Assam Inland Water Transport Project

Preparation of Detailed Project Report (DPR), Front End Engineering Design (FEED) and Tender Documents for Development of Ferry Services in Assam

DETAILED PROJECT REPORT FOR GUWAHATI GATEWAY GHAT - FINAL
P.013223
VOLUME 2

Dept of IWT, Govt of Assam, Guwahati
Assam | INDIA

RESTRICTED

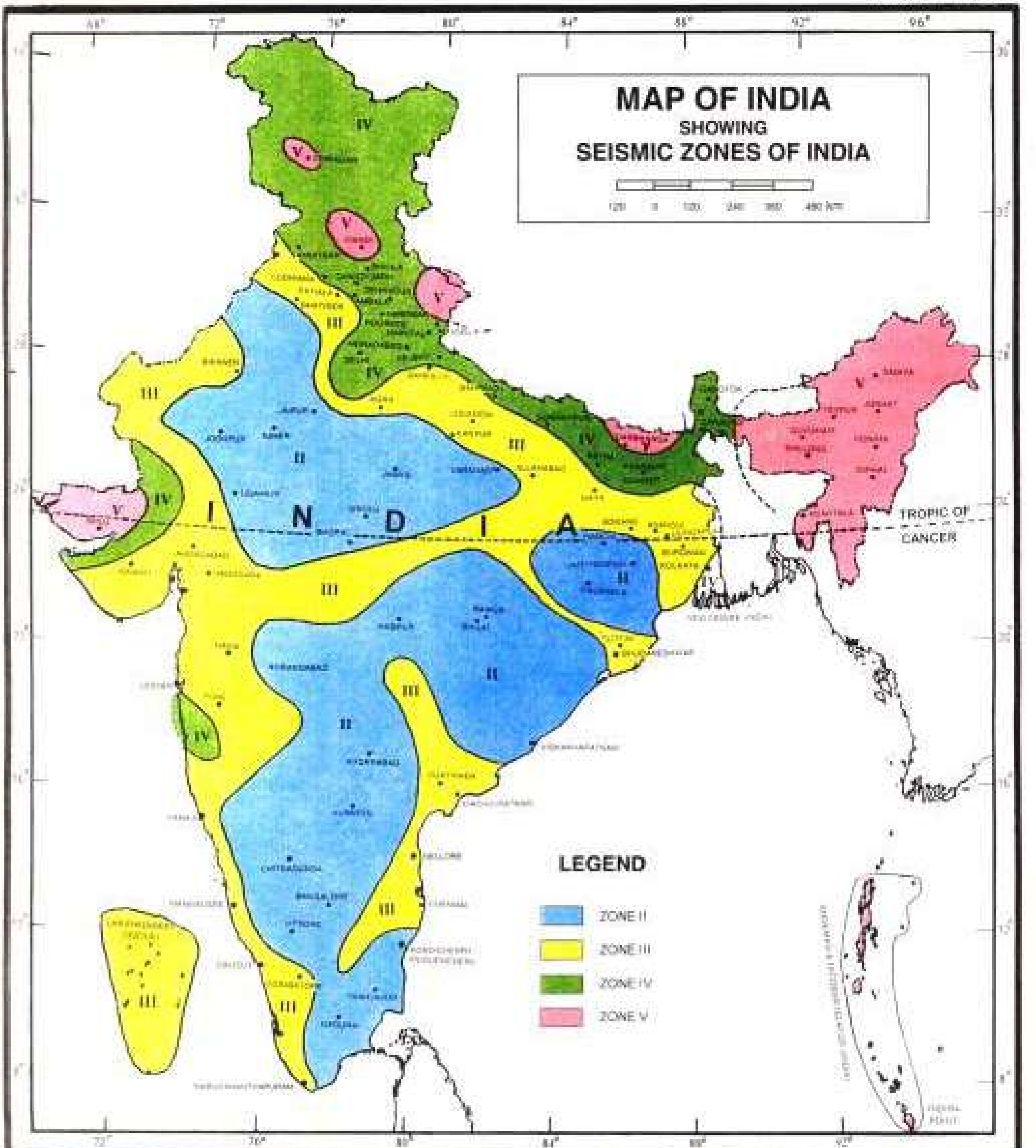
14 August 2021

REPORT

R2-V2

VOLUME – 2

ANNEXURE 1.1 – REGIONAL GEOLOGICAL MAP OF ASSAM

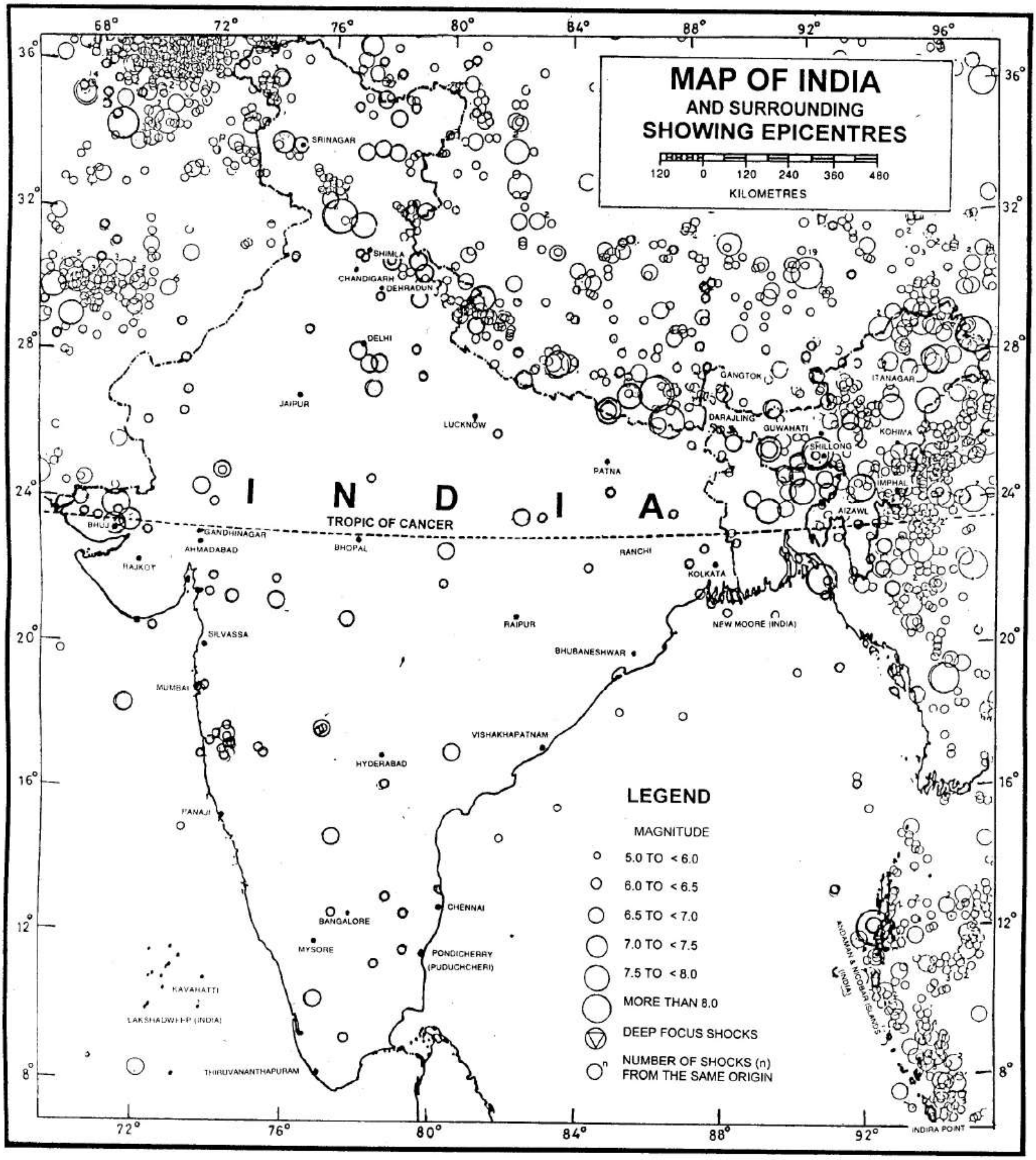


NOTE : Towns falling at the boundary of zones demarcation line between two zones shall be considered in High Zone.

- ☐ Based upon Survey of India map with the permission of the Surveyor General of India.
- ☐ The responsibility for the correctness of internal details rests with the publisher.
- ☐ The territorial waters of India extend into the sea to distance of twelve nautical miles measured from the appropriate base line.
- ☐ The administrative headquarters of Chandigarh, Haryana and Punjab are at Chandigarh.
- ☐ The interstate boundaries between Arunachal Pradesh, Assam and Meghalaya shown on this map are as interpreted from the North-Eastern Areas (Reorganization) Act, 1971, but have yet to be verified.
- ☐ The external boundaries and coastlines of India agree with the Record/Master Copy certified by Survey of India.

FIG. 1

ANNEX A
(Foreword)



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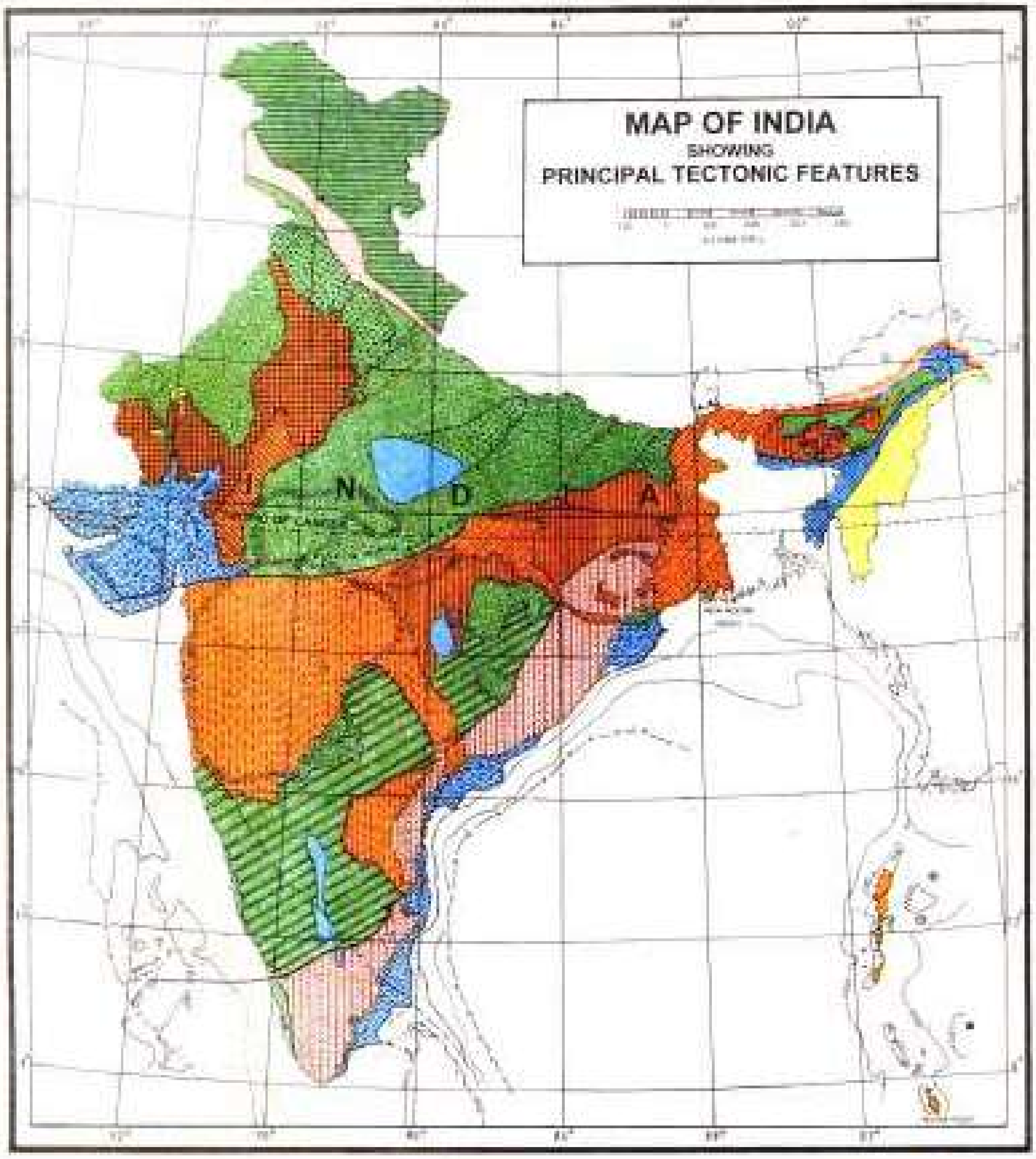
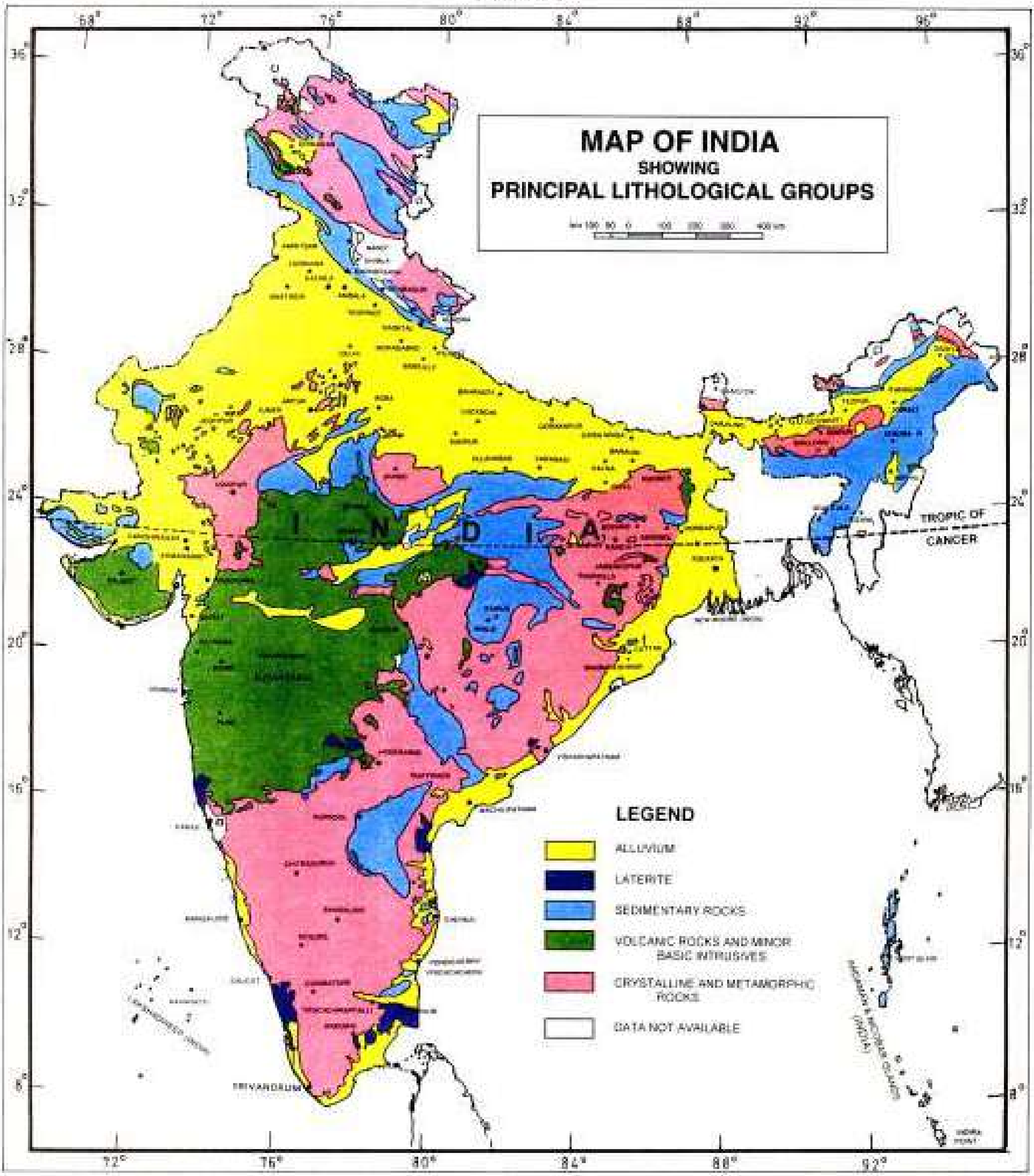
ANNEX B
(Foreword)



ANNEX C

(Foreword)



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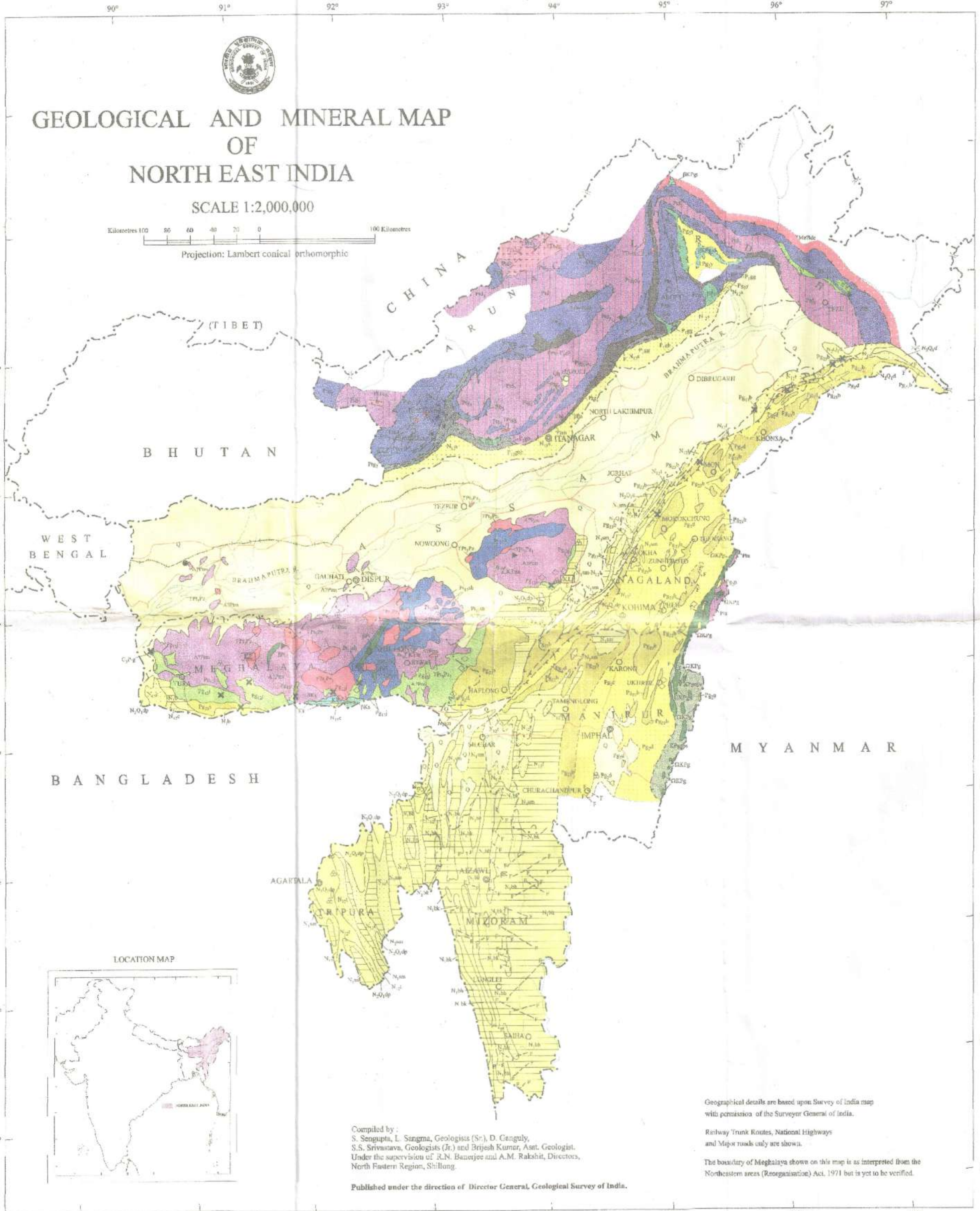


LEGEND

SEDIMENTARY AND METAMORPHIC ROCKS

- Q — QUATERNARY (Q): Undifferentiated fluvial sediments (Q); Hapoli Fm (Qh)
- N_2Q_1 — PLIO-PLEISTOCENE (N_2Q_1): Dihing Fm (N_2Q_1d), Dupitila Fm (N_2Q_1dp) and Namsang Fm (N_2Q_1n)
- N_{12} — MIO-PLIOCENE (N_{12}): Tipam Gp (N_{12}t) and Chengapara Fm (N_{12}c); Middle Siwalik Gp (N_{12}s)
- N_1 — MIOCENE (N_1): Surma Gp (N_1sm), Bokabil Fm (N_1bk), Bhuban Fm (N_1bh) and Baghmara Fm (N_1b)
- Pg_{23} — EOCENE-OLIGOCENE (Pg_{23}): Barail Gp (Pg_{23}b) and Simsang Fm (Pg_{23}s)
- Pg_2 — EOCENE (Pg_2): Disang Gp (Pg_2d), Phokphur Fm (Pg_2p), Yingkiong Fm (Pg_2y)
- Pg_{12} — PALAEOCENE-EOCENE (Pg_{12}): Jaintia Gp (Pg_{12}j)
- KPg — CRETACEOUS-PALAEOCENE (KPg): Oceanic Pelagic Sediments (KPgops)
- K — CRETACEOUS (K): Khasi Gp (Kk)
- P — PERMIAN (P): Bhareli Fm (P_{12}gbh), Garu Fm (P_1gg) and Bichom Fm (P_1gb)- Gondwana equivalents in Arunachal Pradesh
- CARBONIFEROUS-PERMIAN (CP): *Lower Gondwana* (C_3P-g)
- PALAEOZOIC (Pz): Miri Fm (Pzm), Undifferentiated Miri and Bichom Fms (Pzm-P_1gb) of Arunachal Pradesh
- Pt_{12} — PALAEOPROTEROZOIC-MESOPROTEROZOIC (Pt_{12}): Shillong Gp (Pt_{12}sh)
- Pt | Pt — PROTEROZOIC (Undiff.) (Pt): Lumla Fm (Ptp_2), Dirang Fm (Ptp_3), Khetabari Fm (Ptp_4), Tiding Fm (Ptp_7); Gorubathan Fm (Ptg_1) of Daling Gp and equivalents, Potin Fm (Ptg_2), Tenga Fm (Ptg_3), Reyang Fm (Ptr_1) and undifferentiated Potin and Khetabari Fm (Ptg_2p_4), Buxa Fm (Ptb_1) and equivalents, Nuimi Fm (Ptb_2), Dedja Fm (Ptb_3); Sela Gp (Ptd_1), and Naga Metamorphics (Ptn)
- A?Pt — ARCHAEAN (?) - PROTERZOIC (Undiff.) (A?Pt): Gneissic Complex of Meghalaya (A?Ptm)

IGNEOUS ROCKS

PLUTONIC

ACID

- γTt — TERTIARY (Tt): Tourmaline Granite (γ Tt-tg) of E. Himalaya
- γMz — MESOZOIC (Mz): Lohit Migmatite Complex with diorite intrusives (γMz?ldc) of E. Himalaya
- $γPt_3Pz_1$ — NEOPROTEROZOIC - I.R. PALAEOZOIC (Pt_3Pz_1): Kyrdem, Nongpoh, Mylliem Granites, South Khasi Batholith and equivalent granites (γ Pt_3Pz_1)
- γPt — PROTEROZOIC (Undiff.) (Pt): Gneissic Granites of Arunachal Pradesh (γPtgg)

INTERMEDIATE / BASIC

- ζKTt — CRETACEOUS - TERTIARY (KTt): Alkali Complex of Sung Samchampi (ζKTts/ζKTtss)

ULTRAMAFIC

- σKTt — CRETACEOUS - TERTIARY (KTt): Tiding Serpentinite (σKTts) of N.E. Himalaya.

VOLCANIC

- βKPg — *CRETACEOUS - PALAEOGENE* (KPg): Abor Volcanics (*younger phase*) (βKPg_2a), Tuting Volcanics (βKPgt) of N.E. Himalaya
- βK — CRETACEOUS (K): Sylhet Trap (βKs) of Meghalaya
- βP — PERMIAN (P): Abor Volcanics (older phase) (βPa)
- βPt — PROTEROZOIC (Undiff.) (Pt): Khasi Greenstone (βPt)

OPHIOLITES

- ΩKPg — CRETACEOUS - PALAEOGENE (KPg): Ophiolites of Nagaland (ΩKPg)

STRUCTURAL INDEX

Fault · Thrust · Geological boundary : confirmed / inferred · Unmapped area

MINERAL INDEX

Apatite	Base metals	Bauxite	Coal	Dimensional Stone
Dolomite	Fire clay & clays	Fuller's earth	Glass sand	Graphite
Iron ore (BMQ)	KL Kaolin	Limestone	Qz Quartzite	Sillimanite

GEOGRAPHICAL INDEX

Int. boundary · State Capital · Major town · Railway line · Road
State boundary · Drainage

Digital cartographic processing for printing by :
N.R.S. Reddy, R.M. Sundaram, Geologists (Jr.) and B.K. Singh, S.T.A.

ROAD AND RAIL CONNECTIVITY MAP OF ASSAM

ANNEXURE 2.1 – FLOOD FREQUENCY ANALYSIS AT PANDU

Log Pearson Type III

RANK	PEAK FLOW, Q , m3/s	LOGQ	(log Q – avg(logQ))^2	(log Q – avg(logQ))^3	Return Period (n+1)/m	Exceedence Probability (1/Tr)
1	71900	4.857	0.034	0.006	37.000	0.027
2	62000	4.792	0.014	0.002	18.500	0.054
3	58600	4.768	0.009	0.001	12.333	0.081
4	58500	4.767	0.009	0.001	9.250	0.108
5	58244	4.765	0.008	0.001	7.400	0.135
6	55092	4.741	0.005	0.000	6.167	0.162
7	54100	4.733	0.004	0.000	5.286	0.189
8	53389	4.727	0.003	0.000	4.625	0.216
9	53286	4.727	0.003	0.000	4.111	0.243
10	52600	4.721	0.002	0.000	3.700	0.270
11	51700	4.713	0.002	0.000	3.364	0.297
12	51188	4.709	0.001	0.000	3.083	0.324
13	51100	4.708	0.001	0.000	2.846	0.351
14	50958	4.707	0.001	0.000	2.643	0.378
15	49470	4.694	0.000	0.000	2.467	0.405
16	49386	4.694	0.000	0.000	2.313	0.432
17	48365	4.685	0.000	0.000	2.176	0.459
18	47734	4.679	0.000	0.000	2.056	0.486
19	47610	4.678	0.000	0.000	1.947	0.514
20	47188	4.674	0.000	0.000	1.850	0.541
21	46856	4.671	0.000	0.000	1.762	0.568
22	45620	4.659	0.000	0.000	1.682	0.595
23	45542	4.658	0.000	0.000	1.609	0.622
24	44100	4.644	0.001	0.000	1.542	0.649
25	43918	4.643	0.001	0.000	1.480	0.676
26	42024	4.623	0.002	0.000	1.423	0.703
27	41200	4.615	0.003	0.000	1.370	0.730
28	40480	4.607	0.004	0.000	1.321	0.757
29	40282	4.605	0.005	0.000	1.276	0.784
30	39424	4.596	0.006	0.000	1.233	0.811
31	39354	4.595	0.006	0.000	1.194	0.838
32	37934	4.579	0.009	-0.001	1.156	0.865
33	37747	4.577	0.009	-0.001	1.121	0.892
34	36196	4.559	0.013	-0.002	1.088	0.919
35	35009	4.544	0.017	-0.002	1.057	0.946
36	33000	4.519	0.024	-0.004	1.028	0.973

No. Years in Record	36					
Avg_Qpeak_cfs	47808.222					
Avg_LogQ_cfs	4.673					
Sum {(log Q – avg(logQ))^2}	0.198					
Sum {(log Q – avg(logQ))^3	0.001					
Variance_LogQ_cfs	0.006					
Stdev_LogQ_cfs	0.075					
Skewness (Cs)	0.036					
Skew Coefficient (Cm)	0.360					
Variance of Regional Skewness V(Cm)	0.302					
Variance of Station Skewness (V(Cs):	0.143					
A value	-0.327					
B value	0.931					
Weighting Factor (W)	0.679					
Weighted Skewness (Cw)	0.140					
Table Cw upper	0.200					
Table Cw lower	0.100					
Calculated Cw Value	0.140					
Tr	K lower	K upper	Slope	K calculated	LogQTr	QTr
25	1.8	1.8	0.3	1.8	4.8	64681
50	2.2	2.2	0.5	2.2	4.8	68715
100	**2.5**	**2.5**	**0.7**	**2.5**	**4.9**	**72642**

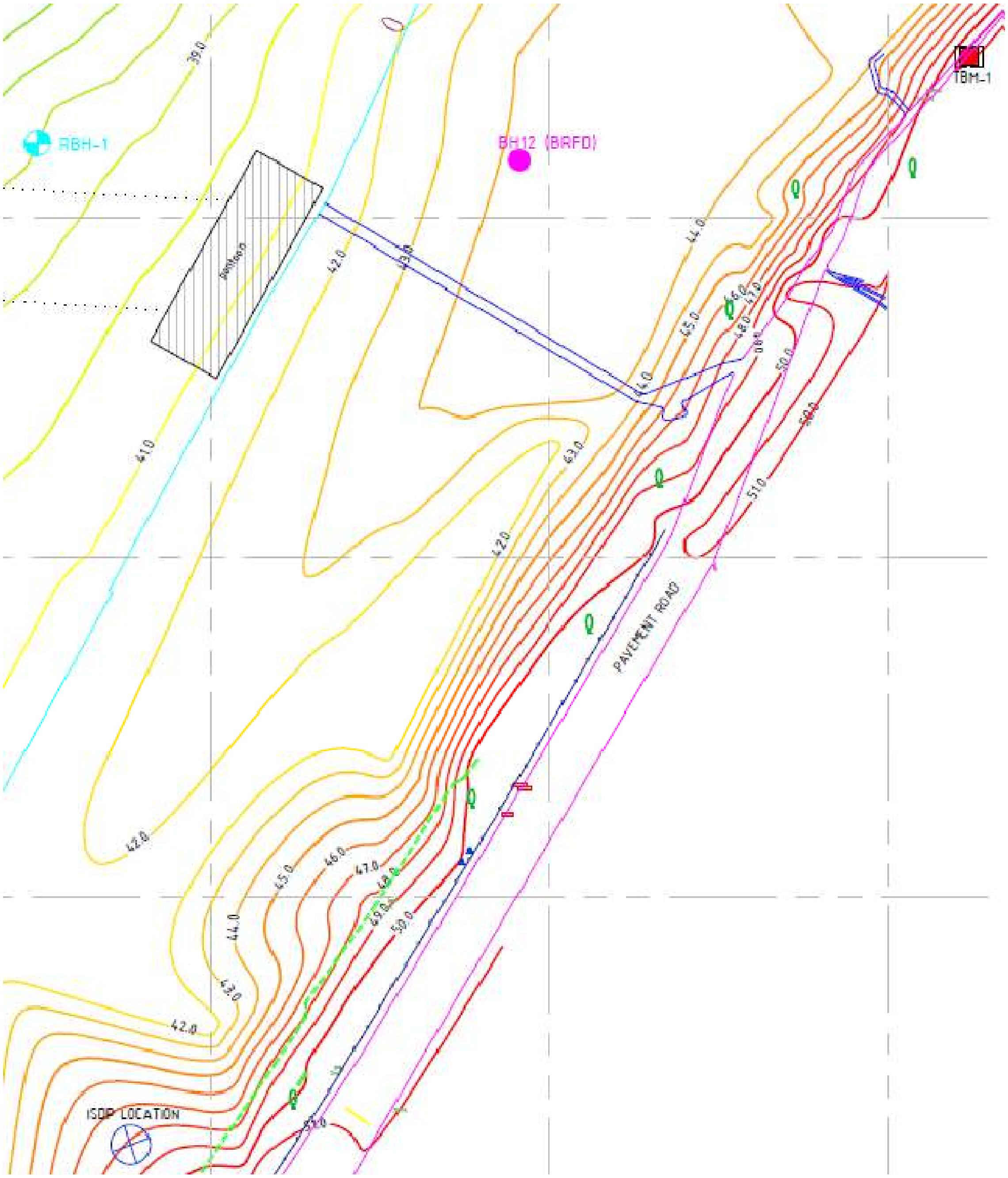
Gumbel Type 1

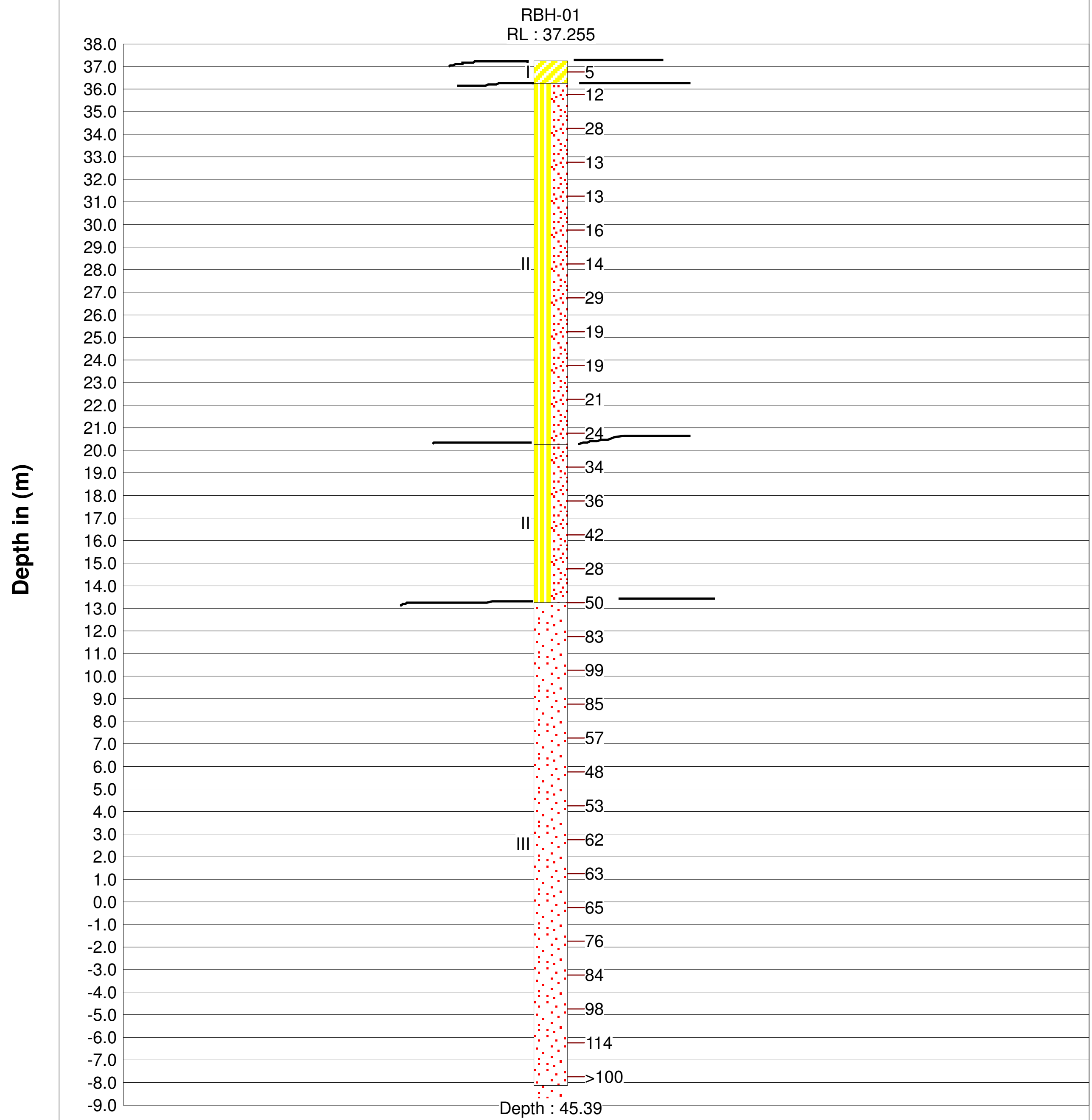
Discharge (decreasing order)(Y)	N	m	Return Perod(T)=(N+1)/m	Mean(X)	(Y-X)^2	Variance	Standard Deviation
71900	36	1	37.000	47808	580413756	69634388	8344.7222
62000		2	18.500		201406556		
58600		3	12.333		116462468		
58500		4	9.250		114314112		
58244		5	7.400		108905458		
55092		6	6.167		53053419		
54100		7	5.286		39586468		
53389		8	4.625		31145081		
53286		9	4.111		30006049		
52600		10	3.700		22961134		
51700		11	3.364		15145934		
51188		12	3.083		11422898		
51100		13	2.846		10835801		
50958		14	2.643		9921100		
49470		15	2.467		2761505		
49386		16	2.313		2489383		
48365		17	2.176		310001		
47734		18	2.056		5509		
47610		19	1.947		39292		
47188		20	1.850		384676		
46856		21	1.762		906727		
45620		22	1.682		4788316		
45542		23	1.609		5135763		
44100		24	1.542		13750912		
43918		25	1.480		15133829		
42024		26	1.423		33457227		
41200		27	1.370		43668601		
40480		28	1.321		53702841		
40282		29	1.276		56644021		
39424		30	1.233		70295182		
39354		31	1.194		71473873		
37934		32	1.156		97500264		
37747		33	1.121		101228193		
36196		34	1.088		134843705		
35009		35	1.057		163820089		
33000		36	1.028		219283445		

Return Period(T)	**Mean(x)**	**Standard Deviation(s)**	**K(T)**	**Flood flow**
25	47808	8344.72218	2.04	**64861**
50			2.59	**69437**
100			3.14	**73980**

ANNEXURE 3.1 – GEOTECHNICAL INVESTIGATION RESULTS

Guwahati Gateway Terminal: RBH-1





LEGENDS

Loose grey silty sand [I]

Dense grey silty sand. [II]

Very dense greyish brown to dark grey silty sand. [III]

N Values Shown Thus :—>100

CROSS SECTION OF SOIL PROFILE

Job No.: 30906

Sheet

BORELOG DATA SHEET

Boring Method : Shell Auger & Rotary Wash Boring.	**Site :**	**BH** : RBH-01	
Boring Diameter : 150 mm		**Sheet :** 1 of 2	
Casing Diameter : 150 mm	**Co-Ordinate :**E373749.00, N2896822.00	**R.L.** : 37.255	
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
	Orientation : Vertical	**Date** : 6.2.2019	

Sample In-situ Tests Depth (m)	Type	No.	Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
0.50 - 0.95	P	3905	0.40	3/3+2=5			Loose grey silty sand with fine mica flakes.	I	
						1.00		36.26	
1.50 - 1.95	P	3906	1.40	4/5+7=12					
3.00 - 3.45	P	3907	2.90	6/12+16=28					
4.50 - 4.95	P	3908	"	4/6+7=13					
6.00 - 6.45	P	3909	"	5/6+7=13					
7.50 - 7.95	P	3910		7/7+9=16					
9.00 - 9.45	P	3911		5/6/+8=14			Medium dense grey silty sand with fine mica flakes.	II	
10.50 - 10.95	P	3912		6/12+17=29	6.2.19 / 10.50				
12.00 - 12.45	P	3913		5/7+12=19					
13.50 - 13.95	P	3914		8/9+10=19					
15.00 - 15.45	P	3915		6/8+13=21					
16.50 - 16.95	P	3916		6/10+14=24					
						17.00		20.26	
18.00 - 18.45	P	3917		9/15+19=34					
19.50 - 19.95	P	3918		11/15+21=36					
21.00 - 21.45	P	3919		10/20+22=42			Dense greyish brown sandy silt with fine mica flakes and silt lamination.	II	
22.50 - 22.95	P	3920		6/10+18=28	7.2.19 / 22.50				
						24.00		13.26	
24.00 - 24.45	P	3921		19/22+28=50					
25.50 - 25.95	P	3922		27/38+45=83					
27.00 - 27.45	P	3923		31/48+51=99					
28.50 - 28.95	P	3924		20/39+46=85			Very dense greyish brown to dark grey silty sand with fine mica flakes and nodule pieces.	III	
30.00 - 30.45	P	3925		22/26+31=57	8.2.19 / 30.00				
31.50 - 31.95	P	3926		19/22+26=48					
							Continued		

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
6.2.2019	8.30	3.90
7.2.2019	8.00	3.95
8.2.2019	8.00	3.95
9.2.2019	7.30	3.95
10.2.2019	7.30	3.95

Remarks: Area: Guwahati Gateway Ghat

S.W.L. (m)
-
(BGL)
(RL)

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30906

C.B
Supervisor

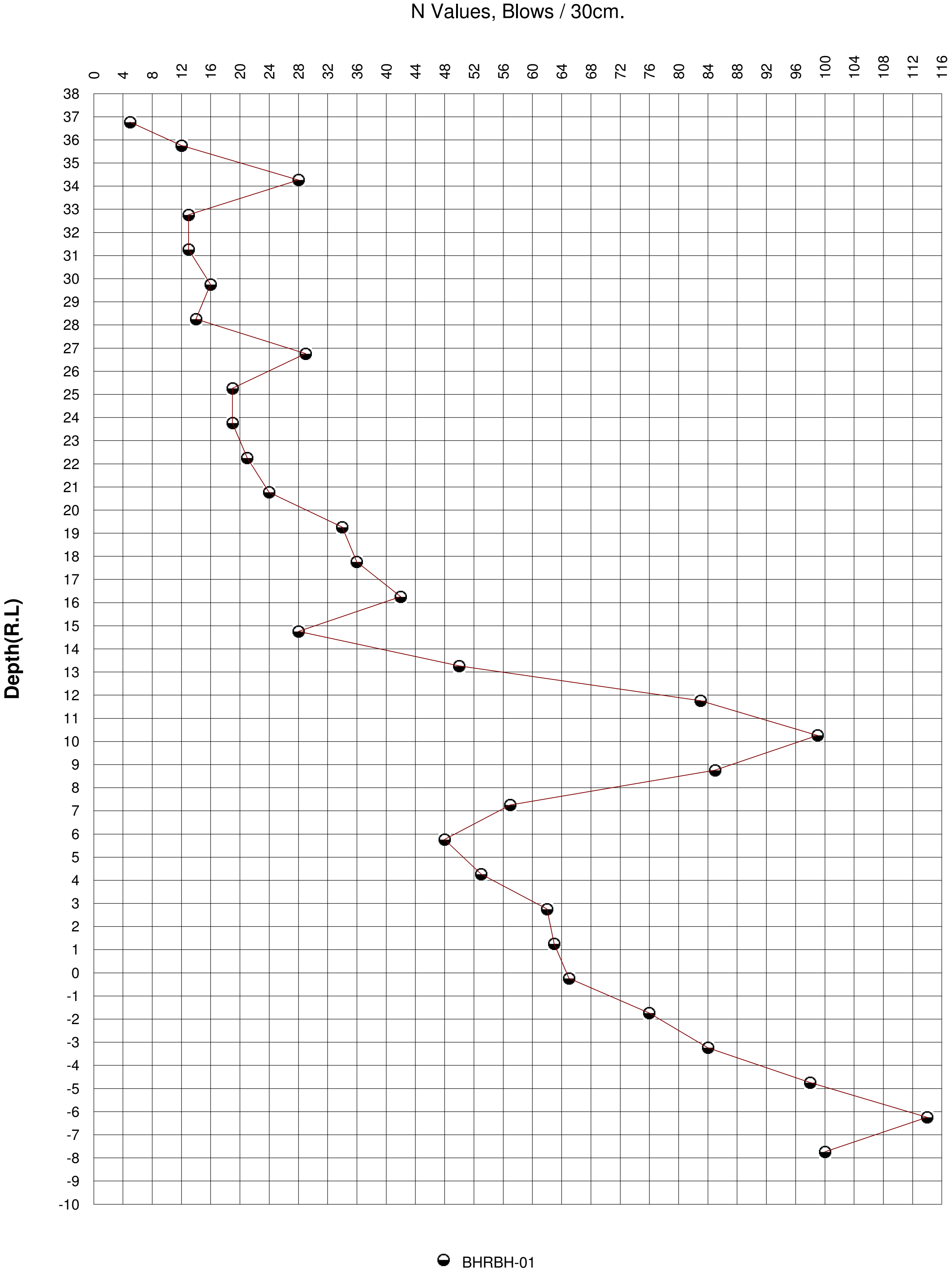
BORELOG DATA SHEET

Boring Method : Shell Auger & Rotary Wash Boring.	**Site :**	**BH** : RBH-01
Boring Diameter : 150 mm		**Sheet :** 2 of 2
Casing Diameter : 150 mm	**Co-Ordinate :**E373749.00, N2896822.00	**R.L.** : 37.255
Boring Equipment : Mechanical Cable Tools/NX Drilling.		
	Orientation : Vertical	**Date** : 6.2.2019

