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Parametric Study of Foundation of Tension and Suspension Tower with Square and Rectangular Base

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Abstract *- Foundation of transmission tower plays very important role for safety and better performance of tower as it transmits loads of the transmission system to earth. This paper presents the parametric study of the isolated and pile type of foundation of the self supported suspension and tension type transmission tower for square and rectangular base for different soil conditions. Foundation of tower has been designed for five different base width of tower by changing the ratio of longitudinal face and transverse face LF:TF = 1:1, 1:1.1, 1:1.2, 1:1.3, 1:1.4. Five types of soil conditions were used. From the comparison, it was concluded for every type of soil condition the minimum cost of foundation for suspension tower was for base width ratio LF:TF = 1:1.2 to 1:1.3 and for tension tower minimum cost was for LF:TF = 1:1.3 to 1:1.14.*

Keyword - Suspension tower, Tension tower, Isolated Foundation, Pile foundation

1. INTRODUCTION

Because of the present demand of high and extra high voltage transmission the sizes of towers of transmission line are increasing, resulting in very heavy loads and due to that it requires very heavy foundation. In any project of transmission line it requires very large number of foundations. Other than financial aspect, it is also known that the failure of foundation of transmission tower is also a big reason for collapse of tower. These failures are due to certain deficiencies in design or due to construction or classification of foundation. Wastage of resources happened many times because of over safe design of foundation due to inappropriate classification. Due to very different soil conditions occurs in the line of transmission and remoteness of sites, design task and selection for suitable foundation is challenging. The foundations have to be designed for different types of soil to suit the particular type soil conditions.

The study was carried out to check the feasibility of design of isolated and pile foundation for different soil conditions by changing the base width ratio. The main objective of study is to provide the best and economical tower foundation design as per Indian specification for variety of soils.

2. DATA REQUIRED

For the design of any type of transmission tower foundation basic data required are different types of loads coming over foundation and soil data. Following data is required for the design of foundation.

2.1 Types of loads on foundation :

Foundation of transmission towers are generally subjected to 3 different types of forces:

1. Compressive force (downward thrust)
2. Tensile force or uplift
3. Lateral thrust of side force in both longitudinal and transverse direction

The magnitude of forces depends on transmission tower type and also on transmission line capacity. The design loads for foundations must be taken 10% higher than these forces from the towers.

2.2 Soil Data :

The following parameters of soil are required for design of foundation.

1. Density of soil
2. Limit bearing capacity of soil
3. Angle of soil frustum

3. MODEL ANALYSIS AND DESIGN

3.1 Pile foundation

Design of pile foundation has been carried out using Staad Foundation software. To calculate the capacity of pile the excel sheet has been developed using IS 2911: 2010.

- Vertical capacity of pile
  - For granular soil

$$Q_u = A_p(½ D\gamma N_\gamma + P_D N_q) + \sum_{i=1}^{n} K_i P_{Di} \tan\delta_i A_{si}$$

- For cohesive soil

$$Q_u = A_p(½ D\gamma N_\gamma + P_D N_q) + \sum_{i=1}^{n} K_i P_{Di} \tan\delta_i A_{si}$$

- Uplift capacity of pile

The uplift capacity of a pile is given by sum of the frictional resistance and the weight of the pile (buoyant or total as relevant). Uplift capacity can be obtained from static formula by ignoring end-bearing but adding weight of the pile (buoyant or total as relevant).

3.2 Excel sheet

Excel sheet has been developed for design and stability analysis of foundation.

