TRANSMISSION TOWERS

Parametric Study & Optimum Analysis

By

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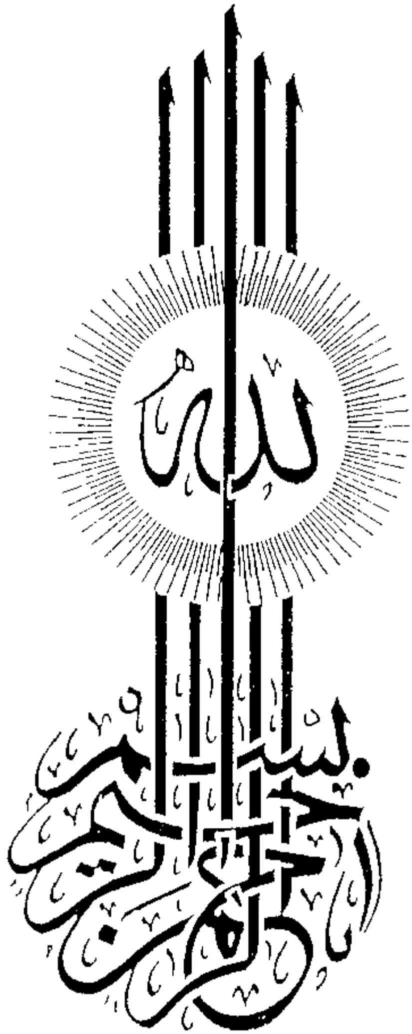
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TO ...

Those Who LOVE me, and ...

Those Whom I LOVE

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NOTATIONS

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

A	:	The cross sectional area of member.
a	:	The span length.
B_1	:	Lower breadth of tower.
B_2	:	Upper breadth of tower.
B_a	:	The average waist line dimension.
Bx	:	The maximum waist line dimension.
Bn	:	The minimum waist line dimension.
br1	:	Lower breadth of main part or panel.
br2	:	Upper breadth of main part or panel.
c	:	Drag factor.
d	:	The diameter of wire.
E	:	Young's modulus of Elasticity.
F	:	Wind force.
Fy	:	The minimum yeild stress.
F_{cr}	:	The critical stress.
G	:	Vertical force due to weight.
H	:	The tower height.
HL	:	The height of the lower cross arm above ground level.
HA	:	The actual height of the point of intersection of leg members.
$H_{c.g.}$	:	The height of c.g. of wire loads.
H_w	:	Load due to wind on wire.
H_{GW}	:	Load due to wind on earth wire.
ho	:	The reference height (=10 m.)
$[K_a]$	:	The over-all stiffness matrix of the tower.
$[\bar{K}_a]$	:	The over-all stiffness matrix in a banded form.
k	:	Vertical Load to unit horizontal load ratio.
l_i	:	Height of panel (i).

M : The overturning moment at ground level.

P_h : Wind pressure at height h.

R : The resultant force.

r : A multiplication factor.

T_w : Tension due to broken wire.

T_{GW} : Tension due to broken earth wire.

t : The thickness of member.

V_f : Load factor.

V_i : Weight of insulator.

V_w : Weight of wire.

V_{GW} : Weight of earth wire.

V_o : Wind speed at height ho .

V_h : Wind speed at height h.

α : The turning angle of route.

θ : The angular rotation of tower.

Δ_x : The horizontal displacement in X direction.

Δ_y : The horizontal displacement in y direction.

ΔT_w : Differential Tensioning in wire.

ΔT_{GW} : Differential Tensioning in earth wire.

$\emptyset$: The solidity ratio.

$\emptyset_i$: The slope of cross diagonal in panel (i).

λ : The slenderness factor of member.

CONTENTS

INTRODUCTION

In Egypt, as a developing country, the continued increase both in its population as well as in energy demands has stimulated the need to electrical power which is supposed to increase for agicultural and industrial developments. Moreover, growth of electrical power is needed for the construction of new cities in the Delta and Sinai as well as the direction towards new urban areas in the desert. Thus, constructing new overhead transmission lines is now very essential to transmit the power needed. For these lines, the self supporting towers are much more economical than guyed towers where the required area for construction is expensive or even not available as in the Delta contrary to that in Sinai or new urban areas.

The importance of using self supporting towers in Egypt necessitates a thorough study of its suitability with respect to the design which takes into account the local enviromental conditions such as electrical, climatic and topographical conditions. Thus, research is required to cover such an important national problem and to throw light on self supporting towers under local enviroments. Also, the importance of minimizing the cost of constructing such transmission lines necessitates a parameteric study and optimum analysis of the towers used.

The thesis represents a theoretical study of such problems and deals with the following aspects :

1. The illustration of transmission lines, the different types of transmission towers and the different operating conditions.

2. Different methods of optimization, structural optimization of trusses and an integrated transmission line design system.

3. A parametric study for an optimum configuration of transmission towers.

4. The effect of installing horizontal bracing members (diaphragms) along the tower height.

Two computer programs are written essentially to meet the nature of such theoretical study. The first is an advanced one which generates the tower configuration data while the second analyzes the tower, i.e. determines the internal forces in all its members and the nodal displacements. The program also determines the total weight of the tower.

The thesis is composed of five chapters and three appendices.

CHAPTER 1 deals with the review of previous work in the field of transmission line analysis and design. It gives the design requirements for steel towers according to different specifications and the different cases of loading as well as the loading assumptions. Moreover, it presents the illustration of transmission lines and different classifications of transmission towers.