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	**Type**	**No.**							
33.00 - 33.45	P	3927		17/24+29=53					
34.50 - 34.95	P	3928		21/28+34=62					
36.00 - 36.45	P	3929		19/26+37=63					
37.50 - 37.95	P	3930		17/29+36=65					
39.00 - 39.45	P	3931		20/34+42=76				III	
40.50 - 40.95	P	3932		26/39+45=84					
42.00 - 42.45	P	3933		31/42+56=98					
43.50 - 43.95	P	3934		35/52+62=114	9.2.19 / 43.50				
45.00 - 45.39	P	3935		>100	10.2.19 / 45.39	45.39	End of BoreHole	-8.13	

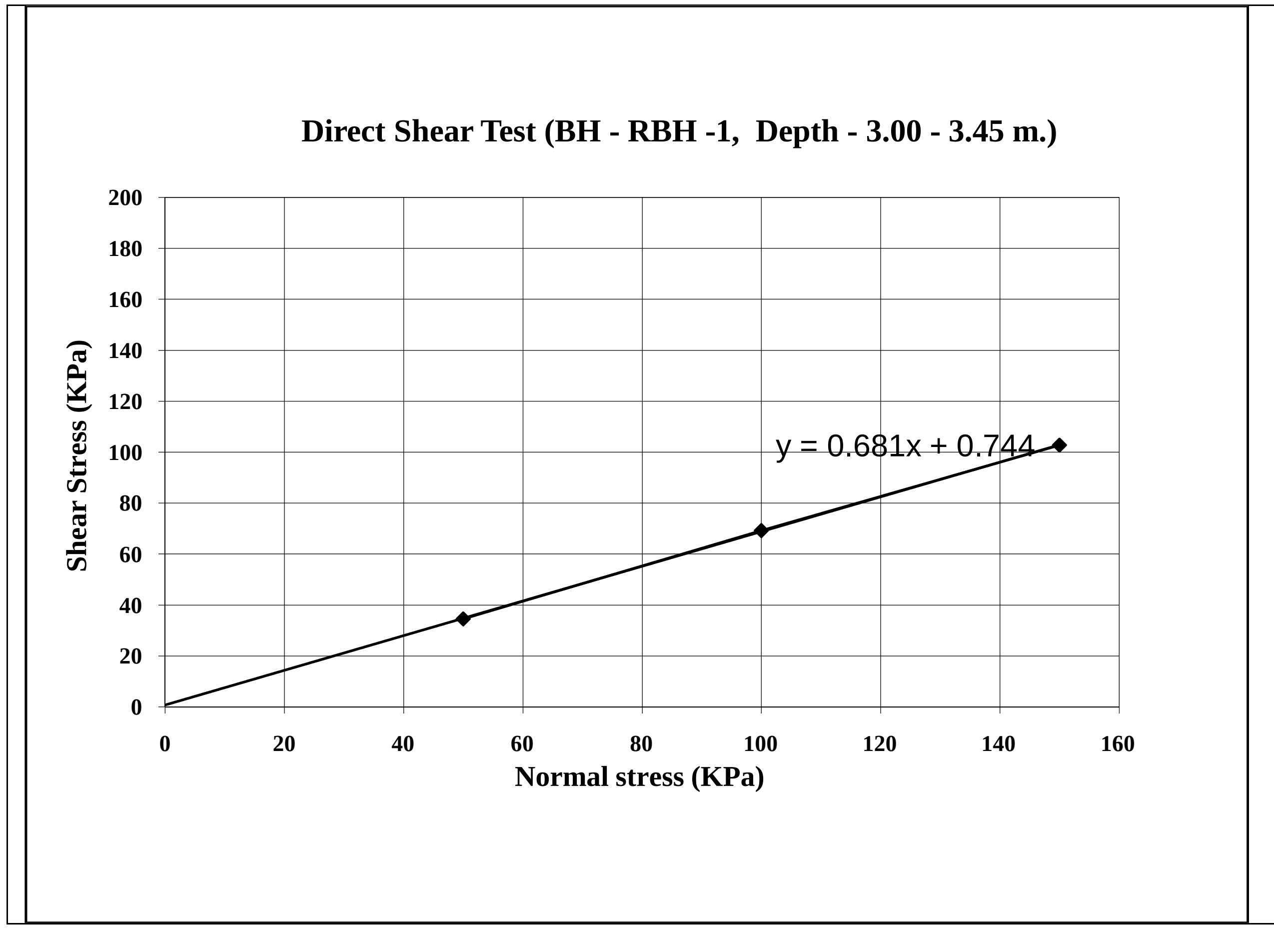
Water Level Observation			Remarks: Area: Guwahati Gateway Ghat	S.W.L. (m)	
Date	**Time (Hrs.)**	**W.L.(m) B.G.L.**		-	D- Disturbed Sample
				(BGL)	B- Bulk Sample
					W- Water Sample
				(RL)	U- Undisturbed sample
					P- Standard Penetration Test
					V- Vane Test
				C.B Supervisor	PC- Cone Penetration Test

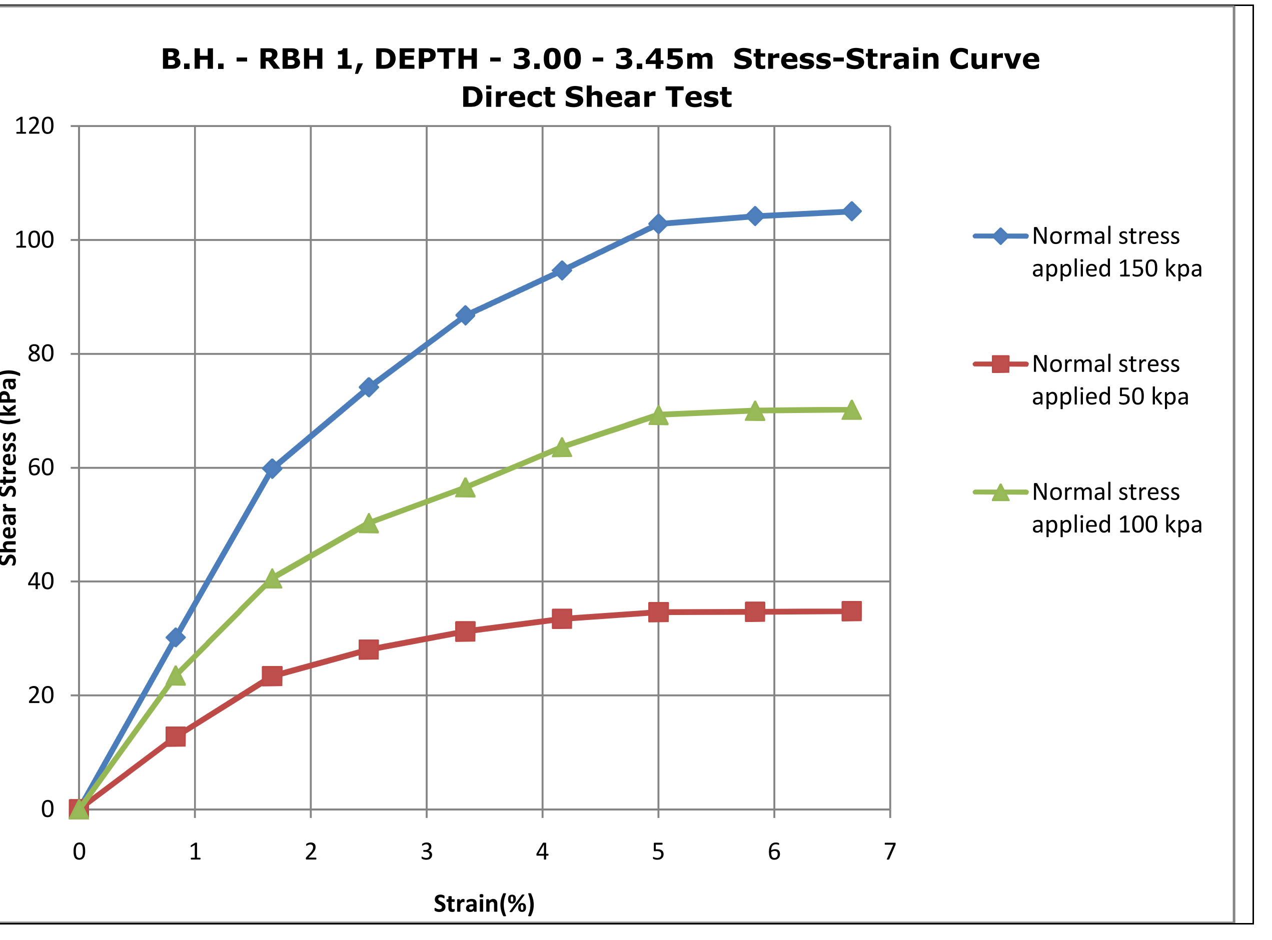
Job No: 30906



GRAPHICAL VIEW OF STANDARD PENETRATION TEST

DIRECT SHEAR TEST GRAPH





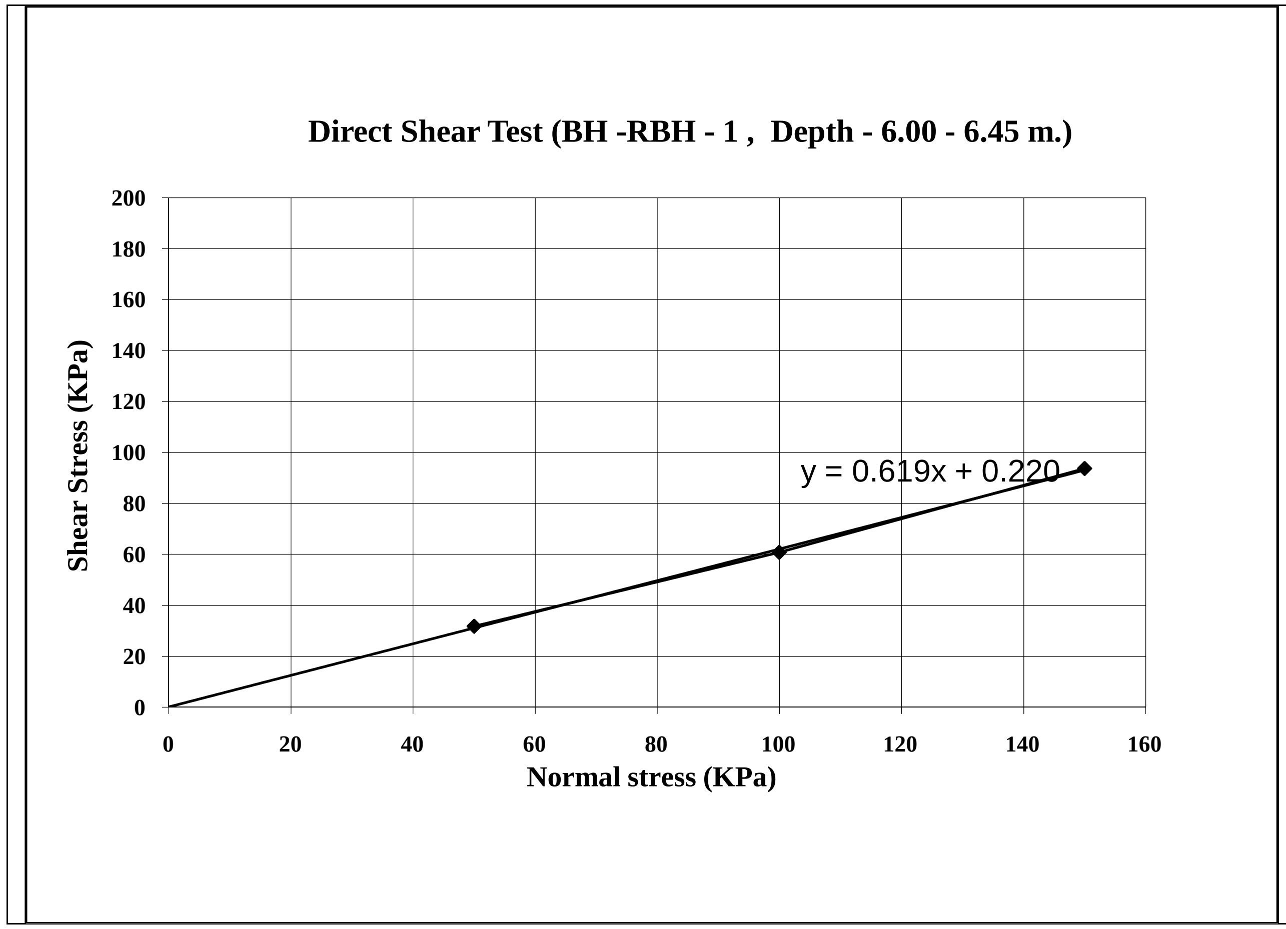
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	03.00-03.40	DS	29	27	18.1	14.0	0.74	34

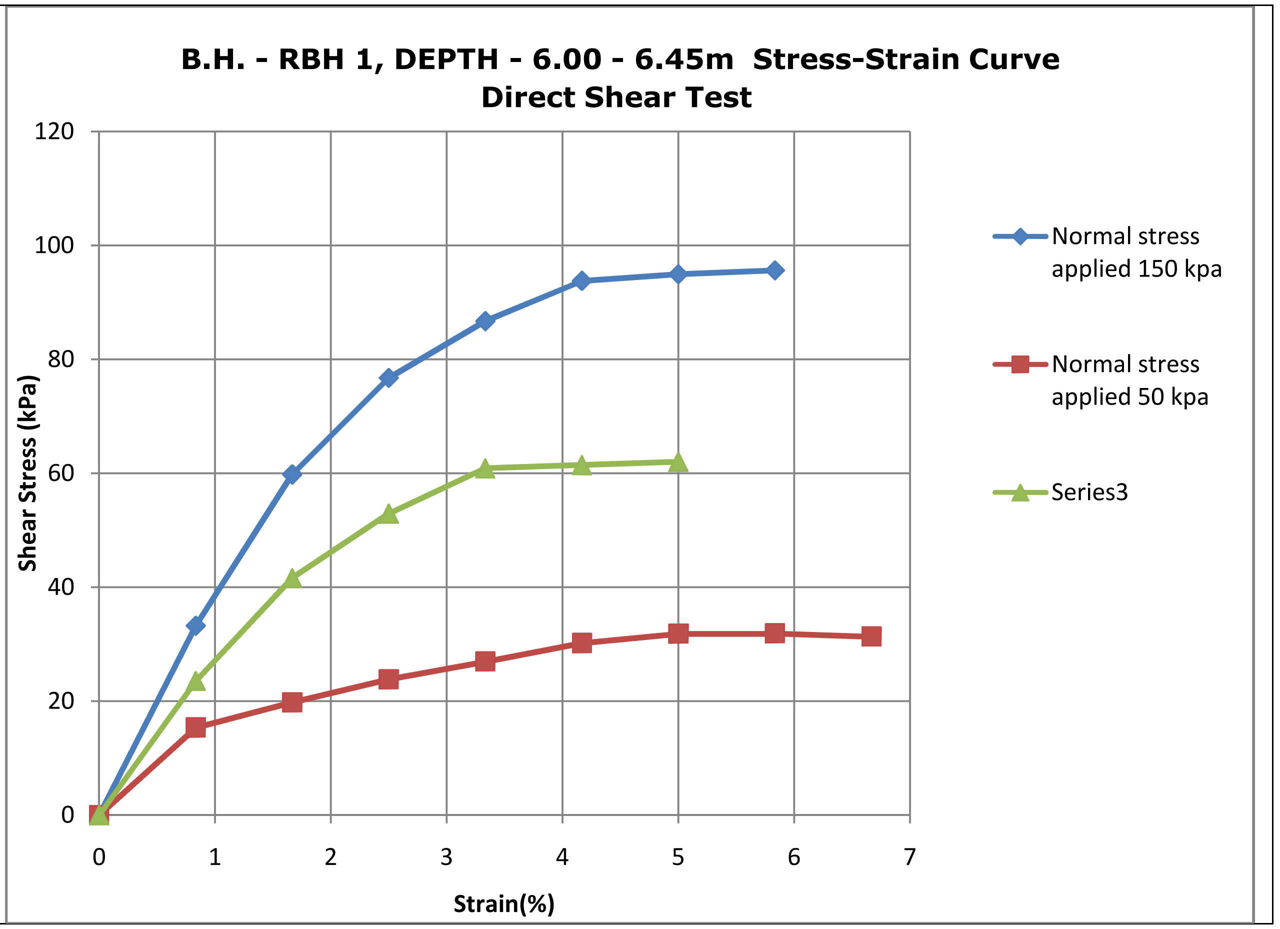
Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

JOB NO.30906

SKM Geosurvey

DIRECT SHEAR TEST GRAPH





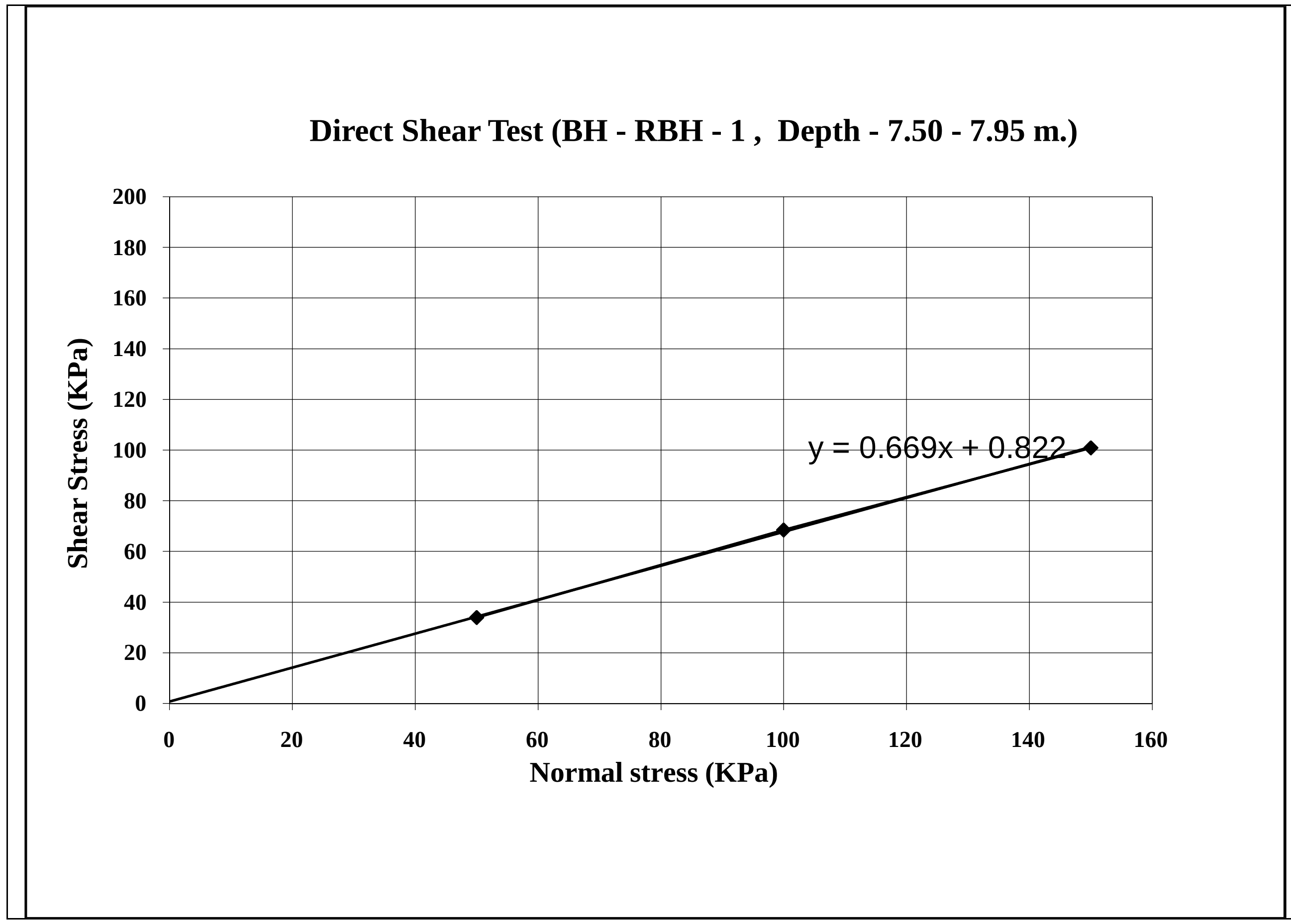
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	0.600-06.45	DS	28	26.5	17.5	13.7	0.22	32

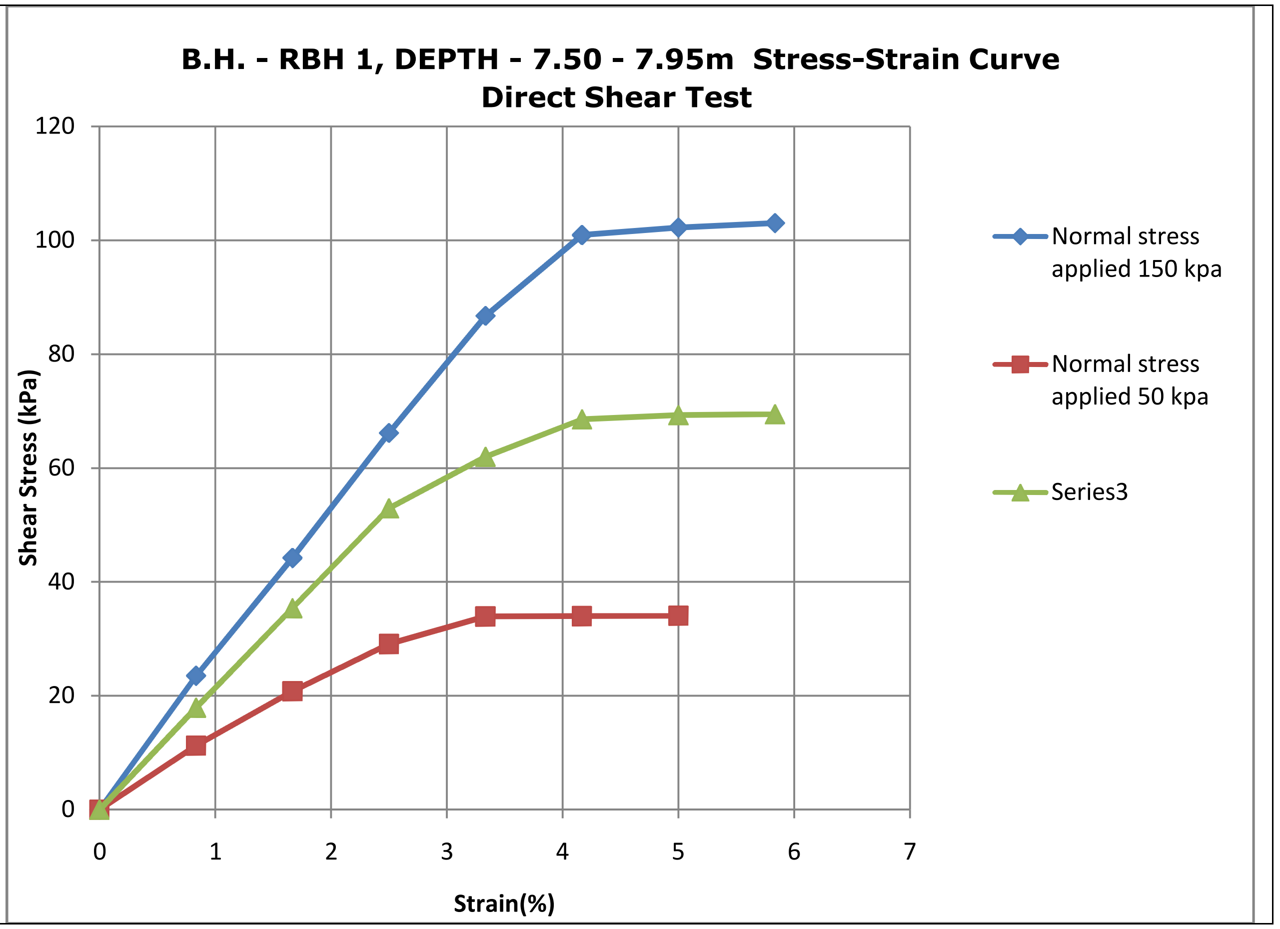
Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

JOB NO.30906

SKM Geosurvey

DIRECT SHEAR TEST GRAPH



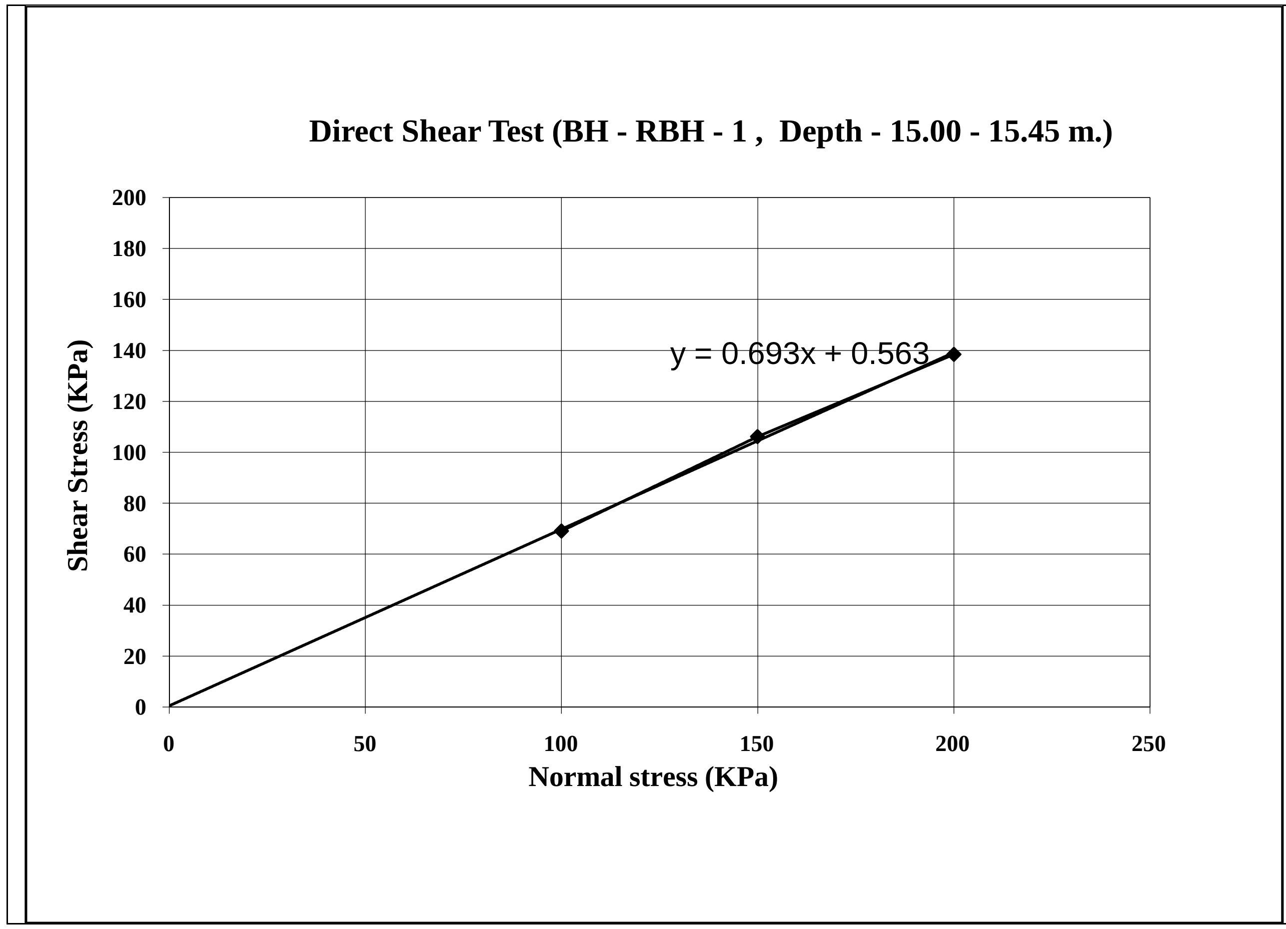


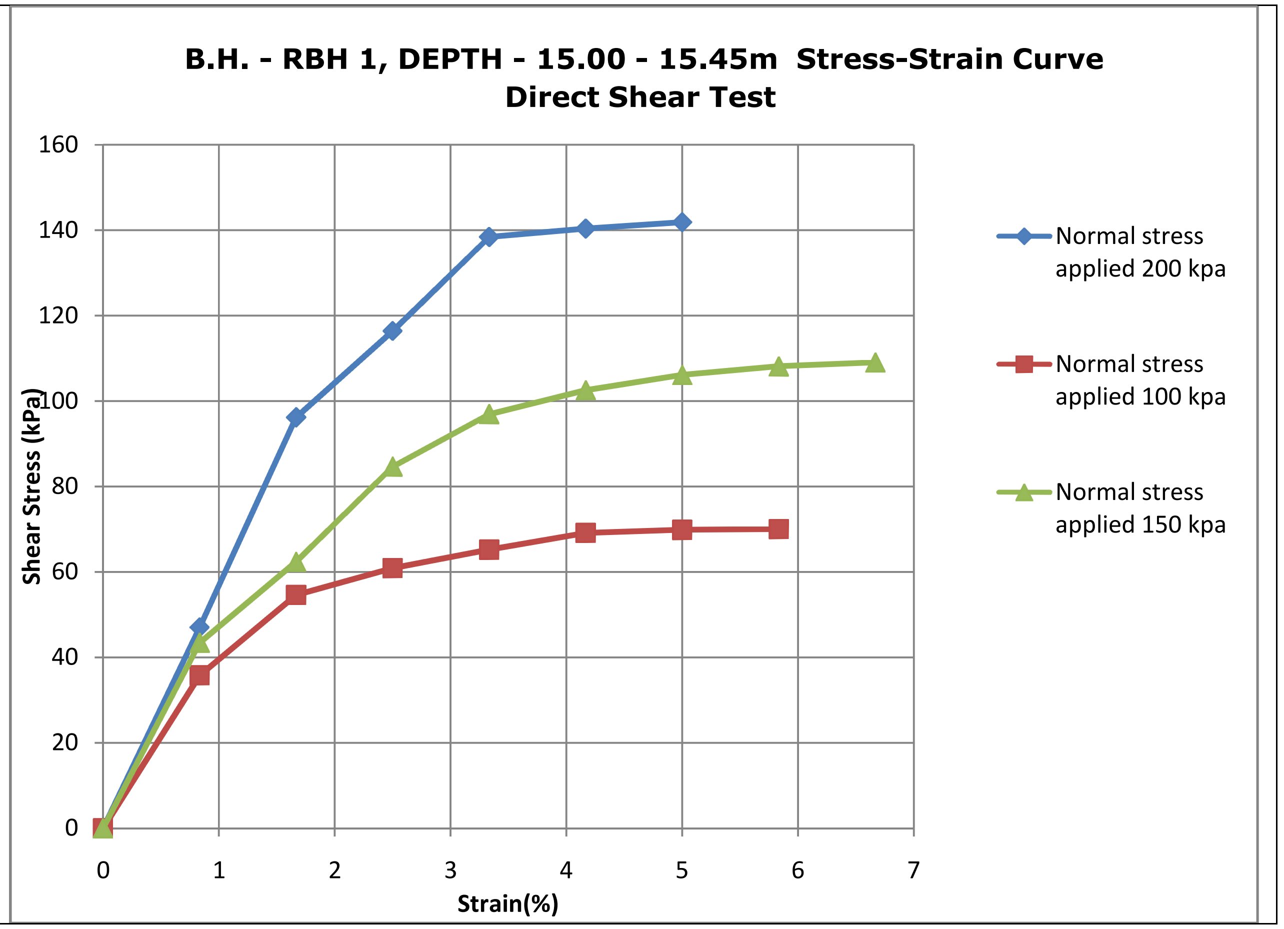
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	7.50-7.95	DS	28	26.6	18.0	14.1	0.82	34

Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

SKM Geosurvey

DIRECT SHEAR TEST GRAPH





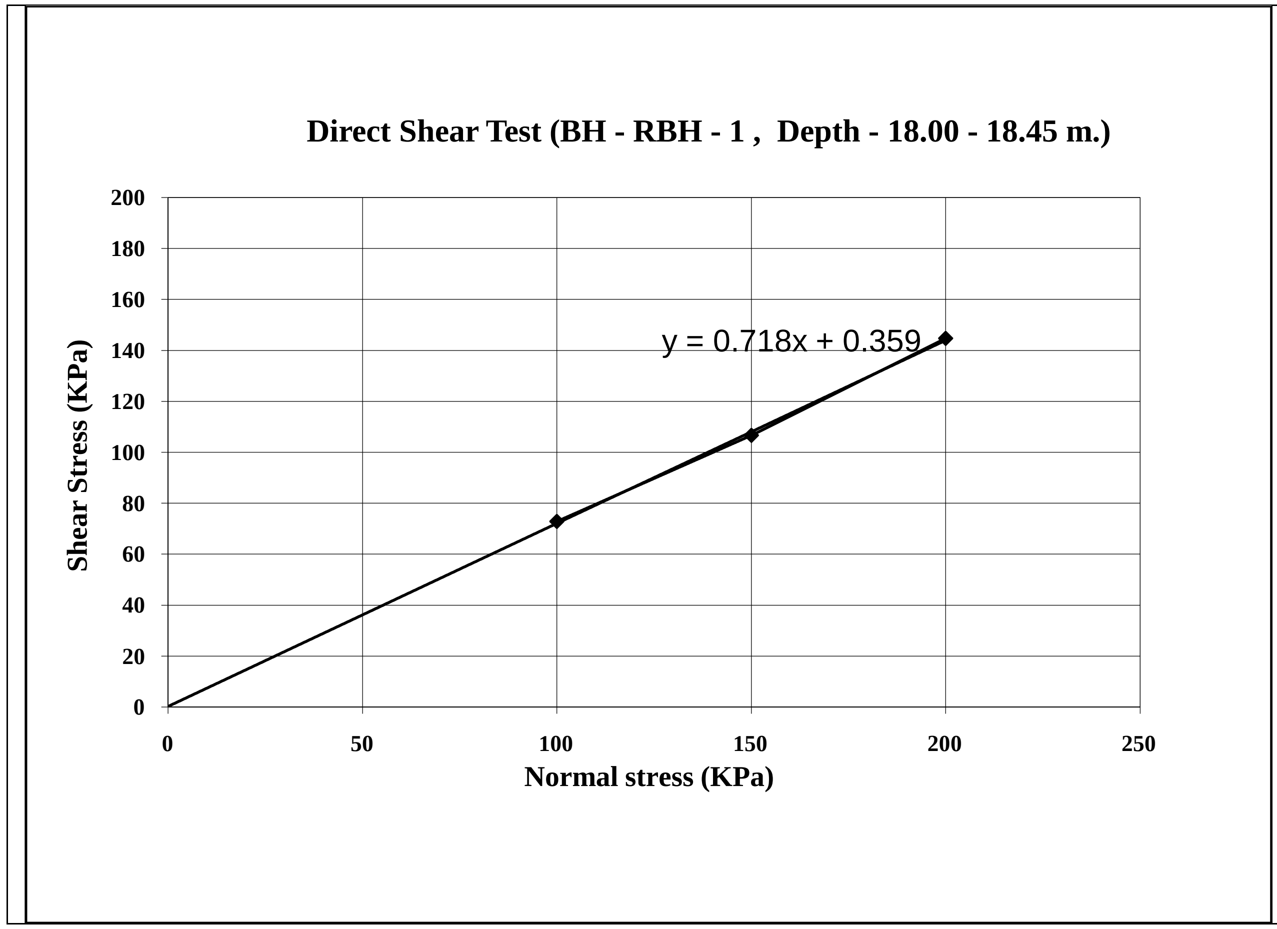
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	15.00-15.45	DS	27	26	18.5	14.6	0.56	35

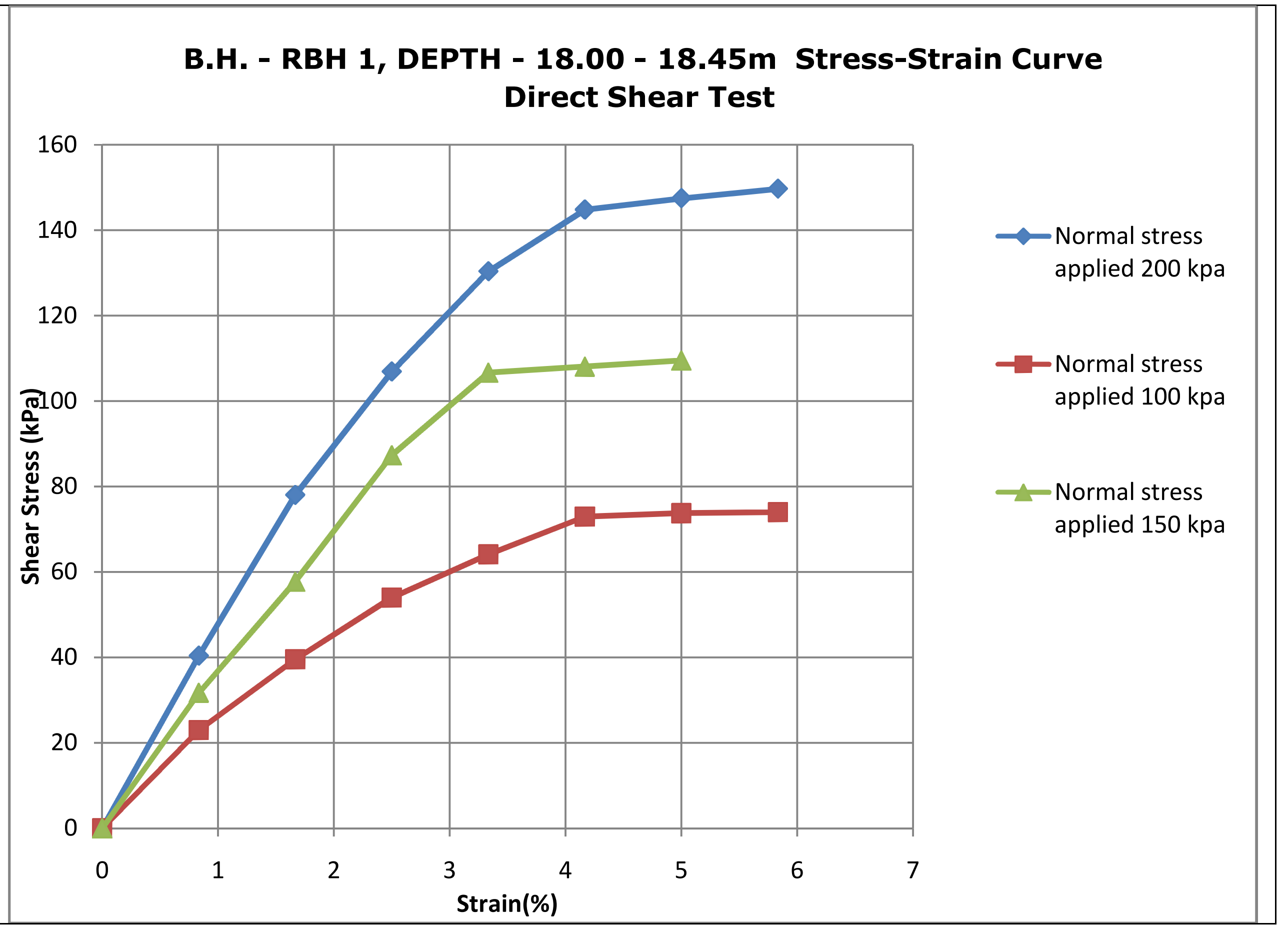
Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

SKM Geosurvey

JOB NO.30906

DIRECT SHEAR TEST GRAPH





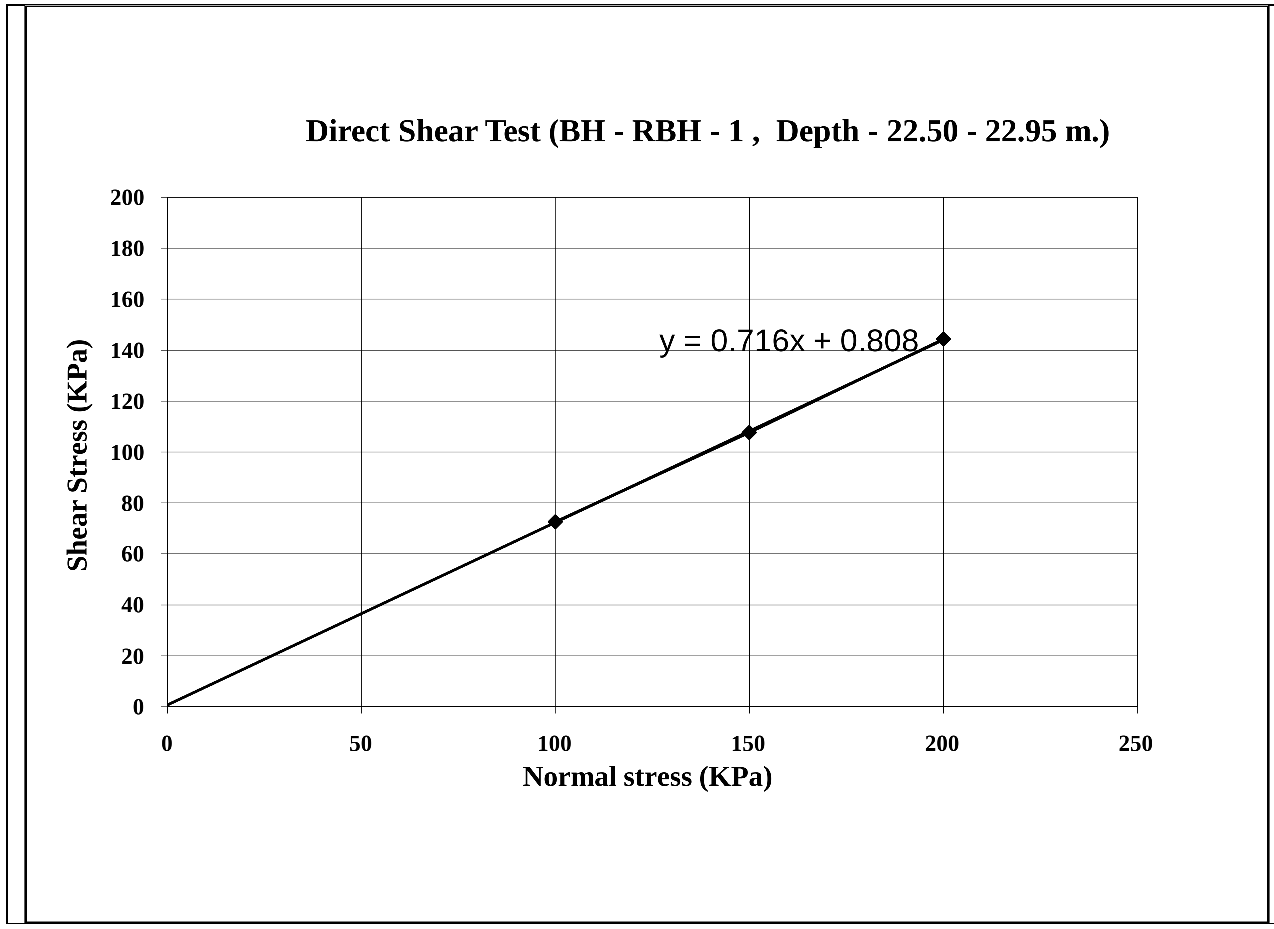
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	18.00-18.45	DS	27	26	19.1	15.0	0.36	36

