CAPACITY CHARTS FOR PILE GROUP OF VARIOUS DIAMETER

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Abstract—The Design of Pile Group are is a consequential part of the overall design of a bridge and it affects to a considerable extent the safety and economy of the bridge. The purport of any substructure is to transfer the load from the superstructure to the earth in such a manner that the stresses are within acceptable limits

Designing a pile group is a difficult and sometimes very time-consuming task. One of the main reasons is that a pile group has a great number of input parameters and variables. There are geometric parameters such as the pile cap thickness, pile type and diameter, Location, angle of rotation and batter (slope) of the piles and pile length. Other important Parameters are the pile bearing capacity and external loads. All these parameters can be combined in an almost infinite number of ways. The larger the pile group is, the more Complex the task becomes.

The main objective of these study Standardize the pile group detail of R.C.C T-Girder bridge in Gujarat so we can use same type of pile group numerous times for different conditions such as the variation in height of pier, variation in Live Load condition, Variation in span length etc.

For the purpose of Standardization of pile group we prepare the charts for the different soil condition at different slenderness and diameter such as 25, 30, 35,40,45,50,

Index Terms— 2 x 3 Pile group; Soil type; Pile Group Capacity; Limiting Value charts;

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1. INTRODUCTION

The design of foundation is most important part of overall design of bridge and it affect considerable safety and economy of the bridge. The purpose of the foundation is to transmit the load of super structure to the earth in such a manner that the stress on the soil are not excessive and resulting deformation are in acceptable limits. The design demand detail knowledge of the soil mechanics, Foundation engineering and the structural Analysis. .

1.1 Need of the study

In the design, Pile groups are an essential part of many bridge constructions. Piling is needed when the soil beneath the bridge supports is too weak to carry the loads, which is often the case. Designing a pile group is a difficult and sometimes very time-consuming task. One of the main reasons is that a pile group has a great number of input parameters and variables. There are geometric parameters such as the pile cap thickness, pile type and diameter, Location, angle of rotation and batter (slope) of the piles and pile length. Other important Parameters are the pile bearing capacity and external loads. All these parameters can be combined in an almost infinite number of ways. The larger the pile group is, the more Complex the task becomes

A designer is always searching for an optimal solution, which usually means the most cost-effective solution. Some pile types are very expensive. Therefore, finding a solution with as few piles as possible is often the most cost effective. It is difficult however for a designer to find an optimal solution when the problem is complex. There are no strict rules or guidelines when designing a pile group, instead designers mostly rely on experience and engineering judgments to establish some of the parameters before starting the analysis. Today, most pile groups are designed by calculating the section forces and deformations in the piles for a specific pile group configuration and then slightly adjusting the configuration and recalculating, until the results are satisfactory. Satisfactory meaning, for example, that the pile group is able to carry the design loads and that there are as few piles as possible in the pile group. Even though several of the parameters have been set, the process of finding a satisfactory solution becomes very iterative

The iterative process and the large number of parameters makes pile group design an ideal target for computer optimization. One of the first attempts at pile group optimization using computers was made in 1981 by James Hill. Since then several more attempts focusing Different aspects have been made, such as those by Hoback and Truman and Chan ET. al. (1992a) (2009).This thesis will examine optimization of pile groups. Different optimization algorithms will be used and compared to develop a computer program that performs the design and optimization of a pile group with respect to location, batter and angle of rotation.

1.2 Objective of Study

Today the computer programs that calculate the forces and deformations in the piles but no programs that provide a practical design and optimization of pile groups such as the one develop in this thesis project. The thesis project mainly focused on the standardization of pile group detail for T-Girder R.C.C Bridge in Gujarat so we can use same type of pile group numerous times for Different Geological Parameter, Height, and Length variation in bridge

2. STUDY/RESEARCH

2.1Study from Earlier Researcher:

Khaled E. Gaaver [1] Perform Experimental Study on Uplift capacity of single piles and pile groups embedded in cohesion less soil And he conclude that the maximum uplift capacity of pile in pile group can be increase with increase in slenderness ratio (L/D) of the pile, SCDOT [2] stated that the group efficiency should be taken as 0.65 for pile groups with minimum spacing of 2.5d and increased linearly up

to 1.0 for pile groups spaced at 4d. J.-Y. Lee and H.-H. Tsang [3] Perform series of experiment of 1 x 2, 1 × 3, 2 × 2, 3 × 3, and 3 × 2 for embedded length-to-diameter ratio l/d = 32 into loose and dense sand, spacing from 3 to 6 pile diameter, in parallel and series arrangement and conclude that A ratio of s/d more than 6d was large enough to eliminate the pile-to-pile interaction and the group effects. It may be more in the loose sand and also flexible piles of series arrayed were more resistant than those parallel arrayed to lateral Loadings. K. Shanker, P. K. Basudhar and N. R. Patra [4] Perform Experimental cum Analytical Study of the Effect of Compressive Load on Uplift Capacity of Pile Groups in Sand and conclude that the maximum capacity of the pile in pile group are within the spacing of the 3D to 6D. Kyle M. Rollins, Kimball G. Olsen [5] Study Pile Spacing effect in cohesive soil and conclude that the maximum result obtain if the Spacing are within 3.3D to 5.65D in cohesive soil.
From the above Researchers Research We use the criteria of Spacing of pile in pile group in Cohesive and Cohesion less soil. Also We do analytical Study of the Different Parameter of the pile such variation in length, Diameter, Spacing in longitudinal Direction ,Spacing in transverse Direction for the purpose of determination of which parameter give more impact on the pullout capacity of the pile in pile group. From the Analysis of that parameter we conclude that the maximum pull out and compression capacity will be affect the from the changing of slenderness ratio (L/D).

