A MODEL FOR VISUAL TREE AND PALM ASSESSMENT

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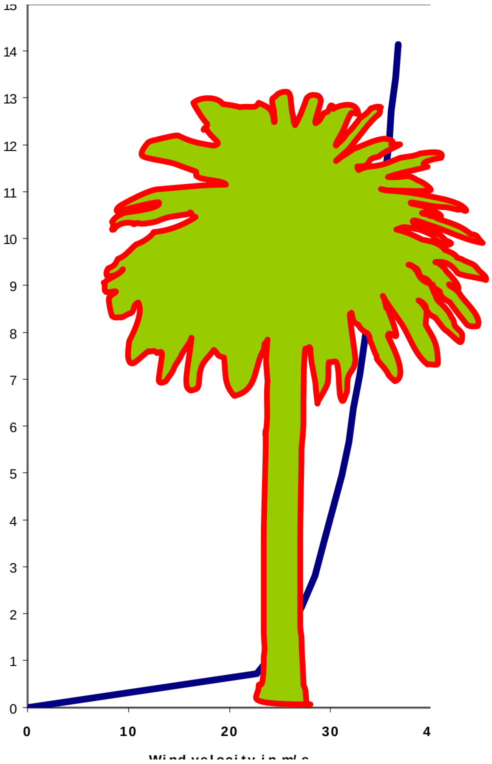

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Prologue

The goal of this paper is to resume 3 years of study and work in the field of tree and palm care.
I have paid a terrible price for this knowledge. Hell started when I discovered some limitations of the commercial tree assessment method that I used to employ.
Doors suddenly closed, on all levels. Editors of some of the biggest Journals and magazines in arboriculture and palm-care responded: “It is years too early to publish your work. Nobody will understand it.” or “Our readership is not interested in the subject you treat.” These were the astonishing reasons they gave me for not considering its publication.
Time will tell.

I might probably have said *no* to gather this view on tree and palm safety, if I would have known the terrible price that I would pay for it. Or maybe I would: the hunger for knowledge is unavoidable and discovering new insights provides the highest fulfilling.
I have the feeling that I have found a clear model for the assessment of the safety of trees. And maybe a starting point for palms. Both which will be enhanced or even rejected in the future, due to progress that hopefully will come. This model is no invention. I just try to distillate in words what nature discloses, so it can be passed through.
Time will tell if it’s worth it.

Introduction

The intention was to design a new model for tree and palm assessment. A model that connects all known elementary knowledge in a logical way. This paper describes briefly the basics of the model, which is very difficult since it is based on what nature discloses.
It is important to note that, in contrast with some known methods, no sales or virtuoso commercial strategies are hidden behind this work. Just the honest intention of passing through knowledge, which might make tree-diagnosis maybe a bit more accessible. Which it is, after all.

The model is constructed upon the following components:

- Wind engineering
- Mechanics and statics: prediction of failure of the wooden body
- Mechanical behaviours that are unpredictable by means of statics
- Visual assessment
- Pathology
- Biology
- An understanding on the differences between dicots (trees) and monocots (palms) on biological, pathological, anatomical and mechanical level
- Common sense

The following components are explained both for trees and palms, since these are some of the very few contact points that both might have in common:

- Analysis of the wind load in the crown and susceptibility of dynamic behaviour (wind engineering)
- Certain mechanical failures that are not predictable by means of current instrumental methods

Other components like mechanics and statics, visual assessment and wood decaying fungi are described briefly only for trees. This is due to the fact that very little is known, at a scientifically published level, for palms about these subjects.
For the reader his comfort, the most important statements are resumed this paper.
The following step would be to study the cited references, since it has no sense to write again what has been written better elsewhere.

Visual assessment of hollow trees: the essence

The essence of visual assessment of the breaking safety of a tree, according to the author, could be resumed in this way:

1. When the vitality of the tree is good enough, many times the tree's safety against breakage can be assessed well visually and with the combination of a wind load analysis and the bending theory of a hollow beam. Because:
The quality repair-growth can deal more efficiently with stress-concentrations. And, due to the efficient barrier-zone and parenchyma-cells, the inner geometry of the ring of sapwood can have a clearly defined form and a coherent mechanical behaviour. In this way, a mechanically highly efficient ring of sapwood can be "constructed" by the tree.
The extent, to which this ring would be structurally enough, can partially be assessed with wind load analysis and the theory of elasticity.
Even then, some types of possible collapses of the hollow tree are not reliably predictable yet. Amongst them are shearing failures, cross-sectional flattening, shell-buckling and torsion, which can only be assessed visually, especially with open cavities.