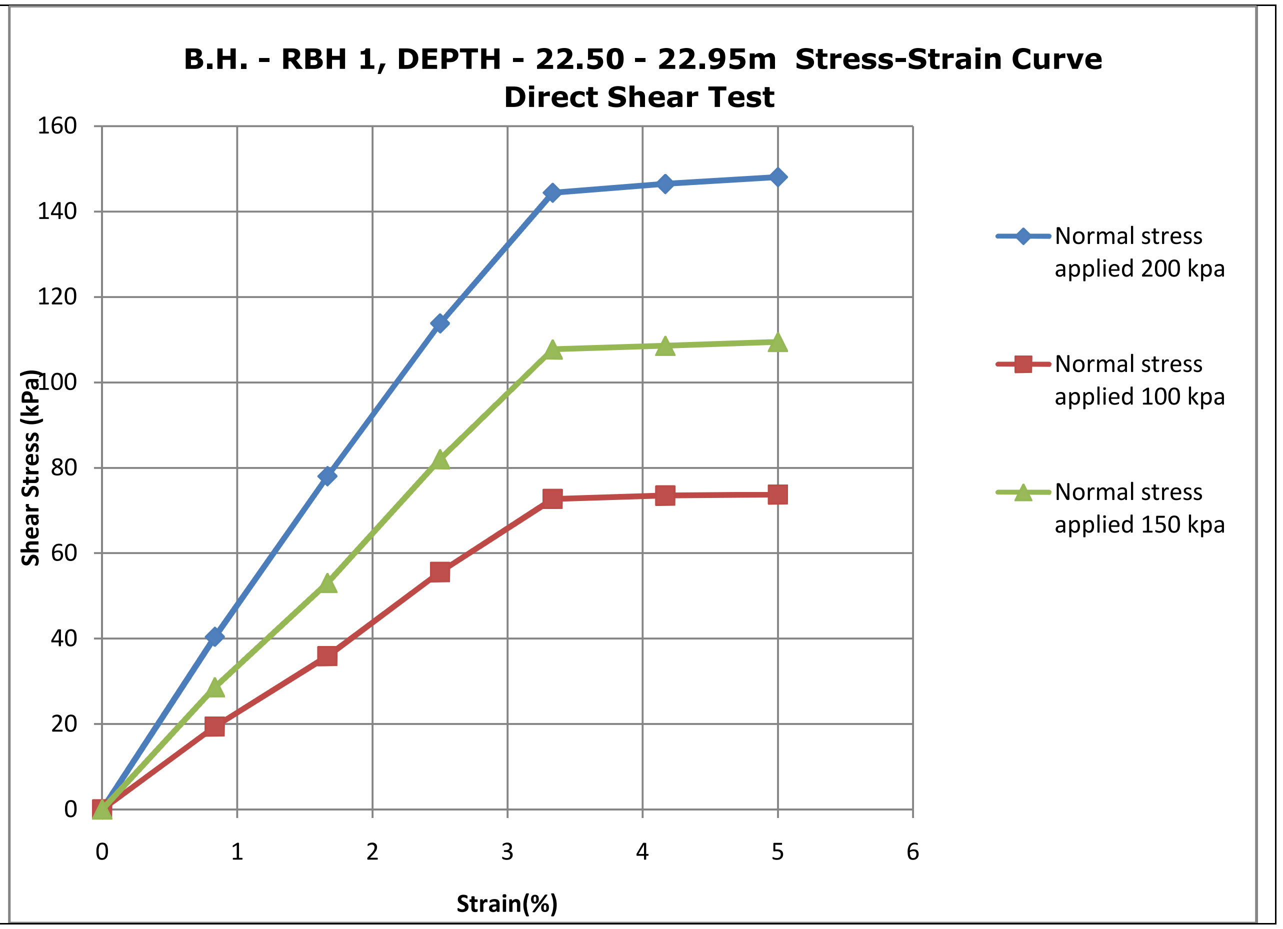
Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

SKM Geosurvey

JOB NO.30906

DIRECT SHEAR TEST GRAPH



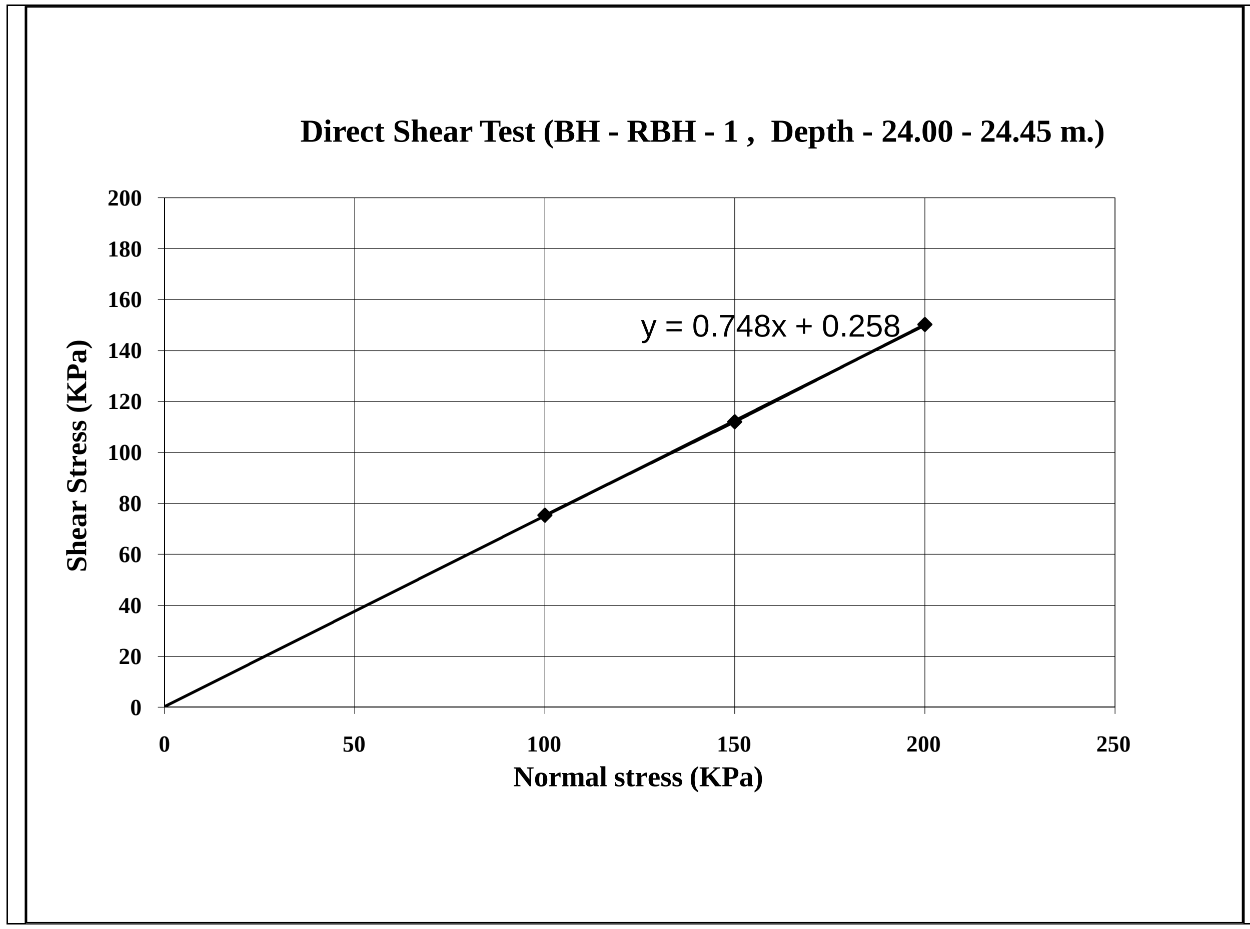


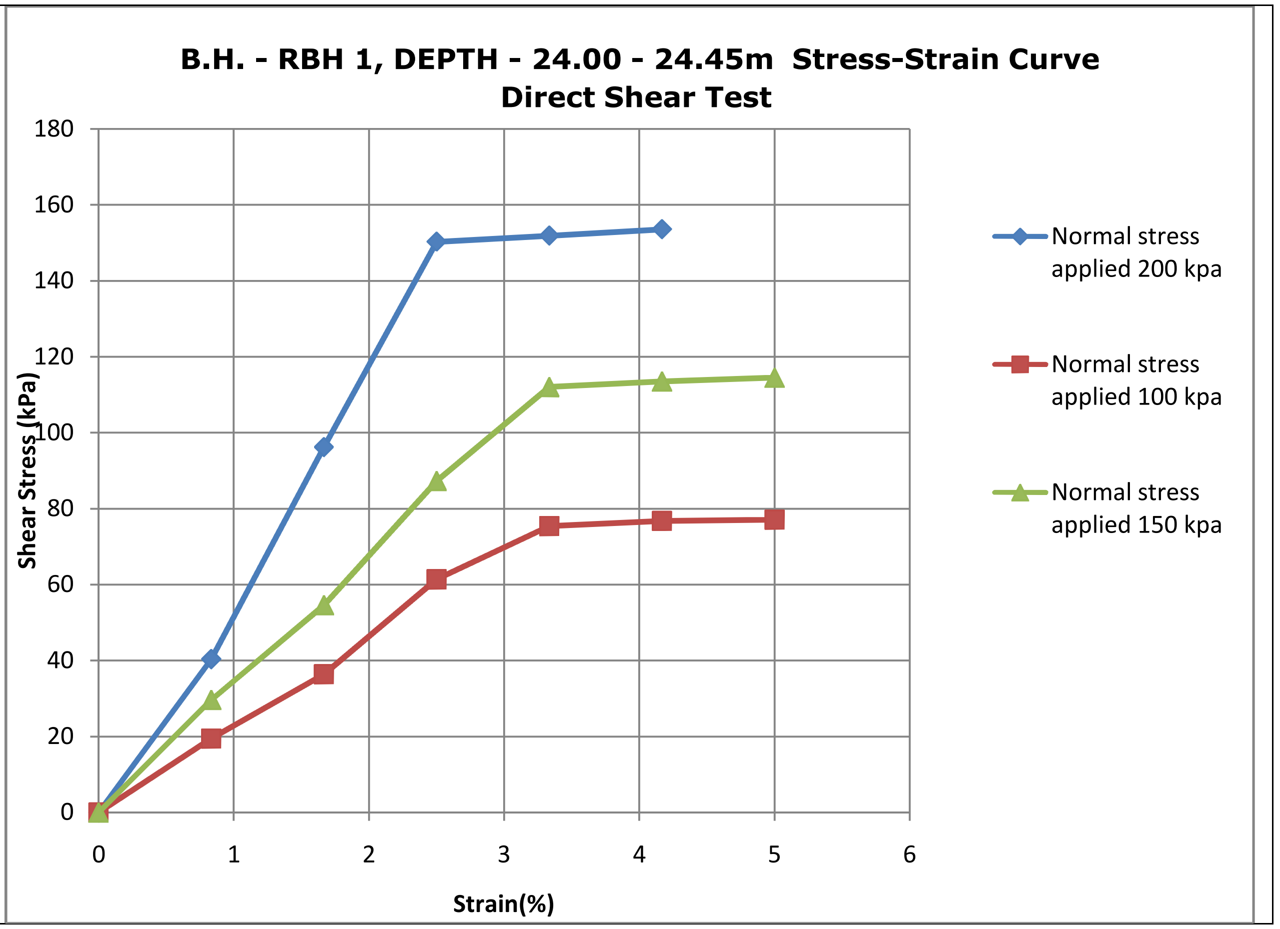
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	22.50-22.95	DS	26	25.1	19.8	15.7	0.80	36

Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

SKM Geosurvey

DIRECT SHEAR TEST GRAPH



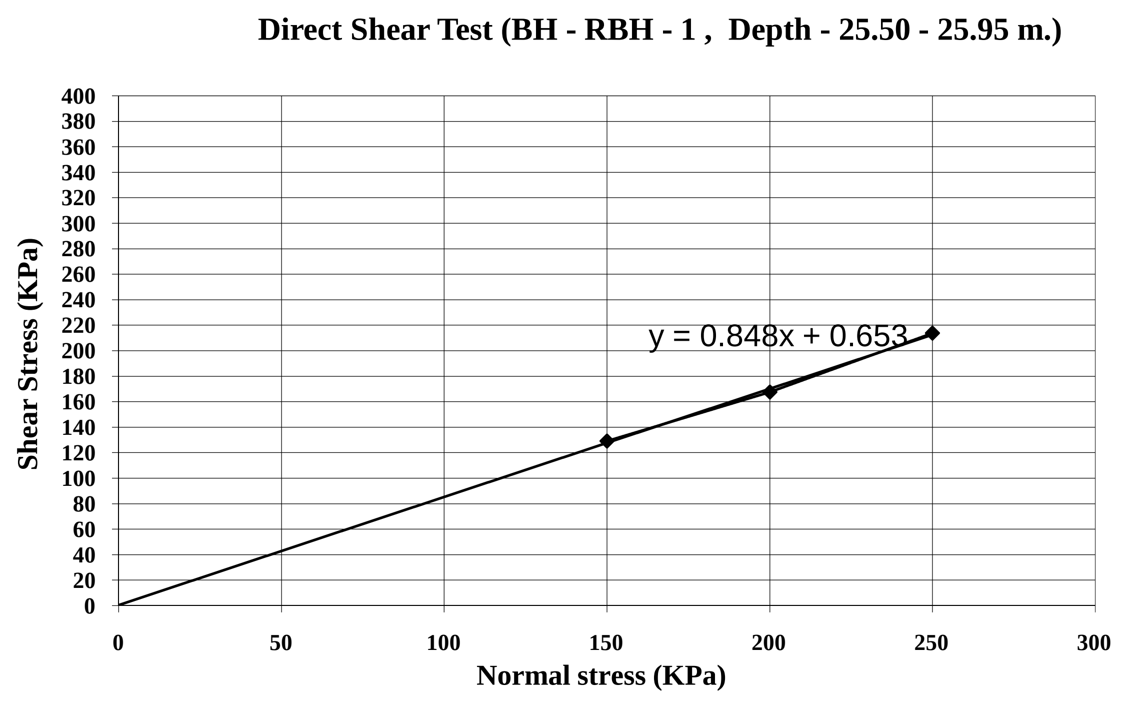


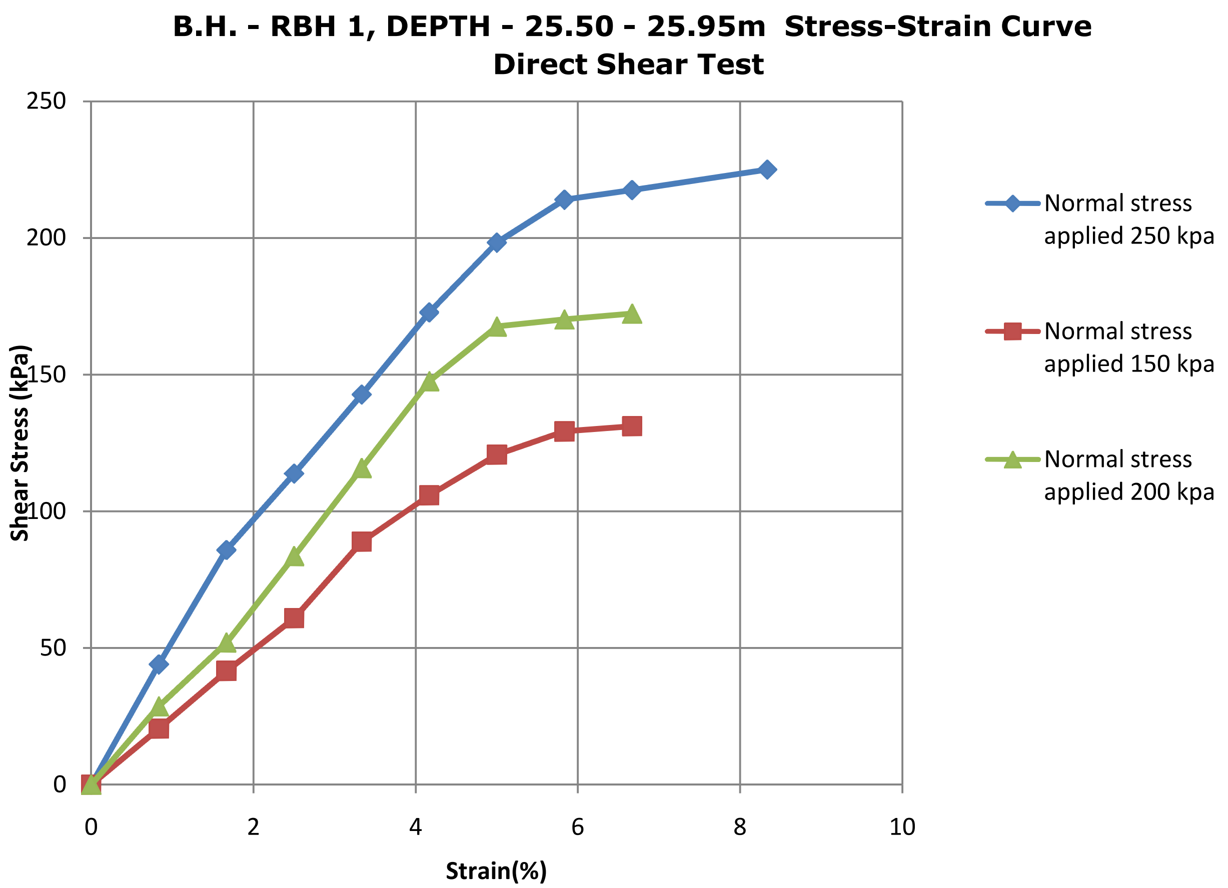
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	24.00-24.45	DS	26	25.2	19.5	15.5	0.25	37

Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

SKM Geosurvey

DIRECT SHEAR TEST GRAPH



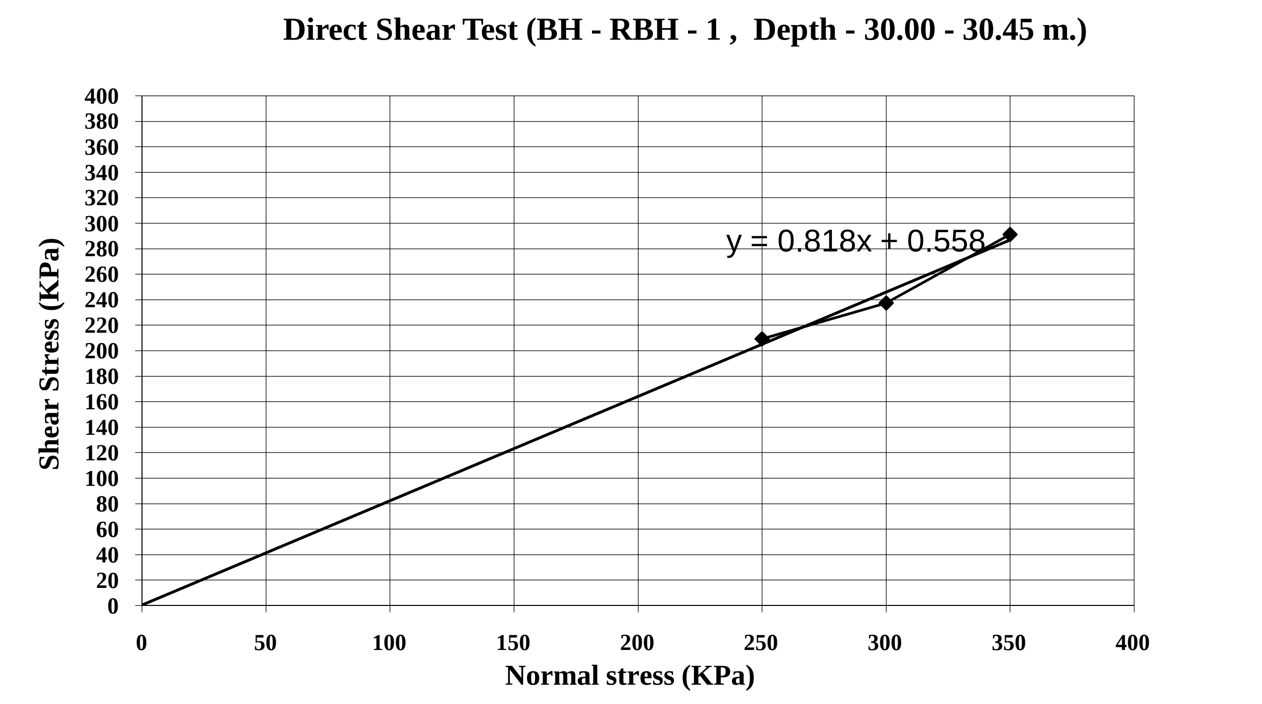


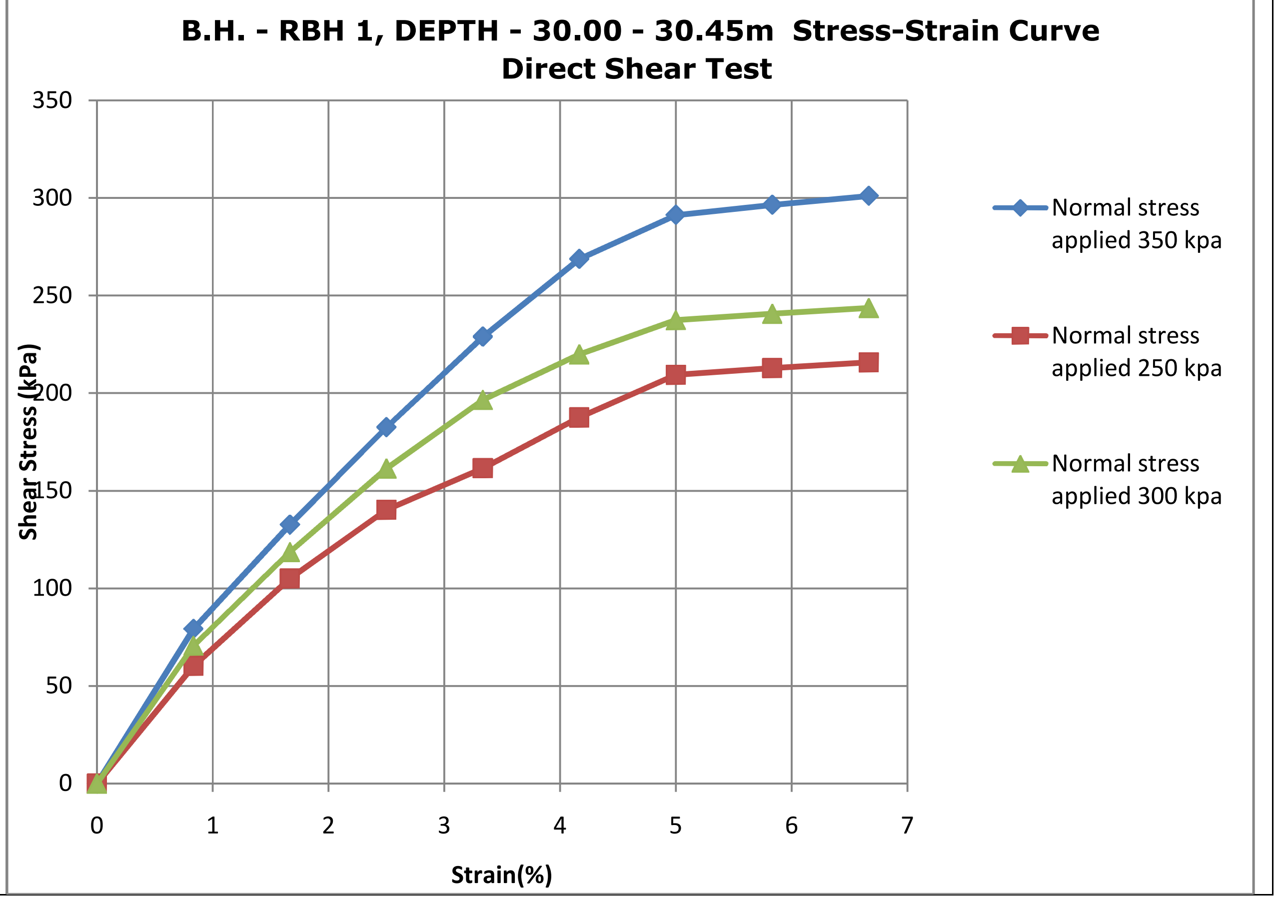
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	25.50-25.95	DS	24	23.2	20.3	16.4	0.65	40

Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

SKM Geosurvey

DIRECT SHEAR TEST GRAPH



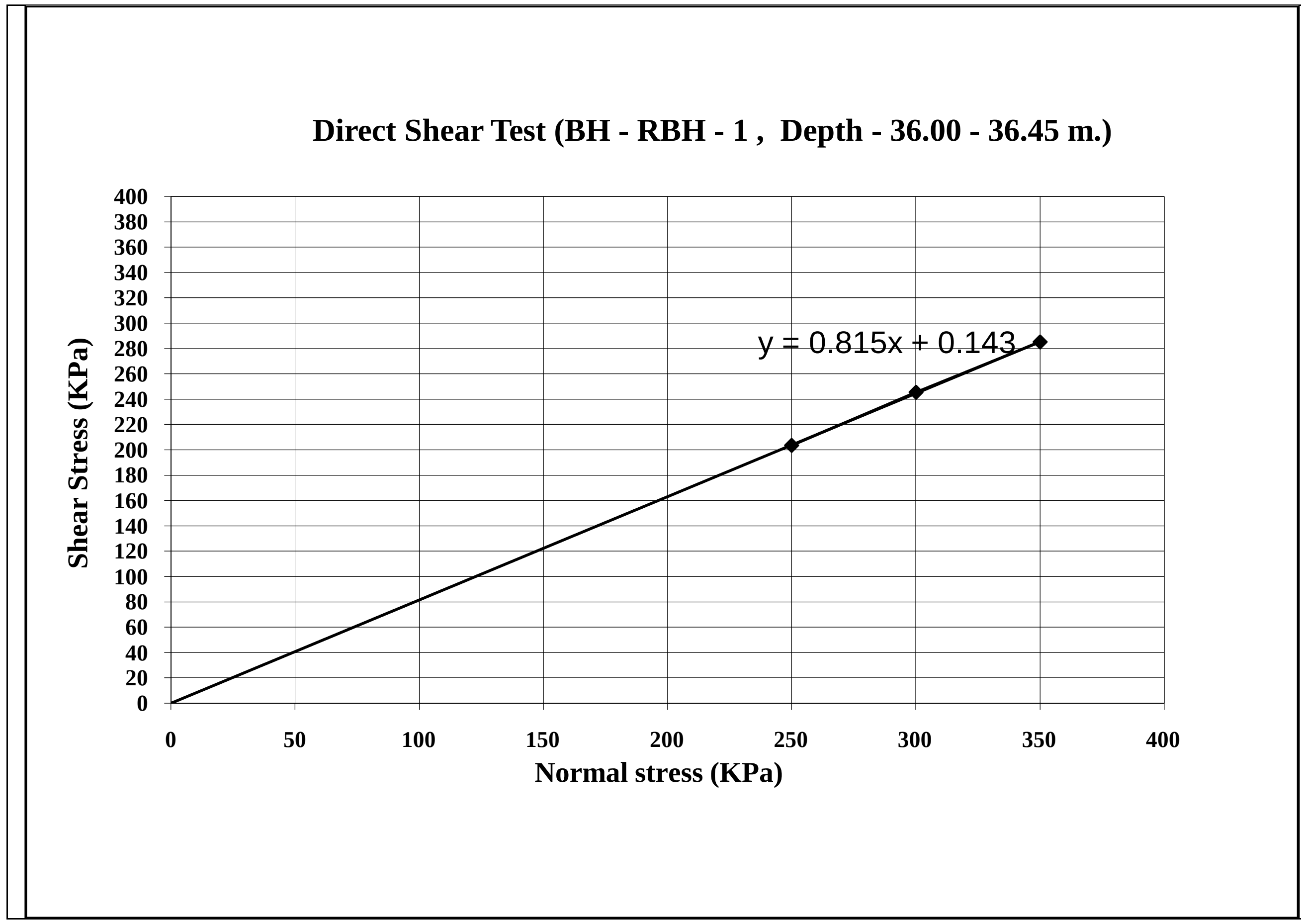


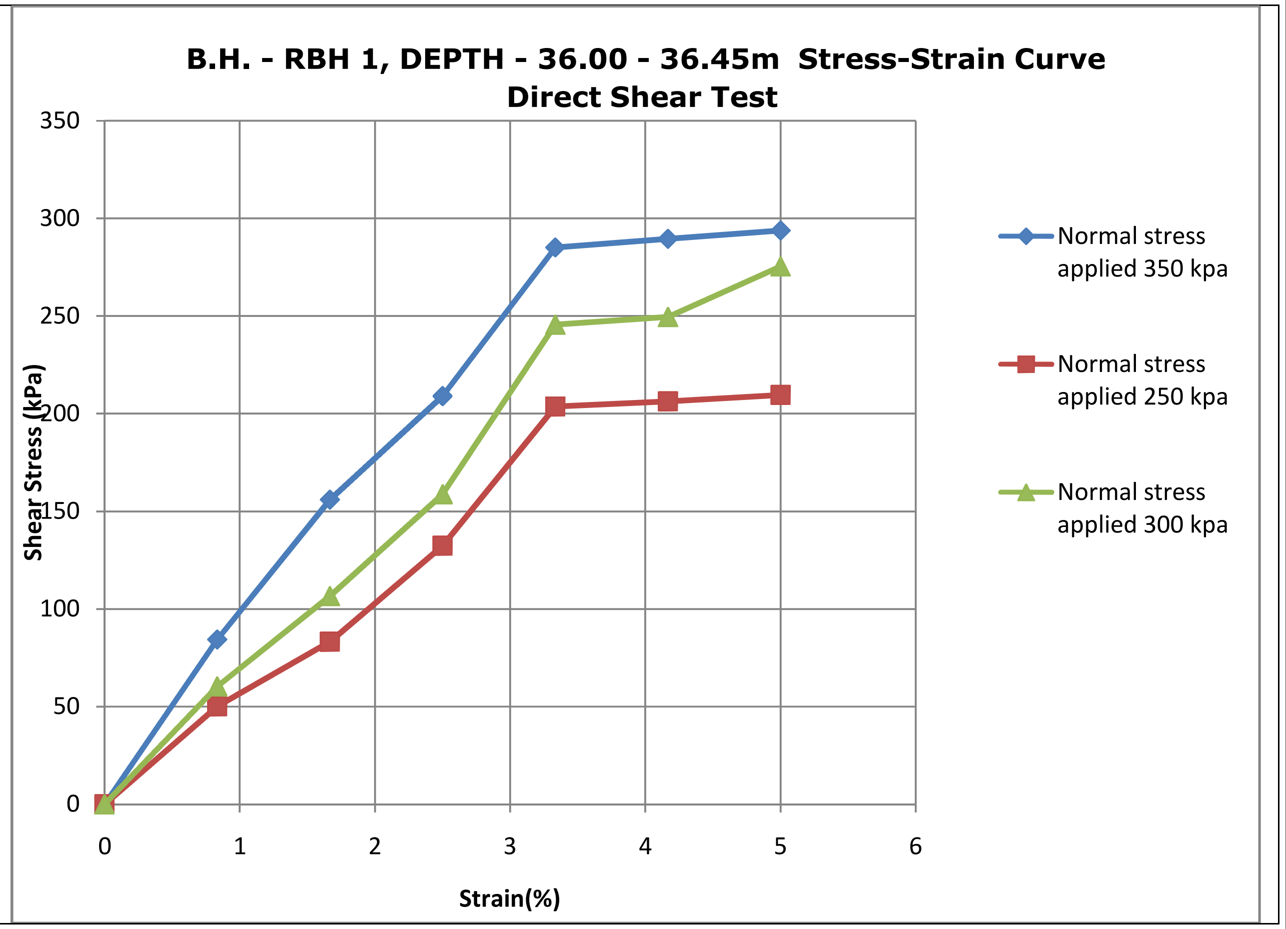
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	30.00-30.45	DS	25	24.2	19.8	15.8	0.55	39

Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

SKM Geosurvey

DIRECT SHEAR TEST GRAPH





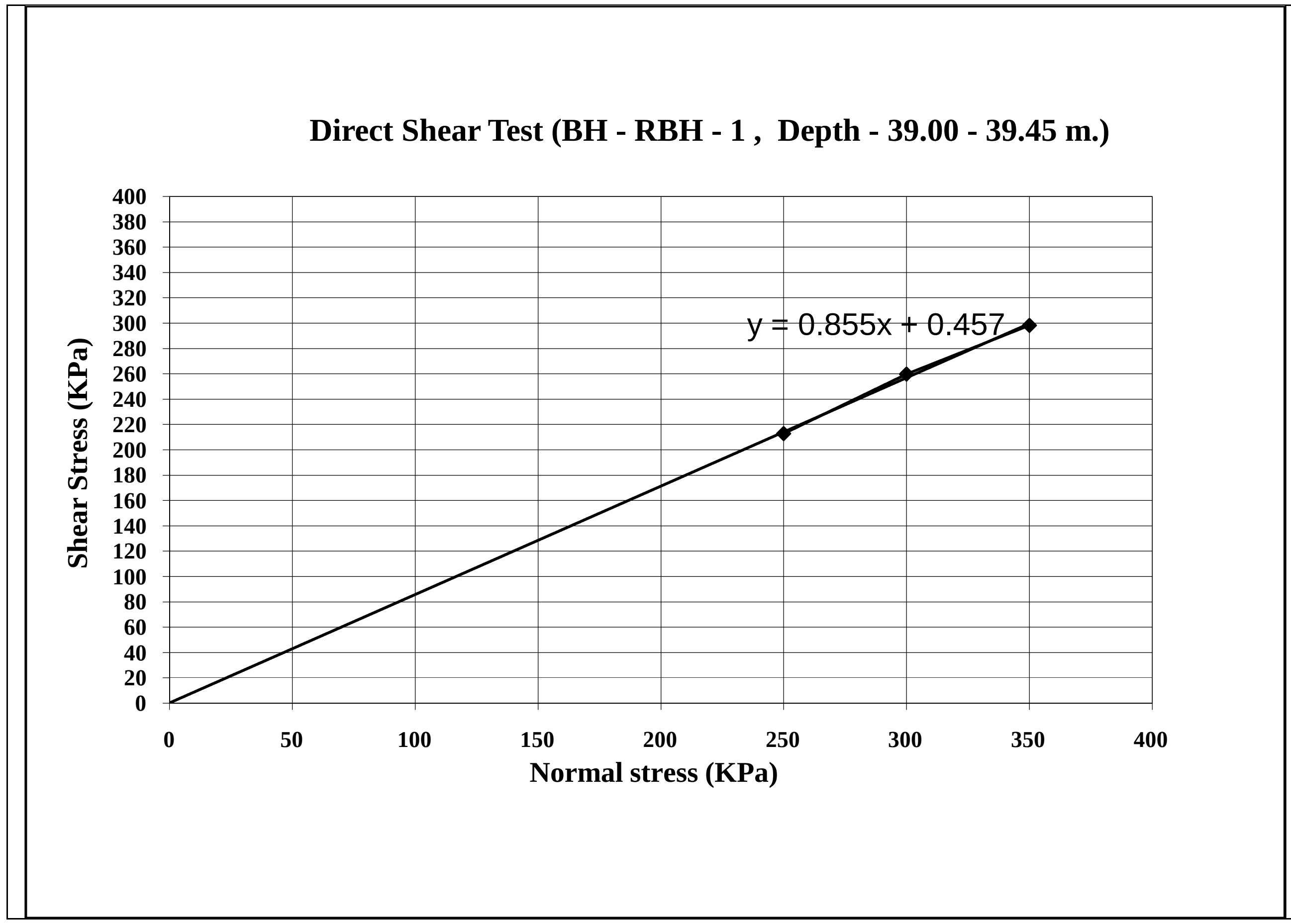
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	36.00-36.45	DS	24	23.2	20.1	16.2	0.14	39

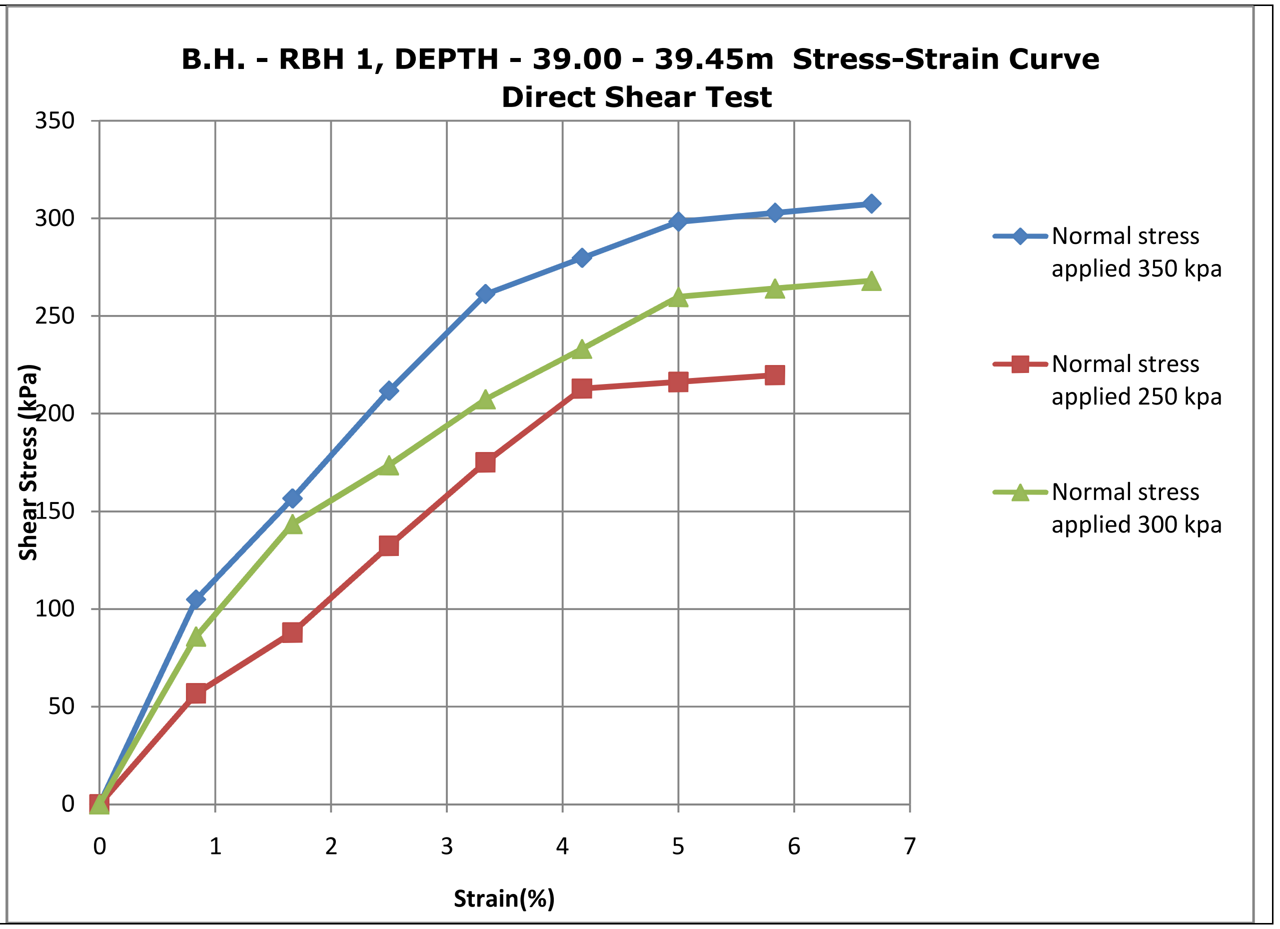
Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

SKM Geosurvey

JOB NO.30906

DIRECT SHEAR TEST GRAPH





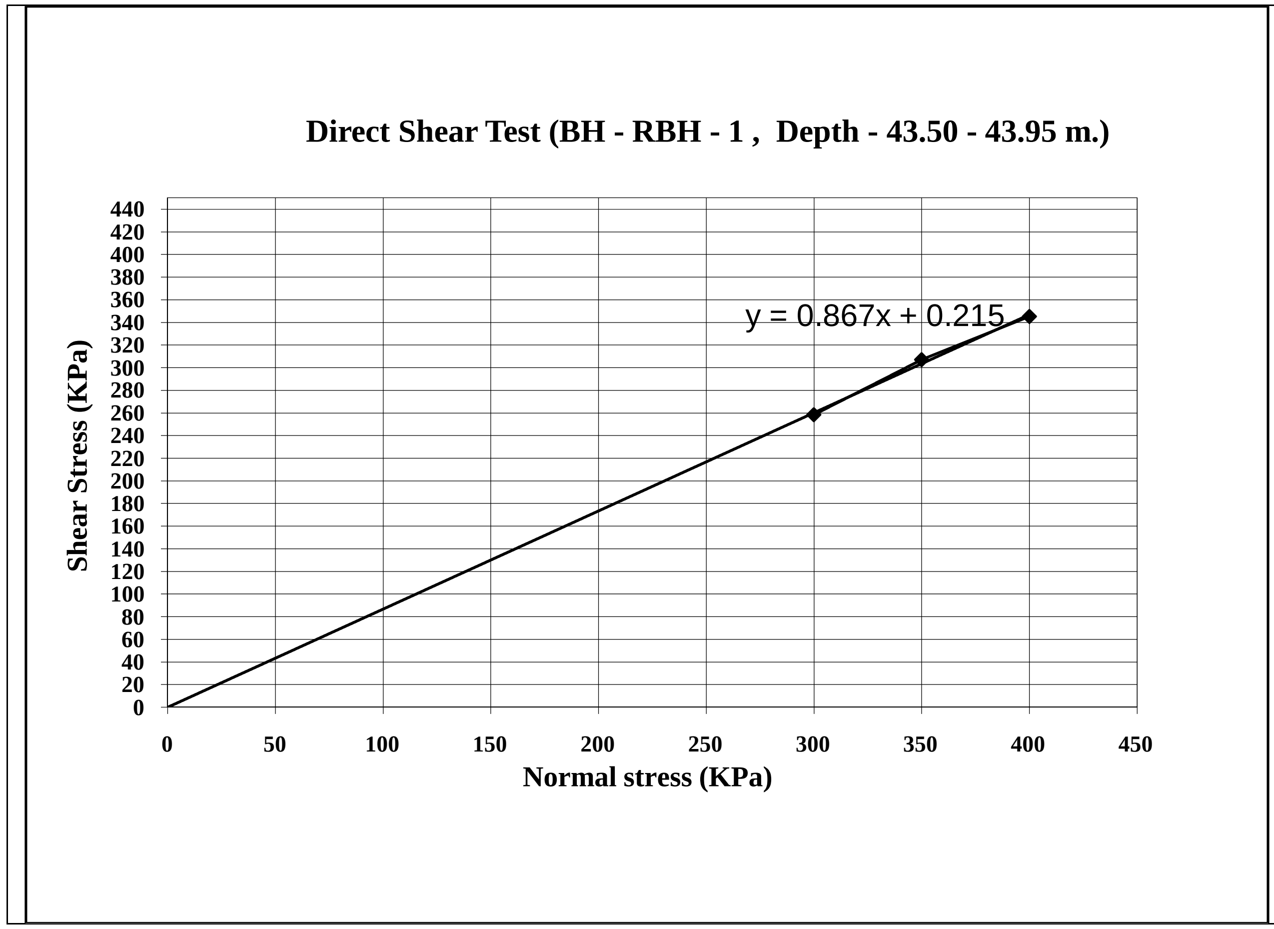
BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	39.00-39.45	DS	23	22.3	20.6	16.7	0.45	41

