CP301 Project

Civil Department

Bearing Capacity of Footings on Clays Improved by Stone Columns : A Numerical Study

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Introduction

- Welcome to our presentation on stone column ground improvement, a quick and effective method for reinforcing foundations.
- Stone column ground improvement involves adding vertical columns of stone into the ground to a depth of at least 4m below the ground surface, enhancing soil stability and load-bearing capacity.
- They offer a versatile solution for various construction projects, have good drainage capacity of the granular material within the columns.
- Join us as we explore the benefits and applications of this innovative technique in ensuring stable and durable foundations.

OBJECTIVE

Investigate and Analyze the effect of stone column on clayey soils.

Numerical simulations us ing **OPTUM G2** software , modelling of the soil-structure system.

Shear stress distribution, and ultimate bearing capacity of footings on clayey soils.

Now why only Stone Columns ?

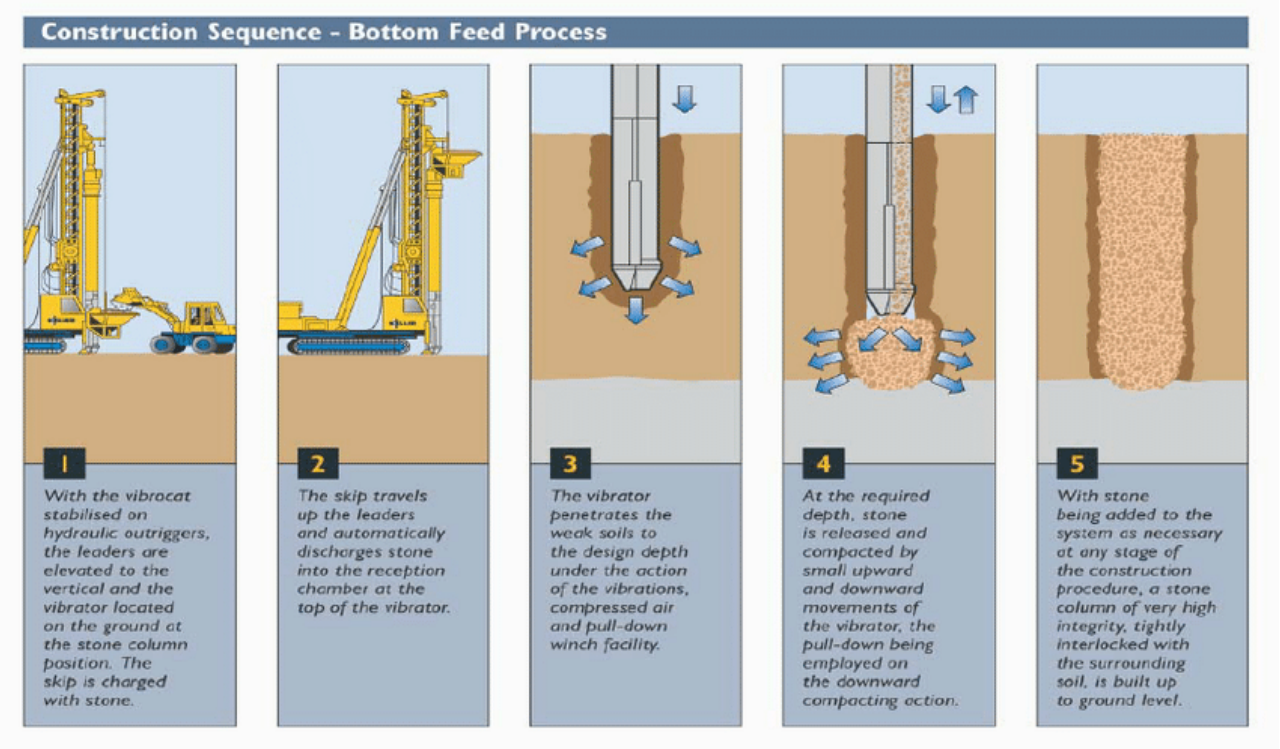
Compared to methods like deep soil mixing or jet grouting, which may require longer curing times and have less predictable performance, as high power vibrator are used which results on failure.

ADAVANTAGES OF STONE COLUMNS:-

-rapid installation process .
-good drainage capacity.
-withstand vertical and lateral loads, perfect for weak soils, such as clays.
-increasing the overall stiffness and strength of the ground.
-densification redistributes applied loads more uniformly.
-Prevent earthquake-induced lateral spreading.

Overall, The use of stone columns provides a robust solution for enhancing stability and bearing capacity in various geotechnical applications.

How Stone Columns are Made



https://youtu.be/XesKo2hHwu4?feature=shared

{ for Reference Youtube video link is attached }

Vibro-replacement or vibro-compaction method

↓

vibrator probe into the ground to the depth

↓

probe is withdrawn, filled with coarse granular material

↓

vibrator is activated, surrounding soil densifies around the granular material

↓

Results in stone column

TERZAGHI'S BEARING CAPACITY

$$Q_{ult.} = c\,N_c + \gamma\,D_f\,N_q + 0.5\,\gamma\,B\,N_\gamma$$

Where,

C = cohesion

γ = unit weight of the soil

Df = depth of foundation / footing

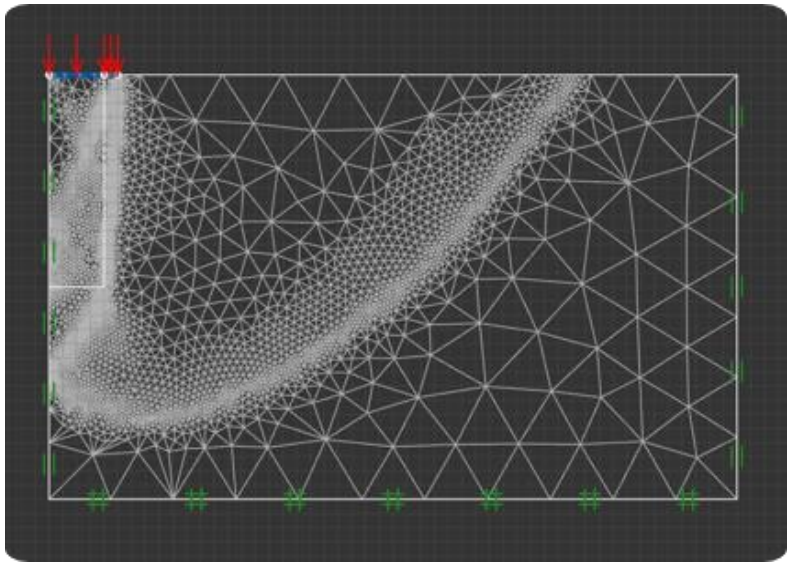
B = width of foot

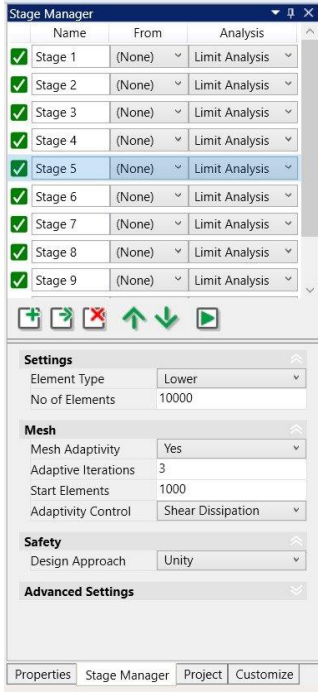
Nc, Nq, Nγ = bearing capacity factors.

Optum G2

G2

- Mesh

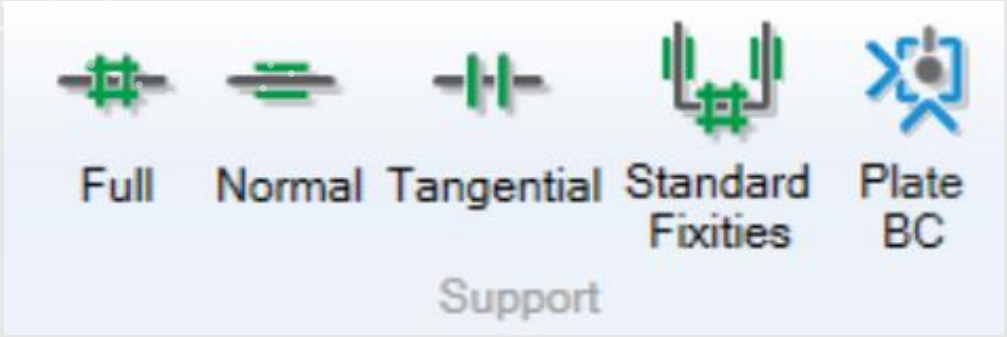




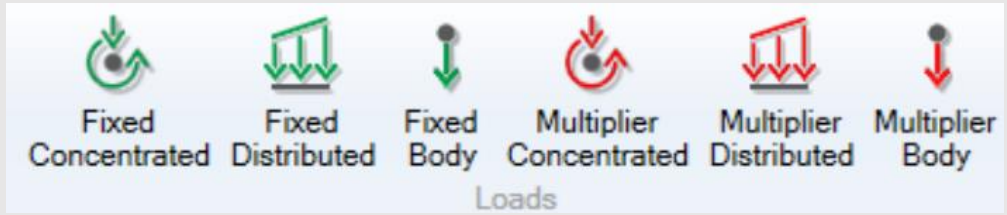
- limit analysis

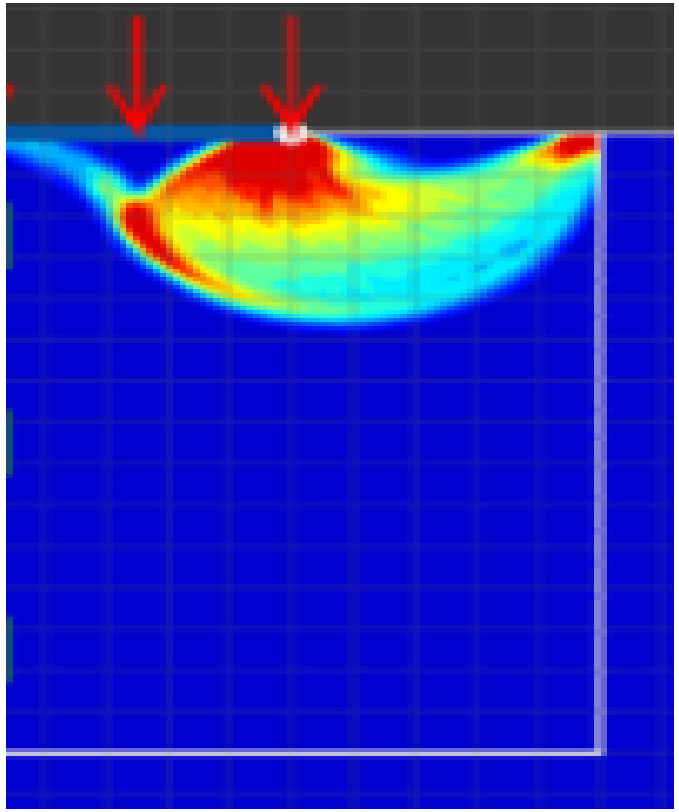
Tools used in the Optum G2 are:

