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Investigation of Index Properties of Soil and Design of Foundation for Railover Bridge in Aligarh Zone, Uttarpradesh

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Abstract: ***In this research study, the Exploration of the behaviour of the soil at the site has been done using field and laboratory tests in order to estimate void ratio, specific gravity, liquid limit and other Index properties .From given data of loads acting from the Pier and Deck of the rail over bridge acting on the foundation ,the number of Under reamed piles required for the construction has been carried out. Under reamed types of piles are specially used in the soils where noise and vibrations due to piles have to be avoided or the strata of adequate bearing capacity is at great depth which makes uneconomical to use driven piles. The standard penetration test has been done in order to estimate in situ properties and density index of the soil. The classification of soil at each depth has been done and various corrections have been applied from the 'N' values calculated at each depth. In order to determine the cohesion and angle of internal friction triaxial test has been performed for each depth of soil and Mohr's circle has been plotted as show in figures.***

***KEY WORDS*-Triaxial Test, Liquid Limit, Under Reamed Ple, Plastic Limit.**

I. INTRODUCTION

Today no. of vehicles are increasing day by day and it has become very important to take some necessary measures in order to tackle the traffic jam conditions & delays in work. Generally it is observe that near the crossing line of Railways huge amount of traffic Jam condition occurs people here to wait for very long time which causes delays in the work. Trains which carry goods more very slowly & takes about 15-20 minutes to clear the crossing line. India's development mainly depends on the roads. If trucks carry goods are delayed it may causes huge amount of loss of money to sellers. As the population is increasing day by day the number of trains & traffic vehicles are also growing very fast as compared to the development of roads in India. There is a need of economical & safe design which can keep the vehicles moving near the Railway crossing without any delay. Construction of "UNDERPASS" may cause huge amount of budget taking into consideration of excavation cost near site, materials for construction & labour may not be economical. Railway over bridge is on the of the best alternative as compared to construction of under pass it is also quite economical & safe design which can avoid traffic Jam conditions & keep the vehicles in pace.

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Governments also supporting the construction of ROB & today this major initiative has taken in every region of state in India. It has also been found that by construction of Rail over bridge no. of deaths near the crossing line has decreased. As the people try to cross the railway line causes threat to their life. As comparison to other types of foundation the function of pile is to transfer structural load acing on foundation to the hard strata .They are helpful in resisting lateral and uplift tension forces .These piles resist heavy loads by friction between its surface and soil particles and bearing action from toe. Under reamed piles have enlarged bases which may be around 6m in diameter. Their shape is similar to an inverted cone which helps to resist large loads acting on them. They are classified under the category of bored cast in situ concrete piles.

II. LITERATURE REVIEW

Various researchers had carried out analysis and design of rail over bridge .Michael Tomlinson and John Woodward (1997) describes in their Journal regarding calculating the resistance of piles subjected to compressive loads and lateral loads .They also discussed about the Ground Investigation ,piling contracts and pile testing. Nabil F Ismael (2001) analysed the behaviour of bored pile in cemented by axial load test on single bored pile in tension and compression .Cylee (2007) has invested the settlement and analysis of distribution of load of under reamed pile. Dilipkumar (2004) determine the uplift capacity of pile subjected t tension by finite element method .Yuo gang Zhan (2012) carried out Modelling of vertical bearing capacity of pile foundation with the help of ABAQUS .Zahra (2013) also carried out the numerical evaluation of tensile bearing capacity of underreamed pile groups in granular types of soil using finite element method .Ken Fleming ,AusticWeltman Mark Randolph (2009) describes choice of piles and economics of design by structural ad constructional consideration. Gupta.S (1986) investigates the types of soil condition for which under reamed pile foundation are superior to other types of foundation.

III. PROBLEM FORMULATION

The specific gravity test is performed with the help of density bottle method at various depth .The results has been shown in the table for each depth .The sieve analysis is carried out in order to determine the particle size distribution and observed values are shown in table. Since

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most of the particle passes through 4.75mm sieve ,the soil is consisting of finer fraction .Hydrometer test is also performed after proper calibration of it and observed values were recorded .The liquid limit and plastic limit test is carried out for each depth in order to predict the behaviour of soil. The details were recorded as shown in table. The triaxial test has also been performed and after measuring vertical compressive load that is deviator stress and Confining pore pressure, the cohesion and angle of internal friction for each depth were analysed.