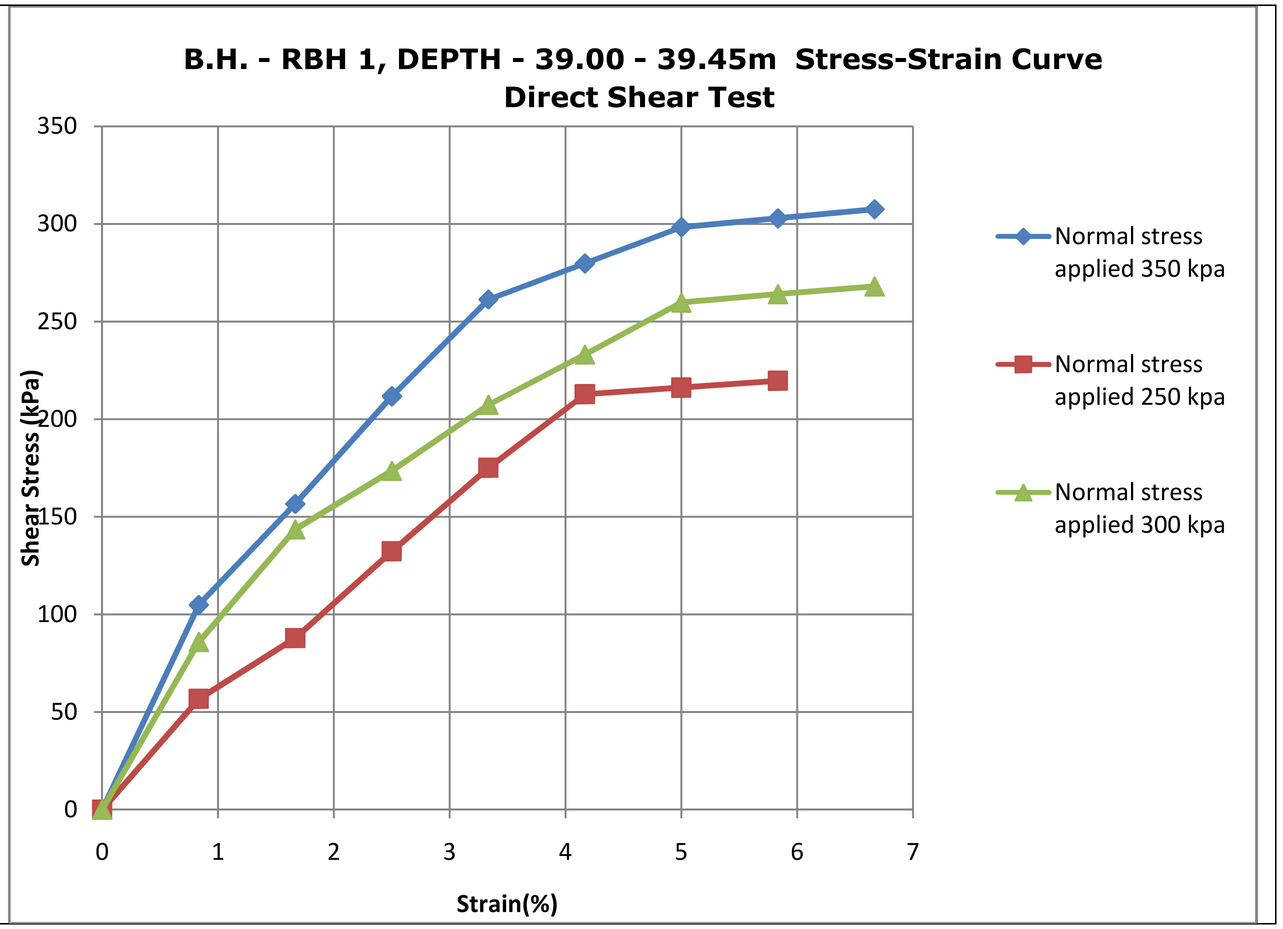
Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

JOB NO.30906

SKM Geosurvey

DIRECT SHEAR TEST GRAPH





BH No.	Depth (m)	Type of Test	Water Content (%) (Initial)	Water Content (%) (Final)	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
RBH-1	43.50-43.95	DS	20	19.3	20.6	17.2	0.21	41

Initial Area = 36 cm^2 , Initial Height = 2.3 cm, Length = 6.0 cm. Breath = 6.0cm and Strain Rate = 0.25 mm/min, Sample Type: Remoulded, Test Condition: Consolidated Drained

JOB NO.30906

SKM Geosurvey

SUMMARY OF TEST RESULTS

SAMPLE DETAILS		N value	Sample Recovery Ratio (%)	Insitu density at site (kN/m3)	Soil Classification	CLASSIFICATION AND INDEX												SHEAR STRENGTH TEST					Consolidation Tests			Chemical Test			
						Atterberg Limits			Physical Properties				Grain Size Distribution					Lateral & Vertical Loading											
Sample Type	Depth (m)					Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI) %	Water Content %	Bulk Density (kN/m^2)	Dry Density (kN/m^2)	Specific Gravity	Gravel %	Sand %	Silt %	Clay %	(Silt + Clay) Fines %	Type of Test	Type of Failure	Cohesion C (kpa)	Internal friction angle ϕ^0	Pocket Penetrometer (kpa)	Initial Void Ratio	Preconsolidation Pressure	Compression Index	p^H	Carbonate Content (ppm)	Cloride content (ppm)	Sulphate content (ppm)
WS*																										6	0.0001	4.874	2.892
SPT-1	0.50-0.95	5	70	16.1	SM	NP	NP							81	19		19												
SPT-2	1.50-1.95	12	65	17.2																						6.5	0.0012	1.187	2.234
SPT-3	3.00-3.45	28	60	18.1	SM-SP	NP	NP							91	9		9	DST		0.37	34								
SPT-4	4.50-4.85	13	60	17																									
SPT-5	6.00-6.45	13	65	17.5	SM-SP	NP	NP							93	7		7	DST		0.22	32								
SPT-6	7.50-7.95	16	65	18	SP	NP	NP							96	4		4	DST		0.82	34								
SPT-7	9.00-9.45	14	60	17.2																									
SPT-8	10.50-10.95	29	65	18.2	SP	NP	NP							96	4		4												
SPT-9	12.00-12.45	19	65	18	SP	NP	NP					2.66		98	2		2												
SPT-10	13.50-13.95	19	45	18.1								2.66																	
SPT-11	15.00-15.45	21	55	18.5	SP	NP	NP							95	5		5	DST		0.56	35								
SPT-12	16.50-16.95	24	50	18.1																									
SPT-13	18.00-18.45	34	66	19.1	SP	NP	NP							96	4		4	DST		0.36	36								
SPT-14	19.50-19.95	36	47	18.2																									
SPT-15	21.00-21.45	42	68	21.6																									
SPT-16	22.50-22.95	28	72	19.8	ML	NP	NP							20	74	6	80	DST		0.8	36								
SPT-17	24.00-24.45	50	66	19.5	SM	NP	NP					2.67	10	48	40	2	42	DST		0.25	37								
SPT-18	25.50-25.95	83	45	20.3	SM-SP	NP	NP					2.67	33	57	10		10	DST		0.65	40								
SPT-19	27.00-27.45	99	46	19.8	SP	NP	NP					2.66		97	3		3												
SPT-20	28.50-28.95	85	51	19.4																									
SPT-21	30.00-30.45	57	44	19.8	SM	NP	NP							79	21		21	DST		0.55	39								
SPT-22	31.50-31.95	48	66	19.3	SM-SP	NP	NP							90	10		10												
SPT-23	33.00-33.45	53	55	19.6		NP	NP					2.66																	
SPT-24	34.50-34.95	62	45	19.9	SM-SP	NP	NP							90	10		10												
SPT-25	36.00-36.45	63	60	20.1	SM	NP	NP					2.65		86	14		14	DST		0.14	39								
SPT-26	37.50-37.95	65	51	20.5																						6.5		9.894	4.521
SPT-27	39.00-39.45	76	58	20.6														DST		0.45	41								
SPT-28	40.50-40.95	84	48	20.4		NP	NP																						
SPT-29	42.00-42.45	98	48	21																									
SPT-30	43.50-43.95	114	41	20.6	SM-SP	NP	NP							91.4	8.6		8.6	DST		0.21	41								
SPT-31	45.00-45.45	36+58+50for09cm N>100	51	20.9																									

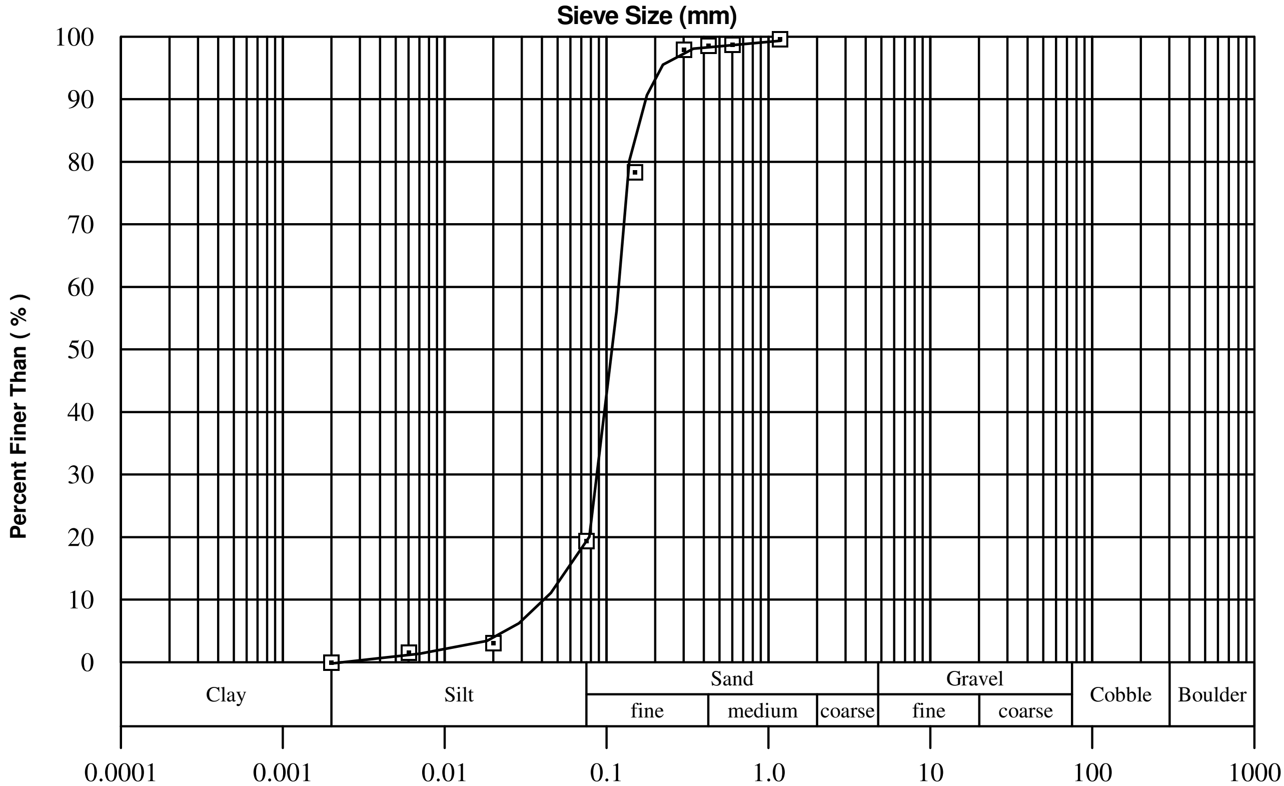
NOTE :

WS* River Water Sample

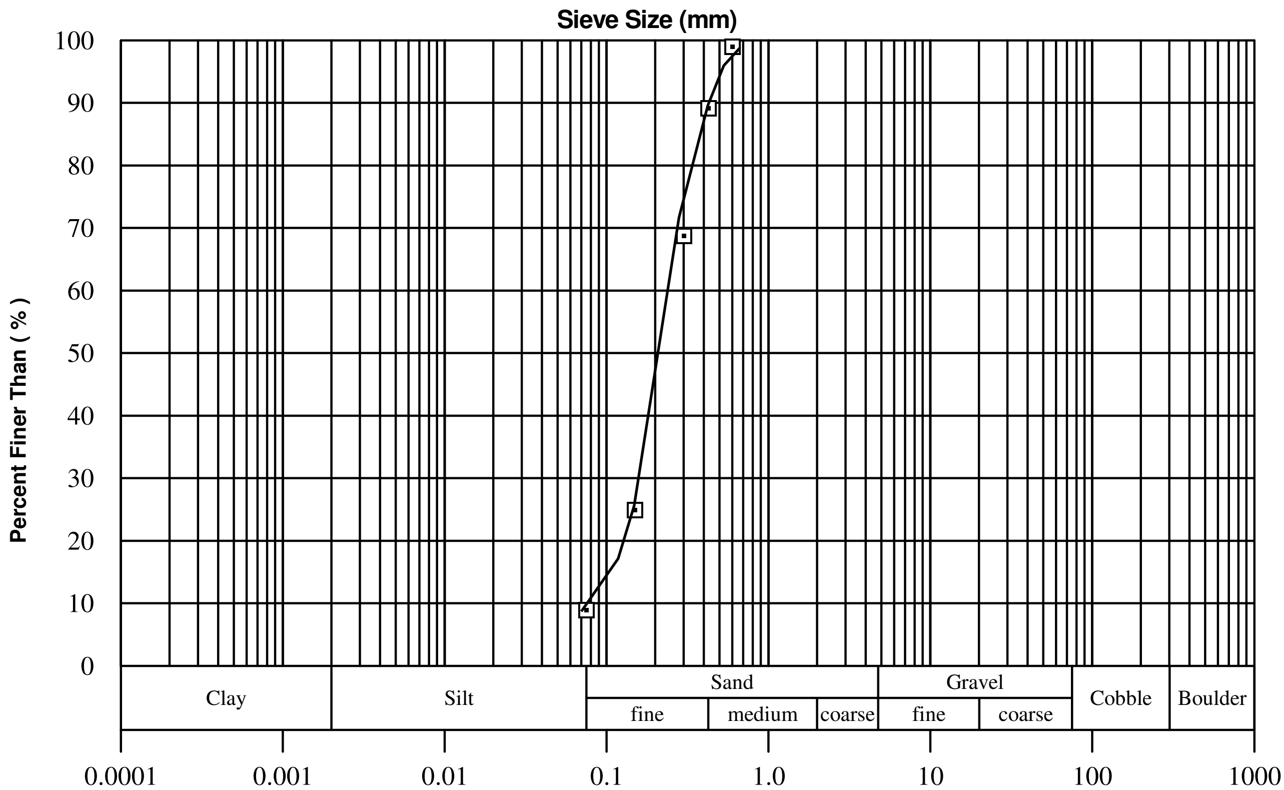
DS	: Disturbed Sample	* :	Insufficient sample	Failure Type		Project :	Guwahati Gateway Ghat
WAX & UDS	: Undisturbed Sample	LL :	Liquid Limit	A	: Bulge		
TUU	: Triaxial Test (Unconsolidated Undrained)	PL :	Plastic Limit	B	: Inclined Shear		
DST	: Direct Shear Test	ND :	Not Detectable	C	: Multiple Shear	Project Code :	
ϕ	: * Angle of internal friction	NP :	Non Plastic	D	: Vertical Shear	Borehole No. :	RBH-1

Coefficient of Curvature (Cc) and Uniformity Coefficient Value from Grain size distribution curve

Borehole No	Depth (m)	Sample no.	Coefficient of Curvature (Cc)	Uniformity Coefficient (Cu)
RBH-1	0.50-0.95	3905	1.282	2.182
	3.00-3.45	3907	1.661	3.466
	6.00-6.45	3909	1.20	3.33
	7.50-7.95	3910	1.168	2.22
	10.50-10.95	3912	1.323	2.353
	12.00-12.45	3913	1.60	2.50
	15.00-15.45	3915	1.088	2.928
	18.00-18.45	3917	1.091	2.0625
	22.50-22.95	3920	1.60	10.00
	24.00-24.45	3921	1.118	11.81
	25.50-28.95	3922	0.434	22.5
	27.00-27.45	3923	1.035	3.333
	30.00-30.45	3925	1.366	9.11
	31.50-31.95	3926	1.877	5.625
	34.50-34.95	3928	1.316	4.75
	36.00-36.45	3929	1.60	6.40
	43.50-43.95	3934	1.428	4.375

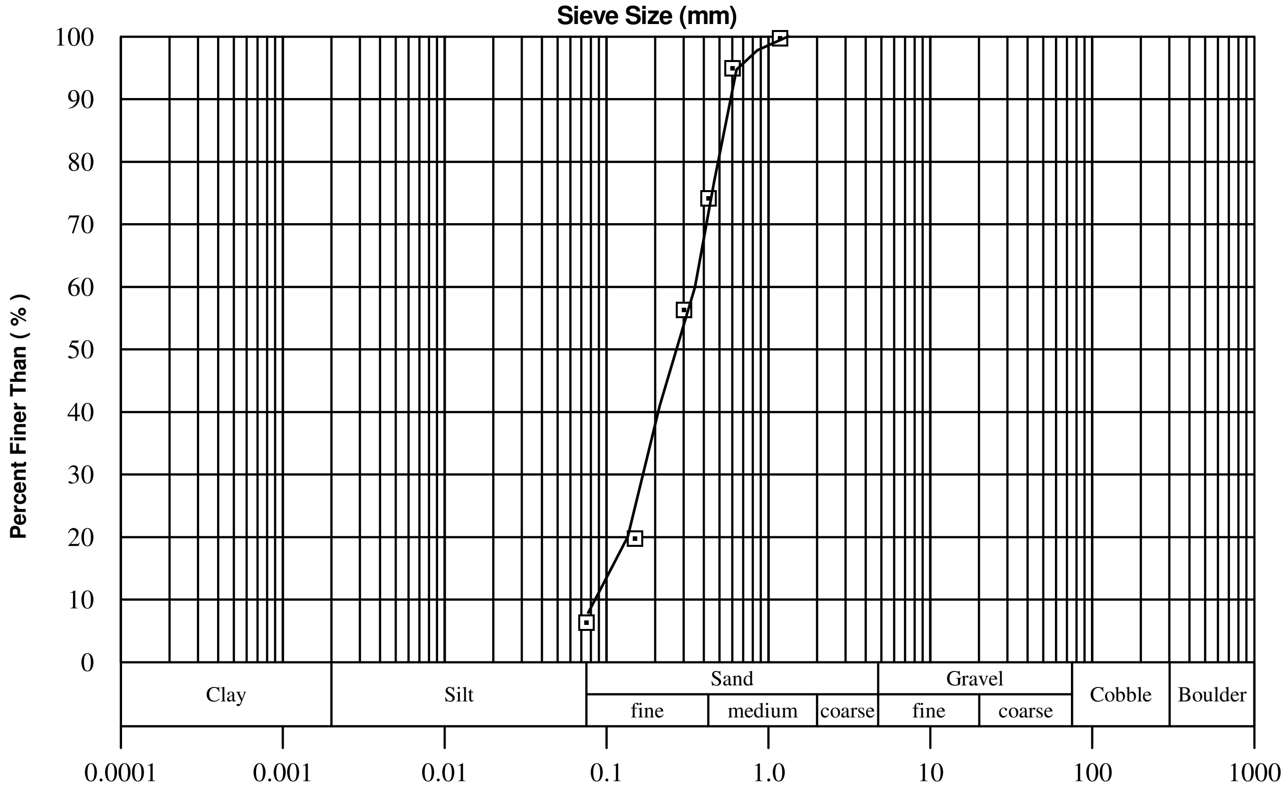


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3905	0.50-0.95		80.60	19.40	0.00

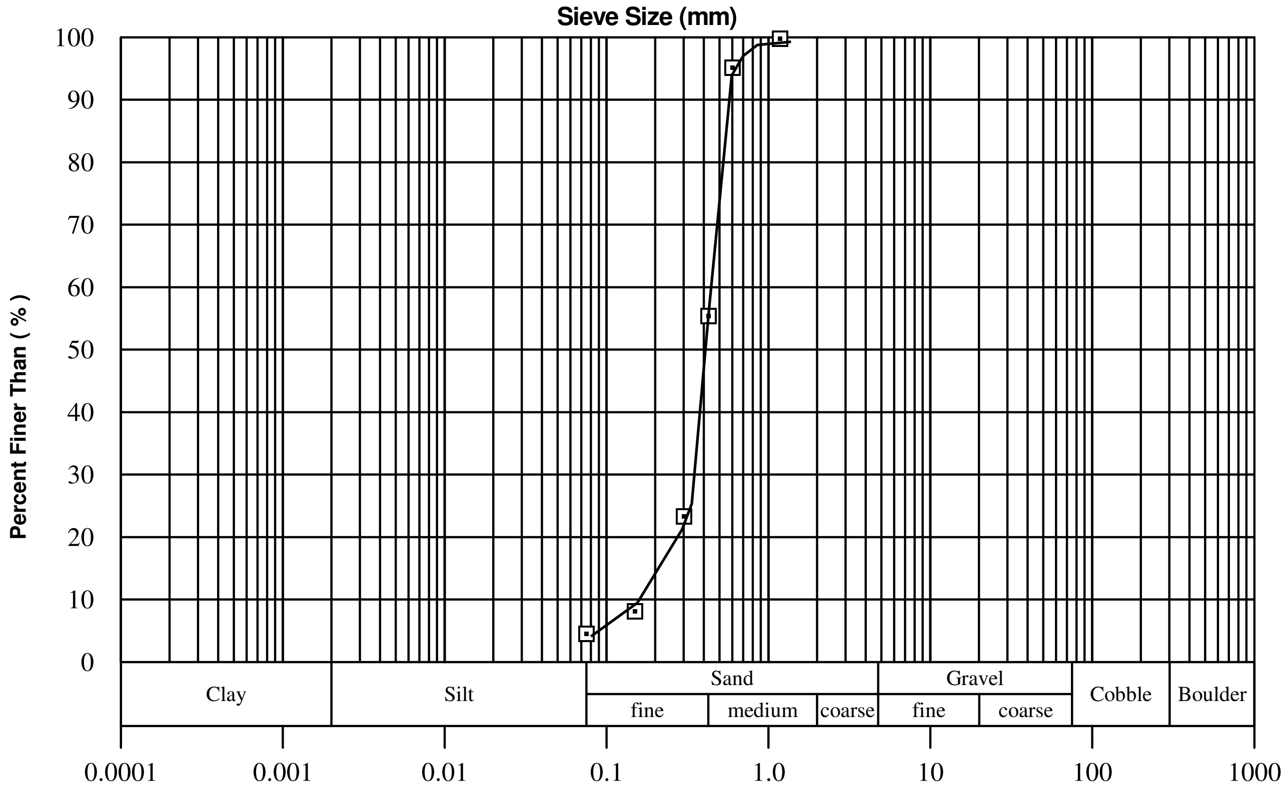


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3907	3.00-3.45		91.00	9.00	

PARTICLE SIZE DISTRIBUTION CURVES

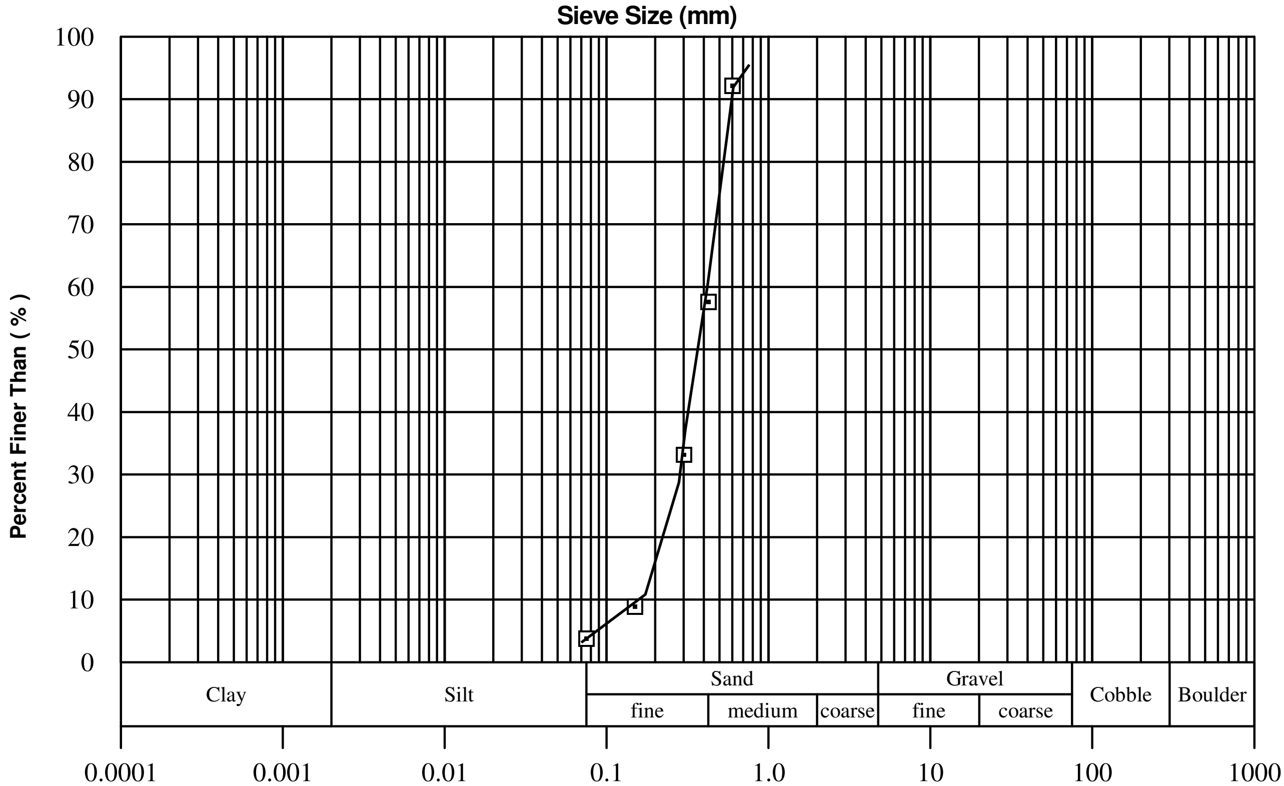


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3909	6.00-6.45		93.60	6.40	

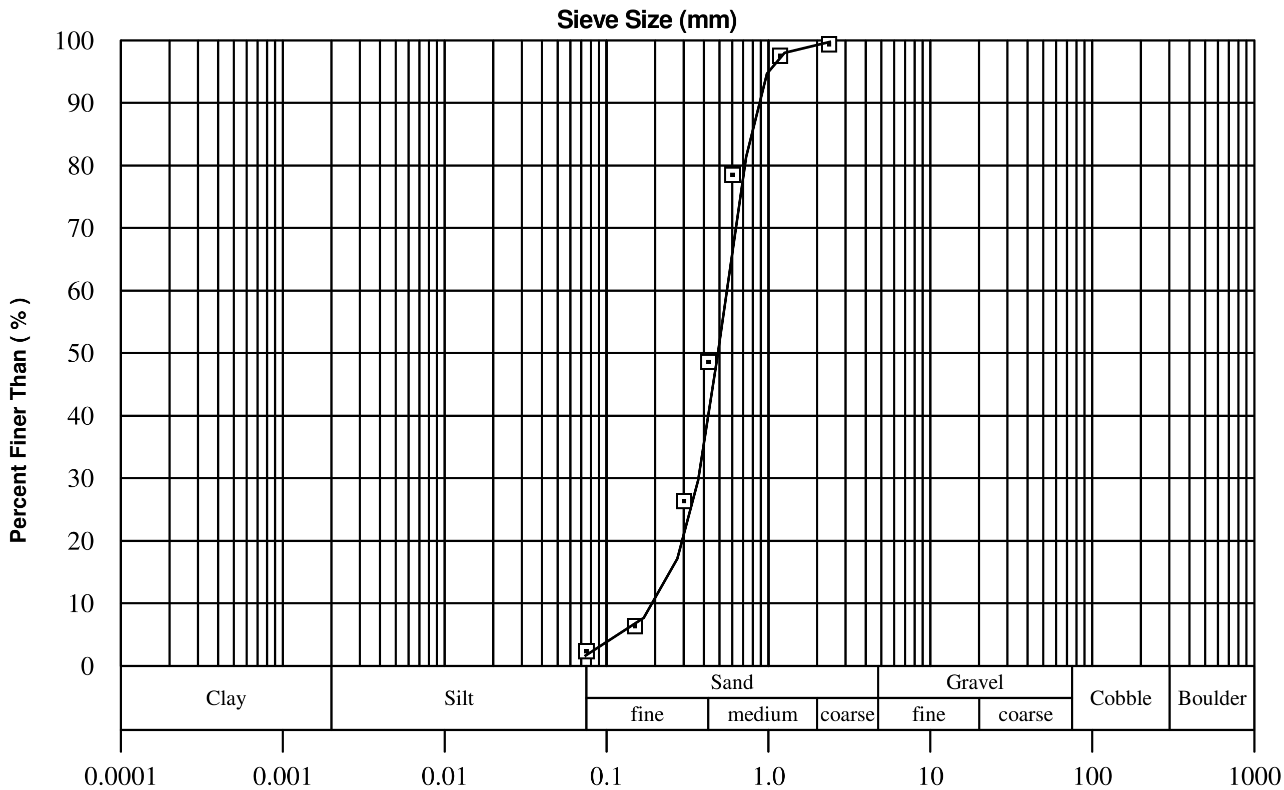


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3910	7.50-7.95		95.40	4.60	

PARTICLE SIZE DISTRIBUTION CURVES

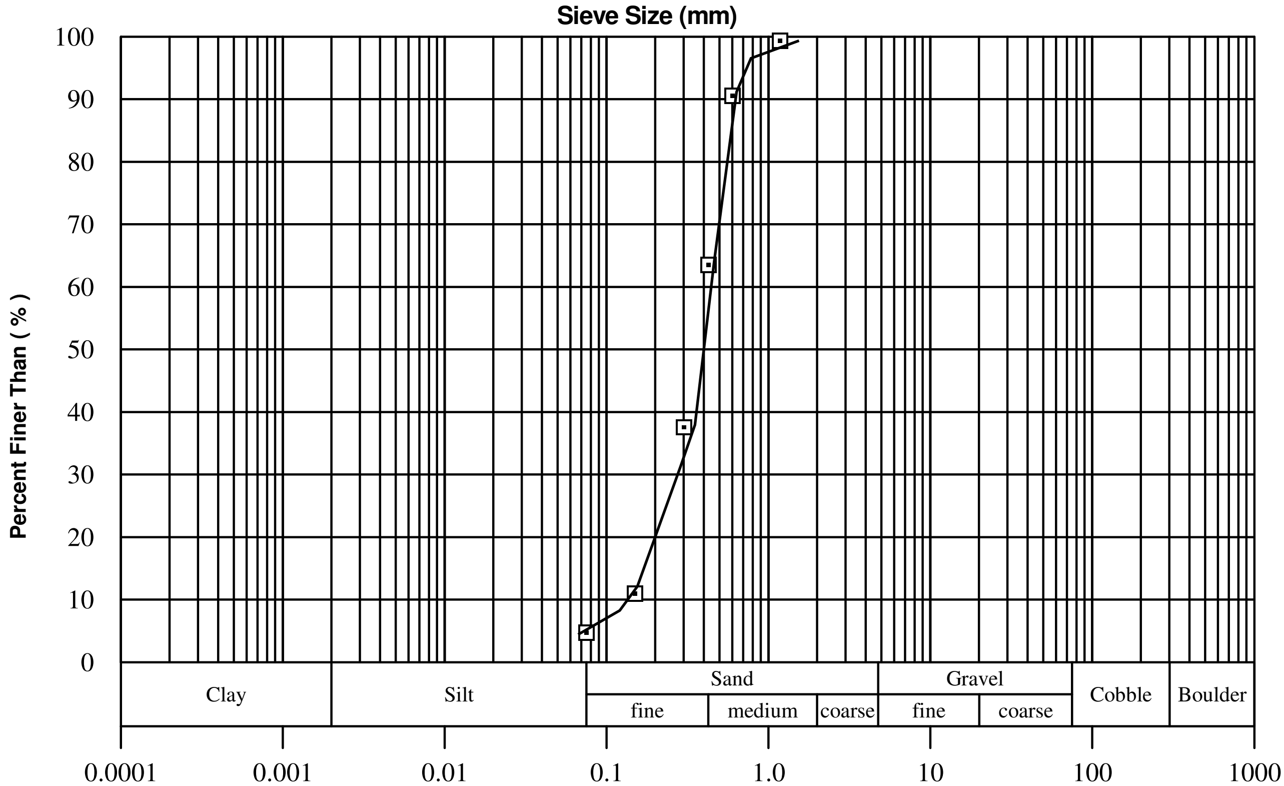


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3912	10.50-10.95		96.20	3.80	

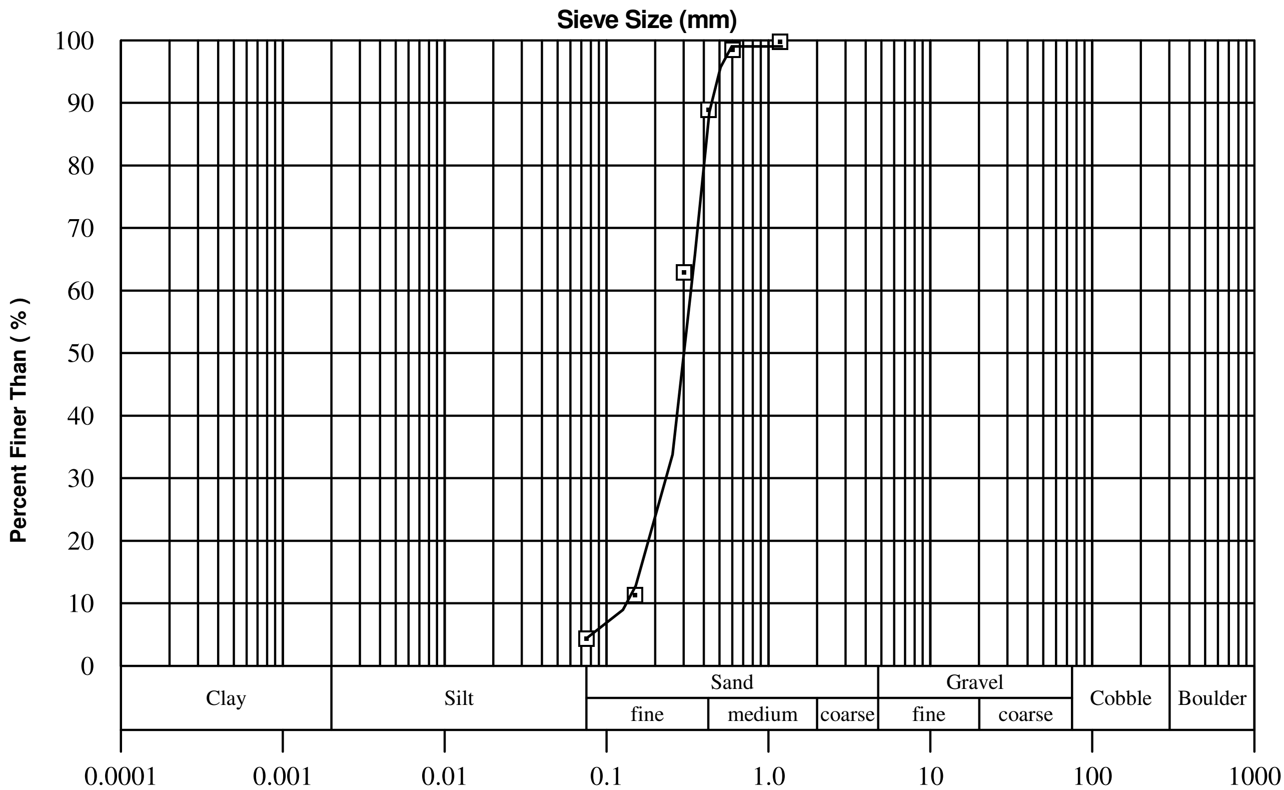


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3913	12.00-12.45		97.60	2.40	

PARTICLE SIZE DISTRIBUTION CURVES

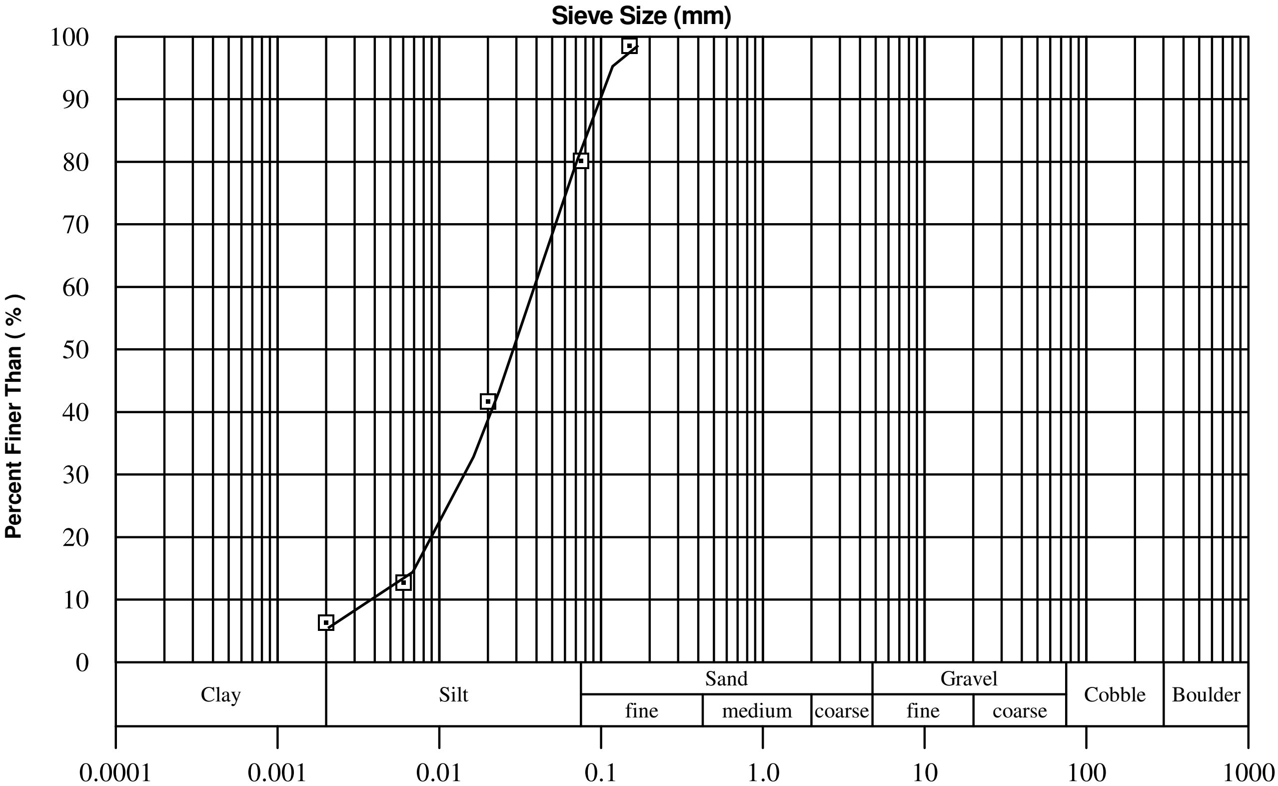


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3915	15.00-15.45		95.20	4.80	

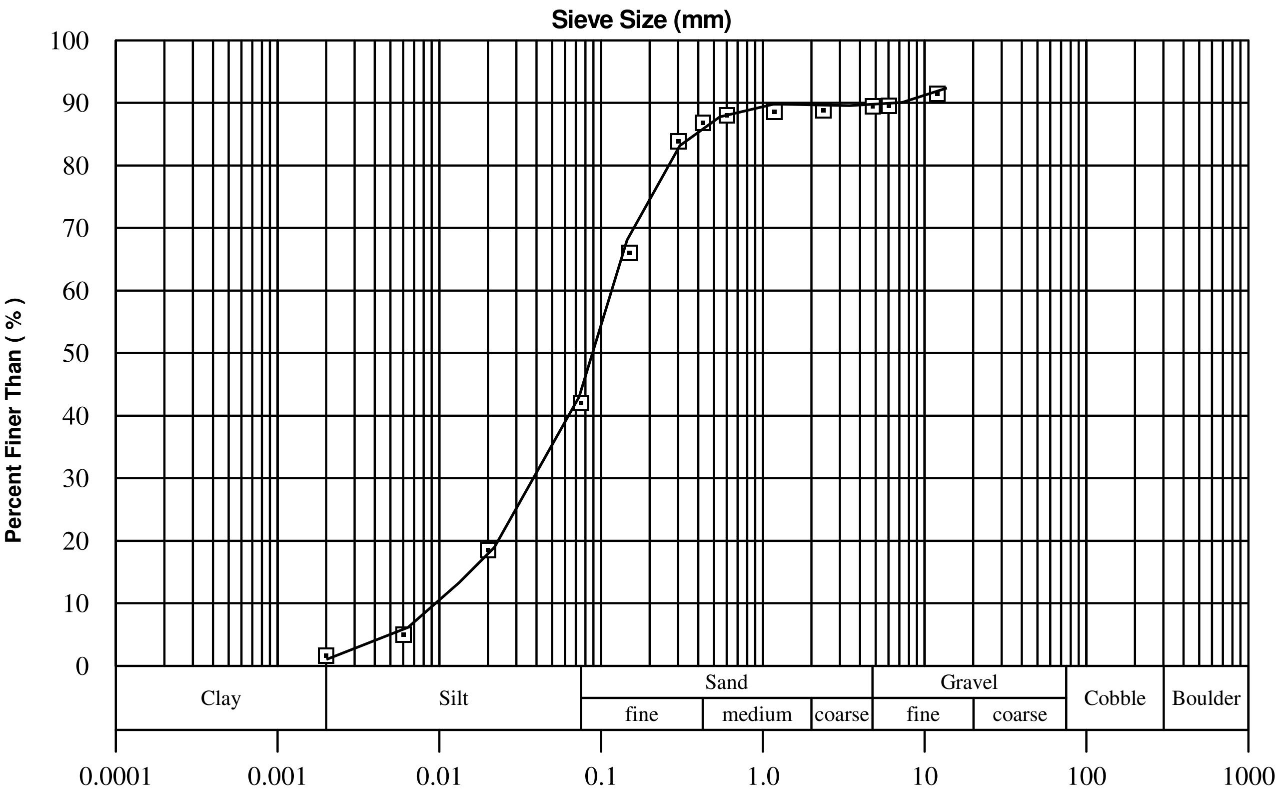


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3917	18.00-18.45		95.60	4.40	