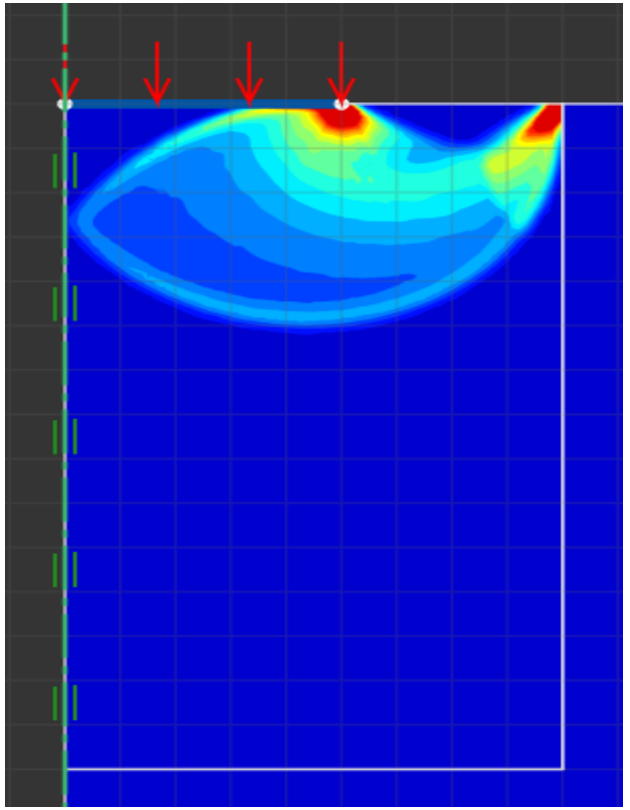
- Supports



- Loads

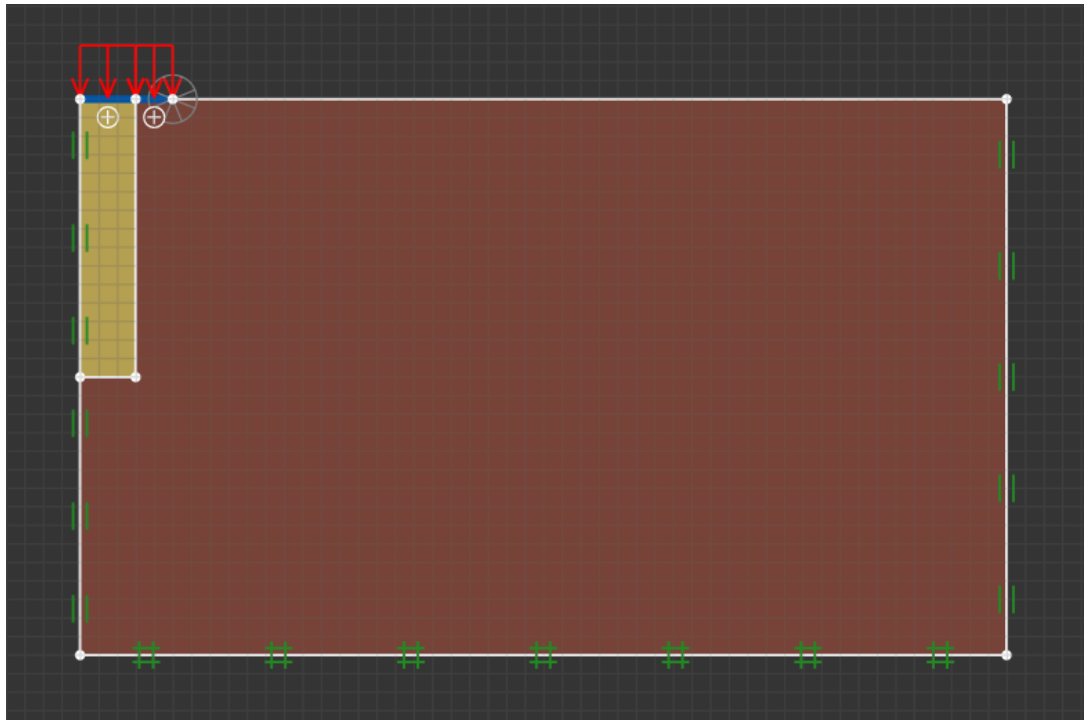






- Shear Dissipation

SCHEMATIC MODEL OF STRIP STONE COLUMN



Software Drawing

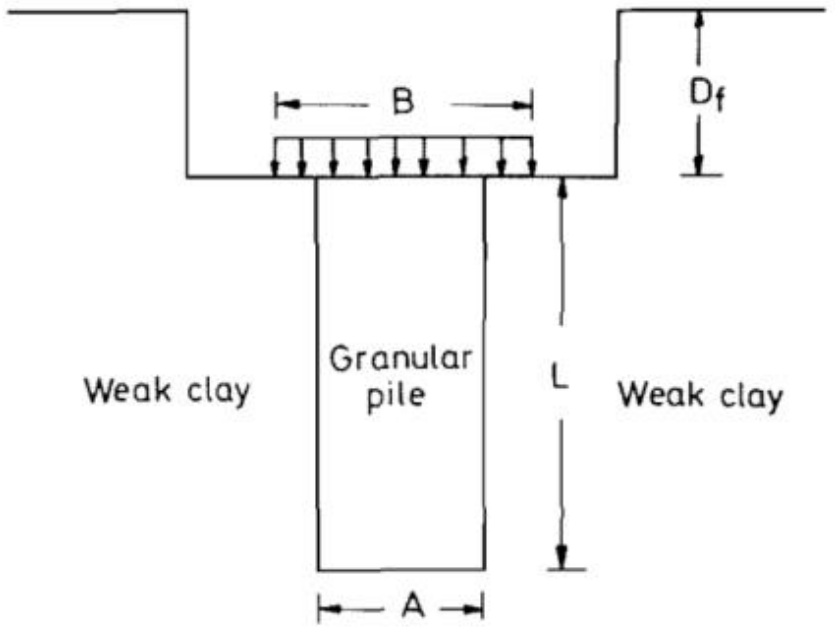


FIG. 1. Granular pile in weak clay.

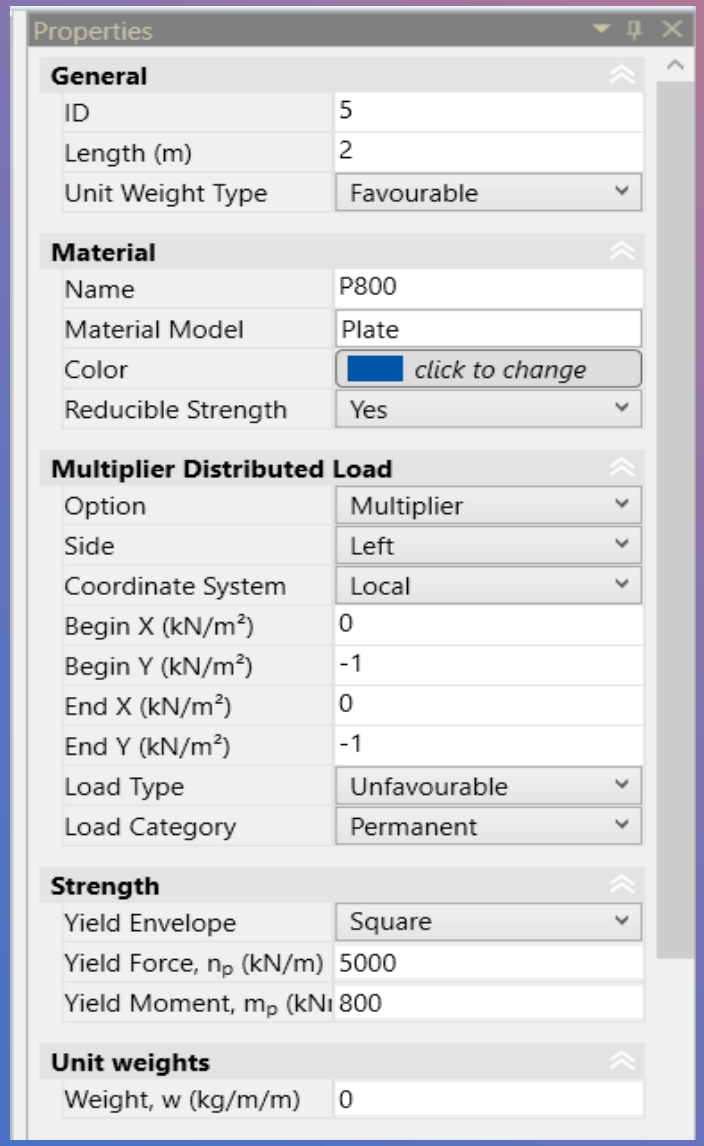
(Problem statement to find Nc, Nq and Ny for the footing)

