STATIC LOAD TEST PRIOR TO WORKS IN CLOSE PROXIMITY OF A MATURE PINE TREE

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United Living are planning to carry out works around a mature pine tree which has a natural 30 degree slant. We were concerned about the impact these works would have on the tree and appointed Treework Enviornmental Practice to carry out a non intrusive test (Static Load test) on the tree to see if these works will have an impact. This practice is one of the only companies that does the Static Load test in UK and we are very impressed with their standards and professionalism.

Unfortunately the test result requires the felling of the tree, not because of the works we are planning to do, but because of the health and slant of the tree.

Below is an extract from their static load test

1 Introduction

1.1 Brief and Context

1.1.1 Treework Environmental Practice was instructed by Sharon Hosegood Associates and United Living in September 2018 to conduct a static load test on a back pine tree (Pinus nigra; T0165) growing in the communal grounds of Rhodes Moorhouse Court, Morden, to assess the likelihood of structural failure of the whole tree through failure of the root plate, following concerns raised about the potential of disturbance to the tree during path construction on the east and north sides of the tree.

1.2 Purpose of this Report

1.2.1 The aim of the static load test is to identify trees that have extremely low safety factors for failure and to recommend remedial works, where possible, to improve these safety factors to acceptable levels. It does not claim to be able to accurately quantify these safety factors or to determine the wind event that would lead to the failure of a particular tree.

1.2.2 This report, and accompanying results in Appendix A, presents the results of the test and gives an analysis and interpretation of the data collected.

1.3 The Tree and its Context

1.3.1 T0165 is a mature black pine (Pinus nigra) growing in an area of soft landscaping adjacent to the tennis courts, which lie to the east of the tree. The tree is surrounded by shrubs and smaller trees in planting beds and areas of lawn, and is the tallest of the surrounding trees. The tree is 23 m in height and has a pronounced lean of 30 degrees from the vertical towards the east. The lean is historic, and the crown morphology indicates that the tree has clearly been in a leaning position for a long time. The tree has an unbalanced crown that is biased to the east in the direction of the lean; this probably developed because the tree originally had other trees to the west of it, two of which failed in the 1987 hurricane. The tree appears to be in reasonable physiological health. A play area is planned to the east and north of the stem at a distance of c. 1.5 m and a new footpath is planned running north-south, prompting concerns about the state of the roots and rootplate stability.

2 The Test and Analysis

2.1.1 The static load test makes an assessment of the reaction of the tree to the load applied during the test in terms of the bending of the stem and the inclination of the root plate. These results are then extrapolated to how the tree might react in a chosen storm event (modelled in a Wind Load Analysis) as that event might affect the tree in its particular context, and an assessment is made of how close the tree is predicted to come to threshold criteria given the loads it is being tested to support. The extrapolation is based on known relationships for the elastic properties of wood and rootplate inclination.

2.1.2 The model behind the assessment is comparable to an engineering test, and the results of the test are assessed against the wind load analysis and expressed as safety factors for failure. To provide a degree of confidence that the subject tree poses a low risk of failure, a safety factor of greater than 1.5 is generally required for both stem fracture and root plate failure.

2.1.3 The static load test does not seek to predict when, or under what conditions, a tree will fail.

2.1.4 A full description of the principles and practice of the static load test and analytical model is given at Appendix B.

2.1.5 T0165 was tested in two roughly perpendicular directions, east (3 tests) and northeast (3 tests). **Three elastometers were placed on the stem in different positions in each test in direction to measure the deflection of the peripheral wood fibres, and two inclinometers were positioned at different positions around the base of the tree in each test to measure the inclination of the root plate.**

3 The Design Wind Load

3.1.1 The wind load analysis defines the design wind load or maximum equivalent bending moment that we would expect the tree to experience during a storm or high wind event of a chosen magnitude or frequency. The design wind load is a bending moment, expressed in kNm. It is the product of the estimated maximum wind pressure for the modelled storm multiplied by the lever arm or load centre (influenced by the height and form of the tree).

3.1.2 The analysis wind load considers the following factors and how they are likely to affect the magnitude of the wind pressure on the tree:

- the average and gust wind speeds for the modelled storm period for the site
- how those speeds might be amplified or attenuated by surrounding buildings or landscape features (this information is expressed as a roughness category: City, Suburb, Countryside or Coast)
- the size and shape of the tree crown
- the drag coefficient of the tree crown (species-specific)
- the natural frequency and of the tree and the damping effect of the crown (speciesspecific)
- the degree of shelter or exposure of the tree
- for leaning trees, the eccentricity of the crown and how this affects the deadweight load

4 Results

4.1.1 Design wind loads of 557 kN/m (east load direction) and 195 kN/m (northeast load direction) were estimated as the maximum equivalent static loads to which the tree would be likely to be subjected in the modelled storm. The greater load for the east direction reflects the slightly larger crown area in this orientation and the additional deadweight load created by the crown eccentricity.

