

PRITHVI GEOSPATIAL LABS LLP-AN ISO CERTIFIED COMPANY

**THE GEOTECHNICAL INVESTIGATION WORK FOR HARIDWAR
ROPEWAY FROM HAR KI PAURI TO CHANDI DEVI**

AT LOCATIONS 1. AT LOWER TERMINAL- LAT.-29.95361725N

LONG.-78.17332202E

AND 2. TOWER NO.5-

LAT.-29.94652429N

LONG.-78.17593977E

SUBMITTED TO-: UKMRC DEHRADUN



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ASSOCIATION WITH PARMAR TESTING

LAB AND RESEARCH CENTRE

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REPORT ON
GEOTECHNICAL INVESTIGATION FOR
Ropeway Project from Hari Ki Pauri to Chandni Devi

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1. INTRODUCTION

There is a proposal by M/s Prithvi Geospatial Labs LLP. to Parmar Testing Lab & Research Centre, Dehradun (U.K.). The job for boring bore holes, in-situ testing, soil sampling and determination of safe bearing capacity (SBC) was awarded by M/s Prithvi Geospatial Labs LLP . to M/s Parmar Testing Lab & Research Centre Dehradun (U.K.) Dated: 23/02/2021

2. SCOPE OF WORK

1. Drilling of 2 nos. of boreholes up to a depth of 4.5m below existing ground surface or refusal whichever occurs earlier.
2. Conducting Standard Penetration Test at 1.5 m depth interval or at change of strata.
3. Collection of disturbed and undisturbed soil samples from drill holes at 1.5m depth interval.
4. Recording of Ground Water Table upto the depth of investigation.
5. Conducting various laboratory tests on soil samples and water samples collected from boreholes.
6. Preparation and submission of this technical report stating safe bearing capacity of soil sub strata.

LOCATIONS OF BOREHOLES

BH No.	LOCATION	DEPTH
1.	Dhobhi Ghat Hari Ki Pauri	4.5 m
2.	Pillar No. 5 Near Kali Mandir	4.5 m

3. INVESTIGATIONS CONDUCTED

This report contains the details of field investigations, Laboratory tests and the recommendations based upon them.

The various results have been presented under two heads, i.e.

- (i) The field tests
- (ii) The laboratory tests



3.1 The field tests include:

- (a) Boring at the proposed site for the purpose of obtaining soil samples from every stratum encountered by the boring tools. Depending upon the type of soil, both disturbed & undisturbed samples were collected. They are needed for various tests to be conducted in the laboratory.
- (b) Standard Penetration tests (SPT) is meant for measuring the penetration resistance of the soil, which is measure of its bearing capacity in-situ. This test is particularly suited to cohesion less soils which are difficult and expensive to be sampled in the undisturbed state.

3.2 The laboratory tests include :

- (a) Bulk density, Dry Density and moisture content of the soil samples at various levels for the estimation of overburden correction in the observed penetration resistance of the soil and for bearing capacity computation from shear failure consideration.
- (b) Grain Size analysis (sieve analysis and hydrometer analysis) of the soil samples for the purpose of soil classification and preparation of Log of the boreholes.
- (c) Atterberg limits test i.e. the liquid limit, plastic limit and plasticity index of fine grained soils passing through 425 micron IS sieve. They give an idea about the type of soil and consistency of soil, i.e. the degree of firmness of a soil to bear external loads imposed on it.
- (d) Shear strength parameters: i.e. the soil cohesion (c) and its angle of internal friction (ϕ). These are needed for the estimation of bearing capacity (B.C.) from shear consideration by Tri-axial/Direct shear Methods.
- (e) Consolidation Properties: The consolidation parameters are required for knowing the ultimate settlements of clayey strata.
- (f) Specific Gravity Tests