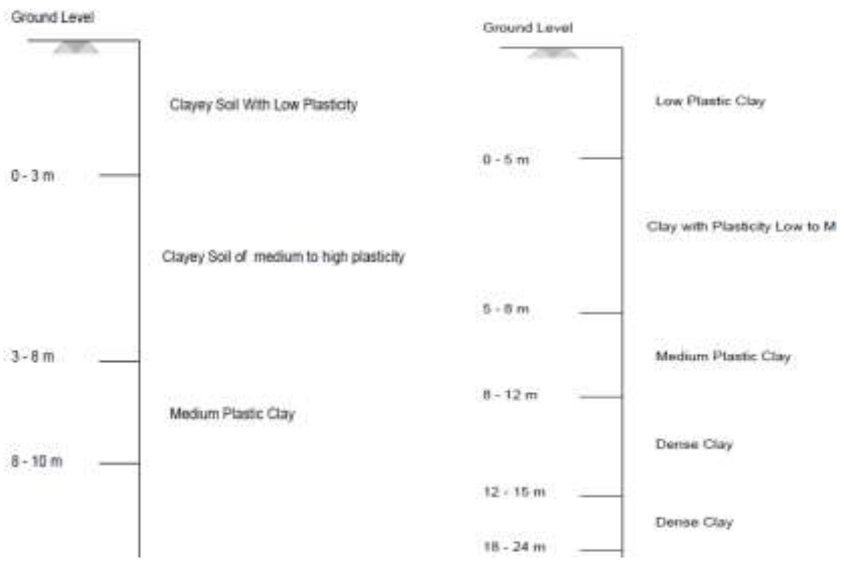
3. GEOLOGICAL DATA COLLECTION AND GENERALIZATION

Geological parameter of soil is most important to estimation the capacity of the pile and pile Group. It create greater impact on the pile foundation. Variation in geological parameter of soil also affect the diameter of the pile, length of the pile, number of the pile in pile group and size of the pile group. Our Gujarat state have too much variety in land forming and soil texture. Some part of our state contain hilly area, some part of our state contain dessert area, some part contain black cotton soil ,some part has granular Soil some part contain silty sand etc. and other large variety of soil are found in Gujarat. Due to the vast variety of land and soil profile we generalize the soil of Gujarat in seven approximate zone which are classifies are as under from the soil texture and soil profile report of Gujarat

From the data of Gujarat Geological department we divide state/region in to seven different zone which are shown below table

Zone 1	Ahmedabad + 1/ 3 portion of Bharuch
Zone 2	Banaskantha, Mehsana ,Sabarkantha ,Gandhinagar,Kheda and Anand
Zone 3	Panchmahal, Dang, Vadodara, 2/3 portion of Bharuch
Zone 4	Surat, Navsari
Zone 5	Tapi, Dang,Valsad
Zone 6	Katch, Patan
Zone 7	Jamnagar, Rajkot, Surendranagar

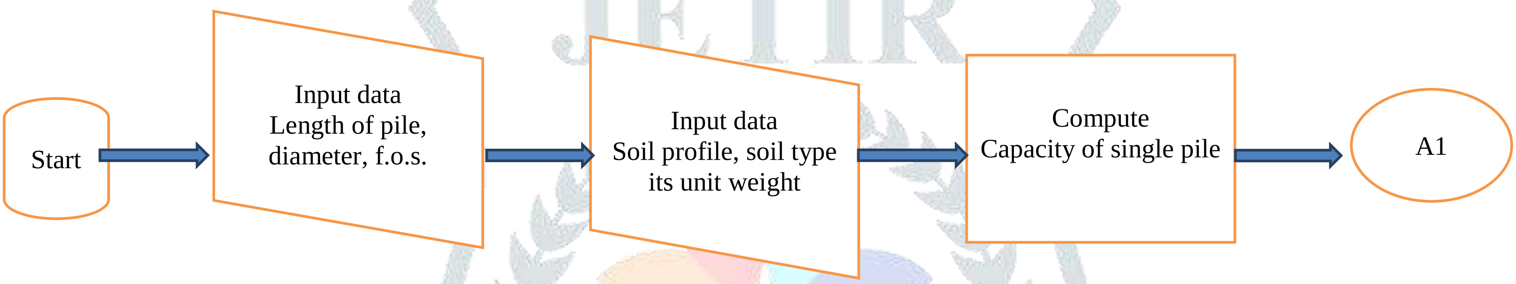
Zone 1 Zone 2 Zone 3



Zone 4 Zone 5

4. Analysis and Design of Pile

For the analysis and Design of pile group the following procedure is to be do which are show by the following flow chart



From the above we input data such as geometry of the pile, geological parameter of soil and do the following Procedure we can calculate single pile capacity in the pile group. From the following equations for cohesive and cohesion less soil

$Q_u = Q_s + Q_p$ (1)

$= f_s A_s + q_p A_p$ (2)

Where,

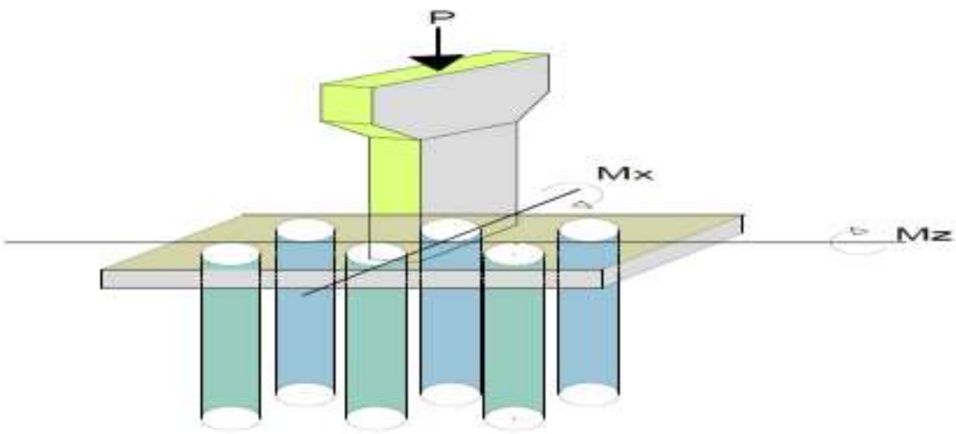
Q_s = Total skin friction resistance, KN, Q_p = Total end bearing resistance, KN, f_s = Unit skin friction resistance, KN/m^2
q_p = Unit end bearing resistance, KN/m^2, A_p = Area of pile tip,m^2, A_s = Curved surface Area of pile, m^2

