

Mechanical Engineering Division - Design Cell

The Design cell at Mechanical Engineering Division was created in 1980's with objective to support the Tower Testing Station activities and take up the consultancy works on design of towers for new transmission lines, analysis and checking of towers designed earlier for further optimization of weight, checking the adequacy of existing towers for up-rating a line, redesign of existing towers with least modifications for upgrading etc.

1.0 BACKGROUND

Overhead transmission line design consists of both electrical and mechanical aspects. The mechanical design of transmission line plays a decisive role in determining the overall solution and hence must be mastered along with electrical engineering if the main goal of obtaining good service from a line is to be achieved. Overhead transmission line consists of tower, foundation, cross arms, insulators, fittings, conductors, overhead ground wires, etc. The transmission line should operate trouble free for a service life of 30–50 years. The cost should be within the limit determined by the importance of the supply and the consumer requirements. The R&D in the field of mechanical engineering aspects of overhead lines had been in pursuance of these two objectives.

Transmission line tower though a steel structure its design is very different from other conventional steel structures. The transmission tower is unique in the sense that a large number of identical designs are repeated in actual practice. A small saving in weight per tower will result in substantial economics. Hence the tower design has to be not only economical but also dependable, capable of withstanding all the prescribed loads and loading conditions. In view of this, the towers are not normally over designed. Due to this reason, the test tower may not go through all the tests in the first instance itself and initial failures are common in the development of an optimum design.

Hence any Tower Testing Station should have the necessary facilities to carryout the performance evaluation and design improvement. Based on this evaluation, proper remedial measures can be suggested to the customers to effect the necessary improvements.

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2.0 SOFTWARE DEVELOPED BY CPRI

During 1980's, CPRI developed MS-DOS based tower design program CTADS (CPRI tower Analysis and Design Software) for use in the analysis and optimum design of transmission line towers. It is being used for the consultancy projects referred to CPRI, for evolving economical tower design starting from and initial design by using an automatic structural analysis. The analysis and design had been done by creating all the members of the tower as pin-jointed space structures and is based on stiffness matrix method of analysis. The program takes care of the various geometrical configurations of the tower, conductor or ground wire sizes, design spans, wind conditions, sizes and properties of

available steel sections, etc. The design loads will be computed and tower is analyzed for different load combinations pertaining to the normal and broken wire conditions and the maximum tensile and compressive forces will be determines the minimum cross sectional area required for the members and selects approximately the required sizes of members from the available list of standard sections for each members of the tower.

The results from the CPRI program was compared with SAP IV analysis (SAP IV is a standard and internationally recognized structural analysis program). The results are found to be in close agreement. The design of few towers tested in the tower testing station were examined, in detail using our program. It has been found that the program is reasonably sufficient and around 5 to 10% savings should be effected in the existing designs. Many of the towers designed using CTADS software for different customers have been successfully tested at out Tower Testing Station.

The present version of the CTADS software has been modified by incorporating graphics features for creating the tower geometry with minimal input under windows operating system. This software is being extensively used for consultancy works on design of new towers, checking/analysis of towers for approval/vetting. The salient features and typical tower model using CPRI tower design software shown below.

