Problems Related To Telecommunication Tower Foundation

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Abstract

Telecommunication towers are very much essential due to rapid growth of the Telecommunication Technology. Towers consist of steel super structure & reinforced foundation. Normally, the tower foundation constitutes about 20 to 40 percent of the total cost of tower. Cost of the foundation can be reduced by reducing their sizes. But when reducing size its stability also reduced. So, the design of economical & reliable foundation is a difficult task.

Several design criteria should be checked when designing of foundation. One criterion is, design against uplifting failure. This study identified that Uplifting force is the most dominant force which the tower foundation is subjected. So, there is a more chance to fail the tower by uplifting rather than failed by bearing, sliding etc. As a solution for increasing the Uplifting capacity undercut phenomenon is provided in this study. Undercut type foundation has lesser dimension than without undercut foundation. Because it has higher uplifting resistance compare with without undercut foundation. This concept was proved by conducting model testing. For model testing individual pad foundation were used. According to the test results Failure Load is 200 – 300% higher than the Design Load. In this way the effectiveness of the undercut phenomenon can be shown to overcome the problem in tower foundation design.

1. Introduction[1]

Telecommunication Tower Construction is most widely growing sector at present. Most of the towers are four leg Green field Towers. This towers Consist of Steel super structure & Reinforced concrete foundation. In design stage foundation is checked for all the possible failure modes such as Bearing, Overturning, Sliding, Settlement etc. & dimensions are providing to satisfy all the failure modes. These failure modes occur due to various forces acting on to the towers. Wind is very frequently acting force & due to that tower foundation is

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failed by Uplifting. In this project describes how to economise the tower foundation by considering this failure mode. Three models were prepared on the ground and provide Uplifting force by using suitable loading arrangement. Then the actual failure load was compared with design Uplifting capacity.

2. Literature Review

For the design of foundation Friction angle (Φ) and Unit weight (γ) are required. When the foundation fails the failure plane makes an angle equal to Φ with the vertical plane. But the actual failure plane can be different. Typical Uplifting failure pattern shows in below figure.

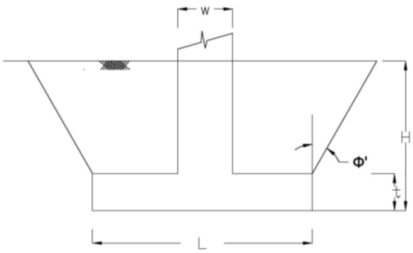

Figure 1: Dimensions of models

Generally following equation is used to calculate uplifting capacity of the foundation.

Uplifting Capacity = Weight of the soil + Weight of the foundation

It is obvious that Uplifting capacity can be increased by increasing Weight of the soil in the failure region. So, failure plane can be increased by providing undercut. So in this study, tried to find out how much this failure plane can be increased by providing undercut.

In order to find the effect of the undercut model testing is need to carry out. Dimensional analysis can be used to convert the results form model to prototype. For that "Bakingham pi theorem" can be used. In this test, Area of the footing (A) and Depth of the footing (D) select as geometric properties, Uplifting force (P) and gravitational acceleration (g) as external effect and soil cohesion (C), unit weight of the soil (γ) and Friction angle (Φ) as surrounding effect can be considered.

So following non dimensional groups were prepared.

$$\pi_1 = \frac{P}{\gamma \times D^3}$$

$$\pi_2 = \left(\frac{A}{D^2}\right)$$

Using same scale in horizontally and vertically in prototype and model π2 can be kept constantly. So by using following equation maximum uplifting capacity of the prototype can be calculated.

$$P_{prototype} = \left[\left(\frac{P}{\gamma \times D^3}\right)_{model}\right] \times \left[(\gamma \times D^3)_{prototype}\right]$$

3. Methodology

3.1 Modal Preparation

Using design uplifting force, 3 different prototypes foundations were designed. Then those were scaled down by using 10:3 scale factor.

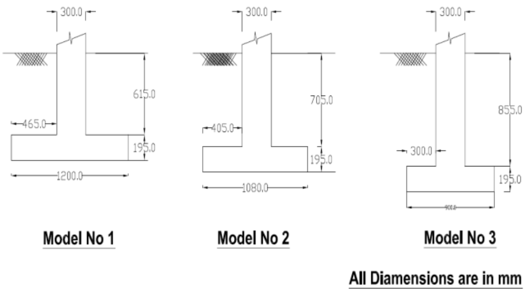

Figure 2: Dimensions of models

Then those modal were constructed on the ground.

3.2 Experimental set up

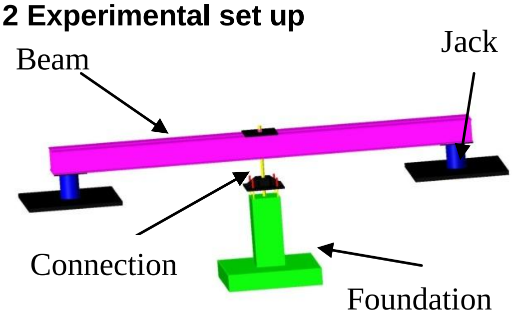

Figure 3: Loading setup

5m long I – beam and 25, 20 ton hydraulic jacks (least count 200kg) were used to provide uplifting force for modal foundations.

First 1m x 1m x 9mm 2 steel plates were laid on the ground where the jacks should be placed. It was spread the reaction of the jacks. Then layers of concrete cubes were placed over the steel plate. After that jack is placed on the cubes & beam is placed on top of it. Then the steel plate which is inserted through the reinforcement of the column & steel beam was connected using the steel rod. Then the pumps were connected to the jacks & before applying force air voids in the jacks were removed. Then the load was increased by 400 kg intervals. This load is hold for 60 seconds to transfer to surrounding soil.

So, this load increment was done until the foundation is failed. Failure of the foundation can be identified in 2 ways.

- Visible Cracks appeared around the soil
- Dial gauge reading will not further increase while applying the pressure

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4. Conclusions

According to the results failure loads are greater than expected values. Major crack line between compacted soil and undisturbed soil shows that no proper bonding between compacted soil and undisturbed soil. Other diagonal cracks proved that applied uplifting load is act on the undisturbed soil.

Foundations were designed assuming that there is no considerable contribution of soil cohesion to resist uplifting force. In failure, rods of the jacks were coming out without considerable amount of decreasing the load. That is because only soil weight is act on the foundation. If there is a considerable effect of soil cohesion, there must be reduction of dial gauge reading due to soil cohesion when separating the soil wedge.

Actual failure load is greater than the value of calculated weight of soil in cracking zone. Because, Load may be applied to away from the cracking zone and that load may not be enough to make the cracks. Because load may gradually reduce and at one point it would be zero. The cracks are visible in only when applied load equal to ultimate load. The point where load become zero cannot be observed.

In this loading pattern soil is not in directly in Active or Passive ranking state. So foundations were designed assuming that, angle of soil wedge which is affected on the footing equal to the friction angle of soil. If soil in active ranking state the angle of failure plane should be equal to $45^{o}-\Phi/2$ (28.5^{o}). If soil in passive ranking state the angle of failure plane should be equal to $45^{o}+\Phi/2$ (61.5^{o}). Resulting angles of failure planes of Model No1 and Model No 3 are in between 28.5^{o} and 61.5^{o}. So this failure pattern is in between active and passive ranking states.

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