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MODELLING AND TESTING TWO-STUMP ANCHORS

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INTRODUCTION

Stump anchor failure in a cable logging system can be catastrophic. There may be more risk of pull-out failure in future stands where the trees are of smaller diameter or the nature of the soils has limited root system development.

If a single stump is not expected to provide sufficient pull-out resistance, then one option is to employ a multiple stump anchor. Four possible configurations of two-stump anchors are shown below :

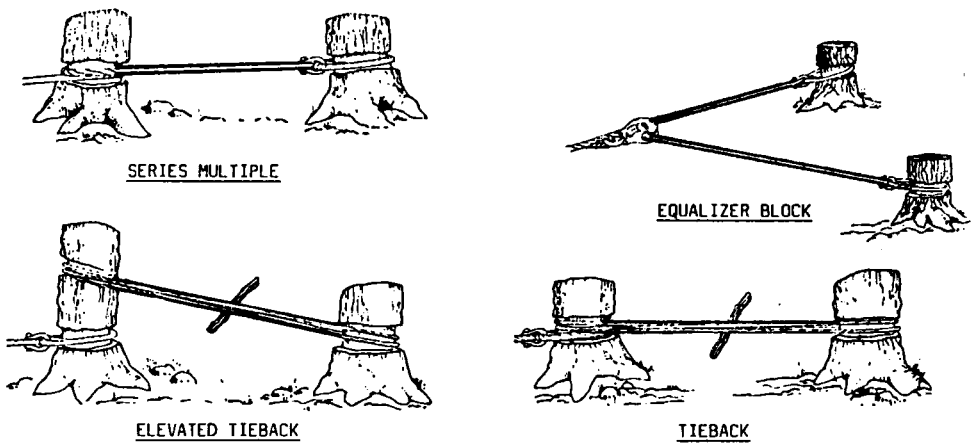

Figure 1 - Multiple anchor rigging configuration

What is the behaviour of these various rigging systems under applied load? To resolve this question, research on anchor systems was conducted at Oregon State University (Toupin 1985). A mathematical model was developed to describe the system behaviour under load and the model's predictions were compared with results from the field testing of young growth Douglas fir stumps.

PREVIOUS WORK

Information on single stump anchors published in the United States includes guidelines presented by Studier & Binkley (1974), and research findings presented by Stoupa (1984). Research in New Zealand has been documented by Liley (1985). Multiple stump anchor testing was reported by Kimbell (1981) for one rigging system.

MULTIPLE STUMP SYSTEMS AND MODEL

The modelled rigging systems illustrated in Figure 1 are described as follows :

(1) Series Multiple System - the skyline is used to link the two stumps together. The skyline is wrapped around the first stump in a notch, passed to the second stump, and wrapped around it in a notch and secured.

(2) Tieback System - the skyline is wrapped around the first stump in a notch and secured. Strawline is used for the tieback line. It is wrapped around the two stumps several times and tensioned by twisting the wraps with a stick. This type of tieback is commonly called a "twister".

(3) Elevated Tieback System - similar to the regular tieback, except the twister is attached higher on the first stump than the skyline.

(4) Equalizer Block System - the equalizer line is tied off to the first stump, passed through the block and tied off to the second stump. The skyline is attached to the block.

To select the best multiple stump anchor system for cable yarding, it is necessary to know how the anchor rigging systems respond to applied load.

The mathematical model which was developed provided load-deformation curves which relate the movement of the stump to the applied load. These loads range from zero to a maximum value based on equations developed by Stoupa. The focus of the model was to determine how the load-deformation behaviour of the individual stumps could be combined to describe the behaviour of a two stump system.

RESULTS FROM THE MODEL

A comparison of the four rigging systems was made by using model results for varying stump capacities and diameters. The tieback configuration results also included the effect of varying tieback pretension. Figure 2 shows the load-deformation curves for a weak first stump, and a strong second stump. The equalizer block curve is significantly lower than the other systems which means that the system has a lower maximum capacity. It will also reach its maximum capacity at a smaller deformation than the other systems. The results with a strong first stump and a weak second stump would be nearly the same as those shown in Figure 2 for the series multiple, the tieback, and the equalizer block systems. The elevated tieback would have nearly the same maximum load, but would experience about 20% more deformation at a given load if the weak stump is the second stump.

