

Comparative Study of Foundation of Suspension Tower with Square and Rectangular Base

Akash M. Popat¹ Prof. Paresh G. Patel²

¹PG Student ²Associate Professor

^{1,2}Department of Applied Mechanics

^{1,2}L.D. College of Engineering, Ahmedabad, India

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 comparative study of the isolated foundation of the self supported suspension type transmission tower for square and rectangular base for different soil conditions. Foundation of suspension 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 was for base width ratio LF:TF = 1:1.3 to 1:1.4.

Key words: Suspension Tower, Foundation

I. INTRODUCTION

Nowadays there is demand of high and extra high voltage transmission, so 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 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.

II. 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.

A. 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.

B. 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

III. MODEL ANALYSIS AND DESIGN

Design of isolated type of foundation consist of two parts

A. Stability analysis

Analysis for stability is required to check the possibility of failure of foundation by sliding, tilting, uprooting, overturning due to load imposed on soil by foundation in excess of ultimate capacity of soil. The most important thing of the design for foundation is the required check for the stability of foundation for different loads coming over it from the tower. The foundation must remain stable for every possible combination of loads it is subjected. The stability for foundation must be checked for the following cases.

- 1) Check for bearing capacity
- 2) Check for uplift resistance
- 3) Check for side thrust
- 4) Check for overturning
- 5) Check for sliding

B. Structural design of foundation

Structural design of transmission tower foundation of concrete involves the design of chimney and the design of base slab. The chimney must be designed for maximum bending moment due to side thrust in longitudinal and transverse direction combined with direct compression or direct tension. The base slab in R.C.C foundations can be designed single stepped or multi stepped. The design of foundations of concrete should be done as per limit state method of design given in IS: 456-2000.

C. Excel sheet

For the design of foundation of towers 400kv suspension towers with varying base width ratio has been designed using Staad Pro. Excel sheet has been developed for design and stability analysis of foundation.