PARTICLE SIZE DISTRIBUTION CURVES

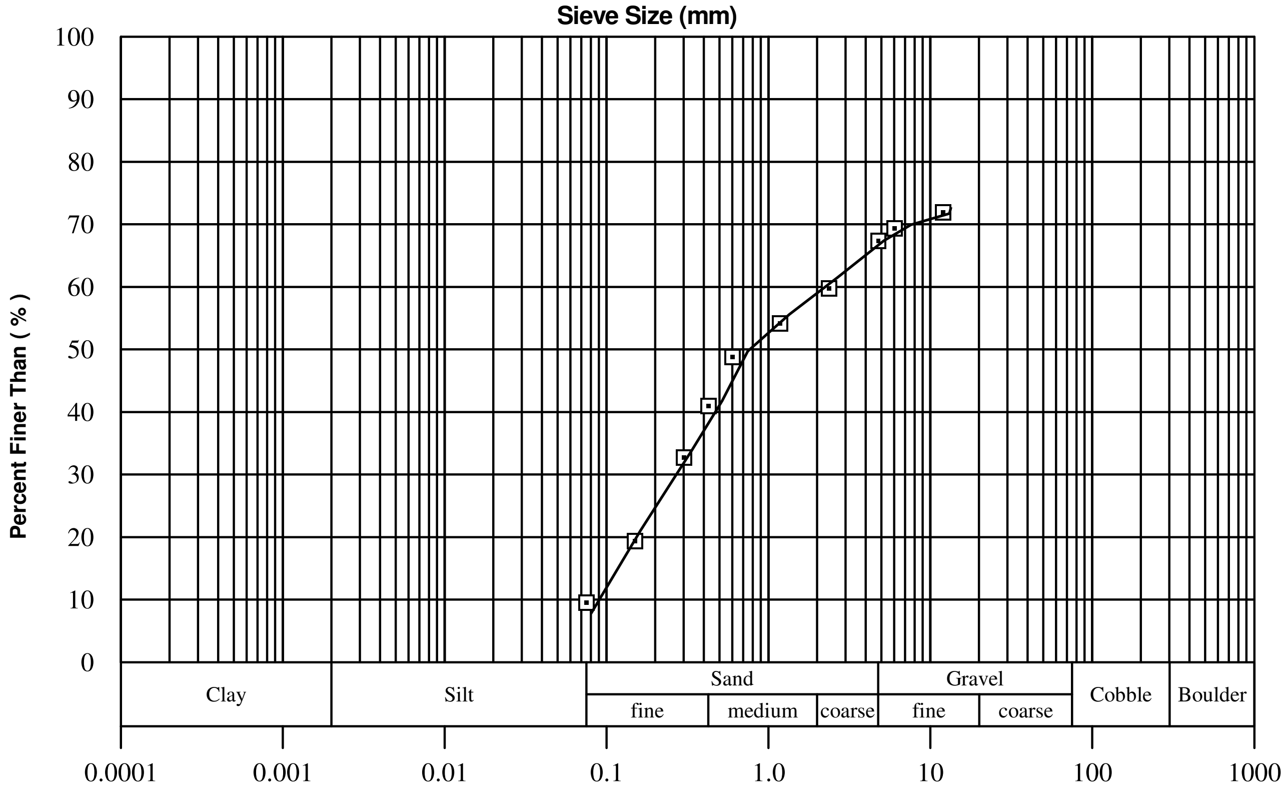


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3920	22.50-22.95		19.80	73.78	6.42

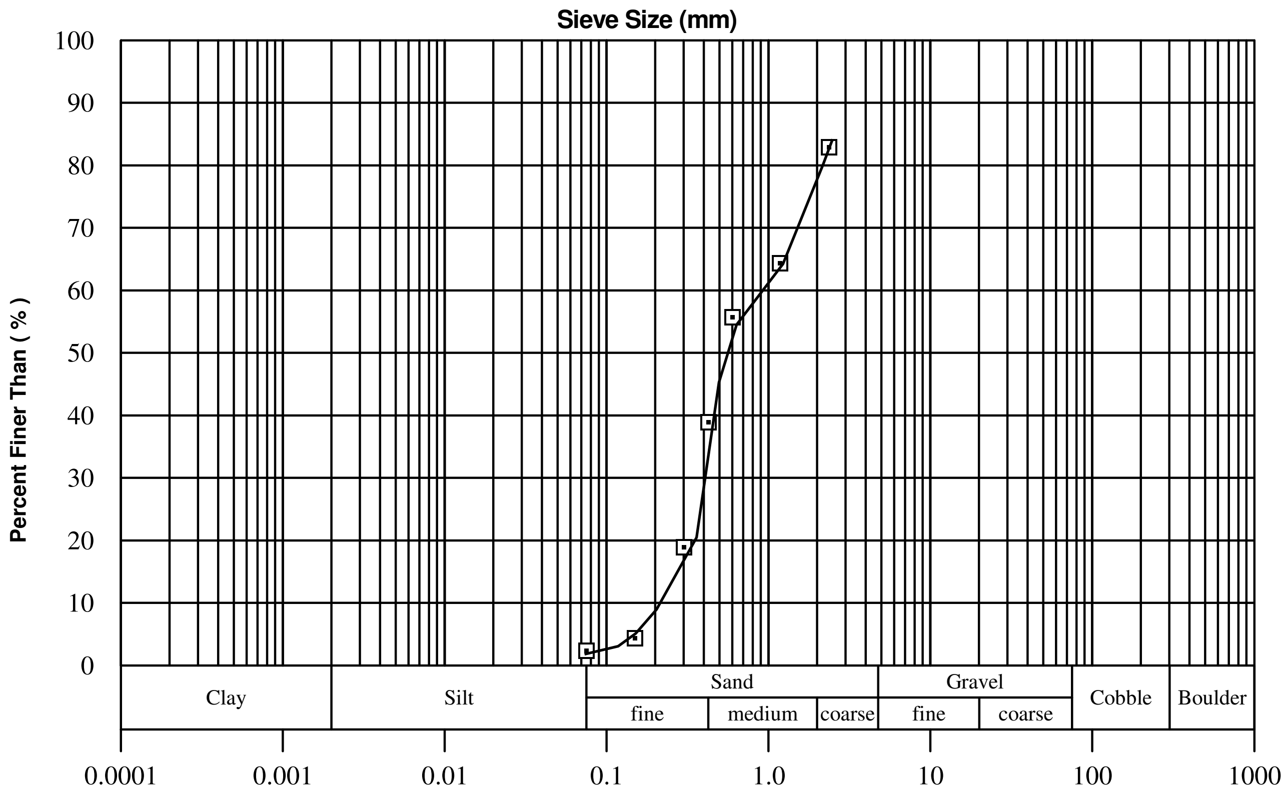


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3921	24.00-24.45	10.50	47.40	40.42	1.68

PARTICLE SIZE DISTRIBUTION CURVES

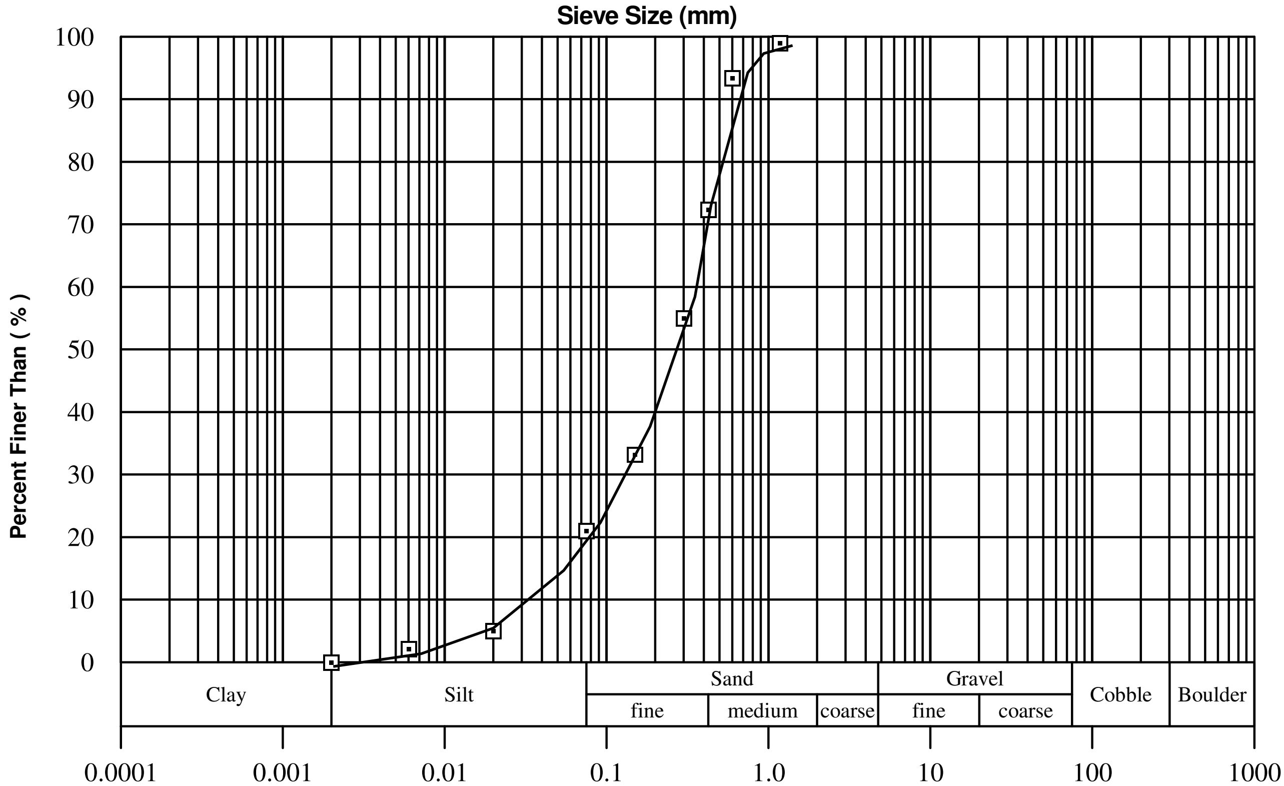


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3922	25.50-25.95	32.60	57.80	9.60	

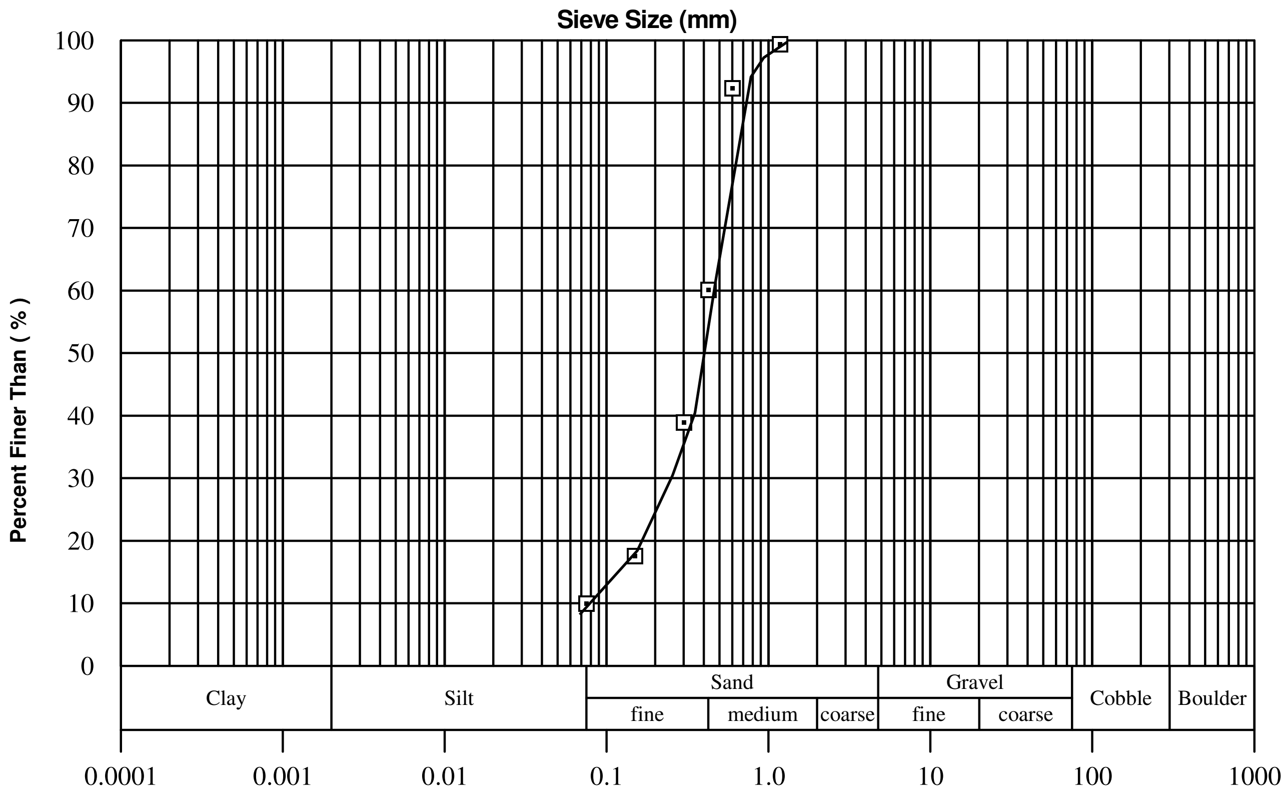


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3923	27.00-27.45		97.60	2.40	

PARTICLE SIZE DISTRIBUTION CURVES

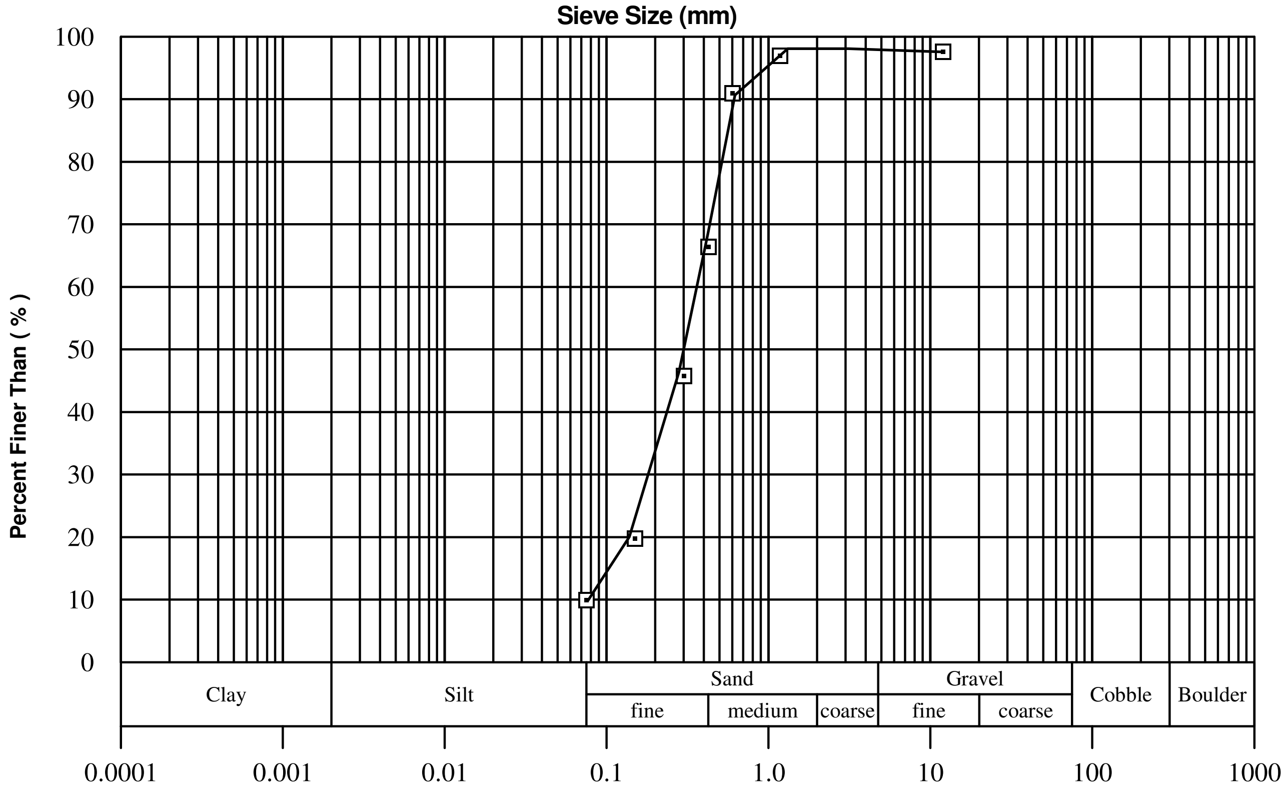


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3925	30.00-30.45		79.00	21.00	0.00

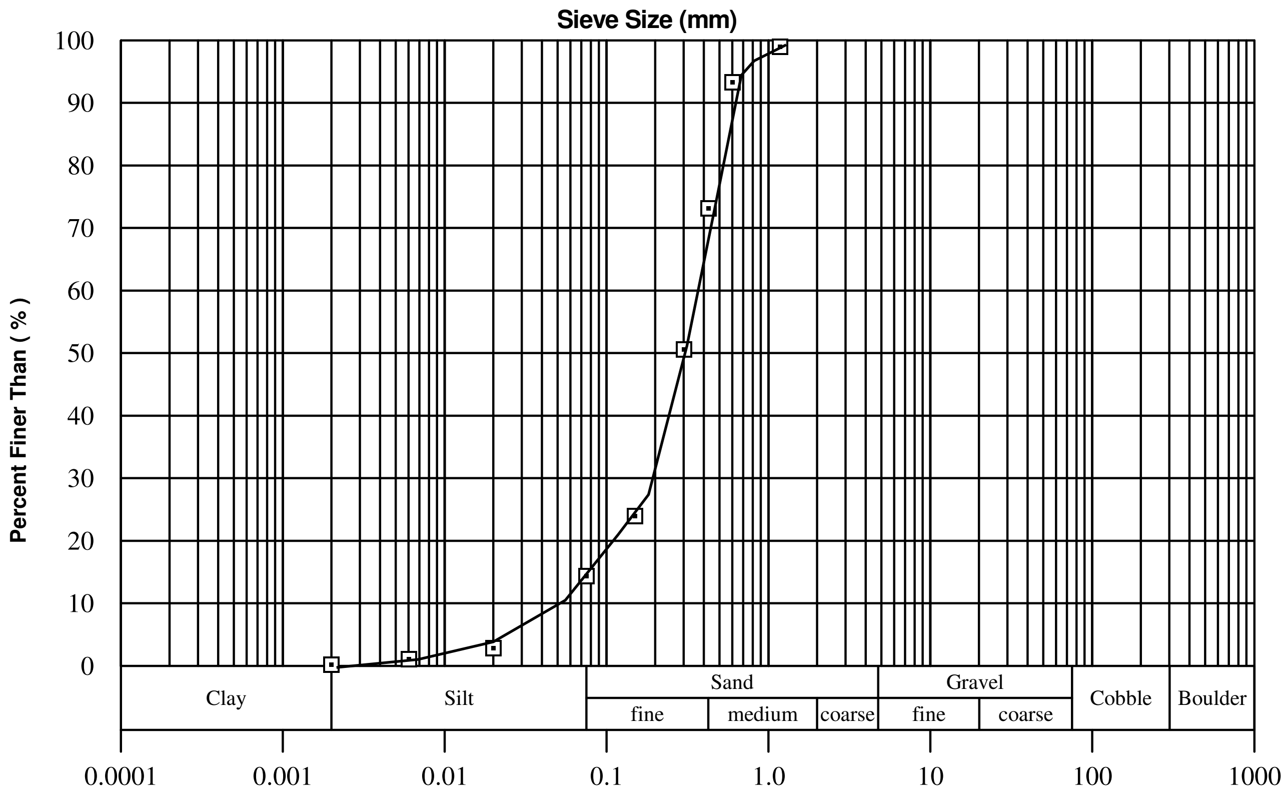


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3926	31.50-31.95		90.00	10.00	

PARTICLE SIZE DISTRIBUTION CURVES

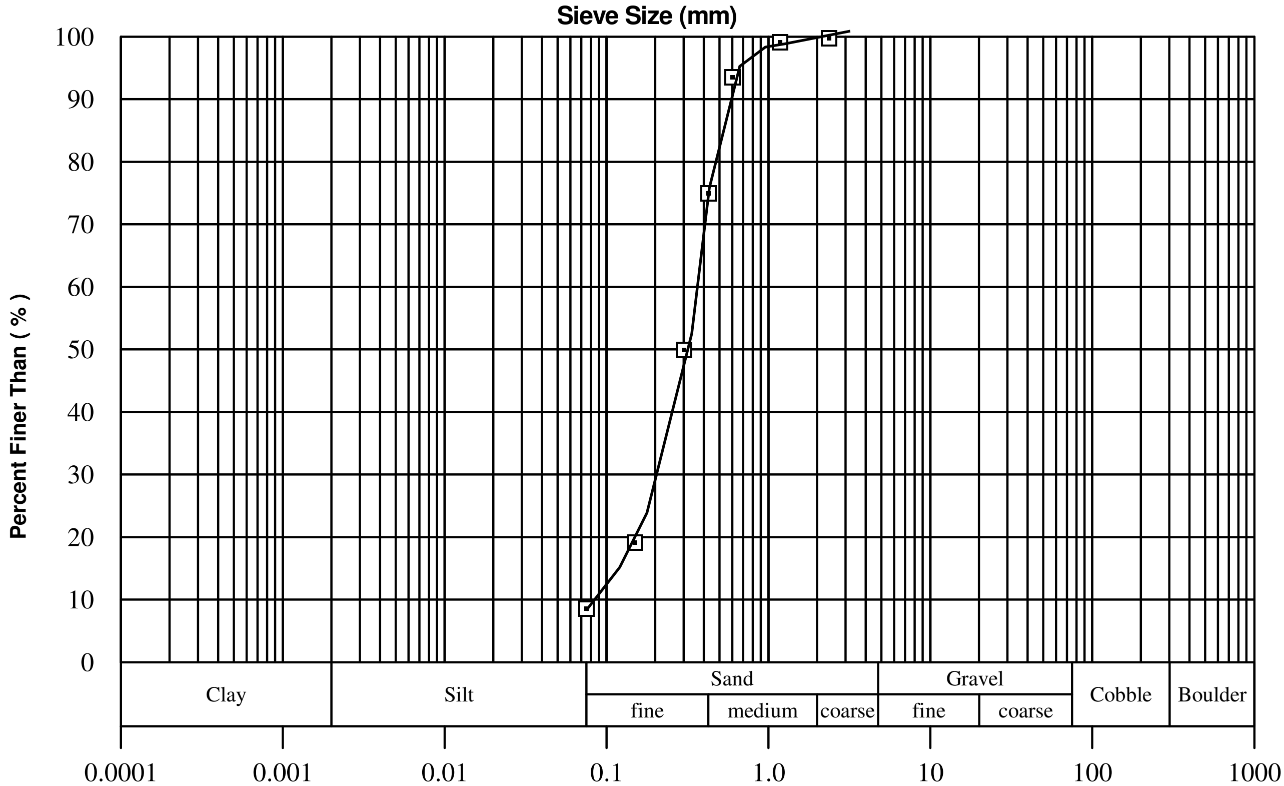


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3928	34.50-34.95			10.00	

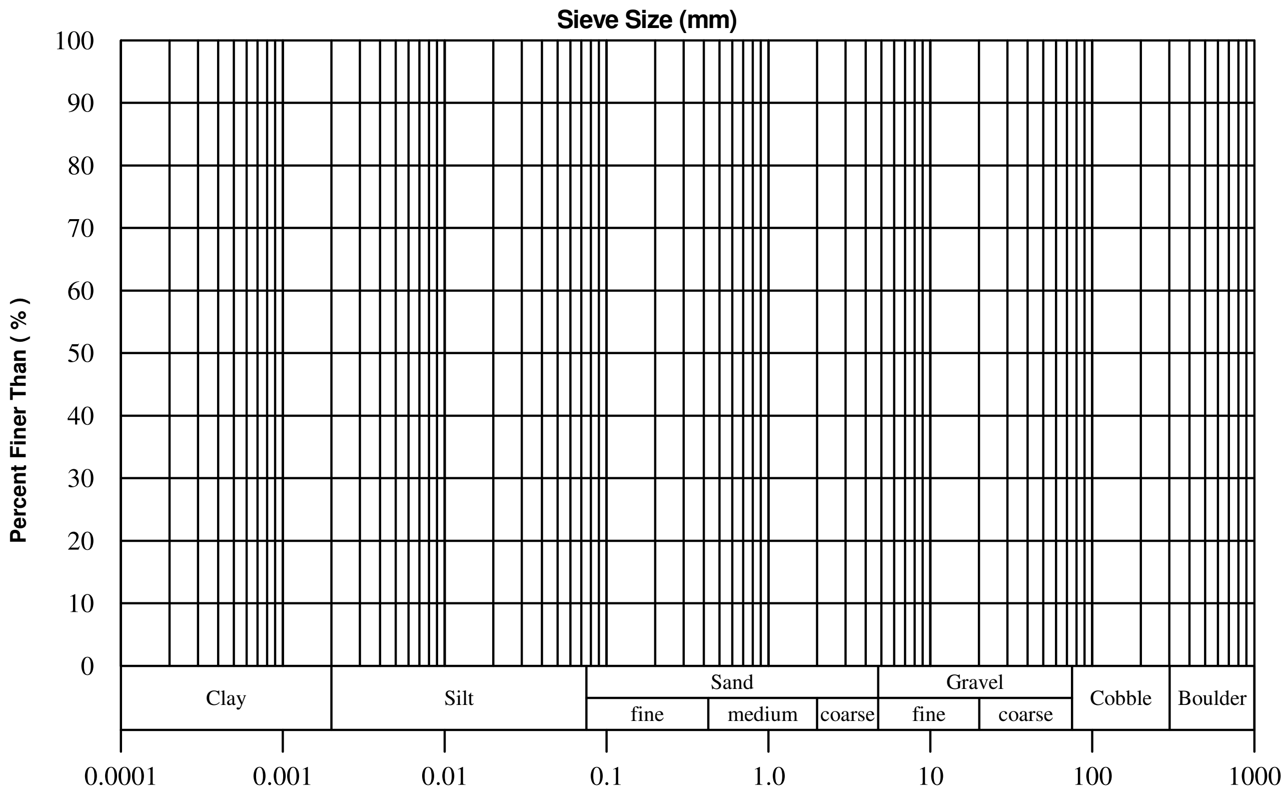


Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3929	36.00-36.45		85.60	14.11	0.29

PARTICLE SIZE DISTRIBUTION CURVES



Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	RBH-01	3934	43.50-43.95		91.40	8.60	



Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay

PARTICLE SIZE DISTRIBUTION CURVES

Boring in Progress (RBH-01

Boring in Progress (RBH-01)

RBH-01-Depth-00.50-0.95m.

RBH-01-Depth-01.50-01.95m.

RBH-01-Depth-03.00-03.45m.

RBH-01-Depth-04.50-04.95m.

RBH-01-Depth-06.00-06.45m.

RBH-01-Depth-07.50-07.95m.

RBH-01-Depth-09.00-09.45m.

RBH-01-Depth-10.50-10.95m.

RBH-01-Depth-12.00-12.45m.

RBH-01-Depth-13.50-13.95m.

RBH-01-Depth-15.00-15.45m.

RBH-01-Depth-16.50-16.95m

RBH-01-Depth-18.00-18.45m.

RBH-01-Depth-19.50-19.95m.

RBH-01-Depth-21.00-21.45m.

RBH-01-Depth-22.50-22.95m.

RBH-01-Depth-24.00-24.45m.

RBH-01-Depth-25.50-25.95m.

RBH-01-Depth-27.00-27.45m.

RBH-01-Depth-28.50-28.95m.

RBH-01-Depth-30.00-30.45m.

RBH-01-Depth-31.50-31.95m.

RBH-01-Depth-33.00-33.45m.

RBH-01-Depth-34.50-34.95m.

RBH-01-Depth-36.00-36.45m.

RBH-01-Depth-37.50-37.95m.

RBH-01-Depth-39.00-39.45m.

RBH-01-Depth-40.50-40.95m.

RBH-01-Depth-42.00-42.45m.

RBH-01-Depth-43.50-43.95m.

RBH-01-Depth-45.00-45.50m.

ANNEXURE 4.1 – DETAILS OF LAND RECORDS

Land Ownership Map
Legend
Bus Stop
Feature 1
Ferry Ghat
Guwahati
Guwahati Gateway Ghat
Mahendra Mohan Choudhury Hospital
Panbazar Police Station
Third Eye College
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
200 m

ANNEXURE 4.2 – NOC

भारतीय अन्तर्देशीय जलमार्ग प्राधिकरण
(पत्तन, पोत परिवहन और जलमार्ग मंत्रालय, भारत सरकार)
INLAND WATERWAYS AUTHORITY OF INDIA
(MINISTRY OF PORTS, SHIPPING AND WATERWAYS, GOVT. OF INDIA)
Regional Office : Pandu Port Complex, Pandu, Guwahati – 781 012 (ASSAM)
• Telefax No. 0361-2570099 • Ph. No. 0361- 2676925, 2676929
• E-mail : iwaighy@yahoo.co.in / dirguw.iwai@nic.in

No.IWAI/GHY/3(20)/NCL/2016-17 (Vol-IV) **Date: 05-08-2021**

To,

The State Project Director
AIWTD Society
3rd Floor, Directorate of Inland Water Transport,
Guwahati-781007

Sub: Amendment to NOC for construction of Terminal at Guwahati Gateway Ghat near Fancy Bazar in NW2-reg.

Ref: (i) Letter no. AIWTDS/138(Part-I)/2018/244 dtd. 24-06-2021
(ii) Online application ID: 132021241 dated 01-04-2021
(iii) Revised online application ID: 752021245 dated 07-06-2021
(iv) Drawing no. P.013223-P-20312-xxx dtd. 17-06-2021

Sir,

Reference above, Competent Authority has accorded the approval of "Navigational Clearance" on your revised proposal for construction of Terminal at Guwahati Gateway Ghat near Fancy Bazar in NW2.

2. This approval (Navigational Clearance) is granted for construction of aforesaid terminal as indicated by you in the prescribed format of IWAI and the GAD, submitted with the proposal. The proposed construction is to be carried out as per Annex-II of IWAI's Office Memorandum dated 27-08-2007 (copy enclosed).

3. It is requested to inform the time/date of commencement of the proposed construction (stage wise/periodical) to IWAI so that the same can be monitored to ensure the required Navigational Clearance. Also, during the construction of the structure, safety of the vessels plying in the vicinity is to be ensured.

Yours faithfully,

(Surendra Singh)
Director

Encl: As above.

Copy to: Chief Engineer (Tech), IWAI, Noida for information

Annex-II

CONDITIONS TO BE FOLLOWED WHILE UNDERTAKING CONSTRUCTION OF STRUCTURE ACROSS NATIONAL WATERWAY

1. The construction of the structure shall commence only after obtaining clearance from the authority.

2. The person shall take up construction as per the approved clearances issued by the authority and get it completed within the time frame mentioned in the application.

3. During construction period, the chairman of the authority or his authorized representatives shall have the right to inspect the site to ensure that the construction is in progress as per the approved clearance. In the event of violation, the authority shall have the right to issue "stop order" immediately for such period as deemed fit by the authority. The work shall be resumed only on getting a fresh clearance from the authority.

4. The person shall undertake construction activity without adversely affecting the smooth voyage movement of vessels through the waterway. Boards indicating "CONSTRUCTION UNDER PROGRESS" shall be erected 500 meters upstream and 500 meters downstream of the location for cautioning the vessels. Necessary warning signals (both day and night marks) shall be provided by the person, as per the directives of the representative of the authority to ensure safety of voyage of vessels while negotiating the construction site.

5. Damage, if any caused to any vessel, crew, materials, cargo etc. due to the construction activities shall be compensated by the person.

OFFICE OF THE GUWAHATI METROPOLITAN DEVELOPMENT AUTHORITY
STATEFED BUILDING, BHANGAGARH, GUWAHATI-781005

Website: www.gmda.assam.gov.in
E-mail: ceogmdaghy@gmail.com, ceo.gmda-as@nic.in

Tel: 0361-2529650/9824
Fax: 0361-2529991

No. GMDA/GEN/203/2016/Pt-II/42

Dated: 25/01/2021

From : Umananda Doley, IAS
Chief Executive Officer
Guwahati Metropolitan Dev. Authority
Bhangagarh, Guwahati -5

To : **The State Project Director,**
Assam Inland Water Transport Development, Society
Ulubari, Guwhati-07

Sub : Issuance of NOC for proposed Terminal at Guwahati Gateway Ghat (South Guwahati)-Regarding.

Ref : Letter No. AIWTDS/244/2020/4 dated 10th December, 2020

Sir,

In inviting a reference to the above, I would like to inform you that construction of ferry terminals etc. at Guwahati Gateway Ghat falls under the category of operation construction as per definition mentioned at Clause 2 (19) and there is no requirement of permission from this Authority under Section 24 of GMDA Act, 1985 (as amended). (copies enclosed).

Enclo: As stated above

Yours faithfully,

25-01-2021

(Shri Umananda Doley, IAS)
Chief Executive Officer
Guwahati Metropolitan Dev. Authority
Bhangagarh, Guwahati -5

Memo No. GMDA/GEN/203/2016/Pt-II/42(A)

Dated: 25/01/2021

Copy for information:

1. S.O. to Chief Secretary, Assam for kind appraisal of Chief Secretary, Assam, & President, PGC, AIWTDS.
2. PS to Commissioner & Secretary, Transport Department, Assam for kind appraisal of Commissioner & Secretary, Transport Department and Chairman, GB, AIWTDS.
3. PA to Hon'ble Chairman, Guwahati Metropolitan development Authority, Bhangagarh, Guwahati-05 for kind appraisal of Chairman.
4. MD, Guwahati Smart City Limited (GSCL) for kind information.

—Sd/—

24. Prohibition of development without permission

After the coming into force of this Act, no development, institution or change of use of any land shall be undertaken or carried out within the Guwahati Metropolitan Area within obtaining the permission in writing from the Authority as provided for here-in-after:

Provided that no such permission shall be necessary —

(i) for the carrying out such works for the maintenance, improvement or other alteration of any building which effect only that interior of the building or which do not materially affect the structural and external appearance of the building;

(ii) for the carrying out by [1][***] the State Government or any local authority of any works required for the maintenance or improvement of a highway, road or public street, being works carried out on land within the boundaries of such highway, road or public street;

(iii) for the carrying out by [2][***] the State Government or any local authority of any works for the purpose of inspecting repairing or renewing any drains, sewers, mains, pipes, cables or other apparatus including the breaking open of any street or other land for that purpose;

(iv) For the excavation (including wells) made in the ordinary course of agriculture operations;

(v) For the construction of unmetalled road intended to give access to land solely for agricultural purposes [3][;

(vi) for operation construction.]

25. Permission for development

(1) Any person or body (including a department of [4][***] the State Government or any local authority) intending to carry out any development on any land shall make an application in writing to the Guwahati Metropolitan Development Authority for permission in such form and containing such particulars and accompanied by such documents as may be prescribed.

---

1 Omitted by the Guwahati Metropolitan Development Authority (Amendment) Act,1989 (Act XXI of 1989), Section 3

2 Omitted by the Guwahati Metropolitan Development Authority (Amendment) Act,1989 (Act XXI of 1989), Section 3

3 Inserted by the Guwahati Metropolitan Development Authority (Amendment) Act,1989 (Act XXI of 1989), Section 4

4 Omitted by the Guwahati Metropolitan Development Authority (Amendment) Act,1989 (Act XXI of 1989), Section 5

respect of which the work is due or compensation or premium on account of the occupation of such land and building and also a rent free tenant.

(18) "Open space" means any land whether enclosed or not on which not more than one-twentieth part is covered with building and the remainder has been laid out as a public garden or used for purpose of recreation or lies waste and unoccupied.

(19) "Operational construction" means any construction, whether temporary or permanent, which is necessary for the operation, maintenance, development or execution of any of the following services: —

- (i) Railways,
- (ii) National Highways,
- (iii) National Waterways,
- (iv) Major Ports,
- (v) Airways and Aerodromes,
- (vi) Posts and Telegraphs, Telephones, Wireless, Broadcasting and other like forms of communication,
- (vii) Regional grid for electricity,
- (viii) Any other service which the State Government may, if it is of opinion that the operation, maintenance, development or execution of such other service is essential to the life of the community, by notification, declare to be a service for the purposes of this clause.

Explanation. — for the removal of doubts, it is hereby declare that the construction of—

(i) new residential buildings not connected with operations like gate, lodges, hospitals, clubs, institution, schools, railway colony, roads, drains, etc., in the case of railways; and

(ii) a new building, new structure, new installation or any extension thereof, in the case of any other service;

shall not be deemed to be construction within the meaning of clause.

(20) "Owner" includes a mortgage in possession, a person who for the time being is receiving or is entitled to receive, or has received, the rent or premium for any land whether on his own account or on account of, or for the benefit of, any other person or as an agent, trustee, guardian or receiver for any other person or for any religious or charitable institution or who would so receive the rent or premium or be entitled to receive the rent or premium if the land were let to a tenant; and also includes the Head of a Department or an Undertaking of the Central or a State Government, the General Manager of a Railway, the Secretary, or other Principal

GOVERNMENT OF ASSAM
OFFICE OF THE CHIEF ENGINEER:PWD(ROADS)
ASSAM: CHANDMARI::GUWAHATI–3

No. CE/CW/41/2019-20/Pt-I/ 12

Dated Guwahati, 25th June / 2021.

To,

The State Project Director,
Assam IWTD Society,
Ulubari, Guwahati-07.

Sub:- Technical approval of DPR.

Ref:- Your letter No. AIWTDS/244/2020/229, Dt. 7/06/2021.

Sir,

In inviting a reference to your letter cited above, I am returning herewith the DPR for the following project, technically approved by the undersigned, for favour of your necessary action.

Sl. No.	Name of scheme	Estimated Amount (Rs. in Crore)
1	"Implementation of the World Bank (IBRD) aided Assam Inland Water Transport Project (AIWTP) (For construction of Ferry Terminal at South Guwahati (Guwahati Gateway Ghat)"	115.99

Enclo:- As above

Yours faithfully,

25/6/21

(D.K. Hazarika)
Chief Engineer, PWD (Roads)
Assam, Chandmari, Guwahati-3

ANNEXURE 9.1 – GEOTECHNICAL DESIGN CALCULATIONS

1.0 Inputs

1.1 Pile Details

Pile Foundation Location	=	Dolphin for Intermediate Pontoons
Reference Bore Hole	=	RBH-1
(All levels are w.r.t. Reduced Level / Chart Datum)		
Existing Ground Level /R.B.L	=	37.26 m
Pile Diameter, B	=	1.520 m
Pile thickness	=	0.0318 mm
Pile Cut-off Level	=	57.00 m
Scour level	=	11.44 m
Pile Founding Level (Pile Tip Level)	=	-7.56 m
Depth of Founding Level from GL /R.B.L	=	44.82 m
Scour Depth	=	25.82 m
Pile Embedment Length	=	19.00 m
Total Pile Length, L	=	64.56 m
Pile Material Density	=	78.50 kN/m^3
Factor of Safety for Vertical Capacity (Ref. Table 9.1, API)	=	2.00
Factor of Safety for Tension Capacity (Ref. Table 9.1, API)	=	1.50
Whether Meyerhof's Correction Applicable	=	yes (yes / no)

1.2 Description and Level of the Layers

Layer No.	Soil Description	Reduced Level (m)		Layer Depth from GL (m)	
		From	To	From	To
1	Medium Dense Sand	37.26	20.26	0.00	17.00
2	Dense Sand	20.26	16.26	17.00	21.00
3	Medium Dense Silt	16.26	13.26	21.00	24.00
4	Very Dense Sand	13.26	11.76	24.00	25.50
5	Very Dense Sand	11.76	7.26	25.50	30.00
6	Very Dense Sand	7.26	5.76	30.00	31.50
7	Very Dense Sand	5.76	2.76	31.50	34.50
8	Very Dense Sand	2.76	-1.75	34.50	39.00
9	Very Dense Sand	-1.75	-7.75	39.00	45.00
10	Very Dense Sand	-7.75	-20.00	45.00	57.26

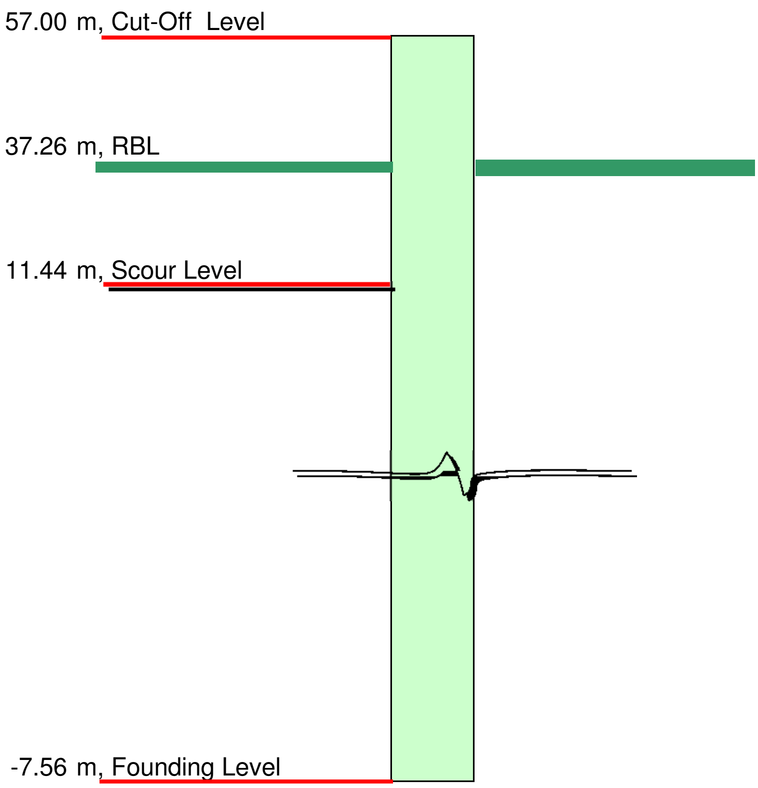
(The soil layer has been slightly modified to suit the calculation process.)