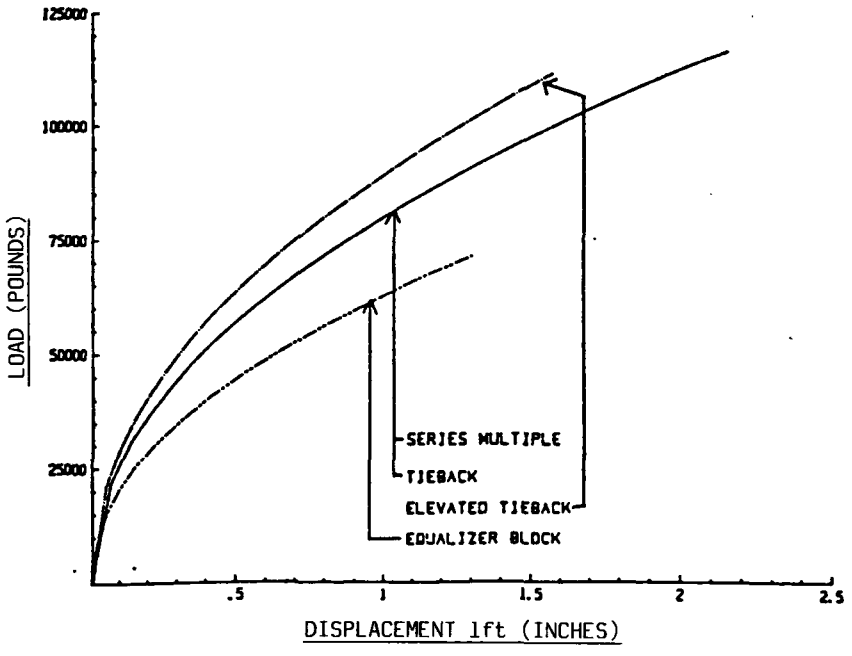

Figure 2 - Model load-deformation curves for four rigging configurations. The curves end at the load where system failure occurs

Based on other model computations, the series multiple, tieback, and equalizer block systems have identical load-deformation curves if both stumps have the same maximum capacity. The load-deformation curve for the elevated tieback system was consistently above the other systems up to its maximum capacity, but its maximum was slightly lower than the regular tieback and the series multiple systems. Additionally, tieback pretension does not greatly affect the model results.

FIELD TESTING

Young growth Douglas fir stumps were field tested using a system of rigging and equipment as shown below :

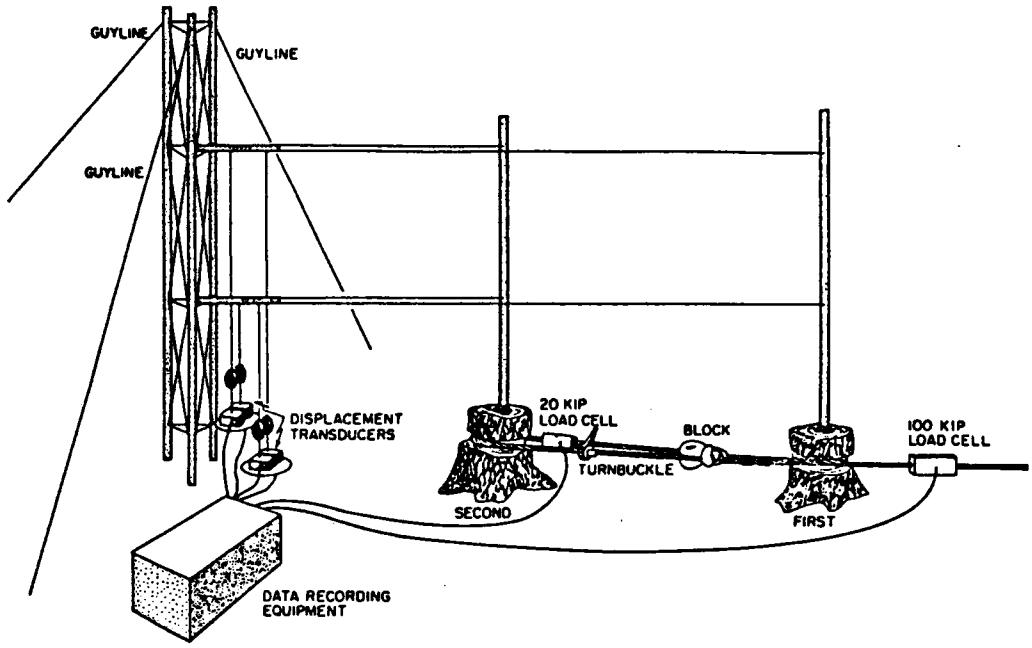

Figure 3 - Side view of the data collection rigging configuration for the series multiple system