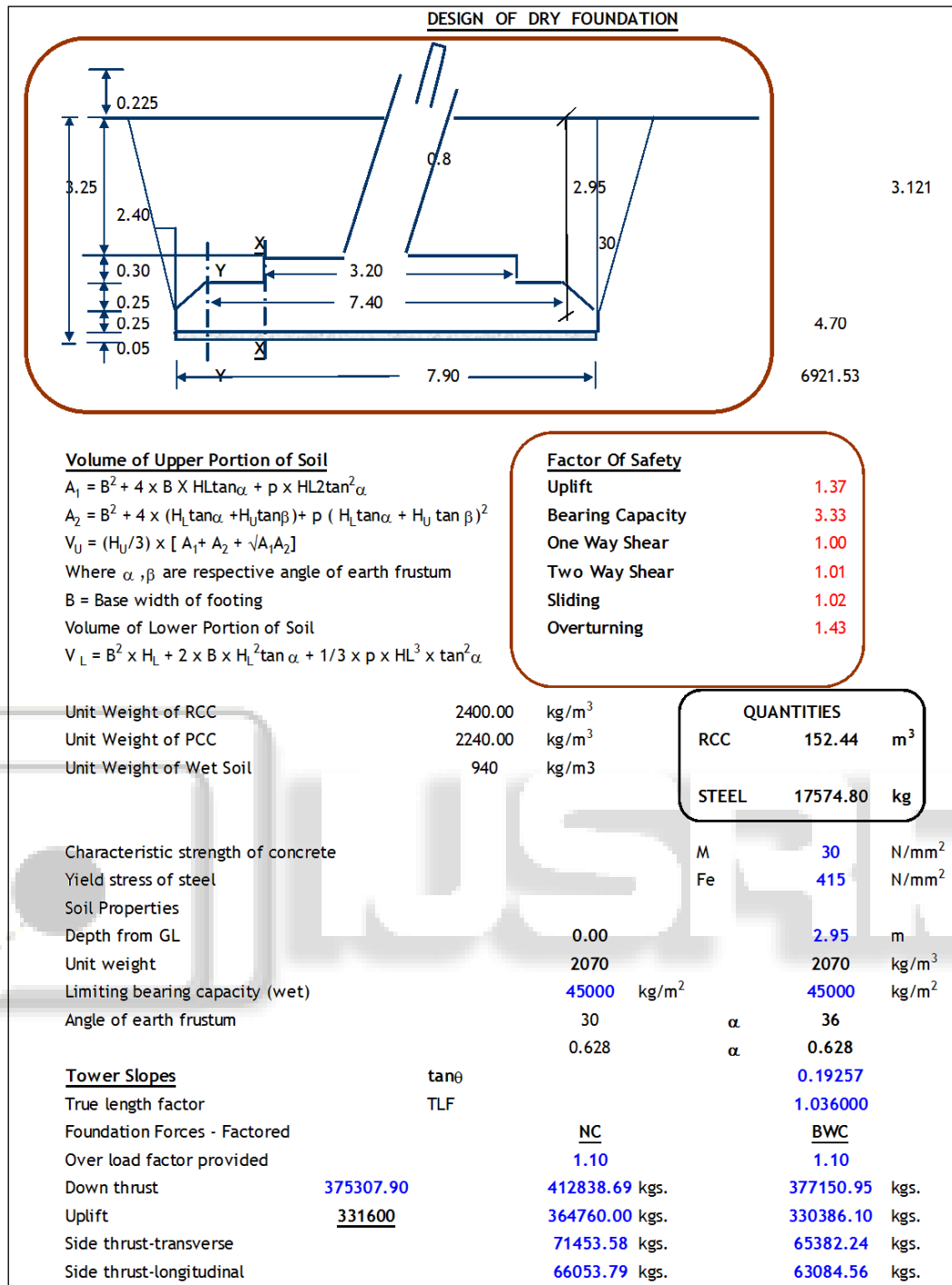


Fig. 1: Sheet for foundation design

D. Soil data used

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

| 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 |

Table 1: PROPERTIES OF SOIL

IV. 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 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 25 numbers of foundations has been designed.

| RATIO | DENSE SAND | LOOSE SAND | SILTY SAND | STIFF CLAY | SOFT CLAY |
|-------|------------|------------|------------|------------|-----------|
| 1:1 | S110DS | S110LS | S110SS | S110ST | S110SO |
| 1:1.1 | S111DS | S111LS | S111SS | S111ST | S111SO |
| 1:1.2 | S112DS | S112LS | S112SS | S112ST | S112SO |
| 1:1.3 | S113DS | S113LS | S113SS | S113ST | S113SO |
| 1:1.4 | S114DS | S114LS | S114SS | S114ST | S114SO |

Table 2: MODEL SCHEDULE

A. 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 foundation is done for same type of soil condition by varying the base width ratio.
- Comparison of cost of foundation for dense sand soil

| SR NO | RATIO | MODEL | RCC (M ³) | STEEL (KG) | APPROX COST (RS) |
|-------|-------|--------|-----------------------|------------|------------------|
| 1 | 1:1.0 | S110DS | 152.44 | 17574.8 | 1377318 |
| 2 | 1:1.1 | S111DS | 144.92 | 16613.29 | 1306065 |
| 3 | 1:1.2 | S112DS | 140.52 | 16528.14 | 1281085 |
| 4 | 1:1.3 | S113DS | 136.21 | 16432.35 | 1256182 |
| 5 | 1:1.4 | S114DS | 142.17 | 16710.86 | 1295730 |

Table 3: Comparison of Cost of Foundation for Dense Sand Soil

The same type of comparison has been done for all other four types of soil conditions and tables have been developed and charts have been plotted.