And the end bearing capacity for the cohesive soil are from the below equations

$Q_u = A_p N_c c_p + \sum_{i=1}^{n} \alpha_i c_i A_{si}$ (3)

The first term gives the end-bearing resistance and the second term gives the skin friction resistance
A_p = Cross sectional Area of pile at tip, m^2, N_c = Bearing capacity factor as 9 pile, C_p = average cohesion at pile tip KN/m^2
α_i = adhesion factor depending on consistency of soil, c_i = Average cohesion for the ith layerKN/m^2,
A_{si} = surface area of the pile shaft in m^2

FORMULATION OF LIMITING VALUE CHARTS



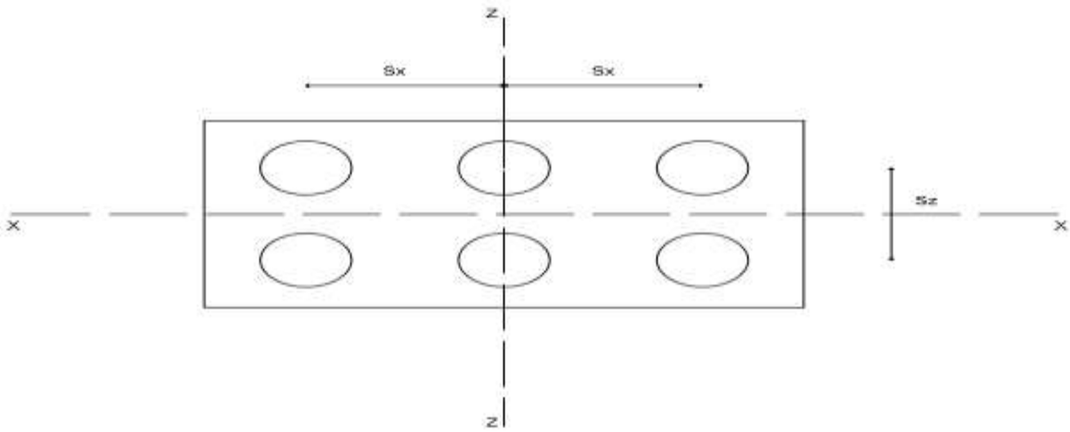
Load coming from the super structure we Can Calculate the maximum pullout and compressive capacity of the pile from the load distribution equation on each pile are as under;

$$P_i = \frac{P}{n} \pm \frac{M_x Z_i}{\sum_1^n Z^2} \pm \frac{M_y X_i}{\sum_1^n X^2} \quad (4)$$

Where,

P_i= total load on i^{th} pile, P= total load acting on the pile group, n = number of pile in pile group,
M_x= Moment acting abut XX axis
M_z= Moment acting about ZZ axis
X_i=Distance of center of ith pile from center of gravity of group in X- direction (Measure from ZZ axis)
Y_i= Distance of the center of ith pile from the center of gravity of the group in Z-direction (Measured from XX-axis)
X^2= Sum of the squares of the distances of center of piles from center of gravity of group in X-direction (measured from ZZ axis)
Y^2=Sum of squares of the distances of center of piles from center of Gravity of the group in Y-direction (measured from XX-axis)

For the formation of the Design chart we use the study from the above researcher and the Analysis we took the pile group of 2 x 3 of standard spacing 3.3D to 6D for the cohesive Soil and 3D to 6D for the cohesion less soil at different slenderness (L/D) and obtain the size of pile group by varying the diameter of the pile. For that size of the pile group we can find the limit of pulling out capacity of the pile from the following equation which are says to be No tension condition Equation



$$e_z = \frac{\sum_1^n Z^2}{Z_i}\left[\frac{1}{n} - \frac{e_X X_i}{\sum_1^n X^2}\right] \quad (5)$$

Also we can find out the maximum load and respective biaxial moment can bear the pile group from the following equation

$$e_z = \frac{\sum_1^n Z^2}{Z_i}\left[\frac{P_{pull}}{P} - \frac{1}{n} - \frac{e_x X_{max}}{\sum_1^n X^2}\right] \quad (6)$$

