

**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.**

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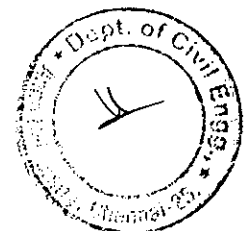
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**1. Introduction**

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

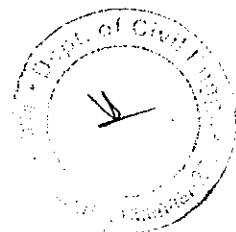


towards western direction from OMR. A road of 18m wide is connecting this village with OMR. On the Southern side of this road and adjacent to existing TNSCB scheme at Semmencherry, the Executive Engineer (Div VI) of TNSCB executed similar project over an area of 30 Acres covering S.Nos: 542 to 544 during 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:

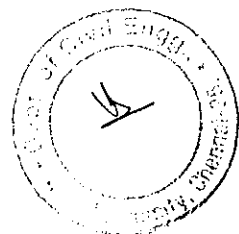
Zone	Number of Blocks	Boreholes
M1	M1 to M6	BH1 to BH12
M2	M7 to M12	BH13 to BH24
H	H1 to H4	BH1 to BH12

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.

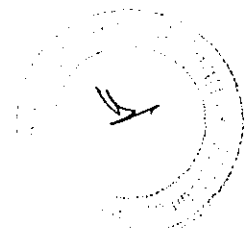
The structure is nine storeyed building and the area of construction is located within 20km distance from Chennai. The Chennai and its neighboring areas is coming under Zone III, hence the structure of this area is to be designed for Zone III conditions. Moreover in the recent past Chennai has experienced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

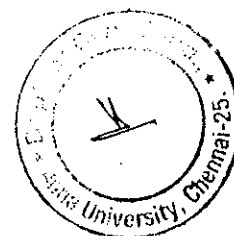
Perumbakkam area has experienced fast development within a period of four years. The land of Perumbakkam area covering survey numbers as per the key plan (Fig. 1a) was occupied by the local people of the area. This entire area was covered with thatched roof houses, semi permanent and permanent buildings. 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.

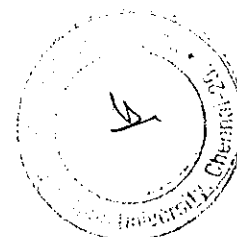
#### 4. Site condition

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

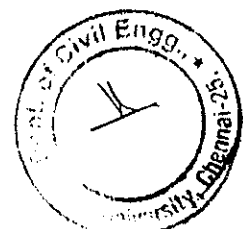
At Zone 'M2' soil investigation was carried out at 12 locations as shown in Fig.1b. It can also be seen that the locations of various blocks. The details of borehole locations and the ground level at each location are presented below:

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 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. 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.

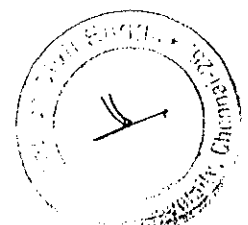
## 6. Soil profile of the proposed site

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

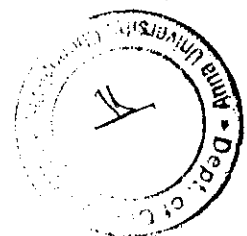
The block M7 is located on the northwest corner of the Zone M2. At the block M7 two exploratory boreholes (BH13&BH14) were made by locating them diagonally opposite to each other in the northwest and southeast corners of the block. At these two boreholes exploration was done to a depth of 8.3m and 8.7m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

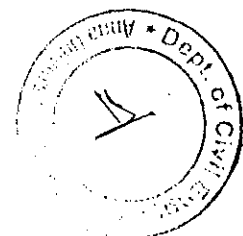
### **Block M8**

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.

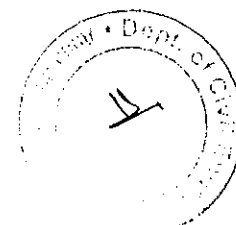


Top layer is silty clay and its thickness is approximately 2.3m at BH17. In this clay layer liquid limit value is more than 58% and FSI values are also more than 55%. These values confirm that the clay layer is active and is susceptible for volume change due to seasonal moisture variation. The N values 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.



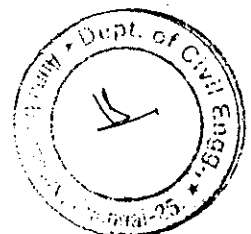
The laboratory test results of samples of clay layer and clayey sand layer are presented in Table 7. The liquid and plastic limits of clay are in the range between 42% and 65% and 13% and 20% respectively. The samples also recorded FSI values more than 70%. Thus clay fines are active and plastic and 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.

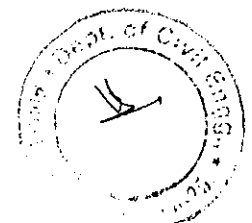
The soil profile logged at BH22 (Fig.11) is almost identical to that of BH21. Top layer is soft clay of 2.6m thick with N value less than 3. This layer is underlain by



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

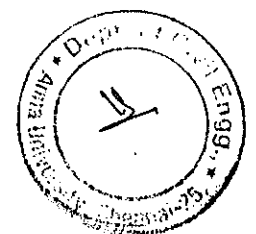


this deposit. The rock layer that lies below the sand is highly weathered till the depth of 6.3m. However the degree of weathering in rock layer is reduced with depth and core recovery of 8% to 12% is obtained in the rock between the depth of 6.3m and 8.3m.

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



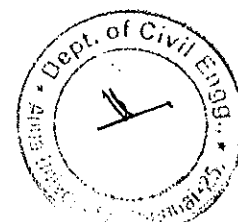


favorable for isolated footing. Moreover excavation of this layer in presence of water or below the water table will create a problem to locate the foundation in this layer provided the water table is reduced well below so that the soil is not losing its strength and provides good environment for construction.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

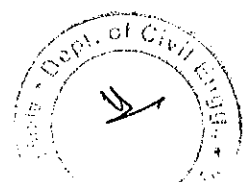
In the absence of consolidation test results, the compressibility parameter,  $m_v$  ( $=1/E$ ) of clay deposit of Zone M2 is obtained from the chart of Stroud (1975) which accounts for the plasticity of clay fines and the value is based on  $N_{60}$  value and is equal to  $1/F N_{60}$  ( $m^2/kN$ ). 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



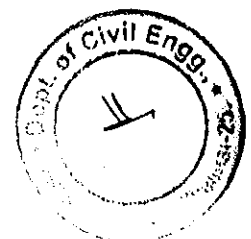
mixed with organic soil, but this layer is at shallow depth; hence foundation can be located below this layer.

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

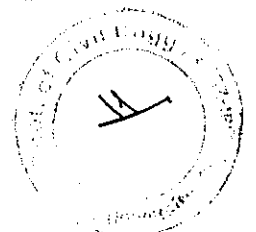
From the comparison made it is clear that foundations are to be located below the water table. The water table level reported is obtained from the borehole during investigation; there is a possibility for variation in the water table level. Therefore it is suggested to ascertain the water table level 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

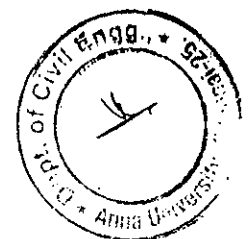
1. The top soil to the depth of 3.0m is poor and highly swelling (expansive) hence does not suitable for any construction or filling work.
2. The maximum depth of occurrence of water table in zone M2 is  $+0.009\text{m}$  (RL) and the soil at this depth is clayey at most of the location hence excavation 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.

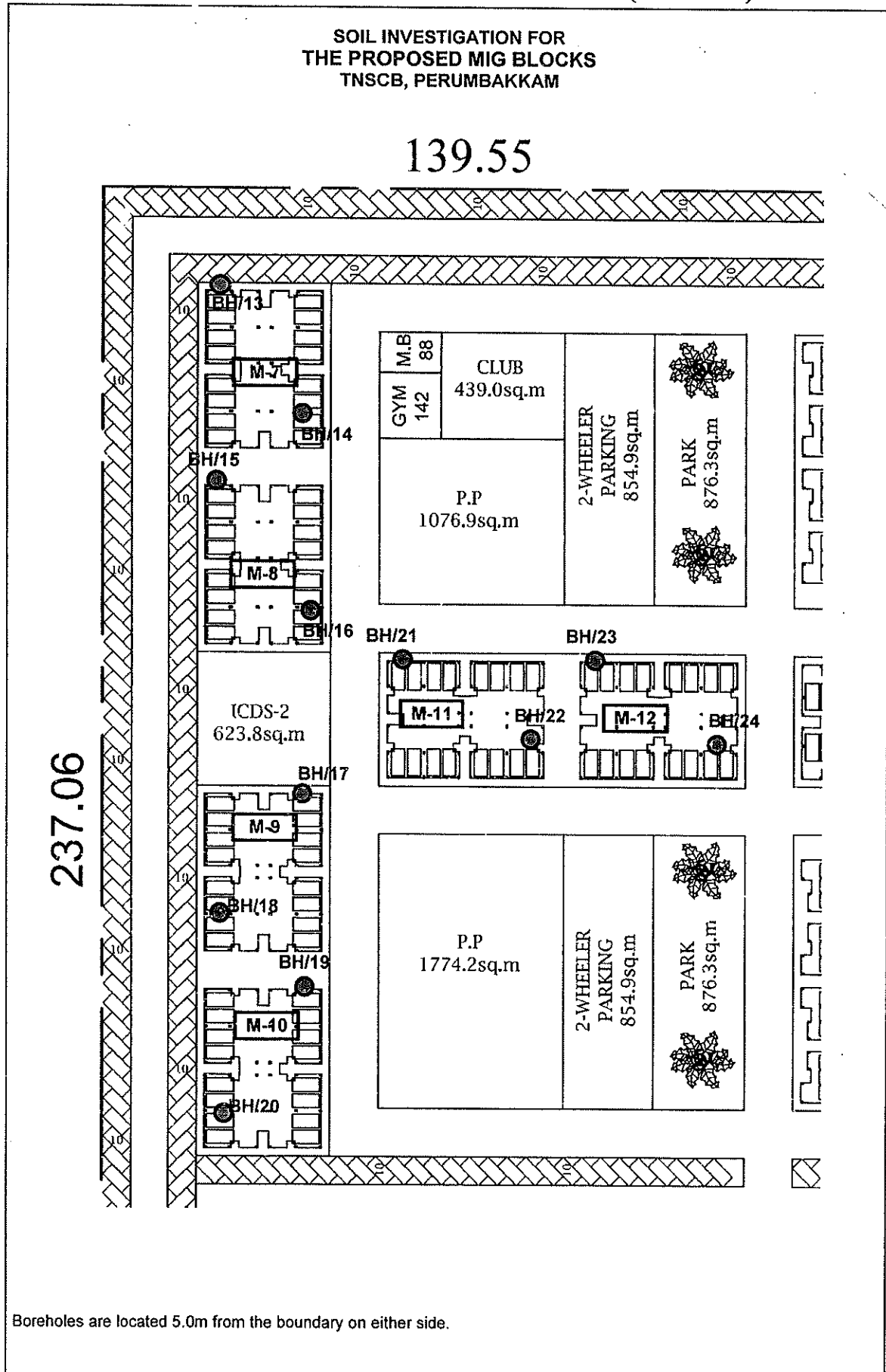
*K. I. L.* — *25/7/2014*

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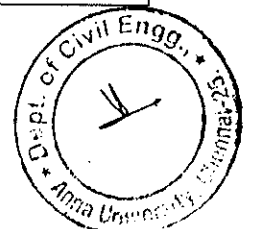
**Dr. K. ILAMPARUTHI, M.E., Ph.D.,**  
Professor & Chairman  
Faculty of Civil Engineering  
Anna University, Chennai-600 025.



