

**COMPARATIVE STUDY OF DESIGN INPUTS IN  
DESIGN OF OVERHEAD TRANSMISSION LINE  
TOWERS**

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## DECLARATION

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## **ABSTRACT**

The Ceylon electricity board is the main electricity producer in Sri Lanka. The supply arm of the Ceylon electricity board is divided into three categories: Generation, Transmission and Distribution. The power lines having the capacity 132 kV and above comes under the transmission category. The transmission lines may be spanning over a few kilometres to hundreds of kilometres, depending on the power station location. The lattice towers are the main supporting structures in the transmission line. The cost of the transmission towers is ranging from 28 to 40 percent of the total cost of a transmission line project.

Every year the power demand may increase by around 10 %. To have uninterrupted power supply the Ceylon Electricity Board must increase its supply capability simultaneously. With this huge power demand CEB must move to 400 kV lines in the near future. The scarcity of new corridors to build new lines demands increase the capacity of the existing lines by using the same corridors. Both requirements demand heavy towers.

The design of the transmission towers and foundations is done according to the CEB specifications, which were produced long ago. The CEB specification is based on the probabilistic method with safety factors while the world is moving towards the reliability-based method.

The CEB towers are known to be the heaviest towers in the region. The largest existing tower uses the maximum available angle iron as the leg members. When increase the tower capacity and the number of circuits to four circuits from two, star angles or combined angles must be used as the leg members. The foundations have to be designed either as raft foundations instead of single footings or pile foundations in fairly good soils.

The towers need to be optimized in order to overcome the limitations in the design as well as to reduce the cost of the projects. The lattice towers are designed for decades and the optimum tower configuration have been already identified by the designers. The optimization of the design input is the next possible approach to design an optimized tower.

The design inputs mainly depend on the code of practice used in the design. In this research, an attempt was made to identify the economic viability of the CEB design inputs against IS 802:1:1 (2015) and IEC 60826 (2017) design inputs. The objective of the research was achieved by identifying the different design inputs against different codes of practices and design two type towers, one line tower (TDL) and one angle tower (TD3) in PLS tower software by using the identified design inputs. The design was carried out according to the ASCE 10:97 and IS 802:1:2 (2016).

To identify the economic viability of the design inputs the support reactions and the member capacity usages were compared using the output of the FEM.

As per the results that the tower weight and the foundation size could be reduced by a significant margin if the design was carried out by using either IS or IEC codes instead of the CEB specifications.

**Key words:** CEB specification, Optimizing tower cost, Transmission tower, Design inputs

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## LIST OF ABBREVIATIONS

IS 802-1-1: (2015)

$A_e$	Total net surface area of member
$A_i$	Area of the insulator string
$C_{dc}$	Drag coefficient for Conductor
$C_{di}$	Drag coefficient for Insulator
$C_{dt}$	Drag coefficient for tower
$D$	Diameter of the cable
$F_{wc}$	Resultant wind load on Conductor
$F_{wi}$	Resultant wind load on Insulator
$F_{wt}$	Resultant wind load on tower
$G_e$	Gust Respond Factor for Conductor
$G_i$	Gust Respond Factor for Insulator
$G_T$	Gust Respond Factor for tower
$L$	Wind span
$P_d$	Design wind pressure

IEC 60826:2017

$A_c$	Wind force on conductor
$A_i$	Wind force on insulators
$A_t$	Wind force acting on a tower panel made of steel angles
$C_{xc}$	Drag coefficient of the conductor
$C_{xi}$	Drag coefficient of insulator
$C_{xt}$	Drag coefficient of supports
$d$	Conductor Diameter
$G_c$	Combined wind factor of conductors
$G_L$	Span factor for wind calculation
$G_t$	Combined wind factor of towers
$L$	Span length or Wind Span
$q_0$	Dynamic reference wind pressure due to reference wind speed $V_R$
$S_i$	Projected area of insulator
$S_t$	Projected area of tower panel
$\Omega$	Angle between wind direction and the Conductor (degrees)

ASCE	American Society of Civil Engineers
BC	Bottom Cross Arm
BCL	Bottom Conductor, Left
BCR	Bottom Conductor Right
BL	Bottom Conductor, Left
BR	Bottom Conductor Right
BWC	Broken Wire Condition

DC-TC	Double Circuit Top Conductor
CEB	Ceylon Electricity Board
DC	Double Circuit
DC-BC	Double Circuit Bottom Conductor
DC-EW	Double Circuit Ground wire
DC-MC	Double Circuit Middle Conductor
DK1/2	Dambulla-Kalundawa tower 1/2

DK2n	Dambulla-Kalundawa tower 2 new
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SSL	Single Circuit Left
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EBCL	Ground wire & Bottom Conductor, Left	SSR	Single Circuit Right
EBCR	Ground wire & Bottom Conductor Right	TBCL	Top & Bottom Conductor, Left
EDS	Every Day Stress	TBCR	Top & Bottom Conductor Right
EMCL	Ground wire & Middle Conductor Left	TC	Top Cross arm
EMCR	Ground wire & Middle Conductor Right	TCL	Top Conductor, Left
ETCL	Ground wire & Top Conductor, Left	TCR	Top Conductor Right
ETCR	Ground wire & Top Conductor Right	TD3	Double Circuit Angle Tower-3
FEM	Finite Element Model	TDL	Double Circuit Line Tower
FOS	Factor of Safety	TL	Top Conductor, Left
GL	Ground wire Left	TMCL	Top & Middle Conductor, Left
GR	Ground wire Right	TMCR	Top & Middle Conductor Right
GWL	Earth wire Left	TR	Top Conductor Right
GWR	Earth wire Right	$V_b$	Basic Wind Speed
HT	High-tensile Steels	$V_{max}$	Maximum Vertical Loading
IEC	International Electrotechnical Commission	$V_{min}$	Minimum Vertical Loading
IS	Indian Standard	$V_R$	Reference Wind Speed
MBCL	Middle & Bottom Conductor, Left		
MBCR	Middle & Bottom Conductor Right		
MC	Middle Cross Arm		
MCL	Middle Conductor, Left		
MCR	Middle Conductor, Right		
ML	Middle Conductor, Left		
MR	Middle Conductor, Right		
MS	Mild Steel		
NC	Normal Condition		
OPGW	Optical Ground Wire		
REL	Reliability		
RSL	Residual Static Load		
Saf / SAF	Safety		
SC	Stinging Condition		
SC-L	Single Circuit Left		
SC-R	Single Circuit Right		