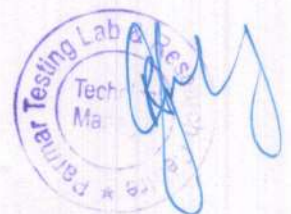
4. FIELD TESTS

The purpose of various field tests required during sub-surface explorations for the foundation of a structure has already been discussed; a brief discussion of these tests is given below:

4.1 BORING AND SAMPLING

Boring was done at 2 locations up to 4.5 m depth from ground for Ropeway Project from Hari Ki Pauri to Chandi Devi, These boreholes have been designated as **B.H. 1, B.H. 2**

Representative soil samples were collected from this borehole at a vertical interval of 1.5m or from depth at which a change in stratum occurred. Disturbed soil samples were collected from SPT sampler while undisturbed soil samples were collected in a Shelby tube (a thin tube sampler) of 38 mm dia and



450 mm long by inserting these tubes in the soil with hydraulic pressure to minimize disturbance. The soil samples were sealed by wax on both sides to avoid any moisture loss and transported to laboratory.

Depending upon the type of soil strata exists in the borehole; a number of undisturbed & disturbed soil samples were collected.

4.2 STANDARD PENETRATION TEST

The boring was supplemented by standard penetration tests (S.P.T.) at 1.5 m interval from top to drilled depth in the bore hole. These tests were conducted in accordance with the procedure laid down in IS:2131-1981 " Method of Standard Penetration Tests for soils" and N-Values (Soil Penetration resistance) were obtained by driving a split spoon sampler 30cm into the ground after giving 15 cm of initial seating drive at respective intervals or at change of strata. N value is the number of blows required to penetrate the SPT sampler 30 cm in the sub strata when it is subjected to an impact load given by a 63.5 kg hammer when it falls freely from 75 cm height.

5. LABORATORY TESTS

To know about the type of soil and to confirm & supplement the information obtained from field tests about the nature of soils strata, laboratory tests as given below were conducted on the soil samples collected from the boreholes at the time of drilling.

5.1 BULK DENSITY TEST

Bulk density determinations were carried out on undisturbed soil samples collected from the boreholes. The results of dry density are calculated from bulk density.

5.2 MOISTURE CONTENT

Moisture Content of undisturbed soil samples was determined by oven drying method to find out In situ Dry Density of soil.

5.3 PARTICLE SIZE ANALYSIS OF SOIL

This was done as per IS: 2720 (Part-IV) – 1985. Samples collected from the borehole were subjected to mechanical analysis for particle size distribution and classification of the soil at proposed site. The analysis was done by wet sieving for particles bigger than 75 micron and by hydrometer analysis for particles finer than 75 micron. Grain size distribution curves of all the soil samples were plotted and are given in figures.



5.4 ATTERBERG LIMITS

For fine-grained cohesive soils, the soil consistency was determined to check their firmness. This was done by determining the liquid limit, plastic limit and plasticity index of such soil samples according to the procedure laid down in IS :2720 Part-V – 1985, “Determination of Liquid and Plastic Limits”.

5.5 SHEAR STRENGTH PARAMETERS

The Shear strength Parameters were determined by Direct Shear tests and Tri-axial tests. Direct Shear tests were conducted on cohesionless soils by packing them at in-situ density in a remoulded state and at saturated conditions. These shear parameters are important from the point of view to check the bearing capacity of the soil of proposed site against shear failure and also for the design of foundation.

5.6 CONSOLIDATION PARAMETERS

Consolidation tests were performed on clayey soil samples on which consolidation settlement is expected. These are important in finding out immediate and final settlement of the sub soil due applied loads.

5.7 SPECIFIC GRAVITY TEST

Specific Gravity of all the undisturbed soil samples was determined by specific gravity bottles.

6. TESTS RESULTS

BH-1, Dhobhi Ghat Hari Ki Pauri Parking -The results of sub-surface explorations of borehole at the site of the proposed structure shows that stratum mainly consist of Gravel Mix Clay Soil upto drilled depth. Of 4.5m Water Table was not encountered at a depth of 4.5m during investigation.