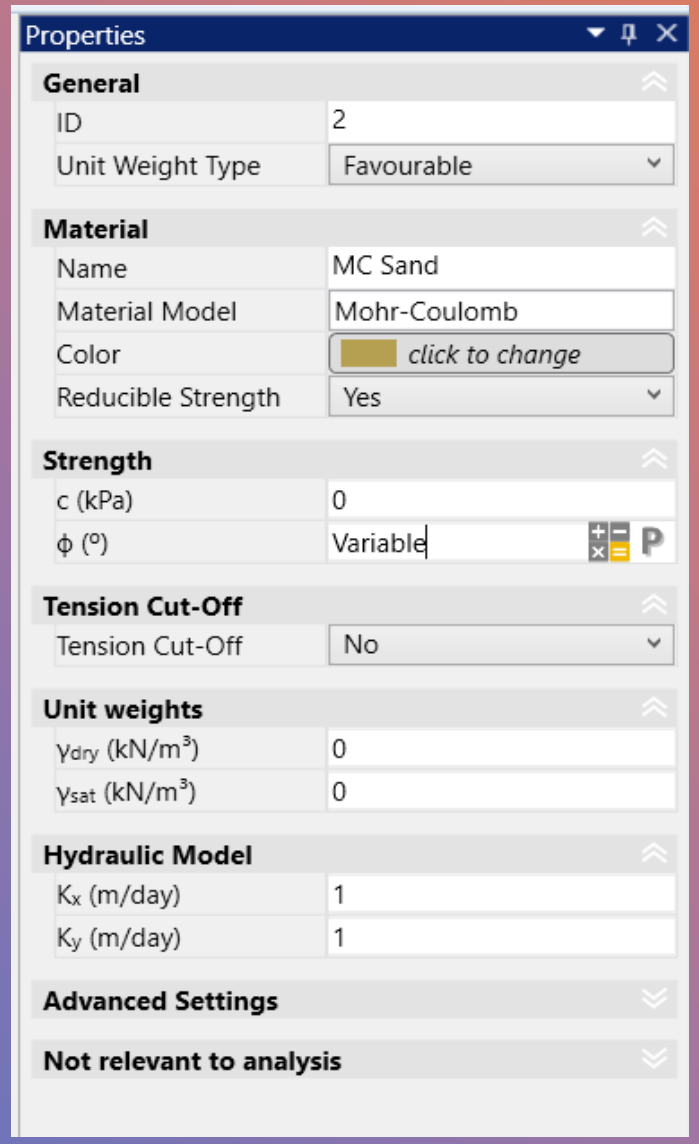
$$q_u = c\,N_c + qN_q + 0.5\,\gamma\,B\,N_\gamma$$

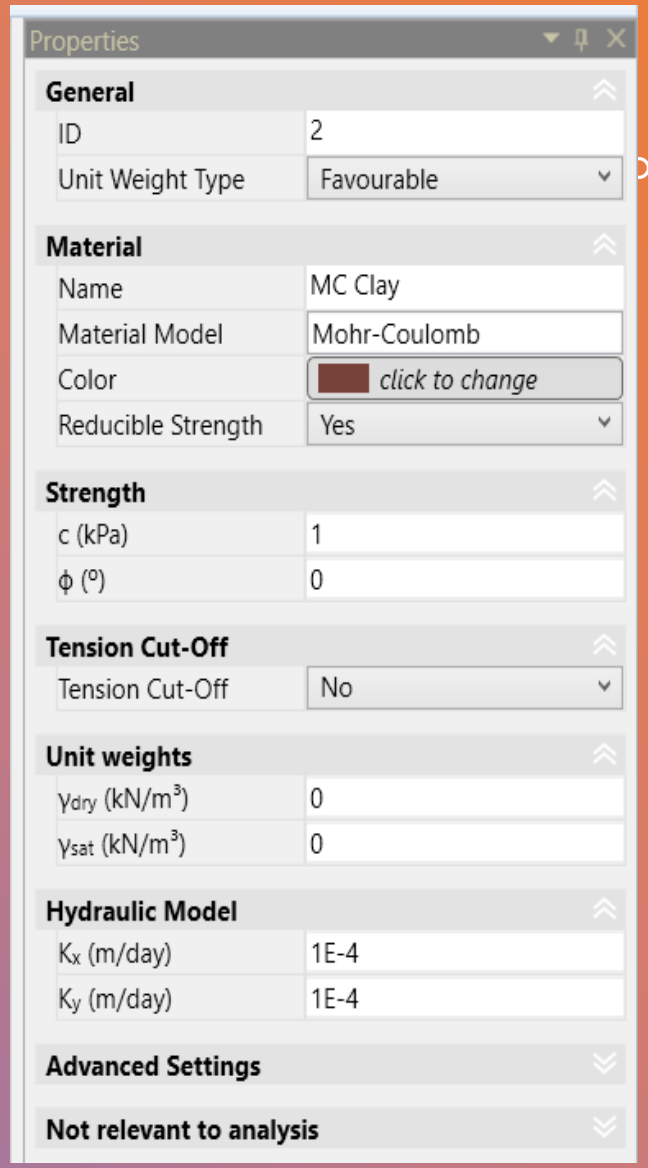
(cohesion (c= 1) and q(surcharge) = 0 and y=0).

$$N_c = q_u / c$$

MATERIAL PROPERTIES





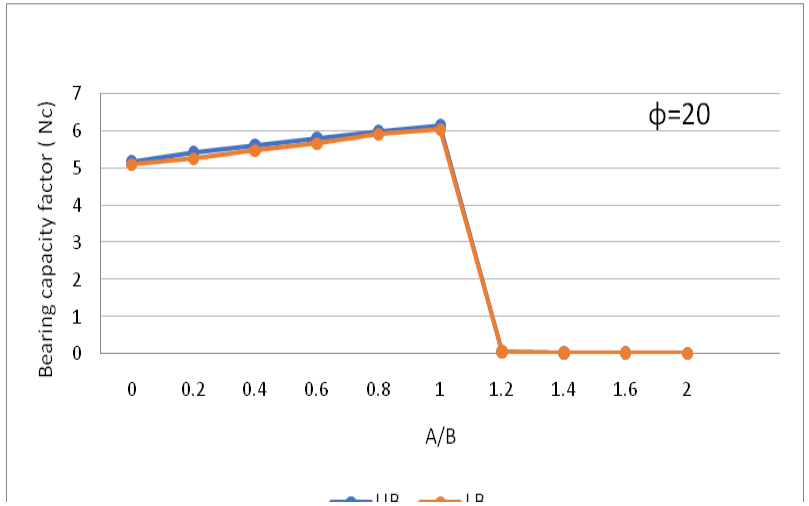


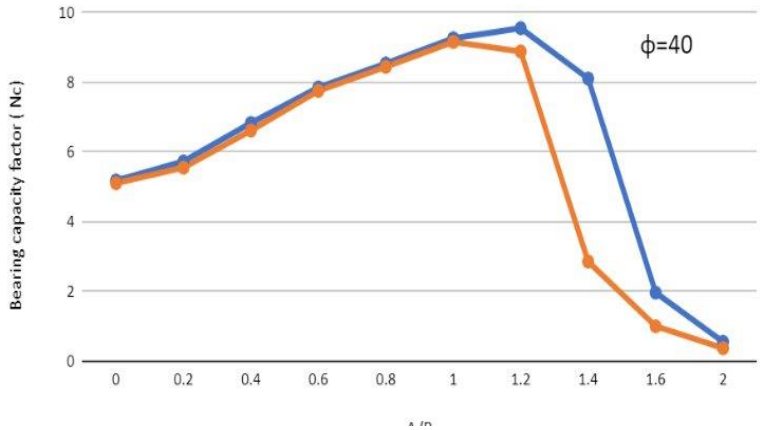
Variation of different ϕ values w.r.t to A/B Ratio

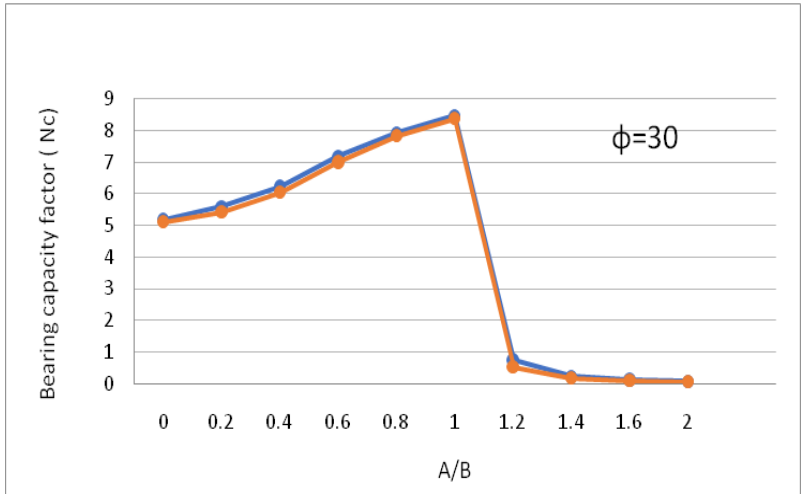
{ for Nc }

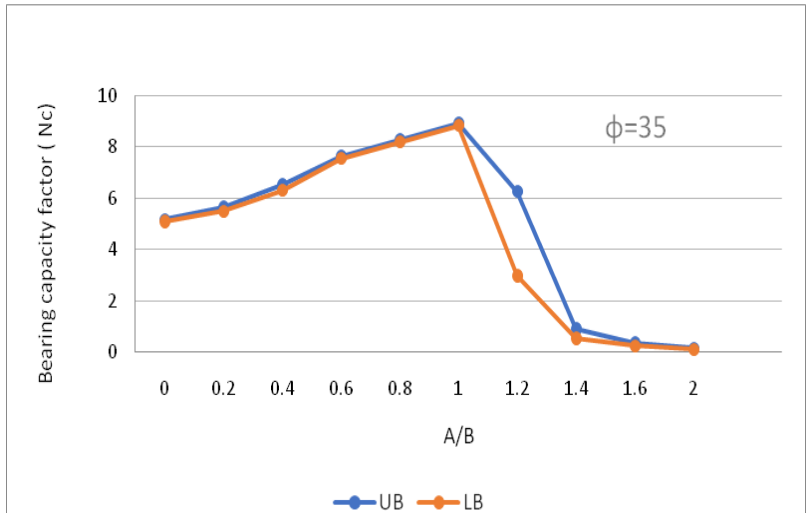
				ϕ=20		ϕ=25		ϕ=30		ϕ=35		ϕ=40		ϕ=45	
	A	B	A/B	UB	LB	UB	LB	UB	LB	UB	LB	UB	LB	UB	LB
STAGE 1	0	5	0	5.177	5.1	5.177	5.1	5.177	5.1	5.177	5.1	5.177	5.1	5.177	5.1
STAGE 2	1	5	0.2	5.405	5.254	5.508	5.349	5.577	5.422	5.657	5.495	5.724	5.543	5.784	5.615
STAGE 3	2	5	0.4	5.612	5.476	5.922	5.767	6.227	6.04	6.516	6.313	6.824	6.608	7.189	6.883
STAGE 4	3	5	0.6	5.802	5.661	6.475	6.304	7.169	6.989	7.647	7.55	7.844	7.746	7.942	7.84
STAGE 5	4	5	0.8	5.978	5.918	7.047	6.894	7.927	7.837	8.292	8.199	8.53	8.433	8.694	8.598
STAGE 6	5	5	1	6.136	6.031	7.545	7.417	8.465	8.364	8.93	8.823	9.252	9.146	9.498	9.387
STAGE 7	6	5	1.2	0.059	0.052	0.17	0.14	0.737	0.513	6.273	2.99	9.542	8.875	10.067	9.787
STAGE 8	7	5	1.4	0.032	0.029	0.07	0.059	0.201	0.154	0.899	0.546	8.097	2.855	10.5	9.479
STAGE 9	8	5	1.6	0.024	0.022	0.047	0.041	0.111	0.09	0.362	0.257	1.962	1	10.675	6.342
STAGE 11	10	5	2	0.019	0.017	0.032	0.028	0.062	0.054	0.156	0.123	0.553	0.369	3.6	1.592