1.3 Soil Parameter of the Layers

Layer No.	Soil Parameters			Interaction Parameters		
	c (kN/m²)	ϕ (deg)	γ_{Sub} (kN/m³)	β	δ (deg)	α
1	0.56	35	8.30	0.37	35	0.00
2	0.36	36	8.60	0.46	36	0.00
3	180.00	0	10.70	0.00	0	0.49
4	0.25	37	9.50	0.56	37	0.00
5	0.65	40	9.80	0.56	40	0.00
6	0.55	39	9.80	0.56	39	0.00
7	0.25	37	9.50	0.56	37	0.00
8	0.14	39	10.10	0.56	39	0.00
9	0.45	41	10.60	0.56	41	0.00
10	0.45	41	10.90	0.56	41	0.00

(For Interaction parameter refer Table 1, API Recommended Practice 2 Geo, 1st Ed. April 2011)

1.4 Schematic Diagram of Pile



2.0 Calculation of Vertical Capacity

2.1 Calculation of Skin Friction: Inner Surface

2.1.1 Layer - 1 : Medium Dense Sand

Layer thickness, L_1	=	17.00 m
Pile embedment in the layer, h_1	=	0.00 m

Ultimate Skin Resistance, Q_{s1} = $(\alpha_1 * c_1 + \beta_1 * P_{d1}) \times A_{s1}$

Shaft friction factor for clays, α_1	=	0.00
Cohesion, c_1	=	0.56 kN/m^2
Shaft friction factor for sand, β_1	=	0.37
Unit weight of soil , γ_1	=	8.30 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d1}

$P_{d1} = (h_1 / 2) * \gamma_1$	=	0.00 kN/m^2
Surface area of Pile in layer 1, $A_{s1} = pi * B * h_1$	=	0.00 m^2
Ultimate Skin Resistance, Q_{s1}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s1}	=	0.00 kN

2.1.2 Layer - 2 : Dense Sand

Layer thickness, L_2	=	4.00 m
Pile embedment in the layer, h_2	=	0.00 m

Ultimate Skin Resistance, Q_{s2} = $(\alpha_2 * c_2 + \beta_2 * P_{d2}) \times A_{s2}$

Shaft friction factor for clays, α_2	=	0.00
Cohesion, c_2	=	0.36 kN/m^2
Shaft friction factor for sand, β_2	=	0.46
Unit weight of soil , γ_2	=	8.60 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d2}

$P_{d2} = P_{d1} + (h_1 / 2) * \gamma_1 + (h_2 / 2) * \gamma_2$	=	0.00 kN/m^2
Surface area of Pile in layer 2, $A_{s2} = pi * B * h_2$	=	0.00 m^2
Ultimate Skin Resistance, Q_{s2}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s2}	=	0.00 kN

2.1.3 Layer - 3 : Medium Dense Silt

Layer thickness, L_3	=	3.00 m
Pile embedment in the layer, h_3	=	0.00 m

Ultimate Skin Resistance, Q_{s3} = $(\alpha_3 * c_3 + \beta_3 * P_{d3}) \times A_{s3}$

Shaft friction factor for clays, α_3	=	0.49
Cohesion, c_3	=	180.00 kN/m^2
Shaft friction factor for sand, β_3	=	0.00
Unit weight of soil , γ_3	=	10.70 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d3}

$P_{d3} = P_{d2} + (h_2 / 2) * \gamma_2 + (h_3 / 2) * \gamma_3$	=	0.00 kN/m^2
Surface area of Pile in layer 3, A_{s3} = pi * B * h_3	=	0.00 m^2
Ultimate Skin Resistance, Q_{s3}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s3}	=	0.00 kN

2.1.4 Layer - 4 : Very Dense Sand

Layer thickness, L_4	=	1.50 m
Pile embedment in the layer, h_4	=	0.00 m

Ultimate Skin Resistance, Q_{s4} = $(\alpha_4 * c_4 + \beta_4 * P_{d4}) \times A_{s4}$

Shaft friction factor for clays, α_4	=	0.00
Cohesion, c_4	=	0.25 kN/m^2
Shaft friction factor for sand, β_4	=	0.56
Unit weight of soil , γ_4	=	9.50 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d4}

$P_{d4} = P_{d3} + (h_3 / 2) * \gamma_3 + (h_4 / 2) * \gamma_4$	=	0.00 kN/m^2
Surface area of Pile in layer 4, A_{s4} = pi * B * h_4	=	0.00 m^2
Ultimate Skin Resistance, Q_{s4}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s4}	=	0.00 kN

2.1.5 Layer - 5 : Very Dense Sand

Layer thickness, L_5	=	4.50 m
Pile embedment in the layer, h_5	=	4.19 m

Ultimate Skin Resistance, Q_{s5} = $(\alpha_5 * c_5 + \beta_5 * P_{d5}) \times A_{s5}$

Shaft friction factor for clays, α_5	=	0.00
Cohesion, c_5	=	0.65 kN/m^2
Shaft friction factor for sand, β_5	=	0.56
Unit weight of soil , γ_5	=	9.80 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d5}

$P_{d5} = P_{d4} + (h_4 / 2) * \gamma_4 + (h_5 / 2) * \gamma_5$	=	20.51 kN/m^2
Surface area of Pile in layer 5, A_{s5} = pi * B * h_5	=	19.15 m^2
Ultimate Skin Resistance, Q_{s5}	=	219.89 kN
Limiting value of Skin Resistance, Q_{lim}	=	2202.03 kN
Hence, Ultimate Skin Resistance, Q_{s5}	=	219.89 kN

2.1.6 Layer - 6 : Very Dense Sand

Layer thickness, L_6	=	1.50 m
Pile embedment in the layer, h_6	=	1.50 m

Ultimate Skin Resistance, Q_{s6} = $(\alpha_6 * c_6 + \beta_6 * P_{d6}) \times A_{s6}$

Shaft friction factor for clays, α_6	=	0.00
Cohesion, c_6	=	0.55 kN/m^2
Shaft friction factor for sand, β_6	=	0.56
Unit weight of soil , γ_6	=	9.80 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d6}

$P_{d6} = P_{d5} + (h_5 / 2) * \gamma_5 + (h_6 / 2) * \gamma_6$	=	48.36 kN/m^2
Surface area of Pile in layer 6, A_{s6} = pi * B * h_6	=	6.86 m^2
Ultimate Skin Resistance, Q_{s6}	=	185.88 kN
Limiting value of Skin Resistance, Q_{lim}	=	789.26 kN
Hence, Ultimate Skin Resistance, Q_{s6}	=	185.88 kN

2.1.7 Layer - 7 : Very Dense Sand

Layer thickness, L_7	=	3.00 m
Pile embedment in the layer, h_7	=	3.00 m

Ultimate Skin Resistance, Q_{s7} = $(\alpha_7 * c_7 + \beta_7 * P_{d7}) \times A_{s7}$

Shaft friction factor for clays, α_7	=	0.00
Cohesion, c_7	=	0.25 kN/m^2
Shaft friction factor for sand, β_7	=	0.56
Unit weight of soil , γ_7	=	9.50 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d7}

$P_{d7} = P_{d6} + (h_6 / 2) * \gamma_6 + (h_7 / 2) * \gamma_7$	=	69.96 kN/m^2
Surface area of Pile in layer 7, $A_{s7} = pi * B * h_7$	=	13.73 m^2
Ultimate Skin Resistance, Q_{s7}	=	537.78 kN
Limiting value of Skin Resistance, Q_{lim}	=	1578.52 kN
Hence, Ultimate Skin Resistance, Q_{s7}	=	537.78 kN

2.1.8 Layer - 8 : Very Dense Sand

Layer thickness, L_8	=	4.50 m
Pile embedment in the layer, h_8	=	4.50 m

Ultimate Skin Resistance, Q_{s8} = $(\alpha_8 * c_8 + \beta_8 * P_{d8}) \times A_{s8}$

Shaft friction factor for clays, α_8	=	0.00
Cohesion, c_8	=	0.14 kN/m^2
Shaft friction factor for sand, β_8	=	0.56
Unit weight of soil , γ_8	=	10.10 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d8}

$P_{d8} = P_{d7} + (h_7 / 2) * \gamma_7 + (h_8 / 2) * \gamma_8$	=	106.94 kN/m^2
Surface area of Pile in layer 8, $A_{s8} = pi * B * h_8$	=	20.59 m^2
Ultimate Skin Resistance, Q_{s8}	=	1233.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	2367.78 kN
Hence, Ultimate Skin Resistance, Q_{s8}	=	1233.00 kN

2.1.9 Layer - 9 : Very Dense Sand

Layer thickness, L_9	=	6.00 m
Pile embedment in the layer, h_9	=	5.82 m

Ultimate Skin Resistance, Q_{s9} = $(\alpha_9 * c_9 + \beta_9 * P_{d9}) \times A_{s9}$

Shaft friction factor for clays, α_9	=	0.00
Cohesion, c_9	=	0.45 kN/m^2
Shaft friction factor for sand, β_9	=	0.56
Unit weight of soil , γ_9	=	10.60 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d9}

$P_{d9} = P_{d8} + (h_8 / 2) * \gamma_8 + (h_9 / 2) * \gamma_9$	=	160.48 kN/m^2
Surface area of Pile in layer 9, $A_{s9} = pi * B * h_9$	=	26.61 m^2
Ultimate Skin Resistance, Q_{s9}	=	2391.09 kN
Limiting value of Skin Resistance, Q_{lim}	=	3059.69 kN
Hence, Ultimate Skin Resistance, Q_{s9}	=	2391.09 kN

2.1.10 Layer - 10 : Very Dense Sand

Layer thickness, L_{10}	=	12.26 m
Pile embedment in the layer, h_{10}	=	0.00 m

Ultimate Skin Resistance, Q_{s10} = $(\alpha_{10} * c_{10} + \beta_{10} * P_{d10}) \times A_{s10}$

Shaft friction factor for clays, α_{10}	=	0.00
Cohesion, c_{10}	=	0.45 kN/m^2
Shaft friction factor for sand, β_{10}	=	0.56
Unit weight of soil , γ_{10}	=	10.90 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d10}

$P_{d10} = P_{d9} + (h_9 / 2) * \gamma_9 + (h_{10} / 2) * \gamma_{10}$	=	191.30 kN/m^2
Surface area of Pile in layer 10, $A_{s10} = pi * B * h_{10}$	=	0.00 m^2
Ultimate Skin Resistance, Q_{s10}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s10}	=	0.00 kN

3.2 Calculation of Skin Frictions: Outer Surface

3.2.1 Layer - 1 : Medium Dense Sand

Layer thickness, L_1	=	17.00 m
Pile embedment in the layer, h_1	=	0.00 m

Ultimate Skin Resistance, Q_{s1} = $(\alpha_1 * c_1 + \beta_1 * P_{d1}) \times A_{s1}$

Shaft friction factor for clays, α_1	=	0.00
Cohesion, c_1	=	0.56 kN/m^2
Shaft friction factor for sand, β_1	=	0.37
Unit weight of soil , γ_1	=	8.30 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d1}

$P_{d1} = (h_1 / 2) * \gamma_1$	=	0.00 kN/m^2
Surface area of Pile in layer 1, $A_{s1} = pi * B * h_1$	=	0.00 m^2
Ultimate Skin Resistance, Q_{s1}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s1}	=	0.00 kN

3.2.2 Layer - 2 : Dense Sand

Layer thickness, L_2	=	4.00 m
Pile embedment in the layer, h_2	=	0.00 m

Ultimate Skin Resistance, Q_{s2} = $(\alpha_2 * c_2 + \beta_2 * P_{d2}) \times A_{s2}$

Shaft friction factor for clays, α_2	=	0.00
Cohesion, c_2	=	0.36 kN/m^2
Shaft friction factor for sand, β_2	=	0.46
Unit weight of soil , γ_2	=	8.60 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d2}

$P_{d2} = P_{d1} + (h_1 / 2) * \gamma_1 + (h_2 / 2) * \gamma_2$	=	0.00 kN/m^2
Surface area of Pile in layer 2, $A_{s2} = pi * B * h_2$	=	0.00 m^2
Ultimate Skin Resistance, Q_{s2}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s2}	=	0.00 kN

3.2.3 Layer - 3 : Medium Dense Silt

Layer thickness, L_3	=	3.00 m
Pile embedment in the layer, h_3	=	0.00 m

Ultimate Skin Resistance, Q_{s3} = $(\alpha_3 * c_3 + \beta_3 * P_{d3}) \times A_{s3}$

Shaft friction factor for clays, α_3	=	0.49
Cohesion, c_3	=	180.00 kN/m^2
Shaft friction factor for sand, β_3	=	0.00
Unit weight of soil , γ_3	=	10.70 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d3}

$P_{d3} = P_{d2} + (h_2 / 2) * \gamma_2 + (h_3 / 2) * \gamma_3$ = 0.00 kN/m^2

Surface area of Pile in layer 3, $A_{s3} = pi * B * h_3$ = 0.00 m^2

Ultimate Skin Resistance, Q_{s3}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s3}	=	0.00 kN

3.2.4 Layer - 4 : Very Dense Sand

Layer thickness, L_4	=	1.50 m
Pile embedment in the layer, h_4	=	0.00 m

Ultimate Skin Resistance, Q_{s4} = $(\alpha_4 * c_4 + \beta_4 * P_{d4}) \times A_{s4}$

Shaft friction factor for clays, α_4	=	0.00
Cohesion, c_4	=	0.25 kN/m^2
Shaft friction factor for sand, β_4	=	0.56
Unit weight of soil , γ_4	=	9.50 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d4}

$P_{d4} = P_{d3} + (h_3 / 2) * \gamma_3 + (h_4 / 2) * \gamma_4$ = 0.00 kN/m^2

Surface area of Pile in layer 4, $A_{s4} = pi * B * h_4$ = 0.00 m^2

Ultimate Skin Resistance, Q_{s4}	=	0.00 kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00 kN
Hence, Ultimate Skin Resistance, Q_{s4}	=	0.00 kN

3.2.5 Layer - 5 : Very Dense Sand

Layer thickness, L_5	=	4.50	m
Pile embedment in the layer, h_5	=	4.19	m

Ultimate Skin Resistance, Q_{s5} = $(\alpha_5 * c_5 + \beta_5 * P_{d5}) \times A_{s5}$

Shaft friction factor for clays, α_5	=	0.00	
Cohesion, c_5	=	0.65	kN/m^2
Shaft friction factor for sand, β_5	=	0.56	
Unit weight of soil , γ_5	=	9.80	kN/m^3

Effective Overburden Pressure at middle of layer, P_{d5}

$P_{d5} = P_{d4} + (h_4 / 2) * \gamma_4 + (h_5 / 2) * \gamma_5$	=	20.51	kN/m^2
Surface area of Pile in layer 5, $A_{s5} = pi * B * h_5$	=	19.98	m^2
Ultimate Skin Resistance, Q_{s5}	=	229.49	kN
Limiting value of Skin Resistance, Q_{lim}	=	2298.19	kN
Hence, Ultimate Skin Resistance, Q_{s5}	=	229.49	kN

3.2.6 Layer - 6 : Very Dense Sand

Layer thickness, L_6	=	1.50	m
Pile embedment in the layer, h_6	=	1.50	m

Ultimate Skin Resistance, Q_{s6} = $(\alpha_6 * c_6 + \beta_6 * P_{d6}) \times A_{s6}$

Shaft friction factor for clays, α_6	=	0.00	
Cohesion, c_6	=	0.55	kN/m^2
Shaft friction factor for sand, β_6	=	0.56	
Unit weight of soil , γ_6	=	9.80	kN/m^3

Effective Overburden Pressure at middle of layer, P_{d6}

$P_{d6} = P_{d5} + (h_5 / 2) * \gamma_5 + (h_6 / 2) * \gamma_6$	=	48.36	kN/m^2
Surface area of Pile in layer 6, $A_{s6} = pi * B * h_6$	=	7.16	m^2
Ultimate Skin Resistance, Q_{s6}	=	193.99	kN
Limiting value of Skin Resistance, Q_{lim}	=	823.73	kN
Hence, Ultimate Skin Resistance, Q_{s6}	=	193.99	kN

3.2.7 Layer - 7 : Very Dense Sand

Layer thickness, L_7	=	3.00 m
Pile embedment in the layer, h_7	=	3.00 m

Ultimate Skin Resistance, Q_{s7} = $(\alpha_7 * c_7 + \beta_7 * P_{d7}) \times A_{s7}$

Shaft friction factor for clays, α_7	=	0.00
Cohesion, c_7	=	0.25 kN/m^2
Shaft friction factor for sand, β_7	=	0.56
Unit weight of soil , γ_7	=	9.50 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d7}

$P_{d7} = P_{d6} + (h_6 / 2) * \gamma_6 + (h_7 / 2) * \gamma_7$	=	69.96 kN/m^2
Surface area of Pile in layer 7, A_{s7} = pi * B * h_7	=	14.33 m^2
Ultimate Skin Resistance, Q_{s7}	=	561.27 kN
Limiting value of Skin Resistance, Q_{lim}	=	1647.45 kN
Hence, Ultimate Skin Resistance, Q_{s7}	=	561.27 kN

3.2.8 Layer - 8 : Very Dense Sand

Layer thickness, L_8	=	4.50 m
Pile embedment in the layer, h_8	=	4.50 m

Ultimate Skin Resistance, Q_{s8} = $(\alpha_8 * c_8 + \beta_8 * P_{d8}) \times A_{s8}$

Shaft friction factor for clays, α_8	=	0.00
Cohesion, c_8	=	0.14 kN/m^2
Shaft friction factor for sand, β_8	=	0.56
Unit weight of soil , γ_8	=	10.10 kN/m^3

Effective Overburden Pressure at middle of layer, P_{d8}

$P_{d8} = P_{d7} + (h_7 / 2) * \gamma_7 + (h_8 / 2) * \gamma_8$	=	106.94 kN/m^2
Surface area of Pile in layer 8, A_{s8} = pi * B * h_8	=	21.49 m^2
Ultimate Skin Resistance, Q_{s8}	=	1286.84 kN
Limiting value of Skin Resistance, Q_{lim}	=	2471.18 kN
Hence, Ultimate Skin Resistance, Q_{s8}	=	1286.84 kN

3.2.9 Layer - 9 : Very Dense Sand

Layer thickness, L_9	=	6.00	m
Pile embedment in the layer, h_9	=	5.82	m

Ultimate Skin Resistance, Q_{s9} = $(\alpha_9 * c_9 + \beta_9 * P_{d9}) \times A_{s9}$

Shaft friction factor for clays, α_9	=	0.00	
Cohesion, c_9	=	0.45	kN/m^2
Shaft friction factor for sand, β_9	=	0.56	
Unit weight of soil , γ_9	=	10.60	kN/m^3

Effective Overburden Pressure at middle of layer, P_{d9}

$P_{d9} = P_{d8} + (h_8 / 2) * \gamma_8 + (h_9 / 2) * \gamma_9$ = 160.48 kN/m^2

Surface area of Pile in layer 9, $A_{s9} = pi * B * h_9$ = 27.77 m^2

Ultimate Skin Resistance, Q_{s9}	=	2495.51	kN
Limiting value of Skin Resistance, Q_{lim}	=	3193.31	kN
Hence, Ultimate Skin Resistance, Q_{s9}	=	2495.51	kN

3.2.10 Layer - 10 : Very Dense Sand

Layer thickness, L_{10}	=	12.26	m
Pile embedment in the layer, h_{10}	=	0.00	m

Ultimate Skin Resistance, Q_{s10} = $(\alpha_{10} * c_{10} + \beta_{10} * P_{d10}) \times A_{s10}$

Shaft friction factor for clays, α_{10}	=	0.00	
Cohesion, c_{10}	=	0.45	kN/m^2
Shaft friction factor for sand, β_{10}	=	0.56	
Unit weight of soil , γ_{10}	=	10.90	kN/m^3

Effective Overburden Pressure at middle of layer, P_{d10}

$P_{d10} = P_{d9} + (h_9 / 2) * \gamma_9 + (h_{10} / 2) * \gamma_{10}$ = 191.30 kN/m^2

Surface area of Pile in layer 10, $A_{s10} = pi * B * h_{10}$ = 0.00 m^2

Ultimate Skin Resistance, Q_{s10}	=	0.00	kN
Limiting value of Skin Resistance, Q_{lim}	=	0.00	kN
Hence, Ultimate Skin Resistance, Q_{s10}	=	0.00	kN

3.3 Ultimate End Bearing Resistance

Ultimate End Bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$

End Bearing Layer (Layer Bearing the Pile Tip)	=	Layer 9
Soil Type	=	Very Dense Sand
Cohesion at Pile Toe, c	=	0.45 kN/m^2
Bearing Capacity Factor, N_c	=	9
Angle of Internal Friction at Pile Toe, ϕ	=	41 deg
Bearing Capacity Factor, N_q	=	50
Unit Weight of Soil at Pile Toe, γ	=	10.60 kN/m^3
Pile Founding Level (Pile Tip Level)	=	-7.56 m
Depth of Founding Level (Pile Tip) from GL	=	44.82 m

For the Determination of Overburden Pressure in End Bearing Calculation,

Effective Depth	=	44.82 m
Corresponding Soil Layer	=	Layer 9

Layer No.	Layer Depth From G.L.		γ_{Sub}	Overburden Pressure at the Bottom of Layer / Pile Tip (what encounters first)
	From	To	(kN/m^3)	
1	0.00	17.00	8.30	0.00 kN/m^2
2	17.00	21.00	8.60	0.00 kN/m^2
3	21.00	24.00	10.70	0.00 kN/m^2
4	24.00	25.50	9.50	0.00 kN/m^2
5	25.50	30.00	9.80	41.01 kN/m^2
6	30.00	31.50	9.80	55.71 kN/m^2
7	31.50	34.50	9.50	84.21 kN/m^2
8	34.50	39.00	10.10	129.66 kN/m^2
9	39.00	45.00	10.60	191.30 kN/m^2
10	45.00	57.26	10.90	- kN/m^2

Hence, Effective Overburden Pressure, P_d = 191.30 kN/m^2

Area of Pile at Toe, A_p 0.149 m^2

Ultimate End Bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$ = 1422.69 kN

Limiting End Bearing Resistance, Q_l = 1784.10 kN

Design End Bearing Resistance, Q_d = 1422.69 kN

Project No.	Steel Pile Capacity for Guwahati Gateway Terminal	Document No.	Date
		AIWTDS/GEO/PILE/01	12-Jun-19
P.013223		Designed: PM	Checked: LR

3.4 Meyerhof's Correction for Ultimate End Bearing Resistance

The end bearing capacity is calculated just in the layer where the pile toe terminates. If the pile toe terminates in a layer of dense sand or stiff clay overlying a layer of soft clay or loose sand there is a danger of it punching through to the weaker layer.

To account for this, Meyerhof's correction is used.

As per Meyerhof's equation, the base resistance at the pile toe is

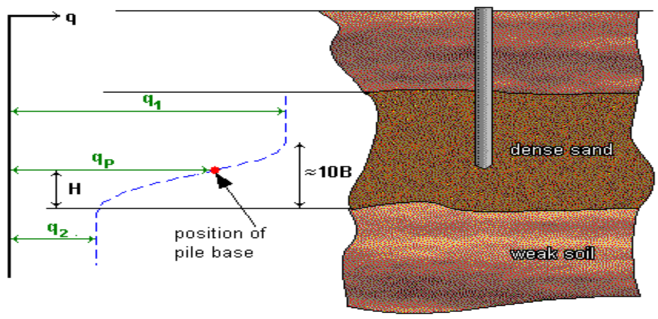
$$q_p = q_2 + \left[(q_1 - q_2) \times \frac{H}{10 \times B} \right]$$

Or it can be written in other form

$$q_p = \left[q_1 \times \left\{ \frac{H}{10 \times B} \right\} \right] + \left[q_2 \times \left\{ \frac{(10 \times B) - H}{10 \times B} \right\} \right]$$

Where,

B is the diameter of the pile
H is the thickness between the base of the pile and the top of the weaker layer
q_1 is the ultimate base resistance in the strong layer
q_2 is the ultimate base resistance in the weak layer



End Bearing Layer (Layer Bearing the Pile Tip)	=	Layer 9
Soil Type	=	Very Dense Sand
Depth equal to 10 times Pile Diameter	=	15.20 m
Thickness between pile tip and weaker layer top, H	=	0.18 m

Details of the End Bearing Layer and the Weak Layer Beneath,

Layer No.	Soil description	c (kN/m^2)	N_c	φ (deg)	N_q	End Bearing Resistance
Layer 9	Very Dense Sand	0.45	9	41	50	1422.69 kN
Layer 10	Very Dense Sand	0.45	9	41	50	1422.69 kN

In the present case,

Diameter of the pile, B	=	1.52 m
Depth equal to 10 times Pile Diameter	=	15.20 m
Thickness between pile tip and weaker layer top, H	=	0.18 m
Ultimate base resistance in the strong layer, q_1	=	1422.69 kN
Ultimate base resistance in the weaker layer, q_2	=	1422.69 kN
Hence Ultimate Base Resistance	=	1422.69 kN
Limiting End Bearing Resistance, Q_l	=	1784.10 kN
Design End Bearing Resistance, Q_d	=	1422.69 kN

3.5 Vertical Capacity of Pile

Ultimate Capacity of the Pile, Q_{ult} = $Q_b + Q_s - W_p$

Where,

Q_b = Ultimate End Bearing = $(c^* N_c + P_d * N_q) * A_p$

Q_s = Ultimate Skin Friction = $\Sigma [(\alpha * c + K * P_d * \tan\delta) \times A_s]$

W_p = Self Weight of Pile = $A_p * L * \gamma_p$

Hence, Q_{safe} = Q_{ult} / FOS Where, FOS = Factor of Safety

3.5.1 Skin Friction, Q_s

Ultimate Skin Friction of the Pile inside layer, Qs = 4567.64 kN
Ultimate Skin Friction of the Pile outside layer, Qs = 4767.11 kN
Total Ultimate Skin Friction of the Pile, Qs = 9334.75 kN

3.5.2 End Bearing, Q_b

Ultimate End Bearing of the Pile, Q_b = 1422.69 kN

3.5.3 Self Weight of the Pile, W_p

Self weight of the Pile, $W_p = A_p * L * \gamma_p$

Where, Cross-sectional Area of Pile, A_p = 0.15 m^2
Total Length of Pile , L = 64.56 m
Unit Weight of Pile Material, γ_p = 68.50 kN/m^3
(Effective Unit Weight - [Pile - Soil])

Hence, Self weight of the Pile , W_p = 657.49 kN

3.5.4 Safe Vertical Compressive Capacity

Ultimate Capacity of the Pile, $Q_{ult} = Q_b + Q_s - W_p$ = 10099.95 kN
Factor of Safety for Vertical Capacity, FOS = 2.00

Hence, Safe Capacity of Pile, $Q_{safe} = (Q_b + Q_s / FOS) - W_p$ = 4721.23 kN

3.5.5 Safe Vertical Tensile Capacity

Ultimate Tension Capacity of the Pile, $Q_{ult(T)} = 0.7 \times Q_s + W_p$

Ultimate Skin Friction of the Pile, Q_s = 9334.75 kN
Self weight of the Pile , W_p = 657.49 kN

So, Ultimate Tension Capacity of the Pile, $Q_{ult(T)}$ = 7191.82 kN
Factor of Safety for Tension Capacity, FOS = 1.50

Safe Tension Capacity of Pile, $Q_{safe(T)} = Q_{ult(T)}$ / FOS = 5013.71 kN

Project No.	Steel Pile Capacity for Guwahati Gateway Terminal	Document No.		Date
		AIWTDS/GEO/PILE/01		12-Jun-19
P.013223		Designed	Checked	
		PM	LR	

Pile Cut-off Level = 57.00 m
River Bed Level = 37.26 m
Scour Level = 11.44 m

Safe Vertical Compressive Capacity														
Pile Founding Level	Penetration below RBL	Penetration below Scour Level	Pile Diameter											
			0.40	0.50	0.61	0.70	0.80	0.91	1.00	1.016	1.22	1.30	1.48	1.52
1.4	36	10	266	338	417	482	554	636	698	710	857	915	1041	1074
0.4	37	11	339	431	532	615	707	812	891	906	1093	1167	1328	1369
-0.6	38	12	419	532	657	760	873	1003	1101	1119	1351	1442	1641	1692
-1.6	39	13	505	642	793	916	1053	1210	1327	1349	1629	1739	1979	2040
-2.6	40	14	598	761	939	1086	1248	1433	1573	1599	1930	2060	2345	2418
-3.6	41	15	698	888	1097	1267	1457	1673	1837	1867	2254	2406	2738	2823
-4.6	42	16	806	1024	1265	1462	1681	1930	2118	2153	2600	2775	3157	3256
-5.6	43	17	920	1169	1444	1669	1918	2203	2418	2458	2967	3167	3604	3717
-6.6	44	18	1040	1323	1634	1888	2171	2493	2736	2781	3357	3583	4078	4205
-7.6	45	19	1168	1485	1834	2120	2437	2799	3072	3122	3769	4023	4578	4721
-8.6	46	20	1303	1657	2046	2365	2718	3122	3426	3483	4205	4488	5107	5266
-9.6	47	21	1445	1837	2269	2622	3015	3462	3800	3862	4663	4977	5664	5840
-10.6	48	22	1588	2019	2494	2882	3313	3805	4176	4245	5125	5470	6225	6419
-11.6	49	23	1729	2198	2714	3137	3606	4142	4545	4621	5578	5954	6775	6987
-12.6	50	24	1864	2370	2927	3382	3888	4466	4901	4982	6014	6419	7305	7533
-13.6	51	25	1994	2536	3132	3619	4161	4778	5244	5331	6436	6869	7817	8060
-14.6	52	26	2125	2702	3337	3856	4433	5091	5587	5680	6857	7318	8328	8588
-15.6	53	27	2255	2868	3542	4093	4705	5404	5930	6028	7278	7768	8840	9115
-16.6	54	28	2386	3034	3746	4330	4978	5716	6274	6377	7699	8217	9351	9643
-17.6	55	29	2516	3200	3951	4566	5250	6029	6617	6726	8120	8667	9863	10170
-18.6	56	30	2647	3366	4156	4803	5522	6342	6960	7075	8541	9116	10374	10698
-19.6	57	31	2777	3532	4361	5040	5794	6654	7303	7424	8962	9566	10886	11225
-20.6	58	32	2833	3603	4449	5142	5911	6789	7450	7573	9143	9759	11105	11452
-21.6	59	33	2831	3600	4445	5137	5906	6782	7444	7567	9135	9750	11096	11442
-22.6	60	34	2828	3596	4441	5133	5901	6776	7437	7560	9127	9741	11086	11431
-23.6	61	35	2826	3593	4437	5128	5896	6770	7430	7553	9119	9733	11076	11421
-24.6	62	36	2823	3590	4433	5124	5890	6764	7424	7546	9111	9724	11066	11411
-25.6	63	37	2821	3587	4429	5119	5885	6758	7417	7540	9103	9715	11056	11401
-26.6	64	38	2818	3584	4426	5114	5880	6752	7411	7533	9094	9707	11046	11391
-27.6	65	39	2816	3580	4422	5110	5875	6746	7404	7526	9086	9698	11036	11380
-28.6	66	40	2813	3577	4418	5105	5869	6740	7397	7520	9078	9689	11026	11370

Project No.	Steel Pile Capacity for Guwahati Gateway Terminal	Document No.		Date
		AIWTDS/GEO/PILE/01		12-Jun-19
P.013223		Designed	Checked	
		PM	LR	

Pile Cut-off Level = 57.00 m
River Bed Level = 37.26 m
Scour Level = 11.44 m

Safe Vertical Tensile Capacity														
Pile Founding Level	Penetration below RBL	Penetration below Scour Level	Pile Diameter											
			0.40	0.50	0.61	0.70	0.80	0.91	1.00	1.016	1.22	1.30	1.48	1.52
1.4	36	10	435	553	683	789	907	1042	1144	1162	1403	1498	1705	1758
0.4	37	11	499	635	784	906	1042	1197	1313	1335	1612	1720	1957	2018
-0.6	38	12	570	725	895	1034	1189	1366	1499	1524	1839	1963	2234	2304
-1.6	39	13	647	822	1016	1174	1349	1550	1701	1729	2087	2228	2535	2614
-2.6	40	14	730	928	1146	1324	1522	1748	1919	1950	2355	2513	2860	2949
-3.6	41	15	819	1041	1286	1486	1709	1962	2154	2189	2643	2821	3210	3310
-4.6	42	16	915	1163	1436	1660	1909	2192	2405	2445	2952	3151	3586	3697
-5.6	43	17	1017	1293	1597	1845	2122	2437	2674	2718	3282	3503	3986	4110
-6.6	44	18	1125	1431	1767	2042	2348	2697	2960	3008	3632	3877	4411	4549
-7.6	45	19	1240	1577	1948	2251	2588	2972	3262	3316	4003	4273	4862	5014
-8.6	46	20	1362	1732	2139	2472	2841	3263	3581	3640	4395	4691	5338	5505
-9.6	47	21	1490	1895	2340	2704	3109	3570	3918	3983	4808	5132	5840	6022
-10.6	48	22	1619	2059	2542	2938	3378	3879	4257	4328	5225	5576	6346	6544
-11.6	49	23	1746	2220	2741	3168	3642	4183	4590	4666	5633	6013	6842	7056
-12.6	50	24	1872	2381	2940	3398	3906	4486	4923	5005	6042	6449	7339	7568
-13.6	51	25	1999	2542	3139	3628	4171	4790	5257	5343	6451	6885	7835	8080
-14.6	52	26	2126	2703	3338	3858	4435	5093	5590	5682	6860	7322	8332	8592
-15.6	53	27	2252	2864	3537	4088	4699	5397	5923	6021	7269	7758	8829	9104
-16.6	54	28	2379	3025	3736	4317	4964	5700	6256	6359	7677	8194	9325	9616
-17.6	55	29	2506	3186	3935	4547	5228	6004	6589	6698	8086	8631	9822	10128
-18.6	56	30	2632	3347	4134	4777	5492	6307	6922	7036	8495	9067	10318	10640
-19.6	57	31	2759	3508	4333	5007	5757	6611	7255	7375	8904	9503	10815	11152
-20.6	58	32	2816	3581	4422	5111	5876	6748	7405	7528	9088	9700	11039	11383
-21.6	59	33	2819	3584	4426	5115	5881	6754	7412	7535	9096	9709	11048	11393
-22.6	60	34	2821	3588	4430	5120	5886	6760	7419	7541	9104	9717	11058	11403
-23.6	61	35	2824	3591	4434	5125	5892	6766	7425	7548	9113	9726	11068	11413
-24.6	62	36	2826	3594	4438	5129	5897	6772	7432	7555	9121	9735	11078	11424
-25.6	63	37	2829	3597	4442	5134	5902	6778	7439	7562	9129	9743	11088	11434
-26.6	64	38	2831	3600	4446	5138	5907	6784	7445	7568	9137	9752	11098	11444
-27.6	65	39	2834	3604	4450	5143	5913	6790	7452	7575	9145	9761	11108	11454
-28.6	66	40	2836	3607	4454	5147	5918	6796	7458	7582	9153	9770	11118	11464

API RECOMMENDED PRACTICE 2GEO/ISO 19901-4 30

Table 1—Design parameters for cohesionless siliceous soil

Relative Density[a]	Soil Description	Shaft Friction Factor[b] β (-)	Limiting Shaft Friction Values kPa (kips/ft²)	End Bearing Factor N_q (-)	Limiting Unit End Bearing Values MPa (kips/ft²)
Very loose Loose Loose Medium dense Dense	Sand Sand Sand-silt[c] Silt Silt	Not applicable[d]	Not applicable[d]	Not applicable[d]	Not applicable[d]
Medium dense	Sand-silt[c]	0.29	67 (1.4)	12	3 (60)
Medium dense Dense	Sand Sand-silt[c]	0.37	81 (1.7)	20	5 (100)
Dense Very dense	Sand Sand-silt[c]	0.46	96 (2.0)	40	10 (200)
Very dense	Sand	0.56	115 (2.4)	50	12 (250)

NOTE The parameters listed in this table are intended as guidelines only. Where detailed information, such as CPT records, strength tests on high quality samples, model tests, or pile driving performance, is available, other values may be justified.

[a] The definitions for the relative density percentage description are as follows:
- Very loose, 0 – 15;
- Loose, 15 – 35;
- Medium dense, 35 – 65;
- Dense, 65 – 85;
- Very dense, 85 – 100.

[b] The shaft friction factor β (equivalent to the "K tan δ" term used in previous editions of API 2A-WSD) is introduced in this document to avoid confusion with the δ parameter used in the Annex.

[c] Sand-silt includes those soils with significant fractions of both sand and silt. Strength values generally increase with increasing sand fractions and decrease with increasing silt fractions.

[d] Design parameters given in previous editions of API 2A-WSD for these soil/relative density combinations may be unconservative. Hence, it is recommended to use CPT-based methods from the annex for these soils.

96 API RECOMMENDED PRACTICE 2A-WSD

Table 9.1—Pile Factors of Safety for Different Loading Conditions

Condition Number	Load Condition	Factors of Safety
1	Design environmental conditions with appropriate drilling loads	1.5
2	Operating environmental conditions during drilling operations	2.0
3	Design environmental conditions with appropriate producing loads	1.5
4	Operating environmental conditions during producing operations	2.0
5	Design environmental conditions with minimum loads (for pullout)	1.5

Limiting Values as per API

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
Type	Soil Description	Limiting Values of Interaction parameters		Limiting value of capacity	
		β	Nq	Skin Friction (kPa)	End bearing (MPa)
1	Medium Dense Sand	0.37	20.00	81.00	5000.00
2	Dense Sand	0.46	40.00	96.00	10000.00
3	Very Dense Sand	0.56	50.00	115.00	12000.00
4	Medium Dense Sand-Silt	0.29	12.00	67.00	3000.00
5	Dense Sand-Silt	0.37	20.00	91.00	5000.00
6	Very Dense Sand-Silt	0.46	40.00	96.00	10000.00
7	Medium Dense Silt	0.00	0.00	0.00	0.00
8	Dense Silt	0.00	0.00	0.00	0.00
9	Sand	0.00	0.00	0.00	0.00
10	Sand	0.00	0.00	0.00	0.00

ANNEXURE 9.2 – ANALYSIS AND DESIGN CALCULATIONS

BERTHING PONTOONS

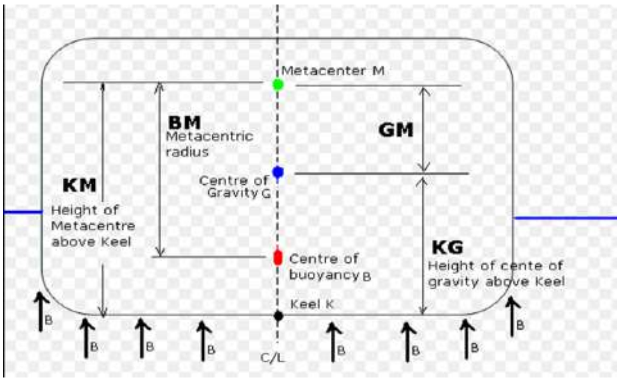
Stability of Berthing Pontoon

The floating stability of the pontoon has been checked for 15m (width) and 60 m (length) of the pontoon.

The loads including self weight , loads from link span and life loads of 5 kN/m^2 have been considered in two load cases, with life loads on half the cross section (load case 1) and life loads fully loaded (load case 2).

The metracentric height (> 0) , the max angle of heel (10 deg) and minimum freeboard (>0.3 m) of the pontoon have been checked to be within the permissible limits.

The Metacentric height is a measure of the vessels's stability under small heeling also called the initial stability. The higher the value of GM , the better the vessel's initial stability. Thus harder it is to get the vessel to heel.