BH-2, Pillar No. 5 Near kali Mandir- The results of sub-surface explorations of borehole at the site of the proposed structure shows that stratum mainly consist of Gravel Mix Clay Soil upto drilled depth. Of 4.5m Water Table was not encountered at a depth of 4.5m during investigation.

The results obtained from field and laboratory investigations carried out on soil samples collected from the borehole at the proposed site are discussed below:

6.1 BULK UNIT WEIGHT

The average bulk density, in-situ moisture content and dry density of the undisturbed soil sample collected from these boreholes is tabulated in log of boreholes.



6.2 PARTICLE SIZE ANALYSIS

The results of Particle Size analysis of the soil samples collected from the boreholes are tabulated in log of boreholes. The description of various soil strata and B.I.S: Soil Classification of strata encountered in these boreholes up to a depth of 3.0m below O.G.L. is also shown in the Log of Boreholes.

6.3 ATTERBERG LIMITS

The Liquid Limit (L.L.), Plastic Limit (P.L.) and Plasticity Index (P.I.) for various fine-grained soil samples collected from these boreholes is given in log of boreholes.

6.4 SHEAR STRENGTH & CONSOLIDATION PARAMETERS

Direct shear tests were performed on some selected soil samples in saturated conditions from each borehole. The samples having some clay were tested by tri-axial test. The results of Shear tests and consolidation tests on Soil Samples collected from various depths are given in log of boreholes.

6.5 STANDARD PENETRATION TEST

The result of these tests for the borehole are calculated for Observed N values and Corrected N values & plotted as P.R. Curves for observed penetration resistance (N-Values) as well as corrected penetration resistance (N-Values) are given in Log of Borehole & in Figure of each borehole. The observed values of 'N' have been corrected for overburden pressure by the following formula.

$$N' = (0.77 \log_{10} 20/p) N \quad \dots\dots\dots (1)$$

where N = observed value for penetration resistance in no. of blows per 30cm penetration of sampler.

N' = Value of penetration resistance corrected for overburden pressure

p = Overburden pressure in Kg/cm²

7. COMPUTATION OF BEARING CAPACITY

A properly designed foundation must satisfy the following basic requirements:

- (i) Foundation must be safe against the shear failure of the supporting soil.
- (ii) The settlement of foundation must be within permissible limit.

The bearing capacities have been determined separately to satisfy both the above mentioned requirements and the smaller of the two values has been recommended as the allowable bearing capacity.



7.1 BEARING CAPACITY FROM SHEAR CONSIDERATIONS

In shear, a foundation can fail in any of the three different ways viz.

- (i) Local shear failure
- (ii) General shear failure
- (iii) In between the above two

The local Shear Failure is assumed to occur for ϕ less than 28.5° & general shear failure for $\phi > 36^\circ$ & between these limiting value of ϕ , interpolated values for local & general shear failure can be determined. In this case bearing capacity for shear failure consideration has been determined.

Adopting a Square foundation over the whole plot and taking the depths 3.0 m below O.G.L. and using Eq.2 below as per code IS 6403 – 1981: “Code of practice for determination of bearing capacity of shallow foundations” and also using codes IS 8009 (Part I) - 1978: Code of practice for calculation of settlements of foundations and IS: 1904-1978 “Structural Safety for Buildings: Shallow Foundation” SBC has been determined.

$$q_a = \frac{1}{F} \left[\frac{2}{3} C N'_c s_c d_c i_c + \gamma D_f (N'_q - 1) s_q d_q i_q + 0.5 \gamma B N'_\gamma s_\gamma d_\gamma i_\gamma W' \right] + \gamma D_f \quad (2)$$

- where q_a = Allowable Safe Bearing Capacity
 F = Factor of safety taken as 2.5
 C_m = Modified cohesive strength
 γ = Unit Weight of Soil
 D_f = Depth of foundation
 B = Width of foundation
 N'_c, N'_q, N'_γ = Modified bearing capacity factors
 s_c, s_q, s_γ = Shape factors
 d_c, d_q, d_γ = Depth factors
 i_c, i_q, i_γ = Inclination factor

7.2 BEARING CAPACITY FROM SETTLEMENT CRITERIA

The net allowable Bearing Capacity based on the maximum settlement of foundation to 50 mm has been computed as per IS: 8009.