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



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

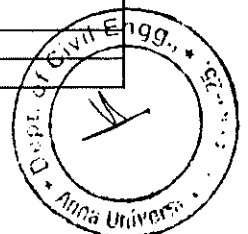


**FIGURE 2 SOIL PROFILE AND SPT N VALUES AT BH 13 - M2**

Project MIG Tenernents, 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
4.5				4.50	4.50	30/4cm				>100	
5.0				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 NO:	SF/KI-48/Zone M2/PMPKM
BORE HOLE NO:	BH/14

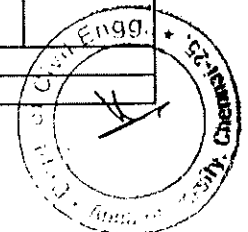
Project : MIG Tenements, TNSCB, Chennai  
 Site : Perumbakke-n, M2 Zone  
 Co-ordinates : Block M7  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

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			2.25	2.25	8	12	13	16	25					
3.0	[Soil Profile]	Greyish brown clayey silty sand with sandy clay lumps & weathered stones		3.00	3.00	21	32	50		82			Medium dense	
3.0			3.75	3.75	32	50/12cm				>100				
4.0	[Soil Profile]	Greyish brown dirty fine to coarse sand with weathered stones		4.50	4.50	50/5cm				>100			Very dense	
4.0			5.00	5.00	Rebound					RB				
5.0	[Soil Profile]	Brownish grey dirty fine to coarse sand with weathered stones		5.00-5.70	5.70	TC core drilling							Very dense	
5.0			5.70	5.70	Rebound									
5.7	[Soil Profile]	Greyish brown highly weathered fractured rock		5.70-6.70	5.70	Diamond core drilling NX size,							Very weak	
5.7			6.70	6.70	Recovery 15% RQD nil									
6.0	[Soil Profile]	Greyish brown highly weathered severely jointed rock		6.70-7.70	6.70	Diamond core drilling NX size,							Weak	
6.0				7.70	7.70	Recovery 8%, RQD nil								
7.0	[Soil Profile]	Brownish grey highly weathered closely jointed rock (Granitic gneiss)		7.70-8.70	7.70	Diamond core drilling NX size,							Moderate	
7.0				8.70	8.70	Recovery 14%, RQD nil								
8.0	[Soil Profile]	TC core drilling from 5.00m to 5.70m DC core drilling from 5.70m to 8.70m												
8.0														
8.2														
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 8.70m

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



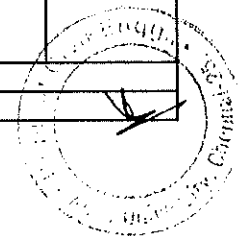
**FIGURE 4 SOIL PROFILE AND SPT N VALUES AT BH 15 - M2**

<b>PROJECT NO:</b>	<b>SF/KI-48/Zone M2/PMPKM</b>
<b>BORE HOLE NO:</b>	<b>BH/15</b>

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

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		
3.0											
3.2					3.00-3.60m	3.60	Rebound			RB	
4.0		Brownish grey highly weathered fractured rock			3.60-4.60	Diamond core drilling NX size, recovery nil					Weak
5.0					4.60-5.60	Diamond core drilling NX size, recovery nil					
5.6											
6.0		Brownish grey completely weathered severely jointed rock			5.60-6.60	Diamond core drilling NX size, recovery 4%					Weak
6.8		Greyish partly weathered jointed rock (granitic gneiss)			6.60-7.60	Diamond core drilling NX size, recovery 13%, RQD nil					Moderate
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>											

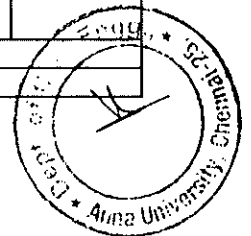


**FIGURE 5 SOIL PROFILE AND SPT N VALUES AT BH 16 - M2**

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)										
5.0		Brownish grey highly weathered fractured rock	4.50-5.80	TC core drilling							Very weak	
5.8					5.80	Rebound				RB		
6.0		Yellowish grey highly / completely weathered calcareous sandstone	5.80-6.80	Diamond core drilling NX size, recovery 10%, RQD nil						Weak		
7.0				6.80-7.80	Diamond core drilling NX size, recovery 13%, RQD nil							
8.0					7.80-8.30	DC Core drilling						
8.1		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												
		TC core drilling from 4.50m to 5.80m										
		DC core drilling from 5.80m to 8.30m & 9.2m to 10.20m										
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

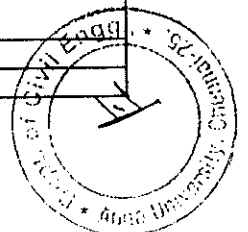
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M9  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

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	Very weak	
4.0				4.00	Rebound					RB		
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	Very weak		
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				8.00-9.00	Diamond core drilling NX size recovery 16%, RQD nil						Weak to moderate	
8.3		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		
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**

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

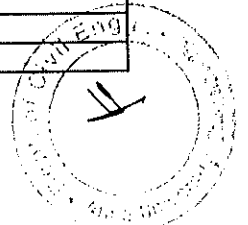
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block MS  
 Diameter and type of boring : 50mm Rotary boring with drilling mud circulation

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		Very dense
4.5		Yellowish grey highly / completely weathered fractured rock	4.50-5.50									Very weak
5.0												
5.5		Greyish brown & grey completely weathered severely jointed rock	5.50-6.50									Weak
6.0												
6.5		Brownish and grey highly weathered severely jointed rock	6.50-7.50									Weak
7.0			7.50-8.50									
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>

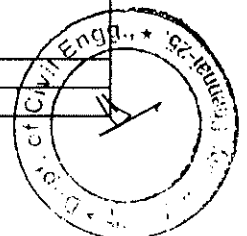
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M10  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

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												
2.0		Grayish soft silty clay with reddish brown patches		1.50	1.50	@SPT wt			1	0		Very soft
2.4												
3.0		Brownish grey dirty fine to coarse sand weathered stones		2.25	2.25	2	12	19	27	31		Dense
3.0				3.00	3.00	16	20	24	31	44		
4.0				3.75	3.75	16	50			>100		
4.0				4.50	4.50	Rebound					RB	
5.0		Brownish grey completely weathered / highly weathered fractured rock	4.50-5.50			TC core drilling						Very weak
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												
7.0		Light brownish and light grey widely jointed hard rock (siltstone)	6.50-7.50			Diamond core drilling NX size, recovery 31%, RQD 28%						Strong
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>

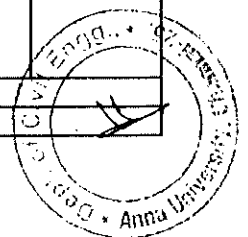
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M10  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

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				N**		
						15	30	45	60			
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		3.00	3.00	29	50/14cm			>100	Very dense	
4.8												
5.0					3.75-4.80	TC core drilling				RB	Very weak	
5.8												
6.0		Light brownish grey weathered closely jointed rock		4.80-5.80	Diamond core drilling NX size, recovery 12%, RQD nil						RB	Very weak
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%						RB	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												

**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**

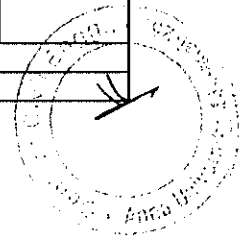
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M11  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

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	[Soil Profile]	Yellowish grey silty clay		0.50								Soft to medium stiff
1.3			0.75	0.75	1	1	2	2	3			
2.0	[Soil Profile]	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	0	
3.0	[Soil Profile]	Black organic sandy clay		3.50	3.50	3	8	9	23	17		Loose
3.4			4.50	4.50	35	50/8cm					>100	
4.0	[Soil Profile]	Dark greenish grey dirty fine to medium sand		5.50	5.50	Rebound					RB	Very dense
4.8			6.0	6.0	TC core drilling							
5.0	[Soil Profile]	Dark brownish grey dirty fine to coarse sand with weathered stones		6.70	6.70	Rebound					RB	Very dense
5.6			6.70	6.70	TC core drilling							
6.0	[Soil Profile]	Brownish grey dirty fine to coarse sand with weathered stones	5.50-6.70		TC core drilling						Very weak	
6.7			6.70-7.70		Diamond core drilling NX size, recovery nil							
7.0	[Soil Profile]	Brownish grey highly weathered fractured rock	6.70-7.70		Diamond core drilling NX size, recovery 10%, RQD nil						Weak	
8.0			7.70-8.70		Diamond core drilling NX size, recovery 19%, RQD nil							
8.7	[Soil Profile]	Brownish and grey highly weathered severely jointed rock	8.70-9.70		Diamond core drilling NX size, recovery 19%, RQD nil						Moderate	
9.1			9.70									
9.0	[Soil Profile]	Br and grey weathered closely jointed rock										
10.0												
11.0	[Soil Profile]											
12.0												
13.0	[Soil Profile]											
14.0												
15.0	[Soil Profile]											
16.0												
17.0	[Soil Profile]											
18.0												
19.0	[Soil Profile]											
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>												

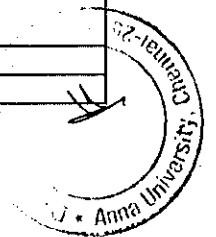


FIGURE 12 SOIL PROFILE AND SPT N VALUES AT BH 23 - M2

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

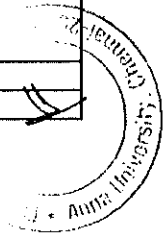
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M12  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

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					RB		
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

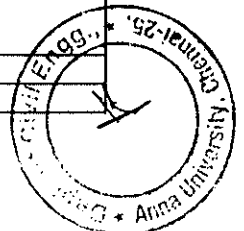
Project MIG Tenements, TNSCB, Chennai  
 Site Perumbakkam, M2 Zone  
 Co-ordinates : Block M12  
 Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