2. The general question that students then ask is: *"But how can the thickness of the residual wall be assessed visually then, especially without the presence of openings?"* The answer is difficult.
A good way of finding a solution to a problem that seems unsolvable is to approach it from another position. If you stare at an object, let's say a glass of water, you'll have one perception of the reality. Nevertheless, if you go and sit in another part of the table, the glass will remain the same, but you are able to look behind the glass. In this way, *your perception* of this glass will be different! In this way, several perceptions of one *reality* are possible. What reality is for each of us, is only one of the many possible perceptions of "the" reality.

Hence, the first question should be approached differently and the reality that can be seen will be different. So, here comes the same issue, observed from an opposite position (looking behind the glass now): *"According to all the criteria employed, the tree needs 3,4 cm of residual wall. Does the tree has that thickness?"* This question is far easier to answer than the first. And, it targets more precisely and directly the main issue.
The starting point of this model for palms and trees was to ignore existing "one-way streets" of thinking (e.g. only tree-statics or only bio-mechanics and pathology). In this way, new ways of thinking can be discovered. The point is to look in a different manner to the same problem.

3. When the tree is not vital enough, the processes of compartmentalisation and compensation are not as efficient regarding extending rots. This can result in an irregular and treacherous geometry instead of an idealised perfect ring, where the tree might fail. Even if the calculations predicted the tree as "safe".

Resumed: In order to assess whether a hollow tree is hazardous or not, this model suggests that the residual wall should have both enough safety reserves regarding wind loads and a low risk of catastrophic mechanical behaviours.

4. The ring of sapwood is what gives the tree its main structural strength, regarding for example torsion and bending, to a tree. Therefore, if symptoms are detected that point towards damages in the sapwood, e.g. due to wood decay fungi, then it is possible that the cross-section suffers an important loss of its load bearing capacity. During the stability assessment, it is also very important to recognise whether a barrier zone has developed in a tree or not.
If the sapwood is damaged, then the water conducting capacity can be diminished. This can lead to a loss of vitality. This loss of vitality usually produces symptoms in the upper crown structures and the bark (secondary growth of the damaged cross-section!). Other symptoms, like growth depressions or dead areas in the bark also may indicate serious structural damages in this load bearing ring of sapwood.

The use of decay-detecting technology or other instrumental methods can further enhance the diagnosis, *provided that the practitioner has sufficient knowledge on visual assessment, in order to employ these devices efficiently.*

5. A word on stress concentrations, deformation energies and repair growth:
According to the theory of Inglis (Gordon 1999), a crack or opening in the tension side of a structure can lead to deformation energies and stress-peaks around the defect. Crack propagations and stress concentrations cause the structure to fail without obeying the theory of elasticity. The bending theory of a hollow beam, e.g. V model or the SIA/SIM methods of Wessolly & Erb (1998), ignores stress-concentrations that might occur around old branch wounds or cavities, or elsewhere in the structure.
Nevertheless, as Griffith found out (Gordon 1999), the higher the stiffness (modulus of elasticity), the higher the resistance against crack-propagation, since the “critical length” of a crack is positively proportional to stiffness.

Successful repair-growth seems to involve a higher stiffness (Wessolly & Erb 1998). Hence, this would lower the risk for crack- and defect propagation in a vital tree.
On the other hand, in a vital tree the locally thickened growth rings and wound-spindles can relieve the notch stresses in the edges of a wound (Mattheck & Kubler 1995). This optimised tree-geometry could lead to less considerable stress-peaks around old branch wounds and cavities.
A tree cannot always react against, or even notice, stress-peaks, crack-formation and crack-propagation. But according to the present theoretical exercise, the repair-growth around defects in a vital tree would lower the risk regarding these features. Partly because of its higher stiffness and higher strength and partly because of the extra wood, laid down where needed.
A declining tree is seemingly not as good in it. Although it has to be noted that tree vitality and failure potential are related but not equivalent. Trees with high vitality can fail, while trees with low vitality can be stable.

