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Various Transmission Tower Analysis & Design Using Professional Software

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Abstract:
Towers and tower like structures are literally speaking the 'pillars' of the infrastructure for transmission of electrical power, telecommunication and broad casting. Substantial savings in material and total cost can be achieved through the selection of efficient structural configuration and rational and optimum designs without compromising on the structural safety and reliability of towers. Formex algebra programs has been developed which, are capable of generating single and double circuit transmission tower. A software has been developed in Visual Basics which, is capable of computing various loads and load combinations specified by the current IS specifications for Transmission towers. The developed software is tested on three large problems and optimal designs have been compared with the results of commercial software "Staad Pro".

1. Introduction

For transmission of electrical energy transmission line is required. Electrical energy being the most convenient and cleanest form of energy, is finding the maximum usage the world over for development and growth of economy and therefore generation, transmission and utilization of the same is increasing. Electrical energy is conveyed through conductors and these conductors must be protected by ground wires. Also the conductors must have sufficient clearances to avoid chances of accidents there must be proper insulation between conductors and line supports, for that reason proper insulators are required.

In planning and design of a transmission line, a number of requirements have to be met. From electrical point of view, the most important requirement is insulation and safe clearance to earthed parts. These, together with the cross section of conductors, the spacing between the conductors, and the relative location of ground wires with respect to the conductors, influence the design of tower.

The solution to a computer-aided structural analysis problem may be considered to involve three stages: preprocessing, processing and post processing. In the preprocessing stage, data required for the analysis of the structure is generated. The structure is analyzed in processing stage and the results from the analysis are presented in a neat form in the final stage. Conventional processes of data generation describing the topology geometry, load and support conditions are however, very tedious, time consuming and susceptible to error. The formex algebra technique is very general, useful and elegant tool for automatic data generation. Language used to implement the concepts of formex algebra is called as Formian. The software is developed in C++ using formex algebra techniques to generate the data. To check the accuracy of data generated and visualize the actual configuration of structure, turbo C++ graphics has been incorporated.

Formain is designed to provide a structural approach to the problems of data generation, in particular to the generation of data related to structural configurations. Being modeled on formex algebra, the language allows powerful statements to be written in a concise and yet readily understood manner. A simple to use three dimensional graphics system in addition to an editor built in the language enable problems of data generation to be accomplished in one programming environment.

Tower structures are normally comprised of several hundred angle members eccentrically connected. Structural analysis of this type of structure required extensive data generation. Formex algebra is used to configure the tower structure.

2. Configuration of Transmission Line Tower

Depending upon the requirements of the transmission system, various line configurations have been considered ranging from single circuit horizontal to double circuit vertical structures and with I strings or V strings in all phases as well as in combination of these.

The configuration of transmission line tower depends on the following factors:

- The length of insulator assembly

- The minimum clearances to be maintained between conductors and also between conductor and tower
- The location of ground wire or wires with respect to the outer most conductor
- The mid-span clearance required from consideration of dynamic behavior of conductors and lightning protection of the line

The minimum clearance of lowest conductor above ground level.

The tower outline is determined by the following factors:

- Tower height from ground level
- Tower width at the base and at top hamper
- Length of cross arm
- Spacing between the conductors

2.1. Transmission Line Tower Height

The factors governing the height of the tower are:

- Minimum possible ground clearance (h1) in accordance to variation in kV
- Maximum sag (h2) for lowermost conductor
- Vertical spacing between the conductors (h3)
- Vertical clearance between the ground wire and top conductor (h4)

Thus height of the tower (H) is given by the equation

$H=h1 + h2 + n*h3 +h4$ (2.1)

Where

H = Height of tower in meter
h1 = Minimum permissible ground clearance in meter
h2 = Minimum sag in meter
h3 = Vertical spacing between the conductor in meter
h4 = Vertical clearance between the ground wire and top conductor in meter
n = 1 for single circuit tower
n = 2 for double circuit tower

Fulfilling tower requirements routine has been developed to find out the configuration of the transmission tower