COMPARISON OF RESULTS

In general, the model predictions compared favourably with the field measurements. At the highest load measured for each test, the average field measured load ranged from 38% to 101% of the model predicted load. While this range is quite large, it is within the prediction limits of the model. The general shape, and order of the field load-deformation curves for the four rigging systems agreed with the model prediction.

DISCUSSION

The model computations indicate that the series multiple and both tieback systems are so similar in behaviour that it is not reasonable to recommend one over the others. However, the equalizer block system appears to have a much lower load-deformation curve, and maximum capacity under some situations, making it less desirable than the others. In general, the maximum capacity of the series multiple or tieback systems approaches the sum of the capacities of the individual stumps. The maximum capacity of the equalizer system appears to be about twice the capacity of the weaker of the two stumps (the angle between the two sides of the equalizer line will further reduce this).

The present model is limited by three features which would be the subject of further attention in more advanced stages of modelling. These are :

- the research has only considered pull-out failure but stumps may fail through other means such as being sheared by the wire rope.
- the computed movement and direction of applied load are parallel to the ground surface. In practice, most skylines rise at an angle from the ground.
- the linkage between the stumps is considered to be rigid, so that any movement in the first stump causes immediate movement in the second. In reality, the linkage is not rigid and may lengthen before the second stump shares much of the skyline load. Linkage length may change as the processes of wire rope stretching and wood crushing take place in the two tieback configurations. For the series multiple system, both line stretch and wood crushing occur as well as skyline movement around the first stump under increasing skyline tension.

As part of the field testing phase of the project, the load transferred to the second stump in a series system was determined. The results shown in Figure 4 indicate the frequency of load transfer from the skyline to the second stump. The variation is a function of the individual stump strengths and the behaviour of the linkage. The graph indicates that on average the second stump takes less than half of the skyline load.

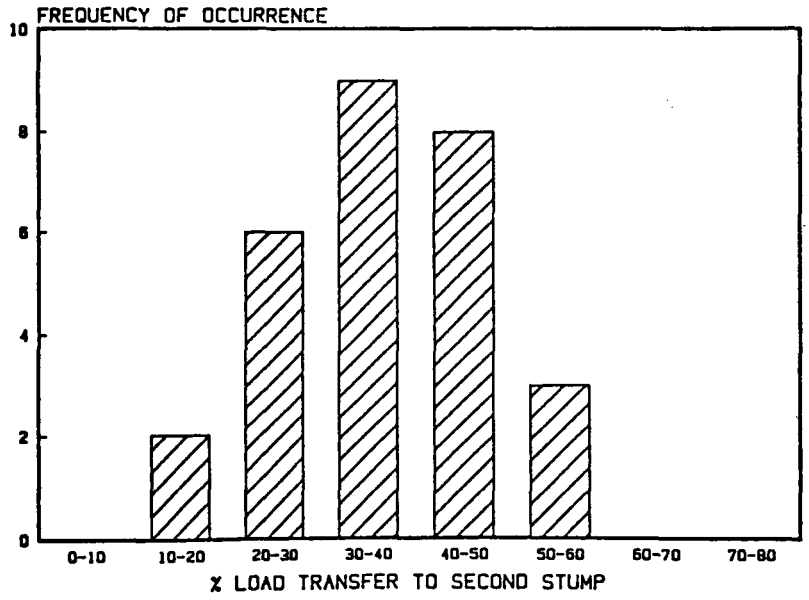

Figure 4 - Frequency of load transfer - skyline to second stump

This research was conducted on Douglas fir in relatively dry soil. It is expected that the results for different soil moisture conditions would vary from those presented by Toupin, but the modelling technique should still apply. The model needs to be expanded to include other species and different timber growing sites.

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