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

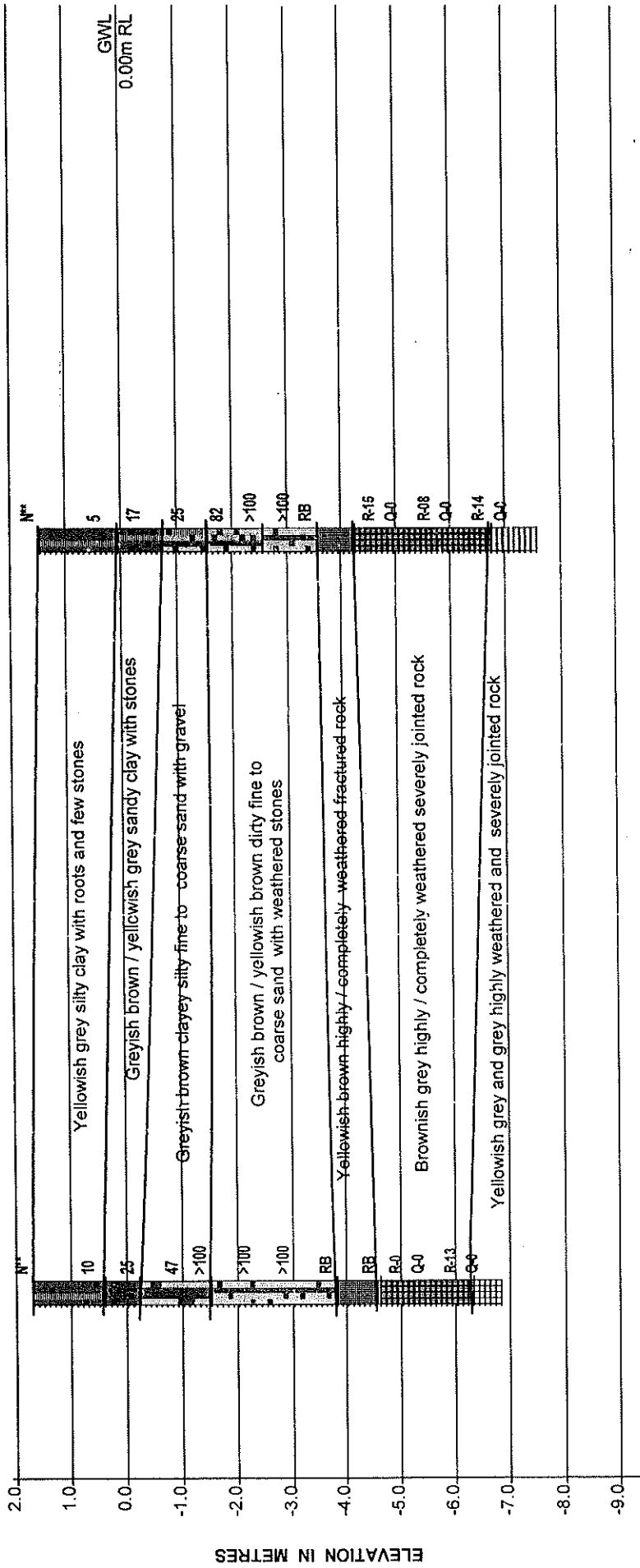
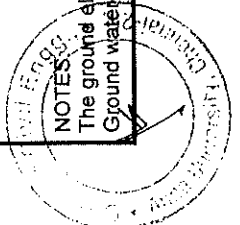


FIGURE 14

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

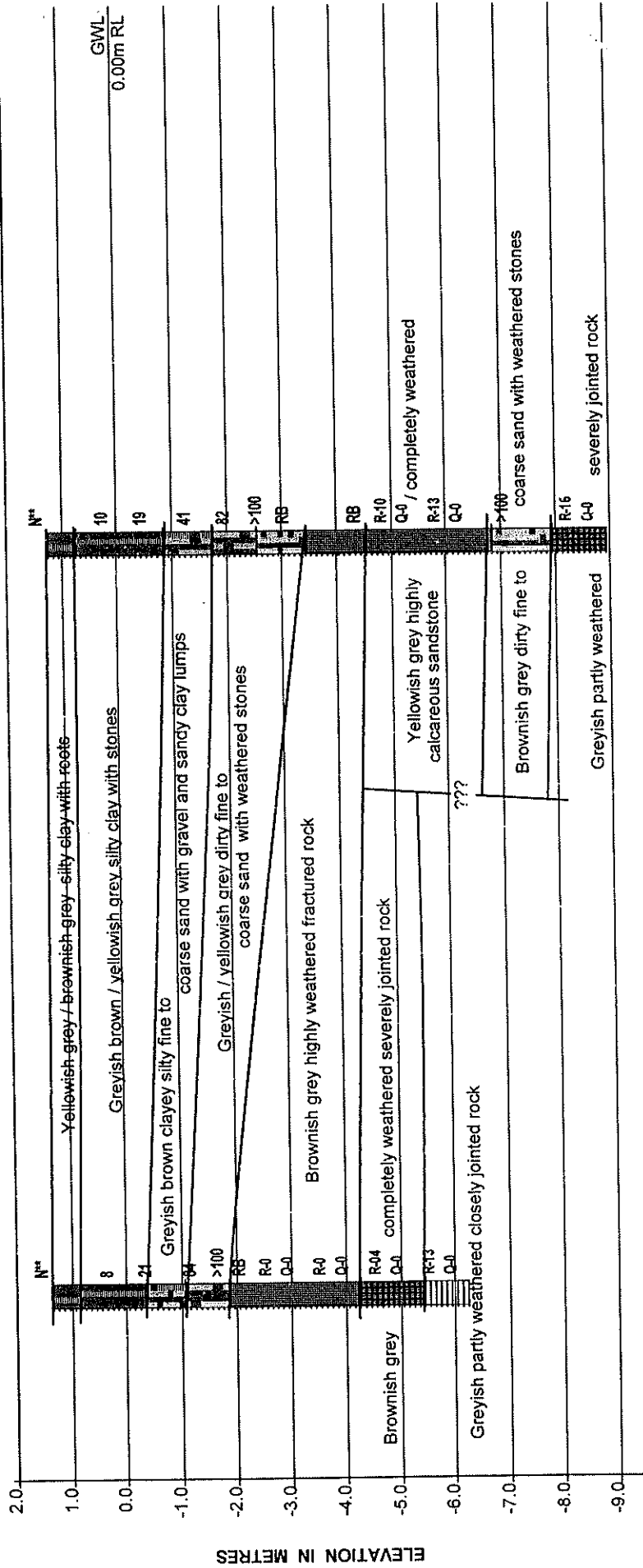
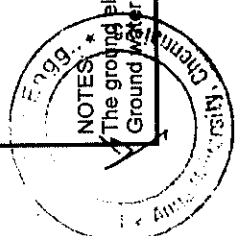


FIGURE 15

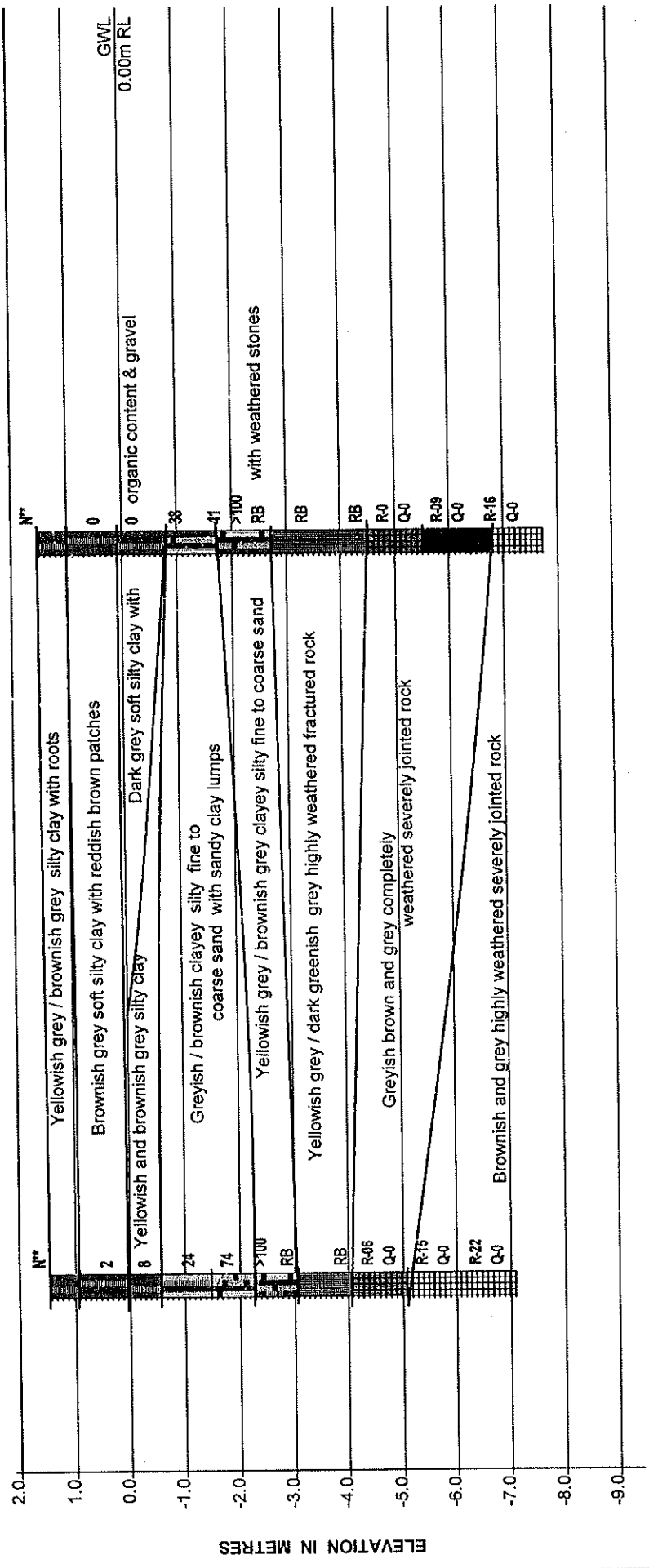
SUB-SOIL PROFILE BH/15 - BH/16 - BLOCK M-8  
TNSCB TENEMENTS AT PERUMBAKKAM



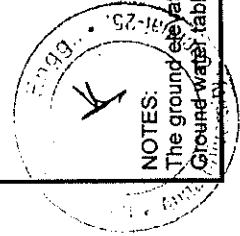
NOTES: \* The ground elevations with respect to the site reference datum.  
Ground water table is from the boreholes

