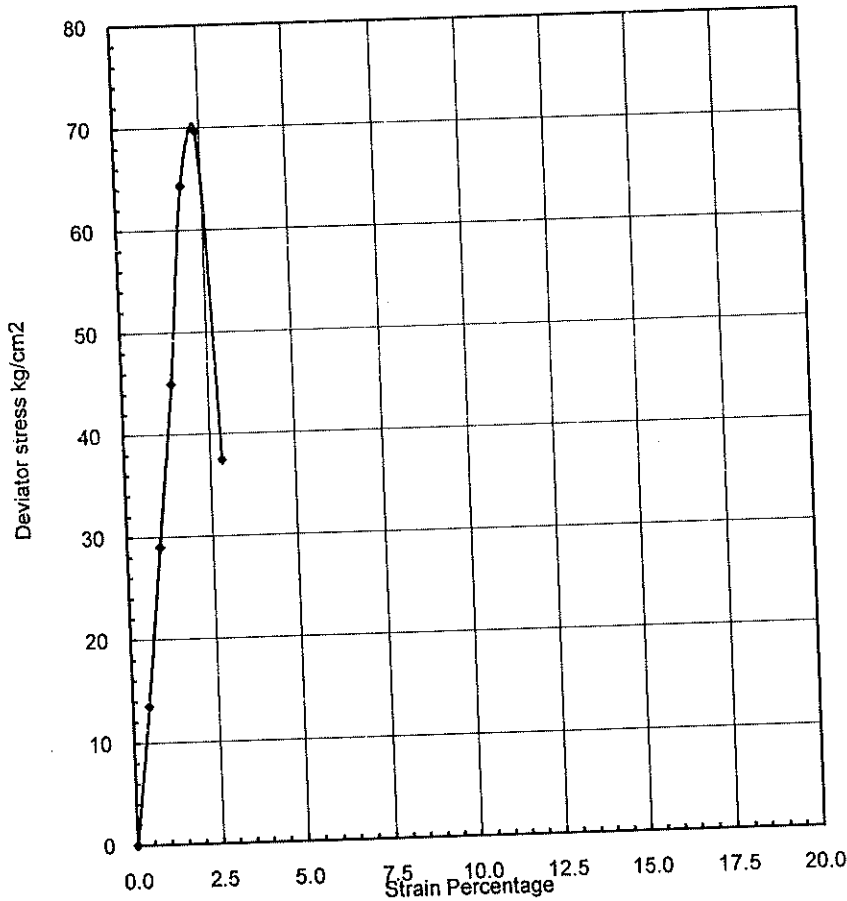
Date of Test            12-Apr-13  
Borehole                BH/19  
Depth                    6.50m to 7.50m (S2)

Description  
Light brown and light grey rock

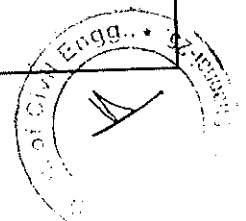
Insitu bulk density            2.758 gm/cc  
Insitu Dry Density            2.642 gm/cc  
Water Content                4.41 %

### Maximum Shear Stress

Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.0	70.0



Results	
Unconfined compression strength $q_u$	70.0 kg/cm <sup>2</sup>
Young's Modulus (secant)	3145 kg/cm <sup>2</sup>



# ANNEXURE CS2

## Unconfined Compressive Strength Test on Rock Core Sample

**Project:**  
TNSCB, MIG, Perambakkam

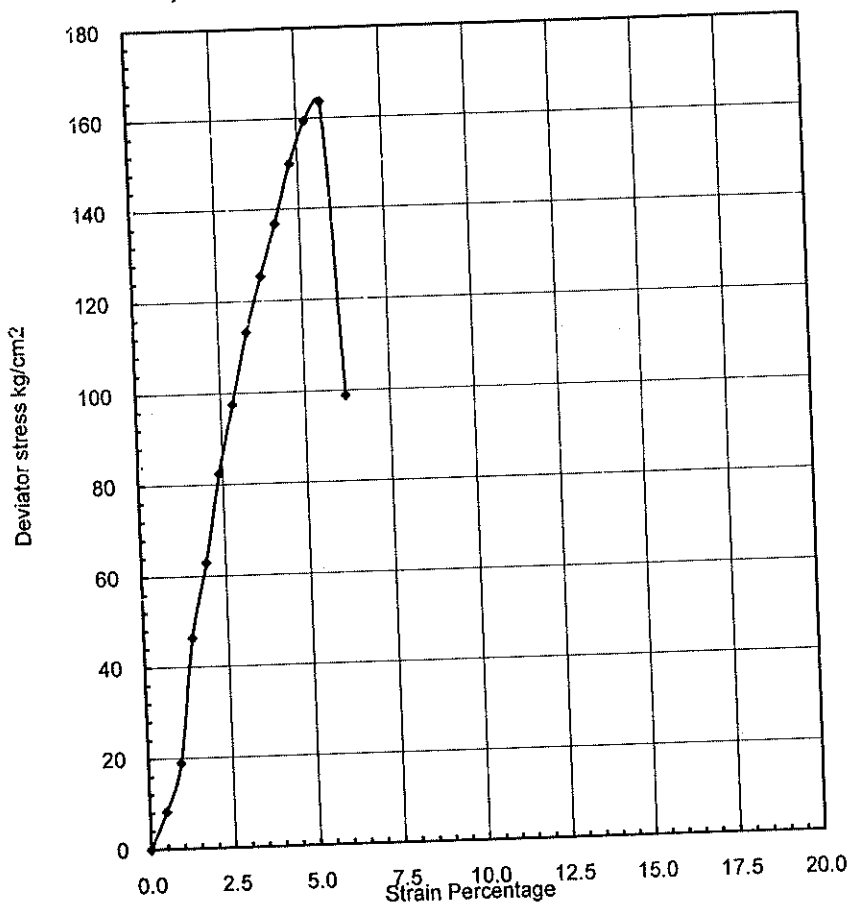
Date of Test            12-Apr-13  
Borehole                BH/20  
Depth                    5.80m to 6.80m (S1)

Description  
Light brown and light grey rock

Insitu bulk density            2.477 gm/cc  
Insitu Dry Density            2.441 gm/cc  
Water Content                1.48 %

**Maximum Shear Stress**

Specimen No:	Deviator stress	Shear stress kg/cm <sup>2</sup>
Specimen 1	0.0	164.0



<b>Results</b>	
Unconfined compression strength $q_u$	164.0 kg/cm <sup>2</sup>
Young's Modulus (secant)	3242 kg/cm <sup>2</sup>