IV. EQUATION FOR DETERMINATIN OF BEARING CAPACITY

Deep foundation are designed when loads are more than 100KN/m2.These type of foundation are used in areas where the soil is quite weak and unpredictable in nature like clayey soil .They are also used to resist lateral and uplift forces. The ultimate bearing capacity for the under reamed pile is expressed by the following equation.

For clayey types of soil, the average soil cohesion around the under reamed bulbs and average cohesion of the soil along the pile stem has been considered.

$$Q_U = A_P N_C C_P + A_A N_C C_A^{/} + C_A^{/} A_A^{/} + kC_A A_S$$

Q_U = *Ultimate* bearing capacity of the under reamed pile

A_P = Area of the pile stem around toe

N_C = Factor for bearing capacity

C_P = Soil cohesion at toe

$A_s^{/}$ = Circumferential area of the cylinder around the under reams

$C_A^{/}$ = Average soil cohesion around bulbs

C_A = Average soil cohesion around the pile stem

$$A_S = \frac{\pi}{4}(D_U^2 - D^2)$$

K = Reduction factor

For sandy soils, the angle of wall friction and average density of soil has been taken into account for determining the ultimate bearing capacity of under reamed pile

$$Q_U = \frac{\pi}{4}(D_U^2 - D^2)\{\frac{1}{2}D_u nbN_b + XN_q \sum_{i=1}^{n} X_i\} + \frac{\pi}{4}D^2(.5DbN_r + bD_u N_q) + .5\pi DbK \tan\delta^*(d^2 + d_f^2 - d_n^2)$$

D_U = Diameter of under reamed bulbs

n = Number of bulbs in under reamed pile

b = Average soil density

N_b & N_q = Factors for bearing capacity

X_i = Depth of the centre of bulbs

d_f = Length of pile

δ = Wall friction angle

Considering Diameter of pile (stem or shaft)= d=0.50m and Cindering diameter of under Reamed bulb = d_u=1.

V. NUMERICAL STUDY

The specific gravity test is carried out at each depth of soil .At 1.5m it is found to contain sand in the dense state of compaction exhibiting plasticity whereas at 7.5m it is found to contain of silty clays exhibiting plasticity. At this depth the soil is having low resistance to penetration. The liquid limit test is conducted by passing the soil through 425mm IS sieve through distilled water in the evaporating dish and left for 24hours for soaking .The liquid limit is determined by plotting a flow curve on a Semi log graph ,with number of blows as abscissa (log scale) and the water content as ordinate and drawing the best straight line through the plotted points .Five tests were conducted for each depth .The percentage of water content in 25 number of blows at 1.5m depth of soil is found to be 18% where as at 3m depth it is found to be 22%.The Plastic limit test is carried out by passing the soil through 425mm IS sieve .The soil is then rolled with fingers on a glass plate and rolling at 80-90 stokes per minutes to form into a diameter .Three test are conducted at each depth in order to determine the plastic limit of soil. The plastic limit at 1.5m depth was found to be 16.6% and at 7.5m depth it is found to be 25%.The calculation of live load and dead load from the rail over bridge has been calculated. The dead load of deck slab is found to be 1171.88KN .The dead load of Longitudinal beam is found to be 1350KN .The dead load of cross beam is found to be 405KN and the dead load of pier cap is 601.81KN .The dead load of pier is about 1239.46KN and hence the total dead load is 4768.14KN .12 trucks of class A loading has been taken as live load after analysis. The total live load is found to be 3360KN .The safe Bearing Capacity is calculated with the help of various parameters concluded from laboratory and field tests carried out. The Design of pile for rail over bridge is carried out considering resistance through skin friction and through bearing action from tip of pile.

VI. RESULTS AND DISCUSSION

1.The soil is found to be non plastic in top strata consisting of mainly silts in dense state of compactness exhibiting plasticity and the lower strata consisting of silty clays exhibiting plasticity and compressible around 7.5m depth having low resistance to penetration.

2.The under reamed piles required for the design of foundation for rail over bridge is analysed to be two .It is concluded that on increasing the number of bulbs the ultimate load bearing efficiency is found to be increase.

3. The designed under reamed piles are compared with piles which resist load through friction and toe bearing action. It is concluded that the ultimate load capacity carried by one cylindrical pile is found to be 1973.2KN .Thus number of piles required is more than four piles whereas only two under reamed piles is required in order to resist the same load from the rail over bridge in Aligarh.

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4.It is also concluded that the number of piles required in under reamed pile design is affected by the spacing ratio that is S/D .It is also analysed that when the spacing ratio is around 2.4 to 2.6 .The ultimate load bearing capacity of pile is maximum..