BH/17

BH/18



ELEVATION IN METRES



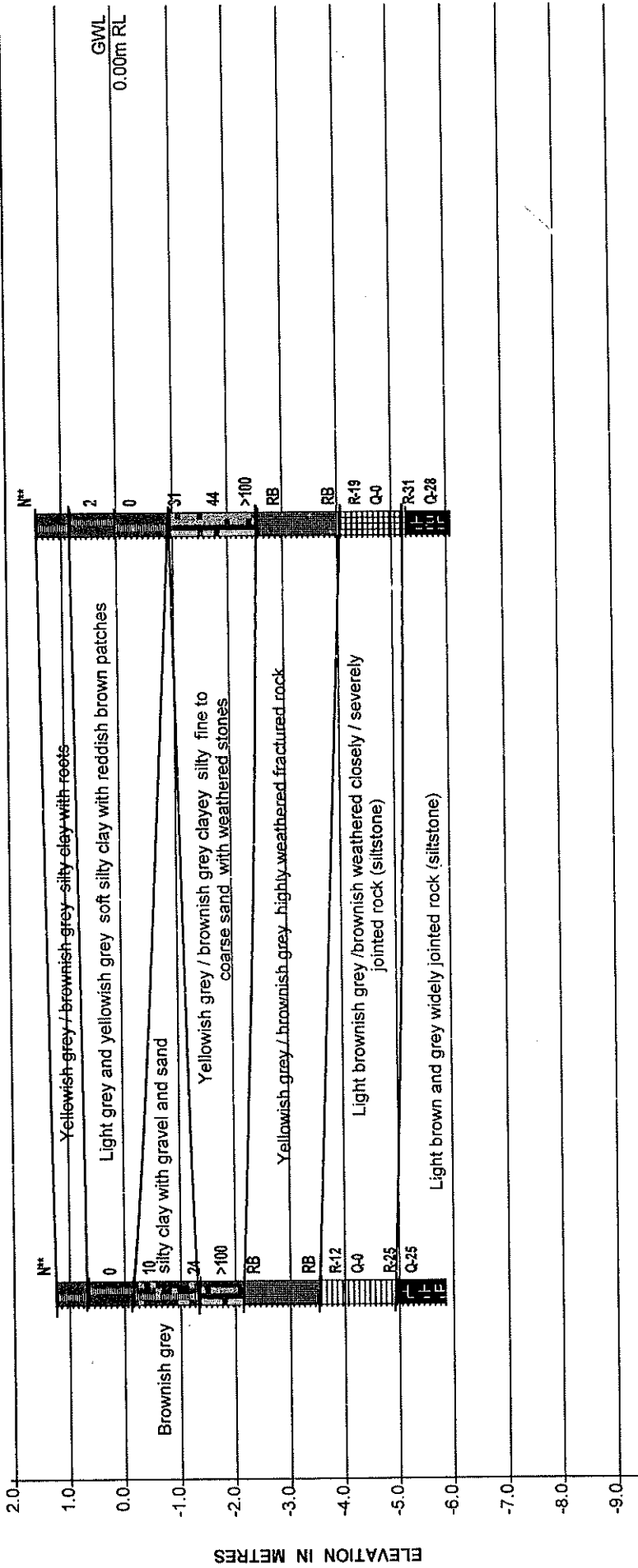
NOTES:  
 The ground elevations with respect to the site reference datum.  
 Ground water table is from the boreholes

FIGURE 16

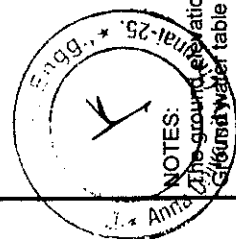
SUB-SOIL PROFILE BH/18 – BH/17 – BLOCK M-9  
TNSCB TENEMENTS AT PERUMBAKKAM

BH/19

BH/20



ELEVATION IN METRES



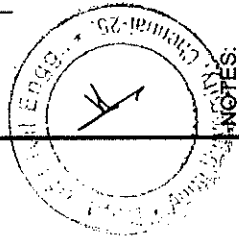
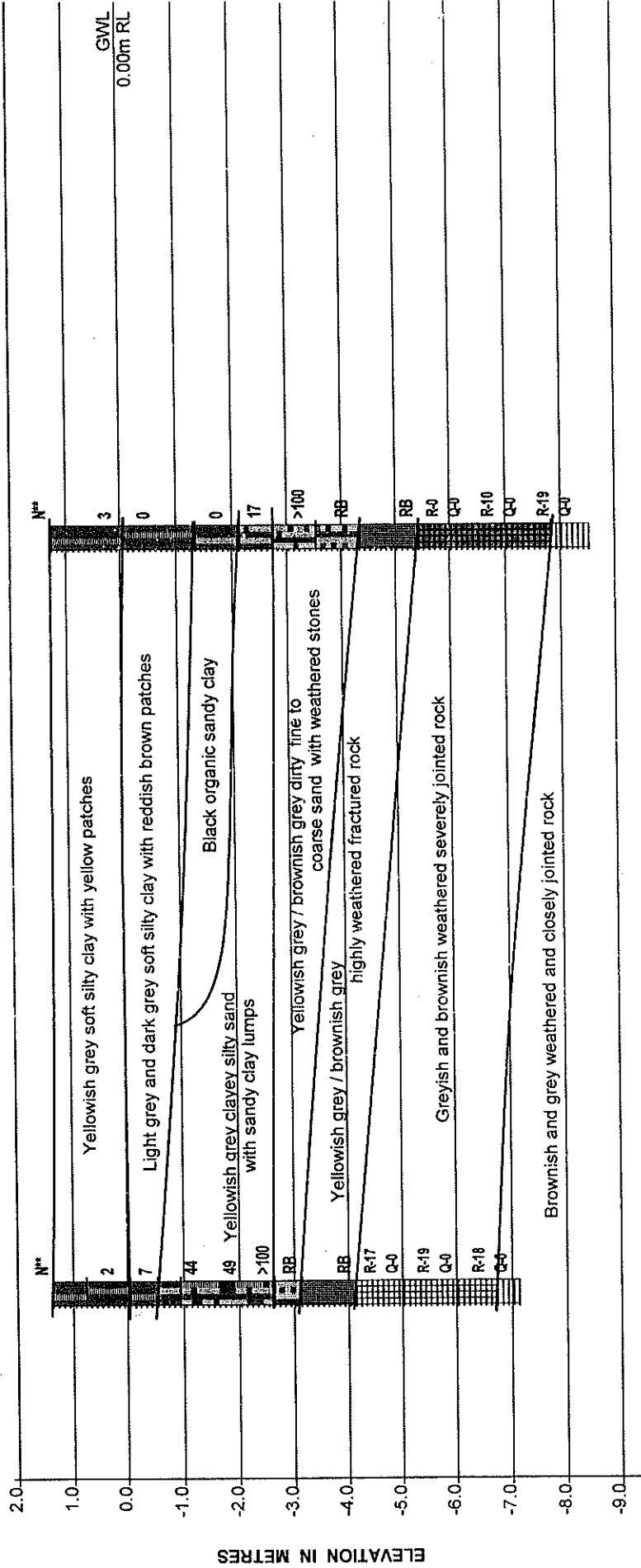
NOTES:  
 1) The ground elevations with respect to the site reference datum.  
 2) The groundwater table is from the boreholes

FIGURE 17

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

BH/22

BH/21

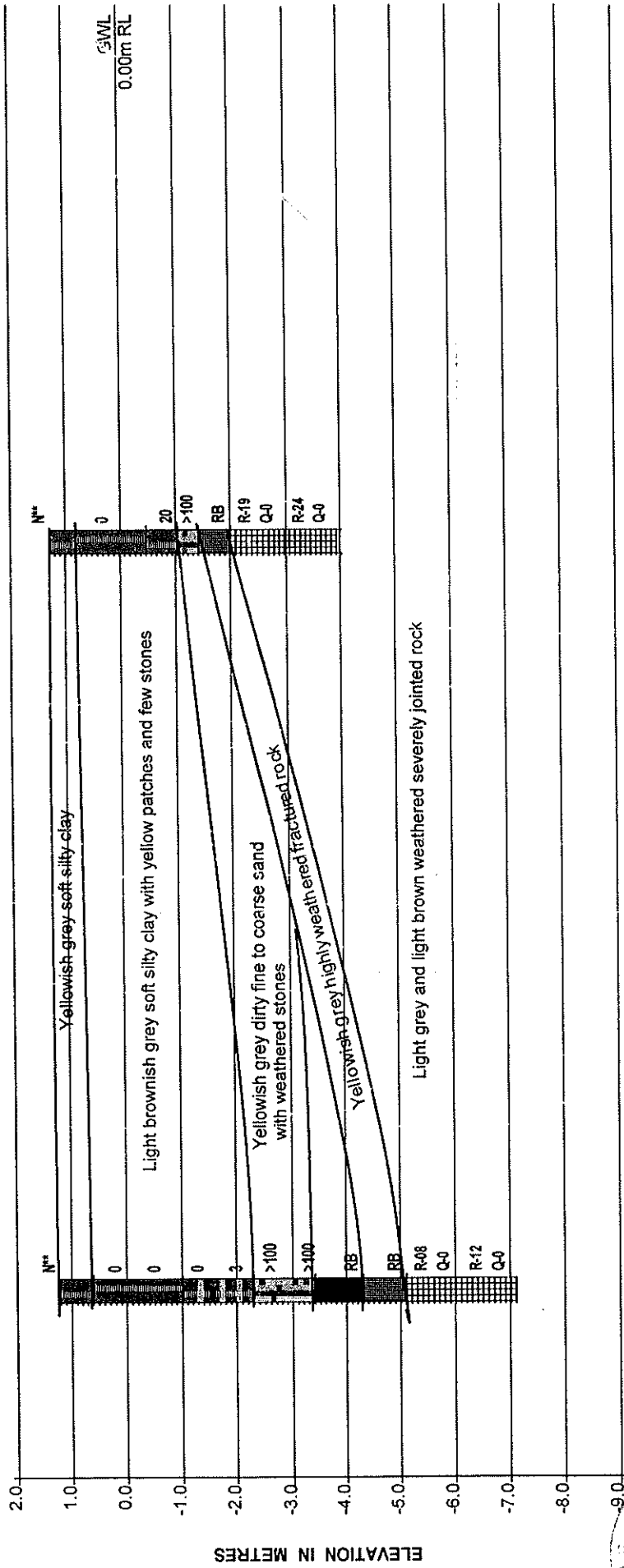


NOTES:  
 The ground elevations with respect to the site reference datum.  
 Ground water table is from the boreholes

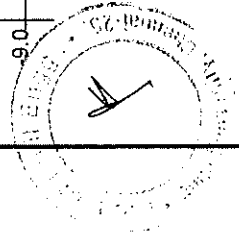
FIGURE 18  
 SUB-SOIL PROFILE BH/21 – BH/22 – BLOCK M-11  
 TNSCB TENEMENTS AT PERUMBAKKAM

BH/24

BH/23



ELEVATION IN METRES



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

FIGURE 19

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

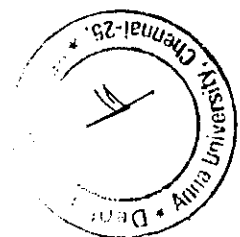
**TABLE 1 LABORATORY TEST RESULTS OF SOIL SAMPLES OF BH 13 - M2**

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**

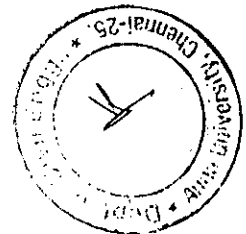
Project: MIG Tenements, TNSCB Perumbakkam

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**

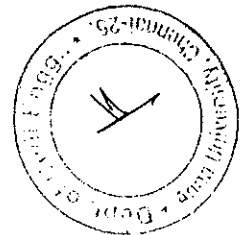
Project: **MIG Tenements, TNSCB Perumbakkam**

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**

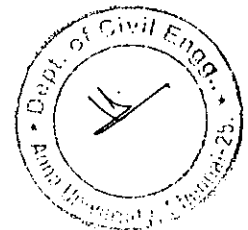
Project: MIG Tenements, TNSCB Perumbakkam

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		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**

