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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IS 802-1-1: (2015)		IEC 60826:2017	
A_e	Total net surface area of member	A_c	Wind force on conductor
A_i	Area of the insulator string	A_i	Wind force on insulators
C_{dc}	Drag coefficient for Conductor	A_t	Wind force acting on a tower panel made of steel angles
C_{di}	Drag coefficient for Insulator	C_{xc}	Drag coefficient of the conductor
C_{dt}	Drag coefficient for tower	C_{xi}	Drag coefficient of insulator
D	Diameter of the cable	C_{xt}	Drag coefficient of supports
F_{wc}	Resultant wind load on Conductor	d	Conductor Diameter
F_{wc}	Resultant wind load on Insulator	G_c	Combined wind factor of conductors
F_{wt}	Resultant wind load on tower	G_L	Span factor for wind calculation
G_e	Gust Respond Factor for Conductor	G_t	Combined wind factor of towers
G_i	Gust Respond Factor for Insulator	L	Span length or Wind Span
G_T	Gust Respond Factor for tower	q_0	Dynamic reference wind pressure due to due to reference wind speed V_R
L	Wind span	S_i	Projected area of insulator
P_d	Design wind pressure	S_t	Projected area of tower panel
		Ω	Angle between wind direction and the Conductor (degrees)

ASCE	American Society of Civil Engineers	DC-TC	Double Circuit Top Conductor
BC	Bottom Cross Arm	CEB	Ceylon Electricity Board
BCL	Bottom Conductor, Left	DC	Double Circuit
BCR	Bottom Conductor Right	DC-BC	Double Circuit Bottom Conductor
BL	Bottom Conductor, Left	DC-EW	Double Circuit Ground wire
BR	Bottom Conductor Right	DC-MC	Double Circuit Middle Conductor
BWC	Broken Wire Condition	DK1/2	Dambulla-Kalundawa tower 1/2
DK2n	Dambulla-Kalundawa tower 2 new	SSL	Single Circuit Left

EBCL	Ground wire & Bottom Conductor, Left
EBCR	Ground wire & Bottom Conductor Right
EDS	Every Day Stress
EMCL	Ground wire & Middle Conductor Left
EMCR	Ground wire & Middle Conductor Right
ETCL	Ground wire & Top Conductor, Left
ETCR	Ground wire & Top Conductor Right
FEM	Finite Element Model
FOS	Factor of Safety
GL	Ground wire Left
GR	Ground wire Right
GWL	Earth wire Left
GWR	Earth wire Right
HT	High-tensile Steels
IEC	International Electrotechnical Commission
IS	Indian Standard
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
SSR	Single Circuit Right
TBCL	Top & Bottom Conductor, Left
TBCR	Top & Bottom Conductor Right
TC	Top Cross arm
TCL	Top Conductor, Left
TCR	Top Conductor Right
TD3	Double Circuit Angle Tower-3
TDL	Double Circuit Line Tower
TL	Top Conductor, Left
TMCL	Top & Middle Conductor, Left
TMCR	Top & Middle Conductor Right
TR	Top Conductor Right
V_b	Basic Wind Speed
Vmax	Maximum Vertical Loading
Vmin	Minimum Vertical Loading
V_R	Reference Wind Speed