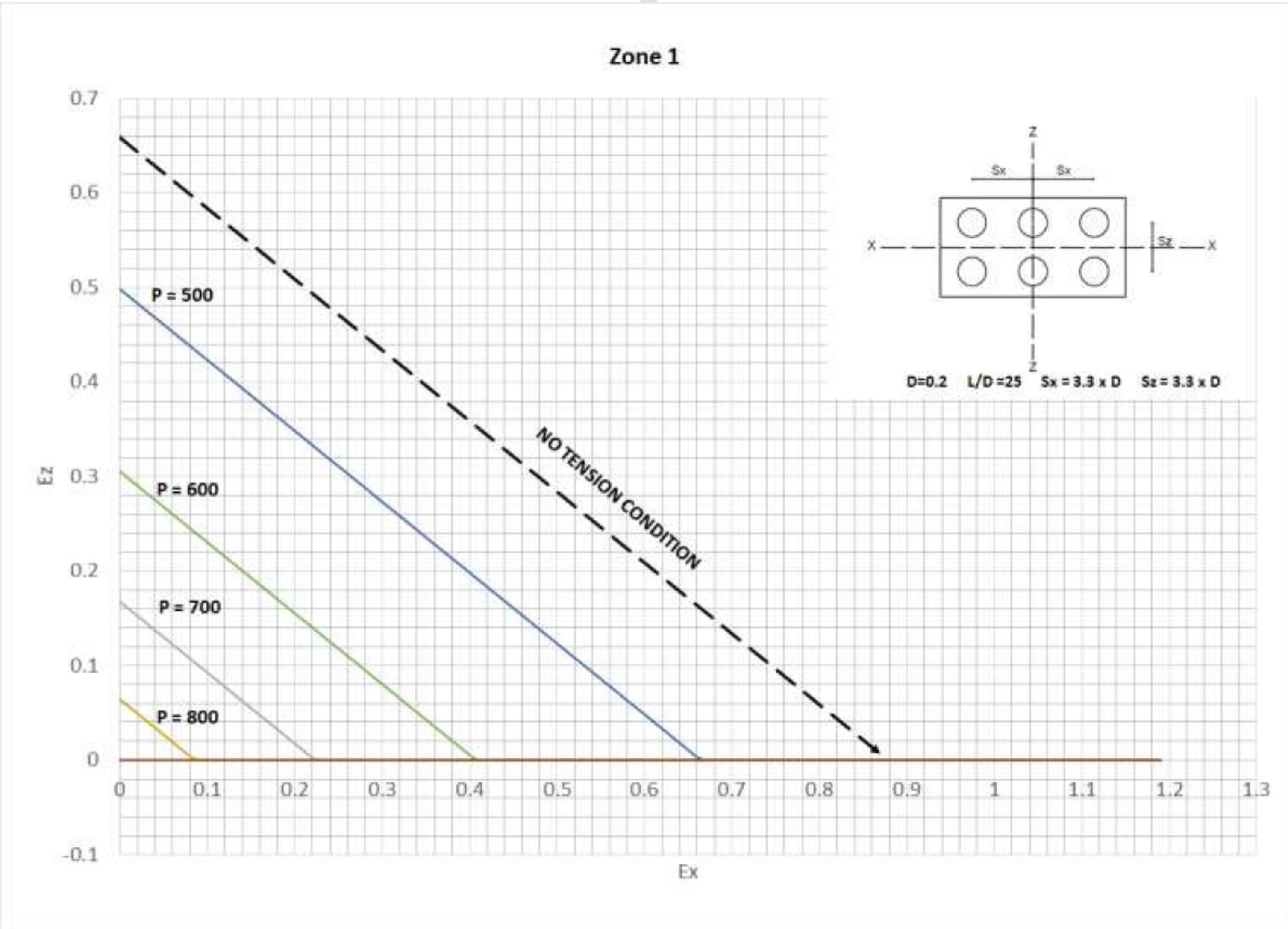
5. Results and Discussion

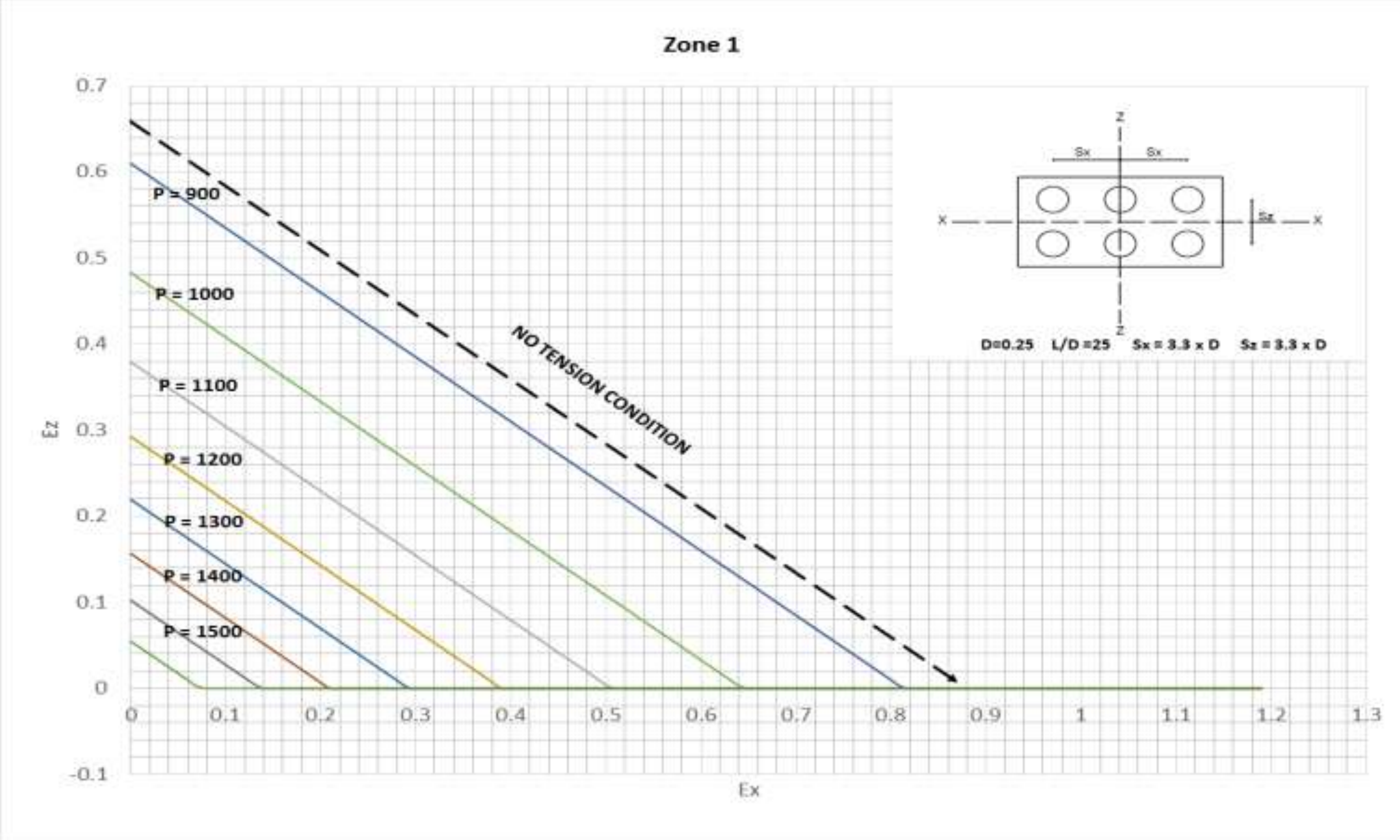
From the Analysis of the Pile Group, equations (5) and (6) we can generate limiting Value charts for different geological condition of the soil and Variation in bridge Structure such as the variation in height of pier, variation in span length etc. The limiting value charts are shown below for Zone 1 (Ahmedabad + 1/3 portion of Bharuch) and Analysis 1 (For Slenderness 25) and diameter 0.2 to 0.5