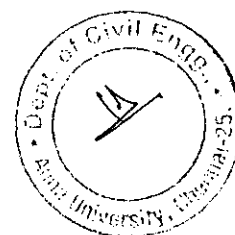
Project: **MIG Tenements, TNSCB Perumbakkam**

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**

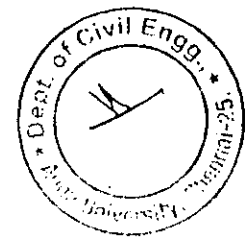
Project: MIG Tenements, TNSCB Perumbakkam

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**

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

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**

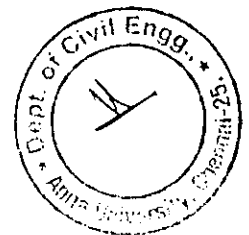
Project: **MIG Tenements, TNSCB Perumbakkam**

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)**

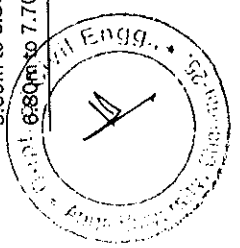
Depth Below GL	Soil	N	Design N'	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.30m	Yellowish grey silty clay with few stones, LI = 0.163	10	10		$c_u = 5.0 \text{ t/m}^2$	59	$m_v = 1/(42N)/\text{m}^2/\text{t}$
1.30m to 1.90m	Greyish brown sandy silty clay with stones, LI = 0.025	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 BH19 (GL = 1.409m RL)**

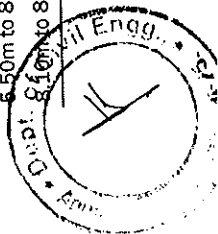
Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.60m	Br grey silty clay with brown & black patches, LI = 0.215	2	2		$c_u = 1.0 \text{ t/m}^2$	45.5	
0.60m to 1.40m	Yellowish grey soft silty clay with reddish brown patches, LI = 0.45	0	1		$c_u = 0.75 \text{ t/m}^2$	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)**

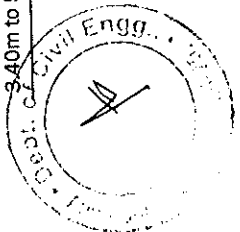
Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 1.30m	Yellowish grey silty clay, LI = 0.24	3	3		$c_u = 1.5 \text{ t/m}^2$	54.1	
1.30m to 2.60m	Dark grey soft clay with reddish brown patches, LI = 0.509	0	1		$c_u = 0.75 \text{ t/m}^2$	73.8	
2.60m to 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)**

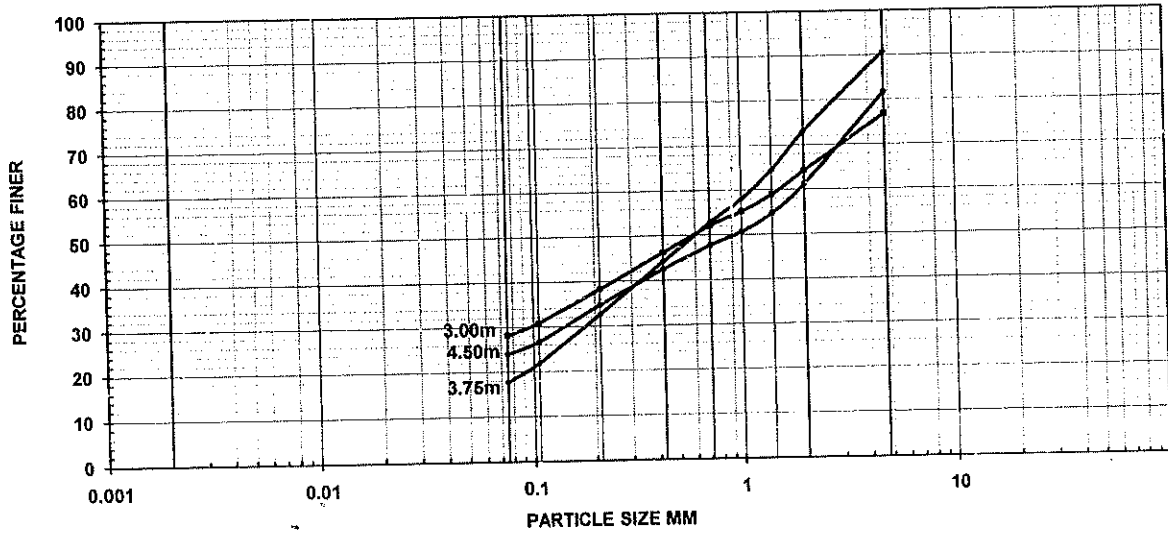
Depth Below GL	Soil	N	Design N	Angle of friction	Shear Strength $c_u$	PI %	Compressibility
0.00m to 0.50m	Yellowish grey silty clay, LI = 0.046	0	1		$c_u = 0.75 \text{ t/m}^2$	46.1	
0.50m to 1.80m	Light brownish grey soft silty clay with few stones, LI = 0.544	0	1		$c_u = 0.50 \text{ t/m}^2$	66.4	
1.80m 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						



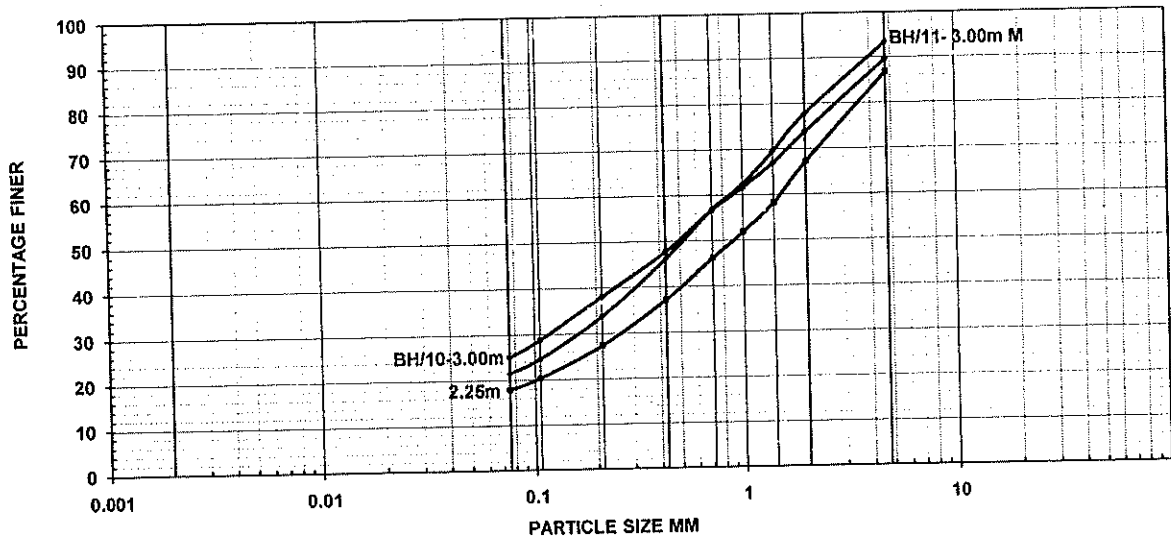
# ANNEXURE G1

## GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Residential Building, Mogapair

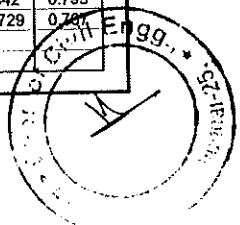


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/9	3.00m	100.0	78.9	64.3	46.3	28.2			23.1	12.6	18.0	18.1	28.2		GCS	0.528	14.684	0.860
BH/9	3.75m	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

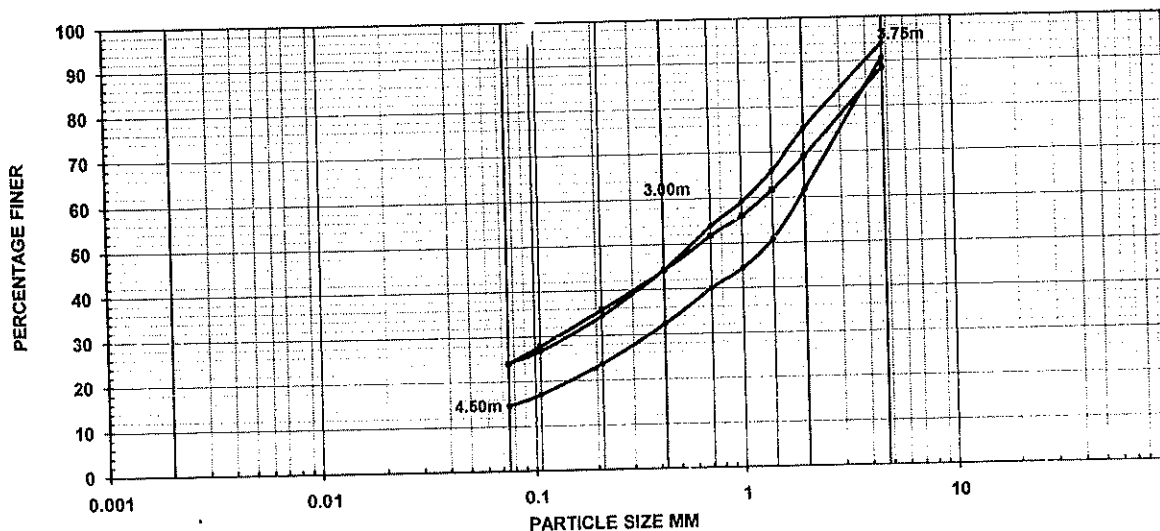
GEO TECHNICAL Solutions, Chennai



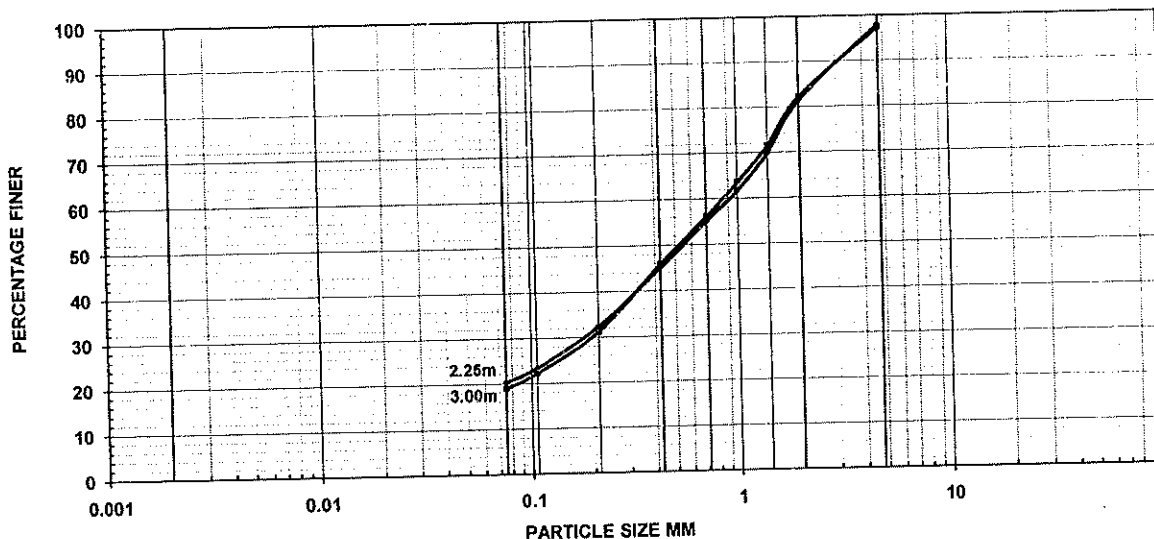
# ANNEXURE G2

## GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Residential Building, Mogapair

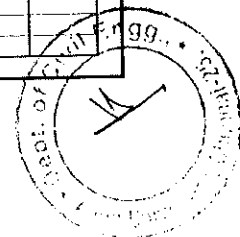


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/12	3.00m	100.0	88.5	69.0	44.3	24.0		11.5	19.5	24.7	20.3		24.0	GCS	0.528	13.751	0.845	
BH/12	3.75m	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	