4.1.2 A theoretical or basic safety factor was calculated for the tree for each load direction using the modelling software. The basic safety calculation is based on the theoretical load-bearing capacity of a solid elliptical stem with material properties consistent with the reference wood properties for that species when exposed to the design wind load. Where a tree has a basic safety of greater than 1.0 then a degree of hollowing can be tolerated. This value is then compared against the safety factors calculated from the measured data to draw inferences about possible strength loss.

4.1.3 An assumption is made that the basic safety factor calculated for stem fracture (based on the ability of the stem to carry the design wind load) should be mirrored by the ability of the roots to carry loads. Safety factors greater than 1.5 are required for root plate stability and stem fracture for the levels of risk to be acceptable.

4.1.4 Basic safety factors of 1.3 (east load direction) and 3.4 (northeast load direction) were calculated for the tree. For the design wind load, the tree would be expected reach 77% (east) and 29% (northeast) of the elastic limit of the stem wood given the dimensions measured at 1.0 m above ground level if the stem were sound and defect free. Basic safety factors for root plate failure would be expected to be within a similar region.

4.1.5 During the test, bending moments of between 19% and 22% of the design wind load in the east load direction and between 34% and 38% of the design wind load in the northeast load direction were generated.

4.1.6 A summary of the safety factors generated by the test is given in Table 1.

Table 1 - Summary of Measured Safety Factor (SF) Results from Test

East: Basic SF 2.8 Northeast: Basic SF 3.4

Minimum Stem SF 1.2 2

Maximum Stem SF 3.8 4.3

Minimum Rootplate SF 0.9 1.5

Maximum Rootplate SF 1.1 2.2

SF = Safety Factor; threshold SF = 1.5.

Figure 4: Design wind load and basic safety factors for the east and northeast test directions (25 cm aerial photograph ©Geostore).

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4.1.7 These results are also summarised as graphs in Appendix A. Data falling within green areas of the graphs indicates an acceptable safety factor greater than 1.5. Data falling within the red areas of the graph indicate unacceptable safety factors of less than one. The grey areas within the graphs indicate safety factors of between 1.0 and 1.5.

Conclusions

5.1.1 The basic safety factors for T0165 are fairly low values, but reflect the characteristics of the tree as a mature specimen with a relatively small diameter for its height and crown size, particularly in the east orientation, and the significant lean to the east.
5.1.2 All safety factors for roots in the east direction except one were lower than 1, and all values were below 1.5. In the northeast direction they ranged between 1.5 and 2.2. For the east direction, these values indicate a loss of stiffness, and indicate that the root plate is not as safe as it would need to be to withstand the modelled storm.
5.1.3 Loss of rootplate stiffness cannot be attributed to any specific causal agent with any degree of confidence. The reactions may be a result of a long-term, historic condition such as a restricted or poor rooting environment, mechanical root severance or historic changes related to the features and levels around a tree, to other unknown changes in the root zone, or to decay Processes. The low safety factors in the east direction, including the basic (or theoretical) safety factor, are also a result of the historic lean and the eccentric deadweight load of the crown caused by crown suppression by other trees that were formally growing to the west of the tree but that failed several decades ago.

Figure 5: T0165 viewed from the east

Figure 6: T0165 viewed from the south-east; note pronounced lean to east

6 Recommendations

6.1.1 Given that the tree therefore be at high risk of uprooting in the modelled storm, remedial action is required to reduce the risk of uprooting to an acceptable level by increasing the rootplate safety factors to above 1.5.

6.1.2 A crown reduction would reduce the height and volume of the crown and therefore reduce the wind load and consequent force on the damaged rootplate. However, a major crown reduction would reduce the photosynthetic capacity and therefore the energy resources the tree would have to regrow roots, especially as the tree is a mature specimen that would be unlikely to respond quickly; compensatory root growth is therefore unlikely to be sufficiently rapid to improve rootplate stiffness and increase safety factors.

6.1.3 Given the low safety factors for rootplate stability and the associated risk of uprooting onto the footpath/tennis courts, ***it is recommended to fell the tree.***