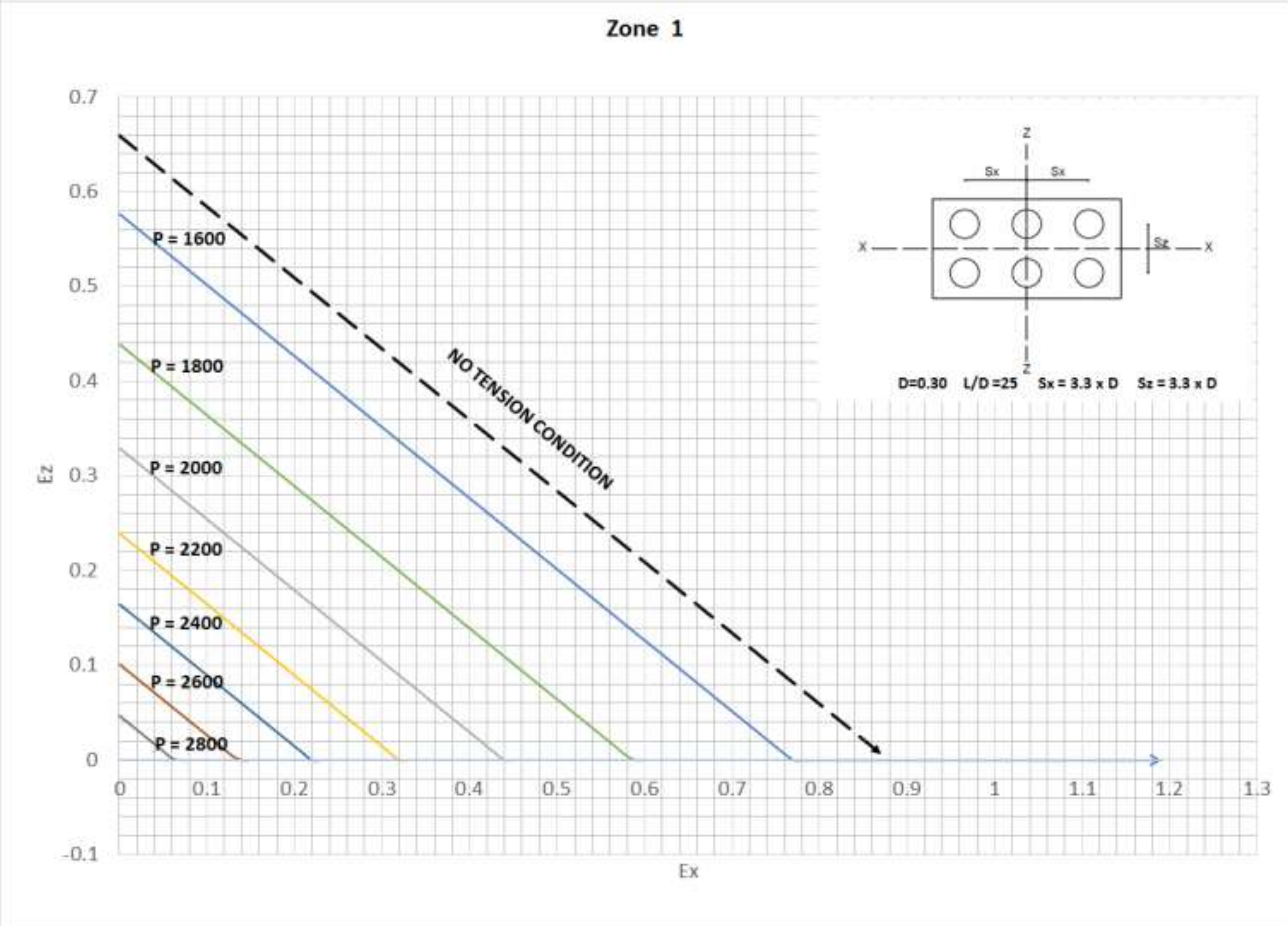
Analysis 1:- For Zone 1 and Slenderness 25