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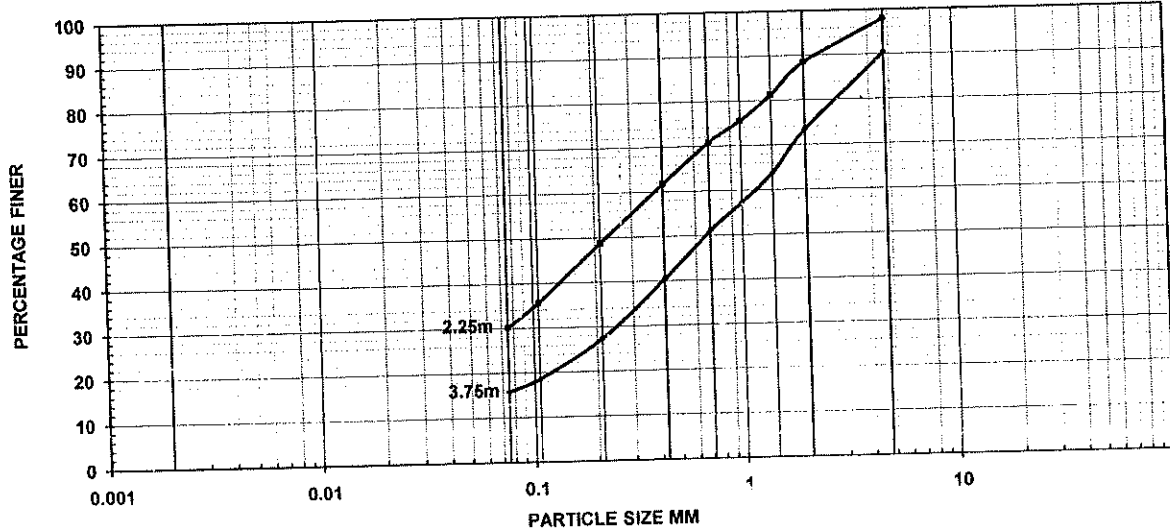




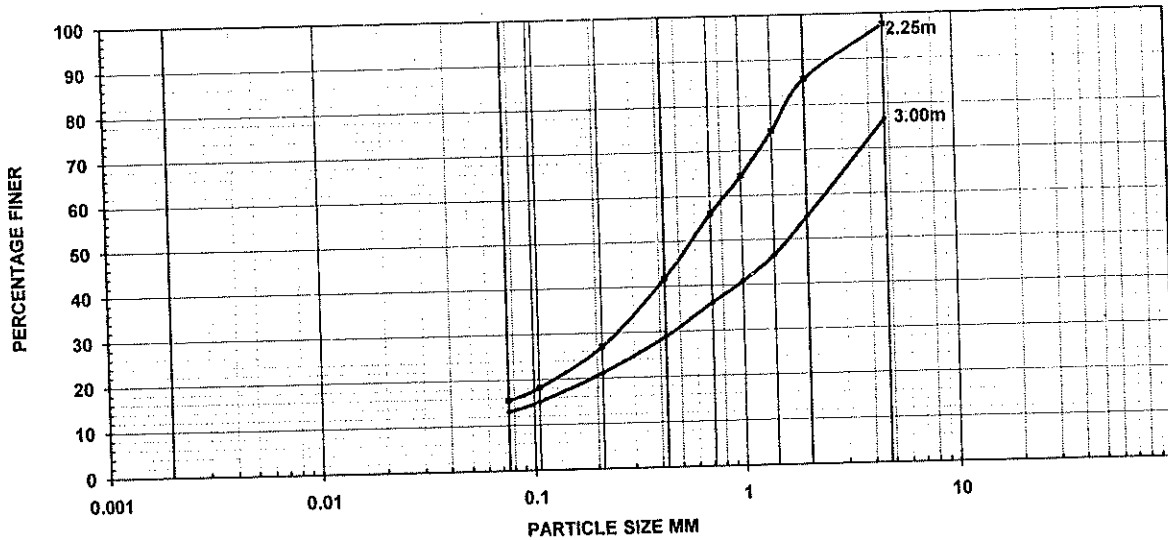
# ANNEXURE G3

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: MIG, Perambakkam

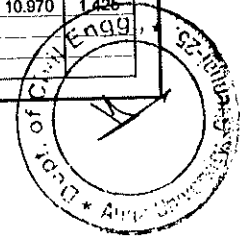


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C	CLASS			
BH/14	2.25m	100.0	98.0	88.5	61.8	30.2		2.0	9.5	26.7	31.6		30.2	SC-SP	0.226	6.717	0.648	
BH/14	3.75m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

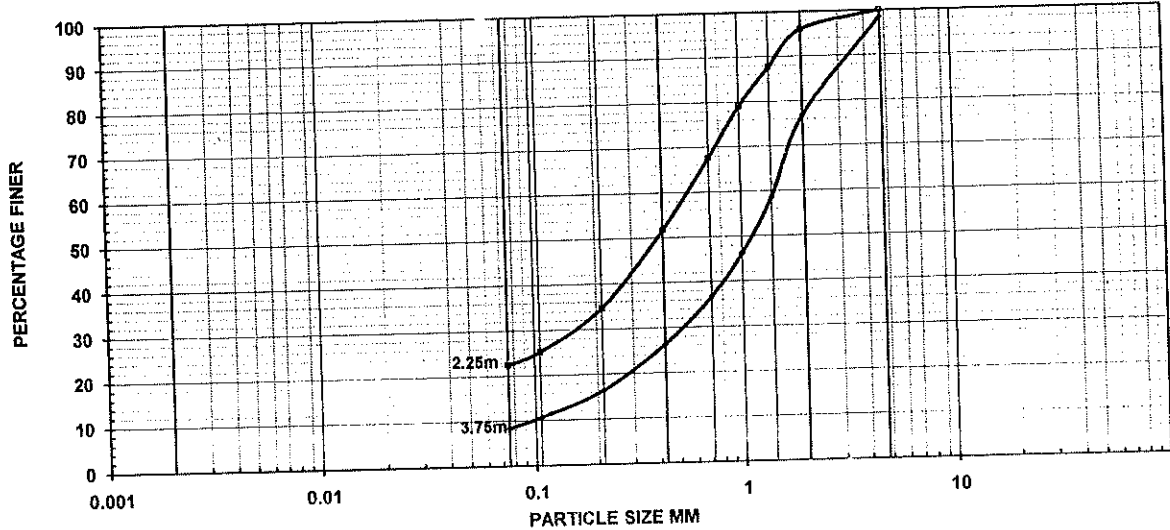
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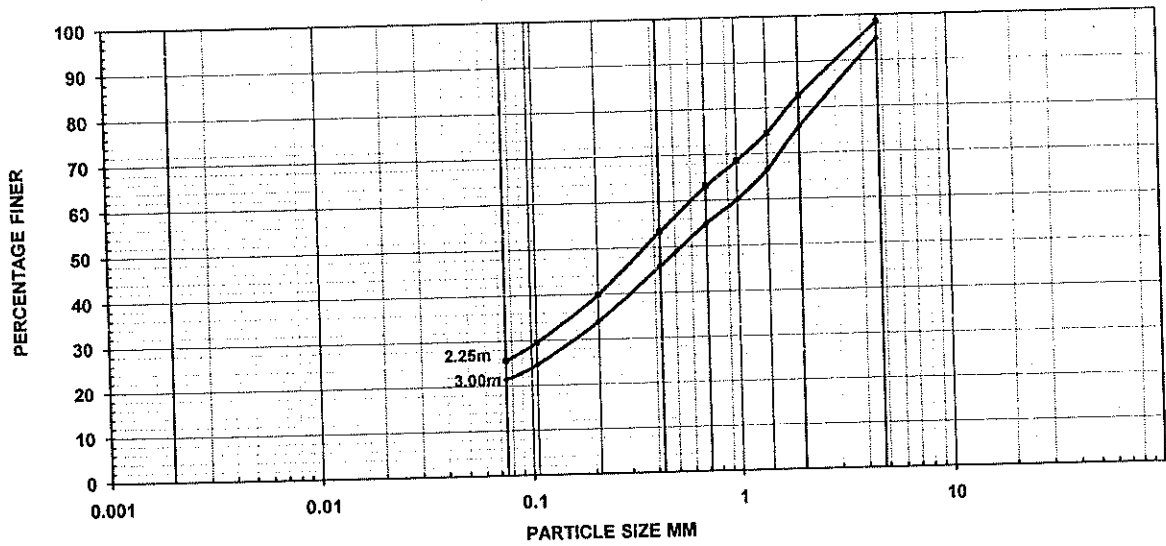
# ANNEXURE G4

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: MIG, Perambakkam

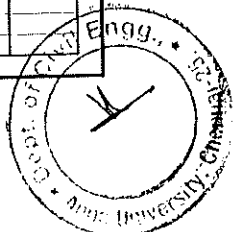


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C				
BH/16	2.25m	100.0	100.0	96.1	51.7	22.5			3.9	44.4	29.2		22.5	SC-SP	0.397	4.813	0.978	
BH/16	3.75m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

