

**AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING**

**Transmission Guyed Towers
(The Stability of Guyed Towers)**

by

Ahmed Abdel Fattah Mahmoud Ahmed

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Structural Division

Ain Shams University

SUPERVISORS

Professor

S. A. Saafan

Ain Shams University

Associate Prof.

Hassan A. Ereiba

Cairo University

Structural Engineering Department

Ain Shams University

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



APPROVAL SHEET

GUYED TOWERS

(The stability of guyed towers as space structures
(nonlinear) and taking the actual shape of the guys)

by

AHMED ABDEL FATTAH MAHMOUD AHMED

Approved by :

- 1- Prof. S. A. Saafan *S. A. Saafan*
- 2- Prof. Kamal Haasan Mohamed *K. Haasan*
- 3- Prof. Ibrahim Mahfouz M. Ibrahim *I. M. Ibrahim*
- 4- Ass. Prof. Hassan A. Ereiba *H. Ereiba*

TO.....

MY MOTHER

MY BROTHERS

MY WIFE

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List of Symbols

The following symbols are used in the present thesis. Other symbols not listed are defined where they are used.

- A = the total compressive cross-sectional area of the built-up column.
- A_{ch} = the cross-sectional area of the chord member.
- A_d = the cross-sectional area of the lacing bar.
- a = the span length.
- b = width of the cross-section.
- d = the length of the lacing bar.
- E = Young's modulus of elasticity.
- [F] = the end action matrices in global coordinates.
- [F_G] = the member end action matrix due to non-linear geometric terms
- G = the shear modulus.
- GJ = the torsional rigidity.
- g_{cr} = weight of the cross-arm per unit length.
- g_c = weight of the conductors per unit length.
- g_L = weight of the tower leg per unit length.
- H = height of the tower.
- I_y = the moment of inertia about the Y-axis.
- I_z = the moment of inertia about the z-axis.
- J = torsional constant.
- [K] = the tangent stiffness matrix in global coordinates.
- [K_G] = the stiffness matrix due to end displacements.

- $[K_s]$ = the elastic stiffness matrix taking into account the effect of axial force.
- L = longitudinal force of conductors.
- L' = longitudinal force of earthwires.
- P_e = Euler buckling load.
- P_h = wind pressure at height h .
- P_{cr} = the critical buckling load.
- Q_c, Q_{Gw} = the load due to wind pressure on conductor and earth wire, respectively.
- r = the radius of gyration.
- $[R]$ = the coordinates transformation matrix.
- $[r]$ = the member orientation matrix in the undeformed configuration.
- Row = the ratio between the critical load and Euler load.
- S_1, S_2, S_3 = the stability functions
- T_{cr} = transverse load on the cross-arm.
- T_e = \sum (transverse load on the earth wire extensions).
- $[U]$ = the end displacement matrix in global coordinates.
- V = shearing force resulting from bending of a built up column.
- w_g = weight of the guys per unit length.
- λ = the slenderness ratio.
- ϕ = the slope of lacing bars.
- ϵ = the axial strain.

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INTRODUCTION

In Egypt, the need to electrical power is remarkably increased for the industrial development and the construction of new areas as in Sinai, which necessitates constructing new overhead transmission lines for which the guyed towers will offer the best solution. Previous studies indicated that the guyed towers are more economical than self supported towers if the required land for construction is cheap and available.

The importance of the use of guyed towers in Egypt implies the necessary studying the suitability of such type of Guyed towers taking into consideration the local environments in Egyptian areas, such as electrical, climatic and topographical conditions.

The guyed towers has the advantages of being light in weight, simple in erection and transportation. Also it has the possibility of using Helicopters by which the towers can be flown to the site and placed quickly and guyed.

The object of this research work is to find the critical buckling load of guyed towers as a space structure taking into account the actual behaviour of the cables.

A parametric study is carried out to study the influence of the cross section and slope of the guys upon the buckling strength of guyed towers having masts of different stiffness beside the influence of instability caused by axial loads, the change in

geometrical quantities of the masts and the actual shape of guys are taken into consideration.

