The Elastic Stability of Palms

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Abstract

A mathematical model and hypothesis are presented, which goal is to enhance visual palm diagnosis. Firstly, the safety factor of the palm trunk regarding elastic stability is calculated. This factor has to be higher than 100%, in order not to buckle under its own weight. If this factor is satisfied, the palm can withstand a certain amount of additional loads, like the weight of a climber or wind loads. Secondly, the additional wind loads are estimated which enables to optimize artificial supports of the palm. The wind load in the palm, and the resulting loading of the supporting structure, has to be assessed undeniably. The input of the expected wind speed for the area, temperature and altitude, enable to optimise this wind load analysis. Thirdly, a hypothesis has been formulated (Sterken, 2005c) which could heighten the efficiency of visual assessment. It is suggested that the critical wind speed for failure of the palm stem depends significantly on the relationship between the modulus of elasticity, the form of the cross-section (not only diameter), the slenderness of the palm (ratio of height vs. the thin stem), dynamic wind loading and mechanical behaviours. Deductions from the Leonardo Da Vinci – Euler - Bernoulli theory and the theory of elastic stability are introduced. The guidelines that are given is to combine the visual assessment of mechanical catastrophic behaviours with the safety factor regarding elastic stability and the wind load analysis for cabling the palm tree.

Earlier components of this model have recently been published in the scientific peer-reviewed *Arboricultural Journal* , Vol. 29, pp 243-265. The content of this publication has been published earlier as a part of the Spanish paper on the modelling of forest trees and palms in *Foresta* (Sterken, 2008).

Key-words: Palms · Safety · Critical wind speed

Data of the complete publication:
Sterken, P. 2008. *The Elastic Stability of Palms.* 15p.
Royal Belgian Library
Keizerslaan, 4
B-1000 Brussel

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Wind load analysis for trees

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In accordance with Eurocode 1, part 2-4.

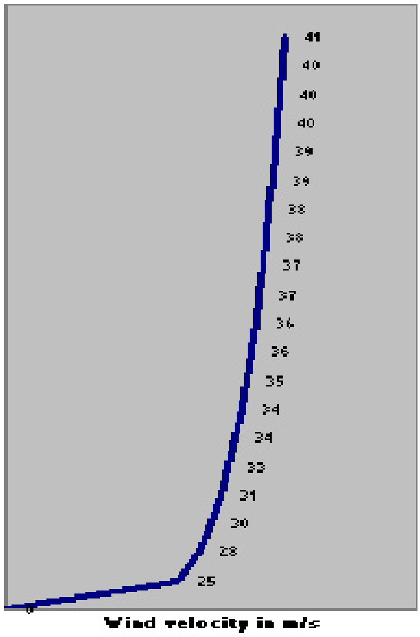
Data input=

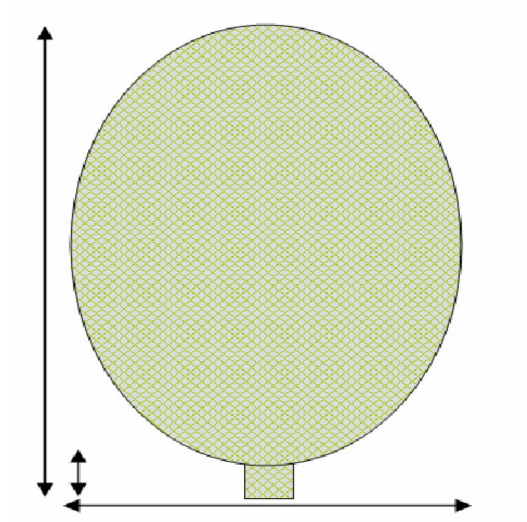
Tree characteristics

Species (see list of species)=	*Quercus robur*	
Height tree=	21.00	m
Crown diameter=	12.00	m
Height trunk=	1.50	m
Circumference=	245.00	cm
Bark thickness=	4.00	cm
Residual wall thickness,t=	9.50	cm
Cw-value (see list of species)=	0.25	
Compression strength= (see list of species)	2.8kN/cm*cm	

Environment

Altitude=	10.00	m
Minimum temperature=	-15.00	°C
Expected wind speed for the area=	130.00	km/h





Results=

Wind load analysis for trees

Crown area=	183.78	m*m
Air density=	1.37	kg/m*m*m
Wind speed=	37.29	m/s
at height=	12.23	m
Wind load=	42.96	kN
	4380.55	kg
Wind induced bending moment=		
	525.17	kNm

Bending fracture of the sound stem=

Critical wind speed=	49.95	m/s
Safety=	179.43	%
Required residual wall thickness=		
	8.32cm	

Torsion safety of the closed and concentric residual wall=

Critical wind speed=	60.43	m/s
Safety=	262.61	%

Bending fracture of the residual wall=

t/R measured=	0.27	
Critical wind speed=	39.12	m/s
Safety=	110.05	%

Dynamics=

Natural frequency=	7.82	
Vcrit_resonance=	27.35	m/s
Equivalent wind load=	23.11	kN

Please consult the following publications, in order to interpret correctly wind load analysis for trees:

Sterken P (2006) Prognosis of the development of decay and the fracture-safety of hollow trees. *Arboricultural Journal.* Vol 29: 245-267

Sterken P (2005) A Guide for Tree-stability Analysis. Second and expanded edition. University and Research-centre of Wageningen: http://library.wur.nl/gkn/

Sterken P (2008) Modelización de la estabilidad del arbolado y palmeras. *FORESTA. Asociación y Colegio Oficial de Ingenieros Técnicos Forestales*. Nº 38: 59-67.

Sterken P (2006) Prognose van de breukvastheid van holle bomen. *KPB Nieuwsbrief. Kring Praktiserende Boomverzorgers*. Dutch ISA chapter. Vol. 27: 1-10. Nederland.

Disclaimer: While every effort has been made to validate the solutions in this worksheet, Peter Sterken is not responsible for any errors contained and is not liable for any damages resulting from the use of this material, nor for any interpretation of the calculations. These calculations are only intended for educational purposes and should only be employed by a professional trained in this method.

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