The foundation should not settle or deflect to an extent causing damage to structure or impair its usefulness. The bearing capacity calculation for foundation shall be governed by IS 1904-1986, IS 6403-1981, and I.S. 8009-1981 (part-I & II) - 1976 on the basis of available information regarding the proposed design have been done.



8. RECOMMENDATIONS

The safe bearing capacity of the soil stratum has been calculated by shear failure criteria and the same is checked for the settlement. If the settlement is within the permissible limit then the SBC derived by shear failure criteria is ok otherwise it has been reduced in such a way that settlement is within permissible limits.

BH-1, at Dhobhi Ghat Hari Ki Pauri Parking

Recommended Net Safe Bearing Capacity

Depth in m	NET SAFE BEARING CAPACITY (Ton/Sq.mtr.)		
	Shear	Settlement	Recommended
1.50	5.1	2.0	2.0
3.00	9.7	6.9	6.9
4.5	12.1	11.6	11.6

BH-2, at Pillar No. 5 Near Kali Mandir

Recommended Net Safe Bearing Capacity

Depth in m	NET SAFE BEARING CAPACITY (Ton/Sq.mtr.)		
	Shear	Settlement	Recommended
M	T/m ²	T/m ²	T/m ²
1.5	12.2	8.1	8.1
3.0	23.1	13.9	13.9
4.5	28.0	20.8	20.8



9.0 CLOSURE

We appreciate the opportunity given to Parmar Testing Lab & Research Centre, Dehradun (UK) to conduct the soil investigation (lab and field tests) and to submit this technical report. This presented report is based on observations made in field and tests conducted on samples collected from two boreholes. In case of any deviation in soil strata from reported one or abnormal/abrupt change in soil sub strata is noticed during actual excavation, kindly contact us before proceeding with further construction to take remedial measure, if any, required for safety of structure.


For Parmar Testing Lab & Research Centre, Dehradun (UK)

10. REFERENCES

1. IS 6403 – 1981: Code of Practice for Determination of Bearing Capacity of Shallow Foundations.
2. IS 8009 (Part I) - 1978: Code of Practice for Calculation of Settlements of Foundations.
3. IS: 1904-1978 “Structural Safety for Buildings: Shallow Foundation”.
4. Foundation design manual, N. V. Nayak, 4th edition, 1996.
5. Soil Mechanics and foundation engineering, V. N. S. Murthy, 4th edition.
6. Foundation analysis and design, Joseph E. bowels.
7. IS-1498, IS-2131 and various parts of IS-2720



LOG OF BOREHOLE, BH-1

NAME OF WORK					BH NO. 1		
SOIL INVESTIGATION DONE FOR Ropeway Project from Hari Ki Pauri to Chandi Devi					BH-1 Dhobhi Ghat Hari Ki Pauri Parking		
DATE OF DRILLING				TERMINAL DEPTH		WATER TABLE (m)	
23/02/2021				4.5		NIL	
DEPTH M	OBSERVED VALUE	CORRECTED VALUE	SAMPLE TYPE	SAMPLE DEPTH IN M	DESCRIPTION OF STRATA	LOG	IS SOIL CLASSIFICATION
0.50			DS	0.50-0.75	GRAVEL MIX SILTY SAND		SM
1.5	5	8	SPT-1	1.50-1.95			
3.0	6	9	SPT-2	3.0-3.45			
4.5	8	11	SPT-3	4.5-5.25			