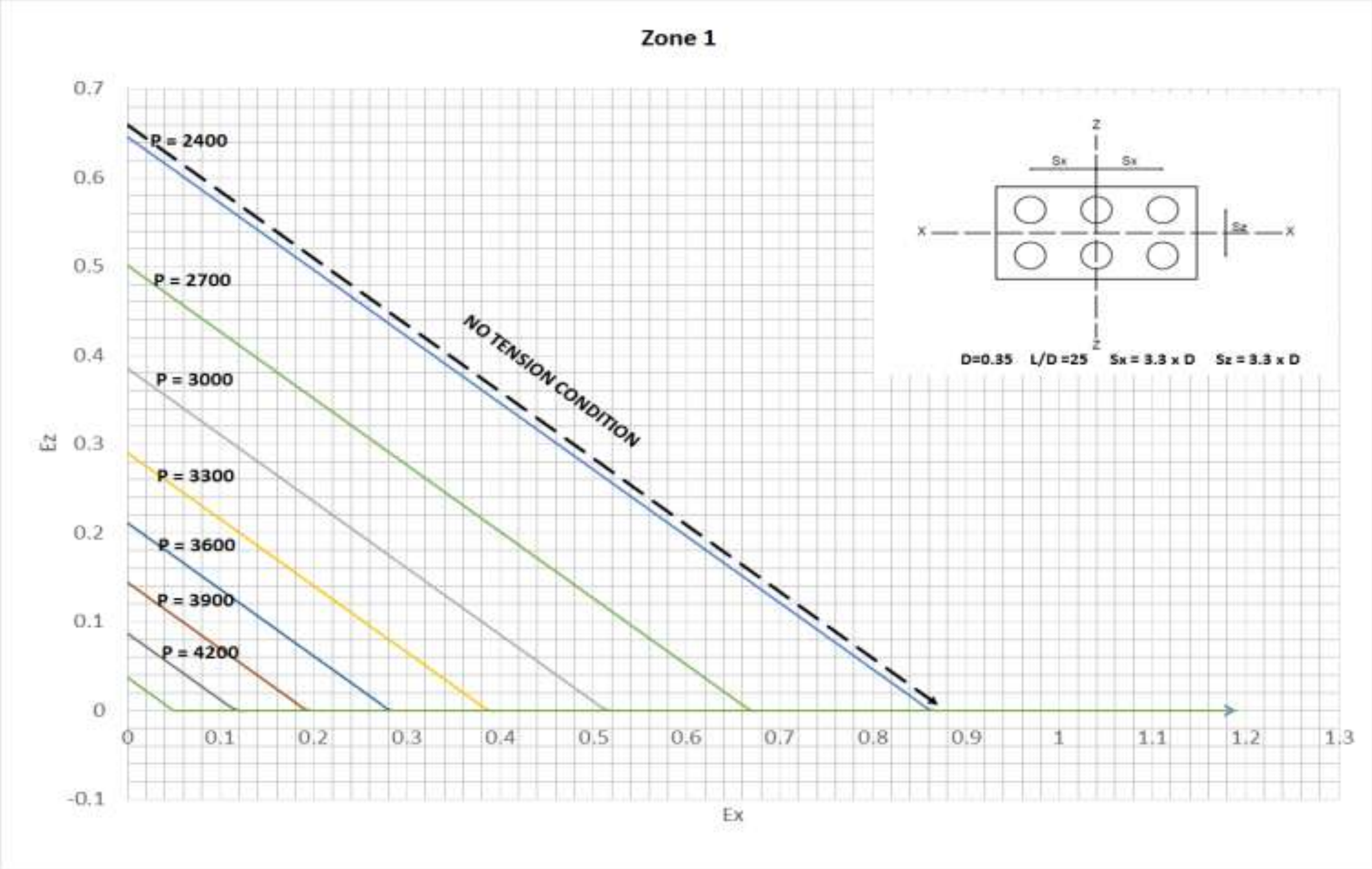
Cases	Diameter	Slenderness(L/D)	Length (m)	Qu
1	0.2	25	5	146.336 KN
2	0.25	25	6.25	288.793 KN
3	0.3	25	7.5	499.871 KN
4	0.35	25	8.75	792.36 KN
5	0.4	25	10	1184.3 KN
6	0.45	25	11.25	1684.9 KN
7	0.5	25	12.5	2310.3 KN

Fixing the diameter of the pile 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5 we obtain length and capacity of each case of pile. From this the following limiting Value chart are to be generated