5. The penetration resistance ''N'' is calculated for each depth after applying over burden and dilantency correction. The recorded values of N have been shown in figure with the variation along depth.

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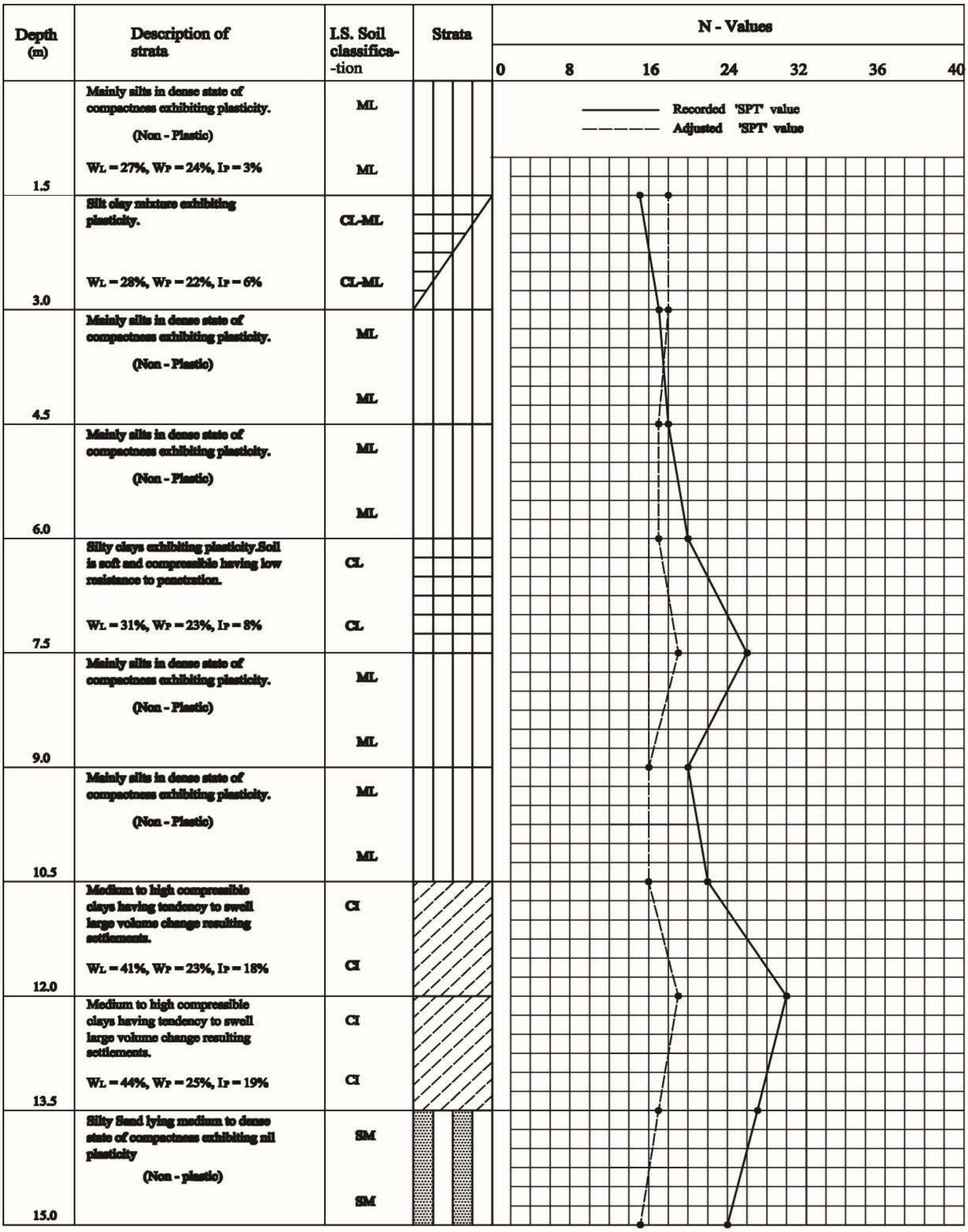
APPENDIX



BORE HOLE # 1

FIG. 1 : BORE HOLE CHART WITH PENETRATION TEST DATA

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OBSERVATIONS

SPECIFIC GRAVITY OF SAMPLE 1 (DEPTH=1.5M)