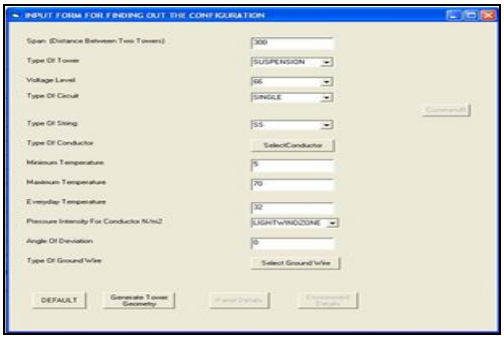

Figure 1: Input form for finding out the configuration

Ground wire details and conductor details are incorporated in software to avoid user input while entering the data

Figure 2: Conductor detail form

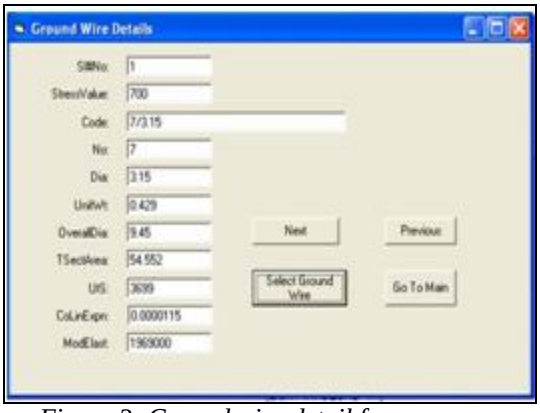

Figure 3: Ground wire detail form

Software will generate the configuration

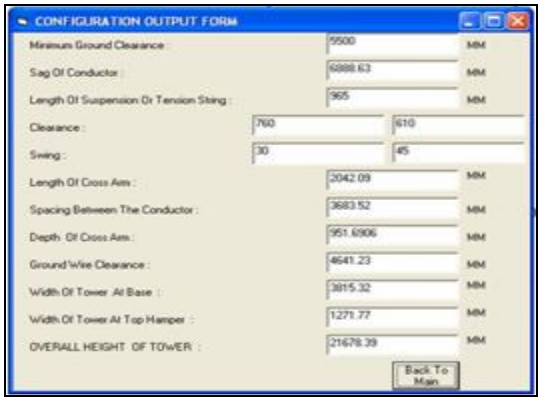

Figure 4: Out form for finding out the configuration

Structure divided into group each panel contains 3 groups. For panel number 1
Group No.1 for vertical members
Group No.2 for inclined members
Group No.3 for horizontal members
For panel number n
Group No.3 * (n-1) +1 for vertical members.
Group No.3 * (n-1) +2 for inclined members.
Group No.3 * (n-1) +3 for horizontal members.
Panel No.1 is given for bottom panel.
Number of panels above the top hamper is decided automatically depending upon the number of circuits.

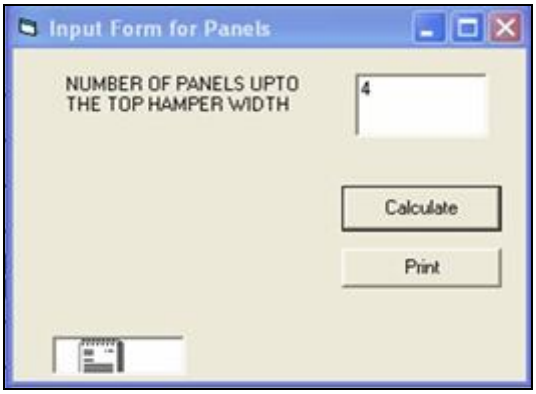

Figure 5: Form for entering number of panels

It will generate the nodal coordinates and member connectivity.

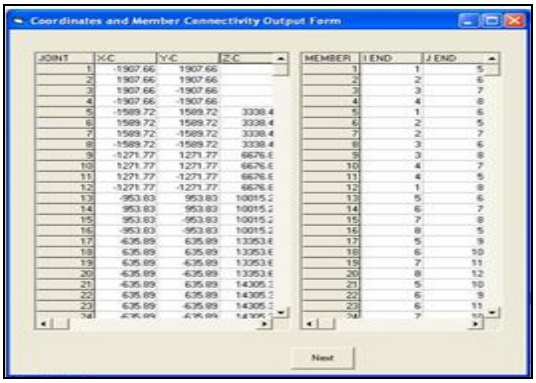

Figure 6: Out form for displaying the nodal coordinates and member connectivity

3. Formex Algebra

Formex algebra is a mathematical system that provides a basis for solution of problems of data preparation and graphics in computer aided design process. Formex algebra allows networks of all kinds to be formulated conveniently and is a valuable tool in dealing with complex configurations. The ideas of formex algebra have been evolved originally for automated data preparation and computer graphics in relation to analysis of structures and in particular space structures. For analysis of such structures, it is very much essential to provide the input data like, interconnection pattern, geometric particulars, material properties, external loads and support conditions. But the major part of the input data consists of the interconnection pattern of the structure. So, it had been focused in this paper particular aspect of data preparation by using formex algebra concept.