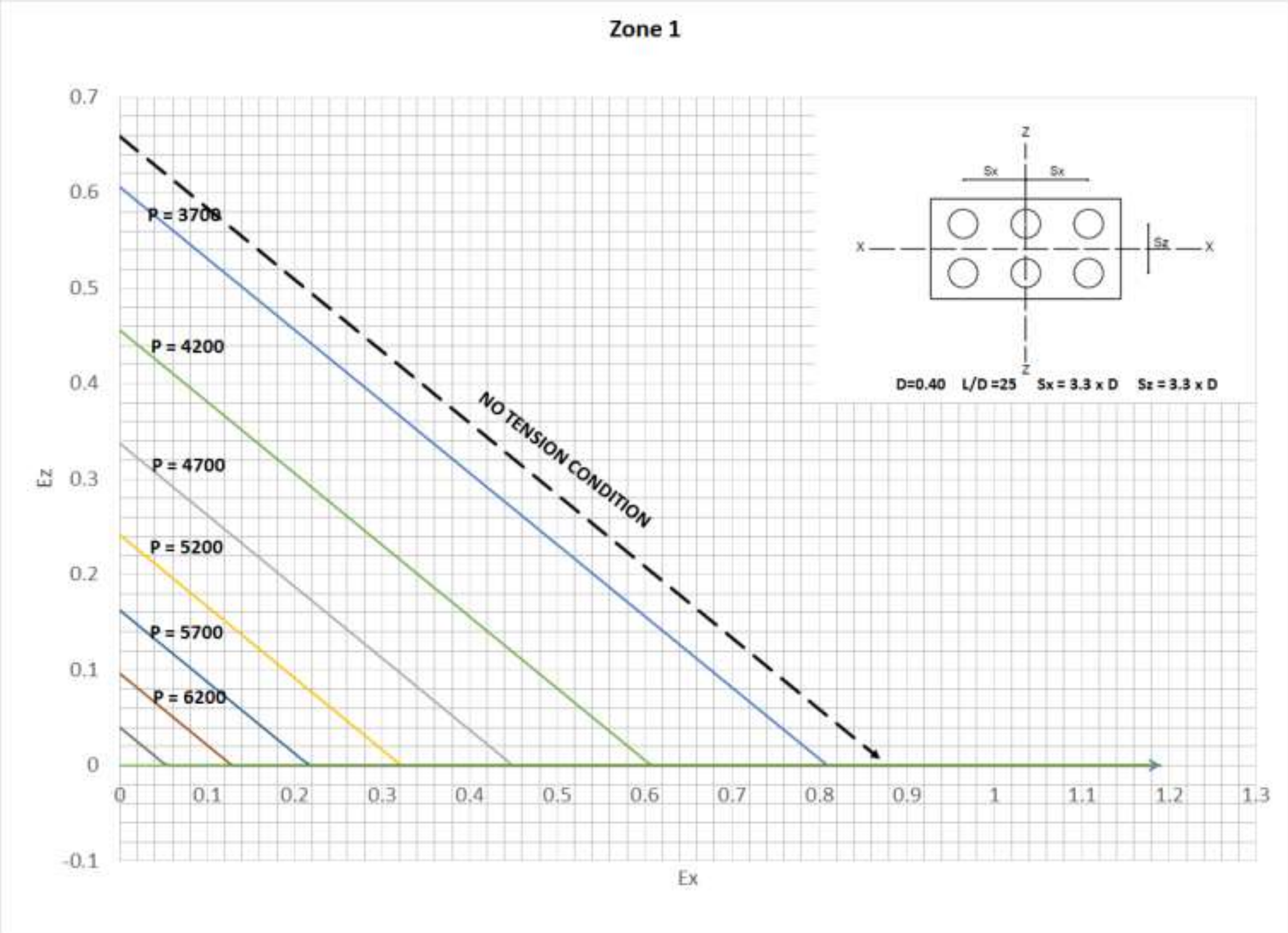



Zone 1
P = 900
P = 1000
P = 1100
P = 1200
P = 1300
P = 1400
P = 1500
NO TENSION CONDITION
D=0.25 L/D =25 Sx = 3.3 x D Sz = 3.3 x D
Ez
Ex

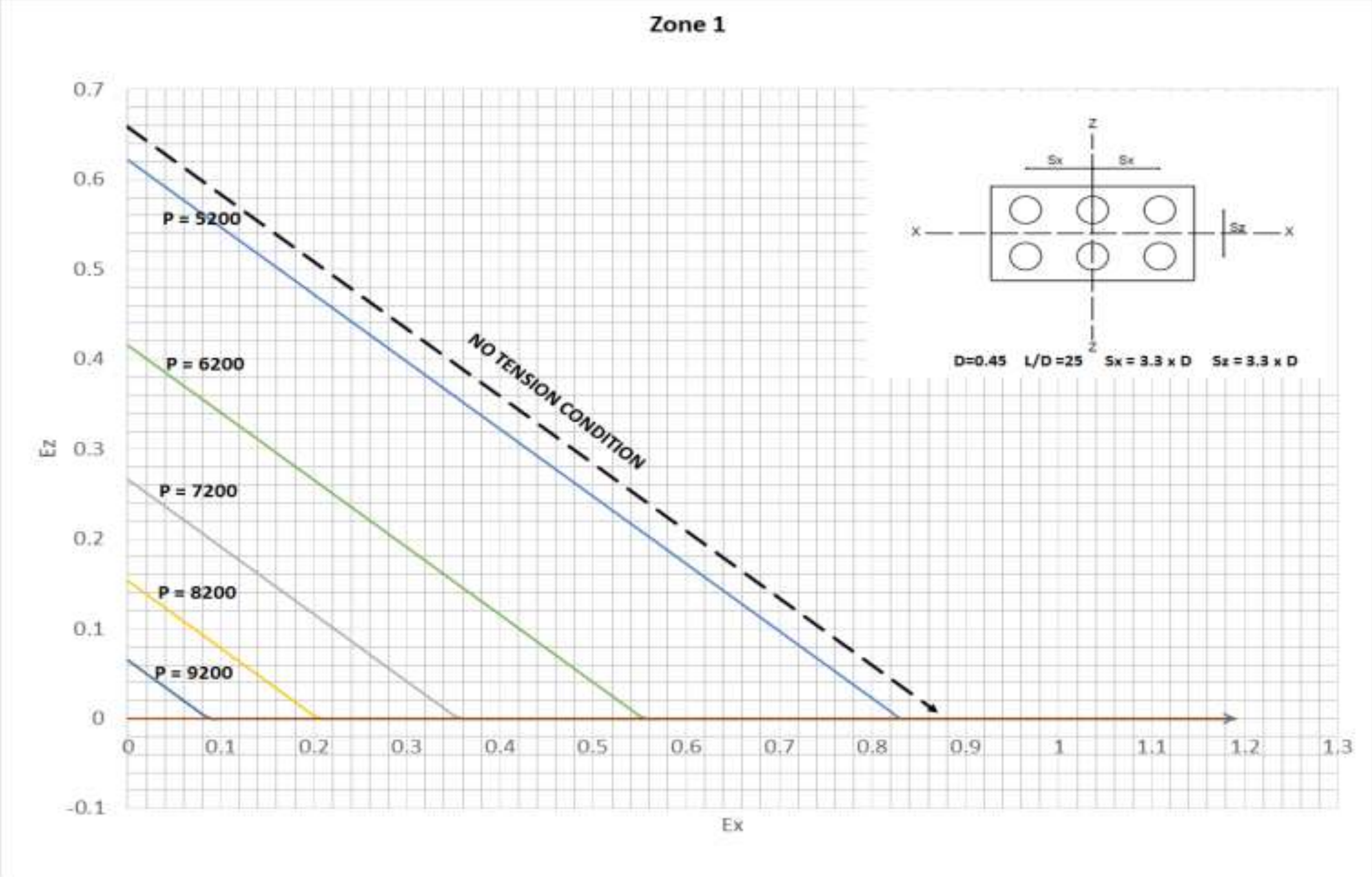

Zone 1
P = 1600
P = 1800
P = 2000
P = 2200
P = 2400
P = 2600
P = 2800
NO TENSION CONDITION
D=0.30 L/D =25 Sx = 3.3 x D Sz = 3.3 x D
Ez
Ex