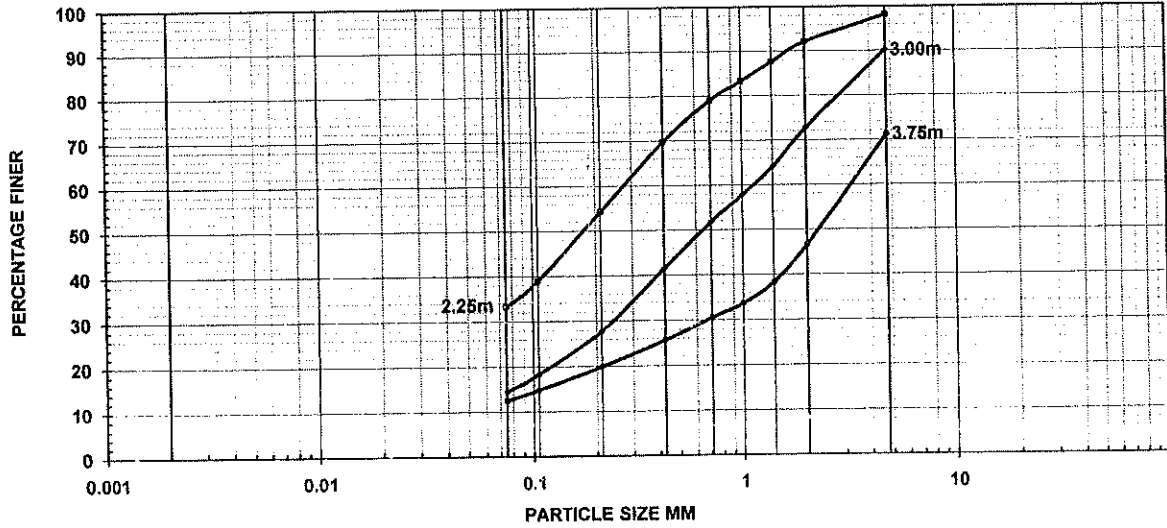
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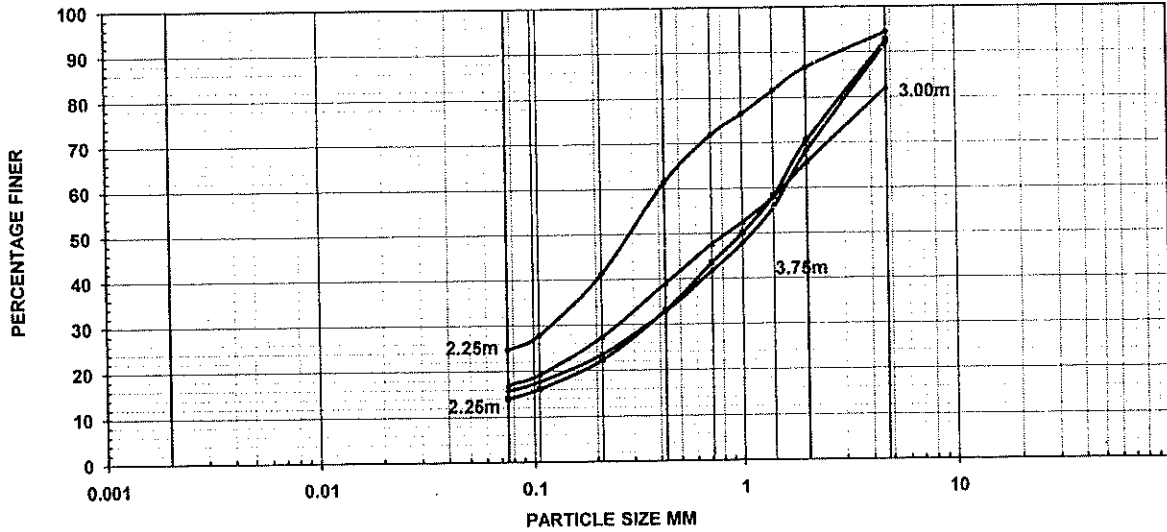
# ANNEXURE G5

## GRAIN SIZE DISTRIBUTION CURVES

PROJECT: MIG, Perambakkam

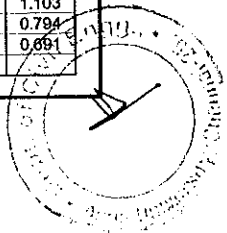


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)								Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		80	20	4.75	2	0.43	0.08	0	G	CS	MS	FS	Si	C	CLASS				
BH/18	2.25m	100.0	98.2	92.1	69.8	33.3			1.8	6.1	22.3	38.5		33.3	SC-SP	0.175	4.668	0.717	
BH/18	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:**

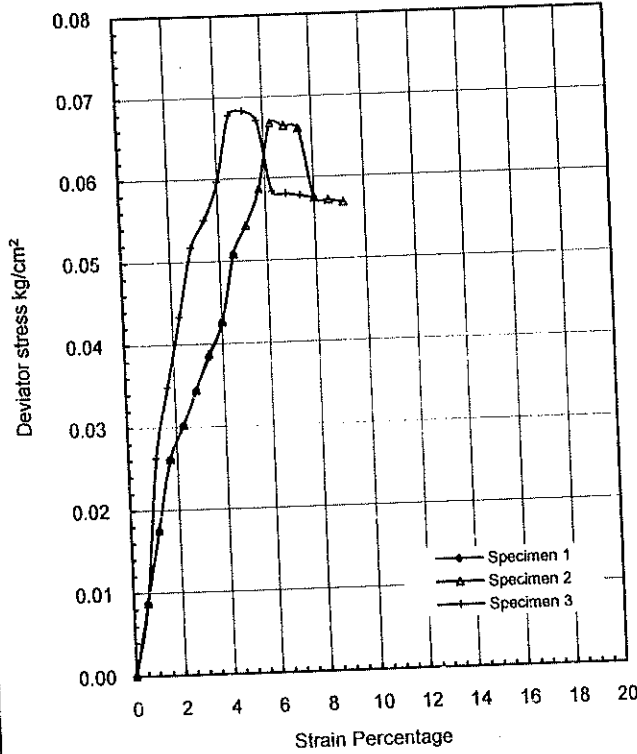
**MIG Perambakkam, M Block**

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 %**

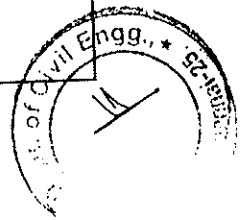
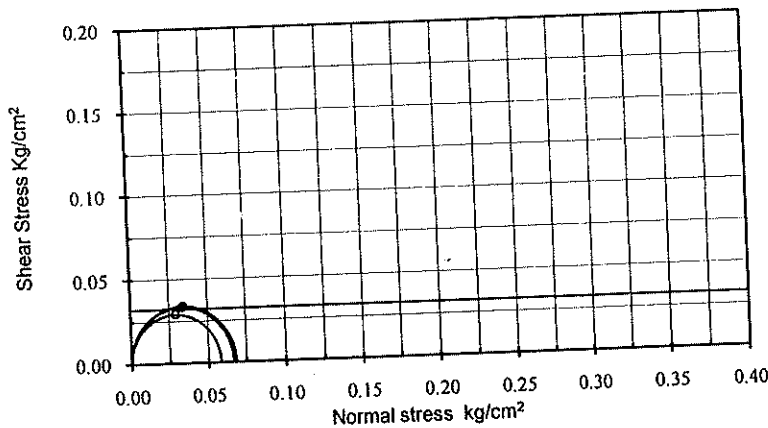
Liquid Limit % **83.30**  
 Plastic Limit % **23.20**  
 Plasticity Index % **60.10**  
 Liquidity Index **1.04**



**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

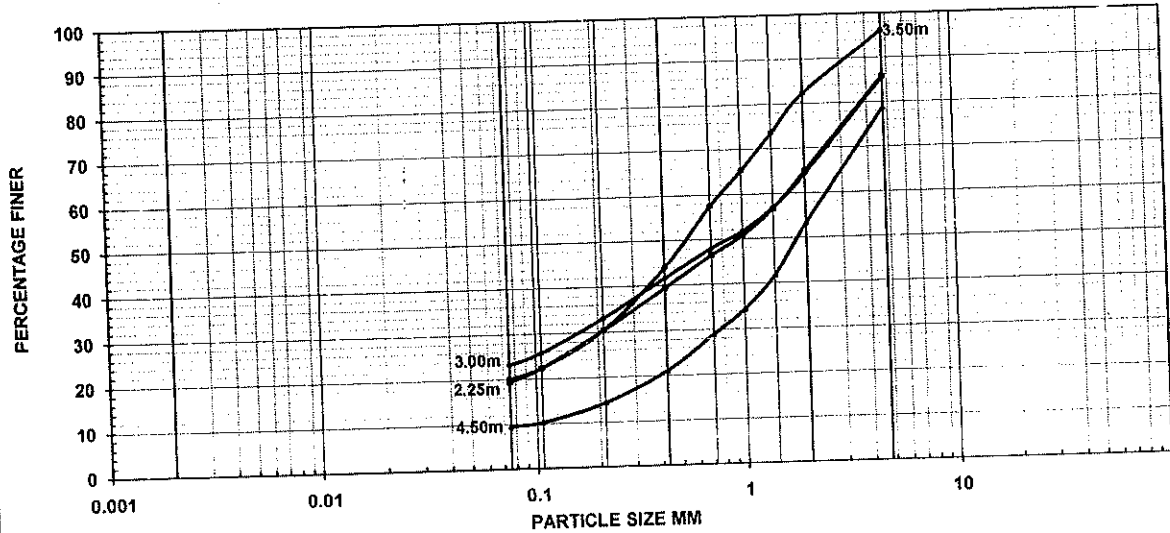
**Results**  
 Unconfined compression strength  $q_u$  **0.064 kg/cm<sup>2</sup>**  
 Undrained Cohesion  $c_u$  **0.032 kg/cm<sup>2</sup>**  
 Secant Modulus (undrained) **1.61 kg/cm<sup>2</sup>**