KG= ak
BK= av
GB=hk
GM=Metacentric height

Input Parameters

Length of Pontoon	L (m)	60	m
Width of the Pontoon	B (m)	15	m
Height of the Pontoon	(m)	2	m
Live loads		5	kN/m^2
Considering S 235 steel plate thickness	m	0.015	m thk

Load case 1 : Live load on one half

	Weight (kN)	Distance to bottom (m)	Moment at Bottom (kNm)	Eccentricity	Heeling Moment (kNm)
Pontoon self -weight	6408.585	1	6408.585		
PontoonLife Loads					
Pontoon Life Loads (at half)	2250	2	4500	3.75	8437.5
Link span loads	1148.25			4	4593
Total	**9806.835**				**13030.5**

Floating Stability

Inertia moment	Io = L x B ^3/12	m^4	16875	
Weight	Fg	kN	9806.8	
Displaced Volume	Vv= Fg/dw	m^3	980.7	
Draught	w=Vv/(LxB)	m	1.1	
Height of the center of Gravity	ak	m	1	
Height of Buoyancy Center	av =w/2	m	0.54	
Height hk	hk= ak-av	m	0.46	
Metacentric height	hm=(I0/Vv)-hk	m	**16.75**	
			>0	ok

Floating Stability is fulfilled

Heeling

Heeling Moment	M	kNm	13030.5	
tan x	M/(hm*Fg)		0.079	
Angle of Heel	x in deg	deg	**4.53**	
			<10 deg	ok

Max angle of Heel of 10 deg is fulfilled

Free Board

F	F=H-w	m	**0.91**	
			> 0.3	ok

Minimum Freebord of 0.3m is fulfilled

Load case 2 : Live load fully loaded

	Weight (kN)	Distance to bottom (m)	Moment at Bottom (kNm)	Eccentricity	Heeling Moment (kNm)
Pontoon self -weight	6408.585	1	6408.585	0	
PontoonLife Loads	4500	2	9000	0	
Pontoon Life Loads (at half)					
Link span loads	1148.25			4	4593
Total	**12056.835**				**4593**

Floating Stability

Inertia moment	Io = L x B ^3/12	m^4	16875	
Weight	Fg	kN	12056.835	
Displaced Volume	Vv= Fg/dw	m^3	1205.68	
Draught	w=Vv/(LxB)	m	1.34	
Height of the center of Gravity	ak	m	1	
Height of Buoyancy Center	av =w/2	m	0.67	
Height hk	hk= ak-av	m	0.33	
Metacentric height	hm=(I0/Vv)-hk	m	**13.67**	
			>0	ok

Floating Stability is fulfilled

Heeling

Heeling Moment	M	kNm	4593	
tan x	M/(hm*Fg)		0.028	
Angle of Heel	x in deg	deg	**1.60**	ok

Max angle of Heel of 10 deg is fulfilled

Free Board

F			F=H-w	m	**0.660**	
					> 0.3	ok

Minimum Freebord of 0.3m is fulfilled

DOLPHINS FOR BERTHING PONTOONS

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat		
SUBJECT:	Wind load calculation - Dolphins for Berthing Pontoons		
PROJECT NO:	P.013223	FILE REF:	CALCULATIONS
PREPARED BY:	MM	DATE:	6/13/2019
CHECKED BY:	AGB	DATE:	6/13/2019

REVISION: 0

REFERENCES			*OUTPUT*	
	CALCULATION OF WIND LOAD - OPERATING CASE			
Table 6.1, DBR	Basic Wind Speed	V_b	30.00	m/s
	Class of structure		Class A	
	Design Life		50	years
	Terrain category		Category 1	
Table 1,IS:875 III	Probability Factor	k_1	1.00	
Table 2,IS:875 III	Terrain-Height-Size Factor	k_2	1.05	
Cl 5.3.3,IS:875 III	Topography Factor	k_3	1.00	
Cl 5.3, IS:875 III	Design Wind Speed	$V_z = k_1 k_2 k_3 V_b$	31.50	m/s
Cl 5.4, IS:875 III	Design wind Pressure	$p = 0.6V_z^2$	595.35	
			0.60	kN/m^2
	CALCULATION OF WIND LOAD - EXTREME CASE			
Table 6.1, DBR	Basic Wind Speed	V_b	55.00	m/s
	Class of structure		Class A	
	Design Life		50	years
	Terrain category		Category 1	
Table 1,IS:875 III	Probability Factor	k_1	1.00	
Table 2,IS:875 III	Terrain-Height-Size Factor	k_2	1.05	
Cl 5.3.3,IS:875 III	Topography Factor	k_3	1.00	
Cl 5.3, IS:875 III	Design Wind Speed	$V_z = k_1 k_2 k_3 V_b$	57.75	m/s
Cl 5.4, IS:875 III	Design wind Pressure	$p = 0.6V_z^2$	2001.04	
			2.00	kN/m^2

Structural Element	Depth/Dia of member (m)	Load per meter - Operating (kN/m)	Load per meter - Extreme (kN/m)
Piles	1.52	0.905	3.042
Deck Slab	2	1.191	4.002

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat				
SUBJECT:	Current load calculation - Dolphins for Berthing Pontoons				
PROJECT NO:	P.013223	FILE REF:		CALCULATIONS	
PREPARED BY:	MM	DATE:	6/13/2019		
CHECKED BY:	AGB	DATE:	6/13/2019	REVISION:	0

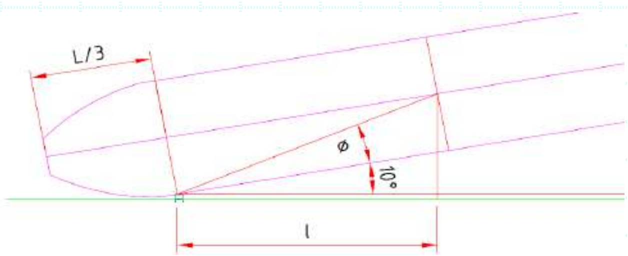
TRACTEBEL ENGIE

REFERENCES			OUTPUT	
	CALCULATION OF CURRENT LOAD - ON PILES			
	Pile Dia		1.52	m
	Velocity of current	V	3.00	m/s
	Design velocity	V_d	$\sqrt{2}$ V	
	Design velocity	V_d	4.24	m/s^2
IRC 6: 2014	Factor for shape of pier	K	0.66	m
Cl 210.2	Pressure due to current	P	$52 K V_d^2$	m
	Pressure due to current	P	617.76	kg/m^2
	Current Force on Pile		939.00	kg/m
	Current Force on Pile		9.21	kN/m

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat				TRACTEBEL ENGIE
SUBJECT:	Berthing Load Calculation - Dolphins for Berthing Pontoons				
PROJECT NO:	P.013223	FILE REF:		CALCULATIONS	
PREPARED BY:	MM	DATE:			
CHECKED BY:	AGB	DATE:		REVISION:	0

REFERENCES			*OUTPUT*	
	CALCULATION OF BERTHING LOAD - IS METHOD			
	Vessel Type		IW Ferry	
	Site Condition		Sheltered	
	Berthing condition		Difficult	
	Dead Weight Tonnage	DWT		t
	Displacement Tonnage	M	95	t
	Length Overall	L_{OA}	30	m
	Length between perpendiculars	L_{BP}	30	m
	Beam	B	12	m
	Draft	D	0.7	m
	Underkeel Clearance		1	m
	Approach Velocity	v	0.5	m/s
	Berthing Angle	ϴ	10	^{o}
	Impact Distance		0.33	
	Water Density	ρ	1	t/m^3
IS 4651,Part III	Berthing Energy to be absorbed by fender	$\frac{1}{2} \times M \times v^2 \times C_e \times C_m \times C_s$		
	where,			

$$C_e = \frac{1 + (l/r)^2 \sin^2\theta}{1 + (l/r)^2} \qquad C_m = 1 + \frac{\pi/4\ D^2\ Lw}{W_D}$$



Cl 5.2.1.2	Virtual Mass Coefficient	C_m	1.12	
	Impact distance from bow	x	9.90	m
	Radius of Gyration of rotational radius	r	7.87	m
		ϕ	49.64	^{o}
		ϴ + ϕ	59.64	^{o}
	Dist from CG of vessel to contact point along waterline	l	3.98	m
Cl 5.2.1.3	Eccentricity Coefficient	C_e	0.80	
Cl 5.2.1.4	Softness Coefficient	C_s	1	
	Normal Berthing Energy	E_{Normal}	1.08	T m
IS 4651,Part IV	Abnormal Impact Factor		2	
	Abnormal Berthing Energy	$E_{ABNORMAL}$	2.17	T m
	Abnormal Berthing Energy	$E_{ABNORMAL}$	21.29	kN m

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat			TRACTEBEL ENGIE
SUBJECT:	Berthing Load Calculation - Dolphins for Berthing Pontoons			
PROJECT NO:	P.013223	FILE REF:		**CALCULATIONS**
PREPARED BY:	MM	DATE:		
CHECKED BY:	AGB	DATE:		REVISION: 0

REFERENCES			*OUTPUT*	
	Fender Manufacturer		Trelleborg	
	Manufacturing Tolrence		10%	
	Temperture Factor		0.978	
	Angle Factor		1.000	
	Velocity Factor		1	
	Rated Berthing Energy	E_R	24.2	kN m
Fender Manual	Designation of selected Fender		AN400 E1.0	
	Rated Energy Absorption of the chosen fender		35.7	kN m
	Rated Reaction corresponding to the chosen fender	R	230.5	kN
			Fender OK	
	Rated Reaction with all factors (To be used for Analysis)	R	262	kN

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat		
SUBJECT:	Current and Wind on Berthing Pontoon		
PROJECT NO:	P.013223	FILE REF:	
PREPARED BY:	MM	DATE:	6/13/2019
CHECKED BY:	AGB	DATE:	6/13/2019
REVISION:	0		

1. Force Due to Wind

[IS 4651 Part, 2 5.3.2]

$F_{wind} = C_w*A_w*P$

P = wind pressure in kg/m^2 to be taken in accordance with IS 875

A_w = windage area in m^2

C_w = shape factor = 1.3 to 1.6

Windage Area

[IS 4651 Part 2, 5.3.2.1]

$A_w = 1.175*B*(D_M-D_L)$

B = Beam in m

D_M = Moulded Depth in m

D_L = Draft in m

Shape Factor

C_w = **1.6**

Wind Pressure

$p_z = 0.6*V^2_z$

[IS 875 Part, 5.4]

	Wind Speed (m/s)	Wind Pressure (kg/m^2)
Operational	**30**	540

2. Force Due to Current

$F_{curr} = P_{curr}*A_{curr}$

P_{curr} = pressure due to Current

A_{curr} = area exposed to current

Current Area

Acurr = Bp*DL

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat			TRACTEBEL ENGIE
SUBJECT:	Current and Wind on Berthing Pontoon			
PROJECT NO:	P.013223	FILE REF:		
PREPARED BY:	MM	DATE:	6/13/2019	
CHECKED BY:	AGB	DATE:	6/13/2019	REVISION: 0

Current Pressure

[IS 4651 Part 3 Clause 5.6]

$P_{curr} = w^2 * v^2/(2*g)$

w = unit weight of water **1.03** t/m^3

g = gravity **9.81** m/s^2

	Current (m/s)	Pcurr (t/m2)	Pcurr (kN/m2)
Operational	**3**	0.487	4.77

3. Ship Data

Beam	**15**	m
Bp	**15**	(assuming 100% of beam)
Moulded Depth	**2**	m
L_{OA}	**60**	m
L_{BP}	**60**	m
Light Draft (D_{light})	**1**	m
Loaded draft (D_{load})	**1**	m
Depth exposed to wind - light condition	1	m
Depth exposed to wind - loaded condition	1	m

4. Force on Jetty

Case 1 - Light Condition

DM - DL	$D_{(light)}$	B_p	Wind Area (m^2)	Current Area (m^2)
1.0	1	15.0	17.6	15.0

Operational Case (kN)		
F_{wind}	F_{curr}	Combine
15	72	87

Case 2 - Loaded Condition

DM - DL	$D_{(load)}$	B_p	Wind Area (m^2)	Current Area (m^2)
1.0	1	15.0	17.6	15.0

Operational Case (kN)		
F_{wind}	F_{curr}	Combine
15	72	87

PROJECT TITLE: Development of Ferry Services in Assam - Guwahati Gateway Ghat

SUBJECT: Load Combinations - Dolphins for Berthing Pontoons

PROJECT NO: FILE REF:

PREPARED BY: MM DATE: 6/13/2019

CHECKED BY: AGB DATE: 6/13/2019 **REVISION:** 0

TRACTEBEL engie

	EQX	EQZ	DL	LL	CL+X	CL+Z	CL-Z	BL	WI+X	WI+Z	ExWI+X	ExWI+Z
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
101			1.0	1.0								
102	1.0		1.0	1.0								
103		1.0	1.0	1.0								
201			1.0	1.0	1.0							
202			1.0	1.0	0.99	0.18						
203			1.0	1.0	0.93	0.39						
204			1.0	1.0	0.87	0.50						
205			1.0	1.0	0.71	0.71						
206			1.0	1.0	0.99		0.18					
207			1.0	1.0	0.93		0.39					
208			1.0	1.0	0.87		0.50					
209			1.0	1.0	0.71		0.71					
301			1.0	1.0	1.0			1.0				
302			1.0	1.0	0.99	0.18		1.0				
303			1.0	1.0	0.93	0.39		1.0				
304			1.0	1.0	0.87	0.50		1.0				
305			1.0	1.0	0.71	0.71		1.0				
306			1.0	1.0	0.99		0.18	1.0				
307			1.0	1.0	0.93		0.39	1.0				

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat		
SUBJECT:	Load Combinations - Dolphins for Berthing Pontoons		
PROJECT NO:		FILE REF:	
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		REVISION:	0

		EQX	EQZ	DL	LL	CL+X	CL+Z	CL-Z	BL	WI+X	WI+Z	ExWI+X	ExWI+Z													
		1	2	3	4	5	6	7	8	9	10	11	12													
308				1.0	1.0	0.87		0.50	1.0																	
309				1.0	1.0	0.71		0.71	1.0																	
401				1.0	1.0	1.0				1.0																
402				1.0	1.0	0.99	0.18			1.0																
403				1.0	1.0	0.93	0.39			1.0																
404				1.0	1.0	0.87	0.50			1.0																
405				1.0	1.0	0.71	0.71			1.0																
406				1.0	1.0	0.99		0.18		1.0																
407				1.0	1.0	0.93		0.39		1.0																
408				1.0	1.0	0.87		0.50		1.0																
409				1.0	1.0	0.71		0.71		1.0																
501				1.0	1.0	1.0					1.0															
502				1.0	1.0	0.99	0.18				1.0															
503				1.0	1.0	0.93	0.39				1.0															
504				1.0	1.0	0.87	0.50				1.0															
505				1.0	1.0	0.71	0.71				1.0															
506				1.0	1.0	0.99		0.18			1.0															
507				1.0	1.0	0.93		0.39			1.0															

PROJECT TITLE: Development of Ferry Services in Assam - Guwahati Gateway Ghat
SUBJECT: Load Combinations - Dolphins for Berthing Pontoons
PROJECT NO: FILE REF:
PREPARED BY: MM DATE: 6/13/2019
CHECKED BY: AGB DATE: 6/13/2019 **REVISION:** 0

		EQX	EQZ	DL	LL	CL+X	CL+Z	CL-Z	BL	WI+X	WI+Z	ExWI+X	ExWI+Z													
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**													
508				1.0	1.0	0.87		0.50			1.0															
509				1.0	1.0	0.71		0.71			1.0															
1001				1.5	1.5	1.2			1.5	1.0																
1002				1.5	1.5	1.19	0.22		1.5	1.0																
1003				1.5	1.5	1.12	0.47		1.5	1.0																
1004				1.5	1.5	1.04	0.60		1.5	1.0																
1005				1.5	1.5	0.85	0.85		1.5	1.0																
1006				1.5	1.5	1.19		0.22	1.5	1.0																
1007				1.5	1.5	1.12		0.47	1.5	1.0																
1008				1.5	1.5	1.04		0.60	1.5	1.0																
1009				1.5	1.5	0.85		0.85	1.5	1.0																
2001				1.5	1.5	1.2			1.5		1.0															
2002				1.5	1.5	1.19	0.22		1.5		1.0															
2003				1.5	1.5	1.12	0.47		1.5		1.0															
2004				1.5	1.5	1.04	0.60		1.5		1.0															
2005				1.5	1.5	0.85	0.85		1.5		1.0															
2006				1.5	1.5	1.19		0.22	1.5		1.0															
2007				1.5	1.5	1.12		0.47	1.5		1.0															
2008				1.5	1.5	1.04		0.60	1.5		1.0															

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat		
SUBJECT:	Load Combinations - Dolphins for Berthing Pontoons		
PROJECT NO:		FILE REF:	
PREPARED BY:	MM	DATE:	6/13/2019
CHECKED BY:	AGB	DATE:	6/13/2019
		REVISION:	0

TRACTEBEL engie

	EQX	EQZ	DL	LL	CL+X	CL+Z	CL-Z	BL	WI+X	WI+Z	ExWI+X	ExWI+Z
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2009			1.5	1.5	0.85		0.85	1.5		1.0		
3001	1.5		1.5	1.5								
3002		1.5	1.5	1.5								
4001			1.2	1.2	1.0						1.2	
4002			1.2	1.2	0.99	0.18					1.2	
4003			1.2	1.2	0.93	0.39					1.2	
4004			1.2	1.2	0.87	0.50					1.2	
4005			1.2	1.2	0.71	0.71					1.2	
4006			1.2	1.2	0.99		0.18				1.2	
4007			1.2	1.2	0.93		0.39				1.2	
4008			1.2	1.2	0.87		0.50				1.2	
4009			1.2	1.2	0.71		0.71				1.2	
5001			1.2	1.2	1.0							1.2
5002			1.2	1.2	0.99	0.18						1.2
5003			1.2	1.2	0.93	0.39						1.2
5004			1.2	1.2	0.87	0.50						1.2
5005			1.2	1.2	0.71	0.71						1.2
5006			1.2	1.2	0.99		0.18					1.2
5007			1.2	1.2	0.93		0.39					1.2
5008			1.2	1.2	0.87		0.50					1.2
5009			1.2	1.2	0.71		0.71					1.2

STAAD-PRO INPUTS – DOLPHINS FOR BERTHING PONTOONS

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 08-Jan-19

JOB NAME Development of Ferry Services at Assam - Guwahati Gateway Ghat

JOB CLIENT Assam Inland Water Transport Development Society

JOB NO P.013223

JOB REV R0

ENGINEER NAME MM

CHECKER NAME AB

APPROVED NAME LR

CHECKER DATE 10-June-19

APPROVED DATE 10-June-19

END JOB INFORMATION

INPUT WIDTH 79

****

*PILE LENGTH

*PILE CUTOFF = 57.00m

*SCOUR LEVEL = 11.44m

*FIXITY LEVEL = 7D = 7 x 1.5 = approx 10m FROM SCOUR LEVEL

*FIXITY LEVEL = 1.5m

UNIT METER KN

JOINT COORDINATES

1 0 57 0; 2 1.5 57 0; 3 6 57 0; 6 0 57 1.5; 7 1.5 57 1.5; 8 6 57 1.5;

29 0.5 57 0; 30 0.5 57 0.5; 31 0 57 0.5; 32 1 57 0; 33 1 57 0.5; 34 1.5 57 0.5;

35 2 57 0; 36 2 57 0.5; 37 2.5 57 0; 38 2.5 57 0.5; 39 3 57 0; 40 3 57 0.5;

41 3.5 57 0; 42 3.5 57 0.5; 43 4 57 0; 44 4 57 0.5; 45 4.5 57 0; 46 4.5 57 0.5;

47 5 57 0; 48 5 57 0.5; 49 5.5 57 0; 50 5.5 57 0.5; 51 6 57 0.5; 52 6.5 57 0;

53 6.5 57 0.5; 54 7 57 0; 55 7 57 0.5; 56 7.5 57 0; 57 7.5 57 0.5; 74 0.5 57 1;

75 0 57 1; 76 1 57 1; 77 1.5 57 1; 78 2 57 1; 79 2.5 57 1; 80 3 57 1;

81 3.5 57 1; 82 4 57 1; 83 4.5 57 1; 84 5 57 1; 85 5.5 57 1; 86 6 57 1;

87 6.5 57 1; 88 7 57 1; 89 7.5 57 1; 99 0.5 57 1.5; 100 1 57 1.5; 101 2 57 1.5;

102 2.5 57 1.5; 103 3 57 1.5; 104 3.5 57 1.5; 105 4 57 1.5; 106 4.5 57 1.5;

107 5 57 1.5; 108 5.5 57 1.5; 109 6.5 57 1.5; 110 7 57 1.5; 111 7.5 57 1.5;

119 0.5 57 2; 120 0 57 2; 121 1 57 2; 122 1.5 57 2; 123 2 57 2; 124 2.5 57 2;

125 3 57 2; 126 3.5 57 2; 127 4 57 2; 128 4.5 57 2; 129 5 57 2; 130 5.5 57 2;

131 6 57 2; 132 6.5 57 2; 133 7 57 2; 134 7.5 57 2; 144 0.5 57 2.5;

145 0 57 2.5; 146 1 57 2.5; 147 1.5 57 2.5; 148 2 57 2.5; 149 2.5 57 2.5;

150 3 57 2.5; 151 3.5 57 2.5; 152 4 57 2.5; 153 4.5 57 2.5; 154 5 57 2.5;

155 5.5 57 2.5; 156 6 57 2.5; 157 6.5 57 2.5; 158 7 57 2.5; 159 7.5 57 2.5;

169 0.5 57 3; 170 0 57 3; 171 1 57 3; 172 1.5 57 3; 173 2 57 3; 174 2.5 57 3;

175 3 57 3; 176 3.5 57 3; 177 4 57 3; 178 4.5 57 3; 179 5 57 3; 180 5.5 57 3;

181 6 57 3; 182 6.5 57 3; 183 7 57 3; 184 7.5 57 3; 423 1.5 57 -3; 424 6 57 -3;

429 -17 1.5 1.49996; 431 5.99997 1.5 1.49996; 432 0 57 -4.5; 433 1.5 57 -4.5;

434 6 57 -4.5; 437 0 57 -3; 439 0.5 57 -4.5; 440 0.5 57 -4; 441 0 57 -4;

442 1 57 -4.5; 443 1 57 -4; 444 1.5 57 -4; 445 2 57 -4.5; 446 2 57 -4;

447 2.5 57 -4.5; 448 2.5 57 -4; 449 3 57 -4.5; 450 3 57 -4; 451 3.5 57 -4.5;

452 3.5 57 -4; 453 4 57 -4.5; 454 4 57 -4; 455 4.5 57 -4.5; 456 4.5 57 -4;

457 5 57 -4.5; 458 5 57 -4; 459 5.5 57 -4.5; 460 5.5 57 -4; 461 6 57 -4;

462 6.5 57 -4.5; 463 6.5 57 -4; 464 7 57 -4.5; 465 7 57 -4; 466 7.5 57 -4.5;

467 7.5 57 -4; 484 0.5 57 -3.5; 485 0 57 -3.5; 486 1 57 -3.5; 487 1.5 57 -3.5;

488 2 57 -3.5; 489 2.5 57 -3.5; 490 3 57 -3.5; 491 3.5 57 -3.5; 492 4 57 -3.5;

493 4.5 57 -3.5; 494 5 57 -3.5; 495 5.5 57 -3.5; 496 6 57 -3.5;

497 6.5 57 -3.5; 498 7 57 -3.5; 499 7.5 57 -3.5; 509 0.5 57 -3; 510 1 57 -3;

511 2 57 -3; 512 2.5 57 -3; 513 3 57 -3; 514 3.5 57 -3; 515 4 57 -3;

516 4.5 57 -3; 517 5 57 -3; 518 5.5 57 -3; 519 6.5 57 -3; 520 7 57 -3;

521 7.5 57 -3; 529 0.5 57 -2.5; 530 0 57 -2.5; 531 1 57 -2.5; 532 1.5 57 -2.5;

533 2 57 -2.5; 534 2.5 57 -2.5; 535 3 57 -2.5; 536 3.5 57 -2.5; 537 4 57 -2.5;

538 4.5 57 -2.5; 539 5 57 -2.5; 540 5.5 57 -2.5; 541 6 57 -2.5;

542 6.5 57 -2.5; 543 7 57 -2.5; 544 7.5 57 -2.5; 554 0.5 57 -2; 555 0 57 -2;

556 1 57 -2; 557 1.5 57 -2; 558 2 57 -2; 559 2.5 57 -2; 560 3 57 -2;

561 3.5 57 -2; 562 4 57 -2; 563 4.5 57 -2; 564 5 57 -2; 565 5.5 57 -2;

566 6 57 -2; 567 6.5 57 -2; 568 7 57 -2; 569 7.5 57 -2; 579 0.5 57 -1.5;

580 0 57 -1.5; 581 1 57 -1.5; 582 1.5 57 -1.5; 583 2 57 -1.5; 584 2.5 57 -1.5;

585 3 57 -1.5; 586 3.5 57 -1.5; 587 4 57 -1.5; 588 4.5 57 -1.5; 589 5 57 -1.5;

590 5.5 57 -1.5; 591 6 57 -1.5; 592 6.5 57 -1.5; 593 7 57 -1.5;

594 7.5 57 -1.5; 604 0.5 57 -1; 605 0 57 -1; 606 1 57 -1; 607 1.5 57 -1;

608 2 57 -1; 609 2.5 57 -1; 610 3 57 -1; 611 3.5 57 -1; 612 4 57 -1;

613 4.5 57 -1; 614 5 57 -1; 615 5.5 57 -1; 616 6 57 -1; 617 6.5 57 -1;

618 7 57 -1; 619 7.5 57 -1; 629 0.5 57 -0.5; 630 0 57 -0.5; 631 1 57 -0.5;

632 1.5 57 -0.5; 633 2 57 -0.5; 634 2.5 57 -0.5; 635 3 57 -0.5;

636 3.5 57 -0.5; 637 4 57 -0.5; 638 4.5 57 -0.5; 639 5 57 -0.5;

640 5.5 57 -0.5; 641 6 57 -0.5; 642 6.5 57 -0.5; 643 7 57 -0.5;

644 7.5 57 -0.5; 657 -11.5801 1.5 -16.08; 659 -12.2201 1.5 0.210037;

MEMBER INCIDENCES

460 7 429; 462 8 431; 682 423 657; 684 424 659;

ELEMENT INCIDENCES SHELL

100 1 29 30 31; 101 29 32 33 30; 102 32 2 34 33; 103 2 35 36 34;

104 35 37 38 36; 105 37 39 40 38; 106 39 41 42 40; 107 41 43 44 42;

108 43 45 46 44; 109 45 47 48 46; 110 47 49 50 48; 111 49 3 51 50;

112 3 52 53 51; 113 52 54 55 53; 114 54 56 57 55; 124 31 30 74 75;

125 30 33 76 74; 126 33 34 77 76; 127 34 36 78 77; 128 36 38 79 78;

129 38 40 80 79; 130 40 42 81 80; 131 42 44 82 81; 132 44 46 83 82;

133 46 48 84 83; 134 48 50 85 84; 135 50 51 86 85; 136 51 53 87 86;

137 53 55 88 87; 138 55 57 89 88; 148 75 74 99 6; 149 74 76 100 99;

150 76 77 7 100; 151 77 78 101 7; 152 78 79 102 101; 153 79 80 103 102;

154 80 81 104 103; 155 81 82 105 104; 156 82 83 106 105; 157 83 84 107 106;

158 84 85 108 107; 159 85 86 8 108; 160 86 87 109 8; 161 87 88 110 109;

162 88 89 111 110; 172 6 99 119 120; 173 99 100 121 119; 174 100 7 122 121;

175 7 101 123 122; 176 101 102 124 123; 177 102 103 125 124;

178 103 104 126 125; 179 104 105 127 126; 180 105 106 128 127;

181 106 107 129 128; 182 107 108 130 129; 183 108 8 131 130; 184 8 109 132 131;

185 109 110 133 132; 186 110 111 134 133; 196 120 119 144 145;

197 119 121 146 144; 198 121 122 147 146; 199 122 123 148 147;

200 123 124 149 148; 201 124 125 150 149; 202 125 126 151 150;

203 126 127 152 151; 204 127 128 153 152; 205 128 129 154 153;

206 129 130 155 154; 207 130 131 156 155; 208 131 132 157 156;

209 132 133 158 157; 210 133 134 159 158; 220 145 144 169 170;

221 144 146 171 169; 222 146 147 172 171; 223 147 148 173 172;

224 148 149 174 173; 225 149 150 175 174; 226 150 151 176 175;

227 151 152 177 176; 228 152 153 178 177; 229 153 154 179 178;

230 154 155 180 179; 231 155 156 181 180; 232 156 157 182 181;

233 157 158 183 182; 234 158 159 184 183; 466 432 439 440 441;

467 439 442 443 440; 468 442 433 444 443; 469 433 445 446 444;

470 445 447 448 446; 471 447 449 450 448; 472 449 451 452 450;

473 451 453 454 452; 474 453 455 456 454; 475 455 457 458 456;

476 457 459 460 458; 477 459 434 461 460; 478 434 462 463 461;

479 462 464 465 463; 480 464 466 467 465; 490 441 440 484 485;

491 440 443 486 484; 492 443 444 487 486; 493 444 446 488 487;

494 446 448 489 488; 495 448 450 490 489; 496 450 452 491 490;

497 452 454 492 491; 498 454 456 493 492; 499 456 458 494 493;

500 458 460 495 494; 501 460 461 496 495; 502 461 463 497 496;

503 463 465 498 497; 504 465 467 499 498; 514 485 484 509 437;

515 484 486 510 509; 516 486 487 423 510; 517 487 488 511 423;

518 488 489 512 511; 519 489 490 513 512; 520 490 491 514 513;

521 491 492 515 514; 522 492 493 516 515; 523 493 494 517 516;

524 494 495 518 517; 525 495 496 424 518; 526 496 497 519 424;

527 497 498 520 519; 528 498 499 521 520; 538 437 509 529 530;

539 509 510 531 529; 540 510 423 532 531; 541 423 511 533 532;

542 511 512 534 533; 543 512 513 535 534; 544 513 514 536 535;

545 514 515 537 536; 546 515 516 538 537; 547 516 517 539 538;

548 517 518 540 539; 549 518 424 541 540; 550 424 519 542 541;

551 519 520 543 542; 552 520 521 544 543; 562 530 529 554 555;

563 529 531 556 554; 564 531 532 557 556; 565 532 533 558 557;

566 533 534 559 558; 567 534 535 560 559; 568 535 536 561 560;

569 536 537 562 561; 570 537 538 563 562; 571 538 539 564 563;

572 539 540 565 564; 573 540 541 566 565; 574 541 542 567 566;

575 542 543 568 567; 576 543 544 569 568; 586 555 554 579 580;

587 554 556 581 579; 588 556 557 582 581; 589 557 558 583 582;

590 558 559 584 583; 591 559 560 585 584; 592 560 561 586 585;

593 561 562 587 586; 594 562 563 588 587; 595 563 564 589 588;

596 564 565 590 589; 597 565 566 591 590; 598 566 567 592 591;

599 567 568 593 592; 600 568 569 594 593; 610 580 579 604 605;

611 579 581 606 604; 612 581 582 607 606; 613 582 583 608 607;

614 583 584 609 608; 615 584 585 610 609; 616 585 586 611 610;

617 586 587 612 611; 618 587 588 613 612; 619 588 589 614 613;

620 589 590 615 614; 621 590 591 616 615; 622 591 592 617 616;

623 592 593 618 617; 624 593 594 619 618; 634 605 604 629 630;

635 604 606 631 629; 636 606 607 632 631; 637 607 608 633 632;

638 608 609 634 633; 639 609 610 635 634; 640 610 611 636 635;

641 611 612 637 636; 642 612 613 638 637; 643 613 614 639 638;

644 614 615 640 639; 645 615 616 641 640; 646 616 617 642 641;

647 617 618 643 642; 648 618 619 644 643; 658 630 629 29 1; 659 629 631 32 29;

660 631 632 2 32; 661 632 633 35 2; 662 633 634 37 35; 663 634 635 39 37;

664 635 636 41 39; 665 636 637 43 41; 666 637 638 45 43; 667 638 639 47 45;

668 639 640 49 47; 669 640 641 3 49; 670 641 642 52 3; 671 642 643 54 52;

672 643 644 56 54;

START GROUP DEFINITION

ELEMENT

_PLATEDESIGN 100 TO 114 124 TO 138 148 149 152 TO 158 161 162 172 173 176 -

177 TO 182 185 186 196 TO 210 220 TO 234 466 TO 480 490 TO 504 514 515 518 -

519 TO 524 527 528 538 539 542 TO 548 551 552 562 TO 576 586 TO 600 -

610 TO 624 634 TO 648 658 TO 672

END GROUP DEFINITION

ELEMENT PROPERTY

100 TO 114 124 TO 138 148 TO 162 172 TO 186 196 TO 210 220 TO 234 466 TO 480 -

490 TO 504 514 TO 528 538 TO 552 562 TO 576 586 TO 600 610 TO 624 -

634 TO 648 658 TO 672 THICKNESS 2

MEMBER PROPERTY INDIAN

460 462 682 684 PRIS ROUND STA 1.52 END 1.52 THI 0.025

****

DEFINE MATERIAL START

ISOTROPIC CONCRETE

E 2.17185e+007

POISSON 0.17

DENSITY 23.5616

ALPHA 1e-005

DAMP 0.05

TYPE CONCRETE

STRENGTH FCU 27579

ISOTROPIC STEEL

E 2.05e+008

POISSON 0.3

DENSITY 76.8195

ALPHA 1.2e-005

DAMP 0.03

TYPE STEEL

STRENGTH FY 275000 FU 407800 RY 1.5 RT 1.2

END DEFINE MATERIAL

CONSTANTS

MATERIAL CONCRETE MEMB 100 TO 114 124 TO 138 148 TO 162 172 TO 186 -

196 TO 210 220 TO 234 466 TO 480 490 TO 504 514 TO 528 538 TO 552 -

562 TO 576 586 TO 600 610 TO 624 634 TO 648 658 TO 672

MATERIAL STEEL MEMB 460 462 682 684

****

SUPPORTS

429 431 657 659 FIXED

****

*SEISMIC LOAD DEFINITION

DEFINE 1893 LOAD

ZONE 0.36 RF 4 I 1.5 SS 1 ST 1 DM 0.05

SELFWEIGHT 1

*50% OF LIVE LOAD

ELEMENT WEIGHT

100 TO 114 124 TO 138 148 TO 162 172 TO 186 196 TO 210 220 TO 234 466 TO 480 -

490 TO 504 514 TO 528 538 TO 552 562 TO 576 586 TO 600 610 TO 624 -

634 TO 648 658 TO 672 PRESSURE 0.5

****

LOAD 1 LOADTYPE None TITLE EQ+X

1893 LOAD X 1

PERFORM ANALYSIS

CHANGE

****

LOAD 2 LOADTYPE None TITLE EQ+Z

1893 LOAD Z 1

PERFORM ANALYSIS

CHANGE

****

*DEAD LOAD

LOAD 3 LOADTYPE None TITLE DL

SELFWEIGHT Y -1

****

*LIVE LOAD CONSIDERED AS PER NON-ACCESSIBLE ROOF LOAD BASED ON IS 875

LOAD 4 LOADTYPE None TITLE LL

ELEMENT LOAD

100 TO 114 124 TO 138 148 TO 162 172 TO 186 196 TO 210 220 TO 234 466 TO 480 -

490 TO 504 514 TO 528 538 TO 552 562 TO 576 586 TO 600 610 TO 624 -

634 TO 648 658 TO 672 PR GY -1

****

*CURRENT LOAD IN X DIRECTION (REFER ATTACHED CALCULATIONS)

LOAD 5 LOADTYPE None TITLE CL+X

MEMBER LOAD

460 462 682 684 TRAP GX -9.21 0 5 45.5

MEMBER LOAD

462 CON GX -43.5 5

****

*CURRENT LOAD IN POSITIVE Z DIRECTION (REFER ATTACHED CALCULATIONS)

LOAD 6 LOADTYPE None TITLE CL+Z

MEMBER LOAD

460 462 682 684 TRAP GZ 9.21 0 5 45.5

MEMBER LOAD

462 CON GZ 43.5 5

****

*CURRENT LOAD IN NEGATIVE Z DIRECTION (REFER ATTACHED CALCULATIONS)

LOAD 7 LOADTYPE None TITLE CL-Z

MEMBER LOAD

460 462 682 684 TRAP GZ -9.21 0 5 45.5

MEMBER LOAD

462 CON GZ -43.5 5

****

*BERTHING LOAD (REFER ATTACHED CALCULATIONS)

LOAD 8 LOADTYPE None TITLE BL

MEMBER LOAD

462 CON GZ -131 5

****

*WIND LOAD IN X DIRECTION (REFER ATTACHED CALCULATIONS)

LOAD 9 LOADTYPE None TITLE WI +X

MEMBER LOAD

460 462 682 684 UNI GX -0.905 0 5

JOINT LOAD

56 57 89 111 134 159 184 466 467 499 521 544 569 594 619 644 FX -0.558

****

*WIND LOAD IN Z DIRECTION (REFER ATTACHED CALCULATIONS)

LOAD 10 LOADTYPE None TITLE WI +Z

MEMBER LOAD

460 462 682 684 UNI GZ 0.905 0 5

JOINT LOAD

432 TO 434 439 442 445 447 449 451 453 455 457 459 462 464 466 FZ 0.558

****

*EXTREME WIND LOAD IN X DIRECTION

LOAD 11 LOADTYPE None TITLE EXWI +X

MEMBER LOAD

460 462 682 684 UNI GX -3.042 0 5

JOINT LOAD

56 57 89 111 134 159 184 466 467 499 521 544 569 594 619 644 FX -1.876

****

*EXTREME WIND LOAD IN Z DIRECTION

LOAD 12 LOADTYPE None TITLE EXWI +Z

MEMBER LOAD

460 462 682 684 UNI GZ 3.042 0 5

JOINT LOAD

432 TO 434 439 442 445 447 449 451 453 455 457 459 462 464 466 FZ 1.876

****

*** SLS COMBINATIONS

***

LOAD COMB 101 DL LL

3 1.0 4 1.0

LOAD COMB 102 EQX DL LL

1 1.0 3 1.0 4 1.0

LOAD COMB 103 EQZ DL LL

2 1.0 3 1.0 4 1.0

***

LOAD COMB 201 DL LL CL+X

3 1.0 4 1.0 5 1.0

LOAD COMB 202 DL LL CL+X CL+Z

3 1.0 4 1.0 5 0.99 6 0.18

LOAD COMB 203 DL LL CL+X CL+Z

3 1.0 4 1.0 5 0.93 6 0.39

LOAD COMB 204 DL LL CL+X CL+Z

3 1.0 4 1.0 5 0.87 6 0.5

LOAD COMB 205 DL LL CL+X CL+Z

3 1.0 4 1.0 5 0.71 6 0.71

LOAD COMB 206 DL LL CL+X CL-Z

3 1.0 4 1.0 5 0.99 7 0.18

LOAD COMB 207 DL LL CL+X CL-Z

3 1.0 4 1.0 5 0.93 7 0.39

LOAD COMB 208 DL LL CL+X CL-Z

3 1.0 4 1.0 5 0.87 7 0.5

LOAD COMB 209 DL LL CL+X CL-Z

3 1.0 4 1.0 5 0.71 7 0.71

***

LOAD COMB 301 DL LL CL+X BL

3 1.0 4 1.0 5 1.0 8 1.0

LOAD COMB 302 DL LL CL+X CL+Z BL

3 1.0 4 1.0 5 0.99 6 0.18 8 1.0

LOAD COMB 303 DL LL CL+X CL+Z BL

3 1.0 4 1.0 5 0.93 6 0.39 8 1.0

LOAD COMB 304 DL LL CL+X CL+Z BL

3 1.0 4 1.0 5 0.87 6 0.5 8 1.0

LOAD COMB 305 DL LL CL+X CL+Z BL

3 1.0 4 1.0 5 0.71 6 0.71 8 1.0

LOAD COMB 306 DL LL CL+X CL-Z BL

3 1.0 4 1.0 5 0.99 7 0.18 8 1.0

LOAD COMB 307 DL LL CL+X CL-Z BL

3 1.0 4 1.0 5 0.93 7 0.39 8 1.0

LOAD COMB 308 DL LL CL+X CL-Z BL

3 1.0 4 1.0 5 0.87 7 0.5 8 1.0

LOAD COMB 309 DL LL CL+X CL-Z BL

3 1.0 4 1.0 5 0.71 7 0.71 8 1.0

***

LOAD COMB 401 DL LL CL+X WI+X

3 1.0 4 1.0 5 1.0 9 1.0

LOAD COMB 402 DL LL CL+X CL+Z WI+X

3 1.0 4 1.0 5 0.99 6 0.18 9 1.0

LOAD COMB 403 DL LL CL+X CL+Z WI+X

3 1.0 4 1.0 5 0.93 6 0.39 9 1.0

LOAD COMB 404 DL LL CL+X CL+Z WI+X

3 1.0 4 1.0 5 0.87 6 0.5 9 1.0

LOAD COMB 405 DL LL CL+X CL+Z WI+X

3 1.0 4 1.0 5 0.71 6 0.71 9 1.0

LOAD COMB 406 DL LL CL+X CL-Z WI+X

3 1.0 4 1.0 5 0.99 7 0.18 9 1.0

LOAD COMB 407 DL LL CL+X CL-Z WI+X

3 1.0 4 1.0 5 0.93 7 0.39 9 1.0

LOAD COMB 408 DL LL CL+X CL-Z WI+X

3 1.0 4 1.0 5 0.87 7 0.5 9 1.0

LOAD COMB 409 DL LL CL+X CL-Z WI+X

3 1.0 4 1.0 5 0.71 7 0.71 9 1.0

***

LOAD COMB 501 DL LL CL+X WI+Z

3 1.0 4 1.0 5 1.0 10 1.0

LOAD COMB 502 DL LL CL+X CL+Z WI+Z

3 1.0 4 1.0 5 0.99 6 0.18 10 1.0

LOAD COMB 503 DL LL CL+X CL+Z WI+Z

3 1.0 4 1.0 5 0.93 6 0.39 10 1.0

LOAD COMB 504 DL LL CL+X CL+Z WI+Z

3 1.0 4 1.0 5 0.87 6 0.5 10 1.0

LOAD COMB 505 DL LL CL+X CL+Z WI+Z

3 1.0 4 1.0 5 0.71 6 0.71 10 1.0

LOAD COMB 506 DL LL CL+X CL-Z WI+Z

3 1.0 4 1.0 5 0.99 7 0.18 10 1.0

LOAD COMB 507 DL LL CL+X CL-Z WI+Z

3 1.0 4 1.0 5 0.93 7 0.39 10 1.0

LOAD COMB 508 DL LL CL+X CL-Z WI+Z

3 1.0 4 1.0 5 0.87 7 0.5 10 1.0

LOAD COMB 509 DL LL CL+X CL-Z WI+Z

3 1.0 4 1.0 5 0.71 7 0.71 10 1.0

****

***ULS Combinations

***

LOAD COMB 1001 DL LL CL+X BL WI+X

3 1.5 4 1.5 5 1.2 8 1.5 9 1.0

LOAD COMB 1002 DL LL CL+X CL+Z BL WI+X

3 1.5 4 1.5 5 1.19 6 0.22 8 1.5 9 1.0

LOAD COMB 1003 DL LL CL+X CL+Z BL WI+X

3 1.5 4 1.5 5 1.12 6 0.47 8 1.5 9 1.0

LOAD COMB 1004 DL LL CL+X CL+Z BL WI+X

3 1.5 4 1.5 5 1.04 6 0.6 8 1.5 9 1.0

LOAD COMB 1005 DL LL CL+X CL+Z BL WI+X

3 1.5 4 1.5 5 0.85 6 0.85 8 1.5 9 1.0

LOAD COMB 1006 DL LL CL+X CL-Z BL WI+X

3 1.5 4 1.5 5 1.19 7 0.22 8 1.5 9 1.0

LOAD COMB 1007 DL LL CL+X CL-Z BL WI+X

3 1.5 4 1.5 5 1.12 7 0.47 8 1.5 9 1.0

LOAD COMB 1008 DL LL CL+X CL-Z BL WI+X

3 1.5 4 1.5 5 1.04 7 0.6 8 1.5 9 1.0

LOAD COMB 1009 DL LL CL+X CL-Z BL WI+X

3 1.5 4 1.5 5 0.85 7 0.85 8 1.5 9 1.0

***

LOAD COMB 2001 DL LL CL+X BL WI+Z

3 1.5 4 1.5 5 1.2 8 1.5 10 1.0

LOAD COMB 2002 DL LL CL+X CL+Z BL WI+Z

3 1.5 4 1.5 5 1.19 6 0.22 8 1.5 10 1.0

LOAD COMB 2003 DL LL CL+X CL+Z BL WI+Z

3 1.5 4 1.5 5 1.12 6 0.47 8 1.5 10 1.0

LOAD COMB 2004 DL LL CL+X CL+Z BL WI+Z

3 1.5 4 1.5 5 1.04 6 0.6 8 1.5 10 1.0

LOAD COMB 2005 DL LL CL+X CL+Z BL WI+Z

3 1.5 4 1.5 5 0.85 6 0.85 8 1.5 10 1.0

LOAD COMB 2006 DL LL CL+X CL-Z BL WI+Z

3 1.5 4 1.5 5 1.19 7 0.22 8 1.5 10 1.0

LOAD COMB 2007 DL LL CL+X CL-Z BL WI+Z

3 1.5 4 1.5 5 1.12 7 0.47 8 1.5 10 1.0

LOAD COMB 2008 DL LL CL+X CL-Z BL WI+Z

3 1.5 4 1.5 5 1.04 7 0.6 8 1.5 10 1.0

LOAD COMB 2009 DL LL CL+X CL-Z BL WI+Z

3 1.5 4 1.5 5 0.85 7 0.85 8 1.5 10 1.0

***

LOAD COMB 3001 EQX DL LL

1 1.5 3 1.5 4 1.5

LOAD COMB 3002 EQZ DL LL

2 1.5 3 1.5 4 1.5

***

LOAD COMB 4001 DL LL CL+X EXWI+X

3 1.2 4 1.2 5 1.0 11 1.2

LOAD COMB 4002 DL LL CL+X CL+Z EXWI+X

3 1.2 4 1.2 5 0.99 6 0.18 11 1.2

LOAD COMB 4003 DL LL CL+X CL+Z EXWI+X

3 1.2 4 1.2 5 0.93 6 0.39 11 1.2

LOAD COMB 4004 DL LL CL+X CL+Z EXWI+X

3 1.2 4 1.2 5 0.87 6 0.5 11 1.2

LOAD COMB 4005 DL LL CL+X CL+Z EXWI+X

3 1.2 4 1.2 5 0.71 6 0.71 11 1.2

LOAD COMB 4006 DL LL CL+X CL-Z EXWI+X

3 1.2 4 1.2 5 0.99 7 0.18 11 1.2

LOAD COMB 4007 DL LL CL+X CL-Z EXWI+X

3 1.2 4 1.2 5 0.93 7 0.39 11 1.2

LOAD COMB 4008 DL LL CL+X CL-Z EXWI+X

3 1.2 4 1.2 5 0.87 7 0.5 11 1.2

LOAD COMB 4009 DL LL CL+X CL-Z EXWI+X

3 1.2 4 1.2 5 0.71 7 0.71 11 1.2

***

LOAD COMB 5001 DL LL CL+X EXWI+Z

3 1.2 4 1.2 5 1.0 12 1.2

LOAD COMB 5002 DL LL CL+X CL+Z EXWI+Z

3 1.2 4 1.2 5 0.99 6 0.18 12 1.2

LOAD COMB 5003 DL LL CL+X CL+Z EXWI+Z

3 1.2 4 1.2 5 0.93 6 0.39 12 1.2

LOAD COMB 5004 DL LL CL+X CL+Z EXWI+Z

3 1.2 4 1.2 5 0.87 6 0.5 12 1.2

LOAD COMB 5005 DL LL CL+X CL+Z EXWI+Z

3 1.2 4 1.2 5 0.71 6 0.71 12 1.2

LOAD COMB 5006 DL LL CL+X CL-Z EXWI+Z

3 1.2 4 1.2 5 0.99 7 0.18 12 1.2

LOAD COMB 5007 DL LL CL+X CL-Z EXWI+Z

3 1.2 4 1.2 5 0.93 7 0.39 12 1.2

LOAD COMB 5008 DL LL CL+X CL-Z EXWI+Z

3 1.2 4 1.2 5 0.87 7 0.5 12 1.2

LOAD COMB 5009 DL LL CL+X CL-Z EXWI+Z

3 1.2 4 1.2 5 0.71 7 0.71 12 1.2

****

PERFORM ANALYSIS

FINISH

Dolphins for Berthing Pontoons Pile design - Compression

Pu

Cross Sectional Properties :-

Unsupported Length of Pile L	=	**58.5**	m
Outside Diameter D	=	**1520**	mm
Original Thickness	=	**25**	mm
Inside Diameter Di	=	**1470**	mm
Outside Diameter Do	=	**1520**	mm
Thickness t	=	**25**	mm
Effective Length Factor K	=	**1.2**	
Yield Strength of Steel fy	=	**275**	N/mm2
Modulus of Elasticity E	=	**200000**	N/mm2
n	=	**1.4**	
Area A = Pi (Di2 - Do2)/4	=	**117417.03**	mm2
Moment of Inertia I = Pi (Di4 - Do4)/64	=	**32812921612.24**	mm4
Section modulas Z = I/(Do/2)	=	**43174896.86**	mm3
Radius of Gyration r = Sqrt(I / A)	=	**528.64**	mm
Effective length Leff = L * K	=	**70200.00**	mm
Slenderness ratio = Leff / r	=	**132.79**	