LABORATORY TEST RESULTS, BH-1

SAMPLE DEPTH IN M	SAMPLE NO.	GRAIN SIZE ANALYSIS							ATTERBERG LIMITS			DENSITY & MOISTURE CONTENT			SHEAR PARAMETERS		
		CLAY	SILT	FINE SAND	MED SAND	COARSE SAND	GRAVEL	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	BULK DENSITY	MOISTURE CONTENT	DRY DENSITY	TEST	C	Ø	
		<0.002 mm	0.002-0.075	0.075-0.425	0.425-2.00	2.00-4.75	>4.75 mm	%	%	%	%	gm/cc	%	gm/cc	TYPE	Kg/cm ²	deg.
0.50	DS	9.2	12.1	17.7	18.6	11.2	31.2	20.7	ND	NP	2.28	7.2	2.13	-	-	-	-
1.5	SPT-1	8.5	13.6	18.9	17.0	13.6	28.4	21.2	ND	NP	-	-	-	-	-	-	-
3.0-4.5	SPT-2	10.0	12.5	16.8	18.1	12.5	30.1	20.5	ND	NP	-	-	-	DIR	0.00	29.2	



SAFE BEARING CAPACITY ANALYSIS BASED ON SHEAR CRITERIA, BH 1

W =	0.5	sq	$c =$	$\phi =$	ρ_c	λ	$\lambda \rho_c$	ρ_i	$M =$	$E, t/m^2 =$	$I_{pm} =$
Gen.1	1								1000	15000	3.568
Local:	0.667										
Foundation		Cor'ction factor						Poisson's ratio,		$\mu =$	0.5
Depth	Length										
D [m]	B [m]	$q_{nf}/2.5$						ρ_t		$\rho_{permissible}$	Re-
L, m =	L, m =	t/m^2						mm		mm	marks
1.5	2	5.1						1.8		75	*
1.5	3	5.5						3.0		75	OK
1.5	10	9.4						16.8		100	*
3.0	2	9.7						3.5		75	OK
3.0	3	9.8						5.2		75	*
3.0	10	13.2						23.5		100	*
4.5	2	12.1						4.3		75	OK
4.5	3	9.2						4.9		75	*
4.5	10	8.4						15.0		100	*