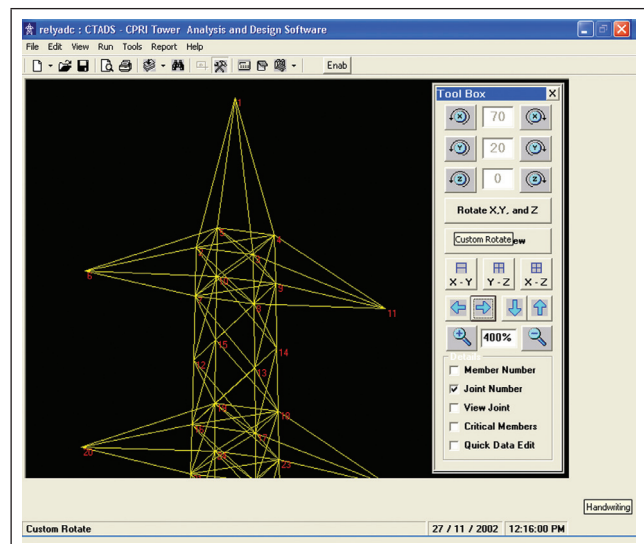
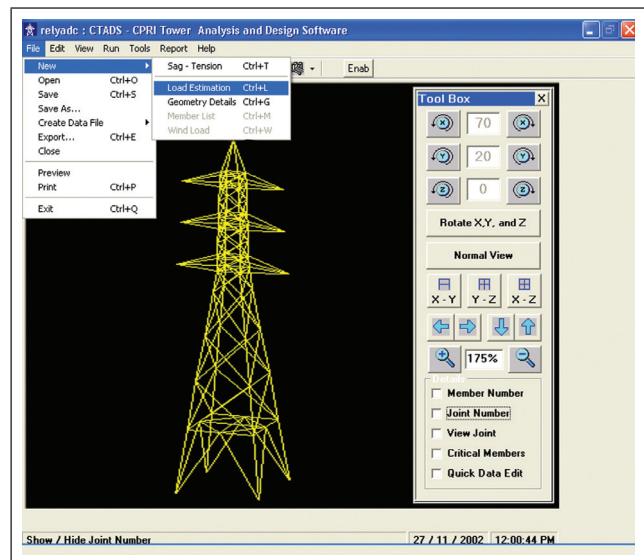
2.1 Salient features of CTADS software

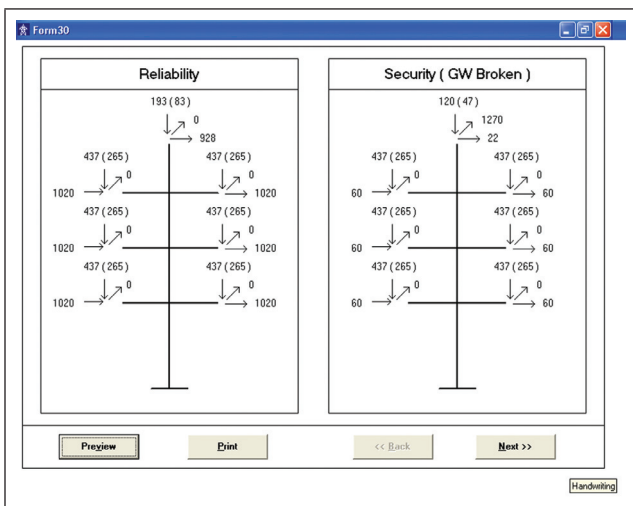
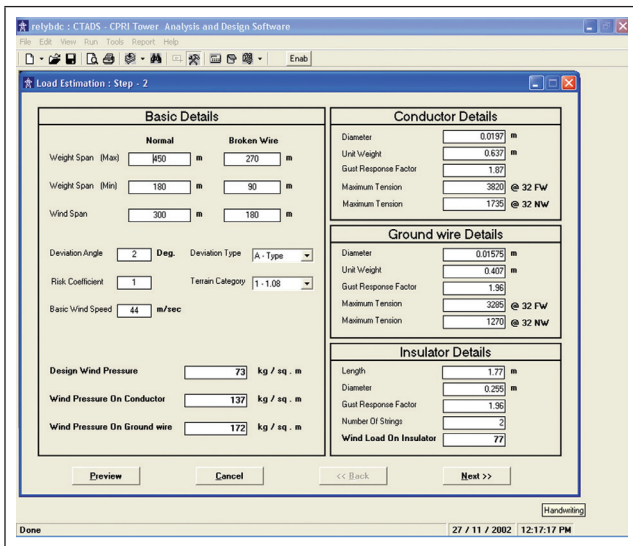
- Front end works under Visual Basic 6.0 and Execution of the CTADS program works under MS-DOS mode back-end.
- Export tower geometry to AutoCAD.
- Automatic introduction of Imaginary members at plan levels.
- Graphical Display of overstressed members.
- Graphical Display of member details like node, length, size, etc.

