Andreas Detter: a simple rule of thumb for rigging forces from full-size tests

In the course of the HSE Rigging Research, studies on rigging forces have been conducted by blocking the friction device and measuring forces in the block at the rigging point during simulated drops. The recorded peak forces did not act parallel to the trunk, but on average at an angle of 30 to 40 ° to the trunk axis. This creates a lateral bending moment that may cause a stem used as an anchor point to fail. The forces that occur at the rigging point (i.e. the block) exceeded the weight of the lowered section by an average of 8 to 12 times, and this factor decreases with increasing mass (HSE Rigging Report 2008). In more recent drop tests with *Teufelberger Ropes*, the *Treemagineers* used logs with a mass of up to 750 kg, which is threetimes the mass of the biggest sections used in previous tests (Donzelli et al 1998, HSE Rigging Report 2008, Kane et al., 2009).

The calculation of the forces that may occur at the anchor point during rigging operations is very complex, since numerous factors interact, and directly or indirectly affect the result. In addition to the mass of the lowered section, for example the properties and length of the rope used also play an important role. For the experiments that are evaluated in Figure 1, only two types of rigging rope (double braid and kernmantle type) with 12 and 14 mm diameter were used. For those rigging systems, a rule of thumb for estimating the peak force in a worst case scenario was derived.

According to this rule, the force peak on the pulley can be assumed to be 8 times the mass of the trunk plus 500 kp (kilopond [kp] is a force unit equal to the weight of 1 kg). The load on the short end of the rope connected to the dropped section (*lead of the line*) can be estimated by dividing this value by 1.8 (HSE Rigging Report 2008). This rule is of course a simplification, but it underestimated the peak forces for trunk sections by less than 10% in 37 drops where the friction device was blocked. On the other hand, the result was only by a quarter too high at max in this series of tests.

The estimates by this rule of thumb should not be readily applied to other rigging scenarios and different kinds of rope. For example, the use of more rigid ropes with higher strength or other braiding may lead to greater peak forces. Other tests show that when lowering crown sections that are still in leaf, even with a locked friction device, peak forces do not exceed the forces generated during the slow "dynamic" deceleration of trunk sections with similar mass. These relationships are further explained in Chapter 8 of the HSE Rigging Report.

Unfortunately, studies where a forcemeter is placed between the pulley and the anchor sling at the rigging point may be misleading (e.g. Donzelli et al 1998, Kane et al., 2009). With this setup, the actual distance of fall is significantly extended, and much greater forces will be recorded than in real tree care operations. In the meantime, however, a load sensor has been developed by *Straightpoint* in cooperation with the *Treemagineers*, which is integrated into a rigging block and thus enables unadulterated measurements of the forces during rigging operations.

Literature:

Detter, A., Cowell, C., McKeown, L., Howard, P., 2008. Evaluation of Current Rigging and Dismantling Practices Used in Arboriculture (Research Report No. RR668), HSE Books. Health and Safety Executive, UK, Norwich, UK. Online @ www.hse.gov.uk/research/rrpdf/rr668.pdf

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Kane, B., Brena, S., Autio, W. 2009. Forces and stresses generated during rigging operations. Arboriculture & Urban Forestry 35, 68–74.

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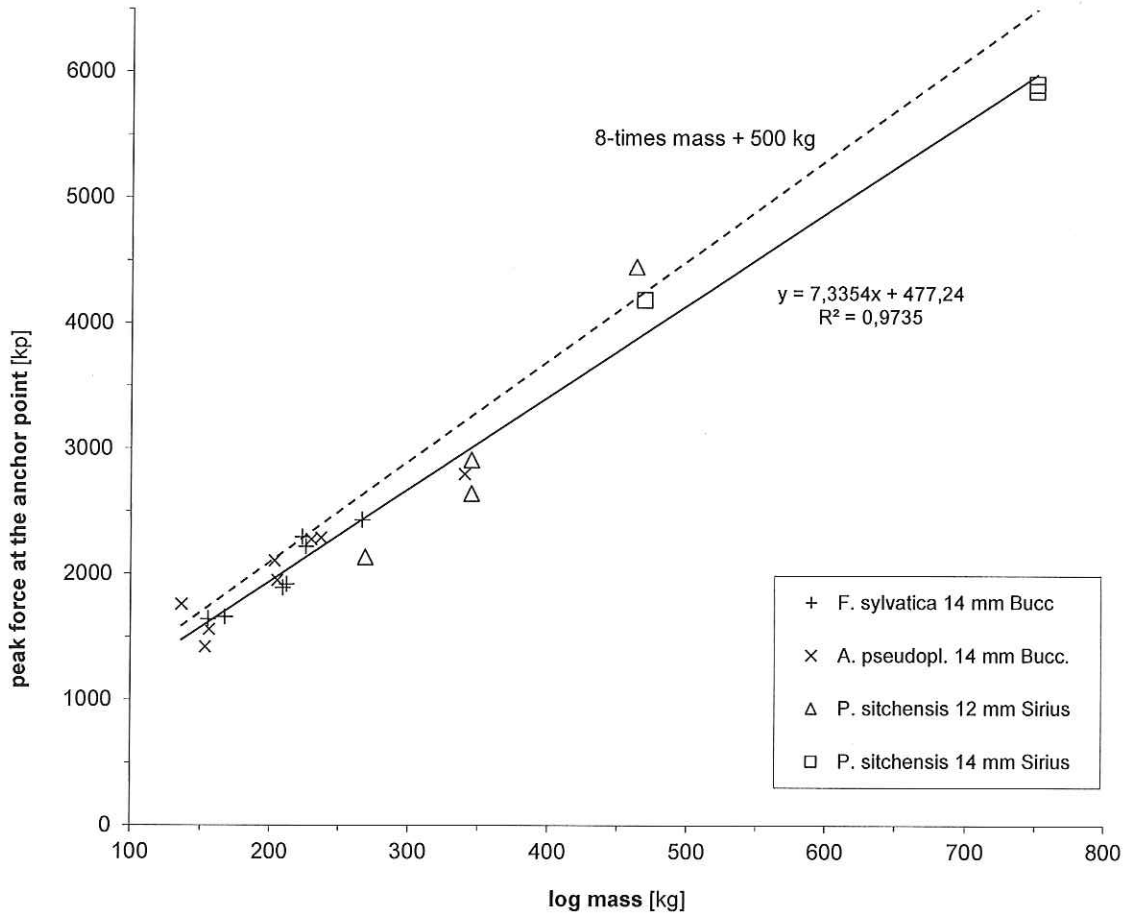
Figure 1: evaluation of forces generated at the rigging point (block) during 37 topping-down operations of trunk sections with locked friction device. Data on P. sitechensis courtesy of *Treemagineers* and *Teufelberger Ropes,* other data from the HSE Rigging Report



Textbox diagram:

The rule of thumb is displayed as the dashed line, the solid line indicates the average correlation between mass of section and generated peak force at the rigging point. The R^2 value of this trend (least squares method) is close to 0.97 which qualifies the mass of the log as a very good indicator of the peak force (cf. Kane et al. 2009). Yet, using different ropes, setting up different rigging systems with reduced rope length or performing different rigging operations may alter the actual forces significantly. Therefore, the rule of thumb can only be applied by with caution and must be adapted to the actual situation by an experienced and competent person.