Visual assessment of palms: the essence

- *Summary*

The safety of trees and palms is of great concern during events of strong wind. A simple model is presented which enables to assess the swinging potential of the palm during events of wind.

- *Introduction*

There is no information or method available yet for assessing the structural strength and safety of palms during hurricanes. Hence, a proposal and starting point for the assessment of the swinging potential of palms has been formulated.
Natural bending sways of the palm can be excited by wind gusts with the same frequency, potentially leading to large deflections and unexpected failure. The critical wind speed v_{crit}, at which the frequency of vortex shedding equals this natural swinging frequency, is predicted in accordance with Eurocode 1 (AENOR 1998). In this context the present model has been developed.
The wind load in the palm is calculated, incorporating the expected wind speed and minimum temperature for the area and the altitude above sea level. This wind load analysis enables to optimise cabling configurations which can stabilise damaged palms to other palms, trees or structures. These artificial supports allow diminishing the risk for uprooting and breakage.

A hypothesis on stem failure of palms has been formulated, based on the observation of broken palms and controlled breakage experiments. Here is suggested that the critical wind speed for failure of the palm depends on the relationship between the modulus of elasticity, the form of the cross-section, the slenderness of the palm and mechanical behaviours.
These mechanical behaviours, e.g. shear, splitting and Brazier buckling, can cause failure of the stem while these are not predictable by means of current instrumental methods.

Finally, this proposal is completely independent from the static integrated methods for trees of Wessolly and Erb (1998).

Conclusions

- *Conclusion on trees*

After assessing whether the existing sapwood, which gives the tree its main structural strength, is able to bear the impacting loads, a prognosis is made regarding the future development of decay in this ring of sapwood. This allows a more accurate assessment of the *future* fracture-safety of the tree or defective branches. The contribution of this method is the *synthesis and an integration* of previously published tree assessment methods
When the absence of intact barrier or reaction zones is suspected in a tree, the residual wall might not behave in the simplified manner, as if it was a hollow beam under pure bending stresses. This due to the invasiveness of certain fungi as regards reaction zones in the sapwood, which can lead to an irregular geometry and a not clearly defined ring of sapwood.

The wind load analyses form the core of the V model and of similar methods, e.g. the SIA-SIM methods of Wessolly & Erb (1998). According to AENOR (1998) this relatively simple methodology is *not* valid, if the structure would be susceptible to the dynamic interaction with the wind. And yes, trees are rather dynamic structures.

Possibly due to this reason, the SIA method *only* employs uniformly distributed crown forms and relatively low and rigid tree-silhouettes. In trees that do not fit in these idealised rigid, low and uniform crown forms, extreme precaution should be taken with this type of calculations.
For example, unevenly distributed crowns or “lion-tailed” trees do not only influence wind loading and torsion, but also can cause displaced crown weights and its centre of gravity. A complex loading combination of bending, torsion and swinging can occur. The form of the trunk (if it’s not as straight as a pole) and its structural defects, root/soil interactions and other variables, can also upset the calculations.

This demonstrates how wind load analysis and stability calculations can only pretend to be a good orientation. They seldom predict the *real* safety of many trees, since they are a simplification of the reality. Important limits of these methods for trees have also been discussed elsewhere by e.g. Peltola et al. (2000); James (2003) and Mattheck & Betghe (2005).
Although these wind load analysis methods can have a highly technical appearance, the calculations still are among the most primitive ones, when compared with other scientific disciplines.

- *Conclusion on palms*

Although the model is in accordance with international engineering standards, it is acknowledged that there is no statistical evidence yet to show a comparison between predicted results from the model against real outcomes. v_{crit} cannot be seen yet as an exact value, since some parameters have to be estimated. Nevertheless, the relative results (in m/s) show good agreement with visual observations of slenderness in palms. The above described experiments can fine-tune these calculations. Cabling is also an efficient solution for reducing oscillations caused by vortex shedding and turbulent gusts.
With the necessary caution, the principles of this model, i.e. wind load, bending frequency, critical wind speed v_{crit} and the visual assessment of mechanical behaviours, can be incorporated in risk-assessments for palms. According to field observations, the formulated hypothesis on stem failure might target precisely the essence of the breaking safety of palms. Finally, the goal of this model and paper, is to set the stage for the future development of the herein briefly proposed visual palm assessment.

Peter Sterken

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Citations

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