S.NO	DETERMINATION	1
1.	Wt. .of Dry and Clean Bottle "WI" (g)	29.90
2.	Wt. of Bottle +Dry Soil "W2"	48.0
3.	Wt. of Bottle + Dry Soil +Water "W3"	91.10
4.	Wt. of Bottle +Water "W4" (g)	79.80
5.	Specific Gravity of Soil $\left[\frac{w_2 - w_1}{(w_1 - w) - (w_3 - w_4)}\right]$	2.67

SPECIFIC GRAVITY OF SAMPLE 1 (DEPTH=3.0M)

S.NO	DETERMINATION	1
1.	Wt. .of Dry and Clean Bottle "WI" (g)	29.9
2.	Wt. of Bottle +Dry Soil "W2"	50.0
3.	Wt. of Bottle + Dry Soil +Water "W3"	92.4
4.	Wt. of Bottle +Water "W4" (g)	79.8
5.	Specific Gravity of Soil $\left[\frac{w_2 - w_1}{(w_1 - w) - (w_3 - w_4)}\right]$	2.68

SPECIFIC GRAVITY OF SAMPLE 1 (DEPTH=4.5M)

S.NO	DETERMINATION	1
1.	Wt. .of Dry and Clean Bottle "WI" (g)	29.9
2.	Wt. of Bottle +Dry Soil "W2"	51.5
3.	Wt. of Bottle + Dry Soil +Water "W3"	93.3
4.	Wt. of Bottle +Water "W4" (g)	79.8
5.	Specific Gravity of Soil $\left[\frac{w_2 - w_1}{(w_1 - w) - (w_3 - w_4)}\right]$	2.67

SPECIFIC GRAVITY OF SAMPLE 1 (DEPTH=6.0M)

S.NO	DETERMINATION	1
1.	Wt. .of Dry and Clean Bottle "WI" (g)	29.9
2.	Wt. of Bottle +Dry Soil "W2"	52.5
3.	Wt. of Bottle + Dry Soil +Water "W3"	92.3
4.	Wt. of Bottle +Water "W4" (g)	79.8
5.	Specific Gravity of Soil $\left[\frac{w_2 - w_1}{(w_1 - w) - (w_3 - w_4)}\right]$	2.68

SPECIFIC GRAVITY OF SAMPLE 1 (DEPTH=7.5M)

S.NO	DETERMINATION	1
1.	Wt. .of Dry and Clean Bottle "WI" (g)	29.9
2.	Wt. of Bottle +Dry Soil "W2"	52.5
3.	Wt. of Bottle + Dry Soil +Water "W3"	93.3
4.	Wt. of Bottle +Water "W4" (g)	79.8
5.	Specific Gravity of Soil $\left[\frac{w_2 - w_1}{(w_1 - w) - (w_3 - w_4)}\right]$	2.68

LIQUID LIMIT AND PLASTIC LIMIT TEST

S.NO	DETERMINATION NO.	1.	2.	3.	4.	5.
1.	NO. OF BLOWS	25	30	35	20	32
2.	Wt. OF SATURATED SOIL (GM)	177	175.5	169.5	183	172.5
3.	Wt. OF WATER (GM0	150	150	150	150	150
4.	Wt. OF WATER (GM)	27	25.5	19.5	33	22.5
5.	WATER CONTENT IN %	18	17	13	22	15

LIQUID LIMIT TEST FOR SAMPLE (DEPTH=1.5M)

S.NO	DETERMINATION NO.	1.	2.	3.	4.	5.
1.	NO. OF BLOWS	25	30	40	20	22
2.	Wt. OF SATURATED SOIL (GM)	183	180	174	189	186
3.	Wt. OF WATER (GM0	150	150	150	150	150
4.	Wt. OF WATER (GM)	33	30	24	39	36
5.	WATER CONTENT IN %	22	20	16	26	24

LIQUID LIMIT TEST FOR SAMPLE (DEPTH=3.0M)

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LIQUID LIMIT TEST FOR SAMPLE (DEPTH=6.0M)

S.NO	DETERMINATION NO.	1.	2.	3.	4.	5.
1.	NO. OF BLOWS	30	20	27	23	40
2.	Wt. OF SATURATED SOIL (GM)	192	205.5	195	198	184.5
3.	Wt. OF WATER (GM0	150	150	150	150	150
4.	Wt. OF WATER (GM)	42	55.5	45	48	34.5
5.	WATER CONTENT IN %	28	37	30	32	23

LIQUID LIMIT TEST FOR SAMPLE (DEPTH=7.5M)

S.NO	DETERMIN ATION NO.	1.	2.	3.	4.	5.
1.	NO. OF BLOWS	30	20	22	32	40
2.	Wt. OF SATURATED SOIL (GM)	198	204	202.5	196.5	193.5
3.	Wt. OF WATER (GM0	150	150	150	150	150
4.	Wt. OF WATER (GM)	48	54	52.5	46.5	43.5
5.	WATER CONTENT IN %	32	36	35	31	29

AT DEPTH 4.5M, THE SOIL IS NON PLASTIC.