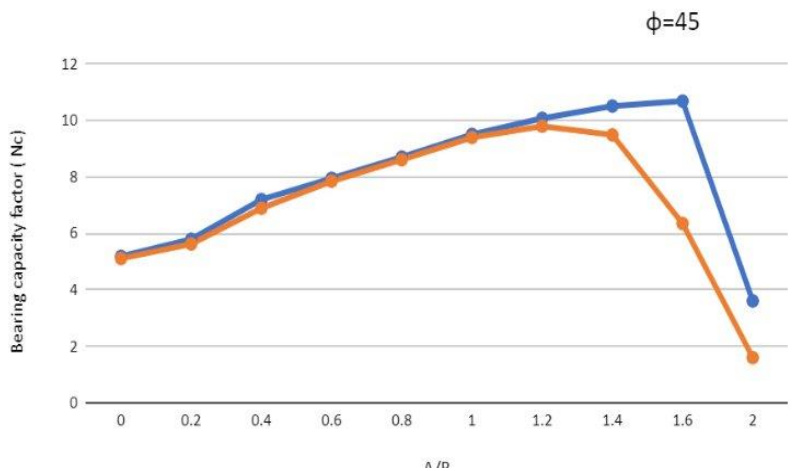
Graphs for different ϕ values – for lower bound and upper bound { for Nc }

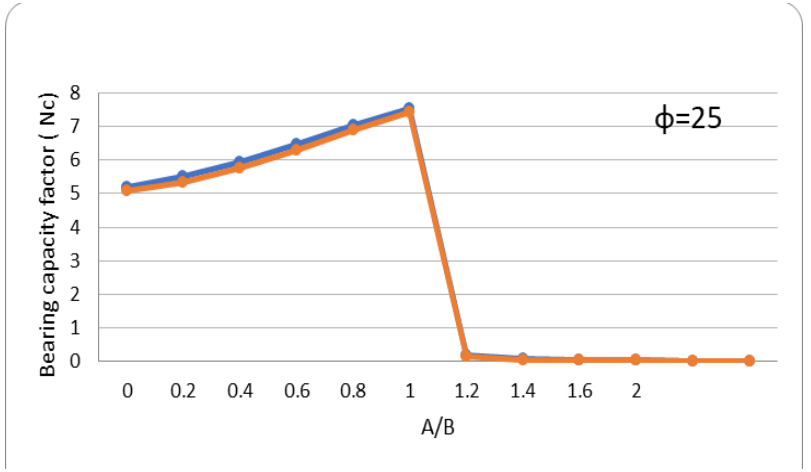




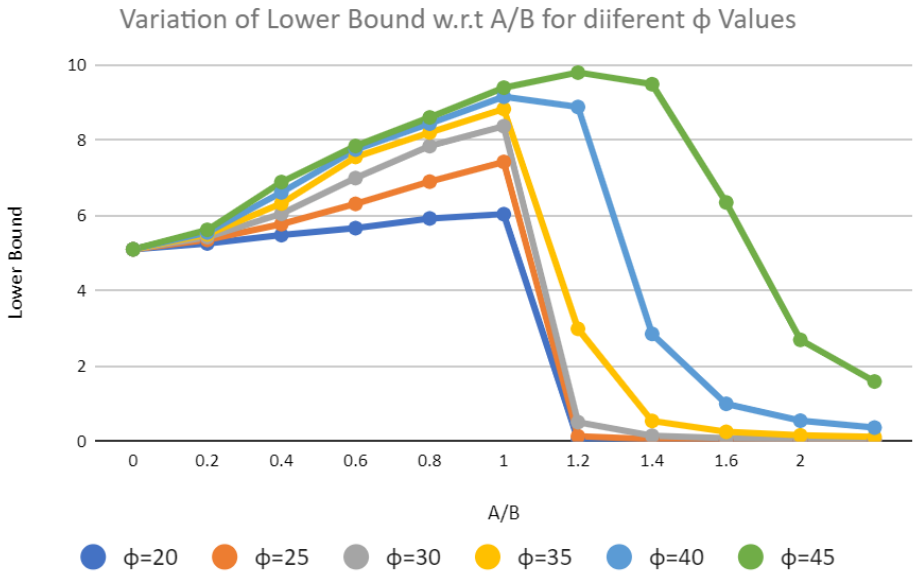


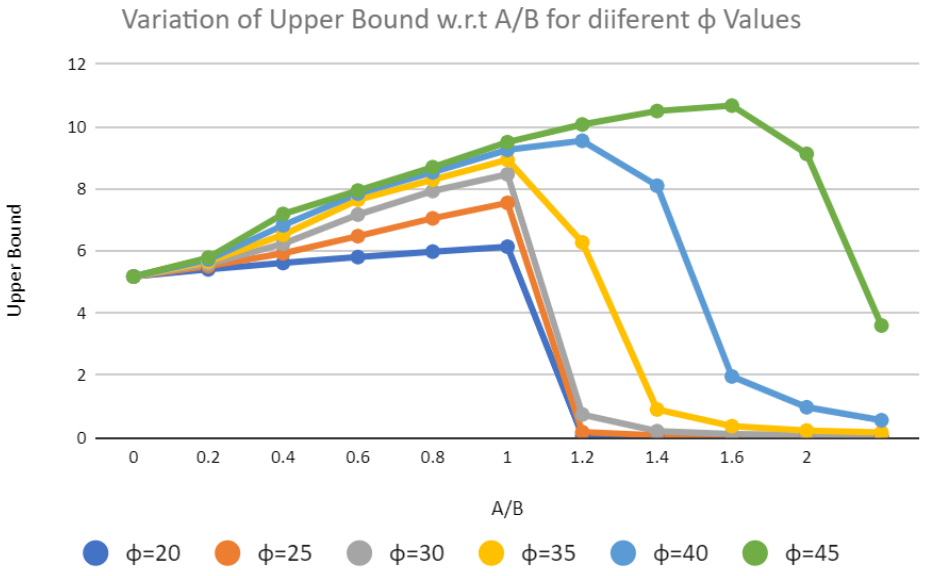






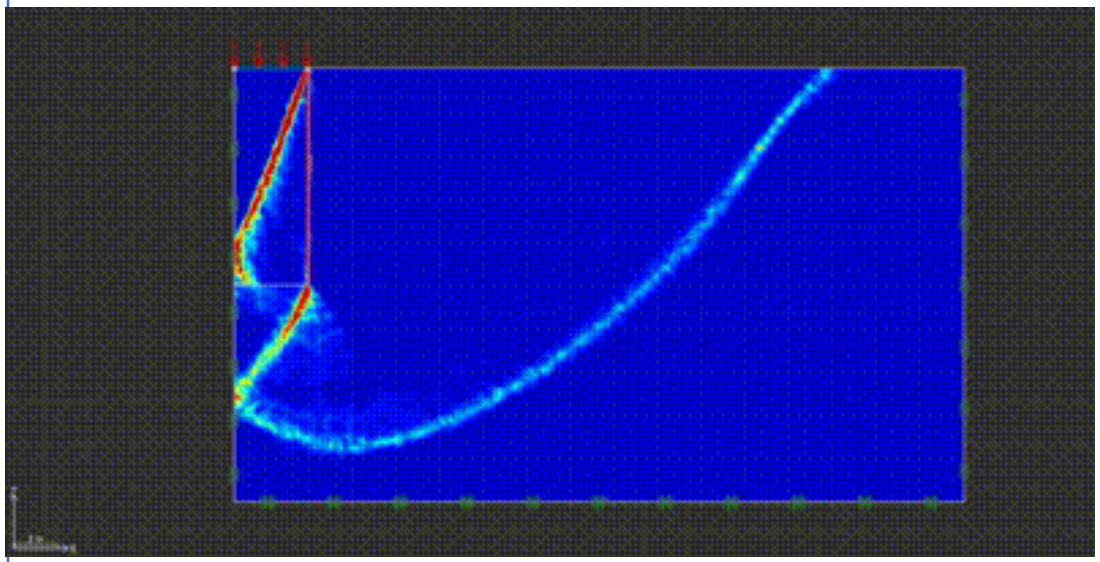
Variation of Lower bound and upper bound for different ϕ values { for Nc }