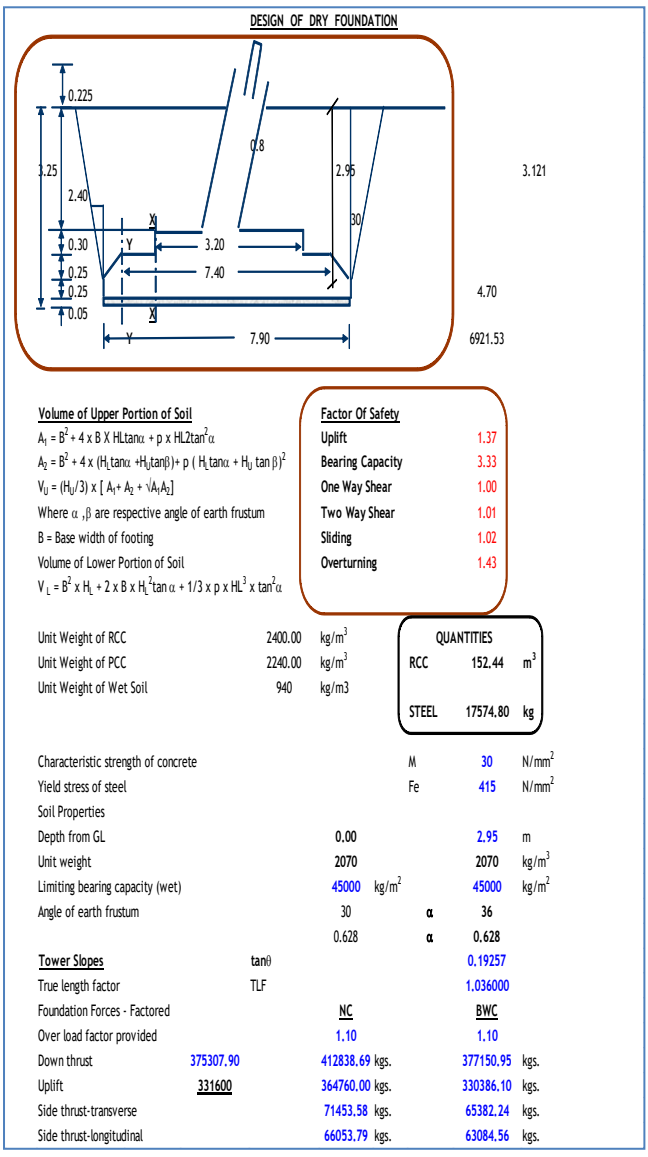
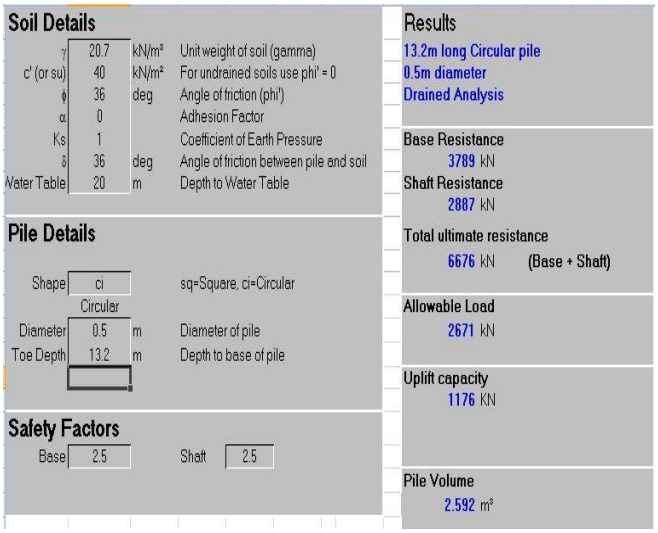


Fig. 1:- Sheet for isolated foundation design

To calculate the capacity of pile another excel sheet has been developed using IS 2911:2010.



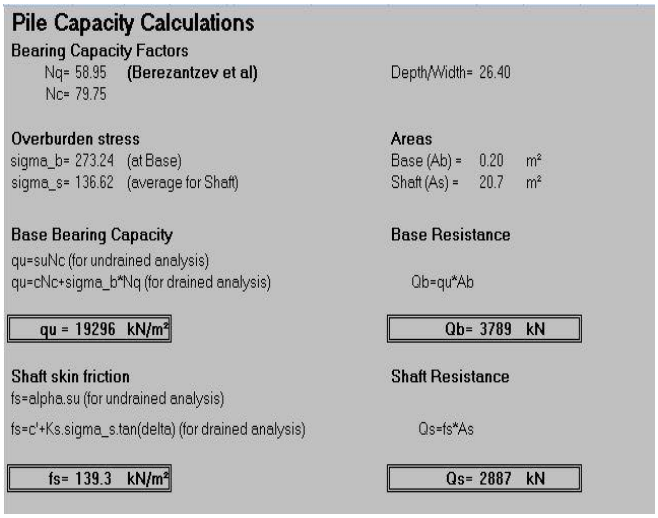


Fig. 2:- Sheet for pile capacity calculation

And after calculating the capacity of pie design of pile cap is done using Staad Foundation.