- Translation/Rotation in X,Y,Z direction, Zoom in, Zoom out, etc.
- User friendly data editor, generation of report, etc.

2.2 Computer Software Facilities

1. CPRITower Analysis and Design Software (CTADS).
2. Structural Analysis and Design Software (STAAD-Pro).
3. AutoCAD 2011
4. FEM Software – MSC. NASTRAN/MSC. Marc





3.0 RESEARCH AND DEVELOPMENT

In the course of its journey from inception to till date the design cell had under taken several research activities. The experience gained over the years in the area of optimum tower design helped us take up the research projects for the benefit of power utilities. The research work carried out has the main objective of developing better design of towers by the use of new configurations, new materials and new types of structures etc. Some of the sponsored research projects were taken up with the Utilities/Manufacturers. The design cell had brought up several publications/ Research papers/Technical reports in the area of optimum design of transmission lines. We offered many solutions/suggestions that were accepted and used towards redesign of towers

and cost effective measures. The typical list of completed research projects are shown below:

1. Feasibility studies of six phase transmission line
2. Standardization of transmission line towers
3. 132 kV Compact steel pole
4. Development of 220 kV Rectangular base tower
5. Development of 66/132 kV Triangular base tower
6. Development of 132 kV Guyed tower
7. Development of 400 kV Narrow base tower
8. Rationalization of steel sections for tower economy
9. Economic span for transmission lines
10. Probability based design of transmission line towers
11. Dynamic analysis of transmission line towers

4.0 CAPABILITIES AND ACHIEVEMENTS

A dedicated team had been built to undertake Research and Consultancy projects in the area of transmission line design and product development. We had successfully completed many challenging consultancy assignments for Indian and Overseas power utilities. Developed Triangular base tower, Rectangular base tower, Guyed tower and tested successfully first time in the country. The expertise has been developed to take up the design of compact transmission lines, tower design with HTLS conductors, ROW issues w.r.t to Uprating/Upgrading of existing lines, Failure investigation studies etc.