A computer programme is built to determine the buckling strength of Guyed towers as space structure.

From the analysis of previous erected towers, it is intended to find an empirical formula for the buckling strength of guyed towers.

CHAPTER 1

Part 1- Guyed Towers in overhead Transmission lines

- 1-1.1 Introduction
- 1-1.2 History of guyed towers
- 1-1.3 Nowadays trends
- 1-1.4 Types of Guyed towers
- 1-1.5 Configuration of Guyed towers
- 1-1.6 Structural Features of Guyed towers.
- 1-1.7 Materials of Guyed towers
- 1-1.8 Minimum Tower height.
- 1-1.9 The advantages and disadvantages of guyed towers compared to self-supporting towers.
- 1-1.10 Limitation of use of guyed towers.
- 1-1.11 Economic comparison between different types of Guyed towers.

Part II- Review of Previous work of the Non-linear elastic analysis of Framed structures.

CHAPTER 1

Part I: Guyed Towers in Overhead Transmission lines:

1-1.1 Introduction:

In almost every country of the world today energy consumption is increasing enormously and electric power is taken an ever growing share. Reasons for its outstanding popularity are many. As a flexible source of heat and light, the electric power is unrivalled and new applications are being found daily. Perhaps the most important of all these applications is that the electricity can readily be supplied to a large number of consumers through the medium of power line.

The continued increase in the demand on the electrical energy, specially in growing countries, has enlarged the interest in constructing thousands of kilo meters of overhead lines to transmit this effecient power to where it will be useful.

In Egypt, the need to electrical power is remarkably increased for the industrial development and the construction of new areas as in Sinai, which necessitates constructing new overhead transmission lines for which the guyed towars will offer the best solution. Previous studies indicated that the guyed towers are more economical than self-supporting towers if the required land for construction is cheap and available.

The importance of the use of guyed towers in Egypt necessitates the required study of its suitability with respect to

design and stability taking into consideration the local environments in Egyptian areas, such as electrical, climatic and topographical conditions.

Construction of guyed towers has to be studied to show the advantage of lightness and simplicity of transportation and erection, besides the possibility of using Helicopters by which the towers can be flown to the site and placed quickly and guyed.

The overhead lines are mainly composed of conductors, earth wires and isolators, all supported by high towers. The assurance of the stability of such towers under the action of ordinary and special cases of loading which may happen is essential for the safety of the overhead lines. The study of the problem of stability of transmission towers is not a simple task if we realise the fact that these constructions are space ones operating in geometric non linear conditions this problem has been previously treated by introducing many simplified assumptions.

In this thesis we tried to examine the behaviour of Guyed towers to be very close to its actual one, this means a three dimensional non-linear solution for such towers.

Therefore a research is required, covering such a national problem, to throw a light on guyed towers under local environments.

1-1.2 History of guyed towers:

the first guyed portal tower was born spontaneously before, 1930, tried at once on a 110 Kv line (Fig. (1-1.1)), and found superior to any other, existing construction. Part of these towers are still in use, and we can see one in the Technical Museum in Finland.

In Finland the first tower was made of steel, but still cheaper a structure was made using timber as tower legs, and so was found the prototype tower for 100 Kv lines used since until to-day, and no better has been found so far. The same structure was used also for several 220 Kv lines although the first 220 Kv. line in 1949 was fitted with steel towers-guyed portals, of course.

The first 400 Kv line, 1956, and the latest one, finished recently, are all of the same constructions, only varying in scale and some details.

In Finland where the basic parameters the conductors, the external loads, the terrain are moderate, there has been no need to change from the portal to some other guyed type. In Canada and the U.S., where climatic and terrain conditions vary in large limits, the v-type proved more suitable, and is in large use, even with numerous variations. The lollipop, pioneered there for 110 Kv line in 1961, also has found abroad several successors in various shapes.

The interest in these structures is growing also outside Europe and North America. Especially some south American countries (Brazil, Chile and Argentina) are just now studying the possibility