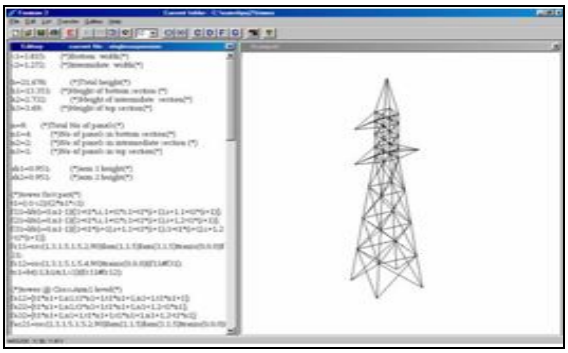

Figure 7: Generation of configuration using formex algebra

4. Design Parameters

The design of transmission line towers is entirely dependent on the selection of correct parameters. A good tower designer should accumulate all necessary design parameters before starting the design work.

According to the reliability, terrain category and wind zone software calculate the loads on conductor, ground wire and on structure using IS code provisions.

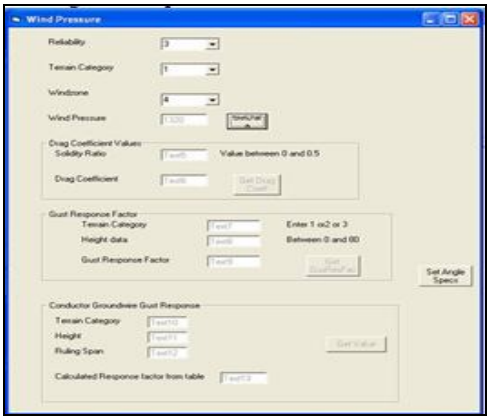

Figure 8: Wind pressure details form

Material details are to be enter

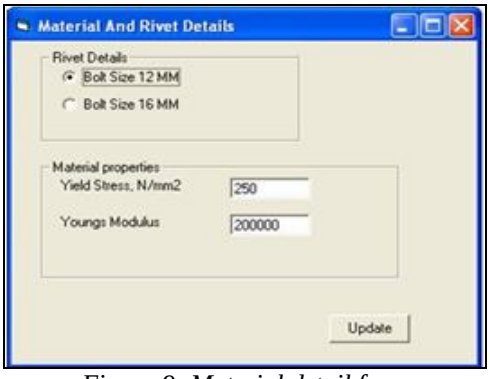

Figure 9: Material detail form

It displays form contain total number of group which are generated depending upon the number of circuits.

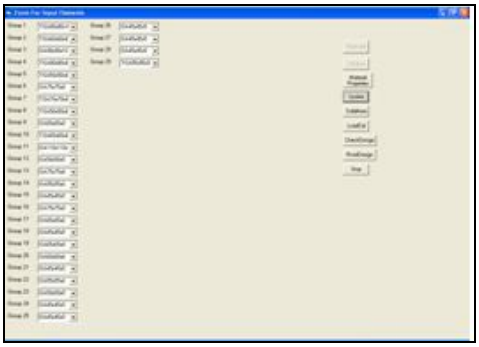

Figure 10: Group details form

Analysis is done using stiffness methods for all load cases, and the maximum compressive and tensile force are find out for the member.