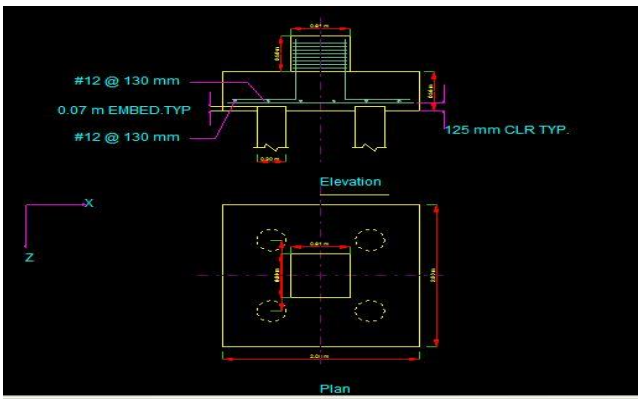


Fig. 3:- Pile cap in Staad foundation

3.3 Soil data used

For the study of foundation under different soil conditions five different types of soil has been used for design of foundation.

TABLE-1. PROPERTIES OF SOIL

SR NO	TYPE OF SOIL	ANGLE OF EARTH FRUSTUM Φ (DEGREE)	UNIT WEIGHT OF SOIL (KG/CUM)	LIMIT BEARING CAPACITY (KG/SQM)
1	DENSE SAND	36	2070	45000
2	LOOSE SAND	29	1750	25000
3	SILTY SAND	27	1750	15000
4	STIFF CLAY	17	2000	20000
5	SOFT CLAY	17	1750	10000

4. RESULTS AND DISCUSSIONS

For the comparative study of design and cost of foundation five different type of soil has been used as shown above. 400kv suspension and tension tower foundations has been designed for five different base ratio of longitudinal face to transverse face LF:TF for 1:1.0 to 1:1.4 for all the five types of soil conditions. So total of 100 numbers of foundations has been designed. From that schedule of model for suspension tower has been shown below.

TABLE-2 MODEL SCHEDULE

RATIO	DENSE SAND	LOOSE SAND	SILTY SAND	STIFF CLAY	SOFT CLAY
1:1	S110DS	S110LS	S110SS	S110STC	S110SOC
1:1.1	S111DS	S111LS	S111SS	S111STC	S111SOC
1:1.2	S112DS	S112LS	S112SS	S112STC	S112SOC
1:1.3	S113DS	S113LS	S113SS	S113STC	S113SOC
1:1.4	S114DS	S114LS	S114SS	S114STC	S114SOC

- Model name description:

S110DS – Suspension tower for base width ratio of longitudinal face to transverse face LF : TF = 1:1.0 for dense sand type soil condition.

- Comparison of cost of suspension and tension tower foundation is done for isolated and pile foundation for same type of soil condition by varying the base width ratio