Forces :-

Axial Force P	=	**3655.15**	kN
Shear Force Sy	=	**63.34**	kN
Shear Force Sz	=	**61.15**	kN
Resultant shear SR	=	**88.04**	KN
Moment about X axis My	=	**1400.30**	kNm
Moment about Y axis Mz	=	**-1444.24**	kNm
Resultant moment MR	=	**2011.63**	kNm

Axial Compression:-

Actual stress in axial compression	=	**31.13**	N/mm2
Elastic critical stress in compression	=	**111.94**	N/mm2
Permissible stress in axial compression	=	**56.18**	N/mm2

Bending :-			
Actual Bending and compressive Stresses	=	**46.59**	N/mm2
Permissible bending stress	=	**181.50**	N/mm2
Combined Axial Compression & Bending:-			
Check,	=	**0.55**	
		NO	
If, < 0.15, then,			
	=	**NO**	**NOT OK**
If, > 0.15, then,			
Cm	=	**0.85**	
Permissible Intraction ratio	=	**1.33**	
	=	**0.96**	**OK**
Shear & Bending :-			
Actual equivalent sheal & bending stress	=	**0.75**	N/mm2
	=	**46.61**	N/mm2
Permissible equivalent sheal & bending stress	=	**247.50**	N/mm2

Dolphins for Berthing Pontoons Pile design - Compression

My

Cross Sectional Properties :-

Unsupported Length of Pile L	=	**58.5**	m
Outside Diameter D	=	**1520**	mm
Original Thickness	=	**25**	mm
Inside Diameter Di	=	**1470**	mm
Outside Diameter Do	=	**1520**	mm
Thickness t	=	**25**	mm
Effective Length Factor K	=	**1.2**	
Yield Strength of Steel fy	=	**275**	N/mm2
Modulus of Elasticity E	=	**200000**	N/mm2
n	=	**1.4**	
Area A = Pi (Di2 - Do2)/4	=	**117417.03**	mm2
Moment of Inertia I = Pi (Di4 - Do4)/64	=	**32812921612.24**	mm4
Section modulas Z = I/(Do/2)	=	**43174896.86**	mm3
Radius of Gyration r = Sqrt(I / A)	=	**528.64**	mm
Effective length Leff = L * K	=	**70200.00**	mm
Slenderness ratio = Leff / r	=	**132.79**	

Forces :-

Axial Force P	=	**3169.57**	kN
Shear Force Sy	=	**68.60**	kN
Shear Force Sz	=	**63.11**	kN
Resultant shear SR	=	**93.22**	KN
Moment about X axis My	=	**1481.95**	kNm
Moment about Y axis Mz	=	**-1534.71**	kNm
Resultant moment MR	=	**2133.43**	kNm

Axial Compression:-

Actual stress in axial compression	=	**26.99**	N/mm2
Elastic critical stress in compression	=	**111.94**	N/mm2
Permissible stress in axial compression	=	**56.18**	N/mm2

Bending :-

Actual Bending and compressive Stresses	=	**49.41**	N/mm2
Permissible bending stress	=	**181.50**	N/mm2

Combined Axial Compression & Bending:-

Check,	=	**0.48**	
		NO	
If, < 0.15, then,			
	=	**NO**	**NOT OK**
If, > 0.15, then,			
Cm	=	**0.85**	
Permissible Intraction ratio	=	**1.33**	
	=	**0.87**	**OK**

Shear & Bending :-

Actual equivalent sheal & bending stress	=	**0.79**	N/mm2
	=	**49.43**	N/mm2
Permissible equivalent sheal & bending stress	=	**247.50**	N/mm2

Dolphins for Berthing Pontoons Pile design - Compression

Mz

Cross Sectional Properties :-

Unsupported Length of Pile L	=	**58.5**	m
Outside Diameter D	=	**1520**	mm
Original Thickness	=	**25**	mm
Inside Diameter Di	=	**1470**	mm
Outside Diameter Do	=	**1520**	mm
Thickness t	=	**25**	mm
Effective Length Factor K	=	**1.2**	
Yield Strength of Steel fy	=	**275**	N/mm2
Modulus of Elasticity E	=	**200000**	N/mm2
n	=	**1.4**	
Area A = Pi (Di2 - Do2)/4	=	**117417.03**	mm2
Moment of Inertia I = Pi (Di4 - Do4)/64	=	**32812921612.24**	mm4
Section modulas Z = I/(Do/2)	=	**43174896.86**	mm3
Radius of Gyration r = Sqrt(I / A)	=	**528.64**	mm
Effective length Leff = L * K	=	**70200.00**	mm
Slenderness ratio = Leff / r	=	**132.79**	

Forces :-

Axial Force P	=	**2668.96**	kN
Shear Force Sy	=	**68.60**	kN
Shear Force Sz	=	**63.11**	kN
Resultant shear SR	=	**93.22**	KN
Moment about X axis My	=	**-2020.68**	kNm
Moment about Y axis Mz	=	**2272.64**	kNm
Resultant moment MR	=	**3041.06**	kNm

Axial Compression:-

Actual stress in axial compression	=	**22.73**	N/mm2
Elastic critical stress in compression	=	**111.94**	N/mm2
Permissible stress in axial compression	=	**56.18**	N/mm2

Bending :-

Actual Bending and compressive Stresses	=	**70.44**	N/mm2
Permissible bending stress	=	**181.50**	N/mm2

Combined Axial Compression & Bending:-

Check,	=	**0.40**	
		NO	
If, < 0.15, then,			
	=	**NO**	**NOT OK**
If, > 0.15, then,			
Cm	=	**0.85**	
Permissible Intraction ratio	=	**1.33**	
	=	**0.90**	**OK**

Shear & Bending :-

Actual equivalent sheal & bending stress	=	**0.79**	N/mm2
	=	**70.45**	N/mm2
Permissible equivalent sheal & bending stress	=	**247.50**	N/mm2

Dolphins for Berthing Pontoons Pile design - Tension

Pu

Cross Sectional Properties :-

Unsupported Length of Pile L	=	**58.5**	m
Outside Diameter D	=	**1520**	mm
Original Thickness	=	**25**	mm
Inside Diameter Di	=	**1470**	mm
Corrosion considered	=	**0**	mm
Outside Diameter Do	=	**1520**	mm
Thickness t	=	**25**	mm
Effective Length Factor K	=	**1.2**	
Yield Strength of Steel fy	=	**275**	N/mm2
Modulus of Elasticity E	=	**200000**	N/mm2
n	=	**1.4**	
Area A = Pi (Di2 - Do2)/4	=	**117417.03**	mm2
Moment of Inertia I = Pi (Di4 - Do4)/64	=	**32812921612.24**	mm4
Section modulas Z = I/(Do/2)	=	**43174896.86**	mm3
Radius of Gyration r = Sqrt(I / A)	=	**528.64**	mm
Effective length Leff = L * K	=	**70200.00**	mm
Slenderness ratio = Leff / r	=	**132.79**	

Forces :-

Axial Force P	=	**718.65**	kN
Shear Force Sy	=	**9.53**	kN
Shear Force Sz	=	**130.50**	kN
Resultant shear SR	=	**130.85**	KN
Moment about X axis My	=	**-858.70**	kNm
Moment about Y axis Mz	=	**-1824.42**	kNm
Resultant moment MR	=	**2016.40**	kNm

Axial tension:-

Actual stress in axial tension	=	**6.12**	N/mm2
Elastic critical stress in tension	=	**111.94**	N/mm2

Permissible stress in axial tension	=	**165.00**	N/mm2
Bending :-			
Actual Bending and compressive Stresses	=	**46.70**	N/mm2
Permissible bending stress	=	**181.50**	N/mm2
Combined Axial tension & Bending:-			
Check,	=	**0.04**	
		YES	
If, < 0.15, then,			
	=	**0.29**	**OK**
If, > 0.15, then,			
Cm	=	**0.85**	
Permissible Intraction ratio	=	**1.33**	
	=	**YES**	**NOT OK**
Shear & Bending :-			
Actual equivalent sheal & bending stress	=	**1.11**	N/mm2
	=	**46.74**	N/mm2
Permissible equivalent sheal & bending stress	=	**247.50**	N/mm2

Dolphins for Berthing Pontoons Pile design - Tension

My

Cross Sectional Properties :-

Unsupported Length of Pile L	=	**58.5**	m
Outside Diameter D	=	**1520**	mm
Original Thickness	=	**25**	mm
Inside Diameter Di	=	**1470**	mm
Corrosion considered	=	**0**	mm
Outside Diameter Do	=	**1520**	mm
Thickness t	=	**25**	mm
Effective Length Factor K	=	**1.2**	
Yield Strength of Steel fy	=	**275**	N/mm2
Modulus of Elasticity E	=	**200000**	N/mm2
n	=	**1.4**	
Area A = Pi (Di2 - Do2)/4	=	**117417.03**	mm2
Moment of Inertia I = Pi (Di4 - Do4)/64	=	**32812921612.24**	mm4
Section modulas Z = I/(Do/2)	=	**43174896.86**	mm3
Radius of Gyration r = Sqrt(I / A)	=	**528.64**	mm
Effective length Leff = L * K	=	**70200.00**	mm
Slenderness ratio = Leff / r	=	**132.79**	

Forces :-

Axial Force P	=	**197.50**	kN
Shear Force Sy	=	**-0.42**	kN
Shear Force Sz	=	**9.93**	kN
Resultant shear SR	=	**9.94**	KN
Moment about X axis My	=	**-411.18**	kNm
Moment about Y axis Mz	=	**-2067.16**	kNm
Resultant moment MR	=	**2107.66**	kNm

Axial tension:-

Actual stress in axial tension	=	**1.68**	N/mm2
Elastic critical stress in tension	=	**111.94**	N/mm2

Permissible stress in axial tension	=	**165.00**	N/mm2
Bending :-			
Actual Bending and compressive Stresses	=	**48.82**	N/mm2
Permissible bending stress	=	**181.50**	N/mm2
Combined Axial tension & Bending:-			
Check,	=	**0.01**	
		YES	
If, < 0.15, then,			
	=	**0.28**	**OK**
If, > 0.15, then,			
Cm	=	**0.85**	
Permissible Intraction ratio	=	**1.33**	
	=	**YES**	**NOT OK**
Shear & Bending :-			
Actual equivalent sheal & bending stress	=	**0.08**	N/mm2
	=	**48.82**	N/mm2
Permissible equivalent sheal & bending stress	=	**247.50**	N/mm2

Dolphins for Berthing Pontoons Pile design - Tension

Mz

Cross Sectional Properties :-

Unsupported Length of Pile L	=	**58.5**	m
Outside Diameter D	=	**1520**	mm
Original Thickness	=	**25**	mm
Inside Diameter Di	=	**1470**	mm
Corrosion considered	=	**0**	mm
Outside Diameter Do	=	**1520**	mm
Thickness t	=	**25**	mm
Effective Length Factor K	=	**1.2**	
Yield Strength of Steel fy	=	**275**	N/mm2
Modulus of Elasticity E	=	**200000**	N/mm2
n	=	**1.4**	
Area A = Pi (Di2 - Do2)/4	=	**117417.03**	mm2
Moment of Inertia I = Pi (Di4 - Do4)/64	=	**32812921612.24**	mm4
Section modulas Z = I/(Do/2)	=	**43174896.86**	mm3
Radius of Gyration r = Sqrt(I / A)	=	**528.64**	mm
Effective length Leff = L * K	=	**70200.00**	mm
Slenderness ratio = Leff / r	=	**132.79**	

Forces :-

Axial Force P	=	**219.05**	kN
Shear Force Sy	=	**-160.35**	kN
Shear Force Sz	=	**-59.97**	kN
Resultant shear SR	=	**171.20**	KN
Moment about X axis My	=	**-894.35**	kNm
Moment about Y axis Mz	=	**2668.28**	\
Resultant moment MR	=	**2814.17**	kNm

Axial tension:-

Actual stress in axial tension	=	**1.87**	N/mm2
Elastic critical stress in tension	=	**111.94**	N/mm2

Permissible stress in axial tension	=	**165.00**	N/mm2

Bending :-

Actual Bending and compressive Stresses	=	**65.18**	N/mm2
Permissible bending stress	=	**181.50**	N/mm2

Combined Axial tension & Bending:-

Check,	=	**0.01**	
		YES	
If, < 0.15, then,			
	=	**0.37**	**OK**
If, > 0.15, then,			
Cm	=	**0.85**	
Permissible Intraction ratio	=	**1.33**	
	=	**YES**	**NOT OK**

Shear & Bending :-

Actual equivalent sheal & bending stress	=	**1.46**	N/mm2
	=	**65.23**	N/mm2
Permissible equivalent sheal & bending stress	=	**247.50**	N/mm2

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat			TRACTEBEL ENGIE
SUBJECT:	Design of Slab - Dolphins for Berthing Pontoons			
PROJECT NO:	P.013223	FILE REF:		CALCULATIONS
PREPARED BY:	MM	DATE:	6/13/2019	
CHECKED BY:	AGB	DATE:	6/13/2019	REVISION: 0

REF.								OUTPUT.
IS 456 : 2000	**Design of Slab - Mx Reinforcement - Sagging**							
STAAD	ULS Sagging Moment in X direction	Mx	1441.824	kN m				
STAAD	Corresponding Torsion	T	1345.662	kN m				Mx + T
	Design ULS Moment	Mu	2787.49	kN m				
STAAD	SLS Sagging Moment in X direction	Mx	1111.932	kN m				
STAAD	Corresponding Torsion	T	669.434	kN m				
	Design Crackwidth Moment	M	1781.37	kN m				Mx + T
	Density of concrete		25.00	kN/m^3				
	Assumed Depth of Slab	D	2000	mm				
STAAD	ULS Shear force		1.462	N/mm^2				
	ULS Shear force	Vu	2924.00	kN				
	Axial Force for crackwidth check	F	0	kN				
	Sagging Reinforcement							
Constants	Grade of Concrete,	f_{ck}	30	N/mm^2				
	Grade of Main Reinforcement,	f_y	500	N/mm^2				
	Grade of Stirrups	f_y	415	N/mm^2				
	$x_{u,max}/d$		0.46					
	Modulus of elasticity of concrete,	Ec	27386.128	N/mm^2				
	Modulus of elasticity of steel,	Es	200000	N/mm^2				
Reinforcement Details	Width of the Slab,	B	1000	mm				
	Clear cover to tension reinforcement,		50	mm				
	Dia. of tension reinforcement (bottom)		32	mm				
	Sapcing of Bars		140	mm				
	Dia. of stirrups		12	mm	4	legged		
	Dia. of compression reinforcement,		0	mm				
	No.of Bars in compression,		0	Nos				
	Clear cover to compression reinforcement,		0	mm				
	Dia. & No. of side face reinforcement,		16	mm	7	Nos		
	Check for Depth							
	Ru		4.017	N/mm^2				
	Effective Depth required,	d_{req} =	832.98646	mm				
	Overall Depth Required,	D_{req} =	910.98646	mm				
	Overall Depth Provided,	D_{prov} =	2000	mm				
	Effective Depth provided,	d_{prov} =	1922	mm				
Cl. G 1.1.C	Limiting Moment of Inertia,	$M_{u,lim}$=	14840.331	Knm	>2787.486 kM m			**Hence Safe**

REF.						OUTPUT.
	Check for Tension Reinforcement					
Cl. G 1.1.B	Required Tensile Reinforcement	$A_{st, req}$	3438.2098	mm^2		
Cl. 26.5.1.1	Minimum Reinforcement	$A_{st, min}$	3267.4	mm^2		
Cl. 26.5.1.2	Maximum Reinforcement	$A_{st, max}$	80000	mm^2		
	Required Reinforcement	$A_{st, req}$	3438.21	mm^2		
	Provided reinforcement	$A_{st, prov}$	5744.6266	mm^2	>3438.21 mm2	**Hence Safe**
	Check for Side face Reinforcement					
Cl. 26.5.1.2	$A_{sf, req}$		1000	mm^2 per side		
	$A_{sf, prov}$		1407.43	mm^2	>1000 mm2	**Hence Safe**
Cl. 40.1	**Check for Shear Reinforcement**					
	Slab width	b	1000	mm		
	Slab Overall Depth	D	2000	mm		
	Slab Effective Depth,	d	1922	mm		
	% of main reinforcement	P_t =	0.2989	%		
		β =	11.654			
		τc =	0.399	N/mm^2		
		τv =	1.522	N/mm^2	>0.399 N/mm2	**Shear Rft Required**
		τv,max=	4.0	N/mm^2	>1.522 N/mm2	**Hence OK**
	Section Capacity		766.878	kN		
	Shear to be carried by stirrups	Vus =	2157.122	kN		
	Actual Spacing required		175.340	mm		
	Minimum Spacing required		300	mm		
	Spacing provided		150	mm	< 175.34 mm	**Hence Safe**
	Check for Deflection					
	Slab Type		Continuous			
	Span of the Slab	L =	4.2	m		
	Span to Depth Ratio		2.200			
	Permissible Span to Depth Ratio		26			
		fs =	173.56757	N/mm^2		
	Modification Factor		1.15			
	Permissible Span to Depth Ratio		29.9		>2.2 mm	**Hence Safe**

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat		
SUBJECT:	Design of Slab - Dolphins for Berthing Pontoons		
PROJECT NO:	P.013223	FILE REF:	
PREPARED BY:	MM	DATE:	6/13/2019
CHECKED BY:	AGB	DATE:	6/13/2019

TRACTEBEL engie

CALCULATIONS

REVISION: 0

REF.					OUTPUT.
Annexure - F	**Check for Crackwidth**				
	Modular Ratio,	m=	7.303		
	Percentage of Tension reinforcement	Pt =	0.003		
	Depth of Neutral Axis,	X =	361.81281	mm	
	Eccentricity	e =	Not Req.		
	Area of Tension Reinforcement	Ast =	5744.6266	mm^2	
	Area of Compression Reinforcement	Asc =	0	mm^2	
	Effective depth	d =	1922	mm	
	Effective cover to compression reinforcement	dc =	0	mm	
	Concrete stress				
	σ_{cbc} =[B/2*X(d-X/3)]+[(X-dc)/X*Asc(1.5m-1)*(d-dc)]		5.4663	N/mm^2	
	Stress in compression steel,				
	σ_{sc}= 1.5*m*σ_{cbc}*(X-dc)/X		0	N/mm^2	
	Stress in tensile steel,				
	σ_{st} = m*σ_{cbc}*(d-X)/X		172.14017	N/mm^2	
	Effective area of crosssection				
	Aeff=B*X+Ast*m+(1.5m-1)Asc		403765.63	mm^2	
	Direct Stress in Concrete(due to tensile force)				
	σ_{ac}= f/Aeff =		0	N/mm^2	
	Total Stress in Compression Steel				
	$\sigma_{sc,tot}$= σ_{sc}-1.5*m*σ_{ac} =		0	N/mm^2	
	Total Stress in Tension Steel				
	$\sigma_{st,tot}$= σ_{st}-m*σ_{ac} =		172.14017	N/mm^2	
	Strain at the level being considered				
	ε1= (D-X)/(d-X)*σ_{sttot}/Es		0.0009037		
	Average strain at the level considered				
	εm= ε1-[(B*(D-X)(a1-X))/3(Es*Ast*(d-X))]		0.0004047		
	Spacing between bars of Tension Rft, S =		140	mm	
	acr =		86.02	mm	
	C_{min}		62		
	Wcr =		0.101	mm	
	Allowable Crack Width =		0.3	mm >0.101 mm	**Hence Safe**

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat		
SUBJECT:	Design of Slab - Dolphins for Berthing Pontoons		
PROJECT NO:	P.013223	FILE REF:	
PREPARED BY:	MM	DATE:	6/13/2019
CHECKED BY:	AGB	DATE:	6/13/2019

TRACTEBEL engie

CALCULATIONS

REVISION: 0

REF.							OUTPUT.
IS 456 : 2000	**Design of Slab - Mx Reinforcement - Hogging**						
STAAD	ULS Hogging Moment in X direction	Mx	2423.961	kN m			
STAAD	Corresponding Torsion	T	1638.502	kN m			Mx + T
	Design ULS Moment	Mu	4062.46	kN m			
STAAD	SLS Hogging Moment in X direction	Mx	1615.974	kN m			
STAAD	Corresponding Torsion	T	1092.335	kN m			
	Design Crackwidth Moment	M	2708.31	kN m			Mx + T
	Density of concrete		25.00	kN/m^3			
	Assumed Depth of Slab	D	2000	mm			
	Axial Force for crackwidth check	F	0	kN			
	Hogging Reinforcement						
Constants	Grade of Concrete,	f_{ck}	30	N/mm^2			
	Grade of Main Reinforcement,	f_y	500	N/mm^2			
	Grade of Stirrups	f_y	415	N/mm^2			
	$x_{u,max}/d$		0.46				
	Modulus of elasticity of concrete,	Ec	27386.128	N/mm^2			
	Modulus of elasticity of steel,	Es	200000	N/mm^2			
Reinforcement Details	Width of the Slab,	B	1000	mm			
	Clear cover to tension reinforcement,		50	mm			
	Dia. of tension reinforcement (Top)		32	mm			
	Sapcing of Bars		140	mm			
	Dia. of stirrups		12	mm	4	legged	
	Dia. of compression reinforcement,		0	mm			
	No.of Bars in compression,		0	Nos			
	Clear cover to compression reinforcement,		0	mm			
	Check for Depth						
	Ru		4.017	N/mm^2			
	Effective Depth required,	d_{req} =	1005.6024	mm			
	Overall Depth Required,	D_{req} =	1083.6024	mm			
	Overall Depth Provided,	D_{prov} =	2000	mm			
	Effective Depth provided,	d_{prov} =	1922	mm			
Cl. G 1.1.C	Limiting Moment of Inertia,	$M_{u,lim}$=	14840.331	Knm	>4062.463 kM m		**Hence Safe**
	Check for Tension Reinforcement						
Cl. G 1.1.B	Required Tensile Reinforcement	$A_{st, req}$	5085.7125	mm^2			
Cl. 26.5.1.1	Minimum Reinforcement	$A_{st, min}$	3267.4	mm^2			
Cl. 26.5.1.2	Maximum Reinforcement	$A_{st, max}$	80000	mm^2			
	Required Reinforcement	$A_{st, req}$	5085.72	mm^2			
	Provided reinforcement	$A_{st, prov}$	5744.6266	mm^2	>5085.72 mm2		**Hence Safe**

REF.				OUTPUT.
Annexure - F	**Check for Crackwidth**			
	Modular Ratio,	m=	7.303	
	Percentage of Tension reinforcement	Pt =	0.003	
	Depth of Neutral Axis,	X =	361.81281 mm	
	Eccentricity	e =	Not Req.	
	Area of Tension Reinforcement	Ast =	5744.6266 mm^2	
	Area of Compression Reinforcement	Asc =	0 mm^2	
	Effective depth	d =	1922 mm	
	Effective cover to compression reinforcement	dc =	0 mm	
	Concrete stress			
	σ_{cbc} =[B/2*X(d-X/3)]+[(X-dc)/X*Asc(1.5m-1)*(d-dc)]		8.3107 N/mm^2	
	Stress in compression steel,			
	σ_{sc}= 1.5*m*σ_{cbc}*(X-dc)/X		0 N/mm^2	
	Stress in tensile steel,			
	σ_{st} = m*σ_{cbc}*(d-X)/X		261.7142 N/mm^2	
	Effective area of crosssection			
	Aeff=B*X+Ast*m+(1.5m-1)Asc		403765.63 mm^2	
	Direct Stress in Concrete(due to tensile force)			
	σ_{ac}= f/Aeff =		0 N/mm^2	
	Total Stress in Compression Steel			
	$\sigma_{sc,tot}$= σ_{sc}-1.5*m*σ_{ac} =		0 N/mm^2	
	Total Stress in Tension Steel			
	$\sigma_{st,tot}$= σ_{st}-m*σ_{ac} =		261.7142 N/mm^2	
	Strain at the level being considered			
	ε1= (D-X)/(d-X)*σ_{sttot}/Es		0.001374	
	Average strain at the level considered			
	εm= ε1-[(B*(D-X)(a1-X))/3(Es*Ast*(d-X))]		0.0008749	
	Spacing between bars of Tension Rft, S =		140 mm	
	acr =		86.02 mm	
	C_{min}		62	
	Wcr =		0.219 mm	
	Allowable Crack Width =		0.3 mm >0.219 mm	**Hence Safe**

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat		
SUBJECT:	Design of Slab - Dolphins for Berthing Pontoons		
PROJECT NO:	P.013223	FILE REF:	
PREPARED BY:	MM	DATE:	6/13/2019
CHECKED BY:	AGB	DATE:	6/13/2019

TRACTEBEL ENGIE

CALCULATIONS

REVISION: 0

REF.						OUTPUT.
IS 456 : 2000	**Design of Slab - My Reinforcement - Sagging**					
STAAD	ULS Sagging Moment in X direction	My	1509.813	kN m		
STAAD	Corresponding Torsion	T	1322.674	kN m		Mx + T
	Design ULS Moment	Mu	2832.49	kN m		
STAAD	SLS Sagging Moment in X direction	My	1006.542	kN m		
STAAD	Corresponding Torsion	T	881.783	kN m		
	Design Crackwidth Moment	M	1888.33	kN m		Mx + T
	Density of concrete		25.00	kN/m^3		
	Assumed Depth of Slab	D	2000	mm		
	Axial Force for crackwidth check	F	0	kN		
	Sagging Reinforcement					
Constants	Grade of Concrete,	f_{ck}	30	N/mm^2		
	Grade of Main Reinforcement,	f_y	500	N/mm^2		
	Grade of Stirrups	f_y	415	N/mm^2		
	$x_{u,max}/d$		0.46			
	Modulus of elasticity of concrete,	Ec	27386.128	N/mm^2		
	Modulus of elasticity of steel,	Es	200000	N/mm^2		
Reinforcement Details	Width of the Slab,	B	1000	mm		
	Clear cover to tension reinforcement,		50	mm		
	Dia. of tension reinforcement (bottom)		32	mm		
	Sapcing of Bars		150	mm		
	Dia. of stirrups		12	mm	4 legged	
	Dia. of compression reinforcement,		0	mm		
	No.of Bars in compression,		0	Nos		
	Clear cover to compression reinforcement,		0	mm		
	Check for Depth					
	Ru		4.017	N/mm^2		
	Effective Depth required,	d_{req} =	839.68338	mm		
	Overall Depth Required,	D_{req} =	917.68338	mm		
	Overall Depth Provided,	D_{prov} =	2000	mm		
	Effective Depth provided,	d_{prov} =	1890	mm		
Cl. G 1.1.C	Limiting Moment of Inertia,	$M_{u,lim}$=	14350.281	Knm	>2832.487 kM m	**Hence Safe**
	Check for Tension Reinforcement					
Cl. G 1.1.B	Required Tensile Reinforcement	$A_{st, req}$	3558.6151	mm^2		
Cl. 26.5.1.1	Minimum Reinforcement	$A_{st, min}$	3213	mm^2		
Cl. 26.5.1.2	Maximum Reinforcement	$A_{st, max}$	80000	mm^2		
	Required Reinforcement	$A_{st, req}$	3558.62	mm^2		
	Provided reinforcement	$A_{st, prov}$	5361.6515	mm^2	>3558.62 mm2	**Hence Safe**

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat				
SUBJECT:	Design of Slab - Dolphins for Berthing Pontoons				TRACTEBEL ENGIE
PROJECT NO:	P.013223	FILE REF:		CALCULATIONS	
PREPARED BY:	MM	DATE:	6/13/2019		
CHECKED BY:	AGB	DATE:	6/13/2019	REVISION:	0

REF.					OUTPUT.
Annexure - F	**Check for Crackwidth**				
	Modular Ratio,	m=	7.303		
	Percentage of Tension reinforcement	Pt =	0.003		
	Depth of Neutral Axis,	X =	347.5516	mm	
	Eccentricity	e =	Not Req.		
	Area of Tension Reinforcement	Ast =	5361.6515	mm^2	
	Area of Compression Reinforcement	Asc =	0	mm^2	
	Effective depth	d =	1890	mm	
	Effective cover to compression reinforcement	dc =	0	mm	
	Concrete stress				
	σ_{cbc} =[B/2*X(d-X/3)]+[(X-dc)/X*Asc(1.5m-1)*(d-dc)]		6.1249	N/mm^2	
	Stress in compression steel,				
	σ_{sc}= 1.5*m*σ_{cbc}*(X-dc)/X		0	N/mm^2	
	Stress in tensile steel,				
	σ_{st} = m*σ_{cbc}*(d-X)/X		198.51255	N/mm^2	
	Effective area of crosssection				
	Aeff=B*X+Ast*m+(1.5m-1)Asc		386707.57	mm^2	
	Direct Stress in Concrete(due to tensile force)				
	σ_{ac}= f/Aeff =		0	N/mm^2	
	Total Stress in Compression Steel				
	$\sigma_{sc,tot}$= σ_{sc}-1.5*m*σ_{ac} =		0	N/mm^2	
	Total Stress in Tension Steel				
	$\sigma_{st,tot}$= σ_{st}-m*σ_{ac} =		198.51255	N/mm^2	
	Strain at the level being considered				
	ε1= (D-X)/(d-X)*σ_{sttot}/Es		0.0010633		
	Average strain at the level considered				
	εm= ε1-[(B*(D-X)(a1-X))/3(Es*Ast*(d-X))]		0.0005131		
	Spacing between bars of Tension Rft, S =		150	mm	
	acr =		90.14	mm	
	C_{min}		62		
	Wcr =		0.134	mm	
	Allowable Crack Width =		0.3	mm >0.134 mm	**Hence Safe**

REF.						OUTPUT.
IS 456 : 2000	**Design of Slab - My Reinforcement - Hogging**					
STAAD	ULS Hogging Moment in X direction	My	2354.48	kN m		
STAAD	Corresponding Torsion	T	1358.999	kN m		Mx + T
	Design ULS Moment	Mu	3713.48	kN m		
STAAD	SLS Hogging Moment in X direction	My	1569.653	kN m		
STAAD	Corresponding Torsion	T	906	kN m		
	Design Crackwidth Moment	M	2475.65	kN m		Mx + T
	Density of concrete		25.00	kN/m^3		
	Assumed Depth of Slab	D	2000	mm		
	Axial Force for crackwidth check	F	0	kN		
	Hogging Reinforcement					
Constants	Grade of Concrete,	f_{ck}	30	N/mm^2		
	Grade of Main Reinforcement,	f_y	500	N/mm^2		
	Grade of Stirrups	f_y	415	N/mm^2		
	$x_{u,max}/d$		0.46			
	Modulus of elasticity of concrete,	Ec	27386.128	N/mm^2		
	Modulus of elasticity of steel,	Es	200000	N/mm^2		
Reinforcement Details	Width of the Slab,	B	1000	mm		
	Clear cover to tension reinforcement,		50	mm		
	Dia. of tension reinforcement (Top)		32	mm		
	Sapcing of Bars		150	mm		
	Dia. of stirrups		12	mm	4 legged	
	Dia. of compression reinforcement,		0	mm		
	No.of Bars in compression,		0	Nos		
	Clear cover to compression reinforcement,		0	mm		
	Check for Depth					
	Ru		4.017	N/mm^2		
	Effective Depth required,	d_{req} =	961.43977	mm		
	Overall Depth Required,	D_{req} =	1039.4398	mm		
	Overall Depth Provided,	D_{prov} =	2000	mm		
	Effective Depth provided,	d_{prov} =	1890	mm		
Cl. G 1.1.C	Limiting Moment of Inertia,	$M_{u,lim}$=	14350.281	Knm	>3713.479 kM m	**Hence Safe**
	Check for Tension Reinforcement					
Cl. G 1.1.B	Required Tensile Reinforcement	$A_{st, req}$	4715.0993	mm^2		
Cl. 26.5.1.1	Minimum Reinforcement	$A_{st, min}$	3213	mm^2		
Cl. 26.5.1.2	Maximum Reinforcement	$A_{st, max}$	80000	mm^2		
	Required Reinforcement	$A_{st, req}$	4715.1	mm^2		
	Provided reinforcement	$A_{st, prov}$	5361.6515	mm^2	>4715.1 mm2	**Hence Safe**

PROJECT TITLE:	Development of Ferry Services in Assam - Guwahati Gateway Ghat			TRACTEBEL ENGIE
SUBJECT:	Design of Slab - Dolphins for Berthing Pontoons			
PROJECT NO:	P.013223	FILE REF:		CALCULATIONS
PREPARED BY:	MM	DATE:	6/13/2019	
CHECKED BY:	AGB	DATE:	6/13/2019	REVISION: 0

REF.						OUTPUT.
Annexure - F	**Check for Crackwidth**					
	Modular Ratio,	m=	7.303			
	Percentage of Tension reinforcement	Pt =	0.003			
	Depth of Neutral Axis,	X =	347.5516	mm		
	Eccentricity	e =	Not Req.			
	Area of Tension Reinforcement	Ast =	5361.6515	mm^2		
	Area of Compression Reinforcement	Asc =	0	mm^2		
	Effective depth	d =	1890	mm		
	Effective cover to compression reinforcement	dc =	0	mm		
	Concrete stress					
	σ_{cbc} =[B/2*X(d-X/3)]+[(X-dc)/X*Asc(1.5m-1)*(d-dc)]		8.0299	N/mm^2		
	Stress in compression steel,					
	σ_{sc}= 1.5*m*σ_{cbc}*(X-dc)/X		0	N/mm^2		
	Stress in tensile steel,					
	σ_{st} = m*σ_{cbc}*(d-X)/X		260.25614	N/mm^2		
	Effective area of crosssection					
	Aeff=B*X+Ast*m+(1.5m-1)Asc		386707.57	mm^2		
	Direct Stress in Concrete(due to tensile force)					
	σ_{ac}= f/Aeff =		0	N/mm^2		
	Total Stress in Compression Steel					
	$\sigma_{sc,tot}$= σ_{sc}-1.5*m*σ_{ac} =		0	N/mm^2		
	Total Stress in Tension Steel					
	$\sigma_{st,tot}$= σ_{st}-m*σ_{ac} =		260.25614	N/mm^2		
	Strain at the level being considered					
	ε1= (D-X)/(d-X)*σ_{sttot}/Es		0.0013941			
	Average strain at the level considered					
	εm= ε1-[(B*(D-X)(a1-X))/3(Es*Ast*(d-X))]		0.0008438			
	Spacing between bars of Tension Rft, S =		150	mm		
	acr =		90.14	mm		
	C_{min}		62			
	Wcr =		0.221	mm		
	Allowable Crack Width =		0.3	mm	>0.221 mm	**Hence Safe**

STAAD-PRO INPUTS – LINK SPAN

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STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 21-May-19
JOB NAME Analysis & Design of Linkspan for Aphlamukh Ghat
JOB CLIENT IWT Assam
JOB REV A
ENGINEER NAME BMR
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 2.655 0; 2 0 2.655 8; 3 31.8896 -0.000428162 0; 4 31.8896 -0.000428162 8;
5 1.9931 2.48904 0; 6 3.9862 2.32308 0; 7 5.97931 2.15711 0;
8 7.97241 1.99114 0; 9 9.96551 1.82518 0; 10 11.9586 1.65921 0;
11 13.9517 1.49325 0; 12 15.9448 1.32729 0; 13 17.9379 1.16131 0;
14 19.931 0.995351 0; 15 21.9242 0.829388 0; 16 23.9172 0.663434 0;
17 25.9103 0.49747 0; 18 27.9034 0.331508 0; 19 29.8965 0.165535 0;
20 1.9931 2.48904 8; 21 3.9862 2.32308 8; 22 5.97931 2.15711 8;
23 7.97241 1.99114 8; 24 9.96551 1.82518 8; 25 11.9586 1.65921 8;
26 13.9517 1.49325 8; 27 15.9448 1.32729 8; 28 17.9379 1.16131 8;
29 19.931 0.995351 8; 30 21.9242 0.829388 8; 31 23.9172 0.663434 8;
32 25.9103 0.49747 8; 33 27.9034 0.331508 8; 34 29.8965 0.165535 8;
39 2.28354 6.47696 0; 40 4.27664 6.311 0; 41 6.26974 6.14504 0;
42 8.26285 5.97907 0; 43 10.2559 5.81312 0; 44 12.2491 5.64715 0;
45 14.2422 5.48118 0; 46 16.2353 5.31521 0; 47 18.2284 5.14925 0;
48 20.2215 4.98329 0; 49 22.2146 4.81732 0; 50 24.2077 4.65136 0;
51 26.2008 4.48538 0; 52 28.1939 4.31943 0; 53 30.187 4.15346 0;
54 2.28354 6.47696 8; 55 4.27664 6.311 8; 56 6.26974 6.14504 8;
57 8.26285 5.97907 8; 58 10.2559 5.81312 8; 59 12.2491 5.64715 8;
60 14.2422 5.48118 8; 61 16.2353 5.31521 8; 62 18.2284 5.14925 8;
63 20.2215 4.98329 8; 64 22.2146 4.81732 8; 65 24.2077 4.65136 8;
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66 26.2008 4.48538 8; 67 28.1939 4.31943 8; 68 30.187 4.15346 8;

69 0 2.655 2.66667; 70 0 2.655 5.33333; 71 31.8896 -0.000428162 2.66667;

72 31.8896 -0.000428162 5.33333; 73 1.9931 2.48904 2.66667;

74 1.9931 2.48904 5.33333; 75 3.9862 2.32308 2.66667;

76 3.9862 2.32308 5.33333; 77 5.97931 2.15711 2.66667;

78 5.97931 2.15711 5.33333; 79 7.97241 1.99114 2.66667;

80 7.97241 1.99114 5.33333; 81 9.96551 1.82518 2.66667;

82 9.96551 1.82518 5.33333; 83 11.9586 1.65921 2.66667;

84 11.9586 1.65921 5.33333; 85 13.9517 1.49325 2.66667;

86 13.9517 1.49325 5.33333; 87 15.9448 1.32729 2.66667;

88 15.9448 1.32729 5.33333; 89 17.9379 1.16131 2.66667;

90 17.9379 1.16131 5.33333; 91 19.931 0.995351 2.66667;

92 19.931 0.995351 5.33333; 93 21.9242 0.829388 2.66667;

94 21.9242 0.829388 5.33333; 95 23.9172 0.663434 2.66667;

96 23.9172 0.663434 5.33333; 97 25.9103 0.49747 2.66667;

98 25.9103 0.49747 5.33333; 99 27.9034 0.331508 2.66667;

100 27.9034 0.331508 5.33333; 101 29.8965 0.165535 2.66667;

102 29.8965 0.165535 5.33333;

MEMBER INCIDENCES

1 2 20; 2 1 5; 3 1 69; 4 3 71; 5 5 6; 6 6 7; 7 7 8; 8 8 9; 9 9 10; 10 10 11;

11 11 12; 12 12 13; 13 13 14; 14 14 15; 15 15 16; 16 16 17; 17 17 18; 18 18 19;

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142 60 27; 143 53 18; 144 52 17; 145 51 16; 146 50 15; 147 49 14; 148 48 13;

149 47 12; 150 39 6; 151 40 7; 152 41 8; 153 42 9; 154 43 10; 155 44 11;

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189 52 66; 190 69 70; 191 70 2; 192 71 72; 193 72 4; 194 73 74; 195 74 20;

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203 82 24; 204 83 84; 205 84 25; 206 85 86; 207 86 26; 208 87 88; 209 88 27;

210 89 90; 211 90 28; 212 91 92; 213 92 29; 214 93 94; 215 94 30; 216 95 96;

217 96 31; 218 97 98; 219 98 32; 220 99 100; 221 100 33; 222 101 102;

223 102 34; 224 69 73; 225 73 75; 226 75 77; 227 77 79; 228 79 81; 229 81 83;

230 83 85; 231 85 87; 232 87 89; 233 89 91; 234 91 93; 235 93 95; 236 95 97;

237 97 99; 238 99 101; 239 101 71; 240 70 74; 241 74 76; 242 76 78; 243 78 80;

244 80 82; 245 82 84; 246 84 86; 247 86 88; 248 88 90; 249 90 92; 250 92 94;

251 94 96; 252 96 98; 253 98 100; 254 100 102; 255 102 72;

START GROUP DEFINITION

MEMBER

_LONGBOTTOM 1 2 5 TO 34

_LONGTOP 73 TO 86 88 TO 101

_BOTTOMCROSS 3 4 106 TO 120 190 TO 223

_TOPCROSS 121 TO 135

_VERTICAL 39 TO 68

_TOPCROSSBRACING 164 165 168 169 172 173 176 177 180 181 184 185 188 189

_DIAGONAL 102 TO 105 136 TO 163

_SAEINCLMEMBER 102 TO 105

_FLOOR 1 TO 34 106 TO 120 190 TO 255

END GROUP DEFINITION

MEMBER PROPERTY INDIAN

121 TO 135 TABLE FR ISMC250

136 TO 163 TABLE FR ISMC250

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39 TO 68 TABLE FR ISMC350
164 165 168 169 172 173 176 177 180 181 184 185 188 189 TABLE FR ISMC200
3 4 106 TO 120 190 TO 223 TABLE FR ISMC350
73 TO 86 88 TO 105 TABLE FR ISMC400
1 2 5 TO 34 TABLE FR ISMC400
224 TO 255 TABLE FR ISMC350
DEFINE MATERIAL START
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 78.5
ALPHA 1.2e-005
DAMP 0.03
TYPE STEEL
STRENGTH FY 250000 FU 410000 RY 1.5 RT 1.2
END DEFINE MATERIAL
CONSTANTS
MATERIAL STEEL ALL
SUPPORTS
1 2 PINNED
3 4 FIXED BUT FX MX MY MZ
DEFINE 1893 LOAD
ZONE 0.36 RF 4 I 1.5 SS 2 ST 2 DM 0.05
SELFWEIGHT 1
MEMBER WEIGHT
1 2 4 TO 34 106 TO 120 192 TO 255 UNI 2.5
LOAD 100 LOADTYPE None  TITLE EQX
1893 LOAD X 1
LOAD 101 LOADTYPE None  TITLE EQZ
1893 LOAD Z 1
LOAD 1 LOADTYPE None  TITLE SW
SELFWEIGHT Y -1.1
MEMBER LOAD
```

```
106 TO 120 194 TO 223 UNI GY -1.335
1 2 5 TO 34 UNI GY -0.5
224 TO 255 UNI GY -1
3 4 190 TO 193 UNI GY -0.667
LOAD 2 LOADTYPE None  TITLE VEHICLE LOAD
MEMBER LOAD
106 TO 120 194 TO 223 UNI GY -10
224 TO 255 UNI GY -5
1 2 5 TO 34 UNI GY -2.5
3 4 190 TO 193 UNI GY -6
LOAD 3 LOADTYPE None  TITLE ROOF LOAD
MEMBER LOAD
121 TO 135 UNI GY -3
LOAD 4 LOADTYPE None  TITLE WIND LOAD
MEMBER LOAD
73 TO 86 UNI GZ 7.4
2 5 TO 19 UNI GZ 6.5
39 TO 53 UNI GZ 2.83
102 105 143 TO 156 UNI Z 1.5
LOAD 5 LOADTYPE None  TITLE temp exp
TEMPERATURE LOAD
1 TO 34 39 TO 68 73 TO 86 88 TO 165 168 169 172 173 176 177 180 181 184 185 -
188 TO 255 TEMP 10
LOAD 6 LOADTYPE None  TITLE temp shrink
TEMPERATURE LOAD
1 TO 34 39 TO 68 73 TO 86 88 TO 165 168 169 172 173 176 177 180 181 184 185 -
188 TO 255 TEMP -10
LOAD COMB 7 1.5 dl+ll)
1 1.5 2 1.5 3 1.5
LOAD COMB 8 1.5 dl +Wl
1 1.5 4 1.5
LOAD COMB 9 1.5 DL+ EQx
100 1.5 1 1.5
```