Chapter 9

Conclusion

The aim of this research is to identify alternative structural members for fabricating power line structures and to show that circular hollow sections (CHS) may be a viable and promising alternative to conventional angular sections.

It has been highlighted that the availability of land and the willingness to sell land by farmers and other land owners have become more challenging than ever. The land owners are reluctant to sacrifice land due to a loss of income and the visual impact the structures have on the surrounding area.

Hence, the requirement of power line structures of the future is to transport more electrical energy per servitude available, the structures should be accommodated on a smaller footprints and the structures should be less visible on the horizon. These requirements could to some extend be satisfied with double circuit CHS structures.

The following concluding remarks are made for this research project.

From a simple load analysis it can be seen that the above mentioned requirements have a direct increase in structural loading which limits the use of conventional angle members for the construction of double circuit power line structures (Appendix A).

It is recommended that connections between tower elements should be similar to existing connection practices where possible.

Studies have shown that circular hollow sections are structurally superior compared with other cross sections in compression (Appendix D and E).

A comparison between the strength of circular hollow members compared with angular members show that CHS members are 1.22 times stronger and when considering the limitations for class 3 compression members is 11.7 times stronger than angle members. The weight of CHS members are 2.3 times less than conventional angle members with equivalent compression resistance. Although the results may seem conservative, it definitely has merit to consider the future use of circular hollow cross-sections for implementation in power line towers.

Circular hollow sections reduce the wind loading on power line structures due to the reduced drag coefficient on round members. This in return also reduces the load on foundations.

The disadvantages of circular hollow sections are the increased material and connection cost e.g. welding. Secondly, the long slender members might be appealing to the public eye but makes an extremely difficult structure to climb. Thus, special climbing features would have to be included for each tower.

The CIDECT manuals were found to be an excellent source of connection design information for just about all the possible variations found in practice. It should be said that it was the intention of the author to implement proven connection formulae for production purposes. This research is not intended to question or improve on the existing design information.

A tubular test tower was designed and fabricated. Firstly, the intentions were to combine the theory behind circular hollow sections and practical tower fabrication and construction that will suit the South African manufacturing climate, where fabrication is more reliant on skilled or semi-skilled artisans compared to more developed countries which uses automated fabrication facilities. Secondly, the fabrication of a physical test tower proves that by correctly modeling and analysing the theoretical model will result in a physical structure that will react according to the design. This is an important step owing to the fact that a large amount of conventional angular towers has been put through this same procedure, full scale tubular transmission towers may now be designed, constructed and tested with more confidence than before - providing a reliable method for future implementation.

In the design of the tubular transmission tower, the author introduced a novel cross arm concept. The new configuration cross arm has only three main structural members compared with a conventional cross arm which has four main members. The new proposed cross-arm reduces the overall weight of the structure and has an impact on cost in terms of less members to fabricate, transport and construct.

An analytical and structural analysis was done on the test tower. Hand calculations were used to show how to design connections. A structural analysis was done using Prokon.

A comparison of the test tower cross arm was done in Prokon and Ansys. The reason for this is to compare a beam element model (Prokon) with a discrete element model (Ansys). This comparison was also used to indicate to what extent the cross arm attachments and conductor attachment point should be modeled. The result shows that there is an excellent correlation between the discrete model and the beam model with more attention given to modeling conductor attachment points. It is concluded that modeling tubular transmission structures as beam elements with the required level of detail yields reliable results.

In order to conclude the validity of the recommended design approach and the integrity of the test structure, physical testing was done at the Eskom tower test facility. The structure was securely fixed to the base of the test bed and strain gauges were fitted on several of the tower members. Steel wire ropes with load cells were fitted to the cross arms of the structure and three typical load cases were evaluated.

Comparing the physical test results with the Prokon model, a maximum of 10% variation between member loads was recorded. The loads in the test tower was in most cases higher compared to the Prokon model.

In summary, the design process proposed here can successfully be used to design and manufacture CHS power line towers. The design process uses current design software, current design standards and current manufacturing techniques.

Further investigation on full scale structures are required in order to study the economics of tubular towers versus angular member towers. This study should include fabricators and construction experts in order to fully evaluate the impact on the power line industry. The author suspects that the fabrication cost of CHS towers will be slightly higher but the overall cost, including erection and maintenance cost will be significantly less. Secondly, the effect that eccentricities local to connections (two plates on top of each other) and eccentricities due to fabrication errors should also be further investigated in order to determine how it will affect the overall member and connection strength.