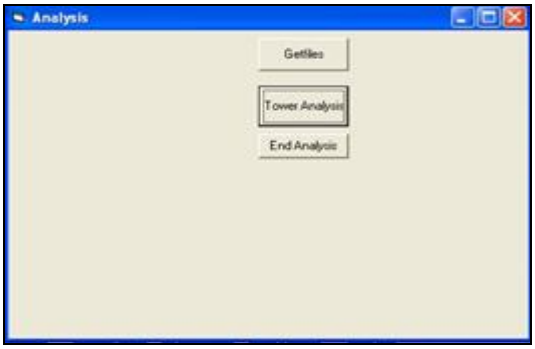

Figure 11: Analysis form

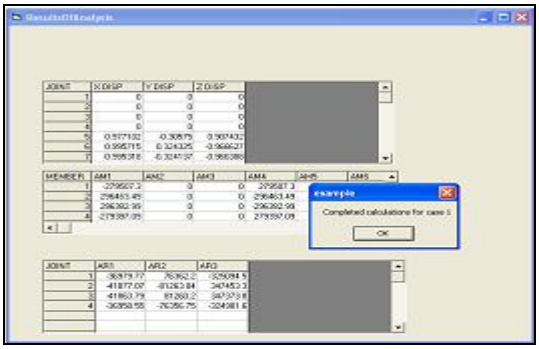

Figure 12: Result of analysis for load case 1 form

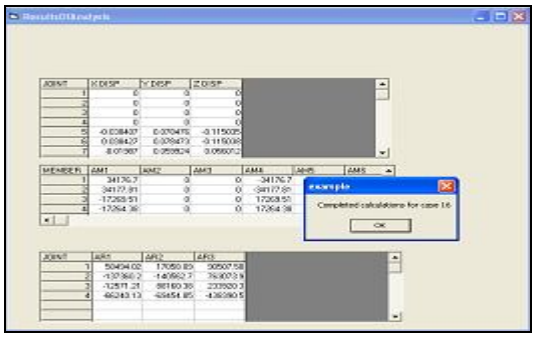

Figure 13: Result of analysis for load case 16 form

The members are designed as per IS: 802

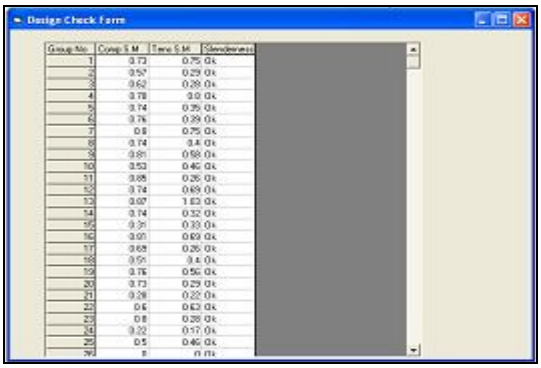

Figure 14: Design check form

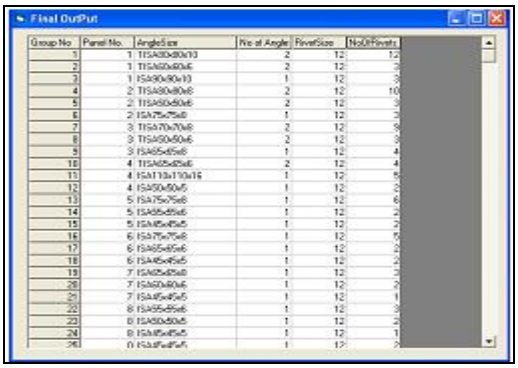

Figure 15: Final output form

Above screen shots are the application of 66kV, which are explained above

5. Conclusion

- Space structure configuration are elegant and impressive but, unless the designer is equipped with suitable conceptual tools, Formex algebra stands alone as an algebra which provides a powerful mathematical basic for new approach to data generation.
- A software is developed for the deciding configuration, analysis and design of transmission line towers using 'VISUAL BASICS 6' language which is very user friendly, interactive.
- Module is developed for automatic generation of configuration of transmission tower by using the input as type of tower, conductor and ground wire details, span between towers and environment details. It proves efficient tool for modeling space structure, under different conditions.
- Routines are developed for automatic computation of wind load on tower members, conductors and ground wire as per IS code provisions and the self-weight of the members, conductor, ground wires and insulators. Interface routines are coded to link the preprocessor and program for analysis of structure. Routines are also developed for design of members and rivets as per IS code provisions. So it saves time and proved to be efficient.
- This software has a strong feature of modifying members in order to arrive at the most economical tower design. Various tower configurations can be generated with ease.

6. References

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