In CHAPTER 2 , the concept of structural optimization and different methods of optimization are illustrated. Also, the structural optimization by computers is presented and this is illustrated with the structural optimization of trusses. Finally, the optimality aspect of transmission lines is clarified by an integrated transmission line design system.

CHAPTER 3 explains in detail the computer programs which help in performing this thesis. Both the generating program and the analysis program are represented by flow charts and many illustrative numerical examples are given to clarify the procedure of intering the input data and the sequence and technique of solution for each one.

In CHAPTER 4, a comprehensive parametric study is carried out to find the optimum configuration of a certain type of transmission towers. The geometric parameters treated are the inclination of main legs (upper to lower breadth ratio), lower breadth to height ratio, the number of panels in the tower height and the type of internal geometric configuration. Moreover, this chapter includes a simulation of actual cases of loading.

CHAPTER 5 concerns mainly with the diaphragm installation effect considering the diaphragm with different shapes and located at different positions along the tower height. In addition, several miscellaneous studies are carried out such as the effect of neglecting wind pressure on tower body, comparison between space truss analysis and space frame analysis, and comparison between space truss analysis and the classic technique procedure by graphical analysis.

Appendix A contains a list of the data generating program while Appendix B contains that of the analyzing program. Appendix C contains the necessary conditions to get a tower with special internal geometric configuration.

In fact, the theoretical study discussed in detail in this thesis provides structural engineers with useful data and informations that help in the choice and design of self supporting towers.

CHAPTER 1

TRANSMISSION LINES & TRANSMISSION TOWERS

1.1 GENERAL

1.1.1 The Electric Power System :

To convoy the electrical energy from the point of generation to the consumers, an electrical power system is required. This comprises generating stations, sup-stations, transmission lines, feeder lines, primary lines, secondary lines and service lines.

The transmission lines may be either buried cables or aerial lines ; Fig. (1.1). The cable line consists of one or several cables with coupling connections. In some cases, it is essential to use the cable lines. In the aerial lines the transmission and distribution are carried out by means of wires situated in open air and fastened by means of line fittings and insulators on the towers.

However, the methods of construction of cable transmission lines will not be discussed here since it is beyond the scope of this thesis.

1.1.2 TYPES OF TOWERS :

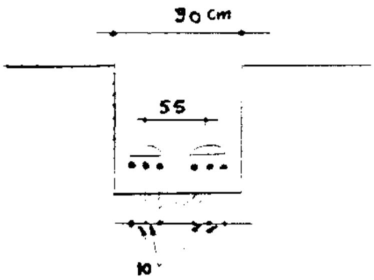
The form of supporting transmission lines varies with the availability and cost of materials, constructional difficulties and the relative importance of the line. However, widely spaced tower structures are used as supports for the aerial transmission lines. There are different kinds of towers ; Fig. (1.2), viz. :

1. Narrow-Based Towers :

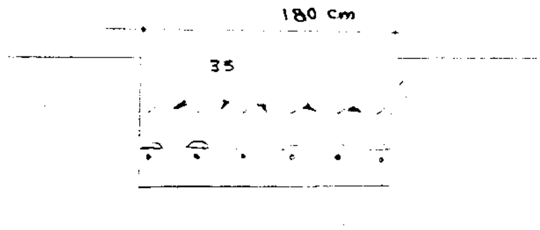
   These are steel latticed structures with bolted or welded connections. Foundations are usually one concrete block cast in place.

2. Broad-Based Towers :

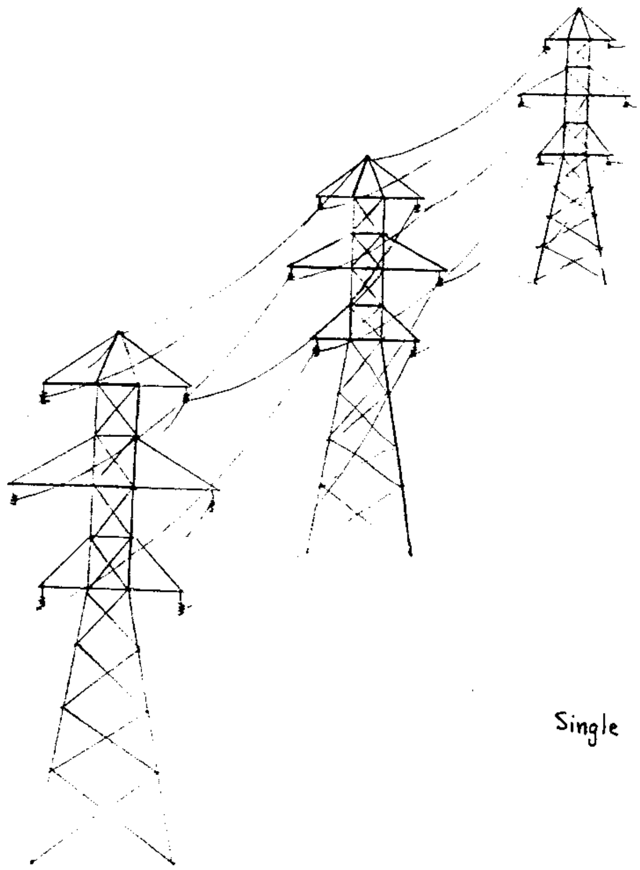
   These are also of steel lattice type construction with bolted connections and a separate foundation for each leg.



Cable line transmitting
132 K.V.



Cable line transmitting
275 K.V.



Single circuit aerial transmission line

Fig. (1.1)