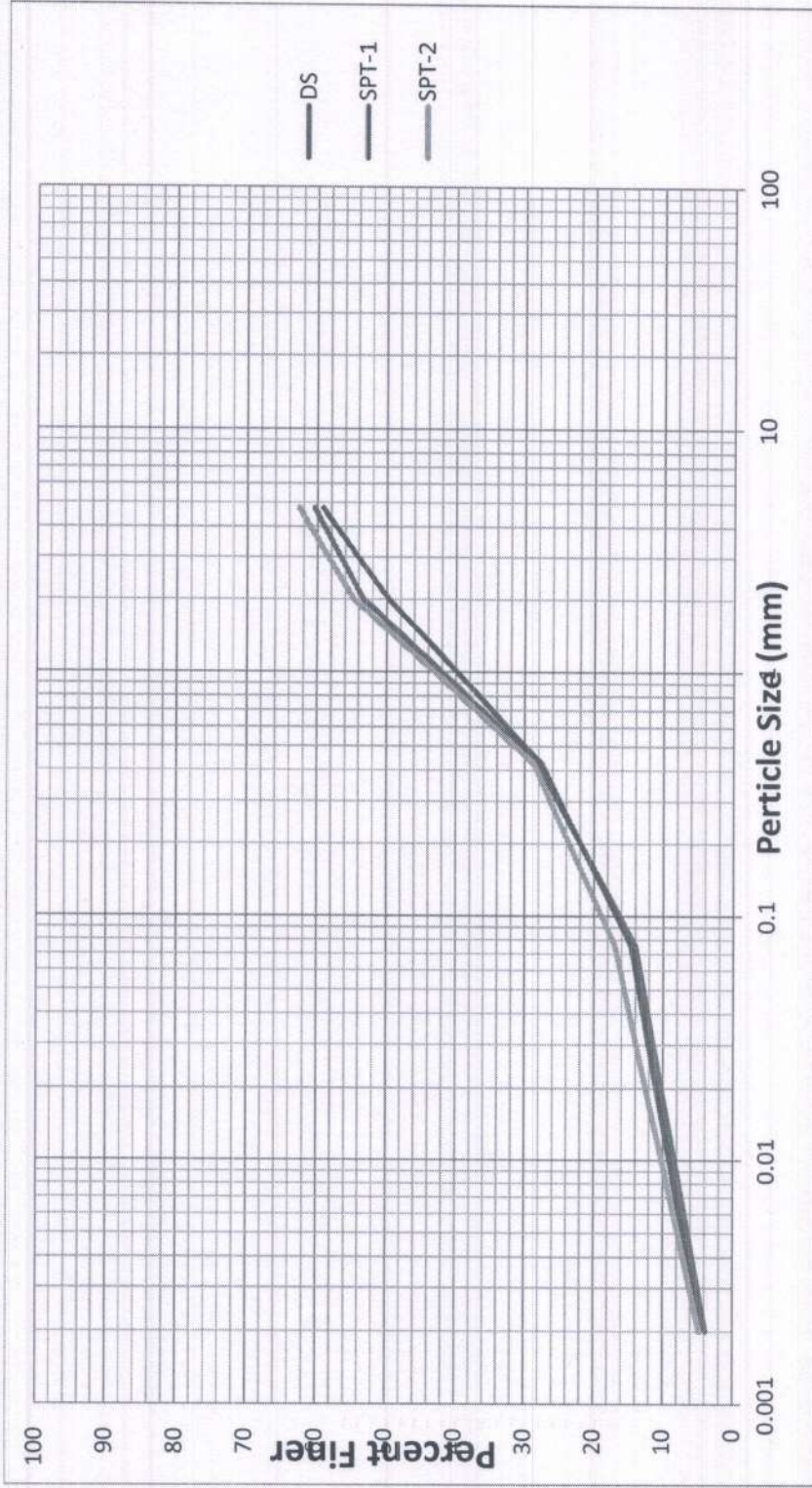


SAFE BEARING CAPACITY ANALYSIS BASED ON SETTLEMENT CRITERIA, BH 1

Foundation		B [m]	F _d =	N ["]	W'	q _{s=25} t/m ²	Permiss. S [mm]	q _{s=s} t/m ²
Depth [m]	Width							
1.5	2.0	1.75	4	0.5	1.013	50	2.0	
1.5	3.0	1.50	4	0.5	0.794	50	1.6	
1.5	10.0	1.15	4	0.5	0.534	75	1.6	
3.0	2.0	2.00	6	0.5	3.472	50	6.9	
3.0	3.0	2.00	5	0.5	2.118	50	4.2	
3.0	10.0	1.30	5	0.5	1.207	75	3.6	
4.5	2.0	2.00	8	0.5	5.786	50	11.6	
4.5	3.0	2.00	8	0.5	5.294	50	10.6	
4.5	10.0	1.45	8	0.5	3.365	75	10.1	




GRAIN SIZE DISTRIBUTION CURVES, BH-1



[Handwritten Signature]
Parimar Testing Lab & Research Centre
Technical Manager

Prithvi Geotechnical Labs LLP
Pin-249201
Date.....
RISHIKESH

LOG OF BOREHOLE, BH-2

NAME OF WORK					BH NO. 2		
SOIL INVESTIGATION DONE FOR Ropeway Project from Hari Ki Pauri to Chandi Devi					BH-2 Pillar No. 5 Near Kali Mandir		
DATE OF DRILLING				TERMINAL DEPTH	WATER		
23/02/2021				4.5	NIL		
DEPTH M	OBSERVED VALUE	CORRECTED VALUE	SAMPLE TYPE	SAMPLE DEPTH IN M	DESCRIPTION OF STRATA	LOG	IS SOIL CLASSIFICATION
0.50			DS	0.50-0.75	GRAVEL MIX SILTY SAND		SM
1.50	8	11	SPT-1	1.50-1.95			
3.00	10	13	SPT-2	3.00-3.45			
4.5	10	14	SPT-3	4.5-5.25			