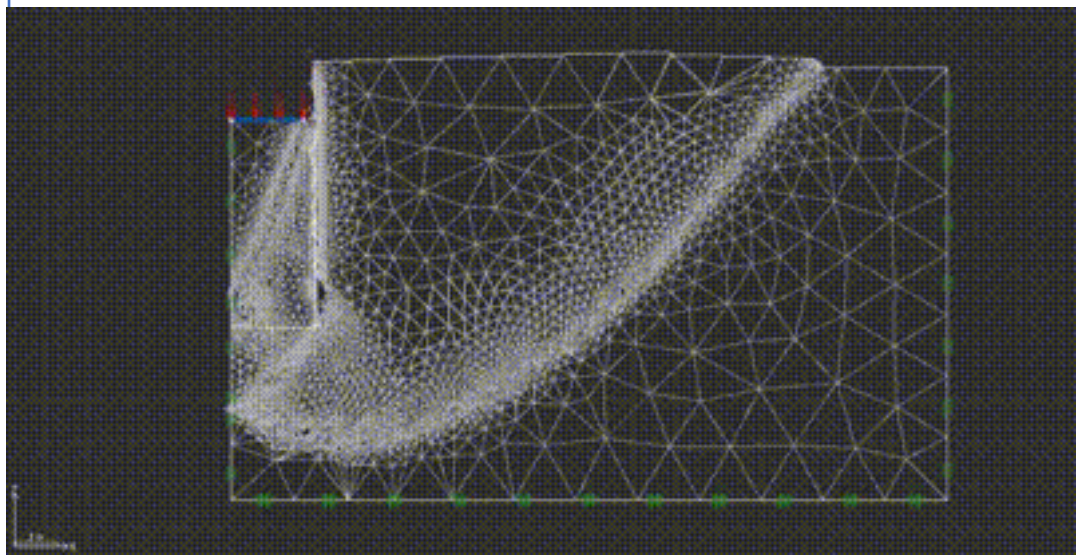




COLLAPSE ANIMATION

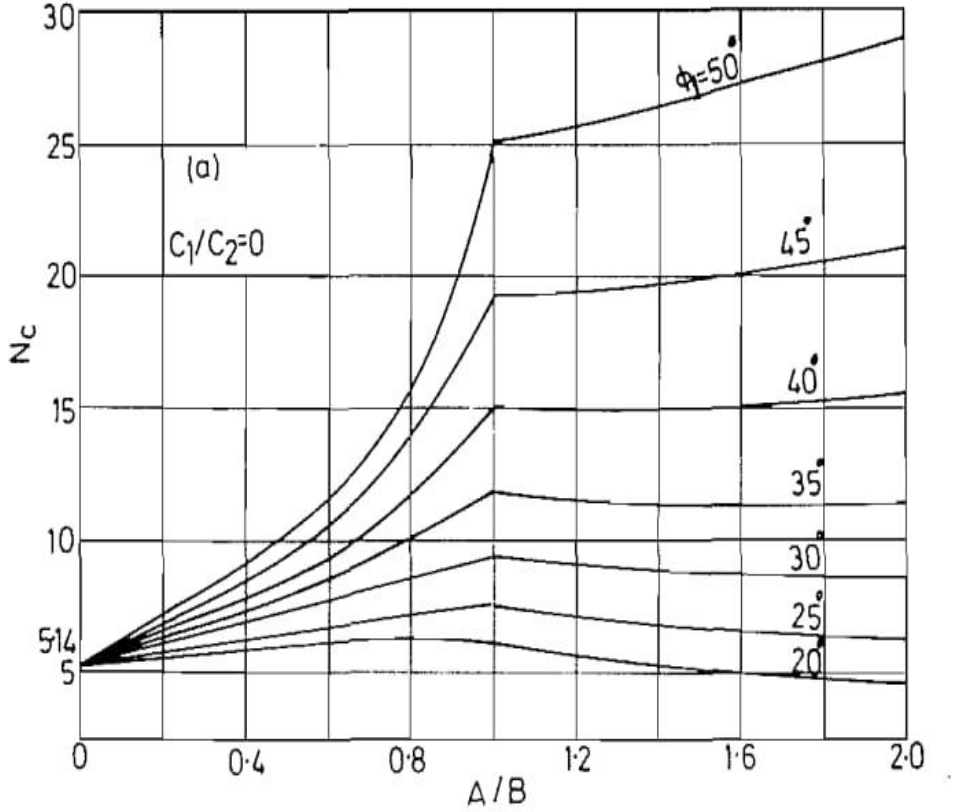
FOR STRIP STONE COLUMN

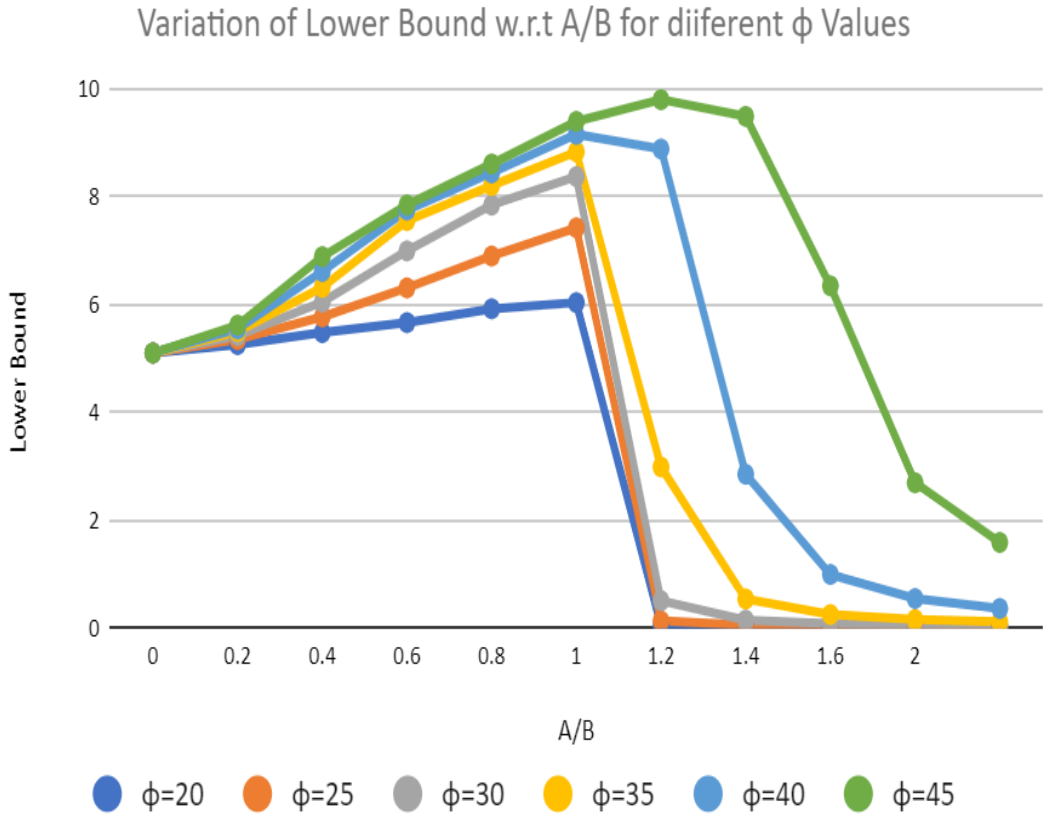




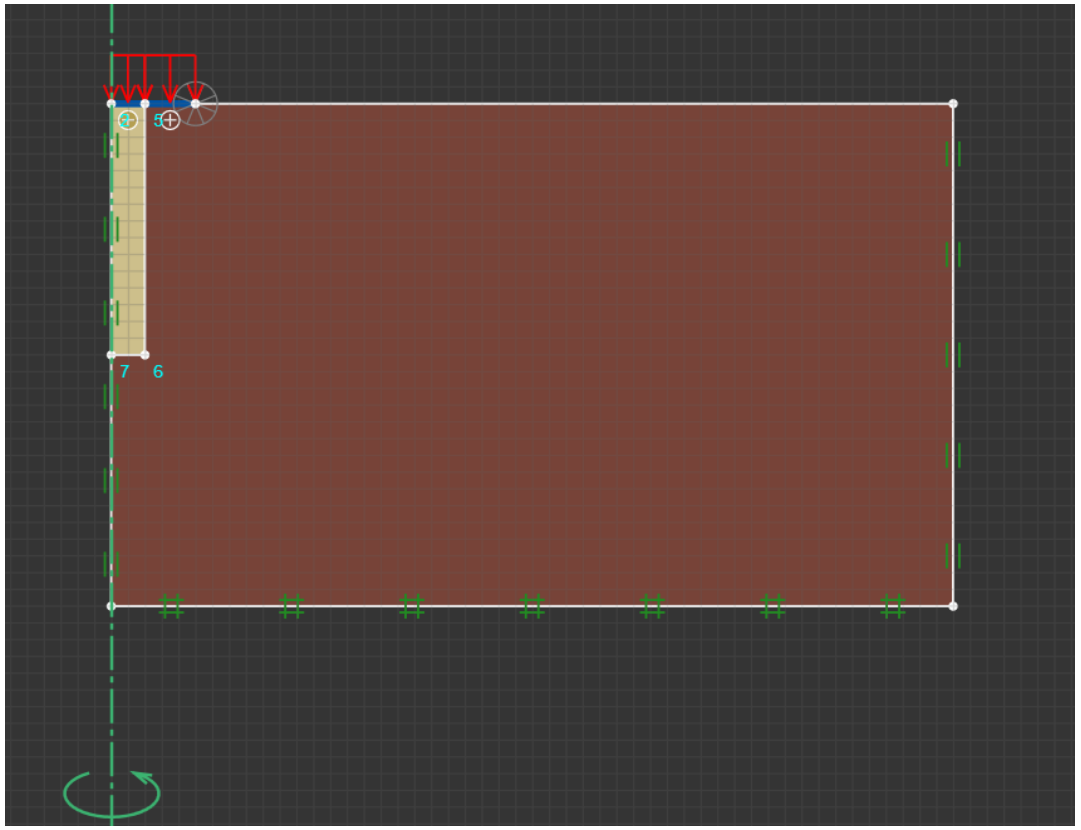
Comparison of obtained graphs based on reference graphs