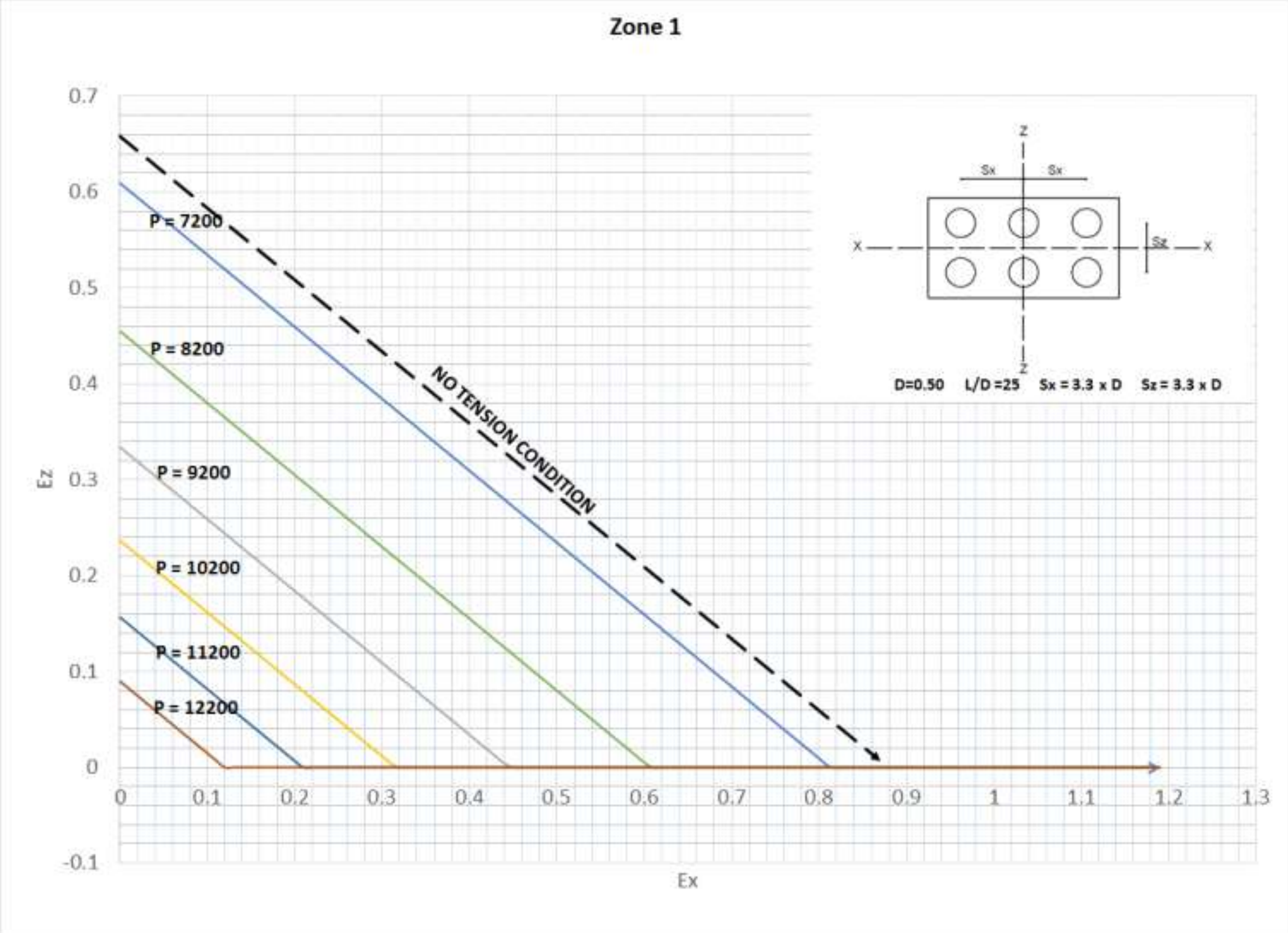


Zone 1
P = 2400
P = 2700
P = 3000
P = 3300
P = 3600
P = 3900
P = 4200
NO TENSION CONDITION
D=0.35 L/D =25 Sx = 3.3 x D Sz = 3.3 x D
Ez
Ex



Zone 1
P = 3700
P = 4200
P = 4700
P = 5200
P = 5700
P = 6200
NO TENSION CONDITION
D=0.40 L/D =25 Sx = 3.3 x D Sz = 3.3 x D
Ez
Ex


Zone 1
P = 5200
P = 6200
P = 7200
P = 8200
P = 9200
NO TENSION CONDITION
D=0.45 L/D =25 Sx = 3.3 x D Sz = 3.3 x D
Ez
Ex


Zone 1
P = 7200
P = 8200
P = 9200
P = 10200
P = 11200
P = 12200
NO TENSION CONDITION
D=0.50 L/D =25 Sx = 3.3 x D Sz = 3.3 x D
Ez
Ex

6. Conclusion

- From the above graph we can directly pick up most suitable type of pile group from the upcoming load and bidirectional moment for the given geological parameters.
- We can also observe that type of pile group is capable to maximum Load and Moment.
- From the prepare chart It would be easily to minimize the variation in Design.

Acknowledgment

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