PLASTIC LIMIT TEST

PLASTIC LIMIT TEST FOR DEPTH=1.5M

S NO.	DETERMINATION NO.	TEST 1	TEST 2	TEST 3
1.	Container no.	1	2	3
2.	Wt. of container	20.5	20.6	20.5
3.	Wt. of cont + wet soil (gm)	21.9	21.7	22.3
4.	Wt. of cont.+ dry soil (gm)	21.7	21.6	22.1
5.	Wt. of water (W) (gm)	0.2	0.1	0.2
6.	Wt. of solids	1.2	1	1.5
7.	Water content in %	16.6	10	13.3

PLASTIC LIMIT TEST FOR DEPTH=3.0M

S NO.	DETERMINATION NO.	TEST 1	TEST 2	TEST 3
1.	Container no.	1	2	3
2.	Wt. of container	20.5	20.6	20.6
3.	Wt. of cont + wet soil (gm)	22.1	22.1	22.5
4.	Wt. of cont.+ dry soil (gm)	21.9	21.9	22.2
5.	Wt. of water (W) (gm)	0.2	0.2	0.3
6.	Wt. of solids	1.4	1.3	1.6
7.	Water content in %	14.2	15.3	18.7

PLASTIC LIMIT TEST FOR DEPTH=6.0M

S NO.	DETERMINATION NO.	TEST 1
1.	Container no.	1
2.	Wt. of container	20.5
3.	Wt. of cont + wet soil (gm)	22.3
4.	Wt. of cont.+ dry soil (gm)	22
5.	Wt. of water (W) (gm)	0.3
6.	Wt. of solids	1.5
7.	Water content in %	20

PLASTIC LIMIT TEST FOR DEPTH=7.5M

S NO.	DETERM INATION NO.	TEST 1	TEST 2	TEST 3
1.	Container no.	1	2	3
2.	Wt. of container	20.3	20.7	20.5
3.	Wt. of cont + wet soil (gm)	21.8	21.9	21.1
4.	Wt. of cont.+ dry soil (gm)	21.5	21.7	21.8
5.	Wt. of water (W) (gm)	0.3	0.2	0.3
6.	Wt. of solids	1.2	1	1.3
7.	Water content in %	25	20	23

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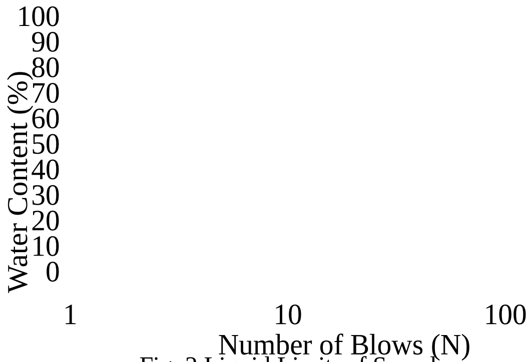

Fig. 2 Liquid Limit o f Sample 1(depth=1.5m)

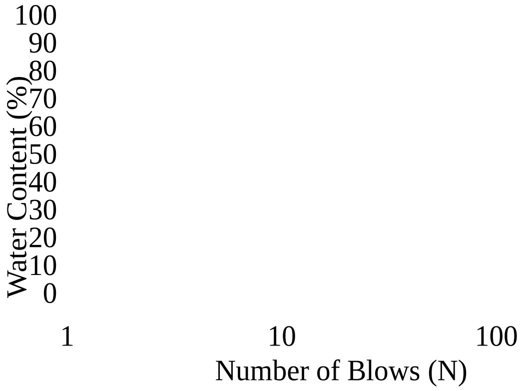

Fig.3 Liquid Limit of sample2 (depth=3.0m)