Paper published by M. R. MADHAV AND P. P. VITKAR





SCHEMATIC MODEL OF CIRCULAR STONE COLUMN



Software Drawing

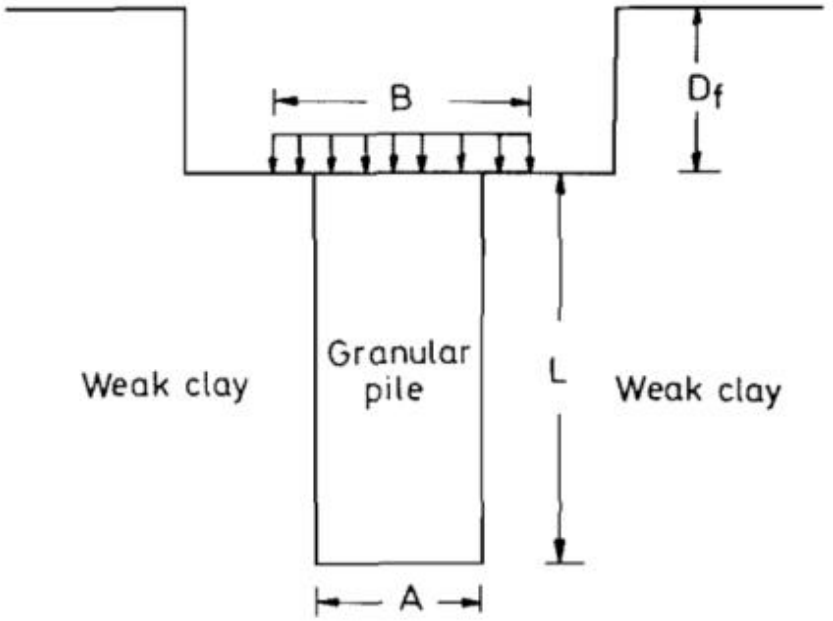
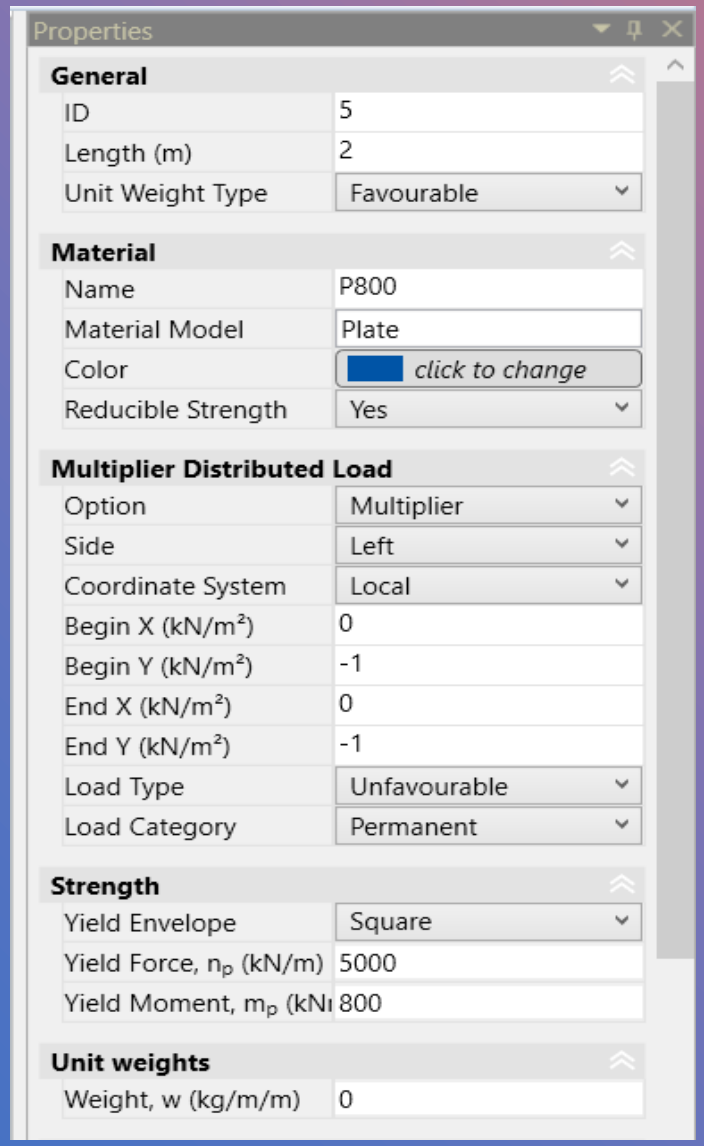
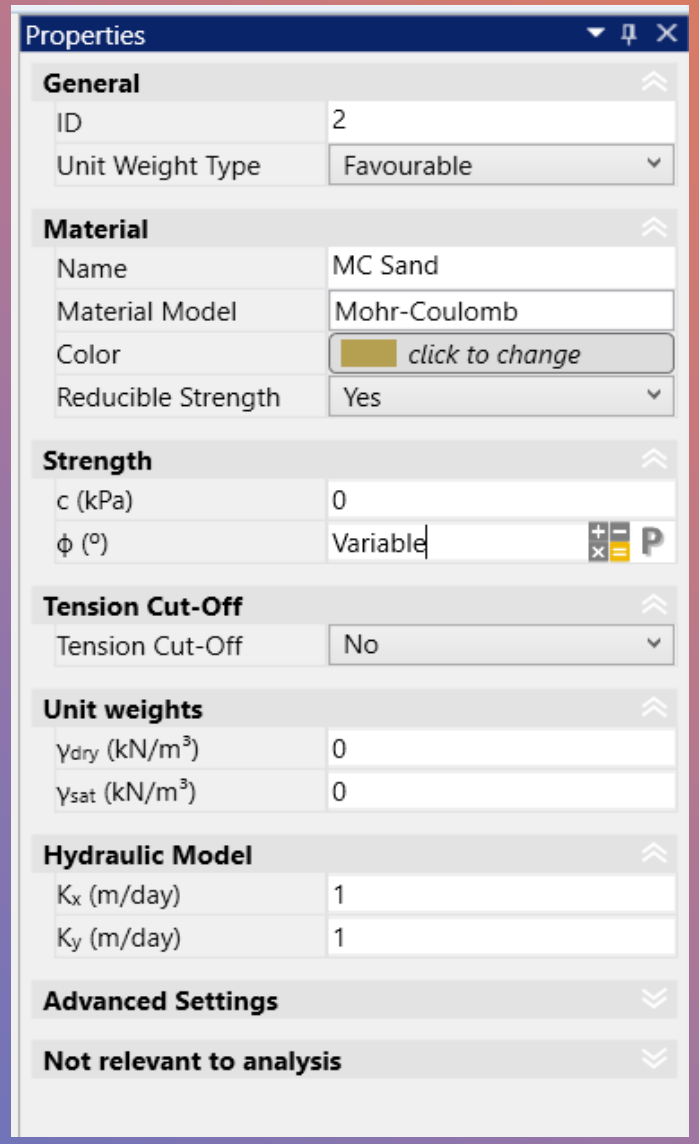
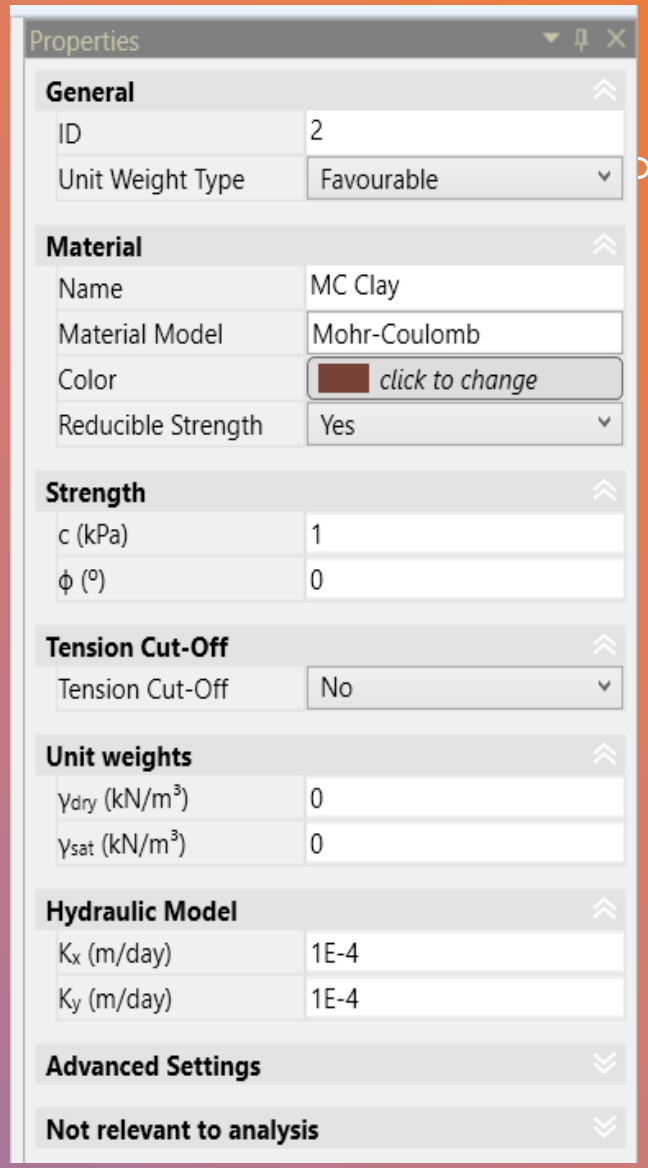


FIG. 1. Granular pile in weak clay.