5.0 CONSULTANCY SERVICES OFFERED TO VARIOUS POWER UTILITIES

5.1 Transmission line towers

1. Design and Development of 66 kV, 110 kV, 220 kV/66 kV, 'MA', 'MC', 'MD' type

- Multi-circuit towers (Narrow based) to M/s Karnataka Power Transmission Corporation Ltd. (KPTCL), Bangalore
2. Design checking of 220 kV D/C 'A', 'B', 'C' & 'D' type towers to M/s Ramjee power construction company Ltd. Ranchi for their clients M/s Central Organization for Railway Electrification (CORE) Allahabad.
 3. Design checking of 400 kV D/C River crossing towers to M/s Hirakud Industrial works (HIW) Cuttack
 4. Design checking of 220 kV D/C River crossing towers to M/s Karnataka Power Transmission Corporation Ltd. (KPTCL), Bangalore
 5. Design checking of 132 kV D/C 2-phase 'A', 'B', 'C' & 'D' type towers to M/s Ramjee power construction company Ltd. Ranchi for their clients M/s Central Organization for Railway Electrification (CORE) Allahabad.
 6. Design and Development of 275 kV, 132 kV, 33 kV 'L', 'S', 'M', 'H', 'R', & 'T' type towers to M/s Unimekar SdnBhd, Malaysia for their clients Sabha State Electricity Board, Malaysia.
 7. Design and Development of 132 kV S/C 'B' type towers to M/s Techno corporation, Agartala for their clients M/s Tripura State Electricity Board, Agartala.
 8. Design and Development of 110 kV, D/C and Multi-circuit 'MA', 'MC, 'MD' type towers to M/s Reliance Salgocar Power Company, Goa.
 9. Up-gradation of 110 S/C to 132 kV S/C to M/s EMC Ltd. Calcutta as a part of MOU between CPRI and M/s EMC Calcutta (Kanakavalli to Kudal transmission line).
 10. Feasibility study on Up-gradation of 132 S/C and D/C to 220 S/C and D/C line 'A', 'B', 'C' type towers using insulated cross arm to M/s Punjab State Electricity Board (PSEB), Chandigarh (Muktstar to Jalalbad transmission line).
 11. Up-gradation of 220 S/C to 400 kV S/C to M/s Power Grid Corporation Ltd. New Delhi.
 12. Tender Design of 66 kV D/C 'A', 'B', 'C', 'D' type steel pole to M/s Utkal Galvanizers Ltd. Bhuvaneshwar for their customer in Syria.
 13. Tender Design of 132 kV and 275 kV D/C 'L', 'S', 'M', 'H', 'R', & 'T' type towers to M/s Unimekar SdnBhd, Malaysia .
 14. Feasibility studies on replacement of conventional Earth wire to Optical Ground wire (OPGW) for 220/110 kV Multi-circuit (Narrow based, Broad based towers) and 220 kV D/C (Broad based and river crossing towers) for M/s Reliance Energy Ltd. Mumbai.
 15. Design and Development of 132 kV S/C 'B' type towers to M/s Techno corporation, Agartala for their clients M/s Tripura State Electricity Board, Agartala.
 16. Failure Analysis/Design checking of 220/220 kV M/C 'MD+9m' type tower M/s Ramachandra Rao Transmission and Projects Ltd, Hyderabad, for M/s KPTCL, Bangalore
 17. Analysis/Design checking of 400 kV D/C 'DA' type tower for M/s MAHATRANSCO, Mumbai
 18. Feasibility study on Up-gradation of 132 S/C & D/C to 220 S/C & D/C line 'A', 'B', & 'C' type towers using insulated cross arm to M/s Punjab State Electricity Board (PSEB), Chandigarh (Muktstar to Jalalbad transmission line).
 19. Analysis/Design checking of 220/220 kV M/C 'A', 'B', 'C', & 'D' type towers to M/s East Coast Construction Ltd, Chennai, for their clients M/s Kerala State Electricity Board, (KSEB) Thiruvananthapuram.
 20. Analysis/Design checking of 400 kV D/C HT link line towers for M/s National Hydroelectric Development Corporation (NHDC), Bhopal.

21. Design of 132 kV D/C, 110 kV D/C, 33 kV D/C 'RC' type tower (River Crossing) for M/s Reliance Salgoacar Power Company Ltd, Goa.
22. Design of 66 kV D/C 'DA', 'DB' 'DC' & 'DD' type towers for M/s Sagar Power Private Ltd, Bangalore.
23. Finite Element analysis of steel conical pole for M/s Railway Design Standards Organization (RDSO), Lucknow.
24. Design of 220 kV Quad Circuit MA, MB & MC type towers to M/s Orissa Power Transmission Corporation Limited, Bhubaneswar.
25. Design of 220 kV D/C DA, DB, DC & DD type towers to M/s ICOMM Tele Ltd, Hyderabad for their customer M/s Nepal Electricity Authority, Katmandu
26. Design of 220 kV Multi-circuit 'MD' type tower to M/s Kerala State Electricity Board (KSEB) Kattakkada, Thiruvananthapuram.
27. Design Checking/Analysis of 400 kV D/C DA, DB, DC & DD type towers to M/s K. Ramachandra Rao Transmission and Projects Private Ltd, Hyderabad for M/s HVPNL.
28. Design Checking/Analysis of 220 kV D/C & 66 kV D/C towers to M/s Punjab State Transmission Corporation Ltd, Patiala.
29. Design Checking/Analysis of 400 kV D/C QA, QB, QC & QD type towers to M/s Chhattisgarh State Power Transmission Company Limited (CSPTCL), Raipur.
30. Design Checking/Analysis of 400 kV D/C QA, QB, QC & QD type towers to M/s Kalpataru Power Transmission Ltd, Gandhinagar for M/s HVPNL.
31. Design Checking/Analysis of 220kV Quadcircuit NMA, NMB, NMC & NMD type towers to M/s K. Ramachandra Rao Transmission and Projects Private Ltd, Hyderabad for M/s HVPNL.
32. Design Checking/Analysis of 400 kV D/C DA, DB, DC & DD type towers to M/s Larsen & Toubro Ltd, ECC, Chennai for Bhutan.
33. Design of 220 kV D/C PV0, PV15, PV30 and PV60/DE type towers to M/s New Modern Technomech Private Ltd, Orissa for M/s KSEB, Trivandrum
34. Design of 220 kV Quad Circuit MA, MB & MC type towers to M/s OPTCL, Bhubaneswar.
35. Design Checking/Analysis of 132 kV D/C DA, DB, DC & DD type towers to M/s Aster Private Ltd, Hyderabad for M/s HVPNL.
36. Design of 220 kV Multi-Circuit MA, MB, MC & MD type towers to M/s KeralaState Electricity Board (KSEB), Kalammassery.
37. Design of 220 kV D/C DA, DB & DC type Narrow base towers to M/s Rajasthan Rajya Vidhyut Prasaran Nigam Ltd. (RRVPL), Jaipur.
38. Design checking/analysis of 400 kV D/C DA, DB, DC & DD type towers to M/s Unitech Power Transmission Ltd, Gurgaon.