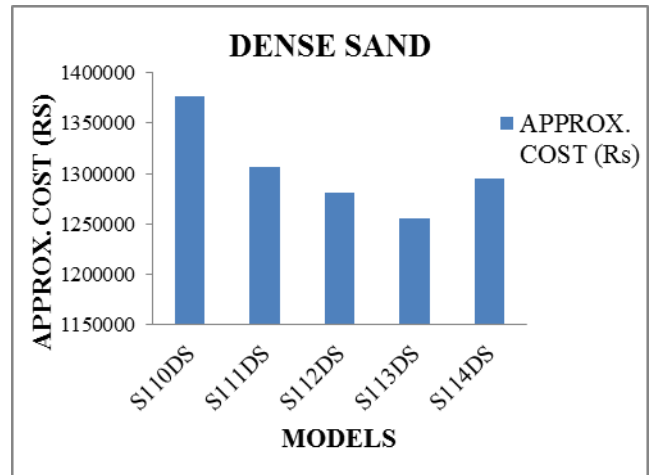


Fig. 2: Cost comparisons for dense sand

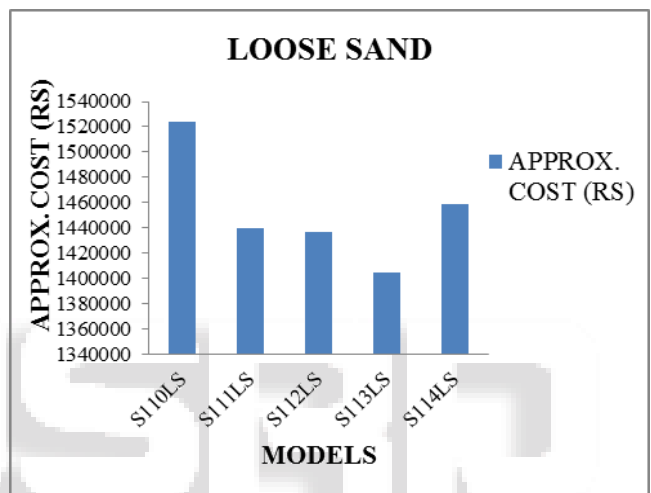


Fig. 3: Cost comparisons for loose sand

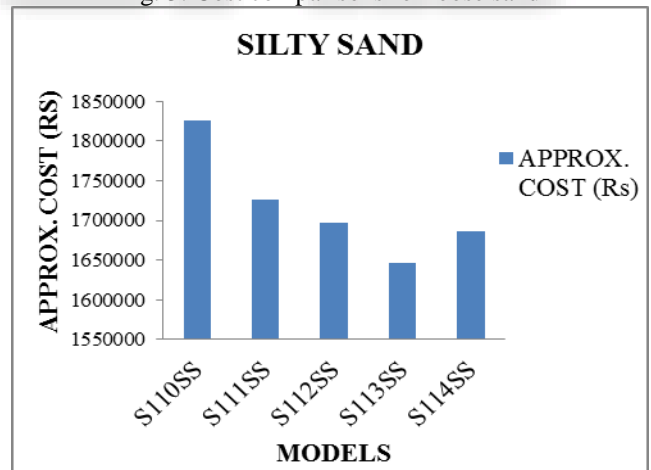


Fig. 4: Cost comparisons for silty sand

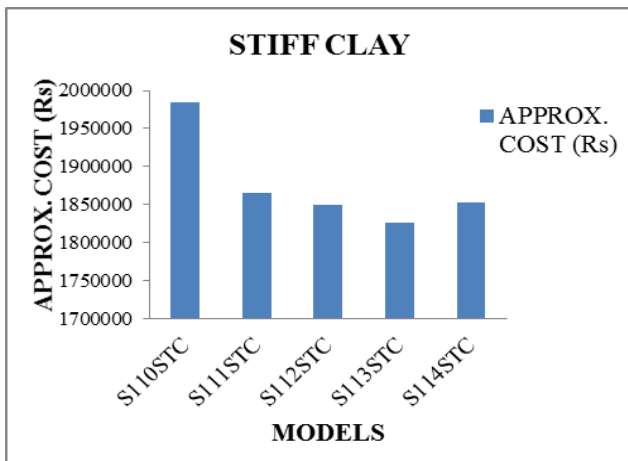


Fig. 5: Cost comparisons for stiff clay

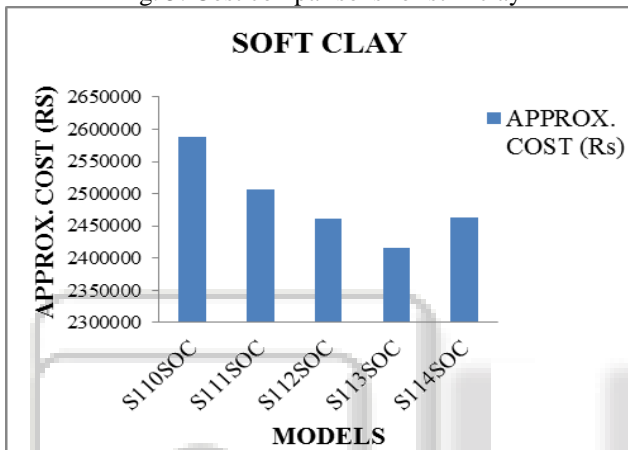


Fig. 6: Cost comparisons for soft clay

V. 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 dense and loose sand compare to clays.
- But for every type of soil minimum cost can be achieved by taking the base width ratio of longitudinal face to transverse face as 1:1.3
- Percentage reduction in cost is 10-11% for sandy type soil whereas for clayey soil percentage reduction is 7-8%.

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