MATERIAL PROPERTIES





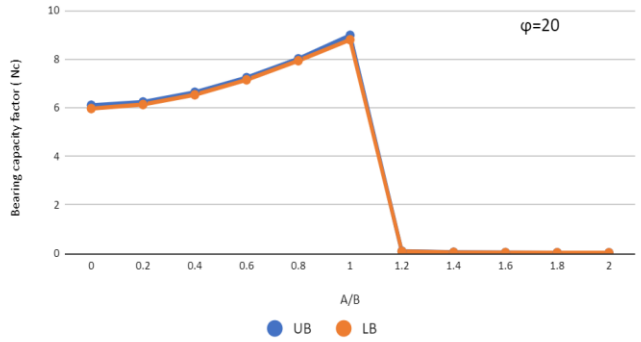


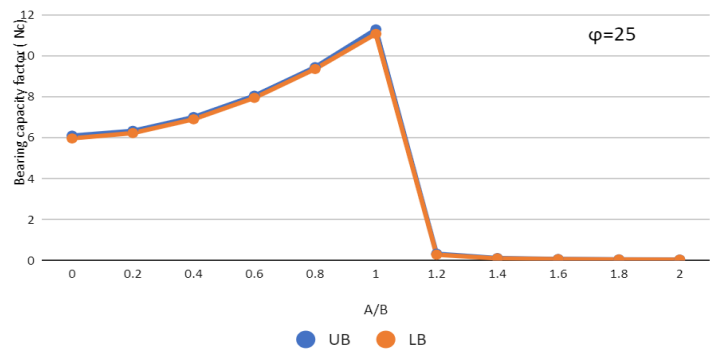
Variation of different ϕ values w.r.t to A/B Ratio

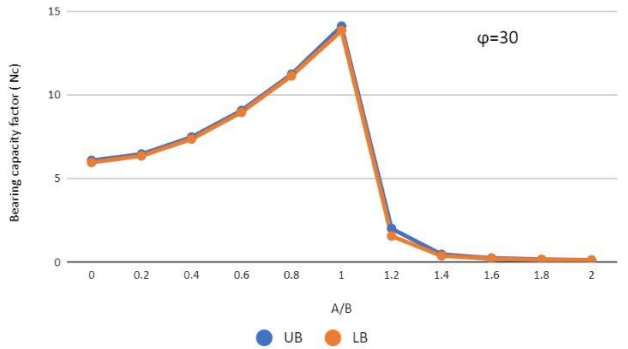
{ for Nc }

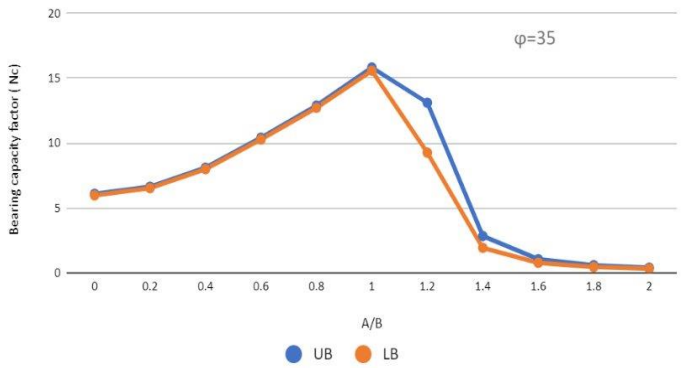
				ϕ=20		ϕ=25		ϕ=30		ϕ=35		ϕ=40		ϕ=45	
	A	B	A/B	UB	LB	UB	LB	UB	LB	UB	LB	UB	LB	UB	LB
STAGE 1	0	5	0	6.097	5.961	6.097	5.961	6.079	5.961	6.079	5.961	6.079	5.961	6.079	5.961
STAGE 2	1	5	0.2	6.232	6.126	6.332	6.224	6.46	6.353	6.626	6.516	6.851	6.74	7.159	7.041
STAGE 3	2	5	0.4	6.631	6.526	7.004	6.896	7.478	7.359	8.091	7.982	8.909	8.714	8.93	8.775
STAGE 4	3	5	0.6	7.232	7.143	8.046	7.942	9.074	8.955	10.404	10.268	10.826	10.656	10.86	10.699
STAGE 5	4	5	0.8	8.007	7.929	9.439	9.349	11.24	11.141	12.873	12.706	13.199	13.015	13.291	13.101
STAGE 6	5	5	1	8.975	8.792	11.281	11.063	14.115	13.851	15.811	15.563	16.303	16.05	16.555	16.285
STAGE 7	6	5	1.2	0.092	0.085	0.337	0.291	2.007	1.558	13.099	9.252	19.421	18.567	20.534	19.981
STAGE 8	7	5	1.4	0.048	0.044	0.124	0.11	0.459	0.372	2.828	1.918	19.82	13.235	24.292	23.314
STAGE 9	8	5	1.6	0.036	0.033	0.079	0.071	0.234	0.197	1.044	0.766	8.547	4.712	26.997	21.978
STAGE 10	9	5	1.8	0.031	0.029	0.062	0.056	0.158	0.136	0.58	0.443	3.597	2.303	27.631	21.091
STAGE 11	10	5	2	0.028	0.026	0.052	0.048	0.122	0.108	0.391	0.32	1.996	1.383	20.838	10.697

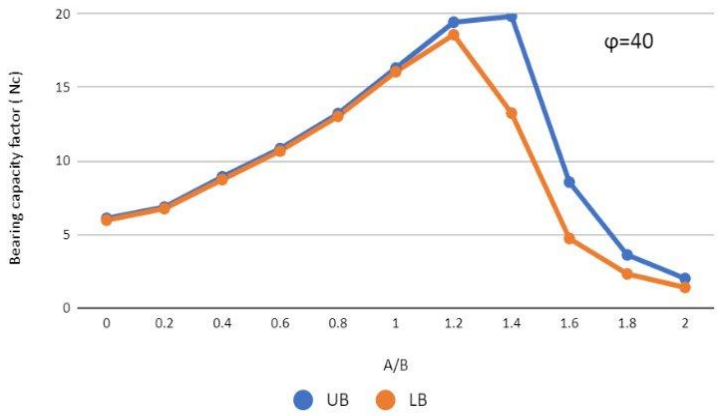
Graphs for different ϕ values – for lower bound and upper bound { for Nc }