5.2 Microwave towers

1. Analysis/Design checking of 90 m, 80 m, 60 m, 50 m square based ground mounted Antenna Towers to M/s ARM Ltd, Hyderabad for their clients in Telecommunication sectors like AIR TEL, Spice Telecom, DOT, etc.
2. Analysis/Design checking of 18m, 30m square based Roof mounted Antenna Towers to M/s Rounak Industries, Nagpur for their clients in Telecommunication sectors like AIR TEL, Spice Telecom, DOT, etc.
3. Analysis/Design checking of 90 m, 80 m, 70 m, 60 m, 50 m square based ground mounted Antenna Towers to M/s Ramboll IMI Soft, Hyderabad for their clients in Telecommunication sectors like AIR TEL, Spice Telecom, DOT-BSNL, etc.
4. Analysis/Design checking of 90 m, 80 m square based ground mounted Micro wave towers to M/s Satvavani consultants and projects Pvt. Ltd, Hyderabad for their clients

in Telecommunication sectors like AIR TEL, Spice Telecom, DOT-BSNL, etc.

5. Analysis/Design checking of 50 m, 30 m, 24 m Roof mounted triangular based tubular towers to M/s Ramboll IMI Soft, Hyderabad.
6. Analysis/Design checking of 80 m, 70 m and 60 m Ground mounted square based towers to M/s Tata Teleservices Ltd, Mumbai
7. Analysis/Design checking of 60 m, 40 m and 30 m Ground mounted square based towers to M/s Idea Cellular, Mumbai.
8. Analysis/Design checking of 50 m and 40 m Ground mounted triangular based tower to M/s TRYLON TSF, Canada and M/s Trylon TSF India Private Ltd, Mumbai

6.0 FUTURE PLANS

In view of accelerated growth of electrical network, the need for adopting bulk power transmission system with all possible ways to make support structures economical and also to reduce the right of way (ROW) requirements, the following projects are to be taken up in near future.

1. Development of FRP composite tower with insulated cross arm for compact lines
2. Design of transmission line towers with High Temperature conductors

The activities of the design cell and the volume of consultancy projects being referred has increased many fold over the past five years.

The Design Cell is further contemplating to add new software in the future to take up the turnkey projects like Design and Development of structural drawings of transmission line towers, Design of Steel/Concrete pole structure and communication tower structures, etc.

ACKNOWLEDGMENT

We express sincere thanks to all the senior colleagues who have put in their hard efforts in creating and bringing forward the Design Cell to its present status namely Shri T.V. Gopalan, Shri S. Sridharan, Shri G.V. Rao, Shri R. Susendran, Dr. K.R.C. Nair, Shri P. Krishnamurthy, Shri P. Muniyappa and Shri M.N. Gundu Rao.

It is our sincere duty to thank all our esteemed Customers, Power Utilities and Manufacturers who had supported all along with sustained effort and cooperation. Our survival lies in their existence.

We are extremely thankful to our present Director General, Shri N. Murugesan for having shown overwhelming support and incredible dedication with clear vision in bringing CPRI as one of the best power premier research organization in the world.