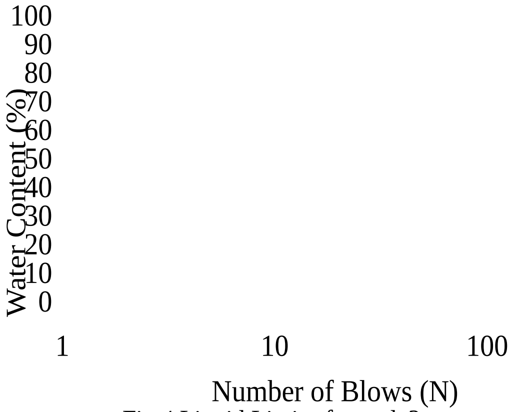

Fig 4 Liquid Limit of sample3 (depth=6.0m)

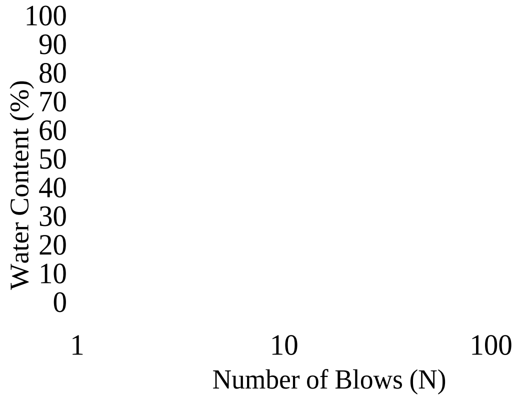

Fig.5 Liquid Limit of sample4 (depth=7.5m)

SIEVE ANALYSIS RESULTS

TEST 1

WEIGHT OF SOIL=500 G

DEPTH=1.5M

S. NO	IS SIEVE SIZE	Wt.RETAINED ON EACH SIEVE (g)	%Wt. RETAINED ON EACH SIEVE	CUMULATIVE % RETAINED ON EACH SIEVE	% FINER
1.	425	0	0	0	100
2.	300	40	8.0	8.0	92.0
3.	212	32.5	6.5	14.5	85.5
4.	150	37.5	7.5	22.0	78.0
5.	75	85	17	39.0	61.0
6.	PAN	305	61	100	0

TEST 2

WEIGHT OF SOIL=500 G

DEPTH=3.0 M

S. NO	IS SIEVE SIZE	Wt.RETAINED ON EACH SIEVE (g)	%Wt. RETAINED ON EACH SIEVE	CUMULATIVE % RETAINED ON EACH SIEVE	% FINER
1.	425	0	0	0	100
2.	300	1.1	0.22	0.22	99.78
3.	212	16.4	3.28	3.5	96.54
4.	150	36.6	7.32	10.82	89.18
5.	75	159.6	31.9	42.72	57.28
6.	PAN	286.3	57.26	100	0

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TEST 3

WEIGHT OF SOIL=500 G

DEPTH=4.5M

S. NO	IS SIEVE SIZE	Wt.RETAINED ON EACH SIEVE (g)	%Wt. RETAINED ON EACH SIEVE	CUMULATIVE % RETAINED ON EACH SIEVE	% FINER
1.	425	0	0	0	100
2.	300	10.0	2.0	2.0	98.0
3.	212	20.0	4.0	6.0	94.0
4.	150	25.0	5.0	11.0	89.0
5.	75	60.0	12.0	23.0	77.0
6.	PAN	385	77.0	100	0

TEST 4

WEIGHT OF SOIL=500 G

DEPTH=6.0M

S. NO	IS SIEVE SIZE	Wt.RETAINED ON EACH SIEVE (g)	%Wt. RETAINED ON EACH SIEVE	CUMULATIVE % RETAINED ON EACH SIEVE	% FINER
1.	425	0	0	0	100
2.	300	11.9	2.38	2.38	97.62
3.	212	7.0	1.9	3.78	93.84
4.	150	14.3	2.86	6.64	87.20
5.	75	109.3	21.86	28.5	58.70
6.	PAN	357.5	71.5	100	0

TEST 5

WEIGHT OF SOIL=500 G

DEPTH=7.5M

S. NO	IS SIEVE SIZE	Wt.RETAINED ON EACH SIEVE (g)	%Wt. RETAINED ON EACH SIEVE	CUMULATIVE % RETAINED ON EACH SIEVE	% FINER
1.	425	0	0	0	100
2.	300	11.9	2.38	2.38	97.62
3.	212	7.0	1.9	3.78	93.84
4.	150	14.3	2.86	6.64	87.20
5.	75	109.3	21.86	28.5	58.70
6.	PAN	357.5	71.5	100	0

TEST RESULTS FOR TRIAXIAL TEST AT 1.5M DEPTH