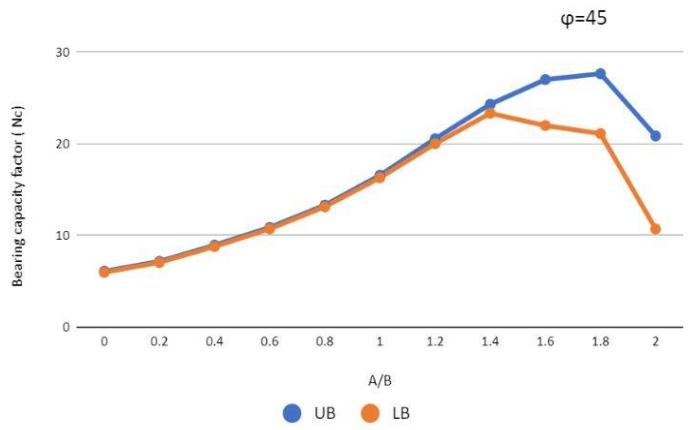




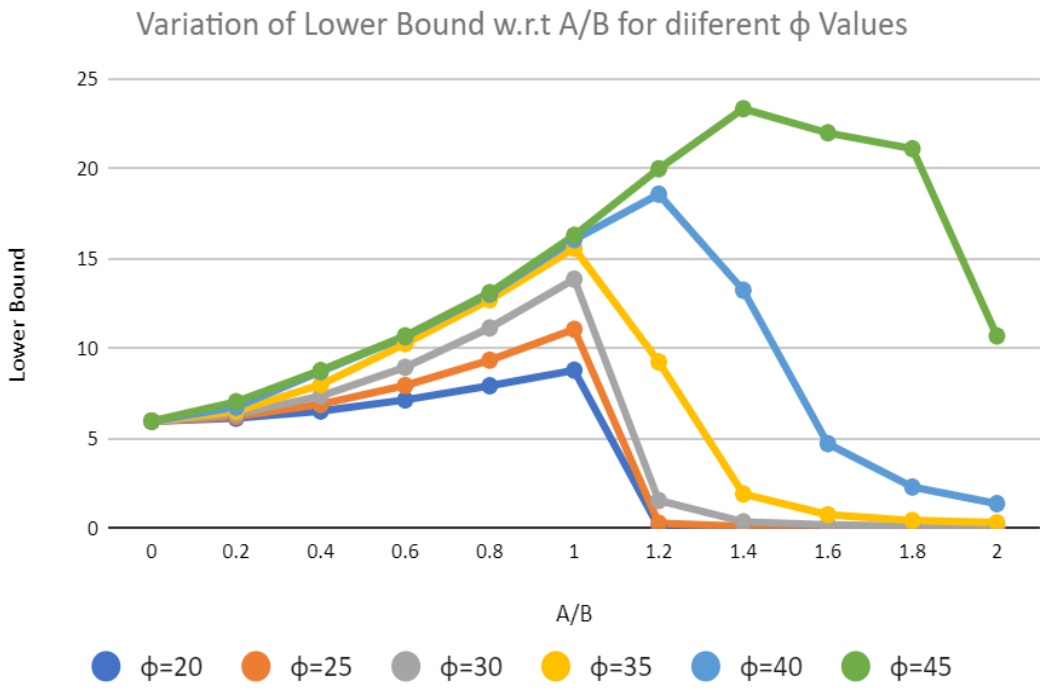


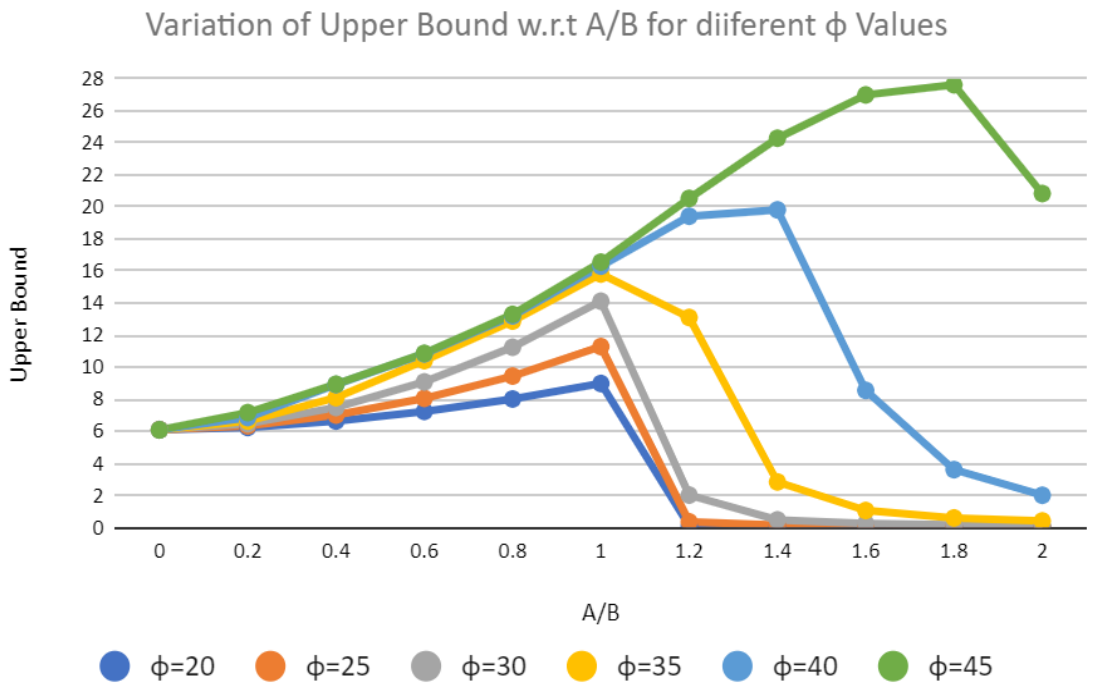






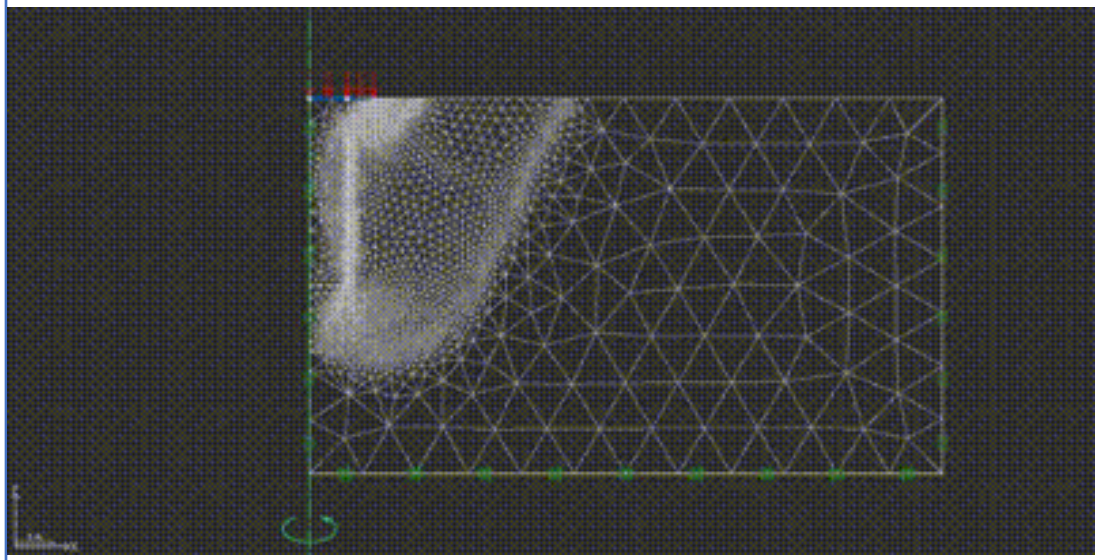
Variation of Lower bound and upper bound for different ϕ values { for Nc }

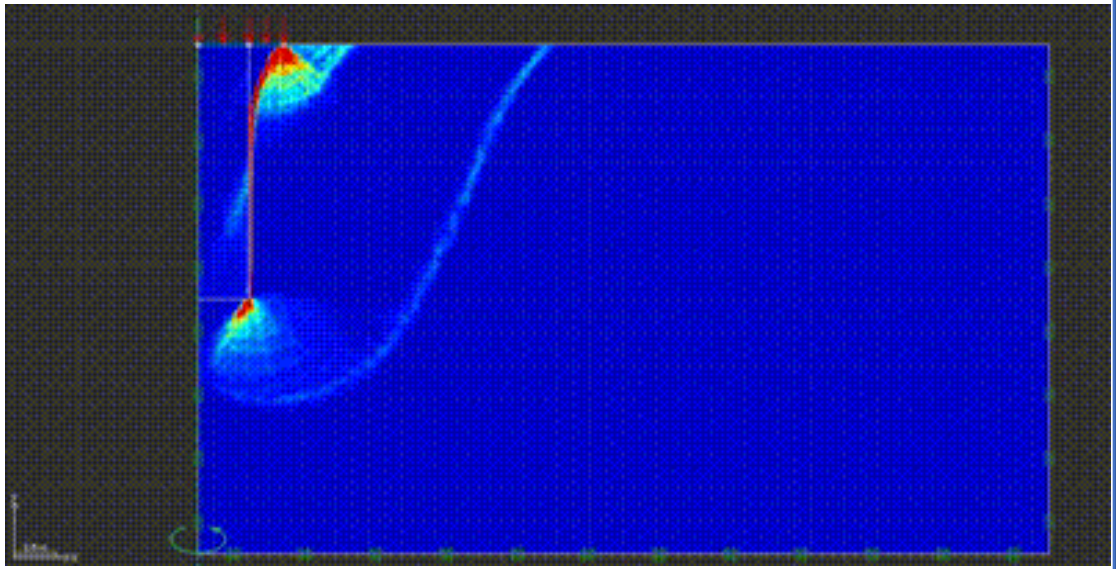




COLLAPSE ANIMATION

FOR CIRCULAR STONE COLUMN





CONSTRUCTION SITE

Required Bearing Capacity = 800 KN/M^2

SOIL PROPERTIES

COHESIVE SOIL

$C = 50\ KN/M^2$

PHI = 0

Bearing Capacity available at construction site

$$q_u = c N_c + qN_q + 0.5 \gamma B N_\gamma$$

$$q_u = 50*5.961 + 0*N_q + 0.5 \gamma B*0$$

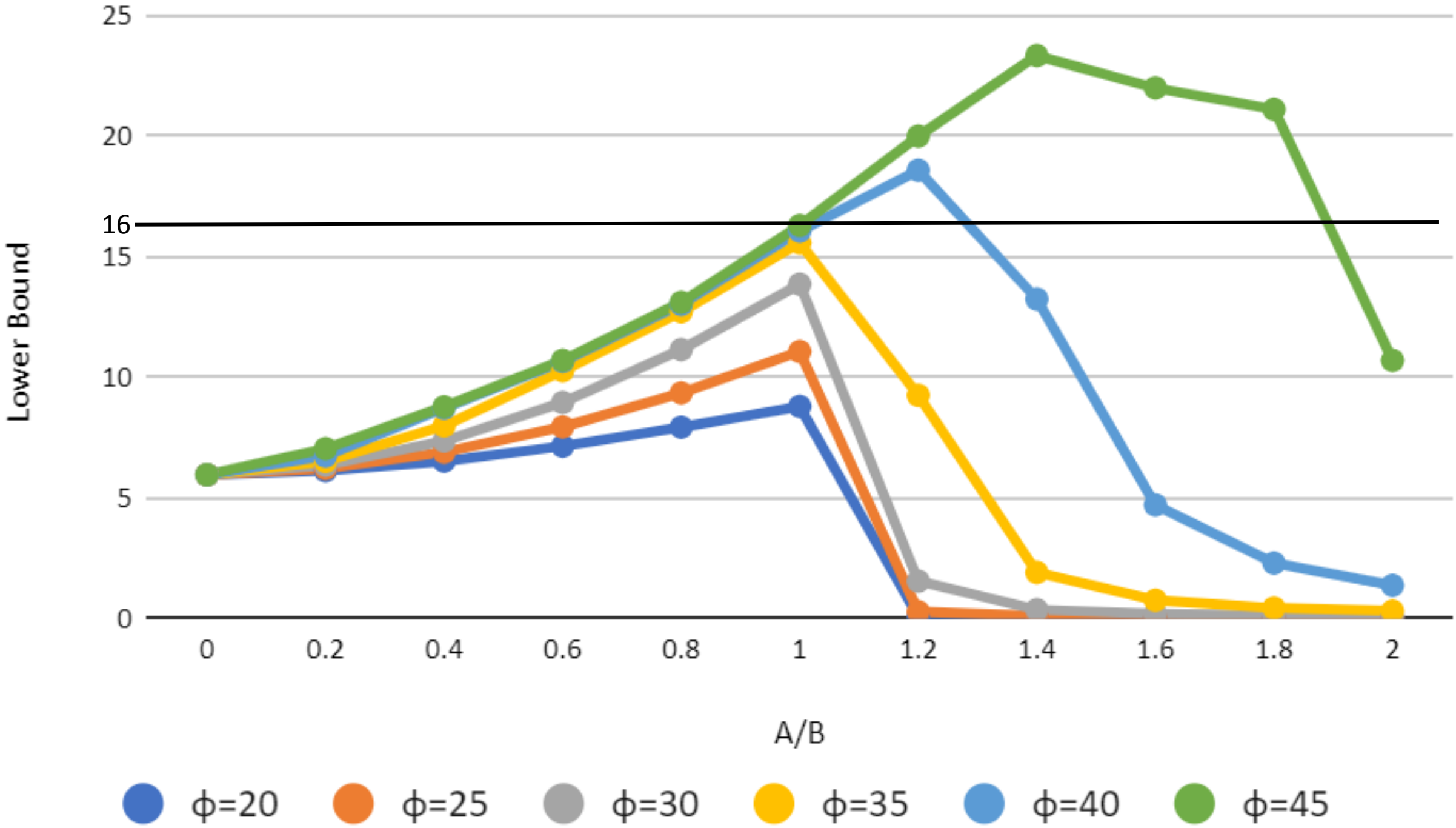
$$q_u = 298 \text{ KN/M}^2$$

Calculation of Nc For required Bearing Capacity = 800 KN/M2

$$q_u = c N_c + qN_q + 0.5 \gamma B N_\gamma$$

$$800 = 50*N_c + 0*N_q + 0.5 \gamma B*0298 N_c$$

$$N_c = 16$$


25
20
16
15
10
5
0
Lower Bound
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
A/B
ϕ=20
ϕ=25
ϕ=30
ϕ=35
ϕ=40
ϕ=45

- From the above graph , we see that for Nc =16 and above ,we can use two values of ,that is 40 and 45 degree and A/B ratio is 1.2

- For 1m radius of circular column, We have to make 1.2m radius of circular stone column.

FUTURE WORK

- We have done our project for cohesive soil (phi =0) , so in future we can do it for different values of phi by increasing it gradually like for 5,10 and 15 degrees

- We have only varied width of the stone column , so in future it can be done for varying depth of the stone column.

- The results obtained can be verified by practical lab testing of stone column for some samples.

CONTRIBUTION

GROUP MEMBERS	WORK CONTIBUTION
Aditya Kumar	Analysis of Circular Stone Column for circular footing
Akash Garg	Analysis of Strip Stone column for Strip Footing
Ayushi Bharadia	Analysis of Circular Stone Column For circular footing
Devesh Kumar Mahar	Analysis of Strip Stone column for Strip Footing
Yash Azan	Analysis of Strip Stone column for Strip Footing


THANK
YOU