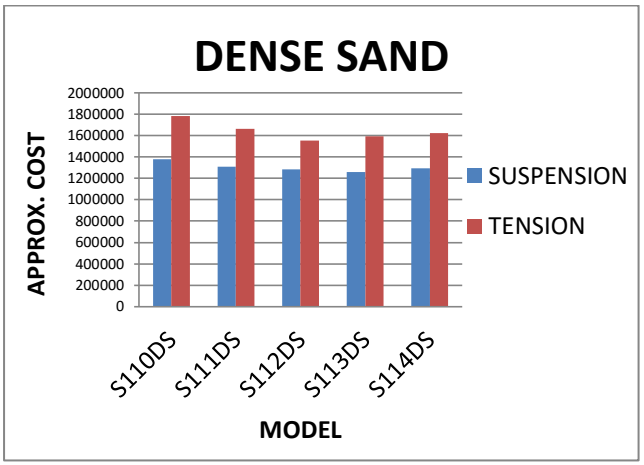


Fig. 4:- Cost comparisons for dense sand

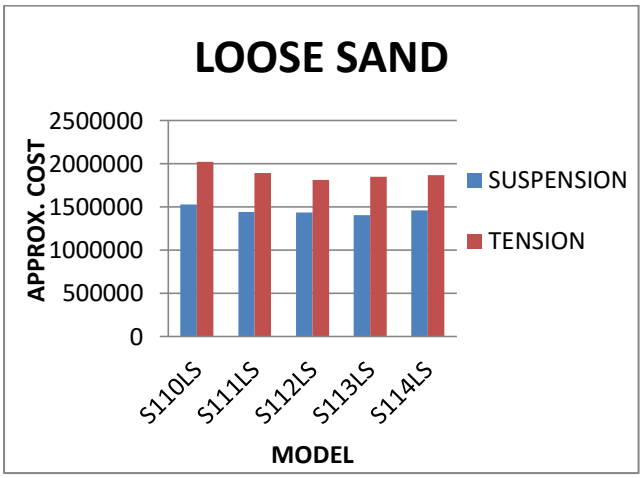


Fig. 5:- Cost comparisons for loose sand

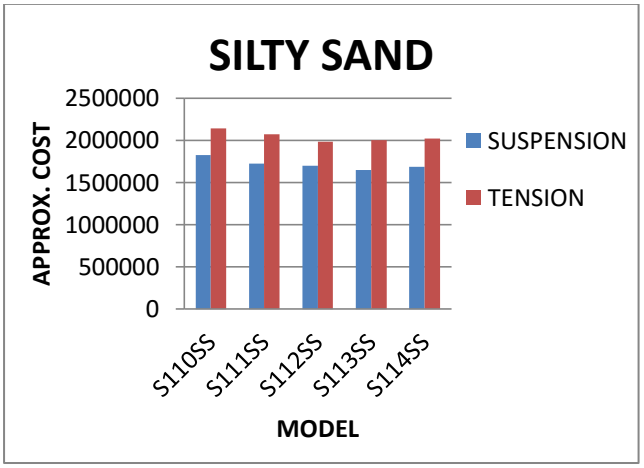


Fig. 6:- Cost comparisons for silty sand

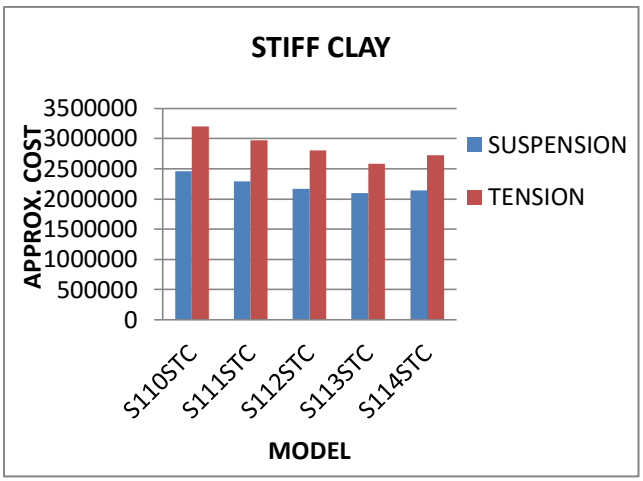


Fig. 7:- Cost comparisons for stiff clay

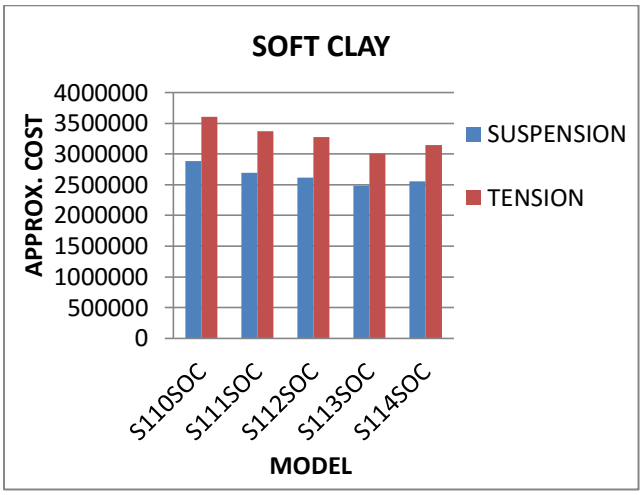


Fig. 8:- Cost comparisons for soft clay

5. CONCLUSIONS

- This study shows us foundation design as per different loadings and as per varying soil conditions for different base width ratio of transmission tower.
- Size of foundation and cost is less for suspension type tower than tension tower.
- For isolated foundation, for every type of soil minimum cost can be achieved by taking the base width ratio between longitudinal face to transverse face as 1:1.2 to 1:1.3
- For pile foundation, for every type of soil minimum cost can be achieved by taking the base width ratio between longitudinal face to transverse face as 1:1.3 to 1:1.4
- Percentage reduction in cost is 8-9% for isolated foundation whereas for pile foundation percentage reduction is 13%.

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