LABORATORY TEST RESULTS, BH-2

SAMPLE DEPTH IN M	SAMPLE NO.	GRAIN SIZE ANALYSIS							ATTERBERG LIMITS			DENSITY & MOISTURE CONTENT			SHEAR PARAMETERS		
		CLAY	SILT	FINE SAND	MED SAND	COARSE SAND	GRAVEL	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	BULK DENSITY	MOISTURE CONTENT	DRY DENSITY	TEST	C	φ	
0.50	DS	7.2	15.2	19.6	17.1	12.2	28.7	19.6	ND	NP	2.22	6.5	2.08	-	-	-	
1.50	SPT-1	8.6	13.4	17.7	19.1	15.0	26.2	20.4	ND	NP	-	-	-	-	-	-	
3.0-4.5	SPT-2	7.9	14.1	18.1	18.6	13.4	27.9	19.8	ND	NP	-	-	-	DIR	0.00	29.0	



SAFE BEARING CAPACITY ANALYSIS BASED ON SHEAR CRITERIA, BH 2

W =	0.5	sq		λ	deg.	$\lambda \rho_c$		$S_u, N/m^2$		M =		$E, N/m^2$		$I_{pm} =$	
Gen.1	1	c =	0	ρ_c	mm	ρ_i	mm	15	1000	15000	3.568				
Local:	0.667	$\phi =$	28.0	mm	0.0	mm	4.3	Poisson's ratio,		$\mu =$	0.5				
Foundation		Correction factor	6.8	$\lambda =$	0.8	mm	7.2								
Depth	Width	Length	$q_{pr} / 2.5$	$\lambda \rho_c$	ρ_i	ρ_t	Permissible	Re-							
D [m]	B [m]	L, m =	t/m^2	mm	mm	mm	mm	marks							
1.5	2	2	12.2	0.0	4.3	4.3	75	*							
1.5	3	3	13.4	0.0	7.2	7.2	75	OK							
1.5	10	10	23.9	0.0	42.7	42.7	100	*							
3.0	2	2	23.1	0.0	8.3	8.3	75	OK							
3.0	3	3	23.4	0.0	12.5	12.5	75	*							
3.0	10	10	32.6	0.0	58.1	58.1	100	*							
4.5	2	2	28.0	121.1	10.0	131.1	75	OK							
4.5	3	3	27.0	164.4	14.5	178.9	75	*							
4.5	10	10	32.1	416.0	57.4	473.3	100	*							



SAFE BEARING CAPACITY ANALYSIS BASED ON SETTLEMENT CRITERIA, BH 2

Foundation		Width	B [m]	F _d =	N ^{''}	w'	Q _{s-25} t/m ²	Permiss. S [mm]	Q _{s-s} t/m ²
Depth	D [m]								
	1.5	2.0	1.75	7	0.5	4.050	50	8.1	
	1.5	3.0	1.50	7	0.5	3.176	50	6.4	
	1.5	10.0	1.15	7	0.5	2.135	75	6.4	
	3.0	2.0	2.00	9	0.5	6.943	50	13.9	
	3.0	3.0	2.00	9	0.5	6.353	50	12.7	
	3.0	10.0	1.30	9	0.5	3.620	75	10.9	
	4.5	2.0	2.00	12	0.5	10.415	50	20.8	
	4.5	3.0	2.00	12	0.5	9.529	50	19.1	
	4.5	10.0	1.45	12	0.5	6.057	75	18.2	



GRAIN SIZE DISTRIBUTION CURVES, BH-2