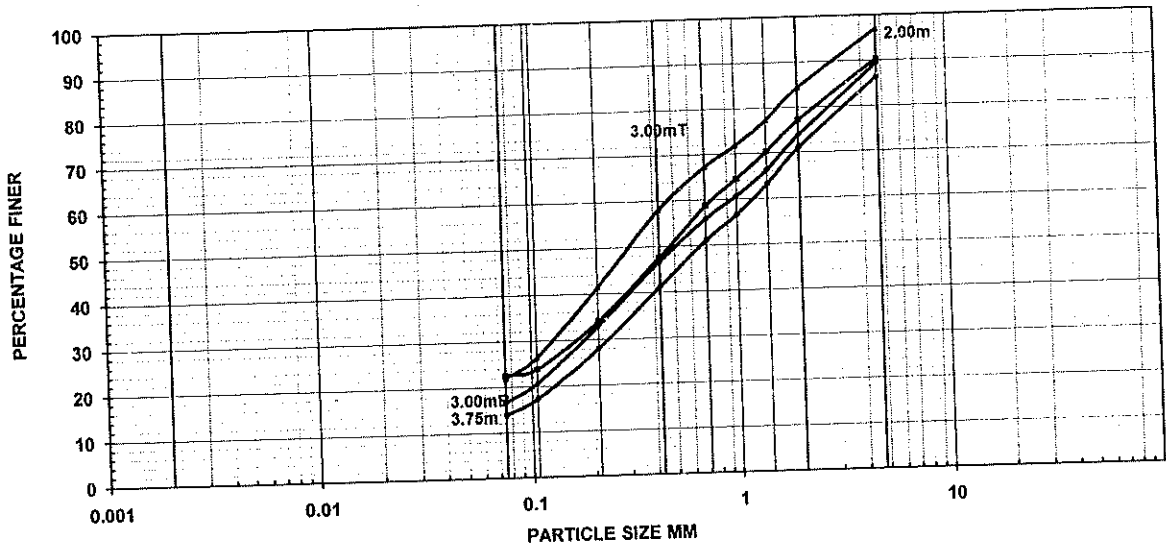
# ANNEXURE G6

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

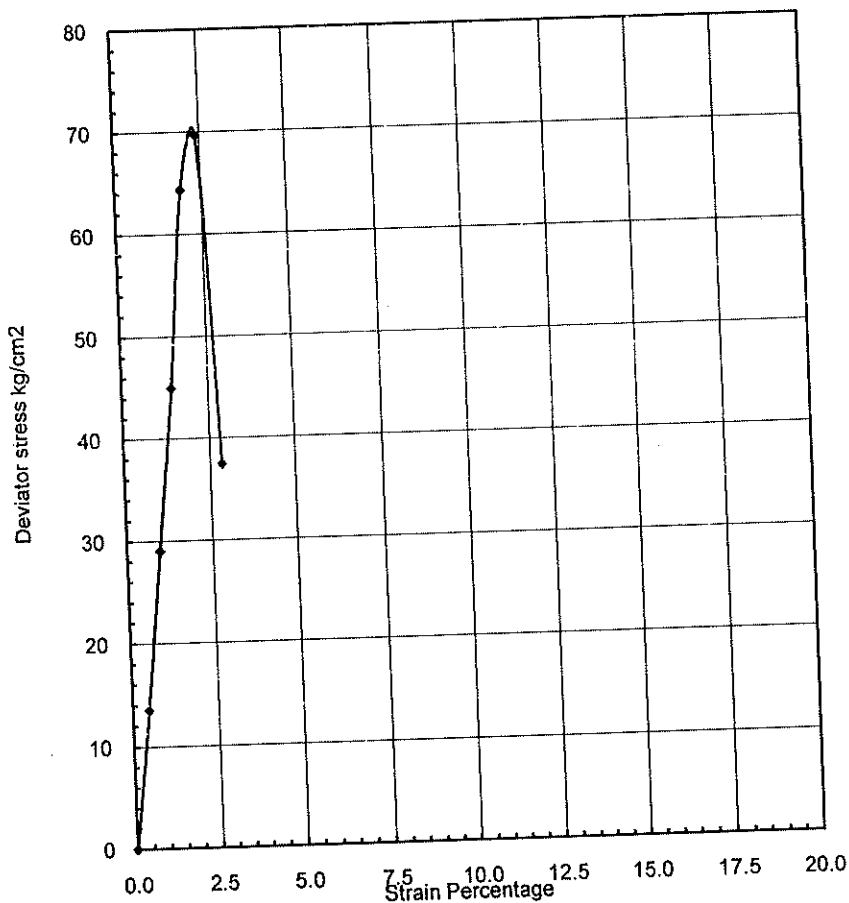
Date of Test           12-Apr-13  
Borehole                BH/19  
Depth                    6.50m to 7.50m (S2)

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



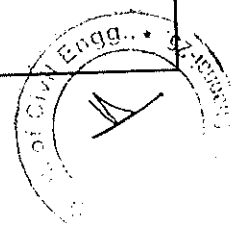
### Results

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

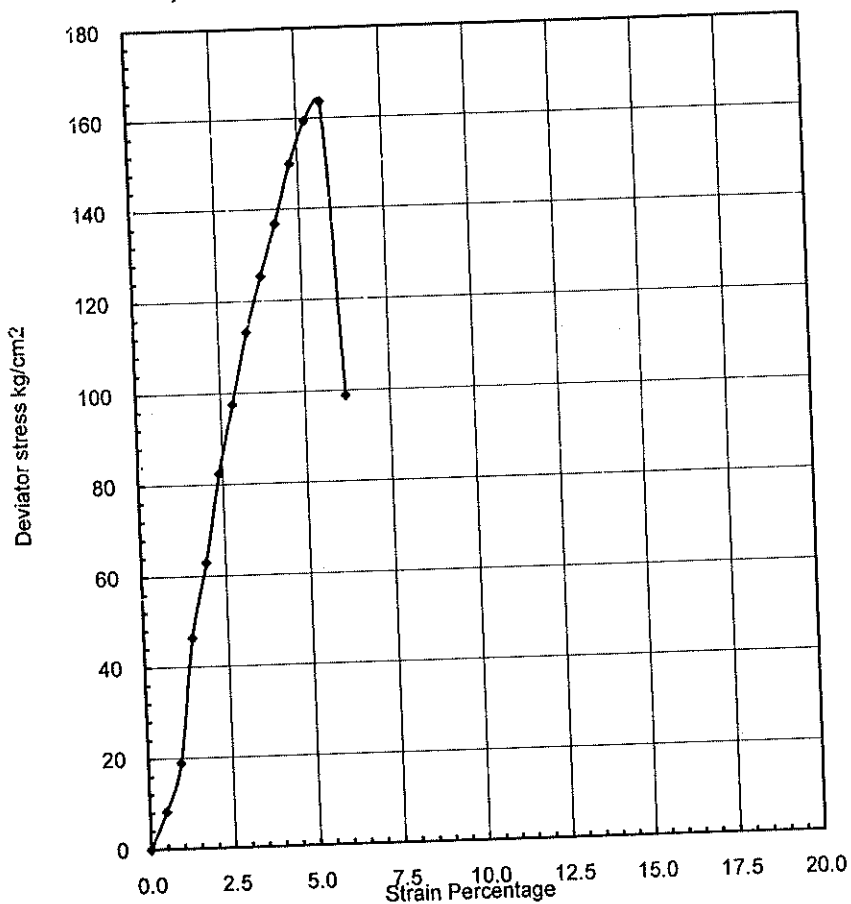
Date of Test            12-Apr-13  
Borehole                BH/20  
Depth                    5.80m to 6.80m (S1)

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



### Results

Unconfined compression strength  $q_u$

164.0 kg/cm<sup>2</sup>

Young's Modulus (secant)

3242 kg/cm<sup>2</sup>

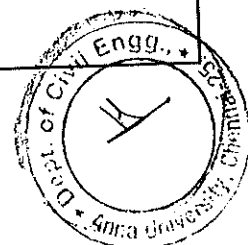


PLATE 1 CORE SAMPLES FROM BH1 to BH14

CORE SAMPLES FROM BH/1 to BH/14  
MIG TENEMENTS, TNSCB, PERUMBAKKAM

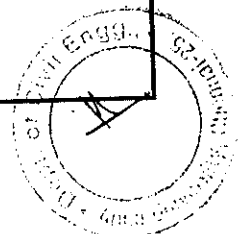
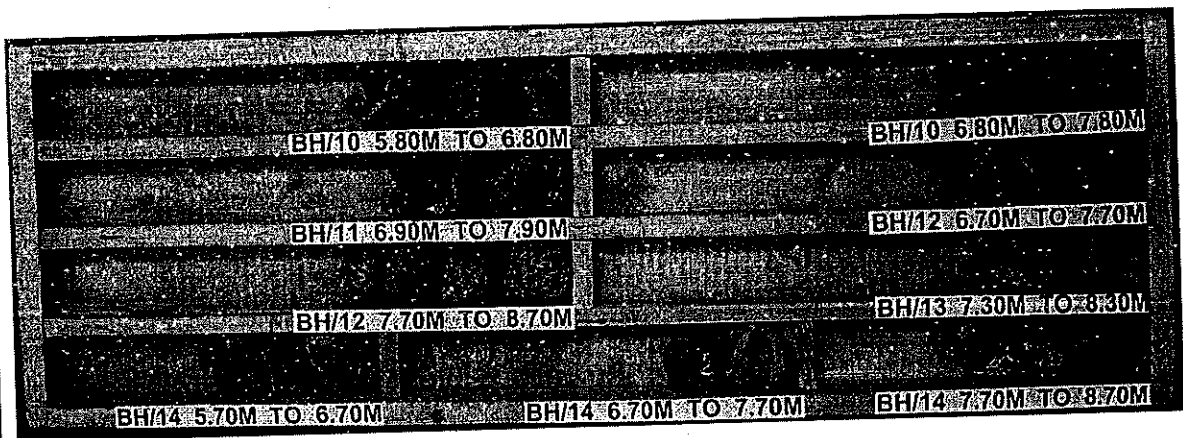
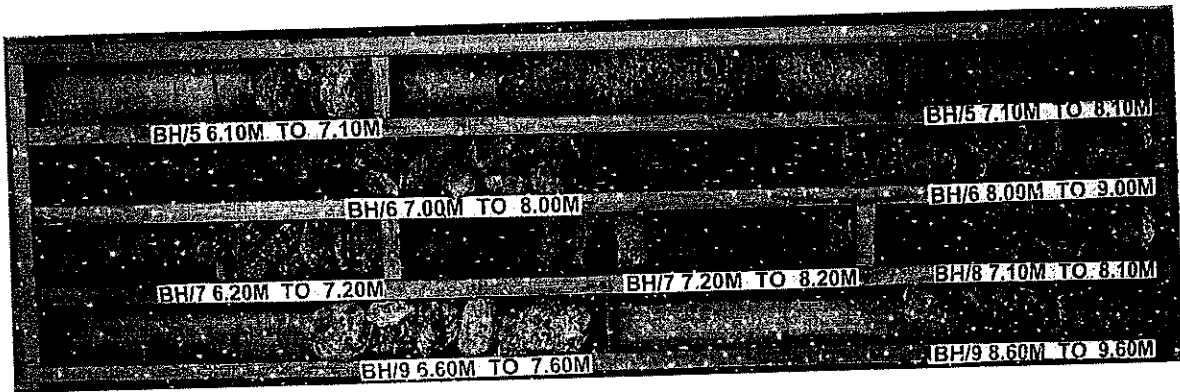
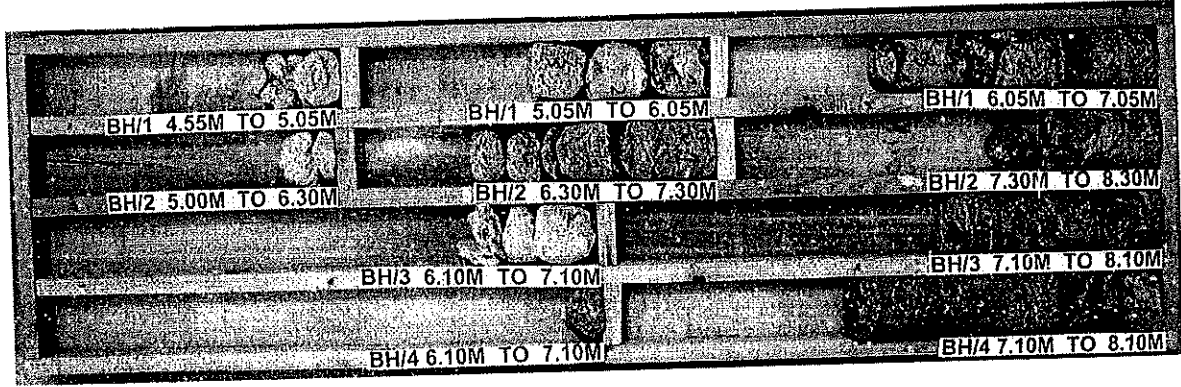




PLATE 2 CORE SAMPLES FROM BH/15 to BH/24

CORE SAMPLES FROM BH/15 to BH/24  
MIG TENEMENTS, TNSCB, PERUMBAKKAM

